WISER

Weather and Climate Information Services for Africa

Pan-Africa Component

Report On CR4D S2S Workshop

United Nations
Economic Commission for Africa

ACPC
African Climate Policy Centre

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ACRONYMS

ACPC	African Climate Policy Center
AMCOMET	African Ministerial Conference on Meteorology
BOM	Australian Bureau of Meteorology
CCA	Canonical Correlation Analysis
CCAFS	Climate Change, Agriculture and Food Security
CFS	Climate Forecasting System
CIFOR	Center for International Forestry Research
CMA	Conference of the Parties serving as the meeting of the Paris Agreement
CORDEX	Coordinated Regional Climate Downscaling Experiment
CPT	Climate Predictability Tool
CR4D	Climate Research for Development in Africa
ECA	Economic Commission for Africa
ECMWF	European Centre for Medium-Range Weather Forecasts,
ENACTS	Enhancing National Climate Services Initiative
ENSO	El Nino Southern Oscillation
GCM	General Circulation Model
GFCS	Global Framework on Climate Services
GHACOF	Great Horn of Africa Climate Outlook Forum
GPC	Global Producing Centre [of the World Meteorological Organization]
ICP	Institutional Collaboration Platform
ICPAC	IGAD Climate Prediction & Applications Centre
MOS	Model Output Statistic
MJO	Madden-Julian Oscillation
MLR	Multiple linear regressions
NMME	North American Multi-modal Ensemble
NWP	Numerical Weather Prediction
RCCs	Regional Climate Centres
PCR	Principal Components Regression
RCOFs	Regional Climate Outlook Forums
RCRP	Regional Climate Research Partnership
SAC	CR4D Scientific Advisory Committee
SAI	Standardized Anomaly Index
TIGGE	THORPEX Interactive Grand Global Ensemble
SARCOF	Southern Africa Regional Climate Outlook Forum
SCIPEA	The Strengthening Climate Information Partnerships – East Africa project
SIP	Seasonal to Interannual Prediction
SST	Sea surface temperature
SVS	Standardized Verification System for Long-Range Forecasts [of the World Meteorological Organization]
S2S	Subseasonal to seasonal forecast
WISER	Weather and climate Information Services for Africa
WMO	World Meteorological Organization

PART I. WORKSHOP SUMMARY

5.1. Background

There is growing evidence that Subseasonal to Seasonal (S2S) forecast is helpful in predicting the likelihood of severe high impact weather (droughts and other dry spells, flooding, tropical cyclones); help in humanitarian planning and response to disasters; agricultural activities, and disease control planning. These forecasts also give indications of river flow and river discharge for flood prediction, and reservoir management; coastal inundation; hydroelectric power generation requirements; likelihood of landslides; transport and insurance needs.

Recognizing the considerable interest in Africa in promoting and capitalizing scientific advances in S2S forecasting at multi-week lead times (15-90 days), the Climate Research for Development (CR4D)[1] in Africa Secretariat initiated regional S2S pilot projects in Central and West Africa. The United Kingdom's Department for International Development (DfID) supported these projects under its Weather and climate Information SERvices for Africa (WISER) programme.

The projects were conducted in collaboration with various institutions, among them the National Meteorological and Hydrological Services (NMHSs), universities, research centres and line ministries in West and Central Africa. The focus was on developing and improving prototype climate forecasts at S2S scales. In addition, the projects aimed at assessing user-informed climate knowledge gaps through user feedbacks in the regional climate outlook forums (RCOFs). Hence, this workshop was held back-to-back with the 45th Great Horn of Africa Climate Outlook Forum (GHACOF) meeting to identify possible areas of collaboration between CR4D and the forums for enhanced possible uptake/use of forecast products. Moreover, participants got lectures on S2S matrices, predictions, methods, data and tools.

5.2. Venue and Date

The workshop was held 8 and 9 February 2017 at the United Nations Conference Centre of the Economic Commission for Africa (ECA), Addis Ababa, Ethiopia.

5.3. Objectives

The main objective of the workshop was to discuss major issues associated with seamless climate forecasts at S2S scale. The workshop further aimed at discussing the following:

- Uncertainties and challenges associated with S2S
- Specific metrics for measuring success of S2S forecasts in selected sectors
- Major findings of the CR4D S2S regional pilot project
- Possible areas of collaboration between CR4D and RCOFs for enhanced uptake of S2S findings

[1] CR4D is an African-led initiative supported by the African Climate Policy Centre of the United Nations Economic Commission for Africa, the African Ministerial Conference on Meteorology, the World Meteorological Organization, and Global Framework for Climate Services. Its objective is to promote and nurture collaborative and user-driven climate research activities to improve climate information needed for decision-making and development planning in various climate sensitive socioeconomic sectors.

5.4. Outputs

The workshop was expected to produce the following outputs:

- Increased knowledge about different types of matrices for measuring success of S2S forecast in selected sectors
- Increased understanding on uncertainties and challenges associated with S2S forecast
- A comprehensive workshop report on the seamless climate forecast at S2S timescale

5.5. Methodology

The workshop's structure included opening remarks followed by presentations on S2S, breakout sessions and panel discussions. For a better understanding among participants, the following power point presentations were made and discussed:

- Overview of methods, tools, data and approaches in S2S
- Analysis, evaluation and verification of S2S at global, regional and national scales
- Sector specific metrics for measuring success of S2S forecasts
- Summary on the findings of the CR4D S2S pilot project in Central Africa
- State of S2S forecasts and matrices for sector specific applications
- Forecast-based planning for disaster risk management: challenges and opportunities
- Analyses and evaluation of uncertainties associated with S2S timescale
- Climate information and fire management

Moreover, there was a presentation highlighting the history, some achievements, and value additions of CR4D to existing research agendas.

5.6. Participants

The workshop gathered some 68 climate scientists, practitioners and researchers. They came from 30 countries, among them Austria, Benin, Botswana, Brazil, Burkina Faso, Burundi, Cameroon, Cabo Verde, Djibouti, Ethiopia, The Gambia, Ghana, Guinea-Bissau, Iceland, Kenya, Niger, Nigeria, Norway, Rwanda, Senegal, Seychelles, Somalia, South Sudan, South Africa, Sudan, Switzerland, Tanzania, Togo, Uganda, and USA (see annex 1).

The geographic distribution of participants is also presented in figure 1. Most were from East and West Africa. However, none from North Africa attended the workshop.

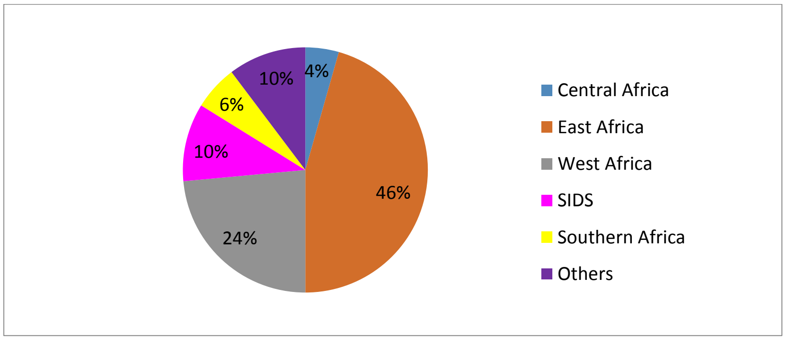

Figure 1. Geographic distribution of participants by sub region and percentage

5.7. Major Events

Three speeches were given at the opening session. The interim CR4D Coordinator, Joseph Instiful, gave the welcome speech. Then, CR4D Scientific Advisory Committee (SAC) representative Pauline Dube provided the opening remarks, followed by the last and official opening one by the coordinator of the African Climate Policy Centre (ACPC), James Murombedzi. They all reiterated that CR4D, as a pan-African initiative, promoted collaborative and user-driven climate research for decision-making and development planning in Global Framework for Climate Service (GFCS) priority sectors. Hence, CR4D is a relevant and timely initiative as it creates an enabling environment for pooling research resources and infrastructure of various institutions, thereby enhancing the availability of quality climate knowledge and products relevant to specific user-sectors through co-designing, co-producing, co-resourcing, and co-ownership.

After the workshop was officially opened, the former CR4D interim coordinator and a member of the CR4D's Scientific Advisory Committee, Richard Anyah, briefed participants on the history of CR4D and its governance structure. He recalled that the history of CR4D goes back to the 2011 CLIVAR Africa Meeting in Cape Town where participants acknowledged a lack of strong linkage between climate science and applications. Eventually, the Africa Climate Conference in Arusha (ACC2013) has led to the formation of CR4D. The CR4D Secretariat was then established in June 2015 and engaged primarily in the establishment of its governance structure. The governance structure comprises the Secretariat, an Oversight Body, the SAC, and Institutional Collaboration Platform (ICP).Subsequently, the Secretariat engaged in proposing major activities including S2S pilot projects to be incorporated into the DfID-WISER project. The S2S pilot projects in West and Central Africa (one in each region) were among those CR4D initiated to test the concept of co-production. This timescale provides a unique opportunity to bring together weather experts and those of climate research communities to improve predictions on a timescale of particular relevance to weather and climate sensitive socioeconomic sectors critical for sustainable development of Africa. Additionally, the Regional Climate Research Partnerships in East and Southern Africa were established along the same objective. Anyah further noted that CR4D was designed to catalyze or facilitate interaction to ensure co-design, which could provide a strong basis for co-resourcing. He concluded his presentation by giving detailed explanation on the value addition of CR4D within the exiting climate research landscapes.

Before the first break, Ernest Afiesimama, a climatologist at the World Meteorological Organization (WMO), gave a general presentation on the methods and tools used in S2S forecasting. He introduced participants to key terminologies, methods, source of predictability and tools on S2S forecasting. He described how methods for S2S forecasts included classical statistical and empirical models, numerical weather prediction (NWP), statistical-dynamical hybrid models, historical analogues and historical composites. With regard to S2S tools, he gave a detailed explanation of the International Research Institute for Climate and Society's Climate Predictability Tool (CPT), the Climate Forecast System (CFS) the Multimodal North American Multi-modal Ensemble (NMME), and the Climate Prediction Center of the United States National Weather Service.

Three subsequent presentations were given on the analysis, evaluation and verification of S2S forecasts at different scales. The first presentation was University of Iceland Professor Haraldur Olafsson, an expert in fluid dynamics, climatology and meteorology. He spoke on the products of the World Meteorological Organization's Global Producing Centres of Long-Range Forecasts, saying there was need to assess the system's quality for user purposes as well as tools for its improvement. For this, it would be critical to define, precisely, the variables being predicted.

The second presenter was by the representative from the Southern Africa Development Community (SADC), Faka Nsadisa. He focused on the Southern Africa Regional Climate Outlook Forum process and regional downscaled products. He said that the temporal and spatial scales, as well as physical definitions associated with each variable must be clearly specified to improve the model skill.

AGHRYMET Regional Centre Representative, Tinni Seydou, was the third speaker. He dwelt on the need to incorporate local processes in regional climate models more effectively to get better representations and thus more accurate forecasts. This requires capacity-building in all the member states of the Community's National Meteorological and Hydrological Services in order to harmonize methods used in national climate forecast downscaling products.

Richard Anyah moderated the discussion during which he asked the panelists[2] the following questions:

- What will be the S2S research priority area in your region?
- What areas of feasible collaboration existed between CR4D and Regional Climate Outlook Forums to promote climate research findings?
- How can other organizations interested in S2S prediction in Regional Climate Outlook Forums be engaged?
- Which communication strategies should be used to promote S2S findings to end users for better acceptance and applicability?
- How can academic advances at an operational forecast centres be implemented and how can their products and services be made relevant to users?

After the panelists responded to the above questions, the floor was opened for general discussion. Participants called for common methodologies and metrics to validate the S2S forecast model, harmonization of different data sets, enhanced capacity-building, better understanding on the relative skill of a multimodal ensemble as opposed to a single model, better forecasting skill for rainfall distribution in space and time, and expansion of RCOFs' products to capture all climate variables in order to best use of findings from the S2S project.

University of Yaoundé I geophysics expert Pokam Wilfred gave a presentation on the CR4D S2S pilot project in Central Africa. A multi-stakeholder team was made up of the project Secretariat University of Yaoundé I, National Meteorological and Hydrological Services and the Center for International Forestry Research. Their task was to improve prototype climate predictions for agriculture at the S2S timescale. Cameroon and Democratic Republic of Congo were selected for this study. Three general circulation model forecasts (BOM, CMA, and ECMWF)[3] were assessed among eleven. A verification of forecasts was conducted using the standardized anomaly index, mean bias, frequency bias, and equitable threat score. Broadly, considering onset dates, models show good skills to forecast "average" or "normal" category of onset dates over Cameroon and

[2] Panelists were Ernest Afiesimama (WMO), Benjamin Lamptey (ACMAD), Faka Nsadisa (SADC) and Laben Ogallo (ICPAC).

[3] The models were by the Australian Bureau of Meteorology (BOM), the Conference of the Parties serving as the meeting of the Paris Agreement (CMA), and the European Centre for Medium-Range Weather Forecasts (ECMWF).

Congo, with higher frequency bias across a large number of stations for the Conference of the Parties, followed by the Bureau of Meteorology and the European Centre for Medium-Range Weather Forecasts. In the case of dry spells, exploration of potential application of bias correction to model forecasts, dry spells detection at threshold of 1mm reveals that the Conference of the Parties followed by Bureau of Meteorology forecasts are clearly improved. This work has been done over four months and its findings are still at the experimental stage and are therefore not yet usable.

A climate modeler at the IGAD Climate Prediction & Applications Centre (ICPAC), Zewdu Segele, presented the S2S forecasts and matrices for sectoral applications. He covered a wide range of issues including the need for S2S prediction research, as well as database of subseasonal forecasts and hindcasts. He said that the European Centre for Medium-Range Weather Forecasts and the Conference of the Parties hosted a database from 11 S2S producing centres. These data consist of forecasts and reforecasts. The forecasts have a horizontal resolution of 30 kilometres to a few hundred kilometres and an ensemble size ranging from 4 to 51. As an example of how the S2S database could be utilized, climatology of onset for 1951-2010 based on the Coordinated Regional Climate Downscaling Experiment (CORDEX) present day simulation over the Greater Horn of Africa region was undertaken. The observed and model climatology were thereafter used to correct bias, calibrate onset dates, and to project onset forecasts relative to climatology in terms of probabilities. Other examples he gave were the cessation dates as well as dry and wet spells. For the wet and dry spells, the S2S forecasts and reforecasts could be used to determine their duration, frequency, climatology and uncertainty in their occurrence. This would have a direct application in agriculture (plant growing stages), disaster risk management, health and water among other socioeconomic sectors.

Another aspect of the S2S forecasts is the extreme event. Teferi Demessie, senior researcher from the Bjerknes Centre for Climate Research at the University of Bergen, Norway, presented an analyses and evaluation of uncertainties associated with the S2S timescale. He said that developing testable hypotheses for the causes of model systematic biases was essential for identifying the development of model biases and their evolution in comparison with the observed climate in S2S timescale. Hence, a reliable estimate of subseasonal forecast could be constrained by model uncertainties. Uncertainty due to model formulation could, however, be improved by multimodal methodologies. A set of daily and monthly ensemble coupled hindcast data from the EC-Earth model was compared with observational data. The daily and monthly ensemble-average hindcasts and the observations were averaged for the specified year period and their difference considered as the model bias.

The representative of the International Federation of Red Cross and Red Crescent Societies, Youcef Ait-Chellouche, spoke of the need for forecast-based planning for effective humanitarian actions. Although many achievements had been made in model forecasting, he said, challenges remained related to geographic area and forecast wording. For example, the forecast geographical areas were mostly too large to provide or finance humanitarian relief. Moreover, wording such as "above normal precipitation with localized dry spells,…" did not offer advice on whether to prepare for flooding or drought. Such wording was – confusing, and casts doubt on the usefulness of the forecast. Hence, he said, the climate community expected to provide an update of the seasonal forecast that justified the need for action.

Under the topic of sector specific metrics for measuring success of S2S forecasts, three consecutive presentations were given. The first was by Jasper Mwesigwa, an agrometeorologist at the ICPAC. He spoke on S2S forecast metrics for agriculture. He said although climate information was a fundamental input for effective agricultural planning and decision-making, its benefits were not fully realized in Greater Horn of Africa due to widespread gaps between available data as well as other information and the needs of agriculture users. For this reason, Hence, ICPAC is working partnering with CCAFS, WISER (SCIPEA, ENACTS), GFCS, NMHSs and other stakeholders to strengthen development, availability, and promotion of the use of relevant climate information CI products in the sector. He further elaborated that climate information CI products important for the agriculture sector included: (1) rain-fed cropping season onset and cessation dates; (2) number and duration of rainy/wet/dry days or spells; (3) seasonal totals; (4) length of growing periods; (5) rainfall intensity and peak of season; (6) standard precipitation index (SPIs) and percentile of precipitation; and (7) water requirements satisfaction index (WRSI) and related seasonal water balance variables.

The second presenter was Pascal Yaka, climate scientist from Burkina Faso. He stated that metric used in health sector should protect people health and well-being from hazards by integrating climate information in the decision making process. The value of forecasts must, therefore, be demonstrated through integration of forecasts in health operational systems which allowing to: (i) develop operational methods and tools (such as climate-health thresholds and indices for extreme weather alerts and climate sensitive disease outbreaks and its space-time dynamics); (ii) health authorities to develop and deploy health-early warning systems and other diagnostics; (iii) develop alert tools that alert health professionals and communities to extreme weather events; (iv) extend the lead-time that health actors have for taking decisions and preventive measures. The main types of information used to construct indicators (metrics) on health risk include climate or environmental hazards characteristics (such as severity, starting time, duration, etc.); climate and environment conditions (humidity, temperature, rainfall, etc.); population vulnerability and exposure factors (such as immunity, remoteness, malnutrition or poverty); and socioeconomic context of a given population.

University of Botswana Professor Pauline Dube gave the final presentation on the relationship between climate information and fire management. Dube, a geographer and specialist in remote sensing, said integrating weather and climate information into decision-making could save money, life and ecosystems. In this regard, proper utilization of climate information from subseasonal to seasonal forecasts, an inter-annual as well as long-term (decadal) forecast was crucial for effective fire management. However, the forecast skill (that is the probabilities and accuracy) of the models should be increased for better fire management. Various institutions produce sizeable amounts of information pertaining to fire management.

5.8. Recommendations

Some of the recommendations from the two-day workshop are summarized below:

- CR4D should take S2S as a crucial area of research to support development needs as it bridges the gap in short- to long-term climate changes
- CR4D projects areas and the accompanied monitoring and evaluation indicators should be defined to measure projects' success
- CR4D should collaborate with regional climate centres /Regional Climate Outlook Forums in capacity-building through fellowships and supporting the attachment of visiting scientists

- CR4D should be involved in co-organizing the RCOF meetings and support the participation of young scientists
- CR4D needs to conduct a gap analysis study of the continent in order to identify the priority areas of CR4D research
- CR4D should have a liberal but federated structure to ensure efficiency in sharing expertise over different regions and take advantage of existing partnerships
- CR4D should initiate a user-feedback forum because most meteorological services operate on a one-way channel mode (that is dissemination) rather than pursuing a two-way communication channel (feedback) CR4D should act as the focal point or authoritative entry point between the international community members interested in climate science and application and African climate communities
- CR4D should conduct joint demonstration projects with universities, research and operational centres to ensure the final products and services are relevant to the users. These products and services should l be verified using the RCOF platform in order to build trust among end users
- CR4D should have a clear communication strategy that raises its visibility and impact within the region and beyond
- CR4D S2S prediction efforts should be linked with other S2S prediction projects in the continent in order to boost synergy

5.9. Tracking Successes

About 70 per cent of workshop participants responding to a survey on the meeting's content rated it as "very good" and said it met their expectation. Among the different sessions, most participants said they were pleased with the panel discussion and rated it highest followed by presentation on the overview of the method, tools, data and approaches in S2S, and analysis, evaluation and verification of subseasonal to seasonal forecast. Overall, about 57 per cent of the participants rated the workshop as very good and 43 per cent as good. They also judged the workshop as a very good initiative that would help build the capability of meteorological services in providing climate information in the S2S domain. The involvement of young scientific researchers in the workshop was also judged instrumental in achieving the CR4D's goal of enhancing future climate research in the region. Most participants recommended similar workshop for other regions.

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5.10. Vote of Thanks

The organizing team thanked the participants for their interest and involvement in the discussions and their presentations. Session chairpersons as well as rapporteurs are also acclaimed. DIFD-WISER was also acknowledged for covering the workshop cost.

PART II. OPENING CEREMONY

2.1. Welcoming Remarks

Three speeches were given during the opening session. Interim CR4D Coordinator Joseph Instiful spoke first, noting that CR4D was a pan-African collaborative initiative to co-explore, co-design, co-produce and co-communicate climate information and services for development planning. This initiative, he said, helped African institutions to access quality climate information and make better use of climate information services. The initiative also allows for African climate science, services, policy, and other stakeholders to bring climate information into the mainstream of development planning. Climate Research for Development - as a partner of the African Ministerial Conference on Meteorology, the Global Framework on Climate Services (GFCS) and World Meteorological Organization WMO - supports regional climate research agendas, including S2S forecasting for GFCS priority sectors. Hence, this workshop is organized back-to-back with the Greater Horn of Africa Outlook Forum meeting to identify possible areas of collaboration and shape the long-term strategy for improving climate prediction at subseasonal to seasonal scale. The workshop also envisaged discussing uncertainties associated with S2S information and metrics for measuring the success of S2S forecasts. More importantly, the workshop was designed to encourage greater use of climate information services by making a business case for sustained investment in such services at all levels. Instiful said the workshop would complement another by WISER on assessing the socioeconomic and environmental benefits of weather and climate using a systems dynamic-based modelling framework to shape policy and decision-making processes.

He told participants that timely and accurate weather and climate reports were vital to Africans whose livelihoods were highly dependent on such information to help communities build resilience against future harsh climate change impacts. Hence, demonstrating the Socio Economic Benefits (SEB) of these services helps to explain the use and benefits of S2S forecasts so that end users know how, when and why they could use weather and climate information.

2.2. Opening Remarks

On the behalf of the CR4D’s Scientific Advisory Committee (SAC), Pauline Dube reminded participants that all countries around the world would likely face the impacts of climate change, although Africa is the most vulnerable continent. This was because most African economies rested on climate sensitive sectors such as rain-fed farming, livestock rearing, water and energy For most of these sectors, S2S changes could be critical in determining whether a family would meet its daily food requirement, whether money would be available to fulfill critical essentials, and if the family would have enough resources to buy seeds and other inputs for the next agricultural season. This indicates that any change of the S2S timescale would have a huge impact on the livelihoods and economy of Africans. Hence, packaging and wide dissemination of climate information at S2S scale would be crucial in reducing the negative climate impact on the aforementioned climate-sensitive sectors.

However, he said, success in packaging and wide dissemination of climate information required the availability of huge resources and sound institutions. CR4D was, therefore, a relevant and timely initiative as it created an enabling environment for pooling and sharing research facilities, resources, and infrastructure among subregional, regional and pan-African institutions. It also helped to build capacity as well as to enhance the availability of quality climate knowledge and products relevant to specific user-sectors through co-designing, co-producing, co-resourcing, and co-ownership approach. Moreover, it would also try to provide adequate answers to the most intriguing questions related to climate information and services including the following:

- What does an increase of 2°C mean for different sectors and to local farmers?
- How are long-term indicated changes manifested at the S2S level?
- What types of climate information is required and when, to assist different economic sectors to be better prepared for the impact of climate change?
- Which climate institute has what?
- How do different sectors use climate information?

In this regard, the CR4D Secretariat has launched a number of activities across various regions of Africa including the establishment of a federated Regional Climate Research Partnership in East and Southern Africa; multi-institution and multi-stakeholder pilot research projects on S2S forecasting and applications in West and Central Africa; mapping of climate institutions, initiatives and experts in Africa; and others. This workshop on S2S would therefore, present ample opportunities to participants to learn and assess the utility of weather and climate information in the development planning. Moreover, the workshop marks a significant step towards addressing the CR4D objectives and creates foundations for users tailored climate forecasts.

2.3. Official Opening

African Climate Policy Centre Officer-in-Charge James Murombedzi made the official opening remarks. He reiterated that there were numerous fragmented initiatives in Africa that sought to support the production and use of climate information services. However, many of these initiatives were of small scale and unable to influence the policy and legislative agenda in Africa because of weak or complete absences of coordination mechanisms. Such a challenge was, he added, more amplified at the continental scale where there was little coherence between the multiple interventions that sought to achieve similar goals. Hence, pan-African initiatives like CR4D might help to coordinate such efforts on the continent. He added that CR4D was an outcome of the African Climate Conference in 2013 in order to advance new frontiers of African climate research, focusing on four priority areas. These areas are (i) creation of co-designed multi-disciplinary research to improve forecast skills and reliability; (ii) filling gaps in multi-sectorial and multidisciplinary data sets for sector-specific vulnerability and impacts assessments; (iii) enhancing Africa's scientific and institutional capacities and networks to undertake cutting edge user-drive climate research; and (iv) fostering effective collaboration and interactions among climate science, services, policy, and practice communities in order to improve mainstreaming of climate services in decision-making.

He told participants that the role of CR4D should go beyond seamless prediction and should help users of climate information to understand the science behind such forecast information; translate climate science research into information for meaningful impact assessments in Africa; catalyze capacity-building and development on impact-based forecasting and systematic observation. He said that CR4D should also contribute to the alignment of user-driven climate research with Agenda 2063, and the 2030 Agenda for Sustainable Development as well as national agendas; and enable linkages between national, regional, and global climate research priorities and issues.

CR4D, in collaboration with international and continental partners, should also provide inputs to the upcoming Intergovernmental Panel on Climate Change special report on the impacts of 2°C/1.5°C global warming on GFCS priority sectors. He also spoke of the need for African scientists and researchers to produce scientific evidence to support the policy making process. In this regard, he said, there was little engagement of African scientists at global levels and in shaping global climate agreements including in the reports of the Intergovernmental Panel on Climate Change. He said while the current workshop would give participants a chance to discuss issues related to S2S, it would also help users to understand the importance of climate information and services in regional and national development planning. Finally, he thanked DIFD for financially supporting the training workshop and officially opened the event.

PART III. GENERAL PRESENTATIONS ON S2S

3.1.Overview, Methods and Tools Used in S2S Forecasting

This presentation was included in the training workshop to provide insight on the use of S2S in decision-making process and to introduce participants to key terminologies, methods, source of predictability and tools on S2S. The WMO's Ernest Afiesimama said that many numerical weather prediction centres still used coupled ocean-atmosphere models to produce ensemble forecasts on the S2S timescales. This meant that there remained a significant opportunity to develop methods that use subseasonal to seasonal forecasts to provide actionable information, including classical statistical and empirical models, numerical weather prediction, statistical-dynamical hybrid models, historical analogues and historical composites. He told participants that many end users had benefited by applying weather and climate forecasts in their decision-making. Yet, he added, there remained ample evidence to suggest that such information was underutilized across a wide range of economic sectors. Moreover, gaps in forecasting still existed.

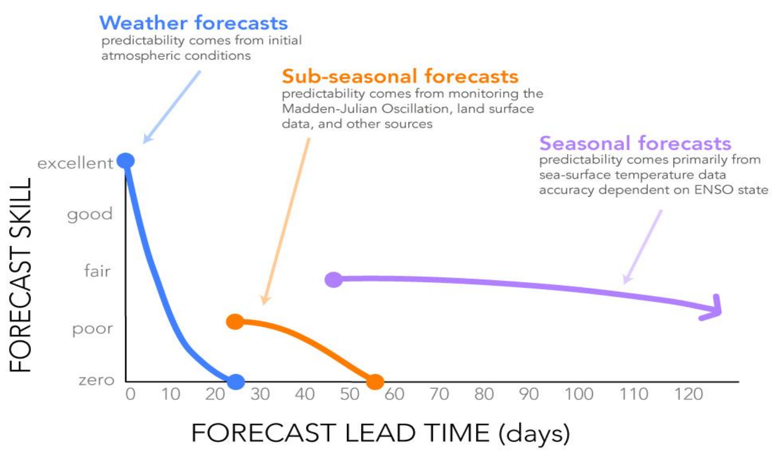

Figure 3. Forecast skill plotted against forecast lead time to describe weather, sububseasonal and seasonal forecasts. Source: *Adopted from http://iri.columbia.edu/news/qa-subseasonal-prediction-project/*

With regard to S2S tools, Afiesimama gave a detailed explanation of the International Research Institute - Climate Information Portal (CIP), the Climate Forecasting System, multimodal ensemble simulation - North American Multimodal Ensemble, and the United States National Weather Service's Climate Prediction Center. He reiterated that the Climate Predictability Tool was a software package for constructing a seasonal climate forecast model. Its design has been tailored for producing subseasonal to seasonal climate forecasts using model output statistic corrections to climate predictions from the general circulation model, or for producing forecasts using fields of sea surface temperatures or similar predictors. CIP is also used in more general

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settings to perform canonical correlation analysis, principal components regression, or multiple linear regressions on any data, and for any application. The Climate Forecasting System, on the other hand, was a useful tool in forecasting tropical intraseasonal oscillations, which are the basis for subseasonal prediction. He also explained the sources of predictability of subseasonal forecasts and that these came from various processes in the atmosphere, ocean and land including soil moisture, snow cover, stratosphere and troposphere interactions, ocean conditions, El Niño Southern Oscillation, Madden-Julian Oscillation, and monsoons. He later concluded his presentation with the following remarks:

- There is growing demand by operational prediction and applications communities for environmental forecasts that fill the gap between medium-range weather and multi-season climate forecasts. This gap at the intermediate forecast range is referred to as the S2S timescale of prediction
- Skillful S2S predictions provide important and valuable opportunities to inform decision makers of changes in the risk of extreme events or opportunities for optimizing resource decisions, especially in the socioeconomic sectors critical for sustainable development
- S2S methods such as statistical, dynamical and a hybrid of both have been used
- Sources of input data (recent observations especially satellite-based, historical and reanalyzes and centres) where output data and products of S2S can be retrieved
- Linkages between the output of S2S and application models for enhanced products for last mile user communities have been noted
- What remains is to f establish, firmly, this community of practice in Africa to maximize the economic utility of S2S in decision-making for socioeconomic development.

3.2.Analysis, Evaluation and Verification of S2S Forecasts

This session comprised of three subsequent presentations devoted to analysis, evaluation and verification of S2S forecasts at global, regional and national scales. The first presentation, by Haraldur Olafsson, an atmospheric scientist at the University of Iceland, looked into the products of global producing centre. He spoke of the need to verify the quality of the system for user purposes as well as tools for its improvement. For this, he said, it would be critical to clarify, precisely, the definitions of the variables being predicted. He told the participants that different verification methods gave different types of "goodness", and that different users had different ideas on what made for a "good or bad forecast" (Fig. 3). Hence, he said, needs must be defined. For example, a hydrologist may need the accumulated precipitation in a watershed; the solar energy sector may need daytime cloud cover; or public warning administrations may need timing and location of wind or precipitation extremes; and a farmer may need accumulated precipitation at a given location.

Predictability and prediction of subseasonal timescale in sub-monthly timescale is relatively underexplored and underdeveloped compared to forecasts with lead times of a month to a season. However, the skill of both subseasonal and seasonal forecasts has been improved in recent years especially the skill of forecasts of indices of coupled ocean-atmosphere modes of variability. He further described that a dynamic based method used to diagnose errors included conservation of vorticity or PV, hypsometric equation, hydrostatic equation, quasi-geostrophic height tendency equation, and conservation of mass. Hence, a large ensemble set can be used for better evaluation of skill and the training and testing of application models. However, he said, this effort required either a large increase in computing cost or a reduction in the model resolution used. Also captured were basic laws governing the numerical weather prediction including conservation of momentum, energy, and water vapor, mass and hydrostatic balance equations, as well as issues on model uncertainties.

He mentioned that forecast verification, which actually evaluates the skill and value of forecasts was explored, more so the metrics of the World Meteorological Organization's Standardized Verification System for Long-Range Forecasts. Olafsson stated that in any given weather forecast, two factors led decreased forecast skill as forecast lead-time increased: these were (i) inevitable uncertainties in the initial conditions; and (ii) necessary approximations in the construction of a numerical model of the exact laws of physics.

Verification was a critical component of making forecasts useful to applications, and seamless verification would be important to the S2S scale. Climate Forecast System forecasts were dynamic in nature as opposed to products from the Climate Predictability Tool, which is mostly statistical. More information regarding the physics of the model, number of member model runs and other such information could be obtained from the National Centers of Environmental Prediction of the United States. Olafsson concluded saying there was a need to unify the verification methodology used for medium-range databases (the THORPEX Interactive Grand Global Ensemble) and seasonal databases (the Climate Historical Forecast Project, EUROSIP, SVSLRF), and that this was an area to which subseasonal to seasonal forecasts could contribute.

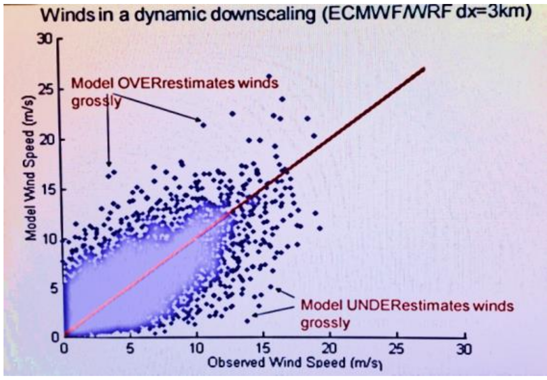

Figure 4. Winds in a dynamic downscaling. *Source:*. Dynamic downscaling to dx=3km (*Massad, lafsson, Rögnvaldssonet al.*)

In the second presentation, Faka Nsadisa, a representative from Southern Africa Development Community, dealt with the Southern Africa Regional Climate Outlook Forum (SARCOF) process and regional downscaled products. He said that the process of regional downscaling products at SARCOF involved the analysis of historical data sets to determine the baselines, generation of a regional forecast using the statistical downscaling approach, analysis of products from the WMO Global Producing Centres, and building consensus on the best forecast estimates. Likewise, the verification methodology in SADC was sated by defining time series of observations; for example OND totals from 1981-2010, followed by calculating the percentile of current observations and assign to tercile. The tercile categorized are as follows: (i) pixels observed in the same tercile as highest probability forecast tercile; (ii) pixels observed in the same tercile as the second highest probability (non-normal event); (iii) pixels observed in the same tercile as the second highest probability (normal event); (iv) pixels observed in the same tercile as the lowest probability (normal forecast); and (v) pixels observed in the same tercile as the lowest probability (non-normal forecast). Such an evaluation scheme, however, rewarded or penalized the forecast based on likely user response to the forecast. Therefore, a forecast of normal to above normal with "above normal observed" was considered a good because of correct forecast bias, while a forecast of normal to above normal with "below observed" was considered poor forecast because of incorrect bias. A forecast of above to normal with "below observed" was considered a false alarm or worse forecast. In general, the SARCOF analysis tried to focus only to the extreme categories and some of the results are summarized as follows:

- SARCOF forecasts have on average performed well over the last 12 years (20012012)
- A positive trend of 13 per cent of HR has been observed (62-75 per cent) on OND period and 20 per cent on JFM season (68-88 per cent)
- A reduction of FAR of 15 per cent has been noticed (35-20 per cent) on the OND period and 35 per cent on the JFM period (40-5 per cent)
- Certain areas appear to perform better than others, potentially due to unpredictable rainfall systems such as cyclones
- There is an improvement on the model parameters over northern Congo and Mozambique, southeast Angola and southern Malawi
- Improvements in methodology and in the WMO's Standardized Verification System for Long-Range Forecast metrics for evaluation are required

The final presentation was given by the AGHRYMET regional centre representative Tinni Seydou. Ever since the centre started rolling out climate outlooks in 1998, he said, tremendous progress had been made with the introduction of new products like onsets and cessation dates. Furthermore, Seydou noted the centre's improved communication techniques, which included media releases, special bulletins, use of mailing lists and website-based platforms that greatly help in disseminating the products from producer to specific users. The main downscaled products at national level were mainly the onset and cessation dates of the rainy season, dry spells and river discharge.

AGRHYMET, like any other national meteorological and hydrological centre, he added, provided extended range forecasts of subseasonal evolution of the rainy season. Quality climate forecasts improved decision-making process to reduce climate-related risks, ensure safety of people and their property, and investments in support of development. However, the service required user-specific needs, especially at local levels. Moreover, he said, the temporal and spatial scales and physical definitions associated with each variable must be clearly specified.

3.3.Analyses and Evaluation of Uncertainties Associated with S2S Timescale

In his presentation, Teferi Demessie of the Bjerknes Climate Research Centre said that development of testable hypotheses for the causes of model systematic biases was essential identifying the development and evolution of the biases in comparison with the observed climate in the S2S timescale. A set of daily and monthly ensemble coupled hindcast data from the EC-Earth model used was compared with observational data. EC-Earth is a coupled global climate model based on the European Centre for Medium-Range Weather Forecast seasonal prediction system (System 3), which several European institutions developed jointly.

The EC-Earth hindcasts were four-month long integrations initialized on February, May, August and November start dates and were run from 1981 to 2010. The daily and monthly ensemble-average hindcasts and the observations were averaged for the specified year and their difference considered as the model bias. The mean monthly sea surface temperature biases in the EC-Earth model remain small during February when the model is initialized. Only a cold (<1ºC) bias in the Eastern Equatorial Pacific and warm errors in the NH western boundary currents are observed. Significant cold biases develop between February and March over the Equator, as well as over the Maritime Continent, in the Arabian Sea and the tropical Indian Ocean, as well as in the southern part of the North Pacific subtropical gyre between the Philippines and Hawaii.

Warm biases develop off the western coasts of the southern continents, especially in the Benguela upwelling. Weaker warm errors also appear on the northern sub-Equatorial Pacific and Atlantic oceans, and in the southern subtropics. The tropical biases continue to grow, more slowly in April, after which the cold error over the Equatorial Atlantic is reduced as the model warms there, reinforcing the general warm error in the southern tropical Atlantic. At the same time, the cold error in the western warm pool becomes more prominent. It could therefore be noted that cumulative biases in sea surface temperature grow slowly; and after four months of simulation, with a strong cold bias with peak error of 3ºC developed in the Central and Eastern Pacific Ocean.

The warm bias in the southern subtropics grows, especially in the upwelling regions of Benguela, Angola. For the EC-Earth model initialized in February, the rainfall errors develop quickly in that month with a nearly zonal dipole in the area of Western Pacific/ Southern Pacific Convergence Zone (SPCZ), and the Maritime Continent. In March, the West Pacific Zonal Dipole immediately weakens and is replaced by a general meridional pattern with a dry bias over the Equator, a wet bias just to the north, and wet biases around 15S-20S in the SPCZ and east of Brazil.

Notable also is the drying over of land in the Amazon and Congo basins. The error pattern continues to intensify over the Indo-Pacific area in the following months. By contrast, over the Atlantic, a wet error over and just south of the Equator develops from April onward. For the case of zonal winds at 10m, again initialized in February, the first month of the forecast sees the development of an easterly bias nearly everywhere in the tropics with the most prominent area of development being the Western Equatorial Pacific. Similar to the rainfall bias pattern, this error weakens in March with the general pattern becoming more zonally uniform.

A band of westerly errors appears just south of the Equator. Westerly errors also develop in the Pacific Inter Tropical Convergence Zone and over the North Equatorial Atlantic during April and May, with the latter replacing the initial easterly error. A strong easterly bias persists over the Equatorial Pacific and slowly but consistently develops in the Northern Hemisphere trade wind regions.

In conclusion, the study found out that westerly surface wind bias over the Equatorial Atlantic was related to the wet bias over that region. Large-scale wind errors affect the evolution of systematic biases over the Equatorial Atlantic, which do not grow monotonically while the equatorial sea surface temperature errors appear generally consistent with wind forcing. Furthermore, the Angola-Benguela region develops a warm sea surface temperature bias irrespective of errors elsewhere. The upwelling over the region was the possibly cause of the bias, while sensitivity analysis shows that the atmosphere and the ocean contribute equally to this bias. The systematic biases of different atmospheric variables and sea surface temperature affect intraseasonal variability at the S2S timescale. Therefore, further research in climate modelling and enhancement of weather observation stations is very critical in dealing with the uncertainties of forecasts related with the S2S timescale.

Based on the above presentations, several comments, recommendations, concerns and questions were raised and are captured below.

- *Harmonization of different data sets is a concern*: There is a need for harmonized approaches that create synergy between different data sets in order to improve data representation and quality. The advancement in data observation methods should feed climate models so as to get accurate products (for example climate forecasts) for better sector assessments, decision-making and policies development
- *Capacity-building is needed to avoid or minimize the black box forecasting tool*: Forecasters and meteorologists should know the basics behind each tool rather than adopting and using it blindly. However, it was noted that most forecasts tools consist of many lines of codes written in different languages, thus capacity-building needs to be stepped up to empower African climate scientists better understand this models. This could be done, for instance, through fellowships and exchange visits.
- *Lack of common methodologies and metrics is a challenge to validate S2S models*: This limits the ability in estimating the skill of subseasonal forecasts across subregions and sectors, particularly in predicting the West African monsoon (Meridional Oscillation of the monsoon trough); Tropical Intraseasonal Oscillation (Maden-Julian Oscillation); teleconnections and El Niño–Southern Oscillation events in West Africa; onset of the rainy season and cessation for agricultural activities; the number of rainy days and dry spells for agriculture and water resources management; heat stress indices (meningitis, cholera and other waterborne diseases); extreme climate events (floods and droughts) for disaster risk
- *National climate forecast downscaling methods needs to be harmonized*: There is a need to better incorporate local processes in regional climate models to get better representations and thus better forecasts. Hence, capacity-building in all national meteorological and hydrological services is warranted to harmonize methods used in national climate forecast downscaling products
- *Forecasting rainfall distribution in space and time is highly important*: Since light and well-distributed rains are better than heavy-isolated ones with poor distribution, accurate prediction of rainfall distribution in time and space is noted as a very important component in agricultural performance
- *Forecast lead time and forecast accuracy are not mutually exclusive*: While it was applauded that a good lead time should be given, caution should be taken not to compromise the forecast quality. Short-term forecasts were noted to have good skills. However, long-term forecast skills are still low and thus require greater attention for its improvement
- *The relative skill of a multimodal ensemble as opposed to a single model is not fully understood*: Some work will be initiated by Climate Research for Development, in collaboration with the World Meteorological Organization subseasonal to seasonal working teams, in order to explore the skill of single and multimodal ensembles in predicting variations at subseasonal to seasonal timescale

- *Defining various categories and levels of climate information users is important for quality decision-making*: decision makers require high-quality, reliable, timely information on current, predicted and projected conditions for safety and security, and for adaptation strategies and measures. However, different end users required different types of climate information
- *The products of Regional Climate Outlook Forums should be expanded to capture all climate variables*: It was noted that most of these products focus on rainfall and temperature. Therefore, the Forums must expand their products to capture windstorms and hailstorms as these elements also influence various sectors of the economy.

3.4.CR4D S2S Pilot Project in Central Africa

University of Yaoundé I Professor Pokam Wilfried presented the CR4D regional project for Central Africa, which focused on S2S forecasts for agriculture. A team comprising experts from the CR4D Secretariat, University of Yaoundé I, Center for International Forestry Research, and the National Meteorological and Hydrological services (NMHSs) undertook the project. Cameroon and Democratic Republic of Congo were selected for this study. Three general circulation model forecasts (BOM, CMA, ECMWF) were assessed among eleven, based on specific criteria. These criteria were that the forecast should be done at least two weeks before the onset of the growing season, with forecast spans of 2, 3 and 4 weeks ahead of the season, knowing that subseasonal to seasonal time ranges were defined between 2 weeks and 3 month scales.

The performance of the models was evaluated considering their outputs, in order to explore potential application bias correction to model forecasts, with several thresholds (5 mm, for onset dates, 0.1 for dry spells). A verification of forecasts was conducted using the standardized anomaly index, mean bias, frequency bias, and equitable threat score. Broadly, considering onset dates, models show good skills to forecast “average” or “normal” category of onset dates over Cameroon and Congo, with higher frequency bias across large number of stations for the Conference of the Parties to the Paris Agreement, followed by the Australian Bureau of Meteorology, and the European Centre for Medium-Range Weather Forecasts. In the case of dry spells, the potential application of bias correction to model forecasts was explored. Wilfred said that dry spell detection at a threshold of 1mm showed that the Conference of the Parties, and the Australian Bureau of Meteorology forecasts were clearly improved. This work has been done over four months but its findings were still at the experimental stage, thus not yet usable.

The reactions after the presentation were around the following:

- The study should cover additional agrometeorological metrics as well as the remaining countries of Central Africa
- Participants were encouraged by the work done in just four months. They requested the CR4D Secretariat to explore ways to collaborate with other regional climate centres in providing impact forecasts in Central Africa
- Participants questioned how farmers could be provided exact information at the beginning of the agricultural season if the project had not yet matured
- “Cross-fertilization” of such work and findings of other regions and centres is essential in creating a robust database on S2S. The main idea here is that CR4D should to create an archive from which other regions could draw. The idea also aims to encourage exchanges between teams present in Africa

- CR4D should verify the accuracy of the products before delivery to the end users because providing reliable products builds trust. The work needs to be seen as a way to stream science and develop a prototype on ho end users, and then making sure that the project o

Climate Research for Development

PART IV. PANEL DISCUSSION

The session's moderator, Richard Anyah, told participants that subseasonal to seasonal forecast had multi-disciplinary stakeholders at the Arusha conference that had identified such forecasts as a priority for agriculture. Therefore, he said, Climate Research for Development in Africa should view S2S forecast as one that bridges the gap in short-term to long-term climate changes. This is because this type of forecasting was a crucial area of research needed to support development. Furthermore, Anyah said although Regional Climate Outlook Forums in Africa provided space for interaction and collaboration between the producers and users of climate and weather information, the research element was mostly missing. Development and delivery of effective climate services for the benefit of all member states required regional cooperation for capacity-building and infrastructure development; progress in the operational implementation of scientific research initiatives; and a regional mechanism for interpretation and interface to national meteorological and hydrological services of global seasonal to inter-annual prediction as well as S2S forecast. This was, therefore, the opportunity for Climate Research for Development in Africa to identify possible collaboration within the Forums in order to promote S2S and other relevant climate research findings. He said that Forums provided consensus seasonal climate outlooks and that stakeholders involved in the generation, dissemination and use of seasonal climate information and services should draw on their experiences For this, he said, collaboration was needed between WMO's global producing centres for long-range forecasts; regional climate centres, and national meteorological and hydrological services. In this regard, Anyah said, S2S had a lot to learn from the Forums including observations and data quality; research agenda; basic information; diagnosis and understanding of processes; modelling, prediction and early warning; seamless approaches; and data verification.

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Then, he invited panelists from IGAD Climate Prediction & Applications Centre (Laban Ogallo), World Meteorological Organization (Ernest Afiesimama), Southern Africa Development Community (Nsadisa Faka) and African Center of Metrological Application for Development (Benjamin Lamptey) to lead in brainstorming ideas on five questions stated below:

1. What will be the S2S research priority area in your region?

   Setting the research priority area involves all players by taking into account the advantages of individual strengths, with vulnerable systems and communities in lead. In general, S2S research priority areas depend on sectors including these:

   - predictability of the West African monsoon (Meridional Oscillation of the monsoon trough); Tropical Intraseasonal Oscillation (Maden Julian Oscillation) in West Africa
   - Teleconnections and El Niño Southern Oscillation events in West Africa;
   - Onset of the rainy season and cessation of agricultural activities and management
   - Number of rainy days and dry spells for agriculture and water resources management; soil moisture content for agriculture and water resource management
   - Heat stress indices (meningitis, cholera and other waterborne diseases)

- Extreme climate events (floods and droughts) for disaster risk reduction

Climate Research for Development in Africa could, therefore, use ICP to identify research areas of concern to the climate centres, conduct the research and have the centres use the results. For example, packaging the information from the seasonal prediction into usable information beyond the current terciles is needed. CR4D could investigate ways to improve the techniques used for the seasonal prediction in the various parts of Africa while regional climate centres work on the transition from research to operations.

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2. What areas of feasible collaboration exist between Climate Research for Development in Africa and Regional Climate Outlook Forums to promote climate research findings?
   It was pointed out that the following are important to strengthen collaboration:

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- CR4D in collaboration with regional climate centres should undertake and evaluate the implementation of the new services as the pilot validation project. The evaluation report could then be discussed at the meeting of the Regional Climate Outlook Forums
- The CR4D Secretariat should be involved in co-organizing the Forums' meetings and help young scientists to attend them because this platform is the best for linking subseasonal to seasonable research to operations CR4D should shall collaborate with the Forums in capacity-building. Capacity-building is needed in many countries first, to conduct the climate outlook forums at the national level, and second to package the results in a usable format for different sectors such as water, agriculture and food security, health, disaster risk reduction, and energy. CR4D should therefore, support the attachment of visiting scientist at regional climate centres and the development of tools and new services as part of the capacity-building effort.

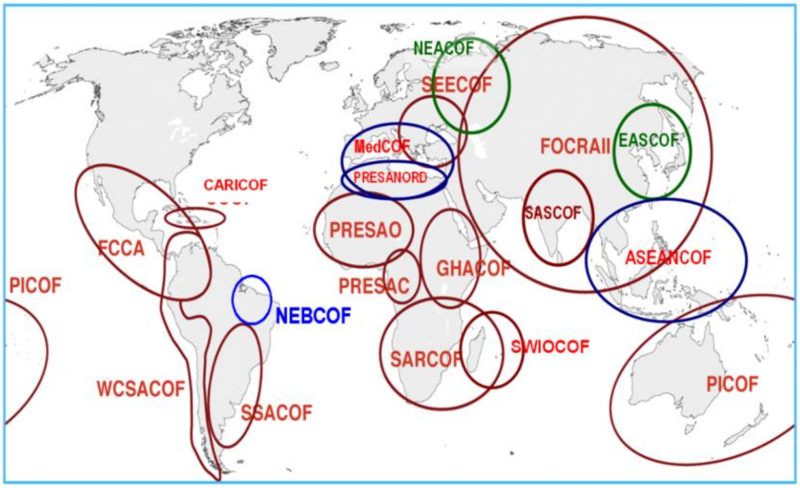

Figure 5. Global distribution of regional climate outlook forums

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3. How should other organizations interested in S2S prediction in Regional Climate Outlook Forums be engaged?

   The best way is to decide this involvement together. An agreement that sets out areas of collaboration and the co-validation of the service should be reached prior to the launch for operational implementation. In this regard, CR4D is expected to undertake the following:

   - Map institutions and expertise in Africa involved in climate services and delivery with a view to engaging them in supporting research
   - Promote findings on methods, tools, data and approaches to S2S prediction in the Forums
   - Develop metrics for measuring the success of forecasts in ways that are useful to farmers and other stakeholder communities
   - Act as a focal point or an authoritative entry point between members of the international community interested in climate science and application with African climate communities

4. Which communication strategies should be used to promote S2S findings to end users for better acceptance and applicability?

   Each user group and producers of information should make that choice. Hence, a one-fit-all communication means may not be appropriate. The key is to leverage on existing structures and strive to build confidence in user communities. Some of the best ways to reach the last mile of users in the dissemination and the usage of the products include these listed here:

   - Community-based climate services broadcast including the use of FM radio
   - Civil society (NGO and churches) or any community platform. Direct contact is more effective than mass media in the correct use of climate services
   - Use of social media.

5. How can academic advances be implemented at the operational forecast centre; and how can the products and services of operational centres be made relevant to users?

   The advanced academic findings should be provided for the operational forecast once validated for use. Under the WMO framework, there exist institutions whose mandate cover significant areas: for example the Global on Climate Services, continental level; ACMAD, regional scale; the IGAD Climate Prediction & Applications Centre, and at the national scale, national meteorological and hydrological services .

   - However, to answer the question, we need to look for the full value chain: Research <-> Operations <-> Applications. This chain requires a platform for exchange of --------- between research and operational community, and another between operational and application community. Communities should decide the nature of the platform, the frequency of meetings, and the medium of communication. Moreover, operational centres should identify the weather and climate phenomena on which universities and research centres require further understanding and investigation. The findings should be returned to operational centres for testing and calibration.
     [EDITOR'S NOTE: THESE BULLET POINTS BELOW NEED AN INTRODUCTORY SENTENCE.] Shifting from traditional climate information to climate information systems requires a strong degree of cooperation among universities, which would design the services; and regional climate centres, which would validate and disseminate the information. To do so, Climate Research for Development in Africa could serve as a

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platform to take stock of potential new findings and organize validation and dissemination workshops in with the regional climate centres.

- Conduct joint demonstration projects between CR4D, universities, research and operational centres
- CR4D could use existing platforms such as the Global Framework on Climate Services in the development of subseasonal to seasonal forecasts, as well as upscaling research findings and experience in the different regions
- National meteorological and hydrological services' data policy should be reviewed to allow universities and research centres to improve the understanding and prediction of forecasts in different regions of Africa

After the panelists responded, the floor was opened for general discussion. The following points were summarized from that discussion.

- Climate Research for Development (CR4D) should consider facilitating professional attachments to the regional climate centres in order to build the capacity of young scientists
- CR4D should have a clear communication strategy that raises its visibility and impact within the region and beyond
- CR4D needs to conduct "a gap analysis study throughout the continent" in order to identify the priority areas for research. In this regard, participants applauded the organization's Secretariat for conducting the subseasonal to seasonal forecast project because this research area was one priority identified at the Arusha conference.
- Subseasonal to seasonal forecasts could be useful to the public and a wide body of institutions that include, Red Cross societies and the United Nations Office for the Coordination of Humanitarian Affairs. Yet these forecasts have not been widely used, for example within the Southern Africa Development Community. Therefore, this makes these types of forecast a priority area in which Climate Research for Development could support African meteorological services. In this regard, it is important that CR4D finance attachment programmes for experts to kick start the subseasonal to seasonal forecasts. Participants acknowledged CR4D's work in establishing the regional climate research partnerships in Eastern and Southern Africa while conducting pilot projects in West and Central Africa. Participants also applauded the organization's plans for an independent company to run a centralized grant management mechanism. However, the research priority areas should be defined by the existing CR4D governance structure without interference from development partners
- CR4D should have a liberal but federated structure to ensure efficiency in sharing expertise over different regions and take advantage of existing partnerships
- CR4D project area's monitoring and evaluation indicators should be defined and used to measure the success of projects
- Implementing the core value of CR4D: co-designing, co-production, co-resourcing and co-communication requires the involvement of a multidisciplinary team that incudes young scientists. Hence, meteorological services should share information on what products and services they could offer, based on their capacity and existing science. This would ensure transparency and help the users to understand the value of meteorological services
- Given that the S2S forecast supports the shift from science-driven to user-driven products, CR4D should learn from uniquely successful user-driven weather and climate

information services: these are RANET, operated by the Kenya Meteorological Department) and South Africa's Severe Weather Forecasting initiative. Therefore, CR4D should have a clear mechanism to support the implementation of successful prototypes

- Participants acknowledged the need for climate centres to build trust with their users so that their information services would be meaningful. In this context, there are still gaps within the meteorological services that CR4D could fill to improve product quality. Fidelity and transparency between the meteorological services and universities, especially data sharing. This would, in turn, contribute to building user confidence in the products and services provided by meteorological bureau. Trust between different stakeholders in the weather and climate field could provide the ground for better subseasonal to seasonal applications
- CR4D should initiate a user-feedback forum because, presently, most meteorological services use a unidirectional mode of information communication (that is dissemination) rather than one that also allows for feedback from consumers of those services
- S2S should have target areas that should be translated to impact scenarios for different sectors. Hence, the interaction between the universities and operational centres is very important

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PART V. SECTORAL APPLICATIONS

5.1. S2S Forecasts and Matrices for Sectoral Applications

IGAD Climate Prediction & Applications Centre's Zewdu Segele covered many issues in his presentation, among them the need for S2S prediction research and for a database of subseasonal forecasts and hindcasts. He said that the European Centre for Medium-Range Weather Forecasting and the Conference of the Parties hosted a database from 11 subseasonal to seasonal forecast producing centres. These data consist of forecasts and reforecasts. The forecasts have a horizontal resolution of 30 kilometres to a few hundred kilometres and an ensemble size ranging from 4 to 51. The coupled and "atmosphere only" models are initialized daily and subweekly[4] to produce 30-60 day forecasts. On the other hand, reforecasts data with periods of 10-30 years are also archived. The reforecast data set is obtained from at least one model and 33 model ensembles at most. These models are initialized daily, subweekly and monthly.

Segele also spoke of the importance of precipitation to agriculture, water, health, and other sectors. He said an understanding of the location and season specific intraseasonal variability of precipitation and associated physical processes is essential. In this regard, the dominant mode of precipitation variability at the S2S timescale needed to be determined; an evaluation of how well S2S forecasts capture the dominant mode of variability needed to be undertaken; and the main atmospheric responses and circulation features associated with different phases of variability needed to be well understood.

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A S2S forecast database could help determine the start of a season, since a S2S ensemble could be used to characterize envelops of possible onset dates. Thereafter, hindcasts could be used to develop onset climatology; determine the biases of the onset dates, and probabilities of the start of the rainfall after certain dates; could also be used in the assessment of the skill of the models in determining the onset dates.

As an example on how the S2S database could also be utilized, climatology of onset for 1951-2010 based on CORDEX present day simulation over the Greater Horn of Africa region was undertaken. The observed and model climatology were then used to correct bias, calibrate onset dates and to project onset forecasts relative to climatology in terms of probabilities. Other examples are cessation dates as well as dry and wet spells. For these conditions, the S2S forecasts and reforecasts could be used to determine their duration, frequency, climatology and uncertainty in their occurrence. This would have a direct application to agriculture (plant growing stages), disaster risk management, as well as health and water among other socioeconomic sectors.

Another aspect of the S2S forecasts is that of extreme events. These could define events that are outside of the 90, 95 or 99 percentile of historical records if deemed appropriate for sectoral applications. Probability of occurrence of these extreme events is determined from model ensemble in the S2S database. Such extreme events include temperature extremes (extended periods of extreme cold or heat, and heat waves), rainfall extremes (droughts and floods), extended periods of dryness in combination with extreme temperatures, weather associated with tropical storms, extreme winds and hail, among others. The WMO has established standard

[4] Pertaining to times of less than a week.

measures for assessing forecast skill for seasonal prediction. Some of these measures include root-mean-squared-error, mean squared error, bias, MSSS, correlation, pattern correlation, anomaly correlation, Brier skill score and ranked probability skill score, among others. Although these measures could still be used in S2S forecasts, Segele said, the sampling of forecasts was an issue that needed to be tackled.

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5.2. Forecast-Based DRR Planning Challenges and Opportunities

Youcef Ait-Chellouche of the International Federation of Red Cross and Red Crescent Societies presented on the need for forecast for effective planning of humanitarian interventions, which calls for a paradigm shift in S2S forecast skill. He said although many achievements had been realized - such as going from weather to risk information and from planning to potential for probable disasters - challenges remained. These challenges arose from donors, decision makers and communities. He provided two examples: first, the geographical area of concern may be too large which makes it difficult to provide or finance the humanitarian relief. In such a circumstance, the donor would wonder whether the required funding is for developmental purposes or for actual humanitarian assistance. Second, the wording of the forecast may be confusing. Terms such as “above normal precipitation with localized dry spells” make it difficult to know whether to prepare for enhanced rainfall (flooding) or prolonged dryness (drought). In this case, the decision makers and the community may question the confidence of the forecast. In order to overcome such challenges, he said, the International Federation of Red Cross and Red Crescent Societies had adopted the “no regret” approach and the humanitarian need responds now operated at different timescales.

The no regret approach is based on three stages namely; get set, ready and go. At the first stage, once the seasonal forecast is issued to inform a community at risk and key players IFRC reviews staff readiness and undertakes their training if necessary; reviews and adapts a contingency plan; and enables an early warning system. At the ready stage, the climate community provides an update of the seasonal forecast, which confirms the need for action. At this stage, IFRC mobilizes resource, reviews or sets the standard operational procedures and initiates dialogue with partners and community on operations and coordination. At the go stage and with a short alert, an IFRC assessment team is ready for deployment, with first support ready, estimated road damages and meetings with communities and authorities.

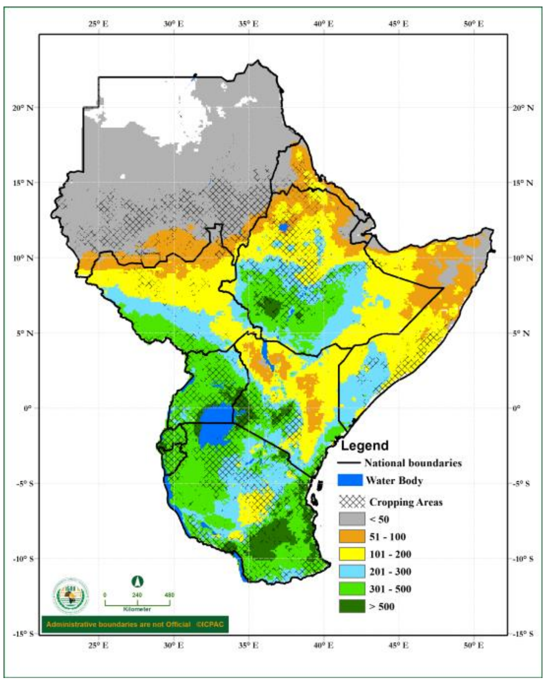
Ait-Chellouche said the IFRC had developed tools based on precipitation to support farming and risks reduction. The tool for agriculture indicates crop type, time of planting, harvest period, drying period and when to sell produce. However, the tool needs to be improved by drawing on the expertise of social anthropology and change behavior of humanitarian specialists. This involves the psychological change from giving instructions (“do these”) to participatory approach (“what can we do together”). In conclusion, he said there was need to translate climate information for disaster risk action. This could be done by seeing climatologist as disaster managers, location as vulnerability, magnitude as expected loss, lead time as range of plausible actions and probability as subjective decision to act or not act.

5.3. Metrics for Measuring Success of S2S Forecasts in Agricultural sector

Acknowledging that climate information was vital for agricultural planning and decision-making, ICPAC’s Jasper Mwesigwa said despite this the benefits of climate information were not fully realized in the Greater Horn of Africa region region due to widespread gaps between the available data and the needs of agriculture users. Therefore, he said, ICPAC had formed partnerships[5] with several stakeholders to strengthen development, availability and promotion of use of relevant climate information in the sector.

He also said that planned climate information products for agriculture sector include: (i) rain-fed cropping season onset and cessation dates; (ii) number and duration of rainy/wet/dry days/spells; (iii) seasonal totals; (iv) length of growing periods; (v) rainfall intensity and peak of season; (vi) SPIs and percentile of precipitation; (vii) the Food and Agriculture Organization of the United Nation's Water Requirement Satisfaction Index and related seasonal water balance variables; and (viii) communication manuals and tutorials, such as the Participatory Integrated Climate Services for Agriculture.

[EDITOR'S NOTE]: This map/figure below needs a title and a source.



[5] Some of ICPAC partnerships are: the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS); the Enhancing National Climate Services initiative (ENACTS); the Weather and Climate Information Service for Africa (WISER); Strengthening Climate Information Partnerships in East Africa (SCIPEA), ENACTS), GFCS, national meteorological and hydrological services (NMHSs)

Commented [o15]: By agricultural users do you mean farmers?

Commented [o16]: Spell out

However, Mwesigwa identified the challenges in developing matrices for measuring successes in S2S forecast for agriculture. These are unfriendly data sharing policies; inadequate skills of agriculture users to process data; data resolution issues – limit application for specific purposes (more ground stations, more station data needed); time lag in data availability and access; and unfriendly data formats, sizes, periodicity, sources and nomenclature. The following priority areas were proposed for research:

- Improve forecast skill and reliability
- Move from general to seamless forecasting
- If forecasts are issued with high certainty, users are more confident to rely on them
- Improve data quality: fill data gaps, improve resolution, formats,
- Improve downscaling tools and methods, for example the determination and use of analogue years
- Harmonize product definitions, thresholds, baselines
- Build capacity of intermediaries and users to interpret, depend and act upon the products so as to maximize the opportunities that come with the seasons

5.4. Metrics for Measuring Success of S2S Forecasts in Health sector

The second presenter was Pascal Yaka, climate scientist from Burkina Faso. He stated that weather and climate information can be used as decision-support tools for emergency planning, response to extreme weather conditions, informing national/ community/health facility response plans for climate-related hazards,

examples : wildfires, floods, storms, landslides, infectious diseases, cold weather, heat stress, chemical and radiological hazards

climate information (Short- Mid and long range 1month to multi-year) has a broad range of applications including :

adaptation of regional or national preparedness and response plans,

general planning to climate variability and change,

investment decisions at middle and long terms.

Examples: planning a vaccination campaign, disease transmission and outbreak, health infrastructure protection risks

METRICS FOR MEASURING SUCCESS OF S2S FORECASTS IN HEALTH SECTOR The metric should be how to perform health workers to integrate climate information in decision making to protect people health and well-being?!

Not only about the accuracy of weather forecasting or climate prediction or models skill !!!

A perfect forecast will not be really perfect until it can lead in decisions making !!!

The value of forecasts must be demonstrated through integration of forecasts in health operational systems which allowing to :

develop operational methods and tools (such as climate-health thresholds and indices for extreme weather alerts and climate sensitive disease outbreaks and its space-time dynamics).

health authorities to develop and deploy health-early warning systems and other diagnostics

develop alert tools that alert health professionals and communities to extreme weather events

extend the lead-time that health actors have for taking decisions and preventive measures.

Main types of information used to construct indicators (metrics) on health risk:

climate or environmental hazards characteristics (such as severity, starting time, duration, etc.);

climate and environment conditions (humidity, temperature, rainfall, etc.);

population vulnerability and exposure factors (such as immunity, remoteness, malnutrition or poverty);

socioeconomic context of a given population

Extreme weather, climate variability, and long-term climate change pose important challenges to the performance and management of health systems and health care services.

Some common challenges in term of information, products, metrics for health sector :

•Understanding how climate and weather influence disease transmission and occurrence (studies of correlation and causality);

•Estimation populations at risk of exposure to hydrometerological hazards (flood bush fire risk map);

•Forecasting health impacts associated with climate variability and climate change;

•Estimation of seasonality of disease occurrence and outbreak;

•Detecting, monitoring and anticipation of climate-sensitive health hazards (e.g. flooding, pathogen transmission, extreme temperatures up to days, months, years in advance);

•monitoring the effectiveness (quality, assessment…) of health planning and interventions;

•Determination of the sensitivity and identification of a reliable climate signal or measurable influence on health exists.

5.5. Metrics for Measuring Success of S2S Forecasts in Energy sector

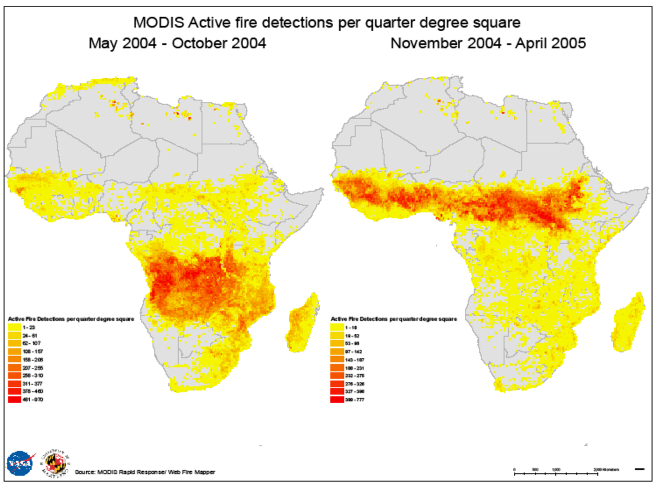
5.6. Climate Information and Fire Management

Pauline Dube from the University of Botswana said proper utilization of climate information from subseasonal to seasonal, inter-annual and even long-term (decadal) forecasts was crucial for improved fire management. In this regard, integrating weather and climate information into the decision-making could save money, life and the ecosystems. However, the forecast skill (that is the probabilities and accuracy) should be increased for better fire management.

Fire is a global phenomenon but large areas of Africa are subjected to frequent wildfires. Fires in Africa account for ~30-50 per cent of the total annual biomass burned globally. The complex interactions between socioeconomic factors and biophysical processes, including climate change, are resulting in change in fire regimes; for example fire timing, frequency, intensity - contributing to processes of land degradation, greenhouse gas emissions and threatening human security. A sizeable amount of information pertaining to fire management is currently produced by various sources.

Figure 6

MODIS active fire detections per quarter degree square



Source: MODIS Global Fire Map product: 28/09/06 – 07/10/06

The Fire Radiative Energy, which is the portion of emitted radiation liberated by the combustion process, is established through the aid of the blackbody concept. Radiative energy helps us to categorize fires in terms of intensity; that is to classify fires in terms of power to damage and difficulty to control.

The global characterization of biomass-burning patterns using satellite measurements of fire radiative energy identified 5 RFP categories:

Commented [o17]: Full out

1) Category 1 (< 100 MW)

2) Category 2 (100 to < 500 MW)

3) Category 3 (500 to < 1,000 MW)

4) Category 4 (1,000 to < 1,500 MW)

5) Category 5 (≥ 1,500 MW)

Dube noted that over 90 per cent of fires globally fall within category 1 and only less than 1 per cent fall into categories 3 to 5. However, she said, these proportions may differ significantly from day-to-day, and by season. There was a link, she said, between climate and fire-related mortality. For example, an average of 532,000 people died during El Niño years as opposed to an average 262,000 during the cooler La Niña years. She said a warmer world due to climate change was going to see more fires.

"It is going to be incredibly difficult in the future to manage forest fires because the intensity of fires is going to be increasing and that changes the strategy of putting fires out.

"Current firefighting methods e.g. aerial suppression may have to be abandoned because they will not work against hotter, more intense fires," she said.

Other Key Issues Discussed [EDITOR'S NOTE: AN INTRO SENTENCE IS NEEDED HERE BEFORE THE LISTING]

CR4D needs to explore the relationship between climate change and health to answer the most intriguing questions such as:

a. Is climate change leading to some emerging diseases in Africa?
b. Are some diseases facing out in some regions because of climate change?
c. Are the models used for climate change and health outcomes able to predict the number of people falling ill as a result of climatic factors?
d. Are the models also able to predict the number of people dying as a result of climate change effects?

2. Question:

A. African countries spend money on solar and wind energy, but the return is usually poor. What method did you use in your area to get these systems functional?

Commented [o18]:

Answer: These systems do not depend on only incoming and outgoing shortwaves. The temperature of the area is critical to the functioning of the system, especially solar energy. High levels of temperature are not good for solar energy i.e. above 40 degrees on the panel.

3. Q: Is a sunshine hour not taken into consideration in the installation of solar panels? It is important to note that temperature can be high without high sunshine.

Commented [o19]: Is this supposed to be the answer to this question? I sdo not see the link.

4. Q: Is it true that a one-year typical meteorological data is enough to help advise on wind energy issues?

A: The minimum data required is 5 years, at best 30-year data. Due to lack of such data, it is advisable to have about a 10-year data to provide such advice.

It is important to note that extreme wind events are not good conditions for investments into wind energy. There is the need to check on atmospheric stability when investing into wind energy.

Sensitivity is required when planning a wind farm because the blades will break when the wind stops. It is important to ensure that there is significant wind all year round to keep the movement of the blades. If there is a point where there will even be challenges with wind supply, the cost of supporting the blades to function should be minimal to make it a prudent investment.

5. Q: Is the analog year analysis able to give daily time series output?

6. A: Yes.

PART VI. Annexes

1. **List of Participants**
2. **Workshop Agenda**
3. **Questionnaire**