MULTI-DECADAL VARIABILITY OF WEST AFRICAN RAINFALL AND ATLANTIC SSTS IN CMIP5 SIMULATIONS

Elinor R. Martin* and Chris D. Thorncroft

Department of Atmospheric and Environmental Sciences, SUNY Albany, NY, USA

*emartin4@albany.edu

1. Introduction

Rainfall in the Sahel associated with the west African monsoon during summer shows large decadal to multidecadal variability (Fig. 1).

Observational and modeling studies have shown Sahel rainfall variability to be associated with changes in global sea surface temperatures (SSTs, Fig. 2) with focus on the north Atlantic and Indian Oceans.

This study aims to determine the ability of CMIP5 models to capture the relationship between Sahel rainfall and global SSTs. We focus on the multidecadal teleconnection between SSTs in the north Atlantic, often called the Atlantic Multidecadal Oscillation (AMO) and Sahel rainfall.

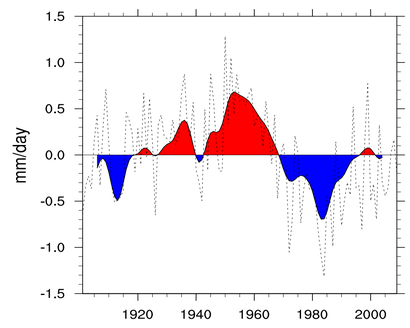

Figure 1: July-August-September (JAS) mean detrended Sahel rainfall and low-pass filter with 10 year cut-off [CRU data].

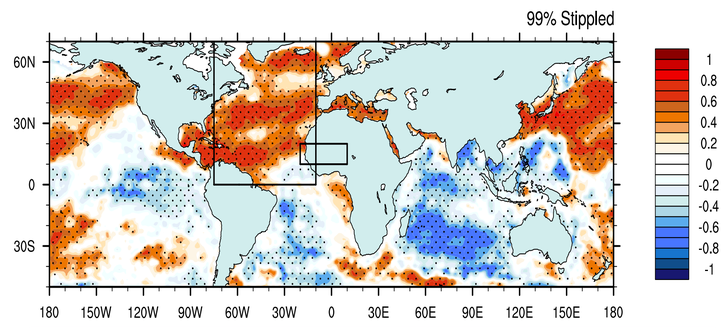

Figure 2: Observed correlations between low-pass filtered JAS Sahel rainfall and global SSTs. Significant correlations at 99 % are stippled. Boxes show region for the Sahel and AMO index [HadISST and CRU data].

2. Model Selection

Select two groups of CMIP5 model output to learn from successful and unsuccessful simulations, based on the following criteria:

1) AMO index decadal variance fraction
2) Sahel rainfall decadal variance fraction
3) Correlation between filtered Sahel rain and N. Atlantic SSTs (AMO)

	Observed	CMIP5 Historical Mean	Group 1: "Good" 6 Models	Group 2: "Poor" 6 Models
AMO decadal variance	66 %	44 %	Above 44 % ☑	Above 44 % ☑
Sahel rainfall decadal variance	43 %	16 %	Above 16 % ☑	Below 16 % ☒
Correlation Sahel rain and N. Atl SST	0.56	0.31	Signif. 90 % ☑	Not Signif. 90 % ☒

3. Results from CMIP5 Simulations

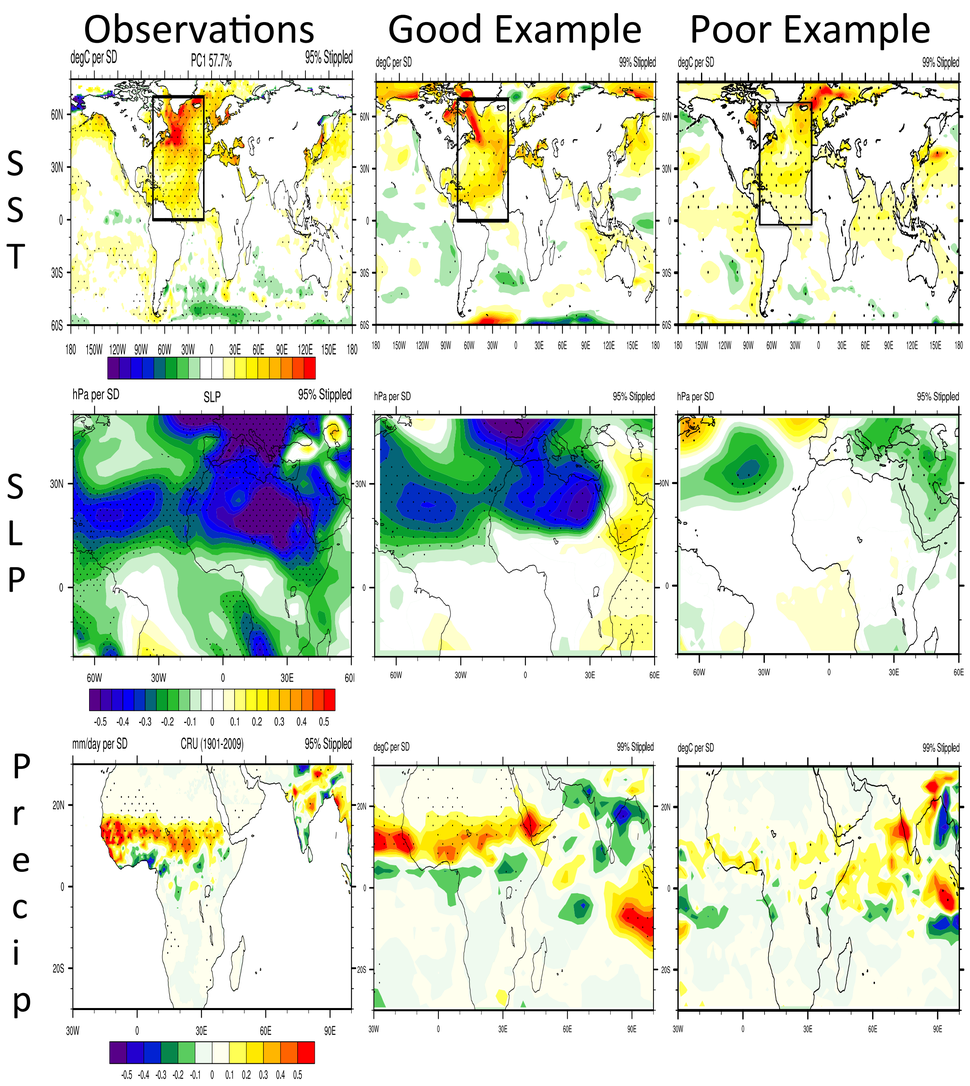

Figure 3: Regression of SST, sea level pressure (SLP from NCEP/NCAR reanalysis) and rainfall onto the first principal component of low-pass filtered north Atlantic (box) SSTs. Columns show observations, a representative example from the good group and a representative example from the poor group.

- Observations:
  1) Horseshoe SST (AMO)
  2) Low SLP – stronger heat low
  3) Increased Sahel rainfall
- "Good" models: Successfully simulate leading SST pattern and the atmospheric response
- "Poor" models:
  1) Weaker SST in tropical Atlantic and Mediterranean
  2) Little SLP response across Africa
  3) Weak West African precipitation response

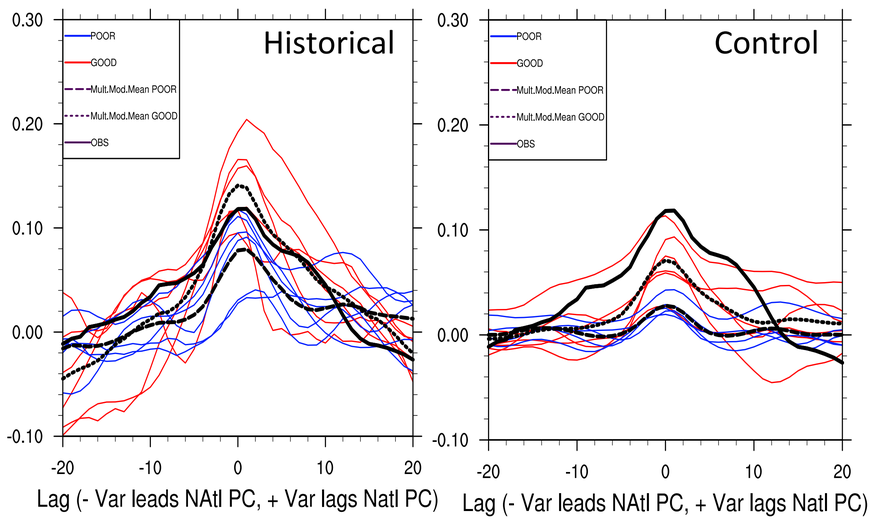

Figure 4: Lagged regression of tropical (0-30°N) N. Atlantic SST for good (red) and poor (blue) simulations onto the first principal component of low-pass filtered north Atlantic (box) SSTs. Historical (left) and pre-industrial control (right).

- Evolution of SST signal is similar to observations
- As seen in SST regression plots (Fig. 3), poor model group has weaker tropical SST signal through evolution
- Weaker tropical SST signal also seen in control simulations (same 12 models), suggesting importance of internal variability simulation

4. Conclusions

- Selected two groups of models to investigate the multi-decadal connection between Atlantic SST and Sahel rainfall
- "Good" group: Successful representation of SST pattern and mechanisms connected to rainfall response
- "Poor" group: AMO-like pattern of SSTs in subpolar region but tropical signal weak, so atmospheric response unlike observation
- Similar results are seen in the control experiments, showing the importance of correct internal variability simulation
- Future work: 1) investigate the role of clouds and aerosols on Atlantic SST spatial structure, 2) Sahel teleconnections with other basins