Beyond seasonal forecasting
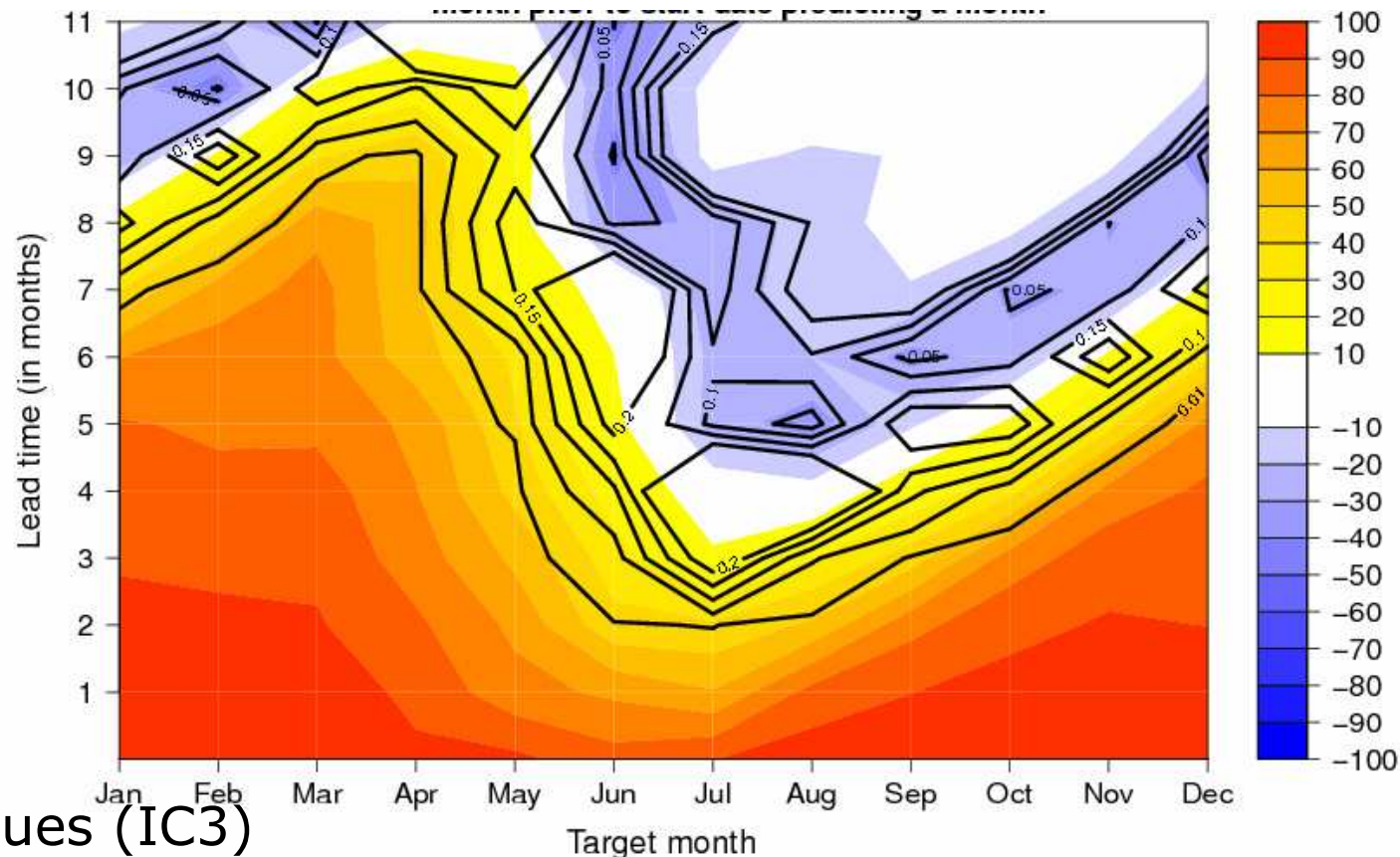
F. J. Doblas-Reyes, ICREA & IC3, Barcelona, Spain

Outline

- Seasonal forecasting beyond a few months
- Dynamical seasonal forecasting: systematic errors
- Forecasting up to one year: global view and tropical indices
- Global-average temperature and trends
- Summary

Simple empirical model: persistence

Correlation (solid line p value) of a Niño3.4 persistence model based on lagged linear regression of HadISST over 1981-2009; first regression model with data for 1951-1980.

L. Rodrigues (IC3)

Experimental setup

- Two forecast systems: System 3 (IFS/HOPE) and EC-Earth (IFS/NEMO)

- Initial conditions: ERA40/ERAInt atmosphere and land, ORA-S3 and NEMOVAR-COMBINE ocean, DFS4.3 sea ice

- Five-member ensemble hindcasts up to 13 months

- Ensemble from five-member ocean analysis and atmospheric perturbations (singular vectors plus SST perturbations in System 3) added to each member

- Initial conditions valid for 0 GMT on the 1st of a month

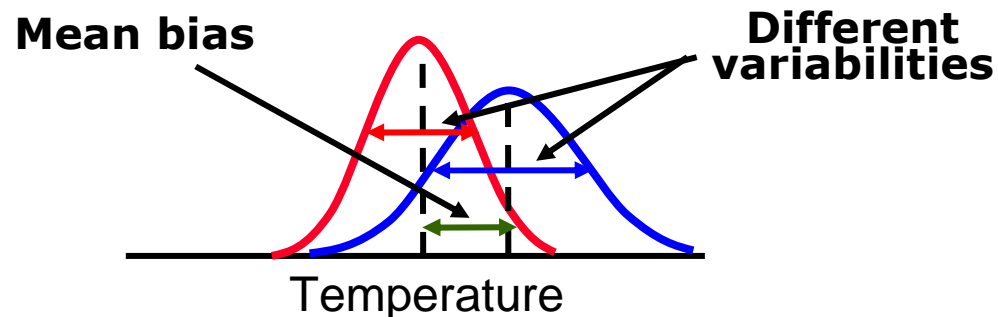- Two start dates per year: May and November

- Forecast period 1976-2005

Systematic errors in ensemble forecasts
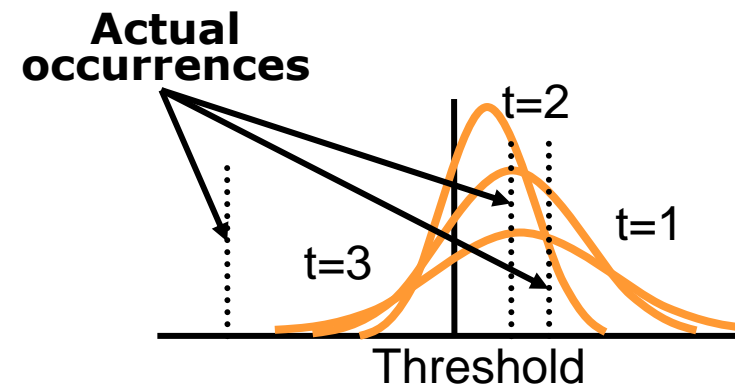
Main systematic errors in dynamical climate forecasts:

o Differences between the model climatological pdf (computed for a lead time from all start dates and ensemble members) and the reference climatological pdf (for the corresponding times of the reference dataset): systematic errors in mean and variability.

o Conditional biases in the forecast pdf: errors in conditional probabilities implying that probability forecasts are not trustworthy. This type of systematic error is best assessed using the reliability diagram.

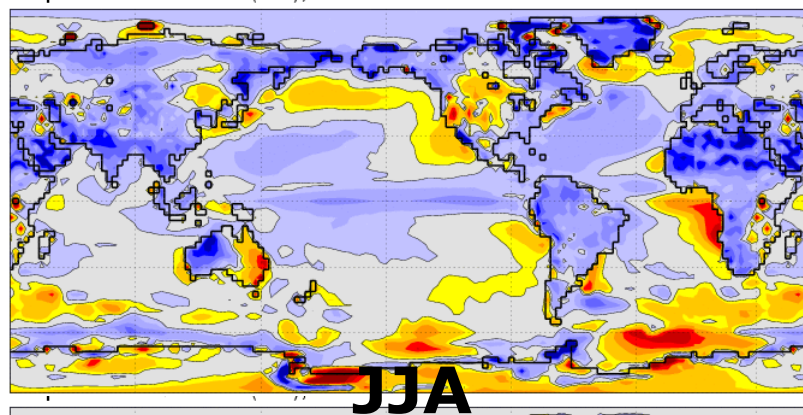**Differences in climatological pdfs**
Reference pdf   **Model pdf**

Mean bias   **Different variabilities**   Temperature

Forecast PDF
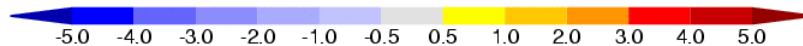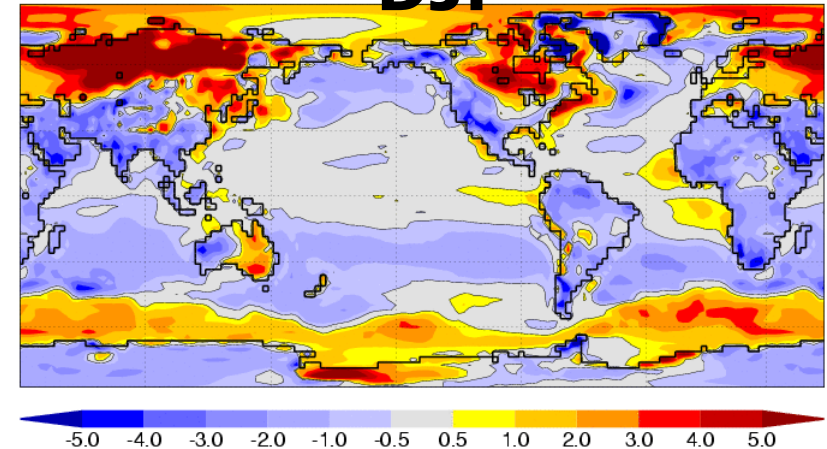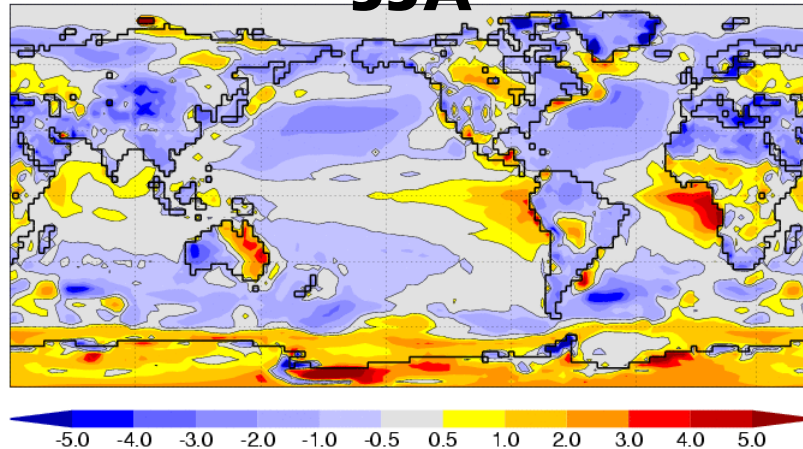**Actual occurrences**   t=2   t=1   t=3   Threshold

Mean error: mean bias

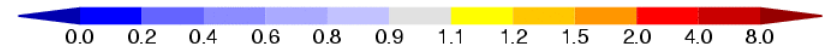Bias of 8-10 month surface temperature re-forecasts wrt ERA40/Int over 1976-2005.
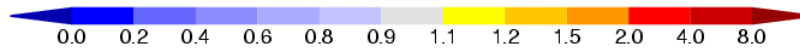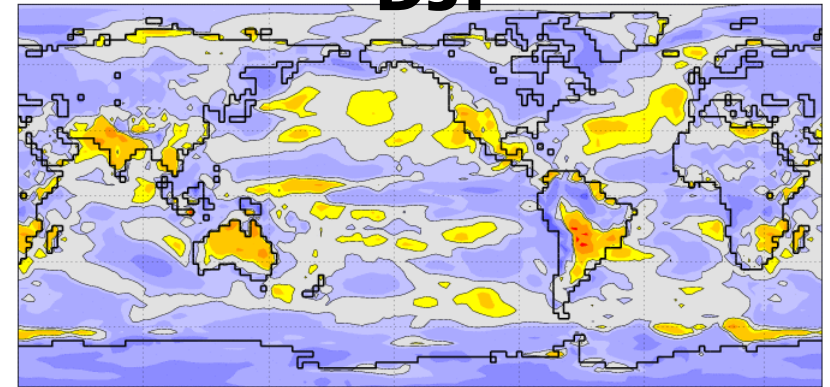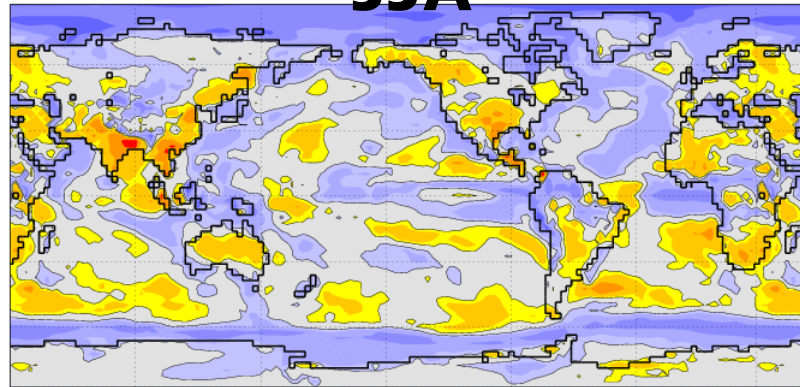
Mean error: standard deviation

Ratio of interannual standard deviation of 8-10 month near-surface temperature re-forecasts wrt ERA40/Int over 1976-2005.
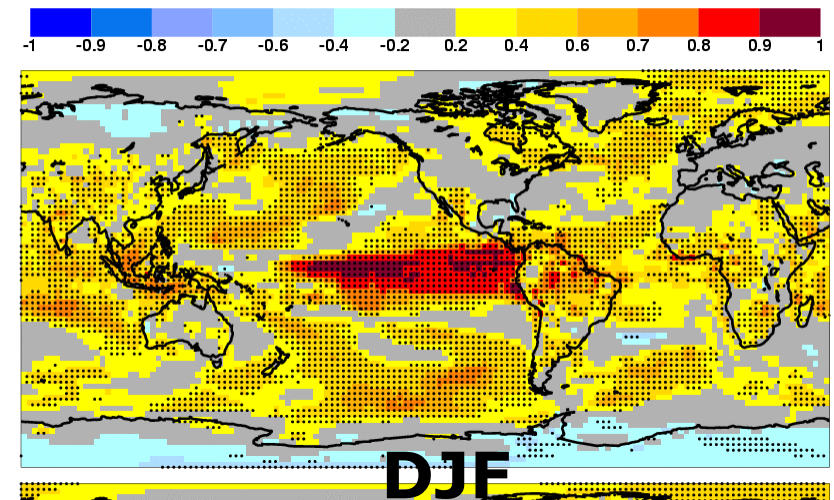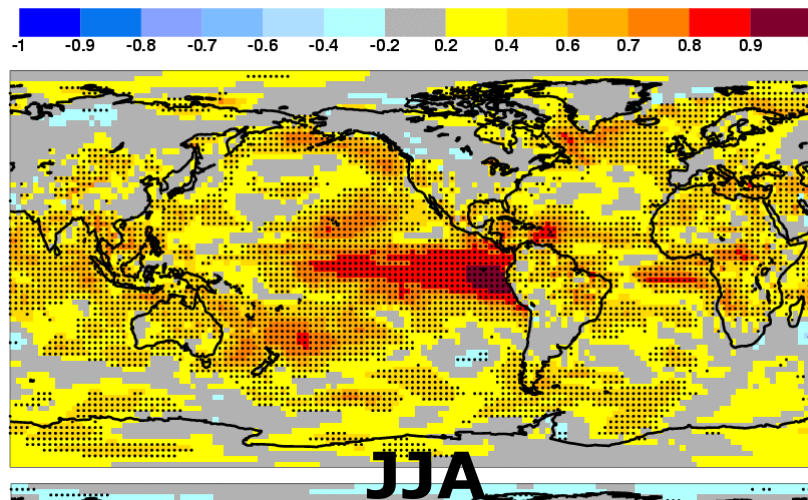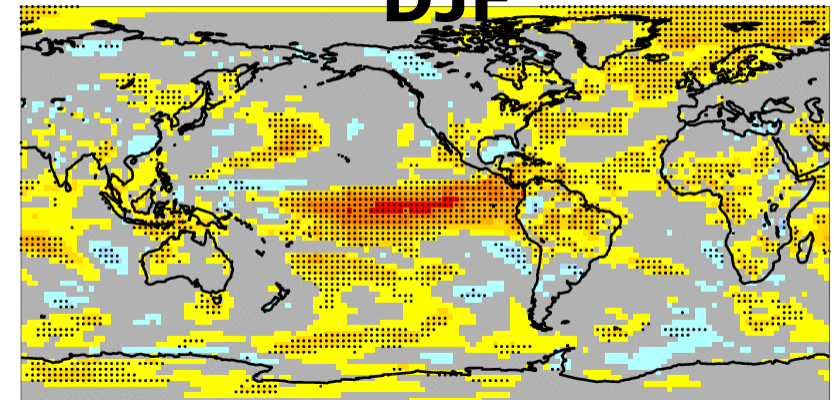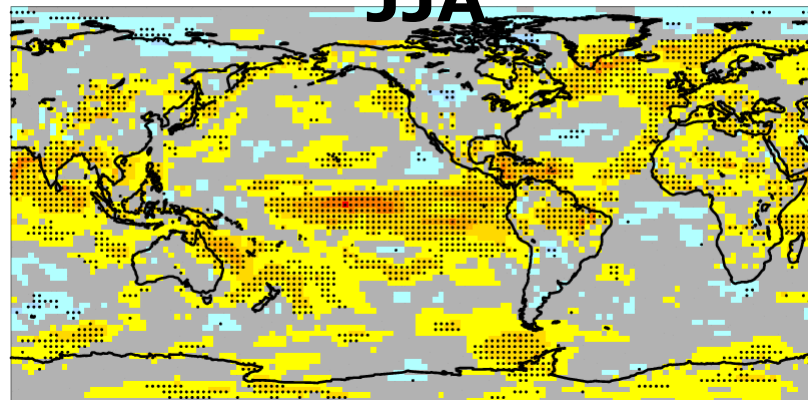
Global skill: lead time effect

Ensemble-mean correlation of EC-Earth near-surface air temperature re-forecasts wrt ERA40/Int over 1976-2005. Dots for values statistically significant with 95% conf.
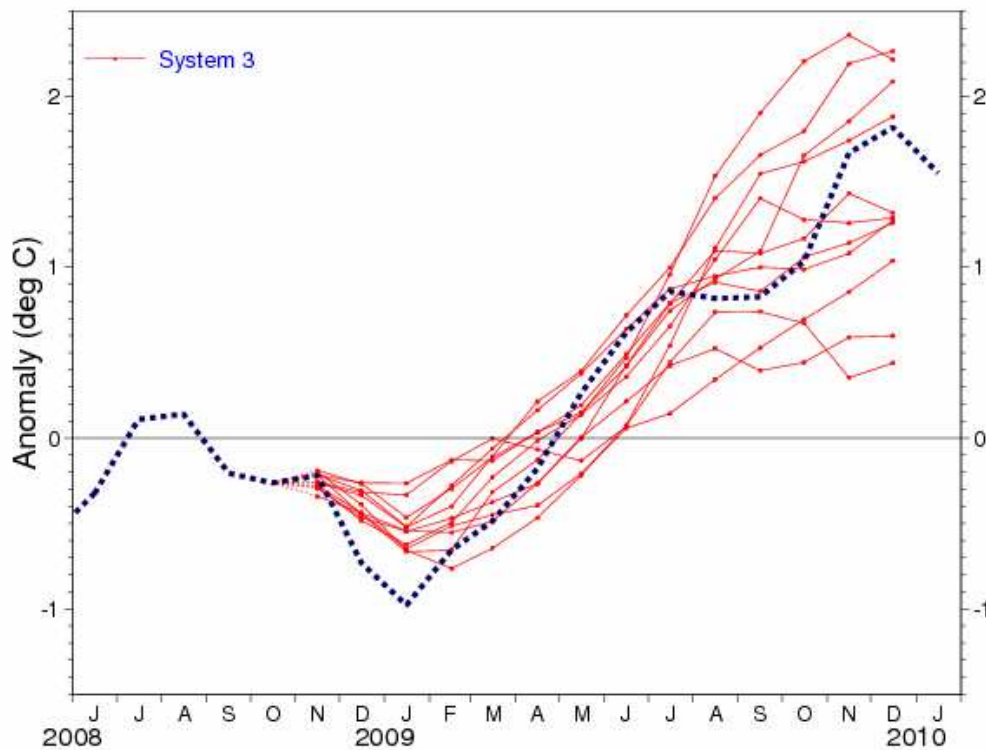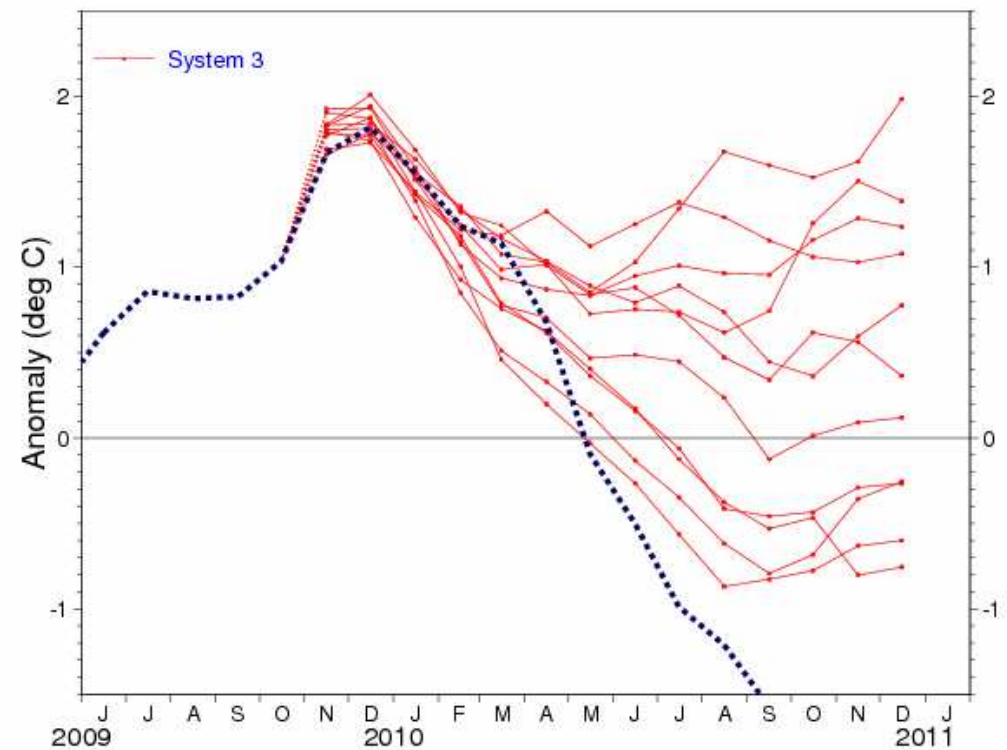
ENSO: Two examples

System 3 annual Niño3.4 sea surface temperature forecasts (red lines) and observations (blue line).
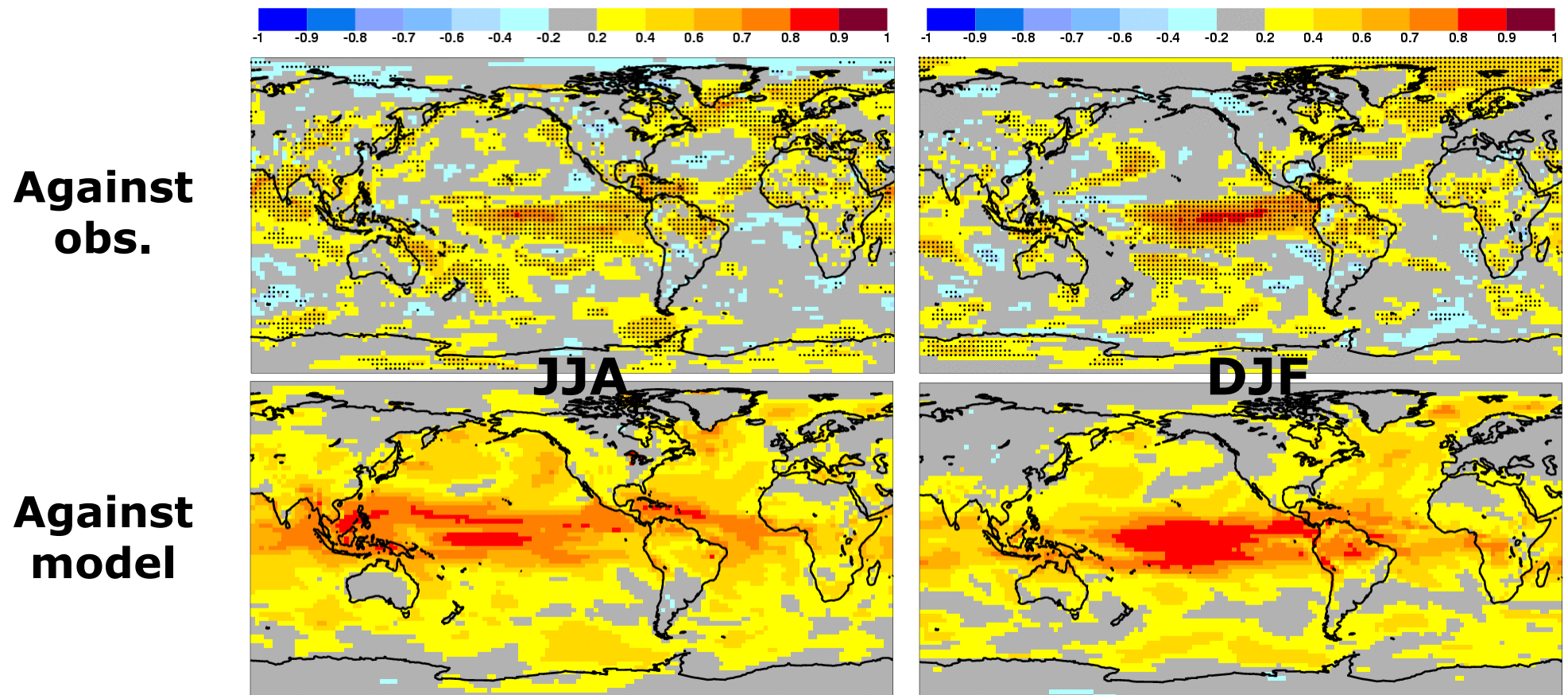
**Nov 2008
start date**

**Nov 2009
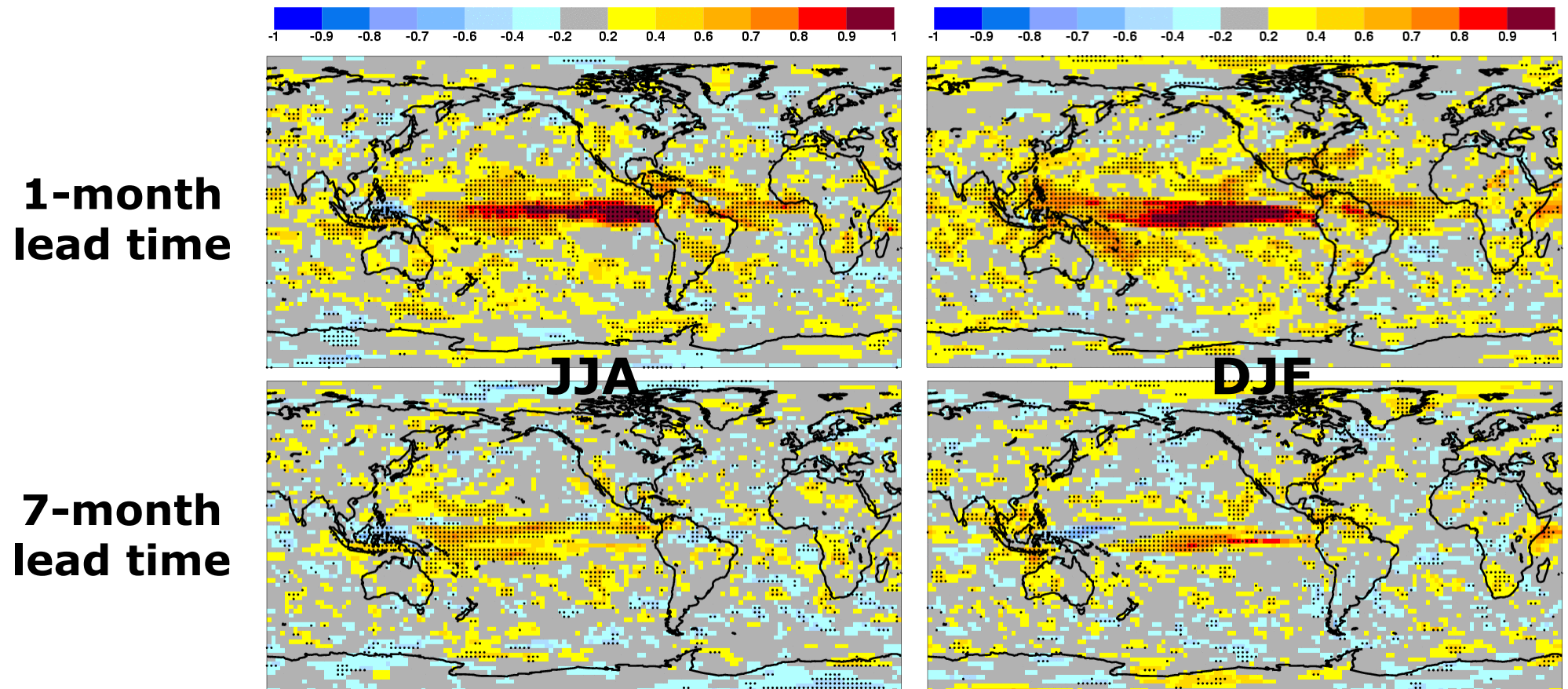start date**

Global skill: theoretical predictability

Ensemble-mean correlation of EC-Earth 8-10 month near-surface air temperature re-forecasts over 1976-2005. Dots for values statistically significant with 95% conf.
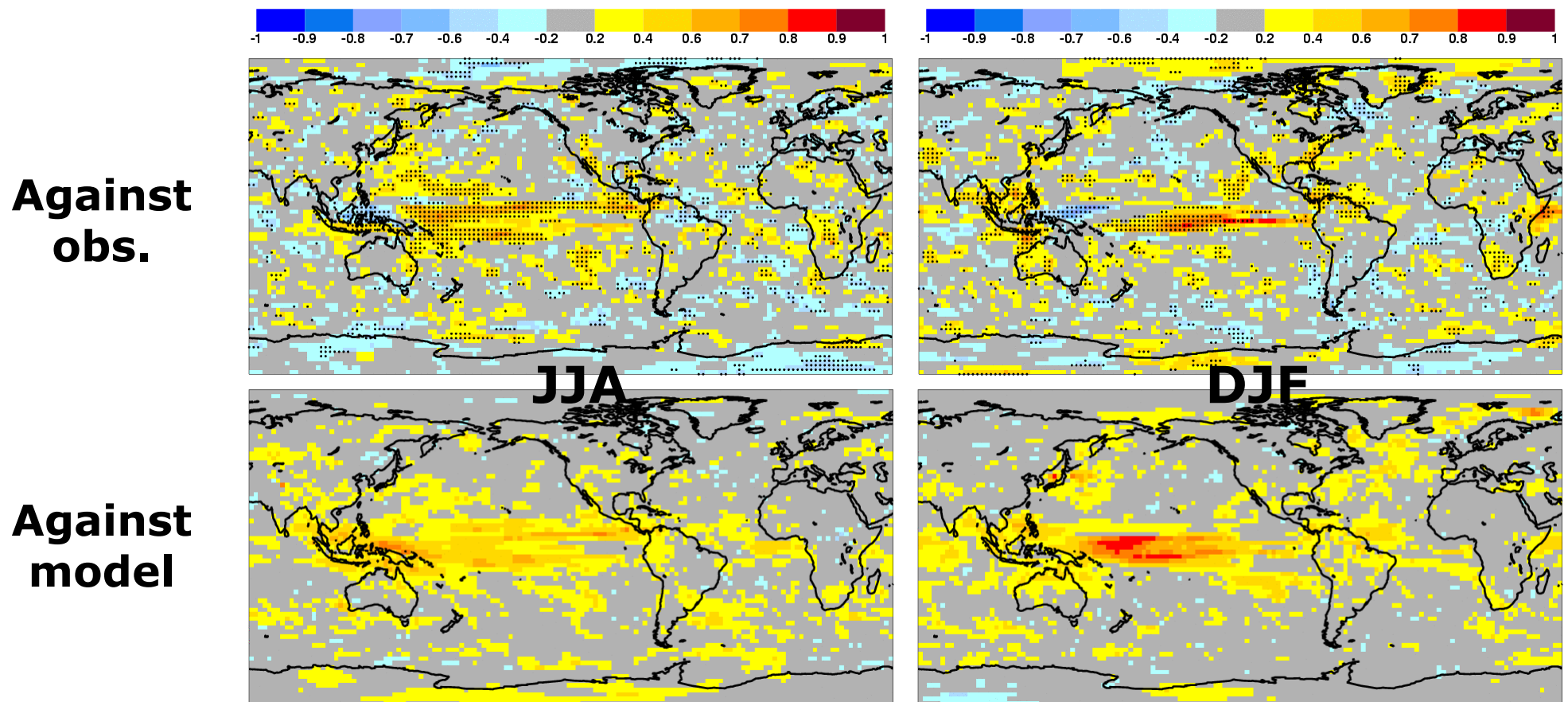
Global skill: lead time effect

Ensemble-mean correlation of EC-Earth precipitation re-forecasts wrt GPCP over 1980-2005. Dots for values statistically significant with 95% conf.
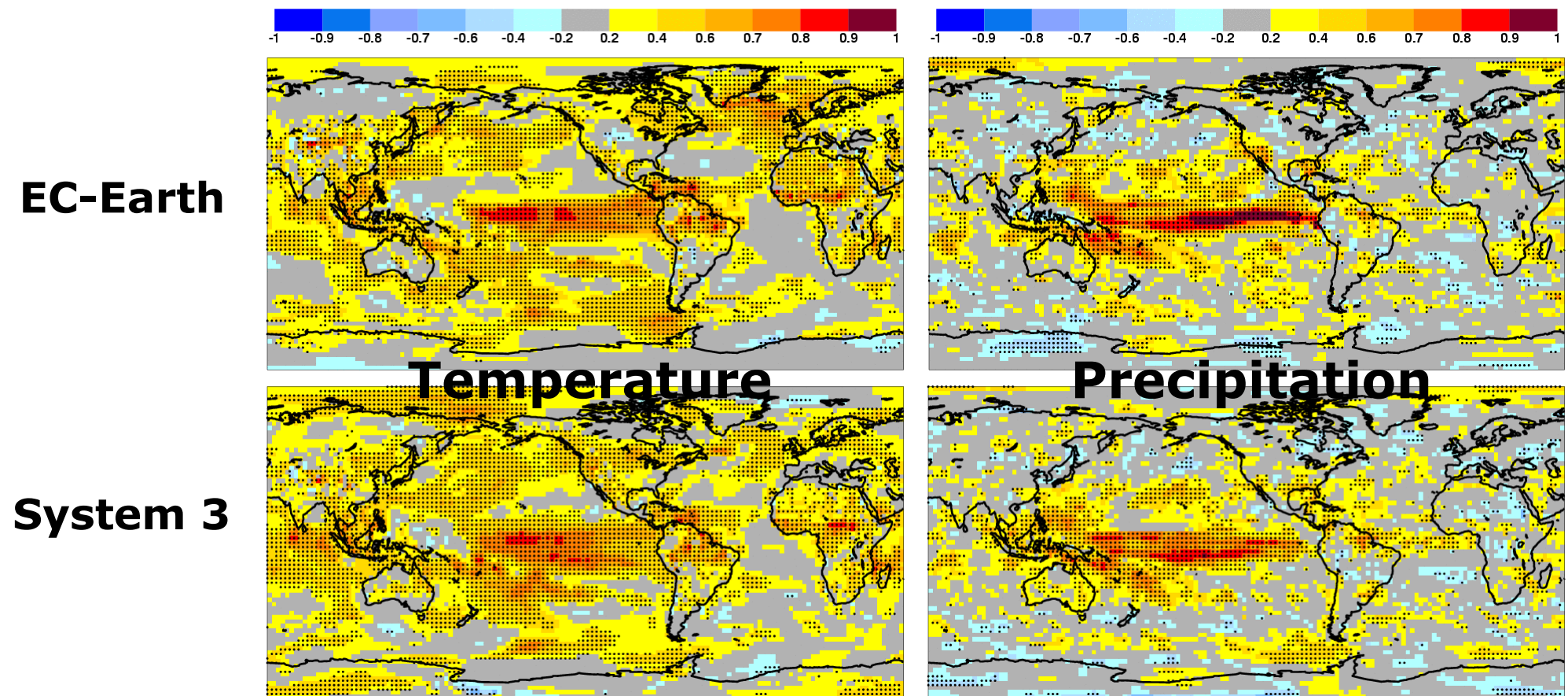
Global skill: theoretical predictability

Ensemble-mean correlation of EC-Earth 8-10 month precipitation re-forecasts over 1980-2005. Dots for values statistically significant with 95% conf.

Global skill: annual predictions

Ensemble-mean correlation of annual averages (months 2-13, Nov start) from re-forecasts (wrt ERA40/Int and GPCP) over 1976-2005. Dots for significant values with 95% conf.

EC-Earth

System 3
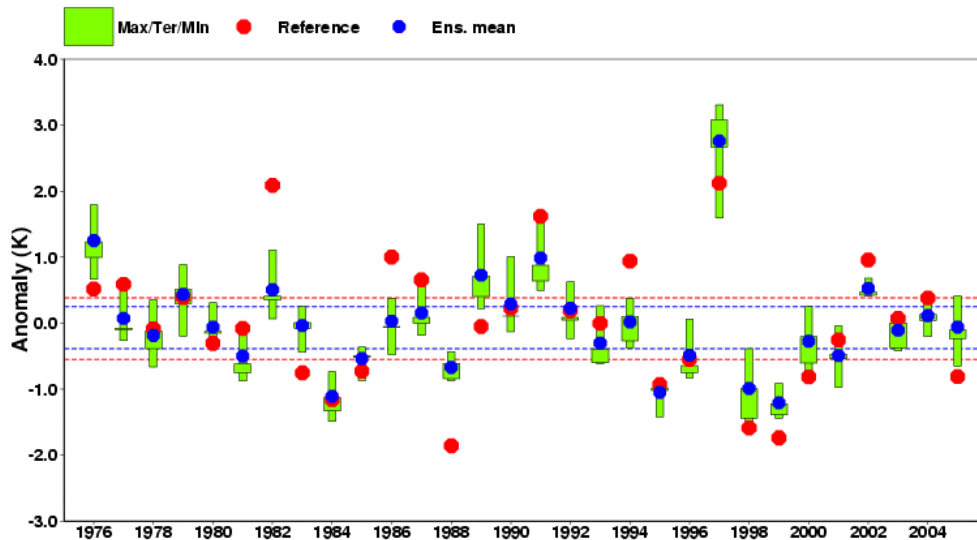
Temperature

Precipitation

ENSO

Niño3.4 time series for ERA40/Int (red dots), five-member ensemble (green box-and-whisker) and ensemble mean (blue dots) 8-10 month (DJF) re-forecasts over 1976-2005.
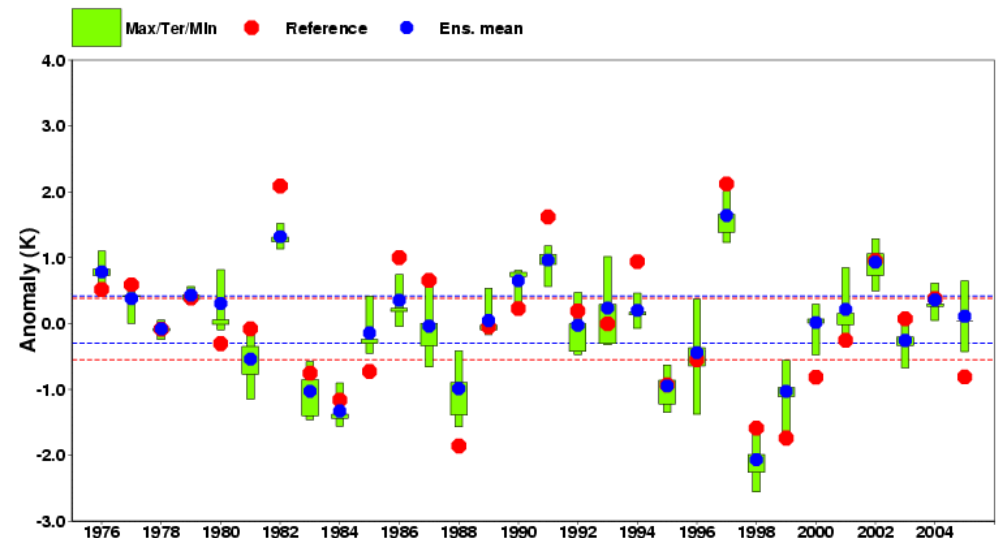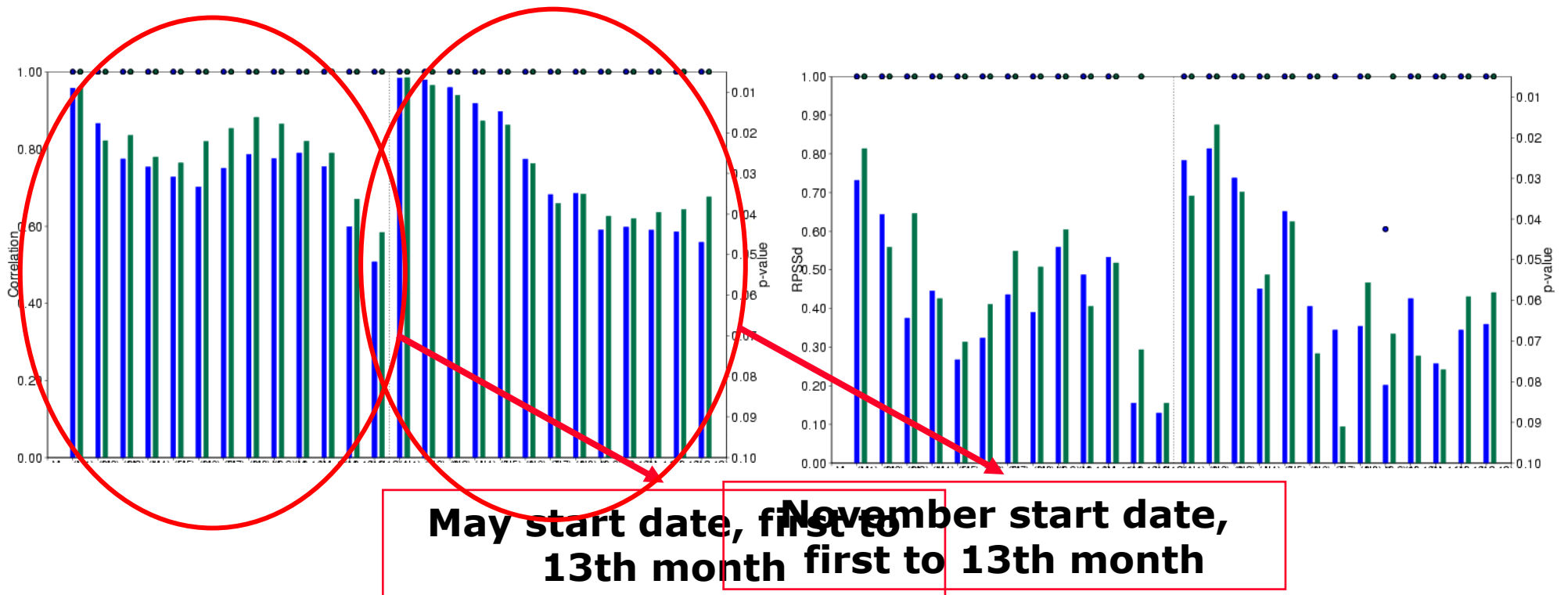
EC-Earth
Ratio sd: 0.83
Corr: 0.80
RPSSd: 0.55

System 3
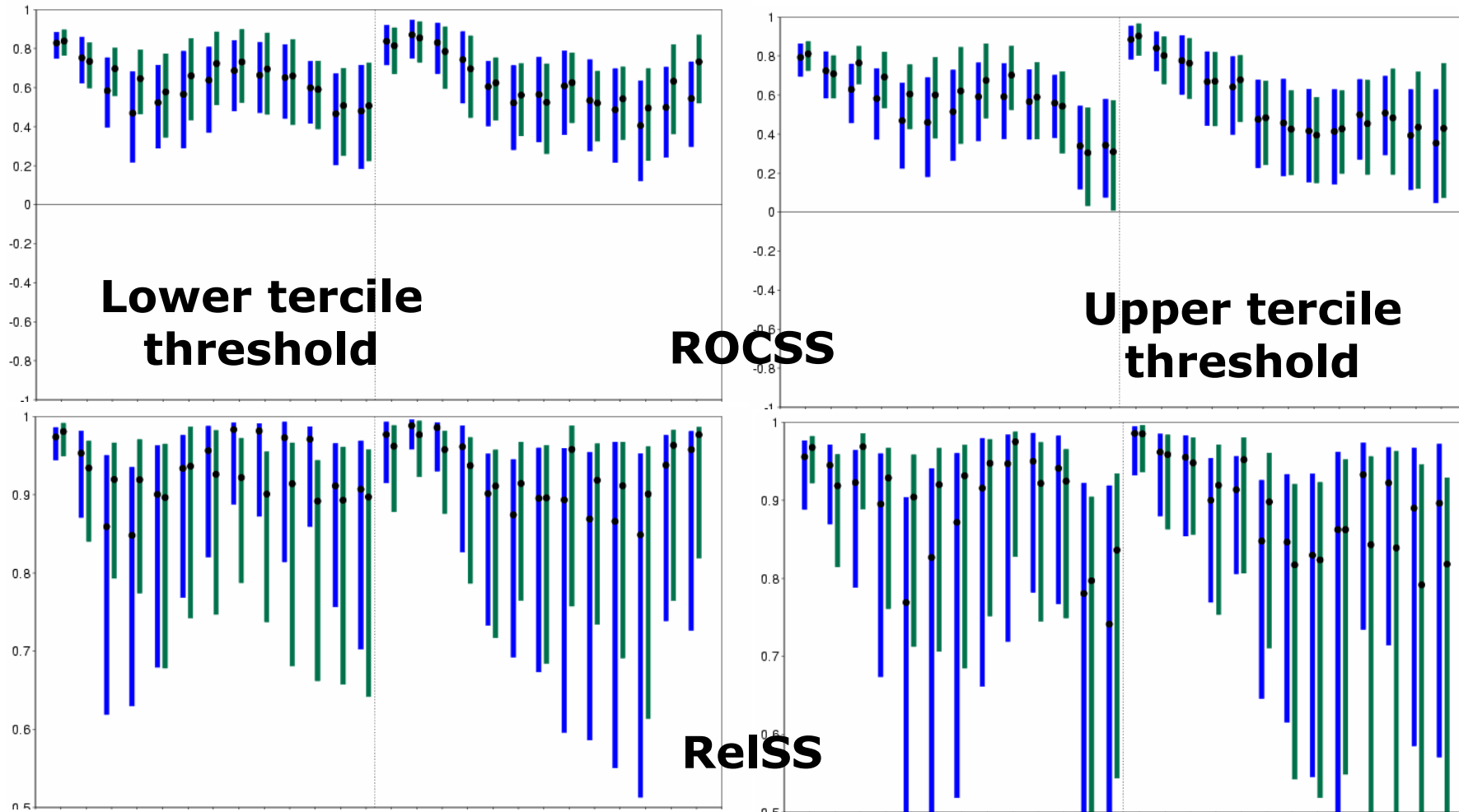Ratio sd: 0.84
Corr: 0.87
RPSSd: 0.56

ENSO

Niño3.4 ensemble-mean correlation (left) and debiased RPSS (right) for EC-Earth and System 3 five-member ensemble re-forecasts with May and November start dates over 1976-2005.
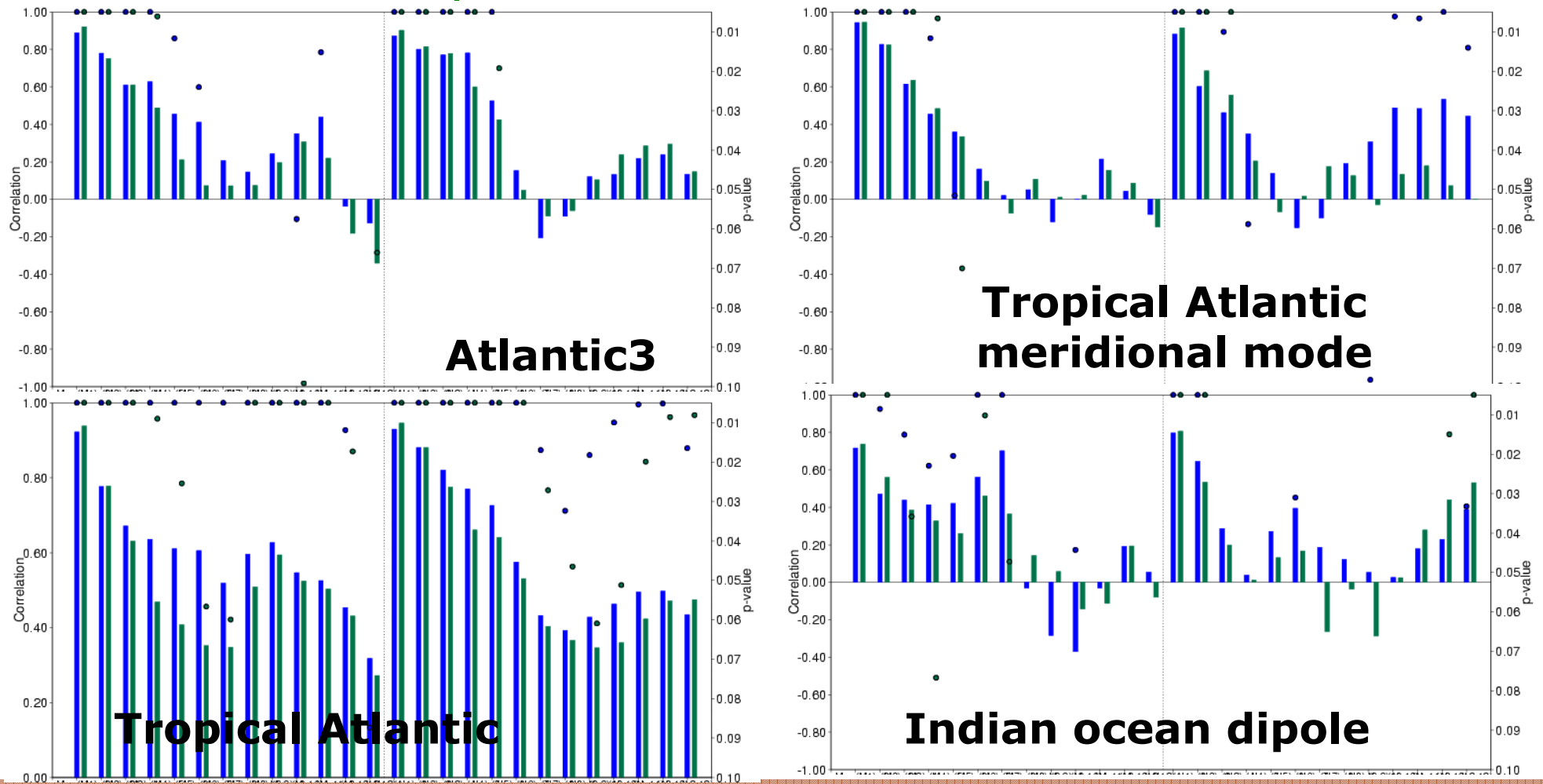

May start date, first to 13th month

November start date, first to 13th month

ENSO

Niño3.4 probabilistic scores (and 95% conf. intervals) for EC-Earth and System 3 ensemble re-forecasts over 1976-2005.

Lower tercile threshold

ROCSS

Upper tercile threshold

ReISS

Other tropical oceans
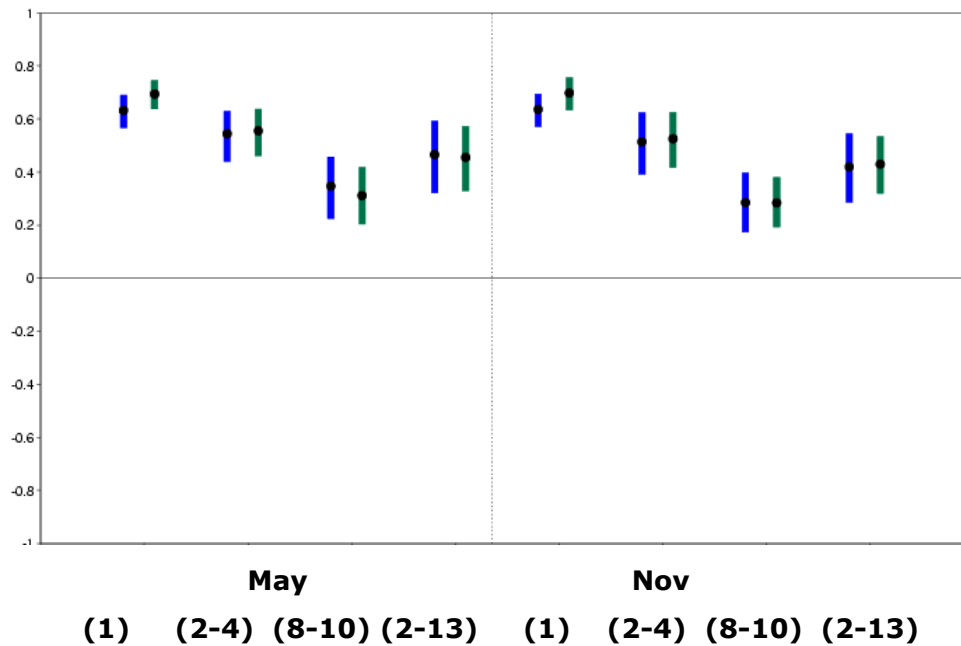
Ensemble-mean correlation of different SST indices for EC-Earth and System 3 re-forecasts over 1976-2005.

Regional skill

Anomaly correlation coefficient (and 95% confidence intervals) for EC-Earth and System 3 five-member ensemble near-surface temperature re-forecasts wrt ERA40/Int over 1976-2005.
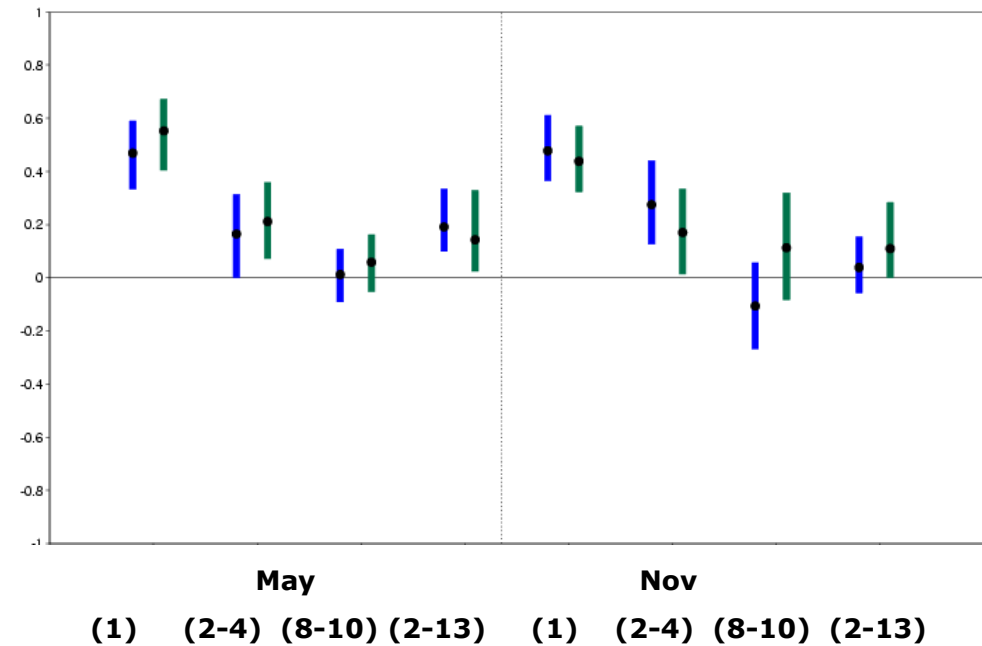
Regional skill

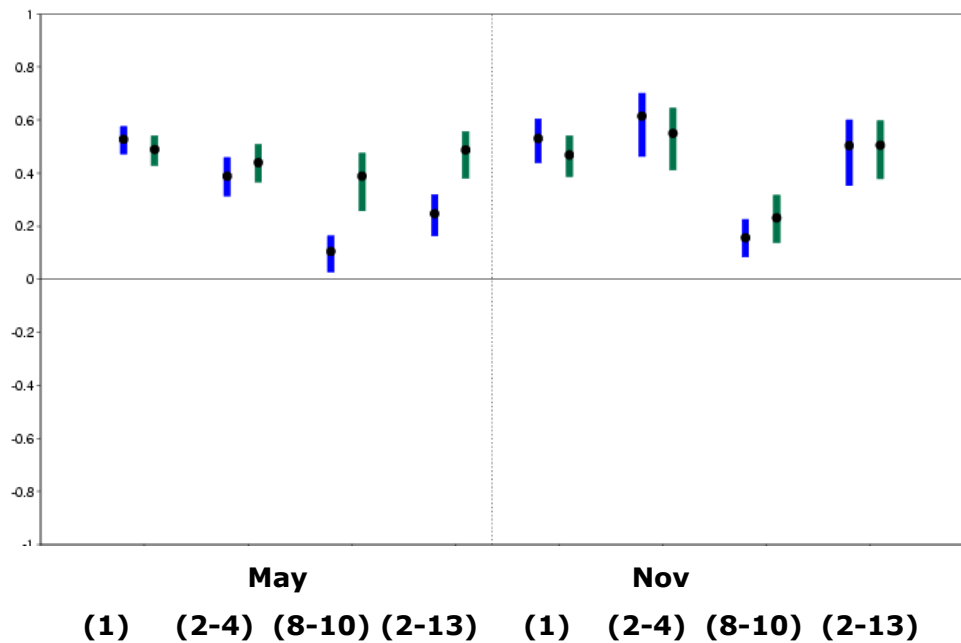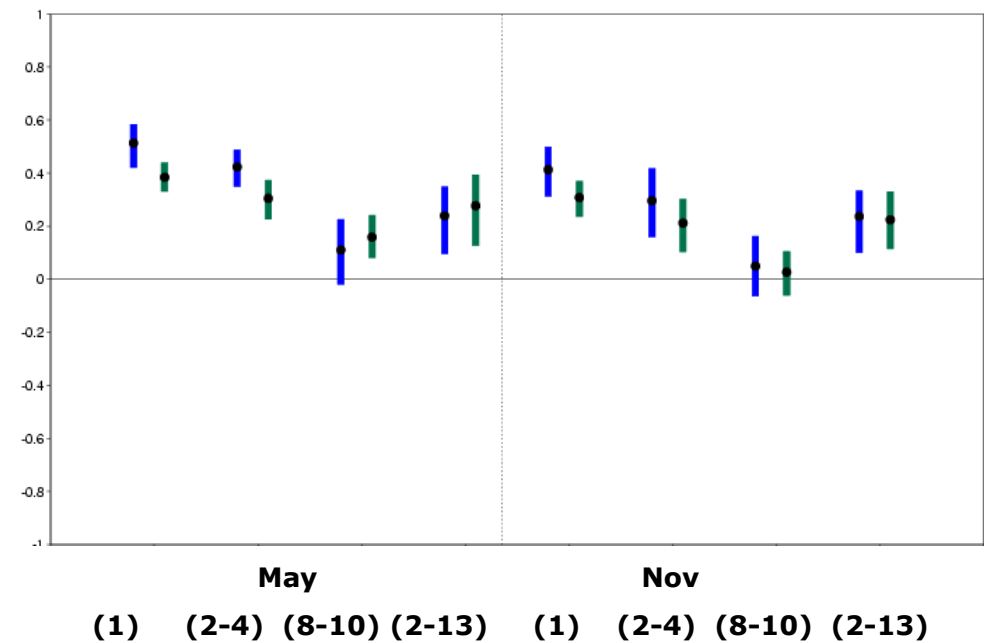Anomaly correlation coefficient (and 95% confidence intervals) for EC-Earth and System 3 five-member ensemble near-surface temperature re-forecasts wrt GPCP over 1980-2005.
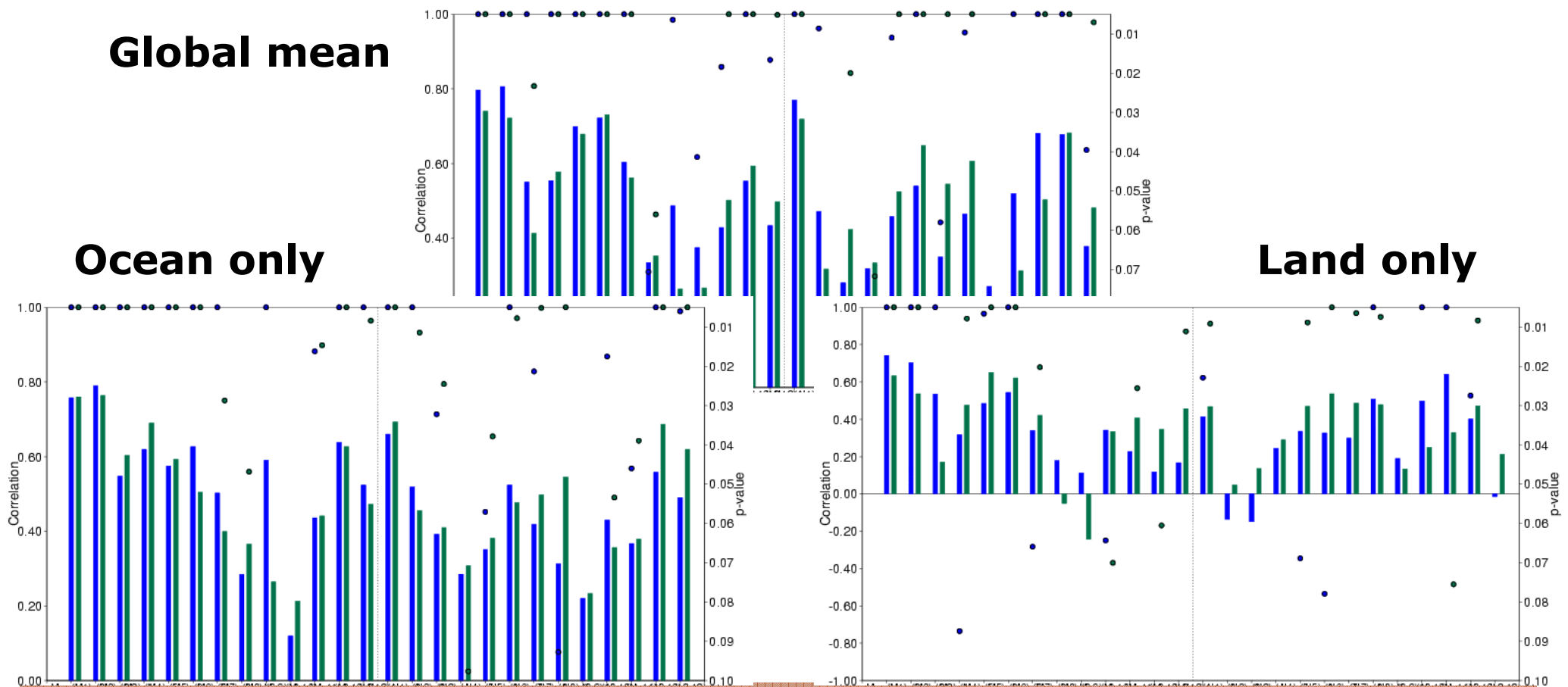

Tropics

Central South America

Global mean

Ensemble-mean correlation for EC-Earth and System 3 five-member ensemble near-surface temperature re-forecasts wrt ERA40/Int over 1980-2005.
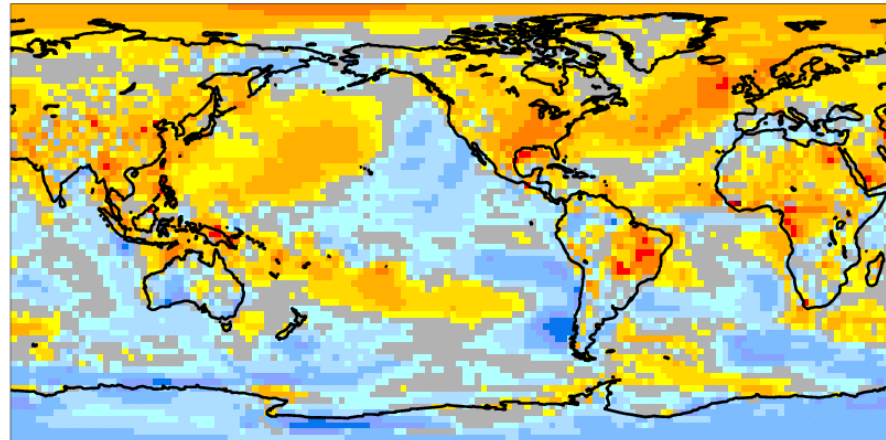
Global mean

Ocean only

Land only

Trends
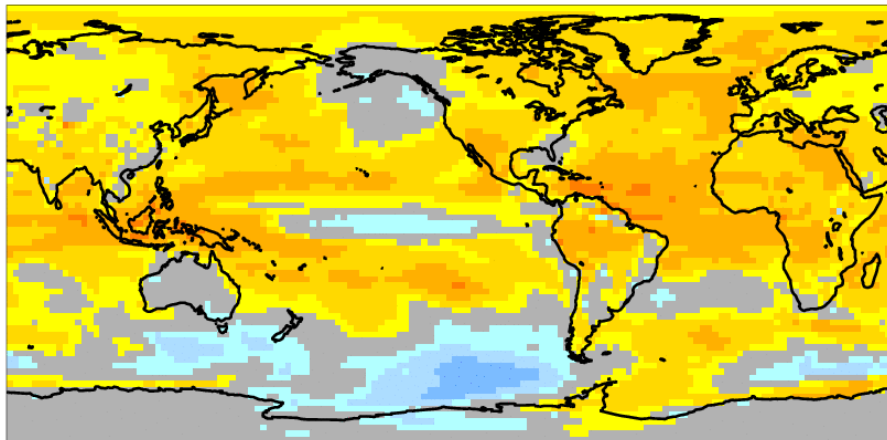
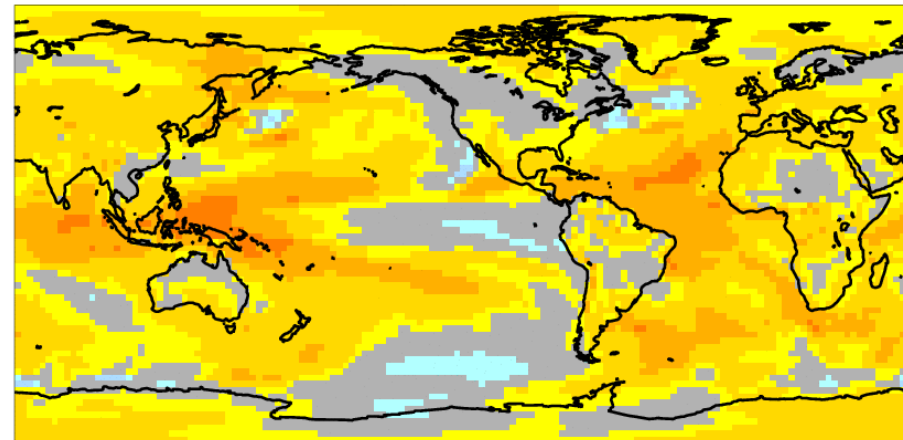Normalized trends of near-surface temperature 8-10 month (DJF) re-forecasts over 1976-2005.

ERA40/Int

EC-Earth

System 3

Summary

- Substantial systematic error, including lack of reliability, is still a fundamental problem in dynamical forecasting and forces *a posteriori* corrections to obtain useful predictions. Forecast calibration such as forecast assimilation is still needed.

- In a preliminary analysis, there is statistically significant skill in ENSO in dynamical models after the first few months beyond simple persistence.

- The annual time scale skill is linked to the good prediction of ENSO and other tropical SST modes, and the reproducibility of global warming.

- Many more processes to be analyzed: sea ice, anthropogenic aerosols, …