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The Future of Climate Services

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The Earth's climate has never been constant; a wide range of variations and changes in space and time, often leading to extremes, is its fundamental characteristic. However, there is conclusive evidence of anthropogenic warming over the past century occurring at an unprecedented pace. Its implication – in the increased frequency and intensity of extreme events– has elevated concerns about the exposure of vulnerable communities to climate risk. The resilience of society to increased climate risk depends on our ability to improve both the social and physical science underpinning systems that monitor, assess and issue impact-oriented weather and climate services and our facilitation of the uptake of knowledge into decision-making processes.

The use of climate information and knowledge is currently sub-optimal, hence the most vulnerable in our society are not benefiting from recent scientific and technological advancements. The *IPCC Special Report Global Warming of 1.5°* has renewed the urgency to step up efforts on weather and climate services, necessitating a long-term vision and enhanced partnerships to meet shared global goals. Timely, actionable, tailored weather and climate services are fundamental to progress on key global policy agendas. The Global Framework for Climate Services (GFCS), the WMO technical commissions and co-sponsored programmes, consolidated and empowered through the WMO Governance Reform, offer unprecedented promise in scaling up and mainstreaming climate services. In this article, we provide an overview of the programmes that have underpinned climate services, the changing policy landscape, highlight challenges and present some key strategies and opportunities for transforming climate services.

Building on strong foundations

A number of programmes and initiatives have been instrumental in laying the foundation for climate services. The First World Climate Conference (WCC-1) in 1979, sponsored by WMO, led to the establishment of the World Climate Programme and World Climate Research Programme (WCRP) in 1980 and the creation of the Intergovernmental Panel on Climate Change (IPCC) in 1988. The main objectives of WCRP have been to determine the predictability of climate and the effect of human activities on climate, while the IPCC serves to provide governments at all levels with scientific information they can use to inform mitigation and adaptation policies, as well as international climate-change negotiations.

The Second World Climate Conference (WCC-2) led to the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) and Global Climate Observing System (GCOS). UNFCCC facilitates the intergovernmental climate change negotiations and GCOS regularly assesses the status of global climate observations of the atmosphere, land and ocean and produces guidance for its improvement. GCOS expert panels maintain definitions of Essential Climate Variables (ECVs) which are required to systematically observe Earth`s changing climate. The World Climate Conference Three (WCC-3) in 2009 led to the establishment of the Global Framework for Climate Services (GFCS) to "enable better management of the risks of climate variability and change, and adaptation

1 Global Framework for Climate Services, WMO
2 The Met Office, United Kingdom
3 National Civil Aviation and Meteorology Service, Senegal
4 Federal Office of Meteorology and Climatology (MeteoSwiss), Switzerland
5 World Bank Group, Washington, DC, USA
6 Japan Meteorological Agency (JMA)
7 National Oceanic and Atmospheric Administration, Boulder, CO, USA
8 International Research Institute for Climate and Society (IRI), Earth Institute, Columbia University, Palisades, NY, USA
9 Rovira i Virgili University, Tarragona, Spain
10 Chilean Meteorological Service, Santiago, Chile

National climate commitments and climate services – the Mongolian perspective

Strengthening early warning systems and climate-risk information is a development priority for the Government of Mongolia as highlighted in its Nationally Determined Contributions (NDCs). With support from the NDC Support Facility and the Global Facility for Disaster Reduction and Recovery, the World Bank is partnering with the National Agency for Meteorology and Hydrology under the Ministry of Environment and Tourism to strengthen Mongolia's hydrometeorological monitoring, forecasting and early warning systems. The aims are to develop a roadmap for hydrometeorological modernization and climate services as a basis for addressing some of the country's key disaster and climate hazards such as dzuds (severe winter weather that leads to a massive livestock mortality event), drought and floods to ensure climate-resilient development in Mongolia.

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 scales". GFCS is proving pivotal in transitioning WMO and its Members from climate products to services. It focused on improved coordination in climate service co-development to better meet users needs and enhance access to those most vulnerable[11].

GGFCS built on the WMO Climate Information and Prediction Services (CLIPS) project launched in 1995 to transition Members towards developing operational climate information.[12] CLIPS increased climate knowledge, improved operational climate-prediction capabilities, and developed the capacities of National Meteorological and Hydrological Services (NMHSs) to deliver climate information to meet the needs of stakeholders. CLIPS was instrumental in the development of the concept of Regional Climate Centres (RCCs) and Regional Climate Outlook Forums (RCOFs).

The policy landscape

Significant changes have occurred in the climate and policy landscape in the last decade. In 2015, three international agreements raised the importance of climate issues in the global agenda: the Sendai Framework for Disaster Risk Reduction, the Paris Agreement, and the 2030 Sustainable Development Goals.

More than 40 developing countries have identified weather and climate services as key actions for their development planning and as a pillar of their ability to commit to the Paris Agreement under their Nationally Determined Contributions (NDCs) for both adaptation and mitigation. This adoption is reflected in low

11 WMO, 2011: Climate Knowledge for Action, WMO No. 1065.

12 Srinivasan et al., 2015: Climate Services – Transitioning from CLIPS to GFCS. WMO Bulletin, 64(1).

carbon growth planning, global climate adaptation, and climate resilience and disaster risk reduction portfolios around the world. In turn, an increasing number of actors are engaging in the different areas of the sustainable development discussion. Such growth requires a parallel increase in sector-tailored and end-user-focused climate services, as well as coordination to avoid fragmentary and piecemeal implementation.

Challenges for climate services

Demand is growing for better sub-seasonal, seasonal and longer-time scale predictions and longer-term climate projections, from global to local space scales. The traditional orientation of NMHS operations and their portfolio must therefore rise to the occasion to meet this demand. Many NMHSs continue to focus on weather-oriented activities and have not fully embraced the user-demand driven ethos required for various climate-sensitive sectors.

In many regions and countries, there is limited or no capability/capacity to expand existing operations into climate services. Long-term, high-quality historical climate time series, as well as the impact data required to develop and translate into services on demand, is often lacking. In many countries, issues around the governance of climate data is a key limiting factor for initiating climate services. NMHSs in developing countries have limited access to global and regional data/product inputs essential for generating climate products on national and sub-national scales. Furthermore, NMHSs often compete for funding within their national state budget and are poorly resourced, making the transition to a service-oriented culture difficult. Lack of resources and seemingly unending demand challenge the development and delivery of sustainable climate services that can help people and organizations make effective decisions. While these aspects may seem daunting, we propose strategies herein to overcome some of these challenges, and go on to highlight opportunities to improve outcomes.

Strategies for transforming climate services

Several recent sources of information (the mid-term review of the GFCS[13], the Global RCOF Review[14] and the WMO Science Summit[15]) have inspired the following suggestions as key strategies for transforming climate services.

Advance science for impact-based seamless services –The decision context and information needs of users in climate-sensitive sectors lie at the heart of effective climate services. Information needs to be tailored to reach the right person in the right form at the right time.This tailoring requires multi-disciplinary science that duly considers the complexity of the systems within which climate information is produced and delivered; the contexts within which users work and use it; and the many factors driving users' decision-making. Inclusion of social sciences and economic expertise is essential to improve understanding of needs, effectively engage stakeholders and to broker knowledge among different entities in the climate services value chain.

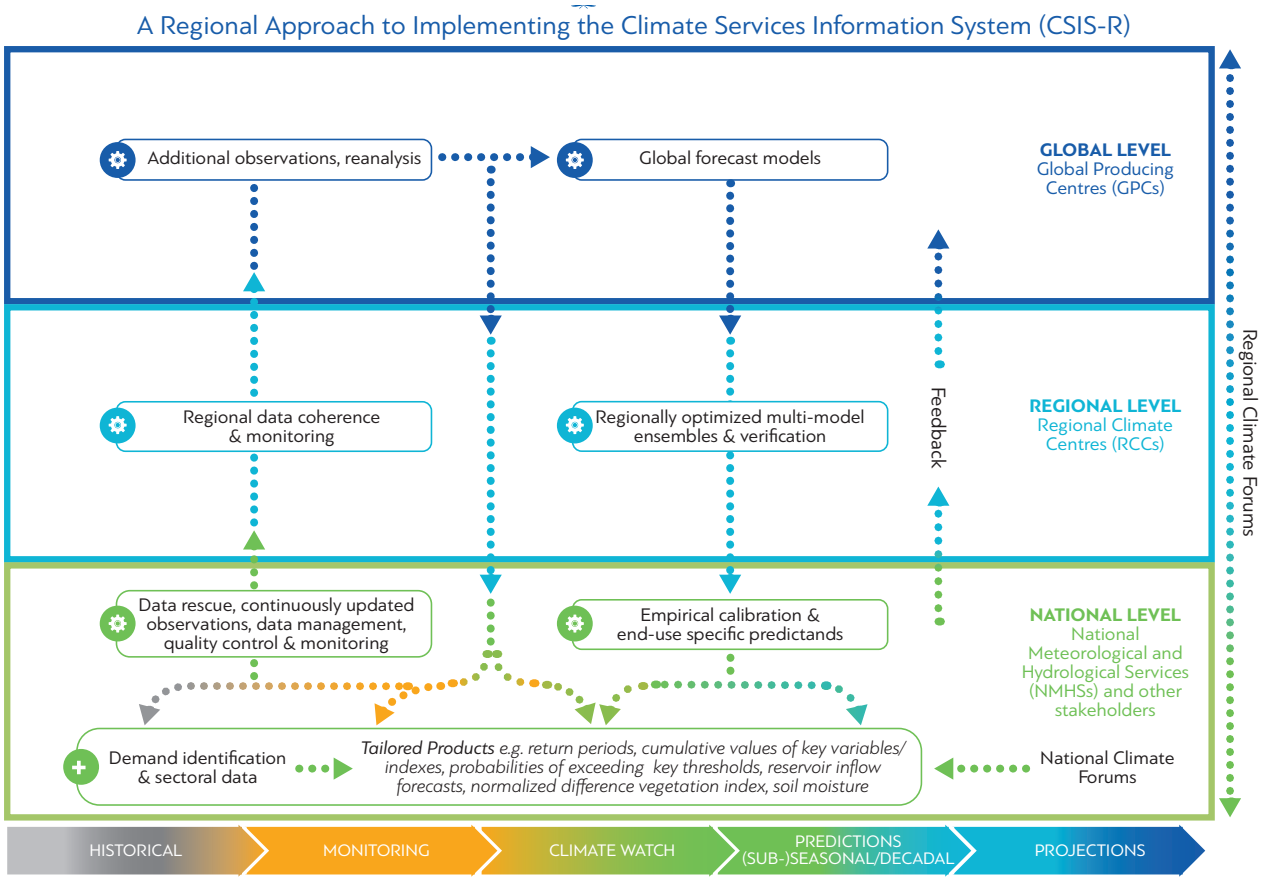
Enhancements are needed in core technical and scientific capabilities, from observations and monitoring, database management, research, modelling and prediction to operationalizing seamless models and improving infrastructure6. These enhancements include meeting current gaps in climate services, such as annual to decadal forecasts. Furthermore, seamless climate information needs to be layered with socioeconomic data to provide the context required to support decision-making for development and sustainable livelihoods. Principles are still lacking for how we compile, share and merge climate and socioeconomic impact data when designing climate services.

For example, as the planting season approaches in Senegal, farmers need climate information about the coming month and season to guide decisions about loans, labour needs, the amount of fertilizer to purchase and what crops to plant. At the end of the growing season, they need to know the market demand for their crop – historical yields and other socioeconomic parameters – as well as information

13 WMO, 2017: Mid-term Review of the Global Framework for Climate Services

14 WMO, 2017: International Workshop on the Global Review of Regional Climate Outlook Forums

15 Hov, Ø. et al., 2017: Nature 552, 168–170



about the upcoming season to inform decisions about how much of their current harvest to set aside for seed and household consumption. The farmers also need to understand how reliable the information is and how to deal with uncertainty in the decision-making process before using it. Multidisciplinary knowledge and expertise are therefore required to ensure efficacy in the co-designing of climate services for farmers.

Enhance information management and coordination across all scales – At present, regional and national entities have access to global products but are on their own when it comes to identifying the most robust signals and assessing information reliability and the likely future states of the climate. The Climate Services Information System (CSIS), the "operational core" of the GFCS, offers a systematic approach for coordinating the development, archiving and facilitation of climate information by decision-makers. The CSIS facilitates the generation and exchange of information at global, regional and national scales, with roles for public, private, non-governmental organizations (NGOs) and academic institutions. The CSIS is the principal mechanism through which information about climate across timescales – past, present and future – is archived, analysed, modelled, exchanged and processed for use. Most critically, CSIS provides guidance on information quality and standards of climate services practice.

Effective access through CSIS, together with expert guidance and training in using products, will help regional and national users quickly identify where the global and regional models are providing the most useful information for their areas of interest. CSIS will also facilitate climate inputs into user-level decision support systems when they develop their own applications.

CSIS has focused on the following:

- Defining the core functions, products and criteria, and establishing the standards and protocols associated with them;

- Developing and deploying a Climate Services Toolkit to facilitate CSIS operations, particularly at regional and national scales. The toolkit comprises

knowledge products, software tools, public domain datasets and training materials to enable the latest scientific and technological advances to be applied;

- Facilitating the seamless and effective use of products by regional and national providers (e.g. RCCs and NMHSs (Figure 1); and

- Expanding and sustaining RCOF and National Climate Outlook Forum (NCOF) or National Climate Forum (NCF) operations. This activity enhances national mechanisms of engagement across the GFCS priorities, while extending and strengthening the benefits and concepts of RCOFs to the national scale.

CSIS facilitates consistency in using climate information by all regional and national user sectors. Critical to the implementation of CSIS are fully functioning RCCs that establish effective means of disseminating information and fostering dialogue between providers, partners and information users at regional and national scales. RCCs leverage data, information, products and engagement across countries within their particular regional domains of responsibility. RCCs, such as the Caribbean Institute for Meteorology and Hydrology, IGAD Climate Prediction and Applications Centre (ICPAC), the International Research Centre on El Niño (CIIFEN), etc., have provided early successes and standards of practices for climate services engagement, development and delivery.

Promote uptake of climate services in planning and policy processes – Integration of climate-change adaptation into national development planning requires systematically accounting for the related risks and opportunities in decision-making at every level from dialogue to policy planning, governance, investment design, implementation and evaluation. Stakeholders and decision-makers need to be equipped with easily available, relevant, accurate and timely climate information that can guide strategic action and provide measurement of evaluation and success.

Formalizing mechanisms to connect climate services to decisions enhances uptake of science into resilience planning processes. For example, the Netherlands, Switzerland and the United Kingdom recently launched updated climate change scenarios (KNMI'14, CH2018, UKCP18, respectively) to underpin government strategy and national adaptation plans. To support the science and policy links, the RCOF product portfolio has been updated with a climate-change component, which will monitor observed trends, review attribution of extreme events to climate change, improve impact predictions, and help ensure that a common national approach is followed in understanding and applying climate information.

At the national level, National Frameworks for Climate Services (NFCSs) can serve as the mechanism to coordinate, facilitate and strengthen collaboration among national institutions and other key stakeholders. NFCSs governance that incorporates representatives of key climate-sensitive sectors to oversee data governance, service development and uptake will further enhance mainstreaming of climate services in planning and policy processes. Monitoring the use of and satisfaction with services, will support iterative feedback required to refine services so that they are more useful and more effectively used.

Enhance capacity along the climate services supply chain – A recent survey of human resources in NMHSs identified a serious capacity gap in most, spanning virtually all professional areas[16]. Most listed climate services, agrometeorology and hydrology/ hydrometeorology in their top five priorities for training[17]. The WMO Reform aims to close this capacity gap by improving training coordination between WMO Members, as well as development partners, and through its centres of excellence. Furthermore, WMO is enhancing the effectiveness of ongoing training activities, such as those linked to RCOFs, to address specific competences across regions. Equally important is for Members and RCCs to develop and sustain linkages between research communities and operational services to expedite the application of research advances in operational weather and climate services. These linkages will enhance the offerings of operational services.

While training the providers is important, training the

16 WMO, 2017: Status of Human Resources in National Meteorological and Hydrological Services

17 WMO, 2017: Status of Human Resources in National Meteorological and Hydrological Services

Climate scenarios as a core climate product – the case of Switzerland

In Switzerland, the need to provide up-to-date, actionable, climate-change scenarios on the local to regional scale was recognized by the Swiss Federal Council in 2014 through the official adoption of the Action Plan of its Climate Change Adaptation Strategy. The mandate was assigned to the Swiss Federal Office of Meteorology and Climatology (MeteoSwiss), which coordinates and conducts these activities in close collaboration with research institutions and centralizes climate services under the umbrella of the Swiss National Centre for Climate Services (NCCS).

The recent cycle of national climate-change scenarios was published in November 2018 (CH2018 scenarios). The new scenarios build on improved scientific understanding and findings since 2011, incorporate results from the latest regional climate-model projections over Europe from the Euro-CORDEX initiative, and take advantage of seven additional years of observations since 2011 to place the projections in an updated climatological context.

To ensure that the scenarios were developed and communicated in a user-oriented way, a comprehensive user survey across various sectors was conducted at the start of the project. As a second measure, a sounding board with key stakeholders was established that advised the project leader throughout the project duration.

In response to the recommendations of users, the results of the new scenarios were structured in six service-oriented products for different user types:

- Researchers – a written technical report with results and methods in full detail.
- Practitioners and decision-makers – a brochure and the new quadrilingual website of NCCS (www.nccs.ch). Both products communicate the results in simplified language and graphics. For the brochure, the results follow a narrative way, using four fictitious personae.
- Users requiring a more comprehensive picture – a web atlas of 20 000 standardized graphics.
- Researchers and science-oriented practitioners – scenario data are freely available and channelled to serve their needs.
- The general public – an animated set of videos and expert statements highlight the main results.

The new climate change scenarios are considered an indispensable service and are the main starting point for triggering the climate services value chain; they thus form the basis for planning measures in the field of climate adaptation and mitigation. For instance, the CH2018 scenarios serve as the reference projections for the Swiss pilot programme on climate-change adaptation, as well as for downstream priority themes of the NCCS, such as hydrological scenarios and spread of pests, and work on climate-change impacts within and across sectors. Finally, the results of CH2018 will feed into the second Swiss action plan on climate-change adaptation.

Innovation through collaboration – the example of Japan

The Japan Meteorological Agency (JMA) has enhanced collaboration with the Japanese research community. One example is the JMA Advisory Panel on Extreme Climate Events, which was established in 2007 and consists of prominent climate scientists from universities and research institutes in Japan. Its mission is (a) to investigate factors that affect extreme climate events in Japan; (b) to advise and assist JMA on issuing statements on such events[1]; and (c) to recommend state-of-science methods to enhance services and knowledge.

This collaboration has improved JMA's operational climate information and services –including those provided to NMHSs in WMO Regional Association II (Asia) by the Tokyo Climate Centre (a WMO RA II RCC[2]). It has also enhanced the capacity of JMA staff members. An expected merit is that the profound knowledge of researchers will contribute to society through climate information. In addition, researchers can look at climate data and products in a timely manner via the website, so that they can review ongoing phenomena and identify emerging research topics. It should be emphasized that collaboration between research and operational services should be designed as a win-win arrangement to enhance the sustainability of engagement.

1 ds.data.jma.go.jp/tcc/tcc/news/press_20180822.pdf
2 ds.data.jma.go.jp/tcc/tcc

recipients of climate services is equally important to ensure capacity to translate and incorporate climate services in their decision-making. User-training aspects can be incorporated into the NFCS action plans and priorities discussed at NCOFs.

Enhance monitoring, evaluation, and knowledge management to improve communication – While global and regional climate and development policy initiatives are aligning with climate services delivery, the concept and common understanding of climate services is not yet widely established. Climate change mitigation and adaptation have become common terms in the policy arena, but many practitioners have no idea what climate services actually are and still question their value.

Valuation would require monitoring and evaluation of the socioeconomic costs/benefits of climate services – a practice that is not currently common in NMHSs. The 2017 mid-term review of the GFCS called for developing and implementing a monitoring and evaluation

process, setting targets, indicators and a monitoring framework. Working jointly with Members and partners to establish the vision and outline a clear roadmap will help improve performance, coordination, and impact, as well as communication about accomplishments. This monitoring and evaluation plan would formalize climate service contributions to the global agenda, as well as evaluate the socioeconomic impacts of weather and climate services.

Foster strategic partnerships – The development community already considers climate a development issue and it is committed to act. It has already brought science and technology into the field to help facilitate climate-resilient development in the face of climate variability and change. Strengthening the knowledge base for adaptation planning through improved access to, and use of, the best available climate data, information and tools is imperative in meeting the climate challenge. There is a need to step up partnerships between the development community, the WMO community, and researchers to develop climate services to meet the short-, medium- and long-term climate challenge.

New models for cooperation should be explored. Initiatives such as the Pilot Programme for Climate Resilience[18] of Climate Investment Funds, the Climate Risks and Early Warning Systems (CREWS)[19] programme, the World Bank Africa Hydromet Programme[20], the Copernicus Climate Change Service Climate Data Store[21], and private, public and academic partnerships are some of the examples that aim to make climate services an intrinsic part of resilient and low-carbon development.

A strong, centralized knowledge management system would support Members and partners to better connect to a broader backdrop of accumulated knowledge, approaches and tools that ensure sustainable effort. The new WMO online Community Platform and Country Profile Database, as well as effective dialogue through face-to-face forums (e.g. RCOFs and NCOFs), facilitate the sharing of experiences and the identification of good practices.

Opportunities ahead

Societies are becoming aware of the effects of changes in the global climate. There are opportunities to scale up the co-production of climate services to respond to their needs:

- Many, if not all, services provide a direct or indirect source of funding to the provider, be it cost-recovery or profit-making. Such funding can be used either to maintain or further develop underpinning capability for the service provider.

- Effective engagement with users of climate information and effective collaboration with the private sector can drive scientific and technological advances in the service, and within the service provider's organization. NMHSs are important data and service providers at the core of the climate services value chain[22], and close collaboration with partners, both provider and user, is needed to be able to co-produce tailored sectoral and cross-sectoral services (on impacts, risks, options for action).

- The role of NMHSs in the climate-change arena is becoming more prominent through participation in climate-change committees and national adaptation plans, while climate-change data and information derived from observations and modelling are recognized as having significant value for climate smart planning[23]. In addition, many of the global and regional funding agencies are providing significant project funding through climate-change funds.

- WMO and several other United Nations agencies have developed the GFCS, which, in turn, is creating

18 www.climateinvestmentfunds.org/topics/climate-resilience

19 www.crews-initiative.org/en. The CREWS initiative supports Least Developed Countries and Small Island Developing States to significantly increase their capacity to generate and communicate effective, impact-based, multi-hazard, gender-informed early warnings to protect lives, livelihoods and assets.

20 www.worldbank.org/en/programs/africa_hydromet_program

21 cds.climate.copernicus.eu/#!/home

22 olc.worldbank.org/content/e-platform-weather-and-climate-services-resilient-development-guide-practitioners-and-policy

23 World Bank Climate Change Knowledge Portal, climateknowledgeportal.worlbank.org

a service-oriented culture as part of an NFCS, thus allowing many countries to engage with a range of sectors in the public and private domains.

- Exchange between NMHSs on the climate service situation in their respective territories is needed. Different countries may face similar challenges and there is an opportunity to share knowledge and regional inputs from developing climate services. For that reason, it is important to enhance the role of RCCs and the strong bond with all the NMHSs of each region, not only to enhance climate services but also to improve capacity-building within each NMHS.

- Working with donors and development banks will help to ensure resources are targeted to regional and national GFCS priorities (e.g. through the Green Climate Fund, CREWS, International Finance Institution grants and loans and bilateral donors, among others).

Future of climate services

Many services are not reaching through to those that need them most. The future of climate services depends largely on how countries organize themselves and effectively utilize mechanisms such as the NFCS and NCOFs to operationalize CSIS at the national level to draw on the best available global and regional inputs required for their weather and climate services, and ensure their effective uptake in the last mile. Advancing social and physical sciences will foster innovation and effective co-design processes to better meet the needs of users. Structured mechanisms to monitor and communicate the benefits of weather and climate services will motivate policy mechanisms to further upscale services into decision-making processes. Partnership with the private sector has the potential to improve service in areas where NMHSs have technical and financial limitations when aligned with WMO' principles on public partnership engagement. These are all opportunities that the WMO Reform will deliver by streamlining internal structures and facilitate strategic partnerships that enhance service delivery.