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Report on needs for climate services

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Authors: **Lars Bärring, Sylvie Joussaume, Erik Kjellström, Helena Martins, Erik van Slobbe**

Reviewers: **Martin Juckes Christian Pagé**

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Abstract

In the context of the emergence of climate services, this report on « *Needs for climate services* » emphasizes the links between the IS-ENES infrastructure and needs for climate services in Europe. It compiles the information collected regarding the needs for climate services in Europe from different workshops and explains what IS-ENES infrastructure can contribute to climate services and provides recommendations for future activities.

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Dissemination Level		
PU	Public	**X**
PP	Restricted to other programme participants including the Commission Services	
RE	Restricted to a group specified by the partners of the **IS-ENES2** project	
CO	Confidential, only for partners of the **IS-ENES2** project	

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Executive Summary

There is an increasing demand for translating the existing wealth of climate data and information into customised tools, products and information, also known as '**climate services'**. Climate services have the potential to build the bridge between Earth's climate system model output data, as supported in Europe by the IS-ENES infrastructure project, and decision makers, by helping the latter to take informed decisions in order to boost the transition to a climate-resilient and low-carbon society. This report aims at presenting the needs for climate information for climate services and discuss what the IS-ENES climate modelling research infrastructure can bring to climate services. It is based on a review of material from different workshops and projects.

This review confirms the importance for users to access model results concerning climate change projections under different scenarios. It also clearly shows that users are diverse and require a wide range of data, information and support in various forms. This leads to a strong demand on climate services to be able to provide the wealth of information required. Furthermore, the review shows that climate service providers need to develop the services in close collaboration with the users. This requires trans-disciplinary approaches such as co-design, co-production and co-evaluation. Their needs can be expressed in terms of metadata, post-processing tools, resolution and downscaling, interactions between experts and non-experts.

The IS-ENES expertise on disseminating climate model results through the international database the Earth System Grid Federation as well as its expertise in supporting the development of data and metadata standards and the development tools and guidance for the climate impact communities, is a strong asset for IS-ENES in the context of the development of the Copernicus Climate Change Service. The IS-ENES involvement in the CLIPC Copernicus precursor project has confirmed this.

1. Introduction

There is an increasing demand for translating the existing wealth of climate data and information into customised tools, products and information, also known as '**climate services'** (e.g. *Hewitt et al., 2012; Asrar et al., 2013*). Climate services have the potential to build the bridge between Earth's climate system model output data and decision makers, by helping the latter to take informed decisions in order to boost the transition to a climate-resilient and low-carbon society.

IS-ENES2 is the second phase project of the infrastructure of the European Network for Earth System modelling (ENES), gathering together the European community developing and exploiting climate models of the Earth system. One of the IS-ENE2's objectives is to facilitate the application of Earth System Models (ESM) simulations to better understand the climate change impacts on society. It aims to enhance the interaction between the climate modelling community, responsible for providing climate projections, and the community developing climate services. Its actions are complemented by the EU FP7 project CLIPC (Climate Information Platform for Copernicus), launched in November 2013, after the start of IS-ENES2 and expanding from IS-ENES2 to deliver an information portal for Copernicus Climate Change Service, gathering model data, observations and climate impact indicators.

This report on « *Needs for climate services* » emphasizes the links between the IS-ENES infrastructure and needs for climate services in Europe. It compiles the information collected regarding the needs for climate services in Europe from IS-ENES2 as well as from other sources of information, such as from other European FP7/H2020 projects (CLIPC, EUPORIAS), Copernicus Climate Change Service (C3S) and the Joint Programme Initiative on Climate (JPI Climate). It then explains what IS-ENES infrastructure can contribute to climate services and provide recommendations for future activities.

2. Review of needs of climate information for climate services

This review gathers information from workshops as well as work performed within IS-ENES2. It reports on needs for users with the objective to better understand the type of climate information needed for societal applications. In particular it strongly benefits from the CLIPC project.

2.1 IS-ENES2 & CLIPC Engagement Workshop at the Circle-2 Lisbon conference

An IS-ENES2 & CLIPC Engagement Workshop on *"Closing the gap between data providers and data users"* was held at the Circle-2 final conference in Lisbon, on the 10th of March 2014. Results are reported in the deliverable D5.2. We summarize here part of the outcomes of the former deliverable, to help to understand all the context of climate services and user needs.

Among the aims of the meeting were:

i) The discussion of user requirements to ensure that the climate information portals develop and communicate user-relevant climate data and information;

ii) The formulation of recommendations to IS-ENES2 and CLIPC for an integrated strategy for user consultation in the coming years.

The workshop was attended by a total of 20 participants from boundary organizations (consultants, national portals, environmental agencies), impact researchers and representatives from IS-ENES2 and CLIPC projects.

The discussion focused on three main issues: Data requirements, context of user needs and organisation of user communities.

The main conclusions resulting from the discussions can be summarized as:

1. **There is a need for climate data providers – users interfaces.** During the sessions several users expressed their interest in using climate services, but have found it difficult to: locate the right data; assess their importance; and assess the limitations of climate models. Users also expressed the need for:
    - Higher temporal and spatial resolution data as the current resolution is not sufficient to study impacts and adaptation strategies at the local level
    - Additional parameters, which are needed for specific studies (e.g. urban fluxes, ocean conditions)
2. The number of potential societal users and the variety of contexts, scale levels, challenges, etc. are too large for climate data providers to be able to cater to their specific needs. **A focus on boundary organisations** (Figure 1) (consultants, national portals, environmental agencies, and climate fora) **and/or specific users such as professional associations is crucial.**
3. Exchanges must be characterized by reciprocity; **both providers and users must learn and be ready to adapt practices**. So, organizing regular feedback on preliminary results is more important than identifying needs (the latter has already been done in so many other projects and workshops).
4. **Some methods to improve the provider - user interface were suggested**:
    - Develop storylines on use of climate data in specific decision-making contexts.
    - Approach professional organisations and establish a structural arrangement for exchanges on climate data.
    - Use professional facilitators to organize and supervise exchanges.
    - Establish test groups.
5. The key message of the sessions was the **need to create structural conditions for intensive engagement between users and providers of climate data**. This requires investments of time, money and effort.

2.2 EEA data needs and recommendations

This section addresses European Environmental Agency (EEA) data needs. The content of this section is taken from the results of a workshop held in Copenhagen on the 13th and 14th of May 2014, organised by the CLIPC project and the EEA (fully documented in IS-ENES2 Milestone M6.1 report). This workshop was initially meant to better define information required for the Climate4impact portal. It also clearly emphasizes EEA's needs for climate information.

In the context of climate change EEAs key interests are to

- Trace climate change itself – providing the general context
- Trace climate related hazards
- Assess the sensitivity of ecosystems
- Assess the effectiveness of climate risk management

This leads to demands on spatial coverage and resolution. The spatial coverage should be as wide as possible, and the resolution sufficiently high to identify relevant change at scales of interest. In addition indicators should be connected with relevant policies and meet the following criteria:

- Thematic and policy relevance
- Full geographic coverage of relevant variables
- Appropriate geographical aggregation
- Long time series
- Reliable data series
- Clear methodology

As far as possible, indicators should provide observations of historical development, projections for future development, and information on uncertainties. There is a need to reflect on the question of attribution to climate change in considering indicators. EEA also stresses the importance of narratives that are an integral part of the EEA indicators.

For the development of indicators, EEA sees a need to link with many expert communities and to consider users involved in country level risk assessments. For future work, it will be relevant to consider possibilities to expand the number of indicators and develop links to future Copernicus climate services. There is also ongoing development between the European Commission's science and knowledge service, the Joint Research Centre (JRC), and EEA to ensure consistent approaches in the production of indicators, including easier access to data.

EEA stresses the importance of user friendliness and opportunities for providing feedback. It is therefore important to identify users of climate model data. Earlier user needs workshops resulted in the recommendation to focus on boundary organizations and reciprocity, as emphasized also in section 2.1.

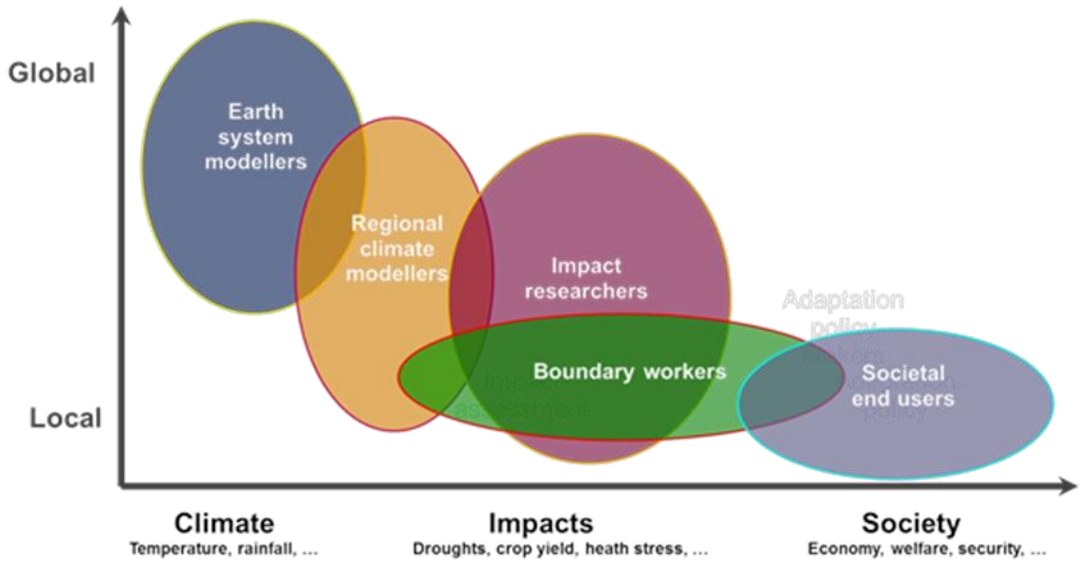

Figure 1 – From earth system modellers to end-users: categories of climate data users.

2.3 CLIPC analysis of user requirements

To get a detailed knowledge of user requirements the CLIPC project analysed experiences with user consultation and engagement, and users' data preferences developed in earlier and ongoing projects and initiatives. Eleven projects, networks and other initiatives were analysed in detail – IS-ENES 1, CLIMRUN, CLIMATE-adapt, JPI Climate, EUPORIAS, COST Action ES1102 VALUE, ToPDAd, CARePOL, IISD Understanding Needs Meeting Demands[1] - and 55 other projects and initiatives were scanned.

The lessons from the reviewed projects and initiatives with respect to user requirements and engagement strategies were reported in the CLIPC project – Deliverable D2.1[2] report and can be summarized as follows:

Lessons learnt from user engagement:

- Users of climate services have to be grouped into distinct categories since a one-size fits all strategy is bound to fail.
- For a good exchange of information and knowledge, it is vital that the information providers understand the concerns, specific questions and goals of the different users.
- Regular contact with users through projects and meetings is important, and therefore the identification of user requirements should be seen as an iterative process.
- One way of improving the communication of climate and climate impact data to intermediary organisations or societal end users is the development of storylines linking basic climate data with information about impacts and their relevance to decision-making challenges.

Lessons learnt from user data requirements:

- Climate scientists and climate impact researchers generally have a high level of knowledge about climate change and the possibilities and limitations of climate data. These user categories make use of climate variables, for different time horizons, using a generic set of climate scenarios or tailored/extreme climate scenarios, usually comparing those with a baseline/reference period. Impact researchers also require data/information for impacts such as impacts on hydrology, ecosystems, agriculture and health. For climate impact researchers (and societal end users) it is relevant to provide information in the form of processed data (climate indices). Spatially explicit information (maps) and first order delta indices are also particularly relevant. In addition, to better respond to the needs of the impacts community, simple post-processing tools should be developed and made available and accompanied by guidance on how to use and interpret the information with proper account of uncertainties and data limitations.
- Societal end users may be more interested in information about extremes, maps or graphs that clearly illustrate climate trends and projected change, including information on recent extremes that have had large socio-economic impacts. Extreme events are important to the society, which implies the need of statistics on heavy rainfall, high temperature, heat waves, droughts, flood events and hailstorms.

[1] A user-oriented analysis of online knowledge brokering platforms for climate change and development, May 2013 https://www.iisd.org/sites/default/files/publications/understanding_needs_platforms.pdf

[2] w3id.org/clipc/docs/D2.1

- Story lines appear to be useful for societal end users. These storylines are related to observed climate trends and projected changes and include information about impacts on biophysical systems and socio-economic sectors. Societal end users may also need additional data such as land cover data, elevation, socio-economic data, and emissions (including scenarios for the future).
- Users from different sectors require different data and information, and have different capacities to access and use the available information, knowledge and data. For example, some users in the energy industry want to know about aerosol variability, cloudiness, radiation, and wind; the fire weather index is an important indicator for the risk of wild fires, and hence important to the civil protection agencies.
- Temporal and spatial resolution: Interest has been expressed in historical weather statistics and climate on time horizons of 1, 2, 10, 30 up to 50 years; for the future, the time horizons mentioned have included 1, 2, 5, 10, 30 years. In addition, there has been a demand for seasonal scales. For weather impacts of heat waves, floods and wind damages, regional scales are regarded as sufficient. The COST-VALUE white paper notes a range of spatial scales demanded by the end user: from local scale (100m x 100m) to regional scales (20km x 20km).
- Meta-data –uncertainty. ESGF has made some efforts in building up a meta-data-base on methods, but not on data, validation, skill score, and results. Tagging the data in a standard fashion will make them well documented and traceable. This labelling is relevant for climate information providers, climate scenario users, and decision makers. It is a risk that climate data will be used in a not-well informed way, possibly leading to bad decisions with potential legal consequences, which justifies the transparent provision and explanation of associated meta-data.
- Users require information about uncertainty (e.g., types of uncertainty included, quantification of uncertainties and/or qualitative information, etc.), information on biases in the data and on robustness. Some of the issues around the communication of uncertainty where explored further in a dedicated workshop jointly organised by several European projects (Otto et al., 2016).

2.4 Summary

This review confirms the importance for users to access model results concerning climate change projections under different scenarios. It also clearly shows that users are diverse and require a wide range of data, information and support in various forms. This leads to a strong demand on climate services to be able to provide the wealth of information required. Furthermore, the review shows that climate service providers need to develop the services in close collaboration with the users. This requires transdisciplinary approaches such as co-design, co-production and co-evaluation (*Street, 2016*). User needs in terms of infrastructure providing climate Earth system model output can be summarized as needs for:

Meta-data

Climate data need to be tagged in a standard fashion that makes them traceable and allows users to assess importance and limitations. A more unified and standard metadata system allows users of climate services to: benefit from automated systems that can properly perform data processing; enable users to use the data in combination with data from other scientific domains; provide proper provenance information (definition of information, methods and software used to create information…); perform better automated quality checks.

A unified system is difficult to accomplish, but the need is high. Without such a system low quality or wrong data risk to be used leading to faulty outcomes and eventually to substandard policy advises or bad decisions.

Post-processing tools

Post-processing tools like: visualizations of climate models and scenarios, indices calculations, sub-setting and re-gridding are needed for tailoring data to the needs of specific users[3]. These should be accompanied by guidance on how to use and interpret the information with proper account of uncertainties and data limitations.

Special attention is needed for information about extremes, maps or graphs that clearly illustrate climate trends and projected change, including information on recent extremes that have had large socio-economic impacts (see also e.g. *van den Hurk et al., 2016*). A new method to allow non-experts to assess extreme events is identification and presentation of analogue events (for instance a year with an extreme drought, or a severe flood event).

Resolution, downscaling and bias correction

Policy makers and businesses usually require local or sub-regional information at higher temporal and spatial resolution than current global and regional climate models are able to provide. The background to these requirements is twofold; the need to have climate and climate change information at the scale relevant for important impact processes, and the perception that more local information is more accurate. Substantial research and development efforts, both within the global and regional modelling communities are ongoing to meet these requirements, and dedicated work-packages within IS-ENES2 are tell-tale signs of these efforts. Meanwhile, users' demand of high-resolution information requires downscaled data.

Typically, such downscaled data is produced either by statistical downscaling of global models data or through dynamical downscaling by means of regional climate models in combination with further downscaling by statistical methods. However, all downscaling methods add another layer of complication. For statistical downscaling of global model data, or further downscaling of regional model data, there are a number of alternative methods one can select depending on the region and intended application, and there is no universally best method. Moreover, this kind of statistical methods typically requires an observational reference dataset for calibration. Even for the most common variables, temperature and precipitation, suitable reference datasets covering all of Europe are still not available at the spatial and temporal resolutions impact modellers and other users need. This will likely change when various C3S reanalysis products become available within few years.

There are several more technical complications with downscaled climate information for which the state-of-the art solution is to take an ensemble approach, i.e. to make use of climate scenarios from many global/regional climate models and apply alternative statistical downscaling methods to each of the scenarios to reach the desired resolution. And then, to combine all this information in the final analysis stage. In this way, the robustness of the information can be assessed. This however imposes a substantial additional burden in terms of data handling and processing capacity that needs to be met by user-friendly interface to the data processing and archiving infrastructure.

Another aspect is that users' requirement for high-resolution data continue to spur substantial research efforts on methods and tools for downscaling (statistical and dynamical).

[3] See for example Climate4Impact web portal and platform

As climate model results do not exactly match the observed climate, as well as to better account for scale mismatches between models and observations, some users may need bias-corrected data. Bias-correction implies that the output from the climate models is adjusted so that it becomes closer to the observations for current climate. As the statistical downscaling methods require a reference dataset typically based on observations, application of such methods produces bias-corrected climate data.

Expert – non expert interactions

All studies on user needs, without exception, stress the need for improved functionality of data information systems for interactions. Modern day portals do pay much attention to user-friendly presentations (e.g. *Sigel et al., 2016*). One of many methods to improve user-friendliness is the presentation of 'storylines', usually case descriptions, being used as examples for situations the users are expected to be in.

But notwithstanding these efforts surveys consistently ask for more possibilities for provider-user interfaces, and this will have consequences for the data provision infrastructures. Information systems researchers do see a shift from first generation systems towards the emergence of a second generation. The first is characterized by science driven design, where users are seen as 'consumers' and the second is user driven, where both science and users influence content and presentation. There are no examples yet of second generation climate data portals, but there is a clear need to innovate in feedback mechanisms. In the European Commission Roadmap on Climate Services (EC, 2015) it is clearly indicated that "**the services preferably should be user-driven and science informed**".

In practice, the requests for climate services have to be a two-way exchange: climate information has to be provided to users, but also users will influence the development of climate services and the underpinning research by defining their needs. Indeed, the climate science community finds itself increasingly exposed to various groups of stakeholders asking specific questions about consequences, uncertainties and probabilities related to climate change.

3. IS-ENES2 contribution to support Climate Service's Needs

IS-ENES is the European research infrastructure for climate modelling. It has been supported by the FP7 program, through two integrated activities projects (IS-ENES, 2009-2013 and IS-ENES2, 2013-2016). IS-ENES supports the European contribution to the international coordinated numerical experiments from WCRP, the Coupled Model Intercomparison Project (CMIP, http://cmip-pcmdi.llnl.gov/) and the Coordinated Regional climate Downscaling Experiments (CORDEX, http://www.cordex.org/). IS-ENES supports the distribution of model results through the international database Earth System Grid Federation (ESGF) from The European climate modelling groups contributing to CMIP (Phase 5) and CORDEX. These experiments serve as a reference for climate research but also for impact studies and policy assessments such as the IPCC Assessment Reports. As emphasized in its Infrastructure strategy document (*Mitchell et al., 2012*), IS-ENES does not aim at providing a climate service to users but rather at providing information that can be used by climate services. From the 2015 European Roadmap on Climate Services (EC, 2015), climate model results from internationally coordinated experiments are recognised as part of the overall challenge of developing tailored climate information for society within the climate services (Figure 2).

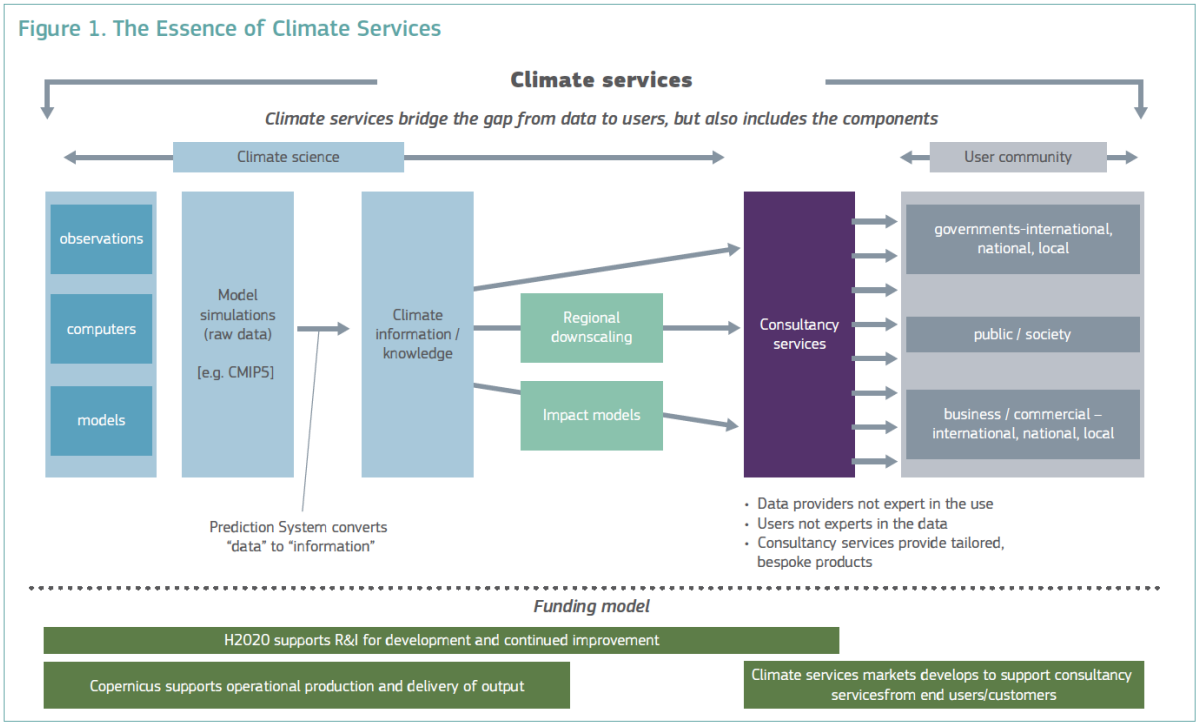

Figure 2: the essence of climate services illustrating how climate services bridge the gap from data (observations and models) to users (from EC, 2015).

3.1 Access to projections through ESGF

The Earth System Grid Federation (ESGF; http://esgf.org/) is an international collaboration for the software that powers most global climate change research, notably assessments by the Intergovernmental Panel on Climate Change (IPCC). ESGF manages the first-ever decentralized database for handling climate science data, with multiple petabytes of data at dozens of federated sites worldwide. It is recognized as the leading infrastructure for the management and access of large distributed data volumes for climate change research. It supports the distribution of model results from CMIP and CORDEX, whose protocols, organised by the World Climate Research Program (WCRP), enable the periodic assessments carried out by the IPCC (e.g. IPCC, 2013) and also more detailed assessments focussing on limited regions like the Baltic Sea region (BACCII, 2015) and the North Sea region (NOSCCA, 2016). These experiments provide a unique base for model evaluation, process understanding and future projections/predictions.

IS-ENES2 supports the European contribution to the development, deployment and maintenance of software for ESGF. IS-ENES2 provides a service to users of model data as well as a service to data providers. ESGF can be accessed by all type of users and most of the model simulations results are available even for commercial use. However, in order to be more easily usable, it requires some additional tools such as those developed within the climate4impact platform (see 3.2).

Bias-corrected data is made available to users in a similar way as climate model output via ESGF and such activities are ongoing within Euro-CORDEX. IS-ENES2 supports the implementation of Euro-CORDEX results in the international ESGF database.

ESGF is complemented by meta-data information on models through the Earth System Documentation (ES-DOC) international project, also supported in Europe by IS-ENES2. As for climate model data, also bias-corrected data made available via ESGF need meta-data information, not just on models but also on bias-correction methods and what observations that have been used in the process of adjusting climate model data.

3.2 Climate4impact portal

IS-ENES climate4impact platform aims to support climate change impact modellers, impact and adaptation consultants, as well as anyone else wanting to use climate change data. It offers access to data and visualizations of global climate models (GCM), regional climate models (RCM) and downscaled high-resolution climate data. Data transformation tools such as indices calculations, downscaling, sub-setting and re-gridding, are provided for tailoring data to different user needs. Guidance on how to use climate scenarios, how the climate models simulate the complex climate system, are provided as well as example use cases in several impact and adaptation themes (*Deandreis et al., 2014*). The climate4impact platform is using data stored on the ESGF.

Currently more than 500 000 datasets are available from the portal, which users can browse through using available filters, such as “project”, “model” or “domain”. Climate4impact allows the user to view the data in the form of maps or more analytical plots before actually downloading the data, helping in selection of the data subsets and therefore considerably reducing the amount of data to transfer. Statistical downscaling is available to the climate4impact platform users, through access to statistically downscaled CMIP5 experiments. The users can dynamically generate these datasets.

The climate4impact platform adds a layer to ESGF that eases the access and use of climate model results for a larger community. It illustrates the types of service required for climate services. The climate4impact platform exposes its capabilities through standard services Application Programming Interfaces (APIs) that have been developed within the CLIPC project. The climate4impact platform capabilities have been used and expanded within the CLIPC project to support its portal services as a central tool for users not experts on climate models.

3.3 IS-ENES and Copernicus C3S

IS-ENES service on data through ESGF answers the need to access model data projections. The climate4impact platform complements this access by adding additional tools and services such as extraction, visualisation, as well as downscaling and bias corrections.

Over the last years, the Copernicus Climate Change Service has been launched, under the responsibility of ECMWF. It aims at providing a climate service for Europe targeting European policy and EEA. It will deliver access to satellite data, reanalyses, seasonal forecasts as well as climate projections.

During its definition phase, several partners of IS-ENES2 have contributed to the scoping of its contour. The workshop on the Climate Data Store (CDS) (Figure 3) on March 3-6, 2015 has been an opportunity to present IS-ENES2, its role and expertise on ESGF, as well as the Climate4impact portal. The workshop on global projections in April 20-21, 2015 was an opportunity to further discuss climate model projections, their strengths and weaknesses.

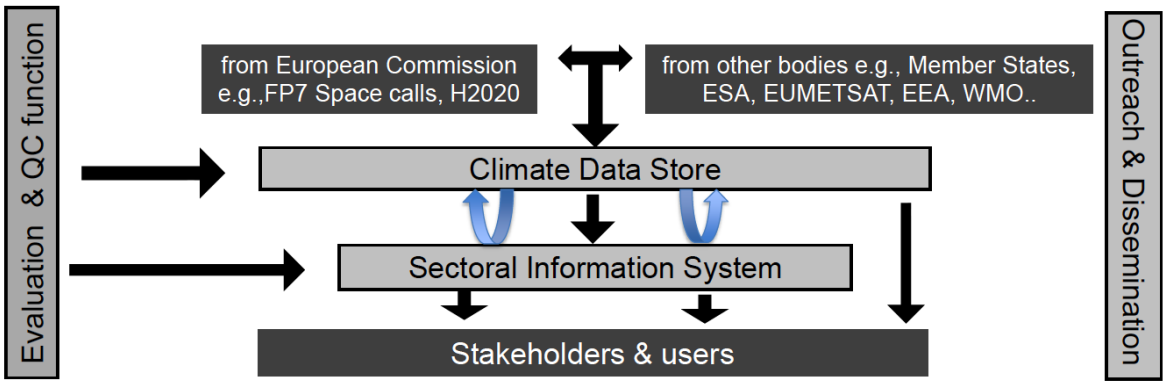

Figure 3: Organisation of the Copernicus Climate Change Service developed under ECMWF

Concerning the access to projections, C3S has decided to broker on ESGF to benefit from all the European and international development. Contributions of IS-ENES to the scoping workshops as well as the CLIPC have most probably been quite instrumental in that decision. This is a strong added value to IS-ENES as it will expand the range of users accessing projections. A call for tender on accessing global projections from CMIP5 was launched at the end of 2015. Lot 1 concerns building an ESGF node for the CDS and is developed under the project "*Climate Projections for the Climate Data Store*", CP4CDS, by a consortium led by STFC with DKRZ and CNRS, based on the expertise from IS-ENES. A consortium led by IPSL has also recently answered the call for tender on accessing regional climate projections based on brokering on ESGF for regional climate model results as well.

4. Conclusions and recommendations

The review clearly emphasizes the importance for a range of users to access climate model projections. It also emphasizes needs for higher spatial resolution as well as access to tools and easy computations of indices and calls for tailored information elaborated in co-construction between experts and users. IS-ENES is the research infrastructure for climate modelling in Europe. It aims at supporting climate science. It does not aim at providing a climate service to users but rather at providing information that can be used by climate services.

The new Copernicus service on climate change, C3S, is a strong opportunity to strengthen the development of common climate services for Europe. It will ease access to model results, projections and seasonal forecasts, develop sectorial information as well as provide access to observations and reanalyses. Its decision to broker on ESGF is a strong added value to IS-ENES as a downstream service from IS-ENES research infrastructure. C3S will benefit from a sustained infrastructure for climate modelling in Europe.

This review clearly emphasizes:

- The importance to further develop the collaboration between the Copernicus Climate Change service and IS-ENES.
- The importance for IS-ENES to sustain its European contribution to the international database for the WCRP coordinated experiments.
- The strong opportunity offered by C3S to develop downstream services for IS-ENES research infrastructure

- The importance for users of the additional services to ESGF brought by the Climate4impact portal, that go in the direction of user requirements. How it will be sustained and will have to evolve with C3S will have to be investigated.
- The need for guidance of users, which could be further developed within IS-ENES, as for example shown through the prototype master classes.

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6. Acronyms

Copernicus: The European Earth observation programme Copernicus, previously known as GMES (Global Monitoring for Environment and Security), provides environmental information (http://www.copernicus.eu)

C3S: Copernicus Climate Change Service (https://climate.copernicus.eu/)

CDS: Climate Data Store of the Copernicus Climate Change Service

CLIM-RUN: FP7 project on climate services "Climate Local Information for the Mediterranean region Responding to User Needs" (http://www.climrun.eu/) targets the energy and tourism sector in the Mediterranean region. It is led by ENEA in Italy.

CMIP5: Coupled Model Intercomparison Project Phase 5, under the auspices of WCRP to prepare IPCC AR5 (http://cmip-pcmdi.llnl.gov/cmip5/)

CLIMATE-adapt: European climate adaptation platform developed by EEA to share information on adaptation in Europe (http://climate-adapt.eea.europa.eu/).

CLIPC: FP7 project "Climate Information Portal for Copernicus " (2013-2016) **(**http://www.clipc.eu/)

COST-ACTION VALUE: COST project (2012-2015) on validating and Integrating Downscaling Methods for Climate Change Research (http://www.value-cost.eu/)

EC: European Commission

EEA: European Environment Agency (http://www.eea.europa.eu)

ENES: European Network for Earth System Modelling (http://www.enes.org) - A consortium of European institutions aiming at helping the development of use of ESMs for climate and Earth System studies.

ESGF: Earth System Grid Federation is an international collaboration with a current focus on serving the WCRP CMIP project and supporting climate and environmental science in general.

ESM: Earth system model representing the Earth's climate system complexity

EUPORIAS: H2020 European project **"**European Provision Of Regional Impacts Assessments on Seasonal and Decadal Timescales » (http:// http://www.euporias.eu/)

GCM: Global climate model

IISD: International Institute for Sustainable Development.

IS-ENES (or IS-ENES1): InfraStructure for the European Network for Earth System Modelling, first phase; FP7 project (http://is.enes.org)

JPI Climate: Joint Programming Initiative "Connecting Climate Knowledge for Europe" (JPI Climate) (http://www.jpi-climate.eu/).

RCM: Regional climate model

ToPDAd: FP7 EC project "Tool supported policy development for regional adaptation" (http://www.topdad.eu/