Climate ExChange

World
Meteorological
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Weather • Climate • Water

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ISBN 978-0-9568561-4-2
Second edition: published November 2012

Tudor Rose

Published by Tudor Rose
www.tudor-rose.co.uk

Acknowledgements

Consulting Editors: Filipe Lúcio and Tamara Avellán, GFCS Office, WMO
Compiled by: Sean Nicklin, Ben Cornwell
Edited by: Dr Jacqui Griffiths, Cherie Rowlands, Michele Witthaus
Designed by: Emma Fairbrother, Bruce Graham, Paul Robinson
Cover design: Libby Sidebotham
Project Managers: Stuart Fairbrother, Toby Ingleton

With thanks to all the authors listed in the contents section for their support in making *Climate ExChange* possible.

Acclimatise
Asia-Pacific Economic Cooperation Climate Center
Australian Bureau of Meteorology
Australian Centre for International Agricultural Research (ACIAR)
Bay of Bengal Programme Inter-Governmental Organisation (BOBP-IGO)
Bogor Agricultural University
Caribbean Institute for Meteorology and Hydrology
Center for Global Environmental Research, National Institute for Environmental Studies
China Meteorological Administration
Climate Works Australia (Monash University)
Deutscher Wetterdienst
Dirección Meteorológica de Chile
Direccion Nacional de Meteorologia – Uruguay
European Space Agency
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India Meteorological Department
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Indonesia Agency for Meteorology, Climatology and Geophysics (BMKG)
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UK Met Office
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Foreword

MICHEL JARRAUD, SECRETARY-GENERAL, WMO

Climate change is accelerating and leading to climate and weather extremes of the greatest socioeconomic and developmental consequences around the world. This is particularly true for those regions, countries and communities that are most climate-vulnerable: the African continent, least developed and land-locked countries and small island developing states.

The 2001–2010 decade was the warmest ever recorded, with an average temperature of 0.21° C above 1991–2000, the warmest decade of the twentieth century, and of 0.46° C above the 1961–1990 annual average of 14° C. The decade witnessed the intensification of climate and weather extremes such as destructive flooding, severe droughts, heat waves, heavy rainfall and severe storms, as well as a dramatic steady reduction of the Arctic sea ice summer cover. The concentration of CO_2 in the atmosphere continued to increase, reaching an average of 389 parts per million, the highest value ever recorded. All these trends were confirmed in 2011 and 2012.

The Rio+20 summit held in June 2012 reaffirmed that climate change is one of the greatest challenges of our time to the attainment of sustainable development and called for reinforced international cooperation to address its impacts. Besides weather and water extremes these include sea level rise, coastal erosion and ocean acidification and make adaptation to climate change an urgent necessity.

As highlighted by the World Meteorological Day celebrated on 23 March 2012, weather, climate and water services are of growing importance for the sustainable socioeconomic development of present and future generations. Advancing knowledge about weather, climate and water is crucial to agriculture and food security, disaster risk reduction, water management, health and many other sectors and will play a crucial role in shaping the global developmental agenda beyond 2015.

The risks of climate variability and change and adaptation to climate change can be better understood and managed only through the development and application of the science and knowledge of climate information and prediction.

The Global Framework for Climate Services (GFCS), initiated at the World Climate Conference-3 (Geneva, Switzerland, 2009), is a major initiative of the United Nations system led by WMO to foster the enhancement and incorporation of climate information and prediction into planning, policy and practice on the global, regional, national and local scales.

The GFCS is conceived to advance global collaboration through multidisciplinary partnerships, improved governance, climate observations, monitoring, research and prediction. Together with capacity-building and exchange of experiences, this will ensure greater availability of, access to, and use of climate services for all countries and in particular enable the most vulnerable in order to limit the impact of, or adapt to, climate change and variability.

In order for the GFCS to achieve its goals, it will have to be user-driven, building on the successes and learning from the challenges of existing initiatives. Most particularly, the National Meteorological and Hydrological Services will have to build on capabilities, facilitating data sharing and thereby demonstrating the benefits of cooperative and multidisciplinary products.

Better climate services through improved quality, accuracy, timeliness, location specificity and user-friendliness of the information will facilitate key societal benefits. These include a reduction in the losses of life and property associated with climate-related natural hazards, enhanced productivity in sectors reliant on climate and a more efficient management of institutions dependent on weather and climate.

After *Elements for Life* (2007) and *Climate Sense* (2009), the World Meteorological Organization and Tudor Rose partner again with *Climate ExChange*. I am confident that this publication will provide a great contribution to illustrate the benefits of, and promote good practices in, climate services.

I wish to thank the over 100 contributing authors who described progresses and challenges in the production and delivery of climate services in priority areas such as water management, agriculture and food security, disaster risk reduction and health. These contributions reflect how people and nations around the world are using or can use climate information to improve their lives and economies in a sustainable way.

Michel Jarraud, Secretary-General, WMO

Preface

DAVID GRIMES, PRESIDENT OF WMO

I am seized by the potential for the Global Framework for Climate Services (GFCS) in reading the Report of the High Level Task-force, where it characterizes a clear and striking appreciation of three key premises: i) everyone is affected by climate, especially by its extremes for their safety and livelihoods; ii) needs-based climate services can be extremely effective in realizing socio-economic benefits by enabling communities, businesses, organizations and governments to adapt through informed choices in managing the associated risks and opportunities; and iii) governments and stakeholder communities at global, regional and national levels can together close the significant gulf between the needs for climate services and the capacity to deliver, especially in places where they need them the most.

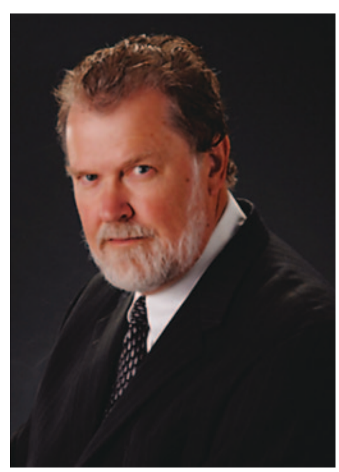
The call for bridging this gap came from the Heads of States and Governments, Ministers and Heads of Delegation representing more than 150 countries, 34 United Nations Organizations and 36 Governmental and non-Governmental international organizations who attended the Third World Climate Conference in 2009. They recognized that investment in climate services would be beneficial for their citizens and institutions to adapt to climate variability and change and to build climate resilient communities. They unanimously adopted a Declaration establishing the Global Framework for Climate Services to mainstream value-added information for decision makers through user-driven and science-based activities.

Following from the High Level Task Force's roadmap for the GFCS, the Sixteenth Session of the World Meteorological Congress (Geneva, 16 May to 3 June 2011) endorsed the Report's broad thrusts and initiated the detailed preparations for its implementation to be approved at its First Extraordinary Session of the World Meteorological Congress in Geneva, 29 to 31 October 2012. This has only been made possible through a dedicated team of writers, the WMO secretariat, and the Executive Council Task Team under my leadership.

The outcomes of the GFCS will empower all in society to better adapt to the risks and opportunities from climate variability and change, and especially those who are most exposed to climate related hazards. A framework of coordinated and complementary actions and measures, exercised at global, regional, national and local scales, offers the promise to all of providing meaningful, needs-based climate services for widespread use. The initial priorities are aimed at improving the provision of climate services for decision-making and policy development related to important health, food security and agriculture, water resources and disaster risk reduction outcomes. The success of the GFCS will be in the engagement of providers and users, requiring a global mobilization of effort and an unprecedented collaboration among institutions across political, functional and disciplinary boundaries.

Climate ExChange provides a wealth of information on developments in the provision of climate services by WMO Members. It also highlights initiatives led by others such as the World Bank and the World Food Programme revealing opportunities for partnerships with non-governmental actors. These articles serve to illustrate the solid foundation on which the GFCS can be based. This publication will be a lasting example of how the GFCS can build upon the existing efforts to advance improvements in the provision of needs based climate services.

I am pleased that, once again, WMO has forged a partnership with Tudor Rose in this endeavour.



David Grimes, President of WMO

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How climate services can help people adapt to variability and change

Filipe Domingos Freires Lúcio, Head, Global Framework for Climate Services Office, World Meteorological Organization

Humanity has thrived over the past millennia because of its ability to innovate and adapt. Adapting to new climate conditions, however, has rarely been painless. It has often involved migration and conflict, accompanied by death and suffering. Today, with billions of mouths to feed, a heavy dependence on vulnerable infrastructure, and the risk that climate change will cause rapid and unprecedented impacts, the stakes are as high as ever.

How the natural environment responds to climate variability and change is critically important to human well-being. While people live everywhere on Earth, from the frozen Arctic to the hot and steamy equator, most plant and animal species are too sensitive to climate to inhabit such a broad range. So when the climate that they are used to warms up or cools down, or moisture levels change, many species must either die or migrate. Today the evidence for how climate affects the living world is everywhere.

A recent study reported that Australia's fish populations are moving southward because the waters around Australia are becoming warmer. Food supplies will be affected unless the fishing industry is able to adapt to this and future changes. The record drought that struck the United States in the summer of 2012 had a significant impact on global food supplies and commodity prices. Will the drought return next year? Knowing the probability of good harvests around the world in 2013 would assist planners and markets to ensure global food security.

Even the microscopic viruses and bacteria that can affect human health are climate-sensitive. Dry and dusty conditions in the Sahel region of Africa often precede outbreaks of meningitis; getting climate information to health providers before such conditions progress can ensure more effective vaccination campaigns. In other regions, a particularly wet season can lead to greater incidences of malaria. The flu virus is transmitted more easily in winter, when the atmosphere is colder and drier. These illnesses kill people and harm the economy, so minimizing their impact is important.

The availability of water for agriculture, industry and households also fluctuates with climate. Planners need to know when to restrict water usage before a pending

Image: Japan Meteorological Agency

Japan Meteorological Agency experts monitoring extreme weather phenomena


Image: Deutscher Wetterdienst

Forecasters at Deutscher Wetterdienst study weather maps

drought draws down reservoirs and other supplies. The failure of the monsoon can lead to hardship and hunger. As the climate changes, the distribution of water resources may permanently shift; for example, melt water from glaciers may be released earlier in the spring, affecting fishing, irrigation, energy production and water supplies.

Climate is also the force behind most disasters caused by natural hazards. Many parts of the world are vulnerable to floods, droughts and severe storms. Seasonal climate variation and extreme rain can contribute to landslides and erosion. As greater warmth speeds up the water cycle, and the warmer atmosphere holds more water, more flooding and severe storms can be expected.

By exacerbating climate variability, climate change will increase the need for climate services. The 2007 assessment report of the WMO/UNEP Intergovernmental Panel on Climate Change (IPCC) estimates that the average global temperature (which is now 15° C) will likely increase by 1.8-4.0° C by the end of the century. This would result in an estimated sea-level rise of 28-58 cm – although larger values of up to 1 m by 2100 cannot be ruled out. The IPCC will update these projections in late 2013 based on the most up-to-date research available.

A number of changes in the climate have already been observed. The world's rivers, lakes, wildlife, glaciers, permafrost, coastal zones, disease carriers and many other elements of the natural and physical environment have started responding to the effects of humanity's greenhouse gas emissions. Rising temperatures are accelerating the hydrological cycle, resulting in heavier rains and more evaporation; they are also causing rivers and lakes to freeze later in the autumn and birds to migrate and nest earlier in the spring. Scientists are increasingly confident that, as global warming continues, certain weather events and extremes will become more frequent, widespread or intense.

Scientists are also starting to predict how the climate will change in specific regions. According to the 2007 report, by 2020 between 75 million and 250 million people in Africa may be exposed to increased water stress due to climate change; in some countries yields from rain-fed agriculture could be reduced by up to 50 per cent. By 2050, freshwater availability in Central, South, East and South-East Asia is projected to decrease, particularly in large river basins. Europe's mountain glaciers will retreat, reducing snow cover and winter tourism, and high temperatures and droughts will worsen in southern Europe. Yields of some important crops and of livestock in Latin America are projected to decline. Warming in the western mountains of North America is projected to cause decreased snowpack, resulting in more winter flooding and reduced summer flows.

The science of climate forecasting

To generate actionable information for addressing these and other climate risks and opportunities, the providers of climate services must, of course, be able to forecast the climate. But if forecasters cannot predict next week's weather, how can they predict the longer term climate? A fair question. Of course, meteorologists *can* predict next week's weather, even if the inherent chaos of the atmosphere means they sometimes get it wrong. The weather forecaster's challenge is that small random movements of air and moisture can divert a broader weather pattern, especially at the local level and beyond the timeframe of a week or 10 days.

These small-scale chaotic movements do not affect climate, often defined as the average weather over a 30-year time period. Climate forecasters do not need to predict whether it will rain in Beijing on Tuesday; rather, they aim to predict that the next winter (or

Image: Uzbekistan NMS

Pre-drilling of ablative measuring rods: Uzbekistan Hydro-meteorological Service

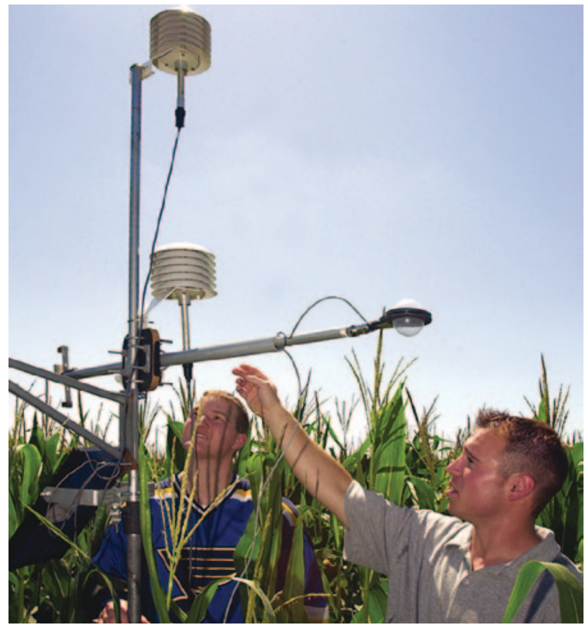

Image: George Tarbay, NIU

Students in meteorology at Northern Illinois University, monitor air temperatures and humidity at a weather station in a DeKalb cornfield. The students worked on research showing trends in northeast Illinois dew-point values

the next decade, or the next century) in Beijing will probably be warmer (or colder) than average. They do this by studying large-scale and long-term processes, such as the Earth's orbit, long-term solar radiation cycles, deforestation and other changes in land cover, ocean temperatures and currents, and greenhouse gas emissions. Their main tools are observations of today's climate, studies of past climates, and computer-based modeling of climate processes.

Certain regions of the global atmosphere are strongly affected by sea-surface temperatures and other slow-changing variables. Researchers have demonstrated that interactions among the atmosphere, oceans and land surface can produce fluctuations that are potentially predictable, and that this makes it possible to predict the climate at seasonal and interannual timescales. The most well understood fluctuation is known at the El Niño/Southern Oscillation (ENSO), which is linked to interactions between the atmosphere and the ocean in the tropical Pacific Ocean. Just like the advances in weather prediction, these advances in climate prediction have been made possible by steady improvements in observations and models.

While climate forecasters are demonstrating an ability to predict the average weather of the next season or the next year over a broad area, they cannot fine-tune the weather forecast for Week 6 in a specific locale. Nevertheless, knowing that there is a high probability that the coming monsoon season will have low, average or high rainfall can help farmers and energy and water suppliers, for example, to plan their activities. Similarly, while individual hurricanes, typhoons and other tropical disturbances cannot be predicted beyond a few days in advance, the provision of probabilities for the future tracks, numbers and intensity of such storms would be extremely beneficial to society.

Concern about climate change is also helping to drive research into the climate system and climate forecasting. The evidence available to scientists – from ice cores and other residues of ancient climates to 21st century satellite measurements and sophisticated models run on supercomputers – has grown exponentially. Thanks to these advances, the level of confidence scientists now have in their understanding of the global climate system is 'very high' – defined by the IPCC as being at least a nine in ten chance of being correct.

The scientific method that has made this progress possible is one of humanity's most impressive cultural achievements. By gathering and analyzing evidence, developing hypotheses and designing experiments to test them, scientists have unlocked many of nature's most closely held secrets. The spirited debate amongst competing theories and research teams reflects the vitality of this search for a better understanding of climate variability and climate change.

Climate services

Seasonal to multiyear climate forecasts are increasingly being used to generate actionable information for decision-making on disaster risk reduction, public health, agriculture, fisheries, tourism, transport, and other weather and climate-sensitive sectors. A growing number of governments are building on their experience in weather forecasting to customize climate information and target it to specific users. These climate services make it possible to incorporate science-based climate information and prediction into planning, policy and practice to achieve real benefits for society

Climate services often involve integrating climate information with information from other sectors. This requires close collaboration between agencies and experts from different fields. The resulting information must then be presented to users in formats that they can understand. When presenting information in the form of probabilities, climate service providers must take special care to communicate the concept of probability effectively to people who may be generalists or specialists in other fields. They should also ensure that the information they generate is easily accessible, whether via open websites or dedicated delivery channels.

As described by the articles in this book, governments in all regions of the world are already providing, or preparing to provide, a wide range of climate services. For example:

- Countries as diverse as Guinea-Bissau, India, Indonesia and Mali are providing climate services to support agriculture and food security. They are carrying out programmes to inform farmers about climate impacts while also seeking feedback from these users on how best to design climate information products for agriculture.
- The Ethiopian Meteorological Organization is adopting modern climate forecasting methods and enhancing the quality of the climatology information that it offers. It plans to increase access to climatology and forecast information related to agriculture, aviation, water, health and energy.
- The North American Drought Monitor, prepared jointly by the United States, Canada, and Mexico, illustrates how individual nations can work together at the regional level to provide climate services. The Monitor is a first step in a larger effort to improve the monitoring and assessment of a suite of climate extremes on the continent, including heat waves and cold waves, droughts and floods, and severe storms.
- The German Heat-health Warning System is demonstrating how climate and health services can collaborate on protecting human health in anticipation of an expected increase in the number of heat waves.
- Every month, the Australian Bureau of Meteorology provides a forecast of the likely shifts in temperature and rainfall for the coming three months, giving the 'probability' or 'likelihood' that rainfall or temperature will be above the long-term median. To make this product as user-friendly as possible, the Bureau conducted market research by interviewing internal experts and high-level external users and then conducting an online survey.
- A demonstration project in Armenia aims to reduce the vulnerability of mountain forest ecosystems to climate change. The project is assessing current observation systems and databases, observed and projected climate changes, and climate extremes and climate risks. The goal is to improve seasonal predictions, implement a Climate Watch System for forest fire, and integrate climate change concerns into forest management.
- A number of countries are establishing climate websites to improve access to climate information and services. Finland's site, for example, provides information on climate change science and on practical means for mitigating and adapting to climate. France's site provides regional scenarios for the country and seeks to link the users and providers of this information.

The Global Framework for Climate Services

The Global Framework for Climate Services is an initiative of the United Nations system that seeks to build on and strengthen these national programmes and services. It was launched in 2009 by the World Climate Conference – 3 as a global partnership of governments and organizations that produce and use climate services. The GFCS enables researchers and the producers and users of information to join forces to improve the quality and quantity of climate services worldwide, particularly in developing countries.

The GFCS takes advantage of the continued improvements in climate forecasts and climate change scenarios described earlier to expand access to the best available climate data and information. Policymakers, planners, investors and vulnerable communities need this information in user-friendly formats so that they can prepare for expected trends and changes.

The GFCS is based on eight principles:

- Give a high priority to the needs of climate-vulnerable developing countries
- Put the primary focus on better access to and use of climate information by users
- Address needs at three spatial scales: global, regional and national
- Ensure that climate services are operational and continuously updated
- Recognize that climate information is primarily an international public good and that governments will have a central role in the Framework
- Encourage the global, free and open exchange of climate-relevant data
- Facilitate and strengthen – do not duplicate
- Build climate services through partnerships.

To succeed, the GFCS must, above all else, be driven by the needs of users. Lessons already learned from existing climate services make it clear that engaging the health, water, disaster and agriculture communities requires supporting the existing priorities and work plans of these sectors. Climate service providers also need to respond to the very specific needs of the distinct user groups within each of these broad sectors. National capacity building is also essential to ensuring that people fully understand the climate products and can apply climate information effectively.

The GFCS actively encourages governments to promote a broad exchange of views about how to tailor climate services. It advocates interdisciplinary collaboration between government agencies, private companies and research institutions, and it promotes collaborative problem-solving and 'learning from others'. Building trust with other sectors will encourage data sharing and make it easier to assemble multidisciplinary datasets and products.

While climate services will build on and link together existing capacities and programmes, funding will clearly remain a critical issue. Dependable funding is needed to sustain national monitoring and information infrastructure, from satellites and weather centers to databases and trained personnel. Long-term operating and maintenance costs also need to be secured. The GFCS therefore informs the international donor community about the benefits of climate services and encourages it to support national programmes and services.

The GFCS is clearly an ambitious initiative. Its success will be measured by its ability to establish an effective and sustained global partnership, strengthen national and regional climate services, and empower people around the world to adapt and respond to the impacts of climate variability and climate change.