Regional forecast quality of CMIP5 multi-model decadal climate predictions

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SEVENTH FRAMEWORK PROGRAMME

Prediction on climate time scales

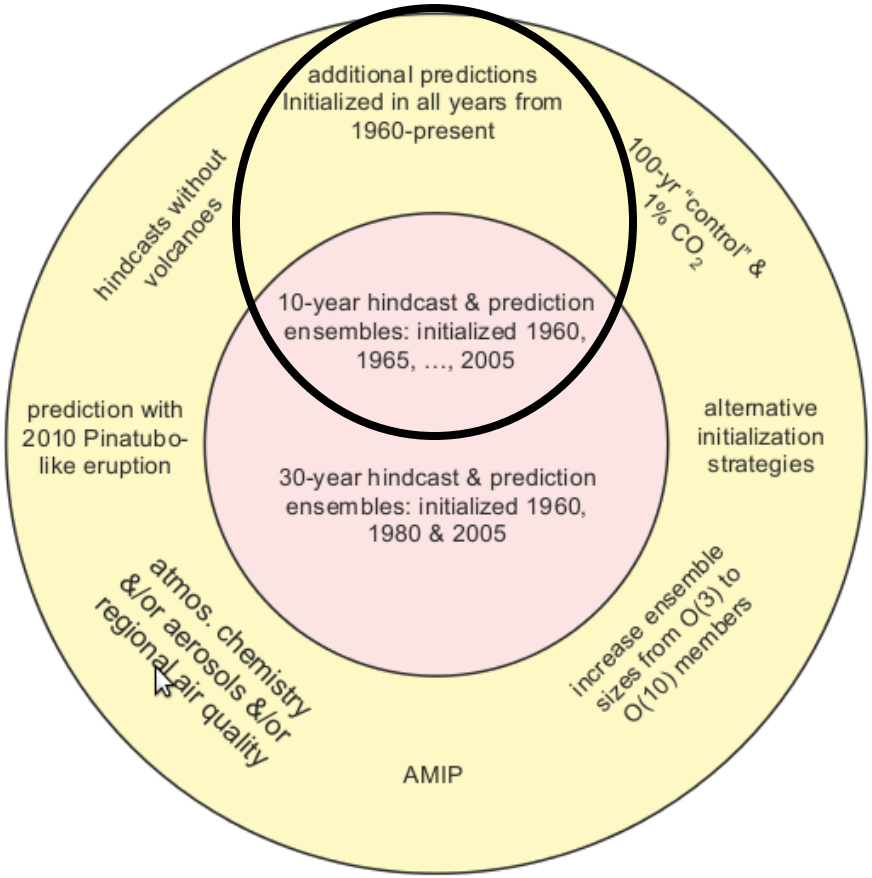
Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialization and systematic comparison with a simultaneous reference.

Meehl et al. (2009)

CMIP5 near-term experiments

CMIP5 core (inner circle) and tier 1 (outer circle) experiments. For the core experiments, the atmospheric composition should be prescribed as in the historical run and then follow the RCP4.5.

Main question: Does the initialization improve forecast quality?

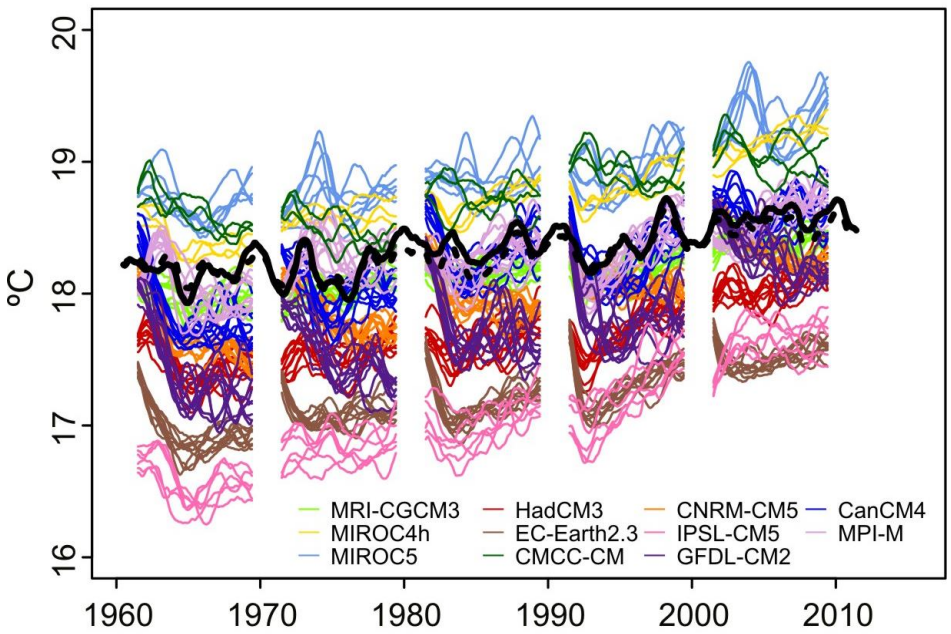


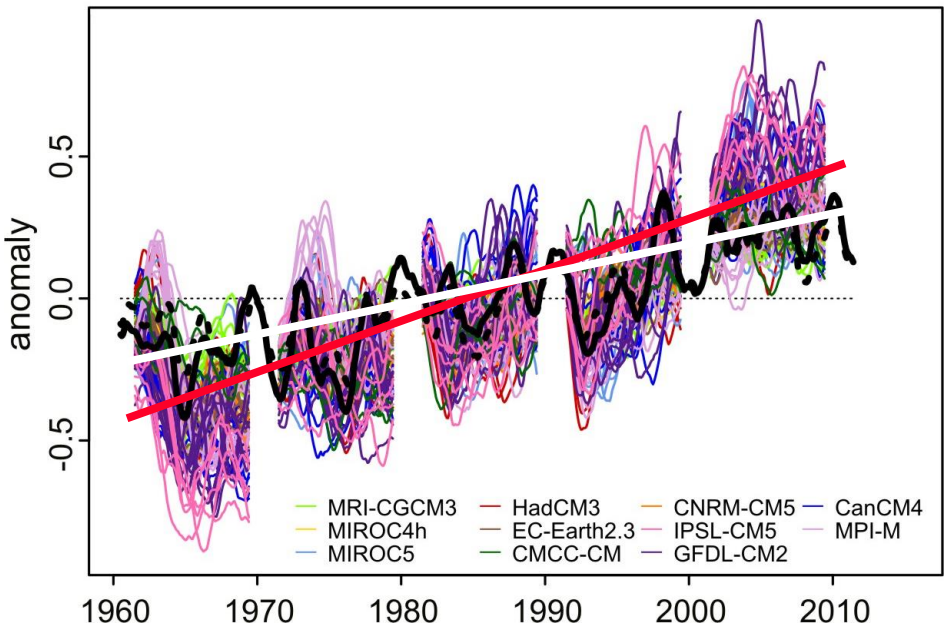
Taylor et al. (2012)

Drift and systematic error

Global mean near-surface air temperature over the ocean (one-year running mean applied) from the CMIP5 hindcasts. Each system is shown with a different colour. NCEP and ERA40/Int used as reference.

The systematic error is very different from one system to another.



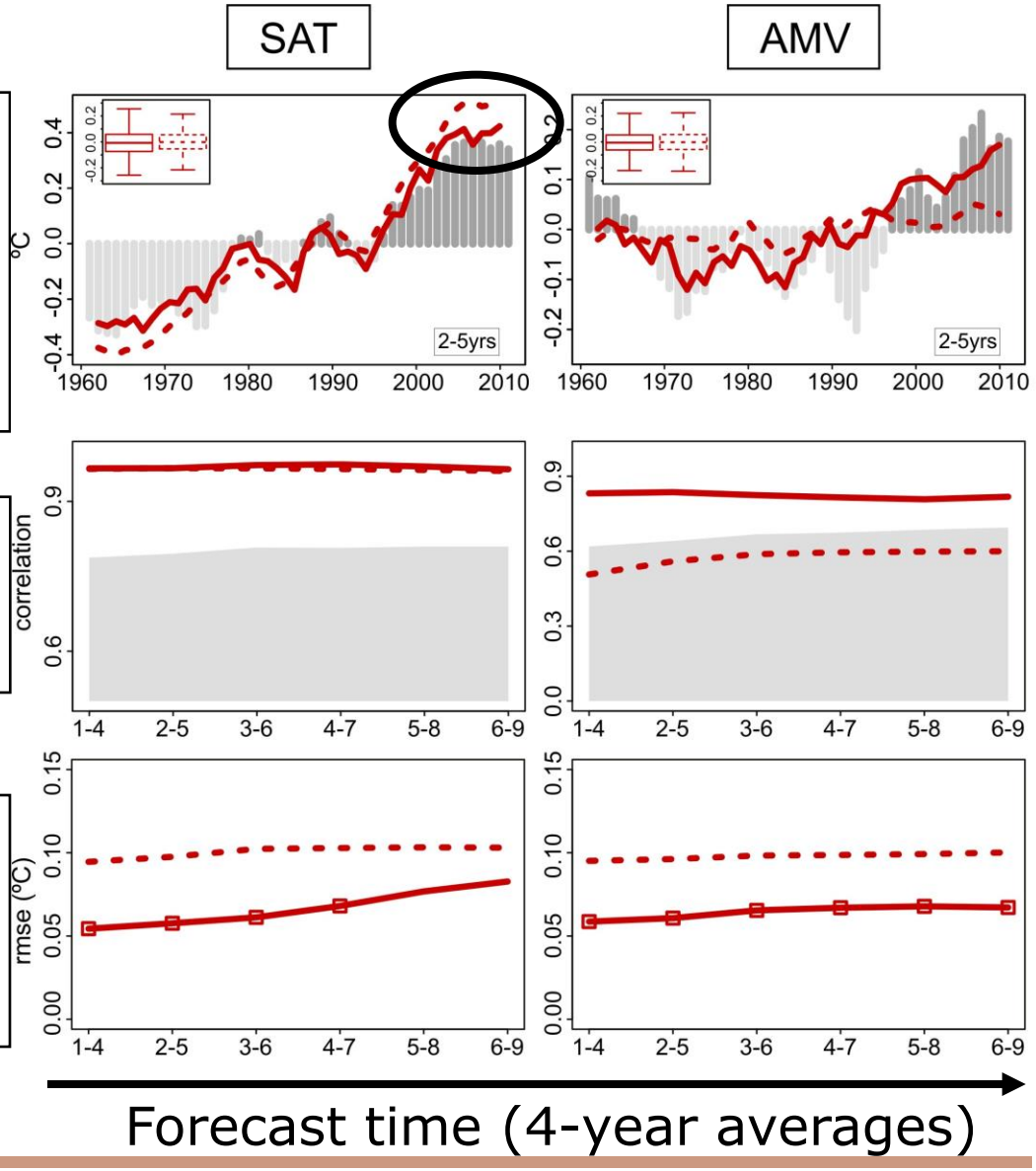


CMIP5 decadal predictions

Predictions (2-5 forecast years) from the CMIP5 multi-model (6 systems, initialized solid, historical and RCP4.5 dashed) over 1960-2005 for global-mean temperature and the Atlantic multi-decadal variability. GISS and ERSST data used as reference.

Correlation of the ensemble-mean prediction as a function of forecast time. Grey area for the 95% confidence level.

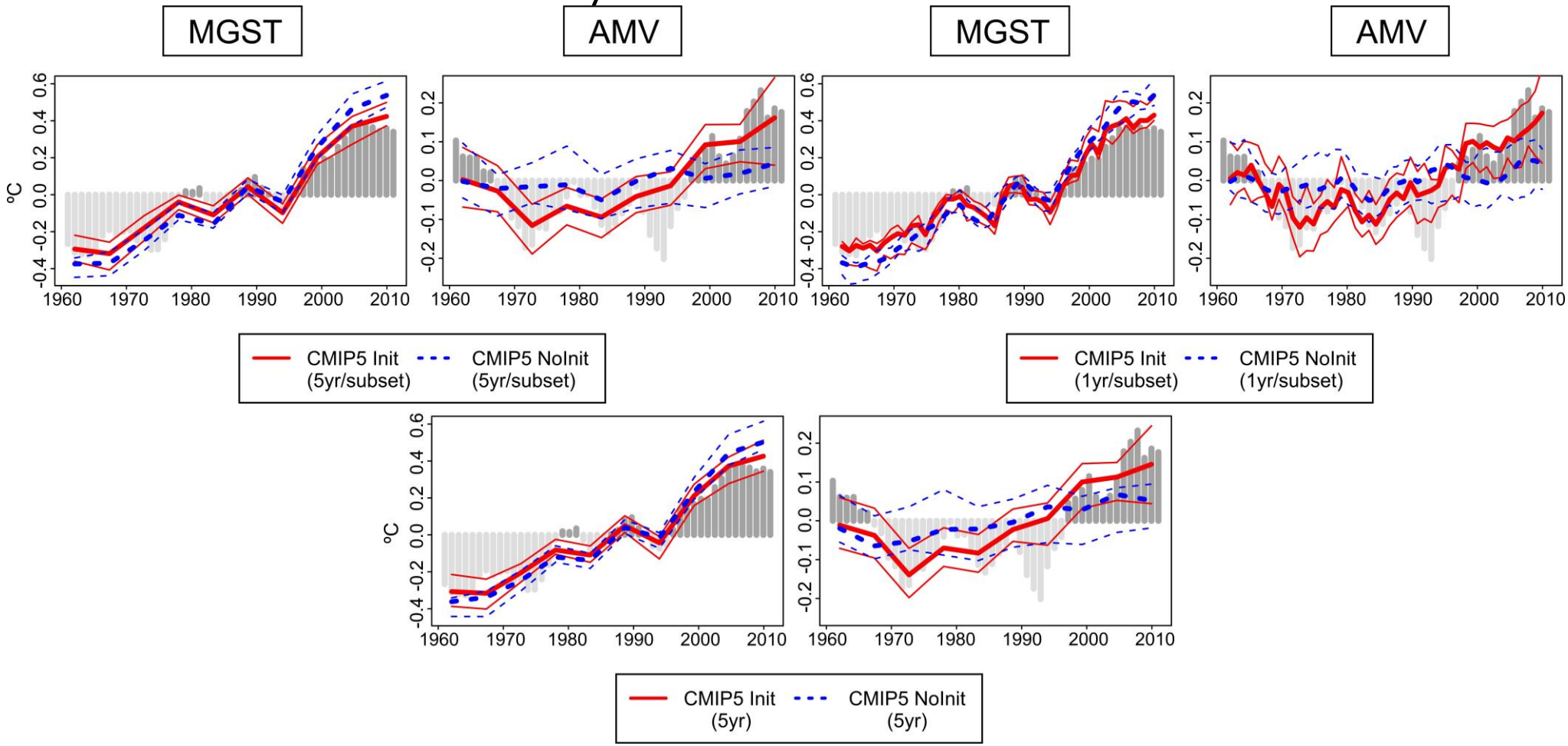
Root mean square error, where dots represent the forecast times for which Init and NoInit are significantly different at 95% confidence level.



Doblas-Reyes et al. (2013)

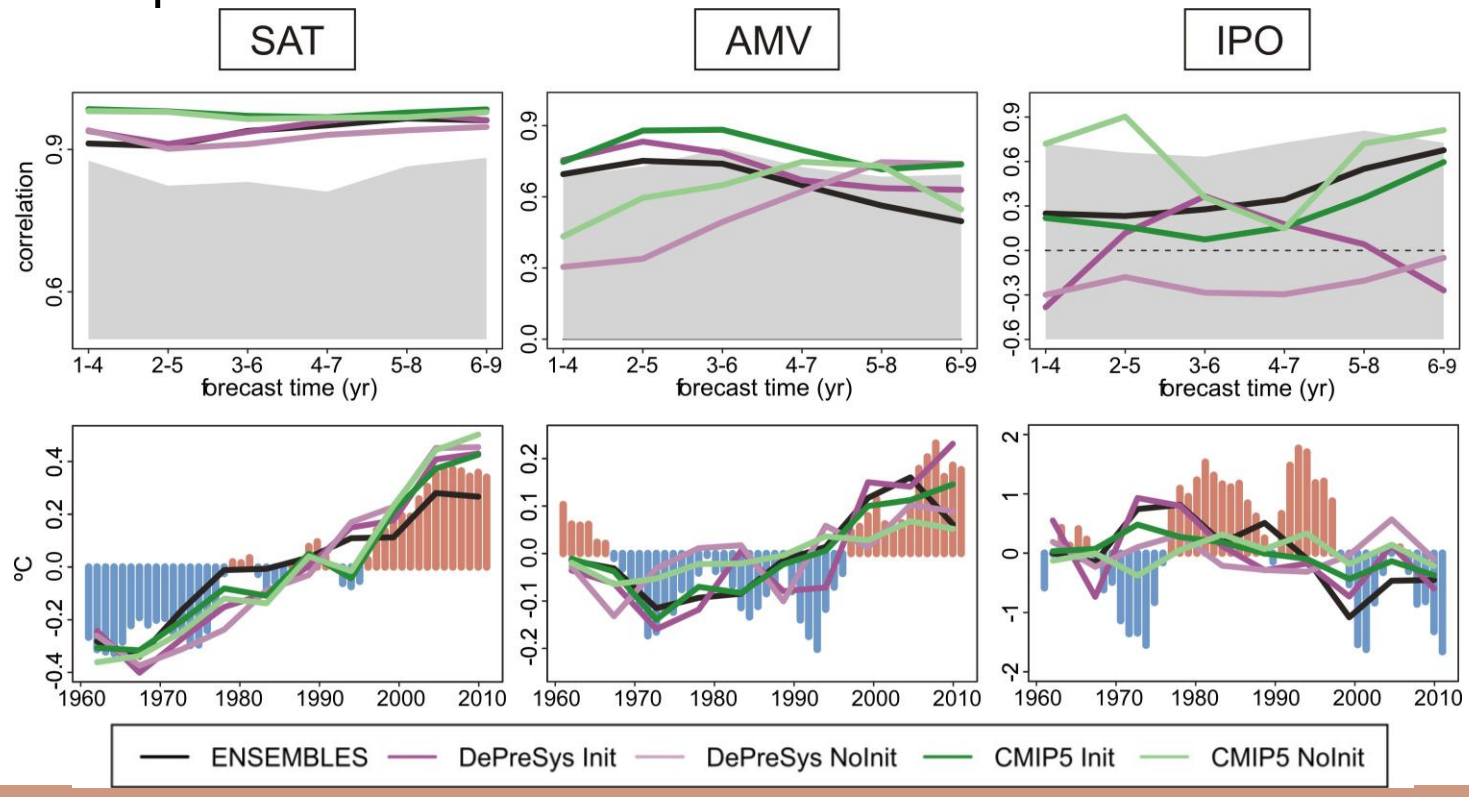
CMIP5 decadal predictions

Predictions (2-5 forecast years) for subsets of the CMIP5 multi-model (Init solid, NoInit dashed) for global-mean temperature and the Atlantic multi-decadal variability. GISS and ERSST data used as reference.



CMIP5 versus other predictions

(Top) Correlation of the ensemble-mean as a function of forecast time for predictions from DePreSys_PP, ENSEMBLES and CMIP5 multi-models over 1960-2005 (five-year start dates) for global-mean temperature, Atlantic multi-decadal variability and Interdecadal Pacific Oscillation. Grey area for the 95% confidence level. (Bottom) Time series for the 2-5 year forecast time. Decadal predictions from. GISS and ERSST data used as reference.



One-year start date temperature

Forecast year 2-5 **Forecast year 6-9**

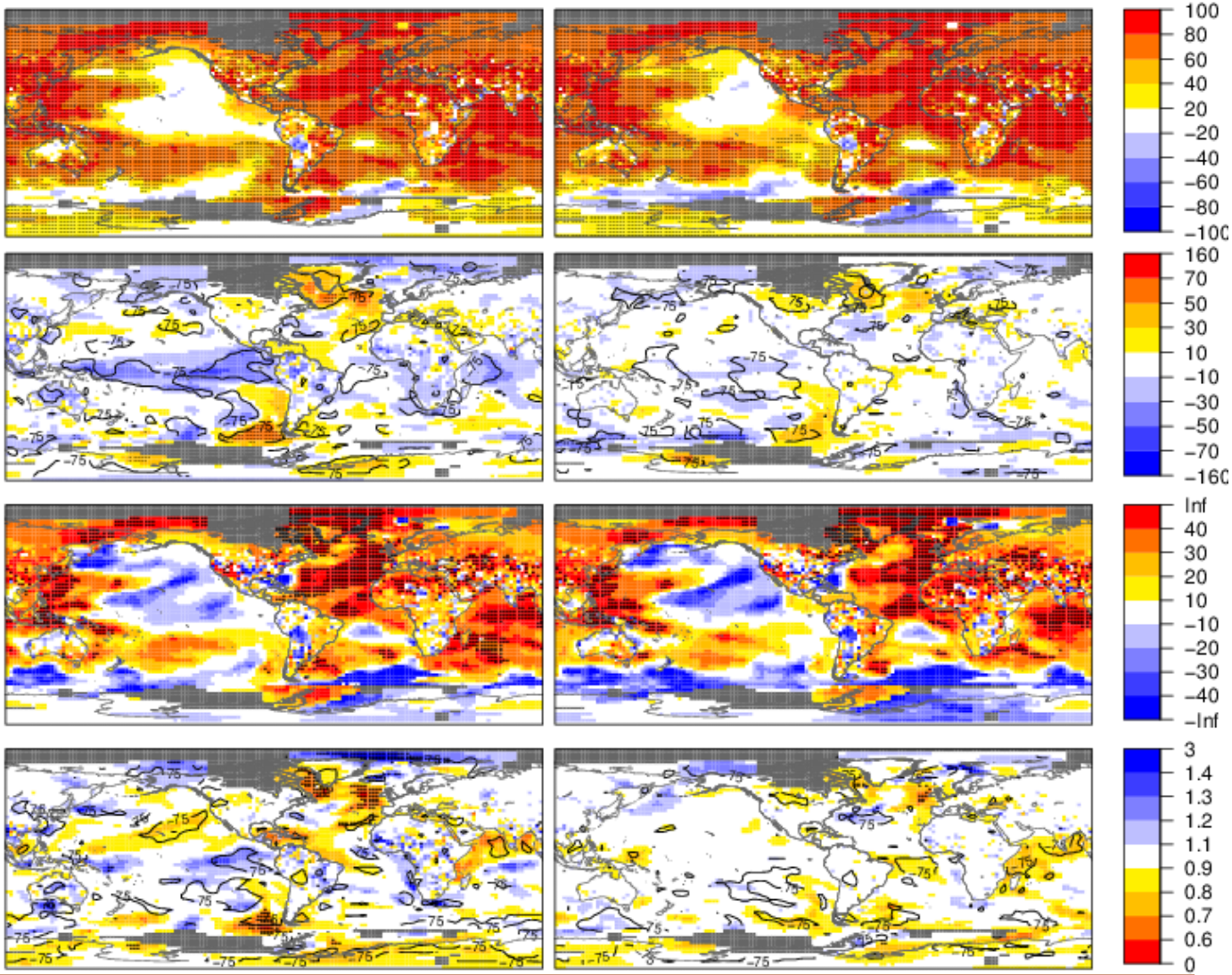
Init correlation of ensemble mean (six systems; ref ERSST, GHCN and GISS)

Init minus NoInit correlation difference

Init RMSSS of ensemble mean

Ratio RMSE Init/NoInit

Doblas-Reyes et al. (2013)

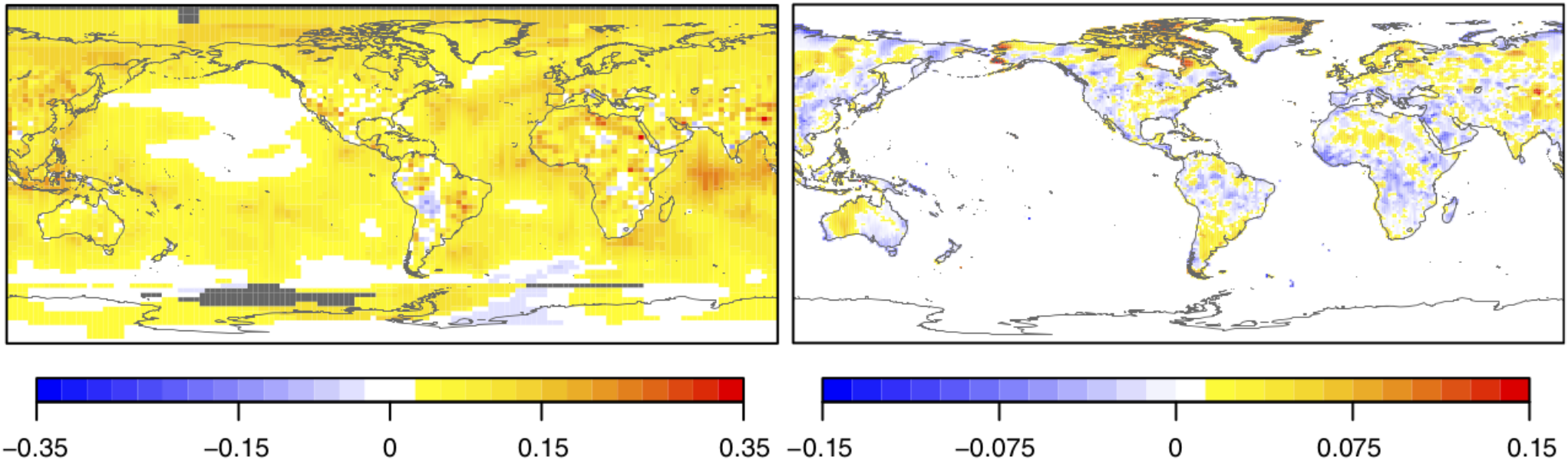


Trends

Ratio between the slope of the linear trend and the residual variability (units year^{-1}) over 1961–2010 for (left) near-surface temperature and (right) GPCC precipitation.

Temperatures from GHCN/CAMS, ERSST and GISTEMP1200 is used as a reference. Monthly values smoothed with a 4-year running average.

Temperature **Precipitation**



Doblas-Reyes et al. (2013)

Five-year start date temperature

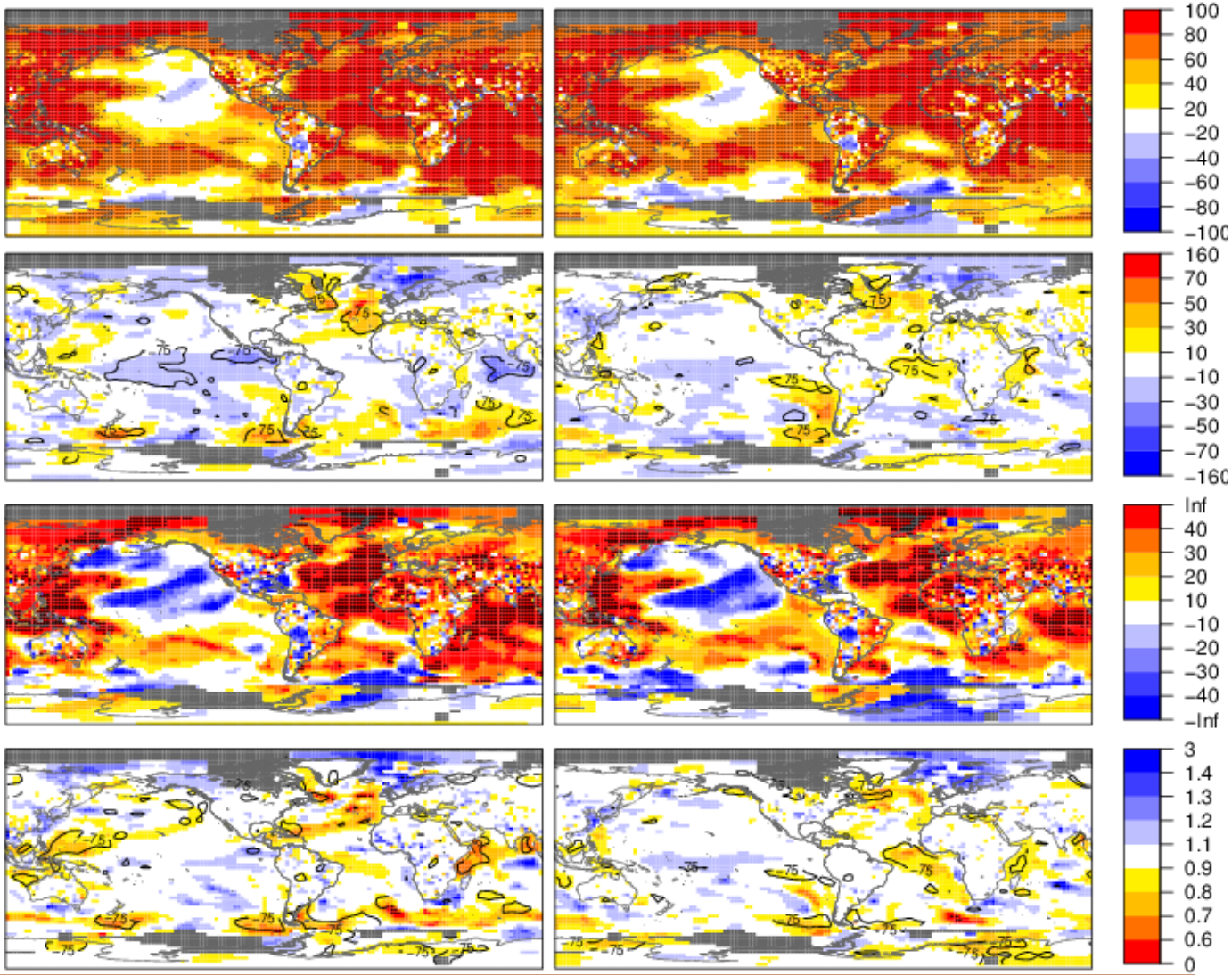
Forecast year 2-5 **Forecast year 6-9**

Init correlation of ensemble mean (12 systems; ref ERSST, GHCN and GISS)

Init minus NoInit correlation difference

Init RMSSS of ensemble mean

Ratio RMSE Init/NoInit

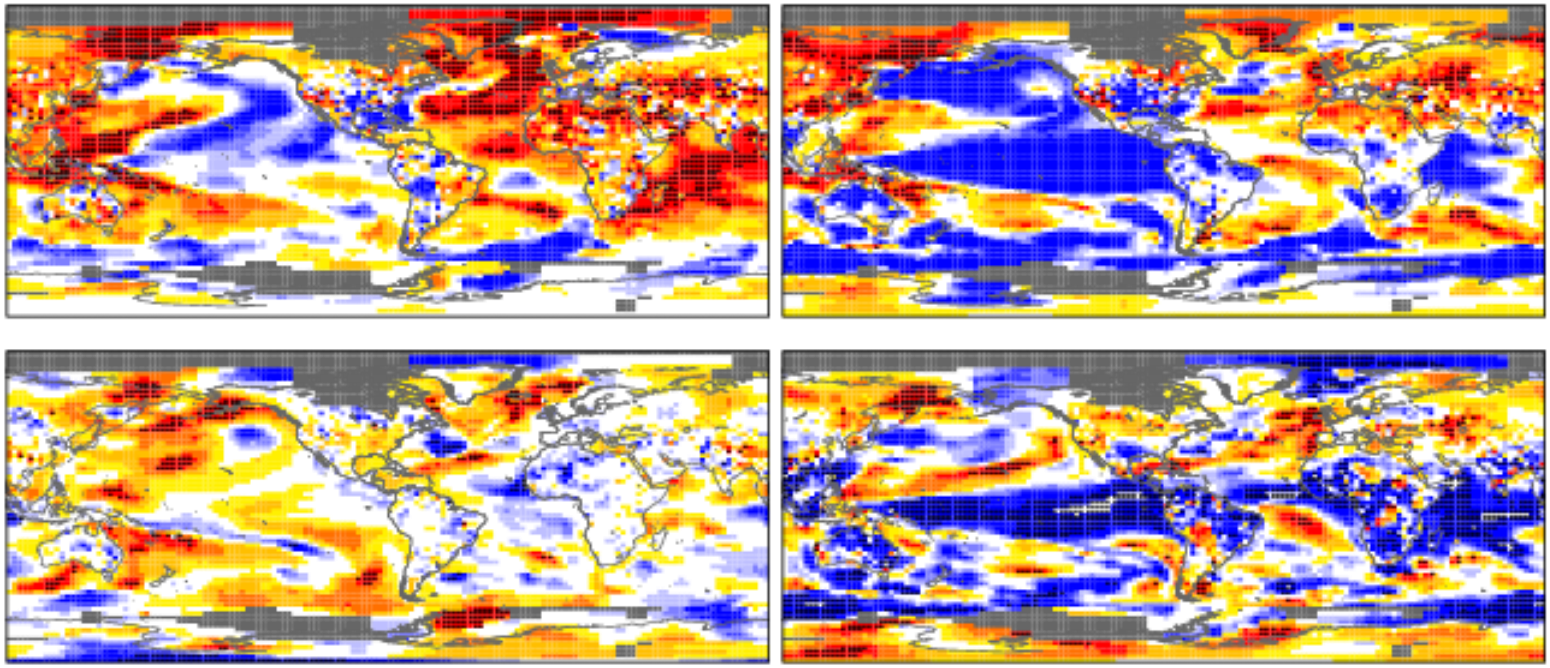


Five-year start date temperature

System a **System b**

Init RMSSS of ensemble mean

Ratio RMSE Init/NoInit

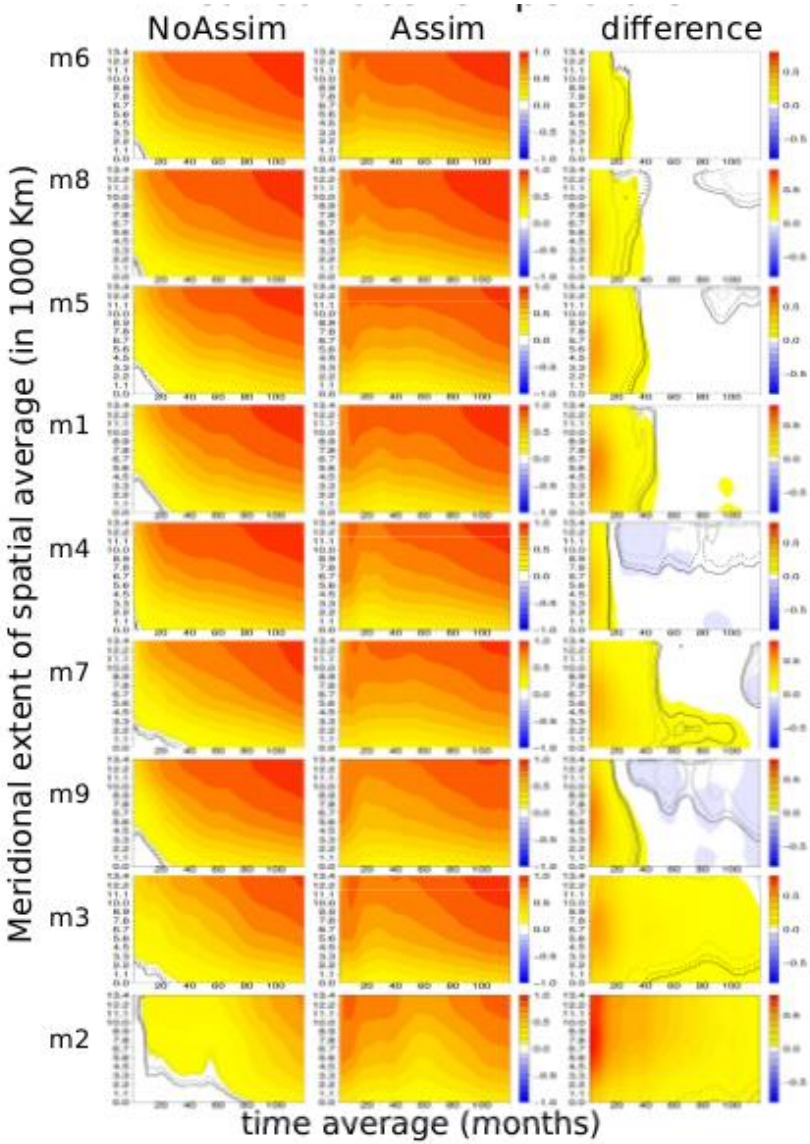


Sensitivity of skill to trend strength

Correlation of the ensemble-mean for near-surface air temperature of the DePreSys_PP (left) Assim, (centre) NoAssim and (right) their difference as a function of the integration along the forecast time (horizontal axis) and the space (vertical axis).

Each line corresponds to a version of DePreSys_PP, ranked in decreasing order as a function of the slope of the linear trend of the NoAssim GMST.

Hindcasts over 1960-2005 have been used and the reference dataset is NCEP R1. Black lines represent the confidence interval.

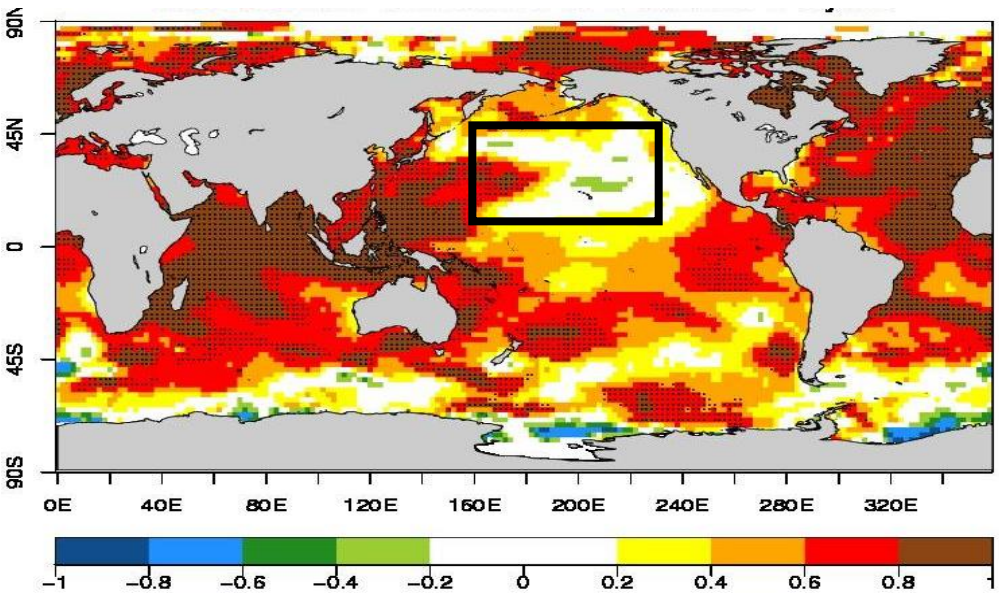


Volpi et al. (2013)

North Pacific prediction

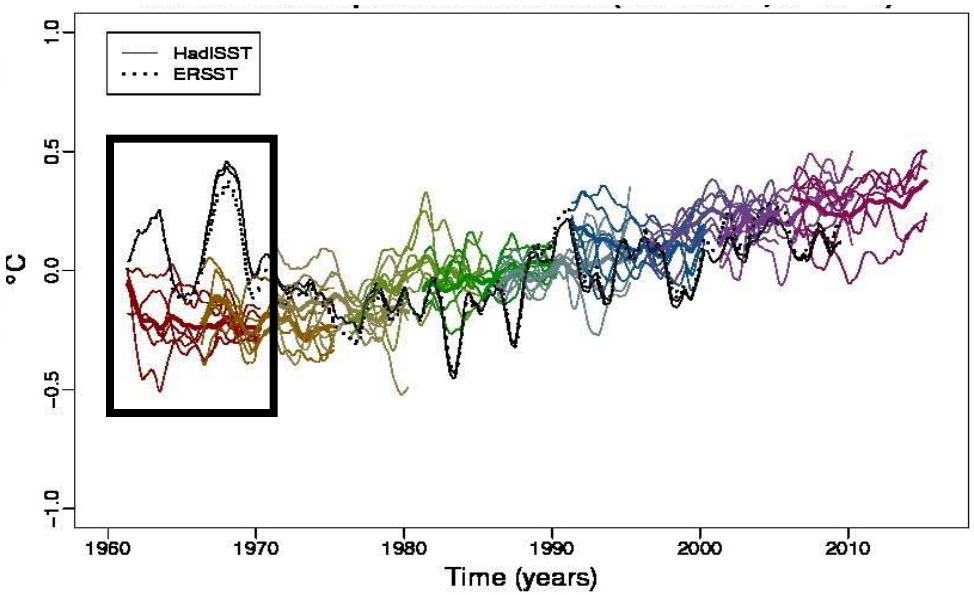
(Left) Correlation of the CMIP5 multi-model SST ensemble mean for the 2-5 forecast years. (Right) Time series of averaged SSTs over the black box, with references in black and each start date in a different colour. Ten start dates used over 1960-2005. ERSST data used for reference.

Note the missed events in 1963 and 1968.



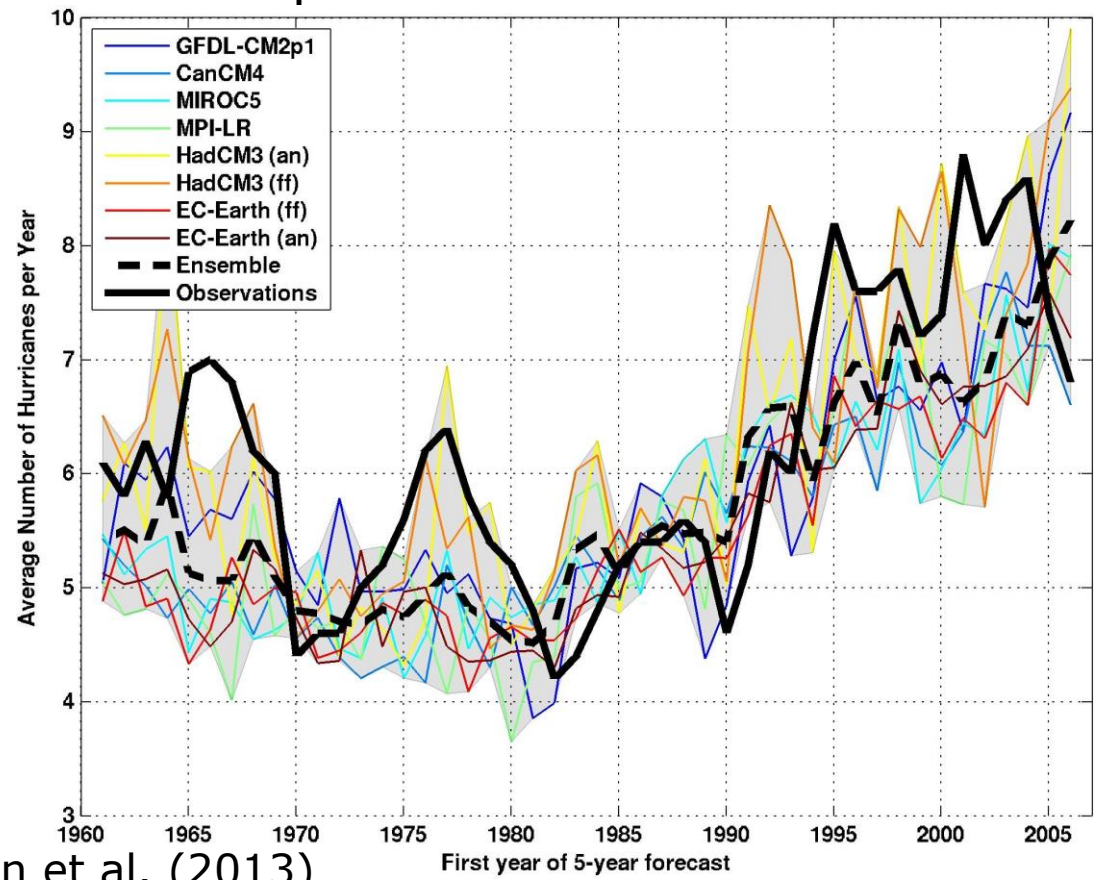
Guemas et al. (2012)

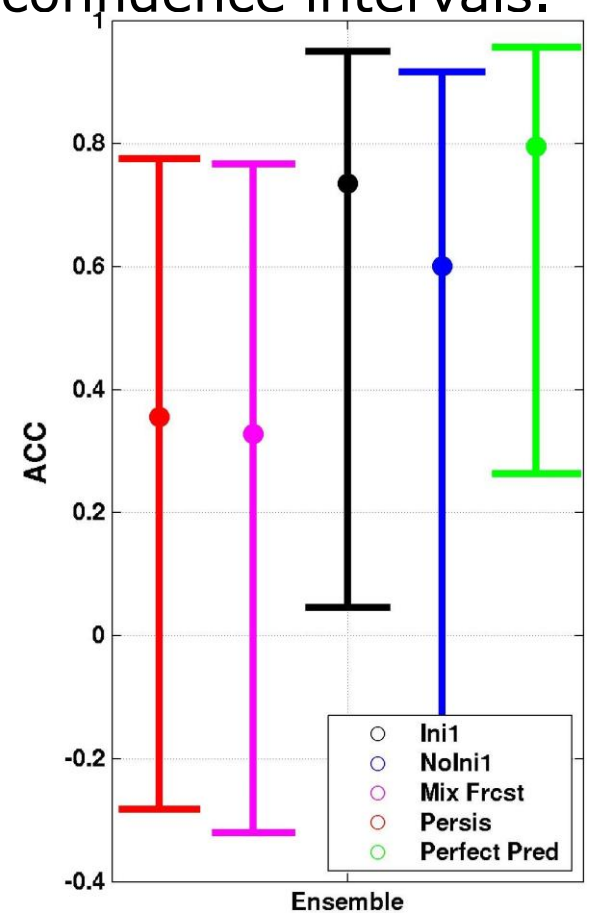
SST anomalies (155-235°E, 10-45°N)



Hurricane frequency prediction

Average number of hurricanes per year estimated from observations and from the CMIP5 multi-model decadal prediction ensemble (forecast years 1-5). The correlation of the ensemble mean for the initialized, uninitialized and statistical predictions are shown with the 95% confidence intervals.



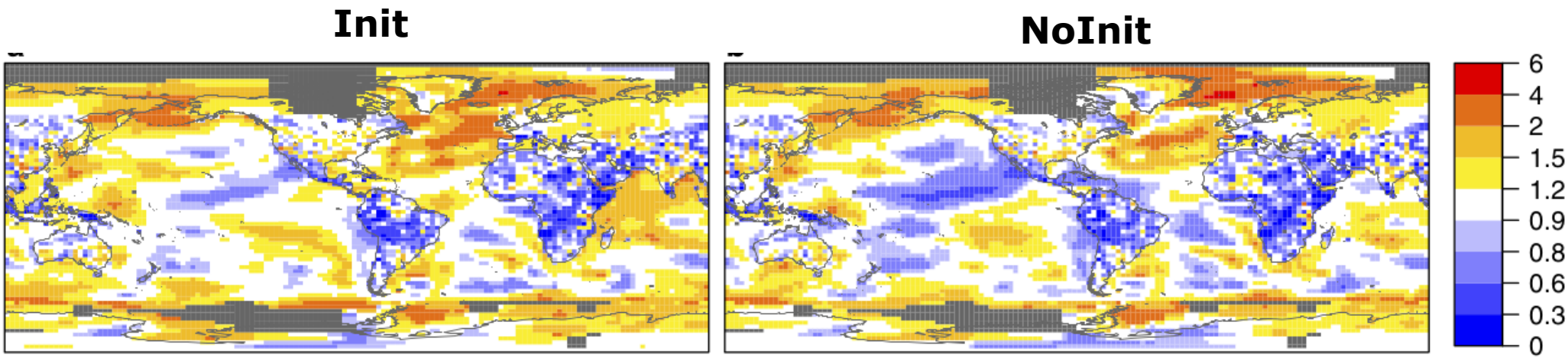


Caron et al. (2013)

CMIP5 spread

Ratio spread/RMSE for temperature from the multi-model CMIP5 decadal initialised (left) and uninitialised (right) predictions (1960-2005) for 2-5 forecast year. One-year start date interval.

The multi-model ensemble spread is not an adequate measure of forecast uncertainty.



Doblas-Reyes et al. (2013)

Five-year start date precipitation

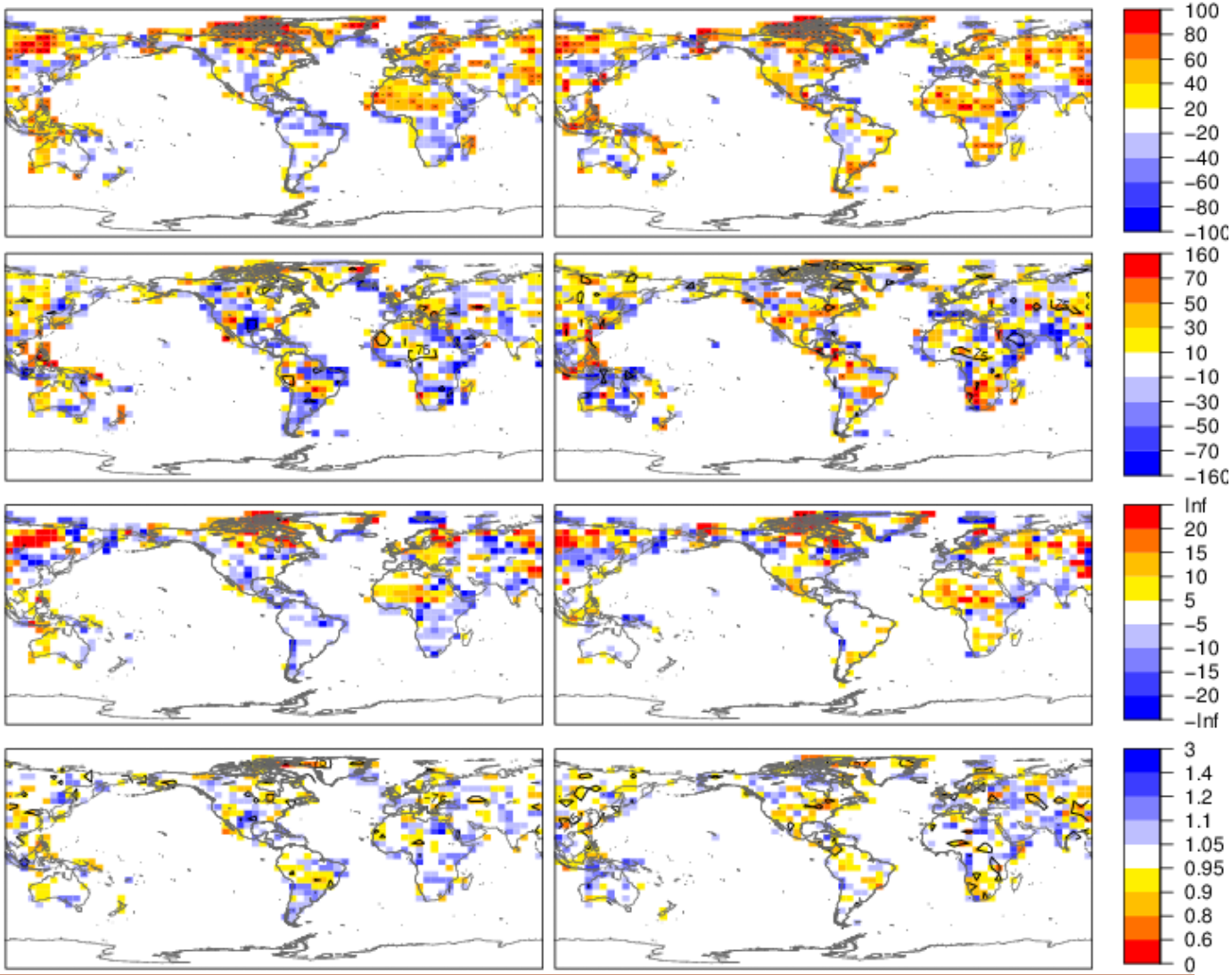
Forecast year 2-5 **Forecast year 6-9**

Init correlation of ensemble mean (12 systems; ref GPCC)

Init minus NoInit correlation difference

Init RMSSS of ensemble mean

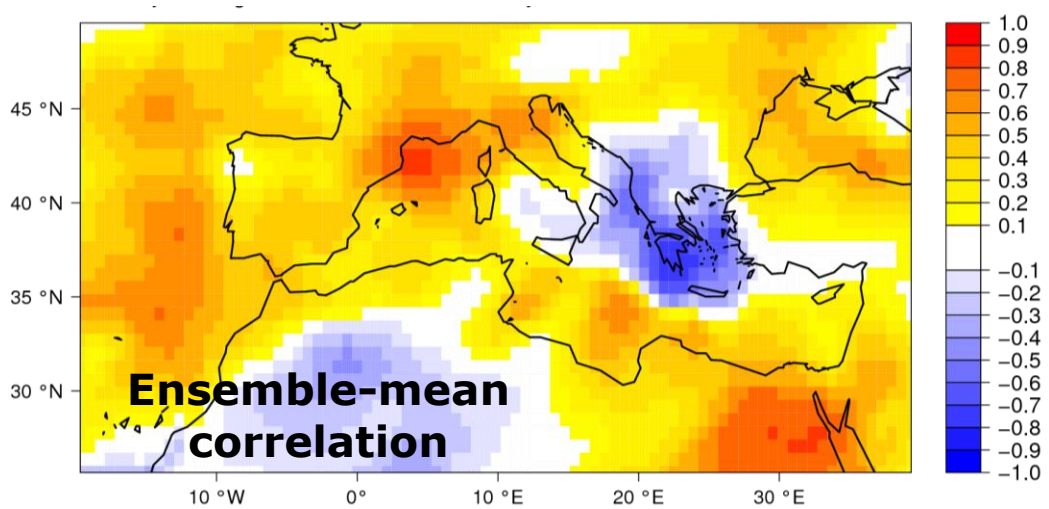
Ratio RMSE Init/NoInit

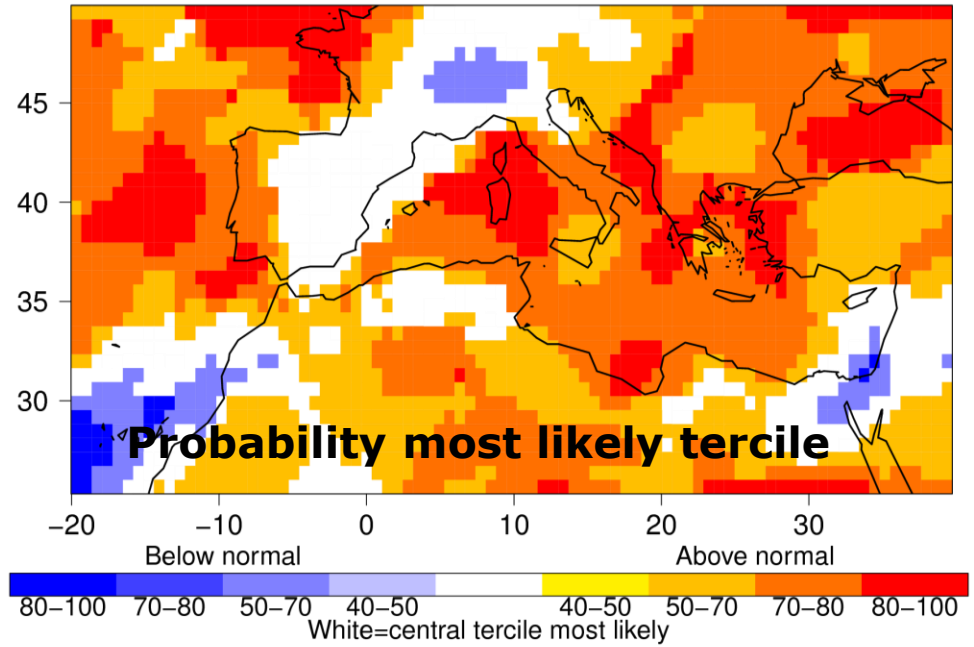


Climate services: renewable energy

Decadal predictions of downward surface solar radiation near-surface temperature from EC-Earth for the Nov 2011 start date, first five years of the forecast, with the climatology computed from 1979-2010 (reference ERA-Interim):

- Large areas with 50-100% probability to be above normal
- Consistent signal across Mediterranean
- Mostly positive correlation (largely non statistically significant)





Some suggestions for CMIP6

- Formulate an appropriate and relevant question.
- Decadal prediction will benefit from being part of CMIP6:
  - Better understanding (to, hopefully, reduce the drift) the systematic error.
  - Control runs for predictability estimates.
- Climate-projections could benefit from decadal prediction being part o
  - Reduction of drift sources.
  - Continuous
- Suggest a tr
- Decadal pre e part of CMIP.
- Real-time de d continue and be enhanced possible.

CMIP5 decadal forecasts

- There is skill in surface temperature with a horizon of several years. Initializing improves skill in various regions.
- Initialization improves GMST and AMV predictions up to 10 years. Causes might be a) phasing of internal variability and b) correction of model forced response.
- There is less skill in precipitation.
- Multi-model spread of limited use as uncertainty measure.
- The CMIP5 decadal experiment offers a huge potential for the analysis of decadal predictability and prediction (beyond forecast quality assessment).
- The impact of many processes still open: sea ice, volcanic and anthropogenic aerosols, vegetation and land use, …