Adapting to climate variability and change: the Climate Outlook Forum process

by Laban Ogallo[1], Pierre Bessemoulin[2], Jean-Pierre Ceron[2], Simon Mason[3] and Stephen J. Connor[3]

Introduction

Weather and climate extremes are associated with loss of life, destruction of property and many other socio-economic miseries worldwide. They threaten livelihoods and the very survival of humankind. The vulnerability of societies seems to be increasing year after year in many developing countries, especially in Africa. The recent Fourth Assessment Report of the Intergovernmental Panel on Climate change (IPCC) confirms that human activities are changing climate by injecting greenhouse gases into the atmosphere (IPCC, 2007). Coping with the negative impacts of the current climate extremes and adaptation to future climate changes are therefore some of the greatest challenges facing humankind today.

Over the last 10 years, an innovative process known as the Regional Climate Outlook Forum (RCOF) has been undertaken by WMO, National Meteorological and Hydrological Services (NMHSs), regional climate institutions and other international organizations to provide consensus-based early warning seasonal climate information for reducing climate-related risks and to support sustainable development efforts in certain regions. RCOFs bring together climate scientists, policy-makers and the general user community to develop warnings of potential impacts of the climate on various socio-economic sectors. The themes of the RCOFs are chosen, depending on the dominant regional climate needs of the users.

This article addresses the potential roles of the RCOF process in adapting to climate variability and change. The topics addressed include:

- The RCOF process itself, including the history and different mechanisms for the development and dissemination of the consensus forecasts;
- Climate predictability at seasonal to interannual time scales;
- Meeting the ever-increasing and diversified user needs;
- Assessing the value and benefits of RCOF products;
- Some success stories in applications of RCOF products;
- Limitations and challenges of RCOF products.

The process

The idea of "climate outlook forums" originated at a Workshop on Reducing Climate-related Vulnerability in Southern Africa (Victoria Falls, Zimbabwe, October 1996). Recognizing that climate predictions could be of substantial benefit to many parts of the world in adapting to, and mitigating the impacts of, climate variability and change, planning was initiated to establish an RCOF with an overarching responsibility to produce and disseminate a regional assessment (using a predominantly consensus-based approach) of the state of the regional climate for the upcoming season. Built into the RCOF process is a regional and national networking of the climate service providers and user-sector representatives.

Recognizing its vulnerability to extreme climatic variability, Africa has been a pioneering and enthusiastic participant in the RCOF process. Participating countries recognize the potential of climate prediction and seasonal forecasting as a powerful development tool to help populations and decision-makers face the challenges posed by climatic variability and change. National and regional capacities are varied but certainly inadequate to face the task alone. Since 1997, when the Forum process started at

1 Intergovernmental Authority on Development Climate Prediction and Applications Centre, Nairobi, Kenya
2 Météo-France, Toulouse, France
3 International Research Institute for Climate and Society, Palisades, New York, USA

Kadoma in Zimbabwe, Africa has benefited from a significant amount of capacity-building and funding, which has enabled the Southern Africa Climate Outlook Forum and the West Africa Cllimate Outlook Forum to meet once a year and the Greater Horn of Africa Climate Outlook Forum to meet twice a year. In parallel, NMHSs and some decision-makers have come to realize the potential benefits to be gained and have played larger roles in the process. Ownership now lies largely with national and regional players, but there is a continuing need for support at all levels to ensure that the momentum gained to date is maintained.

WMO, through its Climate Information and Prediction Services project and Regional Programme, has made an important contribution towards the development and activities of the forums, alongside an array of bilateral and multilateral sources providing financial and in-kind contributions. These include: the Office of Global Programs of the US National Oceanic and Atmospheric Administration, the US Agency for International Development, the European Union, the International Research Institute, the UK Met Office, Météo-France, the World Bank, many NMHSs and several others, including universities and research institutes.

One important aspect of the forums is to bring together experts in various fields, local meteorologists and end-users of forecasts in an environment that encourages interaction and learning. The RCOF process has subsequently been extended to South America, Central America, Asia and the Pacific islands. While the implementation mechanisms of the RCOFs worldwide have been varied, based on the local conditions, the core concept remained the same, cutting across all the regions: delivering consensus-based user-relevant climate outlook products in real-time through regional cooperation and partnership.

Among the challenges identified in the process to date, a key area is the design and delivery of climate information and prediction products that satisfy the needs of end-users. Achieving this will require concerted efforts to demonstrate benefits. This challenge, together with that of sustainability, indicates the continued need to improve the scientific underpinnings of the forecasts for capacity building and for sustained support.

The consensus prediction process that underlines RCOF operations consists of the following elements:

- Determining the critical time for development of the climate forecast for the region in question;
- Assembling a group of experts:
  - Large scale prediction specialists;
  - Regional and local climate applications and forecast/downscaling specialists;
  - Stakeholders representative of climate-sensitive sectors;
- Reviewing current large-scale (global and regional) climate anomalies and the most recent forecasts for their evolution;
- Reviewing current climate conditions and their impacts at local, national and regional levels and national-scale forecasts;
- Considering all factors, produce a consensus forecast with related output (e.g. maps of temperature and precipitation anomalies) that will be applied and fine-tuned (downscaling) by NMHSs in the region to meet national needs;
- Discussing applications of the forecast and related climate information to climate-sensitive sectors in the region; considering practical products for development by NMHSs;
- Developing strategies to effectively communicate the information to decision-makers in all affected sectors;
- Evaluating the session and its results:
  - Document achieved improvements to the process and any challenges encountered;

- Establish steps required to further improve the process for subsequent sessions;

- Providing follow-up updates as appropriate.

RCOFs stimulate the development of climate capacity in the NMHSs. They do much to generate decisions and activities that mitigate adverse impacts of climate and help communities adapt to climate variability. It may also be noted that, in addition to directly supporting the RCOFs, WMO, with other partners, has been making concerted efforts to put in place a number of global and regional mechanisms that would further strengthen RCOF activities. WMO has established designated Global Producing Centres of long-range forecasts, which provide real-time global seasonal forecasts accessible to all WMO Members. WMO, through its regional associations, is also at an advanced stage of establishing Regional Climate Centres to cater to the special needs on climate services of regions.

The RCOF process, pioneered in Africa, includes a training component to strengthen the capacity of regional climate scientists through a regional training workshop on seasonal climate prediction with the support of regional, as well as international, experts. This training workshop is followed by a meeting of regional and international scientists that develops a consensus for the regional climate outlook. The actual forum, however, involves interactions between climate scientists and users for the formulation of response strategies. RCOF also provides a forum for the review of impediments to the use of climate information, experiences and successful lessons regarding applications of the past RCOF products, and development of new strategies for sector-specific applications. Recent RCOFs have been followed by national forums to release the detailed national climate risk information to end-users.

Climate predictability at seasonal to interannual time-scales

It was noted in the previous section that the RCOF process involves the development of consensus seasonal climate outlooks for specific regions, based on seasonal prediction products from various climate centres. It is therefore important to review the predictability of seasonal climate in order to be able to understand the limitations and challenges associated with the RCOF products. In this context, the recent World Climate Research Programme (WCRP) Position Paper on Seasonal Prediction (WCRP, 2007) is also of interest for more detailed consideration of the issues involved.

Predictability of the seasonal climate

Numerical forecasts of the weather lose virtually all skill beyond about 15 days, yet numerical forecasts for the following few months can still be issued. What makes it possible to predict the climate at seasonal time-scales when it is not possible to predict the weather? The evolution of the atmosphere depends on its initial state and on forcing imposed on the atmosphere by external sources such as the Sun and oceanic or continental surfaces. To forecast the weather over the next few days, the primary focus is on forecasting the change of the atmosphere from its initial state. To forecast the climate over the coming few months, the focus has to be on how the atmosphere is likely to be affected by external forcing mechanisms. Because the evolution of these external constraints is generally slow and typically predictable on a range of a few months (most notably for the se-surface temperatures), the effects on the atmosphere can be anticipated to some extent.

The skill at these longer time-scales comes from averaging the forecasts over time (Figure 1). The aim is not to forecast the precise weather on any specific day, but rather the average weather conditions over a number of days. In effect, it is the large-

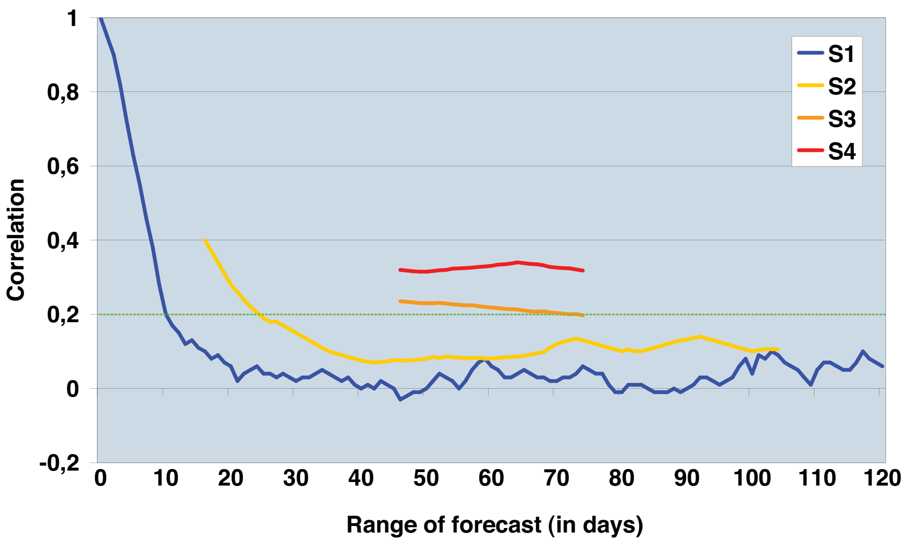

Figure 1 — Anomaly correlation coefficients of daily forecasts (S1) of Z500 over the northern hemisphere (reference dataset ERA 40) using a general circulation model at a resolution of ~300-km mesh, along with those at the monthly scale (S2), seasonal scale (S3) and seasonal-scale ensemble-based forecast (S4), indicating a progressive increase in skill. The green horizontal line indicates 95 per cent statistical significance level for the correlations.

scale behaviour of the atmosphere that is predicted and that is affected by the forcing mechanisms, rather than the small-scale features of the atmosphere that are subject to rapid changes and are impossible to predict precisely.

Accounting for and communicating forecast uncertainty

Because of the long lead-times involved in seasonal forecasts, the uncertainty in the forecast is substantial compared to that for weather forecasts and so it is important to communicate the degree of uncertainty in the forecast. To do so reliably, it is necessary to understand the sources of the uncertainty. The first source comes from the imperfect knowledge of the current state of the climate system.

A forecast involves predicting the future evolution of the current state of the atmosphere; if we do not know what the current state is, the forecast will inevitably be imperfect. Our imperfect knowledge of the current state of the atmosphere is due partly to the inadequacy of the network of observations, and also because of observational errors where measurements are made. Further errors are introduced when these observations are used to construct a description of the current state of the climate system through the assimilation systems. To take account of these uncertainties in the initial conditions, several forecasts are made, each one representing a different estimate of the initial states for the climate system. This procedure leads to an ensemble of forecasts, and the individual ensemble members typically indicate different seasonal climate conditions.

Further uncertainty is introduced because of the imperfect nature of the models used to make the predictions. The models have to simplify the real climate system, for example by discretization and parameterization, and therefore introduce uncertainties into the predictions. These uncertainties are best represented by using results from several models in a multi-model ensemble. Thirdly, the climate system itself has an inherently unpredictable component.

Because of all these uncertainties, a single prediction would represent only one of numerous equally valid predictions. Ensembles of predictions are therefore usually summarized in the form of a probabilistic forecast. Although there are a number of ways of summarizing the various possible outcomes, the most commonly used method is to indicate the probability that the observed climate will be within each of three categories defined using the terciles of the climatological data, namely above normal, normal and below normal. This format is being adopted in all RCOFs.

Seasonal forecast products and skill levels

By far the most common seasonal forecast products are those of seasonal mean temperature and total rainfall, but other seasonal products are produced at many climate centres worldwide. Examples include tropical cyclone activity over the main oceanic basins and predictions of non-climate variables such as streamflow in some of the RCOF regions and malaria epidemic risk (Guofa *et al*., 2004; Thomson *et al.,* 2005) over southern and eastern Africa. Tropical cyclone forecasts are issued, using statistical and numerical models; multi-model approaches appear to be particularly effective.

Because of the probabilistic nature of seasonal predictions, evaluations of predictability have to be made using a long set of forecasts. For statistical models, these evaluations are computed using some form of cross-validated procedure to generate "predictions" for previous years; for numerical modelling, "hindcasts" are generated. For statistical procedures, it is relatively easy to generate the cross-validated predictions as long as observational data are available, but it is very difficult to ensure that these cross-validated predictions do not look better than the predictions actually made in real-time. For the numerical models, it is much harder to make the hindcasts because of computational expense and because of the need for much richer observational data, but it is easier to get a realistic estimate of the skill of the real-time forecasts than for the statistical models.

At present, the skills of statistical and numerical seasonal models are similar. With better observations of the climate system, however, better assimilation schemes and better representation of the climate system's components, the numerical models have the greatest potential for improving current skill levels. The table opposite (from Palmer *et al*., 2008) presents the Brier Skill Score (BSS) for the main parameters (temperature and rainfall) and regions of the globe of the one-month lead seasonal forecasts from the DEMETER multi-model experiment. The BSS is computed separately for forecasts of above-normal conditions (above the upper tercile) and below-normal conditions (below the lower tercile). Positive underlined values indicate skill significantly "better than climatology", while negative underlined values indicate skill significantly "worse than climatology". It should be noted that negative values do not necessarily mean that the forecasts are bad, simply that errors in the reliability of the probabilities are larger than the resolution of the predictions.

Some broad generalizations about the skill can be made. Firstly, temperature is more predictable than rainfall. Most of the models fail in capturing rainfall variability over land areas (with exceptions in a few regions such as the Amazon Basin). Precipitation is particularly

Forecast quality of the DEMETER multi-model seasonal forecasts in terms of Brier Skill Scores (BSS multiplied by 100) for near-surface temperature and precipitation in June, July and August (JJA) and December, January and February (DJF) for 21 standard land regions and below-normal ($E_T^-(X)$) and above-normal ($E_T^+(X)$) categories. The scores have been computed over the period 1980-2001 using seasonal means from one-month lead ensembles starting on 1 May (JJA) and November (DJF). Bold underlined numbers indicate scores which are significant (both positive and negative) with a probability higher than 90 per cent (Palmer et al.*, 2008).*

Regions	2m Temperature				Precipitation			
	JJA		DJF		JJA		DJF	
	$E_T^-(X)$	$E_T^+(X)$	$E_T^-(X)$	$E_T^+(X)$	$E_P^-(X)$	$E_P^+(X)$	$E_P^-(X)$	$E_P^+(X)$
Australia	**10.7**	**10.1**	1.3	-0.4	-1.3	-2.5	-3.1	-3.6
Amazon Basin	**14.4**	9.1	**23.4**	**25.7**	2.2	2.1	**9.5**	**8.9**
Southern South America	**8.5**	**8.2**	-1.2	1.8	**7.8**	5.0	-0.7	-2.8
Central America	**12.1**	**9.9**	**14.8**	6.3	2.6	-0.7	8.7	8.5
Western North America	**6.5**	**7.7**	3.9	2.3	3.2	**5.5**	-0.6	0.0
Central North America	-4.1	-3.6	**-7.5**	0.3	-1.8	**-7.0**	3.7	5.3
Eastern North America	0.6	5.7	4.1	9.5	**-4.5**	**-8.3**	**9.2**	6.0
Alaska	3.0	2.1	0.0	-0.7	-0.1	0.3	2.4	4.9
Greenland	3.6	4.2	**8.0**	5.8	**-1.4**	-0.5	-2.1	-2.0
Mediterranean Basin	**7.6**	**10.7**	3.2	3.2	-0.5	0.1	1.6	-0.9
Northern Europe	-4.4	-4.2	4.8	2.9	-1.0	1.9	-1.1	-0.9
Western Africa	**10.4**	**11.8**	**18.1**	**17.2**	-1.6	-2.0	**-4.9**	**-3.5**
Eastern Africa	**12.6**	5.8	**13.3**	**10.3**	0.1	-0.3	1.2	0.6
Southern Africa	5.6	-1.1	**15.9**	**15.7**	0.7	-1.2	5.4	3.6
Sahara	**7.6**	**7.4**	6.9	3.9	**-2.6**	**-4.8**	**-2.7**	**-2.7**
South-East Asia	10.7	5.9	8.7	**18.1**	**14.7**	**10.3**	3.4	2.5
East Asia	**4.7**	**7.9**	**10.8**	**10.0**	0.6	-1.0	-1.6	-0.9
South Asia	4.9	**13.1**	**7.6**	**8.6**	-1.6	**-3.0**	2.0	0.5
Central Asia	0.8	3.8	1.3	-0.4	0.5	0.1	-3.1	-3.6
Tibet	**10.7**	**10.1**	**23.4**	**25.7**	-1.1	0.0	**9.5**	**8.9**
North Asia	**14.4**	9.1	-1.2	1.8	-1.3	-2.5	-0.7	-2.8

difficult to predict because of its highly localized nature. While not shown in the table, recent results suggest that rainfall frequency may be more predictable than rainfall total. Secondly, the predictability of the tropical atmosphere at seasonal scales is greater than that of the temperate atmosphere (again with some exceptions such as the high skill over the Tibetan plateau). This is because of the greater sensitivity of the atmosphere in the tropics to external forcing compared to mid-latitudes. Thirdly, there is some seasonality to the predictability of the seasonal climate, with generally greater skill for December-February (DJF) than in the June-August (JJA) season. The difference is most notable for rainfall in the tropics. The greater predictability in the DJF season is partly related to the seasonality of the El Niño-Southern Oscillation (ENSO), which is the main source of seasonal predictability and which peaks typically at this time of year. For similar reasons, in eastern Africa, for example, higher skill has been noted during October-December than March-May.

Currently, there are few estimates of the quality of seasonal forecasts that have been released by the RCOFs to the general public, primarily because, in most cases, the forecasts have been issued operationally only for about 10 years. Of late, through a joint project led by the African Centre of Meteorological Application for Development in collaboration with the International Research Institute for Climate and Society (IRI), the Southern African Development Community-Drought Monitoring Centre and the Intergovernmental Authority on Development Climate Prediction and Applications Centre (IPAC), some verification analyses of RCOF products are being conducted, and standards for the verification of operational forecasts are being defined under the auspices of the

WMO Commission for Climatology. Standards for the verification of hindcasts are in place and are detailed in the WMO Standardized Verification System for Long-Range Forecasts (SVSLRF). The SVSLRF verification results for all Global Producing Centres of long-range forecasts are made available through the Lead Centre for SVSLRF Website (http://www.bom.gov.au/wmo/lrfvs/). The Website shows skill levels for model hindcasts.

Research to improve the skill of seasonal forecasts is an ongoing effort, but some significant advances have already been made by combining numerical and statistical approaches. For example, by using downscaling methods, corrections can be made for some spatial biases in the numerical model outputs which can effect substantial improvements in the skill of the forecasts. Further improvements can be made by using statistical procedures that account for the dependence of the model skill on the forecast. For example, over New Caledonia, skill is higher during La Niña compared to El Niño or neutral conditions.

Increasing and diversified user needs

Climate information needs of users depend largely on the intended areas of application, and can vary significantly from sector to sector: a construction industry may require some simple climate risk maps; a roof-water harvesting activity may require only cumulative risk of a water tank not being filled within a given season; a farmer may require not only the risk of achieving certain cumulative precipitation totals, but also the temporal distribution of certain threshold values that would satisfy water requirements for various crop growth stages; a disaster manager may be interested in knowing the risk of a cyclone eye passing over a city, etc.

It was noted in the previous sections that most RCOF products are probabilistic in nature and many users find serious difficulties in using such products, especially in developing countries. Some attempts have been made to compare the released seasonal climate outlook with some analogues of past years falling within the same forecast category. This has enabled some users to relate the RCOF products to some past sector-specific impacts. It has, however, been noted that such comparison may sometimes be misleading without the existence of good baseline data.

Some recent reviews of the RCOF process have shown that they have played a significant role in capacity-building in many parts of the globe (IRI, 2006; Patt *et al.*, 2007; Berri *et al.*, 2000). The Forums have also helped develop links between climate scientists, end-users and other partners, especially in Africa. They have stimulated interest in, and created recognition of, climate needs in addressing regional challenges for coping with climate variability and adaptation to climate change. Several limitations have, however, been noted that include:

- Difficulties in the use of probability-based products;
- Low level of understanding of the seasonal-to-interannual climate forecasts by the users;
- Limitation in many users' ability to define their own specific needs for climate forecasts and information;
- Some users are unaware of the products and services available through the RCOFs and national climate outlook forums;
- Unreliability of some of the available services and untimely attention to the user's climate-related vulnerabilities and sensitivities, including updates, evaluations, follow-ups to proposed changes and improvements;
- Dissemination modes of products and information are beyond the reach of many users.

Some attempts are being made in some regions to develop multidisciplinary pilot projects to enable climate scientists and users to address how best to downscale and interpret RCOF products for sector-specific uses and also to address issues related to cost-benefits. Some of the lessons gained from these pilot projects and other good practices in the uses of RCOF products are reviewed below.

Cost-benefit assessments of seasonal climate predictions

It is not difficult to demonstrate that skilful forecasts are not necessarily useful in the sense of providing the potential for a user to benefit from the forecasts in some way. Part of the difficulty is that there is an additional loss in skill as the climate forecast is converted into forecasts of the impacts, but also the various constraints in terms of the decisions that can be made (including their costs, practicality and efficacy) can make skilful climate forecasts valueless (or worse). Therefore, in addition to estimating the skill of forecasts, the value of forecasts needs to be determined. There are two broad approaches to estimating the value of forecasts: ex-post and ex-ante evaluations. An ex-post evaluation calculates the benefit achieved from forecasts already released considering decisions that were actually made and essentially answer the question of what value has actually been realized. In contrast, ex-ante evaluations calculate the value of forecasts that could have been realized using the forecasts if a set of rational decisions had been made in response to the forecast information, and thus answers the question of what value can be realized.

By far the greatest attention has been placed on ex-ante evaluations. Meteorologists have developed some verification scores that attempt to estimate the potential economic value of forecasts. The most commonly used metric is the economic value score, which is based on the cost-loss model. The cost-loss model compares the savings made by mitigating the impact of a climate event by taking precautionary action against the cost of taking such action. The model thus effectively compares the savings achieved by using correct forecasts with the costs and losses incurred when the forecasts are incorrect. Since the relative values of the costs and losses are not uniquely defined, the economic value score is used to integrate the potential value of the forecasts over all possible cost-loss ratios.

The cost-loss model is a simple and didactically useful model for indicating the potential economic value of forecasts, but is too idealized to give a realistic indication of the actual value of forecasts to many users. As a high priority, the meteorological community needs to work closely with the applications communities to estimate the actual value of the forecasts. However, just as focusing on the skill of the RCOF forecasts without considering their value could be considered blinkered, so also a focus on the economic value of the RCOF forecasts to date provides an incomplete assessment of the value of the RCOF process.

For one, economic estimates of forecast value ignore the social value that can be realized: how does one estimate the value of lives saved through the prevention of a malaria epidemic, for example? But apart from considerations of how the availability of forecasts may enable improvements in climate risk management, the benefit of development of the RCOF process itself needs to be recognized. Even if the RCOF forecasts to date were shown to have had no skill at all, the process has been valuable in strengthening the capability of the climate services of many NMSs throughout the developing world, and creating the potential to provide improved climate information (forecast and otherwise) in the future. It has also helped to establish and/or strengthen a dialogue between the forecast and user communities that will facilitate more effective climate risk management in the future.

Applications of RCOF products

The RCOF process has facilitated a better understanding of the links between the climate system and socio-economic activities. An increasing demand for climate services has been recorded in many parts of the world as a result of these developments. Awareness has been created that climate information, including short-range climate predictions, is an essential element in dealing with the impacts of climate variations. RCOFs have fostered interactions and exchange of information between the climate scientists and users of climate information. More importantly, they have facilitated the mainstreaming of regional cooperation and networking and effectively demonstrated the immense mutual benefits of sharing information and experience.

RCOFs have made a significant contribution to the improvement of the quality of the seasonal rainfall outlook, as well as its communication to the users. The interaction of climate scientists and users from various sectors has improved the dissemination and applications of climate information and prediction products in the region. Since their inception, the forums have demonstrated that climate-related risk-management strategies through the optimum use of climate information and products can contribute enormously to sustainable development in the region. The close interaction between the providers and users of climate information and prediction products has enhanced

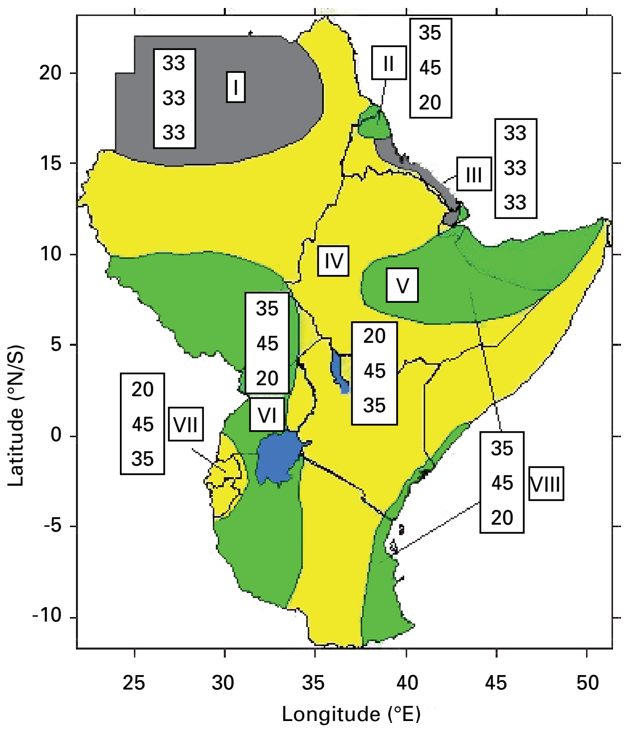

Figure 2(a) — Greater Horn of Africa Consensus Climate Outlook for March to May 2008 by ICPAC and partners including WMO and IRI

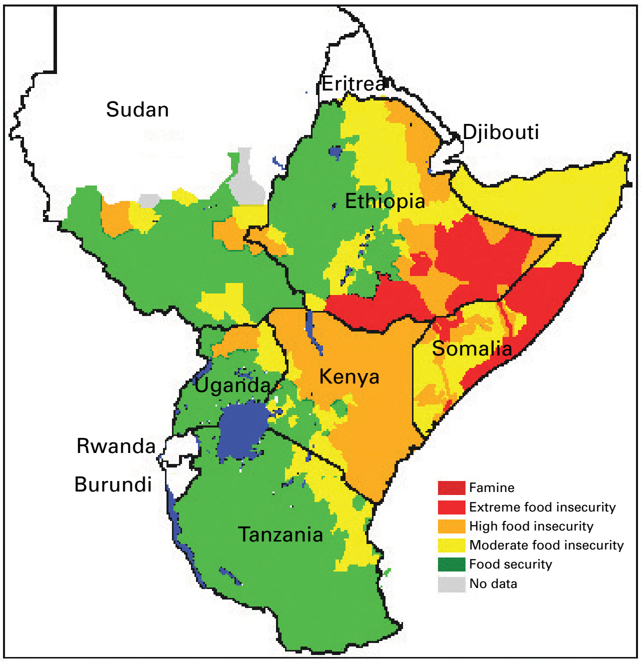

Figure 2(b) — Food Security Outlook for March to July 2008 by Famine Early Warning Systems Network (FEWSNET)

feedback from the users to climate scientists. Such interactions have catalysed the development of many user-specific products.

Climate extremes in some regions are associated with ENSO. ENSO prediction and early warning products continue to benefit the various socio-economic sectors through the provision of early warning information for timely sectoral mitigation against extreme climate events. Based on ENSO and other RCOF information, vulnerability assessments are done and some attempts have been made to put in place sector-specific contingency plans for intervention. Some of these have triggered new disaster-risk reduction policy discussions.

Agriculture and food security

Regional agriculture and food security outlooks are now regularly produced after the climate outlook forums in some regions. In the Greater Horn of Africa, based on RCOF climate outlooks, food security outlooks are provided by the US Famine Early Warning System, the World Food Programme, the United Nations Food and Agriculture Organization and national experts (Figure 2(*a*) and 2(*b*)).

Water resources

Climate information is critical in all components of water resources assessment, development and planning including early warning of hydrological extremes.

Figure 3 provides the prediction of the natural flow of the Senegal River at Bakel (Senegal) in September and October. The management of the Manantali dam (Mali), till the end of the next rainy season, is based on the flow forecasts derived from the downscaled forecasts of rainfall provided by a General Circulation Model (ARPÈGE). This information, coupled with optimization management software, brings the energy production optimization up to near 35-40 per cent and the artificial flood, allowing an area of 50 000 ha for flood recession farming, is guaranteed in three out of four years compared to just one out of five years without any forecast information. (Julie and Céron, 2007).

Public health

Many diseases are indirectly or directly associated with climate. Vector-borne diseases are sensitive to changes in meteorological parameters such as rainfall, temperature, wind and humidity. These include malaria, dengue and Rift Valley Fever (RVF). Extreme climate events can trigger rampant outbreaks of waterborne diseases such as cholera and typhoid in areas where they are not common. Some efforts are now being made to provide warning of changes in epidemic risk by integrating rainfall, temperature and other non-climate information. For example, Malaria Outlook Forums (MALOFs) are now regularly held in association with RCOFs in southern Africa and the Greater Horn of Africa (Pascual *et al*. 2006). The information developed jointly by climate and health experts in these sessions, together with information on population

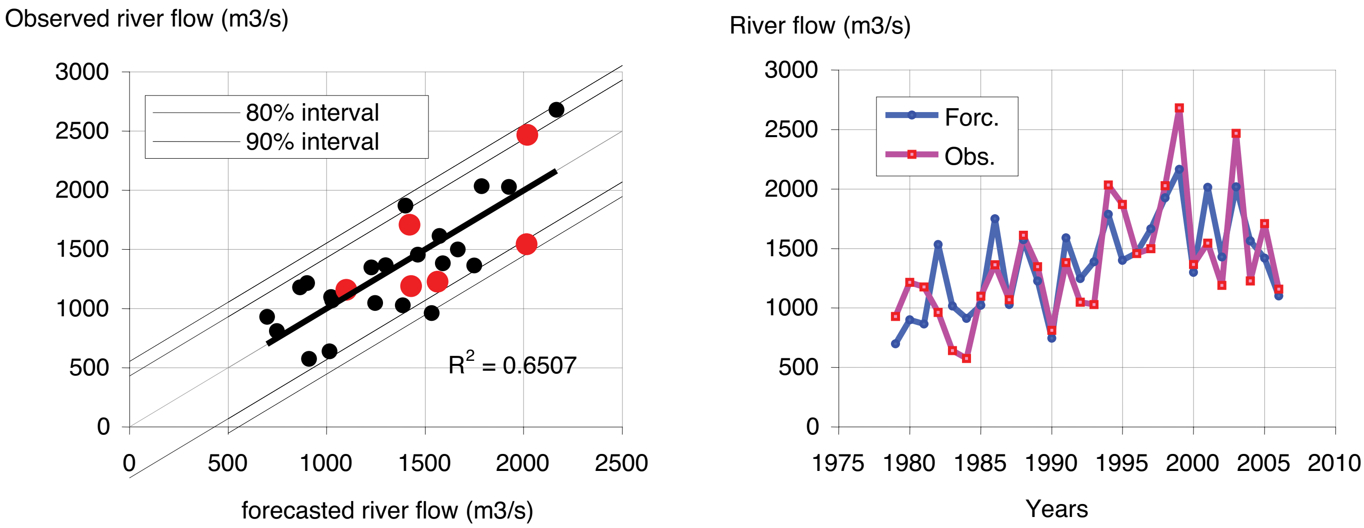

Figure 3 — Prediction of the natural flow of the Senegal River at Bakel (Senegal) in September-October. The left panel show shows forecast flow values in relation to observed flow values (black dots for the calibration period 1979-2000 and red dots for the operational period 2001-2006). The right panel shows the forecast and observed natural flow time series for the entire data period 1979-2006.

vulnerability, food security, immuno-suppression and adequacy of control coverage, gives the health community a longer lead-time over which to optimize the allocation of the resources available to combat malaria.

Outreach and communication

Education and awareness creation is now a core component of RCOFs in some regions. Some regions have also acknowledged the role of the media in demystifying technical climate/weather jargons. National and regional interactive workshops between the media and the climate scientists have been undertaken in close coordination with the RCOFs. In the Greater Horn of Africa, for example, climate and media experts have organized themselves into a regional network called the Network of Climate Journalists of the Greater Horn of Africa.

Conclusions

Over the last 10 years, RCOFs have played a significant role in capacity building in seasonal climate prediction over many parts of the globe. The Forums have also helped catalyse linkages among meteorologists, users, governments, NGOs, universities and international climate institutions. RCOFs have stimulated interest in the impacts of climate variability and change. Some of the forums have targeted certain users with whom specific products could be developed and specific data on benefits of the services/products assembled. They have further demonstrated that the climate products, if successfully used in decision-making processes, can improve user outcomes. Several challenges still remain, not only in providing the required RCOF products on time and in user-friendly formats, but also regarding the regional processes for the improvement of local prediction products. The benefits of the RCOF products are also not being assessed adequately.

NMHSs, the regions and the users of the products must contribute to the sustainability of RCOFs (e.g. demonstrate utility of the forums and value of the products to those who need the information). Additionally, research capacities at the regional level need to be enhanced in order to assess the forecast skills as well as to work towards their improvement. The media have an important role to play in the RCOF process, which needs to be sustained and actively promoted.

While the RCOFs were originally conceived with the main focus on seasonal prediction, the same RCOF mechanisms can be effectively expanded to cater to the needs of developing and disseminating regional climate change information products. Such initiatives are already being taken up by some RCOFs (e.g. the Greater Horn of Africa). Regional assessments of observed and projected climate change, including the development of downscaled climate change scenario products for impact assessments, can be included in the product portfolio of RCOFs. These aspects have already been noted by the United Nations Framework Convention on Climate Change Subsidiary Body for Scientific and Technological Advice and constitute key elements of WMO's contribution to the Nairobi Work Programme on impacts, vulnerability and adaptation to climate change.

RCOFs, with their demonstrated capability of providing regionally consistent and user-targeted climate information, mostly on climate variability at present but also progressing towards climate change aspects, are thus uniquely placed to contribute to decision-making at regional, national as well as sector levels on adaptation to climate variability and change. Improved research, specialized human and technical capacities and user liaison are required to be sustained at regional levels for enhanced understanding of the regional climate processes and climate linkages with the regional specific socio-economic impacts, vulnerability, and the development of adaptation strategies. Concerted support at the local, national, regional and global levels is most essential for these activities, to strengthen and sustain the RCOF processes and pave the way for climate adaptation.

References

Berri, G.J., P.L. Antico and L. Goddard, 2005: Evaluation of the Climate Outlook Forums' seasonal precipitation forecasts of southeast South America during 1998-2002. *International Journal of Climate*, 25, 365-377.

Guofa Zhou, Noboru Minakawa, Andrew K. Githeko and Guiyun Yan, 2004: *Association between climate variability and malaria epidemics in the East African highlands*

IPCC, 2007: *The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (Eds)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Julie, A. and J-P. Céron, 2007 : Seasonal forecasting in West Africa: a strategic partnership for a sustainable development of a cross boundary river catchment, *Elements for Life*, Tudor Rose and WMO, 70-71.

Hellmuth M., A. Moorhead, M.C. Thomson and J. Williams (Eds), 2007: *Climate Risk Management in Africa: Learning from Practice*. International Research Institute for Climate and Society, Columbia University, New York, USA.

Palmer, T.N., 1999: *Predicting uncertainty in forecasts of weather and climate* (also published as ECMWF Technical Memorandum No. 294). http://www.ecmwf.int/newsevents/training/rcourse_notes/pdf_files/Predicting_uncertainty.pdf

Palmer, T.N., F.J. Doblas-Reyes, A. Weisheimer and M. Rodwell, 2008: Towards seamless prediction: calibration of climate-change projections using seasonal forecasts. *Bulletin of the American Meteorological Society* (in press).

Patt, A.G., L. Ogallo and M. Hellmuth, 2007: Learning from 10 years of climate outlook forums in Africa, *Science*, Vol. 318, No. 5847, 49-50.

Pascual, M., J.A. Ahumada, L.F. Chaves, X. Rodo and M. Bouma, 2006: Malaria resurgence in the East African highlands: temperature trends revisited. *Proceedings of the National Academy of Sciences*, 11, April 2006; 103(15): 5829-5834.

Thomson, M.C., S.J. Mason, T. Phindela and S.J. Connor, 2005: Use of rainfall and sea surface temperature monitoring for malaria early warning in Botswana, *Am. J. Trop. Med. Hyg.*, 1 July 2005; 73(1): 214-221.

WCRP, 2007: The First WCRP Seasonal Prediction Workshop. *CLIVAR Exchanges*, Vol. 12, No. 4 (October 2007), 2-5.

WMO, 2007: WMO Conference on Living with Climate Variability and Change: Understanding the uncertainties and managing the risks, 17-21 July 2006, Espoo, Finland. Final report. http://www.wmo.int/pages/prog/wcp/wcasp/meetings/documents/LWCVCFinalReportDraft_may07.pdf

WMO, 2007: *Manual on the Global Data-Processing and Forecasting System*. WMO-No. 485, Vol. 1—Global aspects (revised edition).