EUROPEAN COMMISSION

Executive Agency for Small and Medium-sized Enterprises (EASME)

H2020 Environment & Resources

ANNEX 1 (part A)

Research and Innovation action

NUMBER — 641811 — IMPREX

Table of Contents

1.1. The project summary

Project Number [1]	641811	Project Acronym [2]	IMPREX

One form per project

General information	
Project title [3]	IMproving PRedictions and management of hydrological EXtremes
Starting date [4]	01/10/2015
Duration in months [5]	48
Call (part) identifier [6]	H2020-WATER-2014-two-stage
Topic	WATER-2a-2014 Water cycle under future climate
Fixed EC Keywords	Flood forecasting, Integrated management of water, Water resources, Hydrology, Catchment scale water management, Water policy
Free keywords	Climate Change impacts, risk outlooks, risk management, adaptation strategy

Abstract [7]

IMproving PRedictions and management of hydrological EXtremesFor a better anticipation on future high impact hydrological extremes disrupting safety of citizens, agricultural production, transportation, energy production and urban water supply, and overall economic productivity, prediction and foresighting capabilities and their intake in these strategic sectors need to be improved. IMPREX will improve forecast skill of meteorological and hydrological extremes in Europe and their impacts, by applying dynamic model ensembles, process studies, new data assimilation techniques and high resolution modeling. Novel climate change impact assessment concepts will focus at increasing the realism of relevant events by specific high resolution regional downscaling, explore compounding trans-sectoral and trans-regional risks, and design new risk management paradigms. These developments are demonstrated in impact surveys for strategic economic sectors in a set of case studies in which local stakeholders, public organizations and SMEs are involved. A pan-European assessment of risk management and adaptation strategies is applied, minimizing risk transfer from one sector or region to another. As a key outreach product, a periodic hydrological risk outlook for Europe is produced, incorporating the dynamic evolution of hydro-climatic and socio-economic processes. The project outreach maximizes the legacy impact of the surveys, aimed at European public stakeholder and business networks, including user-friendly assessment summaries, and training material.The project responds to the call by targeting the quality of short-to-medium hydro-meteorological predictions, enhancing the reliability of future climate projections, apply this information to strategic sectoral and pan-European surveys at different scales, and evaluate and adapt current risk management strategies. With its integrative approach, IMPREX will link current management decisions and actions with an emergent future.

1.2. List of Beneficiaries

Project Number [1]	641811	Project Acronym [2]	IMPREX

List of Beneficiaries

No	Name	Short name	Country	Project entry month[8]	Project exit month
1	KONINKLIJK NEDERLANDS METEOROLOGISCH INSTITUUT-KNMI	KNMI	Netherlands	1	48
2	EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS	ECMWF	United Kingdom	1	48
3	SVERIGES METEOROLOGISKA OCH HYDROLOGISKA INSTITUT	SMHI	Sweden	1	48
4	INSTITUT NATIONAL DE RECHERCHE EN SCIENCES ET TECHNOLOGIES POUR L'ENVIRONNEMENT ET L'AGRICULTURE	IRSTEA	France	1	48
5	POTSDAM INSTITUT FUER KLIMAFOLGENFORSCHUNG	PIK	Germany	1	48
6	ARCTIK SPRL	ARCTIK	Belgium	1	48
7	BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SUPERCOMPUTACION	BSC	Spain	1	48
8	MET OFFICE	METOFFICE	United Kingdom	1	48
9	THE RESEARCH COMMITTEE OF THE TECHNICAL UNIVERSITY OF CRETE	TUC	Greece	1	48
10	THE UNIVERSITY OF READING	UREAD	United Kingdom	1	48
11	HELMHOLTZ-ZENTRUM GEESTHACHT ZENTRUM FUR MATERIAL- UND KUSTENFORSCHUNG GMBH	HZG	Germany	1	48
12	STICHTING DELTARES	DELTARES	Netherlands	1	48
13	STICHTING VU-VUMC	IVM	Netherlands	1	48
14	ADELPHI RESEARCH GGMBH	ADELPHI	Germany	1	48
15	HKV LIJN IN WATER BV	HKV	Netherlands	1	48
16	FUTUREWATER SL	FW	Spain	1	48
17	CETAQUA, CENTRO TECNOLOGICO DEL AGUA, FUNDACIÓN PRIVADA	CETAQUA	Spain	1	48
18	UNIVERSITAT POLITECNICA DE VALENCIA	UPV	Spain	1	48

1.2. List of Beneficiaries

No	Name	Short name	Country	Project entry month[8]	Project exit month
19	POLITECNICO DI MILANO	POLMIL	Italy	1	48
20	Centro Internazionale in Monitoraggio Ambientale - Fondazione CIMA	CIMA	Italy	1	48
21	HELMHOLTZ ZENTRUM POTSDAM DEUTSCHES GEOFORSCHUNGSZENTRUM	GFZ	Germany	1	48
22	Bundesanstalt fuer Gewaesserkunde	BfG	Germany	1	48
23	STICHTING WATER FOOTPRINT NETWORK	WFN	Netherlands	1	48

1.3. Workplan Tables - Detailed implementation

1.3.1. WT1 List of work packages

WP Number [9]	WP Title	Lead beneficiary [10]	Person-months [11]	Start month [12]	End month [13]
WP1	Project Management	1 - KNMI	38.00	1	48
WP2	Stakeholder involvement and case-studies definition	8 - METOFFICE	22.00	1	48
WP3	Improved Meteorological predictability and climate scenarios	3 - SMHI	195.00	1	48
WP4	Improved predictability of hydrological extremes	2 - ECMWF	150.00	1	48
WP5	Novel concepts for improved impact and risk assessment	13 - IVM	82.00	1	48
WP6	Coordination of Sectoral surveys	1 - KNMI	6.00	1	48
WP7	Sectoral survey: Flood inundation prediction and risk assessments	12 - DELTARES	83.00	1	48
WP8	Sectoral survey: Hydropower	4 - IRSTEA	51.00	1	48
WP9	Sectoral survey: Transport	22 - BfG	37.00	1	48
WP10	Sectoral survey: Urban Water	17 - CETAQUA	39.00	1	48
WP11	Sectoral survey: Agriculture and droughts	16 - FW	74.00	1	48
WP12	Sectoral survey: Water Economy	23 - WFN	48.00	1	48
WP13	Sectoral integration and climate services	11 - HZG	77.00	1	48
WP14	Communication and dissemination	8 - METOFFICE	63.00	1	48
		Total	965.00		

1.3.2. WT2 list of deliverables

Deliverable Number [14]	Deliverable Title	WP number [9]	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D1.1	Advisory report	WP1	1 - KNMI	Report	Public	21
D1.2	Advisory report 2	WP1	1 - KNMI	Report	Public	39
D1.3	Final advisory report	WP1	1 - KNMI	Report	Public	48
D1.4	Minutes of GA and SAB meetings	WP1	1 - KNMI	Report	Public	48
D2.1	Sectoral summary of climate vulnerability and risk practice	WP2	8 - METOFFICE	Report	Public	12
D2.2	Stakeholder interaction protocol	WP2	8 - METOFFICE	Report	Public	6
D3.1	Meteorological re-forecasts	WP3	2 - ECMWF	Other	Public	12
D3.2	Improved short-term prediction of extremes	WP3	3 - SMHI	Other	Public	30
D3.3	Enhanced skill of seasonal predictions	WP3	7 - BSC	Other	Public	30
D3.4	Hydro-meteor. indices	WP3	7 - BSC	Other	Public	30
D3.5	Impact of increased GCM resolution	WP3	3 - SMHI	Report	Public	26
D3.6	Improved extremes in regional climate	WP3	3 - SMHI	Other	Public	32
D4.1	Verification score card	WP4	4 - IRSTEA	Report	Public	12
D4.2	Hydrological model sensitivity	WP4	10 - UREAD	Report	Public	18
D4.3	Forecast skill developments	WP4	12 - DELTARES	Report	Public	24
D4.4	Improved climate projections of hydrological extremes	WP4	8 - METOFFICE	Report	Public	42
D4.5	Lessons learnt for research and operational exploitation	WP4	2 - ECMWF	Report	Public	48
D5.1	White paper on novel concepts	WP5	13 - IVM	Report	Public	6
D5.2	Intermediate report on novel concepts	WP5	13 - IVM	Report	Public	24
D5.3	Final report on novel concepts, chapter 1	WP5	13 - IVM	Report	Public	48
D5.4	Final report on novel concepts, chapter 2	WP5	1 - KNMI	Report	Public	48

Deliverable Number [14]	**Deliverable Title**	**WP number** [9]	**Lead beneficiary**	**Type** [15]	**Dissemination level** [16]	**Due Date (in months)** [17]
D5.5	Final report on novel concepts, chapter 3	WP5	15 - HKV	Report	Public	48
D5.6	Final report on novel concepts, chapter 4	WP5	21 - GFZ	Report	Public	48
D6.1	Sector Survey Report	WP6	1 - KNMI	Report	Public	48
D6.2	Data Management Plan	WP6	2 - ECMWF	Report	Public	6
D7.1	Correlated flood risk and finance	WP7	13 - IVM	Report	Public	30
D7.2	Compound flood risk events	WP7	15 - HKV	Report	Public	36
D7.3	Flood damage risk assessment	WP7	12 - DELTARES	Report	Public	48
D8.1	Improved hydropower risk assessment	WP8	4 - IRSTEA	Report	Public	48
D8.2	Hydropower policy brief	WP8	4 - IRSTEA	Websites, patents filling, etc.	Public	48
D8.3	Report on needs in hydropower sector	WP8	19 - POLMIL	Report	Public	12
D9.1	Report on vulnerability of water transport	WP9	22 - BfG	Report	Public	12
D9.2	Navigation quality assessment	WP9	22 - BfG	Report	Public	18
D9.3	Potential economic benefit of better forecasts for water transport	WP9	22 - BfG	Report	Public	38
D9.4	Improved transport cost planning	WP9	22 - BfG	Demonstrator	Public	42
D9.5	Impact on adaptive mgmt of transport sector	WP9	11 - HZG	Report	Public	46
D10.1	Fresh water forecasting in urban water system	WP10	17 - CETAQUA	Report	Public	24
D10.2	Impact in Segura and Llobregat basins	WP10	17 - CETAQUA	Report	Public	36
D11.1	Prototype design of drought DSS	WP11	16 - FW	Report	Public	18
D11.2	Index-based drought risk assessment	WP11	16 - FW	Report	Public	36

Deliverable Number [14]	Deliverable Title	WP number [9]	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D11.3	Multihazard drought management tool	WP11	15 - HKV	Report	Public	36
D11.4	Prototype Drought Decision Support system	WP11	16 - FW	Demonstrator	Public	48
D11.5	Climate change in agricultural water accounting system	WP11	16 - FW	Demonstrator	Public	48
D12.1	Dependence of European economy on water issues elsewhere	WP12	23 - WFN	Report	Public	12
D12.2	European economy risks under climate change	WP12	23 - WFN	Report	Public	48
D12.3	Supply and demand strategies affecting future economic damage	WP12	5 - PIK	Report	Public	48
D13.1	Generic integrative modelling approach	WP13	11 - HZG	Demonstrator	Public	20
D13.2	Integrated risk maps	WP13	11 - HZG	Report	Public	32
D13.3	Prototype hydrological module	WP13	18 - UPV	Demonstrator	Public	34
D13.4	Guide on modelling for decision making in the water sector	WP13	11 - HZG	Report	Public	40
D13.5	White paper about adaptation options	WP13	11 - HZG	Report	Public	44
D13.6	Evaluation of EU water-related frameworks	WP13	14 - ADELPHI	Report	Public	48
D14.1	Communication strategy plan	WP14	6 - ARCTIK	Report	Public	6
D14.2	Dissemination and exploitation plan	WP14	6 - ARCTIK	Report	Public	6
D14.3	First summary of outreach activities	WP14	6 - ARCTIK	Report	Public	6
D14.4	IMPREX logo & website	WP14	6 - ARCTIK	Websites, patents filling, etc.	Public	6
D14.5	Protoype hydrometeorological risk outlook	WP14	8 - METOFFICE	Demonstrator	Public	36

Deliverable Number [14]	Deliverable Title	WP number [9]	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D14.6	Policy briefs of EU Water-related actions	WP14	14 - ADELPHI	Report	Public	48
D14.7	Synthesis brochure on risk mgmt	WP14	14 - ADELPHI	Report	Public	48
D14.8	Brochure, videos and press briefing on climate risk mgmt	WP14	6 - ARCTIK	Websites, patents filling, etc.	Public	48
D14.9	Fact sheets on lessons learnt	WP14	14 - ADELPHI	Report	Public	48
D14.10	Workshp agenda and participant lists	WP14	8 - METOFFICE	Report	Public	46

1.3.3. WT3 Work package descriptions

Work package number [9]	WP1	**Lead beneficiary** [10]	1 - KNMI
Work package title	Project Management		
Start month	1	**End month**	48

Objectives

This WP ensures the efficient and timely implementation of project activities, resource allocation and measures maximizing the benefits of the project. It does so by managing the project at 3 levels:
• Strategic management
o Stakeholder involvement and coordination of Sectoral user groups
o Organization of the Science and Service Advisory Board
o Strategic decision making about the evolution and exposure of the project
o Maintain and utilize links with (inter)national programs and projects
• Operational management
o Legal affairs
o Internal communication and meetings, and facilitating partner collaboration
o Reporting to and communication with the EU
o Data management
o Quality assurance
• Risk management
o Guarding progress and budget
o Organize and process an external review
o Implement a Risk contingency plan.

Description of work and role of partners

WP1 - Project Management [Months: 1-48]
KNMI, ARCTIK
The project is designed following a 3-level project management structure, consisting of a Coordination level, Decision taking level, and an external advisory level. The management structure is described in more detail in section 3.2. The entities that are related to the project are (see also Figure 3.4):
Coordination level
• Coordination unit: Project Leader, Administration manager, Data manager, Communication manager, WP-leaders from main WPs
• Sectoral groups: IMPREX partners and stakeholders involved in the case studies addressed in WP6*.
Decision taking level
• Management Board: leaders of all WPs
• General Assembly: delegates of all project partners
Advisory level
• Science and Services Advisory Board: scientific specialists in forecasting, scenarios, stakeholder interaction, risk assessment, and representatives of key sectoral organisations.

Task 1.1: Administrative, legal, and financial coordination (KNMI)
Administrative coordination involves the execution of the overall administrative, legal, and financial responsibilities of the Coordinator. More specifically, this coordination will include the following tasks:
• Coordinate the formation of a Consortium agreement on data exchange, Intellectual Property Rights and the decision taking structure of the consortium;
• To collect appropriate legal, administrative, and financial documentation from the partners;
• To chair formal meetings of the project bodies;
• To operate the financial management of the project;
• To take on the role of intermediary for all communication between the contractors and the EC.

Task 1.2: Consortium coordination, reporting, deliverable production and quality management (KNMI, Arctik, ECMWF, SMHI, HZG-CSC, Deltares, METOFFICE)
On a day-to-day basis the general animation and coordination of the consortium will be assured through implementation of the following tasks:
• Partner communication and coordination
o organizing the kick-off meeting securing partner consensus on the vision, mission, and operational plan for IMPREX.
o all partner consortium meetings are planned to take place approximately every 12-18 months in line with the different stages of development of the project.
o In between all partner consortium meetings, individual WP leaders will organise regular meetings and conference calls between partners involved in the different work packages of the project.
• Reporting
o The Coordination Unit will coordinate the preparation of all required periodic activity and management reports and project reviews for the EC, summarising progress on project tasks, deliverables, and budget usage and reporting any deviations and corrective actions put in place. Three reporting periods are implemented at M18, M30 and M48.
• Deliverable production and quality assurance
o The Coordinator will take overall responsibility to ensure that the deliverables of the project are produced on time and to the required quality level.
o The first production of deliverables will be managed at WP level.
o Before submission to the EC, the quality of all deliverables will be checked at 3 levels by: the partner responsible for producing the deliverable; the WP leader; and the Coordinator. Any issues with quality will be resolved before final approval and submission to the EC.
o Two independent external reviews of the project will be commissioned to the Science and Services Advisory board: a midterm review (M30) and an end review (M48).

Task 1.3: Strategic, operational, and risk management (KNMI)
• Strategic Management
o Periodic validation of the consortium targets (at least twice over the project duration)
o Communication of these orientations to all the project stakeholders using the dissemination actions, in particular with regards the plans for exploitation of results during the project and after project conclusion.
o Adjustments of the development trajectory in case of unforeseen events detected by a continuous surveillance of the project environment (technical, technological, economical, social, etc.).
The members of the Science and Services Advisory Board will play a crucial role in providing direction and advice to the Management Board and will assist in dissemination and exploitation of project results at a strategic level.
• Operational Management
o Each of the WP leaders will be responsible for ensuring the efficient and timely organisation of key tasks and deliverables for the specific WPs that they are leading. This requires coordination of the work of each of the partners involved in the WP. The Coordinator will provide support to all WP leaders in the execution of their responsibilities.
• Risk Management process and contingency plans
o WP leaders will present an assessment of progress, and risks to progress, at the Management Board meeting every six months and propose practical contingency plans where necessary to address any specific identified risks. The type of risks that will be covered in the risk management process include: operational risks; personnel allocations; and time/budget allocation rules (see section 3.2).

Participation per Partner

Partner number and short name	WP1 effort
1 - KNMI	35.00
6 - ARCTIK	3.00
Total	38.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D1.1	Advisory report	1 - KNMI	Report	Public	21
D1.2	Advisory report 2	1 - KNMI	Report	Public	39
D1.3	Final advisory report	1 - KNMI	Report	Public	48
D1.4	Minutes of GA and SAB meetings	1 - KNMI	Report	Public	48

Description of deliverables

• D1.1: Advisory report 1 (review of project progress) covering M1-M18 (KNMI + all partners) (M21). • D1.2: Advisory report 2 covering M19-M36 (KNMI + all partners) (M39) • D1.3: Final advisory report covering M37-M48 (KNMI + all partners) (M48) • D1.4: Minutes of General Assembly and Science and Service Advisory board meetings (KNMI, Arctik) (M48)

D1.1 : Advisory report [21]

• D1.1: Advisory report 1 (review of project progress) covering M1-M18

D1.2 : Advisory report 2 [39]

• D1.2: Advisory report 2 covering M19-M36

D1.3 : Final advisory report [48]

Final advisory report covering M37-M48

D1.4 : Minutes of GA and SAB meetings [48]

Minutes of General Assembly and Science and Service Advisory board meetings

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	GA meeting 1	1 - KNMI	12	General Assembly meetings
MS2	GA meeting 2	1 - KNMI	24	GA meeting 2
MS3	GA meeting 3	1 - KNMI	36	GA meeting 3
MS4	GA meeting 4	1 - KNMI	48	GA meeting 4
MS5	Midterm review	1 - KNMI	30	Midterm review
MS6	Final review	1 - KNMI	48	Final review

Work package number [9]	WP2	**Lead beneficiary** [10]	8 - METOFFICE
Work package title	Stakeholder involvement and case-studies definition		
Start month	1	**End month**	48

Objectives

Coordinate stakeholder interaction

Description of work and role of partners

WP2 - Stakeholder involvement and case-studies definition [Months: 1-48]
METOFFICE, KNMI, ARCTIK, BSC, HZG, DELTARES
One of the first activities of WP2 is to identify a small set of heavily involved users for each of the key sectors, which will largely be based on the stakeholders involved in WP7-12. This core-group of users will form the nucleus of the IMPREX user groups. These groups will be organised on a sectoral base and meet two to four times a year for a few hours at a time. they will provide the key feedbacks and requirements for the specific sector. A combination of teleconference and physical meeting will ensure dynamic interaction. In line with the activities of WP7-12 the groups will work on: agriculture, insurance, infrastructure, water-borne transport, hydroelectric power generation, and drinking water quality. interested parties that are not yet involved in IMPREX are invited to participate in these sectoral user groups. JRC has already expressed its Interest to participate in flood, drought and hydropower planning . Moreover, stakeholders responsible for the implementation of relevant EU directives (WFD/FD) will be invited especially for the two case study regions included in WP7 to ensure the integration of IMPREX climate services into decision making.
In order to ensure the consistency of the project a clear protocol for the interaction with the users will be defined and shared among all project partners. On the one hand, this protocol will ensure that any pre-existing relationship between partners and stakeholders are preserved in the project. On the other hand, the protocol will minimise the stakeholder fatigue by detailing roles, responsibilities and the outcomes that are expected at any given time during the project. For example, the level of commitment expected from each stakeholder and a preliminary calendar of the interactions will be defined at this stage.

Task 2.1: Development of the project dissemination and exploitation plan (METOFFICE, all partners)
This task will identify end users and indirect beneficiaries of the project and design an exploitation plan which will maximise the benefit of the project for both project users involved in the WP6 case-studies and the European community at large. This task is a joint effort with WP14 which focuses on communication and outreach activities beyond the project boundaries. The deliverable corresponding to this task is included in D14.1.

Task 2.2 definition of a protocol for project-user interaction. (METOFFICE, all partners)
This task is devoted to the development of a clear protocol for the interaction between the project and its users. Given the commercial sensitivities of some of the services that may derive from IMPREX it is important that the rules of engagement are made clear to all people involved in the project from the very start. Among other things the protocol will clarify what role (and which level of involvement) each stakeholder is expected to play in each case-study.

Task 2.3: Targeted interview and small interactive workshop with the member of the user groups. (Arctik, BSC)
A series of targeted interviews and interactive workshops will be used to acquire knowledge about the specific needs of the project users. This, once put in the context of the already existing literature on this topic, will provide the whole consortium with a good understanding of the users' needs that are still unmet by the existing technologies. These workshops are organized in close collaboration with WP6*.

Task 2.4: Presentation of main of users' needs to project partners. (METOFFICE, all partners)
This last task will ensure that all knowledge on users' needs that has been acquired during the initial phase of the project is effectively transferred to all project partners to influence the relevant scientific and technical developments within IMPREX.

Participation per Partner

Partner number and short name	WP2 effort
1 - KNMI	2.00
6 - ARCTIK	6.00
7 - BSC	5.00
8 - METOFFICE	6.00
11 - HZG	2.00
12 - DELTARES	1.00
Total	22.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D2.1	Sectoral summary of climate vulnerability and risk practice	8 - METOFFICE	Report	Public	12
D2.2	Stakeholder interaction protocol	8 - METOFFICE	Report	Public	6

Description of deliverables

• D2.1: Summary report highlighting the specific climate vulnerability, sensitivity and exposure and the risk management practice for each stakeholder involved in the WP7-12, as identified in Task 2.4 (METOFFICE, Arctic, HZG, BSC, KNMI, Deltares) (M12) • D2.2: Rules of engagement for project –users interaction developed and distributed to partners, including interview template and text of the informed consent (METOFFICE, BSC) (M6)

D2.1 : Sectoral summary of climate vulnerability and risk practice [12]

Summary report highlighting the specific climate vulnerability, sensitivity and exposure and the risk management practice for each stakeholder involved in the WP6*

D2.2 : Stakeholder interaction protocol [6]

Rules of engagement for project –users interaction developed and distributed to partners, including interview template and text of the informed consent

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS7	Internal workshops to summarise the main users’ requirements	6 - ARCTIK	12	Internal workshops to summarise the main users’ requirements

Work package number [9]	WP3	**Lead beneficiary** [10]	3 - SMHI
Work package title	Improved Meteorological predictability and climate scenarios		
Start month	1	**End month**	48

Objectives

The goal of this WP is to improve the skill of hydro-meteorological forecasts and the reliability of climate projections, in order to provide better predictions of precipitation and extreme events. Based on state-of-the-art systems knowledge, methods and important processes will be explored and added in order to improve forecast on time scales from hours to seasons. Results will enhance the value of climate projections te better assess future precipitation statistics, extremes and its variability. This goal is condensed to two major objectives:
• Improve the predictability of the water cycle and precipitation on short-to-seasonal time scales
• Explore variability and extremes in recent and future climate, and improve the ability to simulate those.
The objectives will be met by upgrading and evaluating short-term to sub-seasonal forecasting systems (task 1), seasonal hydro-meteorological prediction (task 2) and long-term precipitation climate projection (task 3). In addition to model improvement, the usability of resulting precipitation will be amplified by downscaling and postprocessing enhancing the signal. Progress in WP3 will further benefit from utilizing existing collaborations with multi-model initiatives in the field of sub-seasonal and seasonal prediction (S2S, NMME and EUROSIP)
The work in WP3 is linked to WP4 where skill-improved prediction systems provided by WP3 are evaluated from a hydrological perspective and are further processed. The models developed in WP3 provide improved methods and are a precondition for better forecast and projection that feed into sectorial impact assessment applications (WP6) on regional and local scale). Detailed needs that arise during the sectorial studies are channelled through WP2, which coordinates the various impact studies.
The improved predictability feeds into more reliable climate services and better quantification of uncertainties. Scientific results on e.g. the amplitude of improvement of seasonal forecast or climate projection, will be transformed into risk reduction and adaptation strategies in WP13, and communicated via the outreach activities in WP8. Improved skills in short term and seasonal prediction and outcomes from international collaborations such as S2S, NMME and EUROSIP will contribute to the semi-operational hydrological risk outlook for Europe (WP14).

Description of work and role of partners

WP3 - Improved Meteorological predictability and climate scenarios [Months: 1-48]
SMHI, KNMI, ECMWF, BSC, METOFFICE, TUC, UREAD
Task 3.1: Improved forecast of short term and sub-seasonal precipitation (ECMWF, SMHI, BSC)
Forecast of precipitation and hydrological variables relies on numerical weather prediction (NWP) systems, that define the scene on which statistical correction methods and hydrological models can act. Task 1 invests in targeted improvement of NWP systems and re-forecasts of meteo-hydrological weather. All development activities focus on key meteorological variables that are of importance to hydrological impact.
In this task, IMPREX will estimate the current skill of the existing, state-of-the-art, operational NWP systems with focus on precipitation extremes for short and medium range weather forecasts. Improvement of short-term (days) prediction of extreme precipitation events is planned by assimilating surface remote sensing data regarding snow and soil moisture (Harmonie NWP model by SMHI). Land surface data inclusion is crucial for a skilful weather forecast at short and medium range . The assimilation procedure will be further improved by including new horizontal background error variation to better derive small scale variations in surface conditions and thereby improve the prediction of detailed precipitation . This work regarding the update of the meteorological model's capability and state, based on remote sensing data, feeds into Task 4.3. The resulting system will immediately provide improved short-term forecast capabilities, especially concerning local moisture conditions and hydrological impact. The development domain covers Northern Europe and the work links directly to case studies in WP8. Effect of the newly introduced assimilation will then even be assessed over an Iberian Peninsula domain (by means of implementation in a reforecast in WP4.1), which links to the IMPREX case studies on Spanish river basins.
On a global scale, ECMWF's prediction system will release an improved meteorological (retrospective) ensemble re-forecast with lead times of 1-15 days. The re-forecast allows for model errors to be diagnosed and corrected, thereby systematically increasing the forecast skill. Output links to case studies in WP6 (hydropower, transport and agriculture). IMPREX will utilize international collaborations to study the sub-seasonal scale forecast quality of hydrometeorological variables in the new operational Sub-seasonal-to-Seasonal project (S2S), around 10 operational

systems are contributing. Those studies cover the whole of Europe and parts of Northern Africa, which links to IMPREX case studies for hydropower and agriculture on a central-European scale. The analysis is focussed on the first month of forecast as part of the S2S multi-model quasi-operational predictions.

Task 3.2: Improved skill of seasonal prediction of water cycle and precipitation (BSC, METOFFICE ECMWF, TUC, UREAD)

Skilful seasonal forecast requires representation of decisive processes and teleconnection patterns such as the North Atlantic Oscillation (NAO)3. State-of-the-art sub-seasonal to seasonal prediction systems will be applied retroactive for development and testing, and for actual forecasts. Skills are estimated and post-processing extracts usable signals of meteorological and hydrological quantities.

In this task, IMPREX will estimate the current skill of the existing, state-of-the-art, operational seasonal forecast systems for hydro-meteorological variables, with a focus on the prediction of intra-seasonal extremes. The forecast quality of hydro-meteorological variables in the current operational seasonal forecast systems NMME (6 quasi-operational systems) and EUROSIP (4 operational systems), will be scrutinized. The study will cover the whole of continental Europe and parts of North Africa. With that evaluation as a base, seasonal prediction of precipitation-related variables will be improved.

Precipitation forecasts are afflicted by spatially and temporarily varying errors. Advanced post-processing and bias correction needs to take different weather situations into account and the correction schemes aim to shift displaced anomalies to their correct location. Post-processing routines will be enhanced to improve the signal to noise ratios of key processes such as the NAO. Further emphasis will be given to the optimal extraction of the frequency of daily localized extremes through a combination of statistical post-processing such as deconvolution, statistical downscaling and weather type analysis, addressing both flooding and water scarcity.

An additional effort makes use of variability modes and correct simulated precipitation for selected modes of variability for which the forecast model has proven skill. The method does not rely on a one-to-one direct correspondence between the observational and model modes, a restriction of previous methods. Following the same principles, forecasts from sub-seasonal and seasonal scale will be merged in an optimized way. Statistical downscaling of seasonal predictions will also be carried out in WP6.

Further improvement of skill is expected from more suitable ways of initialization of an increased number of model sub-components ("coupled initialization") and from enhancing assimilation methods. In addition to initialization of ocean and sea ice, initialization of land surface promises further improvement . Studies will be carried out covering effects by initialisation of land parameters such as soil moisture and snow and other land variables (BSC). Initial fields for land initialisation will be generated by nudging techniques applied to atmosphere, ocean and sea ice components (BSC). The comparison of the different initialization strategies (with or without inclusion of land-surface fields) allows the benefit of land-surface initialization to be assessed, along with the impact on prediction uncertainty on different variables and time-horizons.

IMPREX links the seasonal forecasting systems of METOFFICE, ECMWF and BSC, evaluated as described above, with their various improvements to case studies in WP6 (as indicated in Figure 3.2) by providing ensemble re-forecasts (temperature and precipitation, standardized Precipitation Index SPI, Evapotranspiration Index SPEI and Standardised Runoff Index SRI) to study the impact on exemplary sectors and regions. This includes assessing agricultural drought risk , impacts on hydropower and economy.

As a sensitive area, a special consideration is given here to the Eastern Mediterranean area, where seasonal prediction skill is promising already based on today's results . TUC will evaluate the different retrospective seasonal forecasts over that area and provide results to WP7 (flood damage) and WP10 (urban water).

Task 3.3: Enhanced value in climate projections of precipitation extreme conditions and variability (SMHI, KNMI, METOFFICE, UREAD)

To advance assessment of future risk potential due to climate change, global climate projections will be analysed for variability of extreme precipitation and connected meteorological processes. Existing CMIP5 simulations will be complemented by new CMIP-style IMPREX climate scenario simulations with updated high-resolution global climate models (GCMs) (EC-Earth with T511 for the atmosphere and 0.25 deg for the ocean or higher and HadGEM3 with n512 in the atmosphere). Both climate models are among the highest resolution GCMs in current use. Increasing the resolution is expected to improve the representation of cyclones and blocking statistics . Thus, evaluation and analysis will concentrate on cyclone tracking (TUC), blocking (UREAD) and circulation indexes (SMHI), and explore how related improvements in IMPREX GCM simulations lead to better representation of precipitation and hydrological extremes by improved large scale circulation.

In this task, IMPREX will estimate the current skill of the existing, state-of-the-art, regional climate models at a wide range of horisontal resolutions including convective-permitting scales with focus on precipitation extremes. To add extra value to the assessment of future extreme conditions, dynamical regional downscaling by non-hydrostatic climate

models will be utilized in unprecedented very high resolution (from 8 km Central-European and 2 km for regional areas to 100 m for selected local study areas) for climate time slices based on reanalysis, pre-existing and up-to-date IMPREX-generated global climate scenario simulations. Recent results point out the critical importance of convection-permitting resolution to reflect the growing importance of convective precipitation rather than stratiform precipitation in a warming climate (Kendon et al. 2012). Results will allow for more reliable risk assessment for future climates, that goes far beyond of what can be achieved from existing CORDEX simulations, which had been carried out largely with hydrostatic models in much coarser resolutions.
Additional downscaling will be carried out for selected weather types and cases by developing high resolution future analogues of large flooding in summer for central European catchment areas, with the help of the regional climate model RACMO (KNMI) at 5 km resolution, as downscaling of IMPREX GCM runs. Furthermore, a very high resolution downscaling (2.5 km) for ~50 selected weather cases over the Benelux region in recent climate and in future climate projections will be carried out. Weather cases will be selected with the highest potential for convective precipitation in local domains and are coordinated with the transport case study in WP9. The downscaling activities benefit from the participants experience in the COST action “VALUE”.
The climate model output will be analysed and enhanced by different ways of post processing. Bias correction will be carried out in the case studies (WP6) according to the respective sector's needs. In this WP3, an exemplary novel correction of precipitation fields will be pursued, using novel multi-segment statistical bias correction of daily GCM and RCM precipitation, targeting the eastern Mediterranean case study WP11.
For better applicability of downscaling results, SPI, SPEI, SRI and related indices from future climate projections will be provided for a central-European domain, the Iberian peninsula, an Eastern Mediterranean domain and Northern Europe. In addition to downscaling of IMPREX-generated climate projections, further downscaling of existing simulations will be performed. METOFFICE provides a test case for extremely high resolution and analyses downscaling for the UK, building on earlier work for the Southern UK with a nation-wide resolution of 1.5 km (for present-day and future timeslices), and down to ~100m for three selected UK catchments (Lancashire Eden, Hampshire Avon, Wensum), for specific short-run events. Resulting knowledge on events will be explored for more general application, and will be applied in WP11 focusing for example on long dry spells followed by heavy rain, which trigger soil and nutrient loss. Extreme rainfall statistics will also be explored for future time periods over the areas of the WP6 case study areas Northern Europe, Iberian peninsula and Eastern Mediterranean (TUC and SMHI), with a focus on short sub-daily extremes, which are so far under-explored and are expected to increase more rapidly and stronger than those on longer timescales. As reference, high temporal resolution gauging met networks will be used.

Participation per Partner

Partner number and short name	WP3 effort
1 - KNMI	30.00
2 - ECMWF	20.00
3 - SMHI	44.00
7 - BSC	36.00
8 - METOFFICE	31.00
9 - TUC	12.00
10 - UREAD	22.00
Total	195.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D3.1	Meteorological re-forecasts	2 - ECMWF	Other	Public	12

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D3.2	Improved short-term prediction of extremes	3 - SMHI	Other	Public	30
D3.3	Enhanced skill of seasonal predictions	7 - BSC	Other	Public	30
D3.4	Hydro-meteor. indices	7 - BSC	Other	Public	30
D3.5	Impact of increased GCM resolution	3 - SMHI	Report	Public	26
D3.6	Improved extremes in regional climate	3 - SMHI	Other	Public	32

Description of deliverables

• D3.1: A retrospective meteorological ensemble 1-15 day re-forecast (ECMWF) (M12) • D3.2: An improved system for short-term prediction of extreme precipitation events (SMHI) (M30) • D3.3: New methods to enhance the skill of seasonal prediction system compared to current skills for hydro-meteorological variables in operational systems (BSC, ECMWF, METOFFICE, TUC) (M30) • D3.4: Hydro-meteorological indices from successively improving seasonal prediction systems, for sectoral impact assessment in WP6 (BSC) (M30) • D3.5: Report of the impact of increased GCM resolution on representation of quantities relevant for precipitation over Europe (e.g. cyclones, blocking statistics and NAO) (SMHI, UREAD, TUC) (M26) • D3.6: Improved representation of hydro-meteorological extremes in climate scenarios by weather analogues (SMHI, KNMI, METOFFICE, TUC) (M36)

D3.1 : Meteorological re-forecasts [12]

A retrospective meteorological ensemble 1-15 day re-forecast

D3.2 : Improved short-term prediction of extremes [30]

An improved system for short-term prediction of extreme precipitation events

D3.3 : Enhanced skill of seasonal predictions [30]

New methods to enhance the skill of seasonal prediction system compared to current skills for hydro-meteorological variables in operational systems

D3.4 : Hydro-meteor. indices [30]

Hydro-meteorological indices from successively improving seasonal prediction systems, for sectoral impact assessment in WP6

D3.5 : Impact of increased GCM resolution [26]

Report of the impact of increased GCM resolution on representation of quantities relevant for precipitation over Europe (e.g. cyclones, blocking statistics and NAO)

D3.6 : Improved extremes in regional climate [32]

Improved representation of hydro-meteorological extremes in climate scenarios by weather analogues

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS8	Reference seasonal forecast data sets	7 - BSC	12	Reference data sets collected

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
				and disseminated (retrospective forecasts (ECMWF), seasonal forecasts
MS9	Regional domains prepared	3 - SMHI	24	Regional domains prepared for dynamical downscaling with non-hydrostatic regional climate models in very high resolution
MS10	Updated data sets of short term and seasonal predictions	3 - SMHI	24	Updated version of data sets available (short term predictions (SMHI), seasonal predictions (BSC), downscaled weather events (KNMI)
MS11	New developments tested for high resolution climate scenarios	3 - SMHI	32	New developments tested (Climate scenarios (SMHI))

Work package number [9]	WP4	**Lead beneficiary** [10]	2 - ECMWF
Work package title	Improved predictability of hydrological extremes		
Start month	1	**End month**	48

Objectives

Hydrological and water resource applications, including forecasting and risk management for shipping, hydropower, agriculture and civil protection are extremely sensitive to the amount, distribution, frequency and intensity of precipitation attributes . Precipitation frequency influences flood and drought related agricultural risks and precipitation intensity strongly influences water quality . The impact of changes to these precipitation attributes on water resource applications is highly complex to calculate, with different sensitivities found across different time scales and between different applications . A better scientific understanding of the natural water cycle variability and extremes is required , yielding an integrated vision of the atmospheric and hydrologic processes to support water management. The current generation of numerical weather prediction systems issue precipitation forecasts that suffer from some severe limitations in quality when it comes to their effective use in hydrological applications, including their accuracy in localizing extreme events in space and time and their reliability in quantifying uncertainties . Improving these forecasts is the key to improving the forecasting of water related natural hazards and the risk they pose to sectoral applications over various time scales, from medium-range to sub-seasonal and climate scales. This is one of the mains topics of the HEPEX initiative concerning present climate . In addition, improved assessments of future climate conditions can likewise benefit from making today's predictions better. Putting current day extremes and their forecasts in the context of future climate conditions is a new challenge for both hydrometeorological forecasters and water managers.
The main objective of this work package is to improve the hydro-meteorological forecasting chain in terms of hydrological hazards, such as floods and droughts at various lead times. New improved hydrological processes schemes and data assimilation methods will be combined with improved NWP models as well as climate models (from WP3) to produce improved hydrological predictions and outlooks that have an impact on the quality of water and risk management decisions. This work package will lead to:

1. A first release of a reforecast dataset of regional and European-wide risks of exceeding critical hydrologic thresholds for various strategic highly vulnerable water resources applications and considering hydrologic hazards at various lead times. This reforecast will represent a reference where new applications can collect essential information on past situations;
2. The assessment of the degree to which available hydro-meteorological data sources can improve the modelling of hydrological processes and enhance the quality of hydrologic forecasts through data assimilation techniques;
3. The improvement of the representation of the hydrological processes in land surface schemes which are essential to capture the hydrological extremes from short- to medium-range and climatic scales;
4. The assessment of the improved performance of a multi-model hydrological forecasting system through advanced model combination techniques;
5. The validation of improvements through the development of score cards that are specifically designed to bring information on the performance of a forecasting system to targeted users' applications. A new perspective will be introduced: the definition of metrics to evaluate the quality of a forecast based on its usefulness in water risk decision-making. This is essential to assess the effects of the different system's improvements and efficiently convey the right information about the quality of the reforecast at different space-time scales to stakeholders and their decision-making problem;
6. Provide input for the seamless ensemble-based advanced hydrological risk outlook (WP14) from the short- through the medium-range scale with associated uncertainty estimates based on the quality analysis of the reforecast dataset;
7. Hydrological ensemble outputs for monthly to seasonal time scales in near-real-time to provide input to the risk outlook tool developed in WP14;
8. Assessment of the potential future changes in flood hazards along with its associated uncertainties (by driving a robust multi-model hydrological system with the WP3 climate scenarios);
9. A comprehensive reporting of products with a clear end-user focus.

The objectives will be achieved through 4 tasks, detailed below. In Task 4.1, a reforecast of hydrological extremes in Europe will be created for the time period from 1980 to 2015. In Task 4.2, the role of precipitation forcing from short- to medium-range and up to climate scales will be analysed, using also the improved precipitation forecasts of extremes from WP3. Data assimilation to improve the hydrological assessment of initial catchment conditions and uncertainty analyses to quantify the sensitivity of hydrological extreme predictability to improved forcing will be the main activities in Task 4.3. This work will lead to improved unified short- to medium-range forecasts of hydrological extremes, which will be further used in the sectoral applications in WP6. They will also contribute to a near-real-time forecast tool for monthly to seasonal timescales that will be set up in the risk outlook of WP14. In Task 4.4, the multi-model hydrological models will be used to produce future projections of the changes to hydrological extreme events.

Description of work and role of partners

WP4 - Improved predictability of hydrological extremes [Months: 1-48]
ECMWF, SMHI, IRSTEA , METOFFICE, TUC, UREAD, DELTARES, FW, UPV, CIMA, BfG
WP4 links to WP3 as it integrates current and improved precipitation (and other hydrological hazard related variables) datasets and products generated in WP3 for short, medium and climate scales, and evaluates these products from a hydrological perspective. Case studies from WP6 will use the products provided here in several sectoral applications and provide feedback on how these products improve the value of forecasts and predictions in concrete applications. WP4 will provide assessments of the key hydrological hazards at the European scale that will be used in the risk assessment of each sectorial application in WP6. WP14 will use hydrological outputs to create a risk outlook for monthly-seasonal timescales.
This work package will benefit from a large range of specialized hydrological models and their optimization towards the sectorial applications

Task 4.1: Development of the regional and European scale reforecast dataset of hydrological extremes (ECMWF, IRSTEA, Deltares, CIMA, BfG, UoR, SMHI, TUC, METOFFICE)
To understand current climate and the quality of current forecasts we will use the various hydrological models to generate a single unified current state-of-the-art reforecast dataset of hydrological extremes . This will build on the work done in the other FP7 projects (see Table 1.1). The reforecast dataset will allow the sectoral applications to understand current skill and strengths of individual hydrological models for their specific needs. It will further serve as guidance for the hydrological model improvements in this work package (Tasks 4.3 and 4.4). The reforecast generated here will also be used in the multi-model combination in Task 4.5. This hydrological reforecast dataset will be based on short- to medium-range and sub-seasonal to seasonal meteorological reforecasts from the UK METOFFICE and ECMWF, including post-processing enhancements from WP3.2. We will verify the hydrological reforecasts on the regional and European scales. Verification will be based on hydrologic threshold exceedances for various hydrologic variables (e.g. peak discharges, flow volumes) and with a particular focus on hydrological extremes (towards high and low flows). It will use new and existing datasets (e.g., streamflow used in the UN-ISDR's 2013 Global Assessment Report on Disaster Risk Reduction (GAR 2013). The verification will stretch from the short, to medium and climatic ranges.

Task 4.2: Analysis of the impact of changes in precipitation attributes from short to medium and climatic ranges (UREAD, ECMWF, Deltares, BfG, FW, IRSTEA)
Building on the uncertainty analyses performed in the FP7 project EUPORIAS, we will perform a full formal sensitivity analysis (e.g. SOBOL or OAT) to establish the sensitivity of hydrological models' responses to precipitation attributes and its uncertainties across various time scales. In particular, this task will test sensitivities of precipitation from different meteorological forecast systems employed in WP3, investigating the impacts of different ways of initializing and producing predictions on the hydrological responses for extremes. This task will produce a 'hydrological sensitivity chart' informing Task 4.3 where targeted improvements should focus. It will also provide evidence of the hydrological impacts of the improvements achieved in WP3. In order to canalize the impact analysis towards helpful and informative scores for stakeholders, this task will also develop score cards where the effect of improvements in hydrological model response is easily visualized, communicated to and understood by users). The verification will be performed against hydrologic gauging stations across Europe using appropriate statistical scores. These score cards will also be used to quantify the effects of the improvements described in Task 4.3.

Task 4.3: Improving forecast skill of extreme events through data assimilation and multi-model combination across time scales (Deltares, BfG, CIMA, ECMWF, SMHI)
Data assimilation is a key system component in improving forecast skill and reducing uncertainties in hydrology4, differentiating the act of forecasting for real-time decision-making from the process of continuous simulation of hydrological response for processes understanding. In this task, we will use state-of-the-art data assimilation schemes to assimilate gauge data (precipitation, snow depth, lake levels, discharge) and remote sensing data (soil moisture, snow cover, precipitation - e.g. from EUMETSAT and HSAF) into hydrological forecasting systems. Data assimilation will be investigated considering also the interactions with the post-processing of the predictions from WP3 that will be used as input forcing to the models. This provides a new perspective for improving forecast quality, with a useful guidance towards where efforts on forecast improvements can be more efficient for water managers . In addition, new and unconventional data (e.g., evapotranspiration from remote sensing, ground water extraction, irrigation, river

levels) will be used to initialise and nudge hydrological models. This task will apply state-of-the-art model combination techniques, such as Ensemble Copula Coupling (ECC), Bayesian model averaging (BMA) and Non-homogenous Gaussian regression (NGR) in order to increase the performance of modelling of hydrological extremes by weighting models according to their previous performance (using the score cards developed in Task 4.2). Finally, we will establish a framework for the provision of near-real-time monthly-seasonal integrated multi-model hydrological forecasts to WP14, where a hydrological risk assessment tool will be developed.

Task 4.4 Improving predictions on the climate scale (METOFFICE, HKV, UPV, FW, BfG)
This task will provide improved hydrological hazard assessments to be used as input to produce improved risk management strategies in water-related decisions for the future . The hydrological modelling results from Task 4.3 will be used together with the newly developed ERACLIM ensemble reanalysis to estimate historical water hazards. High resolution climate model outputs from WP3 (Task 3.3, EC-Earth, HadGEM3, and km-scale local downscaling) will be used to estimate the future risks of hydrological variables of interest to the sectoral impact applications in WP6. This includes activities focusing on: impacts of sea level increase on urban areas, impacts of increase/decrease of inflows on hydropower dam operations, impacts of decreasing river levels on shipping and commercial navigation, etc. A particular focus will be placed on drought evolution on the climate time scale and its possible impacts on agriculture, water supply and other sectors.

Participation per Partner

Partner number and short name	WP4 effort
2 - ECMWF	23.00
3 - SMHI	26.00
4 - IRSTEA	12.00
8 - METOFFICE	16.00
9 - TUC	6.00
10 - UREAD	18.00
12 - DELTARES	23.00
16 - FW	6.00
18 - UPV	6.00
20 - CIMA	6.00
22 - BfG	8.00
Total	150.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D4.1	Verification score card	4 - IRSTEA	Report	Public	12
D4.2	Hydrological model sensitivity	10 - UREAD	Report	Public	18
D4.3	Forecast skill developments	12 - DELTARES	Report	Public	24
D4.4	Improved climate projections of	8 - METOFFICE	Report	Public	42

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
	hydrological extremes				
D4.5	Lessons learnt for research and operational exploitation	2 - ECMWF	Report	Public	48

Description of deliverables

• D4.1: Verification score card for hydrological reforecasts (and initial testing on re-forecast data) by reviewing the most appropriate verification scores for the sectoral applications with particular focus on highly vulnerable water resources of strategic importance (IRSTEA, CIMA, BfG, UREAD, SMHI, TUC, Met Office) (M12) • D4.2: Report on sensitivity of hydrological model outputs relevant for sectoral applications towards the role and attributes of precipitation forcing, focusing on water cycle variability at local/regional scales in Europe, over various timescales (UREAD, Deltares, BfG, FW, METOFFICE, UPV) (M18) • D4.3: End-user-focused report on the advances in the forecast skill of hydrological extremes through data assimilation, seamless predictions and multi-modelling (DELTARES, ECMWF, SMHI, CIMA, BfG, UREAD, SMHI, TUC) (M24) • D4.4: Estimation of hazards based on improved representation of highly vulnerable water resources of strategic importance on the climate scale (METOFFICE, UREAD, HKV, SMHI, UPV, FW) (M42) • D4.5: White paper on lessons learnt and future opportunities for research and operational exploitation (ECMWF + other WP4 partners) (M48)

D4.1 : Verification score card [12]

Verification score card for hydrological reforecasts (and initial testing on re-forecast data) by reviewing the most appropriate verification scores for the sectoral applications with particular focus on highly vulnerable water resources of strategic importance

D4.2 : Hydrological model sensitivity [18]

Report on sensitivity of hydrological model outputs relevant for sectoral applications towards the role and attributes of precipitation forcing, focusing on water cycle variability at local/regional scales in Europe, over various timescales

D4.3 : Forecast skill developments [24]

End-user-focused report on the advances in the forecast skill of hydrological extremes through data assimilation, seamless predictions and multi-modelling

D4.4 : Improved climate projections of hydrological extremes [42]

Estimation of hazards based on improved representation of highly vulnerable water resources of strategic importance on the climate scale

D4.5 : Lessons learnt for research and operational exploitation [48]

White paper on lessons learnt and future opportunities for research and operational exploitation

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS12	Hydrological input data for sectoral surveys available	2 - ECMWF	6	Input data for sectoral case studies for current modelling and forecasting of hydrological extremes
MS13	Retrospective runs with hydrological models completed	2 - ECMWF	12	Output of the first run of the models for sectoral applications to produce

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
				state-of-the-art reforecasts of hydrological extremes
MS14	Forecasts for hydrological risk outlook available	8 - METOFFICE	30	Provision of near-real-time monthy-seasonal hydrological forecast data from the improved hydrological models to allow the creation of a hydrological hazard outlook tool (WP8)

Work package number [9]	WP5	**Lead beneficiary** [10]	13 - IVM
Work package title	Novel concepts for improved impact and risk assessment		
Start month	1	**End month**	48

Objectives

Next to the further development of meteorological and hydrological forecasting tools in WP3 and 4, advances are needed to harness and develop novel concepts that can use the hydrometeorological information to support impact and risk assessments, and in order to benefit the decision-making process. Current scenario or impact assessment techniques have their limitations. They can be expensive in terms of multi-model and multi-scale scenario generation, they are often difficult to interpret for non-scientists, there are gaps between available and required information, and they may not fully harness all of the available and rapidly developing information and data.

In WP5, we will therefore develop and test a number of novel concepts for representing and/or assessing the impacts and risks of hydrological extremes. Each concept builds on an existing gap in current impact assessment procedures. Each concept will then be implemented or tested in (at least) one of the case studies in WP6, in order to gain experience on how these concepts can contribute to improved impact or risk assessments. The actual concepts are described in the specific tasks below.

For each novel concept, we first carry out a review of past scientific and non-scientific literature relating to the current state of the knowledge on which our concepts will develop. Then, the concepts are developed and tested in (at least) one of the case studies. Furthermore, the task identifies possible applications of the concepts in other case studies and/or sectoral assessments, and requirements for further improvements.

Description of work and role of partners

WP5 - Novel concepts for improved impact and risk assessment [Months: 1-48]
IVM, KNMI, HKV, FW, UPV, GFZ
Task 5.1: Large scale climate variability and impacts (IVM, Future Water)
Whilst modelling chains are often used to assess the impacts of hydrometeorological extremes, there is also potential to harness information on future impacts by examining statistical relationships between indices of large scale climate variability and those impacts. For example, it has been shown that there are strong relationships between peak river flows in Europe and indices of large scale climate variability such as Grosswetterlagen and the North Atlantic Oscillation (NAO). Also, several have shown statistically significant correlations between El Niño Southern Oscillation and low flows. However, only little work has been carried out to examine statistical relationships between indices of climate variability and risk. Ward show that flood risk is strongly related to El Niño Southern Oscillation (ENSO) in large parts of the world, and Cane have shown that crop yields in Zimbabwe are strongly related to ENSO. However, very little is known on such relationships in Europe. The method holds large potential for risk management. In regions where strong statistical relationships exist between large scale climate variability, projections of potential impacts could be provided with different lead times, from months to seasons, by harnessing existing predictions of modes of interannual climate variability on those timescales. Here, we propose to develop methods to examine statistical correlations between large scale modes of climate variability and societal impacts of hydroclimatic extremes in a broad sense. We will then use these methods to examine statistical correlations between large scale climate variability and: drought-related agricultural impacts in WP11; and pan-European flood risk in WP7. In both cases, we will also focus on how the information can be used in the decision-making process. We will also work together with WP14 to include the impact results in the risk outlook. IVM will lead task 5.1, carry out a literature review on the concepts, and develop the statistical methods.
Future Water will contribute to developing the methods for assessing agricultural impacts through large scale climate variability.

Task 5.2: Multi-risks (sea-coast) (KNMI, IVM, HKV)
Most studies of hydrometeorological risks and hazards focus on one particular hazard at a time. However, the impacts of extreme hydrometeorological events may be worsened by the coincidence of different hazards. For example, Kew have shown that flood risk assessments that only examine either river floods or coastal floods may result in an underestimation of the actual flood risk in coastal zones. New research is being carried out within the EU RISES-AM project to assess the joint probability of river and coastal flooding at the global scale. At the regional scale, the analysis of compounding events, their joint impact, and the statistical and physical relationship between them implies a focus on (realistic) weather phenomena rather than single-variate climate statistics. Als for future risk assessments, analysis of “future weather”

rather than "future climate" implies a paradigm shift in climate research. High resolution simulations, a different statistical perspective, and a high degree of tailoring output from meteorological projections to make them relevant for the local risk assessment are required.
In IMPREX, we propose to strengthen this novel research, by examining the effects of joint hazard events on risk, based on case studies in the Netherlands. The resulting flood risk maps will provided to WP13, providing an example of integrated risk maps. We will not only consider the joint occurrence of flood related hazard events, but also focus on combinations of events that are important in drought-related issues and in times of water scarcity. For instance, shortages of fresh water supply during summer periods often result from the joint occurrence of low river discharges in combination with salt water intrusion (depending on conditions at the sea side, i.e. expected sea level rise). The short-term history – for instance the water storage in open surface water and in soil water - prior to the occurrence of low river discharges should also be jointly considered when studying drought-related issues. The concepts related to low flows will be applied in the case study of the River Rhine in WP11 (Rhine and Meuse Estuaria). KNMI will lead the task and focus on multiple flood risks from coasts and river/pluvial floods, together with IVM. HKV will develop the methods related to low flows.

Task 5.3: Water allocation schemes (HKV, UPV)
Traditionally, the decision-making process in fresh water management is based on a deterministic approach . However, fresh water supply in summer periods exhibits a large range of uncertainty resulting from inherent uncertain conditions, such as uncertain low river discharges (consecutive period of low discharges), uncertain salt water intrusion (depending on uncertain conditions at the sea), and uncertain water storages in soil and in the surface water system. Additionally, the consequences of insufficient fresh water supply depend on the uncertain needs of the end user/sector (and in some cases also on the duration and seasonal period in which water shortage occurs). This asks for an approach for fresh water allocation that deals with uncertainty in fresh water supply and demand, and its consequences.
We therefore propose to develop a risk-based approach for fresh water allocation in which the probability of drought-related hazard events are jointly considered with the consequences of these hazard events. This information about drought-related risks enables us to prioritise and predicate decisions, and can also be used in the assessment of feasible options and adaptation strategies to manage risks in WP 13. It can help to assess the cost-efficiency of measures to cope with droughts and define cost-efficient solutions through a cost benefit analysis.
The novel approach for a risk assessment of fresh water allocation consists of three major steps:
1. Definition criteria for fresh water allocation (i.e. evaluation of criteria for fresh water allocation in present situation and definition of set water allocation criteria).
2. Set-up of a framework for risk-based fresh water allocation containing the following input: (a) describing the probability of drought-related hazard events, (b) impact of these events on water supply/availability (~ time, space), (c) water demand of end users (~ time), (d) computing water shortage (water demand minus water supply/availability) (~ time, space), (e) impact and consequences of water shortage (damage functions, often depending on the frequency, duration and season in which shortage occurs)
3. Decision support framework for water allocation (evaluation of risk adaptation and mitigation strategies).
Various alternatives and measures (at river basin scale, regional water system, or end user) could be assessed using this risk-based approach and indicate the consequences in terms of costs and risk reduction.
The risk based approach will be demonstrated in a number of case studies, amongst which a case study in the Netherlands, but also a case study in another river catchments in Europe suffering from drought related issues.
HKV and UPV will develop the risk based management instrument (1) to evaluate the impact of climate variability on drought related risks, (2) to support decision making and assess the cost-efficiency of measures to better cope with water scarcity.
HKV will use the case study River Rhine Basin (in the Netherlands) (WP11) to demonstrate the potential of this instrument for fresh water allocation in times of water scarcity. Within the case study HKV will focus on a number of characteristic regions in the Netherlands, amongst which the Rhine-Meuse Estuary. Since the characteristics of droughts in northern European basins are very different from the Mediterranean basins, UPV will focus mainly on the adaptation of the approach to Spanish Mediterranean rivers, based on the experience of methodologies and applications developed by UPV38. UPV will apply the instrument to the Júcar River Basin (Spain) (WP11).

Task 5.4: Probabilistic impact assessment (GFZ, UPV)
Impact assessments in the framework of hydrometeorological risk analyses have in common that complex damaging processes are described by relatively simple, deterministic approaches (Meyer et al. 2013). For instance, for flood damage estimation depth-damage curves are set up for certain objects or land use units using bivariate statistical analysis of empirical or synthetic flood damage data. Just recently some multi-factorial models have been developed for example for Japan and for Germany . Studies have shown that the application of multi-factorial models that take several damage influencing factors into account improve the reliability of flood damage modelling . However, uncertainty remains

relatively high, so that the development of probabilistic damage models is an innovative enhancement, since they inherently provide quantitative information about the model prediction uncertainty. Probabilistic modelling approaches may use Bayesian Networks. An advantage of utilising a Bayesian approach is that it enables a structured region specific updating on basis of local data. This will significantly help to overcome problems associated with spatial transfer of damage models. We propose to test this concept in focussing on flood damage modelling for the flood risk (WP7). Moreover, based on results from WP3 and WP4, UPV will improve a methodology currently used for probabilistic impact assessment of drought, by using Montecarlo simulation and/or optimisation, generating multiple hydrological scenarios conditioned by the hydrological situation at the moment of the assessment, as well as by meteorological forecasts, by means of multivariate ARMAX modelling and/or neural network modelling. The results of the simulation/ optimizations can then be used to derive probability functions for the impacts, in terms of deficits of water supply to the demands (agriculture, urban, hydroelectric), or in economic terms. Also environmental impacts can be assessed in similar manner. The concepts will be tested in relation to droughts in WP11, for the case study of the Jucar River Basin. GFZ will lead the task, and develop the novel concepts on probabilistic impact assessment for the flood damage modelling for the insurance case (WP7).

Participation per Partner

Partner number and short name	WP5 effort
1 - KNMI	19.00
13 - IVM	34.00
15 - HKV	10.00
16 - FW	4.00
18 - UPV	6.00
21 - GFZ	9.00
Total	82.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D5.1	White paper on novel concepts	13 - IVM	Report	Public	6
D5.2	Intermediate report on novel concepts	13 - IVM	Report	Public	24
D5.3	Final report on novel concepts, chapter 1	13 - IVM	Report	Public	48
D5.4	Final report on novel concepts, chapter 2	1 - KNMI	Report	Public	48
D5.5	Final report on novel concepts, chapter 3	15 - HKV	Report	Public	48
D5.6	Final report on novel concepts, chapter 4	21 - GFZ	Report	Public	48

Description of deliverables

D5.1: White paper on novel concepts and state of the knowledge (IVM; M6) D5.2: Intermediate report on development of novel concepts and potential applications (IVM; M24) D5.3: Chapter 1 of the final report on novel concepts and state of the knowledge, focused on "Large scale climate variability and impacts " (IVM; M48) D5.4 Chapter 2 of the final report on novel concepts and state of the knowledge, focused on Multi-risks (sea-coast) (KNMI; M48) D5.5 Chapter 3 of the final report on novel concepts and state of the knowledge, focused on Water allocation schemes (HKV; M48) D5.6 Chapter 4 of the final report on novel concepts and state of the knowledge, focused on Probabilistic impact assessment (GFZ; M48)

D5.1 : White paper on novel concepts [6]

White paper on novel concepts and state of the knowledge

D5.2 : Intermediate report on novel concepts [24]

Intermediate report on development of novel concepts and potential applications

D5.3 : Final report on novel concepts, chapter 1 [48]

Chapter 1 of the final report on novel concepts and state of the knowledge, focused on "Large scale climate variability and impacts"

D5.4 : Final report on novel concepts, chapter 2 [48]

Chapter 2 of the final report on novel concepts and state of the knowledge, focused on Multi-risks (sea-coast)

D5.5 : Final report on novel concepts, chapter 3 [48]

Chapter 3 of the final report on novel concepts and state of the knowledge, focused on Water allocation schemes

D5.6 : Final report on novel concepts, chapter 4 [48]

Chapter 4 of the final report on novel concepts and state of the knowledge, focused on Probabilistic impact assessment

Schedule of relevant Milestones

Milestone number [18]	**Milestone title**	**Lead beneficiary**	**Due Date (in months)**	**Means of verification**
MS15	White Paper on novel concepts	13 - IVM	6	WP meeting for discussing White paper concepts
MS16	Draft results new conceptual models	13 - IVM	36	WP meeting draft model results

Work package number [9]	WP6	**Lead beneficiary** [10]	1 - KNMI
Work package title	Coordination of Sectoral surveys		
Start month	1	**End month**	48

Objectives

WP7-12 consists of several sub-WPs for sectoral analysis and case studies. To avoid stand-alone operation of these sub-WPs and the forecast tool development WPs, coordination between WP3/4/5/6 and within the WP7-12 is needed. WP6.0 manages the interface between the tool development versus tool application. It coordinated data exchange and other internal communication to allow coupling of tools and input/output data, by organizing regular meetings, and development of a common reporting/outreach structure.

Description of work and role of partners

WP6 - Coordination of Sectoral surveys [Months: 1-48]
KNMI, ECMWF, HZG
In IMPREX a strong link between new, enhanced or tailored methods (models, datasets, concepts), and testing of these developments is created. The developments in WP3 and WP4 cover different time scales and episodes, and different areal domains. The sectoral surveys in WP7-12 generally focus on regional areas, and evaluate a mixture of meteorological and hydrological products for different time horizons. Figure 3.2 shows an overview of the range of products and datasets that is exchanged between the WPs. The data manager will monitor this data exchange and is responsible for resolving issues. More detailed experimental designs were compiled during the preparation of this proposal but not shown here.
The following activities are carried out:
• Monitoring and organisation of interaction between tool development WPs and surveys in WP7-12
• Coordinating case studies and (inter-sectoral) links between WP7-12
• Resolving data exchange issues
• Management and initiation of new case studies when appropriate
• Coordination of the reporting of the WP7-12
The monitoring of the progress over the various sectoral surveys is applied by imposing a “heart beat” milestone rhythm, in which all WPs are synchronised with respect to their benchmark analysis, preparedness to ingest new data, pilot tests of updated versions of input data, and full evaluations of sectoral applications of the data.

Participation per Partner

Partner number and short name	WP6 effort
1 - KNMI	2.00
2 - ECMWF	1.00
11 - HZG	3.00
Total	6.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D6.1	Sector Survey Report	1 - KNMI	Report	Public	48
D6.2	Data Management Plan	2 - ECMWF	Report	Public	6

Description of deliverables

• D6.1 Sector Survey report (including activities, results and management) (KNMI + all partners) (M48) • D6.2 Data Management Plan (ECMWF) (M6)

D6.1 : Sector Survey Report [48]

Sector Survey report (including activities, results and management)

D6.2 : Data Management Plan [6]

Data Management Plan

Schedule of relevant Milestones

Milestone number [18]	**Milestone title**	**Lead beneficiary**	**Due Date (in months)**	**Means of verification**

Work package number [9]	WP7	Lead beneficiary [10]	12 - DELTARES
Work package title	Sectoral survey: Flood inundation prediction and risk assessments		
Start month	1	End month	48

Objectives

This work package aims to develop improved short to medium, seasonal and long-term improved flood risk assessments for fluvial flooding. This risk-based information produced in this work package is required by decision makers in public and private arenas, in order to assess strategic decision making on risk reduction and climate adaptation in the short term (efficient warning and decision making, evacuation planning, financial liquidity to cover losses), as well as long term. In particular, results are relevant for civil protection and the (private) insurance sector for household and business policies. Also, new approaches are needed for assessing correlated risks related to flood occurrence and impacts at the local and European scale and application for insurance and the European Solidarity Fund (EUSF). The improved reanalysis, forecasts and hydrologic models from WP3 and WP4 will be used to derive meaningful flood maps offline and in forecast mode at various scales (Bisagnio, Rhine, Europe). Additionally, WP7 will test probabilistic flood damage forecasting.
The case studies for this work package are located in the lowland stretches of the Rhine river (in the Netherlands and Germany, downstream from Bonn), the Elbe river (Germany), Somerset (UK), and also include an EU-wide analysis. The Bisagno Catchment case study whose outlet passes through the City of Genoa (Italy) is included to test potential use in case of flash floods. Further, the Somerset region that experienced extensive flooding in 2013/2014 is chosen as case study area, as well as several water board areas in The Netherlands.
The WP will involve various consultation with stakeholders (as part of WP2), that require flood risk and damage information in the areas of a) civil protection, b) water managers involved with strategic planning against flooding, c) insurance organisations. These stakeholders are listed above.
The objectives of WP7 are:

• To consult with organisations with strategic responsibility for reducing flood risks (water ministries, regional governments), and those organisations covering residual losses (insurance companies, finance ministries, European Commission -EUSF) on their requirements for long-term flood damage assessments, in support of the EU Flood Directive goals and in compliance with the EU risk assessment Guidelines. (in WP2)
• To develop Europe-wide flood inundation maps for the short-medium and seasonal scales, and climate risk assessments. For several case study sites, inundation will be modelled (Rhine, Bisagno). The climate risk assessment will help to develop adaptation strategies, and links to the work in WP13.
• To develop Europe-wide and case study site specific (Rhine and Bisagno rivers) flood damage assessments, and to test the proposed improvements in assessing damages from low-probability flood events, using probabilistic damage models and analysis of correlated risks between river basins within the European region under future climate conditions
• To analyse compound meteorological events that lead to flooding in several highly managed water board areas in The Netherlands, and for Somerset in the UK.
• Collect experiences in using the newly developed approaches and disseminate results to a wide range of stakeholders.

Description of work and role of partners

WP7 - Sectoral survey: Flood inundation prediction and risk assessments [Months: 1-48]
DELTARES, KNMI, UREAD, IVM, HKV, CIMA, GFZ
Task 7.1: Flood inundation extents for Europe, Rhine, Bisagno (Deltares, CIMA):
Currently, only flood levels and/or extreme discharges are provided by the forecasting agencies. However, there is a strong need before and during a flood to have the information available on expected flood extent (for example Germany in 2013 and Great Britain and Serbia in 2014) to allow efficient decision making, evacuation planning and warning. Additionally, this would also allow rapid assessment of the flood damage immediately after the flood occurred.
In this task, the hydrological estimates of WP4 will be translated into inundation extents for Europe, the Rhine (Germany and The Netherlands) and Bisagno basins. Information from WP4 from hydrological and hydraulic models will be used to assess damages at high and low return periods. For Europe, the EFAS forecasts will be used to derive flood extent maps using the Delft 3D Flexible Mesh model, which will feed into the Hydrological Risk Outlook of WP14. For The Netherlands, we will apply newly developed methods to assess correlation effects of failure of dikes along different protected areas for The Netherlands and Germany . For the Bisagno river, Genoa Area official risk assessment studies will be complemented with modelled hydraulic forcing necessary to damage evaluation.

Task 7.2: Flood damage modelling (GFZ, Deltares and CIMA):
Deterministic damage functions suffer from overly simplistic representations of flood damage occurrence. First promising applications of probabilistic approaches for the small scale have been made56, and in IMPREX this application will be extended to the regional and river basin scale. In this approach, multiple flood parameters and vulnerability characteristics of exposed objects are used for estimating damages. The advantage is that more effects can be taken into account which improves the estimation of damaging processes significantly56. The development of probabilistic damage models has the further advantage that it inherently provides quantitative information about the model prediction uncertainty.
This task consists of the development of probabilistic, multi-parameter flood damage models for direct economic damages to companies and households, applicable at the regional/river basin (meso) scale. These approaches will be applied in the Rhine and Bisagno basins, and tested for the European scale. Probabilistic modelling approaches will use Bayesian Networks or bagging decision trees. This approach could be compared to Monte-Carlo simulations of depth-damage functions. These concepts will be developed in WP5, Task 5.4. This work would result in long-term estimates of changes in low-probability damaging flood events, associated economic losses, including the analysis of changes in vulnerability related to socio-economic drivers, based on e.g. SSP pathways.

Task 7.3: Compound flood events (HKV, Deltares, UREAD, KNMI)
The processes that can lead to the occurrence of high water levels are often assumed to be independent; e.g. high runoff, high discharge, high rainfall and wind-driven events. However, the coincidence of these events can lead to compound flood events, and these processes must therefore be studied together, in order to arrive at the correct flood probabilities. When the relevant processes are physically not independent, this must be taken into account in deriving the statistics of the resulting high water levels and floods.
For several locations (specifically: water board areas) in The Netherlands, we will study in close cooperation with the local water authorities if and how large these compound flood events are. This will be done for present and future climates. Key stakeholders for this information are the operational managers of the water boards in The Netherlands that are actively cooperating with the IMPREX project. We will quantify the size of the coincidence of different mechanisms for current and future climates, indicate what is the added value of the IMPREX approach for dealing with this issue, estimate the uncertainty of the estimates using different model approaches and output available in the IMPREX project, and analyse the communalities and differences between the different location and water board areas. This work is done in close cooperation with WP4 and WP5.

Task 7.4: Correlation analysis of EU-wide flood damage (IVM, Deltares):
Previous work has found strong correlations between large scale climate variability and high-flows at both the European46 and global50 scales. Such correlations are, however, not included in current national or EU-wide flood risk assessment, or climate change impact assessments, leading to substantial underestimations of overall risk on the basis of relationships between observed economic losses and hazard probabilities.
Based on concept developments in WP5, this task will focus on the analysis of correlations in flood damages with large scale climate oscillations and forcings, such as the North Atlantic Oscillation (NAO). This task extends previous studies to assess correlations between climate variability and damages directly. Potentially, this information could be combined with information on the predictability of large scale climate variability, to provide seasonal predictions of (anomalies in) risk, and this line of work will be explored. The work will make extensive use of economic loss data (e.g. from the EM-DAT and/or Munich Re NatCatSERVICE databases), next to geophysical data.

Participation per Partner

Partner number and short name	WP7 effort
1 - KNMI	5.00
10 - UREAD	4.00
12 - DELTARES	28.00
13 - IVM	5.00
15 - HKV	6.00
20 - CIMA	18.00
21 - GFZ	17.00

Partner number and short name	WP7 effort
Total	83.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D7.1	Correlated flood risk and finance	13 - IVM	Report	Public	30
D7.2	Compound flood risk events	15 - HKV	Report	Public	36
D7.3	Flood damage risk assessment	12 - DELTARES	Report	Public	48

Description of deliverables

• D7.1: Report on correlated flood risks in Europe and implications for risk finance (IVM) (M30) • D7.2: Report on compound flood events in the Netherlands and UK (HKV) (M36) • D7.3: Report on flood damage risk Europe wide and Rhine and Bisagno Catchments (Deltares) (M48)

D7.1 : Correlated flood risk and finance [30]

Report on correlated flood risks in Europe and implications for risk finance

D7.2 : Compound flood risk events [36]

Report on compound flood events in the Netherlands and UK

D7.3 : Flood damage risk assessment [48]

Report on flood damage risk Europe wide and Rhine and Bisagno Catchments

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS17	Assessment of current practice per sectoral survey	1 - KNMI	12	Assessment of current practice
MS18	First use of prediction/projection data from WP3/4/5	1 - KNMI	18	First use of prediction/ projection data from WP3/4/5
MS19	Use of updated information from WP3/4/5	1 - KNMI	36	Use of updated information from WP3/4/5
MS20	Definition of benefits for risk assessment and decision support	1 - KNMI	48	Definition of benefits for risk assessment and decision support

Work package number [9]	WP8	**Lead beneficiary** [10]	4 - IRSTEA
Work package title	Sectoral survey: Hydropower		
Start month	1	**End month**	48

Objectives

Hydrometeorological predictions in hydroelectricity systems are useful to guarantee people safety and dam security, and to optimize energy production and the economic value of water resources. For this, hydropower users need accurate and reliable forecasts over a range of space and time scales: short-term streamflow forecasts (2-3 days ahead) for flood protection and the security of installations, medium-range forecasts (7-15 days ahead) for the optimisation of production, and long-term predictions for water resources management and environment protection. Hydrological trends and outlooks under future climate conditions help anticipating the effect of changes in runoff volume, extremes and seasonality, directly affecting the potential for hydropower generation . The role of hydropower storage capacity increases with the expansion of intermittent solar and wind energy productions in a society moving towards a low-carbon economy. Storage allows handling the natural variability of hydrometeorological hazards and extremes, and can increase power transmission capabilities between northern and southern Europe. Hydropower reservoirs are often operated for multiple purposes (e.g., domestic/agriculture water supply, environment protection, tourism, flood protection) and conflicts may arise . In several places in Europe, the usefulness of optimization tools and adaptive strategies to define optimal management rules was demonstrated and led to better informed decisions using available forecast information . These tools allow consideration of climatic constraints and variability of water resources, other users, legal/policy requirements, and socio-economic aspects.
Based on the forecasts and products produced in WP3 and WP4, WP8 will evaluate the impacts of improved predictability of hydrometeorological events (considering reservoir inflows and extremes) on the hydropower sector at different temporal scales.

Description of work and role of partners

WP8 - Sectoral survey: Hydropower [Months: 1-48]
IRSTEA , SMHI, UPV, POLMIL
The activities in WP8 will comprise two main impact assessment applications:
1. the implementation of improved predictability of inflows and extreme events on hydropower decision models and the assessment of the operational value of forecasts, at short to medium up to seasonal time scales;
2. the evaluation of the impacts of climate projections on the adaptability of reservoir operation rules in a multi-sector perspective, with focus on 10- to 20-year periods between 2030 and 2100.
Input data for hydropower models will come from WP3 and WP4 (precipitation, temperature and streamflow). Additional post-processing or statistical downscaling (bias-correction and spatial disaggregation), using local data, will be carried out to match hydrological needs at the catchment scale. We will focus on impacts on operational decisions taken at different time scales in single- and multi-purposes energy production/demand systems. Four sites in Europe, covering different hydroclimatic and socio-economic contexts, are included to capture the diversity of conditions encountered in hydropower management. Work will be developed in close collaboration with operational centres of EU weather-sensitive energy production companies.
WP8 provides insights to WP2 on current status of knowledge and needs on the hydropower sector. In multi-purposes reservoir cases, it interacts with other sectoral applications (WP11, Agriculture & Droughts). It also contributes to WP7 for its inter-sectoral assessment and to WP14 for dissemination among stakeholders.
The associated tasks to achieve the objectives for the hydropower sectoral survey are:

Task 8.1: Review of existing knowledge and needs on the hydropower sector (POLMIL , IRSTEA, SMHI, UPV)
A concise and practical overview of existing knowledge and needs will be carried out for a better understanding of the hydrometeorological impacts on both production (operation systems) and consumption in the hydropower sector. This task will highlight open opportunities that may further strengthen the usefulness of climate inputs in the EU hydroelectricity business. It will be based on interviews and contacts with operational users of hydrometeorological products in the hydropower sector, including those involved in the WP8 applications (EDF, Vattenfall AB, A2A trading) and other potentially interested users in or outside Europe. This review will serve as knowledge input to WP2. (M1 to M12)

Task 8.2:Evaluation of hydrological forecasts of the Pan-European HYPE model (SMHI , IRSTEA, POLMIL, UPV)

Hydrological forecasts from the pan-European application of the HYPE model (E-HYPE) produced in WP4 will be applied to the specific case study catchments (Task 8.3 below). This task will measure the added value of E-HYPE improved hydrologic predictions to the hydropower sector in Europe. E-HYPE predictions analysed concern predicted river discharges on daily basis and monthly snowmelt volumes. By using the same input to the different case studies, which use different management models, the assessment can focus on the sensitivity to the choice of hydropower modelling tools. This task will also serve as a benchmark to which improvements and alternative simulations (see Task 8.3) can be compared. (M1 to M36)

Task 8.3: Case study analyses of new data, improved hydrometeorological forecasts and risk assessment methods (IRSTEA, POLMIL, UPV, SMHI)

Applications will be carried out to provide robust conclusions about the impacts of new data, improved hydrometeorological forecasts and risk assessment methods on the hydropower sector in Europe. They concern four sites:

• South-eastern French catchments (IRSTEA): It comprises a set of 10 catchments where the French energy company EDF operates hydropower reservoirs. At EDF, an expert-based semi-automatic hydrologic ensemble prediction system has been running operationally since December 2010 43. It is based on post-processed ECMWF EPS forecasts and a conceptual hydrological model . In a recent IRSTEA-EDF collaboration, a decision model based on a heuristic optimisation of energy production was developed and tested over a short reforecast dataset. Results showed that 7-day probabilistic forecasts of improved quality result in economic gains of energy production of up to 1.5% (over hundreds of M€). The model was applied over a short time series, with few extreme events. In IMPREX we will apply it to a longer reforecast dataset, with higher resolution. The impact of improved forecasts from WP3 and WP4 on the economic gains of energy production will be evaluated using the GR5 semi-distributed hydrological model . The links between quality and value of forecasts will be analysed. Hourly or daily time steps, according to the catchments' dynamics and response times, will be considered in the short to medium-range prediction horizon (lead time up to 7 to 10 days).

• A typical snow-dominated Alpine basin (Lake Como Basin, Italy), heavily exploited for hydropower production in the upper catchment and with a multi-sectoral use in the lower part (POLMIL): This water system comprises one large regulated lake and 16 hydropower reservoirs. It is a large socio-economic system and a paradigmatic example of many Alpine watersheds: large storage capacity distributed in small reservoirs, mainly operated for hydropower production and located in the upper watershed region; regulated lakes in the middle region; and multiple water consumption users, mainly agricultural areas, in the lower region62. Stakeholders include 4 hydropower companies (A2A, Enel, Edipower, Edison), the lake operator (Consorzio dell'Adda), and irrigation districts. Currently, an uncoordinated management prevails, where each operator takes its release decision independently, with no or little information sharing, and a focus on its operating objective only. The case-study area is representative of EU snow-dominated regions vulnerable to extreme hydrologic events, particularly droughts, and with potential to acquire significant benefits from cooperation with an efficient trans-sectoral risk management. In this case-study, a decision model based on stochastic optimization and optimal control tools will be set up. Optimization tools will be applied to cope with increasingly high and frequent droughts that are enhancing the conflict between energy and food production, and threatening the main ecosystem services and flood buffering capacity (inter-sectoral links are addressed in WP13). Models will run at daily time steps, on the short to medium-range prediction horizon (lead time up to 7 to 10 days), and for seasonal forecasts to the long-term planning of release strategies based on snowmelt runoff.

• A typical south Mediterranean basin (Jucar basin, Spain) suffering from significant drought issues, with an important share of water for irrigated agriculture (80%), and conflicts on water allocation in its multi-reservoir system (UPV): The Jucar basin has Europe's largest pumped-storage hydropower project (Cortes-La Muela) and, with its 3 main reservoirs, is an ideal case-study for water use optimization and impact assessment. Water scarcity, irregular hydrology and groundwater overdraft cause droughts to have significant economic, social and environmental consequences38. The situation is expected to be exacerbated by the impacts of climate and socio-economic (global) changes, and the increasing institutional impediments from political disputes among the two main riparian regions. A range of innovative solutions have been implemented, but coordination is still needed, which makes this case a real lab for analyzing risk management strategies to cope with drought events. Legally, hydropower has a lower priority on reservoir releases than agriculture, but significant benefits of cooperation between these uses can be expected. With the help of hydroeconomic optimization models , optimal coordination mechanisms at the basin scale can be designed and evaluated. This case study will use a stochastic optimization hydro-economic model (including the economic value of water use) to investigate potential strategies of coordinated reservoir operation for future scenarios, including improved climate projections from WP3. Gains from improved coordinated reservoir operating rules, considering water values and the spatial-temporal dependence of the hydrological time series in the basin will be analysed. Models will run at daily time steps and focus on impacts of future climate conditions.

• The upper part of river Umeälven, a typical north European catchment highly influenced by snowmelt runoff and volumes in hydropower production, with a multi-reservoir system (SMHI):There are several hydropower companies operating in the river Umeälven, and the main actor in the upper part (Vattenfall AB) will be involved in this case study. The upper part of the river basin includes 4 major reservoirs and 4 hydropower stations, and is partly dominated by high mountain basins and forest areas. In the area, seasonal forecasts of snow melt runoff volumes, together with ground based and remote sensing snow cover monitoring, are key inputs to the decision models of the hydropower companies when planning the production for the current and next winter seasons. Currently, the operational seasonal forecasts are based on hydrological model simulations using an ensemble of historical years of observations of precipitation and temperature as input (Olsson et al., 2011). Forecasts for the April-July accumulated runoff are issued once a month from January until the start of the melt season in April. This case study will focus on comparing the usefulness of the hydrometeorological predictions developed in WP3 and WP4 in comparison to the current operational methods. Spring melt runoff predictions will be made using both the HYPE model applied to the case study area, as well as using the traditional method with ensembles of historical years. (M1 to M48)

Participation per Partner

Partner number and short name	WP8 effort
3 - SMHI	8.00
4 - IRSTEA	24.00
18 - UPV	7.00
19 - POLMIL	12.00
Total	51.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D8.1	Improved hydropower risk assessment	4 - IRSTEA	Report	Public	48
D8.2	Hydropower policy brief	4 - IRSTEA	Websites, patents filling, etc.	Public	48
D8.3	Report on needs in hydropower sector	19 - POLMIL	Report	Public	12

Description of deliverables

• D8.1: Summary report on the review of existing knowledge and needs on the hydropower sector (POLMIL) (Task 8.1) (M12) • D8.2: Report on the assessment of the impacts of improved hydrometeorological predictions and risk assessment methods on the hydropower sector (Tasks 8.2 & 8.3) (IRSTEA) (M48) • D8.3: Policy Brief aiming stakeholders and policy makers summarizing key impacts of improved predictability on the hydropower sector (IRSTEA) (M48)

D8.1 : Improved hydropower risk assessment [48]

Report on the assessment of the impacts of improved hydrometeorological predictions and risk assessment methods on the hydropower sector ((Tasks 8.2 & 8.3))

D8.2 : Hydropower policy brief [48]

Policy Brief aiming stakeholders and policy makers summarizing key impacts of improved predictability on the hydropower sector

D8.3 : Report on needs in hydropower sector [12]

Summary report on the review of existing knowledge and needs on the hydropower sector

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS17	Assessment of current practice per sectoral survey	1 - KNMI	12	Assessment of current practice
MS18	First use of prediction/projection data from WP3/4/5	1 - KNMI	18	First use of prediction/ projection data from WP3/4/5
MS19	Use of updated information from WP3/4/5	1 - KNMI	36	Use of updated information from WP3/4/5
MS20	Definition of benefits for risk assessment and decision support	1 - KNMI	48	Definition of benefits for risk assessment and decision support

Work package number [9]	WP9	**Lead beneficiary** [10]	22 - BfG
Work package title	Sectoral survey: Transport		
Start month	1	**End month**	48

Objectives

The aim of WP9 is to evaluate how improved hydro-meteorological and hydrological forecast products produced in WP3 and WP4 increase operating efficiency and strategic management of the European transportation sector with special focus on Inland Waterway Transport (IWT). In light of continuing transport growth within the European Union there is a need to use the free capacity offered by IWT more consequently in order to release road and railway networks. Although the inland waterways offer a congestion-free network, the ease, safety and efficiency of IWT is sensitive to hydrological impacts from the short term up to the climate time scale.
Short- to medium term forecasts of discharges / water-levels are essential to optimize the load capacity of the vessels as well as to timely take into account that waterways might be blocked due to floods. Navigation related water level forecasts with lead times ranging from 2 days – 8 days are operationally available for the large navigable Central European Rivers Rhine , Elbe, and Danube and are accessible for the IWT via river information systems RIS . These water level forecasts are currently deterministic based on a single meteorological forecast with no additional information about the forecast uncertainty for the users. One of the barriers to publish probabilistic forecasts is finding an adequate way of communicating the calculated (un)certainties to the end-users . The provision of probabilistic forecasts is one of the IMPREX objectives.
Monthly to seasonal forecasts are required for the medium- to long-term planning and enhancement of the water bound logistic chain (stock management, adjustment of the industrial production chain, modal split planning). Despite the great demand and interest of the IWT, no operational forecasts with lead times exceeding 8 days are available for the Rivers Rhine (max. lead time 4 days), Elbe (max. published lead time 2- 8 days depending on the gauge) and Upper Danube (max. published lead time 2-4 days depending on the gauge) due to the large uncertainties and the limited skill on monthly and seasonal scales . Another objective of IMPREX is to find adequate ways to communicate these large uncertainties in collaboration with the users involved.
Climate projections are essential for the optimal future fleet planning of shipping companies as well as for infrastructural waterway management. Potential consequences of climate change for navigation have been analysed for the navigable rivers in Central Europe in the research program KLIWAS "Impacts of climate change on waterways and navigation - Searching for options of adaptation" and with focus on the Rhine-Main-Danube corridor in the EU FP7 project "ECCONET-Effects of climate change on the inland waterway networks" 76 . Regional climate projections from the EU-Ensembles project and regional climate model runs conducted in German research initiatives have been used as input to hydrological models to assess the potential impact of climate change on the water balance and navigation conditions with focus on low and medium flow situations.
The non-waterbound transportation network (roads, railways) is also vulnerable to hydrological extremes, primarily to floods (link to WP7). Reliable information on their vulnerability is essential to reveal hot-spots in the intermodal transportation infrastructure. Hence short- to medium term hydrological forecasts are required to optimize emergency planning, preparedness programs as well as to guide transport via alternative routes / transport modes. For the long-term planning of flood protection measures climate projections about the possible future evolution of extremes are needful. Adaptive management approaches offer here an important step in the strategical planning with the aim to reducing uncertainty over time via system monitoring.
The objectives of WP9 are to
• couple different transport related forecasting chains to IMPREX-products and verify the resulting runoff and water-level forecasts at different lead times (short- to medium-term, monthly, seasonal, climate projection) with special focus on extreme low flow and flood conditions which are harmful for transportation networks (Task 1 – 4),
• develop a pre-operational system for probabilistic short- to medium-term forecasting for IWT based on the current operational system for the River Rhine72 and to apply a cost structure model to demonstrate the economic benefit of probabilistic forecasts to the end-users (Task 3a),
• evaluate the potential skill of meteorological monthly to seasonal forecasting products as input for navigation related forecasting for the Rivers Rhine, Elbe and Danube (up to the gauge Nagymaros in Hungary). A monthly forecast prototype for IWT will be developed in collaboration with the potential end-users based on existing operational and pre-operational forecasting systems. Based on the skill evaluation of the seasonal forecasts possible Seasonal Outlook prototypes for IWT are discussed with the end-users (Task 3b),
• apply climate projections and meteorological extreme scenarios to derive extreme runoff scenarios for the design of waterway infrastructure and for the identification of critical points in the non-waterbound transportation network with

respect to floods (inundation areas from WP7) for Central European Rivers. This aspect was not considered in the previous navigation related impact of climate change projects KLIWAS and ECCONET (Task 3b).
Three main elements will ensure that progress achieved by IMPREX with respect to transportation is applicable for the main axes of the European waterway network and that the findings of IMPREX are beneficial for strategical transport management as well as day-to-day business:
• The data feed from WP3 and WP4 will be directly linked to operational or semi-operational forecasting systems feeding River Information Services (RIS) for the main waterways. BfG is developing and operating those forecasting systems for German stretches of the international waterways.
• The target areas chosen as case studies (Rhine, Danube, Elbe) are part of the backbone of Europe's waterway and non-waterbound network. Therefore improvements demonstrated have a direct economic relevance for the transportation sector. Furthermore these river basins represent different runoff regimes and climate characteristics (Rhine: mixed runoff regime, temperate oceanic climate, Elbe: rainfall-dominated runoff regime, humid continental climate, Danube up to Nagymaros: snowfall dominated runoff regime, humid continental climate) facilitating the transfer of results
• The users involved in WP9 represent the different parties involved in the transport chain with different requirements: shipping / logistic companies (Imperial Shipping group, Royal Dutch Barge Association – Koninklijke Schuttevaer), industrial enterprises relying bulk shipment (BASF), intergovernmental organisations providing free navigation for commercial vessels (Central Commission for the Navigation of the Rhine, Danube Commission) as well as public authorities maintaining and managing the waterways (Federal Ministry of Transport and Digital Infrastructure, Federal Waterway and Shipping Administration). The users will be involved from the very beginning of WP9 giving already input to task 1 (sensitivity and vulnerability of transport due to hydrological extremes) and task 2 (quality assessment framework).
Two case-studies are conducted within WP9 (task 3):
• River Rhine Basin: evaluation of short- to medium-range IMPREX-products with special focus on the quantification of monetary benefits by coupling a cost structure model with BfG's operational hydrological forecast system. Users involved in this case study are: Imperial Shipping group, Royal Dutch Barge Association, BASF, Central Commission for the Navigation of the Rhine, Federal Ministry of Transport and Digital Infrastructure, Federal Waterway and Shipping Administration
• Central European basins of Rhine, Elbe and Danube: applying monthly- to seasonal forecasts as well as predictions on the climate scale. Special attention will be paid to relevant low flow and flood parameters and the added value compared to climatology. Users involved in this case study are the same as in case study River Rhine Basin and additionally the Danube Commission.

Description of work and role of partners

WP9 - Sectoral survey: Transport [Months: 1-48]
BfG, HZG
Task 9.1: Review of existing knowledge (BfG, HZG)
This review addresses the vulnerability and sensitivity of waterway management and the waterbound transportation chain on hydrological extremes and climate change and the needs of the intermodal transportation sector related to improved forecasts and projections. This review will serve as knowledge input to the developments that will be further conducted within WP9 itself, and be executed in close collaboration with WP2.

Task 9.2: Development of an objective quality assessment framework (BfG)
This concerns a framework of hydrological forecasts and projections with special focus on the needs of the transportation sector. Relevant deterministic and probabilistic verification measures for navigation-related forecasts depending on the time scale are identified and integrated in the framework. This framework will be used in Task 9.3 to objectively evaluate the potential improvement of the forecasts by using improved methods from WP3 and WP4.

Task 9.3: Case studies (BfG)
Case studies will be executed that analyse adaptive management approaches, including the impacts of new data, improved hydro-meteorological forecasts and predictions, improved hydrological tools covering a wide range of space and time scales. As meteorological ensembles tend to be biased and underdispersed, the resulting ensemble forecasts for river runoff typically are biased and underdispersed too. Hence standard post-processing methods like Bayesian Model Averaging (BMA) or Ensemble Model Output Statistics (EMOS) are applied to estimate skillfull and reliable probabilistic forecasts from the raw runoff / waterlevel ensemble . These probabilistic runoff and water level forecasts on all time scales are evaluated with special focus on extreme low flow and flood conditions using the objective evaluation framework of Task 9.2.

• Case Study River Rhine Basin: The hydrological model HBV working on an hourly/daily timestep is applied to calculate runoff forecasts from short-to-medium term hydro-meteorological forecasts (lead times up to 14 days). These runoff forecasts are used as boundary condition for the hydrodynamic model SOBEK-River to calculate water level forecasts along the River Rhine. To quantify the impact of the potential improvement of the water level forecast on transportation costs monetarily a cost structure model is applied to the water level forecasts. The results of this model are also used to communicate the potential benefit of probabilistic forecasts to the users. Meteorological products of WP3 provided on a regular raster are regionalized to the subbasins and used as input to the hydrological model, runoff forecasts from WP4 are used as direct input to the hydrodynamic model.
• Case Study Central Europe: The hydrological model LARSIM-ME working on a daily time step which covers the main river basins in Central Europe (River Rhine, River Elbe, River Danube up to the gauge Nagymaros in Hungary) is applied to calculate runoff forecasts / projections / extreme events from monthly to seasonal meteorological forecasts, climate projections and extreme scenarios. Meteorological products of WP3 provided on a regular raster are bias corrected and statistically downscaled to a regular 5 km grid and used as input to LARSIM-ME. Flood inundation maps from WP9 are used to identify flood prone hot spots of the non-waterbound transportation network.

Task 9.4: Formulation of robust qualitative and quantitative conclusions (HZG, BfG):
Conclusions will be drawn about the impacts of new data and improved hydro-meteorological forecasts and predictions on the transportation sector in Central Europe.

Participation per Partner

Partner number and short name	WP9 effort
11 - HZG	6.00
22 - BfG	31.00
Total	37.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D9.1	Report on vulnerability of water transport	22 - BfG	Report	Public	12
D9.2	Navigation quality assessment	22 - BfG	Report	Public	18
D9.3	Potential economic benefit of better forecasts for water transport	22 - BfG	Report	Public	38
D9.4	Improved transport cost planning	22 - BfG	Demonstrator	Public	42
D9.5	Impact on adaptive mgmt of transport sector	11 - HZG	Report	Public	46

Description of deliverables

• D9.1: Report on the vulnerability and sensitivity of waterway management and the waterbound transportation chain on hydrological extremes and climate change (Task 9.1, BfG) (M12) • D9.2: Report on the objective quality assessment framework for navigation related forecasts (Task 9.2, BfG) (M18) • D9.3: Report on the potential economic benefit of the improved forecasts for inland waterway transport via cost structure modelling for the River

Rhine (BfG) (M38) • D9.4: Semi-operational forecasting system for the waterway Rhine and Central Europe forced by IMPREX products (BfG) (Task 9.3, initial version in M30, final version in M42) • D9.5: Report the impacts of new data and improved hydro-meteorological forecasts and predictions on the transportation sector in Central Europe (HZG) (Task 9.4, initial version M34; final version M46)

D9.1 : Report on vulnerability of water transport [12]

Report on the vulnerability and sensitivity of waterway management and the waterbound transportation chain on hydrological extremes and climate change

D9.2 : Navigation quality assessment [18]

Report on the objective quality assessment framework for navigation related forecasts

D9.3 : Potential economic benefit of better forecasts for water transport [38]

Report on the potential economic benefit of the improved forecasts for inland waterway transport via cost structure modelling for the River Rhine

D9.4 : Improved transport cost planning [42]

Semi-operational forecasting system for the waterway Rhine and Central Europe forced by IMPREX products

D9.5 : Impact on adaptive mgmt of transport sector [46]

Report the impacts of new data and improved hydro-meteorological forecasts and predictions on the transportation sector in Central Europe

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS17	Assessment of current practice per sectoral survey	1 - KNMI	12	Assessment of current practice
MS18	First use of prediction/projection data from WP3/4/5	1 - KNMI	18	First use of prediction/ projection data from WP3/4/5
MS19	Use of updated information from WP3/4/5	1 - KNMI	36	Use of updated information from WP3/4/5
MS20	Definition of benefits for risk assessment and decision support	1 - KNMI	48	Definition of benefits for risk assessment and decision support

Work package number [9]	WP10	**Lead beneficiary** [10]	17 - CETAQUA
Work package title	Sectoral survey: Urban Water		
Start month	1	**End month**	48

Objectives

Urban water supply in Europe is highly vulnerable to weather extremes and the long term evolution of their occurrence . Weather extremes affect the fresh water quality and quantity, challenging treatment capacity, safety of drinking-water and reliability of supply. For example, droughts induce low river flow and high concentration of pollutants, while intense rainfall events cause high levels of turbidity protecting microorganisms from disinfection treatment, and rising temperatures reduce dissolved oxygen and increase the probability of development of communities of cyanobacteria releasing toxins into the water. To manage the risks raised by those hazards, drinking-water suppliers are responsible for preparing and implementing water safety plans (WSPs), consisting of a system assessment, operational monitoring and the definition of risk management plans .
While climatological and hydrological outlooks could bring significant improvement in the implementation and definition of the WSPs, this is not a common practice in most of the European drinking water utilities. Current limitations include: (1) lack of a robust methodology for downscaling climate projections and linkage to water quality models, (2) the ability to run predictive water quality models generating key parameters used in decision making, (3) the assessment of the risk of high impact extreme weather events in current and future climate, and (4) lack of operational methods and treatment techniques that could be used to limit current and future risks. IMPREX is designed to address these limitations. Based on the products produced in WP3 and WP4 and on the concepts developed in WP5, WP10 will focus on the above mentioned issues.
WP10 will take the following innovative steps to improve risk management for drinking water supply at various timescales:
• Development of a methodology for downscaling weather and climate foresights (WP3 and WP4)
• Utilizing ensemble weather forecasts and seasonal outlooks leading to the design and test of a water quality forecasting system for some relevant parameters (dissolved oxygen, organic matter, ammonia, nitrates, phosphorous, turbidity, toxins)
• Long-term risk assessment of high impact weather events
• Implementation and test of a number of upgrades in the water treatment system
• Update and Upgrade Water Safety Plans based on these new forecasting tools.

Description of work and role of partners

WP10 - Sectoral survey: Urban Water [Months: 1-48]
CETAQUA, UPV
Different methodologies to utilize weather and climate data will be developed in Task 10.1, focusing on the simulation of fresh water quality and the impacts on urban water systems. The strategies to integrate these forecasts in risk management schemes will be developed in Task 10.2. These two tasks will be assessed in depth in Mediterranean regions and some water resources of strategic importance, but will gain insights that can be applied at European scale. In Task 10.3, the methodologies and strategies developed will be applied in two Mediterranean catchments with vulnerable water resources of strategic importance for supplying the regions of Barcelona and Murcia. This last task will be carried out in close collaboration with the stakeholders (including Aguas de Murcia (EMUASA)), to optimize the relevance and uptake of the outcomes and recommendations in practice.

Task 10.1: Simulation of the impacts of climate variables on urban water systems (CETaqua, UPV)
The following sub-tasks will be performed:
• Development of a methodology to downscale and use climate projections into water quality models. Different spatial and temporal horizons (point to basin, sub-daily to monthly) and different lead times (a few hours in advance to several decades) will be considered.
• Utilization of probabilistic weather forecasts for parameters of major interest for drinking water (e.g. conventional parameters such as temperature or turbidity and advanced parameters such as organic matter or eutrophication). Different predictive methods and modelling tools will be studied, such as multiple linear regression (MLR) model, and the GESCAL model .

• An assessment of the consequences of changing water quality on the operation, design and planning for different features of the urban water system (reservoirs, distribution system, drinking water treatment plant).

Task 10.2 Adaptation of the urban water system according to fresh water quality forecasts (CETaqua).
The following sub-tasks will be performed to upgrade water safety plans (WSPs):
• Analysis of the benefits of an early activation of the adaptation measures based on probabilistic water quality forecasts, and comparison with current activation practices based on measurement.
• Analysis of the benefits of improving water treatment operations, such as a better adjustment of the chemicals needed (typically coagulants and disinfection products) and the type of treatments applied.
• Proposition of structural changes such as the creation of water buffer tanks in order to better control influent water quality conditions.

Task 10.3 Applications in the Segura Basin and Llobregat Basin (CETaqua, UPV).
The methodologies developed in the previous sub-tasks will be applied in different contexts and for different objectives. The Llobregat Basin, supplying the Barcelona Region, and in the Segura Basin, supplying Murcia Region have been selected to perform the following analyses:
• In the Llobregat River, a water quality model will be developed to represent the main events impeding satisfactory water production in the system . The model uses climate variables as input and will simulate several constituents (such as dissolved oxygen, organic matter, ammonia, nitrates, phosphorous) and indirect variables (such as turbidity events in the raw water at the inlet of the water treatment plant). The water quality model will be developed by CETaqua and UPV, in collaboration with local water operators (Aguas de Barcelona, Aguas de Terrassa). Different lead times will be considered (sub-daily predictions to decadal predictions).
• In the Segura basin, a water quality model will be developed, the impacts of the climate variables on the system will be evaluated, and several adaptation measures will be proposed and tested. The main purpose of the modelling part will be to predict the development of communities of cyanobacteria in a reservoir upstream the water treatment plant to anticipate the release of cyanotoxins. Accordingly, a specific monitoring campaign and water quality analysis will be performed. In addition, the drinking water treatment will be optimized in collaboration with the local water operator EMUASA, stakeholder of the IMPREX project. Experiments in a pilot plant will be carried out to evaluate and compare the efficiency of different treatment techniques (e.g. ozone, chlorine, chlorine dioxide, biocides, and electrocoagulation) to remove the toxins (including microcystins, BMAA and anatoxins). Alternative water sources from inter-basin water transfers will also be included in the study. The final result will be a global and cost-effective strategy to manage risks, initiated by weather and climate forecasts and translated into decision making through the water quality model and the water treatment model. This strategy will be studied in collaboration with WP11 that will study the occurrence of drought in the basin at different time scales and the improvement of the drought monitoring system in the basin.

Participation per Partner

Partner number and short name	WP10 effort
17 - CETAQUA	24.00
AquaTEC	8.00
18 - UPV	7.00
Total	39.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D10.1	Fresh water forecasting in urban water system	17 - CETAQUA	Report	Public	24

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D10.2	Impact in Segura and Llobregat basins	17 - CETAQUA	Report	Public	36

Description of deliverables

• D10.1: Report on the adaptation of the urban water system according to fresh water quality forecasts (CETAqua) (M24) • D10.2: Report on the applications in the Segura Basin and Llobregat Basin (CETAqua) (M36)

D10.1 : Fresh water forecasting in urban water system [24]
Report on the adaptation of the urban water system according to fresh water quality forecasts

D10.2 : Impact in Segura and Llobregat basins [36]
Report on the applications in the Segura Basin and Llobregat Basin

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS17	Assessment of current practice per sectoral survey	1 - KNMI	12	Assessment of current practice
MS18	First use of prediction/projection data from WP3/4/5	1 - KNMI	18	First use of prediction/ projection data from WP3/4/5
MS19	Use of updated information from WP3/4/5	1 - KNMI	36	Use of updated information from WP3/4/5
MS20	Definition of benefits for risk assessment and decision support	1 - KNMI	48	Definition of benefits for risk assessment and decision support

Work package number [9]	WP11	**Lead beneficiary** [10]	16 - FW
Work package title	Sectoral survey: Agriculture and droughts		
Start month	1	**End month**	48

Objectives

A major threat to the agricultural sector in Europe is a potential increasing occurrence of droughts, affecting the local and regional food security and economies. Especially in the Mediterranean part of Europe, droughts are relatively frequent, while at the same time, agriculture concerns a major economic sector sustaining a significant part of the food supply for Europe. Also in Northern Europe, below average conditions in water resources availability can have serious consequences for the agricultural sector.
The agricultural sector, water managers and other decision makers can benefit from climatological and hydrological outlooks to anticipate better to drought conditions and take preventive actions to reduce their impacts. However, the use of operational forecasts and projections is still limited due to a number of factors : (1) the importance of downscaling climatic drought indices to find basin-specific relations with local agricultural drought impacts taking into account local management features, (2) lack of management instruments that consider the complex interactions between sectors and joint probability of drought-related hazard events and consequent risks for the agricultural sector, (3) the importance of better understanding relationships between large scale climate variability patterns and indices and regional agricultural impacts, and (4) lack of a generic framework that assesses climate change impacts on the agricultural sector on a pan-European scale, taking into account the different structures of the water resources system and consumptive and competing sectors in each basin. Based on the products from WP3 and WP4 and on the concepts developed in WP5 to represent impacts, WP11 will focus on the above mentioned issues and questions.
This WP will provide an overview of the agricultural sector by means of several case studies focusing on drought forecasting and drought risks in different basins across Europe, and a pan-European assessment of agricultural drought vulnerability under climate change. Through various case studies, new methodologies will be applied to learn from historic drought events and apply these tools and relations to better anticipate future events. The usability of seasonal forecasts of downscaled drought indices to improve predictions of agricultural drought impacts will be studied (task 1 and 2). A new tool will be tested to evaluate the impact of climate variability on drought related risks for the agricultural sector by means of a so-called risk profile (task 3). Relationships will be analysed between large scale teleconnection indices and agricultural impacts for selected basins in Europe (task 4). And a pan-European assessment will be carried out using a new analytical framework called Water Accounting Plus (WA+)7 to study the impact of changing rainfall, evapotranspiration and atmospheric recycling under climate change on water fluxes, flows, stocks, consumption and the agricultural services rendered in river basins (task 5).

Description of work and role of partners

WP11 - Sectoral survey: Agriculture and droughts [Months: 1-48]
FW, TUC, DELTARES, IVM, HKV, UPV, POLMIL
Task 11.1: Exploration of drought indices (FW, UPV, TUC, POLMIL)
Currently, several drought indices (meteorological, hydrological and agricultural) are available online for drought monitoring at the European level. Good examples are the SPI products disseminated by several European institutes, and the more elaborated products by JRC from the European Drought Observatory and the MARS Agricultural Drought Bulletin. However, they are hardly used by water management authorities. Regional water managers often do not have a clear understanding of the relations between these indices and local agricultural drought impacts. Besides, most of these indices can be of use for rainfed agriculture but have a more complex relation with production in irrigated agriculture. For this reason, in several drought-prone Mediterranean basins, water authorities chose to develop their own hydrological drought indices only based on local data and with better-understood relations with the dependent services87.
For each of the case studies this task will explore the relations between (1) drought indices available at the European level and agricultural drought impacts, and (2) the locally used hydrological indices versus agricultural drought impacts. This will be done by establishing relationships, combining statistical and deterministic approaches through (agro-) hydrological modelling. An evaluation will be carried out of the information currently used to monitor drought risks in the case study basins (Segura, Jucar, Como and Messara), serving as a benchmark for each of the case studies. Examples for indicators of agricultural drought that will be used are trends and anomalies in agricultural production based on statistical data and satellite-based anomalies in biomass production . The objective is to better understand which of the

indices are well related with agricultural impacts and under which conditions (drought intensity, severity, magnitude, type of agriculture, seasonality, etc).

Task 11.2: Bringing drought index predictions into local practice (FW, UPV, POLMIL, TUC)
The objective of this task is to incorporate drought index predictions available at the European level in local water management procedures and tools. Currently, in several basins, Drought Management Plans and monitoring systems exist that can be enhanced by using drought index predictions and as such better anticipate to drought. Here, the relations found in Task 11.1 will be used to make this step forward, to reach a TRL (Technology Readiness Level) of 6 ("prototype demonstration in a relevant environment"). Multi-model predictions will be used from WP3 of the Standardized Precipitation Index (SPI) and Evapotranspiration Index (SPEI), delivered by WP3. Bias correction of these ensemble forecasts will be necessary and carried out to make sure that the statistical properties of the prediction data are similar to those in the observations. Based on the relationships found with agricultural drought impacts, a combined drought indicator will be developed tailored to the local agricultural sector and biophysical conditions of the case study. The relations and predictions will also be used for the periodic risk outlook of WP14. The operational value of drought index predictions will be assessed by employing this information in the different management systems of the case studies (Segura, Jucar, Como and Messara). This will lead to enhanced drought management systems for the different basins, developed in close collaboration with the different end-users.

Task 11.3: Application of drought risk management instrument (HKV, UPV)
Already in the present situation, delta regions world-wide encounter problems resulting from fresh water scarcity. Climate change and socio-economic developments make delta societies even more susceptible to consequences arising from drought events. The resulting risks exhibit a wide range of uncertainty, making management decisions even more difficult than they usually already are. As a result, decision making in water resources management and especially making appointments for fresh water assignment rules is becoming increasingly more complex.
This is also the case in the Netherlands, where fresh water availability will be more and more under pressure, due to the predicted effects of climate change. There is a strong wish to make uncertainty in water shortage and drought related risks more explicit. Therefore, we will develop a decision support instrument for water resources management especially related to periods of water scarcity (WP5.3). An integrated risk-based approach will allow us to analyse the effects of climate change but also to assess the effectiveness of management options and interventions. The management instrument will help to identify opportunities and measures and to quantify their subsequent consequences. By combining this with probability of occurrence we can quantify drought-related risks in present and future situation (under the influence of climate change) associated with various measures (which may include controlling water flows in major waterways, local infrastructural solutions to supplement water and local adaptations by the end users). This also allows comparisons of various options to include an assessment of their cost-effectiveness, which helps to prioritise operational and strategic actions and investments.
This task will apply the management instrument to evaluate the impact of climate variability on drought related risks for the agricultural sector, and to assess the cost-efficiency of measures to better cope with water scarcity. This instrument (developed in WP5.3) will consider the joint probability of drought-related hazard events and the consequences of these hazard events for the agricultural sector, yielding a so-called risk profile. The tool will be tested in the Rhine-Meuse Estuary of the Netherlands and Jucar Basin, Spain. It will consider (1) the probabilities of the joint occurrence of low river discharges, salt-water intrusion and limited water storage in the surface and ground water system, (2) the impact on water shortage and the consequences for the agricultural sector (using damage functions, often depending on the frequency, duration and season in which shortage occurs). The resulting risk profile serves as a starting point for new management strategies for risk adaptation and mitigation (explored in WP13).

Task 11.4: Application of large scale indicators (IVM, FW, POLMIL)
This task uses developments in WP5.1 focusing specifically on agricultural impacts in the case studies. Large scale climate oscillations and climate variability (such as North Atlantic Oscillation, El Niño Southern Oscillation, Frequency of Western Circulation and the Mediterranean Oscillation Index) affect the water cycle, and thus the probability of droughts and agricultural productivity. Previous work has found clear correlations between large scale climate variability and river discharge at both the European46 and global scales50. This task extends that work to assess correlations between climate variability and periods of water scarcity, and agricultural drought impacts. The work will be carried out using both observed and simulated data on water availability, satellite-based and local data on vegetation and agricultural production, and ancillary data stored in international database on drought impacts. The operational value of this low frequency information will be tested in a medium long term management model of the Lake Como water system for better anticipation at the river basin scale. These relations will also be used for the periodic risk outlook of WP14.

Task 11.5: Pan-European assessment (FW supported by subcontracted wateraccounting.org, UPV , POLMIL, TUC, HKV)

This task will provide a pan-European assessment of climate change impacts on flows, stocks, consumption and the services rendered in river basins related to agriculture by means of a novel water accounting framework. Water accounting is a new step in water resources management, currently being promoted from the European level, aiming at national and basin-level adoption of this methodology. Current developments are those led by Eurostat having a Task Force on Water Satellite Accounting, the European Environment Agency actively investing and improving the methodology and DG-ENV of the EC, supporting various pilot projects across Europe in this field. In this task, a novel analytical Water Accounting Plus (WA+) framework will be applied, supported by UNESCO-IHE, The International Water Management Institute (IWMI) and FAO.
WA+ examines the exploitable water in a river basin, i.e. the water that is utilized by a certain water use sector (irrigation, industry, domestic, energy, wetlands) or is utilizable for future withdrawals. The input data sets for WA+ are based on state of the art, open-access data from earth observation measurements, hydrological modelling and global GIS datasets of specific water and environmental parameters. Local data sources from the case studies can bring more detail to the water accounting system.
So far, climate change impact assessments using water accounting frameworks have not been carried out, given their relatively recent development. At this point, the methodologies are sufficiently mature to be used also for assessments under future change. IMPREX will make this step forward and study the impact of changing rainfall, evapotranspiration and atmospheric recycling under a changing climate on water resources with an emphasis on agriculture for the case study basins. This task will be carried out in close collaboration with WP12 (Water Economy), and input will be based on climate change scenarios from WP3. For the Jucar case study basin, results will be used in WP13 for strategy and policy development at climatic time scale.

Participation per Partner

Partner number and short name	WP11 effort
9 - TUC	7.00
12 - DELTARES	6.00
13 - IVM	6.00
15 - HKV	7.00
16 - FW	31.00
18 - UPV	6.00
19 - POLMIL	11.00
Total	74.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D11.1	Prototype design of drought DSS	16 - FW	Report	Public	18
D11.2	Index-based drought risk assessment	16 - FW	Report	Public	36
D11.3	Multihazard drought management tool	15 - HKV	Report	Public	36
D11.4	Prototype Drought Decision Support system	16 - FW	Demonstrator	Public	48

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D11.5	Climate change in agricultural water accounting system	16 - FW	Demonstrator	Public	48

Description of deliverables

• D11.1: Prototype design of drought decision support systems including seasonal forecasts (FW) (M18) • D11.2. Exploration of drought indices and agricultural impacts (FW) (M36) • D11.3. Test and evaluation of a multi-hazard drought-risk decision support tool (HKV) (M36) • D11.4. Prototype demonstration and evaluation of IMPREX-enhanced drought decision support systems (FW) (M48) • D11.5. Implementing climate variability assessments in a basin water accounting system (FW) (M48)

D11.1 : Prototype design of drought DSS [18]

Prototype design of drought decision support systems including seasonal forecasts

D11.2 : Index-based drought risk assessment [36]

Exploration of drought indices and agricultural impacts

D11.3 : Multihazard drought management tool [36]

Test and evaluation of a multi-hazard drought-risk decision support tool

D11.4 : Prototype Drought Decision Support system [48]

Prototype demonstration and evaluation of IMPREX-enhanced drought decision support systems

D11.5 : Climate change in agricultural water accounting system [48]

Implementing climate variability assessments in a basin water accounting system

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS17	Assessment of current practice per sectoral survey	1 - KNMI	12	Assessment of current practice
MS18	First use of prediction/projection data from WP3/4/5	1 - KNMI	18	First use of prediction/ projection data from WP3/4/5
MS19	Use of updated information from WP3/4/5	1 - KNMI	36	Use of updated information from WP3/4/5
MS20	Definition of benefits for risk assessment and decision support	1 - KNMI	48	Definition of benefits for risk assessment and decision support

Work package number [9]	WP12	**Lead beneficiary** [10]	23 - WFN
Work package title	Sectoral survey: Water Economy		
Start month	1	**End month**	48

Objectives

The impact of hydrological extremes, especially droughts, will affect economic activities and ecological systems that depend on the availability of water. For example, the lack of water can often result in losses in yields in both crop and livestock production. Production losses combined with change in demand of products and water by different economic sectors may lead local shortages of certain goods, and thus result in need for importing these goods from other regions. However, availability of these imports, particularly those that rely on water, can be at risk considering that production of many commodities are potentially sensitive to climate change on a global scale.
Europe currently meets some of its water needs by importing “virtual” water in the form of goods and services from other countries and regions. This external component accounts for approximately 40% of Europe’s water footprint . Reliance on food, energy and goods, which require water in their production from regions outside of Europe that are themselves vulnerable to hydrological extremes and climate change, may impose water related risks to different economic sectors in Europe. For example, IPCC’s 1 suggests that the Mediterranean Basin, Southern Africa, western United States and southern and eastern Australia will suffer a decrease in water resources with a consequential reduction in production as a result of increase in droughts. This forecast may suggest that the structure of production within Europe and imports may need to be adjusted to respond to climate changes to the availability of water resources around the world. Changes in the locality of production may have a number of subsequent environmental and social effects both in Europe and around the world.
Especially the linkages between different regions within Europe with respect to the interdependence of their production is a potentially large source of climate-change damages. Furthermore, European productivity depends to a large extent on the import of goods from the outside.
This work package aims at understanding and assessing vulnerability of European economy on global supply and production of goods under hydrological extremes (drought and flood damage) and climate change. Specific objectives of this work package are:
• to understand current dependencies of economic sectors in Europe on water resources of Europe and of other parts of the world;
• to elaborate impacts of climate change and hydrological extremes on water resources of the regions that Europe’s economy depend on;
• to elaborate vulnerability of European economy on global supply and production of goods under hydrological extremes and climate change;
• to elaborate how Europe’s dependency upon climate-sensitive imported resources;
• to understand environmental and social effects of this susceptibilities in Europe.
Within this WP, the Water Footprint Assessment (WFA) will be applied to study changes in demand for products within Europe and their water footprints under hydrological extremes (drought) and climate change. WFA covers the full range of activities to quantify and locate the water footprint of a process, product, producer or consumer or to quantify in space and time the water footprint in a specified geographic area and assess the environmental, social and economic sustainability of this water footprint. WFA will be used to elaborate the ability of Europe to meet changes in demand taking into account variations in water availability in producing river basins. In addition, the impacts of droughts and climate change on global water resources will be studied to obtain insight in the effects on the supply of goods and economic security of Europe. For this purpose, outputs of climate change scenarios from WP3 will be used as an input for the assessment. The results will be used in hydrological risk assessment (WP14).
Based on the improved meteorological scenarios of WP3, new projections of future extreme floods developed in WP4 will be used to compute the direct economic damages onto different regional sectors in Europe. Using the global damage transfer model “Acclimate” developed by PIK, the linkages and indirect damages within Europe will be computed. A special focus lies on the question of whether and under which circumstances the indirect effects exceed the direct ones. In a second working phase the scope is broadened by studying global impacts and their indirect effect on Europe. To this end, the generalized methods from WP2 and WP3 are applied to derive projections of global impacts of climatic extremes. Their impact onto the European economy are investigated together with potential adaptation measures to reduce these effects. The results are directly relevant for society and will feed into the outreach activity in WP14.

Description of work and role of partners

WP12 - Sectoral survey: Water Economy [Months: 1-48]
WFN, PIK
Task 12.1: Mapping dependencies of economic sectors in Europe on other parts of the world in terms of water resources (WFN)
This task will develop the baseline case for analysis of future susceptibilities of Europe's imports under climate change and hydrological extremes. To establish the baseline conditions, first, current water footprint of production and consumption in Europe and water footprint of different economic sectors (e.g. agriculture) will be analysed. This will help analysing external component of Europe's water footprint - water consumed in other parts of the world to produce goods consumed in Europe - and identifying key imported products and their production regions. Blue water scarcity and water pollution levels and impacts of hydrological extremes in these regions will be elaborated to understand vulnerability of production of key imported products. Hotspot regions and goods will be identified considering environmental vulnerability (e.g. water scarcity, water pollution level and hydrological extremes) and economic importance (based on EU dependence for production in that river basin/region).

Task 12.2: Assessment of water-related risks of European economy due to dependencies on water resources in Europe and other regions of the world under climate change and hydrological extremes (WFN)
This task aims to identify water-related risks that different economic sectors in Europe may face due to Europe's dependence on water resources elsewhere in the world and international dimension of climate change. This task will consist of:
a) Assessment of water demand changes in Europe: Changes in demand of products and their water footprints for individual regions and sectors within Europe will be elaborated by using existing climate change and socio-economic scenarios. This will help understanding how Europe's water demand will vary under different conditions.
b) Analysis of future susceptibilities of Europe's imports under climate change and implications of this to Europe's water resources: Impacts of climate change on importing regions' water resources and effects of this to Europe's imports will be elaborated by using existing climate change scenarios. Hotspot regions (regions experiencing production losses due to reduced water availability) and products (imported products that are economically significant and climate-sensitive) will be identified. This information and changes in product demand by different economic sectors will be used to understand need for increased production within Europe. The ability of Europe to meet changes in demand taking into account variations in water availability under hydrological extremes will be elaborated. Subsequent environmental effects in Europe will be analysed. The pan-European assessment of agricultural drought vulnerability under climate change from WP11 will be used an input to this analysis. This task will identify risks that different economic sectors of Europe may face due to dependencies on imports and water resources of the other regions under climate change and hydrological extremes.

Task 12.3: Projections of direct impacts on European and global economic productivity from future floods (PIK)
As a result of the Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP) global projections of runoff from 1971 to 2100 are available from 11 global hydrological models based on climate projections of 5 different global climate models (GCMs) using 4 different GHG concentration scenarios (RCPs). This wealth of consistent data allows a robust quantification of future runoff trends and the associated uncertainties, and thus provides the basis for a probabilistic estimation of future flood hazard. WP3 and WP4 aim for improved representations of future climatic extremes an d their impacts. We will embed these into the existing ISI-MIP projections in an effort to understand their differences and learn about the robustness of current projections. A global river and floodplain model, CaMa-Flood3.4 , will be used to translate the runoff projections into spatially-resolved time-series of flooded area and flood depth , which will then be downscaled to the ~10km scale using high-resolution topographic data. From the resulting daily inundation data, relevant aggregated metrics such as times flooded per year, maximum flood depth, etc. will be calculated for each grid point. The flood depth and frequency obtained will be translated into damages to sector-specific production capacity using spatial distribution of economic output for present day conditions and future projections together with existing relations and historical evidence of damages caused by flooding. Relevant damage indicators include the percentage of economic output affected and the restoration timescale. The resulting damages will be spatially aggregated to eliminate higher-order variability and detect robust climate-change signals. We compute the direct damages onto the European economy, but also assess the direct damages outside of Europe to be fed into Task 12.4.

Task 12.4: Estimation of indirect flood damages for Europe with the model Acclimate for different supply and demand strategies (PIK)
After having computed the direct costs to be expected from future floods, the indirect costs through global supply and production failure will be assessed with the global damage transfer model acclimate. Acclimate is a global numerical damage model that captures the dynamic response of the global supply network to climatic impacts, particularly extreme weather events like floods. It estimates the indirect costs that arise through unanticipated production and supply failures

using zeean data as a baseline. Thereby the model depicts the propagation of disaster induced shock waves in a highly non-linear, time-dependent and spatially explicit way. While the model asymptotically optimizes a global welfare function when perturbed by one climatic impact (cost-benefit-analysis), it does not assume that the actors can anticipate climatic impacts in advance (no perfect foresight). This short-term response is complemented by longer term adaptation strategies within the production network which may reduce the costs of climatic impacts. We will focus on the indirect damages witin Europe and also compute the indirect damages for the European economy that are caused by production loss in other parts of the world. Specifically, this will be done by separating the indirect costs according to different strategies which are price-oriented. The initial starting point is to assign a history weight to different demand distribution strategies. Depending on how much weight is put on the history of the supplier-buyer relationship, the global supply network can find back to its initial structure once the disaster is overcome. One example of a particular strategy that can be applied, once a supplier fails to deliver, is to assign a production site's demand to use the most recent delivery as a major reference, i.e. if a production site has fulfilled the last demand request it is anticipated that it will fulfil the subsequent request as well. In this case, it is assumed that the existing trend continuous. This strategy has the advantage that production sites unimpaired by the disaster can react promptly to a breakdown of one of their suppliers. The indirect damages caused by floods will be estimated for different supply-and-demand strategies.

Participation per Partner

Partner number and short name	WP12 effort
5 - PIK	24.00
23 - WFN	24.00
Total	48.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D12.1	Dependence of European economy on water issues elsewhere	23 - WFN	Report	Public	12
D12.2	European economy risks under climate change	23 - WFN	Report	Public	48
D12.3	Supply and demand strategies affecting future economic damage	5 - PIK	Report	Public	48

Description of deliverables

• D12.1: Report on dependencies of economic sectors in Europe on other parts of the world in terms of water resources (WFN) (M12) • D12.2: Report on water-related risks of European economy due to dependencies on water resources in other regions under climate change and hydrological extremes (WFN) (M48). • D12.3: Estimation of indirect future economic damages on Europe from within and outside Europe for different supply and demand strategies through global supply and production failure (PIK) (M48).

D12.1 : Dependence of European economy on water issues elsewhere [12]

Report on dependencies of economic sectors in Europe on other parts of the world in terms of water resources

D12.2 : European economy risks under climate change [48]

Report on water-related risks of European economy due to dependencies on water resources in other regions under climate change and hydrological extremes

D12.3 : Supply and demand strategies affecting future economic damage [48]

Estimation of indirect future economic damages on Europe from within and outside Europe for different supply and demand strategies through global supply and production failure

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS17	Assessment of current practice per sectoral survey	1 - KNMI	12	Assessment of current practice
MS20	Definition of benefits for risk assessment and decision support	1 - KNMI	48	Definition of benefits for risk assessment and decision support

Work package number [9]	WP13	**Lead beneficiary** [10]	11 - HZG
Work package title	Sectoral integration and climate services		
Start month	1	**End month**	48

Objectives

An integration of the experience gathered in WP7-12, and a transfer of this experience towards science-based risk-reduction and adaptation strategies is the main objective of WP7. For two of the survey areas addressed by multiple sectors in WP6, the Jucar River Basin and the Rhine river basin, a (modelling) chain is designed that does right to the paradigm of climate services: transformation of climate/hydrological projections into information that is usable as a base for decision making. This modelling approach is well aligned with the modular structure of the JPI Climate8. This modelling chain combines the pieces of information derived from WP3 and 4 at both the short- term and climate time scales, the information on risk and vulnerability assessment of WP5, and the case study information obtained in WP6 with a newly developed integrative participatory modelling approach that allows iterative exchange of information between physical and social scientists and regional stakeholders.
The modelling chain will be used to analyse potential management strategies and policy implications both for current and future conditions. In both test sites, Jucar and Rhine, the impacts of hydrological high-impact events affect different sectors with different intensities and at different time scales. For instance, in the agricultural sector in the Jucar basin short-term decisions reflect crop management options, while longer term decisions concern crop selection and insurance arrangements. Tradeoffs among multiple and conflicting objectives will be differently affected across different temporal scales.
With this modelling chain, future strategic options will be inspired by analysing decisions under historic conditions, giving body to the paradigm that dealing with current extremes forms a solid ground of experience to anticipate future extremes. It does so by structuring and integrating the heterogeneous experience from WP3, 4, 5 and 6 in a comprehensive synthesis that supports the management of extreme hydrological events . The approach allows a thorough evaluation of cross-sectoral and cross-regional impacts of hydrological hazards (e.g. droughts affecting simultaneously reservoir operation, economic sector, energy and urban water supply).
To ensure applicability of the approach applied to the Jucar basin and Rhine basin to other target areas, a guideline for transferability will be compiled, that will explain which region/site/stakeholder specific information needs to be provided in order to make use of the developed approach.

Description of work and role of partners

WP13 - Sectoral integration and climate services [Months: 1-48]
HZG, ADELPHI, HKV, UPV, POLMIL
The tasks will be exemplary implemented in the Júcar and the Rhine River basins. The approach is transferable to other river basins but also to other contexts in which hydrological extremes turn into high-impact events.

Task 13.1: Integrative participatory modeling approach (HZG, UPV)
This task will develop a participatory modeling approach to test and evaluate risk and adaptation management options for hydrological extremes integrating scientific and end-user knowledge. The modeling approach is generic to assure the transferability to other geographic areas, which will be documented in a set of guidelines for transferability. The approach is based on system dynamics modeling and agent-based modeling, incorporating the hydro-economic modeling tools from WP8 and WP11 to analyze climate risk management and adaptation, including innovative economic policy instruments, such as water pricing, markets or insurances and policy analysis. The economic characterization of the competing water uses will allow to assess economic impacts of different climate change scenarios and potential benefits of adaptation measures.

Task 13.2: Risk mapping (HZG, UPV)
The output of WP3 is transferred into precipitation maps for the Júcar River Basin and the Rhine River Basin conditions. This approach is developed in WP13 as a prototype that can be implemented for other river basins and regions. These precipitation maps will facilitate decision making under uncertainty by providing extremes tendencies at the short-term (task 3.1), seasonal term focus on the prediction of intra-seasonal extremes (task 3.2) and long term climate projections (task 3.3). These maps provide updated precipitation knowledge for the regions showing the range of variability of results. Information will come directly from D3.2 and D3.5. They will be made publicly available.

Task 13.3: Integrating the hydrological hazard module (UPV, HZG, POLMIL)
The input of WP4 on improving predictability of hydrological extremes will facilitate the enhancement of future risk management strategies by improving predictions on the climate scale (as described in task4.4). The combination of WP3 and WP4 contribution into the integrative modelling approach will allow end-users to include this information in their decision making process and facilitate the management of hydrological extremes at different times scales.

Task 13.4: Integrating risk assessment concepts (HZG + all)
Making use of the concepts tested and evaluated in WP5 (task 5.3 and task 5.4), WP13 delivers a step-by-step-guide for assessing the impacts and risks of hydrological extremes linking risk assessment concepts into the integrative modeling approach and providing possible management alternatives. In this way we are able to integrate the above described three levels of ex-ante analysis for extreme hydrological events (task 13.1, 13.2 and 13.3) to test and evaluate which the optimal way to transfer knowledge for the development of risk and adaptation management strategies for hydrological extreme events.
For instance, the risks profiles for the Rhine River basin resulting from drought related hazards events (derived in WP6) serve as a starting point for risk management strategies in WP7. A first step is to identify and assess individual measures that could be undertaken at various scales to reduce risks resulting from drought-related hazard events, viz. (1) measures at river basin scale (by optimizing the distribution of fresh water flows over the Rhine branches, or by measures reducing salt water intrusion in the main water systems), (2) measures at regional scale (construction of water storage basins in the regional water system) or (3) measures at local scale by the end users. The risk based approach from WP5 can help to assess the cost-efficiency of measures to cope with droughts and define cost-efficient solutions through a cost benefit analysis.

Task 13.5: Ex-post analysis (HZG + all)
The application of the participatory integrative modeling chain as a decision-support tool or as a regulatory instrument for policy frameworks will be tested:
• For instance, the effect of actual management decisions after the drought period that the Júcar is suffering will be tested. It is tested how a change in the provisions of water uptake for the agricultural sector influence water management and adaptation.
• For the Rhine River basin a number of measures at various scale levels is combined (task 13.4). New risk management and adaptation strategies are compiled. This will allow to prioritise and predicate decisions and support decision making about new risk management strategies. For instance, it will be used to evaluate the application of new alternative water allocation rules in the Netherlands (at river basin scale and at regional level).
The results will be feed into the deliverable 13.5 providing a white paper on adaptation capabilities.

Task 13.6: Policy implications (ADELPHI,HZG, HKV, UPV)
WP13 links IMPREX results to the key European legislation and policy processes related to water and climate such as the Water Framework Directive (WFD), the Blue Print for Safeguarding European Waters, or agricultural policies (e.g. CAP). This is done by evaluating how climate change (projections of extremes) were considered so far in these policies/ legislations and by providing guidance for improved management planning within the framework of EU directives and policies.
For instance, it will be assessed in a literature review and document analysis what types of measures were included in the River Basin Management plans, how impacts (risk) are considered and represented; and how early warning was integrated in the (risk) management plans and on what basis; Therefore, Task 13.6 starts with analyzing how hydrological extremes were considered in the three steps of the WFD and FD for our primary test sites (Jucar and Rhine River Basin). The results of this analysis will be mirrored against IMPREX findings such as the novel concepts for representing and/ or assessing the impacts and risk of hydrological extremes (WP5) and particular the case study work in WP6, such as a) the evaluation of optimal coordination mechanisms at the Jucar basin scale in terms of water allocation and use (WP8.3), b) the developed drought indicator tailored to the local agricultural sector and risk profile of the Jucár basin(WP11.2), and c) the results from applying the newly developed (WP5.3) drought risk management instrument (risk profile) in the Jucár basin (WP11.3).
Based on the above analysis and additional stakeholder interviews with selected policy makers and decision makers identified in WP2, recommendations for improved management planning within the framework of EU directives and policies will be developed.
For the Rhine river basin we intend to evaluate the application of new water assignment rules as a means in the main water system to deal with drought related hazards. Additionally, we also intend to investigate the measures that could be undertaken in the regional water system and by the end-users (agriculture, industry, navigation, drinking water, etc.). The results of this task will feed into Deliverable D.13.6, D.14.6 (policy briefs), and D.14.7 (Brochure on climate risk management and adaptation strategies).

Participation per Partner

Partner number and short name	WP13 effort
11 - HZG	38.00
14 - ADELPHI	11.00
15 - HKV	10.00
18 - UPV	15.00
19 - POLMIL	3.00
Total	77.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D13.1	Generic integrative modelling approach	11 - HZG	Demonstrator	Public	20
D13.2	Integrated risk maps	11 - HZG	Report	Public	32
D13.3	Prototype hydrological module	18 - UPV	Demonstrator	Public	34
D13.4	Guide on modelling for decision making in the water sector	11 - HZG	Report	Public	40
D13.5	White paper about adaptation options	11 - HZG	Report	Public	44
D13.6	Evaluation of EU water-related frameworks	14 - ADELPHI	Report	Public	48

Description of deliverables

• D13.1: Generic integrative modeling approach (HZG) (M20) • D13.2: Integrated risk maps for test sites (HZG) (M32) • D13.3: Prototype hydrological module (UPV) (M34) • D13.4: Step-by-step guide on standardized modeling approach for climate-sensitive decision making in the water sector (HZG) (M40) • D13.5: White paper about adaptation options prioritization and performance to future expected hydrological extremes. (HZG, UPV, HKV) (M44) • D13.6: Policy implications: evaluation of the integration of hydrological extremes and representation of impacts in the different steps of EU water-related frameworks and policies for the test sites (Adelphi) (M48)

D13.1 : Generic integrative modelling approach [20]

Generic integrative modeling approach

D13.2 : Integrated risk maps [32]

Integrated risk maps for test sites

D13.3 : Prototype hydrological module [34]

Prototype hydrological module

D13.4 : Guide on modelling for decision making in the water sector [40]

Step-by-step guide on standardized modeling approach for climate-sensitive decision making in the water sector

D13.5 : White paper about adaptation options [44]

White paper about adaptation options prioritization and performance to future expected hydrological extremes

D13.6 : Evaluation of EU water-related frameworks [48]

Policy implications: evaluation of the integration of hydrological extremes and representation of impacts in the different steps of EU water-related frameworks and policies for the test sites

Schedule of relevant Milestones

Milestone number [18]	**Milestone title**	**Lead beneficiary**	**Due Date (in months)**	**Means of verification**
MS21	Test sites reports on data and stakeholders	11 - HZG	18	Test sites reports on data and stakeholder availability
MS22	Prototype of the integrative participatory modeling chain	11 - HZG	24	Prototype of the integrative participatory modeling chain
MS23	First conclusions on prioritization method	11 - HZG	36	Internal discussion on prioritization method for choosing adaptation measures
MS24	European policy analysis	14 - ADELPHI	44	Analysis of EU climate change policies and water policies interfaces

Work package number [9]	WP14	**Lead beneficiary** [10]	8 - METOFFICE
Work package title	Communication and dissemination		
Start month	1	**End month**	48

Objectives

This WP coordinates the outreach activities and the dissemination of project's results. The main objective is to design and implement an effective dissemination strategy for the target audiences, which include SMEs, the research community, and public authorities at EU, national and regional levels as well as the general public. The WP activities will be structured in three logically distinct lines of activities.
a) Development a well designed public website and communications platform to facilitate the exchange between the project partners users and stakeholders. The platform will allow the users to access project reports, training material, information on sector-specific workshop, videos, facts-sheets and other material related to IMPREX.
b) Definition and delivery of communication and dissemination activities targeted to specific key audiences and national and international research iniatives such as IAHS Panta Rhei or WMO High Impact Weather (e.g. customised workshops and publications, such as policy briefs and fact sheets).
c) Development and delivery of a hydro-meteorological monthly to seasonal risk outlook tool for the European continent. Having the possibility of engaging with a semi-operation product the users will learn about the project in a hands-on fashion. Such a platform will also provide a natural feedback loop to allow the users to provide information of their needs and/or preferences.

Description of work and role of partners

WP14 - Communication and dissemination [Months: 1-48]
METOFFICE, ECMWF, ARCTIK, BSC, DELTARES, IVM, ADELPHI
Task 14.1: Development and delivery of communication dissemination & exploitation plans (Arctik, Adelphi, ECMWF, Met Office, BSC)
A dissemination and exploitation plan will be developed at the beginning of the project. It will contain detailed information about the activities planned for the duration of the project. The document will also provide an overview of the overall dissemination and exploitation strategy, key messages, target audiences, and communication activities. One of the tasks of this plan will be the identification of a narrative for IMPREX which will in turns help us create a clear message for our target audience. This strategy will be developed in close consultation with specialised beneficiaries.
A preliminary version of the dissemination plan will be developed for month 2, including short-term goals (logo, visual guidelines, preliminary project leaflet). The final version of dissemination and exploitation strategy plan will be submitted by month 6 of the project. The dissemination and exploitation plan will be updated on an annual basis throughout the project. Clear and evaluable objectives will be included and assessed year-by-year.

Task 14.2: Visual identity and IMPREX logo (Arctik)
A coherent and recognizable visual identity for IMPREX will be developed. The layout and colours associated with this identity will then be applied to all standard publications (e.g. fact sheets, case studies, leaflet, website…) to give a unique, but clearly IMPREX-related, visual identity. The design in general and the logo in particular will be clean, photo-oriented and will tell the story of the project at a glance. The visual identity will respect the European Commission visual guidelines for research project.

Task 14.3: Establishment of a community around a well-designed web-site (Arctik)
A dynamic web site based on the example of previous project such as HEPEX, ENHANCE, EUPORIAS, will be the basis for community development around IMPREX. Personas representing different target group will be created. These will be the basis for the development of content in the content matrix. The webpage will be a platform for sharing information and ensures a continuous process of exchange and feedback between the users and the providers of hydrological-risk information.
An active twitter account and a weekly digest will be put together and maintained in order to keep the relevant audience-community engaged. The weekly digest will be tailored differently from week to week for attracting and involving different audiences (scientists – non scientists).
Case studies, stories and guest posts will be the main tools used to keep the community of users involved but a Search Engine Optimisation strategy will be explored as an option to ensure long-term visibility.

Task 14.4: Direct outreach activities (Arctik)
Each year the dissemination and exploitation plan (task 8.1) will identify a set of sectors that will be specifically approached. We will specifically give high priority to the private sector, in particular SMEs both at the European and national levels. Multipliers such as Business Europe, European Business Network, Eurochambre, and the Enterprise Europe Network will in particular be approached with tailored messages and materials. A few representatives of these networks will join the Science and Service Adivory Board.
EU programmes dedicated to SMEs will also be part of the overall mapping exercise. Looking in particular at EMAS, EcoAP, EBAE, ECAP, Retail Forum, Consumption & production platform, EFO / EFP and their own communities as important multiplier sources and actors.
A first step will be to place editorial content that refers to IMPREX on the websites and – where possible – in print publications produced by the identify stakeholders.
A second and parallel step will be to liaise with the identified actors to participate to their conferences or exhibitions (EBN congress, EEN annual conference, SME week).
Project video(s) will serve as an easy and dynamic way to target the different audience with key messages and call for actions.
Finally, the consortium partners will organise a press brief to disseminate the results of the project. The press brief can be organised within the final conference or as a separate event in Brussels.

Task 14.5: Development and delivery of a hydro-meteorological monthly to seasonal risk outlook tool for the European continent (METOFFICE + other partners)
Building upon the development of the seasonal prediction systems and the hydrological prediction systems that will occur within WP3 & WP4 and linking to other relevant activities in Europe, IMPREX will develop and deliver a semi-operational tool able to inform decision makers about the likelihood of occurrence of high risk hydrological events in the forthcoming months. Whilst the ultimate ambition is to develop a multi-model ensemble of hydrological predictions, the emphasis will be put here on the development of a fully working proof-of-concept prototype. The risk outlook tool will be tested and developed over three distinct phases:
• Assessment of the skill over the hindcast period using observations and reanalyses as a benchmark
• Ex-post analysis of the forecast over the most recent season
• Experimental semi-operational prediction for the coming season.
By providing a high-profile tangible output of the project the risk outlook tool will represent the natural way to engage with new potential users. The Risk Outlook tool will be linked to currently existing (sectoral) risk outlook systems, such as operated for agriculture and droughts by JRC, for floods by EFAS, and for water transportation by BfG

Task 14.6: Risk outlook documentation and training material (METOFFICE + other partners)
Documentation and training material will be developed to ensure all potential users know what the risk outlook tool does, how it works and how its output should be interpreted in a decision-making context. This material will be developed in close coordination with the sectoral users boards to ensure it is fit for purpose and it addresses all relevant questions the users might have.

Task 14.7: Project Workshops (METOFFICE, ADELPHI)
There will be two main types of workshop:
• Workshop targeting European decision-makers in both public and private sector. These will mainly focus on the use and the limitations of the hydrological risk outlook tool. Such a tool will be used as a way to present the main outcomes of the project and their use in a decision-making context. The main audience for these workshops will be the sectors and users already involved in WP7-12. There will also be a workshop co-organised with WP4 and HEPEX to explicitly disseminate the results of WP4 activities.
• Workshop addressing the need of strategic planners and policy-makers, focusing on the long-term changes in the hydro-meteorological risk profile for European users. These workshops will provide policy briefs targeted to the people responsible for designing and implementing strategies in support of the Blueprint to safeguard Europe's water resources, the EU Climate Change adaptation strategy, disaster risk reduction, and relevant EU Directives, such as the Floods Directive and Water Framework Directive. The consortium will make sure to invite and confirm the participation of key members of the target groups at the workshop. The workshops will be held in a participatory format; if possible the workshop will be organised on the side of a larger events/conferences. Policy briefs will be formulated, which serve as discussion papers for the workshops and which will be finalised based on outcomes of the workshop.

Task 14.8: Information materials for the general public (Arctik)
Facts-sheets and YouTube videos describing the building blocks of the risk outlook tools and the key processes controlling hydro-meteorological extreme events in Europe will be developed and made available through the project website. They are aimed at a wider audience of people interested in the topic but not directly involved in IMPREX.

As part of the monitoring and reporting activity, a detailed summary of the outreach activities will be drawn, including number of conferences attended for IMPREX, editorial and interviews referring to the project, stakeholder contacted, and database growth. The first summary will be provided in M6.

Task 14.9: Synthesis publications for policy and decision makers (Adelphi, Arctik)
The sectoral assessments of improved utilisation of forecasts and foresights (WP6) as well as the analysis of diverse risk management adaptation strategies (WP713) will reveal important lessons for policy and decision making at multiple levels (from local to EU). To ensure up-take of IMPREX's research results in political decision making and review processes, outcomes of WP6 - 13 will be synthesised and relevant policy lessons formulated in the following set of targeted publications:
• Fact sheets summarising lessons learnt for decision makers from the case studies carried out in WP6
• Brochure on climate risk management and adaptation strategies focusing on climate-sensitive decision-making and the importance for the water sector based on results of WP13.

Participation per Partner

Partner number and short name	WP14 effort
2 - ECMWF	7.00
6 - ARCTIK	8.00
7 - BSC	6.00
8 - METOFFICE	24.00
12 - DELTARES	4.00
13 - IVM	3.00
14 - ADELPHI	11.00
Total	63.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D14.1	Communication strategy plan	6 - ARCTIK	Report	Public	6
D14.2	Dissemination and exploitation plan	6 - ARCTIK	Report	Public	6
D14.3	First summary of outreach activities	6 - ARCTIK	Report	Public	6
D14.4	IMPREX logo & website	6 - ARCTIK	Websites, patents filling, etc.	Public	6
D14.5	Protoype hydrometeorological risk outlook	8 - METOFFICE	Demonstrator	Public	36
D14.6	Policy briefs of EU Water-related actions	14 - ADELPHI	Report	Public	48
D14.7	Synthesis brochure on risk mgmt	14 - ADELPHI	Report	Public	48

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D14.8	Brochure, videos and press briefing on climate risk mgmt	6 - ARCTIK	Websites, patents filling, etc.	Public	48
D14.9	Fact sheets on lessons learnt	14 - ADELPHI	Report	Public	48
D14.10	Workshp agenda and participant lists	8 - METOFFICE	Report	Public	46

Description of deliverables

• D14.1: Final Communication strategy plan (Arctik) (M6) • D14.2: Dissemination and exploitation plan (jointly with WP2 and WP6) (Arctik) (M6) • D14.3: First summary of outreach activities (Arctik) (M6) • D14.4: IMPREX website, visual identity and logo (Arctik) (M6) • D14.5: Semi-operational hydro-meteorological monthly to seasonal risk outlook tool for the European continent plus training material (METOFFICE and ECMWF) (M36) • D14.6: Four policy briefs focussing on the Blueprint, EU adaptation strategy, disaster risk reduction, and water related directives respectively (ADELPHI, Arctik) (M48) • D14.7: Brochure on climate risk management and adaptation strategies focusing on climate-sensitive decision-making and the importance for the water sector (ADELPHI, Arctik) (M48) • D14.8: Project videos and press briefings (METOFFICE, Arctik) (M48) • D14.9: Fact sheets on sectoral and cross-sectoral lessons learnt and best practices from sectoral surveys (Adelphi, Arctik) (M48)

D14.1 : Communication strategy plan [6]

Final Communication strategy plan

D14.2 : Dissemination and exploitation plan [6]

Dissemination and exploitation plan (jointly with WP2)

D14.3 : First summary of outreach activities [6]

First summary of outreach activities

D14.4 : IMPREX logo & website [6]

IMPREX website, visual identity and logo

D14.5 : Protoype hydrometeorological risk outlook [36]

Semi-operational hydro-meteorological monthly to seasonal risk outlook tool for the European continent plus training material

D14.6 : Policy briefs of EU Water-related actions [48]

Four policy briefs focussing on the Blueprint, EU adaptation strategy, disaster risk reduction, and water related directives respectively

D14.7 : Synthesis brochure on risk mgmt [48]

Brochure on climate risk management and adaptation strategies focusing on climate-sensitive decision-making and the importance for the water sector

D14.8 : Brochure, videos and press briefing on climate risk mgmt [48]

Project videos and press briefings

D14.9 : Fact sheets on lessons learnt [48]

Fact sheets on sectoral and cross-sectoral lessons learnt and best practices from sectoral surveys

D14.10 : Workshp agenda and participant lists [46]

Agenda and participant list of two workshops (Task14.7) (METOFFICE, ADELPHI) (M46)

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS25	Draft communication/ outreach plan	6 - ARCTIK	6	Draft communication/ outreach plan
MS26	Website and leaflets available	6 - ARCTIK	6	Website and leaflets available
MS27	Risk outlook in pilot phase and semi-operational	8 - METOFFICE	36	Risk outlook in pilot phase and semi-operational

1.3.4. WT4 List of milestones

Milestone number [18]	Milestone title	WP number [9]	Lead beneficiary	Due Date (in months) [17]	Means of verification
MS1	GA meeting 1	WP1	1 - KNMI	12	General Assembly meetings
MS2	GA meeting 2	WP1	1 - KNMI	24	GA meeting 2
MS3	GA meeting 3	WP1	1 - KNMI	36	GA meeting 3
MS4	GA meeting 4	WP1	1 - KNMI	48	GA meeting 4
MS5	Midterm review	WP1	1 - KNMI	30	Midterm review
MS6	Final review	WP1	1 - KNMI	48	Final review
MS7	Internal workshops to summarise the main users' requirements	WP2	6 - ARCTIK	12	Internal workshops to summarise the main users' requirements
MS8	Reference seasonal forecast data sets	WP3	7 - BSC	12	Reference data sets collected and disseminated (retrospective forecasts (ECMWF), seasonal forecasts
MS9	Regional domains prepared	WP3	3 - SMHI	24	Regional domains prepared for dynamical downscaling with non-hydrostatic regional climate models in very high resolution
MS10	Updated data sets of short term and seasonal predictions	WP3	3 - SMHI	24	Updated version of data sets available (short term predictions (SMHI), seasonal predictions (BSC), downscaled weather events (KNMI)
MS11	New developments tested for high resolution climate scenarios	WP3	3 - SMHI	32	New developments tested (Climate scenarios (SMHI))
MS12	Hydrological input data for sectoral surveys available	WP4	2 - ECMWF	6	Input data for sectoral case studies for current modelling and forecasting of hydrological extremes
MS13	Retrospective runs with hydrological models completed	WP4	2 - ECMWF	12	Output of the first run of the models for sectoral applications to produce state-of-the-art reforecasts of hydrological extremes
MS14	Forecasts for hydrological risk outlook available	WP4	8 - METOFFICE	30	Provision of near-real-time monthy-seasonal hydrological forecast data from the improved hydrological models to allow the creation of a

Milestone number [18]	Milestone title	WP number [9]	Lead beneficiary	Due Date (in months) [17]	Means of verification
					hydrological hazard outlook tool (WP8)
MS15	White Paper on novel concepts	WP5	13 - IVM	6	WP meeting for discussing White paper concepts
MS16	Draft results new conceptual models	WP5	13 - IVM	36	WP meeting draft model results
MS17	Assessment of current practice per sectoral survey	WP10, WP11, WP12, WP7, WP8, WP9	1 - KNMI	12	Assessment of current practice
MS18	First use of prediction/ projection data from WP3/4/5	WP10, WP11, WP7, WP8, WP9	1 - KNMI	18	First use of prediction/ projection data from WP3/4/5
MS19	Use of updated information from WP3/4/5	WP10, WP11, WP7, WP8, WP9	1 - KNMI	36	Use of updated information from WP3/4/5
MS20	Definition of benefits for risk assessment and decision support	WP10, WP11, WP12, WP7, WP8, WP9	1 - KNMI	48	Definition of benefits for risk assessment and decision support
MS21	Test sites reports on data and stakeholders	WP13	11 - HZG	18	Test sites reports on data and stakeholder availability
MS22	Prototype of the integrative participatory modeling chain	WP13	11 - HZG	24	Prototype of the integrative participatory modeling chain
MS23	First conclusions on prioritization method	WP13	11 - HZG	36	Internal discussion on prioritization method for choosing adaptation measures
MS24	European policy analysis	WP13	14 - ADELPHI	44	Analysis of EU climate change policies and water policies interfaces
MS25	Draft communication/ outreach plan	WP14	6 - ARCTIK	6	Draft communication/ outreach plan
MS26	Website and leaflets available	WP14	6 - ARCTIK	6	Website and leaflets available
MS27	Risk outlook in pilot phase and semi-operational	WP14	8 - METOFFICE	36	Risk outlook in pilot phase and semi-operational

1.3.5. WT5 Critical Implementation risks and mitigation actions

Risk number	Description of risk	WP Number	Proposed risk-mitigation measures
R1	Operational risks: information and data not shared effectively within consortium	WP3, WP4, WP5	The Data Manager monitors information/data exchange continuously
R2	Time/budget risks: delays in producing expected deliverables	WP1, WP10, WP11, WP12, WP13, WP14, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	The high frequency meeting of the Coordination Unit to identify delays, assess impacts and implement organisations/budget changes
R3	Competence risks: personnel involved or recruited not able to fulfil tasks	WP1, WP10, WP11, WP12, WP13, WP14, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	Monitoring by the Coordination unit, and implementing adjustments within each organisation
R4	Scientific risks, e.g. a high resolution climate model applied for a specific domain, does not produce a precipitation or temperature climate satisfactorily close to available observations	WP10, WP11, WP12, WP3, WP4, WP6, WP7, WP8, WP9	This is a common type of problem when setting up new geographical domains. Scientists at the model centres alleviate this by intensive model and process evaluation and model adjustments.
R5	Engagement risks, e.g. lack of participation of stakeholders	WP10, WP11, WP13, WP14, WP2, WP6, WP7, WP8, WP9	The “stakeholder interaction landscape” is heavily populated with current developments of e.g. formulation of climate services. IMPREX partners are involved in many initiatives involving stakeholders and will utilize these networks to avoid over-exploitation of stakeholder engagement and promote synergies.
R6	Technical risks, e.g. a new assimilation scheme might not be as efficient as anticipated in improving local simulation of e.g. soil moisture, with impacts on simulation of precipitation.	WP10, WP11, WP4, WP6, WP7, WP8, WP9	Developers have substantial experience in adjusting assimilation schemes and soil parameterizations to optimize performance

1.3.6. WT6 Summary of project effort in person-months

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10	WP11	WP12	WP13	WP14	Total Person/ Months per Participant
1 - KNMI	35	2	30	0	19	2	5	0	0	0	0	0	0	0	93
2 - ECMWF	0	0	20	23	0	1	0	0	0	0	0	0	0	7	51
3 - SMHI	0	0	44	26	0	0	0	8	0	0	0	0	0	0	78
4 - IRSTEA	0	0	0	12	0	0	0	24	0	0	0	0	0	0	36
5 - PIK	0	0	0	0	0	0	0	0	0	0	0	24	0	0	24
6 - ARCTIK	3	6	0	0	0	0	0	0	0	0	0	0	0	8	17
7 - BSC	0	5	36	0	0	0	0	0	0	0	0	0	0	6	47
8 - METOFFICE	0	6	31	16	0	0	0	0	0	0	0	0	0	24	77
9 - TUC	0	0	12	6	0	0	0	0	0	0	7	0	0	0	25
10 - UREAD	0	0	22	18	0	0	4	0	0	0	0	0	0	0	44
11 - HZG	0	2	0	0	0	3	0	0	6	0	0	0	38	0	49
12 - DELTARES	0	1	0	23	0	0	28	0	0	0	6	0	0	4	62
13 - IVM	0	0	0	0	34	0	5	0	0	0	6	0	0	3	48
14 - ADELPHI	0	0	0	0	0	0	0	0	0	0	0	0	11	11	22
15 - HKV	0	0	0	0	10	0	6	0	0	0	7	0	10	0	33
16 - FW	0	0	0	6	4	0	0	0	0	0	31	0	0	0	41
17 - CETAQUA	0	0	0	0	0	0	0	0	0	24	0	0	0	0	24
· AquaTEC	0	0	0	0	0	0	0	0	0	8	0	0	0	0	8
18 - UPV	0	0	0	6	6	0	0	7	0	7	6	0	15	0	47
19 - POLMIL	0	0	0	0	0	0	0	12	0	0	11	0	3	0	26
20 - CIMA	0	0	0	6	0	0	18	0	0	0	0	0	0	0	24
21 - GFZ	0	0	0	0	9	0	17	0	0	0	0	0	0	0	26
22 - BfG	0	0	0	8	0	0	0	0	31	0	0	0	0	0	39

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10	WP11	WP12	WP13	WP14	Total Person/ Months per Participant
23 - WFN	0	0	0	0	0	0	0	0	0	0	0	24	0	0	24
Total Person/Months	38	22	195	150	82	6	83	51	37	39	74	48	77	63	965

1.3.7. WT7 Tentative schedule of project reviews

Review number [19]	**Tentative timing**	**Planned venue of review**	**Comments, if any**
RV1	20	TBD	
RV2	38	TBD	

1.4. Ethics Requirements

Ethics Issue Category	Ethics Requirement Description
HUMANS	- Details on the procedures and criteria that will be used to identify/ recruit research participants must be provided
HUMANS	- Detailed information must be provided on the informed consent procedures that will be implemented.

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project. It cannot be changed. The project number **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

2. Project acronym

Use the project acronym as given in the submitted proposal. It can generally not be changed. The same acronym **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

3. Project title

Use the title (preferably no longer than 200 characters) as indicated in the submitted proposal. Minor corrections are possible if agreed during the preparation of the grant agreement.

4. Starting date

Unless a specific (fixed) starting date is duly justified and agreed upon during the preparation of the Grant Agreement, the project will start on the first day of the month following the entry into force of the Grant Agreement (NB : entry into force = signature by the Commission). Please note that if a fixed starting date is used, you will be required to provide a written justification.

5. Duration

Insert the duration of the project in full months.

6. Call (part) identifier

The Call (part) identifier is the reference number given in the call or part of the call you were addressing, as indicated in the publication of the call in the Official Journal of the European Union. You have to use the identifier given by the Commission in the letter inviting to prepare the grant agreement.

7. Abstract

8. Project Entry Month

The month at which the participant joined the consortium, month 1 marking the start date of the project, and all other start dates being relative to this start date.

9. Work Package number

Work package number: WP1, WP2, WP3, ..., WPn

10. Lead beneficiary

This must be one of the beneficiaries in the grant (not a third party) - Number of the beneficiary leading the work in this work package

11. Person-months per work package

The total number of person-months allocated to each work package.

12. Start month

Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.

13. End month

Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

14. Deliverable number

Deliverable numbers: D1 - Dn

15. Type

Please indicate the type of the deliverable using one of the following codes:

R Document, report
DEM Demonstrator, pilot, prototype
DEC Websites, patent fillings, videos, etc.
OTHER

16. Dissemination level

Please indicate the dissemination level using one of the following codes:

PU Public

CO Confidential, only for members of the consortium (including the Commission Services)
CI Classified, as referred to in Commission Decision 2001/844/EC

17. Delivery date for Deliverable

Month in which the deliverables will be available, month 1 marking the start date of the project, and all delivery dates being relative to this start date.

18. Milestone number

Milestone number:MS1, MS2, ..., MSn

19. Review number

Review number: RV1, RV2, ..., RVn

20. Installation Number

Number progressively the installations of a same infrastructure. An installation is a part of an infrastructure that could be used independently from the rest.

21. Installation country

Code of the country where the installation is located or IO if the access provider (the beneficiary or linked third party) is an international organization, an ERIC or a similar legal entity.

22. Type of access

VA if virtual access,
TA-uc if trans-national access with access costs declared on the basis of unit cost,
TA-ac if trans-national access with access costs declared as actual costs, and
TA-cb if trans-national access with access costs declared as a combination of actual costs and costs on the basis of unit cost.

23. Access costs

Cost of the access provided under the project. For virtual access fill only the second column. For trans-national access fill one of the two columns or both according to the way access costs are declared. Trans-national access costs on the basis of unit cost will result from the unit cost by the quantity of access to be provided.

IMPREX: IMproving PRedictions and management of hydrological EXtremes

Learn from today to anticipate tomorrow

Technical annex of proposal to

Horizon2020 Research and Innovation Action

WATER-2: Integrated approaches to water and climate change

History of changes

Compared to the submitted proposal, the following major changes were applied:

- **Legal constructions:**
  - The legal construction of partner 7 (IC3) is changed: the formal partner is now BSC, and it's (in kind) third party modality with ICREA is explained in Section 4.1; also CVs updated
  - Short names in proposal synchronized with DoA
  - Role of founding partners of CETAqua is clarified in the partner description
  - Section 4.2 is restructured to give clear overview of (linked) third parties and subcontracts
- **Changes to deliverables:**
  - D1.2-1.4 changed into Advisory reports
  - D2.1 inserted in D8.1, other Deliverables of WP2 renumbered.
  - Ethical aspects (Interview template and text of informed consent) added to D2.2, to be delivered in M6
  - Deliverables matched to tasks in most WPs
- **Clarification on subcontracting is provided:**
  - Arctik's subcontracting changed into other costs
  - FW subcontracting explained
  - Subcontracting by Aquatec concerns water quality analysis
- **Clarification on the role of stakeholders (listed in Table 4.1) is given.**
- **Reviewer comments and comments from EU Project officer** were implemented in the work description.
- **Renumbering of WPs**: WP6a-6f were relabeled as WP7-12, and WP7 & 8 as WP13 & 14
- **A Figure depicting the relationships of several tasks with WP13** has been added.

Contents

1. Excellence

1.1 Objectives and key deliverables

Recent hydrological extreme events, such as witnessed in the UK floods last winter, last year's summer floods in Central Europe, droughts, wildfires and flash floods in Southern Europe in several recent summers are just a few examples that demonstrate how vulnerable European society is to water-related natural hazards. Furthermore, the evidence is now ever stronger that climate change will worsen these events. A step improvement in forecasting water-related events through better prediction of meteorological and hydrological drivers of this type of events is urgently needed to appropriately inform science-based risk management strategies and adaptation options. Such enhancement in our forecast capability will increase the resilience of the European society as a whole, and reduce costs for strategic sectors and regions.

IMPREX addresses the following Challenges and bottlenecks identified by the European Innovation Platform (EIP[1]) Water: *"…European knowledge and technology are excellent but scattered … and supply and demand side are not well connected." "There is a lack of awareness of the economic value of water by end-users." "There is a need to overcome uncertainty from meteorological forecasts for flood and drought risk assessment. Different dimensions of risk need to be integrated." "Innovative protection and prevention tools including monitoring and forecasting are needed…" "Integrated risk assessment to minimize climate change impacts is one of the action items in the SIP"*.

IMPREX is designed to support the reduction of Europe's vulnerability to extreme hydrological events through improved understanding of the intensity and frequency of future disrupting features that may be very different from today's reality. The consortium, a combination of expertise and capabilities coming from both the public and the private sector, has an excellent track record in user-driven services and is thus is well positioned to bridge the gap that often exists between users and providers of hydro-climatic information. The project will make substantial progress on our forecasting capability of hydrological extremes and their impacts at short to seasonal time scales. Particular emphasis will be put on the provision of realistic, robust and relevant information on extreme hydrological impacts at climate time scales to governments, business and citizens in Europe. The direct involvement of a broad range of relevant stakeholders that routinely develop risk management strategies in key economic sectors – such as water-supply for agriculture and urban use, hydropower, civil protection, transportation, economic networks and insurance – will ensure the relevance and uptake of the project outputs. IMPREX strongly believes that we can learn from today to anticipate tomorrow. It has the following concrete **objectives and key deliverables**:

- *a measurable **improvement in forecast skill** of meteorological and hydrological extremes and their impacts:* New model configurations and data assimilation techniques will be implemented and verified using past events. Information from state-of-the art climate modelling on future climate-related risks will be enriched by improving the realism of extreme hydrological features and their impacts, that will support the management of those risks through adaptation;
- ***novel risk assessment concepts** that respond to limitations of current methods and assessment practices:* This will enable a further modernization of paradigms in risk management, where decision-making under deep uncertainty, managing trans-sectoral and cross-regional risks, and participatory, engaged approaches are becoming common practice in Europe;
- *a demonstration of the value of the information on hydrological impacts to **relevant stakeholders**:* A set of representative case studies will allow the assessment of an extensive set of sectoral and trans-sectoral surveys on the reliability and robustness of current risk management strategies and future adaptation options;
- ***Improved science-based support for existing and adapted risk management and adaptation strategies**:* This includes the European Floods Directive, the European Blueprint on Water, the European Adaptation Strategy and national adaptation strategies in case study areas;
- *a **Pan-European periodic hydrological risk outlook:*** This outlook will be linked to existing systems such as the European Flood Awareness System and the European Drought Observatory. Guidelines for sector-specific interpretation and application are provided.

1.2 Relation to the work programme

IMPREX responds to the call **WATER-2-2014: Integrated approaches to Water and Climate Change**, which aims at improving the efficiency of water resources management in Europe through improved knowledge of the hydrological cycle under future climate conditions. The call contains two separate topical areas, and IMPREX responds to the 2014 component "**Water cycle under a future climate**".

Over the last decades, the changes in the water sector risk portfolio have not solely been driven by changes in water consumption, water allocation and risk reduction paradigms but also by climatic trends and extreme weather events that force users, managers and decision-makers to re-think and adapt their practices[1]. Coherently with the objective of the work programme, IMPREX will not only focus on the expected changes in hydrological features and their (natural) variability, but also on water management practices. It will support and promote the development of targeted climate services, which ensures that practitioners and society at large will base their decisions on robust science-based information.

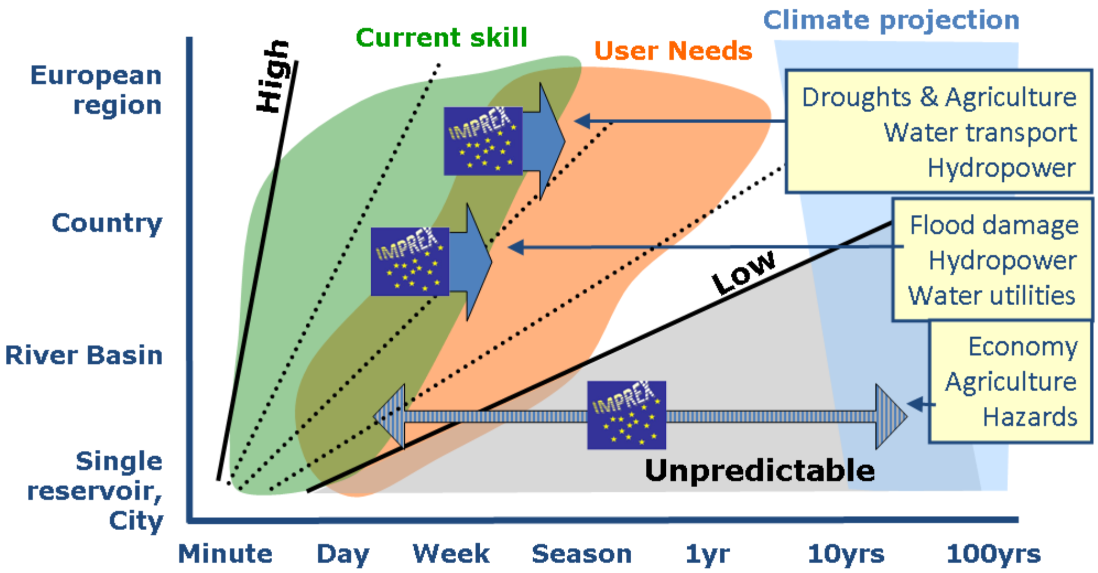

Figure 1.1: Predictability of weather and climate models across spatial and temporal scales (ranging from "High" to "Low"): a mismatch between current forecast skill and user needs persists. IMPREX will improve predictability at short-medium and seasonal time scales (upper two block arrows), and will develop new concepts to allow translation of the experience with present day events into the future (bottom arrow).

With IMPREX we follow the approach to take present prediction and projection systems and their information use as a starting point, and apply those for future projections (see Figure 1.1). This is a new approach different from the "classical" strategy of scenario development, downscaling and impact assessment, such as traditionally followed in assessments by IPCC. IMPREX responds to the call in the following manner:

- *maximise the reliability of projections of precipitation (average, distribution, frequency, intensity) and couple them with water cycle variability at local/regional scales in Europe, over various timescales:* IMPREX is targeting short-term hydro-meteorological predictions by guided improvement of forecasting tools. Reliability of future climate projections will be enhanced by taking advantage of latest developments in the fields of global climate modelling and progressing capability to locally interpret changes in the hydrological cycle. IMPREX will combine state-of-the-art operational multi-model meteorological and hydrological forecasting tools that cover relevant scales from global to local, and will build on the experience with the performance of these tools in past hydrological extremes, selected for their high impact on society and private stakeholders. New concepts will be developed and applied that enhance the ability to visualize and assess the implication of these events when they are set in future climate and society conditions;
- *improve the short-to-medium term forecasting of extreme events, integrating, where possible, information from available data sources:* in IMPREX the skill of short-to-medium-range forecasts will be further

enhanced by systematically exploring key issues such as effects of increased resolution in meteorological and hydrological tools, dynamic selection of modelling systems conditioned on the meteorological regime, better representation of relevant processes (e.g. water extraction, ground water), and data assimilation of non-conventional observations in hydro-meteorological systems (discharge, water levels, snow content);

- *assess the impacts of weather extremes as well as the wider impacts of climate change on the different components of the water cycle in terms of quantity and quality:* a portfolio of relevant case studies (defined by stakeholders linked to the consortium), as well as strategic higher-level trans-sectoral and trans-regional impact assessments form the heart of the IMPREX work-flow. By investigating and integrating sectoral applications, experience with current and updated forecasting capabilities are explored and novel concepts for assessing climate related hydrological impacts in Europe are developed;
- *develop risk management strategies and adaptation options for extreme weather and other climate change-related threats at the appropriate scale(s) (local, regional and continental), taking into consideration the role and involvement of the relevant stakeholders, and potentially putting emphasis on highly vulnerable water resources of strategic importance:* with relevant stakeholders IMPREX will co-design adaptive risk management strategies at different scales based on the concept of sustainability and the need for a safe operating space in water resources management. This includes a systematic survey of changes in trans-sectoral and trans-regional risks well as an assessment of the feasible options to manage these risks. Focus will be given to strategic water resources across Europe (such as aquifers for urban supply in the Mediterranean, and cooling water bodies for energy purposes). With its integrative and transdisciplinary approach, based on real-life experiences of individual water-related sectors, IMPREX will reveal formerly unexplored compounding risks, analyse risk cascades from one sector or region to the other, evaluate dependencies on hydrological extremes in remote areas, and engage scientists and stakeholders in innovative water solutions.

1.3 Concept and approach

Overall concept

IMPREX is based on the philosophy that understanding present-day risks is an effective starting point for adapting to unprecedented future events. Taking into account potential climate trajectories and a collection of experiences in various vulnerable water-related sectors, IMPREX will put current management decisions and practices in the context of an emergent future. In addition, the way in which current operational forecasts of potentially high-impact events at various time scales are utilized can still be improved, not only by enhancing the forecasting skill, but also by customizing the information to the stakeholders' needs, practice and decision context (see support statements in Table 3.1). As such IMPREX will build on recent and ongoing European projects (Table 1.1).

Different decisions are taken at different time scales. Hydrological extremes at short-to-medium time scales may trigger an emergency response, but an expected systematic change in the occurrence frequency of these events is what will guide long-term decisions on, for instance, infrastructure design or financial arrangements[2]. IMPREX uses current operational hydro-meteorological forecasting systems at short-to-medium and seasonal range coupled to core sectoral applications of different water resource management organisations as a starting point. Improvements to these forecasting systems are expected to have an immediate impact on the daily practice of water management. An assessment of future changes in trans-sectoral/trans-regional risk and an improvement of the visualization and quantification of changes in the hydrological cycle and its impacts will help formulate recommendations for adapting to these risks, minimizing risk transfer from one sector or region to another, at a European, national and local level.

The core elements of IMPREX consist of three interconnected science- and user-oriented actions: (a) an improvement in the forecasting and foresighting tools and climatologies of hydrological extremes, (b) application of these developments in the daily practice of stakeholders across different sectors and regions, and (c) dissemination of the experience gained from the sectoral impact analyses to a wider audience by means of user-friendly assessment summaries of impact and adaptation strategies, periodic risk outlooks, and bulletins for public communication. The consortium is composed of some of the key institutes in Europe with excellent experience in delivering meteorological predictions and climate outlooks, hydrological products, and related hydro/climate services, impact analyses and network communication. Several SMEs are included to bring these services to the market or advise the private sector and business (see Table on page 2).

Positioning in the innovation chain

IMPREX is a Research and Innovation Action with a strong emphasis on the utilization of research findings and the development of operational tools in the practical world of water management and resource allocation. The various key deliverables of IMPREX have different Technology Readiness Levels (TRL). Developments of meteorological hydrological forecasting tools will likely become semi-operational at the developing institutions (TRL 7-8) during the course of the project. New concepts of risk assessment (such as analysis of compounding risks, or quantification of dependence on remote hydrological extremes) will be demonstrated in case studies (TRL 5-6). Adaptive strategies for risk and adaptation management for the water sector will be experimentally proven (TRL 3) using modelling techniques.

Table 1.1: Selection of past and ongoing projects relevant to and joined by the IMPREX consortium members

Name	Project purpose, gap to be filled and output used by IMPREX	Partner(s)
EUPORIAS	Development of climate services to maximize the social benefit of new coping technologies. IMPREX pays additional attention to demonstration and application in operational environments, and better understanding of the user-provider relationship	METOFFICE, KNMI, SMHI, CETAqua
ISI-MIP	The Intersectoral Impact Model Intercomparison Project has generated a large number of future climate impact projections; analysis and translation to practical conditions will be applied in IMPREX	PIK, Deltares, METOFFICE
DROUGHT R&SPI	This project improves the research-policy interface in the area of drought monitoring and adaptation; the case study approach followed in IMPREX will allow to implement their indicators for drought management	UPV
IMPACT 2C	Pan-European sectoral analysis of climate change impacts, vulnerabilities, risks and economic costs, as well as potential responses. IMPREX will contribute with its focus on water management.	KNMI, HZG, TUC
PSI-Connect	Innovative knowledge brokering in the field of water management and climate change . Proven knowledge brockering instruments will be applied in IMPREX to interact effectively with endusers and other stakeholders	PIK, Deltares
ECLISE	Realisation of a European Climate Service. IMPREX will provide additional knowledge on the provision of customised climate services for the water sector.	HZG, KNMI, TUC
Other projects in which IMPREX partners participate and of interest to this topic include: AQUASTRESS, BASE, CONHAZ, DEWFORA, Earth2Observe, ECCONET, ENHANCE, GENESIS, GLOWASIS, H-SAF, JPI-Climate, KultuRisk, PREPARED, RESPONSES, SPECS, SCENES, VALUE, WATER-CHANGE, WATCH,		

Links with national and international research and innovation activities

IMPREX consortium partners are involved in many past and ongoing EU projects that provide relevant input, and the project will build directly on knowledge gained and output/deliverables (see Table 1.1). This illustrates the track record of the partners, brings current expertise to IMPREX, and helps reach achievements where these earlier projects have identified important gaps. IMPREX is linked to major hydrological and hydrometereological networks and programs such as IAHS-Panta Rhei, HEPEX and WMO High Impact Weather as partners play leading roles in these. It is also linked to the Copernicus program, and some of improvements will directly benefit services already part of Copernicus Initial Operations (EFAS) or are important for future sectoral Copernicus Climate Services. Seasonal forecasting activities are closely linked with EUROSIP, NMME and the Subseasonal to Seasonal (S2S) working group of WCRP. Several experts of the consortium are IPCC Lead Authors.

Overall approaches and methodology

IMPREX has a work-package (WP) structure that allows an efficient interaction between developers, forecasters, analysts, users, policy advisors and decision makers (see Figure 1.2). In the WP structure, an inventory of current (perceived) risks and climatological/non-climatological trends is used as a starting point for the definition of a number of sectoral surveys, each designed in close collaboration with primary stakeholders in the sectors and regions considered. The different sectors operate on different time scales and thus require different types of information, ranging from more reliable forecasts at short-to-seasonal time scales, to improved representation of the impacts of a changing climate on hydrological risks in the longer term.

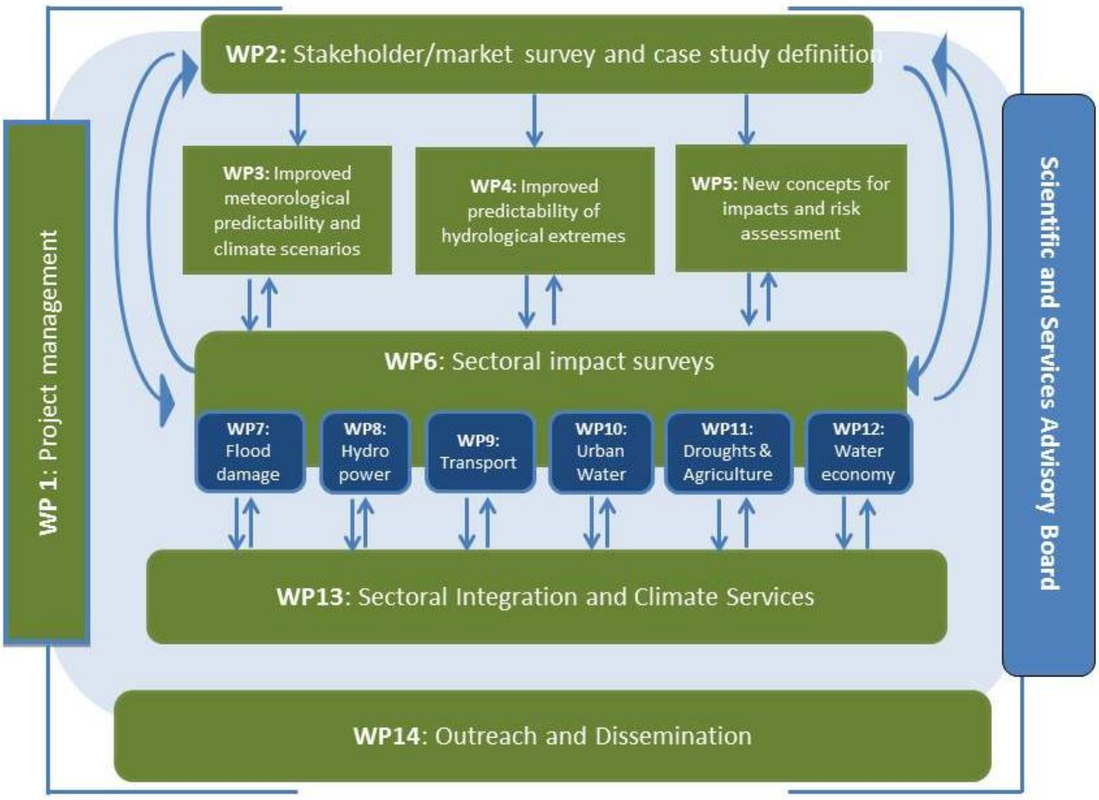

Figure 1.2: Work package structure of IMPREX (Pert Chart), including the Scientific and Service Advisory Board.

WP1 (**management**) organises the internal and external communication, reporting and project monitoring. It organizes the interaction between the project entities, being the coordination unit, a management board, the General Assembly, a number of sectoral groups (see below), and an external advisory board: a scientific and a stakeholder board in which the strategic water sectors are represented (see Figure 1.2 and the summary of support statements from key sector stakeholders in Table 3.1). WP2 coordinates **the stakeholder/market survey and case study definition**, and organizes the interaction between stakeholders within and outside the IMPREX consortium, and the tool developers and sectoral analysts. It analyses how the water-related sector can best be supplied with updates on hydro-meteorological information and risk assessment across time scales, starting from a selection of six sectoral domains (addressed in WP7-12). This will give guidance on the information and knowledge needed in the field to allow adequate adaptation to these risks. The list of case studies may be enriched during the initial phase of the project when actual conditions explored in WP2 justify redefining the original work plan.

The guidance from WP2 is used to direct the development of the meteorological/climatological (WP3) and hydrological (WP4) forecasting tools. In an interactive framework, their subsequent application in the case studies is used to prioritize the developments. For the work on **improved meteorological/climatological predictability** (WP3) further developments will include:

- process studies and atmospheric data assimilation experiments leading to improved representation of meteorological processes important for hydrological extremes at the local scale (for instance, time slice experiments with non-hydrostatic models, data assimilation of high resolution or non-conventional observations) to improve short to medium range meteorological forcings;
- exploring the ability to improve hydro-meteorological predictability at the seasonal – annual time scale in a number of seasonal forecasting systems (such as improved wintertime NAO-conditions[3]);
- high resolution dynamic and statistical downscaling of seasonal forecasts and climate projections, focusing on a realistic representation of the key meteorological processes that represent the driving forces behind extreme hydro-meteorological events at the local scale;
- interactive development of the coupling of meteorological outputs to hydrological and impact assessment models for the applications used in the WP7-12 case studies (such as climate scenarios for flood forecasting applications, crop growth models, and economic indicators).

The meteorological/climate forecasting systems and climate models participating here include at least three global and three regional meteorological modelling systems, including the operational systems of ECMWF and METOFFICE.

The **improved predictability of hydrological extremes** (WP4) is achieved by upgrading multiple hydrological applications operated by the partners in a wide range of applications. The developments of the hydrological tools include:

- improve the climatology of present day risks for floods, droughts and other hydrological hazards, by using unexplored data sources and performing long term hindcast experiments;
- integration of multi-model projections into a single probabilistic forecasting system for hydrological extremes, allowing for a dynamic regime based selection of adequate modules;
- explore and develop data assimilation and initialization techniques (such as satellite-derived evaporation, snow and soil moisture, ground water extraction & irrigation, river/lake levels, discharge records) to improve hydrological predictability at different spatial and temporal scales[4];
- tailor the output of the prediction systems at both short range/small scales (addressing small scale phenomena such as flash floods) and long range/subcontinental scales (such as droughts) to the needs of the different sectoral applications;
- interface hydrological systems with environmental indicators, including effects of e.g. water extraction or anthropogenic heat release, flood/drought damage models, dam operation protocols and economic river transport models.

The selection of models chosen reflects the current systems in use in (semi)operational general and sectoral forecasting systems. The experiments performed are fully adjusted to support the WP7-12 case studies.

Not only a further development of the forecasting tools is needed, also the techniques to extract the relevant information supporting risk assessment and decision making needs additional attention. Scenario or impact assessment techniques currently in use have their limitations. They are expensive in terms of multi-model and multi-scale scenario generation and difficult to interpret by non-scientists. Persistent gaps between available and required information, and changing information requirements as risk assessment procedures develop still exist. WP5 is dedicated to **develop and test novel concepts for climate impact and risk assessment**, adjusted to the present and expected information needs. It anticipates on a modernization of risk assessment, where new tools and protocols are becoming operational. New methods and techniques are explored, which are subsequently tested in the sectoral inventories in WP7-12 and adjusted by feedback interaction where necessary. A summary of the objectives of this portfolio of new concepts is to:

- complement the “classical” downscaling chain (GCM-RCM-Impact model) with realistic very high resolution images of weather events that lead to extreme hydrological impacts (including the potentially large impact of compounding low impact events) in the context of a changing climate. Attention is paid to the framing of these unprecedented extremes in the decision making process[5];
- explore statistical relationships between large scale climate indicators (such as NAO) and hydro-meteorological impacts (rather than discharges as traditionally performed today);

- explore water allocation schemes based on minimizing risk over a given time frame rather than minimizing damage at a relatively short time scale;
- develop probabilistic impact assessments for floods and drought within an integrated risk framework.

WP6 addresses a coordinated selection of **comprehensive sectoral impact surveys guided by case studies**, in which the body of work is carried out in trans-disciplinary teams in (semi)operational environments. The sectoral applications have been carefully chosen to maximize the legacy impact beyond the end of the project, covering a wide range of applications that can be addressed with the available budget. In these sectoral applications, public agencies, non-profit organisations and SMEs contribute to the implementation of the new data sets, scenarios and concepts developed in WP3-WP5. The six sectoral WPs covered by IMPREX and the case studies are selected in order to optimize stakeholder involvement from strategic water sectors and adequately cover regional detail and European climate regimes (see Figure 1.3):

- WP7: Flood inundation prediction and risk assessment: this WP addresses flood inundation risks and related economic damages. Improvements to the forecasting tools (WP3 and WP4) are evaluated at the short-to-medium range time scale by revisiting forecasts of past events with the tool upgrades for several river basins. Forecast system improvements will be synchronized with the European Flood Forecasting System (EFAS). Changes in flood damage risk under different climate outlook scenarios, and the associated implications for e.g. flood insurance will be quantified at river basin and European level;
- WP8: Energy production: hydropower operation is highly sensitive to predicted inflows and extreme hydro-meteorological events, for both reservoir management (optimization of energy production systems) and risk monitoring (dam security). Enhanced predictability of inflow volumes and extreme events across time scales, together with improved realism of climate outlooks, are considered in close collaboration with European energy production companies. Implementation of revised hydrological forecasts/outlooks from WP3 and WP4 are applied in a range of impact assessment tools that are used operationally or under development at the energy production companies;
- WP9: Transport: enhanced forecast predictability at all feasible time scales as well as realistic climate foresights are necessary ingredients for optimizing water transportation efficiency. To evaluate the possible benefit of enhanced short-to medium range forecasts a transportation cost module is applied. For the long-term forecasts and predictions on climate scale navigation-related indicators are evaluated;
- WP10: Urban Water: Key urban water utilities, such as drinking water treatment plants, are vulnerable to the changes in raw water quality driven by climate. Different conditions (e.g. high water turbidity, eutrophication) could produce a shut-down of the water production, an increase in operational cost and a risk to get unsatisfactory drinking water quality. A better understanding of the changes in water quality driven by climate variables (considering weather extremes and climate change) will be provided, together with an evaluation of how the improved forecasts, models and data produced can be used to optimize current plant operations, water systems planning, and water supply risks management;
- WP11: Agriculture and drought: here the focus will be on improving assessment of seasonal agricultural drought risk at the river basin scale for various European climate zones. Improved risk predictions will be tailored to drought management systemss operating in several basins across Europe. A River Basin Water Accounting system will be extended to incorporate climate change effects on basin-wide water resources that are used and utilizable for agriculture, for key drought-prone basins in Europe;
- WP12: Water economy: many water related risks affect regional and European economy and the exchange of goods and capital. This survey explores changes in the water footprint of individual regions or sectors, and analyses the consequences of changes in water related risks (both within Europe and in important trade regions elsewhere in the world) on transnational economy will be analysed.

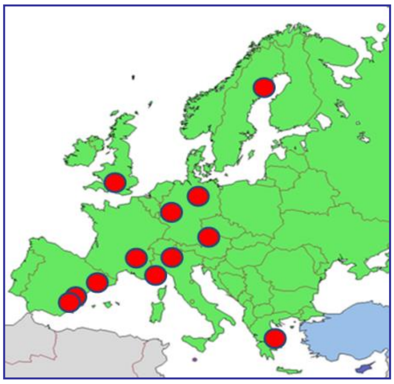

Figure 1.3: Location of case studies

The **Sectoral Integration and climate services** work-package (WP13) provides a bridge between the scientific results of the project and the implementation of adaptation and water management strategies. For a number of selected case studies explored in WP7-12, an analysis is made to demonstrate the most convenient and efficient risk and adaptation management strategies. The basic approach makes use of participatory (agent based) modelling concepts, adopting and feeding back to the stakeholder decision making process[6]. The approach allows a thorough evaluation of cross-sectoral and cross-regional impacts of hydrological hazards (e.g. floods affecting simultaneously safety, dam operation, transport, economic damage, etc.). Existing economic prioritization tools will be enhanced to better facilitate decisions on the most appropriate and efficient adaptation strategies under budgetary restrictions. Application of these decision rules to anticipated future climate events will provide guidance from the water sector to the different national and European Climate Adaptation Strategies. Also, novel risk assessment concepts (from WP5), including the assessment of compounding risks, or alternative water allocation rules, will be evaluated in this framework. As such, WP13 supports the creation of *climate services for adaptation*, defined by the JPI Climate as "User driven development and provision of knowledge for understanding the climate, climate change and its impacts, as well as guidance in its use to researchers and decision makers in policy and business".

The collection of **dissemination and communication activities** is coordinated in WP14. The results from the project need to be communicated down to the level where decisions are actually taken place in order to provide effective stakeholder engagement. In IMPREX this is done by creating three general outreach activities:

- a prototype of a periodic "hydrological risk outlook", that will give an indication of relative hydrological risks given forecasted or projected large scale features. This periodic outlook will be linked to existing European portals such as the European Flood Awareness System and the European Drought Observatory, and where possible integrated or adjusted to the Copernicus contribution to the Global Framework on Climate Services.
- the documentation of the "lessons learned" in the stakeholder-oriented case studies. Fact sheets, websites and presentations on current and future risk of high-impact extreme hydrological events (including relevant information on limits to predictability and sources of uncertainty) will be produced, and published in already existing media (websites, printed publications) of different stakeholder groups (including a number of SME networks) and communicated during stakeholder events (such as World Water Forum);
- a series of publications reporting on the regional high level integrated risk assessments of water-related impacts, tailored to a number of dedicated European policies: the European Adaptation Strategy, the European Disaster Risk Reduction, the Blueprint on European Water Resources, and an analysis of non-European risks relevant to the European area;

The balance between the different objectives and deliverables of IMPREX needs to reflect adequate attention to the scientific development of the forecasting and foresighting tools, to the testing of these developments in current and new (semi)operational applications guided by the sectoral surveys, and to the integrated risk assessment and outreach. This is expressed in the resource allocation to the different WPs. Roughly 45% of the budget will be devoted to improving the forecasting/foresighting tools and concepts, about 40% to its testing and application, leaving roughly 15% for management and dissemination outside the consortium.

Sex and gender analysis

The IMPREX participating organisations actively promote equal representation of men and women in employment and decision-making, and removing institutional barriers to gender equality. All organisation have an equal opportunity policy implemented and many are certified for their equal opportunity practice and procedures (e.g. Athena Swan awards). IMPREX will ensure women's participation as active members in the different consortium entities. In the current structure a number of WPs are led by women, and approximately 25% of all involved people are female (see Section 4.1). We support the mainstreaming of gender issues in water research and policy, as a balanced gender composition helps the sustainability and quality of European water management. We will pay attention to gender equality and diversity by carrying out the communication to the public with the principle that our deliverables (including water-related hazard outlooks) are well understood and assimilated by society in its economic and social diversity.

1.4 Ambition

Beyond the state-of-the-art

In many sectors the adoption of effective risk management is limited because of (1) inadequate forecast skill, (2) limited understanding or interpretation of uncertainty, (3) unknown system responses and/or (4) lack of communication between specialists. IMPREX will bring the current state of the art a step further by addressing each of these shortcomings specifically by:

- improving the *predictability of hydrological extremes* by working simultaneously on the meteorological *and* the hydrological process and event representation, carried out by leading agencies in the field;
- develop a prototype *periodic outlook of multi-sectoral and trans-regional risks* for hydrological hazards, which replaces the traditional "static" way of viewing risks in hydrology by a dynamic view compatible to today's changing world with anticipatory and reactive adaptation to extremes and rare events;
- addressing the synergies and *compounding and cascading effects of risks in different sectors and regions*, by integrating the sectoral analyses into a common decision modelling framework;
- alternative ways of *visualizing climate change effects on impacts and risks*, tailored to society impacts;
- developing and evaluating *novel concepts to minimize risks* and optimize water management;
- using a project design that *involves managers of vulnerable and strategic water resources* from the very beginning in the experimental design, leading to a wide range of sectoral impact surveys.

The innovation potential

To ensure the implementation of research results in practice IMPREX involves four SMEs to enable the transfer of the developed technologies to society. These SMEs are all experienced in working in academic projects while at the same time providing market-oriented solutions and services.

Among the IMPREX concepts that have a high potential to become applicable at the market are the risk based water allocation and a probabilistic water transportation cost model. In addition, analysis of compounding extremes, the use of very high resolution modelling tools for quantifying hydrological hazard impact, an update of the Water Accounting Plus (WA+)[7] framework including the impact of changing rainfall, evapotranspiration and atmospheric recycling under climate change, the integrated cross-sectoral and cross-regional risk assessment, and novel techniques of risk prediction have a market potential. For instance, the methods for risk prediction of agricultural drought, put into practice in operational drought monitoring systems and taking local management and complex interactions between sectors into account, has a big potential for market replication, given the societal and economic importance of the agricultural sector.

2. Impact

2.1 Expected impacts set out in the work programme

The impacts of natural hazards on the strategic water resources for the European society are significant. Expressed in damage costs, the drought event in Catalonia in 2007/2008 caused €160mln in direct impacts for the water agency and water utilities, and more than €1.4bn of wider impacts on the society (direct and indirect costs). The 2013 floods in south and east Germany caused overall losses of €11.7bn, while the UK floods last winter cost the industry €1.8bn. The IMPREX contribution to adequate anticipation of extreme hydro-meteorological conditions, which helps to shape a robust adaptation strategy to cope with future events. This will bring great societal and economic value as it helps to reduce casualties and economic losses, enhance business continuity, reduce emergency costs and increase societal risk awareness. The way IMPREX contributes to the expected impact set out in the call text is described below:

- *More efficient management of strategic water resources in Europe due to better knowledge of the water cycle under the future climate:*
  It is expected that IMPREX research will advance the skill of seasonal forecasts by several percentages and that these improved forecasts will be tailored to also impact the involved water sectors. This will lead to an increase of the period for which skilful predictions of hydrological impacts can be produced, and will allow an increase of the planning horizon for sectors and regions that are vulnerable to hydro-climatic hazards. In addition, any development in the understanding and use of forecasts of extreme hydrological events increases the efficiency of water management and its adaptation to future conditions. This broad coverage of water and risk-related applications in Europe will directly involve stakeholders and also be documented in targeted reader-friendly impact fact sheets and policy briefs for a wide dissemination among stakeholders, water managers and the public beyond the project's network. Examples are:
  - currently, very few of the drought-prone European river basins use seasonal predictions for their water management. Through the use of novel, and more skilful, seasonal prediction systems, IMPREX will contribute to a better interpretation of drought and low flow forecasts. Emergency costs are saved and societal preparedness increased;
  - improving flood forecasting tools will help predict floods earlier and more realistically, with clear benefits for evacuation, emergency response and protection measures;
  - the integration of hydro-meteorological ensemble forecasts in water supply management will improve the safety of drinking-water and the reliability of water supply. This vital utility for public health and a healthy economy has a significant contribution the GDP of Member States and Europe as a whole;
  - the use of hydro-meteorological ensemble forecasts for the hydropower sector allows a better planning of resources allocation and production in time, increasing the economic gains of energy production: a recent study in France indicated up to 5% of economic gain when using a 7-day forecast, while improving the skill probabilistic forecasts increased gains further by 1.5%;
  - An improved quality of the 4-day water level forecast for the River Rhine can reduce transport costs to up to 2%;
  - The European trade market is highly sensitive to hydrological hazards elsewhere in the world, since 40% of the water needed to produce food and industrial goods consumed in Europe is of non-European origin. IMPREX will further explore and quantify this sensitivity.
- *Contribution to management planning across the EU in support of the Blueprint to safeguard Europe's water resources, the EU Climate Change Adaptation Strategy and relevant priority areas of the EIP 'Water':*
  The sectorial surveys conducted in IMPREX contribute to the implementation and adjustment of existing management and climate change adaptation strategies. The participatory modelling work applied to exemplary case studies, including the pan-European assessment, will allow an evaluation of the robustness of the current management and adaptation strategies, to be fed into the Climate Adapt Platform of the EU. This provides deeper insights into the effects of the cascading of risks from one sector or region to the other, and the impact of combined events. An analysis of the interlinked challenges, mentioned for instance in the *Blueprint to safeguard Europe's water resources*, allows an evaluation of strategic water resources, climate change and business potential strategies that makes use of realistic sets of conditions, rather than scenarios that focus on a single sector or hazard type simultaneously. The integral approach enables the allocation of means to increase the resilience of the most vulnerable sectors and regions and increases the cost efficiency of management and adaptation measures. IMPREX will also support the implementation of *The Roadmap to a Resource Efficient Europe* (COM 2011, 571)by providing advice to the Member States on how to set water efficiency targets for 2020 in the face of a changing climate.

- *Contribution in the longer-term to the development of reliable climate services in relation to the water cycle*:
  IMPREX engages both public and private partner organisations as well as end-users to maximize the contribution of tailored information to their benefits. Case study evaluations by the consortium SMEs will add to their product portfolio, supporting the development of a business model for climate services. In

addition, the involvement of IMPREX partners in the Joint Programming Initiative Climate (JPI Climate[8]) and the Copernicus program will allow for an efficient implementation of the project results in main thematic areas, including the climate change, emergency management and monitoring services. The research results generated by IMPREX will significantly contribute to the scientific literature, and to the IPCC agenda for the development of climate resilient pathways.

The expected impacts are strengthened by the broad involvement of external stakeholders in applying the IMPREX work programme. The consortium has already received a substantial number of support letters, including quotes that underline the high potential impact of the project (Table 3.1).

Improving innovation capacity and the integration of new knowledge

Weather and climate services have shown commercial success in many sectors, based on the products that can be offered by private companies and exploited by climate-sensitive industries in the market[9 10 11]. This is a large and expanding market to which IMPREX can contribute with its outputs. Furthermore, IMPREX significantly contributes to the development of water services, by implementing also a hydrological outlook for assessing risks and impacts. Having hydrological outlooks available is essential, but for effective better water resources management and improved decision making they have to be tailored to the variety of customer's needs to be used in operational applications[12]. This is a role that private companies and SMEs can take. They can build value in the business of water-related products and services, and stimulate competitiveness and growth of the market. IMPREX will provide the water-related market with a new product that can be used by hydro-based SMEs to customize services that will directly answer to the needs of their customers in their activities that depend on weather and climate extremes. Today, the interdependence of climate, weather and water is not fully exploited for the growth of water services and products in the market, although weather and climate services have been the business of many enterprises for years. Particularly the market of specialized value-adding services is growing[9 13 14] and the IMPREX hydrological risk outlook will contribute to this growth.

In order to ensure that IMPREX deliverables are in line with stakeholder needs, the project invests heavily in developing a culture of co-design and co-application within the project. WP2 and WP6 will ensure that stakeholders can feed their wishes and requests into the project at a very early stage and have a participatory engagement in the applications during the project lifetime. This is necessary to create a solid basis for a continuous use of IMPREX products by stakeholders in their operational decision-making after the completion of the project. WP13 with lessons learned from this users engagement for better modelling results. WP13 will include stakeholders views and needs through a participatory modelling approach.

Knowledge lies at the heart of the European Union's Europe 2020 Strategy[15] to become "a smart, sustainable and inclusive economy". IMPREX contributes to this goal by creating knowledge on hydrological extremes and their impacts, research that supports the "Water Blueprint" to ensure the resilience of European societies in the face of climate change. It will also contribute to European policy frameworks and policy processes such as the Water Framework Directive (WFD), the Blue Print for Safeguarding European Waters, or agricultural policies (e.g. CAP). Although the WFD is not directly designed to address quantitative issues, its purposes include the mitigation of drought effects (Art. 1(e)) and the promotion of sustainable water use (art 1.b) and improved water quality. Specifically, IMPREX will develop participatory, integrative management strategies, capable of supporting the implementation of management plans for high-impact events.

The enhanced insights in future responses to hydrological extremes will support EU's leading role on considering climate change challenges. In particular, the project meets core elements of the post-2012 strategy by offering (1) innovative research and developments for creating long term solutions (anchored within for instance River Basin Management Plans), (2) improved knowledge on hydrological high-impact events, and (3) identification of cost-effective management strategies.

Barriers and obstacles

The benefit and maximum impact of improvements in individual sectors largely depends on the regulatory and legal framework of each sector. This is usually set by a large range of national, transnational and international bodies and organizations and can change over time. In IMPREX the sectoral applications are carefully chosen and involve named end-users who have significant experience in adapting to such changes. The consortium partners are already delivering many climate and hydrology services to many of the proposed public and private end-users, which minimizes risks of limited take-up of results. In addition the IMPREX impacts are designed in an adaptable and flexible way to mitigate any regulatory-based obstacle.

IMPREX uses particular data standards which evolve. In particular progress on standardization (OGC, ISO, INSPIRE, RDA) is contingent on factors outside the consortium. However, several consortium members are embedded in many of these standardization processes, which will allow to anticipate any changes and develop mitigation strategies.

Europe is currently recovering from a very deep recession and in particular access to financial services and financing of public entities may significantly change over the time period of this project. This can affect all partners of the project, in particular SMEs.

2.2 Measures to maximise impact

Dissemination and exploitation of results

The dissemination and exploitation activities are coordinated in WP2 and WP14, led by METOFFICE and Arctik respectively, both very experienced with the organisation of dissemination and exploitation of hydrometeorological information and risk analyses.

*Table 2.1: IMPREX matrix for the **Dissemination and exploitation plan***

Why? Why are we communicating and for what purpose? The objectives of the IMPREX dissemination and exploitation plan		
Who? Who is the target audience? Who should be part of the communication processes? Who are the adjuvants? Who are our relays and multipliers? Identifying all communication beneficiaries is critical!	**What?** What information needs to be communicated? One-size fits all does not necessarily work. Each of the target groups identified in the plan may have different information requirements. Who responds to what? Survey, track and monitor the target audience.	**How?** Their existing mechanisms, publications etc. which will assist our strategy. Examples include: • Website • Social media • Email • Newsletters • Conferences, events, workshop, B2B
When? **Timing is key!** IMPREX should be specific and meet communication deadlines. Arctik and METOFFICE are aware of milestones in the project plan which trigger a communication exercise. This may be a public participation activity, a specific media or advertising campaign or a project launch, for example.	**By Whom?** Communication plans are active documents which are designed to be implemented! Clear responsibility for a communication task within the consortium will be mentioned, including strict dates. The plan will be updated yearly. Often, communication will be a partnership with others e.g. Governance and Communication Services.	**Where?** **Location** of your communication activities. With the multiplication of target groups, their varieties and geographical spread, one must be careful when planning a communication activity that it will reach the target audience wherever it is at a given time.

- **WP2** focuses on the organisation of the sectoral surveys within IMPREX, where external users are engaged in sectoral user groups, and where the general applicability of the case study pilots to other contexts is explicitly addressed.
- **WP14** organises the communication and outreach activities conveying IMPREX results to a wider range of external stakeholders and parties of interest (see Figure 2.1).

In total 9% of the IMPREX budget is allocated to these WPs. Moreover, dissemination and exploitation is strongly promoted by the core structure of the project, with involvement of a high number of users and in participatory case-studies, exploited by experienced organisations (both SMEs and public research centres), which will ensure the direct use of results in practice.

The IMPREX consortium includes several specialised dissemination practitioners (Arctik, Deltares, IRSTEA, BfG, GfZ, IVM, KNMI, METOFFICE, ADELPHI).

➢ *Communication strategy & Dissemination and exploitation plan*

A dissemination and exploitation plan will be fully developed in the early stage of the project. Focus on dissemination and exploitation activities in all work packages ensures that the full impact of the project is achieved. An online platform - an integral part of the plan - will be complemented with a comprehensive programme of offline activities, training, and dissemination events to ensure the maximum engagement and level of interaction with public and private representatives both within cases and in a wider European context.

The communication and exploitation plan of IMPREX will follow the communication guidelines recommended by the EC: "*Peer-reviewed publications, specialist websites and scientific congresses typically form the principal information channels of the research community. By contrast, 60% of the general public obtains its knowledge of science from TV. Popular newspapers, magazines, radio and – to a growing extent – the Internet also play major roles in informing public awareness and opinion. Between these two extremes come the business-to-business tools, including: commercial, technical, financial and industrial publications; broadcasts; and trade fairs and seminars. All need to be considered in the preparation of a well-balanced communications mix. Local community-related activities may form yet another route to limited but often strategically important audiences*". Table 2.1 summarises the overall communication strategy employed to comply with these guidelines. Based on this inception work, a partner survey as well as a communication workshop will provide the input to a strategy document outlining the activities and timelines, which will be drafted and transferred into the final dissemination and exploitation plan.

➢ *Communication objectives and challenges*

The overall communication objectives are 1) reach the right audience to promote the utilisation of research findings; 2) raise awareness of hydrological risks and of the potential for using a risk outlook; and 3) stream policy recommendations at EU, national, or local level. Several axes and paradigms apply:

- IMPREX has a story to tell. It requires a modern message that will be attractive for the policy-makers, businesses, media but also for the general public. We will develop storylines that resonate with daily lives. Our motto will be 'Learn Learn from today to anticipate tomorrow';
- Make IMPREX tangible / illustrate how IMPREX solves an issue / engage people with compelling narratives;
- Establish sound synergies. Create explicit links and synergies with parallel EU initiatives – strategically integrate IMPREX into highly visible EU events and programmes. We will valorize the IMPREX community as multipliers – the use of co-branding and high-profile "stakeholders" to promote the results;
- Liaise with Member States to better coordinate activities and yield more synergies among Member States as well as with the European Commission and their programmes;
- Spread the policy recommendations. The case studies' results will lead to the formulation of policy recommendations that will be disseminated towards the policy and risk management audience.

Based on our initial evaluation we have identified the following central communication challenges:

- Due to its technical nature, IMPREX can be difficult to describe and understand by policy-makers, media or the general audience. Describing the overall goal of the project with a story, and also defining storylines for each case-study will overcome this barrier;
- IMPREX involves a multiplicity of partners and actors. This requires mastering communication and coordination of promotion activities among actors. The project will decentralise the communication towards the communication partners, while retaining the control of the message produced;

- IMPREX is ambitious in its goal to bridge the gap between science and society. This goal is attainable by shifting away from a research-centric communication and benefit from existing communication channels that target business, interest groups, associations, media and other interested stakeholders;
- We will develop an online / web-based communication strategy – but multiply the communication channels / tools using the same content.

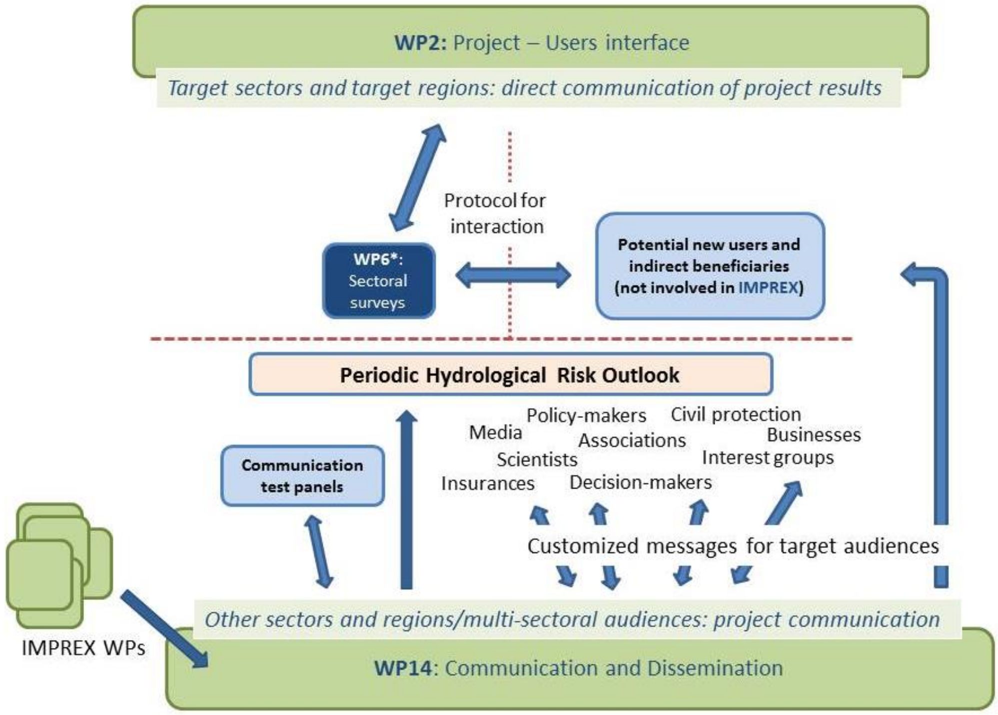

Figure 2.1: Layout of IMPREX dissemination and communication structure, where WP2 primarily addresses users that are explicitly linked to the project, and WP14 organises the project assets to general audiences not directly affiliated to IMPREX.

➢ *Target groups and tools for dissemination*

Defining the target audience is important to get the message of IMPREX across. Three kinds of audiences have been defined. The first audience are the project **users**. These are the direct beneficiaries of the project and are represented for instance by the organisations that will be involved in some of the WP7-12 activities . WP2 will design a co-creation strategy to organise the interaction with this group.

The second category are the **potential users**. This group consists of organisations which potentially benefit from the use of the products that IMPREX will develop. Examples of this arehydropower and the water supply companies that are not involved in the project but who could potentially benefit from the periodic outlooks.

Finally, the third audience are the **stakeholders**. This is a large category of people who are interested in IMPREX, or might communicate this interest during the life of the project. Their engagement and involvement in the project will be designed and managed by WP2, which will also focus on further identifing specific sub-audiences (e.g. academia, decision-makers, policy-makers, contingency planners, general public) within this wide category. The online platform and the social media managed by WP14 will provide the tools to build and maintain an engaged community around the project.

The dissemination of IMPREX is targeted towards identified groups, for which specific tools are developed (see Table 2.2):

- Local risk managers and authorities: river basin managers, water boards, agricultural organisations, energy operators
- Policy makers at (inter)national level: national authorities, European commission
- Risk warning centres: operators of European flood and drought warning centers, (national) hazard centres

- Scientific community: risk assessment, hydrometeorological forecasting and tool development, climate change research
- Private sector: hydropower companies, shipping companies, water supply companies, water consultancy, energy, grid operators, innovation center
- Specialized media at EU and national level
- The general public.

Table 2.2: Overview of dissemination target groups and tools

Target audience	Dissemination tools	WP and task
Local risk managers and authorities	Stakeholder workshops and user goups	2.3
	Sectoral synthesis reports	14.9
	IMPREX website & social media	14.3
	Hydrological risk outlook and training material	14.6
	Hydrological (re)forecasts	4.1
	Climate change projection data	3.3
Policy makers at (inter)national level	Synthesis for policy and decision makers	14.9
	IMPREX website & social media	14.3
	Press briefs	14.4
	Policy planners workshops	14.7
Risk warning centers	Hydrological risk outlook and training material	14.6
	Hydrological (re)forecasts	4.1
	Upgraded seasonal forecasts	3.2
Scientific Community	Pier reviewed scientific papers	all WPs
	Project workshops and conferences	14.7
	IMPREX website & social media	14.3
Private Sector	Targeted publication material	14.4
	Presence at business conferences	14.4
	Participation in Advisory Board	1.2
	IMPREX website & social media	14.3
General public	General information material	14.8
	IMPREX website, social media	14.3
	Video	14.3
Media	General information material	14.8
	IMPREX website, social media	14.3
	Video	14.3

➢ *Data management and Intellectual Property Rights*

IMPREX data sets will be exchanged amongst partners using existing portals that are already community or EC resourced and targeted to specific sectoral applications (earth2observe, ERA, TIGGE, EFAS, EDO, S2S, Global Drought Information System, Copernicus Climate Data Store). Using existing platforms will ensure the project legacy better than a new unknown and untested platform. These portals are already targeted at specific stakeholders and will take their individual needs into account. By using the existing communication channels, the impact of the data set generated in the project can be maximized . Linking the hydrological risk outlook to the Global Disaster Alert and Coordination System platform (GDACS) will contribute to the GEOSS Data-CORE, which will act as an integrator and coordinator. All portals offer access via standard interfaces (Open Geospatial Consortium web-services such as WMS, WFS and WCS, and OPeNDAP as appropriate).

The procedure above will be monitored by a dedicated data manager (member of the project Coordination Unit) who leads a Data Protocol Panel (DPP). This will ensure coordination and standardization through a data exchange inventory and licensing report . The Data manager will monitor the availability of data to all project partners and makes sure that the formats and documentation are in line with the international guidelines. The DPP will be established at the kick-off general assembly and will include representatives from each WP. It will collect and maintain the required data documentation and guidance and keeps close contact with similar bodies within relevant EU projects such as COMBINE, is-ENES, EURO4M, MACC-II, SPECS, Earth2Observe, Copernicus and ERA-CLIM and the corresponding panels sponsored by the World Climate Research Programme (WCRP), WGSIP and the Working Group on Climate Modelling (WGCM). Given the pressing need for the definition and implementation of international data standards, IMPREX will link to other initiatives undertaken in other regions such as those within the framework of the Modelling, Analysis, Prediction and Projection (MAPP) programme of the US National Oceanic and Atmospheric Administration (NOAA). All the data will be provided in NetCDF format, unless required otherwise. The data will comply with the CF standards and the metadata documentation protocol developed for the Fifth Coupled Model Intercomparison Project (CMIP5) archive. It wil also follow the latest standards defined by the initiatives of the European Network for Earth-System Modelling (ENES) consortium.

This approach inherently builds on existing capacity already developed in early FP projects such as GLOWASIS, GEOWOW, EUPORIAS and SPECS or imminent future projects such as Copernicus. This solution is possible as many of the project partners lead the development of these portals and are already coordinating the contribution to various portals through the GEOSS Data Sharing Principles.

All partners will share the knowledge and methodologies developed within the project for achieving the expected results during the project. the consortium will strive to make all data accessible as open source for individuals outside the consortium. All data will be made available on license and details of the access conditions will be provided in the data management plan, which will be updated for every 18 month in line with the reporting period.

The management of Intellectual property rights (IPR) will be regulated in the Consortium Agreement (CA). In particular, the following clauses will be included:

- Research results arising from the implementation of the project will belong to the participants carrying out the research. The intellectual property rights will be applied individually according to rules of the employer and under the applicable European and national laws.
- Partners should be prepared to share their data and data products and should recognise the 'proprietorship' of such data ('rights to first publication/ authorship') acquired from other partners.
- Model algorithms and software developed by partners as well as data in the context of research developed within the project will be available to all project partners for the duration of the project. Wherever possible, software, algorithms and data will be made open source.
- Dissemination activities shall be compatible with the protection of IPR and any existing confidentiality agreements.
- The consortium will publish the results as open access.

3. Implementation

3.1 Work plan — Work Packages, deliverables and milestones

Brief presentation of the overall structure of the work plan

The work plan of IMPREX is designed to comply with the call text, that aim for a mixture of development of predictability capabilities, improved climate projections, (sectoral) impact assessment and decision support. The Work Package (WP) structure as described in Section 1.3 is detailed below. A graphical representation (Pert Chart) of the WP structure is given in Figure 1.2.

Tool development work packages (WP3, 4, 5) are tightly coupled to the impact assessment and integration WPs (6 – 13), while user and external communication are organised in the adjacent WPs 2 and 14. The information exchange between the development and application WPs is contained in concrete deliverables, that are monitored by key milestones described below. A special position is taken by the integration work in WP13, that utilizes information from various tasks distributed over the project. A graphical display of the interaction between WP13 and other tasks is given in Figure 3.1.

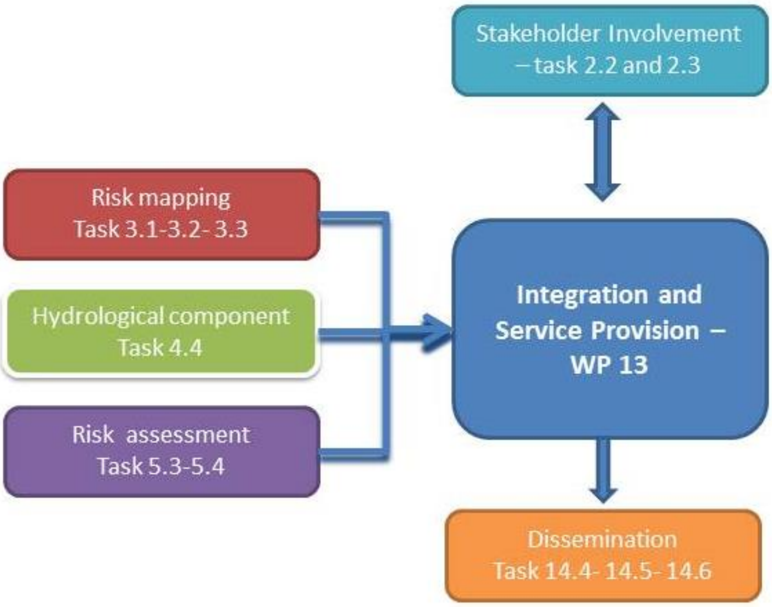

Figure 3.1: Interaction between WP13 (Integration and service provision) and tasks in various other WPs

Although all sectoral survey WPs have their own dynamics and timing, a synchronized monitoring scheme is imposed that contains similar key evaluation moments for each sectoral survey WP: (1) inventory of information needs, coordinated by WP2, (2) preparedness to incept data from WP3, 4, 5, (3) use of updated information from these WPs and providing feedback, and (4) a full assessment of the IMPREX heritage in the (cross)sectoral surveys. Data exchange is monitored by the Data Manager, as described in the sectoral survey coordination WP6.

IMPREX Milestone overview

WP	Milestones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
WP1	Major meeting	1.1																	1.1												1.1																		1.1
	Report and review																														1.2																		1.3
WP2	Dissemination & Exploitation plan						2.1																																										
	Stakeholder workshops												2.2																																				
WP3	Data set exchange												3.1												3.3																								
	Improvements tested																								3.2								3.4																
WP4	Data set exchange						4.1						4.2																		4.3																		
	Improvements tested																																																4.3
WP5	Novel concept tested in practice						5.1																														5.2												5.3
WP6.0	Outreach protocol																								6.1																								
WP6*	Assessment current practice												6*.1																																				
	Data insert and test																		6*.2																		6*.3						6*.4						
WP7	Assessment current practice																		7.1																														
	Prototype model chain																								7.2																								
	Policy analysis																																				7.3				7.4								
WP8	Website		8.1										8.1																																				
	Draft communication plan																																																
	Leaflets and project information						8.2																																										
	Workshops and PR																														8.3																		
	Risk Outlook																								8.4												8.4												

- Analysis of current state
- Data exchange/ingestion working
- Experimental dataset tested
- Achievements fully analysed and documented
- Prototype ready
- Operational version ready
- Meeting or report available
- Website/PR material available

Figure 3.2: Gantt chart of the IMPREX project. Shown are the main milestones per WP or WP-group

Timing of the different Work Packages and their components

The first half year of the project is devoted to the formation of the consortium (via the Consortium Agreement), the communication and stakeholder interaction protocols (where draft Communication and

Dissemination plans are compiled), and the Data Management Plan. However, activities in many WPs will get started soon to prepare for the forecast and tool development and data exchange. Important milestones concern the interaction between the WP3, 4 and 5 on one hand, and WP6 - 13, where information inventories, first ingestion of data, upgrade of information, and full exploitation are timed at annual intervals.

Major reporting periods and intermediate General Assembly meetings are adjusted to this timing by following a delayed schedule (meetings at kick-off, M18, M30 and M48), to allow adequate reporting and anticipation to necessary measures needed to meet the projects objectives. The layered management structure, needed to monitor progress and adjust strategies is designed to make decisions at the appropriate levels in the project organisation (see section 3.2).

3.2 Management structure and procedures

Organisational structure, monitoring milestones and the decision-making

This section describes the management of the project at the Consortium level. The objective is to keep the project on-track by defining and enforcing leadership, control and reporting procedures, which ensures the consistency and cooperation among the activities of the different work packages.

➢ *The Management Structure*

The Management Structure of IMPREX is composed of the General Assembly (GA), a Management Board (MB), and the Coordination Unit (CU) (Figure 3.3). The guiding principles of this structure are:

- To achieve the project objectives in efficient ways
- To maintain control of the overall project, while exploring synergies and encouraging creativity
- To ensure fast flow of guidance and information within the project
- To keep the structure as light as possible
- To provide working procedures offering full transparency for the participants and the Commission
- To support the efficient cooperation between WPs
- To ensure productive links between technology, business and application.

In addition to the internal management structure, the project has an external Science and Service Advisory Board (SSAB) and user and stakeholder groups that are organised around the sectoral surveys (WP7-12).

➢ *The General Assembly (GA)*

The GA is the major decision making body and consists of the project leader and official representative of each partner. It will be responsible for strategic and fundamental decisions defining the overall direction of the project. The GA will also be the body for possible arbitration. Any partner may submit for arbitration by the GA any decision by the MB or CU that appears as contrary to its interests in the project.The responsibilities of the GA include:

- Strategic decisions on the progress of the project
- Decisions on fundamental suggestions by the MB that might impact on the overall scientific direction or on the budget
- Strategic solutions in case of conflict between beneficiaries
- Decisions on arbitration by partners, based on the goals of the project and the Consortium Agreement
- Decisions concerning IPR, both fundamental strategic and for practical cases
- Modifying the Consortium Agreement if necessary
- Modifying the composition of the consortium, according to the provisions of the Consortium Agreement and the rules imposed by the commission
- Approving transfers of the budget if necessary.

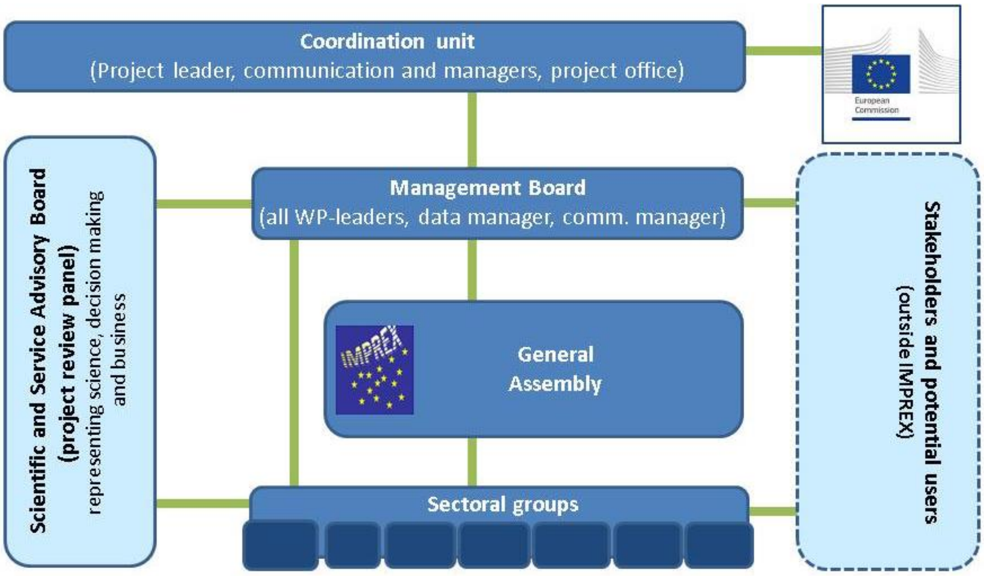

Figure 3.3: Management structure of IMPREX

The GA will convene annualy or on request by one third of its members. The official representatives of the partners in the GA are team leaders and appointed by their organisation. They are responsible for the management of the technical and/or scientific team working in their organisation and the timely production of the reports and results. The Team Leaders report to the management of their organisation, to the General Assembly for overall contractual and technical issues and to the WP leaders for issues specific to the progress of the WP's involving their organisation.

The decision and problem resolving process will be defined in detail in a Consortium Agreement, which will be signed by all beneficiaries prior to initiation of the project.

➢ *The Management Board (MB)*

The MB is responsible for the scientific leadership, for implementing strategies and for internal coordination and follow-up of goals to ensure timely delivery of results. Fundamental decisions by the MB that might impact on the overall scientific direction or on the project budget must be taken in agreement with the GA.

The MB is chaired by the project leader and composed of all WP leaders, the data manager to supervise data exchange protocols (provided by EMCWF) and the communication manager (provided by Arctik). The MB interacts at least bi-annually or according to upcoming needs.The responsibilities of the MB include:

- Scientific guidance and coordination towards the project's goals
- Steering technical and scientific aspects of the project
- Making practical decisions on the progress of the project as indicated by the Milestones
- Ensuring timely provision of deliverables
- Appointing reviewers of the deliverables controlling their scientific quality
- Ensuring exchange of knowledge and coordination between the WPs
- Resolving disputes on scientific questions
- Innovation management
- Controlling the risk management
- Making decisions on the dissemination activities for the CU
- Preparing solutions for IPR issues to the GA.

➢ *The Coordination Unit (CU)*

The Coordination Unit is in charge of the day-to-day management of the project. The CU executes the decisions made by the MB to which it reports. The CU is managed by the lead partner (KNMI), who provides both a project leader and an administration manager. KNMI has an extensive track record in coordinating and participating in complex multidisciplinary projects (see partner description). The communication manager and data manager are also member of the CU.

The CU is responsible for administrative, financial and legal affairs, and support for the advisory board. It receives and distributes the payments made by the EC and will serve as the primary contact point for the EC. Furthermore, the CU has the following tasks and responsibilities:

- Technical coordination (chair meetings of the principal project bodies; provide support to the advisory board and sectoral groups; convey considerations and recommendations to the general assembly and WP-leaders; monitor WP leadership and achievements)
- Financial issues (financial coordination, receiving and distributing EC contribution, reporting)
- Internal communication (organisation of project meetings, management conference calls, Science and Services advisory board meetings)
- Defining the risk management and maintenance of risk register (detect risks and ensure they are solved at the correct level of responsibility)
- Quality management (checking deliverables in a technical sense, editing, resolving issues, assisting the WP leader with quality plans)
- Communication and Dissemination (ensure preparation of draft and final Dissemination & Exploitation plan, and the Communication & Outreach plan; see WP14).
- Organising of MB meetings and support MB in coordination the Innovation management
- Organising GA meetings
- Management of data flow.

The role of the data manager will be to lead the Data Protocol Panel (DPP), supervise data exchange within the project as well as take responsibility of all other data related issues as outlined in the section on Data Management and Intellectual Property below.
The CU is also responsible for the quality control of the project. The process of quality control of the deliverables involves their review and acceptance by the MB. When a deliverable is ready for review, it will be forwarded to the Coordination Unit which will check its structure and format. It will then be forwarded to the persons designated as reviewers of this deliverable by the Management Board. The reports of the reviewers will be gathered, summarized and distributed to the members of the MB that can request changes to the author before approval. The CU will forward approved deliverables to the Commission.

The lead partner is responsible for administrative, financial and legal affairs, and support for the advisory board. It receives and distributes the payments made by the EC and will serve as the primary contact point for the EC. Furthermore, the coordination unit has the following tasks and responsibilities:

- Technical coordination (chair meetings of the principal project bodies; provide support to the advisory board and sectoral groups; convey considerations and recommendations to the general assembly and WP-leaders; monitor WP leadership and achievements)
- Financial issues (financial coordination, receiving and distributing EC contribution, reporting)
- Internal communication (organisation of project meetings, management conference calls, Science and Services advisory board meetings)
- Risk management (detect risks and ensure they are solved at the correct level of responsibility)
- Quality management (checking deliverables, resolve issues)
- Communication and Dissemination (ensure preparation of draft and final Dissemination & Exploitation plan, en Communication & Outreach plan; see WP14).

➢ *The advisory and user board*

In addition to the internal management structure, the project establishes a Science and Service Advisory Board (SSAB) of distinguished experts, which will provide relevant external evaluation and also widen the international and sectoral impact of the project. Principle methods of communication are internet tools, tele/videoconferences and project workshops. The board will be established at the constitutional project meeting. Candidates have already been invited and several have accepted (see section 3.3).

The board is formally committed to two review meetings: a midterm review based on a self-assessment of the scientific status of the project to potentially adjust the planned approaches, and an end-term review dedicated to the overall scientific and outreach assessment of IMPREX. The board is also invited to attend the General Assembly meetings . The Science and Services Advisory Board will be organised and managed by Arctik. The function of the board is:

- to provide and external and international perspective on the development and evaluation of prediction and projection methods in IMPREX
- to make recommendations for new actions and activities in this area
- to survey the relevance of ongoing development for hydrological risk assessment and adaptation.

IMPREX partners and external stakeholders involved or related in the sectoral case studies addressed in WP6 are organized in sectoral consultation groups, led and organized by the WP7-12 leaders. Potentially interested end users and stakeholders that are not formally committed to IMPREX will be invited to participate in these consultation groups. The function of these groups is

- to review the project findings and optimize the benefit to external parties
- To provide a link to sectors and stakeholders wider than can be represented in IMPREX
- To review the relevance of ongoing case studies for later general application
- Advising and assisting on the project knowledge dissemination
- Making recommendations for new actions and activities in this area.

➢ *The work packages (WPs)*

The project is structured in work packages. Each WP has its own leader, objectives and resources. Given the challenges planned in the project, each WP has been divided into tasks with clearly defined activities and outputs. Task leaders are assigned to each task, to assist the WP leader in meeting the goals and deliverables of the WP. The Project leader will support the WP leaders in the implementation of all WPs, stepping in where required to meet the work plan targets. The WP leaders will define the “Quality Plan” (QP) for the work of the teams involved. This QP will define the acceptance criteria for each deliverable. These activities are part of the WP’s in terms of resources and responsibility and are conducted by the partners contractually involved in each WP. The WP Leaders control the progress of the WP and report to the MB. Possible conflicts concerning content quality of deliverables can be escalated to the MB if requested by the WP leader or other WP members.

A list of Milestones (graphically displayed in Figure 3.2) is formulated to keep track of the project progress. For the sectoral surveys carried out in WP7-12, a generic milestone rhythm is imposed, that ensures that results from all surveys can be monitored and evaluated as an integrated package. Cross-sectoral analyses will be facilitated by this synchronization of milestones.

➢ *The decision making process and conflict resolution*

The project is steered and guided following a top-down approach, while issues are raised and problems resolved in a bottom-up approach. The details of the procedures will be described in the Consortium Agreement. Its general principles are:

- The General Assembly is the ultimate decision making body.
- Unless otherwise specified, the decisions are made by the simple majority of the members. In case of equal votes, the vote of the Chairman is decisive.
- In case of a serious failing of one participant which would jeopardize the project, the GA will have the mission to expel this participant. This decision, as well as the one to include a new partner, will be made with the approval of 2/3 of the members of the GA.

The project could be affected by conflicts of various types: technical, strategic, political, shortage of resources, and others. All consortium partners should anticipate the emergence of such conflicts, and discuss the best way to fix them with the Partners. The project employs a multi-level escalation strategy. Conflicts should first be reported to WP Leaders. If not resolved at this level, problems and possible solutions are taken to be officially discussed at the Management Board level where, if necessary, a vote could take place. If no unanimous decision can be found, the MB will report the issue to the General Assembly where the final decision will be taken in a meeting moderated by the Project Leader.

Consortium Agreement

A Consortium Agreement (CA) will define and complete any points not covered by the EC Grant Agreement. The CA will be signed before the project commences. It will be based on the DESCA model. The CA includes in particular details about:

- The organisation of the consortium, as described above
- The financial distribution: the consortium agreed on distributing the Community Financial Contribution on the basis of each participant's effort and activity type
- Procedures for changes in the consortium composition
- IPR and exploitation: definition of the background brought by all participants and related access
- Rights, rules for joint ownership, access rights to project results for participants and 3rd parties
- Dissemination: rules for managing confidentiality and approving public presentations and publications.

Innovation management

IMPREX is driven by the need to improve the applicability of research findings in business and policy making practice. It recognizes the need to develop and apply innovative concepts that improve the quality of forecasts, enhance the information that can be extracted from them, and transfer the results into practice. The innovations developed in IMPREX are achieved by a range of activities, which are coordinated by the MB with supportby the CU. The innovation activities include:

- A separate workpackage (WP5) devoted to the development of new concepts. The leader of this WP (IVM) is represented in the MB, where the entire chain between development, trials and implementation is monitored and guided. The WP5 leader is optimally placed to lead the scanning of the market for further external or internal opportunities in collaboration with the SMEs and sectoral applications
- The SMEs in the consortium (FW, HKV, aDelphi and Arctik) who are experienced business partners with a strong track record of innovation development and implementation. Their experience will enhance the mutual exchange between developers and users, that requires an iterative approach, sustained involvement, and mutual understanding of technical and market limitations. Both FW and Arctik are represented in the MB, which ensures a high level monitoring and guidance of the innovation process
- IMPREX innovations such as novel techniques improving predictability, novel concepts of representing current and future hydrological risks, and novel perspectives of cross-sectoral impacts. An analysis of the technical and market aspects that form a barrier to innovation development and implementation is explicitly addressed in the sectoral (WP7-12) and cross-sectoral (WP13) surveys
- Users and developers are organised around dedicated practical sectoral surveys, where case studies serve as pilot test beds for implementation of innovation. The low level sectoral organisation around these case studies ensures optimal interaction between developers and users
- The operational services driving the technical innovations of forecasts (ECMWF, METOFFICE, SMHI, KNMI) who have a strong track record in interacting with users in the sectors addressed by IMPREX. Both at the case study level (in the sectoral user groups) and at the strategic level (in the Advisory Board), users are enabled to strongly interact with the experienced developers in the IMPREX consortium.

IPR issues regarding the innovation management are addressed in the CA.

Risk management

In a project of this size, duration, and complexity, risk management and contingency planning is important to ensure that the project strategy, operations, outcomes, and budget remain on track. The CU is in charge of defining the risks and of detecting risks. Risks will be mitigated by the MB, in order to prevent any deviation from the plans. To this end, a comprehensive risk management process and risk register will be implemented over the duration of the project. WP leaders will present an assessment of progress, and risks to progress, at the MB meetings and propose contingency plans where necessary to address any specific identified risks. The general types of risks, examples for specific risks and their mitigation covered in the risk management process are summarized elsewhere.

3.3 Consortium as a whole

The IMPREX consortium consists of a powerful combination of research institutions, operational hydro-meteological services, SMEs with a strong risk assessment and communication portfolio, governmental stakeholders and users of hydrometeorological forecasts and risk assessments in private and public entities. The consortium is arranged to optimally address the issues in the call text: improved predictability and scenarios of hydrological extremes, assessment of impacts of these extremes, and development and evaluation of risk management strategies.

ECMWF is Europe's leading institute in the development and exploitation of meteorological forecasts at short-to-medium range, with a rich history in tailoring this information to (European scale) hydrological forecasting and risk assessment systems (including JRC's flood and drought monitoring and prediction systems). Together with **METOFFICE** and **BSC** they are leading organisations in research and operation of seasonal forecasting systems, joined in various European and global collaboration programs. **KNMI, SMHI** and **TUC** have a long track record of (regional) climate research and scenario production, with a strong history in tailoring this information to sectoral applications. **Deltares**, **IVM**, **CIMA**, **UREAD** and **GfZ** are leading organisations in hydrological forecasting andmodelling, damage modelling and risk assessment, providing the essential link between meteorological forecasts and outlooks to risk damage mapping and adaptation planning.

Table 3.1: Expression of support for IMPREX documented in support letters

Stakeholder organisation	Expression
Roeland Allewijn, Director Water safety and Water use Rijkswaterstaat (Netherlands)	"The risk based water allocation approach and the probabilistic drought impact assessment in IMPREX are of great interest."
George Diktakis, General Secretary of region of Crete Greek Directorate of Rural Economy, Civil Protection & Water	"We accept your invitation to take place in the stakeholder board of IMPREX as its results are of direct relevance to us."
Robert Sanders European BIC (Business and Innovation Centres) Network	"The project will develop crucial insights in sectors of the economy with knowledge transfer potential to EU start-up and SMEs…"
Stefan Laeger UK Environment Agency	"We will follow the work on seasonal hydrological outlooks for Europe and target sectors with interest"
Jesus Garcia Martinez, Head of Planning Department Conf. Hidrográfica del Segura	"IMPREX should reveal how currently used drought indicators can be improved and how the predictions can be used to anticipate better to drought"
Tineke Cnossen, Rob Merkelbach, A. Meuleman, J Kooistra Waterboards Noorderzijlvest, Aa en Maas, Brabantse Delta, Hunze en Aa's, Netherlands	"The new approaches developed in this program will be of direct relevance to our (operational) tasks."
Francesco Puma, General Director Autorita di bacino del fiume Po	"Hydroclimatic forecasts have a great potential to better inform hydropower operation and improve strategic water management in highly variable climate conditions."
Joost Buntsma, General Director STOWA (Applied Research Water Managements)	"The development of a risk-based supply and demand protocol fits perfectly in our Deltaproof program."
Josep Lluis Armenter Aigües de Terrassa	"IMPREX is designed to reduce vulnerability to extreme events."
Jose Albaladejo Guillén Managing Director Aguas de Murcia	"EMUASA strongly believes that the project outputs have the potential to positively impact on the health and environment protection."
Paolo Pedergnana A2A trading	"Hydroclimatic forecasts have a great potential to better inform hydropower operation and improve strategic water management in a quickly evolving energy market."
Monica Bocchiardo Comune di Genova	"Fast impact assessment of flash floods is of high interest"

Javier Macián Chief of Exploitation Department Aguas de Valencia (ADV)	"ADV Júcar is very much interested in the water utilities drought risk assessment and adaptation taking into account inter-sectorial implications and integrated basin and water resources management"
Guiseppe Sgorbati/Elisabetta Trovatore, Technical/scientific director Agenzia Regionale Per l'Ambiente (ARPA) – Lombardia and Liguria	"Improved hydrological forecasts have a great potential to support irrigated agriculture in a changing climate."

The consortium is supplemented by experienced SMEs and sectoral research organisations that have extensive experience in risk assessment and adaptation in the six strategic European water sectors addressed in IMPREX: **HKV** and **FW** are SMEs with a large portfolio in servicing public and private organisations dealing with flood and drought risk, while **IRSTEA** and **CETAqua** are (semi-)public research organisations working extensively with hydropower and urban water utilities. Targeted public research organisations **BfG**, **WFN**, **POLMIL**, **UPV** and **PIK** have similarly build up a large portfolio and stakeholder network in shipping, economy and infrastructure. This targeted selection of sectoral expertise centers engage a wide range and areal coverage of affiliated end users that co-design the analyses and assessments in the sectoral surveys. **HZG** has a wide experience in linking geophysical hazard risks to perceptions and decision making by stakeholders at various levels. Participation of two additional SMEs (**Arctik** and **ADELPHI**) ensures an efficient dissemination and synthesis for a wide European audience, including business networks, European policy organisations and media.

The collection of IMPREX partners can build on a pronounced past experience in leading and executing programs designed to tailor hydrometeorological information at multiple temporal and spatial scales to user- and stakeholder specific information needs, adequately servicing risk management and decision support. Strong links exist with effective networks on hydrometeorological modelling, forecasting, and climate services.

The project structure is designed to maximise effective contact and collaboration with users and stakeholders concerned with hydrometeorological risk assessment. In each of the sectoral groups, surveys will be organized among end users, to ensure tailoring results towards end users requirements, and by stimulating commitment of users to participate in IMPREX by co-designing and applying tools and applications (see lists in each WP7-12 description and the summary of commitment and support letters in Table 3.1). In addition, potential users of this knowledge and tools are invited to participate in the workshops and exchange networks that are organized at the sectoral level (WP2).

Finally, a Science and Service Advisory board is linked to IMPREX, consisting of representatives from science, government and end-users. Committed participation in this board have been received from JRC (**Jutta Thielen**), Dutch Ministry of Infrastructure (**Gert Jan de Maagd**), The International Red Cross (risk manager **Maarten van Aalst**), CSIRO (**Penny Whetton**), Climate Services Centre (former director Prof **Guy Brasseur**) and Innovation network EBN (**Robert Sanders**). Invitations have been sent to Prof Myles Allen (Oxford Univ) and UNISDR.

3.4 Resources to be committed

The total grant requested is 7997 k€. 5763 k€ is allocated to 960 person months labor, 575 k€ is requested for other direct costs, 1585 k€ for indirect costs and 73 k€ for subcontracting.

The distribution of **person months** (PM) reflects the objectives of IMPREX to improve forecast skill across important sectoral applications whilst achieving the highest impact (Figure 3.4). The project allocates roughly 1/3 of the total person month to address fundamental scientific questions regarding hydro-meteorological improvements. The impact of these improvements is realized through allocating 1/3 to key sectoral applications and targeted improvements in 10 European case studies with defined public and private end-users. In addition, dedicated outreach, dissemination and cross sectoral integration which has allocated 17% of the person month is used to enhance the legacy of IMPREX. This is complemented by 8% of the person month to develop novel risk strategies. The remaining 5% are allocated to management. A total of 12% of the person months is allocated to European SMEs ensuring a maximum financial exploitation and economic benefit to the European Economic Community.

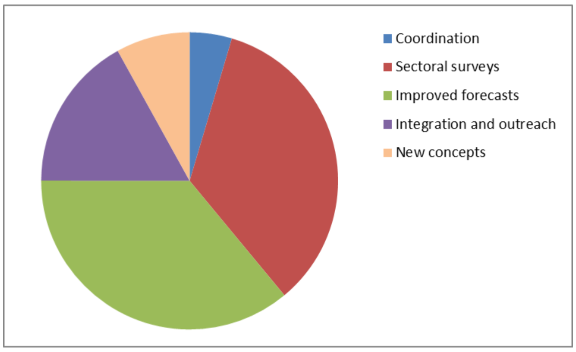

Figure 3.4: Distribution of work effort (PM) per type of activity

Other direct costs concern travels of consortium partners and members of the Advisory Board and User groups, page charges for publications, and small equipment for computing and data storage. For most partners roughly 20 k€ is dedicated to travel and small equipment. KNMI manages also the travel and workshop costs for external users, stakeholders and advisors. Finally, **subcontracting** concerns activities carried out by third parties, including laboratory services and external consultation. Table 3.2 gives an overview of the other direct cost and subcontracting. More information on subcontracts is given in Section 4.2.

Table 3.2: Justification of subcontracting and other direct costs

Partner	**Category**	**Amount**	**Justification**
KNMI	Other direct cost	112 k€	Travel and per diem for users, stakeholders, advisors and KNMI staff (average 4 meetings, 25 persons, 800 – 1200 € per trip)
Arctik	Other direct cost	48 k€	Design and hosting of interactive website
Future Water	Subcontracting	10 k€	Advisory role of Prof W Bastiaanssen on Water Accounting system
AquaTEC	Subcontracting	17 k€	Water quality analyses

4. Members of the consortium

4.1 Participants (applicants)

➢ *1. KNMI*

The Royal Netherlands Meteorological Institute (KNMI) is the national research and information centre for weather, seismology, climate and climate change in the Netherlands. KNMI has a long tradition in operational and scientific activities. Climate research at KNMI aims at observing, understanding and predicting changes in the climate system. KNMI produces climate scenarios to support stakeholders for developing adaptation and mitigation strategies. KNMI has initiated the development of the global climate model EC-Earth and has been a leading partner in the consortium ever since.

KNMI will lead the project, exploiting the wide expertise it has with matching users' requests for climate information with scientifically based assessments of (regional) climate change, and the interplay between climate and (extreme) weather. KNMI will also develop and apply techniques to quantify the role of compounding extreme weather events that challenge current and future society safety and economic operation (WP3, 5 and 7).

Curriculum vitae of persons involved in research and/or innovation activities

Prof. Bart van den Hurk (M) is head of the Modelling R&D division of KNMI, and holds a chair at VU University Amsterdam. His main expertise is on diagnosing and understanding land-atmosphere interaction, developing climate scenarios for the Netherlands, and interpretation of complex climate information for society stakeholders. He coordinated an EU and national climate research projects.

Dr Geert Lenderink (M) Dr. Geert Lenderink is senior scientist at the Modelling R&D division of KNMI. His research fields include modeling of clouds and turbulence, regional climate modeling and analysis, and the production of climate scenarios. Presently he investigates how small scale precipitation extremes could evolve in the future climate using observations, climate models and atmospheric mesoscale models. He is/has been involved in many EU and national projects, including WP coordinator in the EU projects ENSEMBLES and IMPACT2C.

Publications, products, services or other relevant achievements

Van den Hurk, B., Geert Jan van Oldenborgh, Geert Lenderink, Wilco Hazeleger, Rein Haarsma and Hylke de Vries, 2014. Drivers of mean climate change around the Netherlands derived from CMIP5; Climate Dynamics, **42**, 1683-1697; DOI: 10.1007/s00382-013-1707-y

Van den Hurk, B., A. Klein Tank, C. Katsman, G. Lenderink, and A. te Linde, 2013. Vulnerability Assessments in the Netherlands Using Climate Scenarios. Climate Vulnerability: Understanding and Addressing Threats to Essential Resources. Elsevier Inc., Academic Press, 257–266 pp.

Van den Hurk, B.J.J.M., A.M.G. Klein Tank, G. Lenderink, A. van Ulden, G.J. van Oldenborgh, C. Katsman, H. van den Brink, F. Keller, J. Bessembinder, G. Burgers, G. Komen, W. Hazeleger and S. Drijfhout, 2007. New climate change scenarios for the Netherlands; Water Science and Technology, 56, 4, 27-33, doi:10.2166/wst.2007.533.

Lenderink, G. & E. van Meijgaard, 2010. Linking increases in hourly precipitation extremes to atmospheric temperature and moisture changes. Environmental Research Letters, 2, 5, 025208, doi:10.1088/1748-9326/5/2/025208.

Lenderink, G., E Van Meijgaard, 2008. Increase in hourly precipitation extremes beyond expectations from temperature changes. Nature Geoscience 1 (8), 511-514.

Lenderink, G., A van Ulden, B van den Hurk, F Keller, 2007. A study on combining global and regional climate model results for generating climate scenarios of temperature and precipitation for the Netherlands. Climate Dynamics 29 (2-3), 157-176.

Lenderink, G., HY Mok, TC Lee, GJ Van Oldenborgh, 2011. Scaling and trends of hourly precipitation extremes in two different climate zones–Hong Kong and the Netherlands. Hydrology and Earth System Sciences 15 (9), 3033-3041.

Previous projects or activities

- KNMI'14 climate change scenarios for The Netherlands (www.klimaatscenarios.nl): new climate change scenarios for many Dutch stakeholders
- EUPORIAS: Development of climate services to maximize the social benefit of new coping technologies
- IMPACT2C: Quantifying projected impacts under 2°C warming. Collaborative project/Large-scale integrating project, FP7-ENV-2011 (2011-2015)

- Climate Changes Spatial Planning: targeted Dutch research program developing novel climate information tools, sectoral surveys and communication protocols (http://knowledgeforclimate.climateresearchnetherlands.nl/)

Significant infrastructure and/or technical equipment

- EC-Earth (ecearth.knmi.nl): European consortium climate model, participating in the IPCC climate change assessments and used for generating tailored (high resolution) climate information products

2. ECMWF

The European Centre for Medium-Range Weather Forecasts (ECMWF) is an international organisation supported by 32 States: 18 Members (Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Norway, Austria, Portugal, Switzerland, Finland, Sweden, Turkey, United Kingdom) and 14 Co-operating Members (Bulgaria, Czech Republic, Montenegro, Estonia, Croatia, Iceland, Latvia, Lithuania, Hungary, Morocco, Romania, Serbia, Slovenia and Slovakia). ECMWF's principal objectives are the preparation, on a regular basis, of medium-range and long-range weather forecasts for distribution to the meteorological services of the Member States, the development of scientific and technical research directed to the improvement of these forecasts, and the collection and storage of appropriate meteorological data. ECMWF's computer facility includes supercomputers, archiving systems and networks.

ECMWF is an active participant in GEO. In particular, ECMWF has played a leading role in the development and implementation of the TIGGE project (GEO task WE-06-03): ECMWF hosts the international TIGGE and TIGGE-LAM website and archive at http://tigge.ecmwf.int/. Through this portal researchers have access to the full TIGGE archive (500 Tb) of weather forecast information from 10 global weather forecast producing centres, including the ECMWF ensemble prediction system. A key goal of ECMWF's strategy is to develop new global, medium-range weather forecasting products, with particular emphasis on early warnings of severe weather; ECMWF has already developed a number of new such products for its Member States. ECMWF has been active in several research activities using the TIGGE data including for severe weather and for multi-disciplinary applications including hydrology. ECMWF participates in the WMO Severe Weather Forecast Demonstration Project (SWFDP) as a Global Centre providing products with a focus on early warning for severe weather. ECMWF is closely involved with data and metadata standards and is represented on relevant WMO Expert Teams; it is a member of the Open Geospatial Consortium (partner of MetOcean Domain Working Group). ECMWF is also the operational center for the European and Global Flood Awareness System (EFAS and GLOFAS) and executes forecasts and hosts the EFAS-Information System platform. EFAS is financed by Copernicus providing medium range flood warnings in Europe in support of the European Community. GLOFAS (http://www.globalfloods.eu) provides global flood warnings which are used by various stakeholders such as the Red Cross, the World Food Program, the European Emergency Response Coordination Centre (ERCC) and many other national agencies. GLOFAS is pre-operational.

ECMWF provides the results from operational forecast activities to Member States and Co-operating States, the members of the WMO and the public. ECMWF products include current forecasts, climate reanalyses and specific datasets. These are available via the web, point-to-point dissemination, data servers and broadcasting. All ECMWF’s operational forecasts aim to assess the most likely forecast and also the degree of confidence one can have in that forecast. To do this the Centre carries out an ensemble of predictions which individually are full descriptions of the evolution of the weather, but collectively they assess the likelihood or probability of a range of possible future weather.

In IMPREX, ECMWF will lead WP4, produce hydrological hind casts using the EFAS (European Flood Alert System) and EDO (European Drought Observatory) systems. Improve and provide meteorological forecasts as well as a multi-model study to improve inputs to sectoral applications.

Curriculum vitae of persons involved in research and/or innovation activities

Florian Pappenberger (male): he is a principal scientist at ECMWF responsible for a team working in the area of applications of Numerical Weather Predictions including fire, droughts, malaria, energy and floods. He also leads the computational centre of the European Flood Awareness System, responsible for all operational aspects of these medium range flood forecasts. He is a Guest Professor at Hohai University (Nanjing, China) and University of Bristol (Bristol, United Kingdom). His expertise in flood forecasting, hydrological modelling and uncertainty analysis is documented in over 80 publications in international peer reviewed journals and book chapters. His awards include the Arne Richter Award for Outstanding Young Scientists from the European Geosciences Union for his work on Hydrological Ensemble Predictions and the Outstanding Editor Award of the Hydrology and Earth System Sciences Journal. He is part of the EFAS team which received the IES Excellence Award for 'Support to EU Policy' (a European Commission award). He has consultant for the Environment Agency of England and Wales on probabilistic flood forecasting and also works with Industry partners. Until recently, he was also co-chair of the international Hydrological Ensemble Prediction Experiment (HEPEX, www.hepex.org). Florian has led several large European projects on water scarcity and drought predictions (DEWFORA, GLOWASIS), developing a risk culture for Europe (KULTURISK) and European and global flood forecasting (GloFas, EFAS). He also works on global river modelling, ensemble verification and the impact of the uncertainty in land surface processes on seasonal predictions.

Fredrik Wetterhall (male): he is a researcher in the Ensemble Prediction Section at ECMWF. He has large experience in hydrological modelling, hydro-meteorological weather forecasting, precipitation interpolation and downscaling and hydrological impact studies. He did his PhD at Uppsala University and has since then worked as a hydrological researcher at SMHI and worked as post doc at King's College London before joining ECWMF in 2011. During these years he has worked on the FP7 projects DEWFORA, KULTURisk and GLOWASIS and is currently leading the research on the European flood Awareness System (EFAS) at ECMWF. This works includes hydrological model development, verification, post-processing and interaction with the EFAS user community through bimonthly bulletins. He has written over 30 peer-reviewed publications in international journals. Currently, he is co-editor of Theoretical and Applied Climatology and co-chair of the Hydrological Ensemble Prediction Experiment (HEPEX, www.hepex.org).

Emanuel Dutra (male) is a land surface modeller with expertise in the representation of snow, lakes, river routing and soil moisture in land surface models coupled to the atmosphere working at ECMWF and is currently involved in the EU project earth2observe dealing with water resources. In the past was involved in the EU projects GLOWASIS and DEWFORA, focusing on the development of water scarcity indicators.

Gianpaolo Balsamo (male) is a senior scientist working in the model physics section at ECMWF interested in land surface modelling and data assimilation in Numerical Weather Prediction (NWP, interaction of water, energy, carbon over land in Earth System Science (ESS)and global land-atmosphere predictability studies.

Ervin Zsoter (male): he is a scientific analyst in the Evaluation Section at ECMWF. He has large experience in weather forecasting, forecast product development, verification and generally in developing forecast applications. He had worked for the Hungarian Meteorological Service for many years on operational forecasting, automated forecast generation and various forecast verification projects. During his years at ECMWF he worked on product development and verification, such as the Extreme Forecast Index, and in recent years he has contributed to the FP7 European project GEOWOW (GEOSS interoperability for Weather, Ocean and Water) where he has conducted the multi-disciplinary application of modelling of river discharge based on TIGGE ensemble forecasts.

Publications, products, services or other relevant achievements

1. **Relevant publications:**

Zsoter, E., Pappenberger, F. and Richardson, D., 2014, Sensitivity of model climate to sampling configurations and the impact on the Extreme Forecast Index. Met. Apps. doi: 10.1002/met.1447

Dale, M., Wicks, J., Mylne, J., **Pappenberger, F.**, Laeger, S., 2014, Probabilistic flood forecasting and decision-making: an innovative risk-based approach, Natural Hazard, 70(1), 159-172, 10.1007/s11069-012-0483-z

Wetterhall, F., Pappenberger, F., Alfieri, L., Cloke, H. L., Thielen-del Pozo, J., Balabanova, S., Daňhelka, J., Vogelbacher, A., Salamon, P., Carrasco, et al..: HESS Opinions "Forecaster priorities for improving probabilistic flood forecasts", Hydrol. Earth Syst. Sci., 17, 4389-4399, doi:10.5194/hess-17-4389-2013, 2013

Pappenberger, F., Stephens, E., Thielen, J., Salamon, P., Demeritt, D., van Andel, S. J., **Wetterhall, F.** and Alfieri, L., 2013, Visualizing probabilistic flood forecast information: expert preferences and perceptions of best practice in uncertainty communication. Hydrol. Process., 27: 132–146. doi: 10.1002/hyp.9253

Balsamo, G., Pappenberger, F., Dutra, E., Viterbo, P. and van den Hurk, B. (2011) A revised land hydrology in the ECMWF model: a step towards daily water flux prediction in a fully-closed water cycle. Hydrological Processes 25(7), 1046-1054

2. **Products:** TIGGE, the THORPEX Interactive Grand Global Ensemble, is a key component of THORPEX: a World Weather Research Programme to accelerate the improvements in the accuracy of 1-day to 2 week high-impact weather forecasts for the benefit of humanity. The TIGGE archive consists of ensemble forecast data from ten global NWP centres, starting from October 2006, which has been made available for scientific research. TIGGE has become a focal point for a range of research projects, including research on ensemble forecasting, predictability and the development of products to improve the prediction of severe weather. The TIGGE project is overseen by the GIFS-TIGGE working group, which includes representative of the TIGGE data providers and the TIGGE archive centres. TIGGE-LAM is an extension of the TIGGE archive to include Local Area models.
3. **Services:** Magics++ and Metview: Magics++ is the latest generation of the ECMWF's Meteorological plotting software Magics. This object-oriented software supports the contouring of fields, plotting of wind fields, observations, satellite images, symbols, text, axis and graphs (including boxplots). Magics can visualise various formats, for instance GRIB 1 and 2 code data, gaussian grid, regularly spaced grid and fitted data. GRIB data is handled via ECMWF's GRIB API software. Input data can also be in BUFR and NetCDF format or retrieved from an ODB database. Magics can produce plots in various formats, such as PostScript, EPS, PDF, GIF, PNG and SVG. It offers several user programming interfaces (Fortran, C, but also python). Its object-oriented approach makes it easy to learn and use. Metview is a meteorological workstation application designed to be a complete working environment for both the operational and research meteorologist. Its capabilities include powerful data access, processing and visualisation. It features a powerful icon-based user interface for interactive work, and a scripting language for batch processing. Metview can take input data from a variety of sources, it offers powerful data filtering and processing facilities and use Magics to visualise the results.
4. **Packages:** ecFlow is a work flow package that enables users to run a large number of programs (with dependencies on each other and on time) in a controlled environment. It provides reasonable tolerance for hardware and software failures, combined with good restart capabilities. It is used at ECMWF to around half our operational suites across a range of platforms. ecFlow submits tasks (jobs) and receives acknowledgements from tasks when they change status and when they send events. It does this using using child commands embedded in the scripts. ecflow stores the relationship between tasks and is able to submit tasks dependent on triggers.

Previous projects or activities

- **GEOWOW** – The GEOSS Interoperability for Weather, Ocean and Water is a project co-funded under the European Community's Seventh Framework Programme FP7/2007-2013. GEOWOW's challenge is to improve Earth Observation data discovery, accessibility and exploitability, and to evolve the Global Earth Observation System of Systems (GEOSS) for the benefit of all Societal Benefit Areas (SBAs) with particular focus on Weather, Ocean Ecosystems and Water.
- **EFAS & GloFAS** - The European Flood Awareness System (EFAS), developed to produce European overviews on ongoing and forecasted floods, contributes to better protection of the European Citizen, the environment, property and cultural heritage in support to the EU Mechanism for Civil Protection. Since 2012 EFAS is an operational service under the umbrella of the Copernicus emergency management service and run by Member States organisations. The Global Flood Awareness System (GloFAS), jointly developed by the European Commission and the European Centre for Medium-Range Weather Forecasts (ECMWF), couples state-of-the art weather forecasts with a hydrological model and with its continental scale set-up it provides downstream countries with information on upstream river conditions as well as continental and global overviews. GloFAS produces daily flood forecasts in a pre-operational manner since June 2011.

- **DEWFORA** - Drought Early warning and Forecasting to strengthen preparedness and adaptation in Africa is a collaborative project (2011 to 2013) that aimed at developing a framework to help institutions in African countries reduce vulnerability and strengthen preparedness to droughts.
- **GLOWASIS** - Global Water Scacity Information Service was a collaborative European FP7 project aimed at pre-validation of a GMES Global Water Scarcity Information Service. GLOWASIS provided open data on water scarcity and made use of data from GMES Core Services Land and Ocean.
- **Earth2Observe** - Global Earth Observation for Integrated Water Resource Assessment is a collaborative project funded under the DG Research FP7 programme (2014-2017). The overall objective is to contribute to the assessment of global water resources through the use of new Earth Observation datasets and techniques. The project will integrate available earth observations, in-situ datasets and models, to construct a consistent global water resources reanalysis dataset of sufficient length (at least 30 years). The resulting datasets will be made available through an open Water Cycle Integrator data portal: the European contribution to the GEOSS/WCI approach. The datasets will be downscaled for application in case-studies at regional and local levels, and optimized based on identified European and local needs supporting water management and decision making.

Significant infrastructure and/or technical equipment

- **SOS server for river discharge forecasts**: In the context of European FP7 project GEOWOW a dedicated data server was installed at ECMWF to support the provision of the modelled TIGGE ensemble river discharge data. The data provision is managed through an instance of the OGC (Open Geospatial Consortium) Sensor Observation Service provided by one of the project partners (52north). This web service aggregates readings from live, in-situ and remote sensors. The service provides an interface to make sensors and sensor data archives accessible via an interoperable web based interface using the OGC WaterML data standard. The system at ECMWF is set-up by using these OGC standards to support the interoperable storage and acquisition of ensemble type (where not just one but many time series represent a data unit) discharge data from TIGGE in GEOWOW and also other sources like the GloFAS system (Global Flood Awareness System - developed jointly by the European Commission and ECMWF).
- **ECMWF's Meteorological Archive and Retrieval System (MARS)** is the software used to manage the Centre's archive of meteorological data and to provide access to the data. It has two main components, the MARS Server and the MARS Client. Some of the features of the MARS system are: provides facilities to archive and retrieve meteorological data; MARS holds Terabytes of data, mainly using GRIB format for meteorological fields and BUFR format for meteorological observations; for large archives, MARS needs a tape management system for off-line storage. Current tape management systems supported are Tivoli Storage Manager (TSM), High Performance Storage System (HPSS), Veritas, VolCentre; provides monitoring facilities for operators and administrators;enables easy archive and retrieval access via a pseudo-meteorological language; batch and interactive modes are supported, including web access; supports large amounts of data, both in volume and number of items stored; supports a large number of users with differing requirements, e.g. retrieving large data sets occasionally or small data sets at frequent intervals; (Details: http://old.ecmwf.int/products/data/software/mars.html). The grib_api is the application program interface developed at ECMWF to provide an easy and realiable way for encoding and decoding WMO FM-92 GRIB edition 1 and edition 2 messages. With the grib_api library, that is written entirely in C, some command line tools are provided to give a quick way to manipulate grib data. Moreover a Fortran 90 interface is available giving access to the main features of the C library.

3. SMHI

SMHI is a government agency under the Swedish Ministry of Environment offering products to support decision-making in the environmental sector. SMHI is responsible for national meteorological, hydrological and oceanographic forecasting and the production of climate change projections. The main fields of research include weather and climate modelling, data assimilation, hydrology, oceanography and air quality. Climate research is a cross departmental activity, with all six research sections contributing to the development of climate projections, impact assessments and communication with stakeholders, regional authorities and major utilities. SMHI's role in IMPREX is to advance short term prediction systems, to participate in the outlook activity, and to generate improved climate scenarios in increased resolution, targeting a better representation of the water cycle.

Curriculum vitae of persons involved in research and/or innovation activities

Dr. Ralf Döscher (M) is Science Coordinator of the Rossby Centre with a background in coupled climate modelling. Currently Ralf is chair of the EC-Earth Earth System Model consortium. Recent research activities cover studies of climate processes by regional downscaling, climate prediction and ESM development. Ralf co-coordinated the EU project DAMOCLES. He is also involved in a range of national and international projects and networks, such as FP7 EMBRACE and ADSIMNOR.

Prof. Erik Kjellström (M) is head of Rossby Centre and member to the Bolin Centre for Climate Research at Stockholm University. Erik has a background in short term forecast and a strong record in regional climate model analysis. Recent studies focus on high resolution representation of precipitation in regional climate models. Erik is involved in the EU projects HELIX, ECLISE and IMPACT2C.

Dr. David Gustafsson (M) is a Research Scientist in the Hydrology Research Unit at SMHI. David has a background in modelling cold climate hydrological processes, and is now working with in-situ and satellite data assimilation in hydrological models. He is currently involved in the EU projects CryoLand.

Dr. Tomas Landelius (M) is a Research Scientist in the Atmospheric remote sensing Research Unit at SMHI. Tomas has a background in multidimensional signal processing and is now working with reanalysis and satellite data assimilation within the HIRLAM consortium. He is currently involved in the EU projects UERRA and DNIcast.

Dr. Magnus Lindskog (M) is a Research Scientist in the Meteorological Research Unit at SMHI. His main expertise is in data assimilation for numerical weather prediction. He has been involved in several national and international projects and networks. At present Magnus is a Swedish representative in the COST ES1206 project. He is furthermore involved in the EU project DNIcast and in the international HIRLAM project.

Mr. Göran Lindström (M) is a Research Scientist in the Hydrology Research Unit at SMHI. Göran has long experience from development and applications of hydrological models, primarily the HBV and HYPE models. He also works with operational flood forecasting at the SMHI.

Publications, products, services or other relevant achievements

Michelson, D. B., C. G. Jones, **T. Landelius**, C. G. Collier, G. Haase, and M. Heen. "Down-to-earth" modelling of equivalent surface precipitation using multisource data and radar. Q. J. R. Meteorol. Soc. Part A, 131(607):1093-1112, April 2005.

Lindskog, M., Gustafsson N. and Mogensen, K., 2006. Representation of background error standard deviations in a limited area model data assimilation system. Tellus, 58A, 430-444.

Berg, P**., Döscher, R.**, and Koenigk, T.: Impacts of using spectral nudging on regional climate model RCA4 simulations of the Arctic, Geosci. Model Dev. Discuss., 6, 495-520, doi:10.5194/gmdd-6-495-2013, 2013.

Lindstedt, D., Lind, P., Jones, C. and **Kjellström, E.,** 2014. A new regional climate model operating at the meso-gamma scale; performance over Europe. Submitted to Tellus.

Pechlivanidis, I., Bosshard, T., Spångmyr, H., **Lindström, G., Gustafsson, D.,** and Arheimer, B. (2014) Uncertainty in the Swedish Operational Hydrological Forecasting Systems. Vulnerability, Uncertainty, and Risk: pp. 253-262. doi: 10.1061/9780784413609.026

Previous projects or activities

- Coordination of the ***FP7 EMBRACE*** project which aims to make targeted improvements to key process failings in present-day Earth System Models (ESMs) to reduce systematic biases.
- Participation in **CryoLand**, which developing methods for integration of in-situ and satellite based snow and ice information in hydrological models.

- Participation in ***FP7 SPECS & EUPORIAS***, focused on climate prediction on seasonal to decadal timescales which aims to develop and deliver reliable predictions of future climate to public and private stakeholders.
- ***UERRA,*** where an ensemble system of regional (Europe) reanalyses will be developed and run for the climatological time scale (30-50 years). Further downscaled high-resolution reanalyses will also be performed where more near surface ECV observations can be utilized.
- ***DNICast,*** where SMHI will develop data assimilation methods for very short range NWP forecasts to help operate power plants with concentrating solar technologies. Forecasts are needed to yield a better management of the plants thermodynamic cycle and to optimally connect the electricity production to the grid.

Significant infrastructure and/or technical equipment

- SMHI is the central hub for development of the current version of EC-EARTH European consortium climate model, participating in the IPCC climate change assessments and used for generating tailored (high resolution) climate information products.
- SMHI operates the Swedish ESGF date node jointly with the National Supercomputing Centre.
- SMHI hosts the International Project Office for CORDEX (IPOC), coordinating planning, data handling and outreach of the Coordinated Regional Climate Downscaling Experiment (CORDEX).
- SMHI disposes high-performance computing facilities for regional and global climate climate modelling

4. IRSTEA

IRSTEA (Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture - National Research Institute of Science and Technology for Environment and Agriculture; formerly Cemagref) is a national, public institute in France. It has 1600 employees, working in 9 centres in France, within 25 research units. Its activities focus on scientific and technological research in the areas of environment, land management, water risks and natural disasters. It is an institute in joint supervision with the Ministry of Research and the Ministry of Agriculture and is holder of an agreement with the Ministry of Ecology. IRSTEA has built a multidisciplinary and systemic approach to three domains – water, environmental technologies and land – which today form the basis of its strength and originality. The institute boasts a dual culture of researchers and engineers, who tackle environmental matters from three angles: research, innovation and expertise. It was awarded the 5-year label 'Institut Carnot' in 2006, renewed in 2011, by the French Government, which recognizes IRSTEA's commitment to work with industry, notably SMEs, to improve business practices and economic impacts through open innovation.

IRSTEA researchers participating to IMPREX have large experience with the development of hydrometeorological ensemble predictions for operational systems in flood and drought forecasting, as well as water management. In IMPREX, IRSTEA will lead the hydropower sectorial survey in WP8, coordinating the actions under this case-study among the different partners involved. It will also contribute to developments on hydrological modelling and forecast verification in WP4.

Curriculum vitae of persons involved in research and/or innovation activities (all scientists mentioned below are permanent staff, civil servants, working for IRSTEA)

Dr. Maria-Helena Ramos (female) is a senior scientist in hydrology and hydrometeorology, with large experience in ensemble prediction, flood forecasting, uncertainty quantification and communication. She is employed by IRSTEA as research scientist since 2007. She coordinates the research activity in hydrologic ensemble prediction at IRSTEA and has supervised over 20 master's and PhD students. She has participated to national and international projects, including national SCHAPI-MEDDE programs on flood forecasting, EU DG JRC EFAS Project (European Flood Awareness System), EU FP7 XEROCHORE, and currently EU FP7 COMPLEX (2012-2016) and FASEP-Brazil project on urban floods (2013-2015). She is also the coordinator for IRSTEA of the Interreg IVB NW DROP project (2013-2015) on drought governance and adaptation. Since 2009, she has worked on reservoir inflow forecasting and management for hydropower production, with collaborations with EDF Electricité de France and Hydro-Québec (Canada). Since June 2014, she is co-chair of the international initiative HEPEX, Hydrologic Ensemble Prediction Experiment.

Dr. Guillaume Thirel (male) is a scientist in hydrology and hydrometeorology, with experience in ensemble prediction, flood forecasting, data assimilation, remote sensing, and impact of human and climate change on surface hydrology. He is employed by IRSTEA as research scientist since 2012. He coordinates the research activity in climate change impact on surface hydrology at the Hydrology Group of Irstea in Antony. He has participated to national and international projects, including national SCHAPI-MEDDE programs on flood forecasting, GICC-MEDDE funded R²D² (Risk, Water Resources and Sustainable management of the River Durance, France, in 2050), EU DG JRC EFAS Project (European Flood Awareness System), and the Era-Net FP6 IWRM-Net ClimAware (Impacts of climate change on water resources management – regional strategies and European view) project.

Dr. Carina Furusho (female) is a research engineer in hydrology. She is employed by IRSTEA since June 2012. She develops applied research on flood forecasting and impact assessment of urbanizing areas. She has worked for the national French projects AVuPUR (Assessing the Vulnerability of Peri-Urban Rivers, ANR 2008-2011) and VegDUD (Role of vegetation in sustainable urban development - an approach related to climatology, hydrology, energy management and ambiances, ANR 2010-2013). Currently, she is involved in national SCHAPI-MEDDE programs on flood forecasting, the Interreg IVB NW DROP project (2013-2015) and the FASEP-Brazil project on urban floods (2013-2015).

Publications, products, services or other relevant achievements

Bourgin, F., **M.-H., Ramos, G., Thirel**, V., Andréassian (2014): Investigating the interactions between data assimilation and post-processing in hydrological ensemble forecasting, Journal of Hydrology, DOI: 10.1016/j.jhydrol.2014.07.054.

Ramos, M.H., van Andel, S.J., Pappenberger, F. (2013): Do probabilistic forecasts lead to better decisions? Hydrol. Earth Syst. Sci., 17: 2219-2232.

Ramos, M. H., Mathevet, T., Thielen, J., F. Pappenberger (2010): Communicating uncertainty in hydro-meteorological forecasts: mission impossible? Meteor. Appl., 17, 223-235.

Thirel G., E. Martin, J.-F. Mahfouf, S. Massart, S. Ricci, F. Regimbeau, F. Habets (2010): A past discharge assimilation system for ensemble streamflow forecasts over France – Part 2: Impact on the ensemble streamflow forecasts, Hydrol. Earth Syst. Sci., 14, 1639-1653.

Thirel G., F. Rousset-Regimbeau, E. Martin, F. Habets (2008): On the Impact of Short-Range Meteorological Forecasts for Ensemble Streamflow Predictions, Journal of HydroMeteorology, 9, 1301–1317.

Previous projects or activities

- EU FP7 COMPLEX (Knowledge based climate mitigation systems for a low carbon economy, 2012-2016): uncertainty analysis of climate scenarios and their impact on climate-related renewable energy production systems, including hydropower (in collaboration with EDF and SINTEF hydropower companies)
- EDF DTG Grenoble-IRSTEA (2009-2013): development of a heuristic optimization model for the management of reservoir inflows based on hydrometeorological ensemble forecasts.
- Era-Net FP6 IWRM-Net ClimAware (Impacts of climate change on water resources management – regional strategies and European view, 2011-2013): development of a semi-distributed hydrological model for the River Seine basin, including a reservoir-rules management system, to mitigate hydrological extremes.
- GICC-MEDDE funded R²D² (Risk, Water Resources and Sustainable management of the River Durance, France, in 2050, 2011-2013): development of an evaluation protocol to assess the performances of several hydrological models used under changing conditions and understand the impact of climate change on water resources under stress (drinking water, environmental, power electricity and agricultural uses).
- Interreg IVB NEW DROP Project (Benefit of governance in DROught adaPtation, 2013-2015): development of a drought forecasting and reservoir management tool based on ensemble predictions to improve water supply management in the Arzal Dam in Brittany.

5. PIK

The **Potsdam Institute for Climate Impact Research (PIK)**, founded in 1992, is a non-profit research institute addressing crucial scientific questions in the fields of global change, climate impacts and sustainable development (website: www.pik-potsdam.de). At PIK, researchers in the natural and social sciences from all over the world work closely together to study global change and its impacts on ecological, economic and social systems. Researchers examine the earth system's capacity for withstanding human interventions and devise strategies and options for a sustainable development of humankind and nature. Interdisciplinary and solution-oriented approaches are a distinctive characteristic of the institute and research is undertaken by scientists from the following research domains: Earth System Analysis, Climate Impacts and Vulnerabilities, Sustainable Solutions and Transdisciplinary Concepts & Methods. Modelling is the basis and the heart of PIK's scientific work and reputation, and the institute develops and uses a significant number of globally renowned and complex computational models which allow its scientists to assess many aspects of climate and global change phenomena. PIK will contribute its expertise toWP12 by providing projections of direct impacts on economic productivity from future floods as well as estimating indirect flood damages.

Curriculum vitae of persons involved in research and/or innovation activities

Prof. Anders Levermann (M) is Professor of the Dynamics of the Climate System at the University of Potsdam and Co-Chair of Research Domain III – Sustainable Solutions at the Potsdam Institute. From 2010 to 2013 he was lead author of chapter 13, "Sea Level Change" of the IPCC's Fifth Assessment Report (AR5). Since 2012 he leads the flagship activity on global adaptation strategies at the Potsdam Institute. His research expertise covers sea-level change, dynamics of the climate system and the computation of the impacts of climate change on the global infrastructure and supply network as well as the associated costs. He is the scientific director of the web data portal, zeean, that collects and harmonizes global economic flow data.

Dr. Katja Frieler (F) is Deputy Chair of Research Domain II - Climate Impacts and Vulnerabilities at PIK. As a senior researcher she heads the ISI-MIP project since 2012. Since 2013 she leads the development of the impact emulator EXPACT as well as the work package "Biophysical Impacts" within the EU-Project HELIX. Her research focuses on the development of impact emulators that allow for probabilistic projections of regional climate changes as well as on changes in the occurrence of extreme events in terms of global mean temperature change.

Publications, products, services or other relevant achievements

A. Levermann (2014): Climate economics: Make supply chains climate-smart, Commentary in Nature, 506, 27-29, doi: 10.1038/506027a

Frieler, K., Meinshausen, M., Golly A., Mengel, M., Lebek, K., Donner, S., Hoegh-Guldberg, O. (2012): Limiting global warming to 2°C is unlikely to save most coral reefs, Nature Climate Change, 3, 165-170.

Frieler, K., Meinshausen, M., Mengel, M., Braun, N., Hare, W. (2012): A scaling approach to probabilistic assessment of regional climate change, Journal of Climate, 25, 9, 3117-3144.

Frieler, K., is leading the ISI-MIP ESGF Portal which provides global projections of runoff from 1971 to 2100 from 11 global hydrological models based on climate projections of 5 different global climate models (GCMs) using 4 different GHG concentration scenarios (RCPs).

I. Linkov, T. Bridges, F. Creutzig, J. Decker, C. Fox-Lent, W. Kröger, J.H. Lambert, **A. Levermann**, B. Montreuil, J. Nathwani, R. Nyer, O. Renn, B. Scharte, A. Scheffler, M. Schreurs,T. Thiel-Clemen (2014): Changing the Resilience Paradigm, Nature Climate Change, 4, 407-409, doi: 10.1038/nclimate2227

J. Hinkel, D. Linke, A.T. Vafeidis, M. Perrette, R.J. Nicholls, R. Tol, B. Marzeion, X. Fettweis, C. Ionescu, **A. Levermann** (2014): Coastal flood damage and adaptation costs under 21st century sea-level rise, Proceedings of the National Academy of Sciences 111, 3292-3297, doi: 10.1073/pnas.1222469111

Previous projects or activities

- **ISI-MIP** (www.isi-mip.org): The **I**nter-**S**ectoral **I**mpact **M**odel **I**ntercomparison Project (funded by BMBF), is the most comprehensive global climate impact assessment in recent times. This community-driven modelling effort brings together impact models across sectors and scales to create consistent and comprehensive projections of the impacts of different levels of global warming.

- The **ISI-MIP Fast Track** (April 2012 until March 2014, 1.319.944 € funded by BMBF, PT DLR) provided outcomes for the IPCC's Fifth Assessment Report (AR5) spanning five sectors across human society and the natural world (agriculture, water, ecosystems, infrastructure and health).
- **ISI-MIP2** (April 2014 until December 2015, 893.275 € funded by BMBF, PT DLR) will include modelling intercomparison efforts in fisheries, permafrost, biodiversity and energy, as well as those sectors already covered in the Fast Track.
- **HELIX** (http://helixclimate.eu/home): The FP7 project High-End cLimate Impacts and eXtremes focuses on 2, 4 and 6 °C land and coastal impacts and their consequences for food, water security, energy security, flooding, infrastructure, ecosystems, health, migration, and risk of conflict. PIK leads WP4 to systematically estimate the range of potential biophysical impacts associated with 2°C, 4°C and 6°.
- **EXPACT** "Where to stop? Efficient Projections of correlated impacts at different levels of global warming" Development of an efficient, probabilistic Emulator of climate eXtremes and their imPACTs, providing unprecedented, spatially correlated projections of the repercussions of different GMT changes; July 2013 until June 2016, 969.600 € funded by WGL: Pact for Research and Innovation - Funding Line 5: Women in academic leadership positions.
- **PROGRESS** (www.earth-in-progress.de): Potsdam Research Cluster for Georisk Analysis, Environmental Change and Sustainability; 2009-2014, funded by Eastern German excellence initiative with a funding volume of 13 million €; Coordinating role for climatic and hydrological part since application phase in 2008.

Significant infrastructure and/or technical equipment

- PIK operates a high performance cluster computer for scientific calculations (numerical simulation experiments). (2.560 CPU cores for batch processing, provided 50% machine utilization about 12 Mio. CPU hours can basically be delivered to scientific applications every year)
- ISI-MIP ESGF Node (http://esg.pik-potsdam.de/esgf-web-fe/)

6. ARCTIK

ARCTIK S.P.R.L. is a Brussels-based PR, communications and evaluation consultancy, which specialises in European affairs and sustainability. Arctik provides strategic and innovative communication solutions to European institutions and other actors, enabling them to communicate messages, stimulate constructive dialogues and help them evaluate their impacts.

Founded in 2011, ARCTIK offers a wide variety of services to meet all communications needs. The company boasts specialist expertise in a range of areas, including: networking activities; designing and producing communication tools; as well as the logistical management and co-ordination of conferences and events. ARCTIK has a proven track record of delivering tangible results for actors across the European Union.

Curriculum vitae of persons involved in research and/or innovation activities

Cédric Hananel (M) - Director - Brussels

Cédric is the managing director of ARCTIK.

For the past 10 years, Cédric has overseen a number of communications strategies on behalf of the European Commission and has been involved in the creation, development, implementation and evaluation of a range of EC campaigns on environment, energy, climate change and natural hazards.

He has experience and knowledge of EU environmental and energy policies in the fields of eco-innovation, cleantech and resource efficiency. He is specialized in stakeholders and networks' engagement and institutional communication as well as creating conferences and seminars in the area of innovation at European level. Cédric also has a strong experience in managing funded projects and evaluation. He holds a Master in Sociology from the University of Louvain (Belgium), and a Master in Sustainable International Development from Brandeis University, Boston (USA).

Currently, he is also a board member of *the European Partners for the Environment* as well as an advisory board member at *The Centre for Sustainable Design*, he is an invited expert by the *Joint Research Centre* for a foresight study on Eco-industries and an invited lecturer at the *IHECS Academy*.

Elizabeth Van Den Bergh (F) - Project Leader - Brussels

Elizabeth is a communication consultant, project manager and trainer at ARCTIK since January 2014. She has over five years' experience in European Public Relations: designing, planning and executing EU communications and events projects, as well as leading teams of multinational professionals.

Elizabeth has worked for start-ups and established businesses across the public and private sectors. As Head of PR and Events at ICF Mostra Communications, she managed a range of projects on behalf of the European Commission including the 'Sustainable Energy for All' high-level event with Ban-Ki-Moon, the 'Choose your Fish' campaign, the International Year on Biodiversity, among many others. Before joining ARCTIK, Elizabeth worked at eBay. Elizabeth has a Master in Political Sciences and a Post-Master degree in Sustainable Interactive Urban Planning. She also has a 'Train the Trainer' certificate and is PM4SD (Project Management for Sustainable Development) certified.

Elizabeth is Belgian and is fluent in Dutch, English, French and Italian.

Nicolas Baygert (M) - Strategy, EU policy communication - Brussels

Nicolas is a communication/public affairs and energy affairs expert.

He has had extensive experience in EU affairs, working at the Centre for European Policy Studies (CEPS) and several years in a Brussels-based communication and public affairs agency before joining the European Commission DG Energy as a communication and press officer. Since 2011, he has been a lecturer at the Institut des Hautes Etudes des Communications Sociales (IHECS) teaching Environmental Communication and Social Media applied to EU communication campaigns. Nicolas has been working as a consultant for ARCTIK since 2012 providing strategic advice on energy policies and public affairs for EU projects.

He holds an M.Phil. in Political Science, a Master of Arts in International Relations and is currently a PhD candidate in Information and Communication at CELSA (Paris IV-Sorbonne) and the Université Catholique de Louvain (UCL). He is also a columnist for Le Vif / L'Express and le Nouvel Observateur.

Quentin Galland)M) - EU Affairs Consultant - Brussels

Quentin joined ARCTIK as a EU Affairs Consultant in early 2014. A communication expert and political specialist, Quentin has gained experience in several sectors from agriculture, to chemical industries and transport.

Quentin has produced a wide-range of communications strategies for the SusChem platform and other initiatives driven by the European Chemical Industry Council (Cefic) and the Community of European Railway and Infrastructure Companies (CER). He worked for several FP7 projects dealing with resource efficiency and innovation and was in charge of communications work packages. Quentin holds a Bachelor and Master degree in Political Science from the University of Louvain (UCL) and an Executive Master in Communication and EU Affairs from IHECS. He speaks French and English fluently and has a basic knowledge of German.

Currently, Quentin is leading the communication work package for the FP7 ENHANCE project. Additionally, he manages several projects with the European Commission: EMAS, EcoAP and ETV.

Jana Novotna (F) - EU Affairs Consultant - Brussels

Jana works as a EU Affairs consultant at Arctik. She is currently involved in the FP7 ENHANCE project and the communication and logistics of the KARIM and Euromed@Change conferences.

Jana has a good knowledge of EU affairs and experience in event organisation and project management in a number of areas such as - Entrepreneurship, International Trade, Innovation and Civil Protection. Prior to joining Arctik, she worked for a Brussels based NGO and for the British Chamber of Commerce in Belgium, where she was responsible for the full management of two EU Committee task forces in the field of competition and trade and innovation. She organised a number of high profile conferences with speakers from the EU institutions. She has as well conducted a blue book traineeship at the European Commission in DG

Humanitarian Aid and Civil Protection, where she worked on the preparation of an IPA funded project on disaster risk reduction in countries of Eastern Partnership. She further assisted in the management of the PPRD East Project (Prevention, Preparedness and Response to Man-made and Natural Disasters in the ENPI East region) and contributed to the organisation of its final conference.

Jana holds a bachelor degree in International Studies and Diplomacy from the University of Economics in Prague and a master degree in European Studies from the Catholic University of Leuven. She speaks Czech, English and German fluently and has a limited working proficiency in French.

Quentin Ketelaers (M) - Art director / Visual Designer - Brussels

Quentin is a visual designer who joined ARCTIK in January 2012. He is in charge of all visual production at ARCTIK, including, print and web design, video production, digital media, Apps,... He has also worked as computer graphist for The Royal Institute of Natural Sciences in Brussels. He earned a Bachelor in computer graphics from the Haute Ecole Albert Jacquard in Namur (Belgium). Quentin speaks French and has a good command of English.

Publications, products, services or other relevant achievements

Arctik S.P.R.L. is a communication consultancy. Strictly speaking, Arctik does not produce or issue publications. Among it services, Arctik is specialised in stakeholders engagement, event organisation, press and media relations. Additionally, Arctik internal designers provide the creative aspects needed for any project. Arctik S.P.R.L. also developed a comprehensive and user-friendly web tool 'YourEUevent.eu' which offers web facilities for event organisation.

Previous projects or activities

- **FP7 ENHANCE project – http://enhanceproject.eu**
  As dissemination and communication work package leader, Arctik has been leading the communication of the FP7 ENHANCE project. The project, which is about enhancing multi-sectorial partnerships to improve society's resilience to disaster risk, is now running since more than two years. Among its achievements, Arctik developed an attractive website with up to date information, news, events and interviews. Recently, Arctik interviewed European Commissioner Kristalina Georgieva for the role of the European Commission regarding disaster risk reduction. Arctik is also actively preparing an animated video about the project to explain its objectives and purposes to a wider audience.
- **Grid Infrastructure Communication Toolkit - www.grid-communications-toolkit.eu**
  On behalf of European Commission Directorate General Energy, Arctik delivered the Grid Infrastructure Communication Toolkit. The European Commission has launched the Grid Infrastructure Communications Toolkit to encourage a dialogue with citizens, to involve them at each stage of an energy infrastructure project while highlighting the necessity of developing this infrastructure. The toolkit contains different methods to support a constructive dialogue on grid development projects at a local level in Europe and can be used by policy makers, NGOs, Transmission Service Operators (TSOs) and local stakeholders. Arctik participated to the overall project management, designed and created the website, elaborated messages and content, mapped and engaged stakeholders, shaped the agenda of TSOs, and co-organised local workshops to test the toolkit with citizens, local communities and regions.
- **Events organisation**
  The past months, Arctik organised two events on topics related to sustainability, energy, and local development. On 19 and 20 February, Arctik organised a conference on behalf of the **European Association for Information on Local Development** (AEIDL). The conference was about "Reinventing Europe Through Local Development". On 17 March, Arctik organised the "Putting innovation at the heart of 2030 in climate change and energy policies" on behalf of **EnergyPost**, a new independent online media specialised on energy matters.
  In the coming months, Arctik will organised three conferences on energy, sustainable innovation, and SMEs internationalisation. On 30 September, Arctik is organising the "**Euromed@Change**" conference for the European Bic Network association. The conference will look at bridging business opportunities between enterprises in the Euro-Mediterranean region. On 2 October, Arctik organises the "**KARIM**"

project final conference. KARIM advocates for the development of responsible innovation that protects environment and society whilst enhancing business in SMEs. Finally, on 13 November Arctik will organise a conference on energy matters for the **Norwegian Embassy to the EU**.

- *7. BSC*

Legal entity, main tasks and profile match

The Barcelona Supercomputing Center - Centro Nacional de Supercomputación (BSC), created in 2005, has the mission to research, develop and manage information technology in order to facilitate scientific progress. At the BSC, more than 350 people from 40 different countries perform and facilitate research into Computer Sciences, Life Sciences, Earth Sciences and Computational Applications in Science and Engineering. The BSC is one of the four hosting members of the European PRACE Research Infrastructure as well as one of the first eight Spanish “Severo Ochoa Centre of Excellence” awarded by the Spanish Government. The Earth Sciences Department of the BSC (ES-BSC) was established with the objective of carrying out research in Earth system modelling. The ES-BSC conducts research on emissions, air quality, mineral dust and global and regional climate modelling and prediction.

For this project, the ES-BSC undertakes research on the development and assessment of dynamical and statistical methods for the prediction of global and regional climate on time scales ranging from a few weeks to several years. The formulation of the predictions includes the development and implementation of techniques to statistically downscale, calibrate and combine dynamical ensemble and empirical forecasts to satisfy specific user needs in the framework of the development of a climate service.

The department operates the high-resolution air quality forecasting system CALIOPE for Europe and Spain; it also maintains the BSC-DREAM8b model for daily operational mineral dust forecasts for the Euro-Mediterranean region, collaborates with the WMO and the Spanish Meteorological Agency (AEMET) to host the Regional Centre for Sand and Dust Warning System (SDS-WAS) covering Europe, Northern Africa and the Middle East and is an active member of the EC-Earth consortium, whose global climate model is widely used at ES-BSC for research and teaching purposes.

Over the years, the department has been active in numerous European Projects including, including MEDSPA-91, INCO, EUREKA, EARLINET, DEISA, EC-EARTH, EARLINET-ASOS, ACTRIC, IS-ENES and FIELD_AC ,DENFREE (2011), IS-ENES 2 (2013), PREFACE (2013), EUCLEIA (2014) and EUPORIAS (2012). The Earth Science department is the coordinator of the European project SPECS (2012). We also participate and receive grants from the Spanish Government for various R&D projects: RUCSS, PICA-ICE, RESILIENCE.

BSC applies a Third Party modality where the third party is making its resources available to the beneficiary under Article12 of the Grant Agreement - Use of in-kind contributions provided by third parties free of charge.

According to this situation, the third party, the Institut Català de Recerca i Estudis Avançats (ICREA) will not carry out any part of the work and just lends resources to the beneficiary. These resources are directly used by the beneficiary, the work is performed in its premises and there is no reimbursement by the beneficiary to the third party. The third party makes available some of its resources to the beneficiary, which does not reimburse the cost to the third party, but which charges the costs of the third party as an eligible cost of the project. Its costs will be declared by the beneficiary in its Form C but must be recorded in the accounts of the third party. In that context, ICREA resources corresponding to dedicated time of Prof. Francisco J. Doblas-Reyes (ICREA personnel) will be available for the whole duration of the project, mainly for RTD activities.

Prof. Francisco J. Doblas-Reyes is the Director of the Earth Science Department which brings together around 50 people working on the prediction of global weather, climate and air quality, as well as in the analysis of the computational efficiency of Earth science codes

In accordance with the budget of the project, an indicative effort of 3.6PM is allocated to this arrangement. This represents about 8% of the total estimated personal efforts for BSC.

BSC will partner in WP 2, 3 and 8 where the following tasks will be carried out:

- WP2: Define a stakeholder interaction protocol, carry out targeted interviews and use the outcomes to shape the development of case studies in WP6.

- WP3: Improved forecast of short term, sub-seasonal and seasonal precipitation, including an exploration of the impact of improving the land-surface initialisation in sub-seasonal and seasonal predictions.
- WP14: Develop training material for stakeholders, organise, design and deliver a user-orientated workshop and communication material.

Curriculum vitae of persons involved in research and/or innovation activities

Prof. Francisco Doblas-Reyes (M) is an expert in the development of seasonal-to-decadal climate prediction systems and the head of the ES-BSC. He is involved in the development of the EC-Earth climate forecast system since its inception. He was an IPCC lead author in the Fifth Assessment Report, serves in WCRP and WWRP scientific panels, is a member of the ENES HPC Task Force, has participated in a number of FP4 to FP7 projects and is author of more than 100 peer-reviewed papers. He is shaping BSC's plans for the development of a weather and climate modelling service that brings the latest developments of HPC and Big Data research to the Earth science community, increasing at the same time the resilience of the European society to weather, air quality and near-term climate extremes.

Dr Omar Bellprat (M) is an early career scientist at BSC. He has a strong statistical background and a wide expertise in climate modelling on the global-to-regional scale. His main activities focus on the attribution of extreme events on the near term time-scale to either the human influence or the natural variability. He has participated to several international projects (EUCLEIA and SPECS) and is author of several peer-reviewed papers.

Miss Melanie Davis (F) is the Climate Services Manager for Energy within the ES-BSC at BSC. She has eleven years' experience in renewable energy business and policy, and more recently in climate research. Her core role has been the translation of technical science to end users and decision makers. This diverse background enables her to bridge the gap between different communities to develop actionable services from end-user driven research. Melanie has contributed to the development of the first Europeanfunded climate services projects, where she leads various work packages. She is also coordinating a national climate and energy project, funded by the Spanish Ministerio de Economía y Competitividad. She is actively collaborating with climate research institutions and private companies worldwide, and is a member of the International and European Climate Services Partnership (CSP) and European Energy Research Association (EERA).

Publications, products, services or other relevant achievements

Rodrigues, L.R.L., J. García-Serrano and **F.J. Doblas-Reyes** (2014). Seasonal forecast quality of the West African monsoon rainfall regimes by multiple forecast systems. Journal Geophysical Research, 119, doi:10.1002/2013JD021316.

Pavan, V. and **F.J. Doblas-Reyes** (2013). Calibrated multi-model ensemble summer temperature predictions over Italy. Climate Dynamics, 41, 2115-2132, doi:10.1007/s00382-013-1869-7.

Doblas-Reyes, F.J., J. García-Serrano, F. Lienert, A. Pintó Biescas and L.R.L. Rodrigues (2013). Seasonal climate predictability and forecasting: status and prospects. WIREs Climate Change, doi:10.1002/WCC.217.

Guemas, V., **F.J. Doblas-Reyes**, I. Andreu-Burillo and M. Asif (2013). Retrospective prediction of the global warming slowdown in the past decade. Nature Climate Change, 3, 649-653, doi:10.1038/nclimate1863.

Carrassi, A., R. Weber, V. Guemas, **F. Doblas-Reyes**, M. Asif and D. Volpi (2014). Full-field and anomaly initialization using a low-order climate model: a comparison and proposals for advanced formulations. Nonlin. Processes Geophys., 21, 521-537, doi:10.5194/npg-21-521-2014.

Previous projects or activities

- EU FP7, SPECS (Project coordinator): Seasonal-to-decadal climate Prediction for the improvement of European Climate Services. 2012-2017.
- EU FP7, EUPORIAS (WP41 co-lead): EUropean Provision Of Regional Impact Assessment on a Seasonalto- decadal timescale. 2012-2017.
- National project (MINECO), RUCSS: Reducing Uncertainty in global Climate Simulations using a Seamless climate prediction system. 2010-2013.
- Private project, Risk Prediction Initiative: Multi-annual forecasts of Atlantic tropical cyclones in a
- climate service context. 2013-2014. EU FP7, INCLIDA: Initialization of global decadal climate forecasts: a new challenge for multi-scale data assimilation. 2012-2014

Significant infrastructure and/or technical equipment

The BSC hosts MareNostrum III, a Tier-0 PRACE system with 1.1 Pflop/s capacity as well as other High-Performance Computing (HPC) resources, which will be used by ESRs during their training in climate modelling to conduct their experiments. The BSC also coordinates the Spanish Supercomputing Network, which is the main instrument to grant competitive computing time to Spanish research institutions. The BSC is located within a university campus, and has special agreements to use the university residence and other university facilities (libraries, EDUROAM network, etc).

The ES-BSC has substantial in-kind computing resources obtained from their own cluster, the European Centre for Medium-Range Weather Forecasts (ECMWF, United Kingdom) and Parallell dator centrum (PDC, Sweden). These resources relate to a total value of approximately €0.5M/yr.

- *8. METOFFICE*

The Met Office was founded in 1854 and has provided the UK's National Meteorological Service (NMS) since then. This makes the Met Office uniquely positioned to provide meteorological observational data going back to the 1850's. Throughout its long history, the Met Office has been at the forefront of meteorological scientific advance and in the last few decades has become one of the recognised world leading organisations in the field of climate science through its Met Office Hadley Centre.

As a leading organisation in the European Meteorological Satellite programme we are constantly improving the way we use established satellite observations for weather and climate applications, and preparing for the use of new measurements from space. We are engaged in the assimilation of a wide range of satellite data into NWP models, the development of new imagery products for forecasting, climate and environmental applications. We take a leading role in the EUMETSAT NWP Satellite Application Facility and provide advice to the space agencies.

Throughout its history, the Met Office has demonstrated its drive to provide outreach and dissemination across all levels. This is clearly evidenced from our public facing weather forecasts, to the organisation and delivery of workshops and conferences for the scientific research community, and from the publication of scientific papers in leading science journals to briefings and papers for policy makers.

An independent review of the Met Office Hadley Centre commissioned by UK government in 2007 concluded that: 'It is beyond dispute that the Met Office Hadley Centre occupies a position at the pinnacle of world climate science and in translating that science into policy advice.' When it comes to making long-term decisions based on climate projections for the 21st century, the costs and risks are potentially high. Met Office consultants are on-hand to offer advice to help governments and businesses around the world on issues such as protecting global security, safeguarding the provision of energy and growing the economy, now and in a changing climate.

The Met Office has a team of experienced project managers, who hold formal project management qualifications. This team has much experience in managing projects involving multiple partners and users. The Met Office has co-ordinated projects such as the FP6 ENSEMBLES project, and is currently coordinating and managing ongoing FP7 such as EUPORIAS and EUSTACE collaboration projects.

Curriculum vitae of persons involved in research and/or innovation activities

Dr. Carlo Buontempo (male). Carlo leads the climate service development team for Europe. He is the scientific coordinator of FP7 EUPORIAS and the WP leader of WP42 in the same project. Carlo has over 15 years' experience in the development of climate related data sets and in their transformation in user-relevant information. Carlo is lead and co-author of numerous papers on regional climate modelling and climate change impacts on water resources.

Jeff Knight (male). Jeff leads the Modelling Climate Variability team within the Monthly to Decadal Prediction area of the Met Office Hadley Centre. He has over 20 years experience in research in the atmospheric sciences. Jeff and his team's interests include the development and use of monthly to seasonal predictions, development of decadal predictions, climate variability and dynamics, climate modelling, responses to climate forcing factors, and the ocean as a driver of climate. Jeff has published more than 35 papers on these topics in high-quality peer-reviewed journals.

Dr. Pete Falloon (male). Pete has over 18 years of experience in modelling environmental systems. Pete moved to Rothamsted Research in 1996, where he worked on modelling soil, climate and vegetation interactions for 8 years and was awarded a PhD from the University of Nottingham in 2001. Pete has been working on the impacts of climate and land use change on hydrology, soils and agriculture at the Met Office Hadley Centre since 2004 and has contributed to 63 peer-reviewed papers (20 first-author). He currently leads the Climate Impacts Modelling group, working on academic, government and commercial research and consultancy projects. Pete also leads WP2 of the UK NERC project NUTCAT-2050, investigating impacts of climate and land use change on hydrology and nutrient transfers in small UK catchments.

Pete led the Met Office (JULES model) contribution to water and biome impact simulations in the Intersectoral Impact Model Intercomparison Project (ISI-MIP), which contributed to the IPCC WG2 2014 report.

Pete is the lead author on project to deliver report for OECD on "Climate Change, Water and Agriculture: Future Trends and Policy Implications".

Publications, products, services or other relevant achievements

Scaife, A. A., et al. (2014), Skilful long range prediction of European and North American Winters, Geophys. Res. Lett., 41, 2514-2519, doi:10.1002/2014GL059637.

Knight, J. R., M. B. Andrews, D. M. Smith, A. Arribas, A. W. Colman, N. J. Dunstone, R. Eade, L. Hermanson, C, MacLachlan, K. A. Peterson, A. A. Scaife and A. Williams (2014), Predictions of climate several years ahead using an improved decadal prediction system, J. Climate, in press.

Hewitt, C., C. **Buontempo**, P. Newton (2013), Using Climate Predictions to Better Serve Society's Needs, Eos, Transactions American Geophysical Union, Vol 94, 11, Doi: 10.1002/2013EO110002

Falloon, P, Betts R, Wiltshire A, Dankers R, Mathison C, McNeall D, Bates P, Trigg M (2011). Validation of river flows in HadGEM1 and HadCM3 with the TRIP river flow model. Journal of Hydrometeorology,12,1157-1180. doi: 10.1175/2011JHM1388.1

Rutger Dankers, Nigel Arnell, Douglas B. Clark, Pete **Falloon**, Balazs M. Fekete, Simon N. Gosling, Jens Heinke, Hyungjun Kim, Yoshimitsu Masaki, Yusuke Satoh, and Tobias Stacke (2013) Short communication: a first look at changes in flood hazard in the ISI-MIP simulations, PNAS, doi:10.1073/pnas.1302078110 .

Previous projects or activities

- Met Office leads the FP7 project EUPORIAS which will develop a set of fully working prototypes of climate services designed around the need of specific users..
- Met Office is playing a key role in the FP7 project SPECS (Seasonal-to-decadal climate Prediction for the improvement of European Climate Services), which aims to contribute to the improvement of the end-to-end science-to-service chain for climate forecasting. This strong involvement is consistent with the Met Office Hadley Centre's world leading role in the provision of near-term climate forecasting and advice, and underscores their suitability as a provider of the necessary climate information within IMPREX.

➢ *9. TUC*

The Technical University of Crete (http://www.tuc.gr) is a modern technological institution that has established a reputation both in Greece and abroad. The mission of the Technical University of Crete is to develop modern engineering specialties, to place emphasis on research in fields of advanced technology as well as to establish close cooperation with the industry and other production organizations in Greece. 57 laboratories with excellent equipment, high technology infrastructure and brilliant staff members and 129 faculty staff members with international academic careers testify to the high quality of the educational and research work conducted at the modern facilities of the campus. This profile ranks the Technical University of Crete amongst the most prominent research institutions in Greece.

TUC will evaluate the retrospective seasonal forecasts and examine the enhanced value in climate projections of precipitation extreme in the frame of WP3. TUC will contribute to the verification of the hydrological reforecasts with a particular focus on hydrological extremes based on a set of documented flash flood events

(WP4), and will also test the applicability of the advancements and tools developed within IMPREX focusing on the Messara (Greece) study basin (WP11).

Curriculum vitae of persons involved in research and/or innovation activities

Prof. Ioannis K. Tsanis (M) is a full professor at the Department of Environmental Engineering at TUC since 2002. He is also a professor at the Department of Civil Engineering at McMaster University, Ontario, Canada. He published 3 books and over 250 scientific papers and reports and managed 52 projects in areas of climate change impact in water resources, storm kinematics and hydrological extremes, hydro informatics and integrated watershed management. He is a member of international research teams, expert panels in research proposal evaluation teams (NSERC (Canada), NSF (USA) and EU (FP5, FP6, FP7)). Since 2002 he published over 90 journal papers, conferences and technical reports and managed 17 research projects.

Dr. Aristeidis Koutroulis (M) (Dipl. Eng. M.Sc, Ph.D.) is a research scientist/engineer employed by TUC and works in climate change impact studies within HELIX, ECLISE, IMPACT2C, COMBINE, WATCH projects.

Dr. Manolis Grillakis (M) (Dipl. Eng. M.Sc.- Ph.D candidate) works as a TUC research engineer within the ECLISE, IMPACT2C, HELIX projects, involved with climate change impact assessment.

Ms. Vasiliki Iordanidou (F) (Dipl. Eng., M.Sc.) is a TUC Ph.D candidate and works as a research engineer, involved with extreme hydro-meteorological events over Eastern Mediterranean.

Ms. Lambrini Papadimitriou (F) (Dipl. Eng., M.Sc.) is a TUC Ph.D candidate and works as a research engineer, involved with global and regional hydrological modelling.

Publications, products, services or other relevant achievements

Tsanis, I.K., Grillakis M.G., Koutroulis, A.G., Jacob D., "Reducing uncertainty on global precipitation projections", Journal of Earth Science and Climate Change, 5:1, http://dx.doi.org/10.4172/2157-7617.1000178, December 2013.

Grillakis M. G., Koutroulis A. G., **Tsanis I.K.**, "Multisegment statistical bias correction of daily GCM precipitation output", J. Geophysical Research, 118, 1–13, doi:10.1002/jgrd.50323, 27 April 2013.

Koutroulis A. G., **Tsanis I.K.** and D. Jacob, "Impact of climate change on water resources status: a case study for Crete Island", Journal of Hydrology, 479, 146-158, 4 February 2013.

Vrochidou, A.-E. K.; **Tsanis, I.K.**; Grillakis, M.G.; Koutroulis, A.G., "The impact of climate change on hydrometeorological droughts at a basin scale", Journal of Hydrology, 476, 290-301, 7 January 2013.

Tsanis, I.K., Koutroulis A.G., Daliakopoulos, I.N. and Jacob, D., "Severe Climate-Induced Water Shortage and Extremes in Crete", Climatic Change, 106, 4, 667-677, June 2011.

Previous projects or activities

- HELIX: High-End cLimate Impacts and eXtremes. ENV.2013.6.1-3 Impacts of higher-end scenarios (global average warming > 2 °C with respect to pre-industrial level) – FP7-ENV-2013 (2013-2017)
- IMPACT2C: Quantifying projected impacts under 2°C warming. Collaborative project/Large-scale integrating project, FP7-ENV-2011 (2011-2015)
- ECLISE: Enabling CLimate Information Services for Europe - Programme "Environment" FP7-ENV-2010.1.1.4-1. Underpinning work to enable provision of local scale climate information (2011-2014)
- COMBINE: Comprehensive Modelling of the Earth System for better climate prediction and projection (Integrated Project), FP7-ENV-2008-1 (2009-2013)
- WATCH: WATer & global CHange (Integrated Project), Sixth Framework Programme – Global Change and Ecosystems Priority – 4th Call Paragraph II.1.1 Global Water Cycle, Water Resources and Droughts (2008-2012).

10. UREAD

The **University of Reading** is a public research university based in Reading in the United Kingdom. The University of Reading is ranked in the top 1% of universities in the world and enjoys a world-class reputation for teaching, research and enterprise. Its Department of Meteorology is Europe's largest with a world-leading reputation in research focusing on the fundamental science of weather and climate. The Department of

Geography and Environmental Science provides a world-leading centre for hydrological research with research on global flood modelling through to local catchment water quality.

The University of Reading will provide high-resolution global climate output and contribute to the investigation of the impact of resolution on the representation of meteorological phenomena relevant to European precipitation in WP3. The University of Reading has a wealth of experience in developing state of the art hydrometeorological forecasting and climate impact modelling chains for flood and drought prediction at both global, regional and local scales and will contribute to these activities within IMPREX in WP4 and WP6.

Curriculum vitae of persons involved in research and/or innovation activities

Hannah Cloke (F) is a Professor of Hydrology and is a full-time employee of the University of Reading. Professor Cloke is an expert in land surface hydrology, probabilistic flood forecasting, river catchment processes, climate impact on water resources and uncertainty analysis. She currently leads a large consortium project 'SINATRA' researching flooding from intense rainfall, working with many stakeholder partners including the UK Met Office, the Environment Agency, the Flood Forecasting Centre and ECMWF. She is also working on improvements to the Global Flood Awareness System and land surface model parameterisation for flood forecasting.

Len Shaffrey (M) is a Senior Scientist in NCAS and is a full-time employee of the University of Reading. His research focuses on how extremes such as storms, floods and droughts might respond to climate change. He is the Lead PI for the NERC IMPETUS, TEMPEST and TEA-COSI projects and currently leads a team of 3 post-docs and supervises 5 PhD students. Dr. Shaffrey also leads a project to produce initialised decadal climate forecasts using the high-resolution HiGEM climate model.

Publications, products, services or other relevant achievements

Cloke, H. L., Wetterhall, F., He, Y., Freer, J. E. and Pappenberger, F. (2013), *Modelling climate impact on floods with ensemble climate projections.* Q.J.R. Meteorol. Soc., 139: 282–297. doi: 10.1002/qj.1998

Sampson, C. C., Fewtrell, T. J., O'Loughlin, F., Pappenberger, F., Bates, P. B., Freer, J. E., and **Cloke, H. L.**: *The impact of uncertain precipitation data on insurance loss estimates using a flood catastrophe model*, Hydrology and Earth System Science, 18, 2305-2324, doi:10.5194/hess-18-2305-2014, 2014.

Ye, J., He, Y., Pappenberger, F., **Cloke, H. L.,** Manful, D. Y. and Li, Z. (2014), *Evaluation of ECMWF medium-range ensemble forecasts of precipitation for river basins.* Q.J.R. Meteorol. Soc., 140: 1615–1628. doi: 10.1002/qj.2243

Harvey, B. J., **L. C. Shaffrey**, T. J. Woollings, G. Zappa, and K. I. Hodges, 2012: How large are projected 21st century storm track changes?, Geophys. Res. Lett., 39, L18707, doi:10.1029/2012GL052873.

Zappa. G., **Shaffrey, L.C.**, Hodges K.I., Sansom, P., and Stephenson, D., 2013b: The response of North Atlantic cyclones to climate change in CMIP5 models. J. Climate, 26, 5846-5862.

Previous projects or activities

- Project **SINATRA**: Susceptibility of catchments to Intense RAinfall and flooding. This large consortium project is the largest part of the UK Natural Environment Research Council (NERC) Flooding From Intense Rainfall Programme.
- **IMPETUS**. Improving Predictions of Drought for User Decision-Making. A large UK consortium project funded by the NERC UK Droughts and Water Scarcity Programme.
- Developing Enhanced impact MOdels for integration with Next generation NWP and climate outputs **DEMON**. A large UK consortium project funded by the NERC UK Storm Risk Mitigation Programme
- Uncertainty Assessments of Flood Inundation Impacts: Using spatial climate change scenarios to drive an ensemble of distributed models for extreme conditions. NERC **Flood Risk from Extreme Events** programme.
- **TEMPEST:** Testing and Evaluating Climate Model Projections of European Storms. A large UK consortium project funded by the NERC Storm Risk Mitigation programme.

Significant infrastructure and/or technical equipment

- The University of Reading, in conjunction with the UK Met Office, has led the development of the high-resolution 25km (n512) version of the UK Met Office HadGEM3 global climate model.

11. HZG HELMHOLTZ-ZENTRUM GEESTHACHT ZENTRUM FÜR MATERIAL- UND KÜSTENFORSCHUNG GMBH (HZG), Germany

The Helmholtz-Zentrum Geesthacht (HZG) is one of 18 national research centres in Germany belonging to the Hermann von Helmholtz Association (HGF). HZG has three sites at Geesthacht, Teltow near Berlin, and Hamburg, with in total approx. 850 employees.

The Climate Service Center 2.0 (CS2) is an Institution at the Helmholtz-Zentrum Geesthacht. It was initiated by the German Government in 2009 and funded by the Federal Ministry of Education and Research. The CS2 is furthermore supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety as well as by the Federal Ministry of Transport, Building and Urban Development. It is a fundamental part of the German hightech-strategy for climate protection. The CS2 offers a wide range of science-based information and services. Doing so, it responds to the rapidly growing need for advice on climate related questions and fills a gap between science and practice. The CS2 relies on a network of cooperating partners, which includes German academic and private research institutions and other climate service establishments. Involving the customers of climate-information, the CS2 works at the same time to strengthen this network and develops new partnerships with decision-makers from economy and industry.

Curriculum vitae of persons involved in research and/or innovation activities

María Máñez Costa (F) works in the Economics and Policy Department of the Climate Service Center 2.0, Germany, an institution of Helmholtz-Zentrum Geesthacht, as well as being visiting professor at the University of Valencia and Barcelona, Spain. She teaches Water Economics. At CS2.0 she is responsible for economic modelling and capacity development. Máñez Costa´s research explores the vulnerability and adaptive capacity of social ecological systems to climate change. Her research focuses on the development of capacities for adaptation to climate change and the development of methods for managing and communicating climate impacts. She has coordinated various projects at the national and international level, including the European Commission (FP6 and FP7), working on the topic of “Global environmental change“.

Roger Cremades (M) is a natural resource economics and environmental policy researcher with computer modelling experience in international projects. Roger's research agenda focuses on economic models of natural resources under diverse climatic, socioeconomic and policy scenarios, to achieve sustainability under global environmental change. Roger’s actual work at the Climate Service Center 2.0 is on the development of economic instruments related to risk reduction and redistribution in multi-sector partnerships, to provide society with policies that help to cope with climate risks, such as storm surges and droughts.

Josep Osorio (M) is a hydraulic engineer working on the modelling of water-human interactions bringing forward the sedimentation component as an important factor enhanced by extreme events and that has a big influence in the local economies. Josep is currently at the Climate Service Center 2.0 at the department of climate impacts and economics.

Publications, products, services or other relevant achievements

CS2.0 works in the development of prototypes and climate services customizing climate information for various users (private and public sector).

Jancloes M, Thomson M, **Máñez Costa M**, Hewitt C, Corvalan C, Dinku T, Lowe R, Hayden M. (2014) Climate Services to Improve Public Health. International Journal of Environmental Research and Public Health 11(5):4555-4559.

Máñez Costa, M. K. Schwerdtner Manez and S Husain (2013): Adaptation to climate change under changing urban patterns. The climatic perspective of migration. In Ruppel, Roschmann and Ruppel-Schlichting: Climate Change: International Law and Governance.

Máñez Costa, M, Moors, E. and E. Fraser (2012): Socio-economic settings and climate change: Which is driving vulnerability in southern Portugal?. In Ecology and Society

Zou, X., Li, Y., **Cremades, R.,** Gao, Q., Wan, Y., Qin, X.,(2013) Cost-Effectiveness of responses to Climate Change based on Water-Saving Irrigation in China. Agricultural Water Management.

Zou, X., Yue, L., Li, K., **Cremades, R**., Gao, Q., Wan, Y., Qin, X. (2013), Greenhouse Gas Emissions from Agricultural Irrigation in China. Mitigation and Adaptation Strategies for Global Change

Previous projects or activities

- **ENHANCE.** The main goal of the ENHANCE project is to develop and analyse new ways to enhance society's resilience to catastrophic natural hazard impacts, by providing new scenarios and information in selected hazard cases in close collaboration with stakeholders, and by contributing to the development of new Multi-Sector Partnerships (MSPs) to reduce or redistribute risk. Innovation in MSPs is essential, as (ineffective) cooperation between public, private and civil society institutions often leads to failures in risk management. The ENHANCE proposal is unique as it studies the potential for new MSPs for managing different catastrophic hazards, related to heat waves, forest fires, flood, drought, storm surge, and volcanic eruptions.
- **EURO-CORDEX**. COordinated Regional climate Downscaling EXperiment over Europe. (European branch of WCRP CORDEX initiative). Within EURO-CORDEX, a unique set of high resolution climate change simulations for the 21st century for Europe on 0.11° horizontal resolution is currently established. Coordinated by HZG and Wegener Center University of Graz.
- **IMPACT2C.** Quantifying projected impacts under 2°C warming. Enhances knowledge, quantifies climate change impacts, and adopts a clear and logical structure, with climate and impacts modelling, vulnerabilities, risks and economic costs, as well as potential responses, within a pan-European sector based analysis. EU FP7, coordinated by HZG.
- **ECLISE.** Enabling Climate Services for Europe. A European effort in which researchers in close cooperation with stakeholders developed local climate services in order to support climate adaption policies. The central objective of ECLISE was to take the first step towards the realisation of a European Climate Service. Funded by EU FP7, run 2011-2013, HZG WP13 lead.

Significant infrastructure and/or technical equipment

- **CS2.0** has access to big computing facilities within the DRKZ (German Center for Climate Computing).

12. Deltares

Stichting Deltares is the Dutch institute for applied research and development on issues related to living and working in delta areas. The mission of Deltares is to develop, acquire, apply and disseminate integral, multidisciplinary knowledge and knowledge products related to living and working in delta (coastal, estuarine, and riverine) areas, on an internationally leading level. With this, Deltares supports public authorities, private parties and society in their operations and ambitions, related to sustainable development of delta regions. The primary task of Deltares is bringing together science and application: translating scientific knowledge into innovative solutions needed in sustainable (clean and safe) development of deltas. It plays an active role in innovation networks with the ultimate goal of creating societal value, by supporting and speeding up innovation. One specific area of expertise of Deltares is adaptation of Deltaic area's and infrastructure to climate change. Deltares supports the Dutch Government in its decisions to adapt the water management and flood defences in the Dutch Delta in a changing climate, the Dutch Delta Programme.

Deltares will lead WP7 on Flood inundation prediction and risk assessment, and will further substantially contribute to WP4 on prediction of extremes, and has smaller contributions to WP610, WP2 and WP14.

Curriculum vitae of persons involved in research and/or innovation activities

Dr. Albrecht Weerts (M) has a background in hydrology and unsaturated zone physics and environmental chemistry, dynamic modelling of transport through complex media and data analysis. He is expert on data model integration and hydrology, employed by Deltares. Albrecht has been leading research on data assimilation techniques for improving flood forecasting system (quantification and reduction of uncertainties). He has provided advice on the development of flood and drought forecasting systems, and on derivation of extreme values of rivers levels and flows (Rhine & Meuse rivers) and wave parameters for the Dutch coast. He led several projects on hydrological modelling of the Rhine and Meuse including the water balance study on the river Rhine.

Dr. Karin de Bruijn (F) is a senior researcher at Deltares in flood risk management, specialized in flood inundation modelling, flood risk assessment, developing long-term flood risk management strategies and casualty risk assessment. She has a broad experience in the Netherlands, but has also carried out research in

Europe and at the Mekong River Commission in Cambodia. At Deltares she is leading several projects on flood damage estimation, including the model that is being developed for the Dutch government for the assessment of river and coastal flood damages.

Dr. Laurens Bouwer (M) is a senior senior researcher at Deltares, specialized in risk analysis, time series analysis, and climate change impact assessment. He has worked extensively on natural hazard risk and their impacts. He has lead several national and international projects on the impact of floods including economic losses, risk reduction strategies and insurance. He has published extensively in the academic literature on disaster risk and the impact of climate change on economic losses from extreme weather. He is also a Lead Author for the Third and Fifth Assessment Reports, and Contributing Author for the Special Report on Extremes of the UN Intergovernmental Panel on Climate Change (IPCC).

Publications, products, services or other relevant achievements

Bouwer, L.M., Crompton, R.P., Faust, E., Höppe, P. & Pielke, Jr., R.A. (2007). Confronting disaster losses. Science, 318, 753.

Bouwer, L.M. (2013). Projections of future extreme weather losses under changes in climate and exposure. Risk Analysis, 33(5), 915-930.

De Bruijn, K.M. & Klijn, F. (2009). Risky places in the Netherlands: a first approximation for floods. Journal of Flood Risk Management 2 (2009) 58-67.

De Bruijn, K.M. (2004) Resilience indicators for flood risk management systems of lowland rivers. International Journal of River Basin Management 2 (3), pp.199-210.

Liu, Y., **A.H. Weerts,** et al. (2012). Advancing data assimilation in operational hydrologic forecasting: progresses, challenges, and emerging opportunities. Hydrology and Earth System Sciences, 16, 3863-3887.

Mechler, R., **Bouwer, L.M.,** Linnerooth-Bayer, J., Hochrainer-Stigler, S., Aerts, J.C.J.H., Surminski, S. & Williges, K. (2014). Managing unnatural disaster risk from climate extremes. Nature Climate Change, 4, 235-237.

Weerts, A.H., G.Y. El Serafy, S. Hummel, J. Dhondia, H. Gerritsen, (2010). Application of generic data assimilation tools (DATools) for flood forecasting purposes. Computers & Geosciences, 36, 453-463.

Weerts, , A.H., H.C. Winsemius, J.S. Verkade (2011): Estimation of predictive hydrological uncertainty using quantile regression: Examples from the National Flood Forecasting System (England and Wales). Hydrology and Earth System Sciences, 15, 255-265.

Previous projects or activities

- FP7 EARTH2OBSERVE (Coordinator Deltares) (Global Earth Observation for Integrated Water Resource Assessment): The overall objective is to contribute to the assessment of global water resources through the use of new Earth Observation datasets and techniques. For this purpose, the project will integrate available earth observations, in-situ datasets and models, to construct a consistent global water resources reanalysis dataset of sufficient length (at least 30 years). The resulting datasets will be made available through an open Water Cycle Integrator data portal: the European contribution to the GEOSS/WCI approach. The datasets will be downscaled for application in case-studies at regional and local levels, and optimized based on identified European and local needs supporting water management and decision making.
- FP7 DEWFORA (Coordinator Deltares): The principal aim of DEWFORA is to develop a framework for the provision of early warning and response through drought impact mitigation for Africa. This framework will cover the whole chain from monitoring and vulnerability assessment, to forecasting, warning, response, and knowledge dissemination. DEWFORA will address existing capabilities for drought monitoring in Africa and develop improved drought indicators that consider the wider domain of water use and water users, and their dependence on variable water resources. Through these improved indicators vulnerability to drought at different scales across Africa will be assessed. These indicators will be applied to map drought vulnerability in the current climate, but also the change in drought hazard and vulnerability in the future, changed, climate. Through this understanding, drought preparedness and adaptation strategies appropriate to the African context will be developed.
- FP7 RASOR (Rapid Analysis and Spatialisation of Risk): The objective of RASOR is to integrate the technology offering in a single, easy-to-use tool that offers a rapid spatialisation of risk for both international organisations and local and national end users. These tools support multi-risk analysis and can be used throughout the full cycle of the disaster, even if they are principally designed to support the identification and mitigation of risk. The information RASOR generates can be used to foster consensus

between key stakeholders on risk reduction measures, or to convince international donors of the need to offer assistance, by documenting hazards, identifying risks and simulating the effects of catastrophic events.

- FP7 RISES-AM (Responses to coastal climate change: innovative strategies for high end scenario's: adaptation and mitigation): RISES-AM- addresses the economy-wide impacts of coastal systems to various types of high-end climatic scenarios (including marine and riverine variables). It encompasses analyses from global to local scales across the full range of RCPs and SSPs. It considers the still significant uncertainties in "drivers" (physical and socio-economic) and coastal system responses (e.g. land loss or uses, biological functions, economic productivity) within a hazard-vulnerability-risk approach.

Significant infrastructure and/or technical equipment

- Located in two cities in the Netherlands, Delft and Utrecht, Deltares disposes all necessary means to execute day-to-day R&D activities (desks with high-speed internet connection, Window/Linux clusters, multiple OS computers, printers, private audio & video conference room, and high-capacity repository, etc.). Deltares has multi-sized meeting and training rooms, a fully-equipped auditorium.

➢ *13. IVM*

The Institute for Environmental Studies (IVM) is the oldest environmental research institute in the Netherlands (www.ivm.vu.nl). IVM has built up considerable experience in dealing with the complexities of environmental problems, participating in numerous (inter)national research projects and collaborating with several institutes and universities in Europe and beyond. IVM excels in large collaborative EU projects and its researchers have been involved in Framework Programme projects since the 3rd FP and have coordinated a total of 15 large EU projects.

IVM's strength lies in water resources management, and climate variability and water interactons. Several researchers at IVM contribute to the IPCC process as authors for Working Groups II and III. IVM worked in several DG Environment & Research funded projects on natural hazard and climate change risk assessment and adaptation together with the European Commission to assess flood and drought risks and contribute to assessing impacts of the EU flood and WFD directives. IVM is an international leading organization in flood risk assessment modelling and assessments of climate variability and water related extremes. It, therefore, leads WP5.

Curriculum vitae of persons involved in research and/or innovation activities

Prof. Dr. Jeroen Aerts (M) is currently employed by IVM, VU University Amsterdam, as professor of Risk Management, Insurance, and Water Resources Management. He has over 21 years of research and consultancy experience including a vast number of international projects on disaster management, insurance arrangements, poverty and vulnerability reduction, and risk management strategies. He was coordinator of the Dutch climate adaptation programme 2003-2011 (24 Mil. Euro), KvK programme and river management (10 mll. Euros) (and he has been involved in EU projects from FP4 onwards. Jeroen Aerts has large experience as a coordinator of both scientific and multi stakeholder projects.

Dr. Philip Ward (M) is currently employed by IVM, VU University Amsterdam, as a senior researcher and project leader on several projects related to the impacts of future climate change on water resources and flooding/drougts at the regional to global scale. In 2011, Dr. Ward was awarded a VENI grant from NWO to research the impacts of interannual climate variability on flood risk. He is a contributing author to the Fifth Assessment Report of the IPCC.

Publications, products, services or other relevant achievements

Aerts, C. J. H. J., W. J. W. Botzen, K. Emanuel, N. Lin, H. de Moel, and E. O. Michel-Kerjan, 2014: Evaluating flood resilience strategies for coastal megacities. ***Science***, 344, 473-475.

Aerts, J.C.J.H. and Botzen, W.J. (2012) Managing Exposure to flooding in New York City (NYC). ***Nature CC***, 2, 377, doi:10.1038/nclimate1487

Aerts, J.C.J.H., Renssen, H., **Ward, Ph**., Moel de H., Odada, E., Goose, H. (2007) Sensitivity of Global River discharges to Long Term Climate Change and Future Climate Variability. ***Geophysical Research Letters,*** 33, L19401

Ward, P.J., Strzepek, K.M., Pauw, W.P., Brander, L.M., Hughes, G.A. & **Aerts, J.C.J.H.** (2010). Partial costs of global climate change adaptation for the supply of raw industrial and municipal water: a methodology and application. ***Environmental Research Letters***, 5, 044011. doi:10.1088/1748-9326/5/4/044011

Ward, P.J., Beets, W., Bouwer, L.M., **Aerts, J.C.J.H.** & Renssen, H. (2010). Sensitivity of river discharge to ENSO. ***Geophysical Research Letters***, 37, L12402. doi:10.1029/2010GL043215

Previous projects or activities

- FP7 Enhance, on risk management and floods
- NWO VIcI grant on global flood risk and decision making
- FP7 Earth2Observe, on water resources and remote sensing information
- NWO VENI grant on climate variability and flood risk
- Climate Changes Spatial Planning: targeted Dutch research program developing novel climate information tools, sectoral surveys and communication protocols (http://knowledgeforclimate.climateresearchnetherlands.nl/)

14. ADELPHI

ADELPHI research (http://www.adelphi.de/en) was founded 2001 in Berlin as a non-profit international think tank and public policy consultancy for applied sustainability science and policy analysis. adelphi carries out research projects and offers strategic advice on environmental, development and social policies and processes including in the realm of climate change adaptation, vulnerability, disaster risk reduction, and water resource management. Through targeted research, foresight exercises lectures, conferences, publications and educational activities adelphi provides a broad audience with expert knowledge in these areas. Communication platforms, exhibitions, newsletters and social media on a variety of environmental and development issues complement this range of knowledge. adelphi´s more than 100 clients include the European Commission, international organisations, governments, public institutions, corporations and associations.

adelphi will contribute to the integration of climate services carried out in WP13 and will analyse the implications of IMPREX findings on European policies. Moreover, adelphi contributes to the outreach and dissemination activities carried out in WP14 by organizing workshops with European decision makers from the public and private sector and drafting several policy briefs focussing on relevant EU strategies and directives.

Curriculum vitae of persons involved in research and/or innovation activities

Annika Kramer (F) is a senior project manager at adelphi and coordinates the area of Water and Waste Water. Her work also focuses on the fields of Vulnerability and Adaptation and Development and Security. Annika has many years' experience and considerable expertise in the integrated management of water resources and coastal zones. Her work particularly focuses on political, legal and institutional frameworks and socio-economic issues.

Dr. Philip Bubeck (M) works as a Project Manager at adelphi with a focus on the areas of climate adaptation, vulnerability and natural hazard management. He is currently managing two research projects for the Federal Environment Agency, which look at the factors for success in climate adaptation strategies, and German legal and informational policy instruments on adapting to climate change, as well as an FP7 project on natural hazard management.

Publications, products, services or other relevant achievements

Bubeck, Philip; Botzen, Wouter; Kreibich, Heidi and Jeroen Aerts 2012: Long-term development and effectiveness of private flood mitigation measures: an analysis for the German part of the river Rhine. Natural Hazards and Earth System Sciences, 12, 11, 3507-3518.

Bubeck, Philip., Botzen, Wouter., and Jeroen Aerts (2012): A review of risk perceptions and other factors that influence flood mitigation behavior. Risk Analysis, 32(9), 1481-1495.

Pahl-Wostl, Claudia; Ken Conca, **Annika Kramer**, Josefina Maestu, and Falk Schmidt 2013: Missing links in global water governance: a processes-oriented analysis. In: Ecology and Society 18(2): 33. Wolfville, Nova Scotia: Resilience Alliance. Find the issue online: www.ecologyandsociety.org/vol18/iss2/art33/.

Kramer, Annika and Alexander Carius (2012): Water Diplomacy and Climate Change. In: Dennis Tänzler und Alexander Carius (ed.): Climate Diplomacy in Perspective. From Early Warning to Early Action, 65-68. Berlin: Berliner Wissenschafts-Verlag

Bubeck, Philip; de Moel, Hans; Bouwer, Laurens and Jeroen Aerts 2011: How reliable are projections of future flood damage? In: Natural Hazards and Earth System Sciences, 11, 12, 3293-3306.

Previous projects or activities

- KNOW-4-DRR - Enabling knowledge for disaster risk reduction in integration to climate change adaptation (EU, FP7, 2013-2015)
- DESSIN - Demonstrate Ecosystem Services Enabling Innovation in the Water Sector (EU, FP7, 2014-2017)
- Twin2Go - Coordinating twinning partnerships towards more adaptive governance in river basins (EU, FP7, 2009-2011)
- AWARE - How to achieve sustainable water ecosystems management connecting research, people and policy makers in Europe (EU, FP7, 2009-2011)

15. HKV

HKV CONSULTANTS is an independent company that provides consultancy services and research in water and safety. They build their services on a profound understanding of physics, mathematics and decision making processes. Established in 1995, they have grown to a firm with 70 experts working from four offices in The Netherlands, Germany and Indonesia. HKV CONSULTANTS has earned a leading reputation in consultancy and research in flood risk management by taking the initiative in the development and practical implementation of technically innovating and methodological concepts that have found their way into current Dutch risk management practice. They have their own in-house R&D program and collaborate with Dutch universities and European research institutes. Their scope of work:

- Safety, drought and flood risk analyses for regional and urban water systems;
- Disaster management and evacuation plans.
- Research of rivers and estuarine systems;
- High-water analyses for regional water systems;
- Flood forecasting, management and control.

HKV CONSULTANTS completes over 250 projects in these fields annually. Their ability to translate successful innovative solutions and concepts in different physical and institutional settings enabled them to make important contributions to foreign governments in Europe, Asia, Africa and the Americas.

Curriculum vitae of persons involved in research and/or innovation activities, employed by HKV:

Hans Hakvoort M.Sc. (M) is an hydrologist and head of the advisory department Hydrology and Watermanagement at HKV. His main expertise is on the mathematical aspects of flood risk management, including hydrology of catchments, modelling of rainfall-runoff and flow processes, deriving statistics and statistically computing discharge and water level statistics.

Saskia van Vuren Ph.D. M.Sc. (F) is expert in Risk Management (flood safety and fresh water supply) at HKV. The leading thread in her career is advising policy makers and managers to cope with climate change and societal changes in multidisciplinary projects, using technical, stochastic and economical tools. The development of instruments as an input for decision support frameworks is one of her favorite activities. Climate change and spatial development make our society and our economy more susceptible to consequences arising from natural disasters. The resulting risks exhibit a wide range of uncertainty, making management decisions even more difficult than they usually already are. Saskia emphasizes the importance of understanding of risks and uncertainty. It enhances the quality of decision making in water management. Her focus is on water-related risks due to flooding, drought-related issues, salt water intrusion and fresh water supplies. Saskia advises clients on how to handle uncertainties and incorporate appropriate risk levels in decision making. The risk-based approach yields cost savings, resilient and sustainable communities, and it helps to allocate budgets in a cost-efficient way.

Publications, products, services or other relevant achievements

Hakvoort, H.A.M., J.R. Delsman, A.A. Veldhuizen and N. Kukuric, 2009. Hydrological Instrument of The Netherlands. Unifying dutch hydrological modelling expertise for national policy analysis. EGU, Vienna, april 2009.

Wolters, Erwin, **Hans Hakvoort**, Siebe Bosch, Rudolf Versteeg, Maarten Bakker, Joost Heijkers, Michelle Talsma en Kees Peerdeman, 2013. Meteobase: online neerslag- en referentiegewasverdampingsdatabase voor het Nederlandse waterbeheer. Meteorologica, nr. 2 -2013, pg. 15 -18.

Versteeg, Rudolf, **Hans Hakvoort** en Marijke Visser, 2011. Toepassing van op radar gebaseerde gebiedsreductiefactoren bij de NBW-toetsing. STROMINGEN, jaargang 17, nummer 1, pg. 21-31.

Van Vuren, S. & M. Zethof (2014). A Risk-based approach for fresh water management: supporting decision making in times of water scarcity? International Conference, Deltas in Times of Climate Change II, Rotterdam, the Netherlands

Van Vuren, S., H. De Vriend & H. J. Barneveld. A stochastic model approach for optimisation of lowland river restoration works. *Journal of Earth Science*. Special issue on flooding. (submitted).

Benardini, P., **S. Van Vuren**, W. Van der Wiel, M. Wolters, G. Roovers & M. Tosserams (2014). Integrative framework for long term reinvestment planning for the replacement of hydraulic structures. PIANC World Congress San Francisco, USA 2014.

Van Vuren, S., H. J. de Vriend, M. Kok & S. J. Ouwerkerk (2005). Stochastic modelling of the impact of flood protection measures along the river Waal in the Netherlands. *Journal of Natural Hazards*, 36 (1-2), Special issue on Flooding in Europe: Risks and challenges, 81-101.

Previous projects or activities

- **Modelling and system analysis water system of waterboard Rijn and IJssel**. Large project of modeling al catchments of the waterboard Rijn and IJssel. Also assessment of flood water levels.
- **Risk Assessment of the water system of the waterboard The Dommel**. Modeling and risk assessment of the watersystem of waterboard De Dommel, using SOBEK rainfall runoff, SOBEK 1D-FLOW and SOBEK 2DFLOW.
- **Risk based approach for fresh water policy.** Feasibility study for the development of a risk based approach for fresh water distribution in the River Rhine basin that could serve as a basis for new risk management strategies to deal with drought related hazards. (2012-2014)
- **Guidelines and procedures for flood safety and fresh water policy.** Development of guidelines and procedures for the assessment of solutions defined in flood safety and fresh water policy to cope with climate change and societal changes (2012)
- **Development of a risk based approach for river maintenance in Rhine river** (2012)
- **Design of a large number of river intervention projects of the riverine areas.** River intervention plans focusing on flood protection, navigation, nature, land use and recreation (2008 – 2014)

Significant infrastructure and/or technical equipment

- HKV owns an in-house 100-core computer computation-network, which has proven to be very useful for the many projects concerning probabilistical computations of water related issues.

16. Future Water (FW)

FutureWater is a research and consulting organization (SME) that works throughout the world to combine scientific research with practical solutions for water management. FutureWater works at both global, national and local levels with partners on projects addressing water for food, irrigation, water excess, water scarcity, climate change, and river basin management.

FutureWater's key expertise is in the field of quantitative methods, based on simulation models, geographic information systems and satellite observations, and has as its clients World Bank, International River Basin Organizations, Asian Development Bank, European Commission, Irrigator´s Associations and others.

FutureWater will lead the sub-WP11 on Agriculture, given their track-record in science-based solutions and services for agricultural water management at field, basin and regional scales. FutureWater will develop and enhance drought monitoring and management systems for the case study basin Segura, Spain, exploiting their expertise and related projects in this field.

Curriculum vitae of persons involved in research and/or innovation activities

Dr. Peter Droogers (M) is an expert on integrated water resources management with emphasis on water for food issues, climate change, decision support systems, simulation modeling in combination with data mining and remote sensing. He works for FutureWater, and has about 20 years of experience working as a resident in several countries and as non-resident in large number of countries around the world. He is also part-time lecturer at several universities, has written over 50 articles in peer-reviewed journals (h-index of 20) and he is Editor of the high-indexed journal Agricultural Water Management.

Dr. Sergio Contreras (M) is specialized in the ecohydrological functioning of native and agroecosytems of arid and semiarid regions, and its relation with human activities. He has special expertise in the interactions and feedbacks between vegetation and groundwater, in the energy and water balance and in the biomass and agricultural productivity of these regions. He has participated in many international and Spanish research projects and contracts and works for FutureWater since 2013.

Johannes Hunink (MSc.) (M) is specialized in quantitative studies for water resources planning and management, flood and drought hazard assessments, and irrigation and agricultural planning. His particular interest is the integration of spatial datasets and simulation models for decision support and policy making in water resources. Johannes has lived and worked for different private and public organizations in Spain, the Netherlands and Ecuador, and is currently the managing director of FutureWater in Spain.

Publications, products, services or other relevant achievements

Droogers, P., Immerzeel, W.W., Terink, W., Hoogeveen, J., Bierkens, M. F. P., van Beek, L. P. H., and Debele, B. 2012. Water resources trends in Middle East and North Africa towards 2050, Hydrol. Earth Syst. Sci., 16, 3101-3114, doi:10.5194/hess-16-3101-2012.

Hunink, J.E., Immerzeel, W.W., **Droogers, P.,** 2014. A High-resolution Precipitation Two-step mapping Procedure (HiP2P): development and application to a tropical mountainous area. Remote Sensing of Environment, 140:179-188.

Contreras, S. , Alcaraz-Segura, D., Scanlon, B., Jobbágy, E.G., 2013. Detecting ecosystem reliance on groundwater based on satellite-derived greenness anomaly and temporal dynamics. In D. Alcaraz-Segura, C.M. Di Bella, J.V. Straschnoy (eds.) Earth observation of ecosystem services. Chapter 13, 283-302. CRC Press – Taylor & Francis Group. Boca Raton. ISBN: 978-14-665058-8-9.

Hunink, J.E., Droogers, P., Kauffman, S., Mwaniki, B.M., Bouma, J., 2012. Quantitative simulation tools to analyze up- and downstream interactions of soil and water conservation measures: Supporting policy making in the Green Water Credits program of Kenya. Journal of Environmental Management, 111: 187-194.

Droogers, P. (2000). Estimating actual evapotranspiration using a detailed agro-hydrological model. Journal of Hydrology, 229(1), 50-58.

Karimi, P., **W.G.M. Bastiaanssen** and D.J. Molden, 2013. Water Accounting Plus (WA+) – a water accounting procedure for complex river basins based on satellite measurements, Hydrol. Earth Syst. Sci., 17, 2459–2472

Previous projects or activities

- ASSET – Water Accounting system for the Segura River Basin, Spain – pilot project within halting desertification programme of DG-ENV, EC.
- GESEQ – Drought monitoring tool development supported by the Spanish Ministry of Economy
- SIRRIMED – EU FP7 project – Sustainable Irrigation in the Mediterranean Region.
- REDSIM – REmote-sensing based DSS for Sustainable Drought-Adapted Irrigation Management (DG-ENV, EC)

17. CETAQUA

Cetaqua is a non-profit foundation consisting of 3 technology centres with offices in Barcelona, Galicia and Andalusia (Spain). The founding members of Cetaqua in Barcelona are the Spanish National Research Council (CSIC), the Technical University of Catalonia (UPC) and Aigües de Barcelona (Agbar Group).

These entities (Cetaqua's founding members, which are independent entities, apart from Cetaqua) are not going to participate in IMPREX.

CETaqua thus integrates both academia and industry, which enable the centres to be aware of the sector’s current and future needs and to effectively transfer and apply the results of its research.

The main research areas are: impact of global change (including management of floods and droughts); environment and health (involving validation and testing of advanced monitoring technologies, advanced water treatment and sludge management); water and energy; water, economy and society; efficient infrastructure management; and alternative water resources (such as desalination and water reclamation).

CETaqua has a portfolio of more than seventy projects including 12 LIFE projects, 10 of them as a coordinator, 10 FP7 projects as a partner and 10 nationally-funded projects, together with several privately-funded projects and contracts with companies. Moreover, CETaqua has a Programmes and Operations Department specifically dedicated to project management, consortium coordination, quality-assurance, intellectual property regulation, administrative reporting, financial monitoring, communication and dissemination.

CETaqua will lead the WP10 on Urban Water, exploiting its wide expertise in water supply system management and climate risk assessment to improve the safety of drinking-water and the reliability of water supply. CETaqua will gather data from water stakeholders, and coordinate the case studies performed on the water supply systems of Barcelona and Murcia regions, in close cooperation with the local water utilities of the Agbar Group (Aguas de Barcelona, EMUASA - Aguas de Murcia, Aguas de Terrassa) and other relevant stakeholders.

CETaqua participates in the proposal with its linked Third Party AQUATEC, PROYECTOS DE INGENIERÍA PARA EL SECTOR DEL AGUA, S.A.U, which is the Agbar Group engineering company of consultancy services and technology provider of technological solutions to meet challenges of the urban, industrial, agriculture and environmental water cycle. The company has large experience in hydraulic consultancy and automation systems for water cycle management, and all the fields related, such as, remote control and automation, environmental monitoring stations, network optimization, remote reading, master plans, DSS, modelling, control systems of water networks, water quality control, sewage networks, irrigation systems, discharge control, energy efficiency, renewable energy, technologies for the control and prevention of eutrophication, water treatment plants and communication networks.

CETaqua and AQUATEC are affiliated since they are under the same control. Thus, its link pre-dates and will outlast the duration of the action.

Two water operators EMUASA (Murcia, Spain) and Aigües de Terrassa (Terrassa, Spain) have made their support explicit to IMPREX and will contribute to the project´s success.

Curriculum vitae of persons involved in research and/or innovation activities

Laurent Pouget (M) is MSc in Hydro-Informatics and Water Management (joint European degree managed by the University of Nice Sophia-Antipolis) with 10 years of experience in projects related to the water sector, especially in modeling water resources system, river floods, and drainage networks. Since February 2009, he is working in the impact of global change programme of CETaqua, and has managed several international research projects (such as LIFE WATER CHANGE and participation in FP7 EUPORIAS).

Dr. Susana González (F) degree in Environmental Science (University of León) and is PhD Environmental Chemistry (University of Barcelona). Currently working in CETaqua on research projects within integrated water cycle (mainly water quality and environmental risk) as a researcher and project manager, leading several publicly and privately funded projects

Dr. Ignacio Martin (M), PhD in Anaerobic Membrane Bioreactors for Wastewater Treatment (Centre for Water Science, Cranfield University, UK), and Chem. Eng. (Universitat de Valencia , Spain). He has participated and managed several public and privately funded national and EU demonstration projects dealing with, among others, membrane-based technologies, drinking water production and water reuse.

Isabel Mª Hurtado (F) (Specialist and support issues eutrophication of Product Manager at Aqualogy, Spain) is biologist, expertise on ecology, management and control of continental waters. Wide experience on drinking water treatment, coordinating R+D+i projects on reservoir drinking water treatment (algae and fish populations, cyanotoxins, disinfection by-products).

Publications, products, services or other relevant achievements

Laurent Pouget, Isabel Escaler, Roger Guiu, Suzy Mc Ennis, Pierre-Antoine Versini. Global Change adaptation in water resources management: The Water Change project. Science of the Total Environment, num. 440, vol. 1, December 2012, pp.186-193/

Lopez-Roldan R, Kazlauskaite L, Ribo J, Riva MC, **González S**, Cortina JL. Evaluation of an automated luminescent bacteria assay for in situ aquatic toxicity determination Science of the Total Environment. 2012, 440

Lopez-Roldan, R.; **Gonzalez, S.;** Pelayo, S.; Piña, B.; Platikanov, S.; Tauler, R.; de la Cal, A.; Boleda, M. R.; Cortina, J. L. Water Supply- Integration of on-line and off-line methodologies for the assessment of river water quality Water Science & Technology 2013, 13.

Susana González, Ramón López-Roldán, Jose-Luis Cortina, Presence and biological effects of emerging contaminants in Llobregat River basin: A review. Environmental Pollution, Volume 161, February 2012, Pages 83-92, ISSN 0269-7491, http://dx.doi.org/10.1016/j.envpol.2011.10.002.

Susana Gonzalez, Ramón Lopez-Roldán, Jose-Luis Cortina, Presence of metals in drinking water distribution networks due to pipe material leaching: a review. Toxicological & Environmental ChemistryVolume 95, Issue 6, 2013.

Previous projects or activities

- FP7 EUPORIAS (Total project budget 13.0 M€)
  (2012)European provision of regional impact assessment on a seasonal-to-decadal timescale
- LIFE WATER CHANGE (Coordinated by CETaqua, 1.2 M€)
  (2009) Medium and long term water resources modelling as a tool for planning and global change adaptation. Application to the Llobregat Basin
- FP7 AQUAVALENS (Total project budget 11.9 M€)(
  2013) Protecting the health of Europeans by improving methods for the detection of pathogens in drinking water and water used in food preparation.
- LIFE UFTEC (Coordinated by CETaqua, 2.2 M€)
  (2010) Substitution of conventional treatment of raw river water by ultrafiltration membrane technology
- LIFE NECOVERY (Coordinated by CETaqua, 1.8 M€)
  (2013) Nutrient and Energy Recovery in WasteWater Treatment Plants by up-concentration and Adsorption processes

Significant infrastructure and/or technical equipment

- CETaqua puts its research into practice in laboratories and experimental plants, where research and innovation projects on treatment and monitoring technologies are carried out. In addition, CETaqua has access to a network of scientific facilities from UPC-BarcelonaTech, CSIC and the central laboratory of Aigües de Barcelona.
- CETaqua has installed demonstration prototypes for several projects such as at Sant Feliu de Llobregat WWTP (LIFE+ AQUATIK), Sant Joan Despí DWTP (LIFE+ UFTEC and VIECO), Barcelona drinking water network (WATMATIN), Somorrostro beach (BIOTIME), Sant Vicenç dels Horts (LIFE+ ENSAT), Mataró WWTP (LIFE+ BIOCELL) and Montornès del Vallès WWTP (LIFE+ GREENLYSIS).
- AQUATEC staff has access to the facilities of the Contraparada WWTP where R&D projects are developed. The WWTP has a laboratory for analysis of parameters of water quality control and instrumentation for sampling and in situ analysis.

➢ *18. UPV*

Universitat Politècnica de València (UPV) is a public, dynamic and innovative institution dedicated to researching and teaching, with strong bonds with its social environment and a strong presence abroad. One of the pillars of the social recognition of UPV is its research capacity. With over 52 million euro/year in R&D activities, its departments (41), research centres and institutes (40) are participating in many research activities jointly with national and international bodies and companies, with more than 4,000 people directly involved in research. The Institute of Water and Environmental Engineering, IIAMA, of UPV, is formed by around 100 people, including research and administrative staff, with more than 20 full and associate professors and several post-doc researchers, offering an ample scientific-technical baggage consolidated in the last 20 years in subjects related to Water and the Environment. The Research Group of Water Resources Engineering of IIAMA is currently working in different research lines which will contribute to the project: modeling and management of water resources (simulation, optimization and risk-based models); hydrological modeling; drought risk assessment and reduction, drought planning and management; water quality modeling in humanized river systems; impact assessment of climate change on water resources, and adaptation to climate change; water economics and hydro-economic modeling; and participatory ive ory water conflicts resolution.

UPV will contribute to the improved predictability and climate scenarios for droughts in WP4; to the development of a risk-based approach for fresh water allocation and probabilistic impact assessment in WP5; to the review and forecasting of water quality evolution during extreme events, the exploration of drought indices and their local applications, as well as to optimal operation of hydroelectric facilities in WP6; and to the elaboration of risk maps, the development of evaluation procedures for management options and the incorporation of stakeholder preferences in WP13.

Curriculum vitae of persons involved in research and/or innovation activities

Prof. Dr. Joaquín Andreu (M) is Head of the Department of Hydraulic and Environmental Engineering of UPV. He is also responsible scientist of the Research Group of Water Resource Engineering of IIAMA. His main expertise is on Water Resources Engineering, Integrated Water Resources Planning and Management (IWRPM), Systems Analysis and Mathematical Modeling in Water Resources, Decision Support Systems for IWRPM, Conjunctive Use of Surface and Ground Waters, and Drought Management and Planning. He has published several papers related to applied research on the subjects of the proposal (Improving predictions, risk assessment and management of droughts) and he has been editor of five books, among them the one entitled "Drought Management and Planning for Water Resources" (J. Andreu, G. Rossi, F. Vagliasindi, and A. Vela, editors, CRC Press (Taylor & Francis), Boca Raton, 2005.). He has been the Principal Investigator of IIAMA teams for six EU Research Projects (FP6 & FP7), and two EU INTERREG Projects, and participated as member of the research team in several other EU projects. The results of the research have been applied to real drought risk assessment and management in Spanish basins.

Prof. Dr. Abel Solera (M) is Associate Professor of Water Resources & Environmental Engineering. His main research interests are water resources management and decision support systems. He has contributed to several research projects, including EU projects WARSYP, WAM-ME, SEDEMED I and SEDEMED II, SIRIUS, DROUGHT R&SPI, and ENHANCE.

Prof. Dr. Javier Paredes-Arquiola (M) is Associate Professor of Water Resources & Environmental Engineering. His main research interests are water resources management, water quality modeling, and ecological assessment of rivers. He has contributed to several research projects, including EU projects SEDEMED I and SEDEMED II, SIRIUS, DROUGHT R&SPI, and ENHANCE.

Prof. Dr. Manuel Pulido-Velazquez (M) is currently Associate Professor at UPV and senior researcher and vice-director of the Research Institute of Water and Environmental Engineering (IIAMA-UPV). His main research focus is on the development of methods and tools for integrated management of water resource systems, using hydrology, engineering, economics and system analysis techniques. He has published extensively on hydroeconomic modelling, with applications to many different water different issues, including assessment of impacts and adaptation to climate change, obtaining different recognitions (e.g. ASCE-EWRI best water policy-oriented paper award in 2013). He is Associate Editor of Water Resources Research and guest editor in HESS, and has been an external reviewer for several international programs (including the Belmont Forum, Freshwater Security program, for the National Science Foundation, US). He is involved in different EU and national projects related to climate change impacts and adaptation.

Publications, products, services or other relevant achievements

Decision Support System Shell AQUATOOL: Generalized decision support system shell for integrated water resources planning and management, including geo-referenced databases, graphical design capabilities, graphical interfaces for data management and for result analysis, and several modules for hydrological simulation, groundwater simulation, integrated management simulation and optimization, economic assessment, water quality assessment, and environmental assessment. AQUATOOL has been widely used since 1990s by basin authorities in Spain and abroad to assess vulnerability of water resources systems and/or to manage droughts in real time, and the experiences gained have been included in a continuous development line of the system, leading to many publications (first one was: J. Andreu, J. Capilla, and E. Sanchis, "Aquatool, a generalized decision support system for water resources planning and operational management", Journal of Hydrology, Vol. 177, pp. 269-291, 1996).

J. Andreu, J. Ferrer-Polo, M.A. Pérez, **A. Solera and J. Paredes-Arquiola**, 2013, "Drought Planning and Management in the Júcar River Basin, Spain", in Drought in Arid and Semi-Arid Regions, A Multi-Disciplinary and Cross-Country

Perspective, ed. by K. Schwabe, J. Albiac, J.D. Connor, R.M. Hassan, and L. Meza González, Springer, chapter 13, pp 237-249.

J. Andreu, M.A. Pérez, J. Ferrer, A. Villalobos, and **J. Paredes**. "Drought Management Decision Support System by Means of Risk Analysis Models", in Methods and Tools for Drought Analysis and management, G. Rossi et alt. (edt.), ISBN 978-1-4020-5923-0, Ed. Springer, The Netherlands, pp. 195-216, 2007.

Pulido-Velazquez, D., J.L. García-Aróstegui, J.-L. Molina, **M. Pulido-Velazquez**, 2014. Assessment of future groundwater recharge in semi-arid regions under climate change scenarios (Serral-Salinas aquifer, SE Spain). Could increased rainfall variability increase the recharge rate?. Hydrological Processes, DOI: 10.1002/hyp.10191.

Harou, J.J., **Pulido-Velazquez, M.,** Rosenberg, D.E., Medellin-Azuara, J., Lund, J.R., Howitt, R.E., 2009. Hydro-economic Models: Concepts, Design, Applications, and Future Prospects. J. of Hydrology 375 (3-4), 627–643.

Previous projects or activities

- EU FP7 ENHANCE: Improving the resilience of society to catastrophic natural hazards through new risk-management partnerships. (UPV PI: Joaquin Andreu) (2012-2015)
- EU FP7 DROUGHT R&SPI: Fostering European Drought Research and Science-Policy Interfacing. (UPV PI: Joaquin Andreu) (2011-2015)
- EU FP7 SIRIUS: Sustainable Irrigation water management and River-Basin governance: Implementing User-Driven Services. (UPV PI: Joaquin Andreu) (2010-2013)
- EU FP7 GENESIS: Groundwater and Dependent Ecosystems: New Scientific and Technological Basis for Assessing Climate Change and Land-use Impacts on Groundwater. (UPV PI: M. Pulido-Velazquez) (2009-2014)
- EU Interreg IIIc SEDEMED II: Secheresse et desertification dans le Basin Mediterranéen. (UPV PI: Joaquin Andreu) (2004-2006)

➢ *19. POLMIL*

The Politecnico di Milano was established in 1863. Its most eminent professors have included the mathematician Francesco Brioschi, Luigi Cremona, and Giulio Natta (Nobel Prize in Chemistry in 1963). POLIMI is now ranked as one of the most outstanding European universities in Engineering, Architecture and Industrial Design. Its Dipartimento di Elettronica, Informazione e Bioingengeria (DEIB) is one of the major ICT university departments in Europe, with over 800 members. DEIB professors Carlo Ghezzi and Stefano Ceri have been recipient of two IDEAS ERC Grants of 2.5 million € each in the 2008 ERC Call. The DEIB has participated to 69 FP7 projects, for a total cost value of 31M€ (24M€ funding), of which 10 were coordinated by DEIB. In the last three years, DEIB participated in the following EU Projects: CUbRIK, REWIND, SCENIC, Q- ImPReSS, Indenica, MADES, OMP, LarKC, GAMES, MULTICUBE, Synaptic, COMPLEX, iSENSE, FASTER, TOISE, SmartH2O. Beside traditional ICT research areas, DEIB has a strong international reputation in cross- disciplinary fields, including the application of Systems Analysis and Control Theory to the field of modeling and decision-making support tools for participatory and integrated water resources management.

Curriculum vitae of persons involved in research and/or innovation activities

Dr. Andrea Castelletti (M) is Assistant Professor of Natural Resources Management, director of the Hydroinformatics Lab at Politecnico di Milano, chair of IFAC TC8.3 on Modelling and control of Environmental Systems, and Member of the ASCE/EWRI Environmental & Water Resources Systems Technical Committee. He is member of the editorial board of Environmental Modelling & Software, Associate Editor of Water Resources Research, Journal of Water Resources Planning and Management, PlosOne, and Acta Geophysica. His expertise is in modelling and control of water resources systems, model reduction, and water management. He coauthored more than 80 publications including two books on water resources management.

Dr. Matteo Giuliani (M) is a postdoc Research Associate at DEIB. His research interests are in multiobjective and real time control of water resources systems, evolutionary algorithms, and reinforcement learning.

Publications, products, services or other relevant achievements

M. Giuliani, J.D. Herman, **A. Castelletti**, and P.M. Reed, Many-Objective reservoir policy identification and refinement to reduce policy inertia and myopia in water management, Water Resources Research, DOI: 10.1002/2013WR014700. 2014

M. Giuliani, **A. Castelletti**, F. Amigoni, and X. Cai, Multiagent Systems and Distributed Constraint Reasoning for regulatory mechanism design in water management, Journal of Water Resources Planning and Management, 10.1061/(ASCE)WR.1943-5452.0000463, 2014

D. Anghileri, **A. Castelletti**, F. Pianosi, R. Soncini Sessa, E. Weber, Mitigating conflicts at the watershed scale by centralized operation of storing facilities, Journal of Water Resources Planning and Management, doi: 10.1061/(ASCE)WR.1943-5452.0000313, 2013.

A. Castelletti, F. Pianosi, R. Soncini Sessa, Water reservoir control under economic, social and environmental constraints. Automatica, 44(6), 1595–1607, 2008.

A. Castelletti, R. Soncini Sessa, A procedural approach to strengthening integration and participation in water resource planning, Environmental Modelling and Software, 21(10), 1455- 1470, 2006.

Previous projects or activities

- SmartH2O (ICT EU-FP7 - http://www.smarth2o-fp7.eu)
- IMRR-Vietnam (Ministro degli Affari Esteri – http://imrr.info),
- STRADA (EU-INTERREG - www.progettostrada.net).

Significant infrastructure and/or technical equipment

- POLIMI research facilities comprise 30 laboratories, including the recently funded inter- departmental Hydroinformatics Lab (Como campus) (http://hydroinformatics.polimi.it), several high-performance computing facilities on site (PoliCloud) and free access to national supercomputing cores. A large warehouse of case studies, models and software tools for planning and management of environmental resources is available at the POLIMI group.

20. CIMA

CIMA Research Foundation (Centro Internazionale in Monitoraggio Ambientale) is a non- profit organization backed by the Italian National Civil Protection Department, the University of Genova, Regione Liguria Administration, and Provincia of Savona Administration. The Foundation’s aim is to promote scientific research and technical development, high profile engineering and environmental science education. This mission is accomplished through scientific research, technology transfer and high level training services. In the framework of Risk Assessment and EWS, CIMA provided Italian Civil Protection, Other National Civil protection Agencies and hydrometeorological Services (e.g., Albania, Lebanon, Serbia, Croatia, Bolivia, Caricom Countries), as well as a number of local Civil Protection Agencies, with fully operational systems specifically developed for Flood and Wildfire Risk assessment. CIMA also led the development of the Global Flood Model within the Global Assessment report initiative for UNISDR. In the field of remote sensing, wildfire risk assessment, hydrometeorology and hydrologic modelling CIMA took part in several project funded by EU, the Italian Civil Protection, the Italian research and education Ministries, and the regional Governments.

Within IMPREX CIMA will take part in WP4 with its hydrological modelling implementation skills on extended domains in the case of the project improving over Europe an already existing implementation of a Global physically bases continuous and distributed hydrologic model; in WP7 will look at forecast products for flash floods leading the Liguria regional study case in Italy and in WP10 will lead the Genova case study in Italy for impact evaluation.

Curriculum vitae of persons involved in research and/or innovation activities

Dr. Roberto Rudari (M) is Research Director at CIMA Foundation; Ph.D. in Hydraulic Engineering at University of Padova (2002), Visiting Ph. D. at MIT – R.M. Parsons Lab. (2000-2001) Roberto Rudari has more than 12 years’ experience in risk Assessment models and Civil protection applications including EWS. Research in basin geomorphology & flood formation; climate and weather predictability in Europe; hydrologic modelling assisted by satellite information, statistical characterization of land effects and vulnerability estimation of flood events, combined hydro-meteorological forecast systems based on probabilistic concepts. He is special consultant of UNISDR on Risk assessment and Global Risk Assessment with focus on Weather related hazards. Consultant of WMO’s Associated Programme on Flood Management (APFM). Special advisor on Integrated Food risk management for different international institutions. Responsible for the UNISDR Global Assessment Report for the Global Flood Model and Global Flood Risk Computation. Coordinator of the Global Flood Record in the Global Flood Partnership. Coordinator of the RASOR FP7 project - Rapid Analysis for Specialisation of Risk.

Dr. Antonio Parodi (M) is Research Director at CIMA Foundation. He graduated in Environmental Engineering at the University of Genoa (Italy) in 1998 (summa cum laude); visiting student

(march-september 2002) at EAPS-MIT, Ph.D. in Hydraulic Engineering and Environmental Systems Modelling at University of Padua (Italy). He has research and operative experience in hydrometeorology and on fluid mechanics field, with particular emphasis in statistical analysis of extremes and in computational fluid dynamics. In the last 3 years he is also carrying on his research activity in the field of the application of new ICT (Information Communication Technologies) approaches (Grid computing, cloud computing etc) to the hydro-meteorology research, HMR, (Coordinator of three FP7 Projects: DRIHMS, Distributed Research Infrastructure for Hydro-Meteorology Study - www.drihms.eu; DRIHM, Distributed Research Infrastructure for Hydro-Meteorology - www.drihm.eu; and DRIHM2US Distributed Research Infrastructure for Hydro-Meteorology to US - www.drihm2us.eu).

Dr. Simone Gabellani (M) is a Project Leader at CIMA Foundation. Ph.D. in Fluodynamics and Processes of Environmental Engineering at the University of Genoa. Main research and operative experiences are in hydrology and flash flood forecasting. His research activities are focused on modelling of hydrological physical processes at catchments scale. Mainly interests refer to the development of distributed hydrologic models integrated in assimilation frameworks, using satellite data and remotely sensed information, and to snow hydrology. Rainfall field statistical characterization and statistical simulations, quantification of the sensitivity of basin processes to spatial and temporal variations of rainfall fields and to their statistical properties are also topics of his activities. He is principal investigator and co-investigator of different applied research projects.

Publications, products, services or other relevant achievements

Silvestro, F., **Gabellani, S**., Delogu, F., **Rudari, R.,** and Boni, G.,Exploiting remote sensing land surface temperature in distributed hydrological modelling: the example of the Continuum model, Hydrol. Earth Syst. Sci., 17, 39-62, doi:10.5194/hess-17-39-2013, 2013.

Silvestro, F., **Gabellani, S.,** Giannoni, F., **Parodi, A**., Rebora, N., **Rudari, R**., Siccardi, F., A Hydrological Analysis of the 4th November 2011 event in Genoa. Nat. Hazards Earth Syst. SCI., 12, 2743-2752, doi:10.5194/nhess-12-2743-2012, 2012.

Siccardi F., G. Boni, L. Ferraris, and **R. Rudari**, A Hydro-Meteorological Approach for Probabilistic Flood Forecast, 2005, Journal of Geophysical Research, vol. 110, No. D5 ISSN: 0148-0227. D05101, 10.1029/2004JD005314.

Laiolo, P., **S. Gabellani**, N. Rebora, **R. Rudari**, L. Ferraris, S. Ratto, H. Stevenin, M. Cauduro: Validation of the Flood-PROOFS probabilistic forecasting system. Hydrological Processes. http://dx.doi.org/10.1002/hyp.9888 DOI:10.1002/hyp.9888, 2013

Parodi A., Boni G. Ferraris L., Siccardi F., Pagliara P., Trovatore E., Foufula Georgiou E., Kanzmueller D., The "Perfect Storm": From Across the Atlantic to the Hills of Genoa, Eos, Vol. 93. No. 24, pages 225-232, 2012."

Previous projects or activities

- DRIHM, Distributed Research Infrastructure for Hydro-Meteorology; Funds: FP7 – The Project to develop a prototype e-Science environment to facilitate collaboration betweek ICT and Hydro Meteorology researchers and provide end-to-end HMR services (models, datasets and post-processing tools) at the European level, with the ability to expand to global scale. (www.drihm.eu)
- RASOR project - Rapid Analysis for Spatialisation of Risk; Funds: FP7 – the project is and downstream GMES/Copernicus project that aims at enhancing Risck analysis capabilities in a Multi-Risk frameworks at global scale using Models and EO Data. (www.rasor-project.eu)
- OPERA - Civil Protection from floods" funded by the Italian Space Agency to assess the benefit of using Satellite derived information in the DRR cycle with focus on floods, that became one of Italian contribution to Copernicus/GMES. (www.operaprojetc.it)
- Risc-Kit: Resilience Increasing Strategies for Coasts, the Project aims at developing methods, tools and management approaches to reduce risk and increase resilience to low-frequency, high-impact hydro-meteorological events in the coastal zone. (www.risckit.eu)
- The Global Assessment Report (GAR) 2015 is a major initiative of the UN International Strategy for Disaster Reduction (UNISDR). CIMA leads the Global Flood Model development. (http://www.unisdr.org/we/inform/gar)

21. GFZ

GFZ is the German national Research centre for Geosciences, hosting 1100+ staff and is active in all fields of Earth science including geodesy, geology, geophysics, mineralogy, palaeontology and geochemistry, in a multidisciplinary scientific and technical environment.

Section 5.4 "Hydrology" at GFZ Potsdam studies the entire flood risk chain, from the initiating meteorological causes and the outflow in the watersheds, the waves of high water in the rivers and the effects of protective measures to the negative effects of hydrological extreme events. We develop simulation models, calculate probabilities of occurrence and intensity for hydrological extreme events. We undertake exposure assessments on basis of statistical data, land use information and remote sensing. And, we develop, apply and validate multi-parameter flood damage models. Another research focus is on flood risk management and climate adaptation particularly focussed on private precautionary measures.

GFZ will develop methods for a probabilistic impact assessment (WP5 task 5.5), particularly focussed on flood damage modelling utilising Bayesian networks. GFZ will contribute to “WP7: Flood damage and insurance options” in testing and applying the newly developed probabilistic flood damage models in case studies.

Curriculum vitae of persons involved in research and/or innovation activities

Dr. Heidi Kreibich (F) is a senior scientist at the section Hydrology, GFZ since 2007. Her research interests are in the field of flood risk assessment, particularly in vulnerability analysis, loss modeling, damage mitigation and climate adaptation. Heidi Kreibich served as a referee for a number of international journals, for the European Commission (FP7), the Academy of Sciences of the Czech Republic, the World Bank and the insurance industry. She is Member of the Editorial Board of the journal Natural Hazards and Earth System Sciences (NHESS) and was guest editor of special issues of Natural Hazards and NHESS. She is subproject leader of the KfC Project „Climate-proof flood risk management” and was leader of WP 1 “Direct Costs & Production Processes” of the FP7 Project ConHaz.

Dr. Kai Schröter (M) is a postdoc at the section Hydrology, GFZ since 2012. His research interests are in the field of flood risk assessment with a specific focus on rapid flood event analysis, flood damage modeling, flood forecasting and warning and in particular including uncertainty analysis and optimization methods. Kai Schröter serves as a referee for various international journals. His current research at GFZ is within the research program of the Center of Disaster Management and Risk Reduction Technology (CEDIM) on Forensic Disaster Analysis in near real time.

Publications, products, services or other relevant achievements

Kreibich, H., van den Bergh, J. C. J. M., Bouwer, L. M., Bubeck, P., Ciavola, P., Green, C., Hallegatte, S., Logar, I., Meyer, V., Schwarze, R., Thieken, A. H. (2014): Costing natural hazards. - Nature Climate Change, 4, 303-306.

Schröter, K., Kreibich, H., Vogel, K., Riggelsen, C., Scherbaum, F., Merz, B. (2014 online): How useful are complex flood damage models? - Water Resources Research.

Merz, B., **Kreibich, H.**, Lall, U. (2013): Multi-variate flood damage assessment: a tree-based data-mining approach. - NHESS, 13, 1, 53-64.

Kreibich, H., Seifert, I., Merz, B., Thieken, A. H. (2010): Development of FLEMOcs - A new model for the estimation of flood losses in companies. Hydrological Sciences Journal, 55, 8, p. 1302-1314.

Kreibich, H., Piroth, K., Seifert, I., Maiwald, H., Kunert, U., Schwarz, J., Merz, B., Thieken, A. H. (2009): Is flow velocity a significant parameter in flood damage modelling? NHESS, 9, 5, p. 1679-1692.

Previous projects or activities

- FP 7 Project: MATRIX - New Multi-Hazard and Multi-Risk Assessment Methods for Europe
- FP 7 Project: ConHaz - Costs of Natural Hazards
- FP 7 Project: DEWFORA - Improved Drought Early Warning and Forecasting to strengthen preparedness and adaptation to droughts in Africa
- Dutch Knowledge for Climate Project: Climate proof flood risk management
- Large-Scale European Flooding under Climate Change: Meteorological and Hydrological Conditions Translated to Economic Loss (EuFloLoss) funded by the AXA Research Fund

22. BfG

The German Federal Institute of Hydrology (BfG) is a scientific institution ranking as a supreme federal agency of Germany. BfG' research has its focus in the fields of hydrology, water management, and water protection. The German Federal Institute of Hydrology advises different federal ministries and their subordinated authorities, especially the Waterways and Shipping Administration (WSV), in matters of utilisation and management of the German federal waterways. The institute is entirely independent, i.e. without any financial or organisational ties with manufacturers or suppliers.

With its expertise the BfG will lead the work package 6 c sectoral survey transport and will contribute to WP 4. As part of its responsibilities, BfG contributes to national flood hazard management (commissioned by the Federal Ministry of the Interior), water resources management (commissioned by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety), and waterway management (commissioned by the Federal Ministry of Transport and digital Infrastructure). The BfG works embedded within a transboundary network of customers and partners, e.g. in the context of the different river commissions. Selected institutions from this network will act as stakeholders in IMPREX. BfG operates an operational forecasting centre for the German parts of the waterways Rhine and Danube (focus on navigation-related forecasts) and develops and maintains the forecasting systems for the River Elbe and Odra (navigation-related and flood forecasting).

To support its activities the BfG holds hydro- and morphodynamic, hydrological as well as water resources models of major German rivers including their international tributaries. The BfG also has detailed experience and capabilities in modelling the flood routing processes in rivers including effects of flood reduction measures such as dike relocation and controlled retention in storage polders. Furthermore, the BfG offers processing schemes to prepare the output of dynamical as well as of statistical Regional Climate Models (RCM's) and meteorological forecasting models for hydrological modelling as well as components of decision support systems.

Curriculum vitae of persons involved in research and/or innovation activities

The key staff of BfG that will be working on IMPREX will be

Dr. Bastian Klein (male) holds a diploma degree and a doctoral level in civil engineering. His focus during his PhD at Ruhr-University Bochum was on risk-based design of reservoirs and flood risk management. He joined BfG in 2009 as a scientist working on climate change impacts on major rivers in Central Europe as well as updating the operational forecasting system for the Danube waterway. His expertise covers various aspects of climate / hydro-meteorological data treatment, hydrological and hydrodynamic modelling, multivariate statistics, ensemble post-processing, and result presentation/communication. He was involved in various national (e.g. BMBF-RIMAX, BMVI-KLIWAS) and international research-projects (e.g. INTERREG-IVb project ADAPTALP and EU-FP7 project ECCONET).

Dennis Meißner (male) holds a diploma degree in civil engineering. He has more than 10 year experience in hydrodynamic and hydrological modelling in connection with the use of Geo-Information-Systems (GIS) and real-time data. He joined BfG in 2003 as scientist working in BfG's operation forecasting section. In this context he's responsible for the design, set-up and maintenance of the forecasting systems and models operated for the German waterways (Rhine, Danube, Elbe, Odra). His expertise covers various aspects of hydrological and hydro-meteorological data treatment, hydrodynamic and hydrological modelling, and result presentation/communication. He was and still is involved in different working groups of the ICPR.

Publications, products, services or other relevant achievements

Klein, B., Meissner, D., Gerl, N., Hemri, S. and T.J. Gneiting, Assessing the potential skill of seasonal streamflow forecasting for the River Rhine and the Upper Danube Basin, AGU Fall Meeting Abstracts, 2013,1,8

Klein, B., Lingemann, I., Nilson, E., Krahe, P., Maurer, T. and H. Moser, Key concepts for the analysis of climate change impacts for river basin management in the River Danube. River Systems, 7-21.

Meissner, D. and S. Rademacher, Traffic-related Water-Level Forecasts for the Rhine River as a Federal Waterway - Extending the Forecast Period and Improving the Forecast Quality (in German). Korrespondenz Wasserwirtschaft, 2010, 3, 9, 485-491

Meissner D., Klein, B., Lisniak, D. and R. Pinzinger: Probabilistic flow and water-level forecasts – Communication strategies and potential uses for navigation on inland waterways (in German). Hydrologie und Wasserbewirtschaftung, 2014, 58, 2, 119-127

Szépszó, G., Lingemann, I., Klein, B., and M. Kovács, Impact of climate change on hydrological conditions of Rhine and Upper Danube rivers based on the results of regional climate and hydrological models. Natural Hazards, 2014, 72, 1, 241-262.

Previous projects or activities

- ECCONET (Effects of Climate Change on the inland waterway NETwork, EU FP7 Coordination and Support Action) gathered the expertise of partners from meteorology, hydrology, infrastructure operation, transportation and economics in order to assess the effect of climate change on the transport network. The inland waterway network was chosen as a case-study. BfG was responsible for acquiring information on hydrological effects of climate change on navigation which was then used for economic assessments.
- ADAPTALP (Climate ADAPTation and natural hazard management in the ALPine Space, INTERREG-IVb) focused on the management of natural hazards like floods, debris flow or avalanches in the Alpine arc under climate change conditions. In that context BfG evaluated regional climate models with respect to changes in drought and flood triggering situations and carried out hydrological simulations. The most important recommendations of the project partners were summarised in a so-called “Common Strategic Paper” (CSP), designed to support political decisions.
- KLIWAS (Impacts of climate change on waterways and navigation - Searching for options of adaptation, German Federal Ministry of Transport) evaluated possible effects of climate change on the flow regime of the German waterways as well as on the transport dependent enterprises. KLIWAS was coordinated by BfG and is mentioned as case study of a climate service in the GFCS of WMO.
- H-SAF (EUMETSAT Satellite Application Facility on Support to Operational Hydrology and Water Management) provide new satellite-derived products (precipitation, soil moisture, snow parameter) from existing and future satellites with sufficient time and space resolution to satisfy the needs of operational hydrology. For the new products independent validation of the usefulness for fighting against floods, landslides, avalanches, and evaluating water resources are conducted.

Significant infrastructure and/or technical equipment

- LARSIM-ME: Hydrological model for Central Europe
- Operational Water level forecasting system WAVOS for the Rivers Rhine, Danube, Elbe
- Operational forecasting system FEWS for the River Rhine including hydrological model HBV and hydrodynamic model SOBEK

➢ *23. WFN*

Water Footprint Network (WFN) is an NGO dedicated to promoting the transition towards sustainable, fair and efficient use of fresh water resources worldwide by advancing the concept of the ‘water footprint’, a spatially and temporally explicit indicator of direct and indirect water use of consumers and producers; increasing the water footprint awareness of communities, government bodies and businesses and their understanding of how consumption of goods and services and production chains relate to water use and impacts on fresh-water systems; and encouraging forms of water governance that reduce the negative ecological and social impacts of the water footprints of communities, countries and businesses. WFN is a network of academic institutions, governments, non-governmental organizations, companies, investors and UN institutions. The network has extensive knowledge and experience on water use and consumption in industry, nations and consumers. WFN has provided technical expertise and worked with several companies, international organizations and governmental bodies since its establishment. WFN’s technical knowledge and expertise cover a wide range of activities about use of Water Footprint Assessment related to different type of industrial sectors, agricultural production and domestic activities: technical advice, capacity building, awareness raising, tool development and trainings.

Curriculum vitae of persons involved in research and/or innovation activities

Dr. Ertug Ercin (M) is a a civil engineer experienced in interdisciplinary water management in the fields of hydraulic systems, water resources and river basin management and planning, water footprint assessment and environmental impact assessment. He has involved in many national or international projects as team leader, project leader, international expert, and water specialist. He currently works as a project manager at Water footprint Network.

Dr. Guoping Zhang (M) has expertise in the fields of hydrology, water resources and river basin management and planning, water footprint (virtual water) assessment, watershed modelling (quantity and quality), flood risk management, and environmental impact assessment. Dr. Zhang has more than 20 years of research/consultancy experience in these fields and involved in many national or international projects as team leader, project leader, international expert, and/or specialist in a number of Asian, Middle-east and European countries. He has extensive experience in stakeholder engagement and has excelled in communications.

Dr. Ashok Chapagain (M) has been working in the field of water resource management for more than 24 years. He holds a PhD in the field of Water Systems and Policy Analysis, and an MSc degree in Water and Environmental Resources Management. He helped develop the concept of Water Footprint since its inception. He has a strong publication portfolio on the subject of Water Footprint including the 'Water Footprint Assessment Manual' used globally as the foundation document in this field. In his previous professional carrier, he worked for WWF-UK for six years on both UK and international freshwater and sustainable consumption issues, supporting WWF's external engagement with companies, government organisations and the research community to help influence policy and practice on water stewardship and water security.

Publications, products, services or other relevant achievements

Ercin, A.E. and Hoekstra, A.Y. (2014) Water footprint scenarios for 2050: A global analysis,Environment International, 64: 71-82.

WaterStat database (http://www.waterfootprint.org/?page=files/WaterStat)

Water Footprint Assessment (WFA) tool (http://www.waterfootprint.org/tool/home/)

The water footprint assessment manual, Global Standard (http://www.waterfootprint.org/?page=files/WaterFootprintAssessmentManual)

Ercin, A.E., Mekonnen, M.M. and Hoekstra, A.Y. (2013) Sustainability of national consumption from a water resources perspective: The case study for France, Ecological Economics, 88: 133-147.

Previous projects or activities

- UK Environment Agency: Water Footprint Assessment for the catchments of the North East Thames River Basin
- TATA group WFA project – steel, chemicals, power and automotive industry.
- IFC: PACT Project, Partnership for Cleaner Textile.
- C&A Foundation: Water footprint of C&A supply chain

4.2 Third parties involved in the project (including use of third party resources)

Linked third parties

The partner CETAqua has a linked third party AquaTEC who will perform a number of water quality analysis using the local laboratory of EMUASA (see partner description).

Third parties providing in kind contributions free of charge

BSC applies a Third Party modality with the Institut Català de Recerca i Estudis Avançats (ICREA), where the third party is making its resources available to the beneficiary under Article12 of the Grant Agreement - Use of in-kind contributions provided by third parties free of charge.

According to this situation, ICREA will not carry out any part of the work and just lends resources to the beneficiary. These resources are directly used by the beneficiary, the work is performed in its premises and there is no reimbursement by the beneficiary to the third party. The third party makes available resources (dedicated time of Prof. Francisco J. Doblas-Reyes, who is employed by ICREA) to the beneficiary, which does not reimburse the cost to the third party, but which charges the costs of the third party as an eligible cost of the project. Its costs will be declared by the beneficiary in its Form C but must be recorded in the accounts of the third party. ICREA resources will be available for the whole duration of the project, mainly for RTD activities.

Subcontracting

As noted in Section 3.4, two subcontracting constructions are foreseen in IMPREX:

- Some key water quality parameters for this project, gathered by CETAqua (WP10), cannot be detected by standard analysis carried out by its linked third party AquaTEC (toxins produced by cyanobacteria such as microcystins, BMAA and anatoxin). Their analyses well be subcontracted to a laboratory with specialized equipment. This subcontracting will be done for several analyses, summing the amount mentioned in the proposal. In any case, the supplier for any subcontracting cost will be selected under conditions of transparency and equal treatment, taking into account best value for money (best price-quality ratio).
- The subcontracting by Future Water concerns the application of the Water Accounting Plus (WA+) framework and further develop and evaluate this framework using IMPREX-based climate information. In WP11 a tailoring of this global accounting framework to the relevant study areas requires specific expertise that cannot be found in the IMPREX consortium. For this external expertise needs to be hired by Future Water to support building the water accounts under current and future conditions. The subcontracted candidate needs to have the specialized expertise for this task and be able to carry out its services in a relatively short time period, to obtain a optimal “value for money” subcontract. A candidate that matches these criteria is Prof. Dr. Wim Bastiaanssen, who is the founder of Water Accounting Plus (WA+) framework and has broad experience with the use of earth observation and climate modelling outputs to build water balances and water accounts. Options to select alternative candidates that possess expertise at a similarly adequate level to guarantee adequate support will be kept open.

Table 4.1: Stakeholder involvements

IMPREX partner	WP(s) involved	Stakeholders involved
HKV, Deltares	7	Waterboard Noorderzijlvest, Aa en Maas, Rijkswaterstaat, Ministry of Infrastructure and Public Works
UREAD	7	UK Environment Agency
CIMA	7	Municipality of Genova, Regional Environmental Protection Agency of Liguria
SMHI	8	Vattenfall
POLMIL, IRSTEA	8	A2A Trading, EDF
BfG	9	Imperial Shipping company
CETAqua	10	AGBAR Group, Aguas de Murcia, Aigües de Terrassa
Future Water, UPV	11	JRC, Segura River Basin Authority, Farmers´ Associations Acequia Real del Júcar and Campo de Cartagena
TUC	11	Directorate of Rural Economy, Directorate of Water and Directorate of Civil Protection, Hellenic Republic
POLMIL	11	River Po Water Authority, Regional Environmental Agency (ARPA) – Lombardia and Liguria

Stakeholder involvement with no cost for the project

The stakeholders involved in the sectoral surveys in WP7-12 will be consulted, contribute to surveys, invited to meetings and asked to provide feedback on products and concepts developed by IMPREX. More specifically, the stakeholder participation process in WP7-12 will consist of (1) needs analysis; (2) prototype design evaluation (3) capacity building (4) prototype demonstration and testing; (5) final system evaluation.

A summary of these contributions is given in Table 4.1. The support letters (Table 3.1) reinforce these interactions.

The contribution of Waterboard Noorderzijlvest, Waterboard Aa& Maas and the Ministry of Infrastructure and Public Works in WP7 consists of participation to meetings and providing data, models, feedback and knowledge for the case studies.

In WP8, stakeholders consultation will be done through meetings (telephone or face-to-face meetings) with EDF.

In WP9 the stakeholders will participate in a survey on the sensitivity and vulnerability of transport due to hydrological extremes, providing feedback to the draft version of D6c.1. Via workshops or written feedbacks they will provide feedback to the design / content of improved forecast products and its potential economic benefit based on IMPREX products. Also they will participate in workshops / training courses on the interpretation / use of probabilistic forecasts for waterway transport.

The River Basin Authority (Confederación Hidrográfica del Segura) and the Irrigation Water Users´ Association (Comunidad de Regantes) involved in the Segura case study will provide feedback on the decision support tool design, leading to relevant (i.e. meeting users´ needs), accessible (i.e. sufficient human and technical resources) and flexible (i.e. addressing a sufficient range of tasks) support interventions.

With regard to the contributions of Aguas de Barcelona, Agua de Terrassa and EMUASA in WP10 is described in the workplan of this workpackage: the development of the water quality model in the Segura basin (task 6d.3) will be carried while utilizing feedback and recommendations from the stakeholders (including Aguas de Murcia (EMUASA)) in practice.

A2A will contribute with i) participation in local meetings with POLMIL and in the project meething when organized in Milan, ii) by providing data and information on the system and iii) by validating the model built up by POLMIL. A2A will also provide feedback on the operational value of forecasts in the operation of their hydropower system.

Also the external partners involved in WP11 (including JRC) will provide access to databases and reports in order to obtain data to feed the different models. Moreover, they will supply other requested information derived from their experience on hydrological hazards management (answer to surveys, expert judgment, etc.).

ARPA will support POLMIL by providing free of charge hydrometeorological data on the lake catchment and the irrigation districts considered in IMPREX. They will also share time series of data products included in its weekly bulletin (e.g. estimated SWE and evapotranspiration). ARPA will participate and help in organizing local meetings also involving other stakeholders (e.g. farmers) and will support POLMIL in enrolling stakeholders.

The type of contribution from the Directorates of Water, Rural Economy and Civil Protection of the Region of Crete will be providing consultation on the local case study of Messara region on risk management and planning, organization and participation to the local stakeholder meetings, participation to project meetings, and providing local datasets.

5. Ethics and Security

5.1 Ethics

In IMPREX many external stakeholders and (potential) users of weather and climate information will be interviewed and consulted. For these types of interactions details on the procedures and criteria used to select and approach the participants will be provided as part of the Deliverable 2.3 “Stakeholder interaction protocol" (due in M6). Also details on the informed consent procedures will be provided in this protocol document.

5.2 Security

IMPREX does not involve Activities or results raising security issues, or 'EU-classified information' as background or results.

Acronymns

Acronymn	Meaning
ARMAX	Autoregressive moving average model
BMA	Bayesian model averaging
BUFR	Binary Universal Form for the Representation of meteorological data
CA	Consortium Agreement
CAP	Common Agricultural policy
CF	Climate and Forecast
CMIP5	Fifth Coupled Model Intercomparison Project
COMBINE	Comprehensive Modelling of the Earth System for Better Climate Prediction and Projection
Copernicus	The European Earth Observation Programme
CORDEX	Coordinated Regional Climate Downscaling Experiment
COST	European Cooperation in Science and Technology
CU	Coordination Unit
DG	Directorates-General
DG-ENV	DG Environment
DPP	Data Protocol Panel
Earth2Observe	Global Earth Observation for Integrated Water Resource Assessment
EBAE	European Business Awards for the Environment
EBN	European Business and Innovation Network
ECAP	Environmental Compliance Assistance Programme
EC	European Commission
ECC	Ensemble Copula Coupling
ECCONET	Effects of climate change on inland waterways and inland shipping competitiveness
EcoAP	Eco-Innovation Action Plan
EEN	Enterprise Europe Network
EDO	European Drought Observatory
EFAS	European Flood Awareness System
EFP	European Foresight Platform
EIP	European Innovation Platform
EM-DAT	International Disaster Database
EMAS	The European Eco-Management and Audit Scheme
EMOS	Ensemble Model Output Statistics
ENES	European Network for Earth-System Modelling
ENSO	El Niño Southern Oscillation
ERA	European Re-analysis
ERA-CLIM	European Reanalysis of Global Climate Observations
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EUPORIAS	European Provision Of Regional Impacts Assessments on Seasonal and Decadal Timescales
EURO4M	European Reanalysis and Observations for Monitoring
EUROSIP	multi-model seasonal forecasting system

Acronymn	Meaning
EUSAF	European Solidarity Fund
FAO	Food and Agriculture Organization of the UN
FD	Flood Directive
GA	General Assembly
GAR	Global Assessment Report on Disaster Risk Reduction
GCM	Global Climate Model
GDACS	Global Disaster Alert and Coordination System platform
GDP	Gross Domestic Product
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of System
GEOWOW	GEOSS Interoperability for Weather, Ocean and Water
GLOFAS	Global Flood Awareness System
GLOWASIS	Global Water Scarcity Information Service
HEPEX	Hydrological Ensemble Prediction Experiment
HPSS	High Performance Storage System
HSAF EUMETSAT	Satellite Application Facility on Support to Operational Hydrology and Water Management
IAHS	International Association of Hydrological Sciences
IMPREX	IMproved PRedictions and management of hydrological EXtremes
IPCC	UN Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
IS-ENES	Infrastructure for the European Network for Earth System Modelling
ISI-MIP	Inter-Sectoral Impact Model Intercomparison Project
ISO	International Organization for Standardization
IWT	Inland Waterway Transport
JPI Climate	Joint Programming Initiative Climate
JRC	Joint Research Centre
MACC-II	Monitoring Atmospheric Composition and Climate - Interim Implementation
MAPP	Modelling, Analysis, Prediction and Projection
MARS	Monitoring Agricultural ResourceS
MB	Management Board
MLR	Multiple Linear Regression
NAO	North Atlantic Oscillation
NetCDF	Climate and Forecast Metadata Convention
NGR	Non-homogenous Gaussian regression
NMME	North American Multi-Model Ensemble
NOAA	US National Oceanic and Atmospheric Administration
NWP	Numerical Weather Prediction
OAT	one-step-at-a-time method (sensitivity analysis)
OGC	Open Geospatial Consortium
OPeNDAP	Open-source Project for a Network Data Access Protocol
Panta Rhei	“Everything Flows” (IAHS decadal project)
PM4SD	Project Management for Sustainable Development

Acronymn	Meaning
QP	Quality Plan
RACMO	Regional Atmospheric Climate Model
RCM	Regional Climate Model
RDA	Resource Description and Access
RIS	Rhine Information System
S2S	Subseasonal to Seasonal
SIP	Strategic Implementation Plan
SME	Small and Medium Enterprises
SOBOL	Global Sensitivity method
SOS	Sensor Observation Service
SPECS	Seasonal-to-decadal climate Prediction for the improvement of European Climate Services
SPEI	Standardized Evaporation-Precipitation Index
SPI	Standardized Precipitation Index
SRI	Standardized Runoff Index
SSAB	Science and Service Advisory Board
SWFDP	WMO Severe Weather Forecast Demonstration Project
THORPEX	The Observing System Research and Predictability Experiment
TIGGE	THORPEX Interactive Grand Global Ensemble
TRL	Technology Readiness Level
TSM	Tivoli Storage Manager
UNISDR	United Nations International Strategy for Disaster Reduction
VALUE	Validating and Integrating Downscaling Methods for Climate Change Research (COSt Action)
WA+	Water Accounting Plus
WCRP	World Climate Research Programme
WCS	Web Coverage Service
WFA	Water Footprint Assessment
WFD	Water Framework Directive
WFS	Web Feature Service
WGCM	Working Group on Climate Modelling
WGSIP	WCRP Working Group on Seasonal to Interannual Prediction
WMO	World Meteorological Organisation
WMS	Web Map Service
WP	Work Package

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ESTIMATED BUDGET FOR THE ACTION (page 1 of 2)

	Estimated eligible[1] costs (per budget category)									EU contribution			Additional information		
	A. Direct personnel costs				B. Direct costs of subcontracting	[C. Direct costs of fin. support]	D. Other direct costs	E. Indirect costs[2]	Total costs	Reimbursement rate %	Maximum EU contribution[3]	Maximum grant amount[4]	Information for indirect costs	Information for auditors	Other information:
	A.1 Employees (or equivalent) A.2 Natural persons under direct contract A.3 Seconded persons [A.6 Personnel for providing access to research infrastructure]		A.4 SME owners without salary A.5 Beneficiaries that are natural persons without salary				D.1 Travel D.2 Equipment D.3 Other goods and services D.4 Costs of large research infrastructure						Estimated costs of in-kind contributions not used on premises	Declaration of costs under Point D.4	Estimated costs of beneficiaries/ linked third parties not receiving EU funding
Form of costs[6]	Actual	Unit[7]	Unit[8]		Actual	Actual	Actual	Flat-rate[9] 25%							
	(a)	Total (b)	No hours	Total (c)	(d)	(e)	(f)	(g)=0,25x ((a)+(b)+ (c)+(f) +[(h1)+(h2)]- (m))	(i)= (a)+(b)+(c)+ (d)+(e)+(f)+ (g)+(h1)+(h2)+(h3)	(j)	(k)	(l)	(m)	Yes/No	
1. KNMI	514125.00	0.00			0.00	0.00	116875.00	157750.00	788750.00	100.00	788750.00	788750.00	0.00	No	
2. ECMWF	558381.00	0.00			0.00	0.00	22875.00	145314.00	726570.00	100.00	726570.00	726570.00	0.00	No	
3. SMHI	507000.00	0.00			0.00	0.00	25800.00	133200.00	666000.00	100.00	666000.00	666000.00	0.00	No	
4. IRSTEA	235306.00	0.00			0.00	0.00	20200.00	63876.50	319382.50	100.00	319382.50	319382.50	0.00	No	
5. PIK	128300.00	0.00			0.00	0.00	14000.00	35575.00	177875.00	100.00	177875.00	177875.00	0.00	No	
6. ARCTIK	136674.00	0.00	0.00	0.00	0.00	0.00	48106.40	46195.10	230975.50	100.00	230975.50	230975.50	0.00	No	
7. BSC	168300.00	0.00			0.00	0.00	23700.00	48000.00	240000.00	100.00	240000.00	240000.00	0.00	No	
8. METOFFICE	401655.00	0.00			0.00	0.00	25700.00	106838.75	534193.75	100.00	534193.75	534193.75	0.00	No	
9. TUC	130000.00	0.00			0.00	0.00	15500.00	36375.00	181875.00	100.00	181875.00	181875.00	0.00	No	
10. UREAD	220788.00	0.00			0.00	0.00	28681.00	62367.25	311836.25	100.00	311836.25	311836.25	0.00	No	
11. HZG	266255.00	0.00			0.00	0.00	22700.00	72238.75	361193.75	100.00	361193.75	361193.75	0.00	No	
12. DELTARES	343730.00	0.00			0.00	0.00	22800.00	91632.50	458162.50	100.00	458162.50	458162.50	0.00	No	
13. IVM	268800.00	0.00			0.00	0.00	22800.00	72900.00	364500.00	100.00	364500.00	364500.00	0.00	No	
14. ADELPHI	137500.00	0.00	0.00	0.00	0.00	0.00	20200.00	39425.00	197125.00	100.00	197125.00	197125.00	0.00	No	
15. HKV	226618.00	0.00	0.00	0.00	0.00	0.00	21300.00	61979.50	309897.50	100.00	309897.50	309897.50	0.00	No	
16. FW	210840.00	0.00	0.00	0.00	10200.00	0.00	22000.00	58210.00	301250.00	100.00	301250.00	301250.00	0.00	No	
17. CETAQUA	124368.00	0.00			0.00	0.00	20000.00	36092.00	180460.00	100.00	180460.00	180460.00	0.00	No	
- AquaTEC[14]	29920.00	0.00			17500.00	0.00	3500.00	8355.00	59275.00	100.00	59275.00	59275.00	0.00	No	
Total beneficiary 17	154288.00	0.00			17500.00	0.00	23500.00	44447.00	239735.00		239735.00	239735.00	0.00		
18. UPV	237961.00	0.00			0.00	0.00	22700.00	65165.25	325826.25	100.00	325826.25	325826.25	0.00	No	
19. POLMIL	182000.00	0.00			0.00	0.00	20600.00	50650.00	253250.00	100.00	253250.00	253250.00	0.00	No	
20. CIMA	156000.00	0.00			0.00	0.00	20400.00	44100.00	220500.00	100.00	220500.00	220500.00	0.00	No	
21. GFZ	152100.00	0.00			0.00	0.00	20600.00	43175.00	215875.00	100.00	215875.00	215875.00	0.00	No	
22. BfG	270660.00	0.00			0.00	0.00	15000.00	71415.00	357075.00	100.00	357075.00	357075.00	0.00	No	
23. WFN	156000.00	0.00			0.00	0.00	16000.00	43000.00	215000.00	100.00	215000.00	215000.00	0.00	No	
Total consortium	5763281.00	0.00		0.00	27700.00	0.00	612037.40	1593829.60	7996848.00		7996848.00	7996848.00	0.00		0.00

ESTIMATED BUDGET FOR THE ACTION (page 2 of 2)

(1) See Article 6 for the eligibility conditions
(2) The indirect costs covered by the operating grant (received under any EU or Euratom funding programme; see Article 6.5.(b)) are ineligible under the GA. Therefore, a beneficiary that receives an operating grant during the action's duration cannot declare indirect costs for the year(s)/reporting period(s) covered by the operating grant (see Article 6.2.E).
(3) This is the theoretical amount of EU contribution that the system calculates automatically (by multiplying all the budgeted costs by the reimbursement rate). This theoretical amount is capped by the 'maximum grant amount' (that the Commission/Agency decided to grant for the action) (see Article 5.1).
(4) The 'maximum grant amount' is the maximum grant amount decided by the Commission/Agency. It normally corresponds to the requested grant, but may be lower.
(5) Depending on its type, this specific cost category will or will not cover indirect costs. Specific unit costs that include indirect costs are: costs for energy efficiency measures in buildings, access costs for providing trans-national access to research infrastructure and costs for clinical studies.
(6) See Article 5 for the forms of costs
(7) Unit : hours worked on the action; costs per unit (hourly rate) : calculated according to beneficiary's usual accounting practice
(8) See Annex 2a 'Additional information on the estimated budget' for the details (costs per hour (hourly rate)).
(9) Flat rate : 25% of eligible direct costs, from which are excluded: direct costs of subcontracting, costs of in-kind contributions not used on premises, direct costs of financial support, and unit costs declared under budget category F if they include indirect costs
(10) See Annex 2a 'Additional information on the estimated budget' for the details (units, costs per unit).
(11) See Annex 2a 'Additional information on the estimated budget' for the details (units, costs per unit, estimated number of units, etc)
(12) Only specific unit costs that do not include indirect costs
(13) See Article 9 for beneficiaries not receiving EU funding
(14) Only for linked third parties that receive EU funding