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Lessons and practice of co-developing Climate services with users

Deliverable Title	**Lessons and practice of co-developing Climate services with users**	
Brief Description	The main aim of this report is to share the experiences and summarize the lessons learned on how to foster co-development Climate Services (CS) with users and develop standards for user engagement and effective communication of science to users.	
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Summary

This report shares experiences and summarises lessons learned from Climateurope (www.climateurope.eu) project partners HZG, RHMSS, Met Office, Imperial College and BSC on how to foster co-development of climate services (CS) between providers and users, and highlights good practice for user engagement and effective communication of science to decision- and policy-makers.

This report describes not only the good practices in co-developing CS between providers and users, but also focuses on the challenges encountered by continuous multi-stakeholder engagement. The lessons learned of co-developing CS with users are given at the end of the report, in the form of selected case studies.

The authors are deeply grateful to Janette Bessembinder (KNMI), Carlo Buontempo (ECMWF), Jane Strachan (Met Office) and Marta Bruno Soares (University of Leeds) for their valuable comments and suggestions.

Introduction

The amount of available information (e.g. modelled-based climate projections) about climate variability, climate change and climate-related impacts has been increasing rapidly in recent years. Important sources of such information include the Assessment Reports of IPCC (www.ipcc.ch) based on the global Coupled Model Intercomparison Projects Phase 4, 5 & 6 [CMIP4, CMIP5 & CMIP6], and the Inter-Sectoral Impact Model Intercomparison Project [ISI-MIP]; an international network of climate-impact modellers.

In addition, the National Climate Assessment Reports summarise the impacts of climate change at national levels, e.g. all existing information about climate change in Germany is summarised in Brasseur *et al.* (2016). The National Assessment reports for more than 30 countries are currently available at http://www.gerics.de/products_and_publications/publications/detail/063845/index.php.en *(in German).*

The newly established Copernicus Climate Change Service (C3S) combines observations of the climate system with the latest science and develops authoritative, quality-assured information about the past, current and future states of the climate in Europe and worldwide (https://climate.copernicus.eu/about-c3s).

To ensure that climate information is used effectively and appropriately, the Global Framework for Climate Services [GFCS, Hewitt *et al.*, (2012)] has been created by WMO and other UN agencies. The GFCS attracts strong engagement from users, donors and service providers worldwide. The vision of the GFCS is to “enable better management of the risks of climate variability and change and adaptation to climate change, through the development and incorporation of science-based climate information and prediction into planning, policy and practice on the global, regional and national scale” (http://www.gfcs-climate.org/vision).

In 2015 the European Commission published the European Research and Innovation Roadmap for Climate Service, the purpose of which was to help transform climate-related data and other information into climate-related products that may be of use for society (e.g. economic analysis, advice on best practices, development, evaluation of solutions, etc.) The Roadmap clearly gives primacy to CS that are both user-driven and informed by robust science. This means that the process is based on both an understanding of how decisions are made as well as the existing and potential uses of CS in the decision-making processes [Street, (2016)].

All of these activities contribute to raising awareness of climate change, and provide information that supports sound decision-making. For example, energy production and transmission planning could benefit from improved climate variability analysis that will allow energy supply to better match with demand [e.g. Viktor *et al.*, (2017)]. Developing new climate-impact indicators could make climate data useful for advising water-management decisions (e.g. SWICCA Climate Impact Indicators for Province of South Holland, www.swicca.eu).
At the same time, users will not only benefit from information provided in terms of climate data or model projections.

One major challenge for CS is bridging users' needs with the science capability, e.g. providing *customised* service and tools to make robust adaptation decisions. In fact, users are increasingly asking for solutions that are both relevant and specific to their needs. In this context, Lemos *et al*., (2012) suggested that CS should evolve away from the concept of 'useful' information (e.g. what scientists understand as information that could be useful) to the concept of 'usable' information (what users recognise as useful in their decision-making).

Lemos *et al*. argued that usability depends on three interconnected factors: (i) users' perception of information fit; (ii) how new knowledge interplays with other kinds of knowledge that are currently used by users; and (iii) the level and quality of interaction between producers and users. At each point, information can go from useful to usable as it is translated, communicated and/or transformed to approach users' perceived needs.

However, Lemos *et al*., 2012 mentioned that the point at which this transformation happens is not the same for all users, decisions, types of information or information production processes. Furthermore, if climate knowledge is not sensitive to the national civic epistemology at play in each country, scientist–user interactions may fail to deliver more 'usable' climate information [Skelton *et al.*, (2017)]. Skelton *et al.* therefore proposed a new typology of use-inspired research in climate science for decision-making: (i) innovators, where the advancement of science is the main objective; (ii) consolidators, where knowledge exchanges and networks are prioritised; and (iii) collaborators, where the needs of users are put first and foremost.

Brasseur and Gallardo (2016) expect that the users of climate data will be also guided on: how they could use model-based data and projections; how they could deal with uncertainties, and how they could respond to the challenges they are facing and how to interpret existing analysis. Therefore, establishing relationships with users based on mutual trust would improve the credibility, effectiveness and performance of CS. Fostering trust and mutual confidence sets the foundations required for users and providers to learn from each other, and encourages each to invest the time needed in cooperation. Users and providers working together to co-develop CS is one means by which such relationships can be built.

What is co-developing?

Cash *et al.* (2003) provided a new concept about how to translate knowledge into action. The proposed research to cross the knowledge boundary must be:

- **Salient** - relevant to decision-making bodies and provided when it is needed;
- **Credible** - authoritative, believable, and trusted;
- **Legitimate** - developed via a process that considers the values and perspectives of all actors (e.g. scientists and stakeholders).

Within Future Earth, a major international research initiative providing the knowledge and support to accelerate transformations to a sustainable world, Mauser *et al.* (2013) suggested a framework for interdisciplinary and transdisciplinary co-creation the knowledge (Figure 1). Form their point of view, this process consists of three fundamental steps, namely **co-design, co-production and co-dissemination,** throughout which both scientists and users are involved to varying degrees.

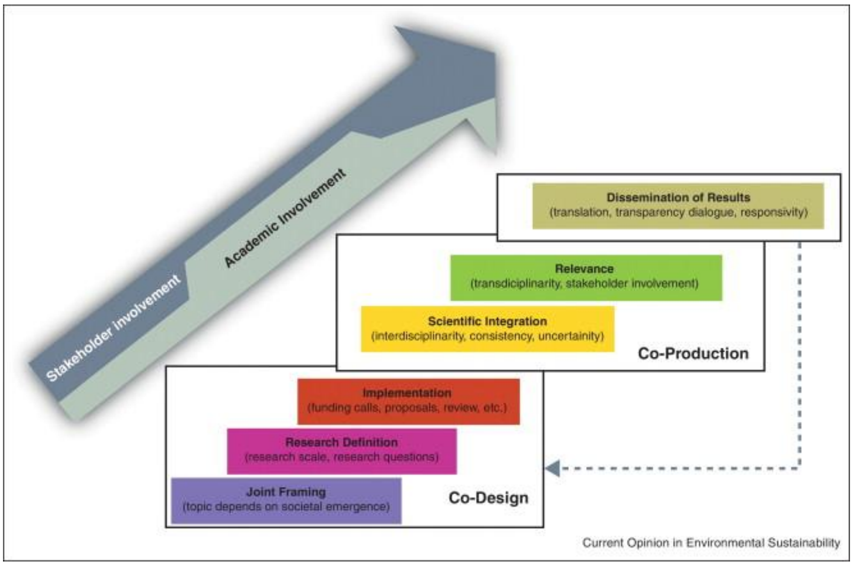


Figure 1. Framework for interdisciplinary and transdisciplinary co-creation of the knowledge castle (from Mauser et al., 2013).

The process starts with **co-design:** it is the collaborative process by which the sustainability challenges faced by society are jointly framed. Mauser *et al.*, (2013) mentioned that during the co-design phase work between, for example, users and scientists, is undertaken in a coordinated, integrated way. It allows a common understanding of the project goals to be established, and for agreement on the roles the different groups will play during the process.

The second step, after Mauser *et al.* (2013), consists of the **co-production** of knowledge. During this phase, integrated research is conducted as a continuous exchange among the participating scientists and with the users.

As the last step of their framework, Mauser *et al.* (2013) proposed the **co-dissemination** of the results among the different relevant societal groups. This includes publication of the acquired knowledge using accessible language and formats, including translation of the results into comprehensible and usable information for the different stakeholders, and an open discussion on the evaluation, applicability and relevance of the results among groups of conflicting interests. Nevertheless, co-dissemination should be considered as being a part of the information sharing process rather than the whole process in and of itself: **communication** needs to be taken into account as a goal, so that the information shared is more likely to be understood and used for decision-making.

The importance of Mauser and Cash's work in describing the processes of co-production of Climate Services has taken room within the community. For instance, the discussions at the fifth International Conference on Climate Services (ICCS5), which took place in 2017 in Cape Town, stated that co-development is now the standard approach in CS [Blome *et al.*, (2017)]. This is based on the realisation that exchange and cooperation between users and CS providers is crucial when building up a product or service in an optimal way.

However, many steps have to be considered to establish a successful co-development of climate services with multiple actors, e.g., information production, interpretation, use and users' feedback. For example, very regular checks are required during the development to see whether the product delivered is what users need/can use. Furthermore, it is important to place scientific knowledge in social, cultural and political contexts (experiences of the regional climate outlook forums; [*Source:* http://www.wmo.int/pages/prog/wcp/wcasp/meetings/documents/rcofs2017/presentations/day2/12_RCOFGlobalReview_Role_Co-production_RCOFs_Daly.pdf)]

Moreover, different user groups can become involved in the production process through different processes [Skelton *et al.* (2017)]: (i) elicitation, where scientists have privileged decision-making power; (ii) representation, where multiple organisations mediate on behalf of individual users; and (iii) participation, where a multitude of users interact with scientists in an equal partnership. Effective and appropriate engagement with users is therefore a cornerstone of effective CS.

User Engagement: who, when, how?

To understand how to engage effectively with users, one must first identify the different communities therein. Users of CS can be categorised in different ways, e.g. according to sector(s) of interest, intended use (e.g. communication, research, decision/policy making) or capabilities all with their specific needs. Bessembinder *et al.* (2012) considered following types of users:

Research and education:

- Researchers working on impacts, adaptation and mitigation studies/assessments. These can be further subdivided if necessary by considering where the researcher is located (e.g. academic institution or within a private institution (e.g. NGO, private company) and their discipline;
- Consultancy companies: varies from companies that do impact/adaptation studies, develop adaptation strategies, up to companies that give information on climate change and/or support to the process of adaptation/mitigation (these can be considered to be climate service providers too);

- Teachers and those developing educational material and curriculum;

Policy makers/NGO/politicians:

- Policy makers: this may be a rather diverse group (consultancy companies may also have many of the roles of policy makers);
- Politicians and other stakeholders/interest groups (those that want to put or represent climate change within the political or public agenda), or sceptics that want the opposite;
- NGO's or other stakeholder/interest groups communicating information about climate and climate change (often also want to put climate change on the political and public agenda - or remove it);

Practitioners:

- Practitioners (e.g. engineers, planners, investment portfolio managers) within local government, industry and business, including financial services providers: a diverse and evolving group of users that can use publically available information, but also are interested in bespoke climate services. Due to their diversity, this is a difficult, but essential, group of users to engage in the development and delivery of climate services. Nowadays, many practitioners are familiar with climate and weather terms such as probability, uncertainties, etc., so in this sense communication can be easier.

General public:

- General public and media (interested, but without specific aim).

Once the different user groups have been identified, it is essential to understand the nature and scope of their various requirements. Tailoring climate information to the users' needs is not as simple as "you ask, we deliver"; it requires continuous contact and interaction with users. To deliver relevant climate information in the right format it is important to know not only who will be using the climate information and data, but how they will use it, why they use it and how to deal with uncertainties.
[*Source:*
http://www.klimaatscenarios.nl/brochures/images/KvRrapport_Klimaatdienstverlening_Maatwerk_CS07_2011.pdf or Bessembinder, Overbeek *et al.* (2012)]. Discussing the nature of the issues with the stakeholders also could increase the awareness that some problems cannot be solved through rational computational approaches and that the users should adjust their requirements to match what science can provide in reality.

Good practices and successful strategies for effective and improved engagement between the users and providers of CS were discussed by Hewitt *et al.*, (2017). The recommendations were provided by the international team of experts enlisted under the World Meteorological Organization's (WMO) Commission for Climatology. Essentially, Hewitt *et al.* outline the different ways of engagement between users and providers of CS (see Figure 2). To illustrate this Hewitt *et al.* (2017) provide a framework, which Golding *et al.* (2017b) then apply in a real-world context:

- A good web-site or an app-based interface or a social media platform connects a CS provider with a large number of users all over the world (see also Goosen *et al.*, (2013), Christel *et al.*, (2017), http://edepot.wur.nl/328078 and the success stories on “seasonal hurricane prediction” & Oasis HUB & CLIPC web-portal);

- A stronger dialogue between users and providers of CS can be achieved via interactive group activities. Focused and sustainable relationships between users and providers of CS should be developed to ensure the users’ needs are being addressed properly;
- Hewitt *et al.*, (2017) advocated for multi-disciplinary teams for a complex decision system;
- Evaluation is essential, ideally before, during or immediately afterwards the events.

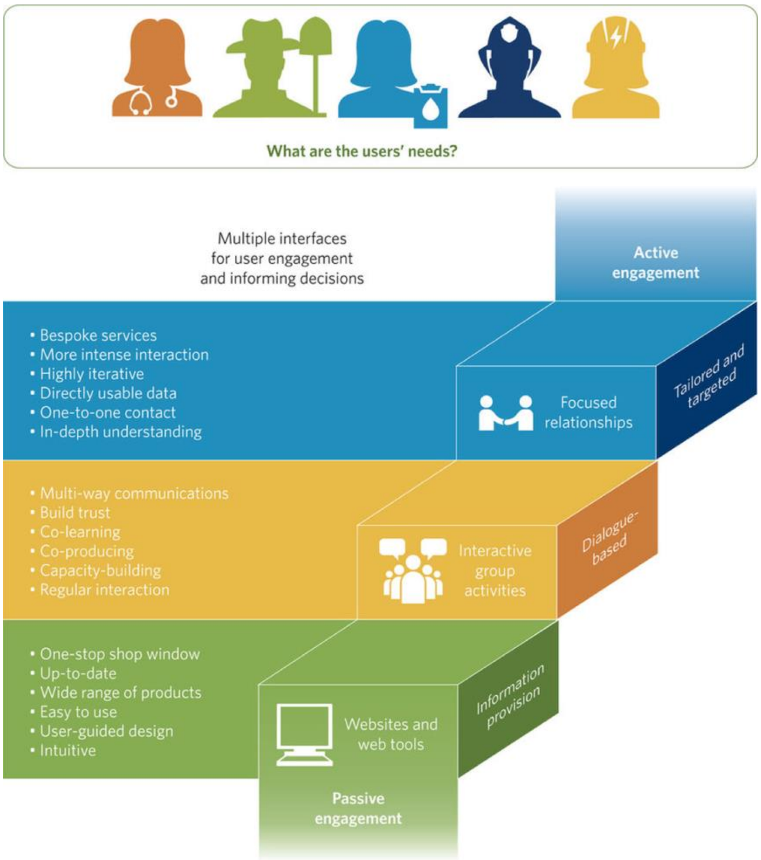


Figure 2. Schematic of three broad categories of engagement between users and providers of climate services Hewitt et al., 2017].

The methods of user engagement might be varied from conventional ones – surveys, interviews and consultations [Christel *et al.*, (2017)], as well as more novel ones – design workshops, interactive exhibits and festivals (www.climateurope.eu). Goosen *et al.*, (2013) highlighted the organising design workshops or Climate Ateliers. This is a more (inter)active way of communicating vulnerability information than preparing and presenting scientific reports, and is also crucial for establishing a collaborative design process.

Lemos *et al.* (2012) highlighted two-way communication and establishing an ongoing relationship between users and producers of climate information for decision-making. First, producers and users should build trust and creditability. Trust and two-way communication help to establish long-term relationships between producers and users, and promote better understanding of each other’s contexts, needs and limitations. Such interaction can not only help to address barriers to climate information use, e.g. levels of uncertainty, but also can might change users' minds by facilitating in-depth discussion of the issues that affect decision-making. Finally, reinforcing feedback loops, where users and producers get to know each other better, may decrease mismatches between different forms of knowledge. This can be achieved through a combination of tacit and explicit knowledge in day-to-day decision-making.

Valuable experiences on the interactions among different actors (scientists and users) can be gained from the participatory modelling method [Voinov and Bousquet (2010)]. Participatory modelling is a practical approach in system dynamics, with the aim of including all interested parties (such as stakeholders or the general public) in decision-making processes relating to environmental questions.

The basic steps of participatory modelling with users are shown in Figure 3.

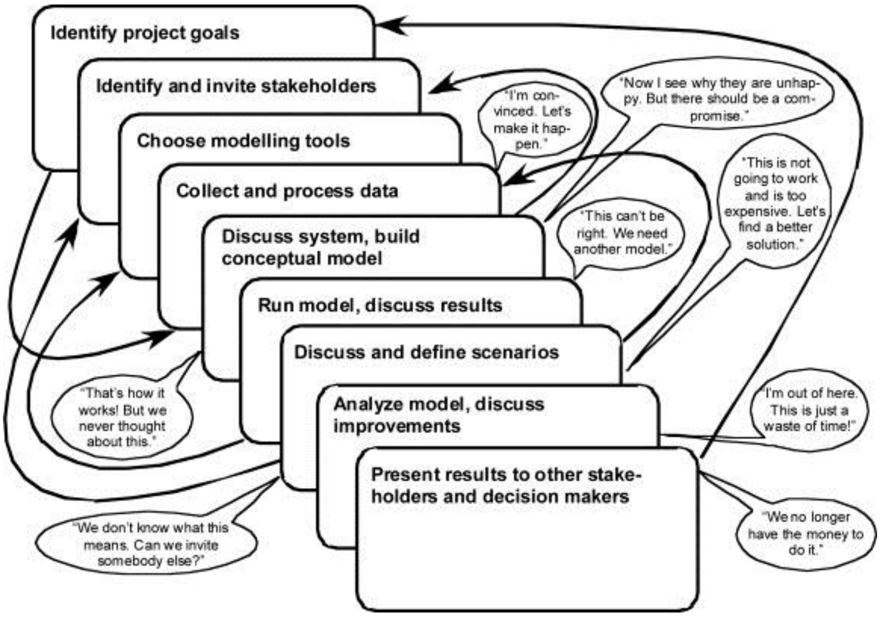


Figure 3. Basic steps of participatory modelling with users [Voinov and Bousquet (2010)].

Voinov and Bousquet (2010) emphasise that participatory modelling should be seen as a process rather than the product, and suggested different types of participation, namely [adapted by Voinov and Bousquet from Pretty, (1995)]:

- Passive participation, in which the objective is just to inform people;
- Active participation to support the decisions, where stakeholders are used to promote and articulate the chosen decisions;
- Interactive participation, where stakeholders share the diagnostic and analytical methods and tools or results;
- Self-organisation, where the lessons from the participatory process are transformed into decisions by the stakeholders themselves.

It is important to involve a diverse selection of stakeholders that represent the variety of interests shared by this group as a whole. In this context, the dialogue cannot benefit all the different groups if it is not planned accordingly. An inclusive and flexible strategy, which empowers weaker groups, should be implemented that allows a balanced representation of all stakeholders. Furthermore, the process of facilitation should ensure that the users have different roles, different interests and different power levels.

In addition to providing recommendations about the selection of stakeholders for participatory modelling, Voinov and Bousquet (2010) also referred to the role of scientists in this process. As modellers, scientists should be clear about the assumptions and uncertainties in a developing model, e.g. it is also important to indicate how large the impact of uncertainties is and how people could deal with it. As facilitators, scientists must be trusted by the stakeholder community, e.g. by being objective and impartial. However, it may be hard to maintain neutrality, especially when scientific knowledge is compromised by certain stakeholders, or when scientists develop their own understanding and viewpoints about the system and its future trends. Voinov and Bousquet (2010) suggested that external facilitation may ameliorate these issues.

Supporting decision making and planning processes by developing and applying Climate Adaptation Services is a challenge. Tools that focus more on supporting interactive design and finding common ground than on optimisation and problem solving can help solve this challenge [Goosen *et al.*, (2013)]. It is crucial to prevent a “data dump” through closely involving the stakeholders’ demands in determining the relevant indicators. Furthermore, it is vital to communicate about uncertainties and to visualise these in impact maps. In close cooperation, researchers gain a better insight into the information needs of the users, whereas users gain a better understanding of the limitations of the science community to address their particular questions. Conflicting information (different models with different outcomes) and experiences with best practices should be discussed with, and explained to stakeholders. In this sense, it is interesting to involve researchers of different backgrounds that cooperate in transdisciplinary teams and that are able to bring together and harmonise scattered and non-uniform impact information.

Success stories

Hegger *et al.*, (2012) conceptualised successful Joint Knowledge Production (JKP) as a process leading to knowledge that is perceived as salient, credible and legitimate from the perspective of both science and public policy actors. The authors classified success conditions into actors, discourses, rules, and resources (see Table 1).

Table 1. Seven expected success conditions for joint knowledge production (JKP) projects. [Hegger et al., (2012)].

Dimension	Success condition	Explanation
Actors	1. Broadest possible actor coalition is present	The success of JKP is enhanced in cases in which the broadest possible coalition of actors is formed, within the practical and strategic limits present; this likely entails both inclusion and exclusion of actors
Discourses	2. Shared understanding of goals and problem definitions	The chance that JKP is successful is enhanced in cases in which participating actors deliberate on the nature and denomination of the policy problem

		(unstructured, moderately structured, or well-structured) and on the type of outcome to be expected (ideas, closure on problem definition, concepts, arguments, or solutions)
	3. Recognition of differences in actor perspectives takes place	Actors in JKP projects can be expected to have diverging and implicit perspectives on the world around them; the success of JKP will be enhanced if the different perspectives of actors are recognized and taken into account; boundary objects can play a mediating role
Rules	4. Organized reflection on division of tasks by participating actors takes place	The chance that JKP is successful is enhanced if actors decide, reflectively, which role to pursue in a project and how to define their identity in relation to the other actors, and they make these choices known
	5. Role of researchers and their knowledge is clear	The chance that JKP is successful is enhanced in cases in which the role of researchers and their knowledge is clear
	6. Innovations in reward structures are present	The chance that JKP is successful is enhanced through novel forms of reward structure
Resources	7. Specific resources such as boundary objects, facilities, organizational forms, and competencies are present	The chance that JKP is successful is enhanced through the availability of specific resources (boundary objects, organizational forms, and competencies)

There are plenty of success stories on how to co-develop CS with users. Interesting examples for Europe have been selected from the following FP7 projects: EUPORIAS, PEARL, IMPACT2C, ECLISE, CLIPC, ENHANCE. The H2020 projects MARCO and EU-MACS are currently investigating what policies, measures and innovations can improve alignment between the demand for and supply of climate services. A number of success stories were presented at ICCS5 for different regions of the world [Blome *et al.*, (2017)]. Golding *et al.* (2017a) exemplified the approach of developing climate services in China that were based jointly on user needs and scientific capability. Furthermore, C3S (https://climate.copernicus.eu) is rapidly accumulating information on user requirements as well as practical knowledge on how to engage with users in the definition and the design of the operational CS.

Therefore, it is very difficult to choose the best examples. For this reason, we decided to limit ourselves to presenting some success stories of our partners and members of the Climateurope network. We would like to show how climate information can be applied successfully in different sectors and how to engage the users in co-developing CS effectively. We also present the success examples on how integrate climate knowledge into policy and planning.

For some stories, we described the process of co-development in more detail.

Climate services for wind energy - The RESILIENCE Prototype

by Marta Terrado, BSC, project partner of Climateurope

The RESILIENCE prototype is a result of a co-production process involving the research community and various users from the renewable energy sector (EDPR, EnBW, VORTEX, etc.). The problem and the domain spaces were jointly defined; user feedback on an early prototype was collected and, lastly, the final product was evaluated.

Renewable energy generation and planning of operations are markedly affected by weather and climate, influencing both energy supply and demand. The RESILIENCE prototype is an interactive climate service for wind industry users to explore probabilistic wind speed predictions for the coming season. The prototype presents a novel interactive way to spot patterns in seasonal wind prediction data. Designed and developed under the FP7 EUPORIAS project and C3S CLIM4ENERGY projects, it was then reused and further elaborated by BSC as part a SIS (Sectoral Information System) project in C3S. It supports wind farm owners, operators and energy traders, who need to understand how wind will vary in the coming months to anticipate revenues, plan maintenance operations or foresee energy prices.

The RESILIENCE prototype puts special emphasis on the challenge of effectively communicating probabilistic predictions to decision-makers. The user interface presents a map with seasonal wind predictions visualised in line symbols for around 100,000 locations of the world. The line symbols encode prediction quality (skill) through opacity and predicted trend of wind speed through line tilt and colour. The percentage of probability that wind speed in the next season will be lower, equal and higher than normal is calculated, and the most probable category of wind speed is indicated according to the obtained results. The available wind power capacities are also shown on the map, representing the maximum amount of power that can be generated with the existing wind farm capacities in a certain area. RESILIENCE illustrates the added value of seasonal climate predictions for the renewable energy sector.

The prototype, which is now running in a pre-operational way, is going to be made operational through the recently awarded H2020 project S2S4E (led by BSC).

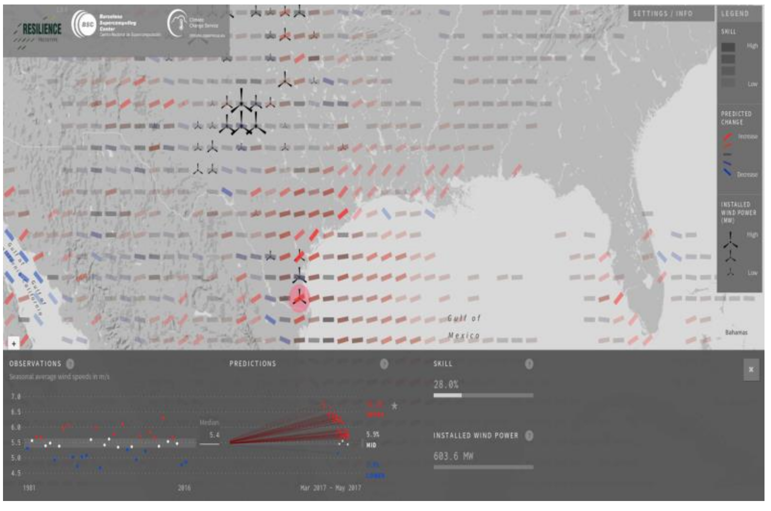


Figure 4. The RESILIENCE prototype.

Seasonal hurricane predictions

by Marta Terrado, BSC, project partner of Climateurope

The seasonal hurricane prediction platform has been developed by an interdisciplinary team of scientists, graphic designers and visualisation specialists in close collaboration with the users. This close cooperation helps to spark a debate between scientists and users to drive forward of the understanding of the hurricane's risk.

Seasonal North Atlantic Hurricane forecasting, although far from perfect, is a rapidly evolving research area. Various centres produce their own forecasts, but to date there was no regularly updated centralised repository for comparing and contrasting these forecasts. Given that North Atlantic hurricanes are the biggest natural peril loss drivers to the insurance industry, it is imperative to understand the science behind these storms in order to understand the risk they pose in any given year. This website will help to collate the views of the leading academics in this research space, and will help to spark debate between scientists and stakeholders to help drive forward our understanding of North Atlantic hurricane risk, volatility and uncertainty.

The website Seasonal Hurricane Predictions is an online platform that brings together predictions from different centres that specialise in Atlantic hurricane prediction (universities, private entities and government agencies) (see Figure 5). It has the objective to track seasonal hurricane predictions and the evolution of hurricane activity from June to November and make them available to both advanced users and non-specialists. The website offers extensive information to promote understanding of the factors that contribute to these meteorological phenomena, which can have devastating consequences, and to help explain why different seasonal forecast models can produce different predictions. The level of activity of the predicted season (low, medium or high) is indicated by a colour code. The actual number of hurricanes occurred to date in the current season is also shown as well as a historical record of the number of hurricanes per year since 1966.

This type of information can be integrated (although with caution) together with many other types of information in the communication of risks to particular businesses (e.g. risks on the shutdown of refineries, ports importing oil products, evacuation of offshore platforms or damages to oil infrastructure) who may trade this information as a risk premium on the market.

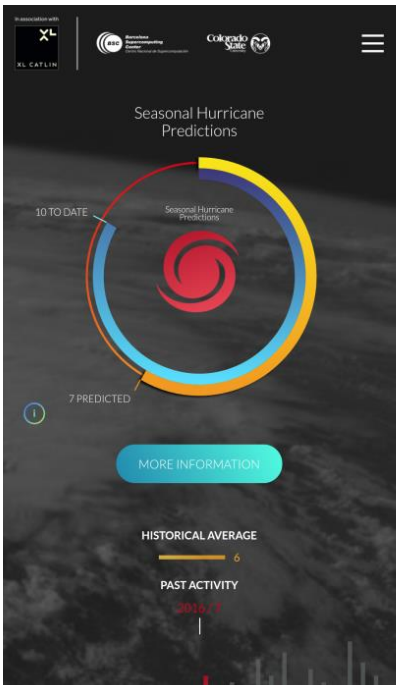


Figure 5. Homepage of the seasonal hurricane prediction platform.

OASIS Hub

www.oasishub.co

by Ralf Toumi, IC, project partner of Climateurope

> *Oasis HUB* is provided in partnership with leading academic, government and specialist organisations. In addition, the overall HUB assists data providers in getting their work to market, quickly and cost effectively. Knowledge and data exchange is crucial for co-production of effective Climate Services, but if providers act as gatekeepers of data, users may struggle to identify their needs independently. The Oasis HUB provides a platform to help address this issue by allowing users to access data themselves.

Oasis HUB is a joint initiative of EIT Climate-KIC, Oasis Loss Modelling Framework (LMF) Ltd and the Oasis+ Consortium formed in 2015. The initiative was formed to increase the availability of information on catastrophe and climate change risk and to assist the development of evidence-based climate adaptation planning. The founding members bring together expertise from throughout the EU, including financial and prestigious academic and research organisations who seek to encourage the development of a broader market within the modelling and services sector in catastrophe and climate change risk and climate adaptation. The Oasis HUB is an online portal/marketplace for the publishing and purchasing of environmental data, adaptation planning tools, models and services. Data resident on, and linked from the Oasis HUB is provided in partnerships with leading academic, government and specialist organisations, as well as building on freely available data. The Oasis HUB also makes tools and services available. Tools fall into the following categories: Hazard Scenario, Meteorological, Mapping, Programming, Hydraulic and Vector. Statistical Consulting and advisory services, enable the better understanding of deployment, and/or the creation of adaptation strategies.

The HUB facilitates the creation of market opportunities in known markets and identifies opportunities in new markets by reducing time and costs to take adaptation from academic theory to actionable outcomes. The Oasis HUB provides access to data, tools and associated services through a simple to use, yet powerful membership community. It is developed for consumers of data, such as Catastrophe Modellers, Resilience/Risk Officers/City Mayors/Smart City Designers, Risk Managers in Financial and Insurance Services, and Real Estate and Critical Infrastructure, and Risk/Operations/Supply Chain Managers, charities and NGO's.

Methods of user engagement for the CLIPC portal

by Swart R.J et al., 2017, HZG-GERICS was a project partner of the FP7 CLIPC project

Co-production of Climate Services is most effective when it draws upon on lessons learned from previous experience. To that end, a user engagement strategy was set up to (a) map experiences from other projects; (b) identify and prioritise user categories; (c) collect user requirements by questionnaire; and (d) involve users' panels in testing subsequent portal versions.

To create a well-functioning, user-oriented portal for climate observations and projections data and an impact indicator toolbox, a detailed understanding of user requirements and regular feedback from users on prototypes of the portal are needed [Swart *et al.*, (2017)].

Figure 6 summarises the process of user engagement through the CLIPC project, which combines elements of user engagement methods from other projects.

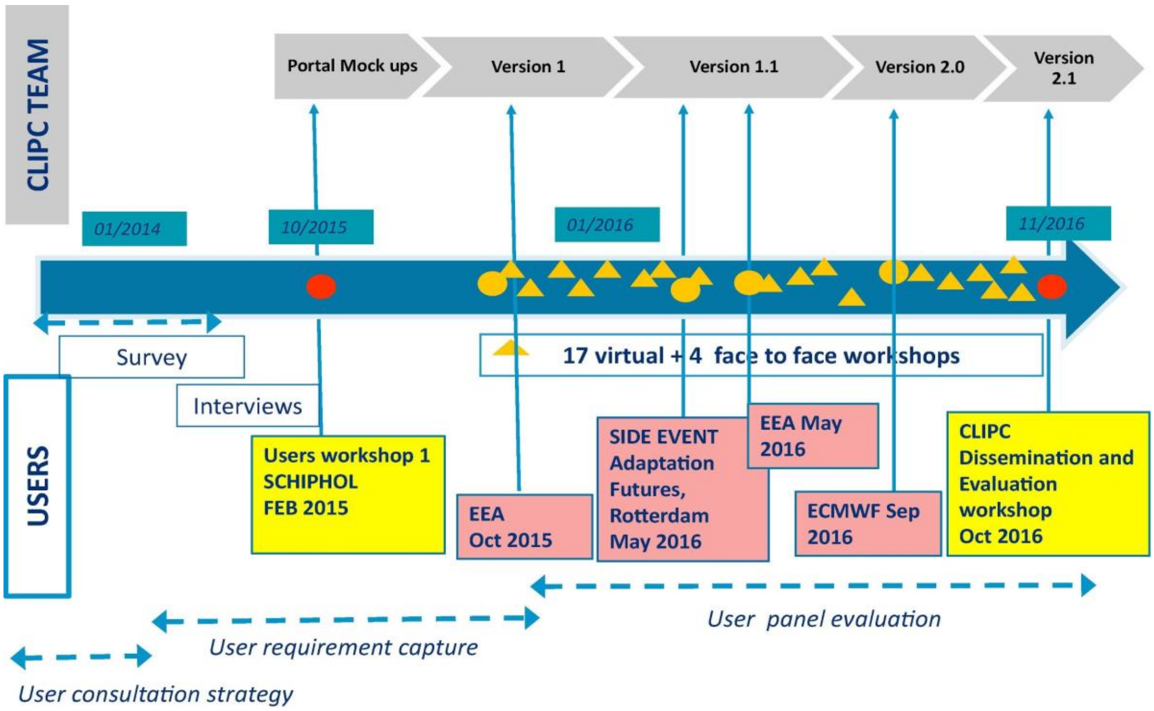


Figure 6. Summary of user engagement process in the CLIPC project [Swart et al., (2017)].

In CLIPC, experiences with user consultation and engagement and users' data preferences developed in earlier and ongoing projects and initiatives were inventoried and analysed. The inventory of 66 projects, 11 of which were analysed in detail, suggests that accessibility of data and user relevance does not only require proper knowledge of potential user groups, their data and information requirements but also their preferences for ways to have data transformed (post-processed), communicated and disseminated. Swart *et al.*, 2016 highlighted the need to devote sufficient resources for users' consultation and the need to engage users in a sustained manner. However, the experience of the authors uncovered several difficulties to engage users effectively in particular end users like policy makers and private sector decision maker (see below).

Integration of climate knowledge from scientists to decision-makers

by HZG-GERICS

Individual solutions are required for each adaptation challenge; they have to be developed in close co-operation with the customers and users. However, it can be challenging to begin the process of co-production of individual solutions without professional support. Toolkits for decision-making such as those developed by GERICS can provide a basis for developing such adaptation solutions. The GERICS adaptation toolkit for companies was developed over 35 interviews with three selected companies during 8 working meetings: the relationships formed during the process of developing this toolkit helped ensure a productive environment for sharing experiences, and the message was clear: there can be no one-size-fits-all approach for climate change adaptation.

The innovative toolkit concept has been developed by the Climate Service Center Germany (GERICS). It supports adaptation processes and includes techniques for a systematic assessment of current and future opportunities and vulnerabilities due to climate change impacts [Boywer *et al.*, (2014), Cortekar *et al.*, (2016)].

To ensure the best possible (pre-)conditions for the application of the toolkits, efficient interaction is required. It includes the moderation of processes, stakeholder consultations, analysis of needs, improvement of system understanding, the translation of scientific results into practicable knowledge and the transfer of user requirements into science. The whole process is carried out in close cooperation with local stakeholders, experts and decision makers in order to combine local knowledge with state-of-the-art scientific climate knowledge. Besides gaining knowledge, this approach supports an integrative view on all relevant aspects to create awareness of synergies and co-benefits, for instance between mitigation actions and adaptation measures. It also allows for solving possible conflicts early along the way.

See more details in "The shades of adaptation: Individual solutions for each adaptation challenge" (https://www.openaccessgovernment.org/wp-content/uploads/2017/11/Climate-Service-Center-ebook-Oct-2017_web.pdf).

Currently, three different types of toolkits are under development. These are a city toolkit and a regional modelling toolkit. Here we present the development of an adaptation toolkit for companies.

GERICS Adaptation toolkit for companies (Unternehmensbaukasten)

GERICS, the Foundation 2° and eight of their supporting companies jointly integrate state-of-the-art knowledge on climate change into business strategies. Groth and Seipold, 2017 presented the project "GERICS Adaptation toolkit for companies (Unternehmensbaukasten)" (Figure 7). It is a prototype product that supports decision makers in the private sector in identifying, developing and implementing effective policies regarding adaptation to climate change. Currently, the toolkit consists of six different module groups which cover the most important key areas for enterprises.

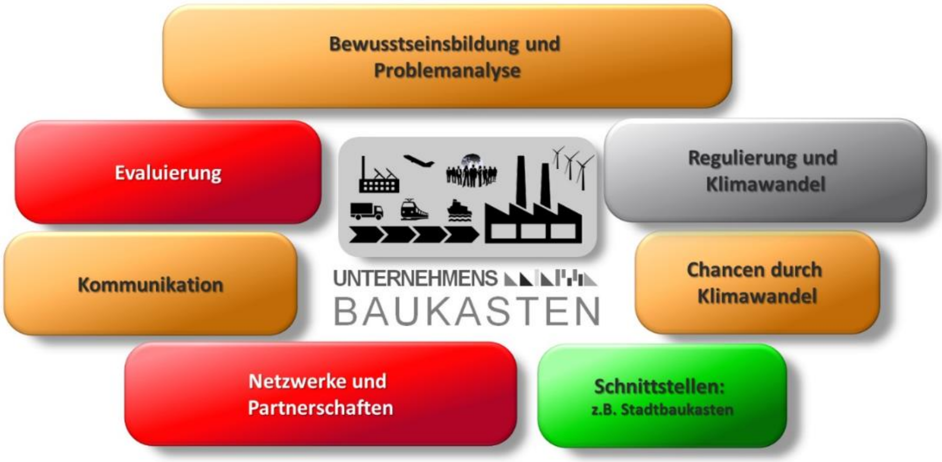


Figure 7. GERICS Adaptation toolkit for companies (Unternehmensbaukasten).

The prototype development consisted of two phases and was structured around a series of working meetings between the contact persons and the scientists from GERICS. These contact persons were nominated by the Foundation 2º and represented different departments of the business companies, e.g. Stagey Management, Finance, Personnel, etc. Foundation 2° (www.stiftung2grad.de) is a joint initiative of German companies in various economic sectors. The foundation aims to encourage policymakers to adopt effective, market-based tax and energy policies that harness the innovative potential of the private sector to encourage decarbonisation. The name of the foundation is informed by its overarching goal: to limit the rise in average global temperatures to well under +2° Celsius.

In total, 35 interviews with three selected companies were carried out during eight working meetings of the first phase of the project. On the evening prior to the working meeting, all contact persons were invited to get know each other; it was also possible to answer open questions and to discuss the framework of the project in an informal and relaxed atmosphere. In the second phase of the project the representatives of CEOs were invited to these meetings as well. The working meetings were structured as a series of one-to-one interviews (four interviews per day from one to one and half hours each) between the contact persons and the scientists of GERICS. Supporting materials were circulated a few weeks before the meetings.

The evaluation of these interviews served as a background for the second phase of the project. As a result, some questions were reworded, redundant questions were deleted, and some questions were added to address weaknesses. In general, positive feedback and responses were received. In this context, the structure, content, and process of work was not changed during the second phase. For the second phase of the project, five new contact persons of the partner companies of the Foundation 2º were invited.

The final feedback round was organised at the end of the project. All participants discussed the results of the interviews (the results were anonymous). Furthermore, each involved business company received the detailed evaluation of their interviews as a confidential document. This evaluation includes (i) company-specific recommendations; (ii) anonymised notes from the interviews; (iii) an anonymous comparison with the other participating companies; and (iv) general recommendations for actions.

In summary, all involved contact persons showed a big interest in the developing of the Climate Adaptation toolkit. In addition to the discussions on company-specific issues, in-depth discussions on the opportunities and risks of climate change were of great importance for involved business companies. From the other side, GERICS gained valuable experiences on the decision-making process.

The project shows that it is a challenge for decision makers to understand how climate change could impact their companies' procurement policies and market growth. This information is, however, important to consider how best to adapt the companies' structures and processes to these changes. At the same time, it is also a challenge for scientists to consequently focus attention on the impact of climate change and adaptation options during the discussions.

The results of the project are clear; there is no "one-size-fits-all" frame for adaptation to climate change. Different mitigation and adaptation measures must be developed in accordance with the specific circumstances prevailing in the local situation.

National Risk Assessment in the Republic of Serbia

by Aleksandra Krzic, RHMSS, project partner of Climateurope

> Action for risk management is often only triggered after extreme events cause sufficient damage to elicit action. However for risk management to be effective, it requires the joint action of key stakeholders from different national ministries, offices and agencies at all levels. Given the nature of working collaboratively between multiple stakeholders, such joint action must be coordinated by an engaged party who can take overall responsibility and ensure that sufficient progress is maintained.

The floods that took place in the Republic of Serbia in May 2014, which were the worst recorded in over 120 years, jeopardised the lives, health and property of more than 1.6 million people in 38 municipalities in central and western Serbia. There were human fatalities too. The total flood damage was estimated at 1.7 billion Euros. In September 2014, only four months after May's floods, the eastern part of Serbia was hit by huge flash floods that triggered many landslides.

These events served as a warning that it is necessary for the Republic of Serbia to take more serious measures, such as planning and realisation of investments that are based on knowledge of risks, which will ensure as much as possible the protection of people and property from natural hazards.

A Working Group made up of representatives of Governmental Institutions, Public Enterprises and Faculties was formed in order to prepare “National risk assessment of natural disasters and other accidents”. The Republic Hydrometeorological Service of Serbia (RHMSS), as special governmental institution responsible for hydrometeorological activities, was appointed as the coordinator and executor for the preparation of National risk assessment of meteorological hazards (heavy precipitation, hail, wind storm, snow blizzards, snowdrifts and black ice, heat and cold waves, and drought). A document was prepared based on harmonisation between various requests made by Sector for Emergency Management (Ministry of Interior), municipalities and public enterprises, and available data on the national level. After completion of the National risk assessment of meteorological hazards, a risk assessment of meteorological hazards at the municipality level was undertaken in cooperation with the official representatives of local government.

Although there was public interest in the effects of climate change on hydrometeorological extreme events, they are not considered directly in the National risk assessment. However, an overview of climate change impacts on selected hazards is given. In this way, the basis for detailed analysis of the impacts of climate change on the risk is set and it will be carried out in the updated National risk assessment.

Climate Impact (Adaptation) Atlas for spatial planning in the Netherlands

by Janette Bessembinder, KNMI, project partner of Climateurope

Since it was not very clear what the users wanted or if what they wanted was not possible ("unstructured problem"), the initial project set-up was changed into a much more interactive set-up. The regular interactive sessions (climate ateliers/workshops) between scientists and provinces resulted in a better mutual understanding and usable products, although somewhat different from the first request.

Background and question: Many climate adaptation measures have consequences for spatial planning in the Netherlands. The development of e.g. overflow areas and ecosystem structures that make adaptation to climate change easier asks for adaptation of the spatial planning. Provinces play an important role in this spatial planning. Regularly they make new plans for spatial planning ("structuurvisies"). Around 2008, they decided that they also wanted to take into account impacts of climate change and adaptation policies. For this purpose they asked the research programme "Climate for Spatial Planning" to provide information on climate change and its impacts on hydrology, ecosystems and agriculture (secondary effects), especially in the form of maps. A project was initiated with various research institutes to produce a climate impact Atlas. During the project, the various provinces were in different stages of the development of plans for spatial planning. A number of them were already including climate change information and had specific requests for information for policy support. Others were still working to put climate change on the political agenda. The request of the provinces was "what does climate change mean for our province?". However, the provinces could not give clear indications on the required information or they requested information that could not be provided (e.g. "risk in euros per km^2").

Approach: For the themes that were important for the provinces, there was still a lack of scientific knowledge (or not enough knowledge to translate it into maps) and often the policy goals were unclear. After some first efforts we decided to choose a different approach/project set-up, because this was not a "structured problem" but an "unstructured problem", which requires a different project set-up with much more interaction between the scientists and the provinces. This project chooses an approach in which the provinces and experts regularly met during expert sessions throughout the project duration. During these sessions, examples of information that could be provided were shown by the scientist (partly with "touch-tables"), and the information and usability were discussed with the provinces. Through this, the requirements of the provinces became clearer, and as a result, the available information could be adjusted, extended or alternatives could be sought. KNMI was involved as an expert on climate (change), with Alterra and DHV as experts on secondary effects. As the final result, a digital climate impact Atlas was developed (updated this year: www.klimaateffectatlas.nl). Although the project did not deliver exactly what the provinces might have had in mind implicitly at the start of the project, the scientists and the provinces were pleased with the final result. They also learned a lot from each other (requirements, what is important for policy development, what are the possibilities and challenges for scientists, etc). See also Goosen *et al.*, (2013).

SEERISK (www.seeriskproject.eu)

by Vladimir Djurdjevic, RHMSS, project partner of Climateurope

One of the best practice examples of cross-border and transnational cooperation in the Republic of Serbia: the keys to success were effective relationship building during inter-sectoral collaboration; cooperation between public and civil society to highlight the social aspects of climate change; intercultural dialogue and connection with the EU macro-regional strategies. This project was able to have greater impact since it worked with communities to determine and disseminate the broader socio-economic implications of climate change.

SEERISK was a transnational project funded by the South-East Europe Transnational Cooperation Programme. The project consortium was comprised of 20 project partners representing nine countries mainly from South-East Europe. Since the climate change general trend in the frequency and seriousness of extreme climate events is increasing in the South-East Europe one of the main aims of SEERISK was to develop and test a Common Risk Assessment Methodology. Following the risk assessment and risk mapping procedure, the social aspect of climate change was also revealed in the pilot areas by the assessment of the awareness and preparedness of the inhabitants and institutions.

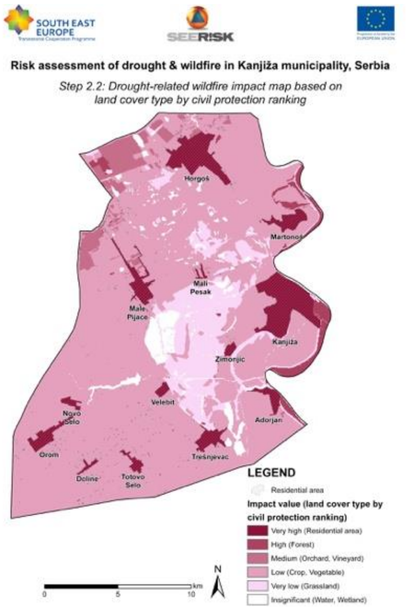


Figure 8. Risk assessment of droughts in Kanjiza Miunicipality of Serbia.

Findings of the survey performed among local people by using the Social Awareness Questionnaire and with local (governmental and institutional) stakeholders are being summarised in the Synthesis of the Social Awareness Questionnaire Surveys and the Synthesis of the Local Document and Interview Analyses. The Project recognised that many research projects on climate change generally used to lack the social side of the issue as an aspect of analysis - although society plays a crucial role as it causes and also suffers from the effects of this complex natural phenomenon. There is a need to go beyond the usual physical interpretation by taking the viewpoint of communities and institutions (disaster management among others), which need to relate to the potential and palpable consequences of transformation in climate conditions. SEERISK project was recognised as one of the best practice examples of cross-border and transnational cooperation in the Republic of Serbia (at the Fourth Conference on cross-border and transnational cooperation in Belgrade, organized by the European Integration Office, Government of the Republic of Serbia).

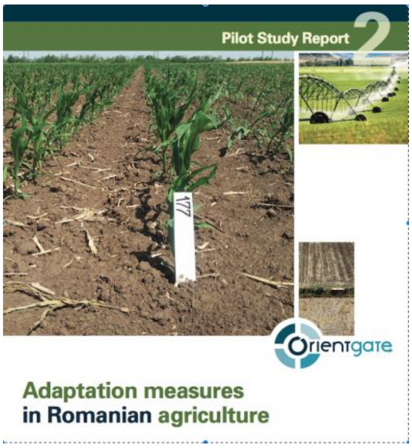
The criteria for evaluating the projects were: the impact of the project results and sustainability of partnerships, visibility, cross-cutting issues, the possibility of multiplication, the relevance for the territory /programme/sector, cross-border impact , effectiveness - a significant impact on target groups, inter-sectoral collaboration, cooperation between public and civil society, intercultural dialogue and connection with the EU macro-regional strategies, as well as effective project management.

ORIENTGATE (www.orientgateproject.org)

by Vladimir Djurdjevic, RHMSS, project partner of Climateurope

Local communities and stakeholders have been involved in the project through a series of trainings, workshops and dissemination events. In years after the project was finalised, experience gained and databases produced during the project were used by several governing institutions in preparation of the strategic documents.

The main objective of the Orientgate project was to communicate up-to-date climate knowledge for the benefit of policy makers, including urban planners, nature protection authorities, regional and local development agencies, and territorial and public works authorities. Project was implemented during period 2012-2015 and it was co-funded by the South-East Europe Transnational Cooperation Programme. The consortium included 19 financing partners, 11 associates and three observers, covering 13 countries, mainly from the region of South-East Europe.



Project reported that in all countries, local communities and stakeholders have been involved in the project through a series of trainings, workshops and dissemination events. These meetings have generated strong interest among stakeholders and in some cases the techniques proposed have been tested successfully. For example, two meetings with the stakeholders were organised in Hungary, one in the Budapest and one in the Veszprém, focusing on the vulnerability assessment of the two municipalities being undertaken under the projects activities. Participants in Budapest concluded that the pilot study would be important for integrating adaptation measures into municipal plans. In Veszprém, the municipal energy strategy and other climate change–related activities were highlighted.

In addition, in years after the project was finalised, experience gained and several governing institutions in preparation of strategic documents used databases produced during the project. For example, Climate Change Adaptation Action Plan and Vulnerability Assessment for the City of Belgrade was prepared using project outputs.

In Romania around 70 stakeholders was involved in one of the projects events to learn about the project and preparation of the pilot study “Climate change adaptation measures in Romanian agriculture”. During the second meeting in Romania 50 participants from local and regional authorities working in agriculture, water resources management and environmental and public administration exchanged experiences and lessons learnt and explored possibilities for reducing the impacts of drought in the region.

Theses interactions with stakeholders were very important in shaping final project outcomes.

Barriers for co-development and the ways to overcome it

Alongside the many advantages that it presents, co-development of climate services with different user groups might not always be easy, in particular when it comes to the integration of climate information into planning processes and decision-making.

Framing problems in a structured way can be an efficient way to communicate with decision-makers; the more structured a problem is, the more consensus exists about which values and information are at stake in the process of problem solving. However, in this process, decision-makers often face two main challenges: (1) they find it difficult to know what climate information and data are best suited for a particular problem and (2) they often perceive that climate information and data coming out of the scientific community is not usable in decisions [Briley L. *et al.*, (2015)].

Regarding policy and decision-making problems, Hisschemöller and Hoppe (1995) have elaborated a two-dimensional categorization comprising: (i) the relevant and available knowledge; (ii) the norms and values at stake. With these two categories four possible types of problems emerged [source: http://www.politicsandideas.org/?page_id=23]:

Structured problems are clearly defined. There is someone in charge of solving the problem and a general agreement of what this solution would entail.

Unstructured problems ("wicked", "ill-structured" or "messy"). These problems are complex: there are no clear boundaries, no specific actor responsible for solving them. There are conflicting values and knowledge that are part of an extensive debate.

Moderately Unstructured problems (two possibilities):
lack of agreement on values – there is a general confidence about the technical aspect of the problem, meaning certainty in relation to the knowledge, but no agreement on the values involved in the problem.
uncertainty of knowledge - there is agreement on the values, but no certainty about the knowledge or the technical aspect of the problem.

For each type of the problem, there are at least two key questions that should be asked [*Source: http://www.politicsandideas.org/?page_id=23]:*

- What type of policy influence is likely to occur? What can we realistically expect to achieve?
- In addition, what is the role of research?

Following this approach, Ordoñez and Echt (2016) suggested the framework to connect a clear objective with the specific context and the type of research to carry out in the think net "Politics and ideas" (see **Error! Reference source not found.**). [*Source:* HYPERLINK "http://www.politicsandideas.org/?page_id=23" http://www.politicsandideas.org/?page_id=23]

Table 2. A framework to solve policy problems.

	Structured	**Moderately structured problems (value agreement)**	**Moderately structured problems (knowledge certainty)**	**Unstructured**
Description	Stakeholders are ready to tackle the issue	Stakeholders share values, but have opposing knowledge.	Stakeholders do not agree on their values or priorities	Wicked: stakeholders do not know where to start.
What is the role of research?	Show clear options for policy design and how an idea can be implemented. • Financing • Capacity • Technical knowledge • Maintaining support	Make sense of existing knowledge. • Gather front-line evidence • Making sense of existing research • Knowledge translation	Bring stakeholders together, find common ground among stakeholders • Accomodating solutions • Long-term research agenda	Structure ('domesticate') or prioritize parts of the problem to move forward. • Front-line knowledge • Developing new visions • Frameworks

Bessembinder *et al.* (2012) argued that some users have difficulty articulating their requirements, e.g. users often ask for a lot of information, whereas in the end they may only use a small part of the requested data/information. To deal with this so-called "unstructured problem" much more time has to be invested in the articulation of and understanding of user's requests via continuous interaction between users and providers [Bessembinder *et al.* (2012)] (see Figure 9).

	Agreement and values and objectives	Disagreement and values and objectives
Certainty and agreement on knowledge	Structured	Semi-structured
Uncertainty and disagreement on knowlegde	Semi-structured	Un-structured

	Outcome preferences certain	Outcome preferences uncertain
Cause-effect relations certain	Causation and outcome preferences are certain – data are voluminous **Computational strategy**	Uncertain due to - opposing preferences - external constraints **Compromise strategy**
Cause-effect relations uncertain	Uncertain due to - incomplete knowledge - inherent uncertainty - competition with rival decision-makers **Judgmental strategy**	Uncertain due to - a combination of reasons **Inspirational strategy**

Figure 9. Types of the problem & related strategies to solve it [adapted by Bessembinder et al., 2012 from Hisschemöller, 1993, Thompson, J.D. (1967/2003)].

A lot of valuable experience on users' requirements related to CS were gathered in the Module 2 "Research for Climate Service Development" of JPI-Climate (http://www.jpi-climate.eu/). This work aimed to collect and analyse information on users' requirements related to Climate Services (including similarities and differences between sectors and countries) [Bessembinder *et al.*, (2012)]. The results are summarised in Table 3.

Table 3. Gathering information on user's requirements: difficulties and ways to overcome them.

Difficulties	***Ways to overcome them***
Difficult to get into contact with representative users for specific sectors The requirements of users within one sector may differ considerably. Besides, there may be different "schools" within a sector (e.g. in the Netherlands there are water boards that use climatological time series for impact studies and do statistic calculations afterwards based on the results of hydrological models, However, there are also water boards that use the "stochastical method" is which the statistical calculations take place before the hydrological impact analysis). Those that may have an overview of the sector don't always know what are the exact/real requirements of the various user groups within a sector.	*Use your contacts* in projects where you are working together with users; Get into contact with *professional organizations* that represent specific users in specific sectors; Understand the representativeness and reach of those you have engaged (i.e. the breadth of the users within a sector they represent); Look for representatives of the various user groups in the same sector; Do not expect to have a representative group/network within a short time; Realize that users' requirements may change, but also that the users within a given sector can change.
Be aware of differences between user groups	Ensure that users little or no experience provide with opportunities to voice their needs;

	Take more time and effort/interaction to understand the requirements are of groups with little background knowledge and to explain what can and cannot be delivered.
Exploring with users their requirements may result in high expectations of what will be delivered later on	An early focus on expectation management – check what users require and why, tell them what is possible and what is not and why, including the dilemmas (e.g. higher temporal resolution may result in less spatial resolution).
Discrepancy between what users desire and what is scientifically sound to deliver	Be aware of how users may interpret data and information; Do not provide through a website that is publicly available data/information that need a lot of guidance to support its correct use and interpretation; Information on the limitations of datasets should be provided
Difficulties in providing information to non-technical users	Ensure that both users and providers understand what the other is saying.

Over the past several years there have been growing interest in investigating the barriers for co-development of CS with users.

Vogel *et al.* (2016) explored the efforts of four water utilities to co-produce actionable science using partnerships with scientific institutions (the PUMA project). They found that co-development could be time-consuming and labour intensive, as the pilot project descriptions document. They concluded that co-development is often not recognized or that the time needed for it is underestimated enormously.

Briley L. *et al.* (2015) illustrated the experiences of the Great Lakes Integrated Sciences and Assessments program (GLISA) and encountered three main barriers to co-development:
(1) Mismatched terminology used by scientists and users to describe the types of information that are available and needed for problem solving (translation);
(2) Unrealistic expectations regarding the development of climate information products for problem solving;
(3) Disordered integration of when users want to bring climate information into decision-making processes

They suggested several methods, which can help to overcome these barriers. One approach to overcome the barrier 1 is the generation of discussion around what types of information users want by describing the inputs that are necessary for their problem. The quickest way to overcome barrier 2 is to use existing knowledge of the limitations for data and information in the stakeholder's geographic location of interest. Barrier 3 can be solved by having the stakeholder describe a particular concern or describe existing vulnerabilities that they face.

A number of examples of seemingly good ideas, which have not worked, were discussed at ICCS5 [Blome *et al.*, (2017)]. Since co-development is time consuming and thus usually expensive, funding plays a crucial role: this is a prerequisite to ensure tailored, high quality services. Additionally, there is a little chance to succeed without political support in particular in developing countries. In addition, the missing institutionalisation of a multi-stakeholder approach is a real barrier to a successful climate service, in particular in Africa.

Based on the experiences of the Regional Climate Outlook Forums (RCOFs), some tensions and trade-offs have been identified between the different user groups of the outlook forums [Blome *et al.*, (2015)]. These were related to e.g., scientific consensus or the balanced representation of users from different sectors.

In the development of the climate information portal (CLIPC), a number of challenges were encountered when developing a climate information portal for and with a broad range of users from different countries [Swart *et al.*, (2017)]. For example, one of them is that there is not one optimal method for obtaining feedback from user communities. A variety of approaches is required to engage a sufficiently broad user group, e.g., using a combination of on-line surveys, interviews, web-based testing and feedback, and user panels. Sustaining dialogue between users and the developers of the information portal is one of the most difficult tasks. Challenges arise from the diversity of user categories, the lack of people's availability, or the lack of financial or other incentives. Effective interaction between portal developers, intermediaries and users requires a lot of time and goodwill, which is often not available [Swart *et al.*, (2017)].

However, it is also important to mention, that if there is a clear advantage for the users, they are more willing to invest more time. The same is true when there is understanding/respect/trust/confidence. In these cases, people are often more willing to give feedback or cooperate, even if it is difficult (experience from the Climate Impact/Adaptation Atlas/ Janette Bessembinder, personal communication).

The stimulants and barriers of user engagement for CS were mentioned in the internal report of the ECLISE project (www.eclise-project.eu, D1.3.). The deliverable can be found at (http://www.eclise-project.eu/content/mm_files/do_824/D1.3%20ECLISE-User%20evaluation%20and%20best%20practices.pdf).

The results of a survey used to obtain this information are summarised in Table .

Table 4 (reproduced from D1.3, ECLISE):

Responses to the question "what were the most important stimulants or barriers to your involvement?"

Stimulants	Barriers
• Actuality of the subject	• The language is too specific
• The need of climate information for the development of water management plans	• Some institutional barriers and limited national funding related to limited person
• Understand future natural disasters and how we can handle them	• The involvement was moderately sufficient due to reforming of the public sector and personnel moving
• It is an important part of my work on hazard/risk management	• Lack of time
• The topic is interesting for me personally	• Limited expertise in the topic
• The topic is extremely important as my activity is influenced by climatic conditions	• The topic is not under my area of expertise or a major issue of concern at work
• Provide high quality information to potential future customers	• We were invited to participate as users in the middle of the project
• Getting information about available data useful for our activities	• Limited time to spend for this activity
• We were involved in data quality assessment in order to steer a correct homogenization activity, and in comparing data interpolation results	• We could not take part directly to the analyses due to lack of human resources
• Comparing results of climatic analyses with previous studies of our service	• The availability of time
• We were involved in data retrieval, and the results of climatic analyses were submitted to us for a better interpretation	
• The analysis of the results obtained	

These results show that most barriers are related to lack of time and resources, or limited expertise in the topic. At the same time, the main stimulant for users for being involved in ECLISE was the opportunity to gain knowledge about climate change. Furthermore, the recommendations of the providers show that frequent contact and an active involvement of the user from the beginning of the project is very important.

It is also worth mentioning that efforts to co-produce climate knowledge are restricted, and even might be counter-productive, if scientists are unwilling to listen to users in the first place. Moreover, while new actors may join or user needs develop, producers of climate information need to be aware of, and responsive to, the political culture that incentivises such changes [Skelton *et al.*, (2017)].

Evaluation of Climate Services via "user interaction"

'User interaction' and 'usability' were used as indicators to evaluate the success of the climate services in the EU FP7 ECLISE project (www.eclise-project.eu). The user communities, identified for the project, varied in spatial scale and sector and were mainly determined by decision makers from businesses, local and regional authorities.

The success of ECLISE was evaluated based on the criteria shown in Figure 10 (extracted from D1.3 mentioned above):

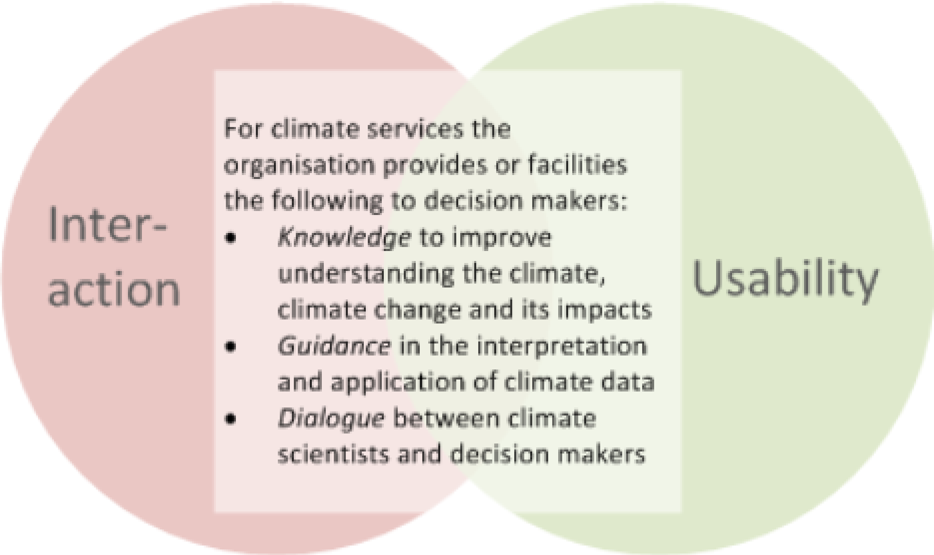


Figure 10. Criteria used for the evaluation of the ECLISE project.

"**Interaction**" was suggested as the indicator to show the degree to which the users have been involved in the problem formulation, research design and in the analysis of the findings. It was mentioned that the interaction between research institutes and users will improve the implementation of public policy or support the decision-making process. Evaluation was based not only on the frequency of the interaction, but also on the involvement of the process of both parties and the understanding of each other. **"Guidance"** is the second indicator, and is an important factor for data to be used in the decision-making process. "**Trust**" was selected by ECLISE as the third indicator that influences both interaction and uptake of information.

However, it should be mentioned that the mechanism to achieve a sound quality control of CS is rather complex [Blome *et al.*, (2017)]. For example, the evaluation should be applied throughout the entire development process and not only to the final product. An appropriate budget needs to be allocated to accomplish all steps that are required for the evaluation. Nevertheless, the most important part of the evaluation is recognised as **transparency**. Climate service providers have to make sure that they are documenting the work not only from providers' perspectives, but also regarding user's needs.

Swart *et al.* (2017) evaluated the effectiveness of the user engagement process in developing information portals. They followed four criteria of WMO (2014). Four criteria are required in the context of climate services for a user interface portal:

- Feedback (identifying the optimal methods for obtaining feedback from user communities); dialogue (building dialogue between climate service users and those responsible for the observation, research and information system pillars of the Framework);

- Outreach (improving climate literacy in the user community, and literacy of the climate community in user needs);
- Evaluation (developing monitoring and evaluation measures for the Framework that are agreed between users and providers).

Lessons learned of co-developing climate services with users

In summary of the results and experiences mentioned above, the main lessons learned from co-developing CS with users are:

- Mauser *et al.*, (2013) describes how the co-production of knowledge changes the way research is undertaken. It requires **appropriate communication tools, institutional arrangements, and tailored funding possibilities**;

- **Individual solutions,** which satisfy the individual requirements and needs, have to be developed in close co-operation with the customers and users. Based on the experiences gained at GERICS, no standard solutions can be provided for questions concerning adaptation to climate change. Unlike mitigation measures, adaptation measures must be framed in accordance with the specific circumstances prevailing in the local situation [Jacob, (2017)]. Hewitt *et al.*, (2017) suggested strongly tailored customer-focused programmes for decision-making.

- **Relationships are one of the keys to success.** User engagement is a **continuous process** that should not be relegated to either the initial or the final stages of a project but which should instead be intertwined in the very fabric of the project at all stages [Buontempo C., (2017)]. Involvement of users in the very early stages of design and development of CS brings people together and creates a feeling of ownership. Furthermore, users' needs change over time or not very clear from the start ("unstructured problem"), and therefore a continuous process of adaptation and feedback mechanisms are required, e.g. a lot of interaction to receive regular feedback on possible approached/methods to produce the CS. It is also very important to show the users how they can benefit from the "final product".

- **Do not underestimate the time and effort** required to establish such relationships from both the users' and scientists' sides [Brasseur, G. P. and Gallardo, L. (2016)].

The EU FP7 project EUPORIAS is a very good example of co-creation of climate services. It critically analysed the results of the five climate service prototypes created within the project [Buontempo *et al.*, (2017)]. This work suggests a rethink of the way in which users are involved in climate service propositions. The authors find that it is rational to change the governance of the projects and to involve users in the definition of the problems more directly, through:

▪ **Building trust and relevance** and knowing the actors involved is key to ensuring a climate service is responsive and delivers what people need over time. Ongoing capacity building, continuous identification of needs, and ownership at the local level, are as important as product development and provision. A climate service is much more than just the information product.

▪ **Knowledge brokering** is an emergent and critical role in the context of increasingly dynamic and uncertain climate events where learning on adaptation, resilience and climate science is continually evolving. It enables the right players to link up for a specific purpose, and facilitates knowledge exchange, innovation and informed decision-making, and allows the creation of multi stakeholder platforms where climate information and uncertainty can be collectively interpreted in creative ways.

▪ **Institutional frameworks, supportive policy environments and funding** are not yet in place or not yet conducive to support co-development processes which engage all actors and demonstrate the benefits of climate services.

Similar lessons learned were highlighted by the participants of the side event “Co-developing Climate Services: brokering climate knowledge from scientists to decision-makers and back” of ICCS5 [Blome *et al.*, (2017)].

Hewitt *et al.*, (2017) highlighted that engagement between the users and the providers of climate information needs to be much more effective and should better link climate information with decision-making. They concluded that awareness raising and capacity building could generate significate values for decision-making. An integrated multi-disciplinary system modelling will help decision-makers to apply climate information more effectively. Hewitt *et al.*, (2017) also suggested that all countries would benefit from convening national and sub-national users workshop preferably hosted by climate services providers, e.g. National Meteorological or Hydrological services. Formalizing partnerships using memoranda of understanding or other suitable mechanisms could be essential for long-lasting and effective relationships and lead to the formalization and clarification of roles and responsibilities for all involved. User feedback, which is elicited wherever and whenever possible, has the potential for further development of Climate Services. Note that it is strongly advised to incorporate user feedback not only at the beginning of the climate service development (when the problem is disentangled) but also in further stages, even at the end if users find that the service is not totally fit to their needs.

Outlook

Improved engagement between users and providers of CS leads to successful uptake and use of climate information for decision-making. In this context, the collection and synthesis of information on what made the co-development successful and what barriers are still are at the heart of Climateurope.

At the beginning of October 2017, Climateurope initiated an online survey to collect and share different views on the co-development of climate services with users. The members of the Climateurope network and the First Climateurope Festival goers have been asked to participate in the online survey, which is available here:

https://docs.google.com/forms/d/e/1FAIpQLSdTt-xOlkymXdBrDDxlY8JLfgXPZ4VAZXO32sUoO6dappI8Yw/viewform

At the time of writing this report, the survey is ongoing. The most interesting stories will be published online on the project's homepage. Furthermore, we will stay in close contact with C3S, which is rapidly accumulating practical knowledge on how to engage with users in the definition and design of operational climate services. We will take into account these results in our future work.

To support co-development of climate services through close collaboration of suppliers/purveyors and users, the European Commission initiated the Call "Demonstration of climate services". The core of the action is the demonstration of climate services in relation to issues where climate-related intelligence can support tangible decision-making processes in the public or private domain.

The winners of this Call are listed in the Table 2.

Table 2. Winners of the Call.

Title	Acronym	Key words	Link
Climate forecast enabled knowledge services	CLARA	Project Clara is developing an innovative solution to improve the position of everyone affected by defined benefit pension schemes. Our objective is to provide certainty to companies by freeing them from their legacy liabilities at a cost significantly below buyout. A crucial part of our product design is to incorporate as much customer feedback as possible to ensure we are building a product that companies want and are incorporating the features that they need.	http://www.projectclara.co.uk
Integrated Climate Adaptation Service Tools for Improving Resilience Measure Efficiency	CLARITY	Operational eco-system of cloud based climate services to calculate and present the expected effects of cc-induced and -amplified hazards at the level of risk, vulnerability and impact functions	http://clarity-h2020.eu
Oasis Innovation Hub for Catastrophe and Climate Extremes Risk Assessment	H2020_Insurance	The project intends to operationalize a system, called the Oasis Loss Modelling Framework, that combines climate services with damage and loss information and provides a standardised risk assessment process that can assess potential losses, areas at most risk and quantify financial losses of modelled scenarios.	

Provision of a prediction system allowing for management and optimization of snow in Alpine ski resorts	PROSNOW	PROSNOW builds a demonstrator of a meteorological and climate prediction system from one week to several months ahead applied to snow management, specifically tailored to the needs of the ski industry. The developed system will be Alpine-wide (France, Switzerland, Germany, Austria and Italy). It associates research institutions for weather forecasts & climate predictions, providers proposing high tech solutions for snow monitoring and management, and a relevant ensemble of eight representative ski resorts in the Alps.	https://geographie.uibk.ac.at/blog/ahc/projects/
Pan-European Urban Climate Services	PUCS	The objective of the PUCS project is to establish a service that translates the best available scientific urban climate data into relevant information for public and private end-users operating in cities.	
Vineyards Integrated Smart Climate Application	VISCA	The main objective of VISCA is making European wine industries resilient to climate changes, minimizing costs and risks through an improvement of the production management (quality and quantity of final product), while evaluating its replicability to other high-added value agriculture sectors.	http://visca.eu

All these projects will demonstrate user-driven climate services in sectors or business networks. The key objectives of these projects were presented at the first Climateurope Festival in Valencia in 2017. In addition to the EU Call “Demonstration of climate services”, ERA4CS launched a joint Call on Researching and Advancing Climate Services Development by Advanced co-development with users and Institutional integration. (http://www.jpi-climate.eu/ERA4CS.activities/jointcall).

One of the main objective of this Call is to demonstrate advanced co-development of Climate Services with users. The feedback loop from users to research development from co-design of research priorities → to co-development of tools → up to the co-production and co-evaluation of products is crucial for refinement of the research strategy. The winner of the calls are the projects, that requires user driven development, translation and transfer of climate and related knowledge, as well as guidance on the use of such knowledge by public and private bodies and other decision-makers, including researchers in a facilitative manner.

In this context, this deliverable will be further developed as a “living document”. Climateurope will follow the results of all these projects and will invite their coordinators to the Final Festival of Climateurope in 2020 to share their experiences in creating and developing user-driven climate services.

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