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Understanding Sahelian rainfall prediction skill in NMME seasonal forecast

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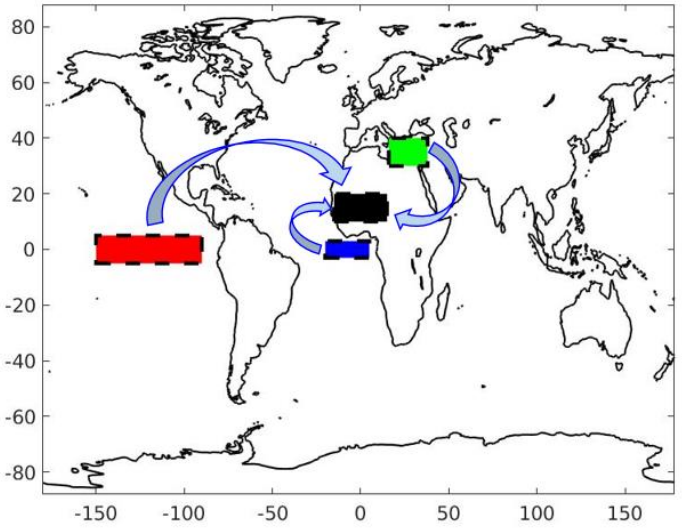
1. Introduction

- 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

Model name	Institute	Ensemble members
CMC1-Can3	Canadian Meteorological Center	10
CMC2-Can4	Canadian Meteorological Center	10
CanCM4i	Canadian Centre for Climate Modelling and Analysis	10
CanSIPSv2	The Canadian Seasonal to Interannual Prediction System version 2	20
GEM-NEMO	Recherche en Prévision Numérique (Paris, France)	10
COLA-RSMAS-CCSM3	National Center for atmospheric Research (NCAR)	6
COLA-RSMAS-CCSM4	National Center for atmospheric Research (NCAR)	10
GFDL-CM2p1	Geophysical Fluid Dynamics Laboratory NOAA	10
GFDL-CM2p1-aer04	Geophysical Fluid Dynamics Laboratory NOAA	10
GFDL-CM2p5-A06	Geophysical Fluid Dynamics Laboratory NOAA	12
GFDL-CM2p5-B01	Geophysical Fluid Dynamics Laboratory NOAA	12
IRI-ECHAM4p5-AnomalyCoupled	International Research Institue for climate and Society (IRI)	12
IRI-ECHAM4p5-DirectCoupled	International Research Institue for climate and Society (IRI)	12
NASA-GEOSS2S	National Aeronautics and Space Administration (NASA)	4
NCAR-CESM1	National Center for Atmospheric Research	10
NCEP-CFSv2	National Center for Environmental Prediction	24

Table 1. NMME models considered in this study. See Kirtmann 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
  - Teleconnetions → 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:

$$PCP = \alpha \cdot eMED_{index} + \beta \cdot Nino3_{index} + \gamma \cdot Atl3_{index} + \epsilon$$

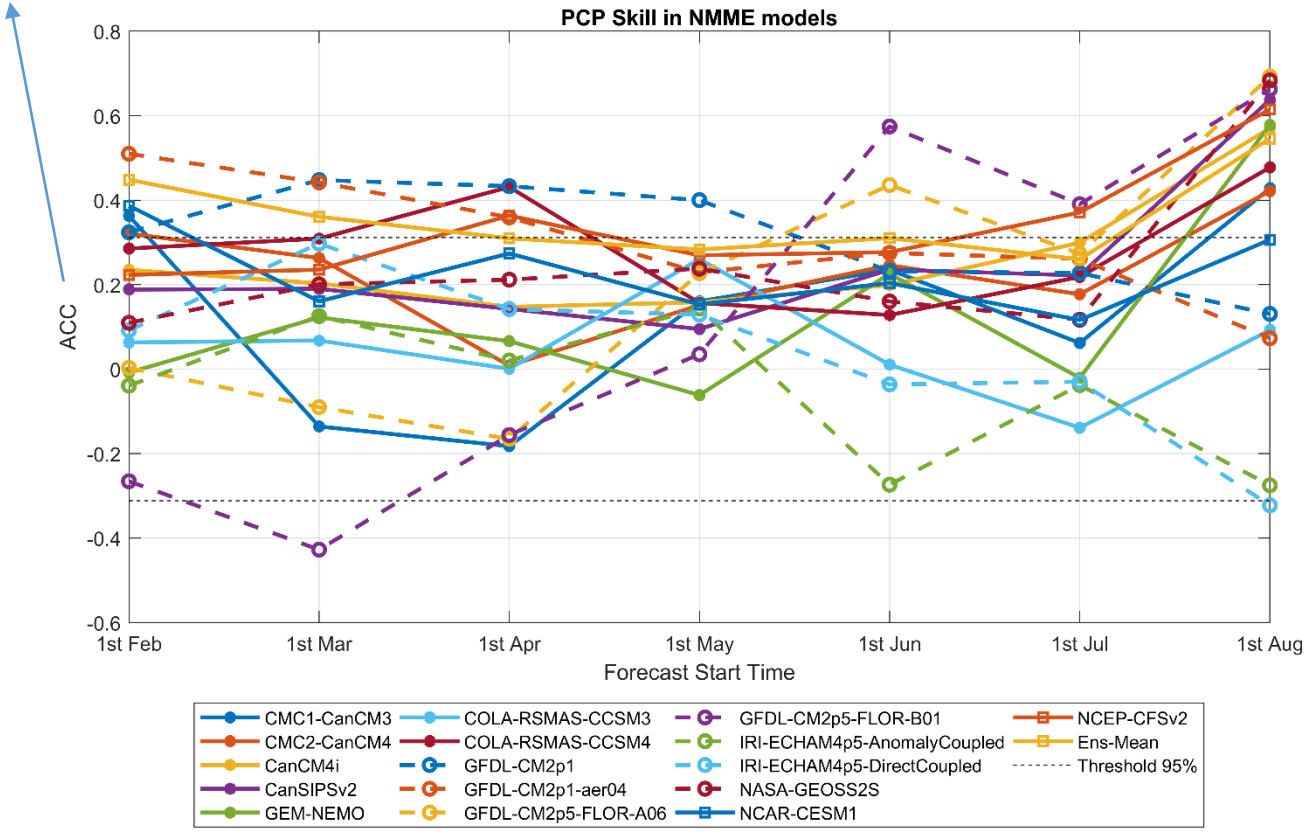
  - Contributions to PCP prediction skill:

$$ACC = \rho(PCP_{obs}, PCP_{nmme}) = \frac{\alpha}{\sqrt{var(PCP_{nmme})}}\rho(PCP_{obs}, eMED_{nmme}) + \frac{\beta}{\sqrt{var(PCP_{nmme})}}\rho(PCP_{obs}, Nino3_{nmme}) + \frac{\gamma}{\sqrt{var(PCP_{nmme})}}\rho(PCP_{obs}, Atl3_{nmme}) + \frac{\sqrt{var(\epsilon_{nmme})}}{\sqrt{var(PCP_{nmme})}}\rho(PCP_{obs}, \epsilon_{nmme})$$

Where $\rho(PCP_{obs}, PCP_{nmme})$ is the correlation betweeen PCP from observations (PCP_{obs}) and PCP from NMME models (PCP_{nmme}).

4. Results

Correlation between PCP index from observations and the one from models



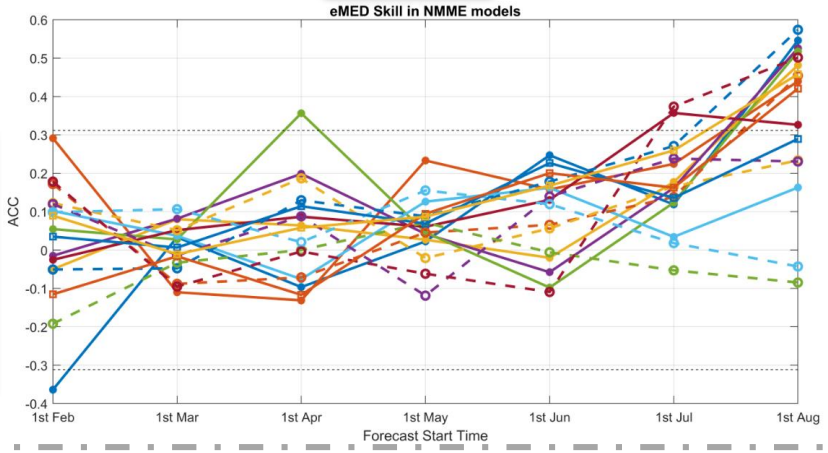
- In general, NMME models do not present skill for predicting PCP over Sahel, although results improve when averaging all the models (Ens-Mean on Figure). Multimodel mean presents PCP skill for most of the forecast start times
- Where does the lack of skill come from?
  - The main sources of predictability 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

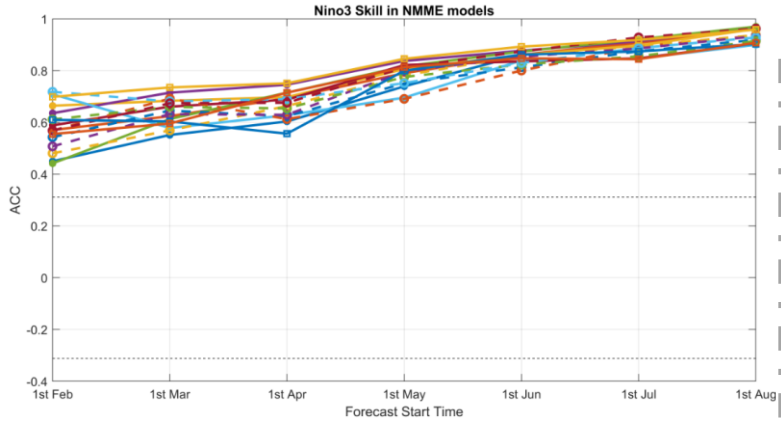
CMC1-CanCM3, CMC2-CanCM4, CanCM4i, CanSIPSv2, GEM-NEMO, COLA-RSMAS-CCSM3, COLA-RSMAS-CCSM4, GFDL-CM2p1, GFDL-CM2p1-aer04, GFDL-CM2p5-FLOR-A06, GFDL-CM2p5-FLOR-B01, IRI-ECHAM4p5-AnomalyCoupled, IRI-ECHAM4p5-DirectCoupled, NASA-GEOSS2S, NCAR-CESM1, NCEP-CFSv2, Ens-Mean, Threshold 95%

Skill in SSTa

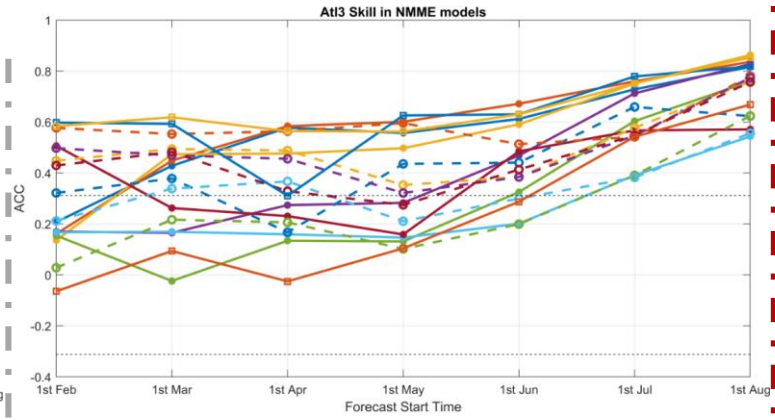
eMED



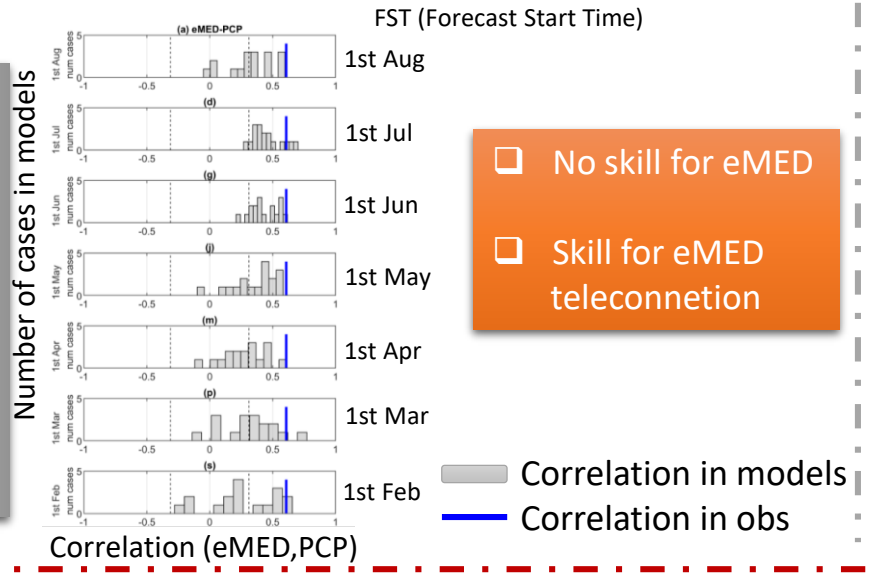
Niño3



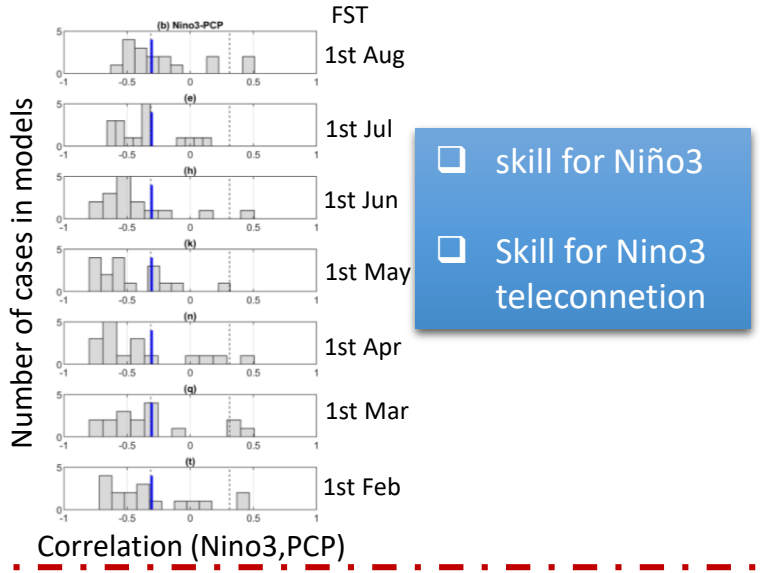
Atl3



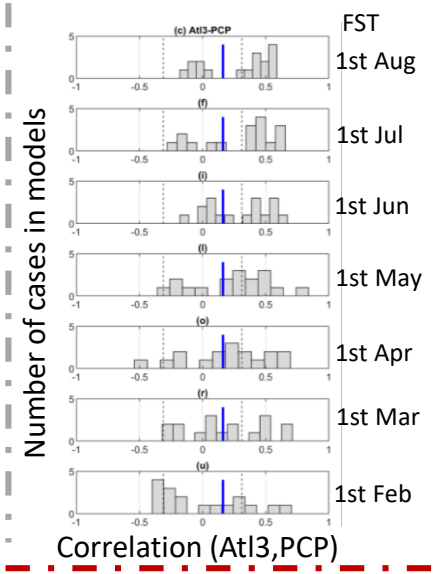
Skill in Teleconnetion



- No skill for eMED
- Skill for eMED teleconnetion



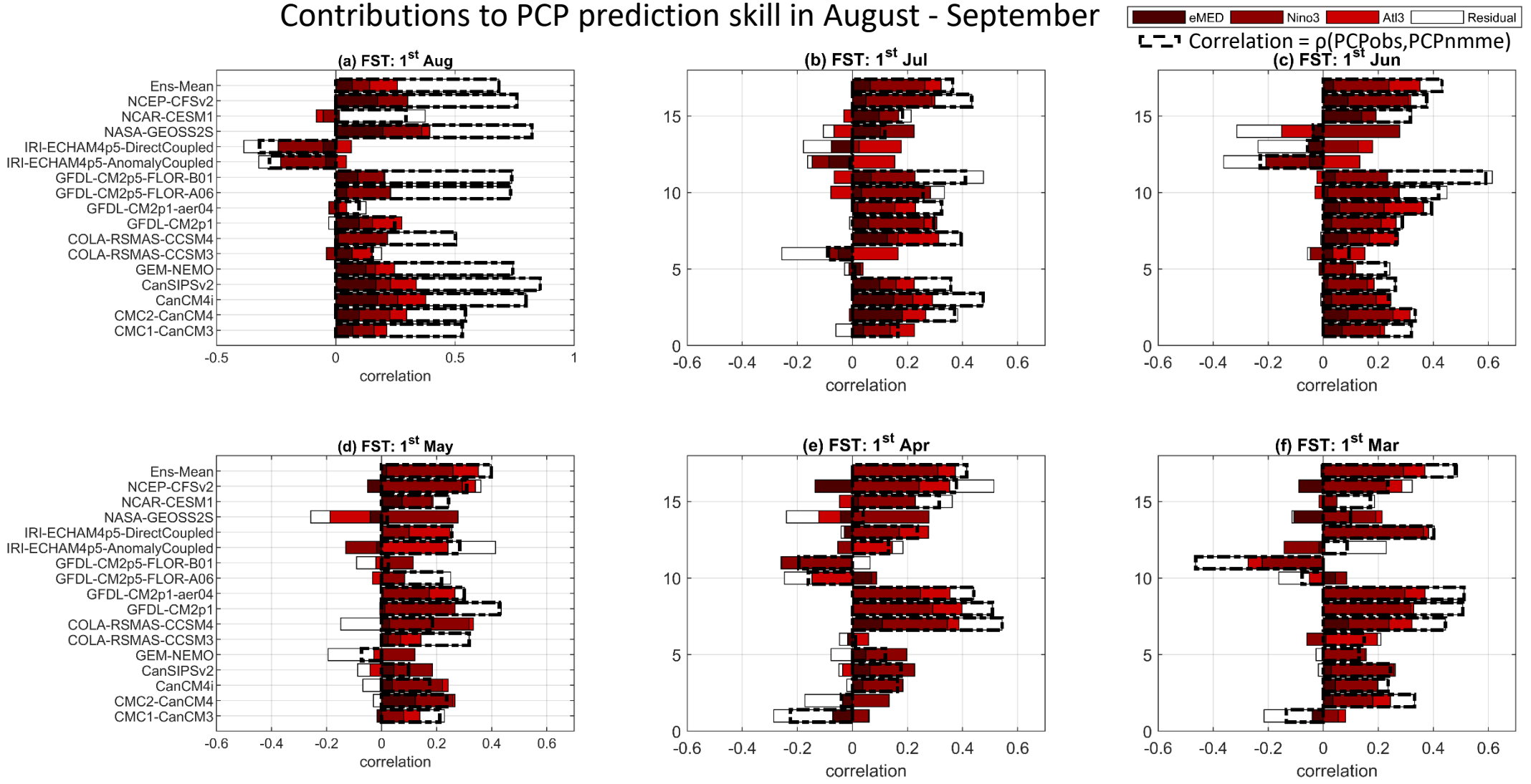
- skill for Niño3
- Skill for Nino3 teleconnetion



- Most of NMME have skill for Atl3
- Atl3 teleconnetion highly model dependent

4. Results

Contributions to PCP prediction skill in August - September



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

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