IS-ENES3 Milestone M2.2
Innovation Plan
Reporting period: 01/01/2019 – 30/06/2020

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ABSTRACT

The IS-ENES3 Innovation Plan is a short report summarising the development of a shared project-wide approach to innovation and reporting on cross-disciplinary fertilisations and a wider sharing of information, knowledge and technologies across fields and between academia and industry.

1} Introduction

1.1} Why have an Innovation Virtual Work-package

M2.2 (Task 2, mo12): Innovation Plan. Short report summarising the development of a shared project-wide approach to innovation and reporting on cross-disciplinary fertilisations and a wider sharing of information, knowledge and technologies across fields and between academia and industry (UKRI).

"Valleys of Death are defined as the period of transition when a developing technology, while perceived as promising, is unable to attract funding for its continued development (Auerswald and Branscomb 2003)."

The broad aim of the Innovation Work package is to ensure that successful technological developments in IS-ENES3 to not become stranded in what has become known as the "valley of death" by being too mature for further research funding but still lacking the ability to become established and exploited to deliver societal benefit.

Figure 1: From Kureha, The Art of Manufacturing: illustrating the difficult and long pathway between successful research and successful commercial exploitation.
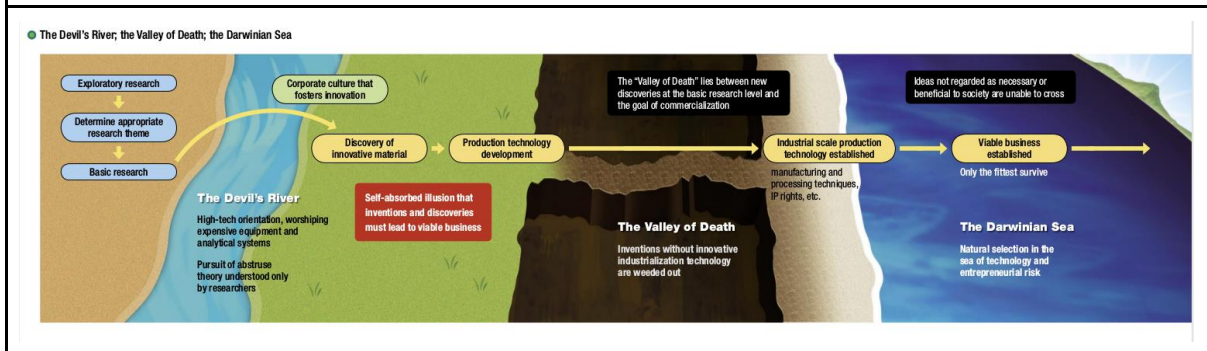
1.2} What is Innovation?

Innovation is at the heart of the H2020 programme, which is defined as a "research and innovation" framework.

What others say

The IPR Helpdesk project defines innovation as "*The successful exploitation of new creations, which when used produce tangible benefits, satisfying needs and wants*" (IPR Helpdesk, 2015). They contrast with "impact" (defined as "*The extent of the benefits derived from the innovation*") and "invention" (the act of creating a new concept or product). Invention can lead to innovation if there is a suitable process of exploitation of the new idea or concept.

Alternative formulations come from DG AGRI[1]: innovation is "an idea put into practice with success" and "Innovation may be technological, but also non-technological, organisational or social. Innovation may be based on new but also on traditional practices in a new geographical or environmental context. The new idea can be a new product, practice, service, production process or a new way of organising things, etc." (DG AGRI, 2014).

Finally the European Central Bank (ECB, 2017): Innovation "*describes the development and application of ideas and technologies that improve goods and services or make their production more efficient.*"

There are many projects that associate innovation with the commercialisation of research outputs, but the quotes above indicate a broader interpretation looking at the transition between research and delivery of societal benefit which could be expressed through commercial use or through provision of services.

Metrics of Innovation

Innovation is a difficult quantity to measure. The survey results indicate a broad range of activities, some targeting individuals others directed at institutions of varying sizes. The definition given in the previous section explicitly states the innovation "does not depend on quantification".

Subjective ranking of innovation activities clearly possible, but difficult to achieve objectively across the broad range of activities involved here. It may be possible to assess activities on a number of independent dimensions through a set of Innovation Key Performance Indicators (IKPI): e.g.

(1) Number of people reached (estimated and provided in size categories);
(2) Number of commercial organizations exploiting the product (count of SMEs, medium enterprises and large enterprise);
(3) Criticality: is the product playing a critical role in a non-research activity, or is it a peripheral contribution (this might be difficult to quantify)?

This concept will be discussed further at the IS-ENES3 2020 General Assembly.

1.3} Innovation Support in IS-ENES3

The Innovation Virtual Work Package

The objective of the Innovation Virtual Work Package in IS-ENES3 is to document and promote activities that bring ideas into productive service. The scope of this activity is best described by looking at it in the context of other activities in the project. The virtual work package is resourced through WP2/NA1 Task 2 of tne IS-ENES3 work programme.

Research: Exploring new ideas has a relatively low profile in IS-ENES3: the project will primarily work with ideas which have already been investigated to a significant extent in national or institutional research programmes.

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[1] EC DIRECTORATE-GENERAL for Agriculture and Rural Development

Development: after creative work has been done, there may be some further hard work needed to convert the bright ideas into a working system, and possibly evaluate them against alternatives in a realistic setting. This class of activity is covered by the JRA work packages of IS-ENES3.

Innovation: Putting new ideas into use to deliver real societal benefits, including, but not limited to, commercial activity. This goes beyond proof-of-concept work, but does not depend on quantification of the impact.

Impact: when a product or service is delivering consistent societal benefits we can talk about impact. Impact will generally take time to accumulate after the end of a project.

This innovation plan is an initiative of the consortium, not a requirement coming from the commission. The Commission does require innovation reports for "Leadership in Enabling and Industrial Technologies (LEIT), Societal Challenges and Innovation in SMEs projects", and there is guidance available expressing specific requirements for those reports. We have taken some structure from those requirements, but adapted it to fit the nature of our project, particularly our role in developing informatics tools and services to support climate modelling and the distribution of climate model data.

Innovation on HPC, Models and Tools

WP4/NA3, Networking on Models, Tools and efficient use of HPC, has a specific deliverable related to innovation, backed up by resources and an activity description in Task 6 "Innovating with software and HPC industry":

D4.5 (Task 3, 4 and 6, mo 44): White paper on innovation on tools, platforms and techniques.
A white paper consolidating the finding within the Innovation task highlighting the opportunities within the market to exploit climate science (Task 6) and the opportunities for climate science to exploit new technologies focusing on software and HPC (Task 4 & Task 3) (UNIMAN).

Innovation Team

The work of the Innovation Virtual Work Package is backed by a support team discussing issues through the `vwp-innovation` Slack channel and online meetings. This group covers all the project Work Packages:

IS-ENES3 Work Package	Contact Point(s)
WP2/NA1 Governance, Sustainability and Innovation	Sylvie Joussaume, IPSL; Bryan Lawrence, NCAS

WP3/NA2 Community engagement	Janette Bessembinder, KNMI
WP4/NA3 Networking on Models, Tools and efficient use of HPC	Graham Riley, UNIMAN
WP5/NA4 Networking on data and model evaluation	Christian Pagé, CERFACS, Sandro Fiore (CMCC)
WP6/SA1, WP7/SA2 (Services)	See note 1
WP8/JRA1 Models & Tools developments	Graham Riley, UNIMAN
WP9/JRA2 Earth System Model Evaluation developments	See note 2
WP10/JRA3 ENES Climate Data Infrastructure software stack developments	Christian Pagé, CERFACS, Sandro Fiore (CMCC)

1. The decision was taken, when the team was set up, that it was not necessary to have representatives from the service activities. This decision should be reviewed.
2. The research activities on models, HPC and tools are partially covered in Task 6 of WP4/NA3 (see previous sub-section), but this should be reviewed. See also comments on ESMVal in the Discussion section.

2} Innovation Survey

A survey of IS-ENES3 was conducted to gain an initial picture of ongoing innovation activities within the project (including activities partially only funded by the project). More details on the process of gathering information are given in Appendix A.

The survey asked for information on innovation activities from each project partner.

There is a range of maturity in the innovation concepts listed. Some of them involve active collaboration with or provision of services to users outside the research community, others refer to potential for developing activities within the IS-ENES3 project.

The survey asked for the Work Package and Task associated with each innovation activity, but did not ask about deliverables. This information would be useful and should be gathered in future iterations.

The survey results are summarised below, full details of the responses are in bit.ly/isenes3-inov-scoping-responses.

2.1} Categories

Respondents were asked to assign innovation categories as defined in the H2020 reporting guidance on innovation.

* Product: Good or service introduced to the market or to the company/organisation that is new or significantly improved in its capabilities, usability, components or sub-systems. Goods include packaged & downloadable software/music/film.
* Process: Production process, distribution method or supporting activity that was implemented within an organisation.
* Method: Organisational method or marketing concept/strategy in business/organisational practices (including knowledge management). Could be either and organisational method - covers workplace organisation or external relations not previously used by your enterprise/organisation - or marketing method - significant changes in product design or packaging, product placement, product promotion or pricing that have not been used before.

The method category was split into "organisational" and "scientific or technological" sub-categories.

The majority of responses (71%) were in the "product" category, with a wide range of software products and web services.
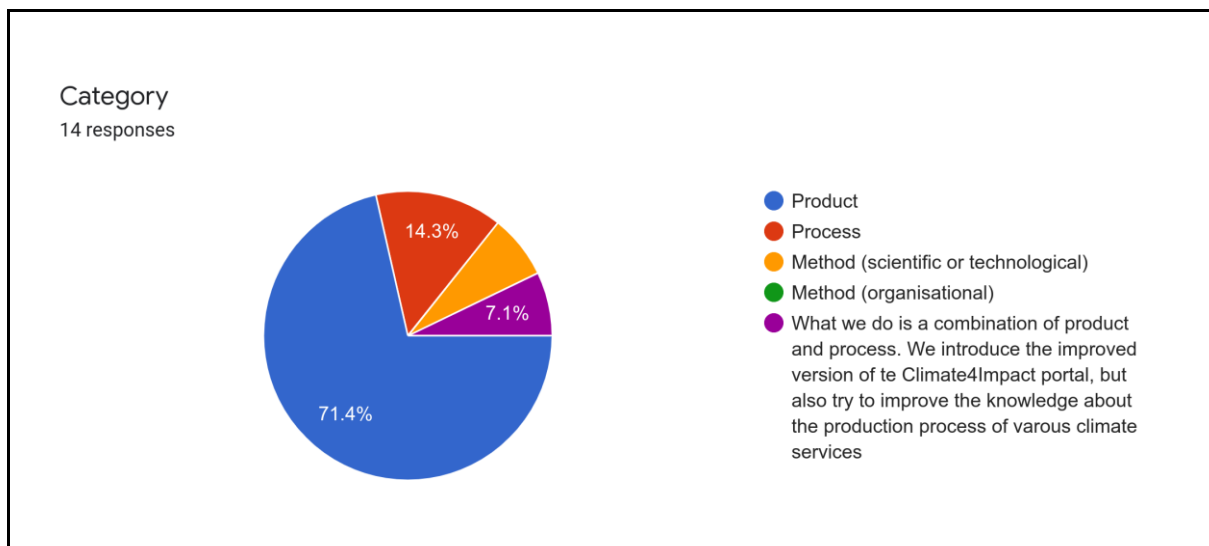

Figure 2: Categories of response in the initial scoping survey. One respondent could not identify a category from the offered list, others reported uncertainty in their choice.

2.2} Survey Responses

This section lists the title and description of each innovation activity, together with the project task number, the lead partner, and the category. In some cases there is a question or

comment to be addressed given in a box after the activity description. These questions and comments will be addressed during discussions at the 2020 IS-ENES3 General Assembly.

Data Request Schema 2.0 [Task 10.6, UKRI, product]

The data request schema 2.0 (M10.2, month 18) will define the ontology for file meta-data specifications. This will be exploited in the CMIP7 requirements capture phase and used by modeling groups submitting data to CMIP7. The Schema will be defined in WP10, and supported in SA2. Innovation will be achieved by working with the WIP and other ESGF partners to ensure that the Data Request Schema is adopted for CMIP7.

Summer schools and training activities [Task 3.2, KNMI, Activity]

The summer school and training activities within our WP are trying to get the tools developed within the IS-ENES projects (e.g. the C4I portal) known to a broader audience. This way we hope that they will be used by more people and that this will lead to new climate services products. We focus especially on young impact researchers and people working for climate services providers (also commercial ones), although climate researchers are also welcome. We also pay special attention to reaching these target groups in eastern European countries.

> Comment: Some more information would be needed in order to get a measure of the innovation dimension of this activity. A survey of the non-research trainees would be useful, with some questions about the domain in which the knowledge acquired will be put to use, and the degree of relevance to their work (e.g. "very useful", "useful", …. "not relevant").

Climate information services [WEnR, Task 3.1; product]

Businesses and governments are increasingly aware of just how vulnerable our economies are to the impacts of climate change. The financial sector needs to factor in climate risks to be able to identify opportunities to reduce the financial impacts of climate change. Climate information services provide improved indicators and metrics to help investors better manage physical climate risks. Wageningen Environmental Research (WEnR) offers user-driven climate services for awareness-raising, risk and opportunity assessment, and complements climate information with knowledge on adaptation strategies for business. Our core expertise lies in the agri-food and financial sectors. Specific needs raised by different financial actors include a need to explore existing tools and datasets for climate risk assessment, with a specific emphasis on incorporating future climate scenarios (e.g. mid-century, for different climate scenarios).

> Question: is IS-ENES3 supporting the development of the service or the operation of the service?

Python bindings for OASIS3 [Task 8.4, UKRI, product]

This activity will produce Python bindings for OASIS3. OASIS3 is widely used by the major Weather and Climate Centres to couple existing Fortran models (such as Atmosphere and Ocean models) together to form a more complex Coupled Model. Python is a widely used language that arguably gives better support for more interactive development of models as well as providing links to many other support libraries. By providing Python bindings to OASIS3 we will open up the power of OASIS3 to communities that are developing, or wish to develop, their codes in Python. It is hoped that this work will help the smaller research centres, students and communities outside of Weather and Climate (such as Integrated Assessment) be able to make use of OASIS3 and where appropriate, couple their models with existing complex models used by the major Weather and Climate Centres.

> Question: although OASIS3 clearly has heavy usage outside the research community, is there a clear usage for the Python bindings in an operational centre?

Cylc development and support [Task 8.5, MetO, product]

Cylc [cylc] is a workflow engine specifically designed for activities that cycle through iterations (possibly indefinitely). Cylc manages the dependencies between suites of tasks and is configured by human-readable text control files. It is suitable for real time, production environments. Examples of pathways to impact in our community is that Cycl can manage the workflows of the complex production environments required to underpin real-time operational activities, such as seasonal and decadal forecasting systems and production activities such as CMIP which can then be exploited for the benefit of society. It should be noted that Cylc is in no way limited to climate and weather uses, it can be used for any workflow.

ALTAIR have an interest in this work.

> Question: what is the contribution of IS-ENES3 to Cylc development and/or deployment?

Earth System Documentation (ES-DOC) [Task 10.5, UREAD-NCAS, product]

Maintain and develop the ES-DOC international documentation infrastructure to support CMIP6 and other MIPs as well as expand the scope of documentation to new areas for the climate modelling process, including model evaluation

The ES-DOC model-process documentation infrastructure is a software ecosystem (pyesdoc [pyesdoc]) built on a data mode (CIM2) of the complete, end-to-end modelling process. As all documentation conforms to the same data model, documentation for a given project can be delivered to the consumers, with powerful search and compare tools to fully make use of the resources.

Climate Impacts Support [WP10, CERFACS, product]

climate4impact and icclim

The climate4impact platform provides service and software already used by impact modelers, companies, SMEs, expert teams, to assess climate change impacts. The icclim software provides the capability to calculate climate indices using python, and it is a very popular package on github and we have many external users. Climate indices can be used to assess present and future climate impacts. To support icclim in standard automated environments, new standards have been developed and lead by IS-ENES to support climate indices, and those standards are essential to integrate those services in large infrastructures and to enhance data sharing.

> Question: as for the training activity, it would be useful to know a bit about the non-research users: what is the domain in which they are exploiting climate4impact and how important is it to them?

Presentation of CORDEX data usage/download statistics [SMHI, Process]

Download statistics collected by the ESGF Dashboard system (developed by CMCC) will be presented at the central www.cordex.org website. Such statistics, divided per dataset, variable type, region etc. is regularly requested by WCRP in its capacity as governance body for CORDEX, various country and regional entities, as well as representatives related to the IPCC process. This Innovation Activity will expedite timely dissemination of up-to-date statistics to help external actors' understanding of how CORDEX data is put to use in their country/region.

> Question: is the innovation component the compiled and published dataset containing the statistics (which would be in the "product" category) or the process of compiling the statistics? It was labelled as "process" in the survey response. We need to distinguish between where the effort goes (which is probably in developing the processes) and the part which has a clear innovation potential (which, I think, would be the compiled statistics in this case).

Metadata standard and tools for climate indices [SMHI, WP10, product]

Climate indices aim at describing aspects and features of the climate and climate changes that directly focus on user needs in various key sectors of society. As such they are produced by many different actors using a variety of common or proprietary software. Currently, this regularly results in that datasets are not compatible and easy to combine and compare. This Innovation Activity provides a common framework (the metadata standard) and the basic software tools for interacting with this framework to harmonise climate indices datasets from different actors and produced by different software.

Web processing service [DKRZ, Task 10.2, product]

The Birdhouse open source framework (https://bird-house.github.io/) will be used to provide and support web processing service deployments at IS-ENES partner sites (especially DKRZ, CMCC, IPSL and CEDA). As part of the IS-ENES3 project this processing services will be deployed and integrated into the IS-ENES Climate Data Infrastructure (CDI). One important client of these services will be the Climate4Impact portal.

Compute and analytics software for single/multi-sector downstream services [CMCC, Task 10.2, product]

The innovation idea would be to exploit compute service software developed in IS-ENES3 to support downstream services across different sectors. The societal benefit would directly relate to the added-value products (output) produced by the downstream services which could be of interest for (exploited by) different stakeholders.
IS-ENES3 could help extending the compute service software developed at CMCC (Ophidia) to tackle more operational and production-level, single/multi sector downstream services.

> Question: will it be possible to pass from "interest for … stakeholders" to "being used by stakeholders" in the next 2-3 years? For "innovation" we, ideally, want to demonstrate that something is being used by stakeholders.

Machine learning findings [CMCC, Task 4.4, method]

Re-use of guidelines and technical outcomes from the IS-ENES3 WP4 reporting (D4.5) for the development of components like Decision Support System (relying on ML algorithms) to be exploited by stakeholders (e.g. Civil Protection).

> Question: will it be possible to pass from "interest for … stakeholders" to "being used by stakeholders" in the next 2-3 years? For "innovation" we, ideally, want to demonstrate that something is being used by stakeholders.

Access to climate model data and analytic tools [CNRS-IPSL, Task 6.1, process]

- Access to data for downstream services: Work with C3S Climate Data Store to provide access to CMIP and CORDEX data.
- Access to downscaling tools (CDFT): Work with the Climate Data Factory that produce downscaled information for CMIP5 and CORDEX using access to ESGF and IPSL developed statistical downscaling tool. This leads to commercial products sold by The Climate Data Factory.
- Training on the ESGF downloader "synda": ease data downloads from the ESGF for all users in a user-friendly way.
- Training on data traceability through the ES-DOC ecosystem: increases analysis consistency by comparing model schemas and tracking dataset modifications.

Question: who are the non-research users in this case?

3} Innovation through IS-ENES Climate Data Infrastructure

The IS-ENES Climate Data Infrastructure (CDI) is composed of climate data infrastructure components supplied by ENES partners, often in collaboration with international partners.

Through a broad range of activities, the CDI contributes to the dissemination of climate projections produced within the World Climate Research Programme (WCRP) Coupled Model Intercomparison Project (CMIP) and Coordinated Regional Downscaling Experiment (CORDEX), and a range of associated data products and services.

The activities of the CDI are primarily targeted at the climate science research community and the climate impacts research community, but there is an important user community outside the research domain.

The IS-ENES3 Sustainability Working Group (SWG)is currently reviewing the services provided through the CDI using a Service Business Model Canvas (SBMC) to describe each service activity. Although the SBMC does not explicitly refer to innovation, the information being gathered by the SWG will clearly be relevant. The SBMC includes information about user communities which will provide valuable insight into the innovation potential of each activity.

4} Copernicus Climate Change Service (C3S)

IS-ENES3 activities feed through into C3S, and through C3S reach a large audience outside the research community. C3S is a new service, and still undergoing considerable evolution, and the user base is expanding. IS-ENES partners UKRI and WEnR are currently engaged in a project which will deliver C3S data products into the European Environment Agency (EEA) Climate-ADAPT portal, which will significantly enhance the non-research user community reached by C3S data products, including data products delivered with the benefit of IS-ENES services and know-how.

C3S is operated under a delegation agreement between the EU and the European Centre of Medium Range Weather Forecasting (ECMWF). The current agreement ends in early 2021 and a 2nd phase is expected. The projects funded under the current delegation agreement will end in April 2021. C3S is committed to maintaining continuity of services between the 1st and 2nd phases, and this continuity is heavily dependent on many of the activities conducted under existing contracts. Consequently, we can expect the work to continue, possibly with some rationalisation of the contractual structure (hopefully with fewer contracts). IS-ENES partners are well placed to play a significant role in the next phase, which is expected to see a consolidation of services and expansion of the user communities. Participation in individual

projects can be competitive, but information sharing with IS-ENES3 can act to preserve coherence among projects which are running and enhance cooperation.

An element of rationalisation is already starting, with the C3S 34f (ESGF Data Services) project taking on a role for providing data services (ESGF data nodes) to support data products delivered by other projects, so preventing the fragmentation of ESGF service activity across multiple projects.

In the initial phases of C3S work, data was delivered using an independent realisation of the ESGF infrastructure branched from the system used for global dissemination of CMIP data. In this approach, IS-ENES2 know-how and software foreground contributed to the innovation activity. The situation is evolving in the new C3S 34g (CMIP6 Data) project, which will deliver new CMIP6 projections into C3S. The IS-ENES know-how is still central, but a number of new developments and rationalisations now make it possible to avoid deploying a complete independent realisation of the services and instead directly exploit existing services.

These changes, taken together, mean that it is likely that, by the end of the IS-ENES3 project, data products from the IS-ENES CDI will be directly viewable in the Climate-ADAPT portal.
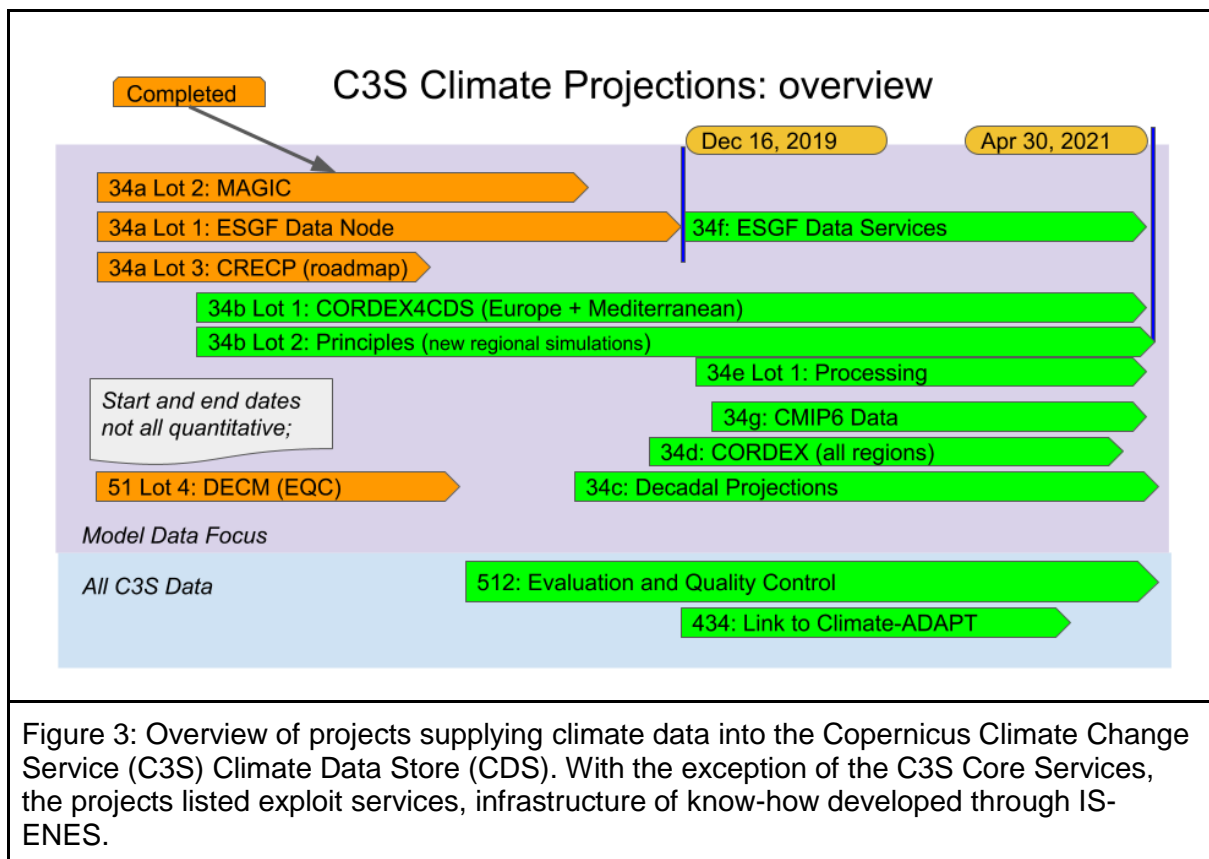

Figure 3: Overview of projects supplying climate data into the Copernicus Climate Change Service (C3S) Climate Data Store (CDS). With the exception of the C3S Core Services, the projects listed exploit services, infrastructure of know-how developed through IS-ENES.

5} Small and Medium-sized Enterprises (SMEs)

The following SMEs are engaged in the IS-ENES3 work programme:

The Climate Data Factory

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https://theclimatedatafactory.com/
Harilaos Loukos (harilaos@theclimatedatafactory.com), who is usually in contact with Sylvie Joussaume and Sebastien Denvil

TEC

Ghislain Dubois (dubois.ghislain@tec-conseil.com), in contact with Sylvie Joussaume

Altair

Working with UKMO. David Block (dblock@altair.com) ;

6} Discussion

The scoping survey has revealed a range of significant innovation activities. There is potential to exploit synergies between the Innovation VWP efforts and work of the Sustainability Working Group (SWG) to characterise the services of the IS-ENES3 Climate Data Infrastructure. The innovation potential of services clearly has sustainability implications (though perhaps only implications for potential sustainability).

The information assembled here will be discussed at the IS-ENES3 2020 General Assembly (GA) and feed into the first period report of the VWP.

The plan for future work will be refined at the GA, but should include:

- Developing metrics for innovation reporting based on survey results;
- Providing feedback to partners on pathways to innovation;
- Exploiting synergy between innovation and sustainability activities in IS-ENES3;
- Continued engagement with WCRP and C3S at all levels.

This review of innovation activities certainly has gaps. One prominent example is the work on the Earth System Model Evaluation Tool (ESMValTool) which will have a significant impact by supporting the work of Working Group 1 in the Sixth IPCC Assessment Report (AR6). This and other, possibly less prominent, gaps will be addressed through discussions at the GA.

Appendix A : Collecting Information on Innovation Activities

A1.1 : Initial Matrix of Activities

A survey in the initial stages of the project to identify the scope of activities and inform decisions on later activities in the innovation WP.   Draft Survey: http://bit.ly/enesInnoS1

- Title: a brief description of the activity; [Text]
- Description: a paragraph describing the innovation, including reference to the origins of the product or activity, the role of IS-ENES3, the expected outcomes, the pathway to impact. [Text]
- WP &Task: identify the task in the project workplan; [Select one]
- Theme: HPC, ICT, Other (specify) [Multiple]
- Category of Innovation: Product, Process, Method (scientific, technical, or organisational), Other. [Select one]
- Lead Partner: [Select one]
- Commercial: [yes/no] (if yes, explain)
- SME involvement: Altair, TEC, climateFactory, Other (specify), none [Select one]
- Comments: [Text]

Examples

[The text in these examples may not represent the latest thinking on the tasks alluded to .. inserted here to illustrate the type of input expected.]

Database of Computational Efficiency on a Range of HPC Platforms

The work planned in these tasks is representative of a wide range of HPC applications used by the climate community, creating a comprehensive database of computational efficiency on different HPC platforms. This information can be exploited by the HPC industry so that the market can produce better performance tools for the applications developed and used by our community and others with similar challenges.

- Workplan: WP4, Task 6
- Theme: HPC
- Category: Other (databse)
- Commercial: yes, database should be exploited by commercial companies
- SME: none
- Partner:
- Comments: to count as innovation, it will need some evidence of adoption by companies ... the idea is not enough.

Data Request Schema 2.0

The data request schema 2.0 (M10.2, month 18) will define the ontology for file meta-data specifications. This will be exploited in the CMIP7 requirements capture phase and used by modeling groups submitting data to CMIP7. The Schema will be defined in WP10, and

supported in SA2. Innovation will be achieved by working with the WIP and other ESGF partners to ensure that the Data Request Schema is adopted for CMIP7.

- Workplan: WP10 (JRA3), Task 6
- Theme: ICT
- Category: Other (Schema)
- Commercial: no
- SME: None
- Partner: UKRI STFC
- Comments: Need to maintain clear communication with WIP and CMIP panel.

A1.2 Promoting Innovation

It is also important to promote innovation: to ensure that people within the project are thinking about and planning the steps necessary to create innovation.

Steps discussed at WP Leader telco [to do], to be carried out by WP leaders during the course of the project:

- Identify gaps in innovation matrix after initial survey: are there tasks which lack a clear innovation target? If so, is that reasonable (e.g. if the task is strongly focussed on supporting other areas of work in the project -- as for WP1)?
- Share information on best practise;
- SMEs: do we have a clear plan to make best use of our partners;

Appendix B: Definition

B.1 : H2020 Guidance on Periodic Reports

http://ec.europa.eu/research/participants/docs/h2020-funding-guide/grants/grant-management/reports/continuous-report_en.htm#dissem

Innovation:

The introduction within a firm or market of a new or significantly improved:

- product (good or service)
- process
- marketing method
- organisational method (business practices, workplace organisation or external relations)

The minimum requirement for an innovation is that the product, process, marketing method or organisational method must be new (or significantly improved) to the firm.

Prototype, testing activities

Proof of S&T feasibility: Results of innovation activities that confirm/verify the technical feasibility of new products and processes in a (near) operational environment. Includes

- prototypes & demonstrations of new products and processes
- results of testing/piloting with users
- trial production and pilot plants in manufacturing
- trials & testing for services, such as how new technologies affect provision or how significant improvements in existing services perform

Clinical Trials (not applicable);

Product

Good or service introduced to the market or to the company/organisation that is new or significantly improved in its capabilities, usability, components or sub-systems.

Goods include packaged & downloadable software/music/film.

Process

Production process, distribution method or supporting activity that was implemented within an organisation.

Method:

Refers to organisational method or marketing concept/strategy in business/organisational practices (including knowledge management).

- organisational method - covers workplace organisation or external relations not previously used by your enterprise/organisation
- marketing method - significant changes in product design or packaging, product placement, product promotion or pricing that have not been used before

Appendix C: References

CDI: IS-ENES Climate Data Infrastructure, portal.enes.org/data/enes infrastructure is-enes

Climate-ADAPT: The European Climate Adaptation Platform, climate-adapt.eea.europa.eu.

CORDEX: **Coordinated** Regional Downscaling Experiment, http://www.cordex.org/.

CMIP: Coupled Model Intercomparison Project, https://www.wcrp-climate.org/wgcm-cmip

[cylc] A workflow engine, GitHub, https://github.com/orgs/cylc/, https://cylc.github.io/

- DOI: 10.1109/MCSE.2019.2906593
  *H. Oliver et al., **Workflow Automation for Cycling Systems: The Cylc Workflow***

Engine, Computing in Science & Engineering Vol 21, Issue 4, July/Aug 2019. DOI: 10.1109/MCSE.2019.2906593
- *Oliver et al., (2018). **Cylc: A Workflow Engine for Cycling Systems**, Journal of Open Source Software, 3(27), 737. DOI: 10.21105/joss.00737*
- DOI: 10.5281/zenodo.594577 Citable DOI for Cylc code releases.

ESMval; Earth System Model Evaluation Tool; www.esmvaltool.org.

[pyesdoc] pyesdoc is a python library for publishing earth system documentation. https://pypi.org/project/pyesdoc/

Innovation Team: https://is-enes.slack.com/app_redirect?channel=vwp-innovation

Innovation Responses: http://bit.ly/isenes3-inov-scoping-responses

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SMBC: Social Business Model Canvas, www.socialbusinessmodelcanvas.com/