
Some lessons from CMIP5 experimental design

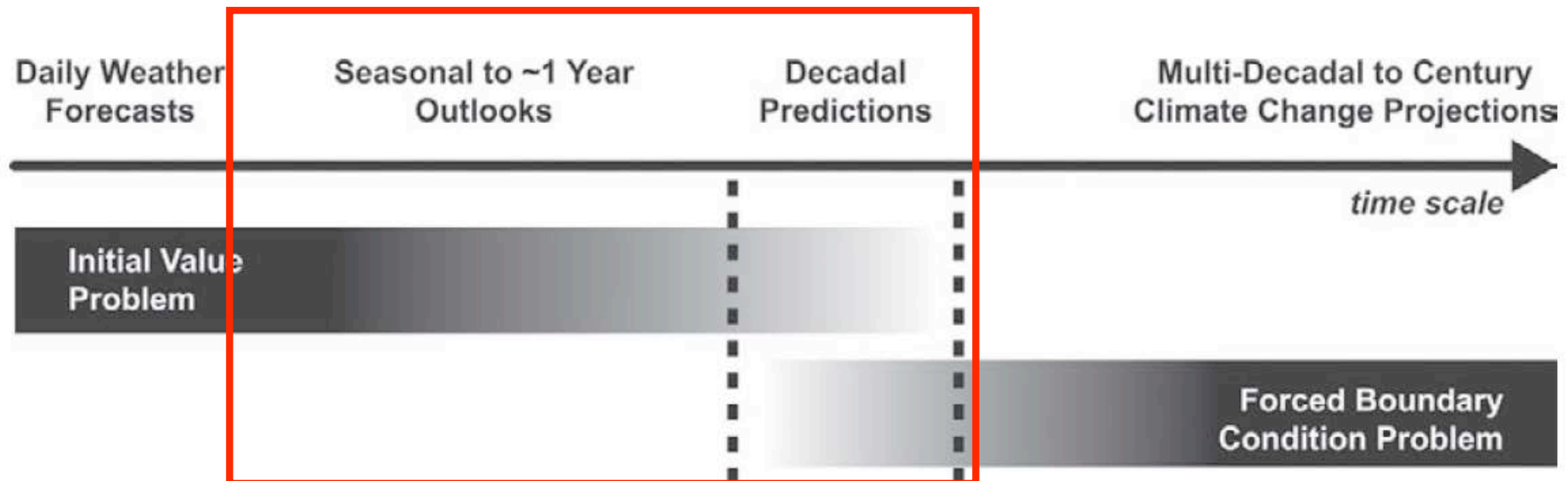
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with support from FP7 projects QWeCI, CLIM-RUN

Prediction on climate time scales

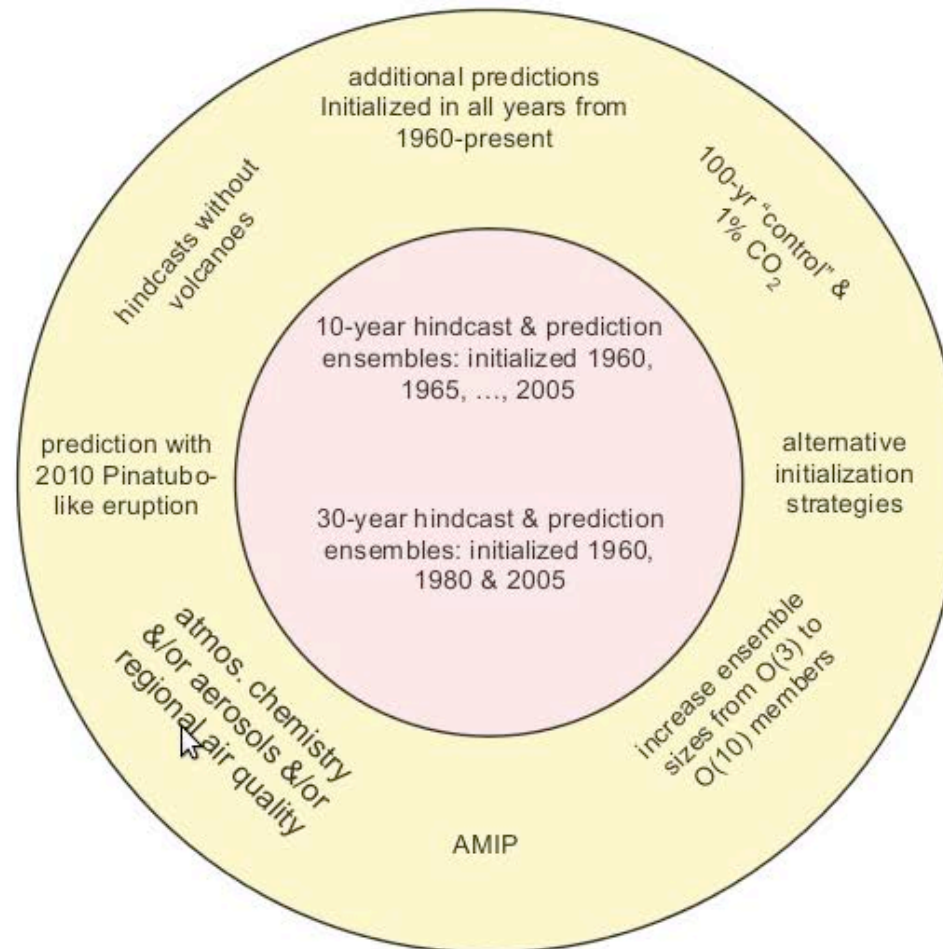
Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (**sub-seasonal, seasonal and decadal**) in the middle. Prediction involves initialization and systematic comparison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



Meehl et al. (2009)

CMIP5 near-term experiments

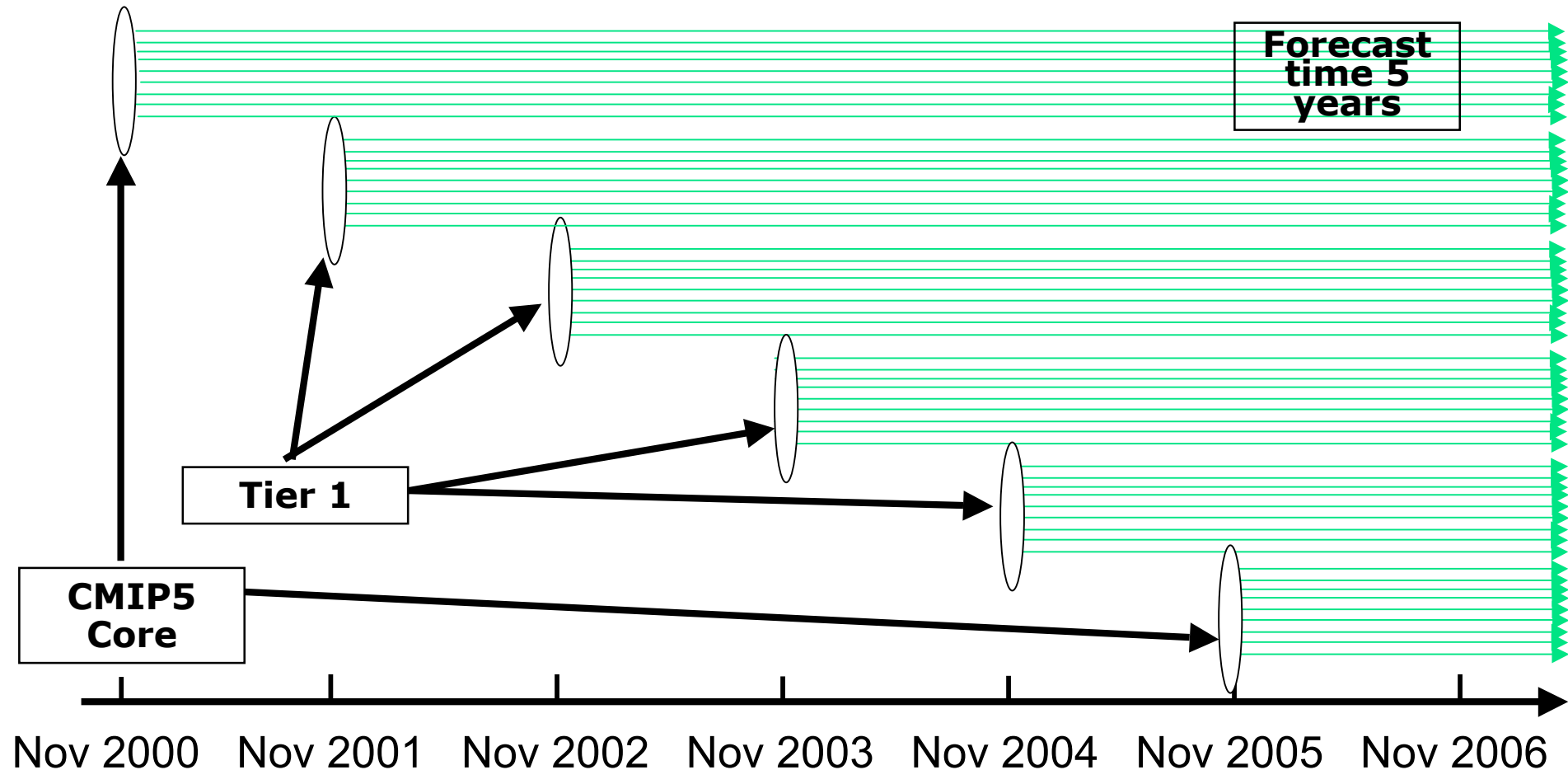
CMIP5 core (inner circle) and tier 1 (outer circle) experiments. For the core experiments, the atmospheric composition should be prescribed as in the historical run and then follow the RCP4.5.



Taylor et al. (2012)

Ensemble initialized climate predictions

Assume an ensemble forecast system with an initialized ESM



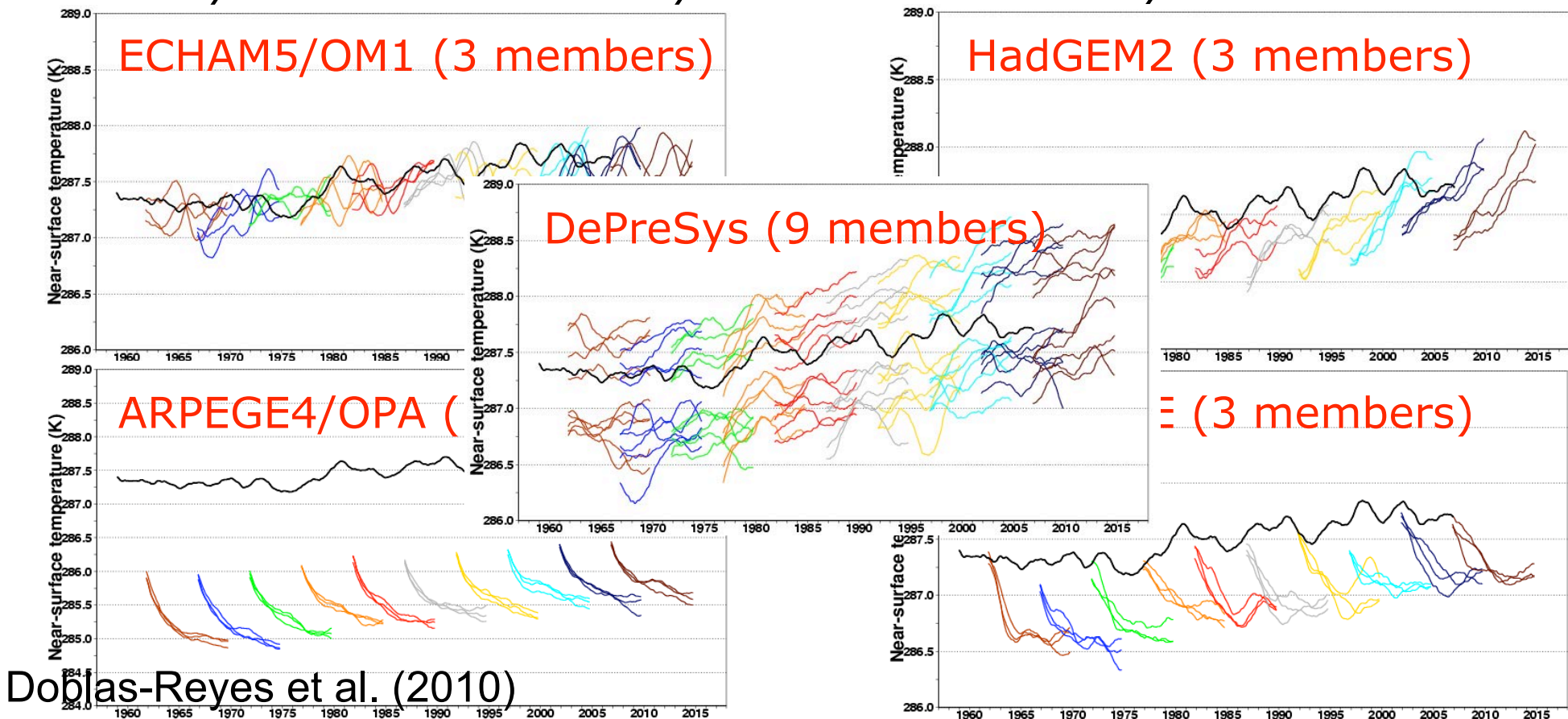
Dealing with dynamical predictions

- Build a coupled model.
- Prepare initial conditions.
- Initialize coupled system
 - The aim is to start system close to reality. Accurate SST and ocean sub-surface is crucial. If worry about “imbalances” use anomaly initialization, otherwise full initialization.
- Run an ensemble prediction and the hindcasts
 - Explicitly generate an ensemble on the e.g. 1st of a given month, with perturbations to represent the uncertainty *in the initial conditions*; run forecasts for 10-30 years.
- Worry about model error a posteriori (full initialization) or a priori (anomaly initialization), linear approach.
- Produce probabilities from the ensemble.

ENSEMBLES: global T_s

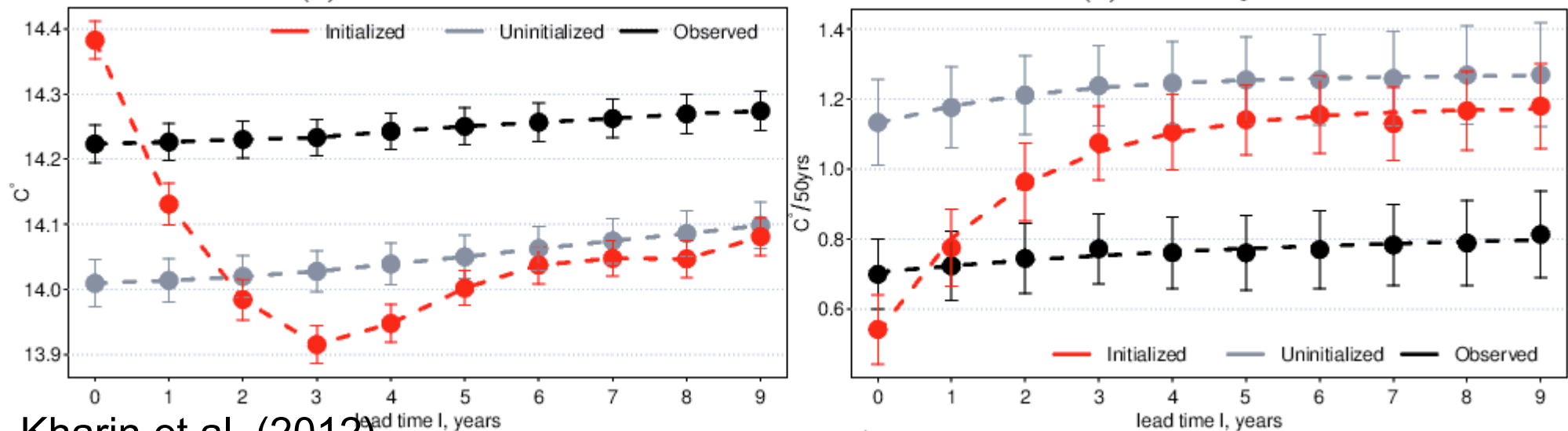
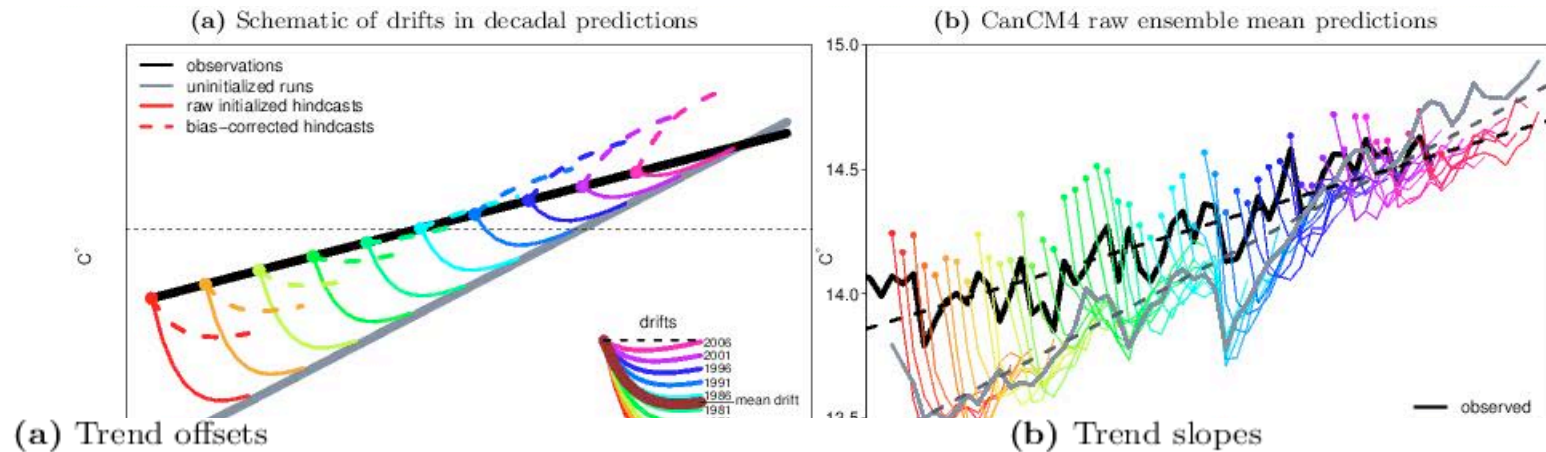
Global mean near-surface air temperature (two-year running mean applied) from the ENSEMBLES re-forecasts. Each hindcast is shown with a different colour. ERA40/OPS is used as reference.

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



Trends and start date frequency

Global-mean temperature from CanCM4 decadal predictions over 1960-2005 with one-year start date frequency.



Kharin et al. (2012)

CMIP5 decadal: indices

Decadal predictions from DePreSys_PP, ENSEMBLES and CMIP5 multi-models over 1960-2005. GISS and ERSST data used as reference.

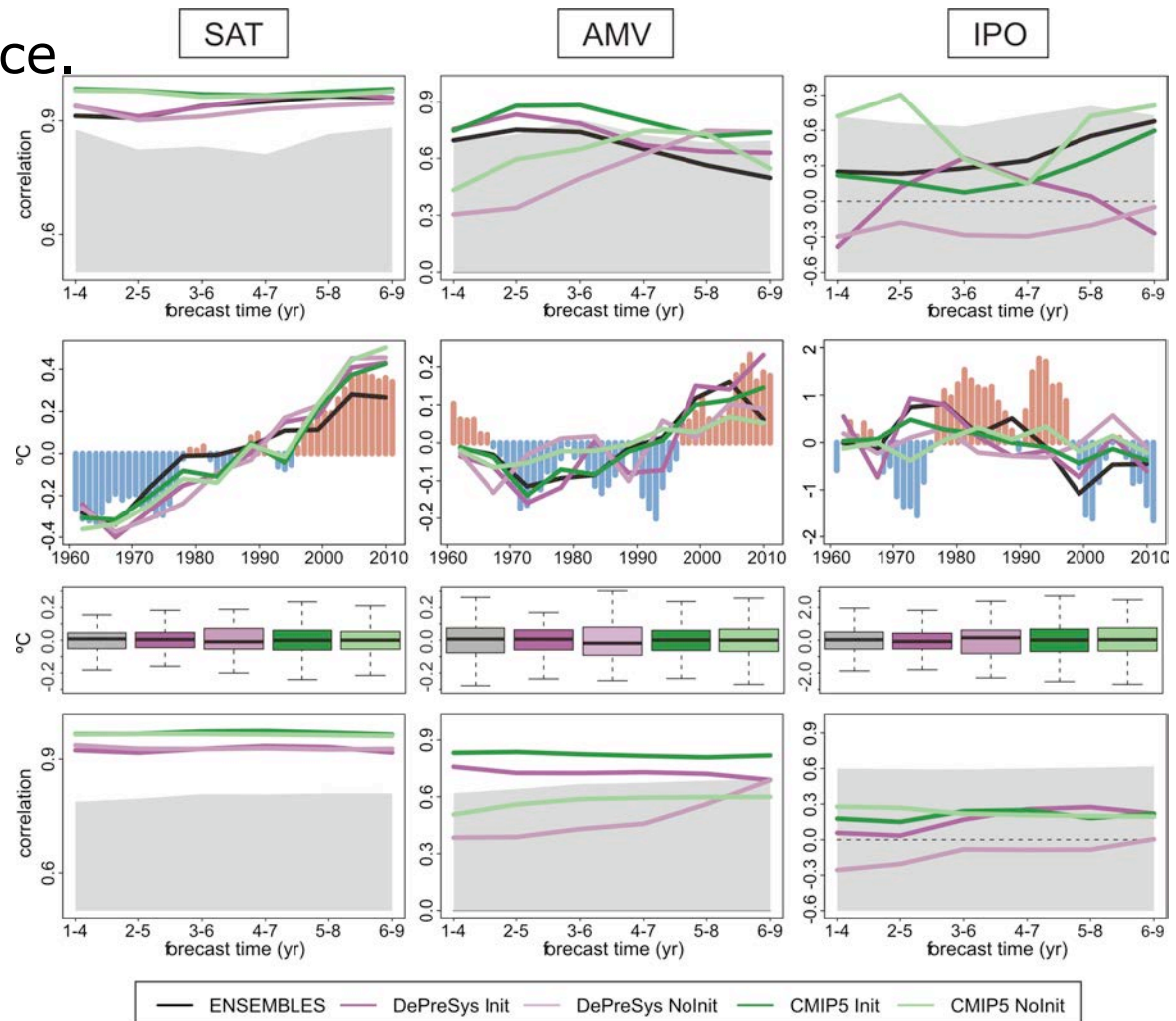
Grey area for the 95% confidence.

Ensemble-mean correlation

Time series

Mean spread

**Ensemble-mean correlation
(1 year start date interval)**



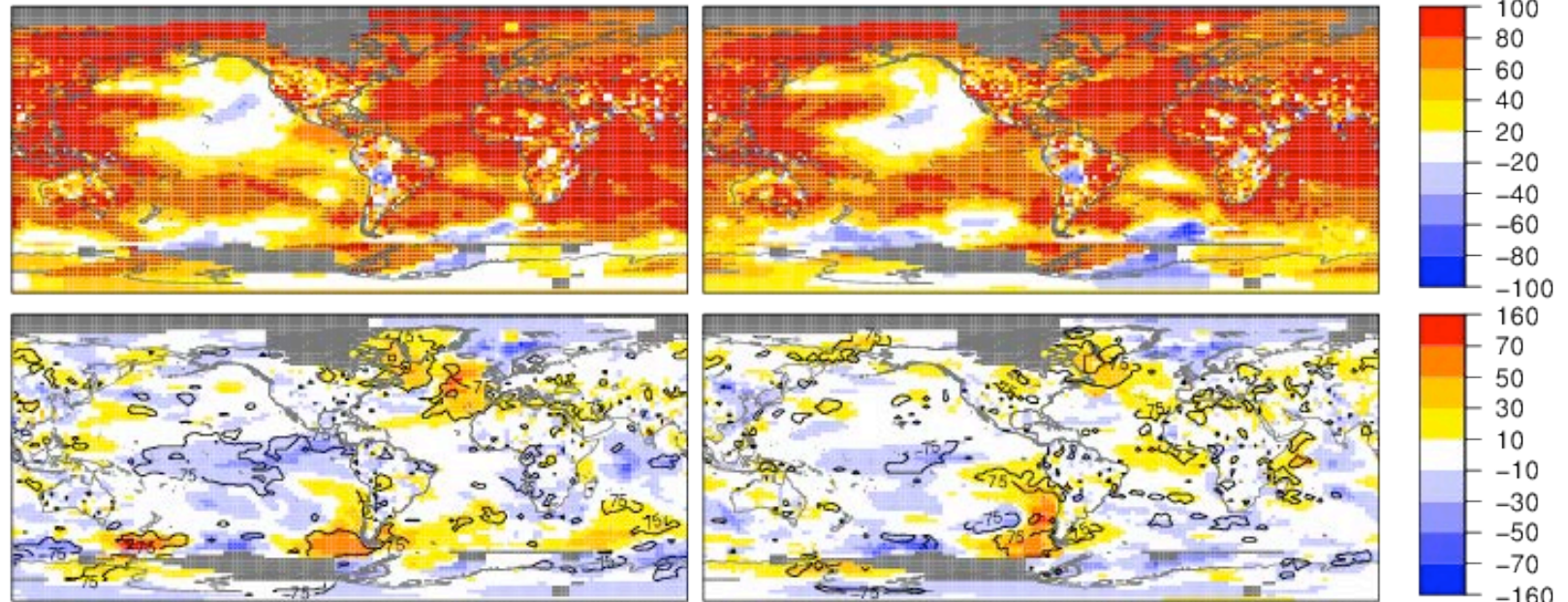
Doblas-Reyes et al. (2012)

CMIP5 decadal: regional temperature

(Top) Near-surface temperature multi-model ensemble-mean correlation from CMIP5 decadal initialised predictions (1960-2005), five-year start date frequency; (bottom) correlation difference with the uninitialised predictions of 2-5 year (left) and 6-9 year (right) wrt ERSST and GHCN.

**Init ensemble-
mean
correlation**

**Init minus
NoInit
ensemble-
mean
correlation
difference**



Doblas-Reyes et al. (2012)

CMIP5 decadal: regional precipitation

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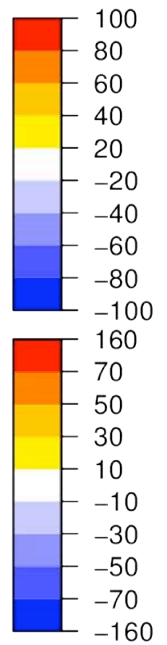
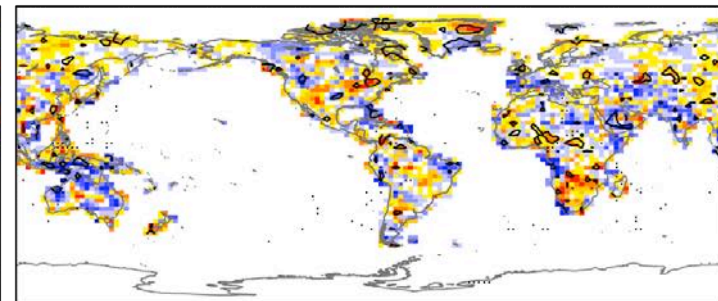
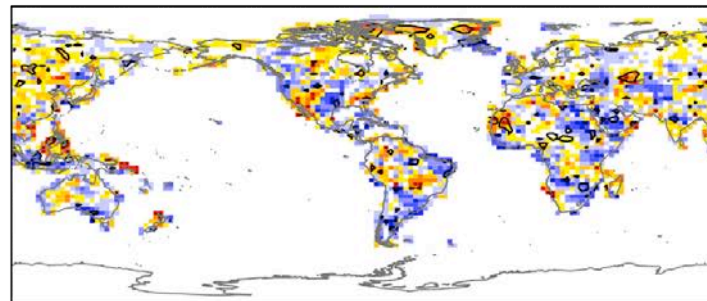
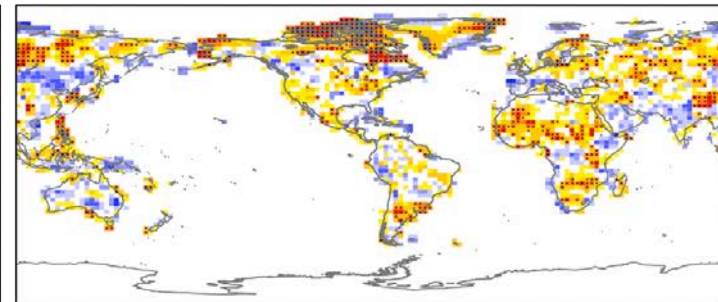
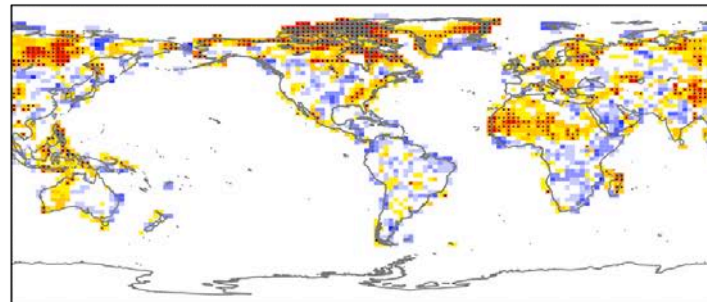


iCrea

(Top) Precipitation multi-model ensemble-mean correlation from CMIP5 decadal initialised predictions (1960-2005), five-year start date frequency; (bottom) correlation difference with the uninitialised predictions of 2-5 year (left) and 6-9 year (right) wrt GPCC.

Init ensemble-mean correlation

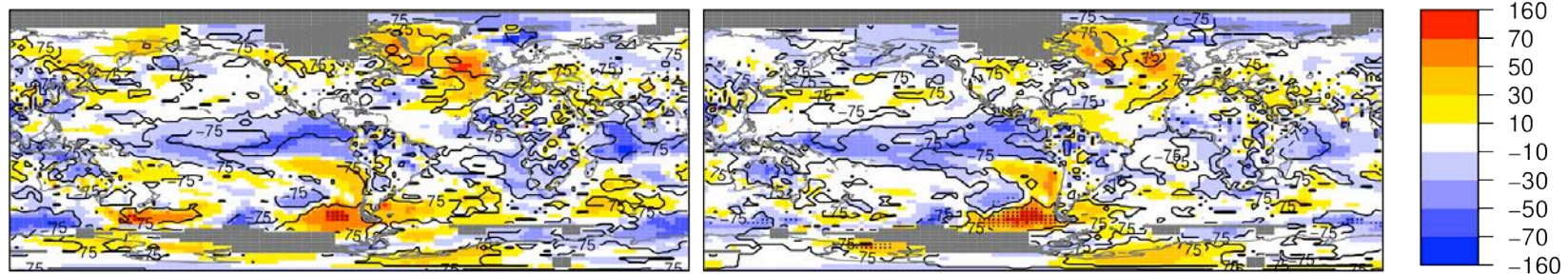
Init minus NoInit ensemble-mean correlation difference



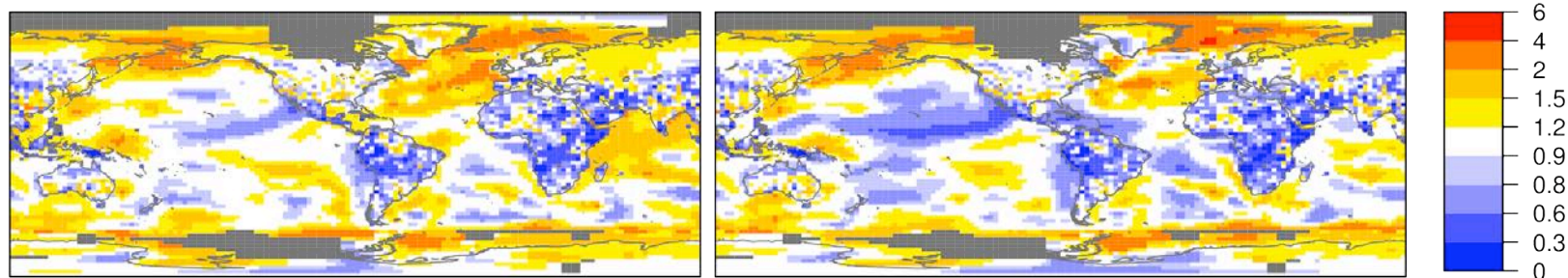
Doblas-Reyes et al. (2012)

CMIP5 decadal: sample size and spread

Temperature multi-model ensemble-mean correlation difference (Init minus NoInit) from CMIP5 decadal initialised predictions (1960-2005) for 2-5 year wrt ERSST and GHCN with five-year (left) and one-year (right) start date interval.



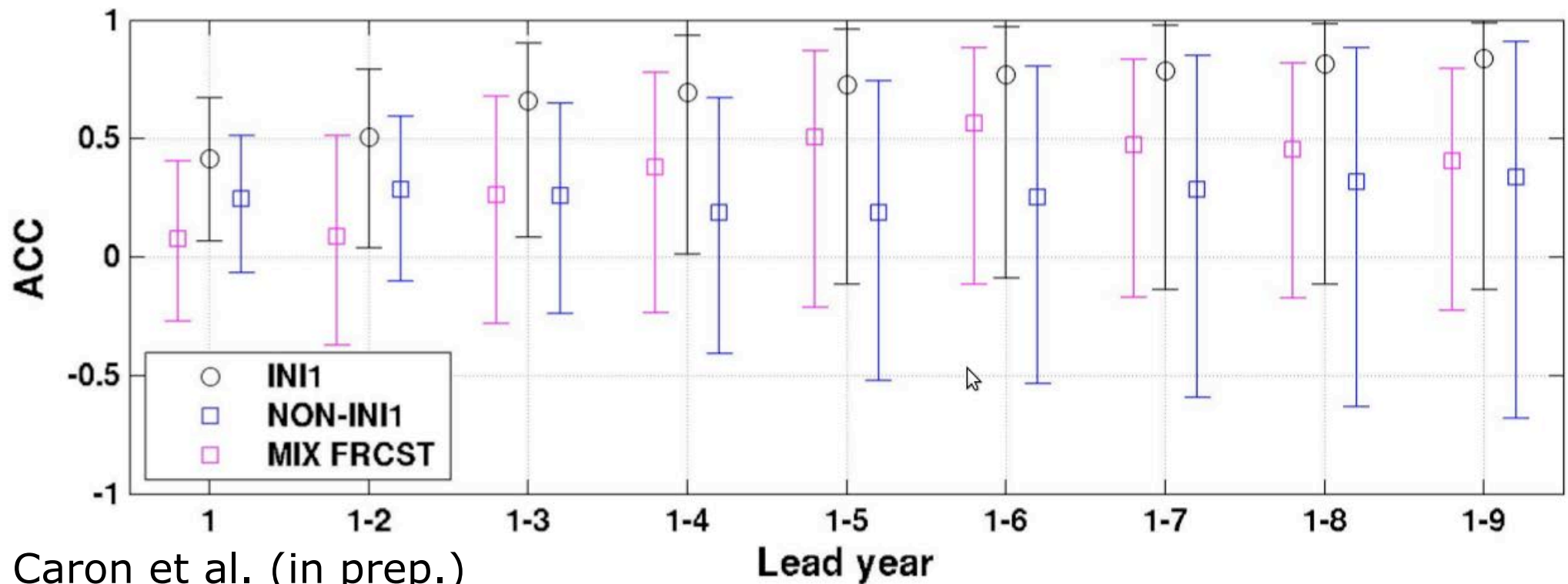
Ratio spread/RMSE for temperature multi-model CMIP5 decadal initialised (left) and uninitialised (right) predictions (1960-2005) for 2-5 year with a one-year start date interval.



Doblas-Reyes et al. (2012)

CMIP5 decadal: hurricane frequency

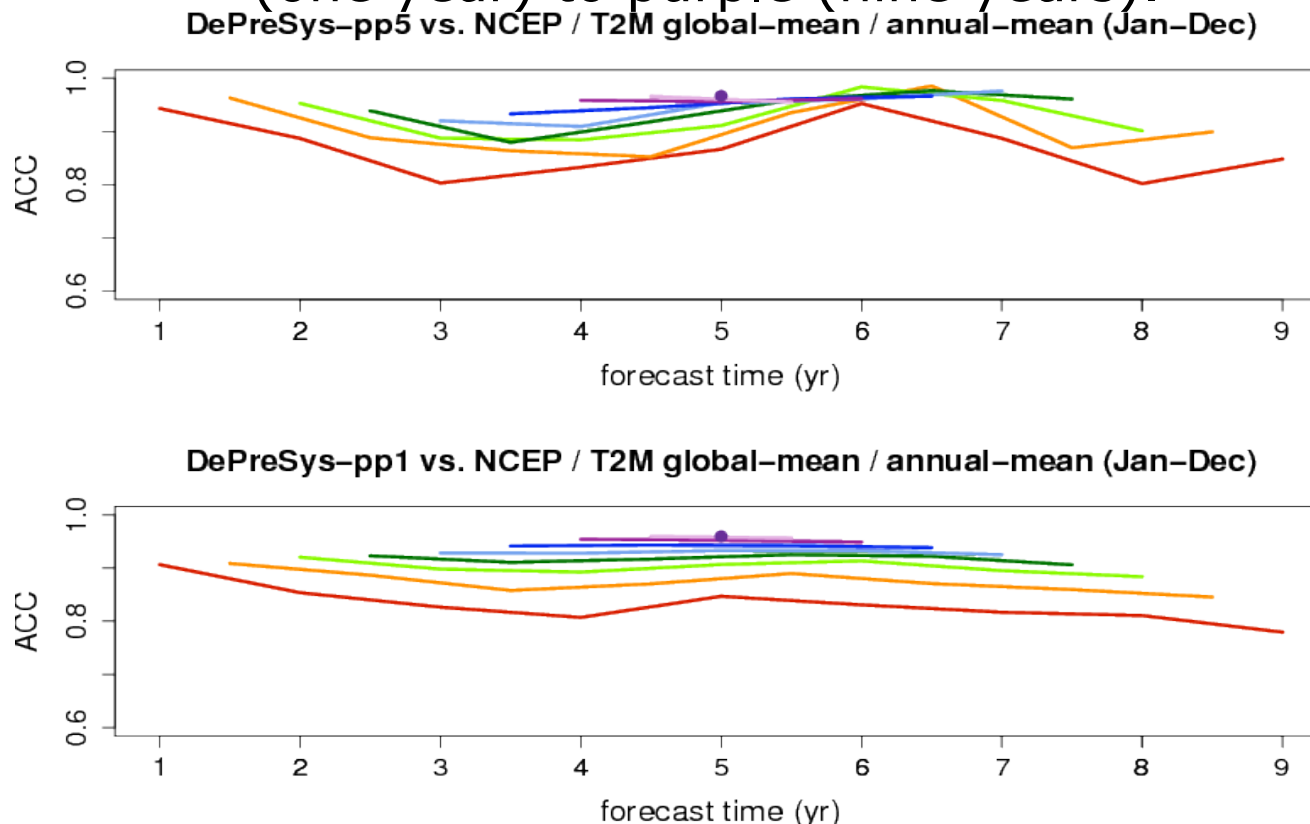
Multi-model ensemble-mean correlation of hurricane frequency based on the SST-based GFDL regression model from the CMIP5 systems with a one-year interval start date frequency (black), the uninitialized simulations (blue) and an empirical model (pink) merging climatology and persistence. 95% confidence intervals estimated taking into account the observed and predicted time series autocorrelation.



Caron et al. (in prep.)

Impact of start date frequency

Annual-mean, ensemble-mean correlation with respect to the NCEP reanalysis for the global-mean near-surface temperature for DePreSys Assim with one start date every five years (top) and every year (bottom). Each colour shows the result for a different degree of averaging, from red (one year) to purple (nine years).



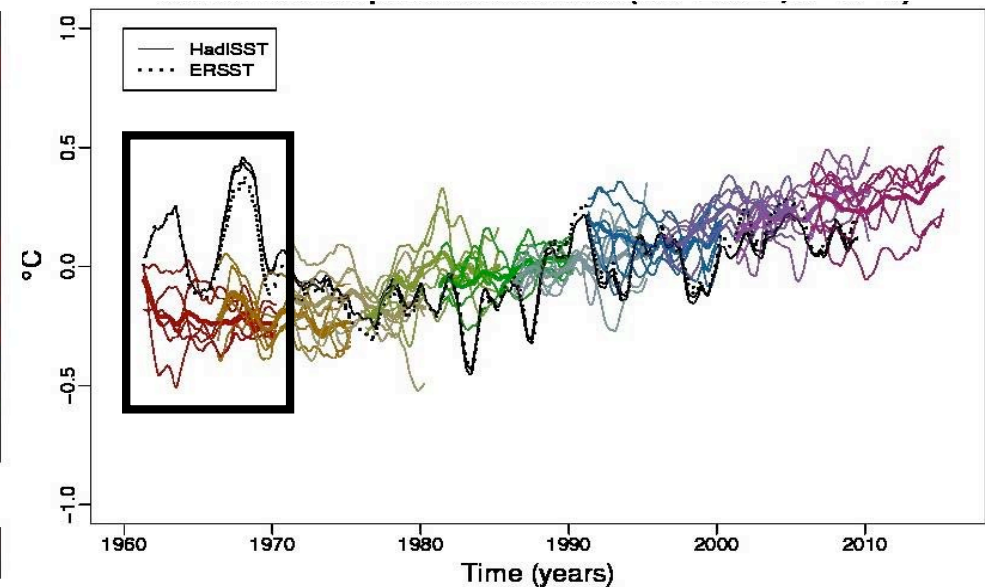
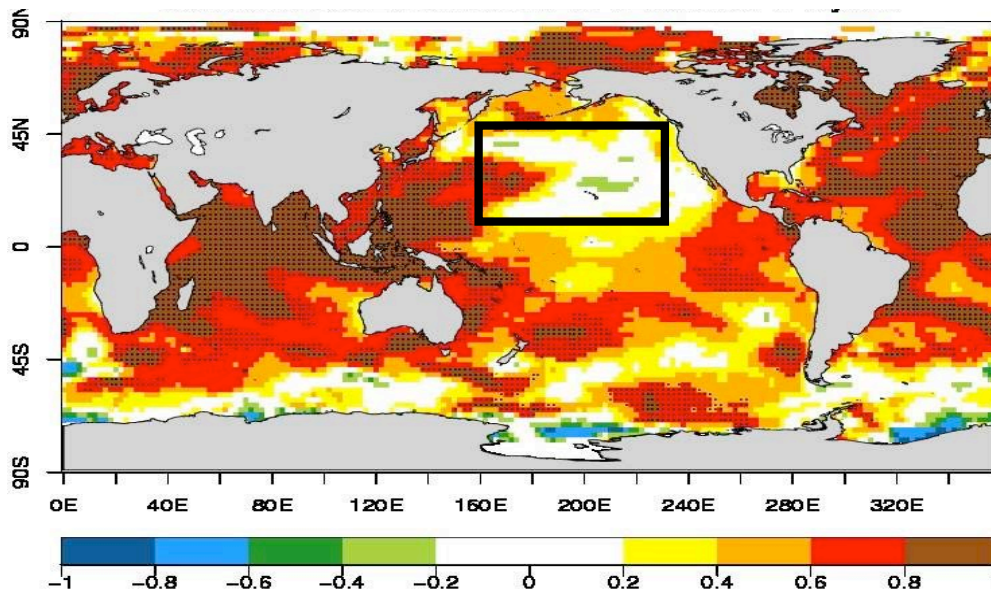
García-Serrano and Doblas-Reyes (2012)

Case studies: North Pacific

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

The North Pacific is the region with very low skill due mainly to missed events in 1963 and 1968.

SST anomalies (155-235°E, 10-45°N)



Guémas et al. (2012)

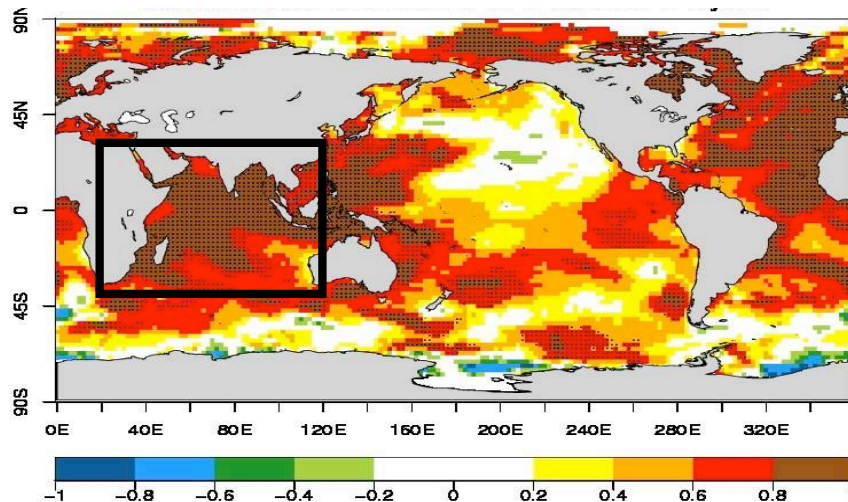
Volcanoes: Indian ocean

(Left) CMIP5 multi-model ensemble-mean correlation of SSTs for the average of the 2-5 forecast years. Ten start dates over 1960-2005 have been used. (Right)

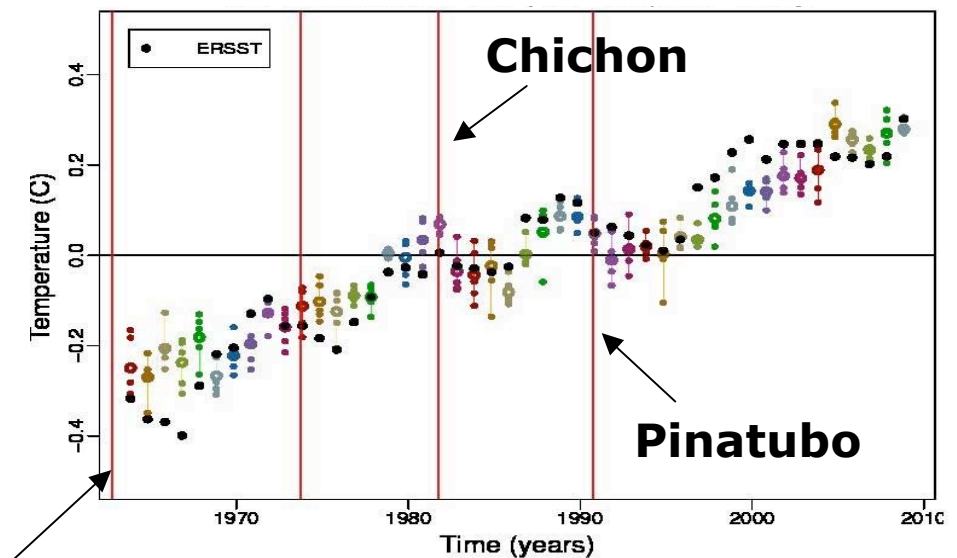
Time series of averaged SSTs over the black box, with the reference drawn in black and the 2-5 year EC-Earth decadal forecasts with each ensemble start date drawn with a different colour. ERSST data have been used for reference.

The Indian ocean is one of the regions with the highest skill due to the upward trend and the role of volcanic aerosol.

CMIP5 SST correlation skill 2-5 years



SST anomalies (20-120°E, 40°S-30°N)



Agung

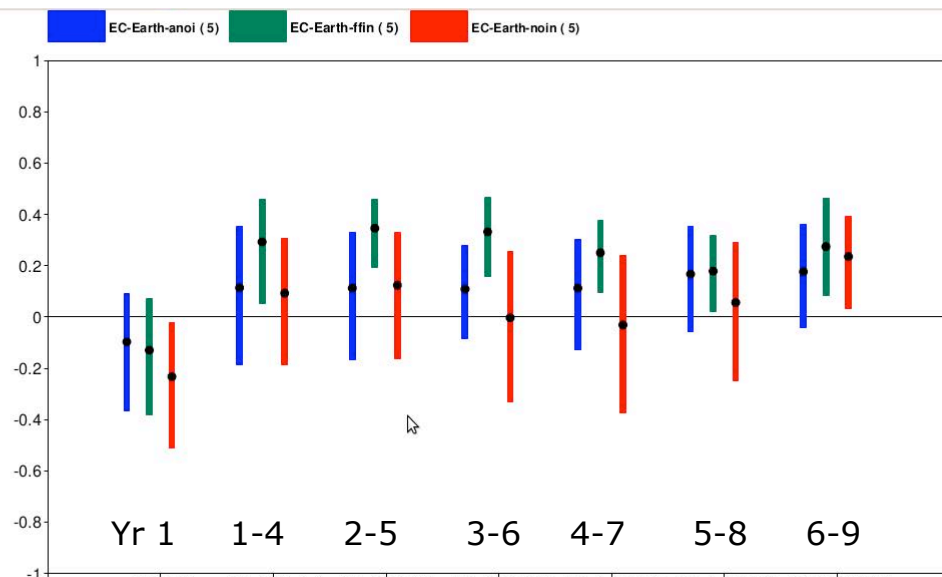
Guémas et al. (2012)

Initialization: full-field versus anomaly

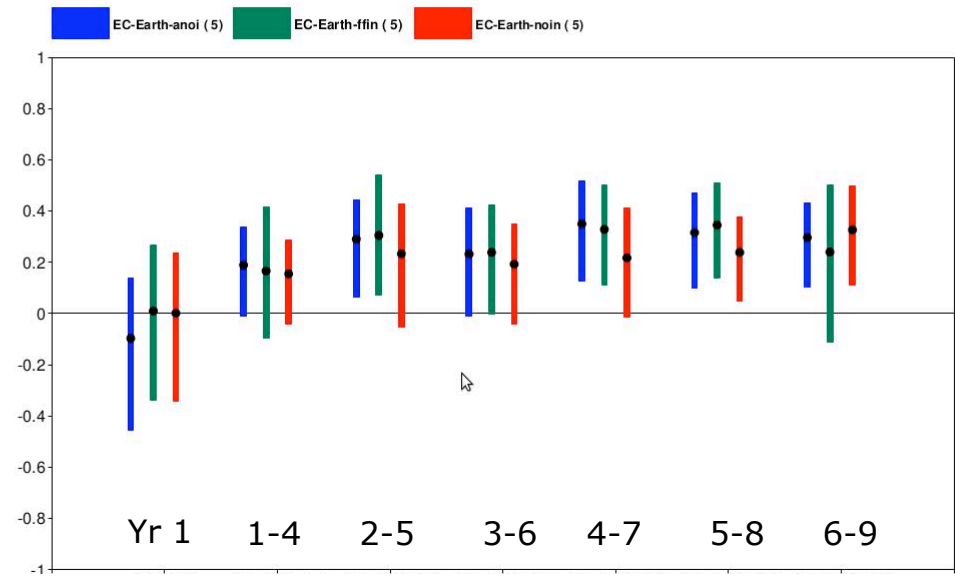
EC-Earth2.3 Brier skill score of air temperature anomalies below the lower tercile over the North Atlantic (left) and Europe (right) for the anomaly-initialization (blue), full-field initialization (green) and uninitialized (red) hindcasts. Hindcasts for ten start dates and five-member ensembles over 1960-2005 have been used. The 95% confidence intervals have been obtained with bootstrap.

ERA40/ERAInterim has been used as a reference.

North Atlantic (ocean only)



Europe (land only)

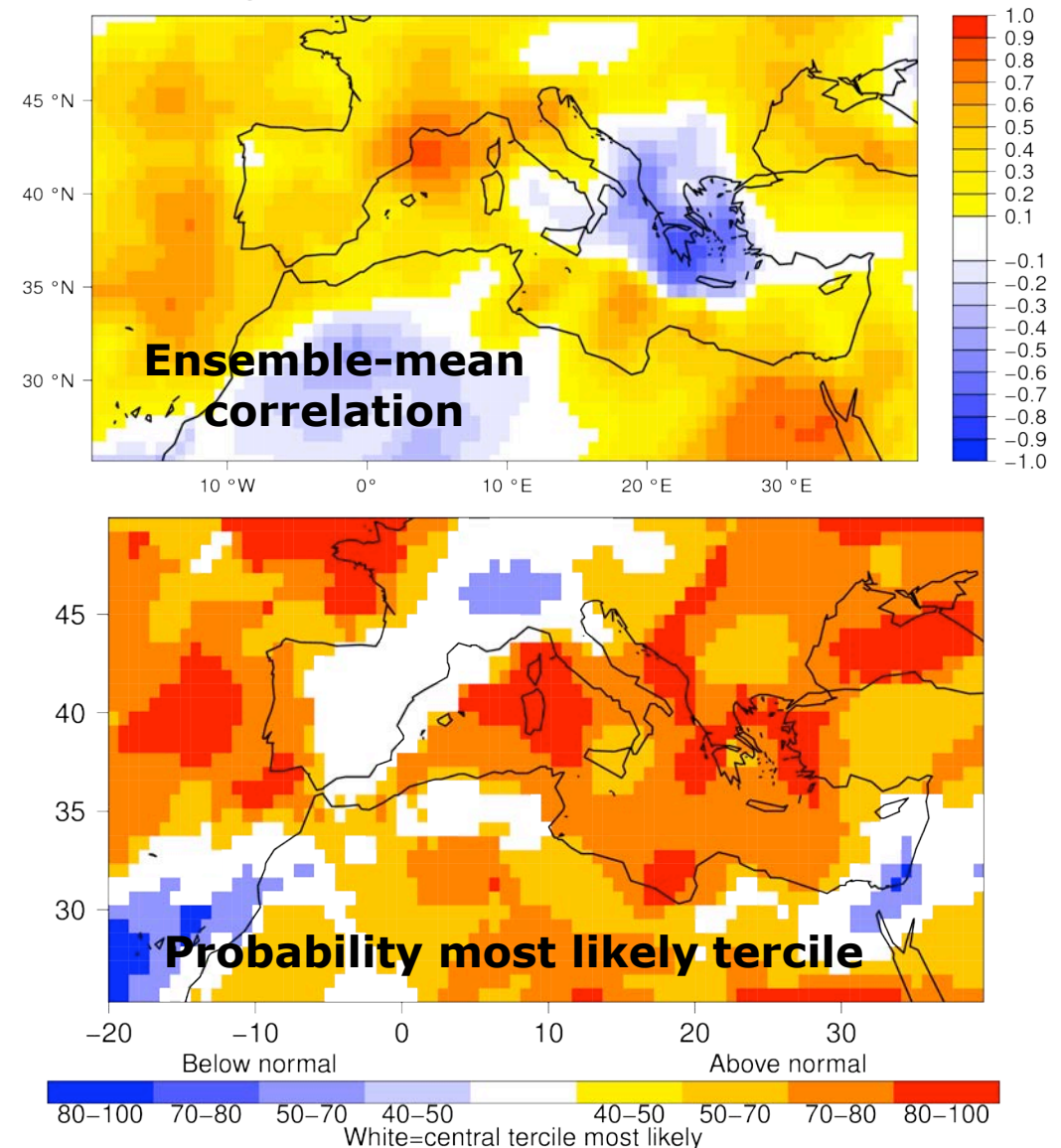


Hazeleger et al. (2012)

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)



Decadal forecasts: open questions

- Is there skill with a horizon of several years? Where? Is it useful? What about extremes?
 - Does initialization of dynamical models improve forecast quality with respect to uninitialized integrations? What is the role of initial conditions versus that of the forcing?
 - Do improved use of ocean data increase forecast quality?
 - What are the relevant physical processes? What is the role of the systematic error?
 - What is the impact of model uncertainty on forecast quality and the best methods to deal with it?
 - The impact of many processes is still open: sea ice, anthropogenic aerosols, ... and the seamless concept has still to be developed further.
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