Climate predictability on seasonal timescales over South America from NMME models through ANOVA

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Goals

» Assess the predictability of the South American climate on seasonal timescales represented by the models participating in the North American Multiple Model Ensemble Project (NMME).

» Analyze the decomposition of the total variance of precipitation and temperature in the contribution from the signal, bias, structural model uncertainty and noise.

» Estimate the potential predictability and analyze the performance of climate models in forecasting the precipitation and temperature.

SON and **DJF** precipitation and temperature forecast
Lead 1 month (e.g. DJF forecast with initial condition from November)
Hindcast : 1982 - 2010

Observed data set:
Temperature CPC
Precipitation CMAP

Institution	Model	Hindcast	Members
COLA	CCSM4	1982-2010	10
GFDL	CM2p1	1982-2010	10
GFDL	FLOR-A05	1982-2018	12
GFDL	FLOR-B01	1982-2018	12
NASA	GEOS5	1982-2010	4
NCEP	CFSv2	1982-2010	24
CMC	CanCM4i	1982-2010	10
ECCC	GEM-NEMO	1982-2018	10

Variance partition through ANOVA

An individual data value X_{tmk} (t denoting time, m model and k realization) can be decomposed into:

$$\mathbf{X}_{tmk} = \mu + \alpha_t + \beta_m + \gamma_{tm} + \xi_{tmk}$$

And the Total Squared Sum, $TSS = \sum_{tmk} (X_{tmk} - X_{000})^2$, can be decomposed in:

$$TSS = SS\alpha + SS\beta + SS\gamma + SS\xi$$

$SS\alpha$: fraction of variance associated to **signal** (α_t)

$SS\beta$: fraction of variance associated to the **bias** β_m

$SS\gamma$: fraction of variance associated to the differences between the models in their responses to a common forcing.

$SS\xi$: fraction of variance associated with **noise** (ξ)

ANOVA

We use ANOVA to estimate the fraction of the variance associated to each term, for instance, the fraction of variance determined by bias between models (β)

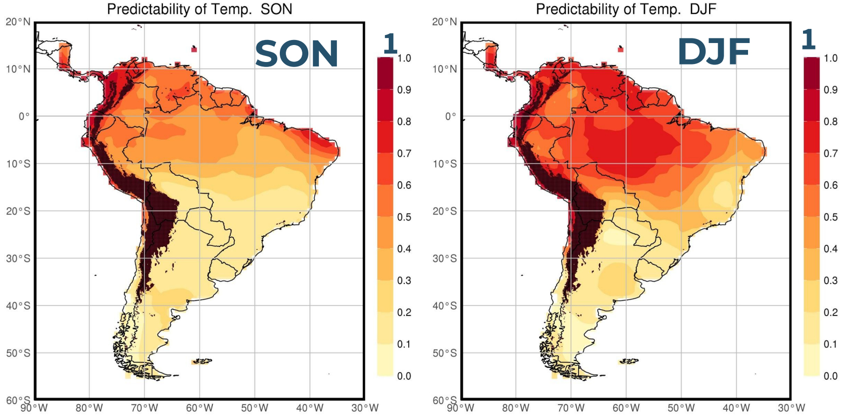
$$(SS\beta - \frac{M-1}{T(Ktotal-1)} SS\xi) / TSS$$

And in particular the **potential predictability**, defined as:

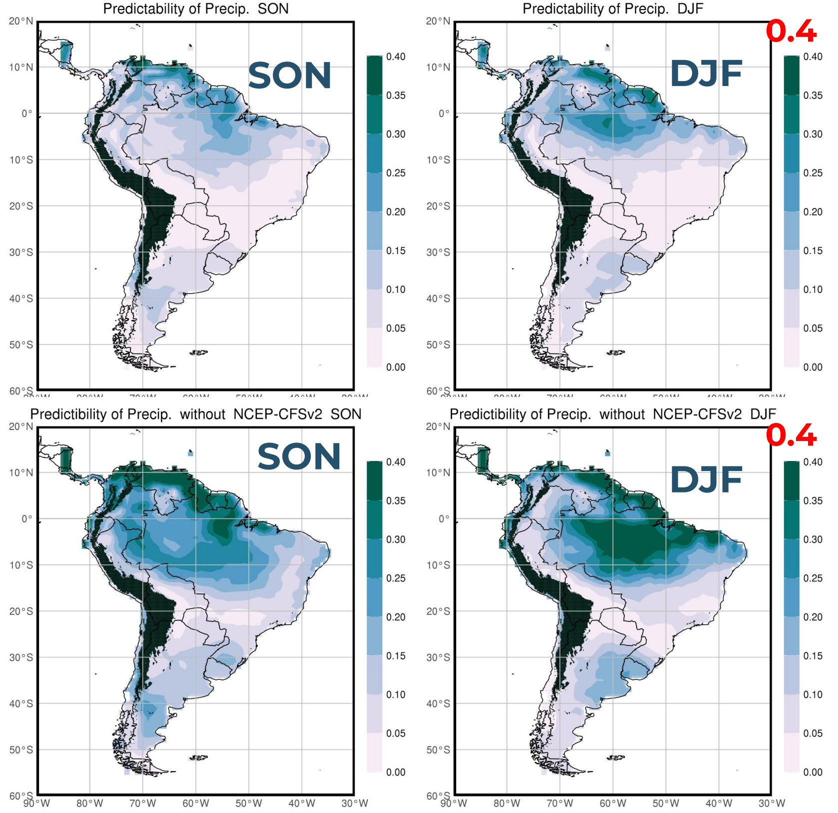
$$\mathrm{PP} = \frac{\sigma_\alpha^2}{\sigma_\alpha^2 + \sigma_\epsilon^2}$$

Predictability

Temperature
Multi-model ensemble



Precipitation
Multi-model ensemble

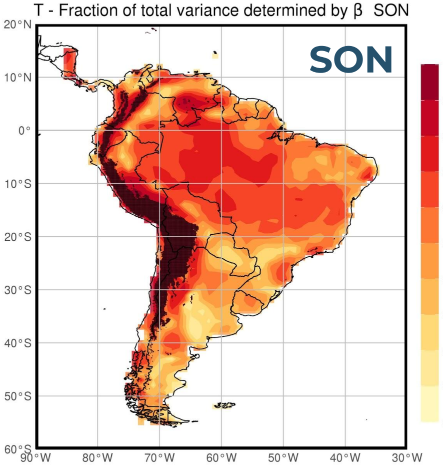


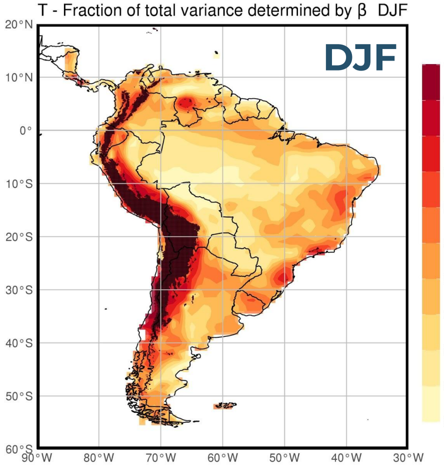
Precipitation is less predictable than **temperature**.
A significant increase in **precipitation** predictability is observed when the CFSv2 model is removed from the set, especially in summer.

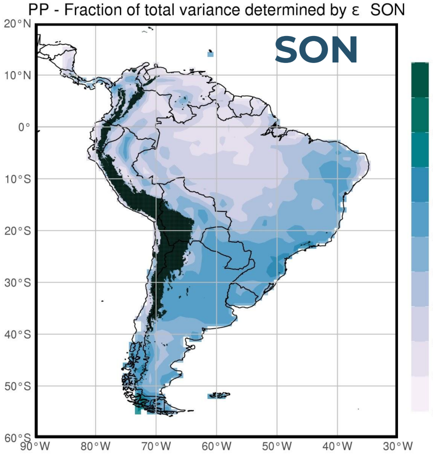
Ensemble without **CFSv2** →

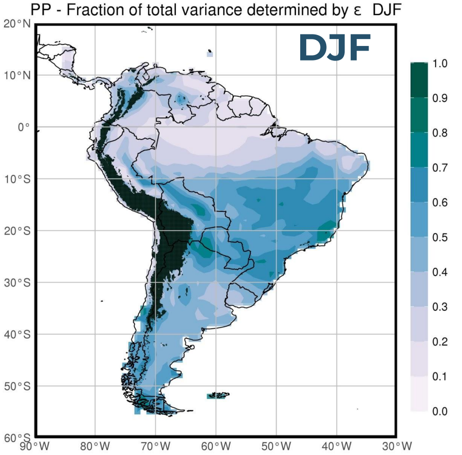
Fraction of total variance of **temperature** determined by **Bias**

Fraction of total variance of **precipitation** determined by **Noise**







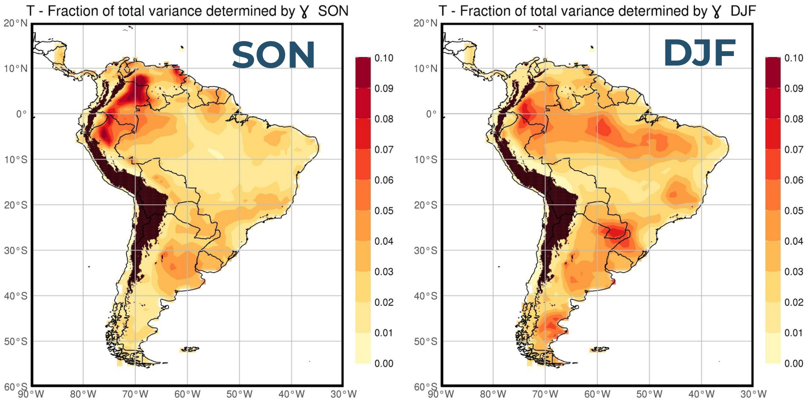


The **biases** of the model contribute significantly to the total variation in **temperature**, while **noise** is the most relevant for **precipitation**.

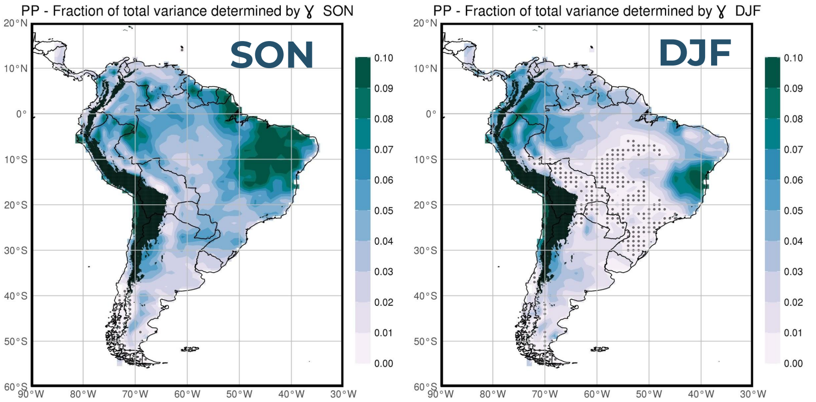
ANOVA

Structural term -> differences between the models in their responses to a common forcing.

Fraction of total variance of **temperature** determined by **structural term**

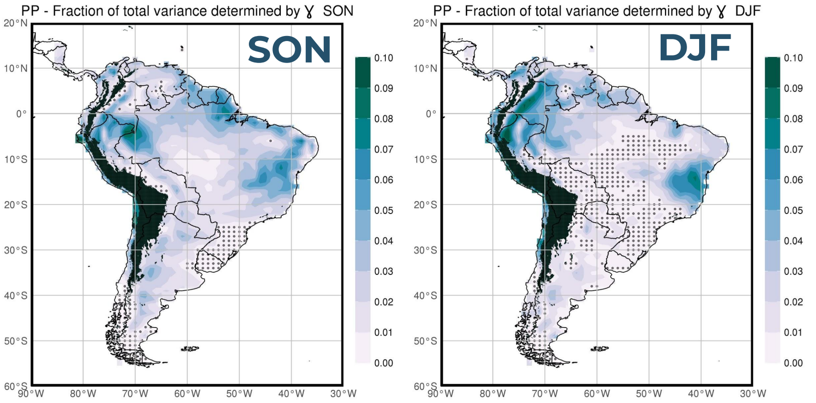


Fraction of total variance of **precipitation** determined by **structural term**



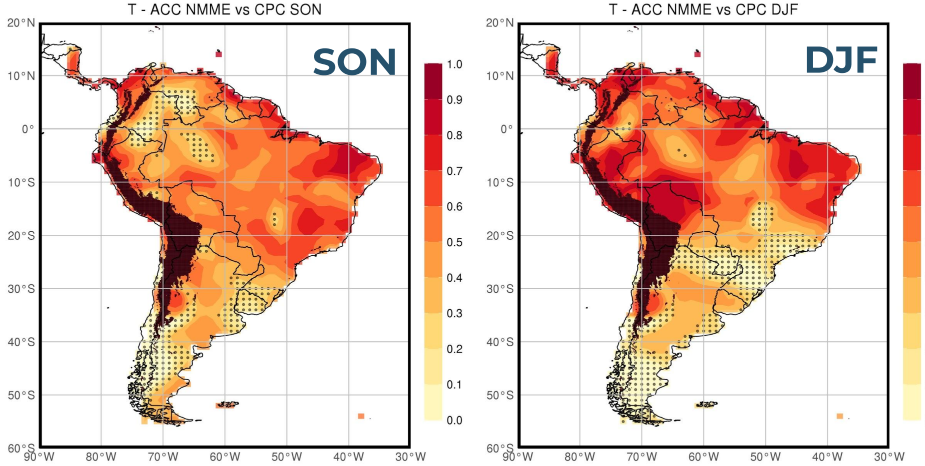
The **structural term** for **precipitation** becomes smaller when the CM2p1 model is removed from the ensemble. A first inspection shows that CM2p1 may lack an adequate representation of the variability associated with ENSO in the region

Without **CM2p1** →

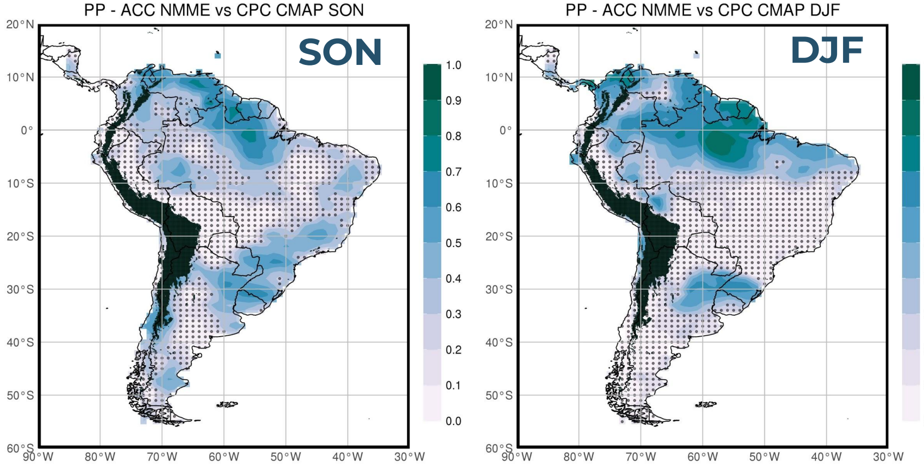


Anomaly Correlation coefficient

Temperature
ACC NMME vs **CPC** data set



Precipitation
ACC NMME vs **CMAP** data set



Forecasting skill for multi-model ensemble for **temperature** is better in the tropical region and lower in north-central Argentina.
For **precipitation** the skill is lower, the maximum is in the equatorial zone and the second maximum is over SESA.

Conclusions

- **Predictability** maximizes in the Tropics, over the Amazon region and presents a second maximum in the extratropics over southeastern South America (SESA).
- The **precipitation** is less predictable than **temperature**, and **precipitation** predictability increases when CFSv2 model is removed from the ensemble. Is it because CFSv2 uses lagged ensembles to make the forecasts?
- The **model biases** are an important contributor to the total variance of the **temperature** while the **noise** is the most relevant for **precipitation.**
- For **temperature**, the structural term is largest in SESA. For precipitation, CM2p1 variability explains most of the structural term, possibly due to a lack of an adequate representation of the variability associated with ENSO in the region.
- Forecasting skill is better for **temperature** than for **precipitation.** The **precipitation** shows two zones with significant skill, which is maximum in the equatorial zone and lowest in SESA

Thank you

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