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Climate services in the UK Met Office – challenges and solutions

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Abstract. The development, delivery, uptake and use of climate services face numerous challenges including the fact that decision-makers often need information that is beyond the current scientific capability, insufficient capacity amongst climate service providers to be able to meet the demands from decision-makers, shortcomings in the awareness and understanding of available knowledge, and insufficient understanding by climate service providers of the needs of decision-makers. This article provides examples of the UK Met Office's international climate service activities in Commonwealth small island states, China and Europe, highlighting specific challenges. Based on experiences developing and delivering climate services and collaborating with a range of actors, some approaches that help overcome, or at least reduce, these challenges include undertaking focused user engagement, collaboration and partnerships, developing prototypes and conducting trials of these prototypes with the users, evolving the science and the services based on the users' needs to better serve societal needs.

Keywords: applied science, climate change, climate services, climate variability, collaboration, decision-makers, science for services, UK Met Office.

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1 Introduction

Decision-makers worldwide are already aware, or are becoming aware, of the threats and opportunities arising from climate variability and climate change. In recognition of this there have been major international activities to develop and deliver climate services and scientific capability to underpin the services, in particular over the past decade, such as World Climate Conference-3 (WCC-3 2009) and the Global Framework for Climate Services (WMO 2014), the ongoing UNFCCC and IPCC processes, as well as important and successful regional and national activities.

There have been, and continue to be, major developments in Earth system modelling, observations, communication and use of uncertainty information, closer engagement with social and economic science for example, as was discussed during the Bureau of Meteorology's Annual R&D Workshop in November 2019. The scientific community has a wealth of data, information and knowledge which can be, and often is, of use to decision-makers. However, the situation needs to continually evolve and improve.

The development, delivery, uptake and use of climate services face numerous challenges. Challenges include the fact that decision-makers often need information that is beyond the current scientific capability, perhaps requiring detail at local scales not properly resolved or represented by climate models, or levels of skill and reliability beyond current knowledge and forecasting capability; the climate service providers don't have sufficient capacity to be able to meet the number of requests from their users or the capabilities to provide the required information; decision-makers are often unaware of what information is available, how to access it, how to use it (and what it should not be used for); climate service providers often have insufficient understanding of the needs of the decision-makers.

This article provides some examples of the UK Met Office's international climate service activities, highlighting the above challenges along the way, and offering some suggested solutions.

2 UK Met Office international climate services

The UK Met Office is the national meteorological service for the UK, providing critical weather and climate services to a large number of public and private sector organizations, and undertakes world-class weather and climate science. The UK Met Office works closely with international, regional and national organizations and engages with climate-sensitive communities and sectors. The international activities are closely aligned to, and support, the World Meteorological Organization. With regard to climate services, the biggest coordinated global activity is the Global Framework for Climate Services (GFCS), co-ordinated by the WMO working with its sister UN Agencies

and a range of organisations worldwide. The GFCS is enabling society to manage better the risks and opportunities arising from climate variability and change, using science-based climate information in several priority areas, namely agriculture and food security; water resource management; health; disaster risk reduction; and energy (Hewitt *et al.* 2012; WMO 2014).

An essential, but challenging area is engagement between the providers and users of climate services. To help address this, the WMO's Commission for Climatology formed a team of international experts to identify and evaluate examples of user engagement; and publish guidance on good practice (Hewitt *et al.* 2017*b*; WMO 2018). Depending on the particular context, there are different levels of engagement that could be appropriate, classified into three broad categories. One category is relatively passive engagement where information is largely, but not entirely, pushed to the users, perhaps through a website or web-based tools. The advantages are that it is easy to keep the information up-to-date, a lot of people can be reached efficiently, and approaches like websites and web-based tools are meant to be easy to use and understand. At the other end are very focussed relationships, a much more intensive engagement approach, which can explore in-depth understanding, be bespoke and highly iterative. The third category are interactive group activities where co-leaning, co-production and capacity building can take place.

As with many other national meteorological services, the UK Met Office's international climate service activities are aligned to the GFCS and draw on the good practice compiled by the WMO Commission for Climatology. The UK Met Office co-develops climate services to support decision making, builds capacity and provides training where helpful, coordinates major initiatives where appropriate, and draws on scientific and technical capability within the UK Met Office and partners. The UK Met Office has been developing and providing climate services for a long time to a wide range of organizations and sectors both domestically and internationally. The following sections provide three examples of recent collaborative activities internationally for and with Commonwealth small island countries, China, and Europe

3 Examples of UK Met Office international climate services

3.1 Climate Service Demonstrators for Commonwealth

The Commonwealth Climate Services Demonstrator project ran from April 2018 to March 2020 bringing countries together to improve resilience to climate change. The focus was on the 25 Commonwealth small island states in the Pacific and Caribbean – these states are some of the most at risk from climate change due to their small geographical area, isolation and exposure. The project drew on capability and outputs from the Met Office Hadley Centre Climate Programme and collaborators in the project to support climate change adaptation. The activities were carried out through close collaboration with key organisations in the Caribbean and South Pacific, particularly the Regional Centres (the Caribbean Institute of Meteorology and Hydrology, the Caribbean Community Climate Change Centre, and the Secretariat of the Pacific Regional Environment Programme) and National Meteorological and Hydrological Services (NMHSs), including the Australian Bureau of Meteorology, and the National Institute of Water and Atmospheric Research in New Zealand. The collaboration helped build scientific links between Commonwealth countries, helped strengthen relationships between providers and users of climate services, and helped raise awareness of climate change and develop capacities and capabilities to build resilience to climate change.

Effective user engagement proved to be an essential challenge to address, and one notable success was a workshop held in Trinidad and Tobago in collaboration with the Caribbean Institute for Meteorology and Hydrology, titled 'Climate change in the Caribbean – Strengthening the science to services interface'. The workshop was held back-to-back with the annual dry season Caribbean Climate Outlook Forum (CariCOF). The workshop was funded by the WMO Climate Risk and Early Warning Systems (CREWS) initiative and aimed to build upon the seasonal forecast CariCOF event and associated training activities earlier in the week, but moved the topic on from seasonal forecasting to climate change adaptation. This logistical setup allowed several of the participants from the CariCOF to participate, and incorporated representatives from Commonwealth NMHSs, national sector organisations and regional sector bodies, alongside climate service providers from regional organisations and universities. This collaborative workshop with the focus of long-term climate change and associated impacts for the Caribbean was very well received and encouraged regional collaboration and shared understanding. Outputs from the workshop included: increased awareness of ways to become involved in the IPCC process in the Caribbean, identification of climate change impacts in the region, co-produced guidelines for best practice communicating long-term climate information in the Caribbean, and co-produced ideas for a potential new Caribbean Sea level rise tool.

3.2 Climate Science for Services Partnership China

The China Meteorological Administration (CMA), the Institute of Atmospheric Physics at the Chinese Academy of Sciences, and the UK Met Office with UK academic partners, formed the Climate Science for Service Partnership China (CSSP China) in 2014 (Belcher *et al.* 2018). This major multi-year programme of activities is enabling scientists in China and the UK to collaborate more closely to develop the climate science and services to help decision-makers in China undertake better informed climate-related risk management across key sectors. The sectors include renewable energy, agriculture and food security, urban environments, and water resources (Golding *et al.* 2017). The collaboration is wide-ranging, spanning the development of underpinning science, climate modelling and observational datasets, the development of prototype climate services, all the way through to close engagement with regional and local climate service providers and their customers, the decision-makers.

A focus of the climate service development in CSSP China is to conduct trials using prototype climate services to engage closely and effectively with potential users of the services. The learning from these trials is also being used to inform the science across the CSSP China programme, and in some cases leading to new scientific developments to improve subsequent versions of the prototypes. The most advanced prototype climate service that has been developed is a probabilistic seasonal forecast of rainfall for the Yangtze River Basin. The scientific capability underpinning this prototype, the user requirement and the prototype itself have

all been documented extensively (see for example, Bett *et al.* 2018; Golding *et al.* 2019). Discussions with stakeholders in the hydropower industry have demonstrated a need for forecasts of rainfall on seasonal timescales, particularly for the summer flood season to inform forecasts of power production for the hydropower companies' customers and to inform flood management plans. Aligned to this, Li *et al* (2016) demonstrated that the UK Met Office seasonal forecast system Glosea5 shows significant skill for summer rainfall in the Yangtze River Basin. A prototype product showing probabilistic seasonal forecasts of rainfall for the summer flood season was developed in 2016 ahead of what was expected to be a very wet season following the large El Nino event in the winter of 2015/2016. The prototype was used in a successful trial with the stakeholders in 2016 informing discussions and planning in the Yangtze River Basin. The skill of the seasonal forecast was evaluated (Bett *et al.* 2018) and the usefulness of the prototype was assessed through close interaction with decision-makers at hydropower facilities along the Yangtze River, along with a survey eliciting user needs from a wider pool of decision-makers. The prototype was then revised for use in trials in subsequent years.

3.3 Collaboration in Europe

There have been major investments in Earth-system modelling and climate service development in Europe, in particular from the European Commission and national funding programmes. This has created a successful, but very crowded landscape in Europe, and the activities were springing up with little or no overall coordination. To address this situation, the European Commission has funded Climateurope, a coordination and support action under the Horizon 2020 framework programme (Hewitt *et al.* 2017*a*). At the core of Climateurope is a managed network of scientific communities, funders and user communities, currently with over 350 members.

The project is enhancing communication and dissemination activities and bringing together European climate modelling, climate observations and climate service infrastructure initiatives. A series of three publications is being produced over the five-year life of the project to map and analyse relevant initiatives, challenges and emerging needs relating to Earth system modelling and climate services in Europe, involving expertise from a range of stakeholders (see Döscher *et al.* 2017 for the first publication). The publication series is intended to have a wide readership including the scientific community, and decision- and policy-makers from industry, professional federations and public sector. In addition to this publication series, the project organises popular webinars, newsletters, short policy briefs, and recommendation on research needs for climate modelling and climate services, primarily for the European Commission and other interested funders.

Perhaps the most innovative, and the most popular activities are the Climateurope Festivals (Kotova *et al.* 2017). The Festivals create new networks and engage with existing networks that are supporting climate services at the European and national levels. Scientists, climate service developers and suppliers, and user communities come together in an informal environment to share their experience and knowledge, and discuss climate services in sectors of interest to the network. Two Festivals have been successfully held so far and one more is planned. The project also has a successful social media presence, in particular on Twitter (@climateurope), which proves very effective especially around the Festivals.

4 Challenges

International climate service activities are proving successul but there are numerous challenges, some common ones are now briefly listed here. Often there is a big gap between the requirements of users and the capability offered by the science and services, particularly in terms of helping inform decisions which may require information at spatial scales and with sufficient certainty beyond current modelling systems and scientific understanding. Language can be a challenge, in terms of technical language used by climate scientists and climate service providers and what such terminology means to different communities and disciplines. Also, given the international nature of climate services and some of the collaborations, we are also at times working from different native tongues. The concept of 'users' is often debated, and it is a tricky issue. For example, who are the users? It can be very difficult to find the right organisations to engage with, and in particular the right people within the organisation to engage with. When we know who the 'user' is then it can still be a big challenge to properly understand what they need. The concept of 'providers' is also not without problems, for example, who are the providers, and how do the users know who the providers are and who best to engage with? Many climate services are developed in projects, perhaps as pilots or prototypes, and the challenge often is what happens when the project finishes, how do we make services sustainable or operational? Finally, there are likely to be shortcomings in the capabilities and the capacities of all of the actors in the climate services supply chain – both the providers and the users would often benefit from developing their capabilities and capacities.

The above is not a comprehensive list, but is illustrative of common challenges around climate service users and providers, capabilities, capacities, context, and sustainability. Possible solutions to alleviate such challenges are often case dependent. However, through experiences developing and delivering climate services and collaborating with a range of actors the UK Met Office have found the following approaches help mitigate these challenges, all of which are recognised to some extent in the examples from around the world documented by the WMO in the 'Guidance on Good Practices for Climate Services User Engagement' (WMO 2018). Undertake focussed rather than passive user engagement, recognising however that this can be very time-consuming. Collaboration and partnerships are likely to be highly and mutually beneficial, especially when working overseas, because it is unlikely that one organisation will have all of the required capability, skills, knowledge and sufficient capacity to develop and deliver useful services. Developing prototypes and conducting trials of these prototypes with the users can prove to be very successful at building relationships, assessing needs, identifying gaps and co-developing services of use to decision-makers. Finally, the science, and the services based on that science, need to evolve based on the users' needs to better serve societal needs.

Conflicts of interest

The author declares that they have no conflicts of interest.

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