

# A Next Generation (NextGen) Approach to Improve the Seasonal Prediction System in East Africa

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## Abstract

The use of an objective seasonal forecast procedure, defined as a traceable, reproducible, and well-documented set of steps that allows the quantification of forecast quality, are preferred and recommended by the World Meteorological Organization in their recent seasonal forecast guidance. However, National Meteorological Services (NMS) in African countries have been issuing seasonal rainfall forecasts using a subjective consensus process, which is based on meteorologists' experiences using Global Producing Center's (GPCs) outputs and other available information. A systematic general objective approach named as NextGen (Next Generation) forecasting system is being developed for some East African countries as part of implementing or strengthening ENACTS (Enhancing National Climate Services; <https://iri.columbia.edu/resources/enacts/>) initiative as well implementing Columbia University's World Project "Adapting Agriculture to Climate Today, for Tomorrow" (ACToday; <https://iri.columbia.edu/actoday/>) project. This new forecast system is based on a calibrated multi-model ensemble (CMME) process using state-of-the-art general circulation models (GCM) from the North American Multi-Model Ensemble project. A canonical-correlation-analysis-based regression is used to calibrate the raw outputs from the GCMs; then the individually-calibrated GCMs are combined with equal weight to make a final CMME prediction. In addition to traditional tercile probability forecasts, NextGen also provides a more flexible format that enables users to extract information for those parts of the forecast distribution of the greatest interest to them in the decision-making process. Therefore, NextGen enables NMS to generate and deliver targeted climate information products relevant to the needs of decision-makers at multiple levels. The NextGen forecast system has so far been implemented in Ethiopia, Rwanda, Zambia, Malawi and Tanzania, and planned to be implemented in more countries in the near future. In this study, we describe the co-design, co-development, and skill assessment of this NextGen system.



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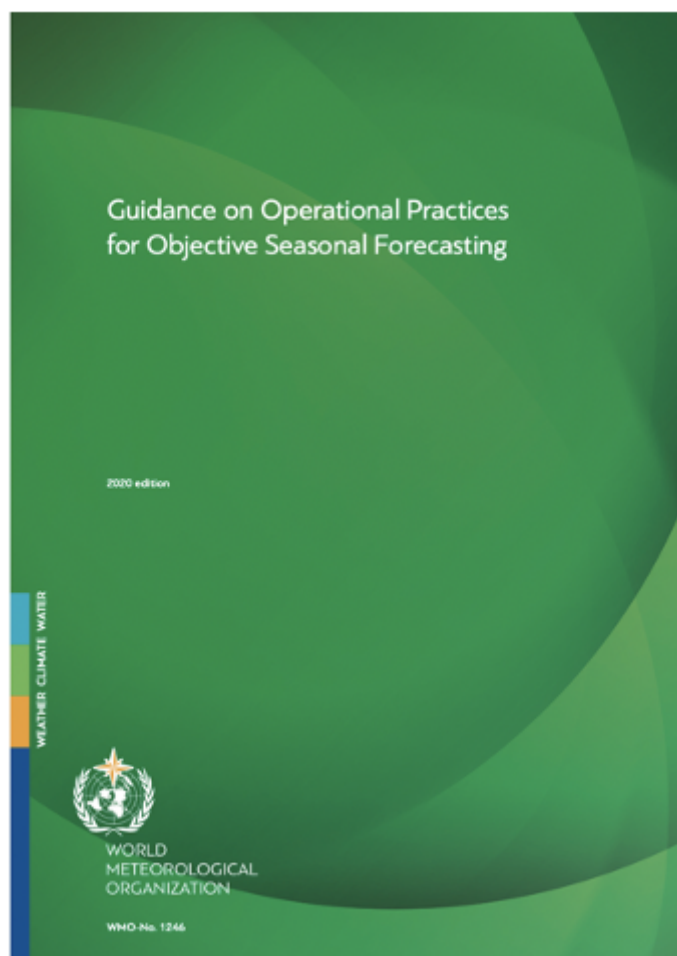
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## 1. MOTIVATIONS & GOAL

- National Meteorological Services (NMS) in African countries have been issuing seasonal rainfall forecasts using a subjective consensus process, which is based on meteorologists' experiences, some globally available forecast and tools.
- The use of an objective seasonal forecast procedure which is defined as a traceable, reproducible, and well-documented set of steps that allows the quantification of forecast quality, are preferred and recommended by the World Meteorological Organization in their recent seasonal forecast guidance.

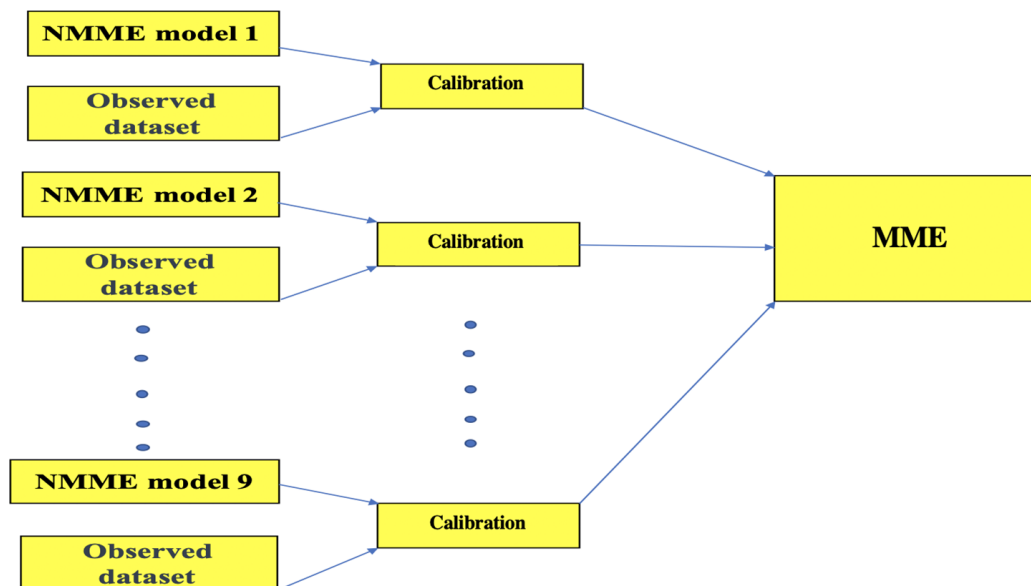


- The Next Generation (**NextGen**) seasonal forecast system is a systematic and objective approach. It enables calibration, combination, and verification of objective climate forecasts from the state-of-the-art general circulation models (GCM) of the North American Multi-Model Ensemble project.
- NextGen is being adopted for some East African countries with close collaboration with NMSs in each country.



## 2. THE NEXT GENERATION (NEXTGEN) SEASONAL PREDICTION APPROACH

### NextGen Approach

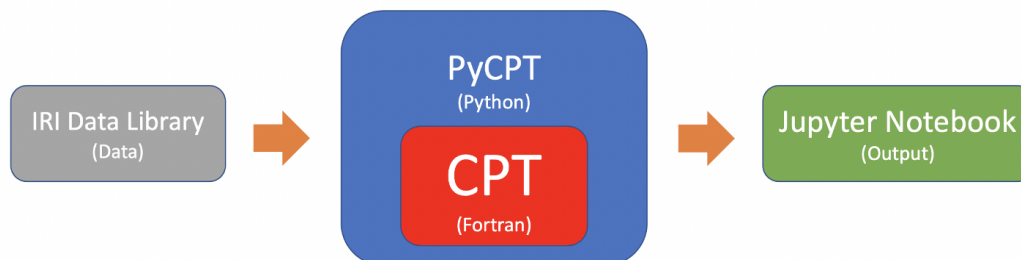


- A canonical-correlation-analysis-based regression is used to calibrate the raw outputs from the GCMs; then the individually-calibrated GCMs are combined with equal weight to make a final calibrated multi-model ensemble (CMME) prediction.
- In addition to traditional tercile probability forecasts, NextGen also provides a more flexible format that enables users to extract information for those parts of the forecast distribution of the greatest interest to them in the decision-making process.

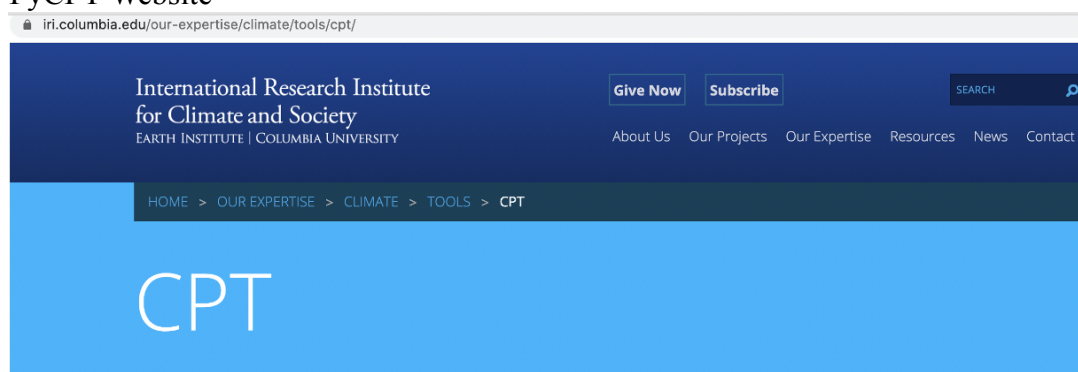


### 3.TOOL FOR NEXTGEN:PYCPT

- PyCPT is a Python library that provides an interface and extra functionalities to IRI's Climate Predictability Tool (CPT), a widely used research and application Model Output Statistics/Prediction toolbox.
- PyCPT Layout



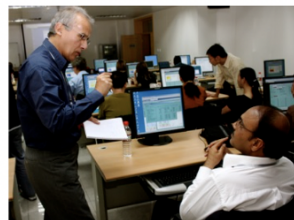
- PyCPT Website



## The Climate Predictability Tool

The Climate Predictability Tool (CPT) is a software package for constructing a seasonal climate forecast model, performing model validation, and producing forecasts given updated data. Its design has been tailored for producing seasonal climate forecasts using model output statistic (MOS) corrections to climate predictions from general circulation model (GCM), or for producing forecasts using fields of sea-surface temperatures or similar predictors. Although the software is specifically tailored for these applications, it can be used in more general settings to perform canonical correlation analysis (CCA), principal components regression (PCR), or multiple linear regression (MLR) on any data, and for any application.

Comments and requests for changes and developments, or access to the source code can be emailed to [cpt@iri.columbia.edu](mailto:cpt@iri.columbia.edu).



IRI-WMO Workshop on Tailoring of Seasonal Forecasts.  
A.Curtis/IRI

#### Important Links

##### CPT Downloads

[Download Latest Version \(2020-09-08\)](#)

[Download Version 15.7.11 \(2019-07-26\)](#)

[PyCPT](#)

##### Release Notes

##### CPT Windows Version Tutorials

[Frequently Asked Questions](#)

[Tutorial \(PDF, English version, July, 2011\)](#)

[Cours d'instruction de CPT \(PDF, French version, Feb 2013\)](#)

[Tutorial Videos for CPTv14.7.4 New Features: \(English\) and \(Spanish\)](#)

[Tutorial Videos for CPTv14 SPI Demo \(English\) and \(Spanish\)](#)



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# Wiki

## IRI PyCPT / Home

Welcome to the PyCPT wiki!

### What's PyCPT?

PyCPT is a python library that provides interface and extra functionalities to IRI's [Climate Predictability Tool \(CPT\)](#), with a special focus on mass-production of seasonal and sub-seasonal forecast skill assessment maps and probabilistic flexible forecasts.

### Installation

The user will need to install Anaconda (Python3), the Climate Predictability Tool and the Python extension of CPT (PyCPT). Detailed instructions are available in [this document](#).

**For Windows users**, we presently recommend to install a Virtual Machine with all needed packages. Instructions and necessary resources can be found [here](#). Read the PyCPTUBuntureADME.txt file located in that link for details.

**[ONLY needed for the x2s version]** Create the file .IRIDAUTH in the main PyCPT folder. It must contain only one line with the Data Library S2S key (104 characters) obtained via [this link](#) | <https://iri.ldeo.columbia.edu/auth/genkey> *Please do not share your key*

### PyCPT structure

```

graph LR
    A[Case Configuration (namelist)] --> B[Download data (if necessary) and execute CPT]
    B --> C[Forecast Skill Assessment]
    C --> D[Forecast Production (Flexible format)]

```

PyCPT is broadly divided in four steps.

Most of the configuration of your particular case happens in the namelist section, found at the beginning of the PyCPT Jupyter notebook. This section enables the user to select predictor and predictand datasets, calibration methods and spatial and temporal domains.

The download and CPT execution section deals with preparing all the needed input datasets and running CPT to produce skill assessment and forecast files, conducting the calibration process selected by the user.

The skill assessment section visualizes predictive skill metrics as maps or text.

And the forecast section deals with the ensemble generation and production of forecast maps and other figures, with a special focus on flexible formats (the use of the entire forecast probability density function).

### Executing PyCPT

Several examples are provided via the Jupyter notebooks available in the [Code] (<https://bitbucket.org/iri-ir-py-cpt/ir-py-cpt>) section.

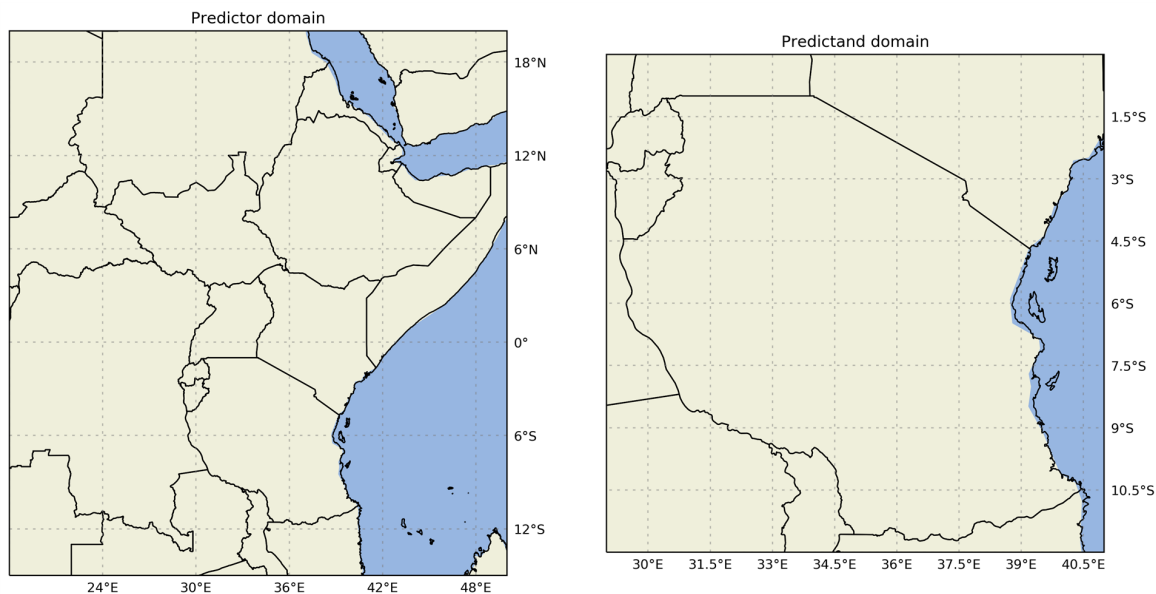
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bitbucket.org

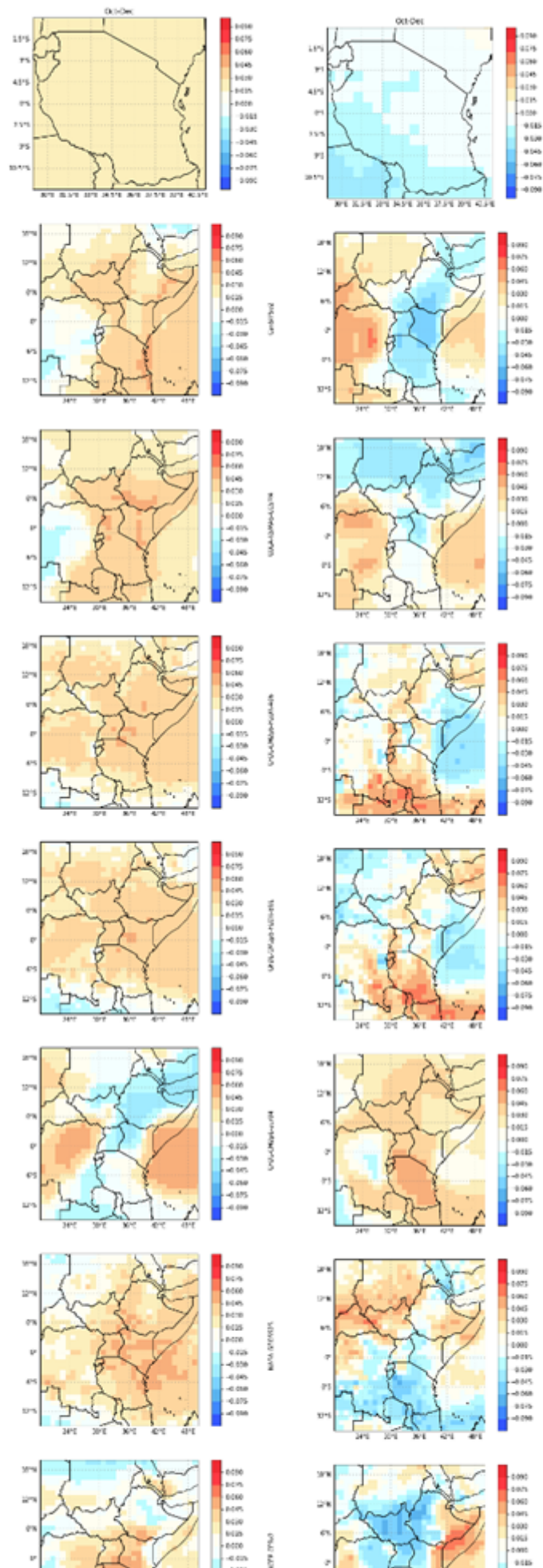
## Domain for CCA



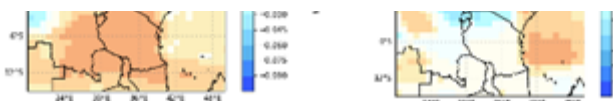
EOF1

## EOF2

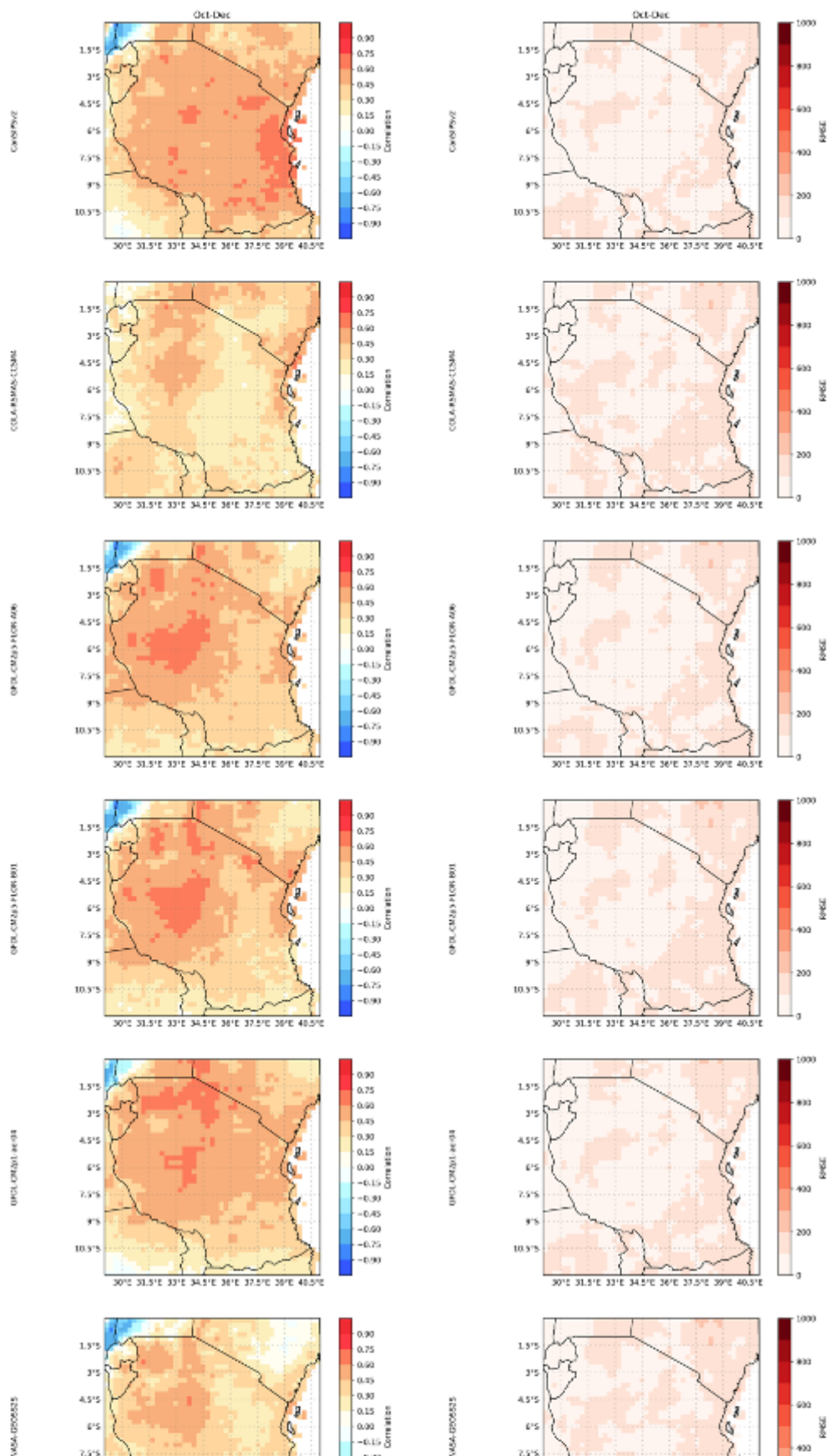




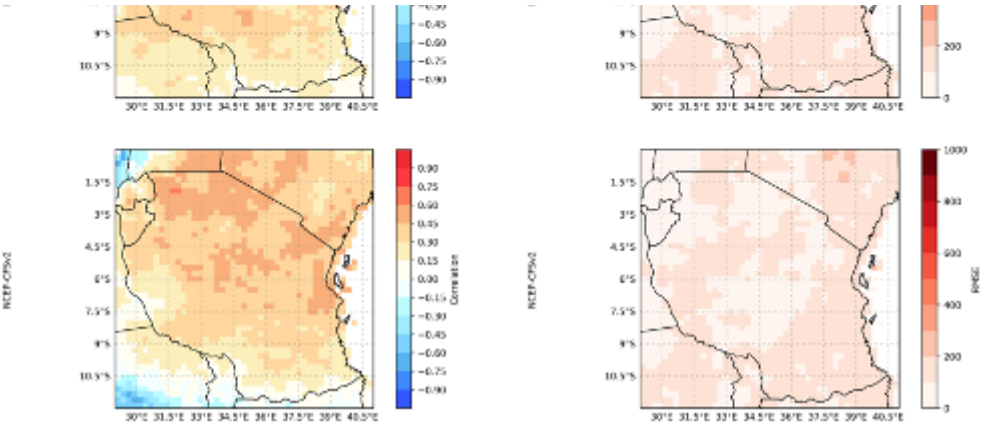




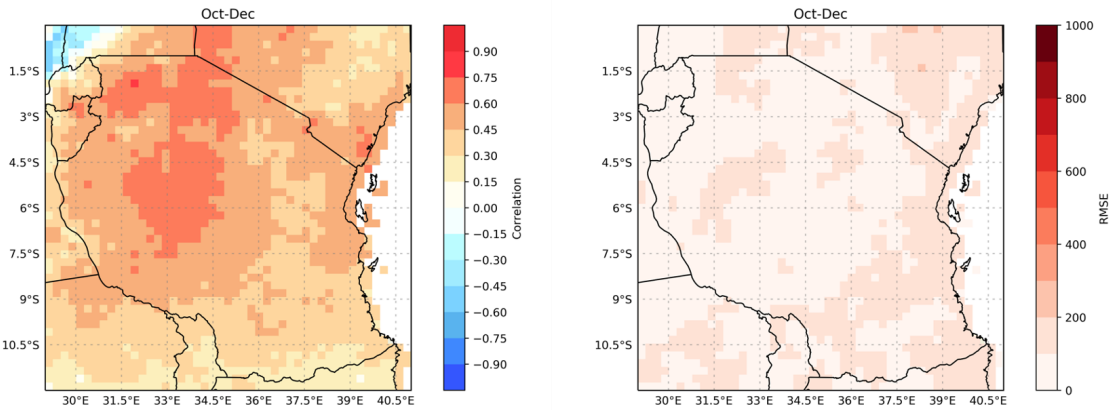
## Spearman's correlation and RMSE maps of each calibrated GCMs







Spearman's correlation and RMSE maps of NextGen (calibrated MME)





## 4.CAPACITY BUILDING OF THE NEXTGEN SYSTEM

- The NextGen approach is being implemented in **Ethiopia, Rwanda, Zambia, Malawi, and Tanzania** as a part of IRI's Enhancing National Climate Services (ENACTS) initiative.
- Part of this implementation is capacity development for the NMS. Several training activities were conducted by the IRI.

Training at National Meteorological Agency of Ethiopia.



Training at Meteo Rwanda.







Online training with Zambia Meteorological Department.





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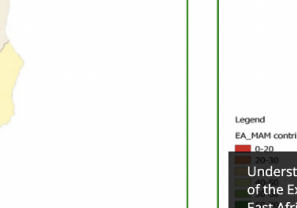
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### Today weather forecast

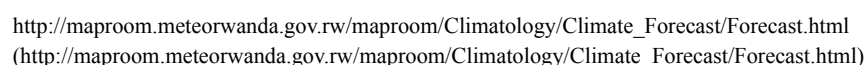
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### Latest News



Understanding the Evolution and Socio-Economic Impacts of the Extreme Rainfall Events in March-May 2017 to 2020 in East Africa





## 6. CONCLUSIONS AND ACKNOWLEDGEMENTS

- NextGen is being implemented for some East African countries (Ethiopia, Rwanda, Zambia, Malawi, and Tanzania) with close collaboration with NMSs in each country.
- Building the capacities for the NextGen system of NMSs through several training activities.
- It is planned to implement the NextGen system in more African countries in the near future.

### **Acknowledgements:**

- National Meteorological Agency of Ethiopia.
- Meteo Rwanda.
- Department of Climate Change and Meteorological Services of Malawi.
- Tanzania Meteorological Agency.
- Zambia Meteorological Department.
- PyCPT development team and Maproom development team at IRI.



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## ABSTRACT

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