Seasonal Prediction and Communication over Senegal
Using a Multi-Model System

Asher Siebert, Sylwia Trzaska, and Andrew Robertson

International Research Institute for Climate and Society, Columbia University, Palisades NY

1. Introduction

This work builds on ongoing collaboration between climate scientists at the International Research Institute for Climate and Society (IRI) and the national meteorological service of Senegal – Agencie Nationale de l’Aviation Civile et de la Météorologie (ANACIM). A new seasonal forecasting system developed by IRI was explored to assess seasonal climate predictability at different time scales and with different lead times. This new forecasting framework is called “NextGen” and is implementing a Python interface to run multi-model analyses using the Climate Predictability Tool (CPT). The new Python interface is called PyCPT.

The NextGen approach to seasonal forecasting creates a framework for user participation and co-production of calibrated, objective, multi-model ensemble climate forecasts employing output from an array of Global Climate Models (GCMs). This development is consistent with recommendations from the World Meteorological Organization that National Meteorological Services develop means of producing objective forecasts that contain information about the full forecast distribution. The analytical tools for PyCPT/NextGen are the same statistical methods used in CPT: canonical correlation analysis, principal component regression and multiple linear regression. The forecasts generated from NextGen/PyCPT show a full forecast distribution in a flexible manner that enables the users to select thresholds of interest and explore probabilities of exceedance and non-exceedance of those thresholds. The general flow diagram for NextGen is shown below in Figure 1.

From the early 2020 to the present, there has been an ongoing collaboration between IRI and ANACIM to foster this work and share research findings on various aspects of Senegal’s monsoon system. This work has been part of the Adapting Agriculture to Climate Today for Tomorrow (ACToday) Columbia World Project and has been focused on seasonal rainfall prediction, seasonal rainy-day prediction, forecast skill evaluation, and seasonal onset prediction. In April 2021, there was a virtual training on this new forecast system with ANACIM staff.

2. Data and methods

In the preliminary analysis, the forecasting method used was canonical correlation analysis and rainfall from five GCMs (COLA-RSMAS-CCSM4, GFDL-FLOR-A06, GFDL-FLOR-B01, NASA-GEOSS2S, NCEP-CFSv2) were used as predictors to forecast observed (CHIRPS) rainfall. These models are part of the North American Multi-Model Ensemble (NMME). One analysis explored the predictability of the July-September (JAS) rainfall from multiple lead times from February to June and examined the skill of individual models. For this analysis, both the predictor and predictand domain was 10-20°N, 10-20°W.

Correspondence to: Asher Siebert, International Research Institute for Climate and Society, Columbia University, Palisades NY; E-mail: asiebert@iri.columbia.edu
Another analysis explored the predictability of seasonal rainfall and rainy-day frequency (in excess of 1mm) for five sub-seasons (May-July (MJJ), June-August (JJA), July-September (JAS), August-October (ASO), September-November (SON)) with a one-month lead time in each case. For this analysis, the NextGen forecast is synthesized from the five member models and the predictor domain is 20-0°W and 5-20°N, while the predictand domain is the same as before.

NextGen forecast skill was also compared to historical subjective forecasts made by the Prévisions Climatiques Saisonnières en Afrique Soudano-Sahélienne (PRESASS) Regional Climate Outlook Forum (RCOF). This analysis has been focused on analyzing the ranked probability skill score (RPSS) of the past PRESASS RCOFs and the NextGen forecast.

More recent research collaboration between IRI and ANACIM has focused extensively on trying to find the best candidate predictors for seasonal onset date on the basis of station rainfall data, several gridded rainfall products and several possible definitions of onset date. There have also been some more recent developments in the capacity of PyCPT and in the inclusion of model data from the European Copernicus model suite, but those developments are not shown here.

Fig. 2  JAS precipitation forecast Pearson correlation skill, initialized from February to June (from left to right) and by COLA-RSMAS-CCSM4, GFDL-FLOR-A06, GFDL-FLOR-B01, NASA-GEOSS2S, NCEP-CFSv2 (from top to bottom).

Fig. 3  Pearson correlation skill of NextGen one-month lead seasonal forecasts of rainfall (top) and rainy day frequency (bottom). From left to right show the results for MJJ, JJA, JAS, ASO, and SON.
3. Analysis and results

The main findings of the first analysis of the five GCMs for JAS rainfall are shown in Figure 2, which displays the Pearson correlation of the five models and five initializations mentioned above with the target season (JAS).

Note that there is particularly high skill at early lead times for the NASA model, and to a lesser degree with the NCEP and COLA models. At a one-month lead time (forecast initialized in June), all models except COLA perform quite well.

Figure 3 shows the results of the second analysis of the NextGen forecast skill for one month lead times for the sub-seasons MJJ, JJA, JAS, ASO and SON (again in terms of Pearson correlation skill). Note that there is particularly good skill for the core of the rainy season (JAS) for both rainfall total and rainy-day frequency.

Figure 4 shows the results of the third analysis of the NextGen forecast skill compared with the historical PRESASS skill in terms of RPSS. This was calculated by digitizing the findings in Pirret et al. (2020). Note that the NextGen forecast RPSS skill compares favorably with the historical PRESASS forecast skill.

NextGen forecasts can be displayed through digital maproom interfaces that can show the forecast probability of exceedance of user-specified thresholds as illustrated by Figure 5 below.

![Precipitation Flexible Seasonal Forecast](image)

**Fig. 4** JAS precipitation forecast RPSS skill of NextGen (left) and the historical PRESASS (right).

**Fig. 5** Flexible IRI Climate and Society Maproom display examples.
User specified thresholds may be more salient than “tercile” categories which have been the historical method of presenting forecast information at many regional climate outlook forums (RCOFs). Historically, the RCOFs have had a tendency to hedge on the “near normal” category (Mason and Chidzambwa 2009). This new approach is less inclined to do so.

4. Conclusions and discussion

In this research, we have shown that the new NextGen approach to seasonal forecasting in Senegal can provide valuable insights in the form of high forecast skill with specific models at an early lead time, high forecast skill for seasonal rainfall totals and rainy-day frequency during the core of the rainy season, and may outperform more subjective approaches taken in the PRESASS RCOF in the past.

This new forecast method may also give the user more flexibility in defining relevant thresholds. Future work will focus on forecasting onset dates, dry spells and using wind fields (Ndiaye et al. 2009) as a means of prediction of seasonal climate characteristics in Senegal.

References

