Assessing Seasonal and Intra-Seasonal Skill at Kaffrine Station in Senegal

CCAFS Project Report

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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Abstract

Predicting rainfall during the July-August-September season in Senegal is crucial for farmers relying on rainfed agriculture. Previous studies have shown that high skill can be achieved across the Sahel. This study examined skill at the station level in Kaffrine, Senegal, which is also the site of a Climate Change and Food Security pilot project site. Using the ECHAM4.5 model forced with Climate Forecasting System sea surface temperatures as part of a two-tiered forecast system, the study examines the ability to predict different variables and how they effect millet crop yields. Results show good seasonal rainfall skill can be achieved at the station level in Kaffrine. They also show that overall millet yield is most highly correlated with the onset of the rainy season.

Keywords

Senegal; Sahel; rainfall; crop models.

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Introduction

In Ndiaye et al. (2009) and Ndiaye (2010), it has been demonstrated that a July-August-September (JAS) seasonal rainfall forecast can have high skill over Sahel. This study examines seasonal rainfall skill at station level. The station of Kaffrine in Senegal has been chosen for this study in part because it represents a major peanut growing region. Kaffrine will also be the site of a future Climate Change, Agriculture and Food Security (CCAFS) pilot project.

The objective of this study is to explore the skill of forecasting seasonal rainfall total and rainfall statistics within the season at station level as well as the skill of crop yield simulated using observed and model rainfall data.

Data

The study used daily data from the Kaffrine station from 1981 to 2010. To run the crop model insolation and minimum and maximum temperature at the nearest record station to Kaffrine which is Kaolack (located 68 kilometers to the west) were used. We also used the Climate Forecast System (CFS) coupled model daily rainfall forecast initialized in early May to assess crop yield. The Extended Reconstructed Sea Surface Temperature (SST) worldwide dataset was also used to assess the skill of the SST as a predictor of rainfall statistics. Zonal and meridional wind at 850 millibars from the ECHAM4.5 model forced with SST forecasted by CFS was also used as part of a two-tiered forecast. Ndiaye et al. (2009) and Ndiaye (2010) used CFS wind but here ECHAM4.5 was forced with CFS SST instead for operational purposes as CFS-forecasted data is not available for recent years.

Methodology

The skill of four rainfall characteristics at the station was assessed: rainfall total, number of rainy days (precipitation greater than 1mm), first significant rainfall event of the season, and true onset date of the rainy season. These indicators are all important for farmers to determine when to plant crops and the best way to care for them.

The first significant rainfall event is defined as the first day of the year after May 1 when a rainfall event totalling more than 20mm over three days or less is recorded. This first event sets the clock of the rainy season and usually determines when farmers plant. But this event is usually not the actual start of the cropping season as shown in Ndiaye (2010). We define the "true onset" as significant event not followed by any dry spell longer than 7 consecutive days. Planting after the true onset ensures the survival of the crop.

Ndiaye (2010) shows that zonal wind over the tropical Atlantic basin can be used as a predictor for Sahel rainfall in general. This study examines whether there are other predictors for the region that can help improve precipitation forecasts. Correlation is used for assessing the predictability of rainfall indices, SST, zonal wind and other general circulation model parameters.

Results

Figure 1 shows the skill of tropical SST in predicting the number of rainy days at Kaffrine. Compared to Fig. IV.8 in Ndiaye (2010), which shows the skill of Sahel rainfall using SST indices, the skill achieved here is higher at the station level than Sahel-wide. The number of wet days are even more predictable than total rainfall. The correlation skill for the number of wet days reaches more than r=0.5 using SST as early as March and reaches its peak in July (r=0.67).

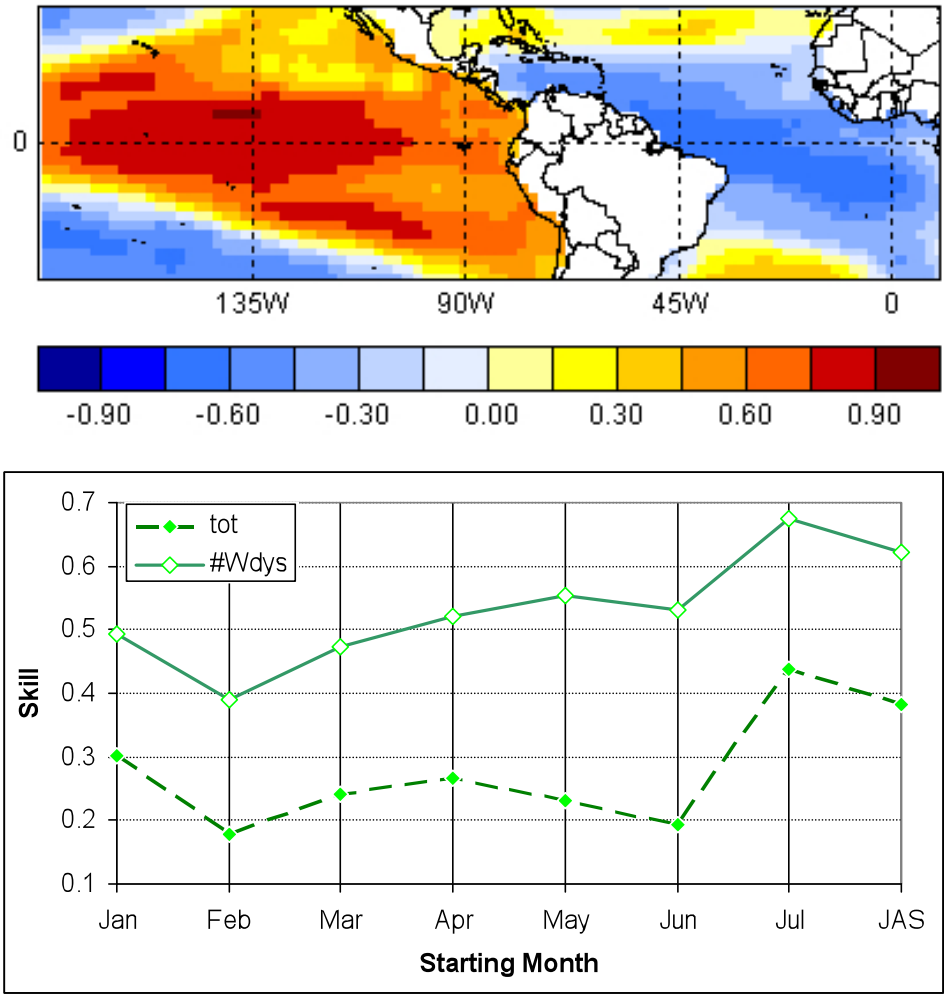

Figure 1. The top panel is the first EOF of SST used as a predictor. The bottom panel shows the skill in predicting the total rainfall (solid line) and the number of wet days (dashed line) over JAS from 1982-2008.

With the ECHAM4.5 forced by the CFS SST forecast, the meridional wind has slightly higher skill than the zonal wind. The skill starts to be significant in May and for total rainfall (r=0.46) and number of wet days (r=0.47). Using the wind from ECHAM4.5 forced by CFS SST does not exhibit the same skill as the fully coupled CFS used in Ndiaye et al. (2009), though. The lower skill using ECHAM4.5 forced by CFS SST might be due to the lack of a fully coupled system or the outperformance of the Global Forecast System, which is the atmospheric component of the CFS, in the ECHAM4.5.

The onset skill improves from r=0.35 to r=0.4 using March initial conditions (Figure 2). The first onset event (onset0) is more predictable with meridional wind than the true onset (onset1).

A crop model was run using observed data to estimate three crop variables of millet: the planting date (first date when the soil is moist enough), the harvest date, and the crop yield. Millet was selected as it is widely planted across Senegal.

Table 1. Correlation between millet crop yield and rainfall events (1987-2007)

	Rainfall	>1mm	>5mm	>10mm	>20mm	>50mm	Onset 0	True onset
Skill	0.41	0.22	0.28	0.39	0.34	0.32	0.49	-0.07

Table 1 shows the correlation between yearly millet crop yield and different rainfall characteristics during the rainy season. The onset of the rainy season is more correlated to the yield than any other seasonal rainfall statistic including total rainfall. In turn, total rainfall is more correlated than the number of wet days. Rainfall events greater than 10mm and total rainfall are equally correlated. In the Sahel the potential evaporation can reach 5mm a day, which can explain those relationships. It's of interest that the first rainfall event is much more correlated than the defined true onset date. This can be explained by the fact that millet can survive a dry spell of seven days and our definition must be revised to 10 days. The

correlation between the planting date and the first significant event (r=0.87) shows the crop model is likely planting the crop at the first significant rainfall event.

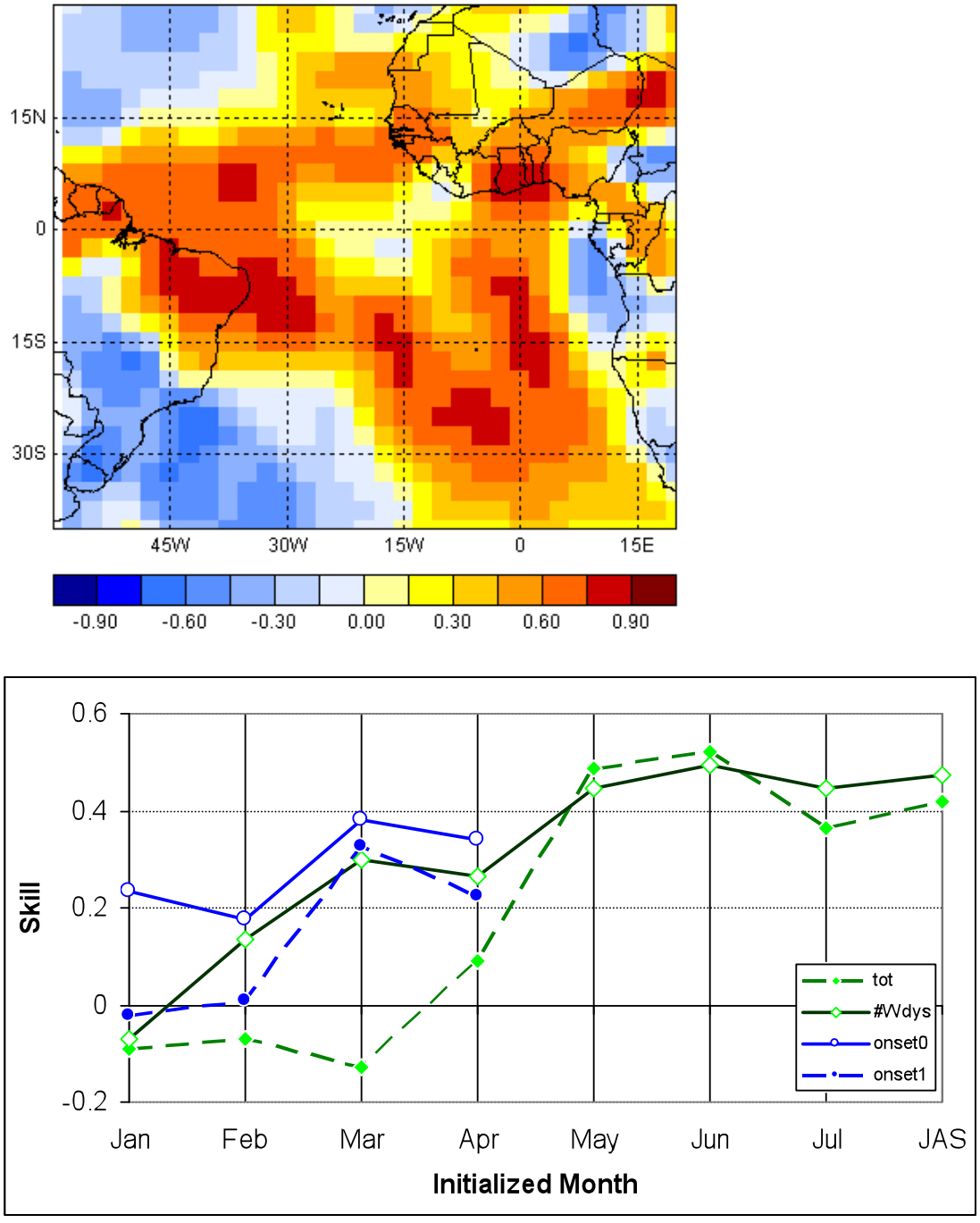

Figure 2. The top panel shows the first EOF of CFS SST. The bottom panel shows the skill in predicting total rainfall (dashed green line), number of wet days (solid green line), first significant rainfall event of the season (solid blue line), and true onset date (dashed blue line) in Kaffrine from 1982-2008.

Conclusion

This study shows that good seasonal rainfall skill can be reached at the station level over Kaffrine region in Senegal. The number of wet days in the season is a better predictor than total rainfall. The CFS winds have higher skill for forecasting rainfall events than the ECHAM4.5 forced with forecasted CFS SST. The reason is beyond the scope of this study but two possibilities are the better performance of the atmospheric component of the CFS (GFS) than the ECHAM4.5 or to the fully coupling system in the CFS compared to the two-tiered runs in the ECHAM4.5.

The onset date skill (r=0.37) is still lower compared to the seasonal total, which is similar to that achieved in Ndiaye (2010). The crop yield is more related to the first significant event of the season (r=0.49) than the rainfall events itself (r=0.41). Rainfall events greater than 10mm have more of an impact on millet yield than number of wet days.

When this study was conducted the CFS runs were discontinued. However, the National Centers for Environmental Prediction recently released a new version of CFS (CFSv2). This new systems promises improved representation of some atmospheric component like the Madden Julian Oscillation, which could further improve predictions in the Kaffrine region and the Sahel at-large. Future studies in the Kaffrine region could also use peanuts as their target crop given the importance its importance in the region's agricultural economy.

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