How Much Can Model Output Statistics Improve Sub-Seasonal Prediction Skill?

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Model Output Statistics

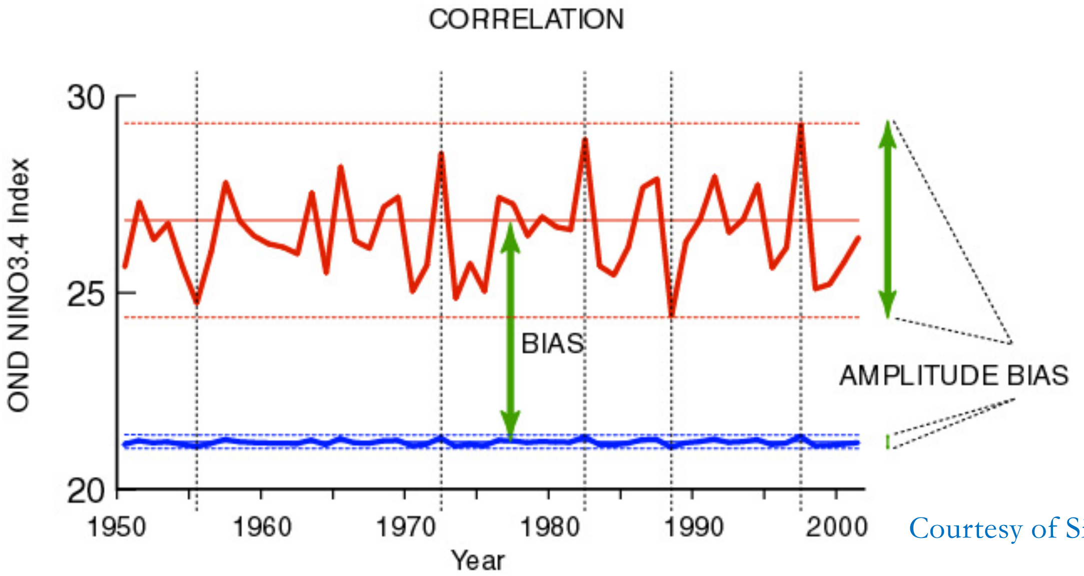
- Because of uncertainties in initial/boundary conditions, unknown or unresolved physical processes and the chaotic nature of the climate system, ***models are always subject to error***.

- Part of those errors are systematic, and can be corrected using **Model Output Statistics (MOS).**

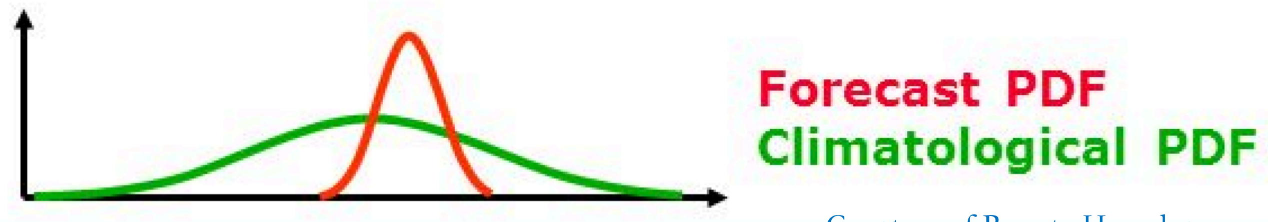
- Other errors are *not* correctible, and it is customary to provide an ensemble forecast to quantify uncertainties. This leads to probabilistic forecasts.

Model Output Statistics

- It is common to use Anomaly Correlation Coefficient to assess forecast skill, but it only measures *association*.
- There are a lot of other forecast attributes of interest!



Courtesy of Simon J. Mason



Courtesy of Renate Hagedorn

Ignorance Score

The Ignorance Score (IGN), or negative log-likelihood score, of a probabilistic forecast of *n* categories can be written as (Good 1952; Roulston & Smith, 2002):

$$IGN = -\log_2(p_k) \qquad\qquad k = 1..n$$

and it can be decomposed into reliability, resolution and uncertainty terms:

$$IGN = REL - RES + UNC$$

(Weijs et al., 2010; Wilks, 2018)

calibration sharpness obs distribution

- It measures the information deficit, or ignorance, of a person having a probabilistic forecast but not knowing the actual outcome.

- Units are *bits* of information. IGN=0 means perfect forecast (zero ignorance).

- Each bit of ignorance represents a factor-of-2 increase in uncertainty.

- Related to expected gambling return if used to place proportional bets on the future (cost-loss scenarios).

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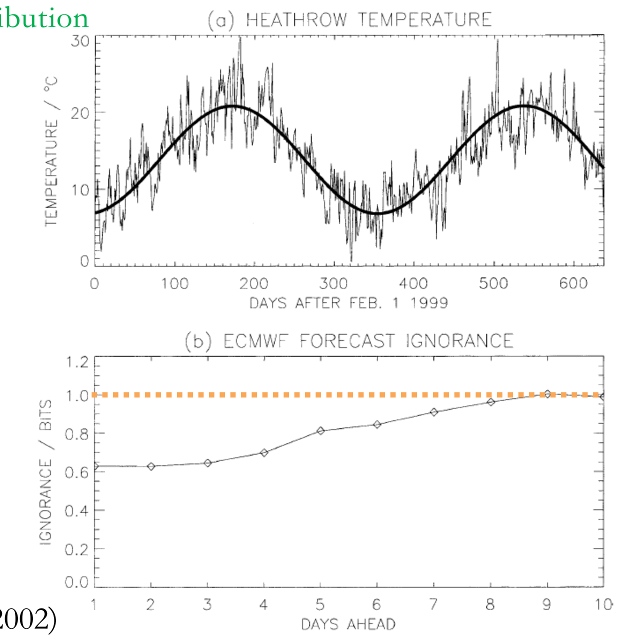
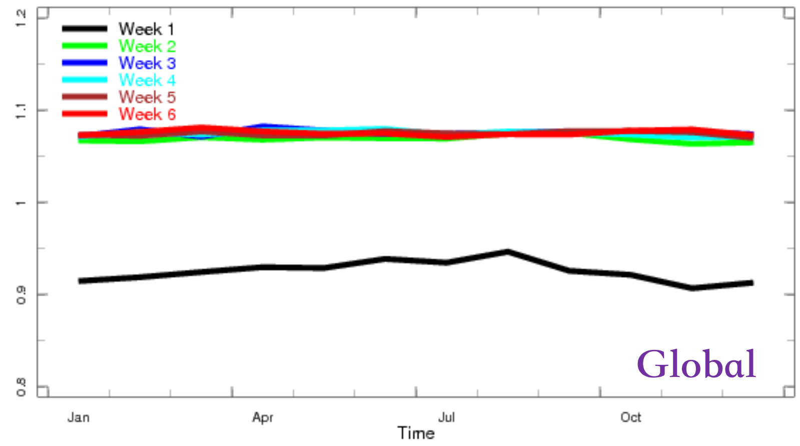
There are different ways to define a skill score for IGN. Here we use climatology as the reference. For equiprobable climatological categories,

$$ISS = -\frac{\log_2(p_k)}{\log_2(n)} \begin{cases} > 1 & \text{Less info than climatology} \\ = 0 & \text{As good as climatology} \\ < 1 & \text{More info than climatology} \end{cases}$$



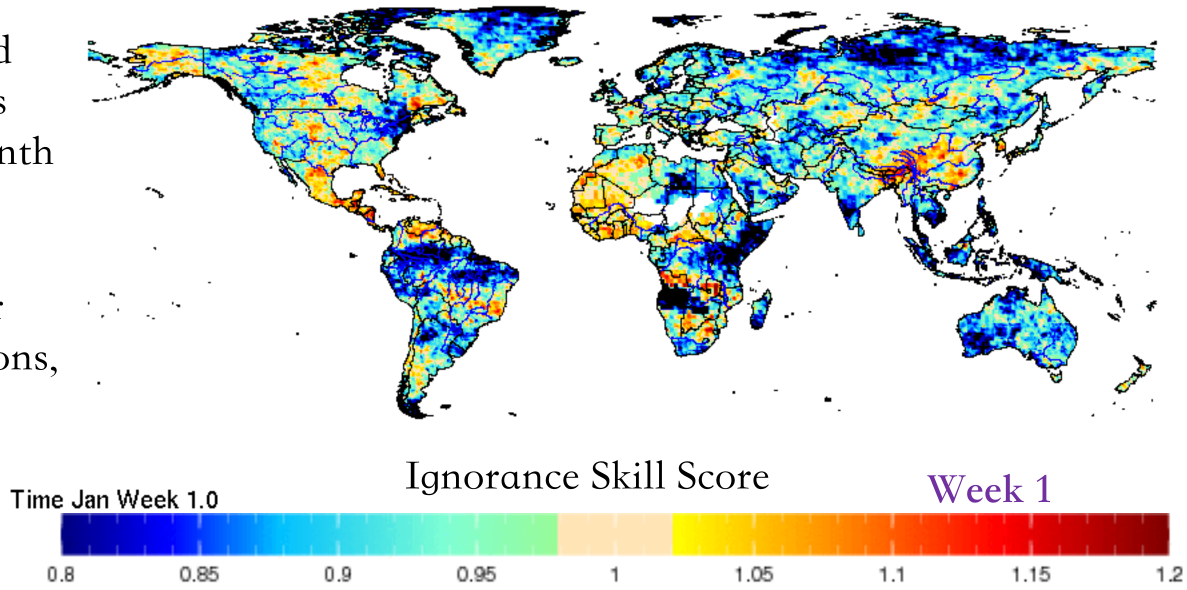
Roulston & Smith (2002)

Seasonality of Sub-seasonal Skill



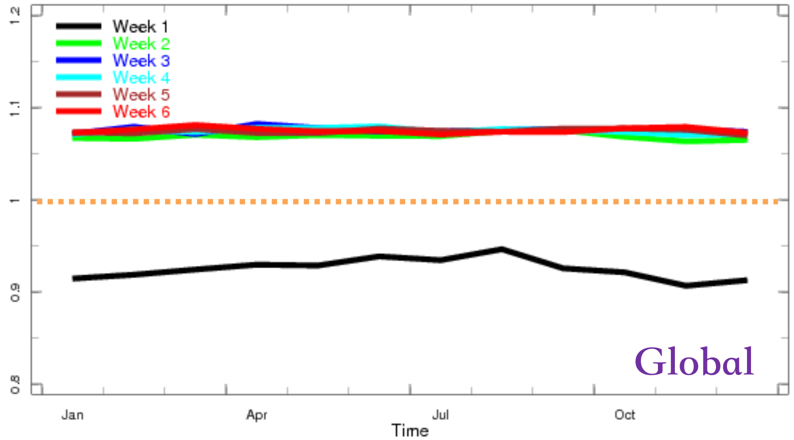
<u>Skill Assessment</u>

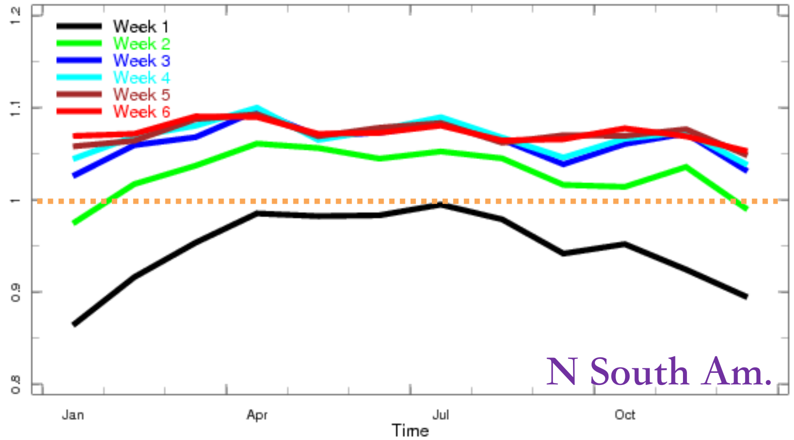
- Model: ECMWF
- Rainfall
- Probabilistic Hindcasts
- Obs: CPC Unified
- All initializations available per month (8-9)
- **Uncalibrated**
- IGN, RPSS, Brier and decompositions, for Week 1-6

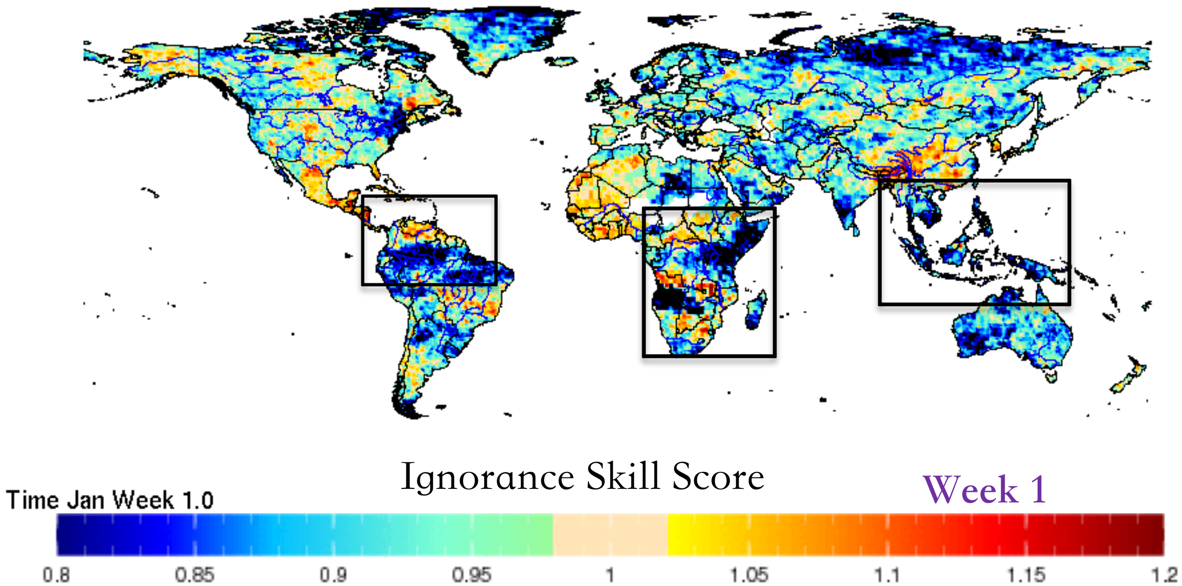


Muñoz et al. (in prep)

Seasonality of Sub-seasonal Skill

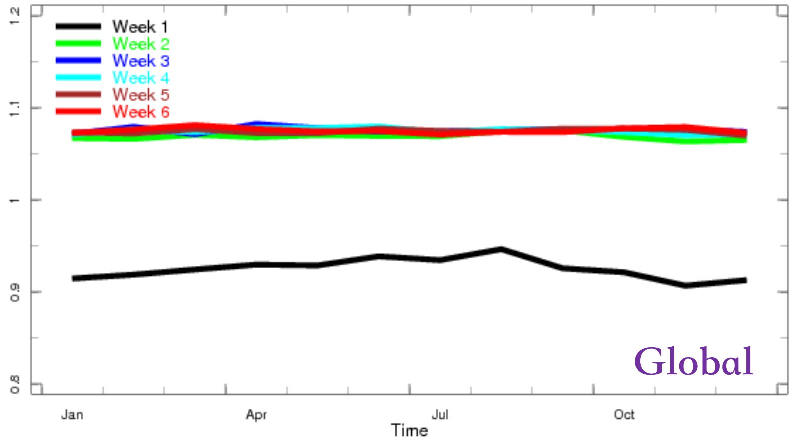


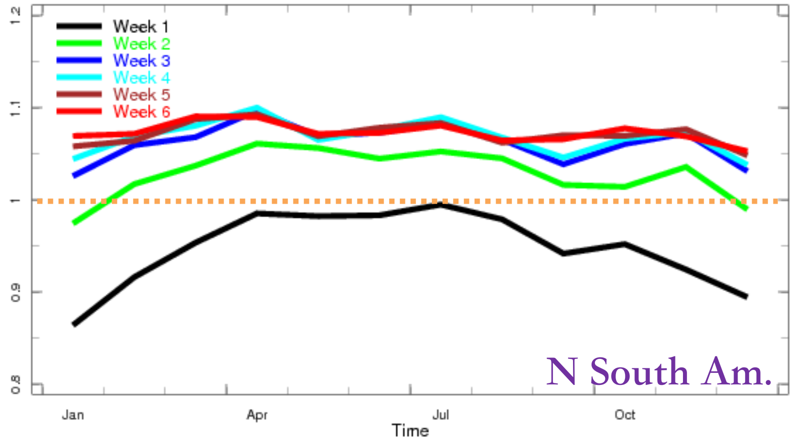


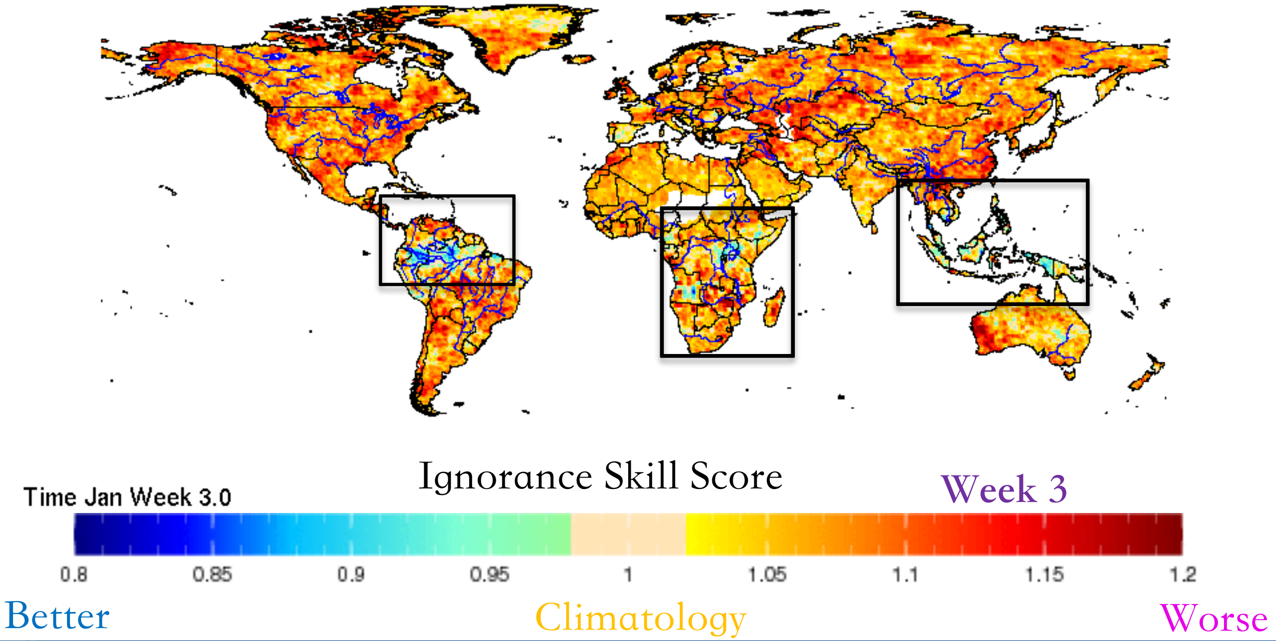


Muñoz et al. (in prep) Better Climatology Worse

Seasonality of Sub-seasonal Skill







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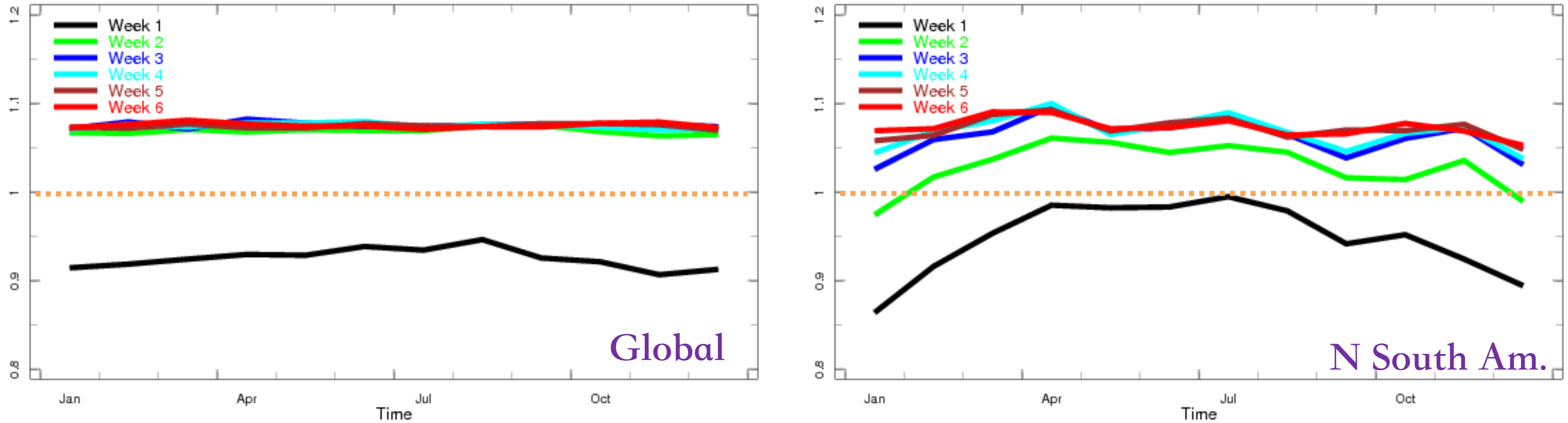
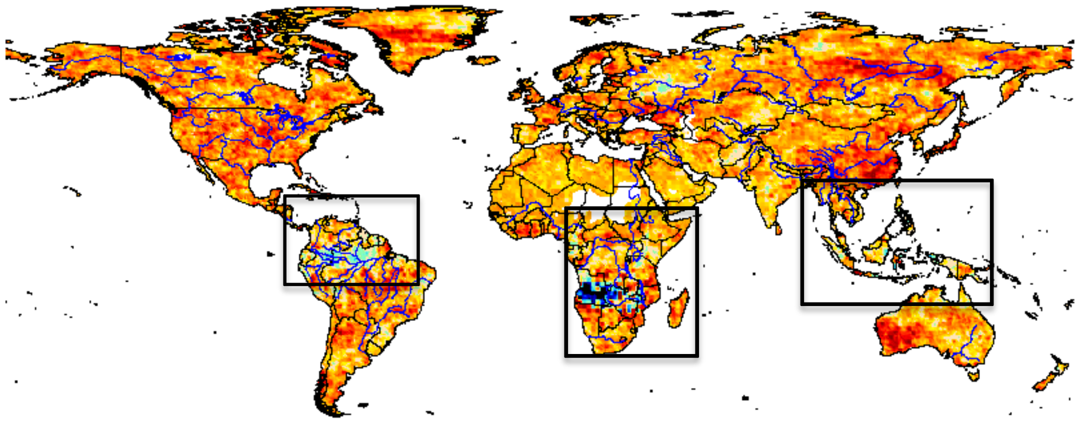
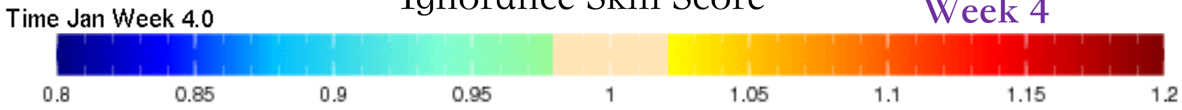
Seasonality of Sub-seasonal Skill





Ignorance Skill Score

Week 4



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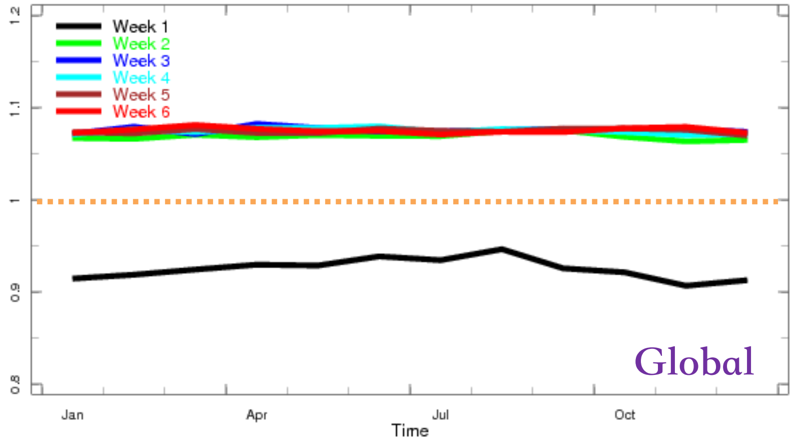
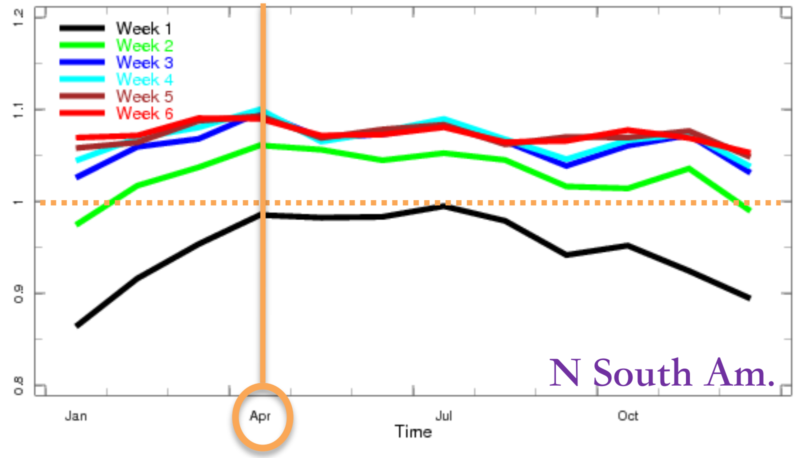
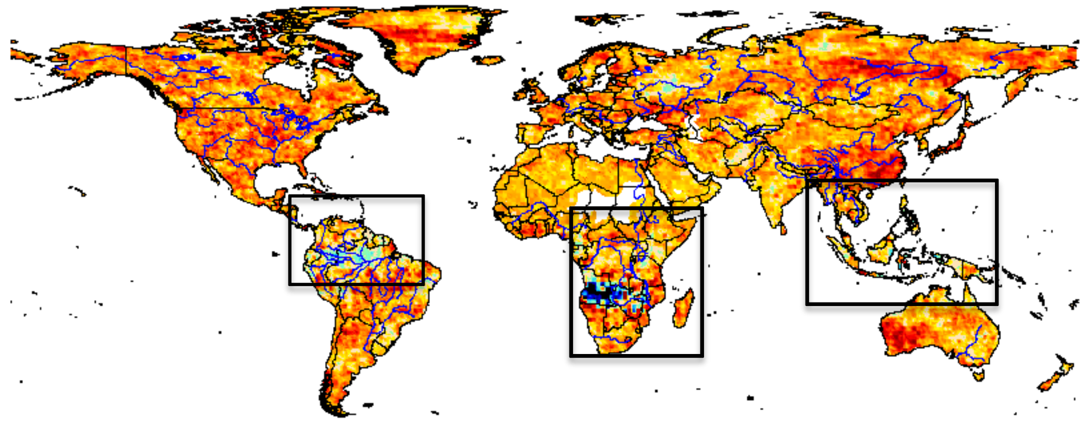
Better Climatology Worse

Seasonality of Sub-seasonal Skill

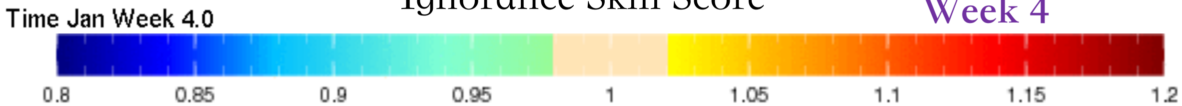






Ignorance Skill Score

Week 4



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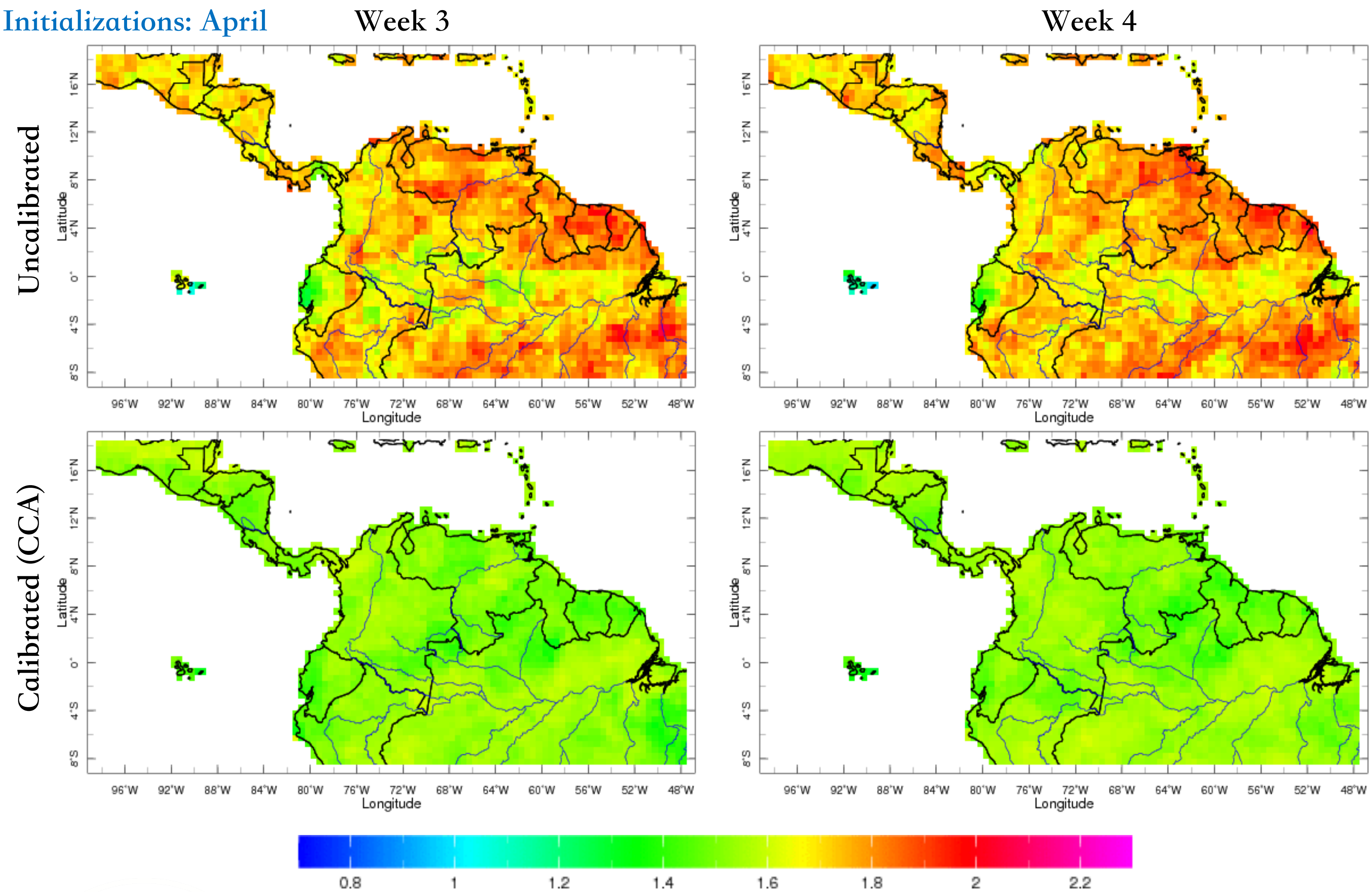
Better Climatology Worse

Initializations: April



Better

Ignorance Score (bits)

Worse

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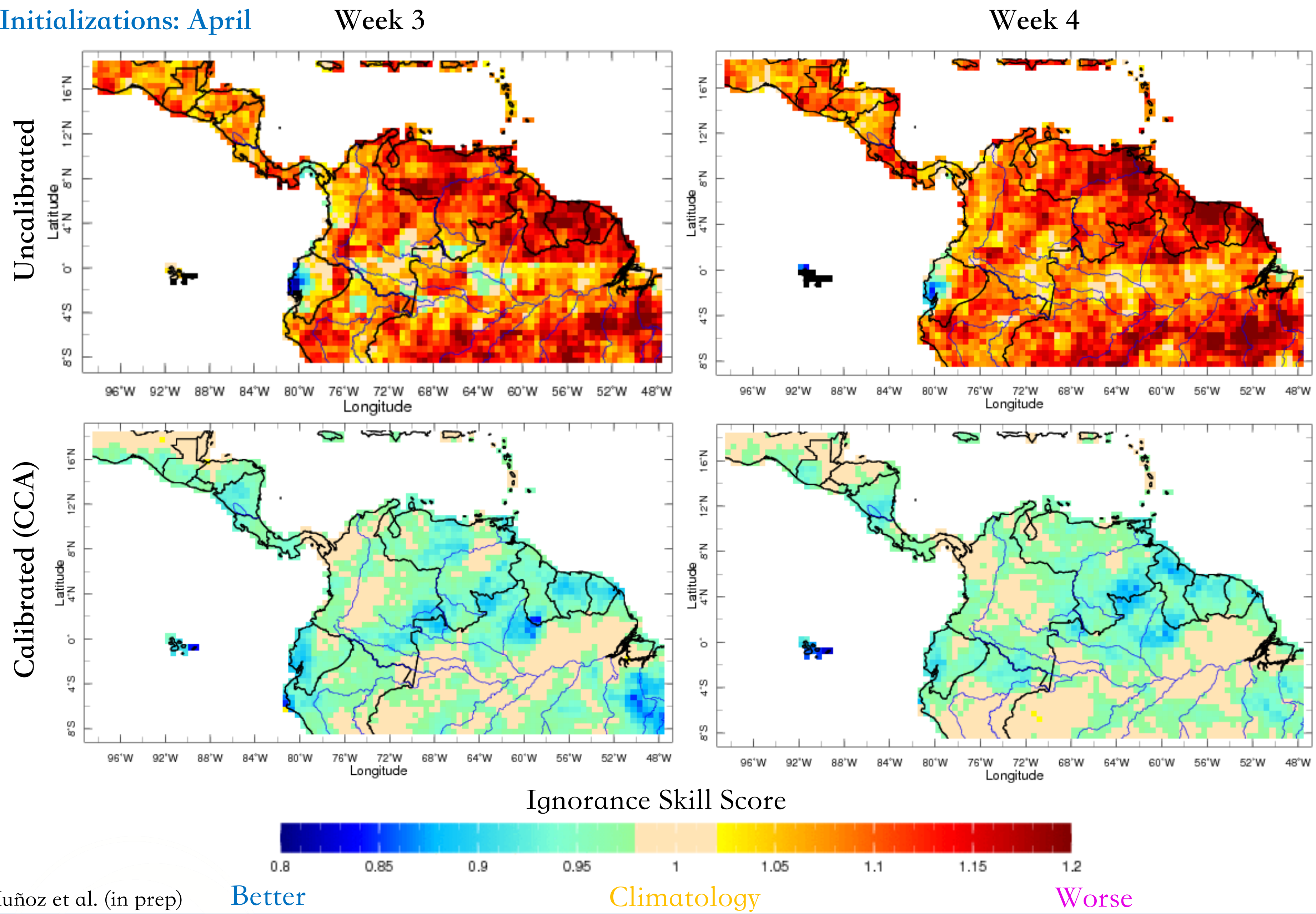
Initializations: April



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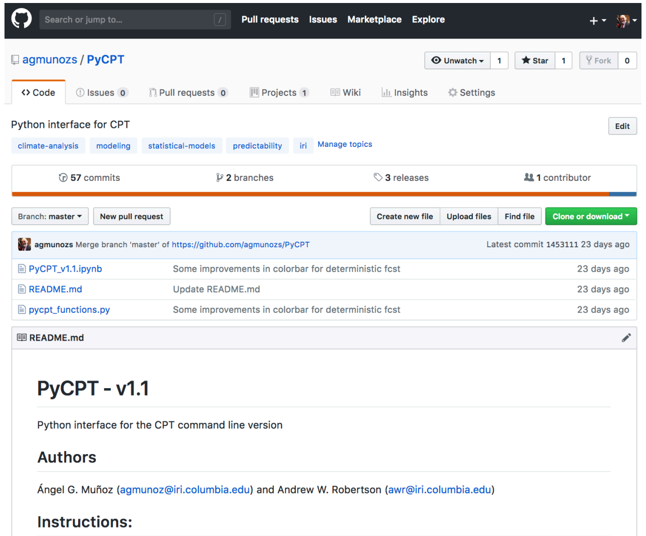
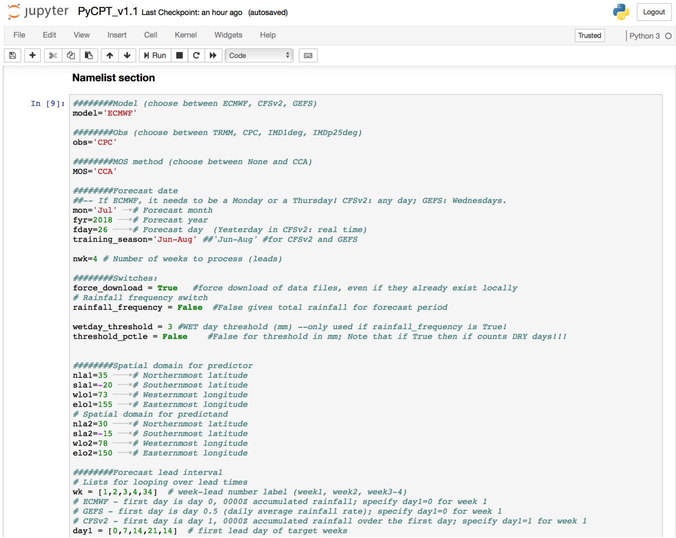
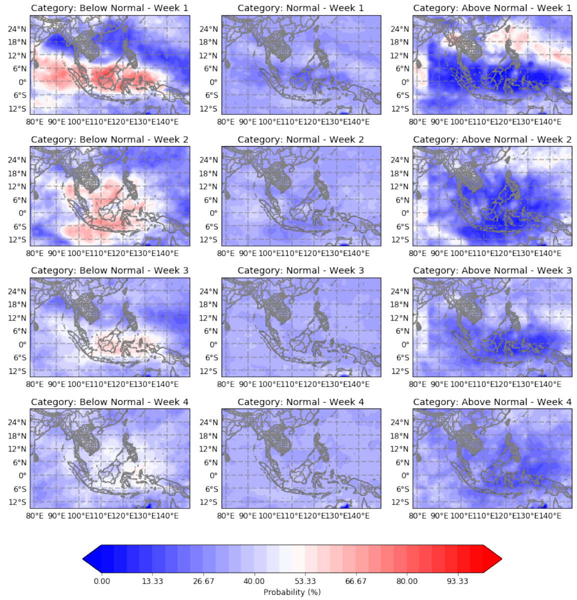
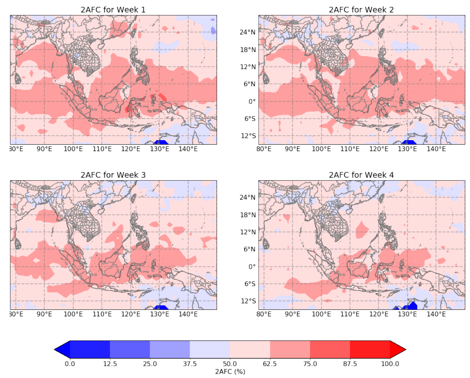
https://github.com/agmunozs/PyCPT

PyCPT









- Python interface for IRI's Climate Predictability Tool (CPT), a widely used research and application Model Output Statistics/Prediction toolbox.
- Publicly available: GitHub.
- Automatically downloads required observations (TRMM, CPC Unified) and S2S model data from the IRI Data Library (**S2S Database** and **SubX** – ECMWF, CFSv2, GEFS, others are being included).
- Computes climatologies, anomalies, a variety of skill metrics (uncalibrated and CCA-calibrated hindcasts) and probabilistic sub-seasonal forecasts.

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Columbia World Project "ACToday" (Goddard)

Conclusions

- Sub-seasonal skill – as measured by the Ignorance Score – at *regional* scale tends to exhibit seasonality. *Global* sub-seasonal skill varies less along the year.

- Generally speaking, uncalibrated sub-seasonal forecast skill is worse than climatology after Week 2. There are some exceptions: Tropical South America, Eastern and Southern Africa, Maritime Continent.

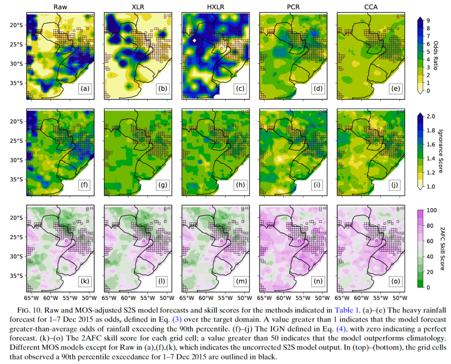
- Model Output Statistics has the potential to improve forecast skill at sub-seasonal timescales. In particular, EOF-based MOS methods like Canonical Correlation Analysis (and Principal Component Regression) show clear skill improvement for different regions of the world, both in magnitudes and spatial patterns.

- Work in progress – stay tuned.

More details?

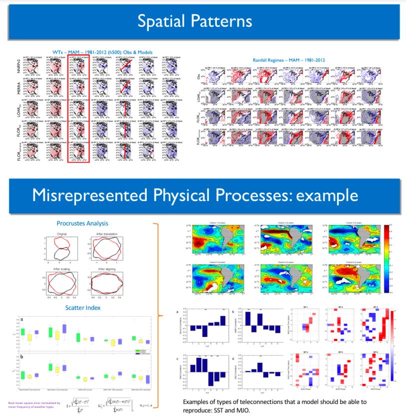
Doss-Gollin, James	Heavy rainfall in Paraguay during the 2015-2016 austral summer: causes and sub-seasonal-to-seasonal predictive skill	**P-C3-04**	Thursday 20 Sept.	Center Green

Doss-Gollin et al (JClim 2018)



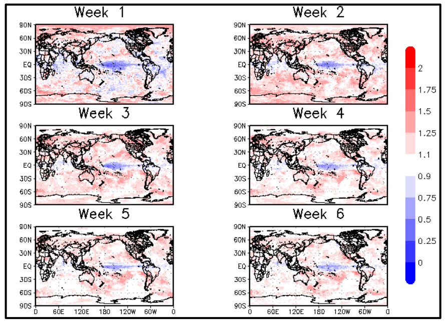
Munoz, Angel G	A Seamless Process-based Model Evaluation Framework for Subseasonal-to-Decadal Timescales	**P-C3-09**	Thursday 20 Sept.	Center Green

Muñoz et al (JClim 2017; in prep.)



Materia, Stefano	A multi-model approach for cold spell sub-seasonal prediction in Northern Turkey	**P-A4-08**	Wednesday 19 Sept.	Center Green

Materia et al (in prep.)



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