# South-South Technical Knowledge Exchange and Learning Initiative (STEKELI) Workshop

Yosef Amha | Dawit Solomon | Teferi Demissie | Brook Makonnen

Workshop Report

CGIAR

AICCRA

Accelerating Impacts of CGIAR Climate Research for Africa

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## Workshop Report

### Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA)

**August 2022**


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CILSS AGRHYMET

ACPC African Climate Policy Centre

IGAD ICPAC

WORLD METEOROLOGICAL ORGANIZATION

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## About AICCRA reports

Titles in this series aim to disseminate interim climate change, agriculture, and food security research and practices and stimulate feedback from the scientific community.

## About AICCRA

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## Acronyms

| | |
|---|---|
| ACMAD | African Centre of Meteorological Applications for Development |
| ACPC | Africa Climate Policy Centre |
| AGRHYMET | Center for Agrometeorological, Hydrology and Meteorology |
| AICCRA-ESA | Accelerating Impacts of CGIAR Climate Research for Africa-Eastern and Southern Africa |
| C3S | Copernicus Climate Change Service |
| CAPC-AC | Central Africa Centre for Application and Climatological Forecasting |
| CCAFS | CGIAR Research Program on Climate Change, Agriculture and Food Security Program |
| CGIAR | Consultative Group for International Agricultural Research |
| CILSS | Permanent Interstates Committee for Drought Control in the Sahel |
| CIS | Climate Information Services |
| CSA | Climate Smart Agriculture |
| DRM | Disaster Risk Management |
| ECOWAS | Economic Community of West African States |
| GCM | General Circulation Models |
| GHA | Great Horn of Africa sub-region |
| GHACOFs | Greater Horn of Africa Climate Outlook Forums |
| GTS | Global Telecommunication System |
| HPC | High-Performance Computer |
| ICPAC | IGAD Climate Prediction and Application Centre |
| IGAD | Intergovernmental Authority on Development |
| IPCC | Intergovernmental Panel on Climate Change |
| NMHS | National Meteorological and Hydrological Services |
| NWP | Numerical Weather Prediction |
| RCCC | Regional Climate Centers |
| RCOFS | African Regional Climate Outlook Forums |
| RECs | Regional Economic Commissions |
| SADC-CSC | Southern Africa Development Community Climate Services Centre |
| STEKELI | South-South Technical Knowledge Exchange and Learning Initiative |
| UIPs | User Interface Platforms |
| UNECA | United Nations Economic Commission for Africa |
| WISER | Weather and Climate Information Services for Africa |
| WMO-ROA | World Meteorological Organization-Regional Office for Africa |
| WRF | Weather Research and Forecasting |

## Contents

# 1. Introduction

In Africa, many actors, programmes, projects, or initiatives are implemented by international organizations or continental institutions, or sub-regional and national entities to improve the development, provision, uptake and use of weather and climate services[1]. For instance, the Regional Climate Centers (RCCs) have been engaged in developing models and methodologies based on ground and satellite observations to forecast/monitor rainfall, crop-water requirements, drought, early warning system, weather/climate, and seasonal and inter-annual variations. They have also provided training in a wide range of expertise in agro-meteorology, hydrology, and equipment maintenance, as well as on topics related to food security, climate change, and sustainable natural resources (land and water) management.

Reliable observed climate data are essential to monitoring past and current weather and climate conditions, producing reliable forecast information, assessing the models' skill, understanding climate variability and long-term changes, and assessing sectoral impacts (agriculture, water resources, and health). Reliable climate information could, therefore, help build resilience against the negative impact of climate change and improve people's livelihood.

A significant amount of resources invested in such areas, however, have produced limited impacts as their interventions are implemented on a small scale, not tailored to end users' needs and often in-uncoordinated fashion that prefers working in a silo. Hence, much of the knowledge, tools, methods and practices produced by these institutions are merely accessible and/or difficult to be understood by the end-users. Strong multi-institutional and multi-stakeholder collaboration that promotes knowledge-sharing platforms and strengthens the capacities of institutions and stakeholders are, therefore, critical to best use their efforts and benefit the end-users.

In recognition of the stated gaps, (*in alphabetical order*) the Africa Climate Policy Centre (ACPC), African Development Bank, the African Ministerial Conference on Meteorology, Food and Agriculture Organization, United Nations Development Programme, World Bank, WMO, and organized a regional workshop in 2017, Saly, Senegal, and discussed the need for a coordinated effort in scaling-up weather-, water- and climate-service delivery in Africa. Workshop participants proposed a common Saly roadmap[2] committed to the regional alliance that promotes knowledge-sharing platforms and builds synergies among key stakeholders in the continent.

As a follow-up to this call, the ACPC and its partners – such as the CGIAR Climate Change, Agriculture and Food Security (CCAFS) program – have taken tangible steps to strengthen the South-South technical knowledge exchange and learning platforms in Africa. In this platform, invited institutions bring key messages, lessons, best practices, peer learning, and recommendations from their own initiatives and share them with others. For instance, under the auspices of the Weather

[2] https://www.sasscal.org/regional-stakeholder-coordination-workshop-defining-a-common-roadmap-for-scaling-up-the-delivery-of-weather-water-and-climate-services-in-africa/

and Climate Information Services for Africa (WISER)[3] initiative, the ACPC and its partners conceived a series of knowledge exchange workshops that led to the production of the document(s) that identified best practices of the African Regional Climate Outlook Forums (RCOFS) processes. Experts from the Intergovernmental Authority on Development Climate Prediction and Application Centre (IGAD-ICPAC), the Central Africa Centre for Application and Climatological Forecasting (CAPC-AC), Agrometeorological, Hydrology, Meteorology (AGRHYMET) Regional Center, the African Centre of Meteorological Applications for Development (ACMAD) and the Southern Africa Development Community Climate Services Centre (SADC-CSC) participated in subsequent workshops. The contributions of these experts were later reviewed, and inputs from National Meteorological and Hydrological Services (NMHSs), regional economic commissions (RECs), and the WMO were captured in the document(s). Climate scientists from two RECs – the East African Community and the Economic Community of West African States (ECOWAS) also participated.

Such a compendium of best practices is a valuable contribution to ongoing efforts to encourage investment in the production, analysis, and uptake of climate information services to support development policy and implementation in Africa and ultimately build climate-resilient societies, ecosystems, and economies in the continent.

A regional workshop was also co-organized by the ACPC-WISER, CCAFS, ICPAC and WMO-ROA in Victoria Falls to establish a multi-institutional and multi-stakeholder dialogue and knowledge-sharing platform in Zimbabwe, where ICPAC experts shared knowledge on objective seasonal forecasting in the agriculture and food security sector. The workshop brought together more than 50 experts from NMHS, RCCs, Research Institutions, Agricultural and Food Security institutions, and relevant actors from 15 Southern, Eastern, and Horn of Africa nations.

One of the recommendations from the above two knowledge/experience sharing workshops was to up-scaling good practices on RCOFS, objective forecasting, climate predictability tool, and coproduction approaches developed/adopted by one RCC to other RCCs/institutions that reside in different corners of the continent. In this planned knowledge-sharing initiative, the Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA-ESA) and its partners brought experts from two regional RCCs, ICPAC and AGRHYMET, to take part and learn from each other best practices. ICPAC is a climate center accredited by the WMO to provide climate services to 11 East African countries to create resilience in a sub-region deeply affected by climate change and extreme weather. The center provides services in a wide range of areas, including environmental monitoring, capacity building, climate forecasting, disaster risk management, water resources, climate information dissemination, agriculture and food security and climate change on various spatio-temporal scales. Likewise, the AGRHYMET is a specialized institution of the Permanent Interstates Committee for Drought Control in the Sahel (CILSS) that encompasses 17 countries from West Africa and the Sahel. It involves training and provision of adequate equipment for the hydro-meteorological station networks. It sets up regional/national multidisciplinary working groups to effectively

[3] WISER was conceived by then DfID now FCDO in 2015 to stimulate the uptake of climate information by policy makers and vulnerable groups including the youth and women.

monitor the meteorological, hydrological, crops, and pastures conditions in the sub-region. Thanks to several initiatives it has been implementing on behalf of the ECOWAS on food security and environmental issues, including climate change, the AGRHYMET's scope of activities now extends beyond the geographical boundaries of CILSS member states to include the whole of West Africa.

Through this planned knowledge-sharing platform for AGRHYMET and ICPAC, both institutions share their best practices and knowledge in the areas of their comparative advantages. Moreover, this knowledge-sharing platform helps professionals build networking, capturing and keeping knowledge while saving money on the cost of training.

# 2. Objective, outputs and format of the workshop

## 2.1. Objectives

The main objecti of this workshop was to provide a platform for ICPAC and AGRHYMET experts to exchange their experiences and build on best practices and ideas along the value-chain of CIS, thereby promoting South-South cooperation between the two institutions. The specific objectives are for these two major RCCs to learn more on:

i. Objective weather and climate forecasting;
ii. Onset forecasting based on daily General Circulation Models (GCM) data from the Copernicus Climate Change Service (C3S) data store;
iii. Coproduction (use and enhancement of products and services);
iv. Monitoring and forecasting on hydrological services, crops and yield and hazards;
v. Data storage and sharing mechanisms between the RCCs and member States;
vi. Regional Coordination of RPCA[4] (Reseau de prévention et de gestion des crises alimentaires and PREGEC[5] (prévention et gestion des crises Alimentaire) in Sahel region,
vii. Monitoring cropping season (climate and weather conditions, desert locust monitoring, phytosanitary monitoring).

## 2.2. Outputs of the workshop

The workshop outputs, among others, include (i) best practices, knowledge and approaches used by AGRHYMET and ICPAC identified and documented; (ii) the capacity of experts enhanced; (iii) South-South cooperation and learning between these two institutions strengthened; and (iv) action points for future collaboration identified and endorsed.

## 2.3. Format

The meeting began in the morning hours of Tuesday, 28 June 2022, with an official opening by an invited official and a panel discussion encompassing heads or representatives of AGRHYMET, ICPAC, WMO-ROA, ACPC-UNECA, and AICCRA. The experience-sharing sessions were later continued in the remaining hours and days, where live discussions were made on various topics identified by the institutions.

[4] Food Crisis Prevention Network

[5] food crisis prevention and management

### 2.4. Budget

AICCRA met all travel expenses, including accommodation, a round-trip economy-class air ticket, home country taxi costs, airport transfers, COVID-19 test costs, and a modest allowance as per ILRI rates for Addis Ababa, Ethiopia.

### 2.5. Participants

Leaders and senior experts from both AGRHTMET and ICPAC participated in the workshop. Representatives from AICCRA, WMO-ROA and ACPC also attended. The total number was 30.

## 3. Opening session

### 3.1. Welcoming remarks

Dr. James Murombedzi, chief of the African Climate Policy Center (ACPC), welcomed all the participants to Addis Ababa and wished them a successful deliberation.

Dr. Joseph Mukabana, a senior research officer representing the World Meteorological Organization - Regional Office for Africa (WMO-ROA), warmly welcomed all participants to this experience-sharing workshop.

Dr. Dawit Solomon, Program Leader of the Accelerating Impacts of CGIAR Climate Research for Africa Eastern and Southern Africa (AICCRA-ESA), also welcome participants to this workshop and hope that participants will benefit from the South-South experience-sharing workshop.

Dr. Zewdu Segele, representing the Director General of ICPAC – Dr. Artan Guleid, welcomed all participants and conveyed ICPAC's commitment to such a south-south cooperation initiative.

### 3.2. Opening remarks

Mr. Fetene Teshome, Director General of the Ethiopian Meteorology Institute (EMI), officially opened the STEKELI workshop. In his opening statement, he reminded participants that there is a strong consensus among African scientists, policy makers and development practitioners about climate change and its impacts on the economy, society and environment. He referred to the recently released Intergovernmental Panel on Climate Change (IPCC) Six Assessment Report that temperature rises are likely to get higher in Africa, where variability in precipitation patterns and the frequency of extreme weather events and other extreme events are projected to place considerable pressure on the livelihood and economies across the continent.

Responding effectively to these challenges requires, among others, the use of CIS and alignment of interventions with the national and regional strategies on development, poverty alleviation, economic growth and others while increasing resilience to the physical impacts of climate change. For instance, the observational network and related data should be linked to forecasting and warning systems to use modern information and communication technologies effectively. However, the generation, uptake and use of CIS in Africa are relatively low because of the inadequate observational network, lack of trained workforce, weak communication and computational capacity.

He also mentioned the importance of organizing an experience-sharing workshop in addressing the above challenges as it provides a platform to experts to share their knowledge and best practices in areas of interest such as observation and forecasting, computational and communication, research and modeling, climate information system services and others. In this regard, he applauded the objective of the STEKELI workshop as it provides opportunities to both AGRHYMET and ICPAC experts to exchange their experiences and build on best practices along the value-chain of CIS in Africa. Moreover, the knowledge-sharing platform helps professionals connect with others, perform better, and become stronger while promoting south-south cooperation.

He appreciated all partner institutions for organizing the STEKELI workshop in Addis Ababa. He expressed his hope that participants will learn more from the proposed areas, including objective weather and climate forecasting, hydrological monitoring and forecast, crop monitoring and yield forecast, onset forecasting based on daily GCM data from the C3S data store, regional coordination of RPCA and PREGEC.

Finally, he hoped this kind of collaboration and coordination would continue and expressed his institution's support for AICCRA's effort in this and future undertakings.

## 4. Overview of AICCRA

Dr. Dawit Solomon made an overview presentation on AICCRA. He noted that AICCRA strives to mobilize CGIAR and its partners' science and innovation to benefit agricultural development in Africa through the generation/packaging/sharing of knowledge/tools in the areas of CIS and climate-smart agriculture (CSA).

AICCRA supports One CGIAR and its partners' programs in three agro-ecological zones in Africa most impacted by climate change. The core countries in Western Africa and Sahelian drylands are Ghana, Senegal, and Mali; in Eastern Africa, dry lowlands to highlands (Ethiopia, Kenya) and in Southern Africa, drylands (Zambia). However, cross-border spill over, cross-regional spillover and South-South collaborations are expected within and between the three regions. Hence, AICCRA is serving as one of the mechanisms for the World Bank and One CGIAR to collaborate and respond to some of Africa's agriculture and climate-related challenges.

He mentioned that AICCRA is fulfilling its role by implementing various activities under three major components: (1) Knowledge generation, technology and service sharing; (2) Partnerships and capacity for delivery; and (3) CIS and CSA technology promotion, delivery and inclusive access to facilitate scaling. Accordingly, ACCRA's Component 1 envisaged to achieve, but not limited to, developing an integrated national agricultural-data hub, strengthening national ag-extension systems and digitally-enabled, contextualizing and dissemination of CIS, ag-advisories and CSA packages to partners and end-users and supporting policy options for a broad-scale adoption of CIS, ag-advisory and CSA.

The second component aims at enhancing national capacity for Next-gen weather forecasting, data generation, visualization and archiving developed and enhanced; strengthening of National Framework for Climate Services (NFCS); strengthening users' capacity on CSA technologies and practices; supporting Africa-wide and regional events and initiatives informed by outputs and outcomes from AICCRA using cross-regional and South-South learning.

The third component is devoted to scaling up strategies for validated and customized CIS and CSA packages in priority value chains. It also covers enhancing access to CIS, ag-advisories and CSA packages along the value chains; built capacity on CIS and CSA co-development and scaling; national policies, strategies and programs informed and CIS and CSA investments influenced by AICCRA outputs (i.e., national policies and investment decisions will be informed through AICCRA funded partnerships, outputs and outcomes).

Dr. Dawit also highlighted the significance of AICCRA's components and interventions area.

In his presentation, he stressed the importance of digital climate and ag-advisory services in improving agri-food systems resilience for millions of smallholders, including women and marginalized groups. However, a good enabling environment (policy and investment) and keen country interest in collaboration on institutional and technical capacity development, co-creation and co-development of digital solutions are vital for delivering ACCRA's objectives.

He finally reminded participants that despite positive efforts and improvements, challenges in scale and capacity (human and infrastructure/ technology) and slow-response from some partners constrained AICCRA's ability to realize its full potential. Hence, more investment in digital climate and ag-advisory services and strong and sustained partnerships with private and public sectors are needed to achieve the desired impact at the required scale.

## 5. Panel discussion

The panelists were Dr. Hamadoun Malienne Director-General, AGRHYMET), Dr. James Murombedzi (Chief, ACPC, UNECA), Dr. Joseph Mukabana (Senior Research Officer, WMO-ROA), Dr. Zewdu Segele (Senior Climate Modeler, ICPAC) and Dr. Dawit Solomon (Regional Program Manager, AICCRA-ESA). Some of the important notes taken from the panel discussion were summarized below.

| No. | Major Points Raised | Recommendation/Way forward |
|---|---|---|
| 1 | Funding of the RCC (ICPAC and AGRHYMET): | A sound funding model that supports operations and institutional development shall be developed and engage development partners |
| 2 | Amendment to data provided by ECMWF as a Global Producing Centre (GPC) | The Data from The European Centre for Medium-Range Weather Forecasts (ECMWF) should be free for initial and lateral boundary conditions because they get free data from NMHSs. |
| 3 | Expansion of RCC's model domain | Existing and future model domain needs consideration in case of new member State joining the RECs, e.g., the |

| No. | Major Points Raised | Recommendation/Way forward |
|---|---|---|
| | | ICPAC domain shall include DRC due to the expansion of EAC |
| 4 | Importance of data sharing | RCCs are data repositories for the countries they serve and hence need legal frameworks for Data Sharing with NMHSs using the newly formulated Unified Data Policy. |
| 5 | Strengthening of collaboration between RCCs and academia to enhance weather and climate research | There is a need for a legal framework between the RCCs (who are repositories of data) and academia (who have experts in weather and climate knowledge) to improve fit-for-purpose research |
| 6 | Need for improved Agriculture Crop Yield Forecasting Model | We shall test the existing models using data from demonstration farms for validation |
| 7 | Enhance the Coproduction of climate information services (CIS) | Coproduction of CIS needs working with stakeholders in the CIS value chain to facilitate the generation of user-driven products. |
| 8 | Need to develop RFCS and support NFCS | RCCs need to be involved in developing the RFCS and support the development of NFCSC (NFWWCS) in countries under their Regional Economic Communities (RECs). |
| 9 | Harmonization of Guidelines on the operation of RCOFS to enhance synergy | This can come from WMO and ACPC/CR4D, but the implementation warrants collaboration with AICCRA and other institutions |
| 10 | Organize similar knowledge-sharing platforms and learn from each other | Identify best practices that enhance various model forecast skills and use them as tools for decision-making to enhance food security and boost resilience |

# 6. AGRHYMET

## 6.1. Hydrological services in AGRHYMET

Dr. Abdou Ali, senior hydro-climatologist and head of the Information and Research Department, presented the hydrological services provided by AGRHYMET. He began his presentation with a brief introduction about AGRHYMET's mandate, mission and technical partners. As the institution in West Africa, he noted that AGRHYMET has a regional database covering the 17 CILSS/ECOWAS countries that integrate data from observation networks, field surveys and those provided by different satellites and models. Along this line, he announced that AGRHYMET was recently endorsed by the ECOWAS commission (July 2020) as the RCC for West Africa and Sahel.

As per the mandate, he noted that AGRHYMET collects, processes and disseminates data on food security, water resources management, and combating desertification and climate impacts in the Sahelian zone. It also strengthens technical and scientific capacities through various training schemes, transferring tools and methods adapted to the Sahelian zone, and strengthening interstate cooperation through knowledge-sharing initiatives.

The hydrological services provided by AGRHYMET cover a whole range of services, including supporting the modernization of national hydrological observation networks, collecting and managing hydrometric data in a regional database, producing seasonal hydrological forecasts, and operationalizing water resources monitoring and flood risk forecasting. Moreover, the hydrological services, such as developing hydrological models adapted to the West-African region and their transfer to member States, producing information on the hydrological risk profiles, and producing future scenarios of water resources, are provided by AGRHYMET.

The hydrological services at AGRHYMET use various hydrometric models to forecast floods and monitor water resources in major river basins. These hydrological models, in particular, include SWAT (Soil and Water Assessment Tool), HYPE (Hydrological Prediction for Environment), VIC (Variable Infiltration Capacity), HydroBLOCK (A Field-scale Resolving Land Surface Model), and Using Artificial Intelligence for Modeling.

AGRHYMET conducts important activities related to developing, adapting and transferring hydrological models to member countries for flood forecasting and water resources monitoring in the river basins, especially in non-gauged basins, as an assessment of the impact of future climate change on water resources. It also implements a regional flood risk forecasting system on flood risks given the increasing flood risk in West Africa.

### 6.1.1. Best Practices/Experiences/Lessons

- AGRHYMET established a regional database called HYDROMET to collect and manage hydrometric data from the main river basins. It also supports expertise, tools and equipment to countries in hydrometric data collection and management.
- AGRHYMET is producing seasonal hydrological forecasts for West-Africa river basins and disseminating such products during the two regional climate outlook forums (PRESAGG[6] and PRESASS[7]) to inform the potential risks of the season as well as to provide best-bet advice for the management of water resources during the dry season.
- AGRHYMET collects and provides combined every 10 days data on the main hydrometric stations in the countries and the satellite information on main dams as well as those from hydrological models to monitor the state of water resources, especially in areas without a measurement network.
- AGRHYMET develops and disseminates a monthly monitoring bulletin/newsletter on the agro-pastoral campaign, with a section on the hydrological situation in the region.

### 6.1.2. Questions and answers

Q1. How is the tercile probability of the seasonal hydrological forecasts defined?

- The tercile for the hydrological forecast is defined in the same as for the climate

[6] The Regional Climate Outlook Forum for the Gulf Of Guinea Countries

[7] Regional Climate Outlook Forum for West Africa, Chad and Cameroon.

forecast. The predictand is the time series of the average discharge of the rainy season over a given period (for 1981 – 2020). Then the time is divided into three classes (average, below average and above average). The probability of the tercile is the probability of having the seasonal discharge follow in one of the three classes.

Q2. How are the users engaged in the hydrological forecasting activities?

- The national hydrological staff is participating in AGRHYMET activities exactly in the same way as the meteorologists. For example, hydrologists of all the member countries actively participate in the RCOF.

Q3. How is AGRHYMET getting the hydrological data?

- AGRHYMET obtains hydrological data from national hydrological services on an operational basis. Every ten days, the NHS transmits the hydrological data to AGRHYMET. AGRHYMET is now in the process of having automatic data transmission from hydrometric stations.

Q4. Is the density of the hydrological network homogeneous between countries?

- The hydrological network density is very different from one country to another.

Q5. Is the Seasonal hydrological forecast uses the rainfall forecast as input?

- The answer is no. The seasonal hydrological forecast uses a direct regression between predictors (SST and wind field) and discharge. The skill is generally higher than the rainfall because of the nature of the hydrological variable as integrating the watershed average.

## 6.2. Seasonal forecast and HYPE model for flood forecast

Dr. Hamatan Mohamed, a hydrologist in charge of operational monitoring of water resources, described the approach employed at AGRHYMET to undertake seasonal hydrological forecasts. He said that AGRHYMET evaluates and provides information to member states on the chances of having flow levels in the major rivers above, normal or below the average flow levels for the coming rainy season as calculated over the reference period 1991-2020. AGRHYMET, through its hydrological seasonal forecast work, also forecasted the average flow during the high water period complementary to the climatic forecasts. However, the products provided to member States use a "consensus forecast" rather than what the model says.

Statistical approaches employed to flood forecast involved predictors (*Monthly SST April, May Monthly SST, Zonal wind 850 hpa, South wind 850 hpa, Zonal wind 925 hpa, South wind 925 hpa*), methods (*RLM: Multiple Linear Regression, PCA: Principal component analysis and ACC: Canonical Analysis*) and Predictants (*Mean discharge for the high water period for each station hydrometric station*).

With the HYPE model, Flood forecast aims to provide a hydrological forecasting and early warning system for climate risks in West Africa (1-10 days). Through this, AGRHYMET envisaged regional and national West African institutions and partners to have efficient flood management and forecasting systems.

#### 6.2.1. Best Practices/Experiences/Lessons

- AGRHYMET provides a hazard map and issues an early warning to member states for efficient flood management and forecasting.

## 6.3. Crop monitoring and yield forecasting in West Africa and the Sahel

Dr. Seydou B. TRAORE presented AGRHYMET's work on crop monitoring and yield forecasting in West Africa and the Sahel. In this presentation, he briefly touched on the history of the crop model development and use at AGRHYMET, followed by some typical model outputs and ongoing and future work.
Crop monitoring and yield forecasting use the DHC (Diagnostic Hydrique des Cultures) crop simulation model by which rainfall amount at the start of the season that allows successful sowing date is determined. He said that more focus is given to those zones with late sowing dates relative to the average and the previous year. The analysis of the sowing situation across CILSS member countries is given at the end of July, while the first estimation of potential crop yields is at the end of August. However, the update on crop yields is done every 10 days after that.

The ongoing and future works of AGRHYMET in crop monitoring include prototype testing (tested at AGRHYMET in 2015; outputs used in bulletins since 2016, and mid-season simulation with different rainfall scenarios) and enhancements to improve rainfall estimates (merging Satellite estimates with station data). Estimate the average starting and cessations dates with remote sensing data and coupling with weather and climate forecasting models)

Realizing some of the shortcomings of the DHC model, including limited application in the Sahelian zone (used only for millet crop), underestimation of yields under optimal watering conditions (<1000 kg/ha all the time) and not accounting for photoperiod sensitivity of local crop varieties predominantly used by farmers, AGRHYMET is adopting SARRA-H. See details in the table below.

The SARRA-H[8] model, which is determinist, simple and robust, help to fill the gaps in the DHC model as it simulates both water and carbon balances (more physiologically oriented) for several crop types under different agro-climatic zones. Good results have been obtained with on-station experimental data using local or about-to-be-released millet, sorghum and maize varieties. The parameterization of the SARRA-H model was done under several sites with contrasted agro-climatic conditions and cropping systems (sawing date, nitrogen fertilizer levels,…).

The SARRA-H model can easily be adapted to crop monitoring needs as it provides user interface allowing easy execution of routine tasks (coupling with R), executes at the decadal time step of simulations on crop status and yield prediction, combines the use of historical and current climate data for the prediction, combines several scenarios (crop species and varieties, sol types and depth and its mapping of results.

### 6.3.1. Best Practices/Experiences/Lessons

- AGRHYMET provides information/advise on soil water reserves (at the end of the dekad), water requirements (for remaining crop cycle) and alerts in case of prolonged water deficit (2 successive decadal) to member States.
- AGRHYMET provides analysis of the sowing situation across CILSS member countries at the end of July while the first estimation

[8] the outcome of researches conducted at CIRAD in collaboration with African partners in the framework of international projects (CERAAS, PROMISE, AMMA)

of potential crop yields at the end of August. The update on crop yields is also done every 10 days from end of August thereafter.

| SARRA H model | Crop model specialization | Input maps | Parameters |
|---|---|---|---|
| – Dry cereal crops (millet , maize, sorghum)<br>– Water, carbon budgets, phenelogy<br>– Daily rainfall, meteorological input data from stations | – Ocelet spatial dynamics modelling environment<br>– Same SarraH processes<br>– Gridded and shape GIS input data<br>– Rainfall estimates from satellite (TAMSAT, CHIRPS) | – Soil (FAO, 13 soil types) for estimating available water capacity<br>– Daily TAMSAT rainfall estimates<br>– 10 days ECMWF data (PET, Rg, Tmin, Tmax)<br>– Onset and End of rainy season (map kriged from historical time series) | – 4 fertility levels: very low to potential<br>– 2 soil depths: shallow (60 cm), deep (2 m)<br>– 8 Crop varieties (2 photoperiodic, 3 fixed cycle x 2 cycle length)<br>– 3 sowing date search methods (first rains, early, from end) |

### 6.3.2. Questions and answers

Q1. Is the methodology used for Yield forecasting or Yield Assessment?

- The methodology was initially conceived for crop monitoring and yield forecasting at a regional level and by the NMHSs. But these latest years, since the results are communicated to stakeholders during the PREGEC meetings, some national agricultural statistics agencies expressed their interest in using them as crop yield estimates for areas with difficult access due to terrorism and also because of budget limitations for conducting yield assessment surveys nationwide. So it is also becoming a yield assessment tool for some countries.

Q2. What is the forecast lead-time?

- The forecast lead-time depends on the cycle duration of the crop variety. The simulation starts from the onset date of the season or the given sowing date till crop maturity.

Q3. How is forecast initialization done?

- The forecast is initialized with observed climate variables (Rainfall, Tmax, Tmin, PET and Solar Radiation) from the onset date till the forecast date, and after that using historical data of the same variables till crop maturity

Q4. How do decision-makers use the forecast?

- The forecast results are published in the AGRHYMET monthly bulletins and presented during the PREGEC meetings in September and November that gather decision-makers from all CILSS/ECOWAS member countries. They are also used by the joint yield assessment teams composed of representatives of national governments (agricultural statistics, NMHSs) and international partners (FAO, FEWSNET, WFP, etc.)?

Q5. What is the confidence level of these probabilistic forecasts?

- Suppose the crops are not yet fully matured (August, September). In that case, three forecast results are produced based on the last 30 years' simulations: the 20$^{th}$, 50$^{th}$, and 80$^{th}$ percentiles for above, average or below-average rainfall scenarios. All the results are communicated in terms of anomalies relatively to the last 5 year average, to conform with the practice adopted by the national agricultural statistics agencies. At the end of the rainy season, only one figure is communicated, corresponding to the results of the simulations done with observed climate data.

Q6. Were verification of these forecasts done?

- Yes, some preliminary verifications were done with historical agricultural statistics data before using the model. Also, every year, the crop yield assessment teams that go to the countries take the forecast results to cross-check them with the national agricultural statistics results. Because of the relatively good agreements with their own figures, many national agricultural statistics agencies resort to them to fill the gaps where they were not able to conduct surveys for various reasons

Q7. Which crops are concerned?

- Currently, we parameterized one variety of maize (90 days duration), three varieties of pearl millet (90 days, 120 days and photoperiod sensitive), and three varieties of sorghum (90 days, 120 days and photoperiod sensitive).

Q8. Are there demonstration farms?

- Since the mid-1980s, pilot demonstration projects were initiated in West Africa, namely in Mali, to promote the use of agrometeorological information by farmers for their farming activities. Most recently, in the framework of CCAFS, seasonal forecast information was also communicated to some rural communities in 5 pilot communities, the so-called Climate Smart villages, in Burkina Faso, Ghana, Mali, Niger and Senegal. We are currently pursuing this activity in 3 rural communities in Burkina Faso in the framework of the ClimSA project.

## 6.4. Agricultural Campaign Monitoring

Dr. Seydou B. TRAORE described that AGRHYMET determined the seasonal forecast of rainfall, starting and cessation dates of the rainy season, dry spell durations and maximum river discharges under its work in agricultural campaign monitoring. Moreover, AGRHYMET serves ECOWAS member countries in determining crop water requirement satisfaction indices, vegetation indices derived from earth-orbiting satellites, warning on crop pests and diseases infestations, prediction of potential crop yields using crop models, and publication of Monthly and Special alert bulletins.

Consequently, AGRHYMET provided a range of data and products to the end-users, including ground observation data on rainfall and water levels in rivers and dams; rainfall estimates from satellites (TAMSAT, RFE2, CHIRPS, etc.). It also provides satellite-derived vegetation indices, climate model outputs (*on temperature, radiation, precipitations, evapotranspiration, sea surface temperatures, etc.*); and socioeconomic data on market prices, children's nutritional status and population movements.

It has been an active partner of the PRESAO[9] process since 1998, where AGRHYMET contributes to determining maximum river discharges, onset, cessation, and dry spell lengths, and ACMAD provides cumulative rainfall.

It also plans to merge satellite rainfall estimates with rain-gauge data at the regional level to compute cumulative rainfall (dekadal, monthly and seasonal) at regional and national levels for each of the 17 CILSS/ECOWAS Member States. It further computes rainfall anomalies (dekadal, monthly and seasonal) relative to WMO standard reference periods (1981-2010 and 1991-2020) and specific years. Under the agricultural campaign monitoring, AGRHYMET conducts climate change impact studies using the merged historical time series (i.e., the evolution of monthly and seasonal cumulative rainfall, onset and cessation dates of rainy seasons and simulated crop yields).

#### 6.4.1. Best Practices/Experiences/Lessons

- AGRHYMET provides seasonal forecasts of rainfall, starting and cessation dates of the rainy season, dry spell durations and maximum river discharges to CILSS/ECOWAS member States. It also identifies zones where rainfall at the start of the season allows sowing, focusing on zones with late sowing relative to the average and the previous year.
- AGRHYMET provides Member States with information on crop-water requirement satisfaction indices for photoperiod-sensitive millet, sorghum and maize crops and root zone water reserves.
- AGRHYMET publishes monthly and special alert bulletins on crop pests and disease infestations, such as favorable conditions in desert locust breeding areas.

## 6.5. Regional mechanism for the prevention and management of food crises (PREGEC)

Dr. Mahalmoudou Hamadoun, Director General of the AGRHYMET Regional Center, presented the Regional mechanism for the prevention and management of food crises (PREGEC). He stated that the history of the Sahel Initiatives for preventing and managing food crisis dates back to 1970-74 when unprecedented famine stroked the region. Consequently, two specialized institutions (AGRHYMET in 1974 and INSAH in 1975) were created to address the adverse effects of drought and desertification and ensure food security in the region. In 1976, the creation of the Sahel Club served as a forum between aid agencies and Sahelian countries. In 1984, the Food Crisis Prevention Network was created by CILSS and S/SC (SWAC). In 1996, the Food Crisis Prevention and Management Project was created and became PREGEC Regional mechanism since 2000.

[9] ACMAD/AGRHYMET/NBA consortium where PRESA GG held for the Gulf of Guinea countries (end of February) and PRESA SS held for countries of the Sudanian and Sahelian zones (end of April)

The RPCA was born in 1984 as a network in recognition of the ill-preparedness of the region to prevent and manage food crises in a coordinated manner. Discussions between the Club, CILSS and their partners were then held around the need for a "NETWORK" to coordinate similar situations in the future better. This network aims to bring the IGOs (ECOWAS, UEMOA and CILSS), regional and international information systems, bilateral and multilateral cooperation agencies, humanitarian agencies, international NGOs, regional professional organizations, civil society, and the private sector together. CILSS endorsed the idea in 1985, and the principles of the PREGEC Charter govern its overall operations.

The regional mechanism for food crisis prevention and management (PREGEC) has established a regional mechanism to prevent and manage food crisis, improve and strengthen existing national mechanisms, monitor the implement the food aid charter and strengthen the food crisis prevention network in the Sahel.

The PREGEC mechanism is a regional monitoring system that includes delegates from CILSS, ECOWAS and UEMOA member countries from national FSN information systems, including early warning system, office of agricultural statistics, market information system, NMHS, crop protection departments, health and nutrition information system, pastoral development departments, National Analysis Units (NAU/CH). Moreover, it has regional and international information systems on food and nutritional security (CILSS, FAO, WFP, UNICEF, FEWS NET, ACMAD), CILSS development partners (European Union, USAID, MIFRAC, CIDA, other cooperation agencies), and international NGOs (ACF, Save The Children, OXFAM, CRS, etc.).

Its functions heavily relied on the expertise of member States through seasonal forecasting in Sahel and Coastal countries, rapid, timely assessments of markets and food security, permanent agricultural surveys carried out in the countries, surveys of household vulnerability to food insecurity, SMART surveys and Sentinel site monitoring (Governments, UNICEF, FAO, WFP, FEWSNET,...), joint annual assessment missions (markets, harvests), satellite imagery, and Multidisciplinary Working Group (GTP) data exploitation.

#### 6.5.1. Best Practices/Experiences/Lessons

- AGRHYMET, in partnership with national, regional and international institutions, put in place a coordinated mechanism to prevent and manage the food crisis in the Sahel/ECOWAS region by improving and strengthening existing national mechanisms and monitoring the implementation of the food aid charter.
- AGRHYMET, together with partners, holds six regional consultations that occur cyclically throughout the year (i.e., the *PREGEC cycle consists of 4 regional technical consultations and 2 RPCA meetings)* to validate the data collected at national and regional levels.
- AGRHYMET established the "*Cadre Harmonise Analytical framework*" to harmonize data collected by different actors and Member States.

## 6.6. WRF Model

Dr. Ibrah SEIDOU SANDA told participants that AGRHYMET acquired a High-Performance Computer (HPC) System for Numerical Weather Prediction (NWP) with WRF model as well as regional ATOVS Retransmission Services (RARS) Antenna for NWP Data assimilation. Both were acquired as part of the ACP-EU programme under the project called Satellite and Weather Information for Disaster Resilience in Africa (SAWIDRA).

The SAWIDRA Project aims at improving the core capacities of AGRHYMET to meet the needs of Disaster Risk Management (DRM) agencies and socio-economic sectors for effective use of weather and climate services and community-focused and real-time early warning systems (EWS) based on the Numerical Weather Prediction (NWP). It also aims to improve the forecast and service-providing capacity of national meteorological and regional climate centers to allow them to provide the proper inputs to the DRM agencies for issuing early warnings.

The HPC infrastructure at AGRHYMET has 2 heads, 2 logins and 1 monitoring, with luster storage nodes (16 compute nodes / 40 cores per node). The interconnect has an Infiniband switch, Gigabit Ethernet for management, Intel Parallel Studio 19.1 and GNU Compilers. The High-Performance Lustre storage capacity is 460 TB, with Red Hat Enterprise Linux Server 7.9 for HPC, Bright Cluster Manager/SLURM workload Manager, and Checkmark for monitoring.

Regional ATOVS Retransmission Services (RARS) Antenna was acquired and installed in AGRHYMET in 2021 (in collaboration with EUMETSAT) and became fully operational (*near real-time acquisition of polar-orbiting satellite data*). The data is assimilated in WRF to improve the short-range forecast.

AGRHYMET runs WRF configuration 4.3 compiled with parallel NetCDF are used over West Africa in two resolutions – 3 km (2000 x 1200 grid points, 45 levels) and 12 km (500 x 400 grid points, 45 levels). One daily run is made for 24 h forecast at 3 km resolution (init: 00H) but 72 h forecast at 12 km resolution (init: 00H).

As the next step, AGRHYMET planned to determine the best configuration for West Africa and implement an ensemble forecast at a coarser resolution (9 ~ 12 km). WRF is used for operational forecasts (daily/weekly/seasonal), and AGRHYMET is prepared to use it for other operational models (hydrology, crop models, etc.).

One of the challenges is converting the data from the RAR antenna into a format usable by WRFDA. Other challenges are the frequent down time of the system, the internet speed and stability and the cost of the licensing of the software. Internet stability and speed, frequent system downtime, and licensing are additional challenges. In the future, the cluster will be migrated to free and open-source software.

### 6.6.1. Best Practices/Experiences/Lessons

- Converting the data from the RAR antenna in a format usable by WRFDA is a challenge that AGRHYMET has faced, suggesting that the provision of equipment by different donors shall be made by considering compatibility with the existing system.

### 6.6.2. Questions and answers

Q1. What are the security measures you have taken to protect your cluster?

- We have implemented pass-wordless access with public/private key authentication. We have also installed fail2ban to prevent brute force intrusions.

Q2. What is the size of your HPC team?

- The team is composed of 2 people: one for the IT aspects and one for the scientific and modeling aspects.

Q3. What is your setup to prevent power failures?

- We have acquired two UPS and one generator. Each of the 2 redundant power supplies of the HPC is powered by a different UPS. The two UPS are connected to the grid power. The generator supplements the grid power.

Q4. Have you checked the format of the radiance data? Because WRFDA can assimilate many formats of data format. Before trying to assimilate radiance data, you should try to assimilate conventional data first to ensure that the program is running smoothly.

- The assimilation of conventional data has been tested and runs smoothly in WRFDA. The format of the satellite data we are acquiring is BUFR, with tables specific to ECMWF. WRFDA can assimilate only PREPARED BUFR (prepbufr), a unique BUFR format used by NCEP. We still have the challenge of converting our data into a format WRFDA can ingest, and we will be pleased to be assisted on the subject.

## 6.7. Operational Weather and Climate Services

Dr TINNI HALIDOU Seydou said that AGRHYMET contributed to dekadal (10 days) briefing on weather and climate. Accordingly, it informs member States about dekadal cumulative precipitation and anomalies (including in remote areas). Rainfall Estimate (RFE) version 2.0 is used to estimate precipitation better.

As to the procedures followed to develop seasonal climate forecasts over West Africa and Tchad, the Regional Climate Centre for West Africa and the Sahel (RCC-WSA) produces monthly seasonal climate forecasts of precipitation and temperature from global circulation model outputs and observational data (CHIRPS, CAMS). CPT is used for statistical-dynamical analyses and produces model and forecast performance maps. The CPT uses merging data with satellite data and with station data.

The forecasts and the performance maps are obtained by following the procedure. Predictors are the data from the global climate center models available on the IRI or the NCEP websites[10]. These data are essentially the hindcasts and forecasts data of ocean surface temperature (SST), precipitation and temperatures at 2m from the ground (temp2m). For the North American multi-models, which are open access, these are the data from the models: nmme, ncar_ccsm4, nasa, gfdl, cmc2, cmc1, cfsv2. Predictands: are essentially the data observed either at the observation stations, the data estimated by satellites, or the merging data. Satellite data are obtained by downloading them from

[10] https://ftp.cpc.ncep.noaa.gov/International/nmme, https://iridl.ldeo.columbia.edu/SOURCES

TAMSAT, CHIRPS, etc. AGRHYMET used CHIRPS data for estimated precipitation and CAMS data for temperature through the CPT tool.

#### 6.7.1. Best Practices/Experiences/Lessons

- AGRHYMET contributes to Dekadal briefing on weather and climate (Current vs. normal decadal ITF position and RFE accumulated precipitation (mm).
- AGRHYMET contributes to the NFCSs in West African countries, supports the setting up of the NFWWCS in Mauritania as well as  provides support to the operationalization of Burkina Faso the NFCS
- AGRHYMET has defined a procedure for developing seasonal climate forecasts during RCOFs, but the forecasts are based on consensus.

### 6.8. ECOAGRIS " Integrated Regional Agricultural Information System" platform

The ECOAGRIS platform[11] serves as an information portal on food and nutrition security in the Sahel and West Africa by improving the quality of information to support decision-making for better response to food and nutrition crises in the ECOWAS/UEMOA/CILSS region.

The ECOAGRIS database contains sub-information systems by sector, and each sector has several indicators. Each subsystem is composed of a set of indicators, and these indicators are defined by regional and national actors through consensus. The sectors (number of indicators) included in the ECOAGRIS platform are early warning (14 indicators), agricultural production (24), agricultural and livestock market (29), breeding (38), fishing and aquaculture (19), agricultural research (5), agro-hydro-meteorology (13), climate change and natural resources (17), macroeconomics (26), agricultural inputs agricoles (22), nutrition (19) and food stocks (6).

ECOAGRIS has technical architecture at the regional level (CTR) and national level (CNE).

The Software architecture for data flow in ECOAGRIS comprises a regional system (to validate country data and publish on the portal), a country system (validation of data entered by the sectors) and a sectorial system (validation of data entered by the sectors). Overall, it has four regional servers at Cloud, AGRHYMET, ECOWAS and UEMOA.

AGRHYMET is working towards ensuring the operationalization of the platform (availability) by making a sustainability plan so that the different tasks of focal points are included in their daily activities and popularize the platform beyond the CNE. AGRHYMET continues to populate the platform and advocate with countries for ownership and sustainability of the platform (by having ECOAGRIS political day to promote the platform as a decision-making tool).

#### 6.8.1. Best Practices/Experiences/Lessons

[11] http://www.plateforme-ecoagris.net/

- ECOAGRIS platform validates data entered by the countries and sectors at various levels by engaging all responsible bodies through consensus.
- ECOAGRIS platform considers thirteen (13) critical sectors and a range of indicators to support response to food and nutrition crises in the ECOWAS/UEMOA/CILSS region.

# 7. ICPAC

## 7.1. Dynamical forecasting techniques and products

Dr. Zewdu Segele, a Senior researcher at ICPAC, presented their experiences with dynamic forecasting techniques and products. He mentioned that the Weather Research and Forecasting Model (WRFv4) Advanced Research – WRF dynamical core – is used for weekly tropical cyclone and intra-seasonal characteristics forecasts. The WRF model at ICPAC runs weekly to produce the weather/weekly forecasts at 10km resolution (Hourly to daily outputs) and generate intra-seasonal rainfall characteristics at 30km resolution (including the start and withdrawal of season and wet/dry spells at the beginning of rainfall season). WRF also tracks the cyclone's path when a tropical cyclone develops in the nearby ocean.

WRF is also used for operational deterministic weekly forecasts. On a shorter time scale, ICPAC provides early warning information every week, and such forecasts are based on the WRF model runs. The type of early warning information provided are rainfall totals; extreme temperatures (min/max, experimental heat stress); extreme rainfall exceeding the 90, 95, and 99 percentiles; and surface winds.

Under Deterministic Tropical Cyclone Forecasts, WRF is run for tropical cyclone track forecasts in spring and fall when they occur (forecasts include trajectory, landfall, rainfall, wind, etc.).

ICPAC provides deterministic heat stress products based on WRF outputs, as it is an emerging environmental hazard exacerbated by global warming and environmental degradation. Deterministic heat stress products from WRF outputs use temperature and humidity as input variables.

ICPAC also does operational onset, dry spell, and wet spell forecasts for the Great Horn of Africa (GHA) sub-region. Forecasting the GHA seasonal rainfall during their different phases is important for providing agro-advisory guidance to the agricultural community, as 75% of the labor force in the region is involved in a smallholder, rain-fed agriculture. Hence, ICPAC is working to provide information to make a science-based decisions for end users. For instance, knowledge of the beginning of the rainy season (onset of the rainfall) is key for making strategic decisions, such as the time of planting, the crop varieties and the choice of crop to plant.

WRF Simulations for onset use several (e.g., MAM 2022 season 34) ensemble members and are completed. These simulations use the CFS2v[12] global forecast as initial and boundary

[12] It is the NCEP version 2 coupled forecast system model and is one of the participating models in the NMME project (http://www.cpc.ncep.noaa.gov/products/NMME/)

conditions to give a better glimpse of the future and its uncertainties. The model has 30km x 30 km horizontal and 40 VR. Rainfall outputs are given in two variables: RAINC and RAINNC from convective and microphysics schemes. All ensemble simulation files are under a specific directory on the ICPAC forecast HPC.

WRF simulation is used to compute onset[13] and dry or wet spells anomalies. In order to compare the predicted onset with the historic 30 years of WRF simulations (driven by reanalysis), we will need the exact onset parameters. In this regard, various techniques are utilized to calculate onset, including thresholds on accumulated rainfall, anomalies, and percentage cutoff. For the operational seasonal rainfall onset forecasts, the threshold on accumulated rainfall technique is used at ICPAC. Hence, the search for onset begins 15 days before the anticipated start of a rainy season.

Onset/Cessation criteria and associated parameters include ***rainzero (float)*** – Threshold for determining dry and wet days (Default is 1.0 mm); ***rtrsholdend (float)*** – Threshold of cumulative rainfall amount over a defined ("numraindays") number of days for onset to occur (Default is 20. mm); ***numraindays (integer)*** – Number of rainy days in which "rtrsholdstart" amount of rainfall is required to be observed (default is 3 days); ***ndayafteronset (integer)*** – Number of days after onset during which a dry spell of "limnorainafter" is counted to determine whether there is onset or not (default is 21 days); ***limnorainydayafter (integer)*** – Maximum length of a dry spell after onset allowed within a period of 'ndayafteronset' for onset to occur (default is 7 days). Key steps for onset analysis are given in the Table below.

#### 7.1.1. Best Practices/Experiences/Lessons

- ICPAC provides early warning information (such as rainfall totals; extreme temperatures (min/max, experimental heat stress); extreme rainfall exceeding the 90, 95, and 99 percentiles; and surface winds) every week to member States based on the forecast using the WRF model.
- ICPAC organizes relevant capacity building to support operational sub-seasonal forecasting at Met Services, where most of the post-processing work is being harmonized using the ICPAC's HPS.
- ICPAC's work provides various deterministic forecast products such as weekly forecasts, tropical cyclone, heat stress, and operational forecasts on the onset, dry spell, and wet spell.
- ICPAC provides reliable and actionable forecast information on the intraseasonal oscillation of rainfall to better support decision-making in the agricultural sector.

[13]Onset, at ICPAC, is defined as the first day of the wet season when a wet spell of accumulated rainfall in 3 consecutive days is at least 20 mm and there is no dry spell of at least 7 days in the next 21 days.

Table 1. Key steps for onset analysis

| Step | Commands to execute at shell prompt | Function |
|---|---|---|
| 1. | ssh –Y country@197.254.1.14 | Login to country account |
| 2. | cd COF60/wrf/CLIMATOLOGYONSET | Change directory, to wrf, to directory to conduct interseasonal characteristics on WRF hindcasts |
| 3. | vi zEditCLIM.sh | Edit the file and set onset thresholds |
| 4. | ./onsetsubmit.sh. | Run the shell script to calculate climatology |
| 5. | cd ../MAMensembleAnalysis | Change directory to work on current WRF forecast |
| 6a. | vi WRF_ensembleDailyRain.ncl | confirm if the season is correct and the COFID is COF60 |
| 6b. | ncl WRF_ensembleDailyRain.ncl | put together ensemble members of all WRF rainfall forecast data for period of interest |
| 7. | cd calculateOnset | Change directory to calculate Onset |
| 8a. | vi zEditWRF.sh | Confirm that onset thresholds |
| 8b | ./onsetsubmit.sh | |
| 9. | cd ../ | |
| 10a | vi zAnomOnsetEnsembleFromData.ncl | plot onset statistics and change COUNTRY (if) |
| 10b | ncl zAnomOnsetEnsembleFromData.ncl | |

### 7.1.2. Questions and responses

Dr. Titike, project leader at ICPAC, highlighted some good practices of weekly cyclone and intraseasonal forecast procedures and products at ICPAC using the Dynamical Regional Climate model. Then, it was followed by an answer and question session:

Q1. On tropical cyclones, there was a question about whether ICPAC considers tropical cyclones over the Southwest Indian Ocean and how ICPAC links with SADC on this specific work.

- Mr. Anthony M. Mwanthi, a climate modeling assistant at ICPAC, responded that the vortex-tracking WRF model operated at ICPAC covers both the northern western (Arabian Sea) and Southwestern Indian Ocean that recently faced devasting cyclones. Cyclone monitoring and forecasting is a good area of knowledge exchange and collaboration between IGAD and SADC since cyclones that make landfall in the SADC region influence the weather in the IGAD region. Another area that can be strengthen was the link between ICPAC and universities. Although it was noted that through projects such as SCIPEA, WISER and CLIMSA, there has been working collaboration between ICPAC and academia, this collaboration has only been targeted to project deliverables/activities.

There is, therefore, a need for strengthening this collaboration on an institutional basis, not just projects. ICPAC can also learn from AGRHYMET, accredited to provide MSc degrees targeting operational work.

Q2. You mentioned that ICPAC has its own criteria and threshold in defining onset; however, the application onset information might vary across sectors, e.g., agricultural planning requires information on soil moisture conditions, so how do you compromise?

- Dr. Titike responded that we use the threshold on accumulated rainfall technique in the ICPAC operational seasonal rainfall onset forecasts. We consider 20 mm of rainfall accumulated for three days for the definition onset. Our onset threshold targets agriculture with the assumption that 20 mm of accumulated rainfall for three days will provide enough soil moisture for planting. As action points, improving onset forecasting and techniques could be a potential area of collaboration between AGRHYMET and ICPAC. Similarly, AGRHYMET and ICPAC can collaborate to strengthen numerical model development capacity and deliver accurate dynamical regional weather and climate forecasting.

Q3. You have presented the ICAPC activities providing capacity-building training focusing on implementing numerical weather prediction using the WRF model to NMHSs. Do you collaborate with regional universities (e.g., the University of Nairobi ) and provide regional climate modeling training?

- Dr. Zewdu responded that ICPAC works with the University of Nairobi as a consortium of different projects. Dr. Hussen added that ICPAC and the University of Nairobi signed MOU focusing on research and graduate program training. Besides, Dr. Titike said the ICPAC developed tools and capacity in numerical weather prediction and objective seasonal forecasting. ICPAC is exciting to work and share knowledge and tools with universities, where we guarantee the sustainability and improvement of tools and techniques developed through different projects.

Q4. Does ICPAC use the seasonal WRF output for comparison with the objective seasonal forecast based on the downscaled global forecast?

- Dr. Titike responded that ICPAC uses the WRF model only for weekly, cyclone, and intra-seasonal characteristics forecasts. We have not yet used it for seasonal forecasting, but ICPAC will take the recommendation as input for future consideration.

## 7.2. Demonstration of Canonical Correlation Analysis using PyCPT

Ms. Eunice Koech, a climate-modeling assistant, described the Climate Predictability Tool (CPT) used at ICPAC. CPT is a statistical tool developed by the IRI and designed to produce statistical forecasts of seasonal climate using either the output from a GCM or empirical predictors (e.g., observed SSTs, Winds etc.).

The statistical downscaling approach is based on General Circulation Model (GCM) outputs and two calibration methods (linear regression and conical correlation analysis–CCA). Regressing model ensemble mean values against observation at each grid point while the CCA identifies an optimal correlation between GCM-predicted rainfall in the tropics and observed rainfall over GHA.

He said that the statistical forecasts in CPT generally involve three steps (features):

- Seasonal climate forecast model construction is a type of forecasting approach that uses CCA, Principal Components Regression (PCR) and Multiple Linear Regression Model (MLR).
- Performing model validation for evaluating model performance (skill maps).
- Producing forecasts based on probabilistic or deterministic approaches.

He further noted that the PyCPT enables ICPAC to automatically download datasets, automatic calibration and assessment of model skill, automatic forecast generation and automatic model ensemble/NextGen. PyCPT layout including IRI Data Library (*Pycpt_dictionary.py:* Python script that holds the URL links to all your datasets), Main python code (*Pycpt_functions_seasonal.py:*) and Jupiter notebook (*PyCPT_seav1.9.2.ipynb:* to run).

He further describes about the dataset, predictor and predictand Domain, Empirical Orthogonal Functions (EOFs) analysis, CCA modes and model validation-skill analysis in Canonical Correlation Analysis using PyCPT.

The *datasets (Default)* are precipitation, sea surface temperature, moisture flux (UQ VQ) and temperature ($T_{max}$, $T_{min}$, $T_{eman}$), while observation/rainfall are CHIRPS, TRMM, CPC, Station (Restricted) and CRU. But users can add other CPT format datasets in the dictionary.

*Predictor and predictand Domain*: PyCPT allows the user to check the interest domain before downloading the data of the user's predictor and predictand domains. However, CCA is domain-dependent (associated with EOFs), where the best domain for your area and season of interest can be obtained through research.

*Empirical Orthogonal Functions (EOFs) analysis*: CCA is a dimension reduction technique and calculates EOFs of both the predictor and predictand. This reduces the number of variables (dimension) from hundreds to about 10. The X and Y spatial loadings represent the ppt model output and rainfall obs. components respectively

*CCA modes:* Pairs of predictor and predictand fields that explain the highest variance can be easily identified. The first CCA pair (CCA mode 1) explains the highest common variance; the second pair is the pair of patterns that explain the highest common variance while orthogonal to pair 1 and so on.

*Model validation-skill analysis* Provides an easy comparison of skills on a single panel for an array of models where several skill metrics are available (Pearson, Spearman, Rocs (Above, Below, GROC), 2AFC, Ignorance).

#### 7.2.1. Best Practices/Experiences/Lessons

- ICPAC deploys a Python library CPT (PyCPT) as it provides an interface and extra functionalities to IRI's CPT, and it provides ICPAC the opportunity to install it in a local computer for both Windows and Linux OS.

#### 7.2.2. Questions and responses

Q1. What similarities and differences are between the two institutions on CCA?

- AGRHYMET just started trialing the use of a Python-based Climate Predictability Tool (PyCPT). However, they utilize the windows version of CPT. Just like ICPAC, they utilize precipitation model output as the predictor variable and CHIRPS data as the predictand variable. The predictor domain is the global tropics from Latitude 20 degrees south to 20 degrees north. Another similarity is that AGRHYMET, like ICPAC, uses all available hindcast period data to train the model.

### 7.3. Demonstration of linear regression and consolidated objective seasonal forecasts

The presentation by Dr. Hussen Seid Endris (Climate Modeling Expert) gave in-depth information about the importance of linear regression analysis in ICPAC's objective seasonal forecasting. He elaborated to the participants that the regression method used a simple linear regression model linearly linking observations with ensemble averages of GCM reforecasts at grid points. The GCM forecasts become the *"predictor" xt,* and the observations become the *"predictand" yt.* Individual GCM forecast is gridded to rain gauge-merged CHIRPS grid (0.5 lat x lon).

Once the regression coefficients a and b have been estimated from hindcasts (e.g., past 30 years), the model can be used to correct a new forecast xt for t=2022. After the calibration, a Gaussian approximation is applied to estimate tercile probabilities. The mean and standard deviations of hindcast used for a gaussian approximation of tercile forecasts relative to the observed terciles boundaries ($x = \mu \pm 0.43\sigma$). The lower tercile is estimated as $\mu - 0.43$, and the upper tercile is estimated as $\mu + 0.43\sigma$. Forecast probabilities for each category are estimated as a proportion of the cumulative probability of the forecast for a given category.

Leave-one-out cross-validation is used to evaluate the prediction skill of the regression model. It uses an entire model fit to all the data except a single year, then makes a prediction at that year; then skill scores are computed for the new time series data.

For objective seasonal and monthly forecasts, the consolidated multi-model ensemble forecast is developed by combining linear regression results and canonical correlations analysis. The forecast probabilities for each tercile category are estimated separately for each individual model, and then these forecast probabilities are combined.

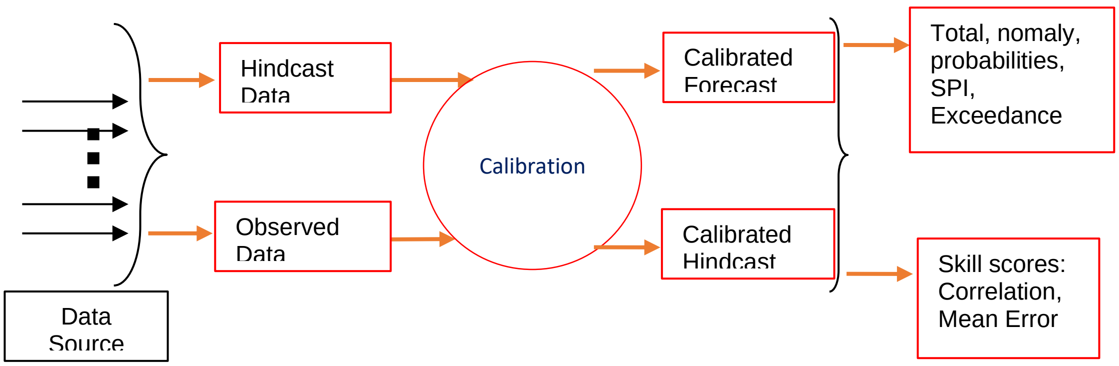
Hence, *objective Forecast = (Reg + CCA)/2*. The linear regression procedure is illustrated in the graph below:

#### 7.3.1. Best Practices/Experiences/Lessons

- ICPAC issues operational seasonal forecasts three times a year during the

Greater Horn of Africa Climate Outlook Forums (GHACOFs). Both linear regression and canonical correlations analysis are combined with having objective forecasting.

- ICPAC started producing an objective seasonal and monthly climate outlook since May 2019 (i.e., the forecast processed and disseminated every month) per the WMO recommendation.




### 7.3.2. Questions and answers

Q1. Could you explain more about how the forecast calibration is done using the regression approach?

- The regression method is based on a simple linear regression model linearly linking observation with ensemble averages of GCM reforecasts at the grid point. In the regression model, the GCM reforecast is considered a predictor and the observation a predictand. Once the regression coefficients (slope and intercepts) are estimated from the hindcast, the coefficients can be used to correct the forecast.

Q2. The size of the hindcast/reforecast data from the global prediction systems is big. How does ICPAC handle the volume of this data?

- Yes, the volume of the hindcast/reforecast data is much bigger than the forecast data size. However, since most forecasting systems have fixed configurations, the hindcast data are downloaded once and stored locally in our cluster until a new model version exists. When this happens, we also download and store them locally. Therefore, we download only the forecast data every month, and they are relatively small.

Q3: How is the skill of the models over the Greater Horn of Africa? Is there an area in the models that perform better?

- The model performance depends on the season and location. Generally, the models have better skills during Oct-Dec (OND) and lower skills during Mar-May (MAM) rainfall seasons. It also appears that models tend to have better skill over the dry areas than the wet areas (for example, over north eastern Ethiopia during the JJAS season).

## 7.4. ICPAC's HPC infrastructure

Mr. Leonard M. Kimotho, IT admin, provided an overview of HPC systems (i.e., usage, system monitoring, security arrangements and maintenance and challenge encountered) at ICPAC. He said that the existing AfDB donates two operational HPCs and WISER, whereas the institution anticipates the arrival of a new HPC through the Intra-ACP ClimSA project.

The AfDB HPC (32 compute nodes and 30 TiB SAN, and 32 GB RAM) was procured in 2017 under the Satellite and Weather Information for Disaster Resilience in Eastern Africa (SAWIDREA) project. In 2019, the WISER HPC (32 compute nodes, 72 TiB SAN, 131 GB RAM) was procured under the WISER programme by DFID/UKAID, while the EU is funding the acquisition of the latest HPC (500 TiB SAN, 256 GB RAM, based on HPE synergy 12000 system) under the Intra-ACP ClimSA project.

The HPC system at ICPAC is being used for operational forecasts (weekly and seasonal), regional NMHSs, climate research (scientific simulations) and training (Pre-COF and occasional trainings for interested parties/stakeholders and other specialized trainings).

The system monitoring includes standard Linux/Unix tools, SunGrid Engine (SGE) and Ganglia where the later system can show other pertinent information concerning the infrastructure.

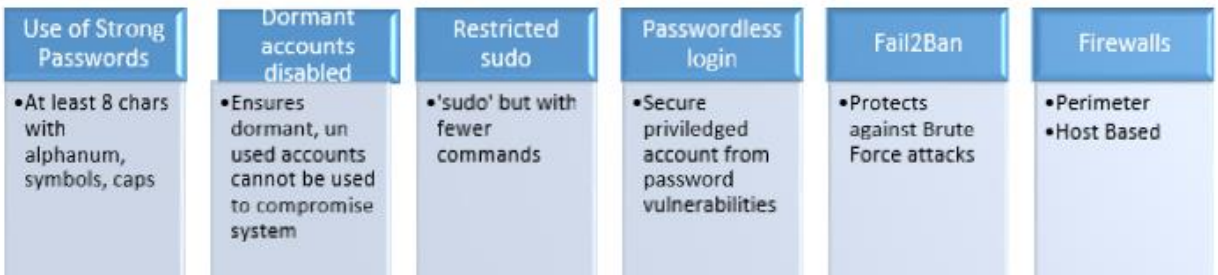
With regard to the operationalization of HPCs, ICPAC has encountered three major challenges such as storage (fills up fast, resort to using quotas where NMHSs set to only 1 TiB), power outages where power backup (Genset) is currently installed and cooling plant outage (rarely happened at a critical time).

Maintenance of HPC at ICPAC involves backup of configuration and user accounts (i.e., monitor logs for suspicious activity), constant monitoring of logs and patching (Operating System Updates and Firmware updates).

The security arrangement is supported by a physically locked rack and restricted access to the server room and involves those mentioned in the figure below.

### 7.4.1. Best Practices/Experiences/Lessons

- ICPAC uses its HPC system at ICPAC to produce operational forecasts (weekly and seasonal) to disseminate to Member States and provides specialized or occasional trainings for interested parties/stakeholders.
- ICPAC's HPC involves constant maintenance and monitoring while its security arrangement is supported by a physically locked rack and restricted access to the server room.
- ICPAC installs RARS Antenna (satellite receiver through EU-funded SAWIDRA project) and tracks all polar-orbiting meteorological satellites (NOAA, EUMETSAT's METOP, CMA FenYun). It enables ICPAC to receive high-resolution satellite data that is assimilated for NWP and the development of severe weather forecasts.




### 7.4.2. Questions and responses

Q1. How many blades does the new system that ICPAC is procuring?

- The new system has 12 blades, each having 4 physical processors. The latest blade technology from HPE favors blade density, i.e., blades with very powerful processing power.

Q2. Are there cost implications in the software ICPAC is using in its HPCs, and how would ICPAC advice AGRHYMET'?

- ICPAC uses only open-source software in its HPC; therefore, there are no cost implications on these. Rocks Cluster is based on CentOS Linux as well as xCAT and OpenHPC.

Q3. How does ICPAC maintain system security while using a public IP address?

- ICPAC has deployed multiple levels of security not only on the perimeter firewall but also on the host-based firewall. This is further enhanced by deploying protection against brute force attacks using Fail2Ban. It is also necessary to use a public IP to enable remote users (NMHSs) to access the system.

Q4. How does ICPAC manage usage by countries?

- NMHSs of member countries each have user accounts on the system. These allow them to log in remotely to carry out their country-specific model runs. Thereafter they retrieve the results. Each country is assigned a storage quota of 1 TiB. This is to ensure fair usage.

Q5. How many staff does ICPAC have dedicated to managing the HPC?

- One staff who is also the ICPAC IT administrator.

Q6. How does ICPAC allocate HPC resources?

- Provision of user accounts is made after authorization from senior ICPAC management. Once authorized, an account is created, and login credentials are shared. Quotas are imposed during the time of creating the account.

Q7. How does the ICPAC IT Administrator manage to handle the workload of both the HPC as well as other ICPAC IT infrastructure?

- It is very demanding. Some management duties have been delegated to other colleagues, e.g., managing the computer labs and the power generator.
- Work time is also divided as 50-50 between the HPC and other IT duties; however, during busy modeling sessions, the Administrator devotes 75-25% between the HPC and other IT duties. However more technical staff would be helpful.

Q8. Can other countries or institutions subscribe to use the ICPAC HPCs?

- The systems were intended for ICPAC and member state NMHSs; however, they can also support other countries or institutions. However, before this can be implemented or approved, it would be prudent to carry out an optimization of the underlying hardware to ensure smooth scaling.

Q9. In case a laptop that has the PKI keys installed is lost, how would the HPCs be protected from unauthorized access?

- This arrangement is only in the IT Administrator's laptop, which is protected by a strong password.
- The arrangement for using PKI keys will be implemented for other users only when it is guaranteed that they can allocate specific workstations for exclusive access to the HPCs. These workstations cannot be used for other purposes.

## 7.5. Coproduction – use and enhancement of products and services

Dr. Calistus Wachana, a researcher at ICPAC, gave a presentation that covered the rationale for the coproduction of climate products and services: realizing the value of the climate information to support decision-making and policy implementation in a highly variable weather and changing environment, introduction to coproduction concepts, ICPAC co-productions benefits and challenges. The ultimate objective is to enable society to manage better the risks and opportunities arising from climate variability and change using science-based climate information.

He noted that the coproduction[14] of CIS in ICPAC intended to provide client-tailored services – including forecast-based advisory services and decision-making by the end user. ICPAC uses various User Interface Platforms (UIPs) to facilitate interactions and enable the climate service actors to come together to develop, deliver and use CIS in support of robust climate-sensitive decision-making. The building blocks of coproduction approaches (co-explore needs, co-develop solutions, co-deliver solutions, evaluate, identify key actors and build partnerships and build common ground from WISER and other ICPAC projects illustrated below.

ICPAC strives to realize the value of CIS by recognizing the knowledge and capacity of users to understand and adapt to the reality of long-term climate change, understanding and using forecasts and probabilities for decision-making, generation of forecasts from local climate knowledge and recording and using climate data – contributing to localized/downscaled information. Moreover, it translates to scenarios that relate to local livelihoods, knowledge and experience, and to levels of uncertainty; listening and responding to locally expressed needs; and making CIS accessible to everyone who needs it (language, communication outreach).

He summarized that ICPAC sees benefits from the coproduction as it opens new opportunities for active collaborations and synergies/peer and cross-disciplinary learning, as well as connects climate services to broader development and risk reduction goals. It also ensures value for money, produces climate information fit for purpose and adapts the products to a specific audience and context as it promotes iterative improvement of user-driven climate services. Furthermore, the

[14] According to Brugnach et al. (2014), co-production defines as "...a process that not only concerns the generation of content or substance, but also how individual actors, groups, or organizations collaborate and organize knowledge” (Brugnach et al. 2014). Co-production of climate services is a deliberate, collaborative product-development work between climate scientists, or producers of climate data, and practitioners, or users who require climate information, including potential or even ‘imagined users’

coproduction attempts at ICPAC helped to build trust and confidence between users and producers of climate information, created an opportunity for user feedback to inform continuous improvement of climate products and promoted efficient and effective communication. ICPAC recognized that coproduction has the potential to mainstream climate services into policy, planning, and decision-making as it engages all actors, puts a focus on decisions and demonstrates how climate information can make a valuable contribution.

The coproduction process has posed some challenges, including a lack of capacity by users to express their demand for products that would benefit them. However, the coproduction process can alter the usual approaches where climate products in the past created at a large scale and often in isolation from their intended users (i.e., most organisations were designed to work in silos).

ICPAC, through its various initiatives, engaged in identifying different lead times for different end users based on understanding the current skill levels and uncertainties in different climate products. However, planning of multi-stakeholder engagement needs time and comes at a cost.

#### 7.5.1. Best Practices/Experiences/Lessons

Coproduction approaches have root in ICPAC's work including

- ICPAC enhances the existing climate products and services and co-produce new climate products and services through the Coproduction of Climate Services for Eastern Africa (CONFER project).
- ICPAC evaluates the performance of WMO IGAD-RCC long range forecasting; climate monitoring; operational data services for supporting LRF& CM; other data services; climate change and climate change projections and provides training on the use of operational RCC products and services by various stakeholders (Intra-ACP ClimSA project).
- ICPAC strengthens decision making levels UIPs such as GHACOFs, Sub- Regional Climate Outlook Forums (IGAD Cluster 1 and 2) and National Climate Outlook Forums (NCOFs) (ACREI Project)
- ICPAC strengthens sectoral UIPs: Food Security and Nutrition Working Group (FSNWG) and supports the establishment of Regional and National Sectoral UIPs for Agriculture & Food Security and Water & Energy (Intra-ACP ClimSa project).
- ICPAC supports the establishment of Regional and National Framework for Climate Services for Eastern Africa region (e.g., for Kenya and Uganda).
- ICPAC develops manual for co-producing climate services-WISER (W2SIP)

*Details of his presentation can be accessed here.*

#### 7.5.2. Questions and responses

Q1. Is there any need for capacity building for the users of climate information to fully participate in the NFCS process?

- All stakeholders involved in establishing and rolling the Regional or National framework for climate services, including users, need capacity building to clearly understand their roles, especially in the engagement and coproduction of climate services. This will help in terms of owning the process and working towards implementing the framework.

Q2. What is the cause the delay in the piloting Regional Framework for Climate Services for IGAD region?

- The delay has been occasioned by WMO delay in sharing the draft guidelines for establishing Regional framework and the

COVID-19 pandemic. The participants asked Dr. Joseph Mukabana, the Senior Research Officer, ROA, to take up the issue to deliver the guidelines.

Q3. What are some of the existing strengths for coproduction and establishing/rolling out National Framework for Climate services?

- WMO/ICPAC support: WMO/ICPAC through Intra-ACP ClimSA project is supporting Kenya, Uganda, and the IGAD region in developing the NFCS and RFCS respectively.
- Impacts of change extremes: most countries in the region face extreme climate impacts such as frequent floods and droughts. The impacts are destabilising the livelihoods and economies of the countries and hence the need for climate services to support resilience of sectors and livelihoods.
- Various Sustainable Development Goals (SDGs): there is increased government and stakeholder's awareness of climate change through various SDGs goals that need climate services for their implementation. In the Government policy review and formulation, the SDGs are referred to; hence, climate has an entry point in the policy formulation.
- The Paris Agreement and Countries National Determined Contributions (NDCs): Most countries in the region have submitted their NDCs which state the adaptation and mitigation proposed in the various sectors of the economy. This services as an entry point of mainstreaming climate service in the key sensitive sectors of the countries
- The COP27: COP27 is being held for the first time on the African Soil and serves as a motivator and rallying call for most African countries to put the climate issue on their development agenda.

Q4. What are some of the existing weaknesses for coproduction and establishing/rolling out National Framework for Climate services?

- Climate products are created at a large scale in isolation from their intended-Most organisations were designed to work in silos
- Capacity and motivation to change and develop new ways of working: users lack the capacity to express their demand for products that would benefit them, or producers (NMHSs) lack the capacity or flexibility to significantly change their services to align to users' needs
- Commitment to mainstream climate services into policy, planning, and decision making: Coproduction has the potential to reverse this trend as it engages all actors, puts a focus on decisions and demonstrates how climate information can make a valuable contribution
- Ensuring ample lead time: Through the coproduction process, the different lead times for the different users can be identified, understanding of current skill levels and uncertainties in different climate products can be built
- Lack of trust in the forecasts
- Complexity of forecasts and meteorological jargon vs. Understanding user needs
- Cost and limited financial resources: Multi-stakeholder engagement is a pre-condition for coproduction but has to be planned for and comes at a cost
- Insufficient sectoral and climate data for enhanced coproduction.

## 7.6. Experiences on data sharing between NMHSs and ICPAC

Recognizing the increasing requirement for the global exchange of all types of environmental data, the WMO proposed various data sharing protocols. These include the WMO resolution 40 (Cg-XII, 1995) – Exchange of meteorological and related data; WMO resolution 25 (Cg-XIII, 1999) – Exchange of hydrological data and products; WMO resolution 60 (Cg-XVII, 2015) – exchange of climate data and products to support the implementation of the Global Framework for Climate Services (GFCS), and WMO Unified Data Policy Resolution – International exchange Earth system data.

The WMO resolution 40 (Cg-XII, 1995) requires free and *unrestricted* international exchange of meteorological and related data and products to provide services supporting the protection of life and property. The two main categories of data are *essential data* (shall be exchanged) and *additional data* (should be exchanged). However, the term "*Free and unrestricted*" exchange is not defined in the Resolution. Moreover, there were substantial challenges in the interpretation and implementation of Resolution 40.

WMO Unified Policy for International Exchange of Earth System Data approved by extraordinary World Meteorological Congress in 2021 to strengthen the world's weather and climate services. It encompasses all WMO-relevant earth system data: weather, climate, hydrology, ocean, atmospheric composition, cryosphere etc. It is clearly committed to free and unrestricted data exchange (term defined directly in the Resolution, literal interpretation). It replaces "*Essential*" and "*Additional*" data (Resolution 40), with "*Core*" data (standard practice, shall be exchanged) and "*Recommended*" data (best practice, should be exchanged). It also includes guidelines for national implementation and public-private engagement. However, there is lack of a regional data-sharing framework – regulation, standard practices/procedures, data formats and legal frameworks – especially on the gridded data. In order to address these challenge, ICPAC through the support of EU funded ClimSA project is holding regional Data Managers Biannual Meetings to assess the impact of existing gaps in climate observing networks and develop a regional climate data sharing framework. A draft regional data sharing protocol is formulated and awaiting endorsement.

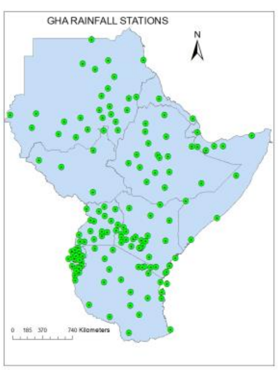
Currently, ICPAC receives *132 station data (Rainfall,* $T_{max}$ *and* $T_{min}$*)* from member states. Out these, 97 are GTS stations (*see the lists in Table below*). This means, most of the observation stations are GTS stations and are used to produce CHIRPS data, leaving ICPAC with very few stations that can be used in the validation process of the merged gridded datsets produced. The number of station observations that ICPAC receive from the member states is insufficient to give the level of detail, as vast sections of the landmass are sometimes not well represented in the respective countries. Moreover, the data received by ICPAC are not in daily timescale rather accumulated ten-daily rainfall. Delays of data from countries also results to late release of climate information to users.

GTS stations are avenues for data sharing (WMO unified data policy resolution) and increasing Automatic weather stations (AWS) in the region have potentials for addressing sparse network challenges that exist in the member countries. Using and sharing satellite data will also greatly increase the potential for better delivery of products and services by the

NMHSs. A regional data-sharing framework is essential, as it will attract, among others, funding opportunities for data rescue and digitization for NMHSs. Moreover, increasing collaboration with private data providers facilitates data sharing while serving as an avenue for more data in the region. In this regard, ICPAC held regional Data Managers Biannual Meetings to assess the impact of existing gaps in climate observing networks and develop a regional climate data-sharing framework. Consequently, a draft regional data sharing protocol is formulated and awaiting endorsement.

### 7.6.1. Best Practices/Experiences/Lessons

- ICPAC produces gridded (merging station and satellite) data at 5km resolution for the region. Blending station data with satellite data is the key to filling the spatial gap and producing regional scale data. The data for GHA comprises of monthly and dekadal rainfall (1981-current) but limited number of stations participate in the blending (>70% of the ICPAC stations are already in GTS).
- ICPAC's gridded data repository established and is available and accessible from ICPAC data Library ([http://digilib.icpac.net/](http://digilib.icpac.net/)). This data library allows users to access, manipulate, and view the data in various formats, visual plots, and save the output. It also allows user to generate climate information for a specific location without interacting with the actual data.
- ICPAC applies gridded data to monitor current and past weather and climate conditions. Accordingly, it provides weather and climate monitoring products on 10-day, monthly, and seasonal time scale.
- ICPAC formulates a draft regional data sharing protocol/framework and is awaiting endorsement to attract funding opportunities for data rescue and digitization for NMHSs and facilitate daily weather data exchange.
  *Details of his presentation can be accessed here* .




**Status of Stations shared by members states**

| | Sudan | S. Sudan | Eritrea | Djibouti | Ethiopia | Uganda | Kenya | Tanzania | Burundi | Rwanda | Somalia | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GTS** | 19 | 5 | 1 | 1 | 17 | 12 | 12 | 15 | 2 | 7 | 6 | **97** |
| **Before request** | 25 | 5 | 1 | 1 | 17 | 16 | 26 | 15 | 2 | 14 | - | **122** |
| **After request** | 25 | 3 | 0 | 1 | 17 | 16 | **41** | 15 | 0 | 14 | 0 | **132** |

Comment from Dr. Mukabana, he appreciated ICPAC's effort in formulating the data sharing protocol with NMHSs. He noted that the data sharing protocol/framework is an important mechanism to enhance the weather and climate data access between RCCs and NMHS.

### 7.6.2. Questions and answers

Q1. What is current practice in data transmission between NHMSs and ICPAC? Is the data transmitted manually or automatically?

- Currently, the data sharing practice is through email, but ICPAC is working towards an automated data transmission system.

Q2. AGRHYMET is having trouble in transforming and utilizing the data from RARS antenna. Is ICPAC currently utilizing the data received from the RARS antenna, and for what purpose ICPAC planning to use this data in future?

- The RARS anntena enables ICPAC to receive high-resolution satellite data that will be assimilated for numerical weather prediction and developing severe weather forecasts. At ICPAC, data from RARS antenna is being received from polar orbiting satellites for the past one year. However, we have not yet started using the data in our operational work. We will be able to use this data once can convert them to a usable format.

Q3. It seems that the number of station data that ICPAC currently receives from NHMHs are few given the region's area coverage. Some countries have a good network coverage. For example, Ethiopia has more than 900 stations. What's ICPAC's plan to get access to more station data? How can AICCRA project support in this data sharing protocol?

- Yes, the number of stations we are currently getting from NMHSs are very few, and most of these observations are GTS stations. We understand this is a major gap and are currently working with the data managers of NMHS on the data sharing protocol. We believe that the data sharing protocol will allow ICPAC to access more station data, and AICCRA's support to the approval of the protocol by PRs will be instrumental.

## 8. Action Points

| No. | Action points to be followed by the organizing/participating institutions |
|---|---|
| 1 | Maintain collaboration between AGRYMET and ICPAC on the SARAH-H model to implement it in the IGAD region |
| 2 | Harmonize efforts and S-S learnings between hydrology, ECOAGRIS, IFRAH, FSNWG, etc. |
| 3 | Promote experience sharing platform to include multidisciplinary working groups at national, regional and continental levels |
| 4 | Arrange a platform to continue the discussion on the definition of "onset" for agriculture that can be used in both RCCs |
| 5 | Coordinate capacity-building training on Meteorology in west African countries (in particular with the EMI) |
| 6 | Establish a framework to harmonize PRECOFs and RCOFs approaches across Africa |
| 7 | Collaborate on the hydrological forecast (stream flow and discharge, WRF-hydro,...), R-package for forecast verification and cyclone |
| 8 | Arrange training to AGRHYMET on objective seasonal forecasting to be used in the SAHEL region |
| 9 | Focus to be given to monitor desert locust |
| 10 | Strengthen HPC-collaboration to capitalize on a set of best practices |
| 11 | Provide support for the development and implementation of the RFCS and NFCS |
| 12 | Improve coproduction of CIS to strengthen decision making process |
| 13 | Harmonize tools and methods on seasonal and sub-seasonal forecasting |
| 14 | Sign a strategic framework (MoU) between the two institutions |
| 15 | Promote a science-policy linkage |

## 9. List of participants

The photo of participants and conference proceedings is found in the AICCRA Flickr link.

| No. | **Name** | **Institution** |
|---|---|---|
| 1 | Bahaga, Titike Kassa | ICPAC |
| 2 | Addah Magawa | AICCRA-ESA |
| 3 | Hussen Seid | ICPAC |
| 4 | Leonard Kimotho | ICPAC |
| 5 | Eunice Koech | ICPAC |
| 6 | Anthony Mwanthi Musili | ICPAC |
| 7 | Zewdu Segele | ICPAC |
| 8 | Calistus Wachana | ICPAC |
| 9 | Abdou Ali | AGRHYMET |
| 10 | Mahalmoudou Hamadoun | AGRHYMET |
| 11 | Mohamed Hamatan | AGRHYMET |
| 12 | Oumarou Moullaye | AGRHYMET |
| 13 | Seidou, Sanda Ibrah | AGRHYMET |
| 14 | Tinni, Halidou Seydou | AGRHYMET |
| 15 | Traore, Seydou | AGRHYMET |
| 16 | Zougmore, Robert Bellarmin | AICCRA-WA |
| 17 | Fetene Teshome | EMI |
| 18 | Brook Makonnen | AICCRA-ESA |
| 19 | Yosef Amha | AICCRA-ACPC |
| 20 | Tamirat Bekele | AAU |
| 21 | Amanuel Melesse | ACPC, UNECA |
| 22 | Tariku Agoji | ACPC, UNECA |
| 23 | Gezahegn Shiferwa | TCND, UNECA |
| 24 | Adeladay Solomon | ACPC,UNECA |
| 25 | Joseph Mukabana | WMO-ROA |
| 26 | James Murombedzi | ACPC,UNECA |
| 27 | Ambaw, Gebermedihin | AICCRA-ESA |
| 28 | Ayalneh Mulatu | AICCRA-ESA |
| 29 | Dawit Solomon | AICCRA-ESA |

## 10. Workshop agenda

**Title: South-South Technical Knowledge Exchange and Learning Initiative (STEKELI) Workshop**
**Date: 28-30 June 2022**
**Venue: The United Nations Conference Center (UNCC), Addis Ababa, Ethiopia**

| **DAY 1 Session I: 28 June 2022** | | | |
|---|---|---|---|
| **Time** | **Events** | **Responsible** | **Chair** |
| **08:30 – 09:00** | **Registration** | AICCRA team | |
| **09:00 – 09:05** | **Welcoming Remarks** | Dr. Dawit Solomon (Regional Program Manager, AICCRA-ESA) | Dr. Robert Zougmoré (AICCRA-West Africa Lead ) |
| **09:05 – 09:15** | **Official Opening** | Mr. Fetene Teshome (Director General, Ethiopian Meteorology Institute) | |
| **09:15 – 09:30** | **Introduction of Participants** | Participants | |
| **09:30 – 09:45** | **Overview of AICCRA and related projects** | Dr. Dawit Solomon (Regional Program Manager, AICCRA-ESA) | |
| **09:45 – 10:30** | **Panel Discussion**<br>*Why do we need such knowledge-sharing platform in Africa and what do you recommend for future collaborations?* | Dr. James Murombedzi (Chief, ACPC, UNECA)<br>Dr. Joseph Mukabana (Senior Research Officer, WMO-ROA)<br>Dr. Zewdu Segele (Senior Climate Modeler, ICPAC)<br>Dr. Hamadoun Malienne Director-General, AGRHYMET)<br>Dr. Dawit Solomon (Regional Program Manager, AICCRA-ESA) | |
| **10:30 – 11:00** | **COFFEE/TEA BREAK (Group Photo)** | | **Organizers** |
| **DAY 1 Session II: 28 June 2022 - ICPAC and AGRHYMET Technical Meeting** | | | |
| **11:00 – 13:00** | **Hydrological monitoring and forecast**<br>**Crops monitoring and yield forecast**<br>**Discussion** | Dr. Abdou Ali<br>Dr. Seydou B. TRAORE | Dr. Yosef Amha (Researcher, ACPC-AICCRA) |
| **13:00 – 14:00** | **Lunch** | | **Organizers** |
| **DAY 1 Session III: 28 June 2022 - ICPAC and AGRHYMET Technical Meeting** | | | |
| **14:00 – 15:30** | **Introduction to Objective Forecast components:** | | |

| | | | |
|---|---|---|---|
| | 1. Introduction to ICPAC's Consolidated Objective Seasonal Prediction<br>2. HPC Management at ICPAC<br>3. CCA through PyCPT<br>4. Linear Regression and Consolidated objective seasonal forecasts including probability of exceedance and SPI;<br>5. Demonstration of Logistic Regression for JJAS rainfall forecast using Pacific SST indices predictors (depending on availability of time, the demonstration will include data download on personal MacOS); | | Mr. Tamirat Bekele (PhD candidate, AICCRA-ESA) |
| **15:30 – 16:00** | Coffee/Tea | Organizers | |
| **16:00 – 17:00** | **Objective forecasting** *(…continued….)* | **ICPAC team** | |
| **18:30 -** | **Dinner Program** | | **Organizers** |
| **Day 2 Session IV: 29 June 2022 - ICPAC and AGRHYMET Technical Meeting** | | | |
| **Time** | **Events** | **Responsible** | **Chair** |
| **09:00 – 10:30** | **Onset Forecasting based on daily GCM data from the C3S data store**<br>1. Downloading data (demonstration using C3S data store); Examples of onset determined from different initializations (May vs. June 2022); Procedure to produce deterministic and probabilistic multi-model onset forecasts;<br>2. WRF (Weekly weather forecasts, Tropical Cyclone tracking, seasonally for onset determination);<br>3. Experience on data sharing between RCC and NMHS;<br>4. Coproduction (use and enhancement of products and services). | **ICPAC team** | Dr. Robert Zougmoré (AICCRA-West Africa Lead ) |

| | | | |
|---|---|---|---|
| **10:30 – 11:00** | **Coffee/Tea** | **Organizers** | |
| **11:00 – 13:00** | **Practical** *(...continued....)* | **ICPAC team** | |
| **13:00 – 14:00** | **Lunch** | | **Organizers** |
| **Day 2 Session V: 29 June 2022 - ICPAC and AGRHYMET Technical Meeting** | | | |
| **14:00 – 15:30** | **Regional Coordination of RPCA (Reseau de prévention et de gestion des crises alimentaires** | **AGRHYMET team** | Dr. Yosef Amha (Researcher, ACPC-AICCRA) |
| **15:30 – 16:00** | **Coffee/Tea** | **Organizers** | |
| **16:00 – 17:00** | **(...continued....)** | **AGRHYMET team** | |
| **Day 3: 30 June 2022** | | | |
| **Time** | **Events** | **Responsible** | **Chair** |
| **09:30 - 11:00** | **PREGEC (Prévention et gestion des crises Alimentaire), monitoring of cropping Season (climate/weather conditions, phytosanitary monitoring, desert locust monitoring, crop/yield assessment)** | **AGRHYMET team** | Dr. Joseph Mukabana (Senior Research Officer, WMO-ROA) |
| **11:00 – 11:30** | **Coffee/Tea** | | **Organizers** |
| **11:30 – 13:00** | **General Discussion and Recommendations to facilitate country uptake** | **AICCRA** | Dr. Dawit Solomon |
| **13:00 – 13:30** | **Wrap-up and Vote of Thanks** | | |
| **13:30 -** | **Lunch** | | |
| **For more information, contact:**<br><br>**Dr. Yosef Amha amhay@un.org; Ms Addah Magawa (ILRI) A.Magawa@cgiar.org** | | | |

About AICCRA

Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) is a project that helps deliver a climate-smart African future driven by science and innovation in agriculture.

It is led by the Alliance of Bioversity International and CIAT and supported by a grant from the International Development Association (IDA) of the World Bank.

Discover more at aiccra.cgiar.org

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AICCRA Eastern and Southern Africa is led and hosted by OneCGIAR centers: