Research and Innovation for Climate Services
Report on the synergy and mismatch analysis

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Authors: Roger Street (UKCIP), Tara Shine (Independent Consultant on Climate Justice, Environment and Sustainable Development), Ines Alterio (ANR), Lisa Bettington (NERC), Margaret Desmond (EPA/University College Cork), Marc Kierans (EPA); Harilaos Loukos (The climate data factory), Petra Manderscheid (BELSPO / JPI Climate), Andrea Sharpe (NERC)
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1 Introduction

The ERA-NET Co-fund action on Climate Services (ERA4CS, European Commission Grant Agreement 690462, www.era4cs.eu) was launched in January 2016 for a period of 5 years. The French National Research Agency (ANR) coordinates this action which brings together 45 partners from 18 European countries. Designed as a tool for initiating and coordinating collaborative action between research funders and performers, ERA4CS aims to overcome the fragmentation and partitioning of research and innovation for climate services (hereinafter identified as CS research and innovation) in Europe and beyond. Its main objectives are to:

- implement a transnational call for research projects;
- monitor and disseminate results from the funded projects;
- analyse the CS landscape and develop a joint vision for CS research and innovation in Europe and beyond; and
- develop new co-alignment tools.

As part of the ERA4CS, Additional Activities are planned throughout the 5 years of the action. Specifically, Work Package 7 (WP7) within the Additional Activities is dedicated to assessing and further developing JPI Climate activities contributing to CS research and innovation. They take strong advantage of the complementarity between research funding organisations (RFOs) and research performing organisations (RPOs) within the ERA4CS consortium and are in line with the overall target of Joint Programming for better alignment between RFOs and RPOs in Europe. In practice, ERA4CS Additional Activities target both a ‘common vision’ and a ‘pilot experiment’ for co-alignment. The results of the these Additional Activities are intended to contribute to developing a strong partnership between Member States as well as Associated Countries, key research organisations and relevant European initiatives up to 2020 and beyond, with the aim of contributing to sustainable development goals as they are affected by climate change.

The inclusive approach used in the ERA4CS Additional Activities seeks to explore the potential and means of enabling EU Member States as well as other RFOs and RPOs to develop a coherent and strategic approach to alignment and collaboration for their national and EC-supported CS research and innovation. ERA4CS fosters dialogue between scientists, between disciplines and with various user sectors for the co-design and co-development of CS research and innovation. Beyond strengthening European integration through more effective exchange and transfer of climate-related knowledge across the EU, ERA4CS supports the development and widening of the JPI Climate programme and associated actions.

Within WP7, Task 7.4 aims to identify:

- research and knowledge gaps, including those related to quality standards and quality control, for CS; and
- complementarities, redundancies and synergies between national, European and international programmes or initiatives.

The results of this task will inform the subsequent task (Task 7.5) that includes a Scoping Forum process through which the joint vision and a common implementation strategy and plan will be identified.
Based on the findings of Tasks 7.1, 7.2 and 7.3, and using additional evidence gathered from dedicated workshops, webinars, desk research and key informant interviews, Task 7.4 included a critical analysis of the evidence gathered at Member State, European and international levels.

This report focuses on that critical analysis and puts forwards a set of recommendations to inform the development of a joint vision and implementation strategy on research and innovation for climate services in Europe and beyond.

2 Critical analysis approach

2.1 Methodologies used

2.1.1 Timeframe

Task 7.4 began in November 2016 and lasted 8 months. Early in this period, Tasks 7.1, 7.2 and 7.3 evaluated JPI Climate activities and mapped relevant activities within the ERA4CS consortium, both across Europe and internationally and this was then used as the basis for further evidence gathering activities, detailed analysis and reporting.

2.1.2 Gathering, augmenting and analysing the evidence

The critical analysis undertaken within Task 7.4 comprised a combination of initial analysis, identification of gaps, information gathering through community engagement activities, face-to-face discussions and internet searches. Analysis of all the evidence was then conducted to identify critical issues associated with synergies, redundancies and gaps, and to produce recommendations. A summary of the activities is given in Figure 1.

Figure 1: ERA4CS Task 7.4 work plan: activities and timescales
2.2 Initial analysis

2.2.1 Definitions used

To ensure clarity and consistency throughout the work, the definitions for the terms ‘gaps’, ‘complementarities’, ‘synergies’, ‘redundancies’ and ‘mis-match’ that were fundamental to the completion of this task were agreed (see Box 1).

**Box 1. Definition of terms**

**Gaps:** two types of gaps were identified:

*Information gaps:* Gaps in available information that could potentially be filled with further evidence gathering. These were used to inform subsequent evidence gathering within Task 7.4 and the development of recommendations related to evidence needed to inform the Scoping Forum process.

*Identified research, knowledge and process gaps:* Identified and verified gaps in research and innovation required to support CS, in the knowledge generated and in the research and innovation process and design. In the latter case, examples are the lack of multi- and inter-disciplinarity engagement from the outset, and fragmented and disparate realms of CS research and innovation.

Where ‘multi-disciplinarity’ refers to drawing appropriately from multiple academic disciplines in the design and development of research to reach solutions based on a broader understanding of the research questions and solutions.

**Complementarities:** this includes research and innovation projects, programmes and initiatives working on similar activities and/or areas, whose outputs provide, or have the potential to provide, a wider or more comprehensive outcome. [In effect these have the potential to provide synergies].

**Synergies:** this includes research and innovation projects, programmes and initiatives that are being designed and implemented collaboratively to deliver added value and/or transformative outcomes.

‘Transformative outcomes’ are those taken from the research and used to create impact, thus linking back to the JPI Climate Strategic Research and Innovation Agenda (SRIA), making outcomes transformative to society.

**Redundancies:** areas or activities that are (or could be interpreted as being) duplicative and do not add any new value or knowledge. While some duplication of effort or conscious redundancies can be positive and necessary for robust research, the focus here is on unconscious or unknown redundancies. Another important characteristic of redundancies is that the value or knowledge generated is not aligned with existing knowledge or evidence.

**Mis-match:** this refers to differences between the information/evidence gathered and could therefore refer to gaps, complementarities, synergies or redundancies.
Using the Task 7.1, 7.2 and 7.3 synthesis documents\(^1\), the team carried out an initial analysis, extracting information on the gaps (both in the information available and identified research, knowledge and processes), synergies, complementarities and redundancies.

### 2.3 Evidence gathering activities

The initial analysis pointed to areas where further investigation and evidence gathering was required. These areas included seeking further contributions from the broader CS community, as well as targeted inputs from the social sciences and humanities and from the Disaster Risk Reduction (DRR) community with an interest in CS. Consideration of this initial analysis and the identified gaps was used to inform the additional engagement activities. All documents used as evidence are listed in Annex 1.

#### 2.3.1 Workshops

Community engagement workshops were held to gather further information and evidence from the broader CS community:

**2.3.1.1 Workshop: 2\&3 February 2017, BELSPO Brussels**

This open invitation workshop attracted 32 participants from across Europe. Participants were provided with background information and findings from the initial analysis. Organised break-out sessions then engaged the participants in discussions that aimed to add to the initial analysis. Focus was placed on identifying evidence and/or sources to fill identified gaps, identifying additional gaps and challenges in understanding and moving forward CS, highlighting potential sources of information that could help better understand the nature and scope of those gaps and challenges, and discussing the potential role of the JPI Climate in addressing these.

The information gathered during the workshop was synthesised (see Annex 1) and used to inform the critical analysis.

**2.3.1.2 Workshops: ClimatEurope Festival, 5–7 April 2017, Valencia**

28 participants were invited to a workshop dinner in the margins of the ClimatEurope Festival in Valencia. Participants were provided with background information on the work to date and encouraged through facilitated discussions to provide their views and perspectives on thematic gaps, research and innovation gaps (including future priorities) and synergies (existing or potential) in delivering the research and innovation needs. Three questions framed the discussion:

1. With reference to the evidence collected by the task team to date, what additional types of evidence (and their source) should be considered?
2. With respect to research and knowledge to support CS, what are the future priority gaps not already identified that should be addressed in the next 5 years, and why?
3. Where, and with whom, do you see synergies (existing or potential) in delivering the research needed to support CS?

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\(^1\) The report for Task 7.1 was in draft form at this stage.
In addition to these discussions, a specific session entitled 'Have your say' was held as part of the ClimatEurope Festival to seek views and perspectives from the broader ranges of participants. Participants were introduced to the task and to the aims of the JPI Climate Strategic Research and Innovation Agenda (SRIA). They were then asked to discuss and identify: a) related research and innovation activities that they were involved in; and b) to provide their views on priority research or innovation gaps for CS. For each of the points raised, participants were also asked in each case to identify existing or potential synergies with other activities or organisations, and the relevance to the JPI Climate SRIA. Information was captured using card templates (see Annex 2).

The inputs from the dinner discussions and the 'Have your say' session were synthesised (see Annex 1) and used for the critical analysis.

2.3.2 Webinars

Initial analysis identified specific evidence gaps with regards to research and innovation for CS from the perspectives of two communities: social sciences and disaster risk reduction. These specific gaps were confirmed in the workshop in Brussels and participatory webinars were held to engage with these communities.

The views and perspectives provided during each of these two webinars were synthesised (see Annex 1) and used within the critical analysis.

2.3.2.1 Social sciences community webinar, 31 March 2017

Seventeen participants joined this participatory webinar, with the aim of seeking views from representatives of the social sciences community to help fill evidence gaps related to the social, behavioural and communications aspects of research and innovation for CS. Two discussion questions were used to frame the webinar in the context of the challenges and the Strategic Mechanism set out in the JPI Climate SRIA with particular focus on: i) the climate decision-making process; ii) societal transformation; and iii) connecting different realms of climate research. The questions posed were:

1. What research are you involved in, or aware of, that is addressing the social dimensions of climate decision-making and/or societal transformation in the context of climate change?
2. What do you believe are the priority research and knowledge gaps related to climate decision-making, societal transformation and/or interdisciplinary research?

2.3.2.2 Disaster risk reduction community webinar, 1 June 2017

Sixteen participants representing researchers, practitioners and CS providers and purveyors joined this webinar aimed at filling knowledge and evidence gaps related to climate services to support disaster risk reduction. Two discussion questions were used to frame the webinar in the context of the JPI Climate SRIA in particular relating to i) the climate decision-making process; ii) informing decision-making in support of disaster risk reduction; and iii) better understanding the interlinkages and relationships between climate change and disaster risk reduction. The questions posed were:
1. What research are you involved in, or aware of, that is addressing CS for disaster risk management decision-making?

- To what extent is the research interdisciplinary?
- Is any of that research conducted in collaboration with other research organisations or supported by a number of funding bodies? (looking to identify synergies)

2. What do you believe are the priority research and knowledge gaps related to CS research to support disaster risk management decision-making?

2.3.3 Other sources of evidence

In addition to the organised community engagement activities, further evidence was gathered via telephone interviews, through network connections, via a questionnaire sent out to a specific number of RFOs, and via information searches. Evidence gathered included, but was not limited to:

- Additional European evidence (from the Copernicus programme, the European Roadmap for Climate Services\(^2\) (hereinafter referred to as the European Roadmap), input from Eastern European RPOs [limited to CzechGlobe], EC note on ‘who does what in climate services’, JPI Climate SRIA and related documents).
- International evidence (from the Climate Science for Services Partnership (China and Brazil), Climate Services Africa, teleconference with UNFCCC, Belmont Forum)
- Information from RFOs to expand upon the information received from RFOs in Task 7.2 in which only six responded. A questionnaire seeking information regarding current and future climate research that relates to the JPI Climate SRIA was sent out targeting as an initial set of evidence, a sample of the RFOs who are members of the ERA4CS consortium (Austria France, Ireland, Norway and UK). The questionnaire template is at Annex 3. The questionnaire was modified by some of the participants to facilitate their participation.

The evidence gathered from these other sources is listed in the Document listing (see Annex 1) and was used in the critical analysis.

2.3.4 Limitations in the evidence

Some gaps were identified that due to constraints on resources and the information available were not filled. These included:

- Information from RFOs and RPOs in Europe beyond JPI Climate and ERA4CS members. Attempts were made to engage others but the ability to contribute was often limited by capacity and time.
- Knowledge of RFO priorities. Despite trying to obtain this information through Task 7.2 and a further questionnaire sent to some RFO’s, comprehensive information has been difficult to gather. A difficulty for the RFOs themselves is the fact that often they do not fund research and innovation for CS per se, but do fund research and innovation that will have climate science themes running through them. This research could be of relevance to CS, but it is difficult to identify without thorough investigation of what each funded

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\(^2\) [A European research and innovation Roadmap for Climate Services' 2015 Directorate-General for Research and Innovation](https://doi.org/10.2760/308281)
project is doing. The results of seeking responses to the questionnaire from a sample of the RFOs and follow-up discussions with some of those responding, clearly suggest that this information has value within JPI Climate.

3 Highlights from the evidence gathered

All the evidence gathered was reviewed and analysed with the aim of identifying complementarities, synergies and redundancies and presenting the identified research and knowledge gaps. This was then used to provide the basis for the critical analysis. The highlights presented below are exemplary of the analysis of the evidence gathered, but also demonstrate the challenges and opportunities towards developing a vision and an implementation strategy for CS research and innovation.

3.1 Complementarities and synergies

The activities identified under these two categories are seen in the context of efforts that bring together diverse capacities and capabilities, including those linked to different disciplines and transdisciplinary activities, within a consortium, community or network. All have the aim of collaborating to enhance the effectiveness and added value of the research (contributions to knowledge and scholarship) and of its outcomes (e.g., addressing complex societal challenges).

A number of factors have contributed to increasing interest in working collaboratively on research and innovation activities\(^3\) supporting CS that, in turn have enhanced complementarities and led to synergies. Primary drivers include the complexity of the challenges associated with the research and the move to innovation, leading to the need to engage across multiple disciplines and skills (i.e. collaborative and participatory research and innovation). Additionally, the resources (financial, human and infrastructure) required for effectively delivering such research and innovation, including as reflected in the requirements by funding bodies operating at different levels, necessitate working collaboratively. This is even more apparent when working at the transnational, European and international levels for which the different political, geographical and institutional considerations necessitate collaboration involving multiple institutions and organisations.

Complementarities result from research and innovation activities working on similar activities or areas; their outputs when brought together can provide a wider or more comprehensive outcome or understanding. Synergistic activities arise when activities are designed and implemented collaboratively with the intention of delivering outcomes together.

The available body of evidence was analysed to identify and understand the nature and scope of complementarities and synergies with the result that they were found to fall primarily into one of the following three types:

1. Focused at a specific level: organisational, national, transnational and international.

\(^3\) Research and Innovation action: primarily consisting of activities aiming to establish new knowledge and/or to explore the feasibility of a new or improved technology, product, process, service or solution. For this purpose they may include basic and applied research, technology development and integration, testing and validation on a small-scale prototype in a laboratory or simulated environment. Projects may contain closely connected but limited demonstration or pilot activities aiming to show technical feasibility in a near to operational environment.
2. Focused on a particular subject: the complementarity or synergy is primarily data, product or process-based.
3. Focused on community: working across the CS landscape to establish or sustain an engaged CS community.

3.1.1 Focused at a specific level

There are a number of research and innovation activities in support of CS that involve the bringing together of capacities and capabilities within an organisation, or across organisations at a national, transnational, or international level. These activities include both project-level (e.g., within a single or across multiple projects) and programme-level activities (e.g., includes and goes beyond project-level activities). The complementarities and synergies arise through working relationships, shared infrastructure or synthesis of the outcomes. In the case of synergies, collaborations are planned and implemented from the start.

**Example of complementarities:**

*National, transnational and European platforms:* Although there are a number of climate adaptation and climate service platforms developed through various mechanisms often operating independently, efforts are underway through the European Environment Agency (EEA) and with the support of DG CLIMA to encourage sharing of lessons learnt and to work together as a community, including efforts within the European Environment Information and Observation Network (EIONET).

**Examples of synergies:**

European wide:

**JPI collaborative efforts:** Although needing more attention, there are examples of collaborative efforts among the JPIs. These include JPI Climate and JPI Urban Europe contribution to the ENSUGI proposal on sustainable urbanisation that could also create synergies with the ERA4CS research projects URCLIM and CitiSense with a focus on developing prototypes of climate services for key sectors. JPI Climate and JPI Oceans are collaborating in the preparation of a joint activity (ERANET or other instrument) on the Next Generation of Climate Science in Europe.

ECRA Collaborative Programme, High Impact Events and Hydrological Cycles: ECRA is an alliance of European climate research institutions seeking to streamline and coordinate collaborative climate change science. A planned joint COST Action proposal towards stakeholder involvement and/or White Paper development and integrating social science perspective has the potential to generate synergistic activities with a focus on the impacts of, and adaptation strategies for, extreme sea levels and mean sea levels.

**Organisational:** The Stockholm Environment Institute (SEI) Initiative on CS brings SEI expertise together to bear in the emerging field of climate services. A key aspect of this initiative will be to develop and apply an SEI participatory framework for climate services, drawing on existing knowledge from external sources as well as new interdisciplinary research.

**National and Transnational:** There are examples of CS research and innovation being developed and delivered at the national level, but also across countries within specific transnational areas and among countries at similar latitudes. Examples of these at the national level are highlighted...
within the Task 7.1 national dialogues (e.g., Italy and Austria), but also are evident from the responses by the RFOs in which cross-organisational (and disciplinary) research proposals are evident. At the transnational level, Climate-ADAPT identifies four macro-national regions (Baltic Sea, Danube, Alpine and Adriatic and Ionian) for which specific EU-agreed strategies exist highlighting increased co-operation and engagement.

3.1.2 Focused on a particular subject

Although complementary and synergistic research and innovation activities that are primarily focused on a particular subject often operate at the European or international level, they can lead to the establishment of consortia and communities of practice. They are included here as their remit is primarily focused on a particular area such as data, modelling, or product and service development or processes (e.g., standardisation).

Examples of complementarities:

**Quality Control/Quality Assurance and standards:** The complementarity in this area is associated with the multiple and joined-up discussions related to the needs for and challenges around the development and delivery of quality control/quality assurance and standards for climate services. These joined-up discussions are reflected in the growing the market challenge within the European Roadmap, similar deliberations within the CSP and in activities and deliberations within the JPI Climate, including when developing its SRIA and within the ERA4CS. In addition, the Copernicus Climate Change Service (C3S) is developing sectoral information system demonstrators, and evaluation and control processes. This area of research and innovation is ripe for complementarity efforts and efforts are needed to facilitate such for the benefit of the market and its growth. It should be noted that without complementary (and synergistic) activities the potential for redundancies is high.

**Climate Predictability:** Working with the Belmont Forum has resulted in a number of collaborative activities on this subject. For example the 2015 Call for ‘Climate Services Collaborative Research action on Climate Predictability and Inter-regional linkages’ aimed to contribute to the overall challenge of developing climate services with a focus on the role of inter-regional linkages in climate variability and predictability. Each of the resulting research projects involved international and regional coordination provided through a research consortium supported by at least three participating partner agencies (with at least one outside of Europe). The projects were encouraged to incorporate relevant research associated with the socio-economic implication of the resulting knowledge/information, risks and benefits analysis, and impediments to the use of the climate understanding in decision-making.

**Arctic:** Arctic ECRA has contributed to the three Horizon 2020 projects currently addressing Arctic climate change (INTAROS, APPLICATE and Blue-Action) with many active Arctic ECRA participants from across Europe that will work together in a coordinated manner to 2020.

**Impact Assessments:** The ERA-NET on Climate Services [European] Roadmap: Cross-sector impact assessments (AXIS)\(^4\), includes the need to strengthen international leadership of European research, in particular its contribution to the Global Framework for Climate Services (WMO-GFCS), the Inter- Sectoral Impact Model Inter-comparison Project (WCRP/ISI-MIP) and the Future Earth Programme, and eventually to IPCC assessments, UN SDGs and the Belmont

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Examples of synergies:

**Market development:** The overarching EU call topic of Climate services market research covers two topics, which are addressed in MARCO (Market Research for a Climate Services Observatory) and EU-MACS (European Market for Climate Services). MARCO and EU-MACS will collaborate on the following similar but not identical fields of action: business modelling and innovation dynamics, market inventories and stakeholder engagement, and case studies. The synergies will be created through common/joint actions, meetings and reports.

**Arctic:** The JPI Climate Joint Call for Transnational Collaborative Research Project on Russian Arctic and Boreal Systems aimed to improve the fundamental understanding of key biological and physical drivers and feedbacks in the Russian Arctic/Boreal system (tundra-taiga-coastal region) to enable better representation of these processes in climate models. The intention was to strengthen the coordination of research activities at the European level, and collaboration beyond with the involvement of Russian researchers and funders to address concerns related to the risk of fragmentation and duplication of research efforts and resources at the European level. To this end, consortia included at least on partner based in a research institution within the Russian Federation and partners from at least two European countries participating in the call.

**Data:** Collaboration in the area of meteorological and climatological data has a long tradition led by the Global Climate Observing System (GCOS) and the WMO Commission for Climatology. The European Meteorological Services Network (EUMetNET) provides a framework to organise cooperative programmes between its members, including observing systems, data processing, research and development, and training, and contributes to the GFCS and coordinates access to national meteorological service in situ observations for the Copernicus services. Furthermore, the GFCS Implementation Plan recognizes the Group on Earth Observations (GEO) as a framework for supporting climate services in the GFCS priority areas. Through such synergies and collaborations, questions are being addressed and action undertaken around the quality and quantity of climate data needed to support climate change science and climate services.

**Disaster Risk Reduction:** The Disaster Risk Management Knowledge Centre (DRMKC) provides a network approach to the science-policy interface in disaster risk management across the Commission, EU Member States and the DRM community within and beyond the EU. The DRMKC reinforces the development of disaster science partnerships and networks, including the exploitation of the knowledge gained.

### 3.1.3 Focused on community

As recognised within the European Roadmap, a sustained, supportive and collaborative European climate service community is central to strengthening the market for climate services and delivering on the Roadmap challenges and JPI Climate SRIA. Such a community can play many roles, particularly considering the nature of climate services within Europe and internationally (preliminary developments and differentiated capacities and capabilities). Many of these complementary and synergistic activities are themselves in early stages of development;
evolving and finding their specific niche and defining relationships as part of a collaborative community.

**Examples of complementarities:**

*Partnerships with existing relevant networks and platforms:* A number of networks and platforms already exist in the areas of CS in support of climate change adaptation (CCA) and DRR and there are examples where they have established relationships towards working collaboratively or have focused efforts to exchange knowledge and develop ways forward. Examples of this type of relationship include the broadening collaborative engagement between the CCA and DRR communities reflected in the links between the EEA platform Climate-ADAPT and PreventionWeb that serves the information needs of the DRR community, and dialogues on the subject conducted through different fora (e.g., discussion groups within IKM4DRR) and conferences (e.g., Climate Change’s role in Disaster and DRR⁵). This collaboration, particularly focusing on climate services is evident in the remits and activities of two Coordination and Support Actions (CSA), ESPREssO and PLACARD that are looking across and enhancing the relationship by facilitating dialogues and enabling coherence of DRR and CCA.

*European Community:* Activities under the European Climate Observations, Modelling and Services (ECOMS and ECOMS²⁶) and ClimatEurope (funded under H2020 as a CSA aim to develop a European-wide managed network for Earth-system modelling and climate service activities, including coordinating and integrating ongoing and future European Climate modelling, observations and infrastructure initiative.

**Examples of synergies:**

*European countries:* The JPI Climate's focus on connecting climate knowledge for Europe by gathering European countries to jointly coordinate climate change research and fund new transnational research initiatives that provide useful climate knowledge and services. The JPI Climate Strategic Mechanism is an enabler of connections between different parts of the research and innovation community on the European level and beyond, while contributing to achieving results in JPI Climate’s three challenges. Although yet to be fully implemented, previous JPI Climate activities (joint calls, ERA4CS, and activities within the previous JPI Climate working groups) have contributed to synergistic action by members and involving other European and international bodies. The challenge will be to realise the opportunities offered by the implementation of the Strategic Mechanism.

*Internationally:*  
*The Climate Services Partnership* (CSP) and its International Conference on Climate Services, particularly the established working groups that include economic valuation of climate services, ethics and research priorities, have demonstrated the added value of the resulting collaborative and synergistic activities. In addition, with IGBP, IHDP and WCRP, Future Earth is bringing together other related research activities as an international platform to ensure knowledge is generated in partnership, including with society and users of science.

*The IPCC Special Report on Managing the Risks of Extreme Events and Disaster to Advance Climate Change Adaptation* brought together the DRR and CCA communities to explore the challenges of

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understanding and managing the risks of extreme events and disasters. It draws on the knowledge of research experts and policy-makers from both DRR and CCA communities to introduce innovative thinking on adaptation and disaster risk management; an example of synergistic action that has enabled further activities exploring the relationships.

There is a role for JPI Climate in working in a more strategic manner with these complementary and synergistic initiatives within Europe and internationally as JPI Climate and its members are already engaged. As the community expands and the market for climate services grows the need for such networks operating at the European level and linked internationally is increasingly necessary. For the JPI Climate, identifying an appropriate role and operating within and with these other initiatives will be essential and challenging.

3.2 Redundancies

By identifying redundancies, it should be possible to better orient and inform future investments, including by identifying opportunities to potentially align initiatives and establish priorities for action. The evidence was analysed to identify examples of redundancies and these were found to fall into the following three types:

1. Incoherence: multiple, uncoordinated or duplicative institutional, thematic, sectoral, or technical activities.
2. Research not informing research: research or innovation initiatives that are undertaken without reference to similar initiatives (past, present, planned) by others, resulting in thematic overlaps: organisationally, nationally or internationally.
3. Lack of an enabling environment: leading to redundancies and in some cases preventing or impeding the development of climate services.

3.2.1 Incoherence

Incoherence is a key factor contributing to redundancies in CS research. This incoherence can be:

- Institutional: such as inadequate collaboration between RFOs or between the JPIs at European level. At the national level this could relate to the existence of multiple disconnected CS providers (public and private).
- Thematic: such as the lack of collaboration and interlinkages between CS research with research on adaptation, mitigation and disasters risk reduction; the lack of collaboration between the social sciences research and CS research; or the existence of duplicative work on modelling and scenario development at the national, regional and international level.
- Sectoral: such as not recognising the similarities and differences between the CS needs of different economic sectors such as agriculture, water and transport.
- Technical: such as lack of clarity due to the existence of multiple definitions of CS, the inefficiencies and risks associated with multiple web-based CS platforms without standardised approaches, quality assured data or information services.

**Examples of incoherence:**

*International:* The Global Framework for Climate Services, the Group on Earth Observation (GEO), the CSP and initiatives under the United Nations Framework Convention on Climate Change (UNFCCC) such as the Research Dialogue, all seek to share information and knowledge,
coordinate research actions and promote collaboration. However, our evidence and subsequent analysis indicate that there is considerable duplication of effort especially in Europe while there are many gaps and in developing countries, particularly in Africa. Overall it is not clear who leads, how effective the planned coordination is in practice or how the different activities build on and complement each other.

*Europe:* JPI FACCE, JPI Water, JPI Oceans, JPI Urban Europe and JPI Climate all engage in climate change research in support of CS but with inadequate collaboration on this specific theme so that research efforts risk being disconnected, fragmented, duplicative and at worst redundant. The JPIs are all independent and have different mandates. While some co-operation is taking place as a result of exchanges, there is no formal exchange on a thematic basis and as a result co-operation with the different JPIs happens less systematically than may be required.

In June 2016, all JPIs and other Public-to-Public networks (e.g., ERA-NETs) were invited to a first workshop, back-to-back with the H2020 Programme Committee of Societal Challenge 5 to jointly design the amendment of the H2020 Work Programme 2017. A similar activity is planned by the EC for autumn 2017. In doing so, the EC wants the JPIs to cooperate more and to jointly identify who does what in climate research.

Co-operation between the JPIs does exist and these can be used as examples on which to base further action. For example, there are CS related activities within some of the JPIs (e.g., Water) and within JPI Climate (e.g. the water-related initiatives under the ERA4CS projects) for which closer ties would be beneficial. While co-operation between the JPIs is increasing (e.g. inviting all JPIs to an ERA-NET workshop) and joint projects are being developed (e.g. between JPI Oceans and JPI Climate), formal co-operation on specific themes is an area that needs development.

More broadly the evidence collected indicates that incoherence also arises from inadequate engagement and collaboration between JPI Climate, Copernicus and Climate−KIC on CS research and innovation (e.g., the relationship between the ERA4CS projects and the C3S sectoral impacts pilot projects, and related activities at the national level).

*National:* Coherence between institutions providing CS at the national level is hindered by the fact that some actors do not identify as being CS providers (for example in Norway), there are different interpretations of climate change research and climate change services, and methods and approaches are not standardised. Some countries such as Germany and the UK have a longer experience of developing and institutionalising CS, yet challenges remain as the number of providers multiplies (e.g. in Germany there are many commercial providers) and parallel efforts (e.g. between providers of weather and CS) can lead to redundancies.

### 3.2.2 Research not informing research and innovation

Good practice in research dictates that new research should build on, add value to, or call into question existing knowledge and evidence. However, research cannot inform research and innovation if the results are not disseminated or translated. This includes sharing information about research that is being supported within different countries and at different levels. Too often in the field of CS new research and innovation have not been adequately informed by earlier research findings and as a result redundancies occur when the same research questions are answered multiple times or when the same obstacles are repeatedly identified but without progressing to the next level of investigation. Research findings related to the need to better communicate climate information or the social sciences aspects of CS tend not to be acted on.
More broadly RFOs and RPOs tend to operate in an isolated way, thus reducing the opportunity for current and past research to inform future research priorities and projects.

**Examples of research not informing research:** There has been a proliferation of research on user needs, where multiple studies have investigated the demand for and use of CS. The tendency has been to continue to survey user needs (to answer questions about lack of demand for CS) without acting on the survey findings and progressing to the next stage of research. Redundancies in research effort therefore lead to redundancies in the uptake of CS.

Research and innovation to support CS is not sufficiently informed by existing and evolving knowledge and evidence (and practice) from other relevant disciplines (a conclusion from the work of JPI Climate WG3). In particular, research from the social sciences related to decision-theory and communications is not specifically being used to inform CS research and innovation. Examples include consideration of the needs of adaptation management, robust decision-making and the different participatory methodologies for supportive and informative CS. Without these types of services, important advances in social sciences which would benefit decision and policy makers are not being appropriately supported by CS.

For example, of the 26 projects approved under the 2017 ERA4CS Joint Call on Researching and Advancing Climate Services Development, seven appear to have an element of interdisciplinarity requiring engagement with the social sciences (Citisense, ClimAPP, Co-Cli-Serve, CoClime, EVOKEd, INDECIS and Dust CLIm). Efforts to enhance co-operation across these projects and to challenge them to look beyond traditional CS informed by the evolving decision-making processes of targeted users would significantly enhance the impacts of this suite of projects. In order to reduce redundancies, CS research and innovation needs to recognise that the practice and needs of users for knowledge and guidance is rapidly evolving and the need to reflect these changes in the design and development of supportive CS. Examples include adaptation pathways, robust decision-making and the different participatory methodologies; all of which need supportive and informative CS.

### 3.2.3 Lack of an enabling environment

An enabling environment is a set of interrelated conditions, such as legal, organisational, institutional, financial, political and/or cultural, that impact on the capacity of researchers and CS providers to fulfil their role. Examples of the lack of an enabling environment for CS research identified include the absence of standards, of quality controls and of evaluation to ensure and demonstrate that CS are reliable and robust, and that can also protect the interests of trustworthy providers. A lack of investment at the national level in CS research and innovation (e.g., funding of climate information platforms) is an obvious fiscal barrier. Inadequate identification of the barriers and options to increasing CS demand, including financial, regulatory and cultural barriers means that the necessary remedial steps needed are not taken. A lack of transparency of data and information and an incomplete mapping and engagement of CS providers and purveyors in Europe hinder the development of an environment that promotes and values CS research.

Evidence within the EU and more broadly shows that standards, practices and policies requiring the exploration and communication of climate risks and responses (adaptation and mitigation) can promote investment in CS research and innovation. In addition, enabling the growth of a CS market (public and private), including by creating a sustained demand for CS, will increase the demand for supportive research and innovation. This focussed demand reduces the risk of
fragmented and less relevant research and innovation typically associated with under-funded and under-valued initiatives.

**Examples of the lack of an enabling environment**

At the country level, a range of factors create an enabling environment for CS including: education and professional development, policy, legislation and regulation (e.g. that require adaptation planning and thus create demand for CS); quality assurance, transparency and oversight to support a quality and trustworthy CS market; adequate funding of CS research; and effective and culturally-appropriate communication programmes and channels. It is considered that inadequate consideration of the social sciences and humanities in the field of climate change research for CS is one of the main reasons why the uptake of CS continues to be slow.

### 3.3 Gaps in research and knowledge

#### 3.3.1 Typology

The complete body of evidence was analysed to identify research and knowledge gaps. These were found to fall into four types that broadly correspond to the three challenges plus the strategic mechanism in the JPI Climate SRIA:

1. Understanding the processes and consequences of climate change (SRIA challenge 1)
2. Improving knowledge on climate-related decision-making processes and measures (SRIA challenge 2)
3. Researching sustainable societal transformation in the context of climate change (SRIA challenge 3)
4. Enhancing connections and reducing fragmentation (SRIA Strategic Mechanism)

The SRIA also recognises that ‘solutions to the complex problems associated with addressing climate variability and change will not be successfully developed within a siloed approach to research and innovation’. As such, the challenges and strategic mechanism overlap and this overlap was also reflected in the evidence gathered and analysed for this work. Many of the gaps were identified as falling under more than one challenge and also under the strategic mechanism. These gaps included efforts towards:

- Enhancing the perception of the value of climate services to users - linked to challenges 2 and 3 and the Strategic Mechanism;
- Improving guidance, including that available through information platforms - linked to challenge 2 and the Strategic Mechanism;
- Translation of climate science into services, including linking to impacts - linked primarily to the three challenges, but also seen as requiring efforts linked to the Strategic Mechanism
- Communications of climate science and climate services - linked to all three challenges and the Strategic Mechanism;
- Supporting the process of learning and knowledge exchange - linked primarily to the Strategic Mechanism, but drawing on the outcomes from the three challenges;
- Driving integration across disciplines, including social sciences, and across scales - linked to all three challenges and the Strategic Mechanism.
These are examples of cross-cutting research and innovation needs, but demonstrate the challenges in terms of the research and innovation that will need to be reflected in the implementation strategy and plan to be developed through the Scoping Forum (ERA4CS Additional Activities Task 7.5).

3.3.2 Description and examples

In classifying the evidence into four types it became apparent that the most frequently identified is type 2 (about 45%) while the least frequent is type 1 (about 13%), types 3 and 4 being of similar frequency (about 21%). This indicates that the focus of research going forward is likely to be on the use of CS and the links to decision-making rather than on the generation of climate information or on climate processes.

3.3.2.1 Understanding the processes and consequences of climate change (SRIA challenge 1)

The gaps identified in this category cover some thematic examples (e.g. extreme events and their impacts), technical issues (e.g. downscaling, use of analogues) and dissemination issues (availability and lack of data). It should be noted that the lack of information on any fundamental climate process, except for extreme events, was mentioned as a gap in the evidence.

**Examples:**

Request for more standards to have harmonized data (and probably metadata) to facilitate the interoperability of data sets from different sources and scales (national/regional): This request includes standardization and harmonization of data to facilitate comparability and coherence (especially at national and regional levels).

Request for higher resolution data to better fit with understanding and addressing specific local impacts (at city or catchment scale for example): CS needs to provide more downscaled and easily access information matched to user needs and user capacity. There is demand for high resolution scenarios for decision-making at city/local/catchment level.

There is concern about possible threshold effects associated with the essential climate variables (linked to identifying ‘dangerous’ climate change in different sectors). Identifying these potential effects and their non-linearities and associated uncertainty was identified as being critical for mapping thresholds and sensitivities and the need for action.

3.3.2.2 Improving knowledge on climate-related decision-making processes and measures (SRIA challenge 2)

The evidence here is centred on the knowledge needed to facilitate the uptake and dissemination of CS. Co-construction of CS, including through participatory methodologies, was identified as a knowledge gap, as well as gaps around the cultural dimensions of CS and their impacts on social acceptance and use. Several evidence sources highlighted the need for the social sciences to be engaged with and inform CS research from the outset, as a core element rather than a parallel or linked area of research. Evidence gaps also included the need to demonstrate the value and co-benefits of CS in order to increase demand. Evaluation and quality standards are gaps that must be addressed in order to increase the acceptance of CS. Finally, knowledge gaps were identified related to specific disciplines, namely health, human migration and all aspects of mitigation.
**Examples:**

Gaps in knowledge related to assessing and communicating the economic and non-economic (social and cultural) benefits and value of climate services. Examples were given from European and African contexts to illustrate this point which is critical to understanding and creating a market for CS.

Gaps in knowledge related to understanding the role of CS in supporting decision-making over different time frames (e.g., from the shorter-term DRR decisions to longer-term CCA decisions).

Enabling decision-making across spatial scales from national, to city, to neighbourhood scales, but also transnational and catchment levels informing CCA and DRR decision-makers by allowing them to move from generic responses to ones that are focused on specifics within a given context.

Enabling the co-development of research and innovation engaging multiple disciplines (e.g., social and natural sciences, to move away from social sciences being merely consulted as part of a project to having social sciences inform the design and implementation of research and innovation supporting CS)

### 3.3.2.3 Researching sustainable societal transformation in the context of climate change (SRIA challenge 3)

Many examples from the available evidence express the need for a thriving CS market as a precondition for sustainable societal transformation. This is consistent with type 2 gaps being the most prevalent in evidence sources: the more effective and efficient CS will be in supporting decision-making, the stronger and faster their market uptake, and thus societal transformation. The available evidence also expresses the need for legal, ethical and social equity frameworks to guide the dissemination of CS. The evidence suggests that these are largely absent at present and that these gaps create risks to CS uptake, credibility and user trust. Other gaps identified that are necessary to secure societal transformation are those relating to institutional strengthening (e.g., governance and funding), as well as enhancing the capacity and role of the public in constructing narratives and contributing to filling knowledge gaps.

**Examples:**

Legal aspects of CS (especially related to the ownership of CS and responsibility for quality and reliability) and liabilities related to the quality and appropriate use of CS.

Understanding the CS value chain: understanding demand, barriers to the uptake of CS, as well as making CS more actionable and practical while preserving their scientific soundness.

Integration of CCA, DRR and sustainable development as a decision-framing supported by CS.

Knowledge on obstacles to the development of a commercial market for services (that is not dominated by universities or research-based organisations) and includes supporting an appropriate mix of public and private sector actors.
3.3.2.4 Enhancing connections and reducing fragmentation (SRIA Strategic Mechanism)

The SRIA aims to connect people, problems and solutions in a systemic approach. This analysis identifies gaps in the CS landscape that will need to be addressed to develop such a systemic approach. The evidence reveals concerns among the community about structuring CS between public/free and private/commercial CS and the role of all actors (researchers, practitioners, providers as well as the public) in working together to provide a quality service. A common concern seems to be the need to rapidly develop and make accessible CS while maintaining high-quality services. This calls for the clarification of roles, exchange of information within the CS landscape (case studies, guidance, good practices, tools and methodologies), and effective ways to co-ordinate and ensure coherence at national and European level (e.g. through national contact points). This clarification and connectivity is important to support service development as well as to enable a wider circle of CS researchers, purveyors and providers to engage in a systemic ERA-NET for CS.

**Examples:**

Knowledge gaps linked with understanding the different roles of actors in the development and provision of CS, including intermediaries and the role of the public versus private sector, as well as how the different actors can and should work together.

Lack of research in iterative and participatory methodologies to bring user perspectives into CS and to provide opportunities for social learning.

Lack of clarity and consensus about which services should be public and which should be provided by the private sector (recognising the different political and legal circumstances), and the impact on associated business models and the interplay between these sectors.

Identifying and effectively taking forward research and innovation that addresses these identified gaps and reflects the SRIA challenges and Strategic Mechanism will require an implementation strategy and plan that embrace the challenges and opportunities reflected in the SRIA mission, aims and principles.

4 Critical analysis: Implications for research and innovation supporting climate services

In this section the authors took a step back from the insights and analyses carried out in the previous sections to reflect on what the findings mean for CS research and innovation and the associated communities, particularly the JPI Climate. This helped identify and provide the rationale for conclusions that can be drawn to improve contributions, including by JPI Climate, to supporting CS research and innovation.

To inform this critical analysis, the broader picture of research and innovation supporting CS at national, EU and broader international levels was first drawn as the basis for identifying key concerns and opportunities. As such, this critical analysis of the evidence provides the framework for the recommendations that follow in Section 5.
4.1 Context

4.1.1 The landscape of research and innovation supporting climate services

The increasing recognition of climate change as a key societal challenge and the requirement from decision makers and those preparing supportive policies for scientifically-based knowledge and evidence to inform local to global actions has led to increased research and innovation efforts commensurate with that demand. The result has been a proliferation of research and related scientific endeavours (e.g., knowledge translation and exchange), with a number of RPOs, RFOs and coordinating bodies at different levels (e.g., JPI Climate, GFCS, as well as various business organisations) becoming involved (see Figure 2). This increase in demand for supportive knowledge and services, and commensurate investments has occurred while at the same time there have been continued and increasing efforts by some (including influential politicians) to dismiss or even discredit the science. These efforts are often based on alternative objectives (e.g., vested interests), an incomplete understanding of the science or denied acknowledgment of the role of science in understanding and addressing societal challenges.

Figure 2: Scheme of relationships within European climate services landscape

With its new SRIA launched in 2016, JPI Climate aims to actively inform and enable the transition to a low emission, climate resilient economy, society and environment that is aligned with Europe’s long-term climate policy objectives. The development of CS has been one of the JPI Climate priority areas (JPI Climate Strategic Research Agenda, 2011). Two specific areas reflecting this priority are the implementation of the ERA4CS through a partnership of 18 European countries, and the enhancement of the role of social sciences and humanities within climate change research. On the former, in spring 2017, ERA4CS announced funding for 26 projects that over the next three years are intended to advance climate services for decision makers at various levels and in multiple sectors. The intention is to monitor developments
within these projects putting an emphasis on creating synergies from the beginning through networking events.

The role of social sciences and humanities was a focus under the JPI Climate SRA (see Working Group 3 activities and outputs), is seen as an integral part of delivery of the SRIA challenges and strategic mechanism, and with respect to CS research and innovation will be strengthened through a dedicated Action Group to advise on future work and to fill research and innovation gaps.

To contribute to the implementation of the Paris Agreement, JPI Climate priorities for the coming years include further integrating the European CS infrastructure as a basis for CS provision, strengthening research co-operation at the international level with focus areas in Africa, Latin America and potentially China and the Pacific Islands, and advancing knowledge on cross-sectoral impact assessments particularly including socio-economic considerations.

Of the RFOs from which information was provided (Austria (BMWFWF), France (ANR), Ireland (EPA), Norway (RCN) and UK (NERC and ESRC)), their existing strategies and plans include research⁷ (and to a lesser degree innovation⁸) activities that are consistent and well aligned with the three JPI Climate challenges. For the most part, the identified investments appear to emphasise fundamental (upstream) research versus applied research/innovation (e.g., UK (NERC), France and Ireland reported investments focused on primary or upstream research, and UK (ESRC) estimated that it funded 70% fundamental research and 30% applied). Norway's report, on the other hand identifies a shift towards programmes that also emphasise applied research.

The research reported by the RFOs and by participants within the various engagement events was seen as contributing to more than one of the SRIA challenges and Strategic Mechanism (reflecting their purposefully designed overlapping nature). To some degree these broad-based contributions to the SRIA also reflects the interdisciplinary nature of many of the research activities (e.g., Earth System Sciences Programme within Austria and interdisciplinary and transdisciplinary requirements of KLIMFORSK).

Each of the RFOs reported activities that are consistent with and that could contribute to the Strategic Mechanism in that they are enhancing connections at different levels. These activities include:

- Enhancing connections across disciplines (e.g., Norway calls to improve climate research and address weaknesses and fragmentation of research groups related to transition to a sustainable, low emission society (2016) and social transformation in response to climate change (2013));
- Promoting coordination and enhanced impact at the national level (e.g., National Climate Research Coordination Group (Ireland, EPA), the Research and Innovation for our Dynamic Environment Forum (UK) and the Alliance of French Environment Research Performing Organisations; and

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⁷ Research: systematic investigation aimed at establishing new knowledge
⁸ Innovation: the process, including its outcome, by which new ideas respond to societal or economic needs and demand and generate new products, services or business and organisational models that are successfully introduced into an existing market or that are able to create new markets and that contribute value to society.
• Providing exchange opportunities to participate in science and research (e.g., Sparkling Science and Citizen Science in Austria).

All responding RFOs have noted existing strategies and/or plans (e.g., France with the ANR work programme and the National Research Strategy (2015) entitled France Europe 2020 and KLIMAFORSK long-term overall plan) for calls in areas related to the SRIA challenges. Of particular note is that most of these strategies and plans are due for renewal in or around 2020 (e.g., France, Ireland and Norway). This timing would suggest there is potential for mutually-beneficial alignment and learning from the JPI Climate Scoping Forum process among its members and within the JPI Climate with a role for JPI Climate in helping to realise this potential.

The European Research and Innovation Roadmap for Climate Services was published as a framework for shared solutions and pathways facilitating the development of a market for climate services that provides benefits to society. With its three challenges – enabling market growth, building the market framework and enhancing quality and relevance – it has been used to inform investments under H2020, but also related research and innovation by different European organisations, including within JPI Climate. As such, there is a mutually beneficial relationship between the further development of the European Roadmap and the implementation of the JPI Climate SRIA. The challenge is that in developing a strategy and plan for implementation of the SRIA, JPI Climate needs to strike an appropriate balance between being informed by and influencing the European Roadmap development.

In the context of H2020, and following on from engagement during the preparation of the European Roadmap, a broad package of actions within the different H2020 work programmes has been introduced consistent with the European Roadmap (e.g., market research (EU-MACS and MARCO), growing the community (ClimatEurope) and exploiting the added value of climate services (CLARA, CLARITY, H2020_Insurance, PROSNOW, PUCS and VISCA)). The European Roadmap, however, is seen as a living document and as such there is a recognised need to both monitor the status of related actions and to update it. This updating is seen as requiring the same level of engagement as its initial development if the European Roadmap is to continue to have the necessary impact. Questions will need to be asked, especially in the context of the role of an updated European Roadmap and the need for and nature of further investments by those acting at different levels within Europe to develop and support a CS market.

Across the European landscape of CS research and innovation there is space and reasons for promoting activities at various levels within Europe, including through: actions of H2020; actions of Copernicus; actions promoted by and undertaken within the JPI Climate and by its members and beyond; actions within other JPIs (Oceans, Water, FACCE and Urban Europe); actions funded by other European bodies (e.g., ESA, ECRA, EEA and JRC); international co-operation actions including with partners beyond the EU; and actions funded by other entities and the private sector (e.g., EIT Climate-KIC). To some extent, the JPI Climate is already working across this landscape with complementary activities and synergies, but this engagement is not consistent and as targeted (e.g., engagement across Europe, across the JPIs and other European bodies, and within related international initiatives).

Consideration will need to be given to the different roles the JPI Climate can and should play within this landscape, but also how these roles will need to change with the updating of the EU Adaptation Strategy (2017-2018), the operationalisation within Europe of the Paris Agreement, Sendai Framework and SDGs, the evolution of activities by the other players within Europe (e.g., Copernicus and FP9), and the internationalisation of CS research and innovation.
There is a recognised need to broaden the scope of international co-operation on CS research and innovation both within and outside of the EU; looking to align research and innovation agendas and to develop joint activities at the international level. This means engaging more European countries, in particular Eastern European countries. There are opportunities to realise this latter objective. Initial dialogues with non-member countries, engagement within the ERA4CS and further evidence gathered during this task demonstrates that there are activities underway in these countries supporting the three SRIA challenges and its strategic mechanism, including through connecting interdisciplinarity and transdisciplinary groups and joint projects.

There is also a recognised need to strengthen European leadership on CS research and innovation, particularly through partnerships in Africa and Latin America. These activities can build on existing linkages (e.g., EU-Africa Partnership and the EU and Latin America and the Caribbean mechanism) and existing research relationships and investments, as well as existing expressions of interest in collaboration with European actors in the area of CS (e.g., regional climate change centres and the African Climate Policy Centre). Together these offer potential opportunities that could have beneficial impacts on delivering the SRIA (and the European Roadmap challenges).

Identified priorities internationally are related to filling significant gaps in climate observations, the understanding of climate impacts and CS in developing countries. For example, identified among these priorities is support for the Africa-CORDEX project to develop an Africa Atlas for 1.5, 2 and 4 degrees similar to the European IMPACT2C web-atlas. JPI Climate can help to create opportunities for EU/Africa collaborations to address these gaps and to add value to European CS research and innovation.

The international context as reflected in GCOS, GFCS and the Belmont Forum also poses challenges and opportunities for the JPI Climate and the delivery of its SRIA.

The GCOS Implementation Plan 2016 focuses on observations for adaptation, mitigation and climate science by supporting the development of a global climate observing system. This focus is achieved by supporting national and regional networks, and encouraging consistent, comparable climate-quality observations that are fundamental to prediction of future climate, climate change and extremes, but also to enabling planning and risk reduction, improving climate science and understanding and providing public information about the climate. Implementation and future updates of this plan will be critical to implementation of the SRIA.

The GFCS Implementation plan 2016-2018 is comprised of actions intended to catalyse the development and application of climate services that support nations and communities to develop sustainably, reduce disaster risk and adapt to climate change. These synergistic objectives include priority applications to improve decision-making in climate-sensitive areas, connecting user needs with CS through sustained engagement mechanisms that ensure user-driven services delivery, and enhancing core technical and scientific capabilities to support user-driven CS. The strong link of these objectives and priorities to the JPI Climate SRIA challenges and Strategic Mechanism suggests that working together in areas of common concern could provide mutual benefits.
The Belmont Forum\(^9\) aims to accelerate delivery of the environmental research needed to remove critical barriers to sustainability by aligning and mobilizing international resources. Its funding is intended to add value to existing national investments and to support international partnership in interdisciplinary and transdisciplinary scientific endeavours. Collaboration in the past (e.g., JPI Climate and Belmont Forum Climate Services Collaborative Research Action on Climate Predictability and Inter-Regional Linkages) has proven beneficial and should provide an exemplar for further joint efforts.

Internationally, the trilogy of agreements (Paris Agreement, Agenda 2030 with the SDGs, and the Sendai framework) will be drivers of demand for a new generation of CS. The integrated nature of these agreements and their common pursuit of low carbon and climate resilient development, mean that CS will be required to inform both the plans to consistently implement the new agendas, as well as the monitoring, evaluation and reporting on progress towards the goals set out across the three agreements.

The challenge ahead is to identify the role CS can play in informing coherent approaches to the implementation of the agreements at the international and national levels. For example, at national and sub-national levels, implementation will require CS capable of informing the full range of plans and communications required in the international policy context (e.g., Nationally Determined Communications (NDC), National Adaptation Plans (NAP), Adaptation Communications, mid-century low greenhouse gas emissions strategies, SDG strategies, national and local disaster risk reduction strategies, national reports to the High Level Political Forum on progress towards Agenda 2030 and National Communications).

### 4.2 Concerns arising from the critical analysis

The increasing demand for, and supply of, research supporting the development of knowledge and CS, the incomplete understanding of the knowledge being generated and the attempts by some to discredit both the research and knowledge generated provide both challenges and opportunities for the research and innovation community. These are challenges and opportunities where JPI Climate could and should be playing an effective role within Europe and globally. The JPI Climate existing vision ‘to actively inform and enable the transition to a low emission, climate resilient economy, society and environment that is aligned with Europe’s long-term climate policy objectives’ explicitly identifies a role in addressing these challenges and opportunities. But even more so, in pursuing this vision, the SRIA goes further, indicating that ‘the JPI shall develop and coordinate a pan-European research programming platform to provide useful climate knowledge and services for European and national climate strategies and plans and that contributes to the UNFCCC and the UN Sustainable Development Goals’. It has also been pointed out that this pan-European research programming platform should also contribute to the Sendai Framework.

As such, it can be argued that the JPI Climate is fundamental to addressing the above identified societal challenges and in taking advantage of the opportunities offered by international and national efforts to address them. The development by the JPI Climate of its SRIA comprised of three overarching challenges and a Strategic Mechanism that together can contribute to the broader spectrum of societal challenges helps focus and support innovative, relevant and informative climate research.

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\(^9\) The Belmont Forum is a group of the world’s major and emerging funders of global environmental change research and international science councils.
The evidence gathered through task 7.4 does show that this willingness for the JPI Climate to play a role in addressing societal challenges is to some degree reflected in actions, but that the actions are not yet mature or have limited recognition of this desired attribute. The SRIA provides the framework, and there is now a need to implement it; initiating, expanding, refocusing and maintaining research and innovation activities to address these limitations and thereby enhancing and demonstrating the value of the JPI Climate.

4.3 Considerations for JPI Climate in implementing its SRIA

Considering the analysis of the evidence gathered and the European and broader CS research and innovation landscape, the following specific concerns and opportunities have been identified that should be considered within the JPI Climate Scoping Forum when developing a vision and implementation strategy and plan for the SRIA.

4.3.1 Limited alignment of CS research and innovation supporting CS within Europe and internationally

*Limited understanding and sharing of information on research (and innovation) investments supporting CS being made by RFOs and RPOs across Europe*: The JPI Climate has had some success at seeking alignment through joint calls (e.g., Call for Transnational Collaborative Research Projects, Call for Climate Service Collaborative Research action on Climate Predictability and Intra-regional Linkages and the ERA4CS joint call on Research and Advancing Climate Service Development) and actions within the working groups established under its previous Strategic Research Agenda (See Task 7.1 report). Furthering this alignment is limited by the lack of a shared understanding of investments and strategies by RFOs and RPOs.

*Multiple efforts at the European level identifying related research and innovation agendas (JPI Climate, European Roadmap, JPIs, ECRA, JRC, etc.)*: There is some coordination of such efforts within the European Roadmap working group and through some sharing of information. There are also research and innovation agenda-setting efforts at the international level (GFCS, UNFCCC, Future Earth, PROVIA, etc.). However, the level of coordination, engagement and communication among these efforts (degree of transparency possible and necessary) is not always clear, nor is the role of the JPI Climate in these efforts.

*There are opportunities to build on examples of alignment*: These include working with the different JPIs that are addressing climate change knowledge and evidence issues in a sectoral manner such as JPI Urban Europe in the context of the EN-SUGI ERA-NET to develop a joint Roadmap on urban adaptation activities, and JPI FACCE working with 11 RFOs in a collaborative programme aimed at improving adaptation and mitigation strategies and measures for agriculture in the face of climate and land use change. The question is to better understand how to build on these examples strategically within the context of the SRIA for the mutual benefits of all involved.

*Limited clarity as to the JPI Climate’s (current) and required role with respect to coordination of research and innovation to support CS at the international level*: For JPI Climate as an organisation there is no mandate to be part of and to influence the international processes as Governing Board (GB) members represent the national research interests of their respective member countries; nor does there seem to be a systematic approach to having a single voice when participating internationally which would potentially enhance influence. As a voluntary
collaboration initiative and without legal entity status, JPI Climate has limited influence in official processes.

*Lack of clarity and agreement on the expectations, including from its members and those participating, as to role and type of representation that is appropriate within related international fora:* This relates to fora such as GFCS, Future Earth, Belmont Forum, relevant research dialogues within the UNFCCC, and the IPCC, and the need for clarity as to the role of JPI Climate within these fora and the added-value from a JPI Climate perspective.

*Increasing risk of duplication and redundancies, and limited potential for complementarities and synergies:* This situation is the result of the increasing amount and diversity in the scope of CS research and innovation. This has implications for the effectiveness of funding and the quality and relevance of the resulting research and innovation, as well as the development and use of research infrastructure.

*Potential collaboration of the JPI Climate with research and innovation in Africa, Latin America and more broadly internationally:* Collaborative initiatives in Africa and Latin America require a strategic direction and clearly identified priorities, working within related existing and developing initiatives (e.g., CLIM-DEV (Climate for Development in Africa) the EUROCLIMA development programme and related initiatives under H2020 and within C3S).

### 4.3.2 The changing European and international related agendas will require greater alignment of CS research and innovation

*The existing and evolving alignment the international agreements on climate change, DRR and sustainable development, and EU-related policies and strategies:* This alignment provides both opportunities and challenges for CS and the associated research and innovation. There are also opportunities and challenges associated with the implementation of the existing EU Adaptation Strategy (and its updating). The challenges at the national level are to implement these agreements in an aligned and coordinated manner through domestic action and to connect with others to work collaboratively, share and learn. The SRIA provides a framework that could be used to enable and facilitate the required alignment and coherence. For the JPI Climate this potential for alignment and the challenges at the national level should be considered as an opportunity in implementing its SRIA.

The evidence gathered within task 7.4 suggests that research and innovation supporting CS should be supporting the alignment and coordination of both decisions and the decision-making processes.

The alignment challenges at the national level have direct relevance to identifying and prioritising research and innovation as the decisions countries make and the plans they develop in response to international agreements will need to be informed by CS. The challenge for JPI Climate is to contribute to the development of relevant CS of the highest quality that are able to inform these plans and their implementation, but that can also be used to monitor and evaluate their implementation. Addressing these challenges will require consideration of the extent to which JPI Climate should be developing new and using its existing implementation instruments to enable and facilitate appropriate alignment.
4.3.3 Limited engagement of the research and the broader CS communities in climate change research and innovation at a national and European level

The evidence and subsequent analysis pointed to a number of concerns that the JPI Climate should consider and interpret in developing its vision and implementation strategy and plan:

- Limited opportunities for users, surveyors, providers and researchers at the national level to engage to support national efforts (research, innovation and promotion)
- Limited engagement of RFOs and RPOs from those European countries not currently JPI Climate members in CS research and innovation, and more broadly in related activities (e.g., related H2020 CSAs and international activities).

There are a number of barriers to widening the engagement (e.g., the cost of participation and that lack of clarity on the added value of participation). In addressing this limitation, the JPI Climate will need to identify and explore means of addressing these barriers, including that extent to which the current governance structure and processes are responsible for those barriers. This exploration should also consider mechanisms that JPI Climate should be using that would support broadening engagement across Europe, and the dependence of such mechanisms on strengthening the partnership with the European Commission?

Despite a number of past and ongoing initiatives looking to include more Eastern European RFOs and RPOs with the objective of widening and integrating a more comprehensive expertise and knowledge base (e.g., COST; widening pillar in H2020; various bilateral national activities) the research and innovation gap between western and Eastern European countries (and other countries in Europe) remains a problem. JPI Climate should be in the position to clearly articulate its role and priorities in closing this gap and widening its partnership work, which should build on previous efforts and initial relationships as well as partners already involved in ERA4CS (Czech Republic, Slovakia and Greece).

4.3.4 Research not building on previous and ongoing research, and innovation not able to draw on broader research and innovation

The evidence and analyses suggest that this concern is primarily related to limitations in the dissemination of research and innovation outcomes and the breadth of science that is drawn upon within research and innovation activities. Particular concerns which should be considered by the JPI Climate are:

- **Limited knowledge synthesis, translation and mobilisation to inform innovation, decisions and policy:** For research and innovation supporting CS, there is a lack of knowledge synthesis and translation that looks across related investments focusing on the outcomes from the perspective of informing further research and innovation, but also to inform decisions and policy-makers.
- **Coordination, but also the identification of related projects and their findings, is not seen as anyone’s responsibility and is not undertaken systematically:** This limitation (partially due to lack of funding as research funding does not normally address related coordination efforts across research projects and programmes) results in *ad hoc* or sporadic interactions often depending on the personal engagement of researchers and research organisations.
• Reliance for mobilisation of the resulting knowledge is focused on using traditional scientific media (papers, conferences and workshops) and for the most part is project-focused. Within Europe, there have been some efforts by the European Commission (e.g., MEDIATION) and the JPI Climate (see Task 7.1 report) to draw across research, but for the most part, mobilisation of the results has been limited.

There is a role for the JPI Climate in addressing coordination, translation and mobilisation of knowledge. This is linked to its aim ‘to achieve greater impacts through the involvement of the public and private sectors in knowledge creation and mobilisation’. The challenge will be to identify what and how the JPI Climate will undertake this role towards realising this aim.

4.3.5 Limited engagement and integration of social sciences and humanities into all aspects of climate change research

This concern is clearly recognised within the JPI Climate and within the broader CS research and innovation community. Particular aspects identified are:

• Expected engagement across the SRIA challenges and strategic mechanism: Current engagement across the disciplines is limited and there is a lack of clarity as to the expectations for multi-, inter- and transdisciplinary research within each of the SRIA challenges and the strategic mechanism. Linked to this is the need to overcome limited recognition and reflection of the social science and humanities research agendas and framings, and potential contributions.

• Expectation of the proposed social science Action Group: A social science Action Group within JPI Climate is useful, but should not be misconstrued as being all that is required to engage the social science and humanities communities within climate change research. Approaches to achieving the desired engagement will need to be explored within the Scoping Forum process, including the potential benefits from connections with other platforms engaging with social sciences and humanities aspects of societal transformation related to climate change (e.g., PERSON project (European Platform for Energy Research in the Socio-economic Nexus)).

4.3.6 Reflecting the changing nature of the required research and innovation, including in terms of the evolving and growing needs of decision and policy makers

Research and practice related to the evolving nature of decision-making is not being used to inform research and innovation supporting CS or the design and development of climate services: For example, understanding the implications for CS as a result of the development of adaptation pathways as a decision framing approach, including the integration with other evolving approaches (e.g., robust-decision making). This includes understanding and supporting decision-making framings with relevant information on associated uncertainties and limitations.

Innovation (TRLs greater than four\(^{10}\)) is undervalued within the research community, both funders and academic communities. This concern is reflected in the scope of both research investments

\(^{10}\) Technology Readiness Levels – although there are many different specific definitions, in the context of research and innovation, they can be grouped to distinguish four different levels. Within the OECD these are: Fundamental research (TRL 1-3), development or applied research (TRL 3-5), demonstration (TRL 6-7) and early deployment
by RFOs and research being undertaken by RPOs. Many academics also have difficulty in moving towards innovation activities.

Identified research and knowledge gaps collected during this task appear to signal a shift in emphasis towards more applied research and to innovation which potentially reflects the need to enhance the demand for CS). This shift also appears to reflect the growing understanding that CS need to inform and influence decision-making and is critical if the societal transformation envisaged by the Paris Agreement and referred to in the JPI Climate SRIA is to be achieved. This shift is also evident from the responses during the engagement events that identified a need to include a focus on engineering and technologies and an increasing emphasis on SRIA challenges 2 and 3. Fundamental research across disciplines remains important, particularly that affecting the quality and relevance of CS. Gaps emphasised reflect the need for multi- and interdisciplinary research and include better understanding and reflecting of for example extreme events in CS, quality assurance/quality control and standards for CS, and legal, ethical and cultural aspects of CS.

The intentional overlap between the SRIA challenges is reflected in the identified existing research activities and in research and innovation gaps: Many of the research and innovation gaps identified were seen as addressing more than one challenge and including efforts related to the Strategic Mechanism. In developing an implementation strategy and plan, JPI Climate should consider what this mean for the JPI Climate implementation strategy and how JPI Climate can maximise the benefits of this cross-challenge opportunity.

4.3.7 Limited research and innovation contributing to the SRIA Strategic Mechanism

The SRIA clearly recognises that research and innovation that can contribute to the process of connecting and learning is critical to the delivery and success of the Strategic Mechanism. Specific areas identified are:

- **The SRIA requires that the JPI Climate explores and learns from transdisciplinary research processes and shares the results.** This includes exploring and tracking complex interrelations between the disciplines and understanding the underlying forces and interdependencies driving systems’ dynamics, and facilitating joint problem solving in cross-sectoral areas like resilience and risk reduction. There are opportunities to link to existing activities exploring and using these approaches (e.g., related activities within the social sciences and humanities research communities, H2020 projects such as PLACARD and ESPRESSO, other JPIs, C3S and broader adaptation and resilience communities).

- **Limited integration across disciplines is challenging efforts within JPI Climate in engaging in these activities and enhancing connectivity.** Based on the JPI Climate vision and SRIA, there is a need to **explore and identify the specific niche and added-value of and for JPI Climate engagement in these existing activities.**

- **Lack of clarity in the specific roles and priorities in delivering the strategic mechanism.** This concern is particularly related to the JPI Climate’s roles in enabling and facilitating synergies and complementarities, and activities targeted at maximising the benefits and reducing the negative impacts of redundancies. **There is currently lack of definition of the areas that should be prioritised, and if there are areas and activities in which JPI Climate should or should NOT be involved in.**

(TRL 8-9). The European Investment Bank distinguishes between research (TRL 1-3), Development (3-6), Innovation (TRL 6-8) and Production support (TRL 9).
These limitations, left unaddressed will render less effective the entire body of CS research and innovation and JPI Climate contributions, as they risk reducing the effectiveness of the investments. Also, in terms of CS, the limitations may affect the quality and relevance of CS and thereby affect the pull and uptake of CS due to poor engagement and knowledge exchange and a lack of understanding of the value. It is important to understand how and why people use, understand and trust CS.

4.3.8 Limited efforts to effectively disseminate the results of research and innovation supporting CS, particularly with the aim of demonstrating quality, value and relevance

Lack of a defined and implemented role in demonstrating and communicating the value and relevance of climate knowledge and services: Defining and implementing this role will need to consider the specific role and priorities for the JPI Climate amongst the many other actors at the national, European international levels who are or should be involved. These considerations will also need to include defining the JPI Climate’s role in addressing those discrediting or misunderstanding the science and the potential of moving to the development and delivery of a positive narrative on climate change and CS.

Lack of targeted research and innovation activities or links to existing efforts within this evolving area: The Strategic Mechanism provides the basis to address this concern; the challenge will be to identify priority areas and a timeline for such research and innovation and for establishing linkages with existing activities.

5 Recommendations

The recommendations presented in this section address the issues, concerns, weaknesses and opportunities identified in Section Four. The recommendations are cognisant of the mission of JPI Climate and seek to build on that mission to identify measures to inform the implementation of the SRIA.

JPI Climate’s mission is to align and inform strategies, instruments, resources and actors at national and European levels by connecting the various research communities with research funders and performing organisations, within and across European countries, and beyond Europe.

The analysis and recommendations from Task 7.4 are to be used by Task 7.5 to forge a common vision, implementation strategy and plan for CS research and innovation. The JPI Climate should consider these findings and recommendations to inform the Scoping Forum process and its contributions towards the development of the required vision, implementation strategy and plan.

The JPI Climate Executive Committee and the team delivering Task 7.5, with the support of the Central Secretariat, should review these recommendations to define an action plan that would be brought to the autumn 2017 GB meeting for approval. The effectiveness of these recommendations in supporting the 2018 Scoping Forum process should be reviewed with the intention of revising the recommendations for future Scoping Forum processes. For those recommendations that go beyond the Scoping Forum process, the action plan should include
proposed milestones and timelines with progress monitored and evaluated by the GB. The action plan should be revisited, revised and updated on a biannual basis.

The following recommendations aim to increase the effectiveness, relevance and impact of CS research and innovation by strengthening co-operation and alignment, by enhancing societal relevance and by establishing a stronger global position for JPI Climate.

5.1 Strengthen co-operation on climate service research and innovation to maximise effectiveness and impact

The JPI Climate SRIA states that intensified co-operation between researchers from different countries, scientific traditions, disciplines and perspectives enhance innovation and scientific quality.

JPI Climate should solidify its position as the key player on CS research and innovation in Europe with responsibility for coordination and co-operation.

R1.1. JPI Climate should take advantage of the full range of instruments available to it (mapping, synthesises, workshops, white papers, pilots, joint strategy papers, and joint calls (multi-national, ERA-Net and Article 185), and explore other potential instruments (e.g., those arising from operationalising the Strategic Mechanism) to promote greater collaboration and alignment of CS research and innovation at the EU level.

- JPI Climate should identify appropriate mechanisms and means to undertake synthesises of research evidence and outcomes and to make this information more widely accessible (e.g., publishing on the JPI Climate website, and shared through ClimatEurope, the EC, etc.), and to facilitate information sharing and greater alignment. These mechanisms should involve encouraging RFOs and RPOs to jointly share the outputs of their activities. The increased sharing that would result from these synthesises would promote greater alignment, and would also help identify gaps and inform actions to fill these gaps that could be shared with JPI Climate members, the EC and more broadly.

- The JPI Climate Strategic Mechanism can play an important role in facilitating knowledge and information exchange and collaboration (e.g., as part of ongoing work to develop a market for CS in Europe). Linked to operationalising its Strategic Mechanism and its long-term strategy, the JPI Climate should consider holding a targeted workshop as part of the Scoping Forum process to assess needs and opportunities, including the associated research and innovation.

R1.2. JPI Climate should continue mapping ‘who does what’ in CS research and innovation, building on earlier work initiated by the European Commission, so that it has an up-to-date picture of the key actors and their roles and responsibilities to encourage coordination and alignment. This could build on the national research and innovation mapping exercise initiated in Task 7.4, but should also be extended to include all RFOs and RPOs across Europe engaged in CS research and innovation. This mapping should inform the JPI Climate Scoping Forum and be updated through discussion and dialogue between its members as part of the delivery under the Strategic Mechanism.
• The JPI Climate GB should include in its agenda (annually or more frequently) a discussion to better understand the research and innovation investments or plans of its members with the intention of identifying potential complementarities and synergies, and to support discussions related to gaps.
• The EC should promote and enable JPI Climate to play this coordination and facilitation role by participating in the Scoping Forum process and sharing information on its activities related to CS research and innovation.

R1.3. JPI Climate should take a lead role in engaging with and supporting collaboration between all of the relevant JPIs (Water, Oceans, FACCE and Urban Europe) in matters related to CS and wider climate change research. JPI Climate should identify research and innovation priorities to target co-operation between the JPIs consistent with its SRIA to maximise shared benefits and to avoid redundancies, for example through joint working groups, joint networks and joint projects.

R1.4. JPI Climate should engage more strongly with Copernicus, including its C3S, in defining and delivering mutually beneficial research and innovation agendas and sharing strategies, plans, and research and innovation results to promote complementarities and synergies.

R1.5. JPI Climate and its members should seek and enable an appropriate balance between research and innovation activities and investments as a means of maximising the value and benefits to society of the resulting climate services.

R1.6. JPI Climate members should engage proactively in JPI Climate activities aimed at implementing the SRIA. The success of the JPI Climate in delivering and further developing its SRIA will require that all JPI Climate members proactively engage in and support JPI Climate activities, and that its membership is broadened to encompass all of Europe, including currently un- and under-represented regions and countries.

R1.7. JPI Climate and its members have an important role to play in communicating the value of climate research and innovation in terms of the services to society and the role of JPI Climate. In particular, it is important to engage a wide range of actors from climate deniers to decision-makers that have not yet realised the value of CS to their work, organisations and communities. Communication should be included as an important theme in the Scoping Forum process and SRIA implementation.

5.2 Strengthen the alignment of research and innovation supporting climate services to maximise effectiveness and impact

The JPI Climate SRIA states that enhanced alignment of research should improve the efficiency and utility of research investments, including human resources and capacity.

JPI Climate should enhance its efforts to provide opportunities for its members to better align their research and innovation activities in support of CS.

R2.1. JPI Climate members should collaborate at the national level to maximise alignment of research and innovation and to share outputs to support JPI Climate's mapping of CS activities in order to enable collaboration and alignment at the transnational level.
• RFOs should pro-actively share information on their research and research strategies to enable greater alignment. JPI Climate and other fora such as GFCS, Copernicus and the Belmont Forum can provide platforms for sharing information in order to inform the future direction of CS research and innovation, and to maximise opportunities for alignment. This sharing should also consider using such fora as provided by ClimatEurope and CSP. RFOs may wish to explore opportunities to better align their respective research strategies and funding calls to promote collaboration and alignment, to reduce redundancies and to maximise value for money.

• JPI Climate members should include in the evaluation of their research and innovation activities/programmes the identification of added-value (including impact), including complementarities and synergies, and of gaps or areas needing strengthening. The results of these evaluations should be shared with the JPI Climate (e.g., as part of the mapping exercise) with the aim of sharing learning and informing the Scoping Forum.

• RPOs and RFOs via JPI Climate should collaborate to identify redundancies and opportunities and to drive investments into relevant new areas of research and innovation. For example, for CS research and innovation there is a need to move away from uncoordinated duplication of earlier research and to emphasise an approach where CS research and innovation is decision-driven and science informed.

• At the national level, by encouraging and enabling RFOs and RPOs to collaborate in producing publicly available syntheses of generated evidence and outcomes (see earlier recommendation), it would not only make research outcomes more accessible, identify gaps and inform future research and innovation activities, but also increase the potential for complementarities and synergies.

R2.2. JPI Climate members should build on their experience in strengthening coordination, coherence and alignment at the national level, including that with non-member countries and RPOs, to enhance coherence and alignment at the EU and international level. These are key elements to be implemented through the SRIA implementation strategy and plan. The JPI Climate Scoping Forum should provide opportunities to explore and identify how the experiences of its members and others can be used within the JPI Climate to enhance collaboration, coherence and alignment of CS research and innovation.

R2.3. JPI Climate should continue to engage with its members and enable the sharing of experiences and lessons learned through focused JPI Climate workshops and joint meetings targeting specific research and innovation activities. The results of these workshops and joint meetings should be used to inform the identification of joint calls (and the use of other instruments), and should also be part of the Scoping Forum process.

• The JPI Climate should use the fact that a number of the RFOs’ investment strategies and plans are due for renewal in or around 2020 to seek potentially mutually-beneficial alignment within the JPI Climate implementation strategy and plan.

• JPI Climate members should encourage and enable new members to join with the aim of enhancing representativeness and maximising the impact of JPI Climate’s actions related to the alignment of CS research and innovation. This is especially important for under-represented regions and countries, particularly in Eastern Europe.

R2.4. JPI Climate should lead by example and demonstrate the added value of increased cross-project collaborations (i.e. synergies and complementarities). This should include building on lessons learnt from previous joint calls (e.g., the Joint Call for Transnational
Collaborative Research Projects: Societal Transformation in the Face of Climate Change) and purposefully pursuing cross-project collaborations within the ERA4CS cash and in-kind research and innovation projects. These lessons and the challenges identified should be used to inform the Scoping Forum and the delivery of the SRIA Strategic Mechanism.

R2.5. JPI Climate should engage more widely within Europe to share information generated in collaboration with its members, as a basis for increased co-operation and collaboration with ClimatEurope, the EC (including the European Roadmap working group) and the other JPIs, in order to promote greater alignment of research and innovation for CS at the European level.

R2.6. The EC should monitor and regularly update the European research and innovation Roadmap for CS, including as a means to enable greater collaboration and alignment of CS research within and across Europe and to maximise the uptake and impact of research outputs.

- The EC should consider the outcomes of the JPI Climate Scoping Forum in preparations for updating the European Roadmap and for FP9 and beyond, and take on board recommendations related to alignment, inter-disciplinarity, research relevance and the need for innovation to drive societal transformation (e.g., resulting in the need for more investments in research and innovation activities at TRL 4 and higher).
- The EC should promote and encourage increased engagement between JPI Climate and related CS research and innovation activities, including engagement with C3S and related H2020 funded activities, but also with the other members of the informal European Roadmap working group (e.g., JRC, DG GROW, DG ECHO and ESA).
- The EC should actively engage with JPI Climate, including by linking efforts related to updating the European Roadmap with the Scoping Forum process. This engagement and the exchange of information would enhance both processes and improve understanding of who does what on CS research and innovation. The links that both of these efforts have to international activities would also benefit from such engagement and exchange.

5.3 Enhance the societal relevance of research and innovation supporting climate services

The SRIA states that climate change research includes perspectives from natural to social sciences including behavioural sciences and the humanities to the degree they address and support an integrated understanding of climate change as physical, environmental, economic, political, social and cultural phenomenon, as well as of the barriers to actions and approaches to deal with climate change.

JPI Climate should intensify its efforts to promote interdisciplinary CS research and innovation.

R3.1. JPI Climate should promote and encourage multi- and interdisciplinary research (across the three challenge areas and the Strategic Mechanism) with a particular focus on engaging the social sciences and humanities in all aspects of CS research and innovation. This includes supporting the newly established Action Group on social sciences and humanities, but will also require other actions such as a tailored interdisciplinary research
and innovation strategy and plan, interdisciplinary workshops and research and innovation dialogues.

- The implementation of the JPI Climate SRIA should bring social science, humanities, culture, engineering, communications etc. into the core of its work. JPI Climate and its members should also adopt a bottom up approach to CS which starts with understanding the decisions and choices people are taking as the world transitions to climate resilient, low carbon development, and uses this as a basis for determining the research and innovation needed to inform those decisions.
- RPOs and RFOs should facilitate and implement multi- and interdisciplinary CS research and innovation and actively promote and seek opportunities to engage the social, engineering and natural science communities from the outset of programme/project design and implementation. Workshops and research meetings that engage and consult across disciplines will enable the co-design of research questions and responses so that scientists from across the disciplines work together on CS research and innovation.

R3.2. JPI Climate and its members should collaborate to increase the understanding, relevance and profile of CS, and to enhance the understanding and articulation of their value, including providing societal benefits. The priority research and innovation activities identified in the European Roadmap and their reflection in the SRIA, particularly related to increasing the pull and relevance of CS, can inform future RFO and RPO activities.

- RPOs and RFOs should incorporate research on decision-making frameworks into CS research and innovation to better understand the CS needed to inform decision-making across spatial and temporal scales and for different purposes within the adaptation, mitigation, sustainable development and DRR decision-making processes, and in support of the evolving need to integrate these decisions.

R3.3. JPI Climate should use its SRIA Strategic Mechanism to better connect CS research and innovation to the evolving needs of decision and policy makers towards enabling the mobilisation of the outputs to enhance the utility and value of the resulting climate services.

5.4 Establish a stronger global position for JPI Climate in climate service research and innovation

The SRIA states that a well-coordinated JPI Climate will provide a competitive edge in the global climate change science arena. By providing strong science support, it can also foster Europe’s role in international climate policy development and enhance North-South research collaboration.

JPI Climate and its members should play a more significant role on the international stage to share research outputs, and to inform and be informed by international policy and practice.

R4.1. The JPI Climate should establish a process by which it is represented within relevant international fora (e.g., UNFCCC, Future Earth, Belmont Forum, etc.) and at relevant international conferences and meetings. Whilst recognising that JPI Climate members already participate in these fora to represent their countries or institutions, there is also a
need to provide for effective representation of JPI Climate as a whole. This participation would help to inform JPI Climate’s work related to the Scoping Forum and in realising the aims of its Strategic Mechanism.

- JPI Climate and its members should use international conferences (e.g., European Climate Change Adaptation, Adaptation Futures, the International Conference on Climate Services series, and the Global Forum on DRR), as well as platforms like ClimatEurope and the CSP to establish connections and engage in a long term dialogue with other actors in the CS community. Participation in these events would also enable JPI Climate to represent its members and the outcomes of their collective work at the EU and international level.

- JPI Climate and its members should strengthen their engagement at the international level so that the implications of international agreements on policy and decision-making are well understood and used to inform CS research and innovation. For example, to understand the CS needs arising from the implementation of the Paris Agreement, Sendai Framework and SDGs and to understand the roles different actors will play in responding to those needs (JPI Climate, Copernicus, FP9, etc.).

- JPI Climate should engage more internationally on CS research and innovation to share learning and support CS development in Africa, Latin America etc. An initial step may be though the recently funded CSA SINCERE (Strengthening International Cooperation on Climate Change Research) under H2020-SC5-2016-2017 which aims to strengthen international climate change research and innovation cooperation involving European partners expanding JPI Climate to include Eastern European countries and through collaborations in Africa and Latin America.

R4.2. JPI Climate and its members should work together to provide coordinated and aligned inputs to the Belmont Forum, the GFCS (especially the implementation plan) and Copernicus (including its C3S) to share experiences and research outcomes and to be informed by the work of the wider CS community.

R4.3. JPI Climate and its member should enhance awareness within Europe and internationally of the contributions of the JPI Climate. Increasing this awareness should be seen as part of delivering the Strategic Mechanism goal related to connectivity, but also a means of gaining recognition of the value of JPI Climate and establishing its position within Europe and internationally.
**Figure 3: Infographic summary of ERA4CS Task 7.4**

**Aim:** To identify research and knowledge gaps, including those related to quality standards and quality control for climate services, and to identify the complementarities, redundancies and synergies between national, European and international programmes or initiatives.

**Key findings in context:**
Key findings were put into context through reflecting on the evidence gathered in the context of the landscape of research and innovation supporting climate services. With the JPI Climate vision and implementation of its Strategic Research and Innovation Agenda (SRIA) in mind, these reflections led to identification of a number of challenges and opportunities where JPI Climate could and should be playing a role. These challenges and opportunities form the basis of the report recommendations.

**Key Recommendations:**
Building on the mission of JPI Climate, to increase the effectiveness, relevance and impact of research and innovation supporting climate services, JPI Climate and its members should:

1. **Strengthen cooperation on climate service research and innovation to maximise effectiveness and impact**
   - Solidifying JPI Climate’s position and strengthening engagement; making research evidence more widely accessible; providing an up-to-date picture of the key actors and their roles; encouraging coordination and alignment; enabling a balance between research and innovation activities and investments; improving communication.

2. **Strengthen the alignment of research and innovation supporting climate services to maximise effectiveness and impact**
   - Collaborating at the national level; sharing outputs; enhancing coherence and alignment; engaging more widely within Europe to share best practice; demonstrating the added value of increased cross-project collaborations; leading by example.

3. **Enhance the societal relevance of research and innovation supporting climate services by intensifying its efforts to promote interdisciplinary research and innovation**
   - Encouraging multi- and interdisciplinary research; further engaging the social sciences and humanities; better connecting research and innovation supporting climate services to the needs of decision and policy makers; increasing the understanding, relevance and profile of climate services through collaboration.

4. **Collaborate to establish a stronger global position for JPI Climate in research and innovation supporting climate services**
   - Establishing a ‘process’ to represent JPI Climate within relevant international fora and conferences; providing coordinated and aligned inputs into the Belmont Forum, the GFCS and the Copernicus Climate Change Service (C3S); enhancing awareness of the contributions of the JPI Climate.
## Glossary

<table>
<thead>
<tr>
<th>Name</th>
<th>Definition and further information</th>
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<tbody>
<tr>
<td><strong>Belmont Forum</strong></td>
<td>The Belmont Forum is a partnership of funding organizations, international science councils, and regional consortia committed to the advancement of interdisciplinary and transdisciplinary science. <a href="http://www.belmontforum.org/">http://www.belmontforum.org/</a></td>
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<tr>
<td><strong>Climate Science for Services Partnership Brazil</strong></td>
<td>The Climate Science for Service Partnership Brazil (CSSP Brazil) is a research programme that will support the development of capability to underpin services to inform decision makers in climate mitigation and adaptation strategy, supporting climate and weather resilient economic development and social welfare. <a href="http://www.metoffice.gov.uk/research/collaboration/newton/cssp-brazil">http://www.metoffice.gov.uk/research/collaboration/newton/cssp-brazil</a></td>
</tr>
<tr>
<td><strong>Climate Science for Services Partnership China</strong></td>
<td>The Climate Science for Service Partnership China (CSSP China) is a scientific research programme that will help build the basis for services to support climate and weather resilient economic development and social welfare through strong strategic partnerships harnessing UK scientific expertise. <a href="http://www.metoffice.gov.uk/research/collaboration/cssp-china">http://www.metoffice.gov.uk/research/collaboration/cssp-china</a></td>
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<tr>
<td><strong>Climate Services</strong></td>
<td>Being relatively new, various definitions and interpretations exist for the concept of climate services. For the scope of this document, we attribute to the term a broad meaning, which covers the transformation of climate-related data — together with other relevant information — into customised products such as projections, forecasts, information, trends, economic analysis, assessments (including technology assessment), counselling on best practices, development and evaluation of solutions and any other service in relation to climate that may be of use for the society at large. As such, these services include data, information and knowledge that support adaptation, mitigation and disaster risk management (DRM). Taken from 'A European research and innovation Roadmap for Climate Services’ 2015 Directorate-General for Research and Innovation</td>
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<tr>
<td><strong>Complementarities</strong></td>
<td>Research and innovation projects, programmes and initiatives each working on similar activities and/or areas, whose outputs provide, or have the potential to provide, a wider or more comprehensive outcome. [In effect these have the potential to provide synergies].</td>
</tr>
<tr>
<td><strong>Copernicus</strong></td>
<td>Copernicus is a European Union Programme aimed at developing European information services based on satellite Earth Observation and in situ (non-space) data Taken from 'A European research and innovation Roadmap for Climate Services’ 2015 Directorate-General for Research and Innovation</td>
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<tr>
<td><strong>COST Actions</strong></td>
<td>COST Actions are networks centred around nationally funded research projects in fields that are of interest to at least seven COST Member States.</td>
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<tr>
<td><strong>Future Earth</strong></td>
<td>Future Earth is a major international research platform providing the knowledge and support to accelerate transformations to a sustainable world <a href="http://www.futureearth.org/">www.futureearth.org/</a></td>
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<tr>
<td><strong>Horizon 2020</strong></td>
<td>Horizon 2020 is the EU Research and Innovation programme. <a href="http://www.ec.europa.eu/programmes/horizon2020/en">www.ec.europa.eu/programmes/horizon2020/en</a></td>
</tr>
<tr>
<td><strong>JPI Climate</strong></td>
<td>Joint Programming Initiative for ‘Connecting Climate Knowledge for Europe’ <a href="http://www.jpi-climate.eu/home">http://www.jpi-climate.eu/home</a></td>
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| JPI Climate FTA | Fast Tracking Activities, a series of research priorities in climate change response:  
|                | WG1: Moving towards Reliable Decadal Climate Predictions  
|                | WG2: Researching Climate Service Development and Deployment  
|                | WG3: Sustainable Transformations of Society in the Face of Climate Change  
|                | WG4: Improving Tools for Decision-Making under Climate Change Cross-cutting  
| JPI Climate SRIA | JPI Climate's Strategic Research and Innovation Agenda 2016-2025. Its aim is to align and inform strategies, instruments, resources and actors at national and European levels by connecting the various research communities with research funders and performing organisations, within and across European countries, and beyond Europe.  
| JPI FACCE | Joint Programming Initiative Agriculture, Food Security and Climate Change  
|            | [www.faccejpi.com](http://www.faccejpi.com) |
| JPI Oceans | Joint Programming Initiative Healthy and Productive Seas and Oceans  
|            | [www.jpi-oceans.eu](http://www.jpi-oceans.eu) |
| JPI Urban Europe | Joint Programming Initiative for Urban Europe  
|            | [www.jpi-urbaneurope.eu](http://www.jpi-urbaneurope.eu) |
| JPI Water (Water JPI) | Joint Programming Initiative for the water sector  
|            | [www.waterjpi.eu/](http://www.waterjpi.eu/) |
| Mis-match | The differences between the information/evidence gathered and could therefore refer to gaps, complementarities, synergies or redundancies |
| Redundancies | Areas or activities that were (or could be interpreted as being) duplicative and/or not adding any new value or knowledge, for example developing multiple overlapping climate change platforms that work in isolation at a National level. |
| Sendai Framework | A UNISDR Project: The Sendai Framework is a 15-year, voluntary, non-binding agreement which recognizes that the State has the primary role to reduce disaster risk but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders.  
|            | [http://www.unisdr.org/we/coordinate/sendai-framework](http://www.unisdr.org/we/coordinate/sendai-framework) |
| Synergies | Research and innovation projects, programmes and initiatives that are being designed and implemented collaboratively to deliver added value and/or transformative outcomes. |
## Acronyms and Terms

<table>
<thead>
<tr>
<th>Acronym or term</th>
<th>Full title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa-CORDEX</td>
<td>A multi domain (WRCP) project to advance and coordinate the science and application of regional climate downscaling through global partnerships <a href="http://www.cordex.org/">http://www.cordex.org/</a></td>
</tr>
<tr>
<td>APPLICATE</td>
<td>Advanced Prediction in Polar regions and beyond: modelling, observing system design and LInkages associated with a Changing Arctic climate <a href="http://www.applicate.eu/about">www.applicate.eu/about</a></td>
</tr>
<tr>
<td>AXIS</td>
<td>Assessment of Cross(X)-sectoral Climate Impacts and Pathways for Sustainable Transformation. JPI Climate proposal for H2020 funding</td>
</tr>
<tr>
<td>Belmont Forum</td>
<td>The Belmont Forum is a partnership of funding organizations, international science councils, and regional consortia committed to the advancement of interdisciplinary and transdisciplinary science.</td>
</tr>
<tr>
<td>Blue-Action</td>
<td>Arctic Impact on Weather and Climate, <a href="http://www.blue-action.eu">www.blue-action.eu</a></td>
</tr>
<tr>
<td>BMWFV</td>
<td>Austrian - Federal Ministry of Science, Research and Economy, <a href="http://www.en.bmwfw.gv.at">www.en.bmwfw.gv.at</a></td>
</tr>
<tr>
<td>C3S</td>
<td>Copernicus Climate Change Service, <a href="https://climate.copernicus.eu/about-c3s">https://climate.copernicus.eu/about-c3s</a></td>
</tr>
<tr>
<td>CCA</td>
<td>Climate Change Adaption</td>
</tr>
<tr>
<td>CitiSense</td>
<td>Citizen Sensing – Urban Climate Resilience through Participatory Risk Management Systems (ERA4CS funded research project), <a href="http://www.jpi-climate.eu/nl/25223438-CitiSense.html">http://www.jpi-climate.eu/nl/25223438-CitiSense.html</a></td>
</tr>
<tr>
<td>CKB</td>
<td>Climate Knowledge Brokers, <a href="http://www.climateknowledgebrokers.net">www.climateknowledgebrokers.net</a></td>
</tr>
<tr>
<td>ClimApp</td>
<td>Translating climate service into personalized adaptation strategies to cope with thermal climate stress (ERA4CS funded research project) <a href="http://www.jpi-climate.eu/nl/25223441-ClimApp.html">www.jpi-climate.eu/nl/25223441-ClimApp.html</a></td>
</tr>
<tr>
<td><strong>Climate KIC</strong></td>
<td>A European public-private innovation partnership focused on climate change. It consists of companies, academic institutions and the public sector. <a href="http://www.climate-kic.org">www.climate-kic.org</a></td>
</tr>
<tr>
<td><strong>Climate Science for Services Partnership Brazil</strong></td>
<td>The Climate Science for Service Partnership Brazil (CSSP Brazil) is a research programme that will support the development of capability to underpin services to inform decision makers in climate mitigation and adaptation strategy, supporting climate and weather resilient economic development and social welfare. <a href="http://www.metoffice.gov.uk/research/collaboration/newton/cssp-brazil">http://www.metoffice.gov.uk/research/collaboration/newton/cssp-brazil</a></td>
</tr>
<tr>
<td><strong>Climate Science for Services Partnership China</strong></td>
<td>The Climate Science for Service Partnership China (CSSP China) is a scientific research programme that will help build the basis for services to support climate and weather resilient economic development and social welfare through strong strategic partnerships harnessing UK scientific expertise. <a href="http://www.metoffice.gov.uk/research/collaboration/cssp-china">http://www.metoffice.gov.uk/research/collaboration/cssp-china</a></td>
</tr>
<tr>
<td><strong>Climate Services</strong></td>
<td>For the purpose of this document, we are using the broad definition from the European research and innovation 'Roadmap for Climate Service'. This covers the transformation of climate-related data — together with other relevant information — into customised products such as projections, forecasts, information, trends, economic analysis, assessments (including technology assessment), counselling on best practices, development and evaluation of solutions and any other service in relation to climate that may be of use for the society at large. As such, these services include data, information and knowledge that support adaptation, mitigation and disaster risk management (DRM). <a href="http://www.metoffice.gov.uk/research/collaboration/cssp-china">Taken from 'A European research and innovation Roadmap for Climate Services', 2015 Directorate-General for Research and Innovation</a></td>
</tr>
<tr>
<td><strong>ClimatEurope</strong></td>
<td>A coordinate and support programme for Europe’s knowledge base to enable better management of climate-related risks and opportunities, thereby creating greater social and economic value. (A H2020 project: 689029) <a href="http://www.climatereurope.eu">www.climatereurope.eu</a></td>
</tr>
<tr>
<td><strong>CLIM-DEV</strong></td>
<td>Climate for Development in Africa, <a href="http://www.climdev-africa.org/">www.climdev-africa.org/</a></td>
</tr>
<tr>
<td><strong>Co-CIIME</strong></td>
<td>Co-development of CLimate services for adaptation to changing Marine Ecosystems (ERA4CS funded research project) <a href="http://www.jpi-climate.eu/nl/25223446-Co_ClIME.html">www.jpi-climate.eu/nl/25223446-Co_ClIME.html</a></td>
</tr>
<tr>
<td><strong>Co-CI-Serv</strong></td>
<td>Co-development of place-based CLimate SERVices for action ((ERA4CS funded research project) <a href="http://www.jpi-climate.eu/nl/25223444-Co_CliServ.html">www.jpi-climate.eu/nl/25223444-Co_CliServ.html</a></td>
</tr>
<tr>
<td><strong>Complementarities</strong></td>
<td>Research and innovation projects, programmes and initiatives each working on similar activities and/or areas, whose outputs provide, or have the potential to provide, a wider or more comprehensive outcome. <a href="http://www.copernicus.eu/">In effect these have the potential to provide synergies</a>.</td>
</tr>
<tr>
<td><strong>Copernicus</strong></td>
<td>Copernicus is a European Union Programme aimed at developing European information services based on satellite Earth Observation and in situ (non-space) data, <a href="http://www.copernicus.eu/">http://www.copernicus.eu/</a></td>
</tr>
<tr>
<td><strong>COST</strong></td>
<td>Co-operation in the Field of Science and Technology Research (Europe) <a href="http://www.cost.eu/about_cost">www.cost.eu/about_cost</a></td>
</tr>
<tr>
<td><strong>COST Actions</strong></td>
<td>COST Actions are networks centred around nationally funded research projects in fields that are of interest to at least seven COST Member States.</td>
</tr>
<tr>
<td><strong>CS</strong></td>
<td>Climate Services</td>
</tr>
<tr>
<td>Agency/Program</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
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</tr>
<tr>
<td>CSA</td>
<td>Coordination and Support Action</td>
</tr>
<tr>
<td>DRR</td>
<td>Disaster Risk Reduction</td>
</tr>
<tr>
<td>DustClim</td>
<td>Dust Storms Assessment for the development of user-oriented Climate Services in Northern Africa, Middle East and Europe (ERA4CS funded research project) <a href="http://www.jpi-climate.eu/nl/25223454-DustClim.html">www.jpi-climate.eu/nl/25223454-DustClim.html</a></td>
</tr>
<tr>
<td>ECOMS</td>
<td>European coordination of climate services activities, <a href="http://www.eu-eoms.eu/about">www.eu-eoms.eu/about</a></td>
</tr>
<tr>
<td>ECRA</td>
<td>European Climate Research Alliance, <a href="http://www.ecra-climate.eu">http://www.ecra-climate.eu</a></td>
</tr>
<tr>
<td>EIONET</td>
<td>European Environment Information and Observation Network, <a href="http://www.eionet.europa.eu/about">www.eionet.europa.eu/about</a></td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency (Ireland) <a href="http://www.epa.ie">www.epa.ie</a></td>
</tr>
<tr>
<td>ERA4CS</td>
<td>European Research Area Programme - for Climate Services, <a href="http://www.era4cs.eu/">http://www.era4cs.eu/</a></td>
</tr>
<tr>
<td>ESA</td>
<td>European Space Agency, <a href="http://www.esa.int/ESA">www.esa.int/ESA</a></td>
</tr>
<tr>
<td>ESPREssO</td>
<td>Enhancing Synergies for disaster PRevention in the EurOEan Union, <a href="http://www.espressoproject.eu/">www.espressoproject.eu/</a></td>
</tr>
<tr>
<td>Organisation</td>
<td>Description/Link</td>
</tr>
<tr>
<td>--------------</td>
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</tr>
<tr>
<td>ESRC</td>
<td>United Kingdom - Economic and Social Research Council, <a href="http://www.esrc.ac.uk">www.esrc.ac.uk</a></td>
</tr>
<tr>
<td>EU-MACS</td>
<td>European Market for Climate Services, <a href="http://eu-macs.eu/">http://eu-macs.eu/</a></td>
</tr>
<tr>
<td>EUMETSAT</td>
<td>European Organisation for the Exploitation of Meteorological Satellites, <a href="http://www.eumetsat.int/website/home/index.html">http://www.eumetsat.int/website/home/index.html</a></td>
</tr>
<tr>
<td>EUROCLIMA</td>
<td>EUROCLIMA is a regional co-operation programme between the European Union and Latin America, focused on climate change, <a href="http://www.euroclima.org/en/">www.euroclima.org/en/</a></td>
</tr>
<tr>
<td>EVOKEd</td>
<td>Enhancing the value of climate data – translating risk and uncertainty utilizing a Living Labs approach (ERA4CS funded research project) <a href="http://www.jpi-climate.eu/nl/25223447-EVOKED.html">www.jpi-climate.eu/nl/25223447-EVOKED.html</a></td>
</tr>
<tr>
<td>FP9</td>
<td>Ninth EU Framework Programmes for Research and Technological Development</td>
</tr>
<tr>
<td>Future Earth</td>
<td>Future Earth is a major international research platform providing the knowledge and support to accelerate transformations to a sustainable world, <a href="http://www.futureearth.org/">www.futureearth.org/</a></td>
</tr>
<tr>
<td>GFCS</td>
<td>Global Framework for Climate Services, <a href="http://www.wmo.int/gfcs/">http://www.wmo.int/gfcs/</a></td>
</tr>
<tr>
<td>CSP</td>
<td>Climate Services Partnership <a href="http://www.climate-services.org/">http://www.climate-services.org/</a> with its International Conference on Climate Services series (ICCS)</td>
</tr>
<tr>
<td>IGBP</td>
<td>International Geosphere-Biosphere Programme, <a href="http://www.igbp.net">www.igbp.net</a></td>
</tr>
<tr>
<td>IHDP</td>
<td>International Human Dimensions Programme on Global Environmental Change, <a href="http://www.ihdp.unu.edu/">www.ihdp.unu.edu/</a></td>
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</tr>
<tr>
<td>IMPACT2C</td>
<td>Quantifying projected impacts under 2°C warming, <a href="http://impact2c.hzg.de/index.html.en">http://impact2c.hzg.de/index.html.en</a></td>
</tr>
<tr>
<td>INDECIS</td>
<td>Integrated approach for the development across Europe of user oriented climate indicators for GFCS high-priority sectors: agriculture, disaster risk reduction, energy, health, water and tourism (ERA4CS funded research project) <a href="http://www.jpi-climate.eu/nl/25223457-INDECIS.html">www.jpi-climate.eu/nl/25223457-INDECIS.html</a></td>
</tr>
<tr>
<td>INTAROS</td>
<td>Integrated Arctic Observation System, <a href="http://www.nersc.no/project/intaros">www.nersc.no/project/intaros</a></td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change, <a href="http://www.ipcc.ch/">http://www.ipcc.ch/</a></td>
</tr>
<tr>
<td>ISI-MIP</td>
<td>Inter-Sectoral Impact Model Inter-comparison project, <a href="https://www.isimip.org/">https://www.isimip.org/</a></td>
</tr>
<tr>
<td>JPI</td>
<td>Joint Programming Initiatives (JPIs) are Member State driven collaboration processes to pool national research efforts in order to make better use of Europe's precious public R&amp;D resources and to tackle common European challenges more effectively in a few key areas (JPI Climate, Urban Europe, Food-Agriculture-Climate Change, Oceans, Water etc). Members States and also Associated countries agree on a voluntary basis and in a partnership approach, on common visions and Strategic Research Agendas (SRA) to address major societal challenges. On a variable geometry basis, those countries commit to JPIs where they implement together joint Strategic Research Agendas, <a href="http://ec.europa.eu/research/era/what-joint-programming_en.html#">http://ec.europa.eu/research/era/what-joint-programming_en.html#</a></td>
</tr>
<tr>
<td>JPI Climate SRIA</td>
<td>JPI Climate's Strategic Research and Innovation Agenda 2016-2025. Its aim is to align and inform strategies, instruments, resources and actors at national and European levels by connecting the various research communities with research funders and performing organisations, within and across European countries, and beyond <a href="http://www.jpi-climate.eu/media/default.aspx/emma/org/10871632/JPI_Climate_SRIA.pdf">http://www.jpi-climate.eu/media/default.aspx/emma/org/10871632/JPI_Climate_SRIA.pdf</a></td>
</tr>
<tr>
<td>JPI FACCE</td>
<td>Joint Programming Initiative for Agriculture, Food Security and Climate Change, <a href="http://www.faccejpi.com">www.faccejpi.com</a></td>
</tr>
<tr>
<td>JPI Oceans</td>
<td>Joint Programming Initiative for Healthy and Productive Seas and Oceans, <a href="http://www.jpi-oceans.eu">www.jpi-oceans.eu</a></td>
</tr>
<tr>
<td>JPI Water (Water JPI)</td>
<td>Joint Programming Initiative for the water sector, <a href="http://www.waterjpi.eu/">www.waterjpi.eu</a></td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
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</tr>
<tr>
<td>KLIMAFORSK</td>
<td>Large-scale Programme on Climate Research - A RCN programme, <a href="http://www.forskningsradet.no">www.forskningsradet.no</a></td>
</tr>
<tr>
<td>MEDIATION</td>
<td>Methodology for Effective Decision-making on Impacts and AdaptaTION, <a href="http://www.mediation-project.eu">http://www.mediation-project.eu</a></td>
</tr>
<tr>
<td>Mis-match</td>
<td>The difference between the information/evidence gathered and could therefore refer to gaps, complementarities, synergies or redundancies</td>
</tr>
<tr>
<td>NAP</td>
<td>National Adaptation Plan</td>
</tr>
<tr>
<td>NDC</td>
<td>Nationally Determined Communication</td>
</tr>
<tr>
<td>NERC</td>
<td>Natural Environment Research Council, <a href="http://www.nerc.ac.uk">www.nerc.ac.uk</a></td>
</tr>
<tr>
<td>PERSON</td>
<td>Partnership to Ensure Reforms of Supports in other Nations, <a href="http://www.eu-person.com">http://www.eu-person.com</a></td>
</tr>
<tr>
<td>PLACARD</td>
<td>PLAtform for Climate Adaptation and Risk reduction, <a href="http://www.placard-network.eu">www.placard-network.eu</a></td>
</tr>
<tr>
<td>PROSNOW</td>
<td>PROSNOW is an innovative snow falls and snow level seasonal forecast service for ski resorts in the Alpine area, <a href="http://prosnow.euporias.eu/en">http://prosnow.euporias.eu/en</a></td>
</tr>
<tr>
<td>RCN</td>
<td>Norway - Research Council of Norway, <a href="http://www.forskningsradet.no">www.forskningsradet.no</a></td>
</tr>
<tr>
<td>Redundancies</td>
<td>Areas or activities that were (or could be interpreted as being) duplicative and/or not adding any new value or knowledge, for example developing multiple overlapping climate change platforms that work in isolation at a National level.</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
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<tr>
<td>RFO</td>
<td>Research Funding Organisation e.g. Member State Research Agency, Ministerial Department, Local Authority or an industry</td>
</tr>
<tr>
<td>RPO</td>
<td>Research Performing Organisation e.g. University, industry or consultancy</td>
</tr>
<tr>
<td>SEI</td>
<td>Stockholm Environment Institute, <a href="http://www.sei-international.org/about-sei">www.sei-international.org/about-sei</a></td>
</tr>
<tr>
<td>Sendai Framework</td>
<td>A UNISDR Project: The Sendai Framework is a 15-year, voluntary, non-binding agreement which recognizes that the State has the primary role to reduce disaster risk but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders. <a href="http://www.unisdr.org/we/coordinate/sendai-framework">http://www.unisdr.org/we/coordinate/sendai-framework</a></td>
</tr>
<tr>
<td>SSH</td>
<td>Social Sciences &amp; Humanities</td>
</tr>
<tr>
<td>Synergies</td>
<td>Research and innovation projects, programmes and initiatives that are being designed and implemented collaboratively to deliver added value and/or transformative outcomes.</td>
</tr>
<tr>
<td>TRL</td>
<td>Technology Readiness Level</td>
</tr>
<tr>
<td>UKCIP</td>
<td>UK Climate Impacts Programme, <a href="http://www.ukcip.org.uk/">http://www.ukcip.org.uk/</a></td>
</tr>
<tr>
<td>UNFCCC</td>
<td>United Nations Framework Convention on Climate Change</td>
</tr>
<tr>
<td>UNISDR</td>
<td>United Nations Office for Disaster Risk Reduction, <a href="https://www.unisdr.org/">https://www.unisdr.org/</a></td>
</tr>
<tr>
<td>URCLIM</td>
<td>URBAN CLIMATE services (ERA4CS funded research project) <a href="http://www.jpi-climate.eu/nl/25223460-URCLIM.html">www.jpi-climate.eu/nl/25223460-URCLIM.html</a></td>
</tr>
<tr>
<td>WCRP</td>
<td>World Climate Research Programme, <a href="http://www.wcrp-climate.org/">www.wcrp-climate.org/</a></td>
</tr>
<tr>
<td>WG</td>
<td>Working Group e.g. European research and innovation Roadmap for Climate Services Implementation WG</td>
</tr>
<tr>
<td>WMO</td>
<td>World Meteorological Organization, <a href="http://www.wmo.int">www.wmo.int</a></td>
</tr>
</tbody>
</table>
Annex 1. Listing of Evidence Documents\(^\text{11}\)

<table>
<thead>
<tr>
<th>Documentation</th>
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</thead>
<tbody>
<tr>
<td><strong>Initial Analyses Documentation</strong></td>
</tr>
<tr>
<td>Task 7.1 Synthesis Report: Report on activities by JPI Climate WG2 on CS 2011-2016</td>
</tr>
<tr>
<td><strong>Task 7.2 Report</strong>: Report on mapping of ERA4CS member states’ national activities for climate services</td>
</tr>
<tr>
<td>Task 7.2: Annex 5 (RPO responses) and Annex 6 (RFO responses)</td>
</tr>
<tr>
<td><strong>Task 7.3 Report</strong>: Mapping of European and International Activities</td>
</tr>
<tr>
<td>Task 7.4 Initial Analyses based on task 7.1, 7.2, and 7.3 reports</td>
</tr>
<tr>
<td>Additional Evidenced Gathered</td>
</tr>
<tr>
<td>BELSPO Workshop presentation</td>
</tr>
<tr>
<td>Summary presentation of Task 7.4 initial analysis of evidence presentations</td>
</tr>
<tr>
<td>Synthesis report</td>
</tr>
<tr>
<td>Social Science Webinar</td>
</tr>
<tr>
<td><strong>Synthesis Report</strong>: JPI Climate WG3 reports on social aspects</td>
</tr>
<tr>
<td>ClimatEurope Festival</td>
</tr>
<tr>
<td>Dinner session report</td>
</tr>
<tr>
<td>Synthesis report from 'Have your say' session</td>
</tr>
<tr>
<td>DRR and Climate Services Webinar</td>
</tr>
<tr>
<td><strong>Synthesis report</strong></td>
</tr>
<tr>
<td>Additional European Evidence</td>
</tr>
<tr>
<td>C3S Clarification</td>
</tr>
<tr>
<td><strong>A European research and innovation roadmap for climate services</strong></td>
</tr>
<tr>
<td>Eastern European Response – CzechGlobe</td>
</tr>
<tr>
<td>RFO questionnaire</td>
</tr>
<tr>
<td>Responses from RFOs – Austria, France, Ireland, Norway and UK</td>
</tr>
<tr>
<td>JPI Urban Europe – e-mail response</td>
</tr>
<tr>
<td>Who does what in climate services (EC note)</td>
</tr>
<tr>
<td>Who does what in climate services (Partial response from JPI Climate)</td>
</tr>
<tr>
<td>Belmont Forum Activities</td>
</tr>
<tr>
<td>ECRA contributions to climate services</td>
</tr>
<tr>
<td>JPI Climate</td>
</tr>
<tr>
<td>JPI Climate Strategic Research &amp; Innovation Agenda (SRIA)</td>
</tr>
<tr>
<td>JPI Climate Provisional Implementation Strategy 2018-2020</td>
</tr>
<tr>
<td><strong>ERA4CS Joint Call Abstracts for Funded Research Projects</strong></td>
</tr>
<tr>
<td>Additional International Syntheses</td>
</tr>
<tr>
<td>2015 International Agreements and relevance to ERA4CS</td>
</tr>
<tr>
<td>CSSP-China and CSSP-Brazil</td>
</tr>
<tr>
<td>Priority needs for the operationalisation of the GFCS</td>
</tr>
<tr>
<td>Climate Services Africa</td>
</tr>
<tr>
<td>Note on teleconference with UNFCCC</td>
</tr>
<tr>
<td>Belmont Forum – e-mail with link</td>
</tr>
</tbody>
</table>

\(^{11}\) Publicly available evidence is available via hyperlinks in the evidence list above. All other evidence listed is available only to ERA4CS members with access to the ERA4CS extranet: [https://partage.agencerecherche.fr/era4cs/php/browser.php?dir=286&sort=0](https://partage.agencerecherche.fr/era4cs/php/browser.php?dir=286&sort=0)

Note: to be directed to the evidence folder, you will need to first log in, and then re-click the link above.
Annex 2: Report cards used to capture information
(N.B. only front faces of cards are shown; JPI Climate SRIA challenges and Strategic Mechanism were listed on the back)

Card 1: Research Activities

Card 2: Gap
Annex 3. Questionnaire sent to some RPOs

The JPI Climate’s Strategic Research and Innovation Agenda (SRIA 2016) sets out three overarching Challenges that together deal with linking research and innovation to decisions at different scales and a Strategic Mechanism that is about enhancing connections that is also a research topic in itself. Together these challenges and the Strategic Mechanism are intended to develop and support excellent, innovative, relevant and informative climate change research. The slight overlap between the challenges is intentional and recognises the limitation of a siloed approach to research and innovation.

We would be grateful if you could answer the following questions (all boxes expand with text):

1. With reference to each of the JPI Climate SRIA challenges and its Strategic Mechanism (provided in a - d below), please provide: Part A) a brief overview of what you have done to address each (in terms of activities funded in the past 3-5 years); and Part B) a list of relevant research programmes / portfolios / thematic areas and the names / titles of associated projects (more than just acronyms):

   a. **Challenge 1: Understanding the processes and consequences of climate change** – building the knowledge base on the climate system and climate impacts in areas that are relevant for strategic planning and decision-making:

   Part A: A brief overview on how your RFO investments in research are addressing Challenge 1 (Please provide a couple of points or a maximum of 250 words, but if you wish you can attach more as an appendix to your response):

   Part B: Please provide a list of the relevant research programmes / portfolios / thematic areas and the names / titles of associated projects that have been funded in the last 3-5 years. Where possible, please avoid acronyms and abbreviations:

   b. **Challenge 2: Improving knowledge on climate-related decision-making processes and measures** – research to produce the knowledge and evidence needed to support short-term / incremental decisions and understanding decision-making processes themselves:

   Part A: A brief overview on how your RFO investments in research are addressing Challenge 2 (Please provide a couple of points or a maximum of 250 words, but if you wish you can attach more as an appendix to your response):

   Part B: Please provide a list of the relevant research programmes / portfolios / thematic areas and the names / titles of associated projects that have been funded in the last 3-5 years.

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c. **Challenge 3: Researching sustainable societal transformation in the context of climate change** – research to support decision-making in a wider and more holistic perspective, in terms of informing the long-term transition and development of society.

Part A: A brief overview on how your RFO investments in research are addressing Challenge 3 (Please provide a couple of points or a maximum of 250 words, but if you wish you can attach more as an appendix to your response):

Part B: Please provide a list of the relevant research programmes / portfolios / thematic areas and the names / titles of associated projects that have been funded in the last 3-5 years. Where possible, please avoid acronyms and abbreviations:

d. **Strategic Mechanism: Enhancing connections between currently fragmented or disparate realms of climate change research** – research related to improving the quality and relevance of research, and knowledge exchange and mobilising of research to support decision-making?

Part A: A brief overview on how your RFO investments in research are addressing the Strategic Mechanism (Please provide a couple of points or a maximum of 250 words, but if you wish you can attach more as an appendix to your response):

Part B: Please provide a list of the relevant research programmes / portfolios / thematic areas and the names / titles of associated projects that have been funded in the last 3-5 years. Where possible, please avoid acronyms and abbreviations:

2. Across the programmes / portfolios / thematic areas you identified in question 1, to what extent (provide an estimate of the relative percentage) are these funding fundamental research and applied research (innovation)\(^\text{13}\)?

\(^\text{13}\) In terms of technology readiness levels, fundamental research would be TRLs 1-3 or 4, and applied research would be TRLs 4-6 or 7
3. Which, if any of these projects are co-funded and if such, with whom (please do not use acronyms)? These co-funded projects would include those that are also funded by funding organisations responsible for other disciplines; funding organisations within other countries, or international programmes, as well as those funded with support from private businesses?

4. What are your plans for supporting future research (and innovation) that have the potential to address the JPI Climate SRIA challenges and strategic mechanism?

   a. Specific high level programmes / portfolios / thematic areas identified in your plan;

   b. Particular challenges identified from your plan that the identified research (fundamental or applied / innovation) is to address; and

   c. Timeline for this plan and when will this plan be next updated