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Perspective

Improving predictions and management of hydrological extremes through climate services
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ABSTRACT

The EU Roadmap on climate services can be seen as a result of a convergence between the society's call for "actionable research", and the ability of the climate research community to provide tailored data, information and knowledge. However, although weather and climate have clearly distinct definitions, a strong link between weather and climate services exists that is not explored extensively. Stakeholders being interviewed in the context of the Roadmap consider climate as a far distant long term feature that is difficult to incorporate in present-day decision taking, which is dominated by daily experience with handling extreme events. In this paper we argue that this experience is a rich source of inspiration to increase society's resilience to an unknown future.

A newly started European research project, IMPREX, is built on the notion that "experience in managing current day weather extremes is the best learning school to anticipate consequences of future climate". This paper illustrates possible ways to increase the link between information and services for the water sector, by addressing weather and climate time scales and discussing the underlying concepts of IMPREX and its expected outcome.

The climate services paradigm

An agenda for climate change research has been with us already for a couple of decades, clearly triggered by the early climate assessments (e.g. Charney et al., 1979) and first IPCC reports completed in 1990. A significant volume of research has been funded by national and international public entities. Since the debut of the

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[7] http://climatemodeling.science.energy.gov/f/Water_Cycle_Workshop/Day2_Topic1_WhitePaper.pdf.

[8] https://www.wmo.int/pages/prog/wcp/ccl/meetings/ICT-CSIS/documents/presentations/EHP_ICT_Slides.pdf.

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European research Framework Programmes in 1984,[1] climate research has had a prominent position in the calls for proposals. Together with research funding through many national public programmes, this has led to an impressive increase in our understanding of climate, its drivers, and consequences of climate change on our environment, society and economic sectors, as documented in the IPCC assessment report series (e.g. Kovats et al., 2014 for Europe).

Over the years, a shift in the type of climate research has become noticeable, guided by a shift in funding requirements and public requests. Research has moved towards more "actionable climate research" (Asrar et al., 2012), which means that it has placed focus on providing climate information to guide business and policy decisions. Climate change has become a widely recognised topic. Although many aspects of the functioning of our climate system and its predictability remain unresolved, the request for actionable climate research is heard louder and clearer in the recent decade. We do not only want to know what's going on with our climate, we also need to know how to respond and act.

A modern term that appeared alongside with this research shift is "Climate Services". The European Commission has guided the development of a Roadmap (Street et al., 2015), where a definition of climate services is given: "We attribute to the term 'climate services' a broad meaning, which covers the transformation of climate-related data 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)". Our understanding of the climate system is thus intended to be packed as products that help society anticipate and mitigate climate change, adapt to the new situation and manage the potential disasters and new opportunities that are a consequence of it.

The Roadmap also recognises that in order to make climate services an effective means to cope with climate change and its effects, a change of the supply–demand structure of knowledge and information is necessary. We are moving from a situation where a scientific programme is no longer providing information solely to a public or private organisation, but instead to a network where creation and exploitation of knowledge and tools is realised: "We wish, making use of both supply- & demand-side actions, to help creating a European market for climate services in which public bodies and businesses provide cutting-edge customised information services and adaptation solutions to a range of end-users, both in the business to business domain, in the public decision-making domain, to consumers, making Europe a leading actor in this domain" (Street et al., 2015). Co-design, co-production, inter- and transdisciplinarity, relevance and authority are keywords illustrating the current day practice of climate research, innovation and implementation.

Although in meteorology and climate sciences "weather" and "climate" have clear definitions regarding their scope and time scale, the framing of weather and climate tends to distinguish weather and climate as features influence decisions within several water sectors in a quite different way. "Climate" tends to be framed as a future condition, relevant for planning, for which we should prepare or that we should try to avoid. On the other hand, "weather" is presented as a present-day condition that is very relevant for management and short-term decision making. Decision-making for (future) climate conditions is considered to be more difficult, due to the long time range at which climate change becomes decisive and is going to affect business, safety or wellbeing (Street et al., 2015).

"Weather is nearby and short-term, while climate is far away and long-term" is however a paradigm that can be questioned. Weather events in the (far) future will dominate the impacts of climate change in weather-sensitive activities. This notion is clearly addressed in many research projects that explore projections of weather extremes in future climate conditions (e.g. Hanson et al., 2006, 2007[2]). The climatology of weather patterns also in the present climate dictates their exceptionality, which will impact the way our structural and non-structural measures planned for climate change adaptation will respond. There is therefore a need to support decision making facing future weather that may be very different from today's reality. The use of long lasting experience gained with "weather services" (Mason, 1966) will likely significantly benefit the development of appropriate climate services for business and decision making.

Many of the climate change effects on society will affect the water sector. Water supply, wastewater, navigation, hydropower, agriculture, flood protection and drought risk, among others, are all sensitive to variable weather patterns at different space and time scales. Adequate "water services" can be informed by (and provide feedback to) climate services are thus essential to trigger innovation in the water sector and increase its capacity to adapt to climate change (see also the call from the European Innovation Platform EIP Water for water innovation services[3]).

In the first work programme of the European program Horizon 2020 for the Societal Challenge "Climate action, Environment, Resource efficiency and Raw Materials", a call for proposals was launched in the "Water" section: "Water cycle under Future Climate".[4] A striking feature of this call was that the expected impact was very broad and contained many elements that had all to be considered in each single candidate proposal: better precipitation and water cycle projections at various timescales; better forecasts of extreme hydrological events; impact assessment of weather extremes; and development of risk management strategies. Interestingly, (climate) projections and (weather) forecasting, (climate) risk and (weather) impacts were all mentioned in a single call for water research and innovation. Two consortia were selected and funded in response to this call, including the project entitled "Improvement of predictions and management of Hydrological Extremes (IMPREX)".[5] IMPREX is designed on the notion that "experience in managing current day weather extremes is the best learning school to anticipate consequences of future climate". In this paper we elaborate on the link between weather and climate in the context of providing climate services that will contribute to more efficient water services today, which, in their turn, will be better adapted to climate change impacts and conditions of tomorrow. We will illustrate this by discussing the conceptual view and expected outcome of IMPREX.

Link between weather and climate

For many sectors and applications it is difficult to design a robust decision context to anticipate necessary responses to extreme events in a far future. This future is uncertain, and thus is the return-on-investment of near-term decisions. A long history of coping with climatic extremes can help to build a robust framework of scenario assessment, adaptive risk management or cost-effective investment (Berkhout et al., 2013; Fernandez et al., 2014). Examples of this are the public flood protection measures in The Netherlands and the

[1] http://horizon-magazine.eu/article/europe-s-framework-programmes-key-element-research-policy-europe_en.html.

[2] For instance, in the project "Modelling the Impact of Climate Extremes" (MICE) systematic attention is paid to the quality of the representation of extreme weather in state-of-the-art models, as well as to their projected changes and impacts of these future extremes.

[3] http://www.eip-water.eu.

[4] https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-climate_en.pdf.

[5] For the other funded project see http://www.projectbingo.eu.