IPSL-EPOC decadal prediction system: An update from the trenches

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Outline

1. The IPSL-CM6 new decadal prediction system

- Status
- Potential predictability

2. The IPSL-CM5 decadal prediction system

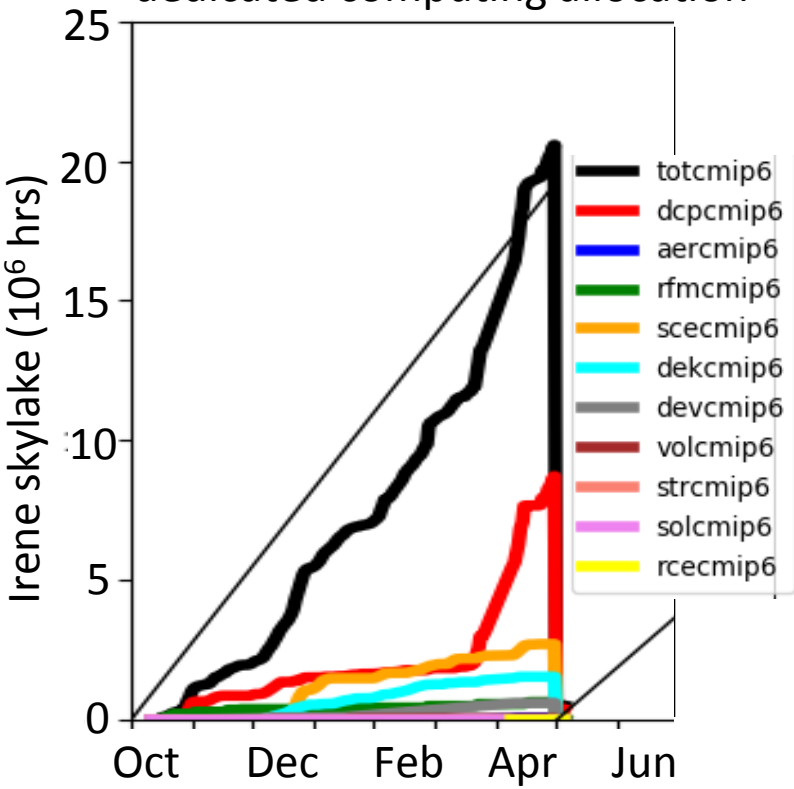
- Windows of opportunity
- Towards a new methodology for debiasing hindcasts

1. The IPSL-CM6 decadal prediction system

DCPP-A experiments

- Based on IPSL-CM6A-LR climate model
- Initialized from a historical run nudged towards SST & SSS anomalies
  See Victor Estella-Perez's talk
- 54 starting dates (1961-2014 each year)
- For each starting date:
  10 members created by perturbing the SST with a spatial white noise of 0.1°C std
  hindcasts of 10 years long
- Performed within 6 weeks in April-May 2019
  8 millions computing hours (27 tCO2)
- Compliance with the CMIP6 Data-Request ongoing
- Analysis still to come….

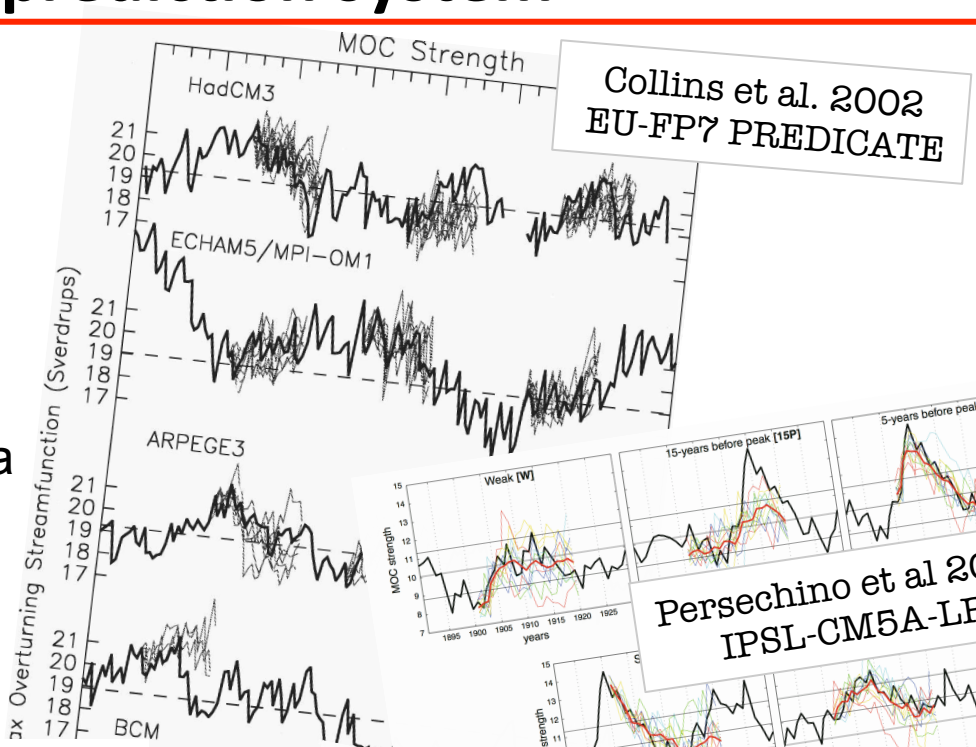
Consumption of the CMIP6 dedicated computing allocation

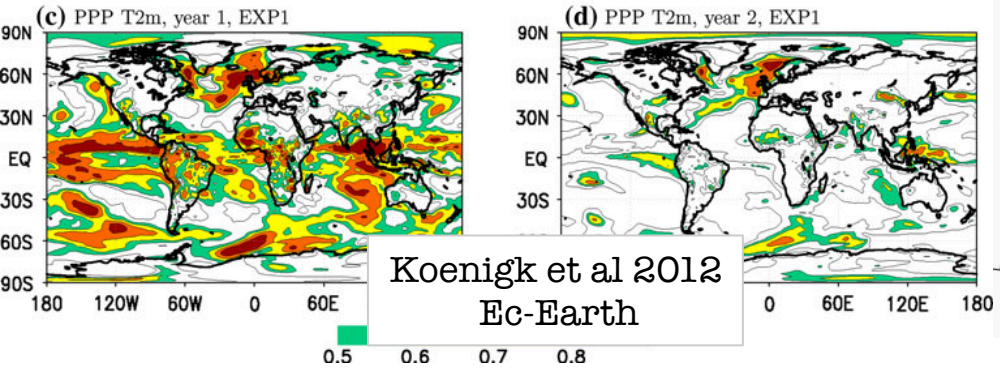


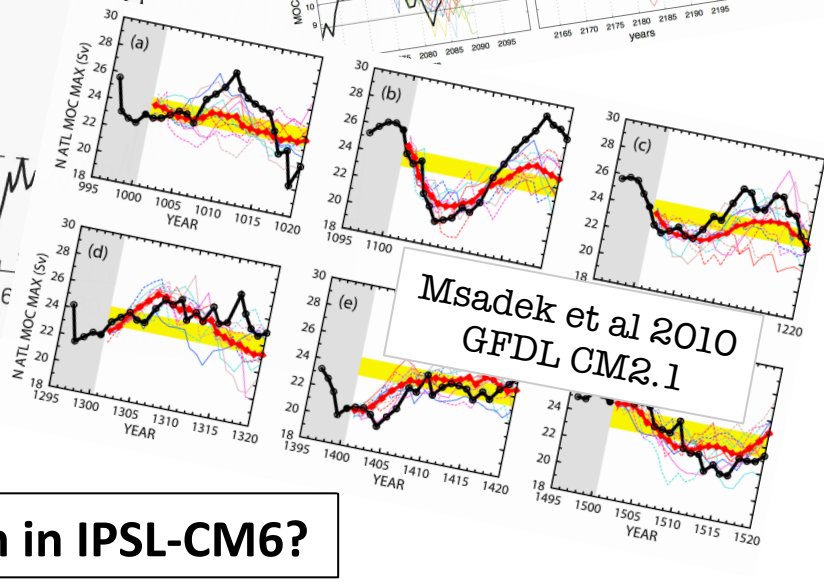
1. The IPSL-CM6 decadal prediction system

Potential predictability

- Classically used as a preliminary evaluation of a model's intrinsic decadal predictability
- Idealized set-up that only requires a long control simulation



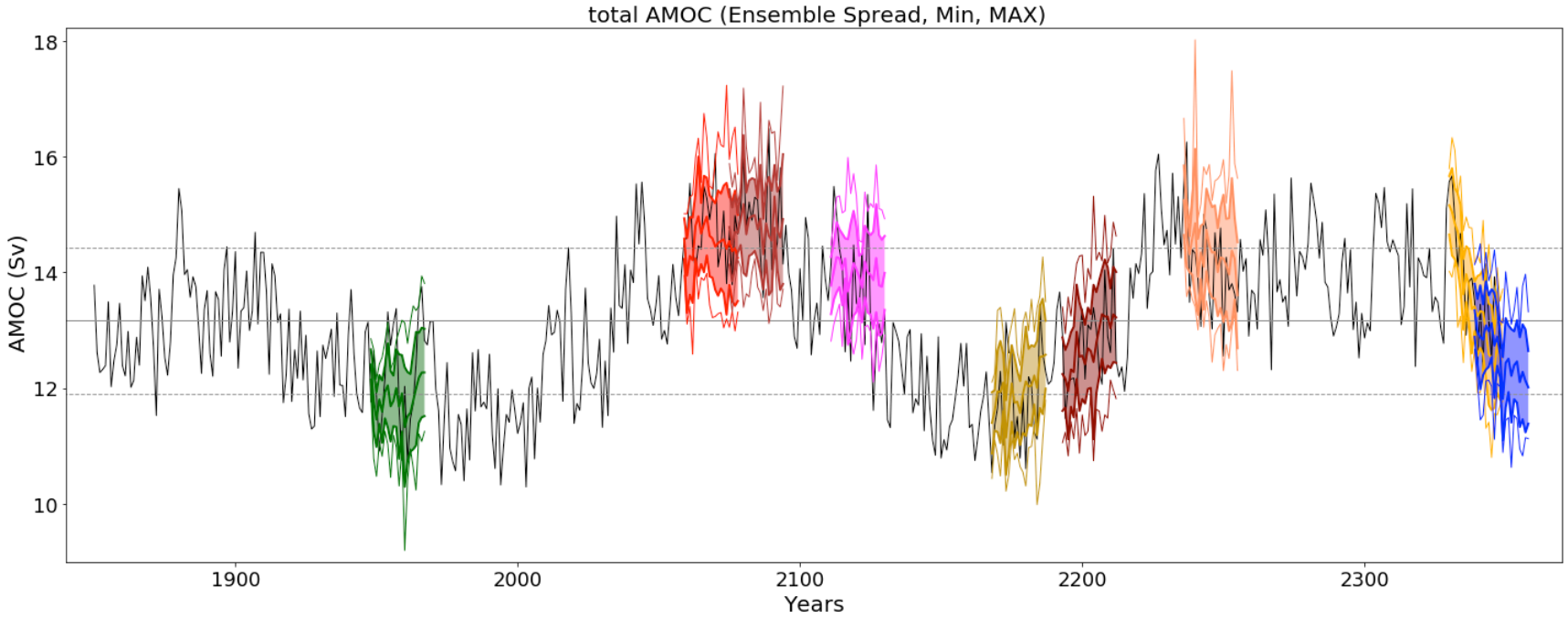




➢ **Potential predictability of the climate system in IPSL-CM6?**

1. The IPSL-CM6 decadal prediction system

Potential predictability: experimental set-up



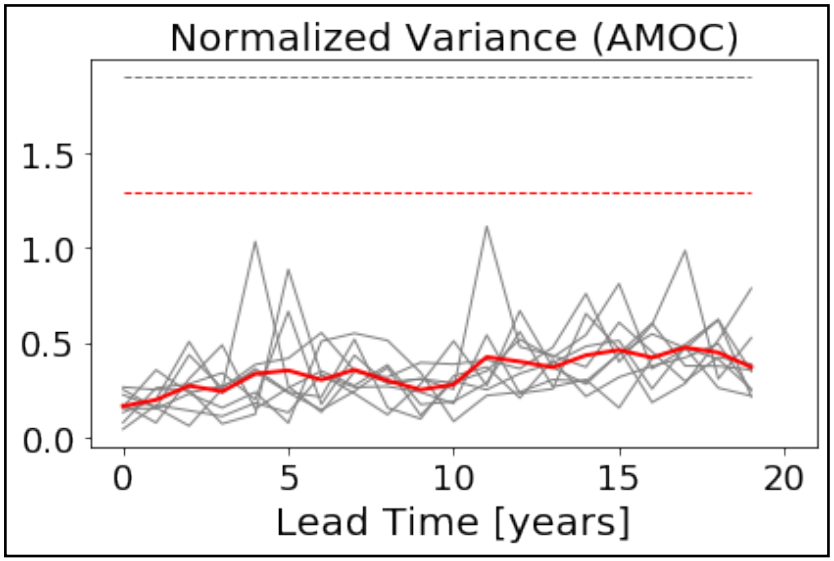
- 9 Starting Dates of pre-industrial Control run with IPSL-CM6A-LR
- Starting dates sampling IPV & AMV conditions
- for each Starting Date : ensemble of 10 members,
  Spatial white noise +/-0.1°C on SST
  20 years long

1. The IPSL-CM6 decadal prediction system

Initial diagnostic of potential predictability

The normalized variance, comparing the spread of the ensembles to the standard deviation of the control run

$$V(t) = \frac{\frac{1}{N(M-1)} \sum_{j=1}^{N} \sum_{i=1}^{M} \left[X_{ij}(t) - \overline{X}_j(t) \right]^2}{\sigma^2}$$



- Unrealistically long predictability

1. The IPSL-CM6 decadal prediction system

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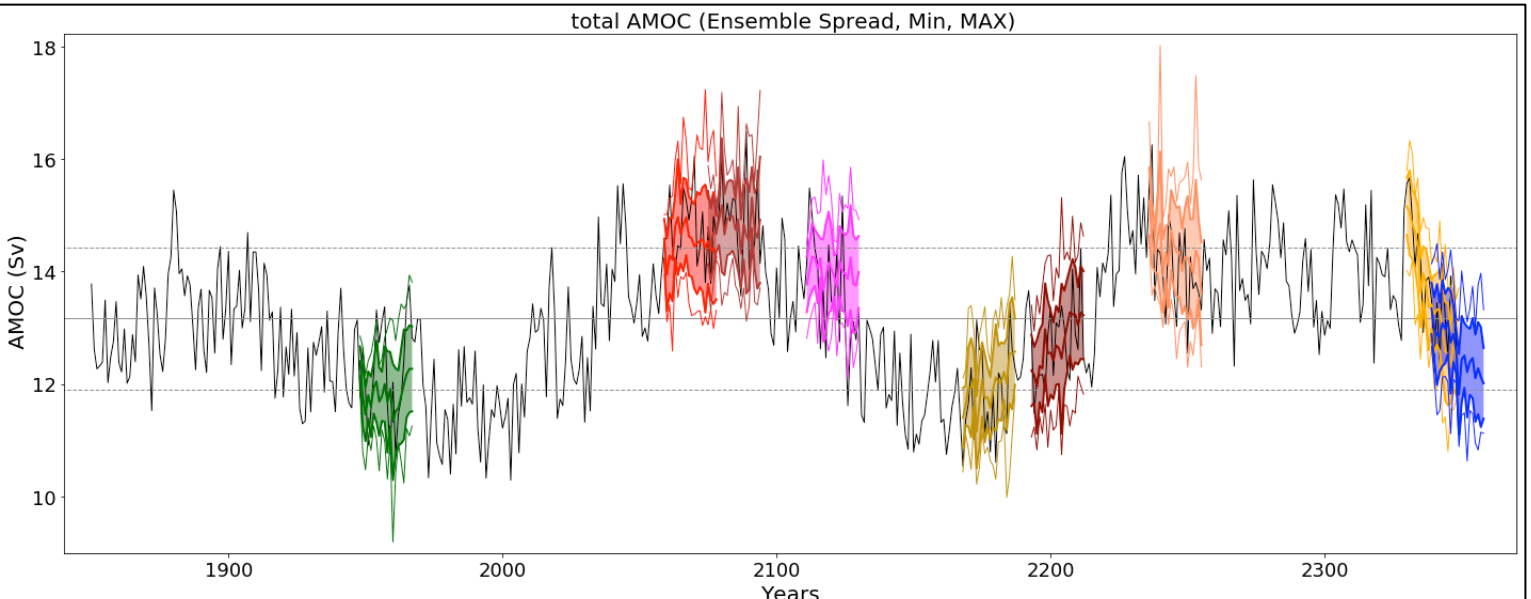
- Unrealistically long predictability
- Comes from a large standard deviation of the control run, due to a strong centennial variability



1. The IPSL-CM6 decadal prediction system

Corrected diagnostic of potential predictability:

The normalized variance, comparing the spread of the ensembles to the standard deviation of the control run

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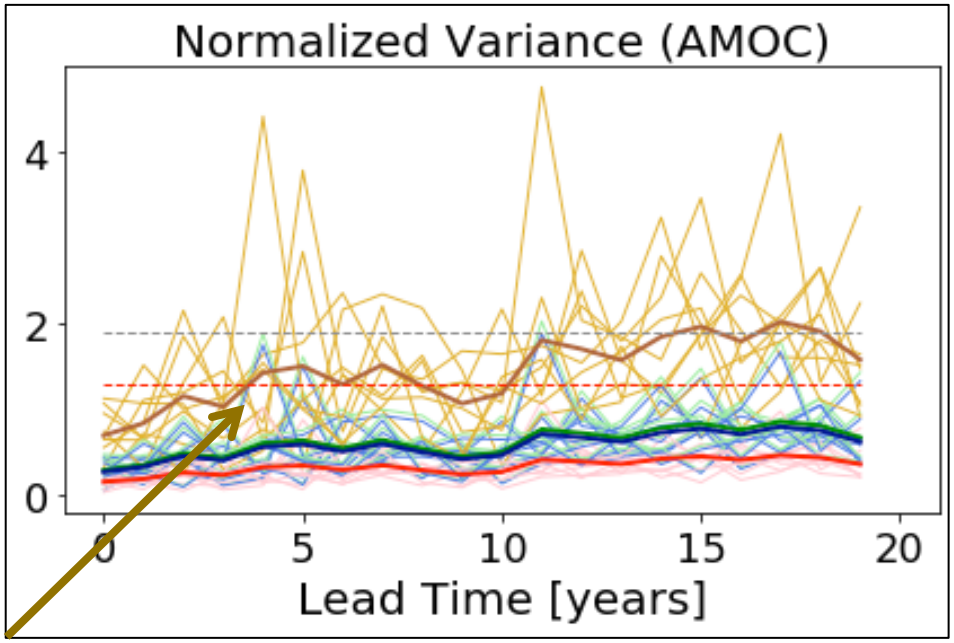
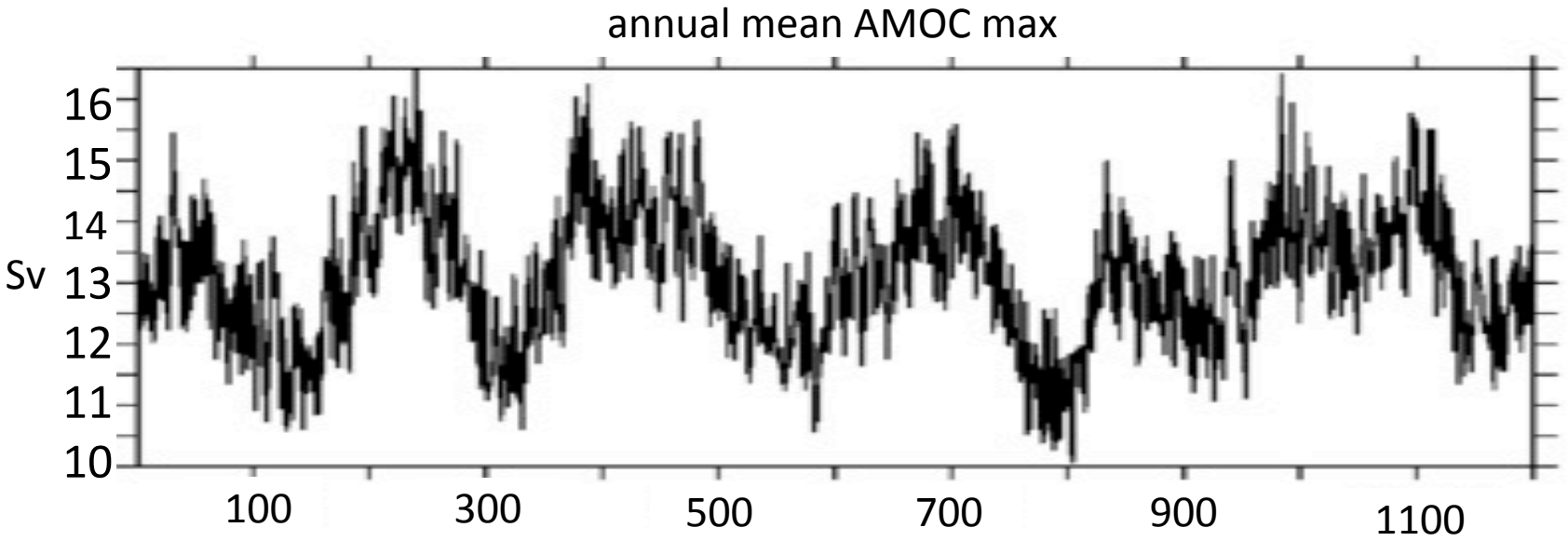


- Unrealistically long predictability
- Comes from a large standard deviation of the control run, due to a strong centennial variability
- Filtering out this low frequency variability returns more expected results

Considering variance of high pass filtered AMOC (periods <200 yrs)

1. The IPSL-CM6 decadal prediction system

Centennial variability



- The new model's strong and robust centennial variability brings us in a new world in terms of
  - response to external forcings
  - response to initialization

- Origins of this variability is not known yet. At least two other CMIP6 model have similarly strong and long variability

- Predictability vs internal variability: a new challenge for CMIP6?

Outline

1. The IPSL-CM6 decadal prediction system

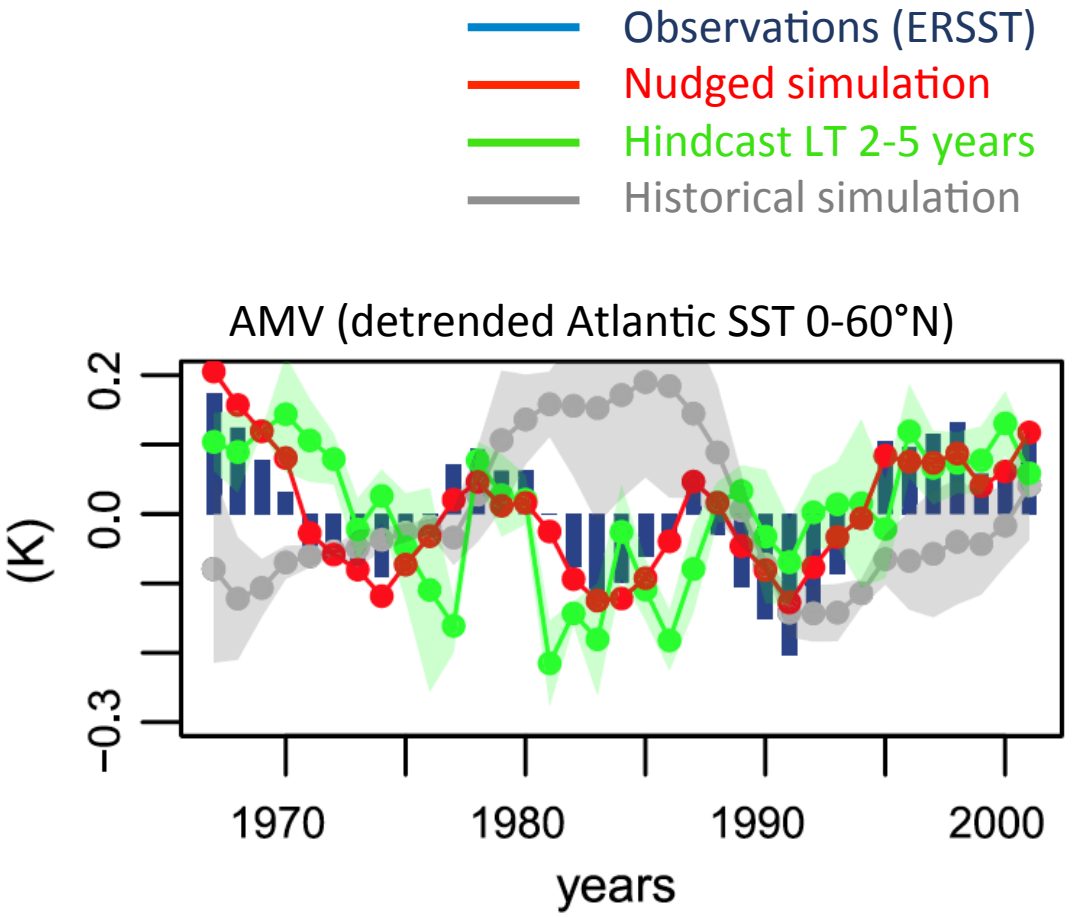
- Status
- Potential predictability

2. The IPSL-CM5 decadal prediction system

- **Investigating windows of optimal predictability**
- **Towards a new statistical debiasing**

2. The IPSL-CM5A-LR decadal prediction system

- CMIP5 version
- Starting 1st January **every year** from 1961 to 2015
- 3 members
- Initialised through nudging in SST (Reynolds et al. 2013) anomalies
- Reasonable predictability of the AMV (r ≈ 0.6)



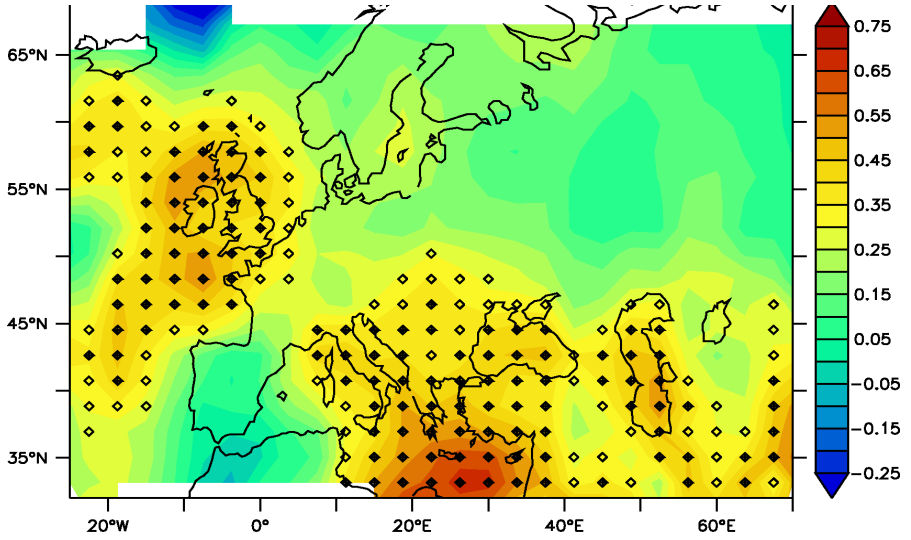
Mignot et al., *Clim. Dyn.*, 2016

2. The IPSL-CM5A-LR decadal prediction system

Skill over Europe: windows of opportunity?

- Some skill over Europe for 2-meter temperature (beyond the effect of the forcing, not shown). Yet, weak and mainly over the UK

ACC for detrended annual mean T2M, LT 1-3 yrs vs. HadCRUT4



2. The IPSL-CM5A-LR decadal prediction system

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- Some skill over Europe for 2-meter temperature (beyond the effect of the forcing, not shown). Yet, weak and mainly over the UK
- Evolution of the skill with the season at the decadal time scale?
- Analysis of "windows of opportunity" i.e. best period for the skill over 1961-2015

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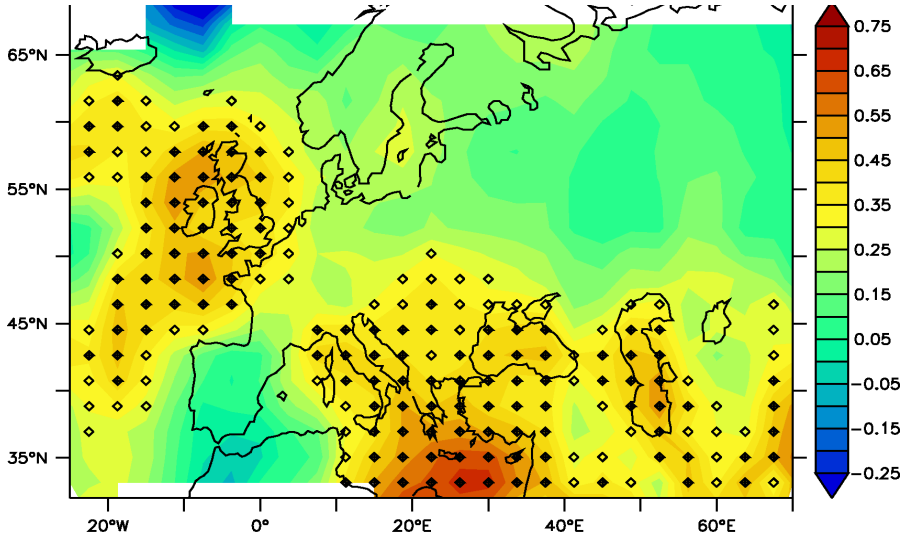

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- Evolution of the skill with the season at the decadal time scale?
- Analysis of "windows of opportunity" i.e. best period for the skill over 1961-2015
- *And the winner is (for the moment)*: MAMJJAS over the period 1975-2011

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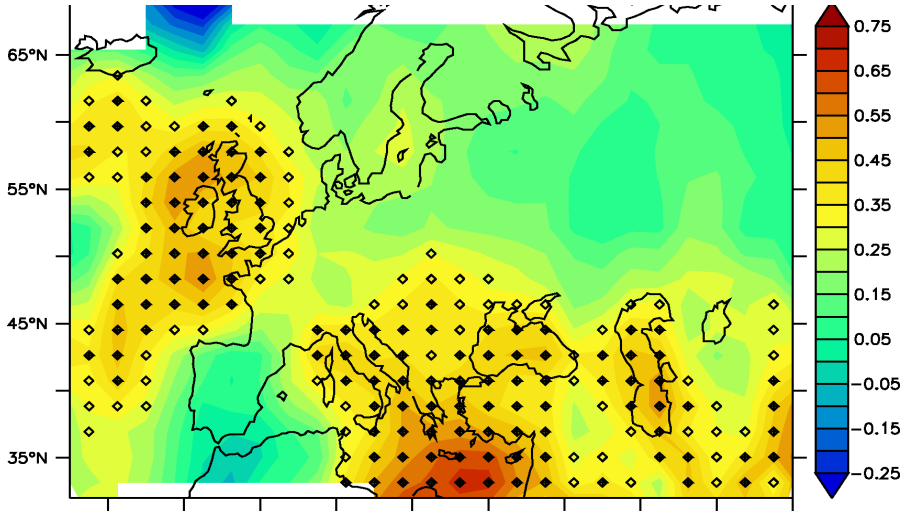
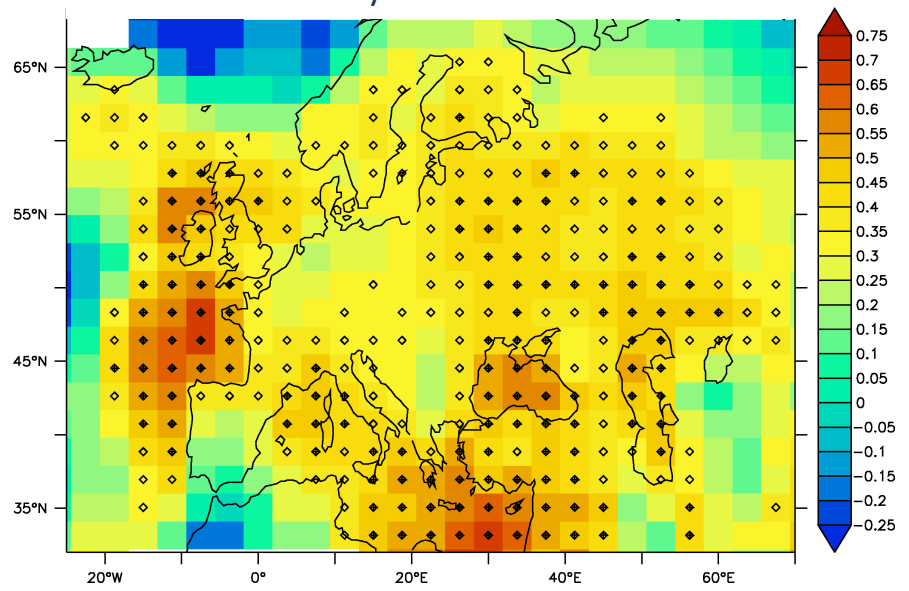


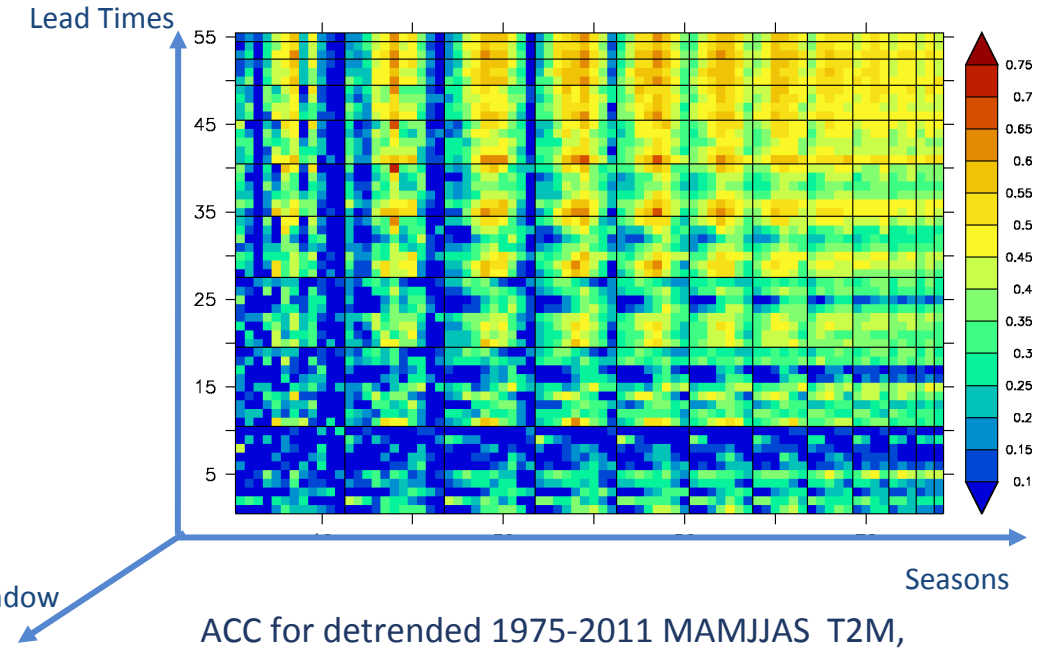
ACC for detrended 1975-2011 MAMJJAS T2M, LT 1-3 yrs vs HadCRUT4



2. The IPSL-CM5A-LR decadal prediction system

Skill over Europe: windows of opportunity?

- **Ongoing: More systematic assessment** exploring phase space depending on months/ seasons, lead times, time windows



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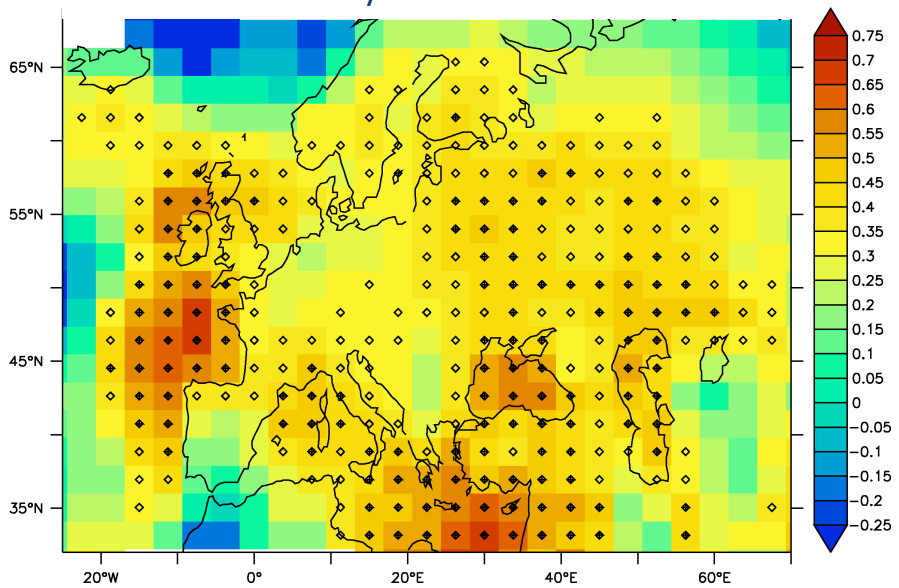


Sgubin et al. in prep.

2. The IPSL-CM5A-LR decadal prediction system

A quantile-quantile debiasing approach to improve reliability

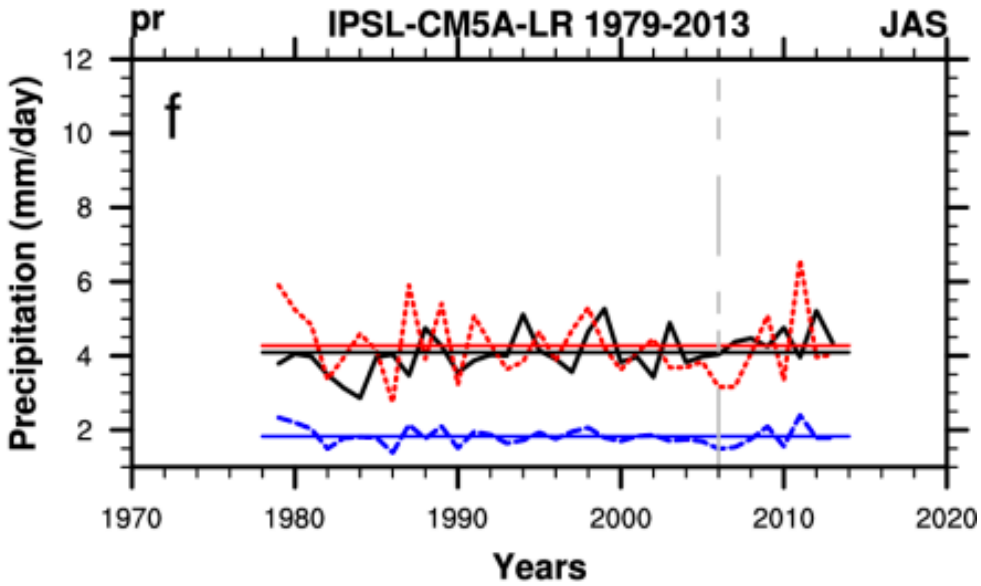
- GCMs **have biases…**
  - **Not only the mean** but higher moments (variance…) and extremes are biased
  - How to correct these statistical biases?
  - How to correct (i.e., remove the bias) the climate model predictions?

Precipitation over the Sahelian box (18°W-10°E; 10°N-20°N) in summer (West african monsoon)

Observations

Raw Outputs

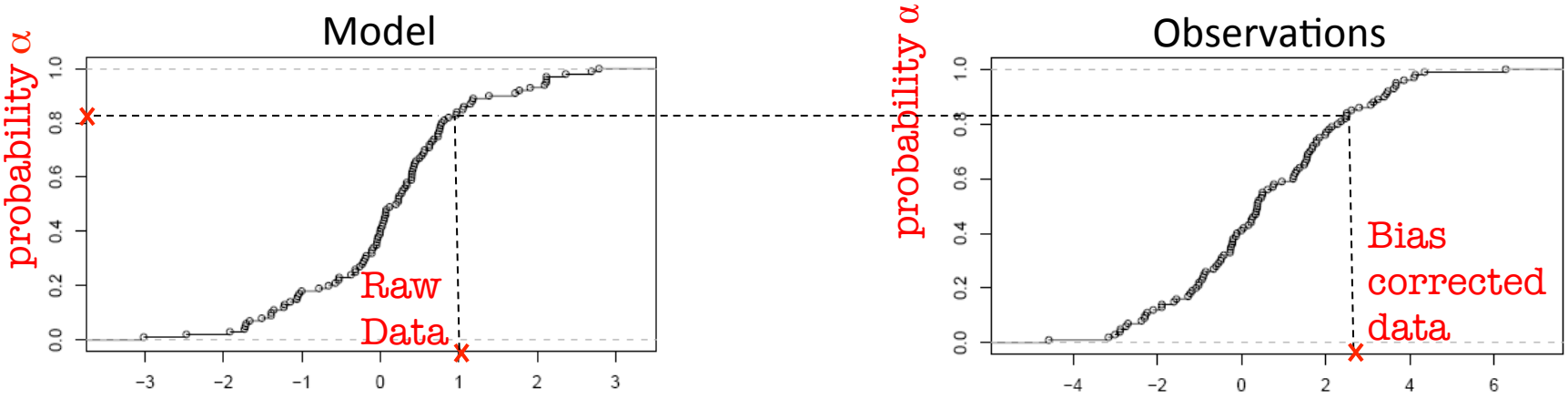
Moise et al. 2018, ESD



2. The IPSL-CM5A-LR decadal prediction system

A quantile-quantile debiasing approach to improve reliability

For each grid cell and each time step, cumulative density function of considered variable:



CDF-t : cumulative distribution function - transform

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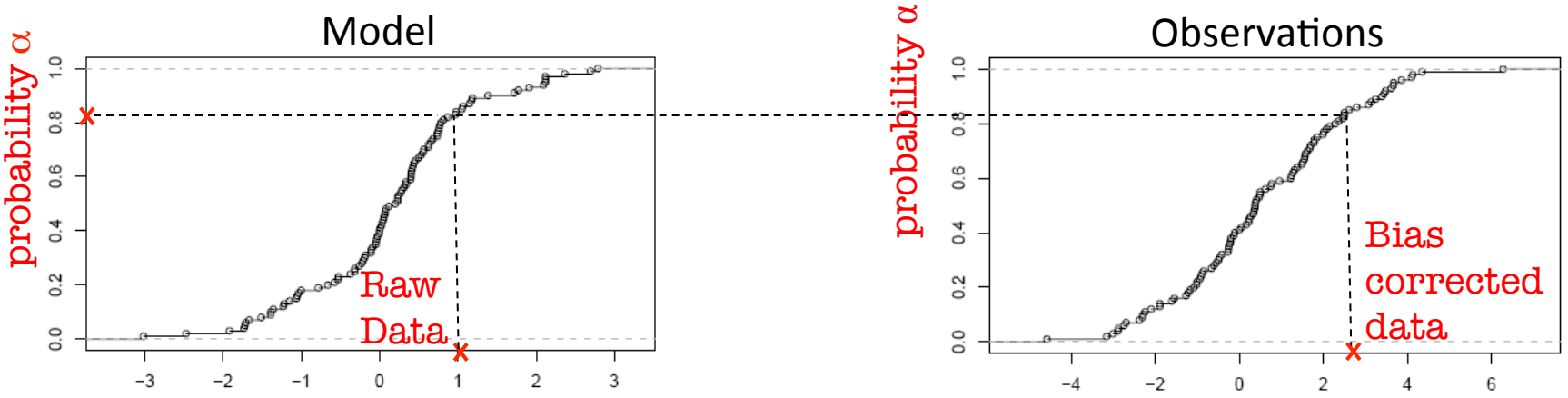

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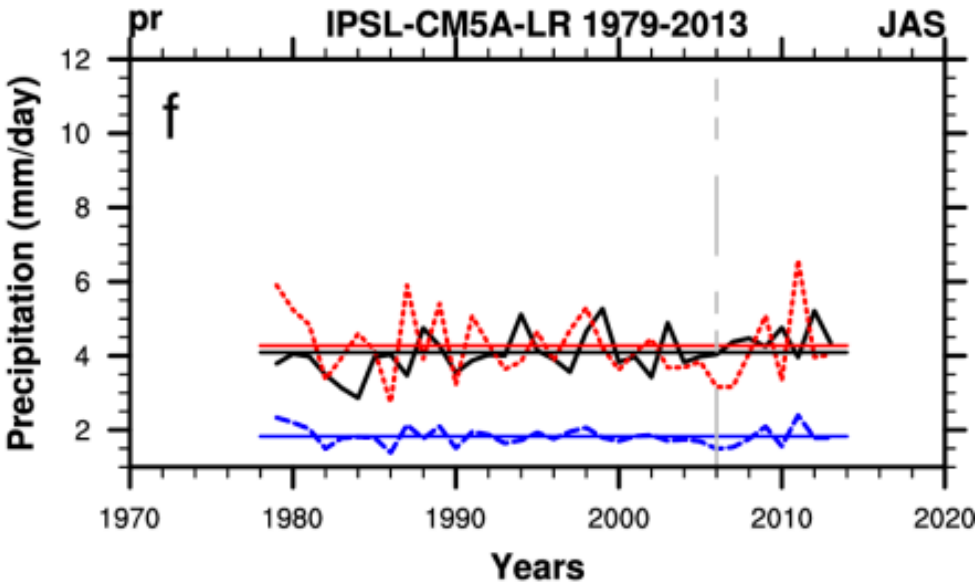

Debiased outputs

Observations

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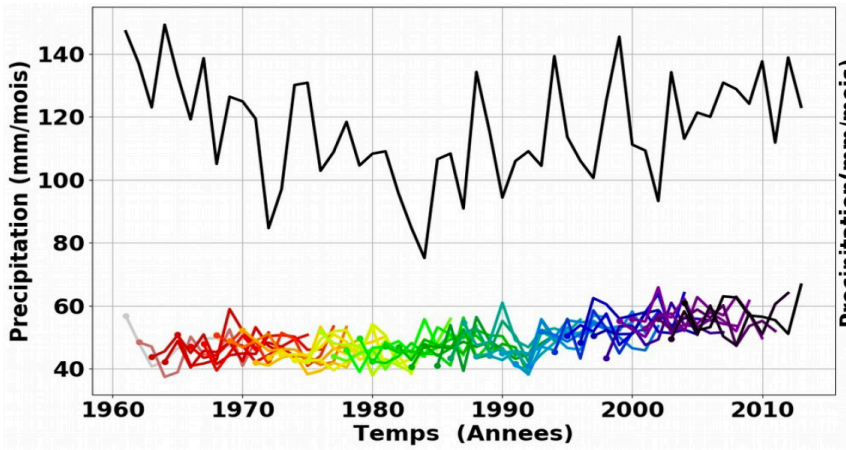
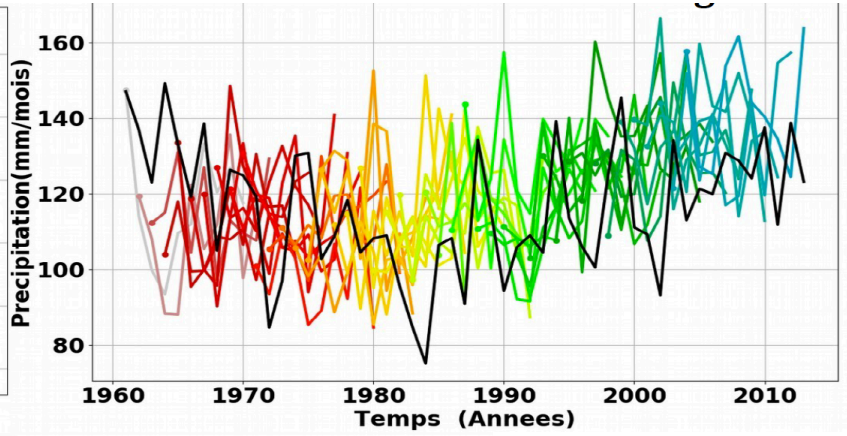
Moise et al. 2018, ESD

2. The IPSL-CM5A-LR decadal prediction system

Raw decadal predictions



Debiased decadal predictions



C. Ndiaye, E. Mohino

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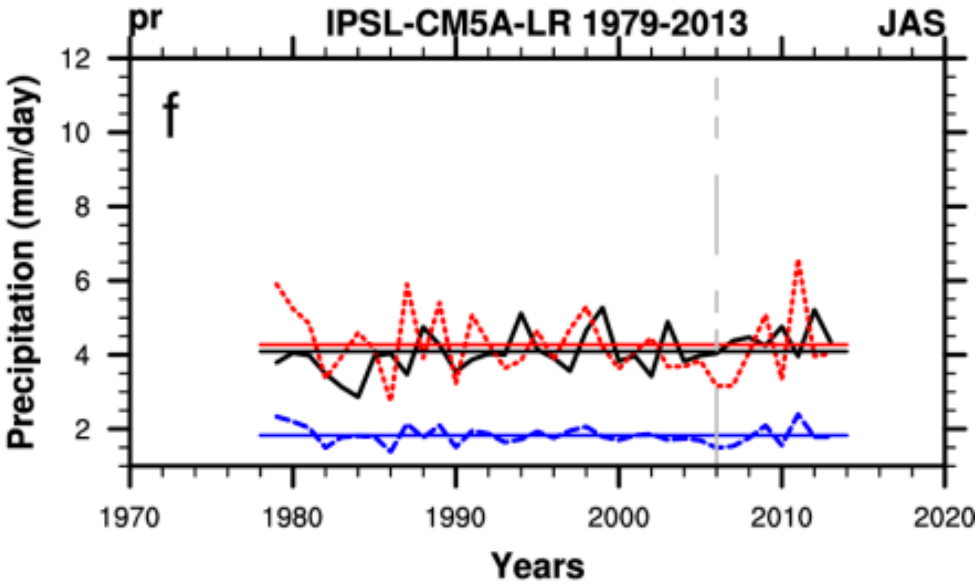


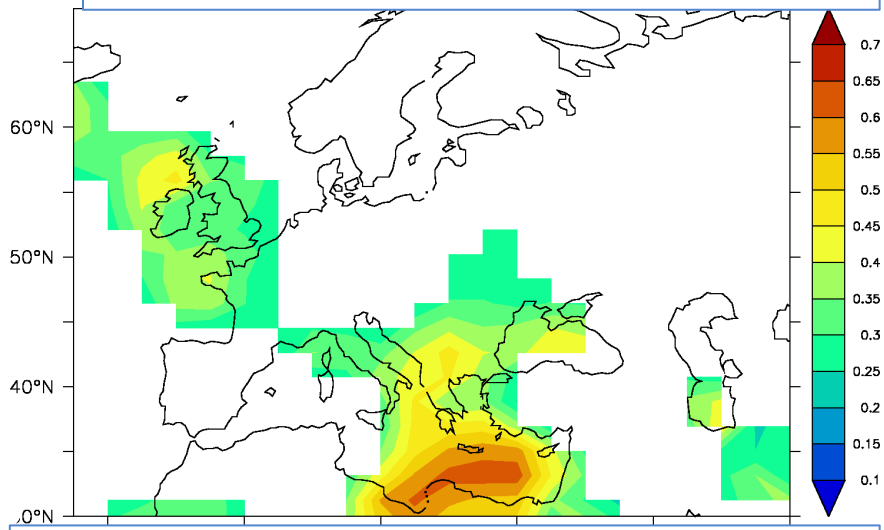
Moise et al. 2018, ESD

2. The IPSL-CM5A-LR decadal prediction system

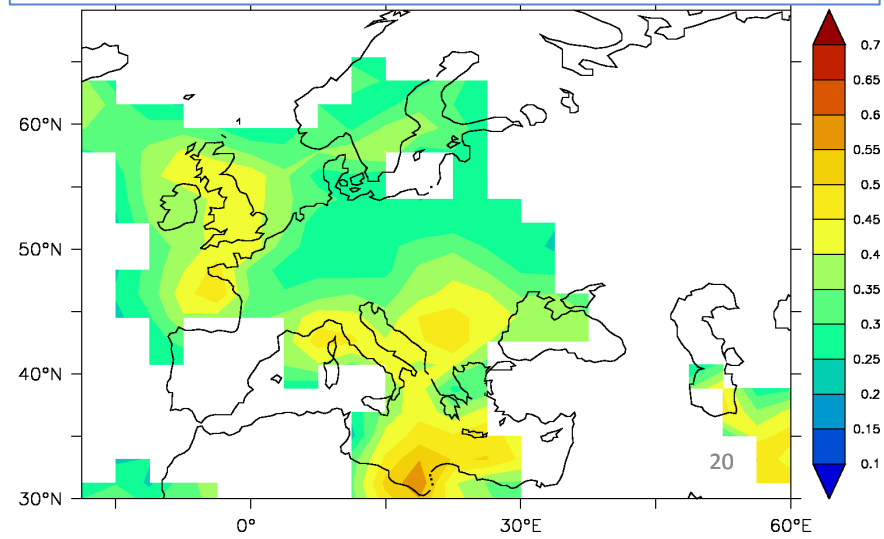
A quantile-quantile debiasing approach

- Back to the European temperatures
- Use of CDF-t (cumulative distribution function - transform) statistical approach to debias the prediction
- Slight improvements of the predictability over Europe at the decadal time scale
- Most importantly: more accurate predictions for applications

Detrended ACC annual mean T2M raw outputs, LT 1-3 yrs vs NOAA-20CR)



CDF-t debias using NOAA-20CR, LT 1-3 yrs



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Conclusions

- Ongoing research based on the CMIP5 system on how to make the best out of decadal hindcasts
  - Systematic search for best windows of predictability (season, time period…)
  - Novel statistical debiasing method (quantile-quantile) to improve accuracy of the predictions
- IPSL-CM6A-LR has a very strong and robust centennial variability which may bring us in a new paradigm for interpretating decadal hindcasts
- CMIP6 system should be available early summer. See V. Estella Perez's talk tomorrow regarding initialization