WORKSHOP REPORT

West Africa regional training on ENACTS-related capacity for National Meteorological Services and the Regional Climate Centre

JANUARY 2022

CGIAR | AICCRA
Accelerating Impacts of CGIAR Climate Research for Africa

Highlights

1

The AICCRA West Africa cluster in collaboration with AGRHYMET and IRI organized a regional capacity training on ENACTS tools. The Agence Nationale de la Météorologie (ANAM) of Burkina Faso hosted National Meteorological Services as well as the Regional Climate Center (AGRHYMET) experts from two AICCRA and three non-AICCRA countries from West Africa to build their capacity to produce more tailored and real-time climate information and services for decision making.

2

Capacity building focused on the following topics:

- Use of Climate Data Tool (CDT) for data organization, quality control, merging of different datasets, data analysis, and visualization;
- Introduction to IRI's Automatic Weather Station Data Tool (ADT); and
- Use of IRI's Next Generation (NextGen) seasonal forecast system for seasonal rainfall forecast.

1: Introduction, objectives, workshop format, and gender considerations

Introduction

The Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) project is being implemented at national and regional levels in West Africa. The national-level implementation includes Ghana, Mali, and Senegal. The regional level implementation for the ECOWAS (Economic Community of West African States) region (AICCRA-WA) is being led by the Alliance of CIAT & Bioversity, while the International Research Institute for Climate and Society (IRI), the Earth Institute at Columbia University, is involved both at national and regional levels. Most of the IRI activities are centered on capacity development (tools and training) around its Enhancing National Climate Services (ENACTS) program. ENACTS has been implemented in three AICCRA countries in West Africa, and it is being strengthened further through the AICCRA project. In addition, the AICCRA project aims to leverage and capacitate AGRHYMET as a Regional Climate Centre to sustainably capacitate National Meteorological Services (NMS) from the broader ECOWAS region, which will help with spillover. Thus, strengthening ENACTS includes training to enhance ENACTS-related capacities at the NMS from the three AICCRA countries but also from three additional West Africa Food System Resilience Program (FSRP) countries. The capacity building includes the following:

- Use of Climate Data Tool (CDT) for data organization, quality control, merging of different datasets, data analysis, and visualization;
- Introduction to IRI's Automatic Weather Station Data Tool (ADT); and
- Use of IRI's Next Generation (NextGen) seasonal forecast system for seasonal rainfall forecast.

Because the training activities are similar, it made sense to combine the different training activities for the different countries as well as involve the AGRHYMET Regional Climate Centre. This ensures effective use of resources, enables countries to learn from each other, and develops capacity at AGRHYMET. AGRHYMET already had some capacity in ENACTS-related areas, which needs to be strengthened. The trained AGRHYMET staff would support the countries' training activities.

It is in this context that a workshop was organized in Ouagadougou, Burkina Faso, bringing together the AICCRA countries, namely Ghana, and Senegal plus non-AICCRA countries such as Burkina Faso, Togo, and Niger. The workshop was organized in two phases, with the first phase focusing on AGRHYMET training and the second phase focusing on countries' training. Both training phases were centered around the CDT tool and NextGen forecasting system. However, a demonstration of the automatic weather station data tool (ADT) was given during both phases of the workshop.
The training was conducted in English and French.

Climate Data Tool (CDT)

The CDT is an open-source, R-based software with an easy-to-use graphical user interface used for data organization, quality control, combining station data with satellite and reanalysis data, evaluating merged and inputs datasets, performing an array of analyses, and visualization.
The CDT software originated from a collaboration between the International Research Institute for Climate and Society (IRI) and the AGRHYMET Regional Center with the aim of improving the quality and availability of data as

well as their accessibility in West Africa. At the end of the training, participants are expected to pass along expertise and cultivate skills within their respective national meteorological services. IRI and AGRHYMET have already conducted CDT training for different countries in West Africa, and this training strengthened the knowledge of those who were already familiar with the tool while introducing it to participants who were new to it.

Automatic weather station Data Tool (ADT)

This application helps tackle the challenges in accessing and processing AWS data collected by different systems/networks (Vaisala, Edkon, etc.), which are on different servers and in different formats, by enabling data quality control, processing, and visualization. In this training, only an introduction to the tool was given.

The NextGen Seasonal Forecasting Approaches

The NexGen approach is a Python interface to CPT (PyCPT) and has been created as a new and easy-to-use tool. This set of libraries enables the user to run CPT via Python scripts and Jupyter Notebooks, helping automate and mass-produce CPT tasks that will normally take more time in the Windows version. PyCPT forecasts are based on calibration and multi-model ensembling of dynamical model output. The seasonal and sub-seasonal versions of PyCPT provide seamless access to the North American Multi-Model Ensemble (NMME) the Copernicus Climate Change Services (C3S), the Sub-seasonal-to-Seasonal Prediction Project (S2S), and the Sub-seasonal Experiment (SubX) Databases, respectively, via the IRI Data Library. These tools will be important enablers of more "seamless" forecasts that better connect the output of the forecast from Global Producing Centers, with user-defined variables of interest at national or regional. What is more, the outputs could be presented in a more user-friendly flexible format.

Objectives and format of the workshop

The overall objectives of the workshop included:

- Coordinate/synchronize training activities across countries and the region to maximize impact and value for money;
- Build further capacity at the Regional Climate Centers so that they provide technical support to the countries in the region

With the overall objective in mind, the training sessions were organized in two phases allowing to meet the overall objective. The first phase consisted training AGRHYMET staff and the second phase was training for National Meteorological Services staff.

Each training had its general and specific objectives as detailed below:

1. Refresher Training for AGRHYMET on CDT and PyCPT

Some AGRHYMET staff were already familiar with the Climate Data Tool (CDT) and IRI's Next Generation (NextGen) forecasting system that uses Python-based CPT (PyCPT), but refresher training was deemed useful to help these staff to deepen their understanding of these systems and tools. Therefore, IRI provided refresher training sessions. The goal of the AGRHYMET refresher training sessions was to build capacity at the regional level so that AGRHYMET can strengthen and expand ENACTS in the region. With respect to the AICCRA project, AGRHYMET was expected to:

- Support IRI during the national Met services staff training;
- Install the systems (CDT, IRI Data library, and PyCPT) at Ghana Met and Mali Meteo; and
- Coordinate training of relevant staff from Ghana Met and Mali Meteo on these and other areas in collaboration with IRI

i. Refresher training on CDT

CDT refresher training was given to AGRHYMET staff who were already familiar with CDT and who work with the data, with the intention to:

1) Review the use of CDT for data organization, quality control, combining station data with proxies
2) More exploration of CDT's data analyses and visualization functionalities.

An overview of a new tool, AWS Data Tool (ADT) was given. This session lasted 3 days (10th through 12th January 2022).

ii. Refresher training on PyCPT

The refresher PyCPT training was given to AGRHYMET staff who were familiar with PyCPT. The training intended to review both theoretical background and practical skills towards generating high-skill seasonal climate forecasts, using the "NextGen" approach. This session lasted 3 days (13th through 15th January 2022).

2. Training of National Meteorological Services Staff from AICCRA and other Countries

Staff from National Met services of Ghana, Senegal, and 3 non-AICCRA countries were trained on CDT and PyCPT. The non-AICCRA countries included Burkina Faso, Togo and Niger. These served as spill-over countries. CCAFS plans to expand ENACTS to these non-AICCRA countries, and the mentioned ones were the starting point for the spill-over.

These two training sessions (CDT and PyCPT) were conducted in parallel by IRI experts with support from AGRHYMET staff who had been trained in the previous training sessions. During these training sessions, AGRHYMET staff were required to be active and to start interactions with national (countries) Met staff in order to build the relationship and identify champions who would work with AGRHYMET to keep the systems running appropriately.

i. Training on Climate Data Tool (CDT) and Introduction of AWS Data Tool (ADT)

The aim of this training was to provide *advanced* training on the Climate Data Tool (CDT) to national meteorological services staff.

The workshop demonstrated a web-based application called Automatic Weather Station Data Tool (ADT).

The specific objectives of this section were that at the end of the training participants would:

1. Review the different functionalities of the CDT tool
2. Use CDT for data preparation, quality control, combining datasets, validation, analysis, and visualization
3. Understand the use of ADT

This training included people who had already received CDT training before, as well as those receiving this training for the first time. Staff dealing with climate data and climatology were the most relevant to attend this training. This session lasted 5 days (17th through 21st January 2022).

ii. NextGen Seasonal Forecasting (PyCPT)

The aim of this workshop was to provide both theoretical background and practical skills for generating high-skill seasonal climate forecasts, using the "NextGen" approach. Specific objectives included:

1. Reinforcing knowledge of seasonal predictability for West Africa
2. Reinforcing knowledge around seasonal forecast methods including relevant statistical methods
3. Outlining the inputs to the NextGen forecasting system
4. Running PyCPT and explaining how to configure it to make the best forecasts in participants' home country, including forecast verification.

This training session lasted 10 days (17th through 28th January 2022).

Gender Considerations

While sending out invitations to participants, countries were encouraged to consider sending at least one third of the participants being women.

Although this was not possible in all countries, 28% of workshop participants from different countries were women.

2: Workshop process

Participants

A total of 18 participants from 5 Meteorological Services and 13 participants from the Regional Climate Center (AGRHYMET) participated in the workshop. The table below summarizes the participants and the countries they came from.

List of participating countries		
#	Countries	Numbers of participants
1	Senegal *AICCRA country	2
2	Ghana *AICCRA country	4
3	Burkina Faso	4
4	Niger	4
5	Togo	4
6	AGRHYMET	13

Phase I: Training for AGRHYMET

The training took place over 6 days and was provided by Mr. Rija Faniriantsoa, senior collaborator and co-developer of the CDT tool, and Dr. Sylwia Trzaska climate scientist, all from IRI. The different sessions were mostly hands-on with presentations or theoretical demonstrations in between. The time allocated to each training (CDT tool and NextGen) was three days.

Opening Ceremony

The opening of the workshop was marked by four messages from four speakers:

A welcome message was given by the General Director of the Burkina Faso National Meteorology Agency (Agence Nationale de la Météorologie or ANAM) who, after welcoming the participants to the workshop, re-emphasized how glad he was for the choice of ANAM to host these training sessions. To close his remarks, he expressed his open support to participants for any solicitation and reminded everyone to respect the measures against COVID-19.

Dr. Robert Zougmore, AICCRA-WA Leader also welcomed the participants and recalled the context of the implementation of the AICCRA project under the support of the World Bank. He pointed out that AICCRA comes as a follow up to the CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS). The

Photo: Presidium of the opening session of the training

objectives are to strengthen the capacity of targeted CGIAR partners and partnering stakeholders to enhance access to climate information services (CIS) and validated climate-smart agriculture (CSA) technologies by targeted beneficiaries in Africa. He acclaimed the excellent collaborations between CCAFS, CRA (Centre Régional AGRHYMET), and CCAFS countries of interest, including Burkina Faso, which has led to significant results.

IRI trainer highlighted the relevance of the training topics on the CDT tool. According to him, this session will help to review the use of the Climate Data Tool (CDT) for data organization, quality control, merging different data sets, as well as data analysis and visualization. In view of the training agenda, he asked the participants to be diligent and focused to achieve the objectives of the workshop. Finally, he thanked the CGIAR and the CRA for their renewed confidence in IRI.

The opening remarks were conveyed by the chief of the Department of Information and Research, a Representative of DG CRA CCR-AO. In his remarks, he stressed that this timely training is an opportunity for the CCR-AO to train a critical mass of regional experts qualified for owning CDT and PyCPT tools in order to improve the delivery of climate services but also to improve the provision of technical support to ECOWAS CILSS countries. He also advocated for a synergy of actions between the CILSS (ClimSA, FSRP, GCCA) and CGIAR (AICCRA) projects for technical support to countries in the use of these tools to improve climate services. He invited participants to diligent attendance to make the most benefit of the training. At the end of his speech, he reiterated his gratitude and thanks to the technical and financial partners of AICCRA and CRA CCR-AOS, especially the World Bank and the European Union for their multifaceted support. With that, he officially opened the workshop activities.

Photo: Participants' group photo

After the opening ceremony, participants introduced themselves, the training agenda was presented, and all logistics were sorted out right before they dive into training topics.

CDT training

The first three days of the training were dedicated to getting started with the CDT tool. Mr. Rija explained to the audience its origin and its functionality mode. It was retained from the presentation of the tool by the trainer that CDT is a set of utility functions for the quality control of meteorological data, the homogenization and blending of stations with satellite data and other proxies such as re-analyses, all functions are available in GUI (Graphical User Interface) mode. It is a free (https://github.com/rijaf-iri/CDT) and open-source software created specifically for national meteorological services. CDT is a set of utility functions that allows its users to:

- Organize millions of stations observations;
- Assess the availability of data and highlight gaps in observation recording;
- Assess and correct data quality issues;
- Combine station observations with variables such as satellite precipitation and climate model re-analysis products to fill

temporal and spatial gaps in observational data;

- Evaluate products in the form of grids, including satellite, re-analysis, and combined data products;

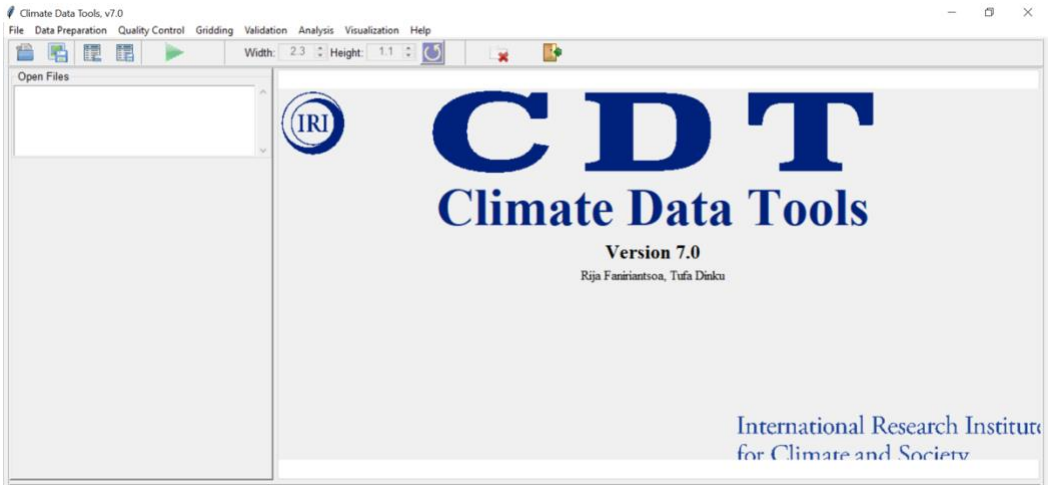

Figure 1: CDT Tool Interface

- Extract data from mesh products, including satellite, re-analyses, and combined data products, at any point, for a selected box, and for any administrative limits;

- Analyze and visualize station and grid datasets.

The CDT interface is illustrated in figure 1 above.

After the presentation of the tool, participants proceeded to install or update CDT (for those who already had it on their laptops) for future applications. This was followed by Session 1 on data preparation and quality control.

Data Preparation and Quality Control

At the beginning of this session, participants configured CDT. Optionally throughout the installation process, CDT users are able to select the language, define the code of the missing values, change the working directory, and define the delimitation framework of the domain on which one would like to work. During the session, participants did more practice on the different components of the organization and data acquisition in order to allow familiarization with the different tasks.

One of the aspects discussed during this session was data quality control. It was noted that the new version of the tool has not evolved compared to the one on which the experts had already been trained on these aspects of quality control.

Interpolation and data blending

Estimates of climate parameters, including high-quality rainfall and extreme temperatures, are particularly important for monitoring the agro-hydro-climatic campaign. They are generally based on two main methods: ground observation stations and remote sensing. Measurements from ground-based observation networks give accurate and reliable values, but only at the point scale, whereas most applications use large spatial scales. To obtain a spatial value from the climate stations, it is necessary to interpolate the measurement data. This session made it possible to explore again with the CDT tool, the classic techniques of data interpolation.

Data Visualization

The CDT tool offers the possibility to visualize climate data. CDT's "visualization" menu offers graphical outputs in the form of graphs and easily customizable maps. It is therefore possible to visualize:

- Individual files
- A temporal sequence of files
- Data from multiple variables on a given date.

Some graphical outputs obtained at the end of the exercises are illustrated in figure 2:

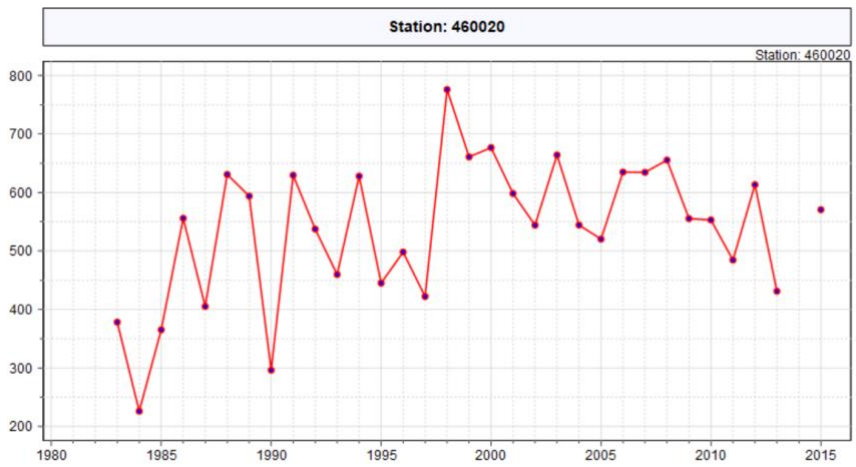

Figure 2: Annual rainfall totals

Exploring the Automatic Weather Station Data Tool (ADT) Web Application

The first phase of this training session ended with a presentation of the ADT application. This application addresses the challenges of accessing, homogenizing, and processing data from automatic weather stations (AWS) collected by different systems/networks, which are located on different servers and in different formats, by allowing the control, processing, and visualization of data quality.

Overview, installation, and use of PyCPT

This session began with exchanges on the basis of seasonal forecasts, the different forecast time scales, and the uncertainties related to forecasts. This session was led by Dr. Sylwia Trzaska of IRI.

Concepts of weather, climate, and climate change were addressed in Sylwia's presentation. She then discussed the basic principle of seasonal forecasting, its verification, and the uncertainties and limitations of the use of seasonal forecasting. Finally, in her presentation, the interpretation of forecast results, the format, and the communication of information to end-users were explained. After this presentation, the participants proceeded to install and use PyCPT. Participants followed explanations about the PyCPT interface and the different lines of code and their manipulation. Participants learned how to choose models, seasons, initialization months, etc. Participants got started with the PyCPT tool through the processing of an application exercise. The exercise consisted of:

- Run PyCPT with CCA, PCR, and noMOS;
- Compare the skills of individual models with the NEXTGEN overall average;
- Interpret the results obtained.

As progress was made in the execution of the codes, the trainer explained and fixed the bugs depending on the case but introduced the participants to the explanations of the results obtained.

Conclusion

Phase I of the workshop training went well overall. Ten participants took part and their capacities were strengthened in the use of CDT and PyCPT.

At the end of this, the roadmap for the future was summarized on the following points:

- A virtual meeting between AGRHYMET and IRI to check progress on PyCPT;
- AGRHYMET experts continued responsibility to handle PyCPT;
- Testing seasonal forecasting approaches with PyCPT in future climate outlook forums (PRESAGG and PRESASS);
- Continued support to countries on the tools learned.

Photo: Presidium of the opening session of the training

Phase II: Training for countries

This training took place in two parallel-group sessions. One group focused on the CDT tool while the other focused on the PyCPT tool. These sessions were led by Mr. Rija Faniriantsoa, senior collaborator and co-developer of the CDT tool, and by Dr. Sylwia Trzaska climatologist, both from the IRI, with the contribution of experts from the AGRHYMET Regional Center.

Opening Ceremony

A message from the General Director of ANAM

The General Director of ANACIM, Mr. ZOUNGRANA Joël, in his remarks, welcomed all participants to the workshop with warm wishes for good health and peace in the subregion. He re-emphasized how glad he was for the choice of ANAM to host these training sessions and the synergy of actions between the different projects such as AICCRA, ClimSa, and FSRP. He asked participants to be diligent as they learn in order to bring about an improvement in data processing, production, and service delivery to meet the expectations of users and decision-makers facing the challenges of climate change. To close his remarks, he expressed his open support to participants for any solicitation and reminded everyone to respect the measures against COVID-19.

A message from the AICCRA West Africa Leader

In his remarks, Dr. Robert Zougmore, set the context for this workshop by specifying that the project is being implemented in East and West Africa and in the case of West Africa, three countries (Ghana, Senegal, and Mali) were selected as pilots. He also recalled that ENACTS (Enhancing NAtional ClimaTe Services) initiative's tools and methods developed and which were the subject of the workshop are very useful for generating climate information in order to meet the needs of users. To close his remarks, Dr. Robert invited all participants to be keen and focused as they follow the training in order to get the most out of the training and be better

equipped in the process of climate information generation for their respective countries.

A message from the IRI's representative

In her remarks, Dr. Trzaska, representative of IRI reiterated her best wishes for a happy new year to all participants. She then noted the specificity of the tools and approaches developed by her institution for the development of climate services. To finish, she recalled the long collaboration that exists between national and regional meteorological services and IRI in the development of technical tools in the field of food and nutrition security.

Opening remarks by the representative of the General Director of the CRA

Mr. TINNI Seydou primarily noted that the General Director had personally wished to officiate this ceremony but due to scheduling constraints, this could not be possible. Thus, on behalf of the DG, Mr. Seydou welcomed all the participants from different countries and the expert trainers. He then insisted on the contribution of CDT and NextGen tools in the production of climate services. He also took the opportunity to re-express his gratitude to the PTFs that are the World Bank and the European Union and to ANAM, the government, and the people of Burkina Faso for the welcome and legendary hospitality they show each time. To conclude, he officially opened the activities of the training workshop on ENACTS.

The participants were then divided into two thematic groups: CDT Group and PyCPT Group.

CDT training

The practical sessions began with a presentation of the CDT tool. Rija FANIRIANTSOA explained to the audience its origin and its functionality mode.

After the presentation of the tool, the participants proceeded to install or update CDT. The different installation steps can be accessed at the following link: https://github.com/rijaf-iri/CDT. Following this installation, participants were able to get to the heart of the matter, namely the handling of the various components of the CDT tool.

Data preparation and quality control

Similar to the training for AGRHYMET described earlier, CDT configuration was carried out to facilitate its use. The configurations concerned the language, the code of the missing values, the working directory, and the definition of the area of interest. This was followed by the actual ownership of the components of climate data preparation for appropriate tasks as exactly listed in the previous training.

This session particularly emphasized data quality control. The importance of using quality control was stressed. Inaccurate data can cause many problems for users when creating reliable climate information products. Participants were introduced to the different types and sources of error that could be found in climate datasets.

Data quality control focused on:

Photo: Practical session of data preparation for participants at the CDT training for countries

- Verification of the geographical coordinates of the stations;
- Verification of false zeros for daily precipitation;
- Detection of outliers for precipitation and temperature:
    - Control of internal coherence
    - Checking for temporal outliers
    - Checking for spatial outliers.

Interpolation and data blending

Participants were first presented with the techniques of interpolating climate variables with the usual methods such as IDW, ordinary kriging, universal kriging, nearest neighbor method, etc. This continued with a practice on techniques for combining station data with satellite data or re-analysis.

Automatic Weather Station Data Tool (ADT) tool presentation

On the last day of the first week, the Automatic Weather Station Data Tool (ADT) web application was presented to the participants and to a team from the ANAM of Burkina Faso (Mr. Guillaume NAKOULMA, Dr. Ulrich Jacques DIASSO, and Sawadogo Lazare). Indeed, ADT is seen as an alternative for ANAM to meet the challenge of harmonizing and managing the data from automatic stations from different dealers. From the presentation on ADT, it was clear that the tool meets the challenges of accessing, homogenizing, and processing data from automatic stations (AWS) collected by different systems/networks (which are on different servers and in different formats, by allowing the control, processing, and visualization of data quality.

Visualization of data maps

After going through and doing the merging process, the participants visualized the different maps in NetCDF format: the raw satellite data map, the adjusted data map, and the merged data map (figure 3).

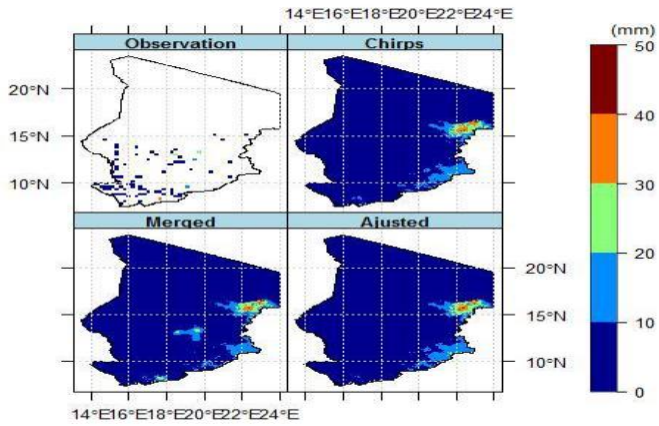

Figure 3: Visualization of maps of observed, raw, adjusted, and merged data

Data validation

For data validation three steps are essential:

- NETCDF data extraction: This step involves transforming the NETCDF merged data into a digital file. At the end of the operation, we obtain a file of the TXT or CSV type readable with EXCEL.
- Comparison of extracted data with observed data
- The definition of statistics: production of plots

Spatial analysis of meteorological parameters

This analysis consists of compiling statistics on the data series and calculating some derived parameters. The calculated derived data are the FTE, the water balance, the cumulative rainfall and anomalies, and the climatological normals and anomalies. For the calculation of the FTE, participants used maximum and minimum temperature data. FTE data were also used to calculate the water balance.

PyCPT training

This training began with a presentation by Dr. Trzaska on the concepts of weather, climate, and climate change. She also discussed the basic principle of seasonal forecasting, its verification, the uncertainties and limitations of the use of seasonal forecasting. She finally explained how participants should interpret the results of the forecasts, their format, and their communication to end-users. After Sylwia's presentation, the participants proceeded with software installation. With support from AGRHYMET staff and Sylwia, the participants installed the PyCPT software. It should be noted that this software requires high-performance machines, which was not the case for all machines. After this step, the participants followed explanations of the interface of PyCPT and the different lines of the code and their manipulation. Participants learned how to choose models, seasons, initialization months, etc.

Getting started with PyCPT

The hands-on exercises of the PyCPT tool continued with Dr. Sylwia. Participants were asked to:

- Run PyCPT with CCA, PCR, and noMOS,
- Compare the skills of individual models with the next-gen overall average,
- Provide relevant feedback on the work done.

Countries presented their results from the exercise given.

A session was devoted to the resolution of the bugs identified by the participants and the continued presentations by countries relating to the given exercise.

Subsequently, each country was tasked with identifying a project as part of the training and preparing a paper to be presented for the rest of the workshop. Thus, the countries, in turn, presented their project idea. Most of these projects focused on sensitivity analyses: sensitivity to models, domains, and predictors.

Participants' individual work

This session began with the presentation of the difficulties encountered by the participants while working on their project. It appeared from this process that the major problem identified was the non-functioning of some model outputs. Thus, Dr. Sylwia made a presentation on the models available in PyCPT with a focus on their period of start and end of the activity and those that are still functional. Figure 4 shows an example of functionality models.

Suite de modèles	Modèle	Résolution	Variables	Période hindcast	Période de prévision
NMME	CanSIPv2	1x1 degree	PRCP, T2M, Tmax, Tmin, SST	1981-2018	Aug 2019-maintenan
NMME	COLA-RSMAS-CCSM4	1x1 degree	PRCP, T2M, SST		1982-maintenant
NMME	GFDL-SPEAR	1x1 degree	PRCP, T2M, Tmax, Tmin, SST	1991-2020	Dec 2020-maintenan
NMME	GFDL-FLOR-A06	1x1 degree	PRCP, T2M, Tmax, Tmin, SST	1980-Jan 2021	abandonnée
NMME	GFDL-FLOR-B01	1x1 degree	PRCP, T2M, Tmax, Tmin, SST	1980-Jan 2021	abandonnée
NMME	NASA-GEOSS2S	1x1 degree	PRCP, T2M, Tmax, Tmin, SST	Feb 1981-Jan2017	Feb 2017-maintenan
NMME	NCEP-CFSv2	1x1 degree	PRCP, T2M, SST, UQ, VQ	1982-2010	Mar 2011-maintenan
EU-C3S	ECMWF-SEAS5	1x1 degree	PRCP, T2M, SST	1981-2016	Sep 2017-maintenan
EU-C3S	MeteoFrance-System7	1x1 degree	PRCP, T2M, Tmax, Tmin, SST	1993-2016	Oct 2019-maintenant
EU-C3S	UKMO-GloSea5S14	1x1 degree	PRCP, T2M, Tmax, Tmin, SST	1993-2016	May 2019-maintenan

Figure 4: Example of functionality models

The hands-on exercises allowed participants to understand the main thrusts of the study and to become familiar with the new forecasting products.

Verification of seasonal forecasts

Participants were given a presentation on forecast verification methods led by Sylwia. This allowed them to understand the formulas for calculating the different scores (Pearson, Spearman, RPSS, GROC) and their interpretation. For more details see the link below.

https://www.cawcr.gov.au/projects/verification/

This verification session was used as a framework for Mr. Asse Mbengue, an agrometeorology engineer from ANACIM to make a presentation on the IRI and ANACIM's Data Library. This tool improves meteorological databases and strengthens the capacity of meteorological services for the production of very high-quality climate services. The tool makes it possible to store data, query them to generate climatic information (accumulation of seasonal precipitation, date of the start of the season, length of dry breaks, frequency analyses...) in a complete Spatio-temporal grid over more than 30 years by combining the observations of the stations with satellite rainfall estimates (for precipitation) and climate model re-analysis products (for temperature). His presentation aimed above all to show participants how to generate the start dates of the season according to the criteria relevant to a country of interest using CHIRPS data and generate a prediction file that will be forced to PyCPT for the forecast of the start dates of the agricultural season in their respective countries. To achieve this, participants had to understand the syntax of the onset date function of the IRI Data Library. For more details on this function see the link below.

https://iridl.ldeo.columbia.edu/dochelp/Documentation/details/index.html?func=onsetDate

Then, each participant had to generate a historical season start date file for their country. For example, the following link is an Ingrid script that was used

https://iridl.ldeo.columbia.edu/SOURCES/.UCSB/.CHIRPS/.v2p0/.daily-improved/.global/.0p05/.prcp/X/(-18)/(-11)/RANGEEDGES/Y/(12N)/(17N)/RANGEEDGES/T/(1%20May)/120/1/3/20/1/15/30/onsetDate/T/sub/#expert

Results can be viewed in this link:

https://iridl.ldeo.columbia.edu/SOURCES/.UCSB/.CHIRPS/.v2p0/.daily-improved/.global/.0p05/.prcp/X/(-18)/(-11)/RANGEEDGES/Y/(12N)/(17N)/RANGEEDGES/T/(1%20May)/120/1/3/20/1/15/30/onsetDate/T/sub/figviewer.html?map.url=X+Y+fig-+colors+coasts+lakes+-fig

After this part, came the presentation of country projects

Projects' presentations by country

Each country had a slot to present its work. The summary of the findings is presented below:

Burkina Faso

The presentation focused on the study of the sensitivity of the domain. The aim was to select several domains (Pacific, Atlantic, and tropical band) for SST predictors, study the differences between outputs for different domains, and compare probabilistic forecast maps with observations for the JAS period (July-August-September). For the models (NASA-GOESS2S, NCEPT-CFSV2,) chosen, the conclusions were as follows:

- Pacific domain: the different models give good skills on most of the territory except in the center;

- Atlantic domain: the good skills of the models are much more visible in the center of the country;

- Large domain (tropical band): difficulty in predicting the center of the country as for the Pacific. The effects of the Atlantic do not seem to be visible. This could be explained by the influence of ENSO in the Pacific whose signal is strong.

In perspective, the same study should be done for the JJA period (June-July-August), take into account the other (European) models, and also study the model outputs for the Indian Ocean.

Togo

The objective of the study project was to search for the best predictors for seasonal rainfall accumulation in Togo. To carry out this study, SST predictors (at the Atlantic and Pacific level) and PRCP (around Togo) were used to assess the outputs of NASA-GOESS2S and NCEPT-CFSV2 models for the MJJ season (May-June-July) with April initialization and for that of JAS (July-August-September) with May initialization.

After analyzing the different outputs of the models, it was clear that:

- With the SST predictor, the NCEP model makes a deficit forecast and NASA a surplus JAS forecast;

- SST on the equatorial band is normal to a deficit in the country;

- Atlantic SST: deficit to normal in the north and surplus in the south

- Surplus Atlantic SST to the north;

- Pacific SST: deficit in the south and surplus in the north

- With the PRCP predictor, the MJJ, deficit in the south, and surplus throughout the country in JAS.

SST in the equatorial domain is the best predictor of cumulative rainfall in Togo. Nevertheless, a more in-depth study of seasonality and with a large enough number of models to be situated.

Niger

The objective of the project was to study with the canonical correlation analysis method (CCA) the sensitivity of predictors (PRCP Vs SST) using the NASA-GEOSS2S, NCEP-CFSv2, CanSIPSv2, COLA-RSMAS-CCSM4 models for the July-August-September season with a May initialization. Two domains were used. An identical domain was first used for predictors and predictants for PRCPs and then a different domain for predictors (Pacific/Atlantic) and predictors (same as the first domain) for SST. After simulation, in terms of skills for the situation in Niger, the results were generally mixed. That said, it was noted that:

- The NCEP model has relatively good skills for the two predictors chosen, on the East and West of Niger;

- For the skills scores, it is the PRCP predictor that gives more confidence, especially on the East and West although it is necessary to highlight an artifact in the North of Chad for the RPSS.

- For NextGen, the SST presents better skills in the two aforementioned parts

- Regarding the prediction with a single model, it was noted that NASA diverges for the two predictors, however, the other three models predicted a wet situation in the country with the exception of the COLA model which predicted a dry situation in the center of Niger

- The NextGen forecast did not clearly represent reality for both predictors.

Senegal

The objective of the study project was to explore the best predictors of candidate variables (SST, PRCP, T2M) to predict the date of onset in Senegal. The underlying observational data used in this analysis come from the Enhancing NAtional ClimaTe Services (ENACTS) dataset which consists of a high-resolution (4 km) merged satellite estimate of precipitation and temperature (Dinku et al., 2022) to calculate the historical date of onset in Senegal (Sivakumar, 1991), adapted by ANACIM). The forecasting tool used in this study is IRI's relatively new Python-based climate prediction tool (PyCPT) (Munoz et al., 2019). The PyCPT interface is accessible via https://bitbucket.org/py-iri/iri-pycpt/src/master/. In this study, the CCA method was used with data from the NMME models CanSIPSv2, NCEP-CFSv2, and EU C3S models ECMWF-SEAS5, MeteoFrance-System7 for PRCP and T2M Predictors. The CanSIPSv2, NCEP-CFSv2, COLA-RSMASS-CCSM4, and NASA-GEOSS2S models were used for the SST predictor. Throughout this analysis, a training window from 1981-2020 was used. The forecast is initialized in June to predict the start date at JJA. At the end of the simulation, it was noted that:

- The SST variable predictor is better than the PRCP or T2M to predict the start date in Senegal, but the skill is low;

- It is important to test the sensitivity of the models for different predictor domains that are identified as good for the expected start date in Senegal

Ghana

Participants from Ghana had to first present a study of the sensitivity of different ocean basins on rainfall forecasting in Ghana for the period June-July-August.

The conclusions were that precipitation as predictors on a space domain covering 20W-20E and 0N 15N) gives the best skills scores in Ghana.

Conclusion and closing of the workshop

The training went well overall. The closing ceremony was chaired by the Director-General of ANACIM with the presence of IRI and AGRHYMET representatives.

The Director-General of ANACIM thanked various participants, followed by IRI's representative who expressed her gratefulness to the financial partners, the participants, the National Meteorological Agency of Burkina Faso who agreed to host the workshop, and the various experts who spared no effort for the organization and achievement of the objectives set for this training. She then urged the participants to continue to work in synergy and to share experiences.

The AGRHYMET representative also thanked the trainers, the national meteorological agency, and all the participants for their attendance throughout the 2 weeks of training for some and 3 weeks for others before declaring closed the capacity building workshop on ENACTS tools (CDT and PyCPT) in the framework of the AICCRA project.

Challenges:

On Monday, January 24, 2022, the socio-political unrest in the host country did not allow the participants to meet for the training. They stayed at the hotel to continue the work of consolidating their achievements.

Recommendations

Although a roadmap was created at the end of the AGRHYMET training to ensure sustainability of systems that were already put in place, and to stay on top of the tools, it is worth to emphasize that most of the tools get updated or upgraded due to different reasons including making them

work better and therefore, AGRHYMET and all the capacitated countries should stay aware of new versions and upgrade as appropriate.

There will be follow-up sessions especially on PyCPT version 2, which performs better than PyCPT version 1, and IRI will train participants to the version 2 of PyCPT in the near future.

Thanks to AICCRA project, AGRHYMET has now a great level of expertise, therefore it should be able to confidently lead and initiate ENACTS-related training sessions in the region, with IRI consultation when needed, as it continues to support other countries on the tools.

Appendices

Appendix 1: Training agenda for AGRHYMET training sessions

Opening session: Monday January 10th, 2022		
Time	**Content**	**Facilitator**
08:30-09:30	• Arrival and registration • Introductions	Organizers (AGRHYMET)
09:30-10:00	Opening remarks • AGRHYMET • AICCRA West Africa • IRI	Abdou Ali Robert Zougmore Tufa Dinku
10:00-10:30	Introduction to the training	Tufa Dinku
10:30-11:00	Coffee break and pictures	Organizers

CDT Training		
Day	**Content**	**Facilitator**
January 10 (Monday)	• Introduction to the new version of CDT • Overview of the new features for Data Preparation and Quality Control Menu	Rija Faniriantsoa
January 11 (Tuesday)	• Overview of the new features for Data Merging and Validation Menu	Rija Faniriantsoa
January 12 (Wednesday)	• Overview of the new features for Data Analysis and Visualization Menu • Demonstration on AWS Data Tools	Rija Faniriantsoa

PyCPT Training		
Day	**Content**	**Facilitator**
January 13 (Thursday)	• Review of probabilistic seasonal forecast: rationale, methods, sources of uncertainty probabilistic approaches and probabilistic forecast verification • Review of CPT and PyCPT, comparison	Sylwia Trzaska
January 14 (Friday)	• Review of PyCPT installation process and basics in Python • PyCPT installation and exploration	Sylwia Trzaska
January 15 (Saturday)	• Exploration of PyCPT, predictor/predictand pairs and skill interpretation	Sylwia Trzaska

Appendix 2: Training agenda for countries' training sessions

Opening session: Monday January 17th, 2022		
Time (Monday January 17th)	**Content**	**Facilitator**
08:30-09:30	• Arrival and registration • Introductions	Organizers (AGRHYMET)
09:30-10:00	Opening remarks • ANAM • AGRHYMET • AICCRA West Africa • IRI	Joel Zoungrana Abdou Ali Robert Zougmore Sylwia Trzaska

10:00-10:30	Introduction to the training	Sylwia Trzaska & Rija Faniriantsoa
10:30-11:00	Coffee break and pictures	Organizers

CDT Training		
Day	**Content**	**Facilitator**
January 17 **(Monday)**	**Review** ● Overview CDT main menu ● Data Preparation and processing ● Climate Data Quality Control	Rija Faniriantsoa
January 18 **(Tuesday)**	**Review** ● Interpolation for climate data ● Reanalysis downscaling ● Merging station observation with satellite rainfall estimates and reanalysis data ● Validation of gridded data (satellite rainfall estimates, reanalysis)	Rija Faniriantsoa
January 19 **(Wednesday)**	● Overview: CDT data analysis and visualization ● Daily rainfall analysis	Rija Faniriantsoa
January 20 **(Thursday)**	● Rainy season analysis ● Climate Extremes Indices ● Drought indices	Rija Faniriantsoa
January 21 **(Friday)**	● Spatial Data Analysis ● Demonstration on AWS Data Tool ● Connection with CDT	Rija Faniriantsoa

PyCPT Training

Day	Content	Facilitator
January 17 **(Monday)**	Morning: Basics on seasonal climate forecast ● Rationale behind seasonal forecast ● Main methods for seasonal forecast ● Principles of a MOS Afternoon: Lab – Introduction to accessing and manipulating data in IRI Data Library	Sylwia Trzaska
January 18 **(Tuesday)**	Morning: Basics on probabilistic forecasting ● Sources of forecast uncertainty ● Probabilistic approaches ● Probabilistic forecast verification methods Afternoon: installation and exploration of CPT functionalities	Sylwia Trzaska
January 19 **(Wednesday)**	Morning: Lab – exploring CPT, focus on predictors Afternoon: Lab – exploring CPT, focus on verification	Sylwia Trzaska
January 20 **(Thursday)**	Morning: Introduction to PyCPT ● PyCPT vs CPT ● Python basics for PyCPT Afternoon: Installing PyCPT ● Overview of PyCPT installation procedures ● PyCPT installation (with assistance from	Sylwia Trzaska

	AGRHYMET and IRI, New York)	
January 21 **(Friday)**	Morning: Overview and exploration of PyCPT modules Afternoon: Lab – Using PyCPT, focus on basics ● Definitions (models, predictor/predictand domains); ● Output generation and archiving	Sylwia Trzaska
January 22 **(Saturday)**	Morning and afternoon: Lab - Using PyCPT ● Exploring predictor/ predictand and domains ● Interpreting skill	Sylwia Trzaska
January 24 **(Monday)**	Morning and afternoon: Lab – PyCPT ● Finalizing countries predictive system	Sylwia Trzaska
January 25 **(Tuesday)**	Morning and afternoon: Country Result Presentations & Discussions	Sylwia Trzaska
January 26 **(Wednesday)**	Morning: Compiling a report Afternoon: Final discussions, next steps, wrap-up	Sylwia Trzaska

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