**European ERA4CS Joint Call for Transnational Collaborative Research Projects 2016**
**Topic B - Researching and Advancing Climate Service Development by Institutional integration**

| **1. Project title** |
|---|
| **MEDiterranean Services Chain based On climate PrEdictions** |
| **2. Project acronym (max. 30 characters)** |
| **MEDSCOPE** |
| **3. Sub-topic(s)** |
| Development of new methods and tools; Localization of Climate Information and uncertainties Evaluation |
| **4. Duration** |
| 36 Months |
| **5. Publishable abstract (Maximum 2000 characters; includes spaces)** |
| The World Climate Research Programme coordinates international research efforts devoted to improving forecast capabilities at seasonal to decadal timescales. In the Mediterranean region, several initiatives (e.g. CLIMRUN, EUPORIAS) have developed methods and tools for creating prototypes of climate services addressing users' needs in specific sectors, whereas the purpose of the Mediterranean Climate Outlook Forum is to satisfy the high demand for user-oriented operational climate information. The MEDSCOPE project aims at advancing such initiatives by improving climate forecast capabilities and related services on seasonal-to-decadal timescales. The strategy will be based on exploiting the range of existing datasets of climate observations and forecasts to improve our understanding of sources and mechanisms of predictability. This will be complemented by targeted sensitivity experiments focusing on key drivers of Mediterranean climate variability. Improved process understanding will serve as a basis to develop innovative empirical forecasting systems as well as novel process-based methods for bias correction, downscaling and optimal combination of sources of information, all of which will be publicly released via a toolbox. Extracting and tailoring the best information to produce climate services will fill the existing gaps between climate model output and applicable services. Special efforts will be devoted to sensitivity of climate predictions to models' climate drift, to spatial shifts of variability patterns and to the selection of sub-ensembles representative of the needs of specific applications. The added value provided by MEDSCOPE to climate services will be assessed for various sectors with high societal impact, e.g. renewable energy, hydrology and agriculture and forestry. MEDSCOPE will deliver top-quality climate information, supported by cutting-edge research, tailored for climate services in the Mediterranean and will empower their use by the Mediterranean user community. |

| **6. Key words (at least 3 and up to 10)** |
|---|
| Climate predictions, forecast verification, knowledge gaps, sectoral applications, user satisfaction |

| **7. Principal investigators** - Leading Principal Investigator - | |
|---|---|
| *Family name* | GUALDI |
| *First name(s)* | Silvio |
| *Title* | Head of Climate Simulations and Predictions Division |

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|---|---|
| *Name of Organization / University / Research Institute* | Centro Euro-Mediterraneo sui Cambiamenti Climatici |
| *Short Name* | CMCC |
| *Country* | Italy |
| *Phone* | +39 051 4151217 - +39 3341155018 |
| *E-mail* | silvio.gualdi@ingv.it |
| *Personal Web site* | http://www.cmcc.it/people/gualdi-silvio |
| *Other personnel represented by the Leading Principal Investigator not detailed as Partner PIs (e.g. via a sub-contract, within the Lead Principal Investigators department / institution, etc.)* | |
| *Co-PI: Dr. Stefano Materia (7PM) will contribute to the investigation of the impacts of land surface – atmosphere interaction processes and teleconnection to predictability in the Mediterranean, he will coordinate the CMCC sensitivity experiments and the statistical downscaling activities.*<br>*Participants: Dr. Panos Athanasiadis (3PM) and Dr. Alessio Bellucci (3PM) will contribute to improving the understanding of the role of teleconnection on climate variability and its predictability in the target region. Mr. Savino Sasso (2PM) will provide technical assistance to the software development of the tools, whereas Dr. Monia Santini (6PM) and Dr. Valentina Bacciu (6 PM) will contribute to the application of the climate predictions to the agriculture and forestry sectors. Mr. Mauro Buonocore (6PM) will provide the expertise for the communication and dissemination tasks.* | |

| **7. Principal investigators** - Principal Investigator *1* - | |
|---|---|
| *Family name* | GUEMAS (18PM) |
| *First name(s)* | Virginie Martine Regine |
| *Title* | Head of the climate prediction group |
| *Name of Organization / University / Research Institute* | Barcelona Supercomputing Center (BSC)<br>Earth Science Department (ES) |
| *Short Name* | BSC |
| *Country* | Spain |
| *Phone* | +34 934 137 679 |
| *E-mail* | virginie.guemas@bsc.es |
| *Personal Web site* | http://www.cnrm-game-meteo.fr/spip.php?article772&lang=fr |
| *Other personnel represented by the Leading Principal Investigator not detailed as Partner PIs (e.g. via a sub-contract, within the Lead Principal Investigators department / institution, etc.)* | |
| *Co-PI : Javier Garcia-Serrano (32PM) will investigate sources and mechanisms of climate predictability, in particular from teleconnections, and contribute to the development of empirical forecasting system.*<br>*Participants : Albert Soret (24PM), head of the climate services group at BSC, will lead the application in the energy sectors and contribute to downscalling and communication/dissemination activities while Chloe Prodhomme (30PM) will contribute to develop novel methods for climate prediction calibration and verification.*<br>*Project managers : Mar Rodriguez (9PM) and Carine Saut (9PM) will be involved the project management and coordination.* | |

| **7. Principal investigators** - Principal Investigator *2* - |
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| *Family name* | CORTI (15 PM) |
| *First name(s)* | Susanna |
| *Title* | Coordinator of the Climate Dynamics and Variability Group at the Institute of Atmospheric Sciences and Climate (ISAC) |
| *Name of Organization / University / Research Institute* | National Research Council (CNR)<br>Institute of Atmospheric Science and Climate (ISAC) |
| *Short Name* | CNR |
| *Country* | Italy |
| *Phone* | +39 0516399603 |
| *E-mail* | s.corti@isac.cnr.it |
| *Personal Web site* | http://www.isac.cnr.it/en/users/susanna-corti |
| *Other personnel represented by the Leading Principal Investigator not detailed as Partner PIs (e.g. via a sub-contract, within the Lead Principal Investigators department / institution, etc.)* | |
| *Co-PI: Jost von Hardenberg (ISAC – 12 PM) will participate in WP2 (teleconnections), WP3 (verification) and WP4 (stochastic downscaling).*<br>*Participants: Silvia Terzago (ISAC – 15 PM) will participate in WP3 (verification) and WP4 (hydrological products); Luca Mortarini (ISAC – 10 PM) will participate in WP3 (verification) and WP4 (stochastic downscaling); Chiara Cagnazzo (ISAC – 4 PM) will participate in WP2 (investigating sources of predictability); Maurizio Fantini (ISAC – 16 PM) will investigate sources of predictability in WP2 and will participate in information synthesis (WP3); Marta Chiarle (IRPI – 14 PM) will work in WP4 (Hydrological cycle); Guido Nigrelli (IRPI – 14 PM): will work in WP4 (Hydrological cycle).* | |

| **7. Principal investigators** - Principal Investigator *3* - | |
|---|---|
| *Family name* | RODRIGUEZ-CAMINO (10 PM) |
| *First name(s)* | Ernesto |
| *Title* | Head of climate evaluation and modelling |
| *Name of Organization / University / Research Institute* | Agencia Estatal de Meteorología (AEMET) |
| *Short Name* | AEMET |
| *Country* | Spain |
| *Phone* | +34 658693465 |
| *E-mail* | erodriguezc@aemet.es |
| *Personal Web site* | |
| *Other personnel represented by the Leading Principal Investigator not detailed as Partner PIs (e.g. via a sub-contract, within the Lead Principal Investigators department / institution, etc.)* | |
| *Participants: Eroteida Sánchez (20 PM) will work on calibration, verification and ensemble member selection. José Voces (20 PM) will lead the application in the hydrology sector. Beatriz Navascués (5 PM) will work on the application in the energy sector. María J. Casado (15 PM) will work on the development of the empirical forecasting system.* | |

| **7. Principal investigators** - Principal Investigator *4* - | |
|---|---|
| *Family name* | BATTÉ |
| *First name(s)* | Lauriane Alice Madeleine |
| *Title* | Dr |
| *Name of Organization / University / Research Institute* | Météo-France |
| *Short Name* | MF |
| *Country* | France |
| *Phone* | +33 5 61 07 96 80 |
| *E-mail* | lauriane.batte@meteo.fr |
| *Personal Web site* | http://www.cnrm-game-meteo.fr/spip.php?article41 |
| *Other personnel represented by the Leading Principal Investigator not detailed as Partner PIs (e.g. via a sub-contract, within the Lead Principal Investigators department / institution, etc.)* | |
| *PI: Lauriane Batté (12 PM) will investigate sources of predictability at the seasonal time scale and contribute to methods for climate verification.*<br>*Co-PI: Jean-Michel Soubeyroux (3PM) is deputy scientific director at DCSC. He will coordinate work on applications in hydrology and agriculture.*<br>*Participants:*<br>*Constantin Ardilouze (7 PM) is a research engineer focused on the influence of land surface on seasonal predictability. Michel Déqué (3 PM) is head of the seasonal prediction team at CNRM. Together with Jean-François Guérémy (3 PM), they will contribute their experience in climate prediction verification and downscaling. Pierre Etchevers (2PM) and Christian Viel (4 PM) work on operational seasonal forecasting and provision of hydrological climate services and will contribute to WP4. Mathieu Regimbeau (1 PM) is an engineer expert in forest fire indices.* | |

| **7. Principal investigators** - Principal Investigator *5* - | |
|---|---|
| *Family name* | BERTUZZI (6PM) |
| *First name(s)* | Patrick |
| *Title* | Mr. |
| *Name of Organization / University / Research Institute* | Institut National de la Recherche Agronomique |
| *Short Name* | INRA |
| *Country* | France |
| *Phone* | +33 4 32 72 22 25 |
| *E-mail* | patrick.bertuzzi@paca.inra.fr |
| *Personal Web site* | |
| *Other personnel represented by the Leading Principal Investigator not detailed as Partner PIs (e.g. via a sub-contract, within the Lead Principal Investigators department / institution, etc.)* | |

*Indicator Design:* *Iñaki Garcia de Cortazar(3PM), Marie Launay (3PM) are Research Engineers and will be in charge of the of Agroclimatic indicators. André Chanzy(3PM), Marta Debolini(3PM), Dominique Courault (3PM) are scientists working on agricultural production and water resources availability for irrigation. Hendrik Davi (3PM), Nicolas Martin(5PM) are scientist working on forest production and vulnerability to drought , whereas Jean-Luc Dupuy(5PM), François Pimont (4PM) and Eric Rigolot (2PM) will work on climatic indicators on Forest vulnerability to fire. All, together with technical staff and Olivier Marloie (Engineer 3PM) will participate to field observations to assess the indicator relevance. A postdoc (24 PM) will be recruited for the indicator implementation, interpretation and evaluation.*
*Workflows will be implemented to chain the different steps of data processing from the use of WP3 tools to produce the climatic layer of information to the mapping of the final indicator. André Chanzy, Patrick Bertuzzi and Jean-Luc Dupuy will be involved together with computer engineer David Delannoy (3PM), Patrice Lecharpentier(2PM), Olivier Maury(3PM), Dominique Ripoche (2PM), Philippe Clastre(5PM). They will adapt and configure existing modelling tools. An Engineer (18PM) will be recruited to develop the workflows.*

| **7. Principal investigators** - Principal Investigator *6* - | |
|---|---|
| *Family name* | VANNITSEM |
| *First name(s)* | Stéphane |
| *Title* | Dr |
| *Name of Organization / University / Research Institute* | Royal Meteorological Institute |
| *Short Name* | RMI |
| *Country* | Belgium |
| *Phone* | +32 2 3730552 |
| *E-mail* | svn@meteo.be |
| *Personal Web site* | http://climdyn.meteo.be |

*Other personnel represented by the Leading Principal Investigator not detailed as Partner PIs (e.g. via a sub-contract, within the Lead Principal Investigators department / institution, etc.)*

*Participants of RMI*
*Permanent personnel at RMI: Emmanuel Roulin*
*Non-permanent personnel at RMI : Bert Van Schaeybroeck*
*Dr Roulin is expert in hydrological modelling and probabilistic forecasts for hydrological purposes. He will mainly contribute to the development of hydrological products (together with post-processing) of WP4, Task 4.2, with 8 PM. He will also contribute to WP4, Task 4.4 with 0.5 PM and to WP1 with 0.5 PM. So overall for 9PM.*
*Dr Stéphane Vannitsem (PI) is specialized in the use of nonlinear sciences in atmospheric and climate modelling, and in particular in post-processing methods for forecasting and downscaling purposes. He will contribute for 0.5PM in WP1, 0.5PM for WP4. He will contribute by the development of bias correction techniques in WP3, Task 3.1 with 4 PM, on the statistical downscaling with 2 PM and on forecast combination with 2 PM. Overall the contribution will be 9 PM.*
*Dr Bert Van Schaeybroeck is specialized in techniques for post-processing and downscaling. He is also involved in the development of climate projections for Belgium. He will contribute for 2 PM in Task 3.1 of WP 3 on the use of bias correction and calibration techniques, 1.5 PM on stochastic downscaling, and 4 PM on forecast combination and selection techniques. He will also contribute for the communication of the products for 0.5 PM? So overall 8 PM.*

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| **7. Principal investigators** - Principal Investigator *7* - | |
|---|---|
| *Family name* | LAFITTE |
| *First name(s)* | antoine |
| *Title* | Programme officer |
| *Name of Organization / University / Research Institute* | Plan Bleu - Regional activity center of UNEP/MAP |
| *Short Name* | PlanBleu |
| *Country* | France |
| *Phone* | +33 (0)7 86 38 17 20 |
| *E-mail* | alafitte@planbleu.org |
| *Personal Web site* | https://www.linkedin.com/in/antoinelafitte?trk=hp-identity-photo |
| *Other personnel represented by the Leading Principal Investigator not detailed as Partner PIs (e.g. via a sub-contract, within the Lead Principal Investigators department / institution, etc.)* | |
| *Antoine Lafitte is in charge of integrated coastal zone management and climate change impacts. He will dedicate 3PM during the lifetime of the project regarding communication and dissemination activities within Task 4.4* | |

## 8. Executive Summary (Maximum 2 pages)

Skilful climate forecasts on seasonal-to-decadal timescales can have large socio-economic benefits. Seasonal predictions have therefore been performed operationally at centres around the world for more than 40 years. The skill of these predictions derives primarily from tropical phenomena such as the El Niño Southern Oscillation (ENSO), whereas predictability and forecast quality is currently relatively lower over Europe and the Mediterranean region (e.g. Weisheimer et al., 2011; Doblas-Reyes et al. 2013). There is also growing evidence that skilful climate prediction on multiannual (decadal) timescales may be possible, but while recent studies provide encouraging results, much work remains to be done to understand the potential predictability on these longer timescales (Meehl et al., 2014). In general, our limited understanding of the mechanisms and processes responsible for predictability and model systematic errors limit our capability to simulate and predict seasonal-to-decadal climate variability, especially over the Euro–Mediterranean area. Improved global climate model calibration and regionalization techniques as well as better forecast verification methods need to be developed for this region to extract as much climate information as possible from existing forecast systems. **This is the primary and underpinning goal of MEDSCOPE,** from which other user-oriented goals are derived and enabled, such as authoritative tailored climate information, tools for the creation of such information for a wider audience, and examples of the application of the tools in selected sectoral case studies of service development and demonstration of value.

**MEDSCOPE** is a three-year project that will enhance the exploitation of climate predictions from **seasonal to decadal timescales**, maximising the potential of their **application in different economic sectors**, public and private, of relevance for the **Mediterranean region**, here defined as the domain encompassing the Mediterranean basin and the surrounding areas, including North Africa and the Middle East.

MEDSCOPE will mainly focus on the seasonal timescale as a wealth of forecasts (including retrospective forecasts) is already available and, in general, the state-of-the-art of both scientific knowledge and applications are more mature for this case. However, the project will also provide an assessment of the predictability at longer (multiannual) timescales, an evaluation of the available decadal predictions and of their possible application in the region of interest.

The overall outcome of MEDSCOPE will be a set of **tools and methods aimed at improving the production of climate services based on climate forecasts**, enhancing the capability of public and private users and stakeholders to develop and implement strategies of adaptation to climate variability and climate change. Such tools will essentially be based on further development and refining of existing techniques and procedures, such as model output calibration (to tackle problems of systematic model errors), regionalisation (to enhance model resolution and therefore capability of representing small spatial scales) and mixed statistical-dynamical post-processing techniques (to address problems of specific sectoral applications intractable by standard prediction methods).

These ambitious results cannot be achieved without relying on the basis of an **improved understanding of climate predictability** mechanisms and processes in the target region. Improved process understanding is one example where pooling of expertise across the consortium institutions can be expected to deliver the best outcome and contribute to their integration. Furthermore, the consortium represents an opportunity of integration across climate sciences, sectoral applications and users, advancing climate services in the Mediterranean. In pursuing such goals, MEDSCOPE will therefore act as a community builder, giving rise to a powerful **network of expertise**, creation of which would be beyond the capability of the single institutions. The project will seek integration between scientists and users, including the private sector, through **co-design** and **co-construction** of the above common and shared methodologies, techniques, procedures and, ultimately, tools.

The main specific objectives of MEDSCOPE are to:

- **Improve our comprehension of the mechanisms driving the climate variability in the Mediterranean region, and especially those at the basis of the tropical and extratropical as well**

**as polar and mid-latitudes teleconnections, and their impact on the predictability at different time scales (seasonal-to-decadal)**. A thorough evaluation of the state-of-the-art climate forecast systems and of the most recent and comprehensive observational databases will provide information on the main sources of predictability for surface climate variables over the Mediterranean and how these are captured by models. **Sensitivity studies** with improved or idealized representations of boundary components (land surface, tropical oceans) in participating GCMs, will help to assess key processes, including teleconnections, in climate predictability over the target region. The process-understanding analysis will underpin the development of advanced forecast post-processing methodologies, i.e. calibration, regionalisation, automatic and objective selection… Another fundamental goal will be the development of empirical forecast systems based on the analyses of the predictability sources and tailored for specific applications.

- **Provide a set of generalized methods and ready-to-use tools for forecast verification and comprehensive skill assessments – including those for user-oriented applications – for downscaling, calibration and bias adjustment of the forecasts, and develop methodologies of optimal forecast combination to provide a single source of information.** Such tools will be freely available and addressed to practical users from both public and private sectors. The project will refine state-of-the-art methodologies to extract relevant information from dynamical climate prediction systems and assess their robustness and uncertainty. This includes correcting for model systematic errors on the basis of process-understanding, extracting reliable model information for user-relevant variables at user-relevant scales, extensively comparing different sources of climate information from both dynamical and empirical prediction systems and combining and synthesizing these sources of climate information into a reduced set suitable forecasts for applications.
- **Provide prototypes of climate services products based on end-user tailored climate forecasts at seasonal and multi-annual timescales, in relevant economic sectors for the Mediterranean, such as wind energy, water management (hydrology), and agriculture and forestry (and fire risk).** In particular, forecasts of variables and indicators relevant to the considered sectors will be provided by applying the tools and the methods (downscaling, calibration, bias correction, forecast combination) developed in the project. The design of such climate service prototypes will benefit from previous projects results such as EUPORIAS, MOSES, CLIM-RUN, etc. During MEDSCOPE, users' satisfaction and feedback will be evaluated to ensure that the prototypes meet the community needs (primarily MedCOF), building upon the partners' experience on social science applied to climate services (e.g. FP7 EUPORIAS, and Copernicus-EU SECTEUR and QA4Seas).

Evidence from past and current use of seasonal climate forecasts suggests that co-creation of knowledge in an iterative cycle between climate forecast providers, scientists in applied sectors and users is critical to the successful production of actionable science and usable climate services (e.g., Dilling and Lemos, 2011). The benefit of skilful climate forecasts will certainly depend on their performance, but not necessarily in a direct or even linear way. Stakeholders, scientists in applied sectors and climate modellers may give different climate variables different importance and may have different expectations. In addition, different users often have largely different capabilities of extracting useful information from forecasts of different skill. A key outcome of MEDSCOPE is to interact with final users in order to tailor climate forecasts and services to their needs, including quantifying skill and reliability to better meet stakeholder expectations. A dialogue will be initiated among forecast providers, users and stakeholders to identify key variables and level of user-dependent usable skill, facilitated through a limited set of demonstration cases. The interaction with users and stakeholders will be further favoured by the direct involvement of the partners of MEDSCOPE in the WMO-endorsed initiative MedCOF (Mediterranean Outlook Forum, including the associated SEECOF and PRESANORD). The strong and well-established link that the MedCOF has with a number of users and stakeholders operating in the Mediterranean region will guarantee a continuous and systematic co-creating dialogue between these potential users and the project.

## 9. Project description (Maximum 11 pages)

### 9.1 State-of-the-art

The target of producing trustworthy weather forecasts has driven the development of atmospheric sciences in the past century and created a paradigm that has steadily expanded to other sciences and fields, from oceanography to ecosystems, from space weather to financial markets. Over more than 60 years from the first meteorological numerical forecasts, progress in numerical weather prediction has allowed to widen the number and type of variables predicted, the range of predictions and the type of users and sectors involved (Lynch, 2008). Accuracy, reliability and scope of the forecasts have been steadily increasing. Society has reaped endless economic, social and human benefits.

However, extending this paradigm beyond the medium range is posing significant challenges related to limits set by deterministic weather predictability. Seasonal forecasts have been the object of extensive efforts over the last 40 years. More recently, initiatives in North America, Japan and also in Europe have defined some specific strategies and approaches (e.g., DEMETER, ENSEMBLES, MERSEA, CLIMAFRICA, SPECS) and have tried to analyse predictability even beyond the seasonal scale, from one season to several years (e.g., ENSEMBLES, THOR, COMBINE, SPECS, NACLIM). Multi-year predictions are considered as a combined initial conditions and boundary-value problem (e.g. Meehl et al. 2014) and, for the first time, their potential has been assessed by the International Panel for Climate Change in its Fifth Report (IPCC, 2013) and their reliability has been evaluated in several studies (e.g. Corti et al. 2012). The Mediterranean, in addition to be an extremely populated area, is one of the most responsive and vulnerable areas to climate change and variability (Giorgi, 2006; Xoplaki et al., 2012). Understanding and possibly predicting climate variability here has therefore huge societal implications. Nonetheless, so far very little has been done in order to fully explore the potential of climate predictions and related applications on seasonal to decadal timescales in the Mediterranean.

It is well known that seasonal predictions in the mid-latitudes suffer from relatively low skill and that this generally holds also for the Mediterranean. However, recent work has demonstrated that state-of-the-art seasonal prediction systems (SPSs) show remarkable skill in predicting the inter-annual variability of the NAO (e.g., Scaife et al., 2014; Athanasiadis et al., 2014), which, in turn, is known to have some influence on the climate of the Mediterranean. Similarly, there is evidence that relatively well-predictable tropical phenomena, such as ENSO, might have some impact on the Mediterranean (Shaman, 2014; Manzanas et al., 2014), adding to regional climate predictability. All these results suggest that improvements of the current climate prediction skill for the Mediterranean are possible, by improving, first of all, our understanding of those physical processes involved in predictability and then by improving the simulation and prediction of both remote (via atmospheric teleconnections) and local predictability mechanisms and processes, which have influence on the near-surface climate of the region. Furthermore, until recently, most efforts have almost exclusively concentrated on improving modelling techniques, while relatively less attention has been paid to the exploitation of forecast products. More recently, however, the importance of maximising societal benefits of climate predictions (and more generally of climate-related information), working in closer relation with stakeholders and final users, has been recognised. A number of projects and initiatives aimed at developing and improving end-to-end climate predictions and services, showing how climate information can become directly usable by decision makers in different sectors have been launched (e.g. EUPORIAS). Besides, projects such as CLIM-RUN have developed methodologies and tools for creating prototypes of climate services addressing the needs of users of specific sectors. While many (if not most) of the countries in Central and Northern Europe have already in place well developed climate services networks, no such network is available for the entire Mediterranean region.

At the moment, MedCOF (http://medcof.aemet.es) – along with SEECOF and PRESANORD – represents a unique initiative at the regional scale that has highlighted the strong demand for climate information by users and the need for improved services. Even if MedCOF includes a large number of contributors and potential users, its consensus forecast relies on a relatively limited set of information sources and tools,

based on dynamical, statistical and empirical systems.

### 9.1.1 Beyond the State-of-the-art

**MEDSCOPE** will be a **3-year project** aimed at developing and distributing a **toolbox** designed and built to **improve the quality of climate forecasts** in the Mediterranean region on **seasonal to multi–annual scales**, along with a number of **examples of sectoral applications** of relevance for the region. The improved climate prediction information will be achieved both via a better understanding of the Mediterranean climate variability and predictability and on the development of innovative methodologies to extract the information from climate predictions.

Recognising that the wealth of existing climate knowledge and climate forecasts is only partially exploited by users in the Mediterranean area, we will start from the extensive databases of seasonal and decadal predictions already made available from on-going projects and operational programmes (e.g. EUROSIP, APEC, North-American Multi-Model Ensembles, and possibly Copernicus Climate Change Services Seasonal Forecasting System and CMIP6-DCPP, when they will become available). Large multi-model ensembles of predictions will be built from such extensive databases and selected sub-ensembles will be extracted so as to be as representative as possible of the full ensemble, but at the same time, reduced to a reasonable size amenable to be used in sectoral applications..

To reduce the barriers and the gaps that have so far prevented exploiting to the full predictions in the Mediterranean, we will perform a systematic effort of downscaling, bias correction and information synthesis, in order to produce and make available high-quality forecasts that can successfully be used to improve decision making processes. Some of the barriers, on the other hand, are related to the insufficient understanding of key physical processes at the basis of predictability. We know that predictable ocean signals exist, but making them usable is hindered by insufficient understanding of crucial phenomena, e.g. teleconnections (Goddard et al., 2001; Stockdale et al., 2006; Hurrell et al.; 2006) or local processes, such as those related to land-atmosphere interaction (Douville, 2010; Prodhomme et al., 2015).

Advanced process study and understanding is also essential to drive the development of novel empirical prediction systems that will constitute useful benchmarks for dynamical forecast systems. The combination of these two approaches will contribute to the efficient calibration of dynamical forecasts and to the production of more trustworthy predictions, which is one of the main aims of MEDSCOPE.

Building on recent or ongoing climate prediction modelling projects and initiatives (e.g. DEMETER, ENSEMBLES, EUROSIP, SPECS), a crucial need is evident for a coordinated European effort pursuing an optimal exploitation of seasonal-to-decadal predictions based on a multi-model ensemble approach. MEDSCOPE aims at contributing to this effort by combining various European skills and capitalizing on previous efforts, to generate cutting-edge research aimed at improving climate information quality.

The knowledge to be gained in MEDSCOPE will be central to the development of Climate Services and to establishing stable, reliable, usable products specifically thought and designed for the Mediterranean region. To this purpose, MEDSCOPE will address a number of crucial questions:

1. What are the key phenomena/processes driving climate predictability over the Mediterranean region? What are the relative contributions from local and remote sources of predictability?
2. How can a better understanding of processes leading to predictability be exploited to generate advanced empirical forecast system as well as more suitable bias correction, combination and downscaling techniques?
3. What is the maximum level of climate prediction skill that can be reached through optimized post-processing methodologies to extract useful information?
4. Which indicators are relevant and what is the benefit that can be demonstrated for applications in the energy, agriculture and forestry, and water sectors?
5. How can knowledge on the best use tools be shared within the user community so that up-take can move beyond case studies and examples?

### 9.2 Research plan

The idea at the basis of MEDSCOPE is that developing and making available innovative tools to better extract climate information from existing climate prediction systems might improve climate services in

the Mediterranean region. The development of such tools and their use in sectoral applications require an improved understanding of the mechanisms of climate predictability in the region, as well as the cooperation and integration of a network of skills and expertise. To achieve its objectives, the MEDSCOPE research plan is organised around four work-packages (Figure 9.1). The management and coordination of the project will be provided by **WP1 (Management and Coordination)**, which will ensure the overall project monitoring, internal and external communication as well as administration and reporting. It will supervise and facilitate the collaboration and interactions among project WPs and within the team. To this aim, an organizational structure and project governance will be implemented as described in Section 10.3. WP1 will ensure communication via a website designed to disseminate results and products, a wiki web-tool aimed at interactive dissemination of information and an internal data portal to facilitate data exchanges among partners. Risk management through early risk identification and proposition of mitigation measures will be part of its objectives. Finally, WP1 will also be responsible for contacts and interactions with the ERA–NET "European Research Area for Climate Services" (ERA4CS).

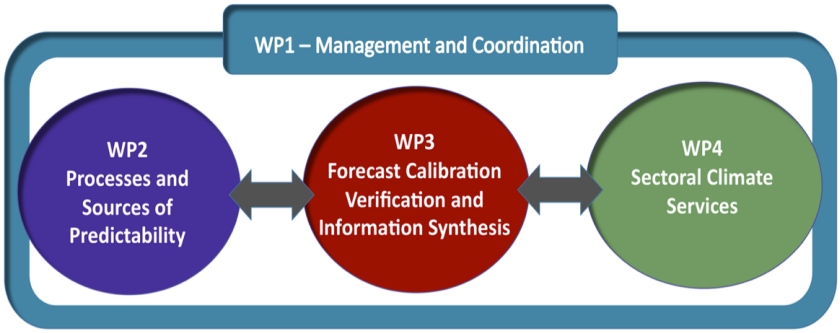


**Figure 9.1: Schematic representing the work-package structure of MEDSCOPE.**

**WP2 (Processes and Sources of Predictability)** will explore the mechanisms responsible for climate variability and predictability in the Mediterranean, focusing on those linked with predictable signals in the oceans or associated with land-atmosphere interaction processes. To this aim, besides an in-depth analysis of observations and results from available state-of-the-art prediction systems, a number of sensitivity experiments will be conducted, designed to identify the sources of predictability at seasonal-to-decadal time scales in the Mediterranean induced by land surface processes, land-atmosphere interactions, large-scale atmospheric patterns and teleconnections with tropical and extratropical oceans. In the same WP, a better understanding of the climate predictability in the target region will be used to develop process-oriented empirical forecasting tools, whereas **WP3 (Forecast Calibration, verification and information synthesis)** will exploit the outcomes of WP2 to develop advanced methodologies to extract relevant and usable information from climate predictions. WP3 will produce innovative tools for climate predictions calibration, downscaling, verification, combination and selection that will be publicly released via a toolbox and shared among project partners and with sectoral applications users in the target region. WP3 will also provide, through the internal data portal, high-quality, high-resolution climate prediction information that will be used in **WP4 (Sectoral Climate Services)** to demonstrate the feasibility of climate services and generate prototypes for three important sectors for the Mediterranean region: renewable energy, hydrology (including water resources management and flood risk assessment) and agriculture and forestry. For each sector, the climate forecast information will be made of indicators and products co-generated with the broadest spectrum of users. These users will consist of both public and private operators, such as regional and national hydro-meteorological services, national agencies (e.g. civil protection) and private operators (e.g. agro-food companies, insurances, logistics, economic traders, etc.), and they will be engaged principally through the well-established MedCOF network.

The cooperative development and the ultimate sharing of the project products among partners (and other users) – i.e. improved knowledge of the Mediterranean climate and its predictability, innovative methodologies and tools for information extraction from climate predictions and for their applications –

will provide a solid foundation for the building and strengthening of a collaborative community of climate service providers in the Mediterranean region, within which a more effective integration of institutions, climate services knowledge, development and use will be favoured.
In the following a detailed description of the work-packages and respective tasks is provided.

| Work-package 1 | Management and coordination | Month 1 - 36 |
|---|---|---|
| Partners (person months) | CMCC (WP Leader, 22), BSC (WP Co-leader, 18), CNR (1), MF (1), AEMET (1.5), RMI (1), INRA (2) | |

**Overall scope**

This WP will provide an efficient and success-oriented management of the project, including (i) the organization of regular partner meetings, (ii) the implementation of efficient interactive tools for internal and external communication, (iii) user engagement to collect needs and feedbacks. The WP will ensure the administrative and financial management through the preparation of the Consortium Agreement (CA), financial guidance and coordination of the financial reporting, as well as the risk management and the implementation of a mitigation plan. It will form the backbone of MEDSCOPE and ensure its smooth accomplishment and completion.

**Specific Objectives:**

- ensure an efficient internal communication between partners and with the ERA4CS board;
- ensure an effective communication and interaction with external users and other relevant projects and programmes;
- implement a website designed to satisfy the communication requirements of the project;
- provide financial guidance to all partners, conduct financial reporting and distribute the ERA4CS financial contributions according to the CA rules;
- ensure high-quality on-time reporting to the ERA4CS board via deliverables and milestones and efficient management of risks via mitigation measures;
- construct a solid basis of institutional integration and community building by providing opportunities to discuss, exchange ideas and collaborate among participant institutions.

For more conceptual, scientific and technical aspects of the management of the project, please refer to section 10, Management Plan.

**Description of activities**

**Task 1.1 [M1-36]: Internal and external project communication** (Lead: BSC, Partner: CMCC, AEMET, CNR, INRA, MF, RMI)

This task will deal with project communication, including internal communication (that will rely on an interactive wiki web-tool), external communication (conducted via a public website), and communication with MedCOF and with the ERA4CS board. The wiki will provide areas to discuss issues, exchange information and documents necessary to achieve the project objectives. Templates, manuals and guidelines needed for an efficient project reporting will be made accessible through this wiki, together with a contact list. Two internal portals, each hosting about 100Tb of data, will be hosted by INRA and by CNR for data sharing among WPs. Quarterly meetings among Task Leaders will be held for an efficient monitoring and coordination of the activities, either via teleconference or during General Assemblies. The coordinator will be responsible for maintaining regular communication with the ERA4CS board, including the delivery of financial and scientific reporting, so as to keep it informed about progresses, arising challenges or risks and to seek advice if necessary, ensuring a timely and efficient management according to ERA4CS rules. An ERA4CS representative will be invited to all General Assemblies.

A website will be designed to satisfy the communication requirements and the dissemination of the project results, accessible and providing quick response with different devices: desktops, tablets and smart-phones and according to the standards required by the most used Operative Systems. The Content Management System will be realized with open source software. The content of the website will be organized in sections dedicated to: (i) institutional information about the project, according to the

guideline provided by the funding institutions; (ii) aims and outcomes of the project; (iii) news and information about project-related events; (iv) results of user engagement meetings and feedbacks; (v) contacts and relations with media and stakeholders. E-training material, including tutorials to disseminate and exploit MEDSCOPE tools, and communication products generated in Task 4.4, as well as results of "*customer satisfaction surveys*" performed within the user community, will be made publicly available through the website. A logo will be designed in order to give a defined and recognizable image to the project. The task will also guarantee the user engagement in the project activities by means of dedicated workshops to be held within appropriate MedCOF meetings. This will help to collect user needs and feedbacks regarding project products but also to further disseminate project results, ensure integration, homogenization and diffusion of those services described in the above research plan. The task will also ensure MEDSCOPE involvement in the MedCOF training activities.

**Task 1.2 [M1-M36]: Administrative and financial management** (Lead: CMCC)

This task aims at implementing an efficient exchange of administrative information and in particular financial documents and reports among partners and with the ERA4CS board. Before the start of the project, the Project Coordination Office (see Section 10.3) will draft a Consortium Agreement (CA) based on the DESCA model, which is widely used and accepted as a model for EU projects. Financial guidance will be provided to all partners through a document, synthesizing the rules, which will be made available to all partners through the project wiki. This guide will give a concise overview of the rules and obligations concerning the Consortium budget according to the regulations of the ERA4CS Grant Agreement and will serve as a manual on how to conduct the financial reporting. The distribution of the ERA4CS financial contribution will also form an integral part of the financial management. The provisions regarding the distribution of the ERA4CS financial contribution will be detailed in the CA according to the Grant Agreement. The distribution itself will be carried out by the coordinator.

**Task 1.3 [M1-M36]: Reporting and risk management** (Lead: CMCC, Partner BSC, AEMET, CNR, INRA, MF, RMI)

Close contact with the WP and Task Leaders, via the 3-monthly meetings (Project Progress Meeting, held mostly in teleconference) and annual project meetings, among other means, will ensure that deadlines are kept, deliverables are fulfilled and milestones are reached. The coordinator will provide the partners with templates and guidelines on how and when to write deliverables, to ensure a timely and coherent submission of the deliverables to the ERA4CS board. All information on the project progress, challenges and results will be gathered by the coordinator and transferred into a scientific report, which will be submitted during the periodic reporting. Being well-informed on the latest developments and the overall progress, the coordinator will be able to identify early possible risks, criticalities and delays. Mitigation measures will be proposed and the ERA4CS representative will be consulted in case of major issues requiring the advice of the ERA4CS. A risk management plan containing a list of potential risks and mitigation measures will be developed, shared with the wiki and kept up-to-date by the coordinator throughout the project.

**Deliverables**

| *#* | *Leader* | *Nature* | *Title* | *Due Month* |
|---|---|---|---|---|
| D1.1 | BSC | Report | Summary reports on project progress – including minutes of the Project Progress Meetings – provided to the ERA4CS. | Quarterly |
| D1.2 | CMCC | Website | Website, including wiki for internal communication and internal mailing lists | 3 |
| D1.3 | BSC | Report | Risk Management Plan, including mitigation measures | 3 |
| D1.4 | CMCC | Report | Annual implementation reports including financial reports | 12, 24, 36 |
| D1.5 | CMCC | Report | Final project report | 36 |

**Milestones**

| *#* | *Leader* | *Means of verification* | *Due Month* |
|---|---|---|---|

| | | | |
|---|---|---|---|
| M1.1 | CMCC | Internal data portal available for data exchange among project partners. | 3 |
| M1.2 | BSC | Project Progress Meeting (in teleconference) | Quarterly |
| M1.3 | CMCC | Mid-term and end-term project meetings | 18 and 36 |

| **Work-package 2** | **Processes and Sources of Predictability** | **Month 1 - 30** |
|---|---|---|
| **Partners (person months)** | MF (WP Leader, 19.5), CNR (WP Co-leader, 49), AEMET (36) BSC (66), CMCC (28) | |

**Overall scope**

This WP will provide an in-depth analysis of the sources of climate predictability for the Mediterranean region at seasonal-to-decadal timescales by means of a thorough evaluation of current state-of-the-art operational or real-time climate prediction systems (e.g., EUROSIP, NMME, APCC, DCPP, and those made available by the project partners). The analysis will be conducted over the re-forecast periods and complemented by carrying out sensitivity studies, with improved or idealized representations of boundary components (land surface, tropical oceans, etc.) to assess key processes in climate predictability over the target region. The WP will develop novel empirical forecast systems tailored for specific applications, based on results from the predictability studies. WP2 will feed WP3 on process-understanding to develop advanced process-based forecast post-processing methodologies. The empirical forecasting systems will be of practical use to WP3 as a benchmark for the evaluation of existing dynamical prediction systems, and to WP4 as a climate prediction tool tailored for the target region. The common sensitivity experiments planned within WP2 performed, analysed and used by all of the participating partners will constitute a powerful mean of institutional integration.

**Specific Objectives:**

- investigate the role of land surface-atmosphere interaction processes in the Mediterranean climate predictability from seasonal to decadal time scales;
- advance understanding of the links between Mediterranean climate variability and remote forcings from the Arctic, Atlantic and Tropical oceans at seasonal to decadal timescales;
- develop an empirical forecasting system for the Mediterranean region.

**Description of activities**

**Task 2.1 [M1-24]: Land surface and Land-Atmosphere coupling** (Lead: CMCC, Partners: MF, BSC)
This task will investigate the impact of land-atmosphere coupling and soil moisture memory on seasonal forecasts in the Mediterranean area. It will explore the predictability driven by land-surface processes and their effects on seasonal predictions of extreme events, with special attention to heat waves and droughts. Ad-hoc metrics and indexes will be developed to this purpose, such as *odds–ratio* of 3/6/12-month Standardized Precipitation Index (SPI). This task will also investigate the possible role of land-vegetation as a driver of predictability on multi-annual timescales in the target region. Analysis will be performed using reforecast datasets and a set of sensitivity experiments specifically designed to assess these feedbacks and to evaluate the forecast length for which the forecast has performance exploitable by users. A preliminary setup would consist in comparing seasonal forecasts initializing or not the land surface from observational data and leaving the land surface free to evolve or constrained to a climatology during the forecasts.

**Task 2.2 [M1-24]: Teleconnections with low-latitudes** (Lead: BSC, Partners: MF, CMCC, CNR)
This task will tackle a comprehensive comparison between the observed atmospheric dynamics linked to the Tropics/Mediterranean teleconnections and the mechanisms simulated by current seasonal forecast systems. It will also explore the potential low-frequency modulation of these teleconnections (particularly those associated with ENSO) induced by the Pacific Decadal Oscillation (PDO), for which coordinated AGCM sensitivity experiments will be carried out. A preliminary setup follows: (i) Two control simulations will be performed prescribing warm/cold PDO phases in the North Pacific and climatological SSTs elsewhere, to isolate the impact on the atmospheric mean-flow. (ii) A canonical evolution of El Niño SST cycle in the tropical Pacific will be added in separate perturbed simulations upon both warm and cold PDO

phases to assess their impact on the extratropical atmospheric response to ENSO. (iii) Experiments will be carried out by adding stochastic perturbation to positive and negative ENSO events to explore the importance of intra-ENSO variance on both time and space variability (e.g., Batté and Doblas-Reyes, 2015). (iv) All simulations will consist of a large ensemble comparable to operational systems (40-50 members) and cover 15 months, from June (developing phase) to August (decaying phase) in the El Niño cycle.

**Task 2.3 [M1-24]: Teleconnections with mid-latitudes** (Lead: CNR, Partners: BSC, CMCC**)**
This task will investigate the sources of seasonal and decadal predictability of mid-latitude large-scale atmospheric patterns (e.g. NAO), including Atlantic SSTs, AMO and Arctic sea ice, and their potential connections to anomalous climate conditions over the Mediterranean region. It will also explore the dynamical mechanisms underlying these variability patterns and the key aspects that should be better represented by climate forecasting systems in order to improve skill. A multi-model approach using re-forecasts from various seasonal (e.g., BSC, CMCC, MF) and decadal (e.g., CMIP5, SPECS and DCPP) prediction systems and tailored statistical methods that will enable the attribution of skill to the various large-scale components will be used. Targeted simulations conducted under the DCPP-C protocol will be also analysed to quantify the dependence of the predicted anomalies on each boundary component as well as on the ensemble size (signal-to-noise ratio varies for different physical processes).

**Task 2.4 [M7-30]: Development of empirical forecast systems** (Lead: AEMET, Partners: BSC)
As an alternative to computationally expensive dynamical forecast systems, empirical approaches have also served as independent seasonal prediction systems (Doblas-Reyes et al., 2013; Eden et al. 2015). In some cases they have been combined with dynamical model outputs to produce better mixed-basis forecasts (e.g. in the case of the Sea Ice Outlook). In this task, we will develop novel empirical forecasting methods based on the improved understanding of sources of predictability in the Mediterranean coming from land surface processes and land-atmosphere coupling (Task 2.1), teleconnections with low-latitudes (Task 2.2) and mid-latitudes (Task 2.3). This task will synthesize the knowledge gained within WP2.

**Deliverables**

| *#* | *Leader* | *Nature* | *Title* | *Due Month* |
|---|---|---|---|---|
| D2.1 | CNR | Report | Sources of climate predictability from seasonal to multiannual timescales in the Mediterranean region. | 15 |
| D2.2 | BSC | Report | Assessment of the ability of state-of-the-art climate prediction systems to represent mechanisms of predictability in the Mediterranean and role of systematic errors. | 21 |
| D2.3 | AEMET | Report/ Software | Empirical forecasting system ready for the operational production of consensus seasonal forecasts, together with a complete documentation. | 30 |

**Milestones**

| *#* | *Leader* | *Means of verification* | *Due Month* |
|---|---|---|---|
| M2.1 | MF | Detailed protocol for common sensitivity experiments | 3 |
| M2.2 | CMCC | Sensitivity experiments completed and data provided to the partners | 12 |
| M2.3 | BSC | Preliminary version of empirical forecast systems available for comparison with dynamical forecasting systems | 18 |

| **Work-package 3** | **Forecast Calibration, Verification and Information Synthesis** | **Month 1 - 30** |
|---|---|---|
| **Partners (person months)** | BSC (WP Leader, 72), RMI (WP Co-leader, 15.5), AEMET (32), CMCC (18), CNR (39), INRA (20), MF (17.5) | |

**Overall scope**
This WP aims at refining state-of-the-art methodologies to extract relevant information from dynamical climate prediction systems and assess their a-priori uncertainty and a-posteriori skill. This includes

correcting for model systematic errors based on process-understanding, extrapolating reliable model information from user-relevant variables at user-relevant scales, extensively comparing different sources of climate information, from both dynamical and empirical prediction systems provided by WP2, and combining and synthesizing such sources of information into a reduced set of representative forecasts suitable for applications in WP4. Therefore, this WP will benefit from the improved process understanding delivered by WP2 to develop process-based methodologies, in particular for forecast calibration and downscaling, and feed the generation of user-targeted climate products in WP4, by providing the list of key climate variables at spatial and timescales requested by WP4 partners. The main product delivered by this WP will be a toolbox to apply the methodologies developed herein. The methodologies and the tools developed will be shared among all partners further contributing to institutional integration.

**Specific Objectives:**

- develop advanced bias correction and forecast calibration methods;
- develop statistical/stochastic downscaling techniques to provide adequate climate prediction information for user-targeted products together with a measure of uncertainty at small scales;
- develop both deterministic and probabilistic multivariable user-driven forecast scores to allow for efficient and targeted forecast system comparison and evaluation of issues focused on Mediterranean applications;
- develop simple approaches for combining/weighting or selecting ensemble members/models to obtain more accurate and more reliable targeted impact forecasts.

**Description of activities**

**Task 3.1 [M1-24]: Bias correction and forecast calibration** (Lead: MF, Partners: BSC, AEMET, INRA, RMI)
All climate prediction systems exhibit systematic errors (e.g. Hazeleger et al., 2012, 2013; Voldoire et al., 2013), which evolve into climate drift (Du et al., 2012), the amplitude of which is generally of the same order of magnitude as the variability we aim to predict. A-posteriori correction of the model drift, thus, is essential to extract information on the predicted variability, be it by applying “bias correction” or “forecast calibration” techniques, either at the grid-point level or on climate indices. The former consists in subtracting from the prediction an estimate of a mean bias at each forecast time, whereas the latter is performed by adjusting model-produced PDFs to an estimate of observed PDFs, thereby correcting the amplitude and distribution of model variability. However, state-of-the-art methods generally do not account for spatial shifts in patterns of variability and assume that the forecast systematic errors are invariant with respect to the forecast initialization time. In this task, we will overcome these limitations by developing new methods based on classification or analogues, and new methodologies accounting for the sensitivity of the prediction drift to the climate model initial state.

**Task 3.2 [M7-30]: Statistical/stochastic downscaling** (Lead: CNR, Partners: AEMET, CMCC, INRA, RMI, MF, BSC)
Most of operational climate predictions with global coupled models are currently limited to relatively coarse resolutions (~100km). Spatial and temporal downscaling are needed for climate service applications in regions with complex topography and for specific sectors, which usually require inputs at higher spatial and temporal resolutions. Based on interactions with WP4, this task will develop and compare statistical and/or stochastic downscaling techniques to provide more adequate climatic information for key variables such as precipitation, near-surface temperature or radiation, wind speed and weather/climatic extremes in general. The RainFARM stochastic precipitation downscaling technique (Rebora et al., 2006; D’Onofrio et al., 2014) will be used to provide ensembles of high-resolution precipitation data (up to 8km over the Mediterranean region), to allow a measure of uncertainty and a more realistic representation of sub-grid precipitation distribution and variability, and of precipitation extremes, crucial for impact studies in the water sector.

**Task 3.3 [M1-24]: Advanced multivariable forecast scores** (Lead: BSC, Partners: MF, CNR)
Forecast quality assessment is essential for users to have a clear overview of potential and limitations of available climate information and for effective forecast system development. Under this task, we will

develop and implement both deterministic and probabilistic multi-variable forecast scores. For example, forecast scores based on the Root Mean Square Error (RMSE) could account for several variables simultaneously if each variable is scaled by its observed variance. For complementarity, new scores will be developed to assess how well the observed variance is captured by a range of variables. Multi-variable EOF-based indices will be developed to produce new forecast scores. Work on probabilistic scores will be focused on model or multi-model reliability, in collaboration with WP2 and WP4, to define which are the key probabilistic events which need to be captured for specific applications. Integrated multivariable forecast scores will contribute to a more automatic and objective comparison of forecast systems.

**Task 3.4 [M7-30]: Forecast system combination and selection of sub-ensembles for applications** (Lead: RMI, Partners: AEMET, CNR, INRA)

Forecasts on monthly up to decadal scales are known to improve when multiple forecasts are combined into a multi-model ensemble (Hagedorn et al., 2005). On the other hand, in some cases, for some specific area or parameter, some ensemble members will very often perform better than the whole multi-model ensemble. It is therefore important to objectively identify overly influential members that could be down-weighted or eliminated from the ensemble (model sub-selection; Dobrynin et al, 2016), but at the same time avoiding over-selection by out-of-sample testing. In order to ensure a sector-tailored approach, the ensemble member selection or the weighting procedure can also be done bearing in mind the specific application for which the forecast will be used and what kind of parameters or indicators will be considered. For instance, for the wind energy sector, the selection or weighting criteria should be based focusing on wind rather than temperature, whereas for the agriculture and forestry sector precipitation and temperature are the main drivers. In this task, different univariate and multivariate sub-selection methods will be explored (including clustering algorithms) and will be used for WP4 forecast applications.

**Deliverables**

| *#* | *Leader* | *Nature* | *Title* | *Due* Month |
|---|---|---|---|---|
| D3.1 | RMI | Report | Synthesis report on the developed methodologies and their added-value on forecast quality. | 24 |
| D3.2 | BSC | Software and Report | Toolbox of R/python software packages – for bias correction, forecast calibration, statistical and stochastic downscaling, process-based forecast quality assessment, multivariable prediction scores, ensemble member combination and selection – made available through the MEDSCOPE website. | 30 |
| D3.3 | MF | Report | Set of recommendation for further improvements of operational seasonal forecasting systems (joint with WP2) | 30 |

**Milestones**

| *#* | *Leader* | *Means of verification* | *Due* Month |
|---|---|---|---|
| M3.1 | CMCC | Preliminary set of tools based on R/python software – for bias correction, forecast calibration, downscaling, multivariable prediction scores, ensemble member combination and selection – made available through the MEDSCOPE website. | 12 (α version) and 21 (β version) |
| M3.2 | CNR | High-quality climate prediction data (bias-corrected and downscaled) made available for applications according to WP4 requests through the internal data portal. | 15, 24 |

| **Work-package 4** | **Sectoral Climate Services** | **Month 13 - 36** |
|---|---|---|
| **Partners (person months)** | AEMET (WP Leader, 45.5), INRA (WP Co-leader, 80), BSC (27), CMCC (30), CNR(53), MF (23), PLAN BLEU (3), RMI (9.5) | |

**Overall scope**

This WP aims at providing specific sectoral seasonal predictions for the Mediterranean region. The goal is

to demonstrate the feasibility of climate services and generate prototypes for three sectors: i) renewable energy, ii) hydrology (including water resources and flood risk assessment) and iii) agriculture and forestry. Climate services design will benefit from previous projects results such as EUPORIAS, MOSES, CLIMRUN, etc. Identification and evaluation of indicators relevant for the Mediterranean region and specific to sectors will be the main focus of this WP. WP4 will be fed by WP2 on sources of predictability and by WP3 on correcting, combining and synthesizing different sources of climate information. An extension to the decadal time scales is necessary to support strategic issues on land management and infrastructure design and will be addressed by adapting seasonal indicators.

**Specific Objectives:**

- identification of specific indicators known to affect wind energy and hydropower, hydrological applications (eg inflow to water dam, river discharge, soil moisture, agriculture (yield, irrigation needs, pest risk) and forest (vulnerability to water stress, fire risk);
- generation of seasonal forecasts of the different sectoral indicators evaluation of seasonal capabilities making use of a set of indicators selected for the Mediterranean region;
- development and assessment of sectoral indicators in decadal time scale simulations, when relevant, and evaluation in selected case studies;
- delivery of an effective and sound communication of the main project results towards identified target groups of relevant stakeholders, particularly through MedCOF.

**Description of activities**

**Task 4.1 [M13-36]: Renewable energy** (Lead: BSC, Partners: MF, AEMET)
This task will design a demonstrative indicator based on wind speed and will explore how this indicator can be translated into capacity factor of wind power to assess the relative performance or usage of any generating power plant. The indicator will describe Mediterranean wind speed and energy density along with their uncertainty for re-analyses and seasonal re-forecasts. Particular focus will be placed on extreme events relevant for the industry such as the 10$^{th}$ and 90$^{th}$ percentiles. Moreover, the task will evaluate hydropower potential over specific pilot areas in the Alps and Pyrenees in summer, from the amount of accumulated snow mountain in late spring. Snow water equivalent will be calculated using both reanalysis data (UERRA) and ARPEGE System 5 re-forecasts (1993-2014). A demonstration of applications of seasonal predictions to hydropower potential will also be provided by expanding the S-ClimaWaRe case study developed in the EUPORIAS project to a few selected pilot hydropower dams.

**Task 4.2 [M13-36]: Hydrological products** (Lead: AEMET, Partners: MF, CNR, RMI)
In this task, empirical prediction tools developed in WP2 will be used to generate seasonal forecasts of water inflow for non-regulated dams. This activity will expand to the Western Mediterranean area the approach implemented in the S-ClimaWaRe case study developed in the EUPORIAS project. The SURFEX/TRIP model for land surface and river routing, with atmospheric forcing inputs from ensemble seasonal forecasts, optimized in WP3, will be used to provide river flow forecasts over pilot regions in the Mediterranean. This activity will expand the RIFF climate service experimented in the EUPORIAS project Besides, indicators of probability of occurrence of climate extremes will be defined and computed for the whole Mediterranean region. A particular focus will be dedicated to the Alpine region, including the use of predictions to estimate snowpack conditions and evolution and the response of selected glaciers through local land-surface/snow models and *ad hoc* empirical statistical models. Finally, following the request of the MedCOF community to generate seasonal hydrological predictions, we will explore the feasibility of estimating the probability of floods and dry periods using hydrological re-forecasts (Roulin and Vannitsem, 2015).

**Task 4.3 [M13-36]: Agriculture and forestry** (Lead: INRA, Partners: CMCC, AEMET, MF)
This task will provide a set of impact indicators describing the influence of climatic factors on plant growth, development and vulnerability, and it will compute seasonal forecasts of these indicators, taking into account the current vegetation status. The following four groups of indicators will be generated: (i) agro/eco-climatic metrics (Caubel et al., 2015); (ii) soil water balance, crop phenology and yield

production using Crop and Soil Vegetation Atmosphere Transfer models to identify potential yields and water shortage risk; (iii) forest productivity and mortality indicators derived from ecophysiological modelling (Dufrêne et al., 2005); (iv) forest fire risk using both consolidated and new indicators that account for added fire drivers (fuel moisture, biomass, e.g. Ruffault et al., 2012). Two types of outcomes will be produced for each of the four considered groups: one group (i) over the whole Mediterranean region on a ~25 km resolution grid. For the other groups (ii - iv), the indicators will be obtained from biophysical modelling at high-resolution (~5 km or less) for a few selected pilot areas (in Italy, France and Spain), where the necessary additional local information regarding soil-plant initialization and parameterization can be obtained. Since decadal forecast are highly relevant to support agriculture and forest management (for example, in the evaluation of adaptation options), seasonal indicators will be adapted to the decadal time scale. Additionally, the possibility of merging current best estimates of crop development based on driving indicator models with seasonal observed and forecast weather data will be explored following the concept of "optimizing climate information" by merging multiple sources.

**Task 4.4 [M13-36]: Capitalization and communication of the products** (Lead: CMCC; Co-leader: Plan Bleu; Partners: AEMET, MF, INRA, CNR, RMI, BSC)
This task will deal with results communication strategy and design of dissemination documents. It will produce material in order to capitalize results by communicating the main outcomes to support decision making processes. The results will firstly be shared with the experts and users from the Mediterranean Climate Outlook Forum (MedCOF, SEECOF, PRESANORD) to receive their feedbacks and improving the efforts to address their needs. This exercise will strongly benefit from previous experience of the partners in social science applied to climate services (e.g. FP7 EUPORIAS, and Copernicus-EU QA4Seas). Several types of tailor made communication products will be prepared: the project brochure, factsheets, and policy recommendations. In order to have a maximum impact, different products will be adapted to the different kinds of identified stakeholders for a more effective tailor-made communication. The task will also produce E-training material, including tutorials to disseminate and exploit MEDSCOPE tools and will organize and perform targeted "*customer satisfaction surveys*" within the user community, particularly MedCOF, and make them publicly available through the website. This will exploit the partners' experience in the Copernicus-EU SECTEUR project.

**Deliverables**

| *#* | *Leader* | *Nature* | *Title* | ***Due* Month** |
|---|---|---|---|---|
| D4.1 | AEMET | Report | Report assessing the quality of sectoral (energy, hydrology, agriculture and forestry) predictions -based on indicators covering the whole Mediterranean region- publicly available through the MEDSCOPE website. | 30 |
| D4.2 | INRA | Report | Report assessing the added-value of methodologies developed in WP3 on sectoral (energy, hydrology, agriculture and forestry) predictions -for the target regions and locations defined in concert with end-users-publicly available through the MEDSCOPE website. | 36 |

**Milestones**

| *#* | *Leader* | *Means of verification* | ***Due* Month** |
|---|---|---|---|
| M4.1 | CNR | Definition of case studies for testing WP3 methodologies | 13 |
| M4.2 | BSC | List of variables, specific locations and frequency needed from WP3 for each application sector stratified into two successive releases expected at M15 and M24 | 13 |
| M4.3 | CMCC | Feedbacks to WP3 on the intermediate release of climate information tailored for applications | 18, 27 |

## 10. Management Plan (Maximum 5 pages)

### 10.1 Appropriateness of the conceptual approach, feasibility of aims and objectives of project, feasibility and suitability of project design and method

MEDSCOPE will advance climate prediction and services for the Mediterranean region using the following strategy (Figure 9.1):

- building on the wide existing datasets of numerical prediction experiments and observations as well as performing targeted sensitivity simulations for an **improved understanding of predictability processes and mechanisms** (WP2),
- exploiting this better understanding to develop **innovative empirical forecast systems, process-based methods for bias correction, downscaling and optimal combination of sources of information** that will be publicly released as a toolbox (WP3),
- assessing and communicating the **added-value of improved climate predictions for** a variety of **application sectors** and enhancing the existing links and collaborations with the **user community** (WP4).

WP2 will not only provide input for WP3 but also respond to WP3 needs in terms of improved process understanding for an optimal design of novel techniques for the toolbox to be made public. Similarly, close collaboration will take place between WP3 and WP4 to make WP4 capable to formulate specific needs in terms of climate information and WP3 to provide the targeted climate information. The management and coordination WP1 will organise the consortium collaboration with regular meetings and efficient communication tools (website, wiki) as detailed in the project description.

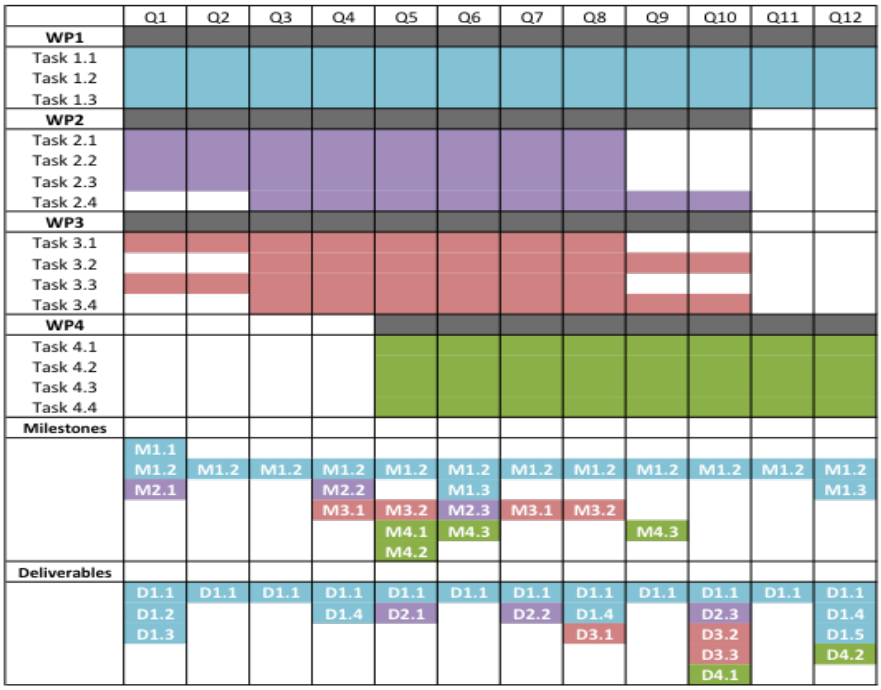


**Figure 10.1 Gantt chart of the MEDSCOPE schedule.**

MEDSCOPE builds on previous successful projects in which several MEDSCOPE partners were involved, including SPECS, CLIM-RUN and EUPORIAS. These projects have demonstrated some skill and reliability over the Mediterranean area for climate prediction at seasonal, annual and multi–annual timescales. While this forms a strong basis to produce climate-service applications products for different sectors (WP4), the skill is known to strongly depend on space and time. Therefore, there is a strong need for advanced state-of-the-art research in this area, focused first on identifying and understanding the sources of predictability (WP2) and, subsequently, performing refined calibration and verification of the forecast systems (WP3).

**10.2 Competence and expertise of team and complementarities of consortium**

The MEDSCOPE consortium covers the wide expertise required to carry out a successful project on climate prediction and services on seasonal to decadal timescales, as detailed below, with key background and competences in seasonal-to-decadal forecasts, climate research, climate services and participation to and management of (Mediterranean-related) projects. Sufficient computing and data storage resources are available at the partner centres to carry out the experiments and diagnostics detailed in the proposal. Likewise, the consortium members' consolidated experience with user-oriented research projects provides a practical framework to deliver the final public toolbox. In particular, BSC has developed a set of tools for forecast verification, such as S2dverification. Similarly, CMCC has a well-established expertise in developing user friendly tools for meteo-climatic data diagnostics and decision supporting tools acquired in the course of several projects (e.g. MARSOP-4, OTTIMA, TESSA, IONIO). Close existing contacts with institutions from the private sectors will ensure an efficient development and use of MEDSCOPE results for applications.

**10.2.1 Development of climate prediction capability**

MEDSCOPE partners have mutually complementary expertise that allows to generate seasonal to decadal forecasts operationally or near-operationally, post-process and bias correct them, compare and combine them with empirical forecasts (optimal forecast combination) and improve their quality through understanding sources and mechanisms of predictability. In particular these competences include:

- operational 7-month predictions by **Météo-France** as part of the EUROSIP consortium since 2005;
- operational 6-month forecasts by **CMCC** delivered since 2014 to the Asian Pacific Climate Centre, South Korea (APCC, here);
- near-operational decadal forecasts by **BSC**, yearly since 2012, as part of the coordinated exercise organised and publicly disseminated by UK MetOffice here;
- near-operational yearly prediction of the September Arctic sea ice extent from June by **BSC** as part of the sea ice outlook (here);
- operational seasonal forecasts by **AEMET**, since 2011;
- since January 2016, **Météo-France** and **CMCC** contribute to the Copernicus Climate Change Services (C3S) Pre-Operational Multi-Model Ensemble seasonal prediction system;
- recognition of **Météo-France** as one of 12 Global Producing Centers of WMO and its responsibility for the Regional Climate Center long-range forecasting node for WMO Western Europe Region 6;
- expertise of the **RMI** in operational weather and hydrological forecasting and particularly in the development of bias correction and calibration techniques and forecast verification.

**10.2.2 Wider climate expertise**

On top of specific experiences in climate prediction, a strong climate dynamics background is available in the consortium, which constitutes an essential asset to improve our understanding of the mechanisms responsible for predictability. Examples include:

- the current development and implementation of metrics and post-processing tools for climate data in several relevant national and international projects by **CNR**, **CMCC** and **BSC**: in PRIMAVERA (H2020), these groups focus on the development of process-based metrics tailored for different regions and seasons, assessing Pacific, Atlantic and Arctic variability and their teleconnection to Europe, measuring climate variability and predictability in the extra-Tropics. In CRESCENDO (H2020), **CNR** implements new metrics to assess Earth System Model spatial and temporal trends in land and vegetation cover resulting from improved representation of land-use change and vegetation dynamics.
- the participation of **CNR** to ECOPOTENTIAL (H2020), providing model scenario data for ecosystem impact modelling, including statistical and stochastic downscaling of large-scale scenario information, with development of tools for the comparison with available earth observations.

**10.2.3 Mediterranean region**

Key expertise on Mediterranean climate, crucial for MEDSCOPE, is strong within the consortium, as evidenced for example by:

- the leadership role by **CMCC**, since May 2015, of the Copernicus Marine Environment Monitoring

Service Mediterranean Monitoring and Forecasting System (MED-MFC).

- the coordination of the Mediterranean Climate Outlook Forum (MedCOF) by **AEMET** which produces consensus seasonal predictions for 34 Pan-Mediterranean countries.

**10.2.4 Climate services**

Providing efficient and targeted climate services is also an expertise of the MEDSCOPE consortium:

- the participation of **AEMET** to MOSES (Managing crOp water Saving with Enterprise Services, H2020) European project.
- the close working links of **AEMET** with the DG Water of Spain, Basin Authorities and research institutions related with water management.
- the rank as first institute for agricultural research in Europe, and second in the world, of the National Institute of Agricultural Research (**INRA**).
- the leadership role in several projects of targeted research for sustainable agriculture, a safeguarded environment and a healthy and high quality food, by **INRA.**
- the participation of **BSC, AEMET** and **Météo-France** to the EUPORIAS (European Provision Of Regional Impacts Assessments on Seasonal and Decadal Timescales, FP7) European project which provides seasonal prediction tailored products for water and agriculture sectors (**AEMET)**, wind energy sector (**BSC)**, and water, energy and agricultural sectors (**Météo-France)**.
- the strong and long-standing expertise of **RMI** in operational hydrological forecasting.
- the involvement of **CMCC** in several European projects on climate impact assessment and service production in the Mediterranean region such as CIRCE (Coord.), CLIMRUN, ORIENTGATE (Coord.).
- the long track record on projects, activities and interdisciplinary collaborations of **CNR** for impact studies of climate change in the fields of hydrology, ecosystems and natural risks.

**10.2.5. Project management**

Within the MEDSCOPE consortium there is a strong and consolidated experience in project management as shown by:

- the coordination of the SPECS (Seasonal-to-decadal climate Prediction for the improvement of European Climate Services, FP7) European project by **BSC** (2012-2017).
- the 10-year **CMCC** portfolio of research projects, which includes 144 funded projects: 2 funded projects in FP6, 35 funded projects in FP7, 9 funded projects to date in H2020, and 98 funded projects under other EU and international research grants (tot. of ca. 44 M €). In about half of the implemented projects, CMCC acted as the coordinator.

Ample expertise is therefore available to manage MEDSCOPE.

**10.2.6. Gender balance**

Regarding gender balance, MEDSCOPE counts three women as Principal Investigator (PI) of their institutions (Lauriane Batté, Susanna Corti and Virginie Guemas) out of 7 participating institutes. The Work Package (WP) leadership is shared by 1 man and 1 woman for WP1 and WP3, 2 women for WP2 and 2 men for WP4. The overall coordination of the project is shared by one man (Silvio Gualdi) and one woman (Virginie Guemas). MEDSCOPE therefore benefits from an outstanding gender balance.

**10.3 Overall coordination, monitoring and evaluation of the project**

A successful project management requires considerable attention to the management structure and specific human resources are needed to facilitate communication and collaboration within the consortium, organize meetings, manage the reporting of scientific activities and of financial matters to the Commission. To this end, MEDSCOPE will establish a **Project Coordination Office**, a **Project Governing Board** and a **Project Scientific Advisory Board**, with the aim of coordinating the work of all participants, their roles and the management of the resources in order to achieve the project's goals in an efficient and effective way.

• **Project Coordination Office (PCO)**. The PCO will be formed by a Project Coordinator (Silvio Gualdi, CMCC) and a Project Co-Coordinator (Vierginie Guemas, BSC), together with the appropriate secretarial and administrative staff, and it will coordinate, execute and monitor the implementation of all project activities and administrative tasks, including finance and legal issues; ensure the exchange of information

among participants; ensure the compliance with the Grant Agreement and its Annexes and with the Consortium Agreement; coordinate the periodic reporting and organize the preparation of the project meetings, workshops and events for a successful implementation and dissemination of the project results. The PCO will be the link between the ERA4CS board and the project consortium.

**Project Governing Board (PGB).** The MEDSCOPE PGB will be responsible for the general supervision of the correct and timely development and progresses of the project, reporting possible deviation with respect to the planned activities. It will also guarantee an effective and usable exploitation of the project results within and outside of the consortium, also after the completion of the project (see also Section 10.3.1 Risk Management). It will be composed of the WP leaders and co-leaders and will be chaired by the Project Coordinator and Co-Coordinator. An ERA4CS nominated representative (the Project Officer) shall be entitled to attend meetings of the Governing Board in an advisory role.

The PGB components will be in close mutual contact via email and will meet regularly (every three months) via Project Progress Meetings (PPM) held in teleconference throughout the duration of the project. In addition, the PGB will meet in person during the project annual meetings and other events.

**Scientific Advisory Panel (SAP)**. The SAP will be composed by at least five international leading experts on climate forecasts and their applications. Laurent Dubus (EDF, expert of wind energy), Frederic Levrault (expert of climate impacts on agriculture), Fatima Driouech (Head of the National Climate Centre of Morocco, vice-chair of the MedCOF, vice-chair of IPCC-WG1, and expert on climate forecasting) and Ralf Ludwig (Prof. at the Ludwig-Maximilian University in Munich and expert of climate impacts on water resources and hydrology) have accepted to be part of the SAP. One more expert in seasonal-to-decadal climate predictions in the Mediterranean will join the panel. The SAP will be invited to the project Annual Assembly and it will be responsible for providing advice, guidance and evaluation on the overall science plans and directions and on the progress in achieving the results. It will review the Annual Implementation reports.

Quarterly progress reports will be prepared for the European Commission for the on-going evaluation of the project's progresses. Milestones and deliverables are spread evenly all along the 3 years. The success of the project will be assessed, in particular, through the pervasiveness of dissemination and use of the rich toolbox of innovative methods to be released as well as through the end-user products generated and disseminated (see also Task 1.1 and Task 4.4).

**10.3.1 Risk Management**

The Project Governing Board (PGB) will engage into an iterative process identifying best practices, which will be used to update and improve the implemented activities. The circular lessons-learned process will include different phases such as:

(i) monitoring: recording and cataloguing emerging issues, either positive or negative. The monitoring will classify the cases in two main types: issues that may need immediate actions, and issues that may be addressed at a later time. The catalogue of such issues/problems will be an IT document continuously updated and at the disposal of the PGB for its decisions.

(ii) Identification of corrective actions: based upon the risks described in a Risk Register included in the Risk Management Plan (Deliverable 1.3) and according to the weight and urgency of the problems, actions will be identified to tackle the different issues, and will be recorded in the catalogue.

(iii) Internal audits: these will ensure and document that the management system accomplishes its tasks and meets its targets.

The WP leaders will regularly report to the PGB, during the PPMs (see Section 10.3) that will be held (in teleconference) every three months to discuss, evaluate and analyse the progress of the project and the quality of the products, also considering the feedbacks from the users. The outcomes of the monitoring, corrective actions and internal audits will be fed back into the management process and will be the basis of possible revisions of activities discussed and agreed with the ERA4CS representative.

An important risk, which can be identified from the outset of the project is linked to the logical interconnection of work-packages 2, 3 and 4. WP3 relies on results of WP2 work and WP4 relies on results of both WP2 and WP3 work in terms of improved seasonal forecasts over the Mediterranean region. Such "user-adapted" forecasts should be the product of a number of specific project-developed

tools (choice and development of specific climatic indices, model calibration techniques, downscaling techniques, statistical post-processing methods). Such tools will all become available throughout the project and starting at an early enough stage in the project implementation to allow for iteration of products in response of user feedbacks. If this availability should lag and be late, it becomes essential to consider the risk of delays propagating through the project development and be prepared to minimize their impact on the overall success. This will be done by exploiting the vast amount of similar forecasts already available in several databases, in Europe and elsewhere. Such forecasts, although of presumably lower quality and of possibly different characteristics than those which will be produced within this specific project (within WP2 and WP3), will anyhow allow progress development of WP2, WP3 and WP4 until the new experimental and improved forecasts will become available in the course of the project life. Another important risk to be avoided is connected to ensuring that the results of the project continue to be used after the project completion, in terms of continued use of the tools released and disseminated, especially within MedCOF. This will be attained by facilitating the integration of these tools into the operational procedures and professional practices of the MedCOF public and private users, and by implementing an appropriate survey within MedCOF.

**10.4 Open Knowledge plan**

MEDSCOPE will follow the policy recommendations set by the JPI Climate guidelines on Open Knowledge. In particular, the project results will be disseminated – primarily through the project website – keeping in mind the need to make climate knowledge creation, transfer and exchange transparent and interactive, contributing to narrow the gap between climate research communities and external users. The most important hard deliverables of the project, the set of user-friendly tools for climate prediction verification and downscaling, will be developed in open source software (e.g. Python). The goal is for these tools to have maximum uptake and impact in promoting development of climate services. Fact-sheets will be created to explain project-related climate science questions to a large public and to provide potential end-users with clear and transparent explanation on how the released tools and methods have been developed. Tutorials for the tools and post-processed data created within MEDSCOPE will also be provided. Target users will be consulted to evaluate a proper technical level of the tutorials. The possibility will be explored to have more than one version of tutorials depending on the target audience. MEDSCOPE results will also be widely presented at international conferences and published in top-quality international peer-reviewed Open Access journals and books. Costs related to Open Access publications are foreseen in the partner budgets. For the internal working documents, the use of open formats, i.e. ODF (e.g., *.odt, *.ods, *.odp) will be adopted.

**10.5 Climate-Friendly Research**

In organising its research activities, MEDSCOPE will follow the JPI Climate guidance on climate-friendly research. Firstly, most of the project internal communication will take place via teleconferences. Meetings will be organized online between the WP and Task leaders every 3 months to ensure coordination of efforts and deployment of resources. The launch of the project will be held in concurrence of an international conference (see also Section 14), so that partners can attend without adding any further travelling. This way, the event will also have a larger resonance. Only two other project meetings will be organized in person: a mid-term and an end-term meeting. Also in this case the concurrence of international conferences will be exploited to reduce travelling and thus the project footprint. With a similar spirit, the user engagement workshops will also be held in correspondence and collaboration with the MedCOF meetings, which already collect the participation of project partners and numerous potential users of the project products. Furthermore, the participants of MEDSCOPE meetings will be encouraged to choose the less impacting means of transport (e.g., trains instead of planes, when possible, and public transports instead of taxi). To this aim, meetings will be organised in locations easily reachable with public transports. Finally, special attention will be devoted to the choice of the food offered at the canteens/cafeterias/buffets during the project meeting, favouring those that are fresh, regional, seasonal, vegetarian, organic and fair-trade.

## 11. Impact, Engagement and Dissemination plan (Maximum 5 pages)

### 11.1 Impacts

#### 11.1.1 Envisaged societal impacts

The results from MEDSCOPE will translate an enhanced comprehension of the climate predictability mechanisms into improved tools and methods of extracting climate information from predictions and, into a better readiness from seasons to years ahead to climatic conditions in the Mediterranean region. These results will help the development of better decision support tools, resulting in a better management of the environmental risks, which, in practice, will imply a reduction of emergency interventions' costs, a better integration of climate-dependent products or services into markets (e.g. renewable energy or agricultural products), a higher business stability and resilience of society towards the impacts of climate variability and change.

MEDSCOPE will steer collaboration and networking between seasonal-to-decadal climate prediction providers and specialized end-users. Its contribution to societal welfare and well-being will mainly, but not exclusively, unfold in the three application sectors selected: agriculture and forestry, energy and water resources. Through improvement of climate information available on seasonal-to-decadal timescales, the use of the tools produced within MEDSCOPE could easily extend benefits to other areas of the Mediterranean region and to a wider number of sectors.

In the agriculture sector, improving the use of reliable and trustworthy climate information on seasonal-to-decadal timescales is crucial to better anticipate agricultural practices (seasonal timescales) and to ensure satisfactory levels of food productions through adaptation of crop and land suitability (decadal timescales). Better exploiting climate information in the energy sector will ensure an optimized production tailored to the expected demand and contribute to prevent power outages. Water resource management is an essential key element for human society. Seasonal predictions will contribute to better management decisions and practices in drought-prone river basins, flood risk assessments or adaptation planning, reducing in all these cases the emergency costs and improving societal preparedness to hydro-climatic hazards.

MEDSCOPE will contribute to demonstrate the feasibility and usefulness of seasonal-to-decadal predictions for each of these three priority sectors.

MEDSCOPE societal impacts will be channelled mainly through its close connection with end-users, capitalizing on the already existing network of experts in operational climate prediction operating under the umbrella of the Mediterranean Climate Outlook Forum (MedCOF).

#### 11.1.2 Value and transferability for the user community

Providing user-relevant climate information is one of the key goals of MEDSCOPE embodied in the Sectoral Climate Services WP (WP4) dedicated to exploiting the knowledge gathered and the progress made during the project to improve climate services in three different sectors.

Value and transferability for the user community will be ensured by a close contact with stakeholders from both the private and the public sectors (see also Section 11.2.1). MEDSCOPE has a bottom-up approach in the sense that it focuses on a specific region with identified end-users and applications. As mentioned in Section 11.1.1, in MEDSCOPE tools will be developed so that they can be more easily generalized for other applications in different regions or sectors as needed.

Furthermore, fundamental traits of MEDSCOPE are co-design and co-construction of its products with potential users. WP4 is specifically designed to understand and collect user needs, which is essential to product transferability. These efforts will ensure that generated products fit user needs and disseminated tools be easily up-taken and integrated into users and stakeholder practices.

Additionally, dissemination to the scientific community will occur through involvement in international projects and programmes such as HyMeX, WCRP S2S prediction project, and GFCS climate prediction based services.

#### 11.1.3 Complementarity to other initiatives

MEDSCOPE will capitalize on existing knowledge from ongoing and past EU research projects and

international links. In particular, it will build onto the Mediterranean Climate Outlook Forum initiative (MedCOF) and support its activities. Regional Climate Outlook Fora (RCOFs) are now recognized to be key elements of the emerging Global Framework on Climate Services (GFCS). RCOFs help ensure consistency in access to and interpretation of climate information for groups of countries having similar climatological and socio-economic characteristics. They facilitate improved understanding and interpretation of available climate prediction information and promote more coherent action among scientists, sectoral users and policy makers.

MEDSCOPE will contribute in particular by generating tools tailored for RCOFs, especially for MedCOF.

MEDSCOPE will extend some of the activities carried out within the framework of the SPECS project (Seasonal-to-decadal climate Prediction for the European Climate Services) on developing seasonal to decadal climate prediction capabilities as well as EUPORIAS (European Provision Of Regional Impacts Assessments on Seasonal and decadal timescales) and CLIM-RUN (Climate Local Information in the Mediterranean region Responding to User Needs), which focused on developing climate services respectively for Europe and the Mediterranean region. Prototypes developed under EUPORIAS and CLIM-RUN will be further tested and improved.

MEDSCOPE will contribute to the activities of the Working Group on Seasonal to Interannual Prediction (WGSIP) and the Decadal Climate Prediction Project (DCPP) sponsored by the WCRP, as well as the Subseasonal-to-Seasonal Prediction Project (S2S). MEDSCOPE will be complementary also to the QA4Seas and Clim4Energy projects funded by Copernicus–C3S which will run in parallel and will focus respectively on delivering a toolbox for climate prediction quality assessment and impact on the energy sector (one of the sectors tackled by MEDSCOPE). The project, more generally, will complement the Copernicus–C3S climate prediction activities by advancing science that will improve their applications into the Mediterranean area and by providing feedbacks that will help improving the climate prediction systems used to produce the forecasts.

**11.1.4 Institutional integration**

The ERA4CS Joint Call aims at supporting research in order to develop more advanced tools and methods on how to produce, transfer, communicate and use reliable climate and related information, including how to deal with the associated uncertainties.

MEDSCOPE proposes to achieve such goals by developing a set of tools and methods which will provide improved global climate model calibration and regionalization techniques, as well as better forecast verification methods for the Mediterranean region, to extract as much climate information as possible from existing forecast systems.

The cooperative design and development and the ultimate sharing of these tools among partners (and other users) will provide a solid foundation for the building and strengthening of a collaborative community of climate service providers in the Mediterranean region within which a more effective integration of climate services knowledge, development and use will be favoured.

MEDSCOPE, therefore, besides providing a substantial advancement of our scientific understanding of the climate predictability on seasonal-to-decadal timescales, and besides developing and releasing advanced tools to improve the extraction of relevant information from climate prediction systems and assess their robustness and uncertainty, will serve as a community builder for future climate service activities based on climate predictions in the Mediterranean area, contributing to the building of a common and shared knowledge. More specifically, MEDSCOPE will bring together 7 partners (and 1 associated partner at zero cost) from 4 countries covering a wide range of complementary expertise as described in the Management Plan. The spectrum of participants ranges from operational meteorological services and seasonal forecast providers to institutes focused on sectoral applications with close ties to end-users. **WP2**, in particular, contributes to institutional integration by carrying out common sensitivity experiments, which will in turn be analysed by all participating partners.

The success of MEDSCOPE will rely on close links between different partners, which originally focus on different areas of research (e.g. **WP3-WP4** interactions with different partners involved), and this collaboration is anticipated by common deliverables across the project.

The wide range of well-established skills and competences brought together by the MEDSCOPE

consortium will allow tackling and addressing the very ambitious and challenging objectives of this proposal. Furthermore, it will provide a fundamental impulse to the building of a more extended collaborative network of climate service providers in the Mediterranean region, involving the MedCOF community in co-designing, co-developing and sharing methodologies and tools to improve climate predictions and applications in the region.

### 11.2 Engagement

#### 11.2.1 Who and how will benefit or make use of the MEDSCOPE research?

A great variety of users will benefit from and make use of the MEDSCOPE research, including private sector users, public institutions and agencies, the scientific community and the public at large. Privileged private and public sector users will be those operating in the three sectors subject to specific attention in WP4: energy, agriculture and forestry and water management, concrete examples being Energias de Portugal Renováveis (EDPR), Électricité de France (EDF), Iberdrola, the Spanish and French Transmission System Operators Red Eléctrica de España (REE) and Réseau de Transport d'Électricité (RTE) for energy; the Regional Agriculture Chamber (PACA Region), CIRAME (Regional agro-meteorological centre), ONF (Forest National Office), CED (Executive commission of the Durance River), ARPAE (Agenzia Prevenzione, Ambiente ed Energia Emilia-Romagna) and the Water DG of the Spanish Ministry of Agriculture, Food and Environment, in the sectors of agriculture, forestry and water management.

At the end of the project, these operators will have at their disposal a set of methods and tools, which will easily integrate in their operational and productive practices thanks to early user engagement and consultation.

In addition, the scientific community will benefit through information and knowledge exchanges via technical reports and via the peer-reviewed literature, while the general public will ultimately benefit via qualitative and quantitative improvement of those public services capable of exploiting improved seasonal and decadal predictions.

#### 11.2.2 User engagement methods

User engagement and in-depth consultation, mostly integrated with MedCOF, will be applied from a very early stage of the project and will take place using a variety of methods and communication channels, especially workshops, surveys and use of user engagement experiences accrued during previous or contemporaneous (general and/or sectoral) similar projects (see also Section 9.2, WP1, Task1.1).

It is furthermore envisaged that the role of users will not be limited to their expression of perspective needs in the fields of climate prediction information, but will be widened to encompass the role of continuous (Alpha and Beta) testers of tools and methods under development. Intermediate Alpha and Beta release products (see Section 9.2, WP3 description) will be put at the disposal of different test users (with priority being given to prospective users of MedCOF) with the aim of early diagnoses of possible difficulties/faults/inadequacies. This will make the project capable to re-adjust and re-steer to better suit users' needs and capabilities, as well as to face and address possible unforeseen criticalities. This high degree of flexibility should make the project sufficiently design-fault-tolerant, in order to minimize the associated risks of not reaching completely the final goal. Such engagement and in-depth consultation of a set of key users will be put into practice mostly through a sustained and organized interaction with the MedCOF network.

Other relevant users will also be identified and engaged exploiting the outcomes of relevant projects, such as EUPORIAS and the Copernicus SIS (Sectoral Information Systems). MEDSCOPE has the advantage of including key personnel (PIs) and institutions directly and actively involved also in the MedCOF and in the EUPORIAS project. The strong link with MedCOF, in particular, will facilitate an effective coordination with the activities of the Forum, especially regarding the workshops and training courses that it organises (http://medcof.aemet.es/index.php), and where the MEDSCOPE products (tools and applications) can be showcased in a way to favour users feed-backs and co-construction.

The coordination with MedCOF to ensure MEDSCOPE involvement in the Forum workshops and training courses will be the responsibility of WP1 (Project Management), whereas WP2, WP3 and WP4 will provide the contents.

**11.3 Dissemination**

The main outputs and products of the MEDSCOPE project will be a set of tools and methodologies aimed at improving the production of climate services based on climate forecasts, enhancing the capability of public and private users and stakeholders to develop and implement strategies of adaptation to climate variability and climate change. Such tools will be focused in particular on specific sectors and based on further development and refining of existing techniques and procedures, such as model output calibration (to tackle problems of systematic model errors), regionalisation (to enhance model resolution and therefore capability of representing small spatial scales) and mixed statistical-dynamical post-processing techniques (to address problems of specific sectoral applications intractable by standard prediction methods).

The tools will consist of a series of software packages based on open source software (e.g. R and Python) that will be stored and made publicly accessible via the project website. Along with software packages (tools), several types of other tailor made communication products will be prepared, such as e-training material, including tutorials to use, disseminate and exploit the tools produced by the project.

In addition, all results, tools and products will be disseminated during the thematic targeted workshops that MEDSCOPE will organise in collaboration with MedCOF, exploiting, in particular, the partners' experience in other projects, such as, for instance, the Copernicus-EU SECTEUR project. In order to have a maximum impact, different dissemination products will be adapted to the different kinds of identified stakeholders for a more effective tailor-made communication.

MEDSCOPE will complement and expand MedCOF training and outreach activities through its efforts toward wider and more effective public dissemination services, as e.g. dissemination of factsheets, e-learning material, online videos, intended to various levels of specialization of the target audiences. These products will explain a wide variety of science questions and help the understanding of climate information.

Further to this, a project brochure and policy recommendations will be produced and disseminated through the website and other usual channels, including international workshops, meetings and conferences, such as the European Geosciences Union General Assembly or sector-specific events (e.g. WindEurope annual event, Adaptation futures).

Regarding the assurance that information and products generated by the project will survive the project itself and will continue to be used after the project completion, this will be attained first of all by transferring, by the end of the project, all relevant information contained in the project web site into the MedCOF web site. In addition, continued use of the projects tools and results will be assured by facilitating the integration of such tools into the operational procedures and professional practices of the MedCOF public and private users.

Regarding the transparency and protection of all results generated within the project, MEDSCOPE will adopt the JPI-Climate transparency principle and the Open-Knowledge Guidelines (see also Section 10.4). As far as data and software, open licenses (e.g. Creative Commons) and open formats will be used.

All project-related publications will be open access and "Gold Standard" will be used as the publication preferred root. The Open Knowledge Plan is perfectly consistent with the use of Creative Common licenses.

All MEDSCOPE methodologies, software and information will be constantly made available to all partners. The Consortium Agreement will contain a statement on Intellectual Property Rights.

## 12. Budget justification

MEDSCOPE is three-year project that involves 7 partners (plus 1 associated partner at zero costs) from 4 European countries. The overall budget of the project is 5,372,198 Euros, with a substantial part of the resources (about 65%) allocated for personnel. MEDSCOPE has an ambitious plan of scientific investigation, methods and tools development that we foresee will require the effort of more than 700 Person Months (PMs). Importantly, the number of PMs involved in the project are almost equally distributed between the scientific and technical developments in WP2 and WP3 (56%), and the climate service development (including dissemination activities) in WP4 (38%), whereas a 6% is allocated for the project management in WP1.

MEDSCOPE, will also conduct a number of sensitivity experiments, in order to improve our understanding of the predictability mechanisms. In order to perform these simulations we have allocated about 10% of the project resources. This amount of allocated resources is the result of a careful evaluation of the number of experiments we plan to do, which has been translated into an estimate of the core-hours required to run the simulations on the high-performing computing (HPC) resources made available, and finally considering the costs of the computing time certified by the HPC centers. Approximately a 2% of the total budget has been devoted to equipments and consumables. These, in particular, will consist of a data storage that will be used to ensure the effective data exchange between partners and WPs, and funds for open-access publications, acquire licenses and production of dissemination materials. Finally, we have allocated about 2.5% of the total budget for travelling. This relatively small amount reflects the "Climate Friendly Research" approach undertaken by MEDSCOPE, and our wish to reduce the resources for connectivity, which can be equally effectively conducted via teleconferences, concentrating them to the research and development activities.

In the following we provide a detailed budget justification illustrated partner by partner.

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CMCC is coordinator of the project and leads WP1 (Management and Coordination), ensuring the on-time reporting to the European Commission via deliverables and milestones and the efficient management of risks related to the project activities. Furthermore, CMCC is responsible of the development and maintenance of the project website. For these activities, CMCC will need 18 Person-Months (PMs) for WP1.

CMCC is involved in WP2, leading Task2.1 and contributing to Task2.2 and Task2.3. In particular, within these tasks, CMCC will contribute to the identification and characterization of the sources of climate predictability for the Mediterranean area. To this aim, CMCC will also conduct a number of sensitivity experiments, targeted at improving our understanding of the land surface-atmosphere feedbacks and to enhance the comprehension of teleconnection mechanisms that link the variability of the Mediterranean region to (more predictable) climate variations in remote areas of the globe, such as Tropical and mid-latitude oceans. For these activities, CMCC will need 19 PMs for WP2.

In WP3, CMCC will contribute to the statistical downscaling activities performed in Task3.2 with 12 PMs. In particular in this Task, CMCC will contribute to the implementation and release of tools aimed at the production of downscaled seasonal forecasts over the entire Mediterranean region.

CMCC is also involved in the climate service demonstration activities in WP4, contributing to Task4.3 in formulating and applying indicators related to the agriculture and forestry sector at the regional and local scale. For these activities, CMCC will need 28 PMs.

20k Euros are allocated as travel funds for: 2 CMCC persons attending each of the planned Project General Meetings: 2 persons attending an international conference related to climate prediction and services per year.

We foresee to spend 5k Euros (consumables) for the publication of at least two scientific papers prestigious journals of the climate prediction sector in open access mode, and 2k Euros for one lap-top.

Other costs (625.224 €) include: computing costs (420k €), Audit costs (8k €) and overheads, calculated according to H2020 rule (197.224 €, equal to 25% of the direct costs).

Concerning computing costs, CMCC plans to perform a set of sensitivity experiments within WP2,

together with their respective control runs. These experiments will be composed of ensembles of control and perturbed sensitivity simulations and will be conducted with either atmosphere only, atmosphere–land surface and atmosphere–land surface–ocean coupled models and we foresee a total of approximately 14 Million core-hours. At a cost of 0.03 Euros per core-hour, it makes a total computing cost of approximately 420k Euros.
Finally, CMCC will cover travel expenditures of the partner "PLAN BLEU", involved in the project as partner at zero costs.

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BSC co-leads the management and coordination WP (WP1) and leads Task 1.1 on internal and external project communication as well as D1.2, D1.3 and D1.5. BSC will therefore need 18 Person-Months (PM) for WP1.
BSC leads Task 2.2 on teleconnection with low latitudes and is involved in Task 2.1, 2.3 and 2.4 of WP2 on sources of predictability. BSC will take part in the coordinated sensitivity experiments, process analyses and building on empirical forecasts and therefore will need 24PM, 24PM, 12PM and 6PM for Tasks 2.1, 2.2, 2.3 and 2.4 respectively, i.e. 66PM for WP2.
BSC leads WP3 on calibration, verification and information synthesis as well as Task 3.3 and participates in Task 3.1 and 3.2. BSC will coordinate the building and release of MEDSCOPE toolbox and therefore needs 72PM in total for WP3 (24PM for each Task : 3.1, 3.2, 3.3)
BSC participates in WP4 on climate services and lead Task 4.1 on wind energy. BSC will need 24PM for this task. Additionally, BSC is involved in Task 4.4 with 3PM. That makes a total of 27PM for this WP.
Travels are planned for 2 BSC members to attend each of the two General Assemblies as well as 2 members per year attending an international conference related to climate prediction and services. That makes a total cost of 20,000 euros for travels.
To store all the climate experiment outputs that will be downloaded or produced during MEDSCOPE, the storage system of the department BSC will have to be expanded. For the amount of data that the project is expected to exploit, we need around 0.5PB of raw space. That will require the acquisition of 3 disk cabinets (1 head node + 2 JBODs which costs about 21,000 euros) and 126 4TB disks (which cost about 27,720 euros). That makes 21,000 euros of Equipment and 30,000 euros of Consumables.
To invite Laurent Dubus member of the Scientific Advisory Board to the two General Assemblies, we will need 4000 euros as well as another 2000 euros to invite one member of PlanBleu to one of the General Assemblies.
Other costs (370.750€) include: overheads (234.750 €, 25% of the total direct costs according to H2020 rule), audit costs (6000 €), computing costs (130.000 €). Concerning computing costs, to carry out 3 sensitivity experiments for WP2 together with their control experiment and accounting for the need to run 10 members of 6-month predictions initialized at 2 start months a year for 40 years for each experiment, BSC will run 6*10*0.5*2*40 = 2400 years of simulations. Each simulation year runs for 5.2hours on 502 processors (which give the optimal performance) so that it makes a total of 6.5 Million CPUhours accounting for failures and the need to test and repeat jobs. At a cost of 0.02 euros a CPUhour, that makes a total computing cost of 130.000 euros.

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CNR participates in the management and coordination WP (WP1) will therefore need 1 Person-Month (PM) for WP1.
CNR Co-leads WP2 on Sources of Predictability on seasonal to decadal timescales in the Mediterranean Region, leads Task 2.3 on teleconnection with mid-latitudes and is involved in Task 2.2. CNR will also take part in the set up and analyses of the coordinated sensitivity experiments, and therefore will need 49 PM for WP2.
CNR participates in WP3 on calibration, verification and information synthesis, specifically in Task 3.2, 3.3 (task leader) and 3.4. To support these activities CNR will need 39 PM for WP3.
CNR participates WP4 on climate services and will contribute to Task 4.2 on hydrological products. For

this task it will need 51 PM. Additionally, CNR is involved in Task 4.4 with 3PM. That makes a total of 53PM for this WP.
Travels are planned for 4 members of the MEDSCOPE to attend each of the two General Assemblies as well as 3 travels to international conferences related to climate prediction and services for 1 member of the team. That makes a total cost of 22,000 euros for travels.
Other costs (164.537 €) include: overheads (162.037 €, 25% of the total direct costs according to H2020 rule), audit costs (2500 €)

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AEMET leads WP4 on climate services as well as Task 4.2 on hydrology and participate in Task 4.1, 4.3 and 4.4 and therefore will need 45.5 PM
AEMET leads task 2.4 on development of empirical forecast systems and therefore will need 36 PM
AEMET participates in WP3 on calibration, verification and information synthesis and is involved in Task 3.1, 3.2 and 3.4 and therefore will need 32 PM
AEMET participates in WP1 on management and coordination and therefore will need 1.5 PM.
Travels are planned for 3 members of the MEDSCOPE to attend each of the two General Assemblies as well as 2 travels to international conferences related to climate prediction and services. That makes a total cost of 20,000 euros for travels.
Other costs include only overheads (120.000, 25% of the total direct costs according to H2020 rule)

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MF will contribute as a project partner to WP1, and requests 1 Person-Month (PM) for this WP.
MF co-leads WP2 on sources of predictability and is involved in Tasks 2.1 and 2.2, and will therefore need 19.5 Person-Months (PM) for WP2.
In WP3 on calibration, verification and information synthesis, MF leads Task 3.1 on bias correction and forecast calibration and is involved in Tasks 3.2 and 3.3; 17.5 PM are therefore requested for WP3.
MF is involved in all four tasks of WP4 on climate services and requests 23 PM for this work-package.
Travel and subsistence budget requested is 18000 € to cover for travel costs for the two MEDSCOPE project meetings for two participants as well as participation to international conferences on climate prediction and services in Europe.
Other costs include only overheads (125.996, 25% of the total direct costs according to H2020 rule)

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INRA participates in the WP1 management and coordination WP and will therefore need 2 Person-Month (PM) for WP1.
INRA participates in the WP3 (20 PM). It will apply tools developed in WP and develop the workflows to produce the data bases needed in WP4. INRA will give a feedback on the use of WP3 products. INRA will be in charge of WP4 data storage management.
INRA Co-leads WP4 on Sectoral Climate Services and leads Task 4.3 on Agricultural and Forestry Impacts.(80 PM). INRA will develop for agriculture and forestry. INRA contribution is in fact the aggregation of 4 sub-tasks with the development of:

- agroclimatic indicator over the mediterranean (20 PM);
- indicator on Water ressource and agricultural production at territory scale on pilot site (20 PM);
- indicator on forest production and health at territory scale on pilot site (20 PM);
- climatic indicator dedicated to forest fires over the mediterranean forest (20PM).

INRA contribution requires the contribution of several disciplines (agrometeorology, agronomy, forestry, crop and phenology modelling, IT computing, Data managing, etc.) and will mobilize scientists, computer engineers and technicians from 3 research Units (22 permanent PM for “US1116 AgroClim”, 14 permanent PM for UMR1114 EMMAH Environnement Méditerranéen et Modélisation des Agro-Hydrosystèmes » and 24 permanent PM for “UR0629 URFM Ecologie des Forêts Méditerranéennes”. In addition, 42 PM (postdoc and Computer engineer) will be necessary for the

indicators design and the implementation of the processing chains which will require developing complex workflows with multisource geographical data.
Total travel costs amout is 30.000 €. Travels are planned for 3 members of the MEDSCOPE to attend each of the two General Assemblies as well as 2 travels to international conferences related to climate prediction and services. That makes a total cost of 20,000 euros.
4000 € are allocated to invite stakeholders at general assemblies
Data acquisition in the pilot areas is important in order to evaluate the different indicators. Regular field trip are necessary to collect information (40 * 150= 6000€).
Equipment requests (18 000 €) include the renewal of 3 PC computers and the investment in a data storage system (100 TB disks) needed by the project.
Consumable requests (24000 €) cover measurement costs, software licenses, publication fees, communication documents and 14000€ for data acquisition participation on the pilot site (site maintenance, consumables, sensors renewable, …)
Other costs include only overheads (180.558, 25% of the total direct costs according to H2020 rule)

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RMI contributes as a project partner to WP1 and will therefore need 1 Person-Months (PM).
RMI contributes to Task 3.1 in WP3 (bias correction and forecast calibration) and requires 6 PM for that.
The RMI will participate to Task 3.2 in WP3 on statistical/stochastic downscaling and requests 3.5 PM.
The RMI leads Task 3.4 in WP3 on forecast combination and selection and needs 6MP.
The RMI takes part in WP4, Task 4.2 on hydrological products where post-processing will be applied to study floods and 8 PM are requested for that.
In line with the other partners, the RMI contributes to communication of the products (Task 4.4) and requests 1.5PM for that.

Other costs include only overheads (53.875, 25% of the total direct costs according to H2020 rule)

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**14. Suggested International Conferences**

Provide suggestions of **major** international conferences alongside which it would be appropriate to hold mid-term and end-of-term meetings

As part of the MEDSCOPE Climate Friendly Policy, the launch meeting as well as the mid-term and end-of-term project meetings will be held in correspondence with broad-spectrum international conferences, which already collect the participation of numerous project partners. This plan will minimise the project travelling costs and, more importantly, the project CO2 footprint. Furthermore, it will also provide the opportunity to disseminate the MEDSCOPE message and outcomes to a wide audience.

Besides, the user engagement workshops, where the results of the projects and the methods and tools developed will be presented, illustrated and discussed with a set of potential users, will also be organised to minimise the travelling costs and the environmental impacts and maximise their effectiveness. To this aim, MEDSCOPE will work in close coordination with the MedCOF to organise common and side events in correspondence with the MedCOF meetings.

In the following is a list of possible project meetings and stakeholder engagement workshops, scheduled in concurrence with important international meetings:

- MEDSCOPE launch meeting: EGU Assembly, April 2017 (in case this date will be too early, then EMS Assembly, September 2017);
- MEDSCOPE first user workshop engagement: MedCOF meeting November 2017;
- MEDSCOPE mid-term meeting: EMS Assembly, September 2018 (in case this date will be too early, then EGU Assembly, April 2018);
- MEDSCOPE second user workshop engagement: MedCOF meeting November 2018;
- MEDSCOPE third user workshop engagement: MedCOF meeting November 2019;
- MEDSCOPE end-term meeting: EGU Assembly, April 2020 (EMS Assembly, September 2020).