Technical Proposal

Copernicus Stress-test Tool Kit (CSTK)

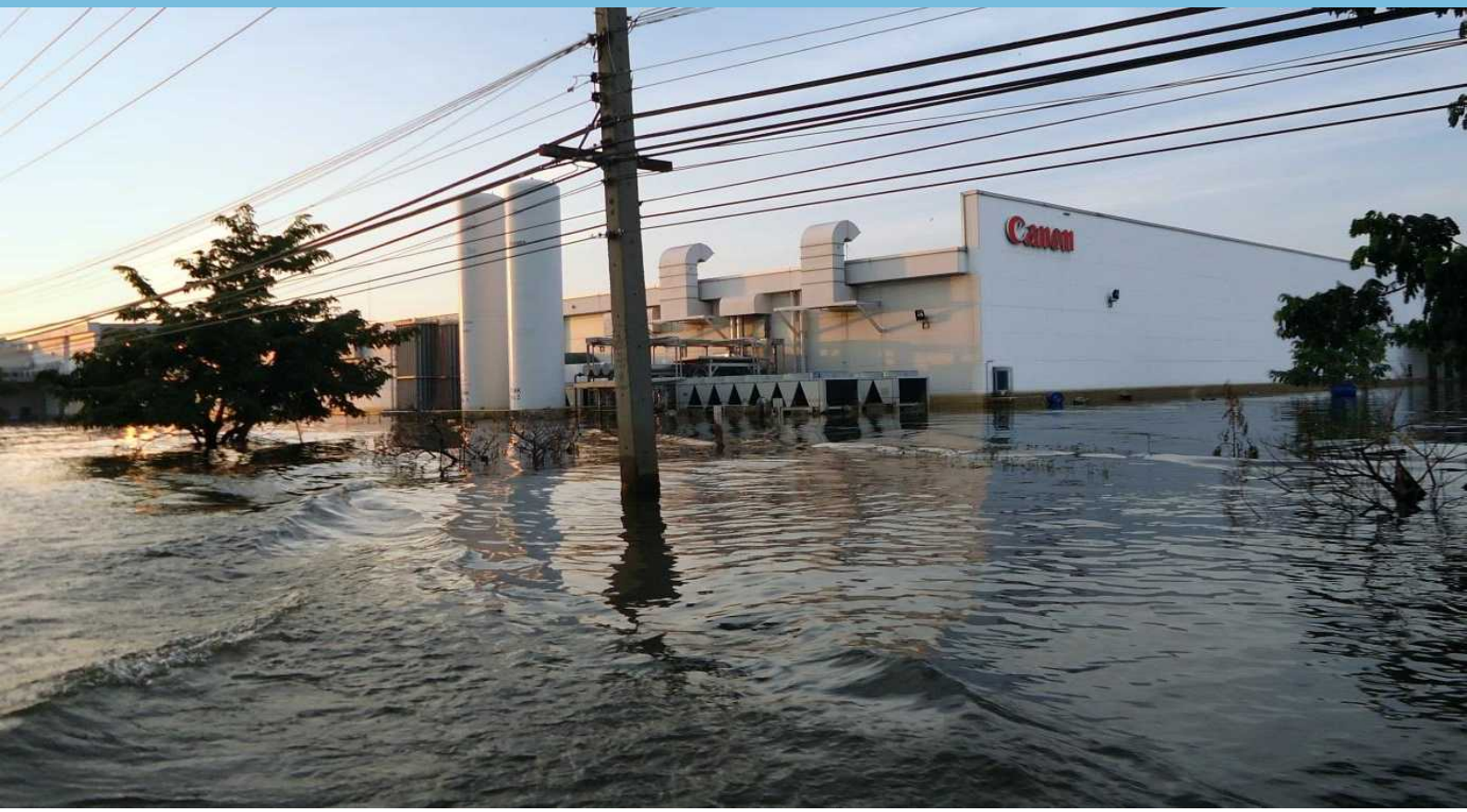

Photo: Thailand floods 2011 (by Mathijs van Ledden)

Technical Proposal

Copernicus Stress-test Tool Kit (CSTK)

Deltares – The Netherlands

In association with:

Royal Netherlands Meteorological Institute – The Netherlands

Barcelona Supercomputing Centre – Spain

Royal HaskoningDHV – The Netherlands

Loughborough University – UK

Arcadis – The Netherlands

Copernicus Climate Change Services, C3S_422 Lot 1: Global

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1. Track record

Deltares

Deltares is an independent institute for applied research in the field of water, subsurface and infrastructure. Throughout the world, we work on smart solutions, innovations and applications for people, environment and society. Our main focus is on deltas, coastal regions and river basins. Managing these densely populated and vulnerable areas is complex, which is why we work closely with governments, businesses, other research institutes and universities at home and abroad. Our motto is Enabling Delta Life. As an applied research institute, the success of Deltares can be measured in the extent to which our expert knowledge can be used in and for society. For Deltares the quality of our expertise and advice is foremost. Knowledge is our core business. All contracts and projects, whether financed privately or from strategic research budgets, contribute to the consolidation of our knowledge base. Furthermore, we believe in openness and transparency, as is evident from the free availability of a selection of our software and models. Open source works, is our firm conviction. Deltares employs over 800 people and is based in Delft and Utrecht and has offices in Singapore, Indonesia (Jakarta), and the USA (Deltares USA Inc., Silverspring).

Deltares has an ISO 9001:2008 Quality Assurance Certificate provided by Lloyd's Register Quality Assurance. This quality assurance certifies the "Deltares Quality Management System" (DQMS) which includes standard procedures and practices assuring our quality of services. In addition, Deltares employees are committed to an "Anti-Corruption Code" describing what is expected of our staff when interacting with clients, partners and colleagues.

Water and the subsurface involve not only technological issues, but also natural processes, spatial planning and administrative and legal processes. We apply our understanding of those processes in an integrated way, improving the quality of life in deltas, coastal areas and river basins. The integrated approach allows us to come up with innovative solutions.

Our proposed service builds on various EU-FP7 projects in which Deltares has played or still plays a large role. Within the FP7 project **GLOWASIS**, led by Deltares, a similar prototype service was pre-validated and tested. It was shown that such a global service could be set up and run, and that it can provide valuable information for water managers and policy makers in Europe. Within the FP7 **DEWFORA** project, also led by Deltares, this concept was further tested and evaluated, though the geographical focus in that project was on Africa. The FP7 **Earth2Observe** project, which is on-going and is equally led by Deltares, delivers global water resources analysis (i.e. Essential Climate Variables (ECV)) via an open access OpenDAP server and associated portal (https://wci.earth2observe.eu/thredds/catalog.html or https://wci.earth2observe.eu/portal/) that is hosted at Pacific Marine Laboratory (PML). The ECV's provided by Earth2Observe are particularly useful as a baseline and for providing background information for the proposed service.

In CSTK **Deltares** takes the role as climate service developer, and is supplying and advising the following companies and organisations: **Kimberly Clark Company, Anglian Water Services, US Army Corps of Engineers, World Resources Institute, ING bank and many other public and**

private organizations.

Infrastructure available at Deltares

Deltares software gives users rapid access to the latest advances in the area of water and the subsurface, including hydraulics and hydrology. Together with users and research partners, we engage in a constant cycle of application and development that results in ever wider use of our knowledge through the medium of our software. The integration of data, software and expert knowledge enhances the range of applications available to users. Our aim is to provide open architecture software, fully compatible with third-party programmes under the name **Deltares Systems**.

Deltares also has its own **physical laboratory facilities** (including an environmental laboratory, a Delta Flume and a Geo Centrifuge). These are used to conduct water and subsurface research for the validation of new models and software, and also to test designs and scale models for hydraulic and geo-engineering structures of for the biochemical strengthening of the subsurface

The iD-Lab (**interactive Data Laboratory**) is a new real-time demonstration, training and research facility, where we can run collaborative research sessions, experiment with global and local models, demonstrate projects and tools to clients, and respond to disaster events. It is open for use internally and for external partners, and is intended to be used as workshop venue of the CSTK project.

Location where services will be performed: Delft, The Netherlands

Percentage of the contract: 45%

Royal Netherlands Meteorological Institute (KNMI)

The Royal Netherlands Meteorological Institute (KNMI) is the Dutch national weather service. It is an agency of the Ministry for Infrastructure and the Environment. Primary tasks are weather forecasting and the monitoring of weather, climate, air quality and seismic activity. KNMI is the national research and information centre for meteorology, climate, air quality, and seismology.

KNMI focuses on monitoring and warning for risks with an atmospheric or seismic origin. In addition, KNMI offers advice and strategy prospects for both acute and future dangers. We strive to make our high-quality knowledge and information in the area of weather, climate, and seismology operationally available 24 hours a day, seven days a week. In addition, we continuously extend and deepen this knowledge in co-operation with research institutes, universities and businesses. As a scientific institute KNMI contributes to the international climate research and contributes to the process and reports of the Intergovernmental Panel on Climate Change (IPCC).

KNMI has a long record of activities related to climate services, both on the national as well as the European to global scale. It has been involved in several EU-funded projects which provide users (policy makers, the scientific community, commercial partners) with tailored science-based assessments through our Climate Services activities as well as detailed state-of-the-art datasets. It provides these assessments and datasets using sustained and operational IT based services

(ECA&D, Climate Explorer, KNMI Datacentre, climate4impact.eu).

The **IS-ENES climate4impact** (www.climate4impact.eu) (C4I) website is oriented towards climate change impact modelers, impact and adaptation consultants, as well as other experts using climate change data. On C4I access to data and quick looks of global climate models (GCM) is provided, as well as regional climate models (RCM) and downscaled higher resolution climate data. C4I uses the ESGF infrastructure, but also has its own data store. The portal provides data transformation tooling for tailoring, mapping & plotting capabilities. Guidance on the use of climate scenarios, documentation on the climate system, frequently asked questions and examples in several impact and adaptation themes are presented and described, along with the steps required to connect GCM data to impact model input data. C4I is developed in the FP7 funded IS ENES projects, and co-developed with CERFACS, SMHI, University of Cantabria and Wageningen University. KNMI is the leading partner and hosts the portal.

The **C3S-MAGIC** project, coordinated by KNMI, is the C3S project that will include the global climate projections from CMIP5 (and later CMIP6) in the Climate Data Store. Software is built that allows C3S users to retrieve global climate model projection data and perform elementary post-processing operations on these data. The Netherlands E-Science Center, BSC, SMHI and DLR (leading the development of the ESMValTool) are major partners in C3S-MAGIC.

Infrastructure available at KNMI

KNMI has available all necessary equipment for atmospheric model simulation, as well as data storage. This includes a BULLx B500 supercomputer, 396 compute nodes, 4752 cores; 58 Tflop/s, 9.5 TB memory. A mass storage system is available (tape robot) with a capacity of 2 PB. Workplaces equipped with workstations are available, interconnected via broadband network.

Location where services will be performed: De Bilt, The Netherlands

Percentage of the contract: 16%

Barcelona Supercomputing Center (BSC)

The Barcelona Supercomputing Center-Centro Nacional de Supercomputación (BSC-CNS) is a prestigious research centre at both national and international levels. The BSC-CNS combines unique high performance computing facilities and in-house top research departments on computer, life, and Earth sciences, and in computational applications in science and engineering. The BSC-CNS is the main provider of public supercomputing services in Spain, including not only the access to cutting-edge computers and technology, but also top-of-the-range training and education, the development of purpose-built applications for both public and private actors and first-class innovation. The BSC-CNS also coordinates the interests in supercomputing at the national level via the Red Española de Supercomputación and represents Spain in international initiatives such as PrACE and the Big Data Value Association. The BSC-CNS has a total staff of about 475 employees.

Established in 2006, the Earth Sciences Department of the BSC-CNS is structured around four groups (Climate Prediction, Atmospheric Composition, Computational Earth Sciences, and Earth Science Services), with more than 55 employees, including technical and support staff. The BSC-ES international activity includes the coordination of the two World Meteorological Organisation (WMO) regional centres specialised in sand and dust warning and forecasting, as well as the participation in

climate services initiatives like the Climate Services Partnership (CSP).

BSC members have participated in several projects relevant to the CSTK proposal, out of which two Seventh Framework Programme (FP7) projects excel. The **EUPORIAS** (EUropean Provision Of Regional Impact Assessment on a Seasonal-to-decadal timescale) project intends to improve our ability to maximise the societal benefit of these new technologies. This project wants to develop a few fully working prototypes of climate services addressing the need of specific users. 2012 the 24 project-partners, representing a diverse community ranging from UN organisations to small enterprises, have been increasing the resilience of the European Society to climate change by demonstrating how climate information can become directly usable by decision makers in different sectors.

SPECS (Seasonal to decadal Prediction for the Climate improvement of European Climate Services) is an FP7 project that undertakes research and dissemination activities to deliver a new generation of European climate forecast systems, with improved forecast quality and efficient regionalisation tools to produce reliable, local climate information over land at seasonal-to-decadal time scales, and provide an enhanced communication protocol and services to satisfy the climate information needs of a wide range of public and private stakeholders. The impact of SPECS consists in the provision of improved seasonal-to-decadal climate forecast systems to relevant operational platforms, which include the European global producing centres (GPCs) of climate forecasts, the Regional Climate Outlook Fora (RCOFs) and the World Meteorological Organisation (WMO) Lead Centre for Long-Range Forecasts Multi-Model Ensemble (LC-LRFMME).

Other European projects where the BSC-ES is involved playing a role on seasonal forecast quality evaluation and the development of interactions with the users are **EUCLEIA, PREFACE, PRIMAVERA, IMPREX, ECOMS2** and **ERA4CS,** while the group develops the first climate services national project that illustrates the challenges of climate services based on sub-seasonal and seasonal predictions, RESILIENCE.

Beyond active participation in many European and National projects, the BSC-ES is currently involved in the Copernicus initiatives including **QA4Seas** (C3S 51 Lot 3; Quality Assessment Strategies for Multi-model Seasonal Forecasts) which is coordinated by Prof. Francisco Doblas-Reyes. This BSC-ES Copernicus flagship project aims at developing a strategy for the evaluation and the quality control (EQC) of the multi-model seasonal forecasts provided by the Copernicus Climate Change Service to respond to the needs identified among a wide range of stakeholders. It is also worth mentioning here that Francisco's team plays an active role being involved in other Copernicus initiatives: CAMS-84, Clim4Energy, SECTEUR and, recently awarded, MAGIC.

The infrastructure of BSC

BSC-CNS is the National Supercomputing Facility of Spain and hosts a range of high-performance computing (HPC) systems, including MareNostrum III, one of the most powerful supercomputers in Europe with 48,128 cores and 1.1 Pflops capacity (the Barcelona Supercomputing Centre has just approved the purchase of a new supercomputer, MareNostrum 4, that will have a performance capacity of 13,7 Petaflop/s). The BSC-CNS is a key element of and coordinates the Spanish Supercomputing Network, which is the main framework for granting competitive HPC time to Spanish research institutions. Furthermore, BSC-CNS is one of six hosting nodes in France, Germany, Italy and Spain that form the core of the Partnership for Advanced Computing in Europe (PRACE) network. PRACE provides competitive computing time on world-class supercomputers to researchers in the 25 European member countries.

Location where services will be performed: Barcelona, Spain

Percentage of the contract: 14%

Royal HaskoningDHV

Royal HaskoningDHV is an independent, international engineering and project management consultancy with 135 years of experience. Our professionals deliver services in the fields of aviation, buildings, energy, industry, infrastructure, maritime, mining, transport, urban and rural development and water. Backed by expertise and experience of more than 6,000 colleagues across the world, the company works for public and private clients in over 150 countries. Royal HaskoningDHV understands the local context and delivers appropriate local solutions.

Royal HaskoningDHV focuses on delivering added value for our clients while at the same time addressing the challenges that societies are facing. These include the growing world population and the consequences for towns and cities; the demand for clean drinking water, water security and water safety; pressures on traffic and transport; resource availability and demand for energy and waste issues facing industry.

Royal HaskoningDHV aims to minimise our impact on the environment by leading by example in our projects, our own business operations and by the role the company see in “giving back” to society. By showing leadership in sustainable development and innovation, together with our clients, the company is working to become part of the solution to a more sustainable society now and into the future.

More specifically to this proposal, Royal HaskoningDHV offers services that cover the entire flood risk management cycle, from concept to feasibility, impact assessments, design, tender process, site supervision, and operation & maintenance. Due to its broad consultancy network it has a large portfolio of industrial clients that are potential end-users of the proposed service as well as great experience in flood risk management studies for these type of clients (especially agri-food and petrochemical companies).

As an example, several food risk assessment studies have been performed following the **Thailand floods of 2011** which demonstrated the impact of flood events on industrial and commercial facilities. It is recorded as the costliest flood event that ever occurred. Many companies were looking for flood risk reduction measures to protect their facilities. Royal HaskoningDHV consulted various private clients, such as **Coca-Cola** and **Heineken**, on their flood risk level and designed appropriate flood risk reduction measures.

In the **climate stress test** of the **Westpoort port area of Amsterdam** Royal HaskoningDHV has tested the area for different climatic stress variables: heat, drought, pluvial flooding and river/coastal flooding. The company assessed the relations between these stress variables and their impact on different infrastructure in the area. In strong collaboration with local stakeholders (public and private) concrete plans were developed to incorporate climate resilience and water robustness. Two phases were distinguished in this project: the vulnerability scan and the adaptive planning. The experience of this project relates strongly to the stakeholder sessions and translation of the climate impact to the stakeholders which are presented in this proposal.

In the **Unilever Flood Resilience** project Royal HaskoningDHV implemented a flood resilience programme for the Corporate Risk Control group of Unilever. Flood hazard assessments were performed for several high-risk sites. Furthermore, a guideline, brochure and web-seminars were developed to disseminate the relevant information about flood resilience (awareness, prevention and response) to all Unilever site managers globally.

RHDHV takes the role of consultant, and is advising the following companies and organisations:

- **Schiphol** Schiphol Group is the owner and operator of Amsterdam Airport Schiphol, Rotterdam The Hague Airport and Lelystad Airport, and holds a majority share in Eindhoven Airport. They also work closely with foreign airports which strengthens their position. They include the airports of Aéroports de Paris, JFK International Airport's Terminal 4 in New York, Incheon Airport, Brisbane Airport, Hong Kong and Aruba.
- **Unilever** This multinational consumer-goods company is one of the largest consumer goods company and has over 400 brands that are supplied to the market in around 190 countries all over the world. Their vast supply chain network of sourcing areas, manufacturing plants and distribution network makes Unilever an interesting company to assess climate impacts
- **De Heus** Royal De Heus is an international organisation with a leading position in the animal feed industry and belongs to the global top-15 of feed supplier companies. Their activities spans 50 countries in Europe, Asia, Middle East, Africa and Latin America and comprise the production and export of complete ranges feed, concentrates and premixes.
- **FrieslandCampina** FrieslandCampina is one of the world's largest dairy companies and produces and sells consumer dairy products in more than 100 countries. FrieslandCampina wants to make a contribution to the global challenges of scarcity of natural resources and improve their sustainability.

Location where services will be performed: Amersfoort, The Netherlands

Percentage of the contract: 8%

Loughborough University

Changing Environments and Infrastructure is one of the major Research Challenges prioritised by Loughborough University (LBU). The Centre for Hydrological and Ecosystems Science (CHES) resides within the Department of Geography and contributes to this research agenda through work on hydro-climatology, water resource management, urban flood modelling, geomorphological processes, and ecosystem services. Within CHES there is relevant specialist expertise in regional climate modelling, climate risk assessment, hydrological modelling, stakeholder analysis, and adaptation options appraisal for managed and natural freshwater systems. Other pertinent research includes the reconstruction of multi-decadal drought and flood indices as well as the analysis of atmospheric drivers of heatwaves and extreme hydrological events.

Our climate-related research and consultancy is supported by a range of sources including the UK Department of International Development, Environment Agency, Research Councils, World Bank and United Nations agencies. Examples of recent projects that reflect the above technical expertise in climate services and resilience planning include:

Piloting a Real-Time Surface Water Flood Risk Mapping Service Within ResilienceDirect to Support Local Emergency Decision-Making (2016): Natural Environment Research Council. Links real-time heavy rainfall forecasts issued by the Met Office to an urban flood model run on a high performance computing system at Loughborough University. Maps of the resulting pluvial flood surfaces will be disseminated to emergency services via the Cabinet Office's ResilienceDirect platform.

CCRA2: Contributions to Chapters 2 and 8 (2015-2016): Committee on Climate Change. Pro bono technical advice and contributing author to the 2017 UK Climate Change Risk Assessment chapters

on Scientific Approach and Context (Chapter 2) and Cross-Cutting Issues (Chapter 8).

Evaluating the Resilience of Critical Infrastructure for Emergency Response to Extreme Flood Events in Leicester City (*2014-2015): Natural Environment Research Council.* An assessment of the potential impacts of fluvial and pluvial flooding on the travel-time of emergency responders across Leicester City. This involved modelling flood extent in relation to the transport network and critical infrastructure such as hospitals, care homes, ambulance and fire stations to identify areas most at risk from impeded access.

Robust Water-Management Strategies for California Central Valley Water Plan (*2014): RAND Corporation*. Technical review of the draft Water Plan including appraisal of key vulnerabilities and options for mitigating risks posed by external drivers (such as urban growth, temperature and precipitation change) to water management in the California Central Valley. The review also identified knowledge gaps and called for more explicit representation of climate scenario uncertainties.

Including Climate Uncertainty in Water Resources Planning and Project Design - Decision Tree Initiative (*2013): World Bank and Alliance for Global Water Adaptation (AGWA)*. The development of a set of guidelines and decision-support framework to incorporate climate uncertainty in World Bank water resource project design and planning.

Technical Review of the first UK Climate Change Risk Assessment and Evaluation of the Sensitivity of UK Embodied Water Imports to Climate Change (*2012): Committee on Climate Change.* An independent review of the methodology and delivery of the first UK Climate Change Risk Assessment. This involved document analysis and expert consultations. In an extension to the review, vulnerability of embodied water imports was assessed using data on key commodities, their source areas and expected regional climate changes to show the extent to which import substitution could impact UK water demand.

Reconstructing a 200-year Drought Series for the East of England (*2012): Anglian Water Services Ltd*. Reconstruction of multi-decadal river flow series from synthetic rainfall series to evaluate the impact of severe droughts on reservoir yields in East Anglia. Technical assistance was provided to scrutinize the hydrological modelling methods and trend analyses applied by the lead contractor (Mott Macdonald).

River Itchen Initiative (*2010): WWF-UK*. Evaluation of macro-invertebrate data and methods used to set environmental flows in the River Itchen. Hydrological modelling was performed to establish the effectiveness of various water licensing options in relation to these target flows under climate variability and change. The analysis demonstrated the extent to which smart licenses might meet the water demands of both the public and environment *despite* climate variability and change.

Adaptation and Resilience of Coastal Energy Production and Supply (*2011-2016): Engineering and Physical Sciences Research Council*. This PhD project explored the meaning of 'successful adaptation' for communities in the neighbourhood of long-lived coastal infrastructure (new nuclear power plants). Indicators of adaptation processes and expected outcomes have been established through document analysis and semi-structured interviews of various interest groups (public, private and government stakeholders).

Evidence Needed to Manage Freshwater Ecosystems in a Changing Climate (*2010): Environment Agency*. A synthesis of research literature combined with solicitation of expert opinion of key knowledge gaps constraining the adaptive management of freshwater ecosystems under climate change. Ambiguity about environmental flows and management of rising water temperatures were identified as priority research areas.

Adaptation and Resilience of Water Resource Systems to Climate Change (*2009-2012): Engineering and Physical Sciences Research Council*. This PhD project 'mined' water meter information held by Anglian Water Services Ltd to establish sensitivity of household micro-component water use to

meteorological conditions. The study showed the elasticity of external water and shower use to temperature, and the effect of the 2012 hose-pipe ban on household water use, having accounted for dramatic variations in weather conditions.

The climate service developer **Loughborough University** is supplying and advising the following organisations: **Acclimatise, Anglian Water, Department for International Development, EDF, and the Environment Agency**.

Location where services will be performed: Loughborough, United Kingdom

Percentage of the contract: 9.5%

Arcadis

Arcadis is an international company that provides consultancy, design, engineering and management services in the fields of Infrastructure, Water, Environment and Buildings.

In order to produce exceptional value for our clients, employees and shareholders, we organize our services into four main business lines, each with its own area of strength and strategies. At the same time, these segments are naturally and inextricably woven together, inspiring us to work across disciplines and geographies to deliver exceptional solutions for complex issues.

Over the years, we have worked diligently to retain our core values, and we've made it our priority to ask ourselves the tougher questions about who we want to be -as a trusted consultant, as an employer, and as a corporate citizen.

With over 27,000 professionals worldwide and € 3.4 billion in revenues the company has an extensive international network that is supported by strong local market positions. We have over 350 offices in over 40 countries around the world and are active in projects in more than 70 countries and we are the third largest International Design firm. We support UN-Habitat with knowledge and expertise to improve the quality of life in rapidly growing cities around the world.

Our mission is to improve quality of life around the world by creating places of distinction and providing sustainable solutions that enhance the built and natural environments. In doing so, we produce exceptional value for our clients, employees and shareholders.

We are able to deliver complex turnkey projects by relying on our technical and management skills. We focus our services on four main business lines:

Infrastructure business line encompasses services for transportation (traffic management, highways, roads, railways, ports, waterways, bridges, tunnels); land development (residential, industrial, recreational, urban and rural planning); energy (hydropower, windmill farms, grids); and mining (program and project management).

Environment business line is focused on activities that protect the environment and enhance sustainability. The largest activity is the clean-up of legacy issues related to soil, groundwater and sediment pollution, and the decommissioning of industrial operations. Arcadis also assists clients with site closures and redevelopment, incident response, transactional services, environmental impact assessments, planning and permitting, regulatory compliance, product stewardship, ecosystems restoration, climate change issues, energy efficiency and renewable energy, health & safety issues and services for noise abatement, air quality, solid waste disposal and the preservation of nature and landscape.

Activities in the **building** business line relate to buildings in which people live, work, shop, relax or otherwise spend time. We are involved in a broad range of project work that includes inner city (re)developments, office buildings, industrial sites, data centers, hotels, resorts and other leisure facilities, shopping centers, hospitals, schools, museums, public buildings or a mixed use of these functions.

Water business line is focused on the entire water cycle. We support the supply of clean drinking water by water planning, hydraulic modelling, treatability studies, regulatory compliance analysis and treatment system design. For wastewater, we advise on collection, advanced treatment technologies, reuse, bio-solids and odor control, and we deliver design and engineering services. In addition, we provide management and consulting services to operators to maximize performance of systems. We also advise on water management, for rivers, coastal zones, urban and rural water, and on issues related to climate change.

Arcadis takes the role of climate-service adopter, and is advising the following companies and organisations: **Nestlé**, **AKZO-Nobel**, **ASR insurance**, **Pro-rail**, **NS** (Dutch national rail), **Eneco**, **Engie**, and many others.

Location where services will be performed: Arnhem, The Netherlands

Percentage of the contract: 8%

2. Quality of the resources to be deployed

2.1. Description of the resources

Deltares has ample experience in providing advice and software and tools for operational services for water management. Also, Deltares has played a key role in the development of the climate adaptation strategy of The Netherlands, notably for river and coastal flood risk (the Delta Programme), as well as climate impact studies and adaptation planning in various other countries world-wide. Clients include public and private entities managing water, environmental control as well as coastal and urban infrastructure operators. Since the main strength of the proposal is the further development of climate stress-testing, **Loughborough University** has been added, to provide hand-on approaches for training of the CSTK approach. By teaming up with two key players in the climate analysis and modelling field in Europe, **KNMI** and **BSC**, a strong consortium has been formed to bring relevant ECVs and CIIs to adopters of climate services from the consulting world. These three organisations also possess all required infrastructure, software and access to data required for developing this service. Two key global players in the field of water and urban infrastructure design, **RHDHV** and **Arcadis** are involved, to adopt, test and disseminate the Climate Stress-test Toolkit (CSTK) to the end-users in the public and private domains.

The key people from these six organisations, including WP leaders, are described below. Their full CVs as well of others listed in Table 1 are included as well, in Section 2.2.

Dr. Laurens Bouwer (Deltares) is the proposed Project Manager, and an expert on climate change and water resources management. He has worked on the assessment and management of extreme events. He has lead/contributed to several (inter)national research and consultancy projects in India, Vietnam, USA, Turkey, Sri Lanka, Algeria, Germany, Netherlands, and the EU. He also contributed to several European Commission-funded (FP7 and H2020) research projects, including RESPONSES, CONHAZ, ENHANCE, BASE, GREEN-WIN and IMPREX. Laurens has published extensively in the academic literature on these topics (48 ISI papers, h-index=22), including 4 papers in *Nature Climate Change*. He was 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), and he is a member of the Munich Climate Insurance Initiative (MCII). He is also editorial board member of the recently established journal *Climate Services* (Elsevier).

Prof.dr. Bart van den Hurk (KNMI) is the proposed WP2 leader, who has developed a scientific career at the Royal Netherlands Meteorological Institute (KNMI) as researcher, involved in studies addressing modelling land surface processes in regional and global climate models and constructing regional climate change scenarios. He is strongly involved with the KNMI global modelling project EC-Earth, and is co-author of the land surface modules of the European Centre for Medium Range Weather Forecasts (ECMWF). He lead the FP4 project ELDAS (on soil moisture modelling) and leads H2020 IMPREX (on hydrological extremes), in addition to a number of national research projects. From 2014 onwards he occupies the chair “Climate Interactions with the Socio-Ecological System" at the Institute for Environmental Studies, at Amsterdam Vrije Universiteit. Since 2008 he is member of the board of the division “Earth and Life Sciences" of the Dutch Research Council (NWO-ALW). He is convenor at a range of incidental and periodic conferences, and editor for the journal *Hydrology and Earth System Science* (HESS). He now leads the R&D department on Weather and Climate modelling at KNMI.

Prof.dr. Francisco Doblas-Reyes (Barcelona Supercomputing Centre), director of the Earth Sciences Department of the BSC-CNS, has been involved in the design, development, assessment and dissemination of multi-model climate forecasts for the last 20 years. He participated in some of the most successful multi-model research and operational seasonal prediction exercises organised in Europe (DEMETER, ENSEMBLES, EUROSIP) and has a privileged relationship with operational multi-model efforts around the world (NMME, IRI, APCC). He has led many efforts to ensure an efficient use of multi-model seasonal forecasts in different sectors and is working towards transposing this experience to the rapidly-growing climate services sector through his involvement in the Global Framework on Climate Services, the World Climate Research Programme and a plethora of FP7 and H2020 projects.

Dr. Hanneke Schuurmans (Royal HaskoningDHV) is senior project manager and leading expert on hydrometeorology and early warning systems, and it is her goal to help society to become more climate resilient. She holds a water resource management and hydrometeorology degree from Wageningen University and a PhD from Utrecht University. Hanneke has over 16 years of experience worldwide and at different scales (cities to transboundary river systems) with climate related projects and early warning systems for both floods and droughts. A result-oriented attitude, solid background knowledge and the skills to communicate with different stakeholders enables her to provide the costumer with tailor made solutions. Hanneke has successfully executed project in which she plays to role of linking pin between knowledge institutes and end-users.

Prof.dr. Rob Wilby (Loughborough University), is Professor of Hydroclimatology in the Department of Geography of Loughborough University, UK, His main research focus is on climate variability and change in relation to the management of freshwater environments. He has ample experience in applying climate-stress tests, and developing tools for adaptation planning for public and private organisations. He has helped to develop the SDSM-DC (Statistical Downscaling Model), http://co-public.lboro.ac.uk/cocwd/SDSM/sdsmmain.html.

Jeroen Rijsdijk (Arcadis) is a principal advisor with over 25 years of experience within Arcadis. Working as a specialist in the early days of his career and nowadays leading teams of engineers on various topics of urban water management and conveyance. With his knowledge of water management he is traveling abroad the world to share this with clients. Therefore in the last couple of years he switched from being a team leader to become a business advisor to fully utilize his expertise in the field of asset management, urban water management and sewerage. Current developments in the field of climate adaptation and asset management of the built urban area are a big part of his daily routine.

Table 1: HR Profiles

Title	Broad description of work in relation to Service	List of personnel who fit the profile and whose CVs are submitted with tender	Qualifications	Effort / engagement in months
Project manager	Consortium coordination and planning; interaction with ECMWF	Laurens Bouwer (Deltares)	PhD, MSc Physical Geography, Expert climate change impacts	4.5
Scientist	Climate impact indicators	Ad Jeuken (Deltares)	PhD, MSc, Expert climate adaptation	2
Scientist	Water supply modelling	Marta Faneca Sanchèz	MSc Hydrogeology	6
Scientist	Hydrology	Ron Passchier (Deltares)	MSc hydrologist	2.75
Scientist	Hydraulic engineering	Anke Becker (Deltares)	MSc Hydraulics	1.25
Research analyst	Database hosting, Visualisation interface	Vacancy (Deltares)		1.25
Research analyst	Database hosting, Visualisation interface	Vacancy (Deltares)		5
Scientist	Supervise work on event selection	Bart van den Hurk (KNMI)	Prof. in climate sciences, dept. manager	1.2
Scientist	Execute and analyse simulations and dissemination	Rein Haarsma, Hylke de Vries (KNMI)	Senior climate scientist	8
Research analyst	Technical assistance, data handling	Vacancy (KNMI)		1.2
Team leader	Supervise work on climate analysis	Francisco Doblas-Reyes (BSC)	Research professor, head of department	6
Research analyst	Climate data handling	Vacancy (BSC)		18
Analyst	Stakeholder consultations, use-case development	Tjeerd Driessen (RHDHV)	MSc Water management	2.75
Analyst	Stakeholder consultations, use-	Matthijs van Ledden (RHDHV)	MSc Hydraulic engineering	1

	case development			
Analyst	Stakeholder consultations, use-case development	Hanneke Schuurmans, (RHDHV)	PhD, MSc Physical Georgraphy	1
Analyst	Stakeholder consultations, use-case development	Nanco Dolman (RHDHV)	MSc Urban water management	1.5
Scientist	Stakeholder consultations, development of tools and training	Robert Wilby (Loughborough)	Professor of Hydroclimatic Modelling	3
Research assistant	Stakeholder consultations, development of tools and training	Vacancy (Loughborough)		18
Analyst	Stakeholder consultations, use-case development	Jeroen Rijsdijk (Arcadis)	Civil Engineer	5.5

2.2. CVs of key personnel

(See following pages)

PERSONAL INFORMATION

Laurens M. Bouwer, PhD

P.O. Box 177, 2600 MH Delft, The Netherlands

+31 88 335 7637

Laurens.Bouwer@deltares.nl

Sex ☒Male ☐Female | Date of birth 24-12-1975 | Nationality Dutch

CURRENT POSITION

Senior Advisor

WORK EXPERIENCE

2013 - present	Deltares Senior Advisor/Researcher
2008 - 2008	University of California, Santa Barbara Visiting Scientist
2001 - 2013	Institute for Environmental Studies, Vrije Universiteit Amsterdam Researcher
2000 - 2001	Munich Reinsurance Company Intern
1999 - 2000	Vrije Universiteit Amsterdam Assistant

EDUCATION AND TRAINING

2006 - 2010	PhD - Vrije Universiteit Amsterdam - PhD Flood risk and climate change
1995 - 2001	MSc - Vrije Universiteit Amsterdam - MSc Physical Geography

Other relevant training

ERC Grant writing

Supervision of PhD students

Media training

Lecture training

Acquisition training

Scientific writing in English

PERSONAL SKILLS

Mother tongue(s): Dutch

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C2	C2	C2	C2	C2
German	C1	C1	C1	C1	B2
French	B1	B1	A2	A2	A1

ADDITIONAL INFORMATION

PUBLICATIONS

See https://scholar.google.nl/citations?user=Ggd07cYAAAAJ&hl=en

PROJECTS

2016 - present: United States: Critical infrastructure and future flood resilience in South Florida (CIFRe)

Senior researcher

Analysis of critical infrastructure vulnerability in Broward county (South Florida), for coastal flooding under projected climate change and sea-level rise.

2016 - present: Netherlands, Sri Lanka: Flood Risk Assessment for Colombo Metropolitan Region

	Senior researcher
	Development of flood risk maps for Metro Colombo, including estimates of monteray damages to buildings and other assets.
2016 - present	EU, Netherlands: Water management for road authorities in the face of climate Change (WATCH)
	Senior researcher
	Protocol for national road authorities (NRAs) in Europe, to account for climate change in the management of pluvial flooding and drainage in design, operation and maintenance of road infrastructure.
2015 - present	EU,Netherlands: Green growth and win-win strategies for sustainable climate action (H2020 GREEN-WIN)
	Senior researcher
	Research into novel finance options for climate change mitigation and adaptation, including development of coastal flood adaptation case studies.
2015 - present	EU,Netherlands: Improving predictions and management of hydrological extremes (H2020 IMPREX)
	Work package leader WP7 on Flood risk
	Set-up and application of multi-parameter flood damage model for the Rhine and Meuse river basins.
2015 - present	Afghanistan,Netherlands: Afghanistan – Multi-hazard risk assessment, cost-benefit analysis, and resilient design recommendations
	Senior researcher
	Development of national flood damage model, cost-benefit analysis of mitigation options, assessment of scenarios for projected socioeconomic change.
2014 - 2016	United States: Flood and drought risk management under climate change: methods for strategy evaluation and cost optimization
	Project leader
	Development of optimal and robust adaptation strategies for flood and droughts risks in South Florida.
2013 - 2016	EU,Netherlands,European Union: Bottom-up Climate Adaptation Strategies towards a Sustainable Europe (FP7 BASE)
	Sub-task Leader
	Development of a flood risk model for Europe, development of impact assessment and flood risk adaptation strategies.
2012 - 2014	EU,Netherlands,European Union: OASIS – Open Access Catastrophe Model (Climate-KIC)
	Leader flood damage module
	Development of damage function library, and flood loss model.
2011 - 2014	Netherlands: IPCC Fifth Assessment Report: Impacts, Adaptation and Vulnerability (AR5)
	Lead Author Chapter 23 “Europe”
	Writing scientific review
2010 - 2012	Netherlands: IPCC Special Report Managing the Risks of Extreme Events and Disasters to Advance Climate Change (SREX)
	Contributing Author Chapter Changes in Impacts of Climate Extremes
	Scientific review of literature on disaster risk and climate change
2010 - 2013	EU,Netherlands,European Union: European Responses to Climate Change (FP7 RESPONSES)
	Project Manager, and Work Package Leader EU Cohesion Policy
	Project coordination, risk analysis, policy analysis

PERSONAL INFORMATION

Dr.Ad Jeuken PhD

P.O. Box 177, 2600 MH Delft, The Netherlands

+31(0)6 53670749

Ad.Jeuken@deltares.nl

Sex ☐Male ☐Female | Date of birth 05-10-1968 | Nationality Dutch

CURRENT POSITION

Expert advisor climate adaptation

WORK EXPERIENCE

2008 - present Deltares
Expert advisor climate change adaptation

2001 - 2007 RIZA, Rijkswaterstaat (Department of Transport, Public Works and Water Management)
Positions held: Head of the department of Estuaries. Team leader, and senior advisor water quality a

1994 - 2000 KNMI (Royal Dutch Meteorological Institute), department of Climate Research, de Bilt
Climate Researcher

EDUCATION AND TRAINING

2000 - 2000 PhD - Faculty Applied Physics – Technical University of Eindhoven - Climate Modelling

1987 - 1993 MSc - Wageningen University - Environmental Science

PUBLICATIONS

2016 Ad Jeuken, Mette Termansen, Marco Antonellini, Theo Olsthoorn, Eelco van Beek, Climate Proof Fresh Water Supply in Coastal Areas and Deltas in Europe. Water ResourcesManagement DOI: 10.1007/s11269-016-1560-y

2016 Ad Jeuken, Laurène Bouaziz, Gerald Corzo, Leonardo Alfonso, Analyzing Needs for Climate Change Adaptation in the Magdalena River Basin in Colombia, In book: Climate Change Adaptation, Resilience and Hazards DOI: 10.1007/978-3-319-39880-8_20

2016 T Ermolieva, T Filatova, Y Ermoliev, M. Obersteiner, K. de Bruijn, A Jeuken, Flood Catastrophe Model for Designing Optimal Flood Insurance Program: Estimating Location-Specific Premiums in the Netherlands, Risk Analysis DOI: 10.1111/risa.12589

2015 Peter C. van Veelen, Karin Stone, Ad Jeuken, Planning resilient urban waterfronts using adaptive pathways, Water Management DOI: 10.1680/wama.14.00062

2015 John Matthews, Ad Jeuken, Guillermo Mendoza, Designing for Climate Confidence: Moving Beyond Uncertainty in Sustainable Water Management, Water Monographies 3-2015 20-29

2015 Saskia E. Werners, Maarten J. van der Vlist, Wil A. H. Thissen, Ad Jeuken, Pieter J. T. M. Bloemen, Editorial: Decisive moments in climate change adaptation, Journal of water and Climate Change

2014 B. Gersonius, R. Ashley, A. Jeuken, A. Pathinara, C. Zevenbergen, Accounting for uncertainty and flexibility in flood risk management: comparing Real-In-Options optimisation and Adaptation Tipping Points, Journal of Flood Risk Management DOI: 10.1111/jfr3.12083

2014 Ad Jeuken, Marjolijn Haasnoot, Tim Reeder, Philip Ward, Lessons learnt from adaptation planning in four deltas and coastal cities, Journal of Water and Climate Change DOI: 10.2166/wcc.2014.141

2010 Kwadijk, J.C.J., Haasnoot, M., Mulder, J.P.M., Hoogvliet, M., Jeuken, A., Van der Krogt, R.A.A., Van Oostrom, N.G.C., Schelfhout, H.A., Van Velzen, E.H., Van Waveren, H., De Wit, M.J.M., Using adaptation tipping points to prepare for climate change and sea level rise: a case study in the Netherlands. , Wiley Interdisciplinary Reviews: Climate Change DOI: 10.1002/wcc.64 729-740

PROJECTS

2016 - present EU: EEA Report on Climate Adaptation and Disaster Risk Reduction

core writing team, expert

writing

2016 - 2017 Climate Risk Informed Decision Analysis – Stresstest and planning guidance

Project Leader.

writing, editor, expert missions, training, presentation

2015 - present	Indonesia: EU H2020 Greenwin Climate Adaptation Expert Expert support of Jakarta flood risk pilot in which adaptation pathways are developed and economically evaluated.
2015 - 2010	Netherlands,Viet Nam: Training on climate change adaptation Trainer Training, Lecturing
2015 - 2015	Netherlands: Catalogue of small scale water supply measures Project leader Editing, liaise with the clients, coordination of consortium of 4 parties.
2014 - present	Netherlands: Climate Adaptation - Adaptive Delta Management Program leader Responsibility for coordinating research activities. Activities include participating in network with other parties on this subject, writing articles, presentations
2014 - 2016	Croatia, Turkey: Technical Expert for ECRAN (Environment and Climate Regional Accession Network) Trainer, water expert presentation, training, facilitator
2014 - 2016	Global, Global: Special issue on Climate Proof Fresh Water Supply Guest Editor
2013 - 2014	Colombia: Climate adaptation in Colombia: a tipping point analysis Project leader, climate adaptation planning expert Responsible for leading the project executed by a consortium of 4 Dutch organizations. Activities include reporting and presenting overall project results, policy analysis, expert workshops, training and communication with the Colombian counterparts.
2013 - 2015	Global,Global: Special issue Decisive moments in climate change adaptation. Guest editor inviting contributions, reviewers. Proposing decisions to Editor in Chief
2012 - 2016	European Union: Bottom-up Climate Adaptation Strategies towards a Sustainable Europe (BASE) Work package leader, expert Responsible for the management of the work package on upscaling and integration and leading the Deltares team in the project. Activities include research, writing and presenting results and project management.
2012 - 2012	Netherlands: Building risk-based approach for fresh water supply in Rhine-Meuse Delta Project Leader Together with consultant (HKV), in an assignment for Rijkswaterstaat, a conceptual approach was developed for risk-management and decision support for fresh water supply. Responsibility was to lead this project. Activities include: management, sub-contracting consultants, final reporting, defining objectives with the client.
2010 - 2015	Netherlands: Delta Program Rijnmond Drechtsteden Project Leader Activities include: management, sub-contracting consultants, final reporting, defining objectives with the client and presentations.
2010 - 2014	Netherlands: Knowledge for Climate - Climate proof Fresh water supply Consortium Leader As Consortium leader responsible for leading the consortium (9 universities and institutes). Activities include managing the overall project, leading scientific and stake holder events, leading scientific special issue on end results, presenting the consortium externally on various occasions.
2007 - 2009	Netherlands: Climate proofing The Netherlands Waterland Team Leader management, sub-contracting consultants, final reporting, and presentations.

PERSONAL INFORMATION

Marta Faneca Sànchez

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+31 (0) 6 524 17 847

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Sex ☐Male xFemale | Date of birth 16-04-1981 | Nationality Spanish

CURRENT POSITION

Researcher - Geohydrologist

KEY QUALIFICATIONS

Marta Faneca Sanchez is hydrogeologist at Deltares, she works in the Unit of Groundwater and Subsurface Systems. She studied geology and hydrogeology at the University of Barcelona and at the Polytechnic University of Catalonia. She is specialized in the analysis of groundwater systems, and in groundwater modelling. She has experience working on projects evaluating the impact of dry periods on the groundwater system, defining indicators to assess groundwater related risks, and developing measures and strategies to counteract or prevent negative impacts of drought. Her projects also include the combination of field work, modelling, and collaborative processes, as well as the analysis of the climate and socio-economic scenarios on the groundwater system. Most of the studies have as main goal a better understanding of the system, assessing the impact of drought on the system, and the definition of the best policy measures to achieve sustainable groundwater management and supply. Marta has worked in projects in The Netherlands, Spain, Bolivia, Bangladesh, Kenya, Colombia and Mozambique, both in the technical aspects and in the coordination and management aspects.

WORK EXPERIENCE

2011 - present — Deltares
Researcher/consultant Hydrogeology

2009 - 2011 — TNO Geological Survey of The Netherlands
Researcher - Geohydrologist

2008 - 2009 — Aluvial Consulting
Groundwater consultant

EDUCATION AND TRAINING

2007 - 2008 — - The FCHIS and Fundación UPC International Centre for Groundwater in the Polytechnic University of Catalonia - Postgrade in Hydrogeology

2004 - 2005 — - Mineral Processing department of the Civil Engineering and Geosciences Faculty of the Technical University of Delft - Second master thesis

2000 - 2003 — - Gemological School of the University of Barcelona - Gemology

1999 - 2004 — - University of Barcelona - MSc Geology

Teaching Assignment

Groundwater modeling in several capacity building courses within projects

PERSONAL SKILLS

Mother tongue(s): Catalan, Spanish

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
Dutch	C2	C2	C2	C2	C2

Portuguese	B1	B1	B1	B1	B1
English	C2	C2	C2	C2	C2
French	A1	B1	A1	A1	A1

Levels: A1/2: Basic user - B1/2: Independent user - C1/2 Proficient user
Common European Framework of Reference for Languages

ADDITIONAL INFORMATION

PROJECTS

2014 - present
EU: MARS: Managing Aquatic ecosystems and water Resources under Multiple Stress. EU FP7 project 2014 – 2018
Groundwater expert and developer of storylines for Drivers and Pressures

Development of groundwater management options (base flow, natural water retention) and development of programmes of measures that mitigate effects of climate change and secure ecological flows and fresh water supply for agriculture, drinking water and nature (wetlands and streams).

2015 - 2016
Bangladesh: Bangladesh Delta Plan 2100

Groundwater expert

review and summarize issues, challenges and opportunities related to groundwater in Bangladesh. Assess in terms of potential measures for groundwater management. Quantify effects of measures on groundwater

2015 - present
Global,Global: Global Groundwater Risk Indicators

Groundwater expert and modeller

definition and development of indicators and quantification of the indicators by means of processing global modeling results

2016 – present
Colombia: ESCACES2: Evaluating Abundancy and Scarcity of Groundwater under Climatic Extremes, Valle del Cauca, Colombia2
Project leader and Groundwater Expert

Coordination of Activities, modeling of the groundwater system and configuration of the forecasting tool

2014 - 2016
Colombia: ESCACES: Evaluating Abundancy and Scarcity of Groundwater under Climatic Extremes, Valle del Cauca, Colombia
Project leader and Groundwater Expert

Coordination of Activities, modeling of the groundwater system and configuration of the forecasting tool
Coordination of the project regarding planning, finances, relations with consortium members.
Groundwater modeller.

2013 - 2013
Kenya: DEWFORA - Improved Drought Early Warning and FORecasting to Strengthen Preparedness and Adaptation to Droughts
Groundwater expert

Development of a drought vulnerability index and map for Kenya.

2012 - 2014
Netherlands: Go-Fresh: local adaption and mitigation strategies and measures to ensure sustainable fresh water supply in the future.
Project leader assistant

Co-responsible for the management of the project, planning and coordination. Expert groundwater modeller in two work packages.

2012 - 2014
Colombia: Pilot project Flood Forecasting Early Warning System in Colombia

System developer

Configuration of the early warning system.

2012 - 2013
Netherlands: 3D Conceptual models for all groundwater bodies of The Netherlands

Groundwater expert

Integration of information and groundwater system analysis.

12 - 2012
Netherlands: Modelling climate change effects on a Dutch coastal groundwater system using airborne Electro Magnetic measurements.

PERSONAL INFORMATION

Ron Passchier BEng, MSc

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Sex ☒Male ☐Female | Date of birth 18-02-1959 | Nationality Dutch

CURRENT POSITION

Hydrologist / Expert Water Resources Management

WORK EXPERIENCE

1991 - present Delft Hydraulics / DELTARES
Hydrologist / Water Resurces specialist

1987 - 1990 De Ruiter Environmental Technique
Environmental Specialist and hydrologist

1986 - 1987 Jacob Blaustein Institute for Desert Research
Researcher

EDUCATION AND TRAINING

1977 - 1985 M.Sc. - Free University, Amsterdam - Geographical Hydrology

Other relevant training

International course in Hydrogeological Modelling

Application of GIS in water resources management

PERSONAL SKILLS

Mother tongue(s) Dutch

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	Excellent	Excellent	Excellent	Excellent	Excellent
	Replace with name of language certificate. Enter level if known.				
German	Fair	Good	Good	Excellent	Fair
	Replace with name of language certificate. Enter level if known.				

Other languages Arabic, French, Indonesian, Italian, Norwegian, Portuguese, Spanish

ADDITIONAL INFORMATION

PROJECTS

2016 - present Mexico: Proyecto Integral de Prevención de Inundaciones y Uso Eficiente del Agua para el Estado de Oaxaca, México
Water Resources Planner

Development of a solution strategies, with several possible strategies. Adaptation of room-for-the-river and water demand management strategies to local conditions, implementation and application of the Ribasim water resources model.

2012 - 2013 Vietnam: Vietnam Cumulative Impact Assessment of small hydropower projects

Hydrologist

Assessment of the impact of the hydropower plants on the river regimes under present and climate change scenarios.

2012 - present Bolivia: Development of a flood early warning system for the Beni

International coordinator / hydrologist

Development of the flood hydrology models.

2010 - 2010	Afghanistan: Integrated Water Resources Assessment and Management Plan for the province of Uruzgan, Helmond basin, Afghanistan Expert in water resources planning
	Surface water hydrology and simulation of water resources system with the RIBASIM water balance model. Assessment of impact of developments on the Kajaki reservoir.
2009 - 2010	Angola,Mozambique,South Africa,Zambia,Zimbabwe: Dam Synchronisation and Flood Release Project in the Zambezi river Hydrologist and expert in water resources planning
	Key advisor for the implementation of the water resources system approach.
2009 - 2011	Syrian Arab Republic: Water Resources Management of Orontes River Basin
	Water Resources Planner
	Technical Assistance project on water resources management at the Ministry of Irrigation.
2006 - 2007	Lesotho: Water Sector Improvement Project (Umbrella TA)
	Expert in water demand management and water resour
	Development of water demand management strategy and application of RIBASIM model for water resources planning.
2005 - 2005	Philippines: Water Resources Management Project CEBU
	Water Resources Planner
	Development of RIBASIM Water Resources Management simulation model for the study of the long-term sustainable development of the water resources of middle Cebu island.
2004 - 2004	Greece: Peloponnesus IWRM Study
	Hydrologist
	Application of the Sacramento model for water availability
2003 - 2003	Mali: Inner Delta Impact Study
	Project Leader and Hydrologist
	Simulation of the Inner Delta with RIBASIM water resources model
2002 - 2006	Honduras: PMDN (Proyecto de Mitigacion de Desastres Naturales)
	Hydrologist
	Advisor to the World Bank for the implementation of new infrastructure
1997 - 1998	Trinidad and Tobago: Water Resources Management Strategy
	Water Resources Planner
	Development of water resources strategy, hydrological modeling and definition of institutional settings
1996 - 1997	India: Tunghabdra Irrigation Pilot Project
	Hydrologist
	Application of the Operational Management in Irrigation System (OMIS) software for the optimization of water use in agriculture. Analysis of hydrological data, set-up of database, on-the-job training of staff members
1993 - 1993	Chile: Maipo-Mapocho river study
	Hydrologist
	Study and modeling of water resources system, assessment of groundwater contribution to water availability, setup and application of water resources model
1991 - 1992	Indonesia: National Water Plan
	Water Resources Planner
	Water balance studies on a national scale, applications of a distribution model for water resources management, agricultural production forecasting, based on water resources and design of data base system on water resources.
1990 - 1990	Italy: Basilicata Master Plan Study
	Water Resources Planner
	Design of water resources model, simulation of combined two-river system, effects of groundwater extraction on salt/fresh water interface, study of coastal erosion

PERSONAL INFORMATION

Dipl.-Ing.Anke Becker

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+31621287295

Anke.Becker@deltares.nl

Sex ☐Male ☒Female | Date of birth 20-01-1979 | Nationality German

CURRENT POSITION

Senior researcher/consultant

WORK EXPERIENCE

2006 - present	DELTARES (former WL | Delft Hydraulics), Delft, the Netherlands Researcher/consultant, Department of River Engineering and Transport over Water
2005 - 2006	Institute of Hydrology, Water Resources Management and Environmental Engineering, Ruhr-University Bochum, Germany Research engineer (flood risk management)
2004 - 2005	Institute of Hydraulic Engineering and Water Resources Management , RWTH Aachen University, Germany Scientific engineer (dam break modelling)
2002 - 2004	Institute of Hydraulic Engineering and Water Resources Management ,RWTH Aachen University, Germany Student employee (numerical modelling of groundwater flow and transport processes)

EDUCATION AND TRAINING

1998 - 2004	Diplom-Ingenieur (M.Sc.) - RWTH Aachen University, Germany - Civil Engineering

Teaching Assignment

2014 - 2014	On the job training of staff of CorMagdalena, Columbia, on the use of SOBEK 1D and 2D Overland Flow modules for river induced flooding
2012 - 2012	Training course SOBEK1D given to engineers of Ministry of Emergency Situations, Azerbaijan
2011 - 2011	Training course SOBEK1D, SOBEK2D en SOBEK1D2D given to engineers and scientists of Office for Naval Research, USA
2009 - 2009	Training course SOBEK1D, SOBEK1D2D and SOBEK-Morphology given to engineers and scientists of Bundesanstalt für Gewässerkunde, Germany
2005 - 2006	Lecture Open Channel Flow for students of Ruhr-University Bochum, Germany

PERSONAL SKILLS

Mother tongue(s): German

Other language(s):

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	Excellent	Excellent	Excellent	Excellent	Excellent
Dutch	Excellent	Excellent	Excellent	Excellent	Excellent
French	Excellent	Excellent	Excellent	Excellent	Good

ADDITIONAL INFORMATION

PUBLICATIONS (selection)

2014

A. Becker, M. Scholten, D. Kerkhoven, A. Spruyt, Das behördliche Modellinstrumentarium der Niederlande (transl.: The official [hydraulic] modelling instruments oft he Netherlands), Dresdner Wasserbauliche Mitteilungen, Tagungsband 37. Dresdner Wasserbaukolloquium 2014, Simulation Techniques and Models for Hydraulic Engineering and Water Management, p. 539-548

PROJECTS

2016 - 2016	Ecuador: Assessment of structural measures for flood control and improvement of navigability in teh Guayas river and estuary, Ecuador expert hydro- and morphodynamic modeling
2016 - 2016	Ecuador: Assesssment of flood water levels around the city of Guayaquil expert hydrodynamic modelling
2015 - present	Netherlands: Maintenance of flood plain vegetation project leader project leader, assessment of possibilities for a more flexible maintenance of flood plain vegetation in the Dutch main rivers
2014 - present	Netherlands: Maximum discharge Dutch and German Rhine project leader Project management, planning the numerical modelling activities necessary to determine the maximum discharge that can reach the Dutch Rhine at Lobith, including dike overtopping and dike breach scenario's and the modelling of inundations of the back-country
2013 - present	Germany: Flood modeling along the German and Dutch Rhine project leader
2013 - 2015	Colombia: Magdalena river, Colombia: SOBEK-model (1D2D) Model set-up, hydrodynamic calibration, scenario studies, capacity building
2013 - 2015	Romania: Lower Danube, Romania: large-scale Delft3D-models (3D and 2D) Model set-up, morphodynamic and hydrodynamic calibration, and assessment of the functioning of measures to improve navigability
2013 - present	Netherlands: Specialist advice Dutch main rivers Specialist advice on the hydrodynamic modelling of the Dutch main rivers (Rhine branches, Meuse, Delta area, IJssel and Vecht delta and IJssel lake) in Simona/WAQUA (2D) and SOBEK (1D)
2012 - 2012	Azerbaijan: Kura and Araz rivers, Azerbaijan: SOBEK-model (1D) Calibration and sensitivity analysis, SOBEK training and capacity building
2011 - 2011	France: Loire, France: SOBEK-model (1D) Model set-up, calibration, study of measures to mitigate the tidal influence
2011 - 2012	Netherlands: Dutch Upper Rhine delta Development, calibration and verification of a 2D-hydrodynamic model for the Dutch upper Rhine delta
2011 - 2012	Netherlands: River Meuse Development, calibration and verification of a 2D-hydrodynamic model for the river Meuse
2010 - 2011	Germany: Danube, Germany SOBEK-model (1D)
2010 - 2011	United States: Pearl River, Louisiana, USA: SOBEK-model (1D, 2D and coupled 1D2D) Demonstration of different modelling techniques, model set-up and calibration, SOBEK training
2010 - 2011	United States: Kootenaai River, Idaho, USA: SOBEK-model (1D, 2D and coupled 1D2D) Demonstration of different modelling techniques, model set-up and calibration, SOBEK training
2009 - 2009	Netherlands: Dutch Rhine delta models for ICPR Project leader of a project in which several 1D hydraulic models (SOBEK-RE) of the Dutch Rhine delta are built for use within the International Commission for the Protection of the Rhine
2008 - present	Netherlands: Room for the River project Sub-project leader Hydrodynamic expertises for flood mitigation measures, based on expert judgement or numerical modelling (1D-SOBEK and 2D-WAQUA)
2008 - 2009	Czech Republic,Germany: Elbe river, Germany/Czech Republic Development and calibration of a 1D morphological model in SOBEK/DelWAQ (from Ústí nad Labem, Czech Republik till Geesthacht, Germany)
2005 - 2006	Germany: Unstrut river, Germany: Flood risk management Development of flood scenarios using multivariate statistics

Curriculum vitae

PERSONAL INFORMATION

Bartholomeus Johannes Josephus Martinus (Bart) van den Hurk

POSITION

Atmospheric sciences

WORK EXPERIENCE

01/07/2014–Present

Manager R&D Weather and Climate modelling

KNMI, De Bilt (Netherlands)

After a brief interim leadership of the former KNMI group Global Climate Research I have been appointed as manager of the R&D group Weather and Climate Modelling since mid September 2014. The KNMI Management Team consists of 9 group leaders and 4 business unit managers.

The research group consists of approximately 50 people, of which about half externally funded, and works on the development of EC-Earth, Harmony, Lotos-EUROS and other applications. It has a strong track record in providing climate services (including the Climate Explorer and various Copernicus C3S and Hor2020 projects) and doing demand driven research for the Ministry of Infrastructure & Environment.

01/01/2003–01/07/2014

Senior researcher Regional and Global Climate

KNMI, De Bilt (Netherlands)

In 2003 I became a permanent staff member at KNMI, and since then I am strongly involved with the KNMI global modelling project EC-Earth, maintenance of stakeholder contacts concerning climate change and national Water Safety policy, acquiring research grants (including a Hor2020 project on water oriented climate services IMPREX), and (co-)author of approximately 130 peer-reviewed scientific publications.

01/09/1995–01/01/2003

Series of Postdoc contracts

KNMI, De Bilt (Netherlands)

Just after my Wageningen PhD I was recruited on a postdoc position at KNMI in September 1995. Since then I have developed a scientific career addressing modelling land surface processes in regional and global climate models, data assimilation of soil moisture, and constructing regional climate change scenarios. By acquiring new research grants (including a European FP4 project on soil moisture data assimilation ELDAS) I was able to fund my own projects for a number of years. Frequent work visits to ECMWF have been devoted to the co-development of the land surface module HTESSEL/CTESSEL.

01/01/2014–Present

Professor Interaction climate and the socio-ecological system

Institute for Environmental Studies, VU University, Amsterdam (Netherlands)

This chair is appointed on behalf of KNMI. Here new climate information concepts are co-developed and tested with IVM staff, including Future Weather and Forecast Based Financing.

01/01/2005–01/01/2014

Professor Regional Climate Analysis (Buys Ballot Chair)

Institute for Marine and Atmospheric research, Utrecht University (IMAU), Utrecht (Netherlands)

Also this chair was on behalf of KNMI, and I have been teaching masters students and supervising

PhD-students (of which 8 have been granted a PhD). Also I have been involved in several research networks and member of various national and international boards and panels.

EDUCATION AND TRAINING

01/03/1989

MSc Environmental science Wageningen University

01/01/1996

PhD Land surface modelling Wageningen University

Wageningen (Netherlands)

Title of thesis: Sparce-canopy parameterizations for meteorological models

PERSONAL SKILLS

Mother tongue(s): Dutch

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C1	C1	C1	C1	C1
German	B1	B1	A2	A2	A1
French	A1	A1	A1	A1	A1

Levels: A1 and A2: Basic user - B1 and B2: Independent user - C1 and C2: Proficient user
Common European Framework of Reference for Languages

Communication skills

Experienced speaker and writer for professional and non-professional audience

Media training and frequent appearance on national radio and television

Organisational / managerial skills

Line Management (currently leading team of 50 persons)

Project Management (PI and co-PI of range of international research projects)

Job-related skills

Key publications since ~2012:

van den Hurk, B., Kim, H., Krinner, G., Seneviratne, S. I., Derksen, C., Oki, T., Douville, H., Colin, J., Ducharne, A., Cheruy, F., Viovy, N., Puma, M. J., Wada, Y., Li, W., Jia, B., Alessandri, A., Lawrence, D. M., Weedon, G. P., Ellis, R., Hagemann, S., Mao, J., Flanner, M. G., Zampieri, M., Materia, S., Law, R. M., and Sheffield, J.: LS3MIP (v1.0) contribution to CMIP6: the Land Surface, Snow and Soil moisture Model Intercomparison Project – aims, setup and expected outcome, Geosci. Model Dev., 9, 2809-2832, doi:10.5194/gmd-9-2809-2016, 2016.

van den Hurk, BJJM, LM Bouwer, C Buontempo, R Döscher, E Ercin, C Hananel, J Hunink, E Kjellström, B Klein, M Manez, F Pappenberger, L Pouget, M-H Ramos, PJ Ward, A Weerts and J Wijngaard, 2016: Improving predictions and management of hydrological extremes through climate services: www.imprex.eu. Climate Services, 1, 6–11, doi:10.1016/j.cliser.2016.01.001.

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

Curriculum vitae

PERSONAL INFORMATION

Hylke de Vries

Meelbeskamp 12, 1112GW Diemen (Netherlands)

(+31)0614683044

hylke.de.vries@knmi.nl

www.knmi.nl https://sites.google.com/site/hylkedevelop/

WORK EXPERIENCE

2013–Present

Researcher

KNMI, De Bilt

2009–2012

Postdoc

KNMI, De Bilt

2007–2007

Lecturer

Universitat Innsbruck, Innsbruck (Austria)

2007–2009

Postdoc Rubicon laureate

University of Reading, Reading (United Kingdom)

2006–2006

Postdoc

Utrecht University

EDUCATION AND TRAINING

2002–2006

PhD Atmospheric dynamics

Utrecht University

1996–2001

MSc Theoretical Physics

University of Amsterdam

Other relevant training

- ECMWF course on numerical weather prediction (NWP), ECMWF
- GEFD Summer school on geophysical fluid dynamics at DAMTP,Cambridge
- Writing and presenting in English, James Boswell Institute (UU)

PERSONAL SKILLS

Mother tongue(s) Dutch

Other language(s)

UNDERSTANDING		SPEAKING		WRITING
Listening	Reading	Spoken interaction	Spoken production	

English	C1	C2	C1	C2	C1
German	B1	B2	B1	B1	B1
French	A2	A2	A2	A2	A2
Swedish	A1	A1	A1	A1	A1

Levels: A1 and A2: Basic user - B1 and B2: Independent user - C1 and C2: Proficient user
Common European Framework of Reference for Languages

Organisational / managerial skills

2015-present: organiser of KNMI biweekly seminar

ADDITIONAL INFORMATION

Publications

See https://scholar.google.nl/citations?user=njwW2HUAAAAJ&hl=en

Projects

2017-present: MSc project on long-term verification of Harmonie (supervising N. Nortier)

2016-present: NWO project ICOWEX on coincident weather extremes (supervising postdoc N. Ridder)

2016: MSc project on verification of Clouds in Harmonie using MSG (supervising Ch. van Dalum)

2015: MSc project on air-sea interaction, precipitation and convection over the Gulf Stream (supervising student S. Scher)

2014-present: NWO project on understanding Sea level variability using Altimetry (supervising postdoc P. Sterlini)

2013-2014 Developing KNMI scenarios for Sea Level Rise along the Dutch coast

2014: MSc project on Extratropical transition of tropical cyclones (supervising M. Baatsen together with R. Haarsma)

2013-2014 Embrace: coupling a global wave model in EC-Earth

2013: MSc project on Wavebreaking of extratropical Rossby waves (supervising Chr. Weijenborg together with R. Haarsma)

2009-2012 KNMI/GasTerra/NAM project on Future Cold Spells

2007-2009 NWO Rubicon Laureate. Baroclinic instability and counter propagating Rossby waves

europass Curriculum vitae

PERSONAL INFORMATION Reindert Julius Haarsma

P.O. Box 201, 3730 AE, De Bilt, The Netherlands
+31 30 2206768
haarsma@knmi.nl
Date of birth: 20-09-1953, Nationality: Dutch

POSITION Climate Dynamics

WORK EXPERIENCE

01/04/1981–01/01/19989 Researcher at KNMI, The Netherlands

The research was focused on climate variability of planetary scales, which resulted in the the PhD thesis "Instability Mechanisms in a Barotropic Atmosphere" at the Free University of Amsterdam.

01/06/1989–01/06/1990 Post-doc Hadley Centre, UK

During this post-doc year I have investigated the impact of climate change on tropical cyclones based on the Hadley Centre model.

01/06/1990–present Senior Researcher KNMI, The Netherlands

My research has been focused on climate variability and climate change. In particular on interannual to decadal time scales and on the ocean-atmosphere interaction. Topics that I have studied are the North Atlantic Oscillation, Atlantic Meridional Overturning circulation, Sahel drought , variability in the Southern Ocean, Tropical and South Atlantic variability, Hurricanes and transition to extra-tropical storms, decadal prediction.

Apart from analyzing data I was the initiator of the development of the intermediate climate model EC-Bilt and was co-developer of the SPEEDO climate model.

During the last years my focus has been on high resolution global modelling. I am co-chair of HighResMIP.

01/08/2002–01/08/2003 Visiting Professor at the University of Sao Paulo

Research on South and Tropical Atlantic variability at Institute of Oceanography Supervising PhD students. As a follow up I have visited USP again for 3 months during 2006.

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EDUCATION AND TRAINING

01/07/1980 **MSc Physics Utrecht University**

09/03/1989 **PhD Free University of Amsterdam (VU)**

Thesis: Instability Mechanisms in a Barotropic Atmosphere

PERSONAL SKILLS

Mother tongue(s): Dutch

Other language(s):

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C1	C1	C1	C1	C1
German	A1	A1	A2	A2	A1
Portuguese	C1	C1	C1	C1	C2

Levels: A1 and A2: Basic user - B1 and B2: Independent user - C1 and C2: Proficient user
Common European Framework of Reference for Languages

Communication skills: Experienced speaker and writer for professional audience. Regular contacts with Dutch and international journalists on extreme events such as hurricanes and droughts.

Organisational / managerial skills: Workpackage leader of European projects (COMBINE, PRIMAVERA). Co-chair HighResMIP.

Publications: https://scholar.google.nl/citations?user=t9H1z1cAAAAJ&hl=nl&oi=ao

Other skills: **Music** Founder and player of Sambaband Oladom in 1996. (www.oladom.com)

Driving licence: BE

europass Curriculum Vitae

PERSONAL INFORMATION

Francisco J. Doblas-Reyes

Barcelona Supercomputing Center-Centro Nacional de Supercomputación (BSC-CNS), Jordi Girona 29, 08034 Barcelona, Spain

+34 93 413 77 19 NA

francisco.doblas-reyes@bsc.es

http://www.icrea.cat/Web/ScientificStaff/Francisco-Javier-Doblas-Reyes-499

Sex Male| Date of birth 07/06/1968 | Nationality Spanish

WORK EXPERIENCE

OCTOBER 2014 - PRESENT

ICREA research professor working as director of the Earth Sciences Department

Barcelona Supercomputing Center - Centro Nacional de Supercomputación (BSC-CNS, Barcelona, Spain)

- ☐ Management of one of the four scientific departments of the BSC-CNS
- ☐ Gaining competitive funds and computing resources
- ☐ Research in climate modelling, efficient computing and Big Data, and atmospheric chemistry

DECEMBER 2009 – PRESENT

ICREA research professor working as senior scientist and head of the Climate Forecasting Unit

Institut Català de Ciències del Clima (IC3, Barcelona, Spain)

- ☐ Development of a seasonal and interannual climate prediction capability
- ☐ Illustration of the application of climate information in energy production
- ☐ Gaining competitive funding and computing resources
- ☐ Management of a research group of around 25 people

MARCH 2000 - NOVEMBER 2009

Research scientist

European Centre for Medium-Range Weather Forecasts (ECMWF, Reading, UK)

- ☐ Execution of the tasks of several European projects
- ☐ Contribution to the development of the operational multi-model seasonal climate forecast system

Research institute and a 24/7 operational service, producing and disseminating numerical weather predictions to its Member States

FEBRUARY 1999 - FEBRUARY 2000

Post-doctoral scientist

Centro de Astrobiología, Instituto Nacional de Técnicas Aeroespaciales (Madrid, Spain)

- ☐ Research on modelling of planetary atmospheres

Public research body specialized in aerospace research and technological development

JANUARY 1997- FEBRUARY 1999

Post-doctoral scientist

Centre National de Recherches Météorologiques, Météo-France (Toulouse, France)

- ☐ Execution of the tasks of several European projects

Public research body specialized in weather and climate forecasting

OCTOBER 1992 - SEPTEMBER 1996

PhD student

Department of Earth Physics, Astronomy and Astrophysics II (Universidad Complutense, Madrid, Spain)

- ☐ PhD thesis on atmospheric physics

Public university

EDUCATION AND TRAINING

JUNE 1997

BSc degree in Mathematics

Universidad Complutense of Madrid (Spain)

SEPTEMBER 1992-MAY 1996

PhD in Physics

Universidad Complutense of Madrid (Spain)

Thesis entitled “Atmospheric blocking: GCM simulation and associated precipitation patterns”

OCTOBER 1986-JUNE 1991

MSc degree in Physics

t

Universidad Complutense of Madrid (Spain)

PERSONAL SKILLS

MOTHER TONGUE(S) Spanish

OTHER LANGUAGE(S)

	UNDERSTANDING		SPEAKING		WRITING
	LISTENING	READING	SPOKEN INTERACTION	SPOKEN PRODUCTION	
English	C2	C2	C2	C2	C2
	Replace with name of language certificate. Enter level if known.				
French	C2	C2	C2	C2	C1
	Replace with name of language certificate. Enter level if known.				

Levels: A1/2: Basic user - B1/2: Independent user - C1/2 Proficient user
Common European Framework of Reference for Languages

ORGANISATIONAL / MANAGERIAL SKILLS

☐ Leadership (currently responsible for a team of 50 people)
☐ Proven ability to obtain competitive resources (both financial and computing time)
☐ Experience in preparing strategic plans and periodic reports, as well as in representing the department in public and private fora

PUBLICATIONS
PRESENTATIONS
PROJECTS
CONFERENCES
SEMINARS
HONOURS AND AWARDS
MEMBERSHIPS
REFERENCES

PUBLICATIONS, SELECTED PEER-REVIEWED PUBLICATIONS (OUT OF MORE THAN 100)

☐ Massonnet, F., O. Bellprat, V. Guemas and F. J. Doblas-Reyes (2016). Using climate models to estimate the quality of global observational data sets. *Science*, **6311**, 452-455, doi:10.1126/science.aaf6369.

☐ Doblas-Reyes, F.J., I. Andreu-Burillo, Y. Chikamoto, J. García-Serrano, V. Guemas, M. Kimoto, T. Mochizuki, L.R.L. Rodrigues and G.J. van Oldenborgh (2013). Initialized near-term regional climate change prediction. *Nature Communications*, **4**, 1715, doi:10.1038/ncomms2704.

☐ 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*, **4**, 245-268, doi:10.1002/WCC.217.

☐ Thomson, M.C., F.J. Doblas-Reyes, S.J. Mason, R. Hagedorn, S.J. Connor, T. Phindela, A.P. Morse and T.N. Palmer (2006). Malaria early warnings based on seasonal climate forecasts from multi-model ensembles. *Nature*, **439**, 576-579.

PROJECTS, AS PI (SELECTION OF PROJECTS, TOTAL COMPETITIVE FINANCIAL RESOURCES OBTAINED FROM 2010 OVER FIVE MILLION EUROS)

☐ PRIMAVERA (PRocess-based climate sIMulation: AdVances in high resolution modelling and European climate Risk Assessment), PI, European Commission H2020, 2015-2019, contract 641727, 1,277,425 euros

☐ SPECS (Seasonal-to-decadal climate Prediction for the improvement of European Climate Services), coordinator, European Commission FP7, 2012-2017, contract 3038378, 1,615,305 euros.

HONOURS AND AWARDS

☐ Recipient of the Mumm-Gerbier Prize in 2006 (http://www.wmo.int/pages/about/awards/winners_mumm_en.html

Curriculum Vitae

PERSONAL INFORMATION

Tjeerd L.A. Driessen

Royal HaskoningDHV, Rivers & Coasts, Jonkerbosplein 52, 6534 AB Nijmegen, The Netherlands

+31 88 3485003 +31 6 1262 1288

tjeerd.driessen@rhdhv.com

https://nl.linkedin.com/in/tjeerddriessen

Sex Male| Date of birth 29/06/1984 | Nationality Dutch

WORK EXPERIENCE

FEBRUARY 2010 - PRESENT

Consultant water management

Royal HaskoningDHV, Nijmegen, The Netherlands

- ☐ Modeller of hydrological and hydraulic software for application in large river basin studies
- ☐ Project manager of river studies for the Dutch government
- ☐ Consultant on flood risk reduction for private clients

Consultanty and engineering firm

FEBRUARY 2008- APRIL 2008

Project management employee

SWECO AB, Stockholm, Sweden

☐ Setting up an international project application for INTERREG Baltic Sea Region that aimed to promote technical studies among youngsters with use of the climate change theme.

Consultanty and engineering firm

EDUCATION AND TRAINING

SEPTEMBER 2006-NOVEMBER 2009

MSc in Hydrology and Quantitative Water Management

Wageningen University (The Netherlands)

- Thesis entitled '*The hydrological response of the Ourthe catchment to climate change, modelled by the VIC and HBV models*'
- Two minors: '*Climate Change*' and '*Natural Resource Management*' obtained at the Swedish University of Agricultural Sciences (SLU) Uppsala

SEPTEMBER 2002-AUGUST 2006

BSc degree in Soil, Water, Atmosphere

Wageningen University (The Netherlands)

Thesis entitled '*Modelling of three joined water reservoirs in R-script with a Kalman Filter application*'

PERSONAL SKILLS

MOTHER TONGUE(S): Dutch

OTHER LANGUAGE(S)

	UNDERSTANDING		SPEAKING		WRITING
	LISTENING	READING	SPOKEN INTERACTION	SPOKEN PRODUCTION	
English	C2	C2	C2	C2	C2
	Replace with name of language certificate. Enter level if known.				
German	B1	B1	B1	B1	B1
	Replace with name of language certificate. Enter level if known.				

Levels: A1/2: Basic user - B1/2: Independent user - C1/2 Proficient user
Common European Framework of Reference for Languages

COMMUNICATION SKILLS

- good communication skills gained through my experience as business developer and project manager
- good facilitation skills gained through the various trainings I facilitated and the training course 'Basis of Faciltiating' that I followed.

ORGANISATIONAL / MANAGERIAL SKILLS

☐ Project management (I have proven to be able to work with multi-disciplinary teams and closing projects with healthy project results)

☐ Proven ability to help clients and receive high customer satisfaction

PUBLICATIONS
PRESENTATIONS
PROJECTS
CONFERENCES
SEMINARS
HONOURS AND AWARDS
MEMBERSHIPS
REFERENCES

PEER-REVIEWED PUBLICATIONS

☐ Driessen, T.L.A., Van Ledden, M. (2013). The large-scale impact of climate change to Mississippi flood hazard in New Orleans, *Drinking Water Engineering and Science.*, **6**, 81-87, DOI:10.5194/dwes-6-81-2013, 2013.

☐ Driessen, T.L.A., Hurkmans, R.T.W.L., Terink, W., Hazenberg, P., Torfs, P.J.J.F., and Uijlenhoet, R. (2010). The hydrological response of the Ourthe catchment to climate change as modelled by the HBV model, *Hydrology and Earth System Sciences*, **14**, 651-665, DOI:10.5194/hess-14-651-2010, 2010.

PROJECTS

☐ *General flood risk approach for SEVESO companies in the Rotterdam harbour (2016)*
Client: Deltalinqs.
Description: In the new European SEVESO III guideline companies with potential risk for major industrial accidents are expected to describe their flood risk. In this project we provide a tool box for SEVESO companies within the Rotterdam harbour area which allows them to generally describe their flood hazard and possible effecfdd

☐ *Flood Emergency Response Plan Victor Guedes (2015-2016)*
Client: Victor Guedes/Unilever.
Description: Victor Guedes is a company of Unilever and is the second largest olive oil producer in the world. Their factory is located in the floodplains of River Tagus and faces a considerable flood risk. As project manager I was involved in the site assessment, creating guidelines for setting up the flood ERP document, proposing flood protection measures and reviewing the client's documents.

☐ *Unilever Flood Resilience (2014-2015)*
Client: Unilever Insurance N.V.
Description: Unilever Insurance N.V. requested assistance in their flood resilience program. Together with flood, industrial and communication experts I have performed flood hazard assessments and reviewed Flood Emergency Response Plans for 7 Unilever sites and developed a guideline, brochure and a 8-minute video to make site managers more aware of their flood resilience. I was project manager in this project.

☐ *Flood hazard assessment for 19 terminals world-wide (2013)*
Client: Private client (confidential)
Description: I performed six flood hazard assessments for the client's terminals all over the world. The scope of this study was to make a quick scan of the flood hazards, volcanic hazards and earthquake hazards for all terminals. I analysed in particular the flood hazard of six terminals in New Zealand and Brazil.

☐ *TAPB (Heineken) Flood Protection (2012)*
Client: TAPB/Heineken, Nonthaburi, Thailand
Description: For the Nonthaburi brewery of TAPB/Heineken a conceptual design was created for a system of location-specific flood protection measures and storm water drainage improvements. Long-term solutions were proposed as well as accompanying cost estimates. I was the project manager, and coordinated the design process.

☐ *ThaiNamthip (Coca Cola) Flood Protection (2012)*
Client: ThaiNamthip/Coca Cola, Pathum Thani and Rungsit, Thailand
Description: For two sites of the ThaiNamthip company (member of Coca Cola) a flood risk analysis was performed. The design levels were used as input for the conceptual design of a system that includes location-specific flood protection measures. Short-term and long-term solutions were proposed as well as accompanying cost estimates. I was the project manager, performed the flood risk analysis and coordinated the design process.

Curriculum Vitae

PERSONAL INFORMATION

Mathijs van Ledden

HaskoningDHV Nederland B.V., Rivers & Coasts, George Hintzenweg 85, 3068 AX Rotterdam

+31 88 348 9271 +31 6 52 36 19 87

mathijs.van.ledden@rhdhv.com

https://www.linkedin.com/in/mathijsvanledden/

Sex Male| Date of birth 25/3/1975 | Nationality Dutch

WORK EXPERIENCE

2003 - PRESENT — Director Flood Risk

Royal HaskoningDHV, Rotterdam, The Netherlands

- ☐ Consultant in the fields of coastal and river flood challenges various national and international projects as senior expert on hydraulics and morphology
- ☐ Senior expert providing advice on hydraulic and morphological issues to public and private clients

2010 – PRESENT — Delft University of Technology, faculty Civil Engineering, section Hydraulic Engineering.

Delft University of Technology, faculty Civil Engineering, section Hydraulic Engineering.

- ☐ Supervisor
- ☐ Guest lectures

1999-2003 — PhD Research

Delft University of Technology

- ☐ PhD Student, Lecturer River and Coastal dynamics

1998 — Projectmanager

Rijkswaterstaat

- ☐ Project specialist sand-mud mixtures

EDUCATION AND TRAINING

2010 — MBA

Tulane University, MBA

2003 — PhD

Delft University of Technology, PhD

Thesis entitled '*Large-scale sand-mud segregation in estuaries and tidal basins*'

1998 — MSc

Delft University of Technology, Hydraulic Engineering, Master of Science (cum laude)

Thesis entitled 'Zand-slibsegregatie in de Nieuwe Merwede (in Dutch)'

PERSONAL SKILLS

MOTHER TONGUE(S): Dutch

OTHER LANGUAGE(S)

	UNDERSTANDING		SPEAKING		WRITING
	LISTENING	READING	SPOKEN INTERACTION	SPOKEN PRODUCTION	
English	C2	C2	C2	C2	C2
Replace with name of language certificate. Enter level if known.					

French	A2	A2	A2	A2	A2
	Replace with name of language certificate. Enter level if known.				
German	A2	A2	A2	A2	A2
	Replace with name of language certificate. Enter level if known.				

Levels: A1/2: Basic user - B1/2: Independent user - C1/2 Proficient user
Common European Framework of Reference for Languages

COMMUNICATION SKILLS ☐

ORGANISATIONAL / MANAGERIAL SKILLS

☐ Project Management
☐ Consultancy
☐ Conceptual thinking
☐ Design review

☐ Hydraulic and morphological analysis and modelling
☐ Design flood mitigation measures (dikes, barriers)
☐ Flood Risk Assessments
☐ Flood Early Warning Systems
☐ Environmental Impact Assessments

PUBLICATIONS
PRESENTATIONS
PROJECTS
CONFERENCES
SEMINARS
HONOURS AND AWARDS
MEMBERSHIPS
REFERENCES

PUBLICATIONS, SELECTED PEER-REVIEWED PUBLICATIONS (OUT OF MORE THAN 100)

☐ 2015: Van Ledden, M. Reducing coastal risk - The absence of a flood disaster should be breaking news, Crisis Response Journal, volume 11, issue 2, December 2015.

☐ 2015: Van Ledden, M., Van den Brink, H.W., Klein, J., Caires, S., Groeneweg, J. A novel technique for rapid flood forecasting in coastal areas. Conference on Coastal Management, Amsterdam, The Netherlands.

☐ 2014: Ledden, M. van, Brink, H.W. van den, Caires, S., Groeneweg, J., Van den Berg, N.J.F. A Storm Surge Atlas for low-lying deltas with pilot application for the North Sea. Deltas in Times of Climate Change Conference, Rotterdam, The Netherlands.

☐ 2014: Ledden, M. van, Berg, N.J.F. van den, De Jong, M.S., Van Gelder, P.H.A.J.M., Den Heijer, C.J., Vrijling, J.K., Jonkman, S.N., Roos, P.C., Hulscher, S.J.M.H., Lansen, A.J. An idealized meteorological-hydrodynamic model for exploring extreme storm surge statistics in the North Sea. ICCE conference 2014.

☐ 2013: Jonkman, S.N.; Hillen, M.M.; Nicholls, R.J.; Kanning, W., and van Ledden, M. Costs of Adapting Coastal Defences to Sea-Level Rise — New Estimates and Their Implications Journal of Coastal Research.

☐ 2012: Van Ledden, M.; Jong, M. de; Heijer, K. de; Gelder, P. van Alternatieve benadering voor maatgevende waterstanden Nederlandse kust. H_2O

☐ 2012: R. Martyr, B.S.E.; J. Casey Dietrich, PhD; J. J. Westerink, PhD; P. Corbitt Kerr, MSc; C. N. Dawson, PhD; J. M. Smith, PhD; H. Pourtaheri, PhD; N. Powell; M. Van Ledden, PhD, MBA; S. Tanaka, PhD; H. J. Roberts, MSc; H. J. Westerink; L. G. Westerink; Rethinking Levee Designs to Reduce Hurricane Flooding in the Lower Mississippi River; Journal of Waterway, Port, Coastal, and Ocean Engineering

☐ 2011: P. Corbitt Kerr; J. J. Westerink; J. C. Dietrich; R. C. Martyr; S. Tanaka; D. T. Resio; J. M. Smith; H. J. Westerink; L. G. Westerink; Ty V. Wamsley; M. van Ledden; W. de Jong; The Generation, Propagation and Attenuation of Hurricane Storm Surge in the Lower Mississippi River under Varying Flow Conditions, Journal of Hydraulic Engineering.

☐ 2011: Van Ledden, M., Driessen, T.J., Groot Zwaaftink, M. Hoogwater Mississippi 2011. H20 (in Dutch).

☐ 2010: Arnold, E., Van Ledden, M. Nieuwe sluitingsstrategie voor het London Avenue Canal in New Orleans succesvol getest. Land+Water (in Dutch).

☐ 2009: Van Ledden, M., Gilman, J., Emmons, S., Hydraulic boundary conditions for the IHNC storm surge barrier. AWRA conference, Seattle.

☐ 2009: Van Ledden, M., Kluyver, M., Dolfsma, R. Ontwerp van IHNC stormvloedkering: een race tegen de klok. Land en Water (in Dutch).

☐ 2008: Van Ledden, M., Bass, R., Kluyver, M., Powell, N.J., Dean, R. Hindcast of wave overtopping and levee erosion at grass-covered levees during Katrina. PIANC conference, Mobile, Alabama.

europass Curriculum Vitae

PERSONAL INFORMATION

Hanneke Schuurmans

HaskoningDHV Nederland B.V., Water, Laan 1914 no 35, 3818 EX Amersfoort, Nederland

+31 88 348 3721 +31 6 46367260

hanneke.schuurmans@rhdhv.com

https://www.linkedin.com/in/schuurmans

Sex Female| Date of birth 5/3/1977 | Nationality Dutch

WORK EXPERIENCE

2010 - PRESENT

Leading expert hydrometeorology and early warning

Royal HaskoningDHV, Amersfoort, The Netherlands

- ☐ Consultant in the fields of climate related challenges in various national and international projects
- ☐ Project manager in the field of hydrometerology and early warning
- ☐ senior expert on climate change, hydrometeorology and early warning (floods and droughts)
- ☐ manage the development of product innovations within the department of hydrology and water management

2009-2010

Researcher/consultant climate and hydrology .

FutureWater, Wageningen, The Netherlands.

- ☐ Supervisor
- ☐ Guest lectures

2003-2008

PhD Research

Utrecht University, Physical Geography, The Netherlands

- ☐ PhD Student, Lecturer

2001-2003

Consultant quantative hydrolgoy

Grontmij (Sweco), Houten, The Netherlands

- ☐ Project specialist sand-mud mixtures

EDUCATION AND TRAINING

2008

PhD Physical Geography

Utrecht University PhD

Thesis entitled '*hydrological now- and forecasting system"*

1998

MSc in Hydrology and Quantitative Water Management

Wageningen University, Master of Science (cum laude)

Thesis entitled 'Assimilation of remotely sensed latent heat flux in a distributed hydrological model'

PERSONAL SKILLS

MOTHER TONGUE(S) Dutch

OTHER LANGUAGE(S)

	UNDERSTANDING		SPEAKING		WRITING
	LISTENING	READING	SPOKEN INTERACTION	SPOKEN PRODUCTION	
English	C2	C2	C2	C2	C2
French	A2	A2	A2	A2	A2

Spanish	A2				
	Replace with name of language certificate. Enter level if known.				
German	A2	A2	A2	A2	A2

Levels: A1/2: Basic user - B1/2: Independent user - C1/2 Proficient user

ORGANISATIONAL / MANAGERIAL SKILLS

- ☐ Project Management
- ☐ Consultancy
- ☐ Conceptual thinking
- ☐ Design review

- ☐ Early Warning System
- ☐ Climate impact assessment
- ☐ Project management of innovation projects
- ☐ Communication and Capacity building
- ☐ Remote Sensing in water resource management

PROJECTS (SELECTION)

- *Flood Forecasting System Sava river basin*

Client: World Bank
Position: Deputy overall project manager, expert hydrometeorology and early warning
> 2016 – present, Balkan (Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Serbia)

- Flood Risk Modelling and Pre-Feasibility Studies for Flood Risk Management in Mudeni Aru River Basin

Client: World Bank
Position: Senior hydrologist and flood risk expert
2016 – present, Sri Lanka

- Flash Flood Forecasting Application

Position: Project manager, expert hydrometeorology and Early Warning Systems
> 2016 – present, Ghana

- Development of an early warning application that helps the most vulnerable ones to protect themselves better to future floodings and which is free for them with the help of co-funding from private sector.

Task: Project management, stakeholder participation, business development
Client: Viawater
Risk assessment and Early Warning Floods and Droughts
2015 – 2016, Ghana

Curriculum Vitae

PERSONAL INFORMATION

Nanco Dolman

Royal HaskoningDHV, Water, Entrada 301, 1096 ED Amsterdam, The Netherlands

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nanco.dolman@rhdhv.com

linkedin.com/in/nanco-dolman-b329831

Sex Male| Date of birth 02/05/1972 | Nationality Dutch

WORK EXPERIENCE

SEPTEMBER 2004 - PRESENT

Consultant and leading professional

Royal HaskoningDHV, Amsterdam, the Netherlands

- Leading professional/ specialist Water Resilience in Urban Areas
- Consultant Water in Spatial Planning
- Project manager Integrated Water Management

Consultancy and engineering firm

AUGUST 2011- NOVEMBER 2015

Lecturer and teacher

Rotterdam University of Applied Sciences, Rotterdam, the Netherlands

- Water Management
- Spatial Development and Planning
- Adaptive Urban Development

Research and education

MAY 1998- AUGUST 2004

Project engineer

Oranjewoud (Antea), Almere, the Netherlands

- Modelling (surface) water systems, channel flow, rainfall runoff, water quality.
- Urban water in spatial planning.

Consultancy and engineering firm

EDUCATION AND TRAINING

SEPTEMBER 1991-APRIL 1998

Master of Science in Civil Engineering

Delft University of Technology (The Netherlands)

Specialized in Water Management in urban areas.

SEPTEMBER 2006-AUGUST 2008

Bachelor degree in Landscape Architecture

Amsterdam Academy of Architecture (The Netherlands)

Completed bachelor part of Master of Landscape Architecture.

PERSONAL SKILLS

MOTHER TONGUE(S) Dutch

OTHER LANGUAGE(S)

	UNDERSTANDING		SPEAKING		WRITING
	LISTENING	READING	SPOKEN INTERACTION	SPOKEN PRODUCTION	
English	C2	C2	C2	C2	C2
	Replace with name of language certificate. Enter level if known.				
German	B1	B1	B1	B1	B1
	Replace with name of language certificate. Enter level if known.				

Levels: A1/2: Basic user - B1/2: Independent user - C1/2 Proficient user
Common European Framework of Reference for Languages

COMMUNICATION SKILLS

- Inspirational speaker, gained through my experience as part-time lecturer and teacher.
- Communication skills, both oral, written as in facilitation of processes, gained through my experience as project and process manager.
- Strategic advisor in communication, gained through my years of experience working for Amsterdam Airport Schiphol (1998-present).

ORGANISATIONAL / MANAGERIAL SKILLS

- Proven ability to help clients and receive high customer satisfaction.
- Project management; I have proven to be able to work with multi-disciplinary teams and closing projects with healthy project results.

PUBLICATIONS
PRESENTATIONS
PROJECTS
CONFERENCES
SEMINARS
HONOURS AND AWARDS
MEMBERSHIPS
REFERENCES

PEER REVIEWED PUBLICATIONS

- 'Scenario analysis of rainwater and use on a large scale – assessment of runoff and economic performance fort the case study Amsterdam Airport Schiphol' in *Urban Water Journal*, Volume 14, Issue 3, pages 237 – 246, October 2015. United Kingdom.
- 'New Orleans after Katrina: Building America's Water City', in *Proceedings of Built Environment*, Volume 40, Issue 2, June 2014. United Kingdom.
- 'Water-sensitive urban design: learning from experience', in *Proceedings of the ICE - Municipal Engineer*, Volume 166, Issue 2, pages 86 –97, June 2013. United Kingdom.

PRESENTATIONS (SELECTION)

- 'Water & the Dutch City', lecture at the Asia-Netherlands Water Learning Week 'Building Capacities for Water Resilient Cities', 7 June 2016, Amsterdam, the Netherlands.
- 'Water Sensitive Urban Design', guest lecture in international 'Planning & Design of Urban Space' course at Wageningen University, May 2012, April 2013, April 2014, April 2015 & April 2016 Wageningen, the Netherlands.
- 'How flood risk is planned for in other countries' – Brisbane Flood Community of Practice, 27 October 2015, Brisbane, Australia.

PROJECTS (SELECTION)

☐ *Climate Stress Test Schiphol Airport (2016), the Netherlands*
Client: Amsterdam Airport Schiphol

☐ *Climate Change Study Singapore Airports (2016-present), Singapore*
Client: Civil Aviation Authority of Singapore (CAAS)

☐ *Climate Stress Test Westpoort Amsterdam (2016), the Netherlands*
Client: Dutch ministry of Infrastructure and the Environment

MEMBERSHIPS

- UN-ISDR "Making Cities Resilient" Advocate, 2015-present.
- Reviewer for IWA Journal of Water and Climate Change, 2014-present.
- Mirror editor of DeltaForum Magazine (NL), 2009-2010.
- Royal Dutch Water Network, 1998-present.
- KIVI NIRIA (Dutch engineering association), 1998-present.

REFERENCES

- F.J.M. van de Ven MSc PhD, Associate Professor Urban water Management Department Water Management Faculty of Civil engineering and Geosciences Delft University of Technology, Delft, the Netherlands.
- R.E. de Graaf MSc PhD, Professor of Adaptive Urban Development, Rotterdam University of Applied Sciences, Rotterdam, the Netherlands.
- J.D. Waggonner III, FAIA, Principal at Waggonner & Ball Architects, New Orleans, United States of America.
- R.D. Pittman, Business Manager - Strategy/Innovation at OMA (Office for Metropolitan Architecture), New York, United States of America.

europass Curriculum Vitae

PERSONAL INFORMATION

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http://www.lboro.ac.uk/departments/geography/staff/rob-wilby/

Sex Male| Date of birth 26/09/1965 | Nationality British

WORK EXPERIENCE

SEPTEMBER 2008 - PRESENT — Professor of Hydroclimatic Modelling

Department of Geography, Loughborough University, Loughborough, UK

- Research in regional climate modelling and impacts, hydroclimatic data reconstruction
- Delivery of short courses in regional climate modelling and professional training in hydrology
- Management and delivery of multi-disciplinary research projects
- Supervision of post-doctoral researchers, PhD and Masters students
- Software and data development to support climate risk management
- Technical advisory work and climate services

AUGUST 2007 – AUGUST 2008 — Independent Climate Science Advisor

Self-employed consultant, Nottingham, UK

- Technical advisory work and climate services
- Procuring consulting contracts and supporting a range of climate vulnerable clients
- Climate data analysis and modelling

APRIL 2003 – JULY 2007 — Climate Science Manager

Environment Agency of England and Wales, Head Office, Bristol, UK

- Development and delivery of a portfolio of climate projects to support Agency functions
- Provision of technical advice and writing guidance for Government departments
- Project management and reporting
- Stakeholder liaison and partnership building

APRIL 2001 – MARCH 2003 — Reader in Physical Geography

Department of Geography, King's College London, UK

- Research in regional climate modelling and impacts on urban environments
- Teaching environmental management, hydrology, and climate modelling
- Software and data development to support climate risk management
- Technical advisory work and climate services

SEPTEMBER 1993- MARCH 2001 — Senior Lecturer/Reader in Physical Geography

Department of Geography, Derby University, Derby, UK

- Teaching and research in climate and water
- Development of regional climate modelling software (SDSM)

JULY 1996-SEPTEMBER 1999 — Visiting Scientist

National Center for Atmospheric Research (NCAR), Boulder, Colorado, USA

- On leave of absence from Derby University
- Research in regional climate modelling and hydrological impacts
- Research program manager of A Consortium for the Application of Climate Impact Assessments (ACACIA)

JANUARY 1992-AUGUST 1993 — Post-doctoral Research Scientist

National Rivers Authority, UK

- Research in climate impacts on water resources
- Stochastic weather generator development

APRIL 1990-DECEMBER 1991

Assistant Water Quality Information Officer

Severn-Trent Water, Raynesway, Derby, UK

- Compliance monitoring and reporting of raw-water and domestic water samples
- Statistical analysis of water quality trends

EDUCATION AND TRAINING

OCTOBER 1987-APRIL 1991

PhD

Department of Geography, Loughborough University, Loughborough

Thesis title: *The influence of climate on the hydrogen-ion budget of upland catchments*

SEPTEMBER 1984-JUNE 1987

BSc (Hons) Geography

Department of Geography, Loughborough University, Loughborough
First Class. Undergraduate Prize Winner

PERSONAL SKILLS

MOTHER TONGUE(S) English

OTHER LANGUAGE(S)

	UNDERSTANDING		SPEAKING		WRITING
	LISTENING	READING	SPOKEN INTERACTION	SPOKEN PRODUCTION	
French	A2	B2	A2	A2	A2

Replace with name of language certificate. Enter level if known.

Levels: A1/2: Basic user - B1/2: Independent user - C1/2 Proficient user
Common European Framework of Reference for Languages

ORGANISATIONAL / MANAGERIAL SKILLS

- Leadership (as Associate Dean for Research provided strategic oversight of ~70 staff)
- Research project and portfolio management (as a Climate Science Manager and self-employed consultant)
- Organisation and delivery of training workshops, conferences, and technical sessions

PUBLICATIONS
PRESENTATIONS
PROJECTS
CONFERENCES
SEMINARS
HONOURS AND AWARDS
MEMBERSHIPS
REFERENCES

SELECTED PEER-REVIEWED PUBLICATIONS (FROM ~150 PAPERS AND 5 BOOKS)

- Seneviratne, S.I., Donat, M.G., Pitman, A.J., Knutti, R. and **Wilby, R.L.** 2016. Allowable CO2 emissions based on regional and impact-related climate targets. *Nature*, **529**, 477-483.
- Poff, N.L., Brown, C.M., Grantham, T.E., Matthews, J.H., Palmer, M.A., Spence, C.M., **Wilby, R.L.**, Haasnoot, M., Mendoza, G.F., Dominique, K.C. and Baeza, A. 2015. Sustainable water management under future uncertainty with eco-engineering decision scaling. *Nature Climate Change,* **6**, 25-34.
- **Wilby, R.L.**, Dawson, C.W., Murphy, C. and O'Connor, P. 2014. The Statistical DownScaling Model – Decision Centric (SDSM-DC): Conceptual basis and applications. *Climate Research*, **61**, 251-268.
- Brown, C. and **Wilby, R.L.** 2012. An alternate approach to assessing climate risks. *Eos* **92**, 401-403.
- **Wilby, R.L.**, Troni, J., Biot, Y., Tedd, L., Hewitson, B.C., Smith, D.G. and Sutton, R.T. 2009. A review of climate risk information for adaptation and development planning. *International Journal of Climatology*, **29**, 1193-1215.

PROJECTS

- Technical reviewer of the DFID *Weather Information Services for Africa* (WISER), *Climate Information and Services for Africa* (CIASA) and NERC-DFID *Science for Humanitarian Emergencies and Resilience* (SHEAR) programmes

CONFERENCE ORGANISER

- Co-organizer of *Advanced Study Program Summer Colloquium on Uncertainty in Climate Change Research: An Integrated Approach*, NCAR, Boulder, CO (2014)
- Co-organizer of an international workshop on *Toward an Ethical Framework for Climate Services*, Loughborough University, UK (2014)

SCIENTIFIC ADVISOR

- Chair of the EDF Climate Change (BECC) Working Group (2008-present)
- Peer reviewer of UK Government's *First Climate Change Risk Assessment* (CCRA) (2012); contributing author to the *Second CCRA Evidence Report* (Chapters 2 and 8) (2017)

PERSONAL INFORMATION

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jeroen.rijsdijk@arcadis.com

Sex Male | Date of birth 31-05-66 | Nationality Dutch

POSITION

Project Manager

WORK EXPERIENCE

1991 – Present

Project Manager

Arcadis Netherlands

- Project Manager of climate change studies to determine the impact of extreme precipitation events on built urban area. Studies both traditional and 2D simulations.
- Project Manager for design and realisation of multiple collection and transportation systems, sewer systems and pressure pipe systems in multiple municipalities.
- Project Manager of multiple monitoring studies in which the actual behaviour of sewer systems and urban water systems is being measured in real time to validate computerized simulation models.
- Project Manager for multiple hydraulic studies involving water quantity and quality aspects on waste water and storm water handling in urban environment.
- Project Manager of multiple policy studies for multiple municipalities. Studies of how municipalities perform their water management on waste water, storm water and groundwater. Studies included financial scenario planning.
- Project Manager for the renovation of the Raadhuisbuurt district in Langedijk to solve current flood issues, ground water issues and CSO issues.

Consultancy, design, engineering and management services

General Manager and Technical Manager of the global foreign expertise of Aradis on urban climate adaptation and resiliency

China: Wuhan Sponge City Program

Arcadis is the general advisor to Wuhan to advise on demand on different topics and projects Wuhan is working on in the national climate program Sponge City

Consultancy, design, engineering and management services

Overall Project Manager and Technical Team Leader of a team of 6-8 engineers involved

Amsterdam Schiphol Airport: Storm Water Management

Schiphol Airport asked Arcadis to support on the assessment of condition issues with the storm water drainage system and with the analysis and optimizing of the hydraulic functioning of the storm water drainage system.

Consultancy, design, engineering and management services

Overall Project Manager and Technical Team Leader of multidisciplinary team of 15-20 engineers involved

Oil company: Climate proof design storm water drainage oil tank storage terminal Amsterdam

Client wants a 25 year climate proof design of tankpit drainage because of constant flooding issues of accidently contaminated storm water.

Positions held: Overall project manager and technical team leader of a multidisciplinary team of 15-20 engineers involved

Overall Project Manager for the urban water management conceptual and permit phase. And for the design of highway and tunnel drainage and water storage capacity implementation in highway design

The 2nd Coen Tunnel aims at doubling the transport capacity of the ring highway system of Amsterdam. The Tunnel passes the shipping canal North Sea Canal. The highway expansion implies 100% increase of impervious surface in a big city urban environment.

Overall Project Manager

Dutch Waterboards STOWA: Research water quality impact sewer system choice

Building an analytic prediction model for the national Union of Waterboards STOWA to predict the water quality influence of different sewer systems on the local water system. By using the model on the municipality of Capelle aan den IJssel we were able to determine the best sewer design to minimize water quality issues in the water cycle.

Overall Project Manager

Langedijk: Hydraulic review, extreme weather analysis and climate proof design urban area

Perform hydraulic and climate review on the total urban drainage of the municipality. And design a climate proof area to resolve flooding issues.

EDUCATION AND TRAINING

1985 - 1989 **HTS Civiele Techniek**

2006 **TSM Business School**
Management Course

2004 **Routs Laeven en Partners**
Commerciële adviesvaardigheden

2001 **Arcadis/GITP**
Presentatietechniek

PERSONAL SKILLS

Mother tongue(s): Dutch

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	B1/2	B1/2	B1/2	B1/2	B1/2
	Replace with name of language certificate. Enter level if known.				
German	A1/2	A1/2	A1/2	A1/2	A1/2
	Replace with name of language certificate. Enter level if known.				

Levels: A1/2: Basic user - B1/2: Independent user - C1/2 Proficient user
Common European Framework of Reference for Languages

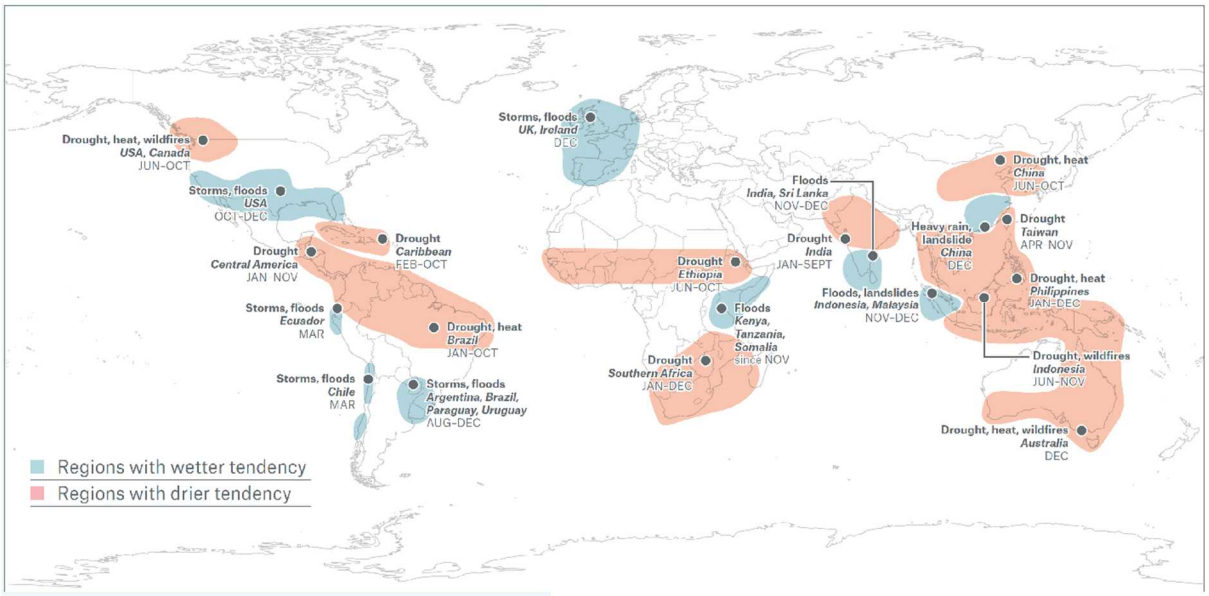
3. Technical solution proposed

3.1. Introduction

Many public and private institutions operate at a global scale: private companies with globally distributed supply manufacturing and chains, as well as specialised consultancy and (re)insurance firms, with a globally distributed portfolio of clients. Awareness of and willingness to act on increasing climate risks is growing among these communities (see Box 1). This is the result of new climate regulations including the Paris Agreement, more knowledge and media attention on the climate change topic, and due to recent catastrophes that adversely affected their assets and investments.

In 2016 the World Economic Forum announced water crises and failure in combating climate-change as the top two global risks of highest concern for the next 10 years. The number of loss events between 1980 and 2014 shows an increasing trend (Figure 1) which resonates with a rise in overall economic losses. The vast majority of these losses were attributed to hydrological (floods and landslides), meteorological (storms) and climatological events (extreme heat, drought, wildfires).

Figure 1: Zones typically affected by rainfall deviation from the long-term mean caused by El Niño Southern



Oscillation (ENSO) events. The diagram also shows clusters of typical loss events per region that occurred in 2015 (Source: Munich Reinsurance Company)

Climate services, including data on projected hazards and risks, as well as tailored advice and decision services, provide tools to gain insight in climate change impacts. It helps to raise awareness of risks and to assess threats and opportunities. However, the climate services market is still immature in terms of size and data, tools and methods that are offered, and alignment with stakeholders' needs. Also, the current traditional approach of supply-driven information on future weather extremes is insufficient, as it does not connect to actual events that have put stress on real-world operations of public and private entities. Therefore we propose to co-develop **stress-test applications**, building on a portfolio of actual and synthetic extreme weather events, perturbed for future climate change, to enable end-users to assess the vulnerability of their assets, operations and markets.

In this proposal we put a main focus on private businesses operating from local to global scale, because these companies have a large impact on society in terms of resource supply, and they are generally exposed to climate change effects due to their often global presence and large agricultural sourcing areas. For example, in case any sourcing areas are located in the zones depicted in Figure 1 it is necessary to assess what climate change impacts are on the production of these sourcing areas

and thus on food supply to the consumer market. In other words, climate resilience of industries is crucial to protect assets and reduce business interruption. The availability of a sound, solid and *scientific* based climate stress test system is of additional importance for private companies as they are also seriously monitored by their investors how they deal with climate change related threats and opportunities. In recognizing the tangible business benefits of disclosure and action, companies are therefore raising their ambitions and need to take well informed steps to mitigate risks, seize opportunities and inform public and investors.

The application of stress tests by commercial organisations is a highly specialised activity, that needs in depth knowledge of the organisations' operations, assets and culture. We will use commercial and non-commercial **intermediate organisations** to transfer the weather event information into tailored services for their clients, who mainly consist of private businesses that so far have found little application of the available climate service tools to their specific situation.

Box 1: Need for climate services in businesses

Company disclosures on climate risk and opportunities show that climate change is increasingly recognized as being relevant to business activities. In 2015, 407 Global 500 companies disclosed a total of 1016 physical risks, with changes in temperature extremes, tropical cyclones, and changes in precipitation extremes and droughts accounting for almost half of all reported risks (Frey et al. 2015). Some key outcomes from another global survey (Seville and Gannon, 2015): i) Water scarcity and political instability driven by climate change are cited as the top two anticipated risks across sectors. ii) Two-thirds of the respondents expressed concern over increased operational and capital costs and reported they had already experienced cost increases or considered them a likely outcome. iv) 70% of the respondents have monitored climate risk in some capacity as part of their enterprise risk management (40 percent) or by looking at a specific driver of concern (30 percent). v) Respondents rely for a large part on publicly available data, reports and websites to inform their climate adaptation work. Internal sustainability teams were also cited as a key resource for climate change risk information. vi) The main barrier to action cited was the challenge of getting climate-related risks recognized as an immediate priority, followed by lack of leadership on climate change.

A stress-test is an approach that assesses the vulnerability to climate change based on stakeholder defined objectives. In this proposal we define a stress-test as:

'*A targeted vulnerability assessment of the climate resilience of public and private organisations by evaluating the response to realistic extreme natural events challenging the operation of smaller or larger sections of the organisations process chain*'

In the application of stress tests for climate resilience we identify the following gaps that will be addressed by the proposal:

- Current climate risk assessments (and the climate information used) often lack relevance for the key performance indicators of business operations and investments. They are often too generic and centred around 'likely' events instead of the most decisive plausible events, even if they have not yet occurred. This is shown by the fact that, despite currently applied risk assessments, companies and organisations are often surprised by extreme events causing major disruption and damage.
- Both global business and local production are parts of complex physical and economic networks, such as water supply systems, value and supply chains, communications etc. Vulnerability and impact indicators that are currently being applied often do not reflect this

complexity. As a result, conventional climate risk analysis may underplay connected or indirect threats and opportunities. These limitations were noted by the 2017 UK Climate Change Risk Assessment, for example.

One way of addressing the acknowledged gaps in climate services is to allow stakeholders to run practice oriented stress tests and virtual training. This requires a relevant set of use cases with realistic environmental boundary conditions. A library of events with sets of environmental boundary conditions is required here. **CSTK will build a collection of events suitable for stress-testing, develop a protocol for constructing and updating an event library, and carry out demonstration pilot case studies in a professional setting where scientists, consultancy and clients interact.**

3.2. Proposed solution: approach and team composition

The CSTK project is designed to advance expertise in hydro-meteorological extreme events in order to facilitate climate resilience stress testing of internationally operating organisations. The consortium consists of Climate Service (CS) data providers **KNMI** and **BSC**, application developers **Deltares** and **Loughborough University (LBU),** with consultants **RHDHV** and **Arcadis**, serving their beneficiaries, consisting of public and private end-user organisations (Figure 2). The inclusion of RHDHV and Arcadis as specialised consultancy organisations with global reach helps to support the business case of this new Copernicus service.

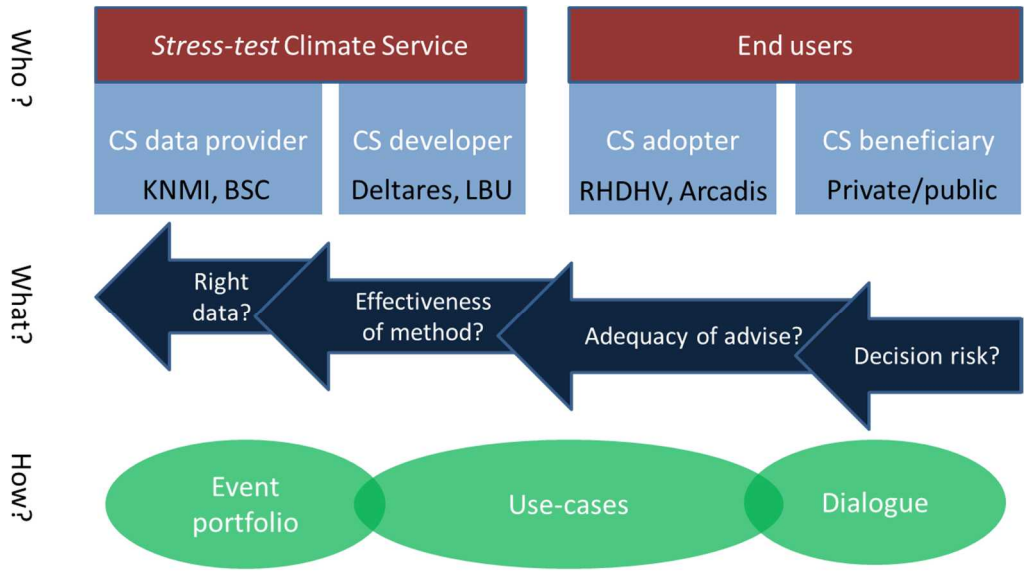


Figure 2: *Top row*: actors involved in the development and demonstration of the Stress-test Tool Kit. Climate Service (CS) beneficiaries are clients of consultancy and other CS adopters. The adopters make use of tools and data generated by developers, using the scientific infrastructure of knowledge institutions. Data and model output is supplied by the CS data providers. *Middle row*: the design of the stress-test tool kit uses the decision context of the beneficiaries as starting point, and works its way towards the development of adequate services, methods and data. *Bottom row*: the CSTK project is structured along the components Dialog (WP1: intake and design specifications), Demonstrators (WP2 and WP3: use case development and evaluation) and the construction of the CSTK toolkit (WP2 and WP3: climate data, modelling and library construction).

For the development of the CSTK, we have secured the commitment of several **private and public**

organisations as **end-users**. This will enhance the uptake of the user-respective on the development of the stress-test tool Kit, as well as the definition of the scope of the approach.

Support letters (see Section 4.9), expressing willingness to be actively involved in the development of the toolkit and to help develop use-cases including testing on their activities, production process and site location(s), were provided by:

- Eneco (energy company)
- AMC (academic medical hospital)
- Anglian Water Services (drinking water company)
- US Army Corps of Engineers – Institute for Water Resources (governmental intermediate organization)

Other organisations that have expressed the same willingness to our consortium during the proposal development include:

- Kimberly Clark
- Nestlé
- AKZO-Nobel
- ASR (insurance company)
- Pro-rail (Netherlands)
- NS (Dutch national rail)

Further, other companies and public organisations in the portfolio of RHDHV, Arcadis and Deltares will be approached for their input in the CSTK design, development and use-case application.

The overall conceptual framework of the CSTK emerges from pilot testing and development with Denver Water, Colorado *[2]* and UK flood risk appraisal *[1].*

The proposed framework (Figure 3) involves coupling two circuits of activity: one to generate plausible boundary conditions from a hydro-meteorological ensemble of cases, and the other to use these products to stress models of user systems and decision sets.

Both circuits begin with collaborative dialogue between the consultancy team, the consultants and beneficiaries of the CSTK. This set of activities establishes the nature of the business, arriving at a shared understanding of the most significant climate vulnerabilities and threats, as well as the policy and regulatory contexts of decision-making processes. These consultations will also establish metrics of success - envisaged as indicators of enhanced climate resilience and economic performance that are meaningful to the adopters and beneficiaries. Using models of the climate-sensitive components of the business with portfolios of adaptation options and decisions, stress tests will then help to discriminate their relative efficacy when exposed to the climate pressures.

Creation of the library of extreme events will also begin with collaborative dialogue to identify past extreme weather events that have been particularly problematic to the partner organizations. A set of criteria will be developed to shift the potentially large sample of relevant extreme events so that they comply with agreed conditions such as the minimum return period, scale of influence, types of economic and social disruption. A library of historic and projected events that meet these criteria will be drawn from the Copernicus Climate Data Store, complemented by additional climate model simulations where needed. Since the derived ECVs will provide only first order impacts, further (local) post-processing will be undertaken to create relevant impact indicators such as extreme high/low river flows, flood water levels, drought indices, and so forth.

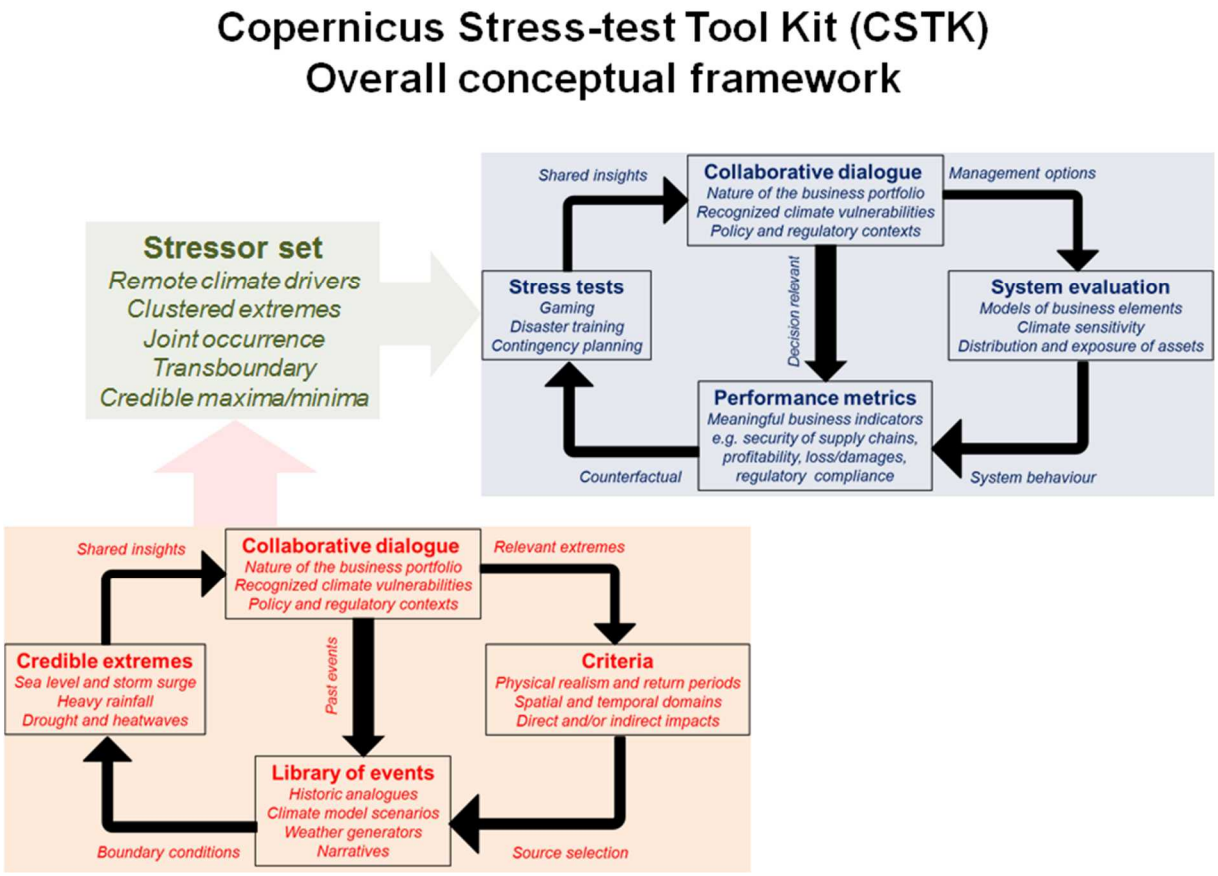


Figure 3: ***Schematic of the interaction between the development of relevant stress tests for climate resilience analysis (upper circle) and the selection of events that can be used for this stress test application (lower circle).***

The resulting library of events will reflect a range of climate extremes; remotely forced and globally manifested (e.g. El Nino episodes); clustered extremes (e.g. persistent passage of cyclones over NW Europe); joint extremes (e.g. heavy rainfall with gales or storm surge); trans-boundary (e.g. heat waves, droughts and multi-basin floods that simultaneously impact multiple nations or connected domains); and credible maxima (e.g. extreme heat waves or intense rainfall). Protocols will be established such that the library of events can be expanded and updated beyond the life of the project to meet the needs of more companies and to reflect scientific developments (Figure 4).

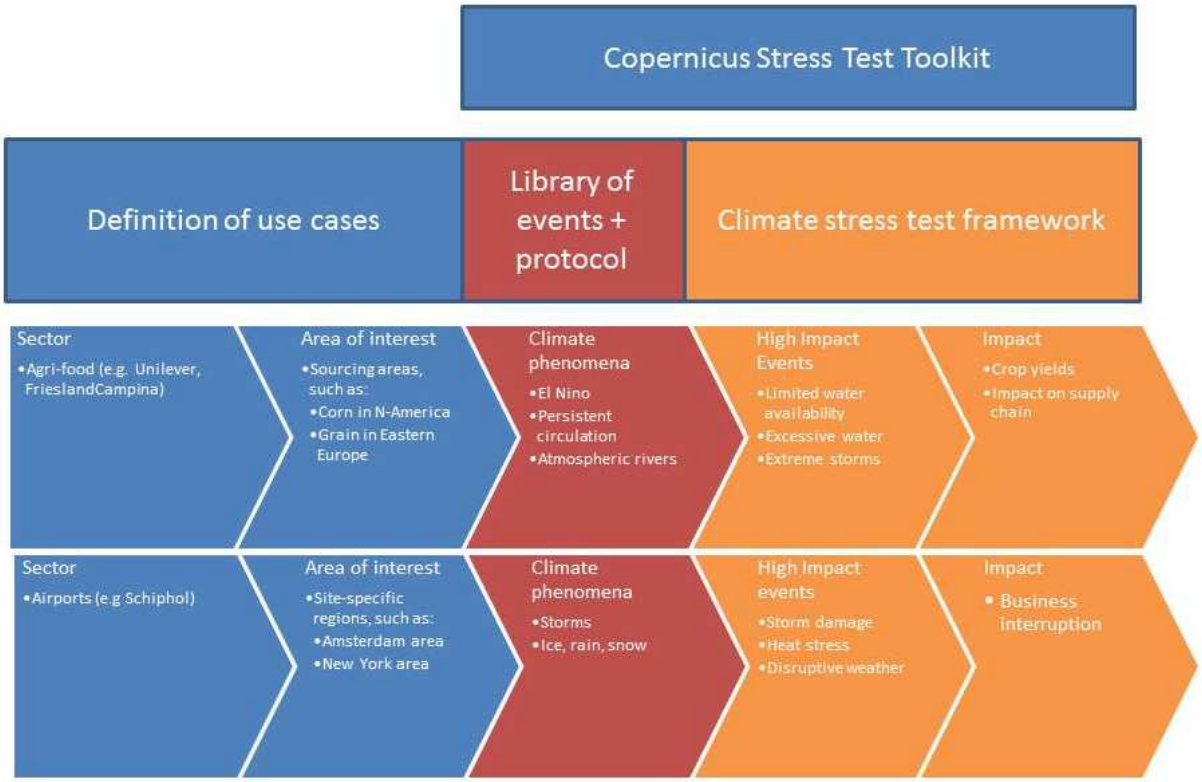


Figure 4: illustration of the definition of use cases and construction of stress test events for a limited number of sectors and stakeholders.

3.3. CSTK delivery and project work flow

The complete workflow of the project is sketched in Figure 5. The CSTK provides an accessible and extendable database of relevant, plausible and realistic extreme weather and climate events and sequences that will allow CS consultants to run stress tests for their clients. Accompanying training packages will deliver guidance on how the data service can be used in connection with existing stress test methods, models and tools. Case studies will demonstrate the added value of such service for a number of private and public client cases in which a stress test is collaboratively applied.

The event library and use cases will be made accessible by a prototype event browser, using selection criteria such as location, spatial/temporal extent, and type of impact. The database will be designed to be extendable after completion of the CSTK project. Many more climate related catastrophic events are imaginable than can be covered within the 18 month duration of this project. Therefore, representative case examples will be used to demonstrate the steps and effort necessary to perform a meaningful stress test. This will be done subject to a generalized protocol that sets criteria for event selection, generation, application and evaluation. After 18 months this will already form a useful start portfolio of cases.

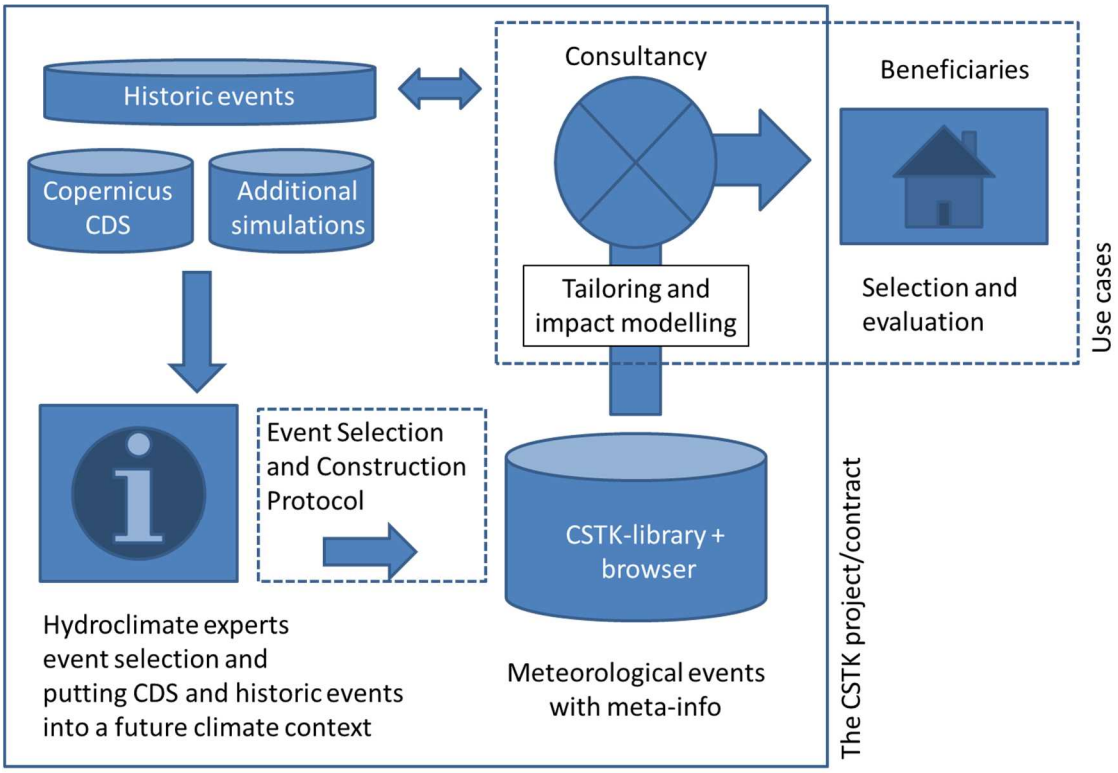


Figure 5: CSTK workflow. Shown are the database of historic and modelled events in the upper left corner, the event selection manipulation in the lower left corner, the definition of a protocol for events to be stored in the CSTK library (lower right corner), and the use tailoring process involving consultancy and climate service developers in the upper right corner of the big square. The clients (beneficiaries) of CS developers and consultants are involved in the development and evaluation of use cases.

3.4. Events for the CTSK portfolio

The development of the event database will be informed by historic events that have led to severe impacts. Attention is paid to the notion that many events are characterized by non-local features: high impact events may consist of chains of related processes distributed in time or place, while other stressful situations might be the consequence of a number of non-exceptional weather and climate remote events that become special because of their collocation in time.

The selection of extreme events is a critical step in the development of the CSTK portfolio, for which a "rating" system will be developed. This will be based on a number of key-variables that characterize the extreme events. Input from the end-users of the climate service is given a strong weight in the selection criteria. These key-variables should, at the very least, contain information on:

- ***Relevance***: does the event have properties that have/will put a considerable stress on companies/organisations performance?
- ***Geographical location***: extreme events are always defined with respect to the local environmental and climatic conditions in which it occurs.
- ***Spatial extent***: large-scale phenomena will generally have more impact than smaller-scale ones.
- ***Time scale***: duration and/or return time of the events.
- ***Expected future change***: in terms of event characteristics and probabilities.

Table 1 provides a sample of potential stress test use cases that could be included in the CSTK database. The final selection of use cases is subject to the survey applied early in the CSTK project (WP1).

Table 1: sample of potential stress test cases that could be selected in the CSTK, including private and public end-user organisations that are actively engaged with the consultancy partners of the project consortium

Sector/ business line	Companies and organisations in consortium portfolio (examples)	Scale of operations	Vulnerable activity	Climate Impact	Example meteorological events
Production of consumer goods	Unilever, Kimberly & Clark, Heineken	Agricultural areas in global network	Agriculture, harvesting, manufacturing	Shortage of water, disruption of plants	Drought in Brazil, Russian heatwave, cold wave in Spain (2017)
Public drinking water supply	Anglian Water Services	Regional	Surface and groundwater supplies	Water scarcity, higher operating costs, environmental impacts of operations	Multi-season droughts such as 1921/22, 1933/34, 1996/97
Manufacturing	Kimberly Clark, Sony, Western Digital, Seagate, Honda Motors	Plants in global network	Logistic (transport, energy supply) and production (plan operation)	Pluvial or coastal flooding	UK Flooding 2013/2014, Thailand flooding (2011)
Airports	Schiphol Group and other airport authorities	Local sites	Air traffic, logistics	Pluvial, storm surge and fluvial flooding; unfavourable traffic conditions	Flood events New York (2011), Bangkok (2011), New Delhi (2011 and 2013), Mexico (2013), London (2013, 2014) , Rome (2014), Malaysia (6 times in 2014), Chennai (2015)
Public healthcare	AMC medical hospital	Local sites	Medical treatments	Pluvial flooding, heat-waves	Heavy rainfall in 2016; heat waves 2003 and 2006
Rail infrastructure	NS, Pro Rail	Regional	Rail transport	Pluvial flooding, heat-waves, cold spells, snow	Heavy rainfall in 2016; heat waves 2003 and 2006

In the project an initial portfolio of 10-15 events will be included, reflecting historical cases of water

availability, drought, heat wave and flooding. From the exemplary sample set of use cases shown in Table 1 a hypothetical collection of events as shown in Table 2 will be processed.

Table 2: Hydro-meteorological characteristics of example of events that can be processed and stored in the CSTK event library

Case selection			Construction of events			
Sector/company	**Hazard**	**Climate events**	**Example event(s)**	**Spatial scale**	**Temporal scale**	**ECVs**
Food production and manufacturing	Harvest failure	Unfavorable growing conditions	Brazil drought	Grid covering Northern half S Am	daily fields between 1 month before and 1 month after drought episode	P, T, E, soil moisture
			Coldwave Spain	Grid covering Europe	subdaily fields 1 week before until 1 week after cold spell	air temp, soil temp, snow cover
Water management	Flooding	Extensive river discharge and coastal surge	Thailand flood	Grid covering SE Asia	subdaily fields 1 week before until 1 week after flood event	P, soil moisture, evap.
Public Drinking Water	Groundwater shortage	Prolonged regional drought	Multi-season droughts	Grid covering Eurasia	monthly fields for sequence of years	P, T, Evap, soil moisture
				Selection of utility locations	timeseries for sequence of years	P, T, Evap, soil moisture
Critical infrastructure	Interruption of air traffic	Winter storms	Snow storm	Selection of airport locations	timeseries for sequence of years	P, T, soil temp, snow cover
			Winter storm with high wind speeds	Selection of airport locations	timeseries for sequence of years	Wind speeds and direction

An impression of the type of analyses as will be carried out in the project is given by the description of examples of historical extreme weather and climate events that were related to climate change and characterised by high impacts, such as number of casualties and socio-economic impacts. The events have been extensively documented in the media and in peer review publications. The events are expressed in terms of climate variables (usually ECVs) and impact indicators (developed in the use cases applications).

3.4.1 Examples of events based on historical records

The meteorological and climate conditions that are listed in the last column of Table 2 can be

classified as heat waves and cold spells, droughts, fluvial flooding and pluvial flooding. Below a few of those extensively documented events are presented, together with an outline of how similar events will be selected and post-processed prior to storage in the event catalogue. The data base from which these events are selected consists of the climate simulations provided by KNMI and BSC generated by (high) resolution global climate models for present and future climate. Statistical analyses concerning the severity of the events, such as return periods, will be performed.

Case 1: The Russian heat wave (summer 2010)

The heat wave in western Russia in the summer of 2010, killed an estimated 55,000 people, was by far the worst such event of the past 33 years, according to a climate index that scientists have devised to gauge the magnitude of heat waves *[5]*. The drought severely impacted the agriculture production and wheat prices soared by about 90 percent during that drought. CMIP5 model simulations show that the percentage of global area affected by heat waves has increased in recent decades *[4]*. Future climate projections invariably point towards increases in the probability of occurrence of extreme and very extreme heat waves in the coming years, in particular, by the end of this century. Under the most severe IPCC AR5 scenario, events like the 2010 Russian heat wave will become the norm and may occur as often as once every two years for regions such as southern Europe, North America, South America, Africa and Indonesia. With large populations, high concentrations of economic activity and urban heat island effects, mega-city regions are particularly vulnerable to future intensification of heat waves *[17].*

Other cases of "Heat Waves and cold spells"

- Cold wave in Spain (January 2017). Low temperatures in combination with windy and wet conditions led to shortages in grocery supplies on the European food supply market at a time of the year when alternative supply chains are particularly scarce[1].
- European heat wave (summer 2003). Hottest since 1540. Over 35,000 heat related mortalities. Main sectors hit by the heat wave were green fodder supply, the arable sector, the livestock sector and forestry. Power plants reported losses of 7% to 15% of nuclear capacity for 5 weeks; with losses up to 20% in hydro generation capacity. Future climate scenarios like KNMI'14 invariably point toward increases in heat waves, their intensity and longevity.

The selection of heat waves will be done by using daily T_{mean} and T_{max} that need to fulfil a criterion over a sufficient long period. For example for the Netherlands a heatwave is defined as period of more than 5 days with a Tmax above 25 C and at least three days above 30 C. Thise definition of a heat wave is regionally dependent and the criteria should account for that. Once selected, relevant additional daily parameters will be calculated such as, for instance surface heat fluxes, humidity, cloud cover, precipitation and wind. These data will be stored in the data base to be used by the impact models.

Case 2. Multi-year drought in North Eastern Brazil (2012-present)

Drought is a natural phenomenon of North Eastern Brazil (NEB). Characterised as a persistent deviation from the long-term climate, it affects the vulnerable residents of the semiarid NEB region, by creating situations of water deficiency and leading to risks in water-, energy-, and food security. The current drought affecting NEB, which began in 2012, however, has an intensity and impact not seen in several decades. It has destroyed large swaths of cropland, affecting hundreds of cities and towns across the region, and leaving ranchers struggling to feed and water cattle. Storage in reservoirs has

[1] http://www.bbc.com/news/uk-38666752

fallen to 5% of their maximum water capacity. Future climate projections for the area show strong temperature increases and reductions in rainfall. Combined with a tendency for longer periods with consecutive dry days, this suggests that the region will have to contend with more frequent and more intense dry spells and droughts, and a subsequent tendency towards systematic aridification of the region *[6].* On inter-annual time scales NEB is strongly affected by El-Nino *[7].*

Case 3. South African drought (2015-2016)

The worst drought in 30 years hit South Africa in 2015-2016. It was associated with a strong El Nino. Maize and sugar crops were severely affected, with estimated losses in the order of $100 million. Also livestock under extensive production systems was strongly affected, with loss of stock, as it is largely dependent on grazing. It caused serious competition for water in river basins and aquifers. The drought presented serious risks to plant operations but also negative image to companies using large shares of scarce water resources. Shongwe et al. *[8]* showed that global warming could decrease the rainfall in southwest Southern Africa, thereby enhancing probability of severe droughts.

Other cases of Drought

- Millennium drought of Australia (2000's). Although Australia's droughts are part of the natural variability, the Millennium drought was considered the worst since European settlement. Starting in 1995 it continued to 2009. Water reservoirs reached historic low volumes.
- European drought (1976). Record breaking drought across Europe. Rainfall throughout the July–August period was down by half the annual average, due to an exceptionally persistent ``blocking'' high-pressure system. Future scenarios for the climate of the Netherlands issued by KNMI (KNMI'14) invariably point to increased drought risk.

Droughts will be selected according to well estabilshed drought indices such as the Standarized Precipitation Evapotranspiration Index (SPEI) and the self-calibrating Palmer Drought Severity Index (sc-PDSI). According to the region they may last a season (moderate climates) or multiple years (semi-arid regions). Once selected, daily values of associated meteorological will be stored in the data base to be used by the impact models.

Case 4: Pakistan flood (2010)

This flood occurred during the same period as the Russian 2010 heat wave. The position and structure of the jet stream that resulted in a high pressure system over Russia, causing the heat wave, simultaneously penetrated deep into the tropics resulting in heavy rainfall and extensive flooding in Pakistan. The case serves as a clear demonstration of how persistent, large-scale anomalous (circulation) conditions such as atmospheric blocking may lead to different types of extreme conditions in places that can be geographically remote. The total economic impact associated with the flooding may have been as much as US$43 billion (€35 billion).

Other cases of Fluvial flooding

- Danube floods of 2013. Extreme (river) flooding in central Europe began after several days of heavy rain in late May and early June 2013. Flooding and damages primarily affected southern and eastern German states, western regions of the Czech Republic and Austria. The flood crest progressed down the Elbe and Danube drainage basins and tributaries, leading to high water and flooding along their banks. The 2013 flood was comparable to the 2002 flood.
- Other European regions are known to irregularly meet with similar conditions. Mass evacuations in the Netherlands in 1995, for example, were triggered by possible dike breaches following exceptional rainfall over the Ardennes and in Germany, leading to dangerously high water levels in Rhine and Meuse. Future climate scenarios point not only to longer dry spells, but also to more intense rainfall *[13]*.

Fluvial floods occur on when the amount of aggregated water discharge in a limited time frame exceeds the storage capacity of rivers in the catchment areas of rivers. The selection of the events will be based on river discharge anomalies that are computed from meteorological parameters and hydrological models. The relevant hydro-meteorological variables, such as rainfall and river discharge will be stored in the data base.

Case 5: Thailand floods (2011)

Severe flooding occurred in the region during 2011. The flooding began at the end of July triggered by the landfall of Tropical storm Nock-Ten. It resulted in a total of 815 deaths, 13.6 million people affected and over 20,000 square kilometres of farmland was damaged. The World Bank has estimated US$46.5 billion in economic damages and losses. Most of this was due to the manufacturing industry (see above), as seven major industrial estates were inundated by water as much 3 meters deep during the floods. Disruptions to manufacturing supply chains affected regional automobile production, hardware availability and caused a global shortage of hard disk drives which lasted throughout 2012. The Thailand flooding was a good example of where a regional event had global consequences.

Case 6: Louisiana floods (2016)

In August 2016, prolonged rainfall in southern parts of Louisiana resulted in catastrophic flooding that submerged thousands of houses and businesses. Estimated economic losses were about $300 million. The majority of this impact arose from reduced yields (soybean, rice, crop, corn) along with lower quality that rendered crops unmarketable. An attribution study found that the probability of these kinds of extreme rainfall events has increased due to global warming (Van der Wiel et al. 2017).

Other cases of pluvial flooding

Thailand January 2017. The flooding in January 2017 was characterized by extreme and long lasting rainfall that caused severe damage. The Department of Disaster Prevention and Mitigation (DDPM) reported that around 1.8 million people have been affected. The flooding strongly impacted rubber production with an effect on the global market of that commodity. The car manufacturing industry was also heavily affected.

Pluvial flooding depends on the amount of precipitation in a restricted time frame and the local terrain conditions and infrastructure. Cases of pluvial flooding will be selected by combining meteorological variables and hydrodynamic models. Data to be stored in the data base are precipitation, and flood levels.

3.4.2 Basis for technical analysis of events

The events will be based on existing archives of model projections and will be complemented by performing additional model climate model runs by KNMI and BSC.

Important existing archives are CMIP5 *[4]* and the upcoming CMIP6 *[14]* data base. The latter will contain specific model simulations such as HighResMIP *[11]* using global high resolution (<50 km) models and the Decadal Climate Prediction Project (DCPP) *[16]* that generates decadal predictions. The first HighResMIP simulations will be produced by the H2020 PRIMAVERA (https://www.primavera-h2020.eu/) consortium and will be ready and post processed in autumn 2017. Both KNMI and BSC are part of PRIMAVERA and will be using the EC-Earth GCM for their climate simulations. BSC also participates in DCPP. In addition to these CMIP data sets, the archive consists of simulations done in the framework of European projects (e.g. SPECS http://www.specs-fp7.eu/) and simulations stored locally at the KNMI and BSC and made for a specific purpose such as a 16-member EC-Earth ensemble for the KNMI '14 (http://www.climatescenarios.nl) scenario's *[15]* . Two distinctive types of events will be selected: (1) those with a clearly identified local impact (that is, events that cause damage at specified locations), and (2) those that are characterized by sequences

of related events at different locations and/or moments that generate a potential impact by affecting a dependent chain of impact-sensitive processes (such as the production – storage – transportation – distribution chain of food). Examples of distributed events collocated in time are increased probabilities of crop failure due to droughts and/or excessive rainfall in several locations simultaneously, for instance imposed by a phenomena with global impacts like ENSO. The number of events to be selected should be flexible because it depends on the requests that emerge during the interaction with the end users and on the available time resources, but will be sample large enough to display enough variability in time and impact to demonstrate the added value of the CSTK product. We envisage a minimal number of 10-15 events distributed among the use cases.

In addition to the selection of events from existing archives of model projections dedicated model simulations will be carried out to generate additional specific events, considered desirable by the clients related to our project team. These simulations provide detailed snapshots, possibly in ensemble mode, covering only short periods and start from either observed states or from states of the archives. Depending on the event these additional simulations will be done with global (high-res) models and/or high-resolution regional climate models (RCMs) (see also Table 3). The design and analyses of these runs follow the 'Future Weather" methodology that provides tailored narratives for high-resolution simulations of high-impact weather in a future climate *[12]*. This methodology has been applied before by KNMI and BSC in earlier simulations and analyses *[10].*

3.5. Use case applications

The stress test events are primarily selected based on known or expected negative impacts. However, to show the added value and test adequacy of the developed event sets we are applying a number of use cases to assess their impacts on operations. For this we will use existing impact modelling tools that normally are being driven by currently available climate data sets such as reanalyses and climate model projections. In the CSTK approach the tools will be used to construct storylines on selected events, increasing the information value for their application in stress tests.

Figure 6 shows the workflow for a range of cases, making use of a selection of hydrological and hydrodynamic impact models, detailed below. The output of these impact models is transferred into impact indicators or performance metrics (see Figure 3), which form the input for various types of stress tests. The key impact indicators are defined below and will be computed for different use case types that will be further developed during the inception phase under task 1.3 (see paragraph 4.5). We envisage an *Agro-food, Manufacturing* and *water management* case (see Figure 6) and a *Critical infrastructure* case. At the base of all use cases will be data produced by the global modelling system PCR-GLOBWB *[18], [19]* (see also paragraph 3.5.1) that will produce a diverse set of hydrological variables such as evaporation and run-off. We also envisage that these variables will be added to the CSTK library.

The **Agro-food case** will be instrumental to tailor climatic events and execute stress tests for globally operating companies such as Nestle or Unilever with potentially vulnerable supply chains. For this use case the CSTK data on temperature, evaporation and precipitation directly into climate impact indicator computations. Examples of possible impact indicators are the percentage of agricultural area where water scarcity is expected, the unmet demand as a percentage of total demand, or the number of days with no rain.

The **Manufacturing case** will be instrumental for globally operating companies such as Kimberly Clark but also companies such as Anglian Water Service that rely on reliable availability of water in river basins. The computation of indicators for these use case requires additional modelling. With the help of a water balance approach and a heuristic water distribution algorithm the RIBASIM model computes a water distribution such that the available water (given by the output of CSTK as discharge

for the RIBASIM model boundaries) is allocated according to priorities by means of the available hydraulic structures (reservoirs, pumps, weirs, etc.). Climate impact indicators such as the number of days where the industrial water demand for the manufacturer is not met or the number of days during which waste water cannot be discharged (given by a threshold of minimum discharge) are derived from the RIBASIM results.

Water managers such as US Army Corps of Engineers are important intermediate organisations that support water users and manage their flood risks. In that sense they will always be an important stakeholder in stress testing water systems and therefore also a major potential user of the CSTK. For the **water management case** the relevant CSTK data is discharge at the model boundaries of a hydraulic model, but the case aims to map flood conditions. SOBEK computes the water level and discharge in a channel network. Possible corresponding climate impact indicators are the number of times the discharge or water level at specific locations exceeds a flood warning level. The SOBEK 2D floodplain module is able to compute the inundation extent, which can be translated into another climate impact indicator: the inundated area. Damage functions can be used to monetize flood impacts.

Managers of **critical infrastructure** such as railways, airports and hospitals need to guarantee high reliability and resilience with respect to climate variability and extreme (temperature, wind and flooding events. The use case on critical infrastructure will build upon the events selected in the other use cases and add data on missing variables such as wind. The impact indicators are very diverse and depending on the final specification of the use case. In general it can be related to the reliability of the service the particular infrastructure should deliver i.e. maximum down time, delay, #outages etc. This use case is likely to apply GIS analysis and simple local flood impact modelling.

The use cases will:

- show case how the CSTK climate events are of added value for stress testing by comparing with normally used downscaled projections and by discussing the outputs of the stress tests with the end users involved.
- and in this way be used for intermediate evaluation of the relevance of the data provided in order to apply improvements.
- be used to develop a protocol on how to use the CSTK events in combination with impact models.

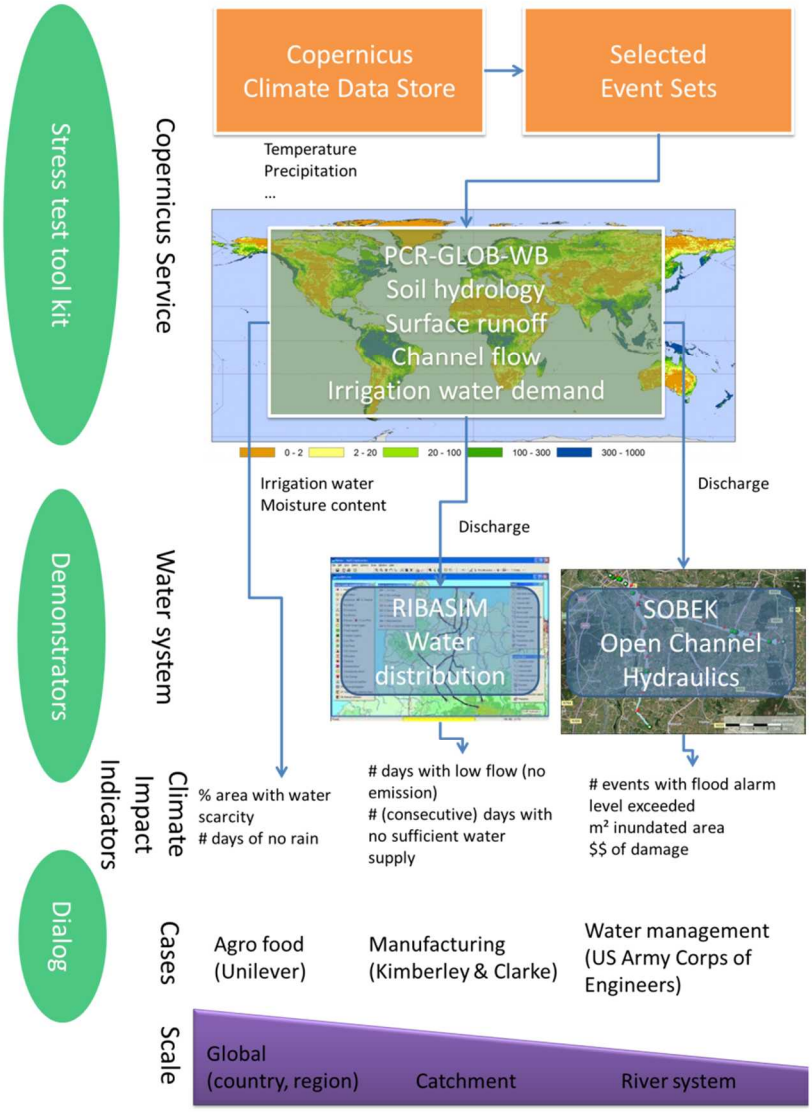


Figure 6: Workflow of the use cases using available hydrological impact models, applied for a sample selection of potential clients.

For all cases where additional models (like SOBEK and RIBASIM) are required we will use site-specific models that are already available. The selection of models will take place in collaboration with the client beneficiaries. Only minor changes like renaming of model objects and limited addition or changes in the water system network will be applied to the models. No development of new models will be carried out within this project.

3.5.1 PCR-GLOBWB

PCR-GLOBWB (PCRaster Global Water Balance) is a large-scale hydrological model intended for global to regional studies and developed at the Department of Physical Geography, Utrecht University (Netherlands). It already provides a basis for global climate services a.o. for the World Resources Institute's Aqueduct tool[2]. PCR-GLOBWB provides a grid-based representation of terrestrial hydrology

[2] http://www.wri.org/our-work/project/aqueduct

with a typical spatial resolution of less than 50×50 km (currently 0.5° globally) on a daily basis. Similar to other large-scale hydrological models, PCR-GLOBWB is essentially a leaky bucket type of model applied on a cell-by-cell basis. For each grid cell, PCR-GLOBWB uses process-based equations to compute moisture storage in two vertically stacked soil layers as well as the water exchange between the soil and the atmosphere and the underlying groundwater reservoir. Exchange to the atmosphere comprises precipitation, evapotranspiration and snow accumulation and melt, which are all modified by the presence of the canopy and snow cover. The exchange with the underlying groundwater reservoir comprises deep percolation and capillary rise and vertical fluxes are shown in Figure 7.

On the global scale, PCR-GLOBWB is used in flood risk studies *[20]*, seasonal prediction, to quantify the hydrological effects of climate variability and climate change change, to compare changes in terrestrial water storage with observed anomalies in the Earth's gravity field and to relate demand to water availability in the context of water scarcity.

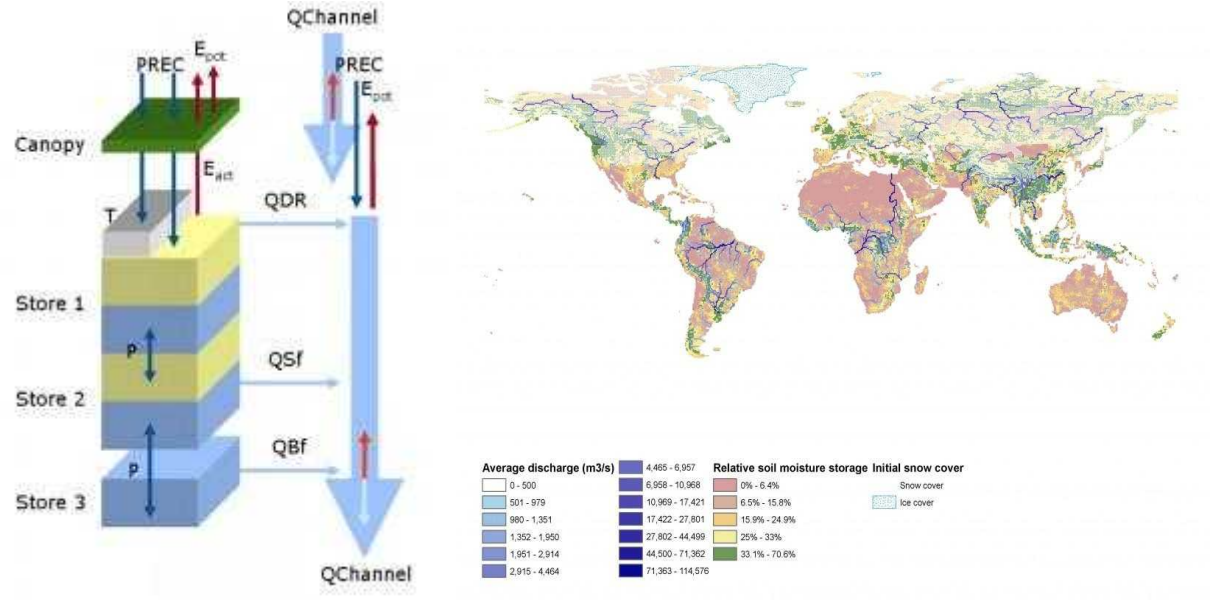


Figure 7: Model concept of PCR-GLOBWB. Left: layers describing the soil hydrology including the canopy, snow cover, soil layers 1 & 2 and the groundwater reservoir 3 as well as the exchange of moisture between them; right: specific runoff components and the direct gains/losses over the drainage network returning discharge along the channel when routed. Right: Composite image of river discharge, relative moisture content and winter snow cover

3.5.2 RIBASIM

RIBASIM (River Basin Simulation Model) is a generic model package for analyzing the water distribution in river basins under various hydrological conditions. The model package is a comprehensive and flexible tool which links the hydrological water inputs at various locations with the specific water-users in the basin. RIBASIM generates priority-based water distribution patterns with the help of a water balance model and an efficient water distribution algorithm. Because RIBASIM allows to specify various types of water usages like irrigation and drainage from agriculture, extractions for and discharges from industry, extractions for fresh water supply, hydropower, and the downstream re-use of water, a number of basin performance indicators are generated directly within RIBASIM. With such indicators a simulated event or scenario can quickly be evaluated.

It has a set of outstanding features which make it a state of the art river basin simulation package. RIBASIM is developed by Deltares (Delft, the Netherlands) and has been applied for more than 20

years in a large number of countries and in a wide variety of projects. Water management organizations world-wide use it to support their management and planning activities. Large and complex river basins have been modelled and simulated with RIBASIM.

3.5.3 SOBEK

SOBEK is a hydraulic modelling suite for flood forecasting, optimization of drainage systems, control of irrigation systems, sewer overflow design, river morphology, salt intrusion and surface water quality. SOBEK is developed by Deltares (Delft, the Netherlands). The modules within the SOBEK modelling suite simulate the complex flows and the water related processes in almost any system. The modules represent phenomena and physical processes in an accurate way in one-dimensional (1D) network systems and on two-dimensional (2D) horizontal grids Figure 8.

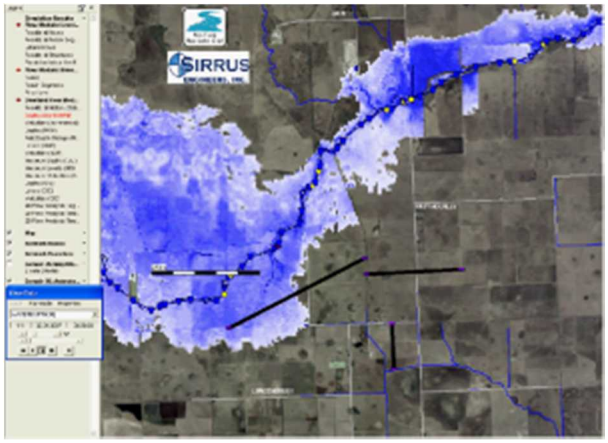


Figure 8: SOBEK 2D inundation model

Model output from RIBASIM and SOBEK is time-series based. The software packages RIBASIM and SOBEK come with own visualization features for time series. In order to present the data to the end users, results can be post processed for the Deltares Data Viewer.

3.6. Legacy of the CSTK

After completion of the CSTK, the portfolio of events can be updated by following the developed criteria for inclusion of events in the portfolio. After completion the CSTK is owned and managed by Copernicus/ECMWF. This updating and adding of events can be done by other organisations, by bringing out small tenders for updates to the dataset. A review panel could be composed of experts suggested by the project consortium, to oversee the future development of the CSTK portfolio.

The CSTK will be brought to the attention of and where possible made available to a broad group of network organizations and platforms such as EU Climate-Adapt, Alliance for Global Water Adaptation, World Meteorological organisation the World Business Council for Sustainable Development etc. (see also Task 3.4 in section 4.5).

3.7. Summary of the equipment

Table 3 Equipment (including hardware and software) to be used for provision of the Service

Equipment	Describe Relevant Function	List each work package for which equipment will be used	Owned / To be Purchased / To be Leased
Climate Model datasets (GCM and RCM)	Selection of existing cases	WP1, WP2	Owned
Climate Model code (GCM, RCM, LAM-CP)	Generation of new cases	WP1, WP2	Owned
EC-Earth decadal climate predictions	Estimation of current climate from large samples (multiple start dates and large ensembles) performed for CMIP5 and CMIP6	WP1, WP2	Owned
Future Weather runs	high-resolution prototype runs	WP1, WP2	Owned
Output available from PRIMAVERA project	high-resolution prototype runs	WP1, WP2	Owned
RACMO model output	regionally downscaled simulations hich have also been used in KNMI'14 scenarios and CORDEX	WP1, WP2	Owned
Harmonie simulations	resolving deep convection and intense precipitation	WP1, WP2	Owned
PCRGlobWB code	Water balance model, simulations of CIIs in use cases	WP1, WP2	Partially owned
RIBASIM /GLobalRIBASIM code	Water allocation model, simulations of CIIs in use cases	WP1, WP2	Owned
SOBEK code	Hydraulic model, simulations of CIIs in use cases	WP1, WP2	Owned

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4. Management and implementation plan

4.1. Introduction

The main objective of the proposed Copernicus Stress-test Tool Kit (CSTK) is to build a library of plausible extreme meteorological events (including meta-data) for stress testing. The set of events will be selected and tested in a collaborative dialogue and in use cases with the adopters (consultants) and end users of such stress tests. For more detail on the project outline see section 3 of this proposal.

This section D provides an overview of the team (Table 1), a detailed management and implementation plan and the pricing for total project broken down in work packages (WP) for the 18 month project. The detailed pricing information is given in the pricing tables. The technical content is outlined in the work package descriptions.

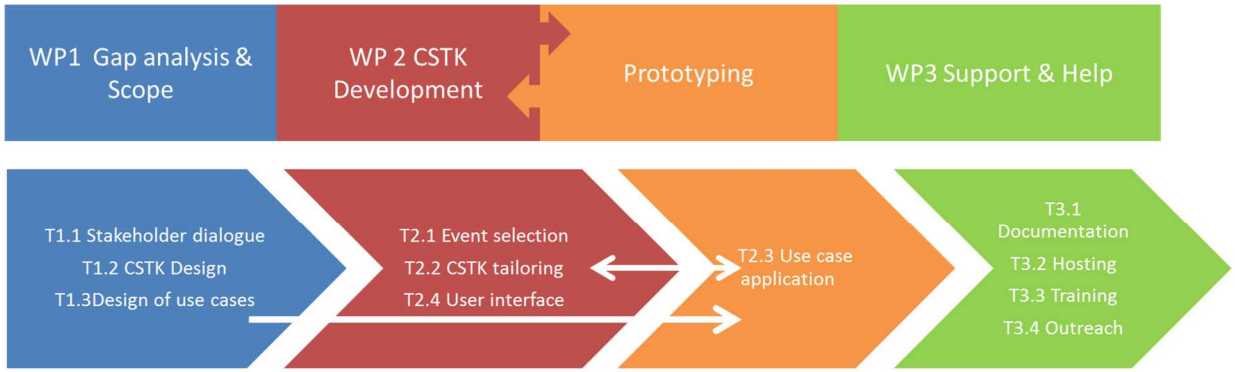

Figure 9 WP structure of the Copernicus Stress-test Tool Kit (CSTK).

4.2. Organigram

The project team exists of the following organisation as displayed in the organigram below.

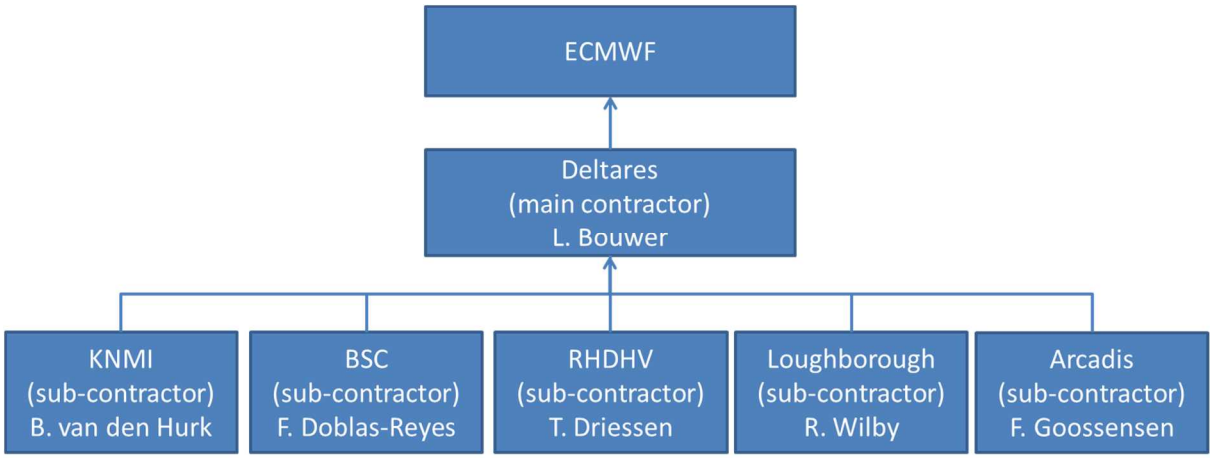

Figure 10 Organigram of the CSTK project.

For communications and progress reporting, monthly teleconferences with ECMWF are planned

for the 18 month duration of the project. In addition, monthly teleconferences with the entire consortium are planned. These are initiated by the main contractor (Deltares), and agenda and minutes will be supplied by the main contractor.

The list of main contractor, sub-contractors, their legal names and addresses is included, below in Table 4.

Table 4 Information on contractor and sub-contractor

Organisation	Contribution	Key personnel	Legal name	Address
Deltares	Coordination lead, development of CIIs	Laurens Bouwer, Ad Jeuken	Stichting Deltares	Boussinesqweg 1, 2629 HV, Delft
KNMI	Sub-contractor, development of ECVs and CIIs	Bart van den Hurk	Royal Netherlands Meteorological Institute	Utrechtseweg 297, 3731 GA, De Bilt
BSC	Sub-contractor, development of ECVs and CIIs	Francesco Doblas-Reyes	Barcelona Supercomputing Center - Centro Nacional de Supercomputación (BSC-CNS)	C/ Jordi Girona 31, 08034, Barcelona
RHDHV	Sub-contractor, end-user engagement	Hanneke Schuurmans, Tjeerd Driessen	HaskoningDHV Nederland BV	Laan 1914 35, 3800 BC, Amersfoort
Loughborough University	Sub-contractor, stress-test development	Robert Wilby	Loughborough University Enterprises Limited	Loughborough, Leicestershire LE11 3TU
Arcadis	Sub-contractor, end-user engagement	Jeroen Rijsdijk	Arcadis Nederland BV	Beaulieustraat 22, 6814 DV, Arnhem

4.3. Gantt chart and PERT chart

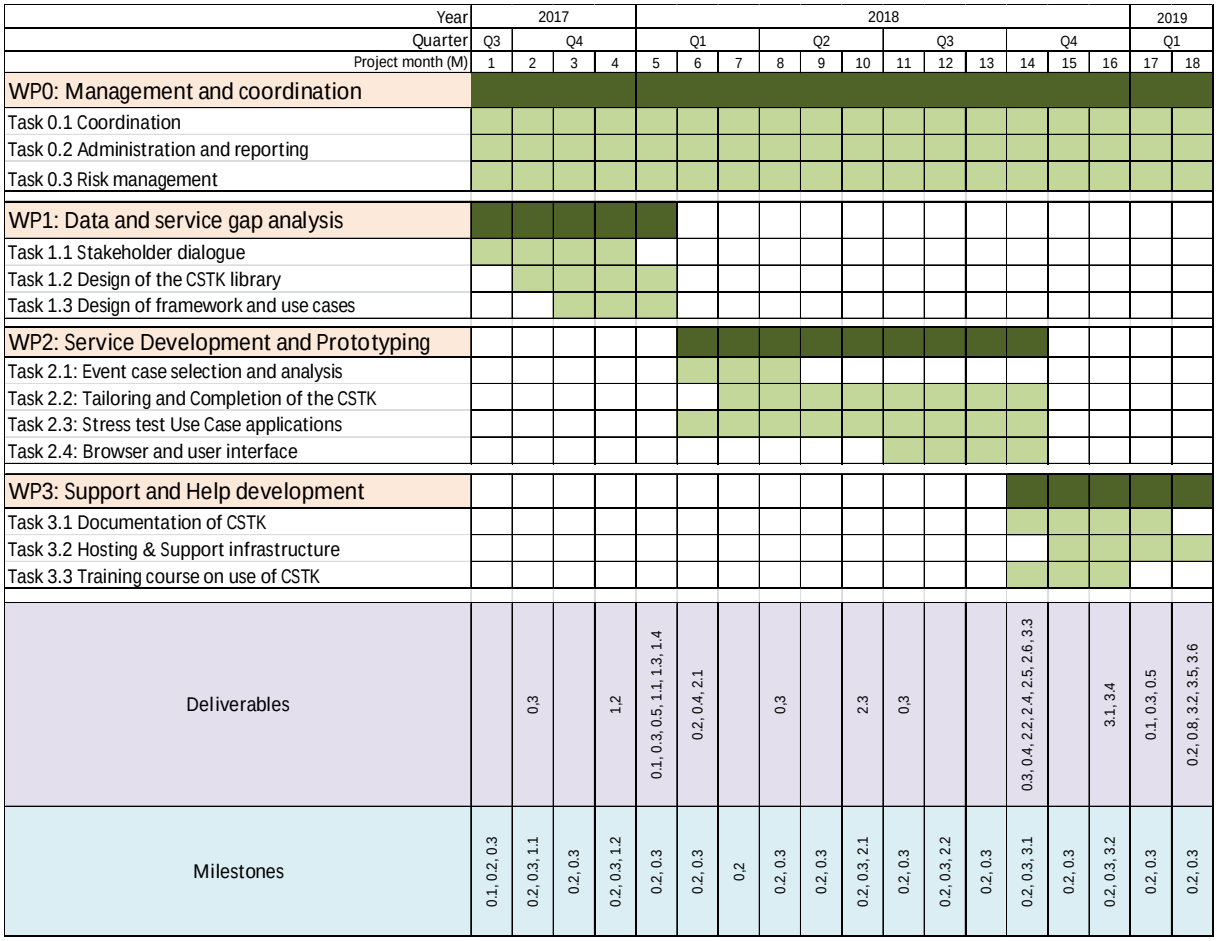

Figure 11 GANTT chart of the project deliverables

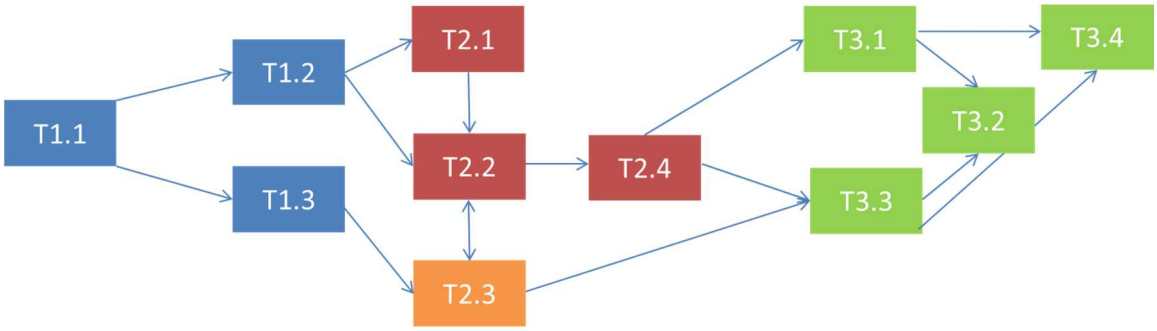

Figure 12 PERT chart visualizing the critical linkages and dependencies between the main tasks.

4.4. Summary of Work Packages and Deliverables

The project consists of WPs as depicted in Figure 9 WP structure of the Copernicus Stress-test Tool Kit (CSTK). and the deliverables are shown in the GANTT chart in Figure 11. A summary of the Work Packages and deliverables are presented in Table 5.

The project is managed by Deltares (WP0). WP1 will produce a clear view of the user requirement (both technical and scientific) regarding the service to develop and the use case to be executed. WP2 will develop and implement the data service, arrange its hosting and develop a simple user interface. WP3 will setup the structure needed to be able to run the service beyond the duration of this particular contract by writing a thorough manual, setting up a support infrastructure for Copernicus/ECMWF and by developing training material and a training course.

Table 5 Summary of Work packages and Deliverables

Work package	**Task**	**Deliverable**	**Effort in person months**
WP0 Management and coordination activities	T0.1 Coordination	D0.1 Preliminary financial information	0.5PM
	T0.2. Administration and reporting	D0.2 Annual implementation reports	1PM
	T0.3. Risk Management	D0.3 Quarterly implementation reports	1.5PM
		D0.4 Draft and final implementation plans	2PM
		D0.5 Letter from the auditors	
		D0.6 Final report	1.5PM
Total WP0 Effort			**6.5 PM**

WP1 Data gap analysis and definition of the scope	T1.1. Stakeholder consultation	D1.1: User requirements	4 PM
	T1.2. Design of Copernicus Stress test Tool Kit (CSTK)	D1.2: Event Selection and Construction Protocol (ESCP)	6 PM
		D1.3: CSTK infrastructural design	5 PM
	T1.3 Design of use cases	D1.4: Framework for use cases	5.4 PM
Total WP1 Effort			**20.40 PM**
WP2 Service development and prototyping	T2.1 Event selection and analysis	Final event selection	15PM
	T2.2 Tailoring and Completion of the CSTK	CSTK event library completed	23PM
	T2.3 Stress test Use Case applications	Intermediate evaluation of use cases	2PM
		Final case reports	26PM
		Stress test protocol	5.5PM
	T2.4 Browser and User interface	Browser and user interface	5PM
Total WP2 Effort			**76.5 PM**
WP3 Support and Help Development	T3.1. Documentation of CSTK	D3.1: Documentation of the CSTK	4.75PM
	T3.2 Hosting & Support infrastructure	D3.2: Support Infrastructure set up	3PM

	T3.3 Training course on use of stress tests and CSTK	D3.3: CSTK User Training material	8PM
		D3.4: CSTK User Training course	2PM
	T3.4 Outreach	D3.5: Final dissemination event	2PM
		D3.6: Peer reviewed paper on the CSTK	2PM
Total WP3 Effort			**21.75 PM**
TOTAL EFFORT			**125.15 PM**

Pricing

An overview of the total budget at the WP level is given in Table 6. The total price is € 1,967,455.92. More detailed financial information is given in the pricing tables.

Table 6 Project budget overview (in Euro's)

Organisation Name	WP0	WP1	WP2	WP3	Total
Deltares	187,003.01	78,621.85	450,195.83	1726,79.20	**888,499.89**
KNMI		38,648.40	268,650.55	11,075.40	**318,374.35**
BSC		26,350.00	226,680.00	17,850.00	**270,880.00**
RHDV		53,440.80	59,614.79	38,632.44	**151,688.04**
Loughborough University		55,400.50	39,584.70	91,011.92	**185,997.12**
Arcadis		47,931.55	74,107.93	29,977.04	**152,016.52**
TOTAL CONSORTIUM	**187,003.01**	**300,393.10**	**1,118,833.80**	**361,226.01**	**1,967,455.92**

4.5. Work package description

Table 7 Work package descriptions

Work package #	WP0	Start/End date	M1
Work package title	Management and coordination activities		
Participants (person months)	Deltares (6.5 PM)		
Other main direct cost elements	Travel (€ 10.000), audits (€ 15.000)		

Main objectives
This WP ensures the efficient and timely implementation of project activities, resource allocation and measures maximizing the benefits of the project. It will maintain links with ECMWF. It will enable internal communication and meetings, and facilitate partner collaboration; it will ensure quality assurance of the project. It will guard the progress and budget of the project, report on progress and implement the risk contingency plan (risk management).

Description of activities
Task 0.1. Coordination Consortium coordination, deliverable production and quality management, organization of meetings, both physical and meetings through monthly teleconferences. These include teleconferences with the client ECMWF, as well as consortium telecalls, and bi-lateral calls where needed. Task 0.2. Administration and reporting Administrative, legal, and financial coordination is included here. This includes progress reporting on milestones, deliverables and finances to ECMWF, as well as development and completion of quarterly, annual and final report, plus financial reporting and submission of invoices to ECMWF. Task 0.3. Risk management A risk management process and risk contingency plans will be implemented, based on the risks identified in this proposal, as well as any other issues arising during the execution of the contract. This is done via signalling in teleconferences and meetings of any issues related to content, process, deadlines and reporting. The responsibility of the main contractor is to act on any risks arising, and notify ECMWF where needed.

Deliverables				
#	*Responsible*	*Nature*	*Title*	*Due*

D0.1	Deltares	Report	Preliminary financial information	M5, M17
D0.2	Deltares	Report	Annual implementation reports	M6, M18
D0.3	Deltares	Report	Quarterly implementation reports	M2, M5, M8, M11, M14, M17
D0.4	Deltares	Report	Draft and final implementation plans	M6, M14
D0.5	Deltares	Report	Letter from the auditors	M5, M17
D0.6	Deltares	Report	Final report	M18

Milestones

#	*Responsible*	*Title*	*Means of verification*	*Due*
M0.1	Deltares	Kick off meeting with ECMWF	Minutes available	M1
M0.2	Deltares	Monthly Consortium progress meetings	Minutes available	Monthly
M0.3	Deltares	Monthly progress meeting with ECMWF	Minutes available	Monthly

Work package #	WP1	Start/End date	M1-M5
Work package title	Data gap analysis and definition of the scope		
Participants (person months)	Deltares (3.25 PM), KNMI (3.4 PM), BSC (3 PM), RHDHV (2.25 PM), Loughborough University (6.75 PM), Arcadis (1.75 PM)		
Other main direct cost elements	Travel (€ 17,000)		

Main objectives

The main objective of this work package is to facilitate a stakeholder dialogue to further develop criteria for the selection of events, establish the structural design of the CSTK service, and develop the stress test procedures for the use cases.

Description of activities

Task 1.1 Stakeholder dialogue *(RHDHV, Arcadis, LBU, Deltares) (M1-M4)*

RHDHV and Arcadis, as CS adopters, together with LBU and Deltares will set up a stakeholder dialogue with the companies that are expressed their support and interest in the service(inner circle companies) to be developed and in addition with other companies in their portfolio and that are introduced in section 1 of this proposal. These companies are considered to be potential end-users and will be consulted to provide input for climate event selection and to tailor the use cases in such a way that they are most useful. The stakeholder dialogue will be executed by means of a scoping workshop (parallel sessions according to the use cases defined in 3.5) with end users and complemented by individual (web) meetings with the inner circle companies and a needs assessment (survey) among a wider group of companies. The stakeholder dialogue will continue beyond the inception phase, in the execution and evaluation of the use cases (task 2.3).

Specific objectives:

- Assess state of the art and specific needs of end users with respect to climate stress testing. What are they using now, what do they need, what is missing?
- Definition of the impact indicators or performance metric and possibly performance thresholds (when does impact/performance become critical) for each use case.
- Definition of the essential climate variables (ECV) that could lead to critical performance and need to be present within the generated events in order to quantify this impact.
- Once these ECV's are known, it should be discussed what type of event(s) should be considered (e.g. short, extreme rainfall or longer dry period) and what sort of additional (meta-) information should be added. These variables are relevant for the Event Selection and Construction Protocol and determine the structure of the CSTK library that is discussed next.

Task 1.2. Design of Copernicus Stresstest Tool Kit (CSTK) library *(KNMI, BSC, Deltares) (M2-M5)*

The Copernicus Stress test Tool Kit (CSTK) will consist of a library of hydro-meteorological events that are potentially very disruptive for selected end users in the use cases.

Specific objectives:

- Establish a robust functional design of the CSTK library that can accommodate the requirements identified in task 1.1
- Design a set of criteria and guidance rules (protocol) for event selection and construction.

This Event Selection and Construction Protocol (ESCP) and the CSTK infrastructure are designed such that the

library can be extended with new events after the current project phase has finished. Each event in the library consists of a dataset of meteorological characteristics (ordered as time series of 2-dimensional fields) plus an extensive description of the background of the event, its relevance as input for stress testing a production chain, information on the statistical properties (including return time of key indicators and climatic trends) and the methodology to create the event. All events have in common that they reflect realistic meteorological conditions, including the spatial and temporal evolution of the relevant meteorological phenomena. They all can be considered to reflect representative high-impact future meteorological circumstances. They are generally constructed by using a combination of archived historical events and snapshots of meteorological model projections (see task 2.1).

The selection of constructed and to-be-supplied events is based on the criteria mentioned in paragraph 3.4. The ESCP that will be constructed in this project contains guidelines on the way candidate events can be evaluated against these criteria. It also contains accepted methodologies to generate events, and protocols to evaluate suitability, quality and statistical properties of the events.

Task 1.3. Design of stress test framework and use cases *(Deltares, RHDHV, Arcadis, LBU) (M3-M5)*

The CSTK not only consists of a library in which climate events are stored (see task 1.2), but will also be accompanied by a protocol that outlines the approach for executing stress test and the required steps to take. It is clear that the approach of a stress test varies for different impacts and for different end-users. For example, site-specific extreme rainfall events for airports may require a different approach for a stress test then for example a regional assessment of long duration droughts that could affect sourcing areas of consumer goods companies that have diverse supply chains. Due to difference in time, space, type of process and type of business the approach, therefore, differs.

Specific objectives:

- Design a framework needed to go from the generated events (output of task 2.2) to useful impact indicators to be used by the typical end-user. We envision that these steps include among others a methodology of the required impact models (see paragraph 3.5), the required simulations and data analysis, but also steps to relate the impact indicators (which are output of the impact model; e.g. water availability) to impact on typical business.
- After establishing the overall framework four use cases will be designed, on the basis of input and feedback from stakeholders consulted in Task 1.1. The design includes among others the selection event set input variables, as well as climate impact indicators, and the specific set-up of the required hydrological, water distribution, hydraulic and impact models.

Deliverables

#	*Responsible*	*Nature*	*Title*	*Due*
D1.1	RHDHV	Document	User requirements	M5
D1.2	BSC	Document	Event Selection and Construction Protocol (ESCP)	M4
D1.3	KNMI	Document	CSTK infrastructural design	M5
D1.4	Deltares	Document	Framework for use cases	M5

Milestones

#	*Responsible*	*Title*	*Means of verification*	*Due*
M1.1	RHDHV	Scoping workshop	Attendance	M2
M1.2	LBU	Needs assessment	questionnaire and survey protocol in place	M 4

Work package #	WP2	Start/End date	M6-M14
Work package title	Service development and prototyping		
Participants (person months)	Deltares (22.75 PM), KNMI (24 PM), BSC (19 PM), RHDHV (2.5 PM), Loughborough University (5.5 PM), Arcadis (2.75 PM)		
Other main direct cost elements	Travel (€ 19,000), Computing/storage (€ 79,780)		

Main objectives

This work package covers the majority of the work in this project. The main objective is to build the CSTK library and the CSTK protocol. Selected use cases will be instrumental to testing the applicability and relevance of the tool and library and to develop the stress test protocol. Lessons learnt from the use cases will be used to adjust and improve the CSTK service. Task 2.2 and 2.3 therefore are executed iteratively.

Description of activities

Task 2.1 Event selection and analysis *(KNMI, BSC, Deltares) M6-M9*

Specific objective:

- Using the selection criteria designed in task 1.2 as part of the ESCP from the existing portfolio of global and regional climate projection a number of events will be selected and further analysed to meet the functional demands set in WP1 and to serve as first building blocks of the CSTK library.

The selection of events will be based on existing archives of model projections (see paragraph 3.4.2 for details). The number of events to be selected should be flexible because it depends on the requests that emerge during the interaction with the end users and on the available time resources, but will be sample large enough to display enough variability in time and impact to demonstrate the added value of the CSTK product. We envisage a minimal number of 10-15 events distributed among the use cases.

Task 2.2 Tailoring and Completion of the CSTK *(BSC, KNMI, Deltares) M7-M14*

Specific objectives

- Further tailoring and complementing of the events selected under 2.1 by adding specific results from additional dedicated model runs.
- Adjustment based on experiences from the use cases and completion of the event description in the CSTK library with additional meta information

In addition to the selection of events from existing archives of model projections as described under 2.1 new dedicated model simulations will be carried out to generate additional specific events, considered desirable by the clients related to our project team. These simulations provide detailed snapshots covering only short periods and start from either observed states or from states of the archives (see paragraph 3.4.2 for more detail). In this task the CSTK content will also be further tailored based on experiences from the use cases (task 2.3) and completed with the necessary and desired meta information (e.g. on the historic events the set is based on and the procedure and models used to make the set).

Task 2.3 Stress test Use Case applications *(Deltares, RHDHV, Arcadis, LBU, KNMI) M6-M14*

Specific objectives:

- Apply stress test with the selected and processed events from 2.1 and 2.2 to use cases on Agro-food, Manufacturing, water management and critical infrastructure (see paragraph 3.5).

- Evaluate the value for decision making of the stress test application with the end users in the cases and propose improvements to event selection, generation and description (feedback to task 2.2)
- Further develop the stress test framework into a protocol based on the experience in the use cases
- Generate global data sets of key hydrological variables (see paragraph 3.5) associated with the CSTK events to support the use cases.

Based on the use cases design from Task 1.3, simulations using the hydrology, water distribution and hydro-dynamic models will be performed to stress the performance metrics in the use cases. The framework which was designed in Task 1.3 indicates the steps that need to be taken in this Task 2.3. The generated events (in Task 2.2) will be used as input to the impact models. Depending on the chosen approach these model simulations will provide insight in the impact of a certain historic event that was perturbed to future weather including climate change or it reveals vulnerability to an event that is newly created in the climate models. Per use case the impact indicator will be targeted to inform business operation and decision making for which the use case was set up. We foresee 3-5 use cases. For Agro- food (e.g. Nestlé) we focus on the impact of large-scale droughts and water availability on crop yields and their respective impact on the supply chains of these companies. For critical infrastructure operators (e.g. Schiphol Airport, Pro Rail) we focus on extreme events of short duration that impact the operation continuity. For manufacturing we focus on extreme persistent drought events that impact heavy water dependent production plants (such as Kimberly Clark) and drinking water supply companies (such as Anglian Water Services). For the water management case we focus on large scale flooding events that challenge risk and water managers (such as USACE, insurance companies) and impact communities and business in the flood plain. The use cases will be evaluated during their execution in a dedicated evaluation workshop (M2.2).

Task 2.4 Browser and user interface *(Deltares) M10-M14*

An user interface and viewer/simple browser will be developed for accessing the CSTK event set and use case application reports. The functional browser allows selecting for events based on an elementary query interface, where location, spatial/temporal extent and type of event can be used as search entry.

Deliverables

#	*Responsible*	*Nature*	*Title*	*Due*
D2.1	KNMI	Report with list of events	Final event selection	M6
D2.2	KNMI	Database	CSTK event library completed	M14
D2.3	Deltares	List of proposed improvements to CSTK	Intermediate evaluation of use cases	M10
D2.4	Arcadis	Reports per use case	Final case reports	M14
D2.5	Deltares	Guidance document	Stress test protocol	M14
D2.6	Deltares	Software	Browser and user interface	M14

Milestones

#	*Responsible*	*Title*	*Means of verification*	*Due*
M2.1	All	Prototype ready	Library of extreme events in place, case studies have been identified and prototype CSTK available	M10
M2.2	Arcadis	Use case workshop	Attendance	M12

Work package #	WP3	Start/End date	M14-M18
Work package title	Support and help development		
Participants (person months)	Deltares (7.25 PM), KNMI (1 PM), BSC (2 PM), RHDHV (1.5), Loughborough University (9 PM), Arcadis (1 PM)		
Other main direct cost elements	Travel (€ 11,000), Computing/storage (€ 30,000)		

Main objectives

The main objectives of this work package are to set up a support structure for the developed service and to initiate actions that will enable continuation of use and even expansion of the service beyond the circle of partners (developers, consultants and beneficiaries) and lifetime of the project.

Therefore, we will create a manual and set up hosting and support of the service with the Copernicus team. Training will be developed that invites a wider group of potential contributors and users of the service. Further outreach activities will be conducted such as writing a peer reviewed paper and linking the developed service to widely used user platforms.

Description of activities

Task 3.1. Documentation of CSTK *(KNMI, BSC) M15*

A manual will be written that describes the overall structure of the CSTK and the different functionalities: including how to select event data from the CSTK library and further process the data according to the CSTK protocol. A special section (dedicated to the support team) will be written on how to expand the data by applying the selection protocol, retrieving data from the CDS, adding extra information from other sources and applying quality control.

Task 3.2 Hosting & Support infrastructure *(Deltares, KNMI) M15-M18*

Together with Copernicus the support structure will be discussed and implemented. Main elements of this envisaged support are: arranging hosting of the library and user interface, setup of a helpdesk function, supported by the manual and specific software training and making further governance arrangements for continuation of the service beyond the lifetime of the project.

Task 3.3 Training course on use of stress tests and CSTK *(LBU, Deltares) M14-M16*

Training will be provided for two main groups: (a) users of the CSTK and (b) climate service providers. The elements of the USER training package mirror the four components in Figure 3(blue box):

(1) Understanding risk and vulnerability of the organisation;
(2) Building models of the vulnerable systems;
(3) Defining indicators of system resilience to climate shocks;
(4) Conducting the stress tests.

Climate service PROVIDERS will be instructed in elements (1) to (4), and on (5) principles for populating the library of extreme events (red box in Figure 3). This is to ensure that the custodians of the CSTK beyond the project will have the tools and knowledge to update/expand the library in a consistent and rigorous way.

User training will involve a mixture of taught primer sessions, hands on practical exercises, group work and discussion. Ideally, the training would be held within the partner organisations to embed the knowledge and tools. A mini-project would be assigned to each participant to be completed during or after the course with the support of an assigned mentor from the consultancy team. The mini-project is intended to develop capacities

in the use of the CSTK as well as to build knowledge of climate vulnerabilities within the partner businesses. Worked cases studies will be developed from task 2.3 for EACH partner organization. In this way , the content will be tailored to the unique circumstances of each partner. Case studies also provide a basis for independent learning and a library of resources that will outlive the project - i.e. legacy materials. A training needs assessment will be undertaken before developing the training materials. Training evaluation by participants would be used to improve content and materials at each successive iteration of the course.

Task 3.4 Outreach *(Deltares, Arcadis, RHDHV) M14-M18*

This task involves further activities to enhance uptake of the CSTK beyond the lifetime of the project. In addition to the hosting and support infrastructure and the training courses in this task we will further materialize the tool, its applications and its benefits in a peer reviewed publication and we will actively promote and link the CSTK across a number of networks and platforms such as EU Climate-Adapt, Alliance for Global Water Adaptation, World Meteorological organisation the World Business Council for Sustainable Development etc.

A 1-2 day workshop will be held at the end of the project so that all participants can 'show and tell' how the CSTK has changed their ways of working and contributed to economic benefits. Part of the event would be open to other organisations (not involved in the original project) to promote broader dissemination and uptake of the CSTK.

Deliverables

#	*Responsible*	*Nature*	*Title*	*Due*
D3.1	BSC	Report	Documentation of the CSTK	M16
D3.2	KNMI	Other	Hosting & Support Infrastructure	M18
D3.3	LBU	Other	CSTK Training Material Portfolios of worked case studies, test data, seminar slides, key readings and external links to tools/resources	M 14
D3.4	LBU	Other	CSTK User Training course 2 x training workshop 2 day duration (one for project beneficiaries/partners; the other for adopters/climate service providers)	M16
D3.5	Deltares	Other	Final dissemination event showcasing CSTK applications to a broader community	M 18
D3.6	Deltares	Other	Peer reviewed paper on the CSTK (draft)	M18

Milestones

#	*Responsible*	*Title*	*Means of verification*	*Due*
M3.1	LBU	Training workshops	Venues and participant lists for the two workshops are finalised; all training materials are prepared	M 14
M3.2	All	Closing workshop	Venue, guest speaker and participant list are in place; mini-case studies are completed	M 16

4.6. Key Performance Indicators

Table 8: Key Performance Indicators

KPI #	KPI Title	Performance Target and Unit of Measure	Frequency of Delivery	Explanations / Comments
1	Stakeholder workshop for use cases (M1.1)	Timing and participants	Month 2	Workshop is held on time, and with sufficient participation from external parties
2	Customers contributing to the design of the CTSK	Number of external institutions	Month 6	A number of external institutions will collaborate in the design of the CTSK by providing their feedback on the first guess made by the contractor
3	Prototype of extreme event library (M2.1)	Timing	Month 10	Prototype is ready
4	CSTK Database (2.2)	Timing and quality	Month 14	The database is delivered on time, and has undergone basic quality checks by the consortium
5	Browser and user interface (D2.6)	Timing and functioning	Month 14	The browser and user interface is delivered on time, and has undergone basic quality checks by the consortium
6	Participants in the second training course	Number of participants	Month 15	A number of adopters/climate service providers will participate in the second training course organised in WP3
7	Case studies for the development of the tool	Number of case studies	Month 15	As part of the CTSK portfolio, a number of case studies will be included in the database
8	Feedback from clients	Expressions about usefulness of case studies	Month 18	Feedback from clients to the consultancy firms about the stress test applications

4.7. Risk management

Table 9: Risk Register for each Work package

All Work packages					
Risk Name	Description	Likelihood	Impact	Response Strategy	Period
Project team	Problems related to project members and contracting	2	2	Avoid: Consortium Agreement will be drawn up at the beginning of the project	M1-18
Recruiting delayed	Recruiting of staff delayed at e.g. KNMI, BSC, Loughborough	3	3	KNMI, BSC, Loughborough foresee the need to hire staff.	M1-6
CDS products unavailable for assessment	Risk that the ECV and climate indicator products are unavailable	2	3	Accept: Inform ECMWF as part of monthly technical assessment report	M6-18
Budget	Budget shortage caused by more extensive data volume to be stored	3	4	Reduce: Consult ECMWF for moving data to CDS or acquire additional storage capacity either temporary of definitive	M6-18
WP1 too case specific events	Wrong balance between representativeness and specificity of events	3	2	Reduce by seeking compromise	M4-M6
WP2 Too narrow spatial and temporal limits of events	This reduces wider applicability	3	3	Reduce: Complement with corresponding downscaled global Climate or regional projections to have consistent large scale coverage	M4-M12
Too complex stress-test procedure for use cases	No availability of suitable models. Limited capacity at client	3	2	Avoid by simplifying or choosing different use case	M6-12
WP3 limited governanc	No natural continuation of service	2	3	Accept and reduce by increasing promotion and seeking new opportunities	M1-18

e structure					
Incompatible requirements between CSTK and CDS	Gaps in the daa sources of the CSTK	3	2	Need to consider alternative sources of data	M3-M6
Case studies identified in WP1 not familiar to the partners	Descriptions of the case studies will be needed by experts	2	2	Reduce; Additional experts from KNMI and BSC will be called in	M3-M6
Browser/ Viewer	Browser/ Webviewer not ready on time	2	2	Deltares has experienced web-developers that should be able to deliver in time; Reduce: If needed, Deltares will outsource the activity to a local consultant to be ready in time.	M12-18

4.8. Proposed payment plan

Payment	Sum	Milestone/deliverable	Month
First payment	€ 295,118.39 (15 %)	Contract completion	M1
Second payment	€ 590,236.78 (30 %)	D1.3 CSTK infrastructural design	M5
Third payment	€ 786,982.37 (40 %)	D3.4 Training materials	M15
Fourth and final payment	€ 295,118.39 (15 %)	D0.6 Final report	M18

4.9. Remarks on Model Framework Agreement

Clause 1.2 | Definitions and Interpretation
We suggest to include to the definition of "Technology", as defined in Clause 1.2 , the following: "(electronic) data". This because the current wording does not provide clear definition of data regarding IPR classifications and associated rights of ownership.

Data and specifically pre-existing data do not fall under the definitions of either 'Assets' (page 5) or 'Technology' (page 12) and therefore Pre-Existing Technology (page 10). It may fall under the definition of Deliverables, but as it is pre-existing it does not fit the definition.

Clause 1.2.1| Definitions and Interpretation
Here the "Good Industry Practice" is defined as:
" the degree of skill, diligence, prudence, efficiency, timeliness and foresight which would reasonably be expected from a skilled and experienced contractor of similar services seeking to comply with his contractual obligations and seeking to avoid any liability arising under any duty of care that might reasonably be contemplated by such a contractor"
English law provides that the consultants will have a duty to perform his services with 'reasonable skill, care and diligence', while the definition of Good Industry Practice places a much broader and bigger obligation. Thus, in the event of any failure, a higher risk is imposed on the consultant regarding his attributable liability, than is required by statutory definition.

We kindly request you to bring the definition in this clause in accordance with the statutory requirement.

Clause 3.3, and 3.4.3 | Pre-Existing Technology, and Integrated Technology
With respect to Clause 3.3 Pre-Existing Technology, and 3.4 Integrated Technology, Deltares can agree to supply (royalty-free) license rights to its software should such be necessary for the use by ECMWF of the Deliverables, however such licenses must be governed by our applicable license conditions.

Therefore please add the following wording at the end of Clause 3.3:

> *"However, to the extent that the Pre-Existing Technology required by ECMWF to render the Deliverables useable consists of software (either in the form of source or object code or executable versions), the license for the ECMWF on such software shall be governed by the applicable license conditions as determined by the Contractor, and not by the provisions contained in this Agreement"*

..and similar wording at the end of Clause 3.4.3:

> *"However, to the extent that the Integrated Technology required by ECMWF to render the Deliverables useable consists of software (either in the form of source or object code or executable versions), the license for the ECMWF on such software shall be governed by the applicable license conditions as determined by the Contractor, and not by the provisions contained in this Agreement"*

Further, we assume the ownership of any technology that is developed by Deltares during the term of the Agreement (including the Service Contract), independently from the Services provided under the Agreement, will not transfer to ECMWF, and not be classified as "Technology" under the Agreement.

Clause 5.5.1.1 | Termination
This clause gives ECMWF the right to immediately terminate the Agreement in the instances mentioned. However, we suggest an amendment to sub-clause vi:

> *" ..and Contractor's failure to comply with the obligations cannot still be remedied."*

Article 5.8.1 and 5.8.2 | Indemnities
i) 5.8.1: the indemnity stipulated is not in any way related or limited to losses caused by breaches or negligence by the Contractor. Furthermore, the further operation or use of the Deliverables is completely outside the control of the Contractor. It is impossible and unreasonable to expect that the Contractor can give such an indemnity. Therefore, please have Clause 5.8.1 deleted.

ii) 5.8.2:
- Deltares kindly requests that the liability in relation to 5.8.2.1 and 5.8.2.4 will be limited under Clause 5.9.3., which states the Contractor's total Aggregate Liability.
- We request to add a sentence at the end of Clause 5.8.2:

> *"The obligation for the Contractor to indemnify ECMWF under this clause shall not apply where ECMWF caused the breach or liable act referred to in 5.8.2.1. – 5.8.2.4. above, or shall be reduced proportionally to any contribution ECMWF made to the breach or liable act referred to in 5.8.2.1. – 5.8.2.4. above."*

Since the Contractor shall not be responsible for a breach or liable act, where caused or contributed to by ECMWF.

Clause 5.9.3 vs. 5.9.4, and 5.9.7 | Limits of Liability
i) 5.9.3 vs. 5.9.4: The difference in total aggregate liability of that of the Contractor and ECMWF is unreasonably off balance. While the contractor's liability shall not exceed two (2) times the Price agreed upon under the Service Contract, ECMWF's liability is a mere half the Price.
We request to get this in balance by bringing the liability of the Contractor down, and that of ECMWF up to one (1) time the agreed upon Price.

ii) 5.9.7: this clause stipulates the (broader) categories of "Direct Loss", yet the defined category only applies to ECMWF. Thus, we request to have this clause amended to mutual benefit of both parties.

4.10. Support letters

Support Letter Eneco

To: Dr. Laurens Bouwer
Deltares
PO Box 177
2600 MH Delft
The Netherlands

Subject: Letter of Support 'Stress-test Toolkit' proposal

Dear Dr. Bouwer,

We, Eneco Group, hereby express our support for the proposal titled "Stress-test Toolkit" submitted by Deltares and partners to the Copernicus Climate Change Service programme, implemented by ECMWF.

The topic of Climate Services, and in particular Stress-testing for multi-national businesses, is of great interest to us, as well as many other business in Europe and around the world. Our business spans five countries and over twenty locations world-wide.

Traditional approaches use single or multiple scenarios are insufficient, when considering the impacts of actual events in the past that have affected our business. The innovative approach proposed by this consortium, to simulate the effects of past events perturbed to a future climate, will help us to assess current and future vulnerabilities in a real-world setting.

When the project is granted, we are very interested to take an active part in the project, by participating in one of the case study applications of this Stress-test Tool Kit. We hope that by applying this stress-test, we are able to analyse our business vulnerability to extreme weather events, as well as projected climate change.

Therefore this service will be of direct value to our strategic decision making on future site location choices as well as production and business operations.

We hope this proposal will be favourably evaluated by ECMWF.

Sincerely,

Michel Kerkhof
Manager Strategic Partnerships

Support Letter AMC

To: Dr. Laurens Bouwer
Deltares
PO Box 177
2600 MH Delft
The Netherlands

Subject: Letter of Support 'Stress-test Toolkit' proposal

Dear Dr. Bouwer,

We, Academic Medical Center, hereby express our support for the proposal titled "Stress-test Toolkit" submitted by Deltares and partners to the Copernicus Climate Change Service programme, implemented by ECMWF.

The topic of Climate Services, and in particular Stress-testing for multi-national businesses, is of great interest to us, as well as many other business in Europe and around the world. Our business spans 1 country and 1 location world-wide.

Traditional approaches use single or multiple scenarios are insufficient, when considering the impacts of actual events in the past that have affected our business. The innovative approach proposed by this consortium, to simulate the effects of past events perturbed to a future climate, will help us to assess current and future vulnerabilities in a real-world setting.

When the project is granted, we are very interested to take an active part in the project, by participating in one of the case study applications of this Stress-test Tool Kit. We hope that by applying this stress-test, we are able to analyse our business vulnerability to extreme weather events, as well as projected climate change.

Therefore this service will be of direct value to our strategic decision making on future site location choices as well as production and business operations.

We hope this proposal will be favourably evaluated by ECMWF.

Sincerely,

Mattijs J. Maris
Manager bedrijfsvoering Arbodienst AMC
AMC

Support Letter Anglian Water Services

Anglian Water Services Limited
Thorpe Wood House
PETERBOROUGH
PE3 6WT

Tel: 01733 416624
Email: smoncaster@anglianwater.co.uk

Our ref SM_RW_20170227

Your ref N/a

Professor Rob Wilby
Department of Geography
University of Loughborough
Loughborough
Leicestershire
LE11 3TU

February 27 2017

Dear Rob

Support for Copernicus project

Further to our recent discussion, we are pleased to confirm that we are willing to support your work on the Copernicus Stress-test Tool Kit (CSTK) project.

We understand that the CSTK project will deliver a library of credible climate extremes, with well-defined return periods under present and projected conditions, as well as protocols for stress-testing the affected water resource systems.

Our involvement will include working with the project team to (a) identify the types of event that are significant for our supply system, and (b) develop metrics for describing business vulnerability and the effectiveness of planned interventions. We understand that the level of time-commitment is flexible but that over the next 18-months we will be required to attend at least two workshops and are likely to be needed to support the roll-out of the Tool Kit. We are happy to support this level of effort and wish you luck with your funding bid.

Please let me know if you have any queries

Yours sincerely

Steve Moncaster
Supply Demand Strategy Manager

Registered Office
Anglian House,
Ambury Road,
Huntingdon,
Cambridgeshire. PE29 3NZ
Registered in England
No. 2366656

an AWG Company

Support Letter US Army Corps of Engineers

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, INSTITUTE FOR WATER RESOURCES
7701 TELEGRAPH ROAD, CASEY BLDG.
ALEXANDRIA, VA 22315-3868

REPLY TO
ATTENTION OF

CEIWR-ZA

24 February 2017

Dr. Laurens Bouwer
Deltares
PO Box 177
2600 MH Delft
The Netherlands

Dear Dr. Bouwer:

I'm very pleased to confirm the Institue's support for the proposal titled "CSTK", as submitted by Deltares and its partners to the Copernicus Climate Change Service Programme, and implemented by the European Centre for Medium-Range Weather Forecasts (ECMWF) - an independent intergovernmental organization supported by 34 different countries.

The proposal's content is of great interest to the Institute, and in particular as it applies to "Stress-testing" for water resources management (WRM) systems. The timing of the proposal is also fortuitous, as the Institute for Water Resources is participating in an activity involving the development of strategies and tools for planning and executing domestic water resources planning and water management programs in the U.S. which would likewise benefit from the "CSTK" proposal, along with it having potential applicability in U.S. Government international water programs. Stress-testing procedures represent an important methological approach, particulalry in our utilization of the U.S. Army Corps of Engineers' (USACE) Hydrologic Engineering Center (HEC) sofware suite, with elements thereof also used by many other ministries and institutions around the world.

In particular, the Institute is participating in two studies where cooperation around "stress-testing" would have concrete opportunities for synergies with your proposal. The first is a pilot study funded by California Department of Water Resources (CA DWR) to apply bottom-up vulnerability / decision scaling principles that will require the use of data to stress-test the system in the Sacramento valley here in the U.S. The second is an initiative to build tools to allow the application of stress testing routines within our HEC software.

We recognize that uncertainties associated with changing conditions due to future population growth, migration, demographic and land-use shifts, climate, and other factors impacting water supply and demand signals are insufficiently captured by the tratitional forecasting approches, and that the use of a plausible set of scenarios which can help frame critical performance thresholds that identify failure points for WRM systems holds great promise in more effectively commnicating risk-based information to decision makers.

Therefore, it is our hope that the work accomplished from a successful proposal would not only directly benefit Deltares and its partners, but would also serve to enhance the continued cooperation between our respective organizations on the application of these techniques. More specifically, the library of stress event data could also be applied, tested, refined and evaluated in connection with the CA DWR pilot in Sacramento, and the tools we are developing would benefit from the capability to couple with the libraries and be tested using a much broader data inventory.

In closing, let me reiterate our interest in and support of Deltares' "CSTK" proposal, and based on its great potential value and broad applicability, it's our hope that this proposal will be favourably evaluated by ECMWF.

Sincerely,

R.A. Pietrowsky 24 Feb 2017

ROBERT A. PIETROWSKY
Director, U.S. Army Institute for Water Resources