Understanding Sahelian rainfall prediction skill in NMME seasonal forecast

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1. Introduction

- Sahel: semiarid region located in the westernmost part of the tropical African continent, between the south of Sahara desert and the humid savanna (Nicholson, 2013).

- At interannual timescales, precipitation (PCP) variability over Sahel is influenced by the sea surface temperature anomalies (SSTa) over the equatorial Pacific (Nino3), Atlantic (Atl3) and eastern Mediterranean (eMED). Therefore, the SSTa over these basins are the main sources of predictability (Losada et al., 2010; Janicot et al., 2001; Mohino et al., 2011; Joly and Voldoire, 2009; Rodriguez-Fonseca et al., 2015).
2. Objectives

- To analyze the PCP prediction skill over Sahel in a set of seasonal forecast models investigating where the skill (or lack thereof) comes from.

  We focus the study on PCP prediction in August – September.
3. Data and Methodology

Data

Observational: PCP from GPCPv2.3 and SST from HadISSTv1.1

Models: 16 seasonal forecast models from NMME (see Table)

Period: 1982 – 2010

<table>
<thead>
<tr>
<th>Model name</th>
<th>Institute</th>
<th>Ensemble members</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMC1-Can3</td>
<td>Canadian Meteorological Center</td>
<td>10</td>
</tr>
<tr>
<td>CMC2-Can4</td>
<td>Canadian Meteorological Center</td>
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</tr>
<tr>
<td>CanCM4i</td>
<td>Canadian Centre for Climate Modelling and Analysis</td>
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<tr>
<td>CanSSPv2</td>
<td>The Canadian Seasonal to Intertidal Prediction System version 2</td>
<td>20</td>
</tr>
<tr>
<td>GEM-NEMO</td>
<td>Recherche en Prévision Numérique (Paris, France)</td>
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</tr>
<tr>
<td>COLA-RSMAS-CCSM3</td>
<td>National Center for atmospheric Research (NCAR)</td>
<td>6</td>
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<tr>
<td>COLA-RSMAS-CCSM4</td>
<td>National Center for atmospheric Research (NCAR)</td>
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<tr>
<td>GFDL-CM2p1</td>
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<td>GFDL-CM2p4-wiess</td>
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<td>NCEP-CFSv2</td>
<td>National Center for Environmental Prediction</td>
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</tr>
</tbody>
</table>

Table 1: NMME models considered in this study. See Finnigan et al., 2014 for more details.

Methodology

Analysis of the skill in:

PCP and SST → Anomaly correlation coefficients (ACC): correlation between the observed and modeled indices

Teleconnections → correlation between the oceanic index and PCP. Comparison of the results from observations and models

Where skill (or lack thereof) comes from:

Multiple-linear regression analysis:

\[
P_{CP} = \alpha \cdot eMED_{index} + \beta \cdot Nino3_{index} + \gamma \cdot Atil3_{index} + \epsilon
\]

Contributions to PCP prediction skill:

\[
ACC = \frac{\rho(P_{CP_{obs}}, P_{CP_{nmme}})}{\sqrt{\text{var}(P_{CP_{obs}}) \cdot \text{var}(P_{CP_{nmme})}}} = \frac{\rho(P_{CP_{obs}}, eMED_{index})}{\sqrt{\text{var}(P_{CP_{obs}})}} + \frac{\rho(P_{CP_{obs}}, Nino3_{index})}{\sqrt{\text{var}(P_{CP_{obs}})}} + \frac{\rho(P_{CP_{obs}}, Atil3_{index})}{\sqrt{\text{var}(P_{CP_{obs}})}} + \frac{\rho(P_{CP_{obs}}, \epsilon_{nmme})}{\sqrt{\text{var}(P_{CP_{obs}})}}
\]

Where \(\rho(P_{CP_{obs}}, P_{CP_{nmme}})\) is the correlation between PCP from observations (\(P_{CP_{obs}}\)) and PCP from NMME models (\(P_{CP_{nmme}}\)).
In general, NMME models do not present skill for predicting PCP over Sahel, although results improve when averaging all the models (Ens-Mean on Figure). Multimodel mean presents PCP skill for most of the forecast start times.

Where does the lack of skill come from?

The main sources of predictability at interanual timescales are the SSTa over the eMED, Nino3 and Atl3.

Therefore, to know where the lack of skill comes from, it is needed to analyze the skill of the NMME models for predicting the SSTa over these basins as well as their teleconnections with PCP.
4. Results

**eMED**
- Skill in SSTa: No skill for eMED
- Skill for eMED teleconnetion

**Niño3**
- Skill in SSTa: Skill for Niño3 teleconnetion

**Atl3**
- Skill in SSTa: Skill for Atl3 teleconnetion

**Correlation**
- Number of cases in models
- Correlation in models
- Correlation in obs

**FST** (Forecast Start Time)
- 1st Aug
- 1st Jul
- 1st Jun
- 1st May
- 1st Apr
- 1st Mar
- 1st Feb

**Number of cases in models**

**Correlation** (eMED,PCP)

**Correlation** (Nino3,PCP)

**Correlation** (Atl3,PCP)

**Most of NMME have skill for Atl3**
- Atl3 teleconnetion highly model dependent
4. Results

Contributions to PCP prediction skill in August - September

Correlation \( \rho(\text{PCPobs}, \text{PCPnmm}) \)
5. Conclusions

- Most of the NMME models lack of skill for predicting PCP over Sahel in NMME, although results improve when considering the multimodel mean, which presents skill for most of the forecast start times.

- For models to have a good skill in predicting PCP, they need to reproduce correctly:
  1) the SSTa variability of the main sources of predictability as well as
  2) their teleconnections with PCP over Sahel

- Main Sources that could supply skill to NMME models:
  - eMED
    - Good ability for simulating teleconnection
    - No ability for predicting SSTa for any lead time (main reason for the lack of PCP skill)
  - Nino3
    - Good ability for simulating teleconnection for all lead times considered
    - Good ability for predicting SSTa for all lead times considered
  - Atl3
    - Teleconnection highly model dependent
    - Most of models reproduce SSTa for different lead times

- In general, the main contributor to PCP skill in models is Niño3, following by Atl3. For Forecast Start times before than 1st June, eMED also contributes to PCP skill.
6. References


