Prévision saisonnière et décennale: quelques réflexions sur le présent

F. J. Doblas-Reyes

ICREA & IC3, Barcelona, Spain

avec contributions de I. Andreu, M. Asif, L.-P. Caron (Univ. Stockholm), A. Carrassi, M. Davis, H. Du, J. García-Serrano, V. Guémas, F. Lienert, D. Manubens, O. Mula, A. Pintó, L. Rodrigues, D. Volpi

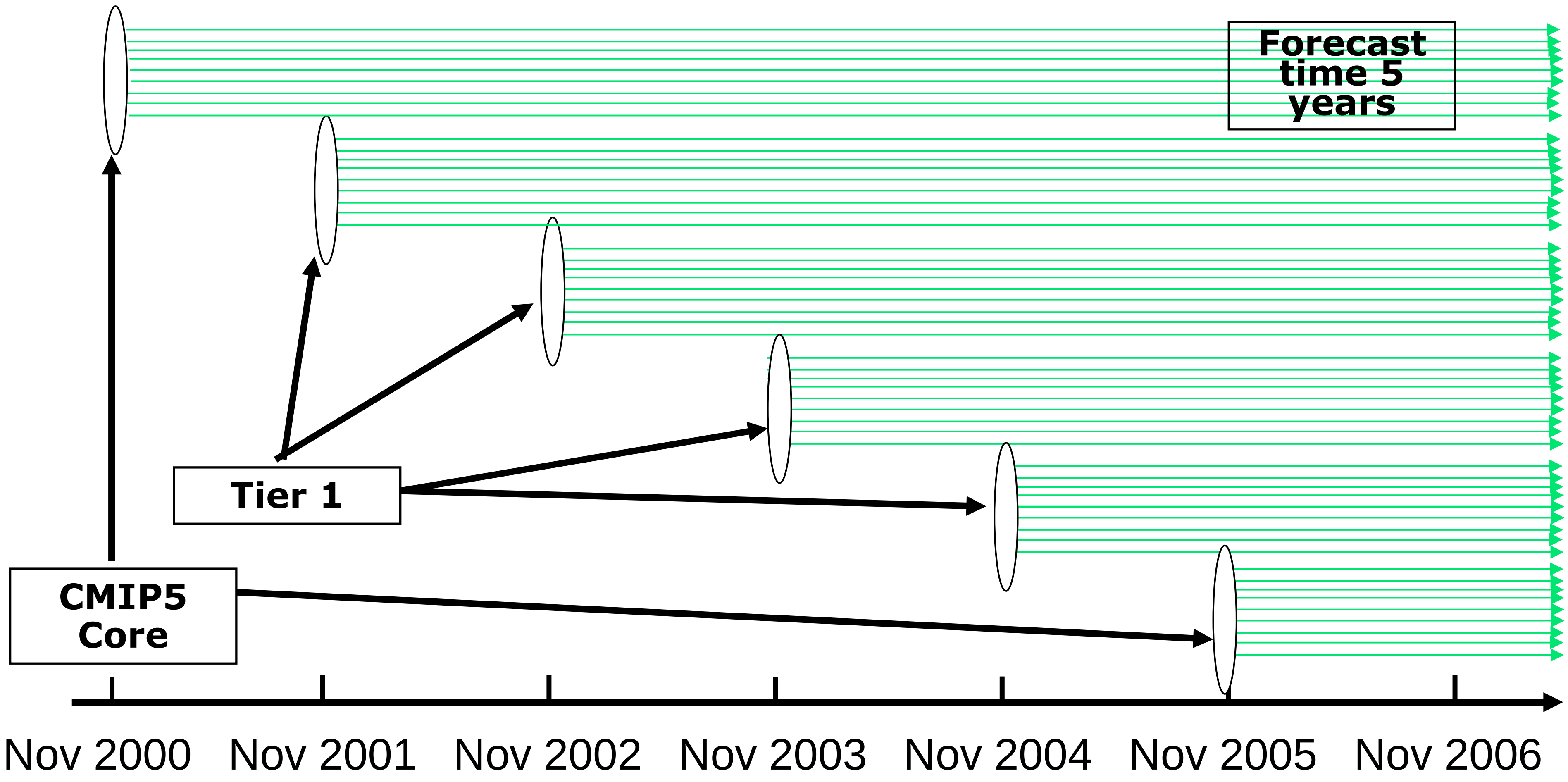
IC3, Barcelona, Spain

Outline

- Seasonal prediction, from the first few months up to the second year
- Forecasting beyond the first year: decadal prediction
- Climate services
- Summary

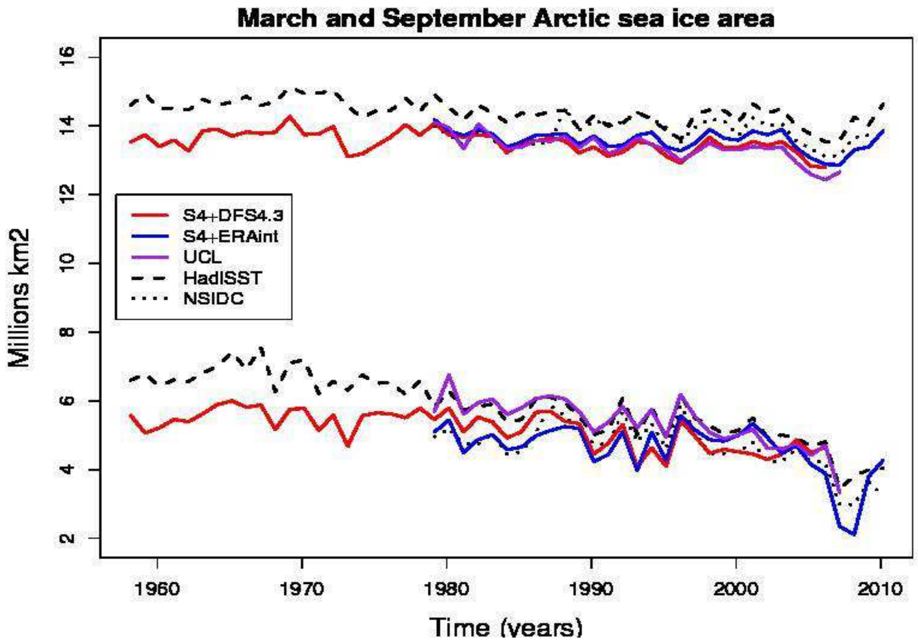
Ensemble initialized climate predictions

Assume an ensemble forecast system with an initialized ESM

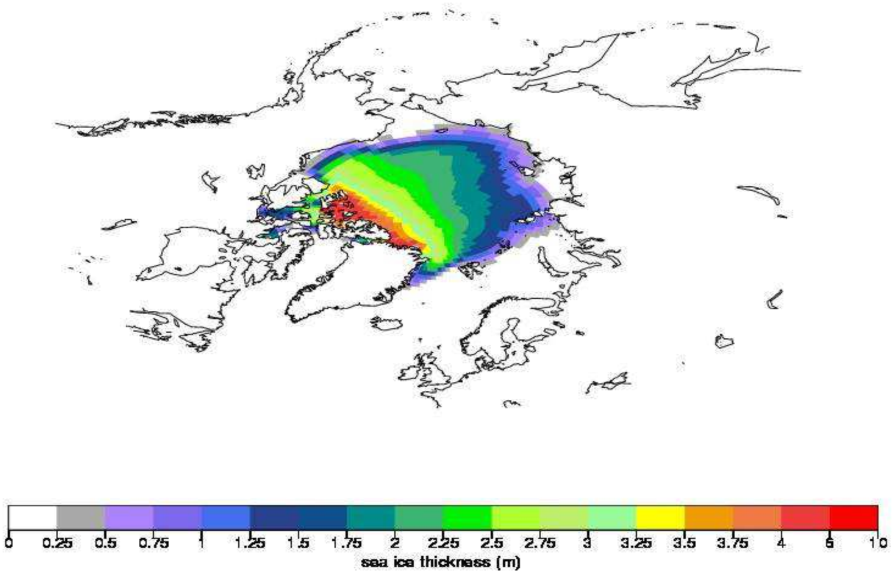


Initial conditions: sea ice

Ocean/sea-ice reanalysis (NEMO3.2 and LIM2 models) forced with DFS4.3 (1958-2006) and ERA Interim (1979-2010) with the ocean nudged toward NEMOVAR-S4. ORCA1 monthly restarts available upon request.



September sea ice thickness (m)



Seasonal forecasts

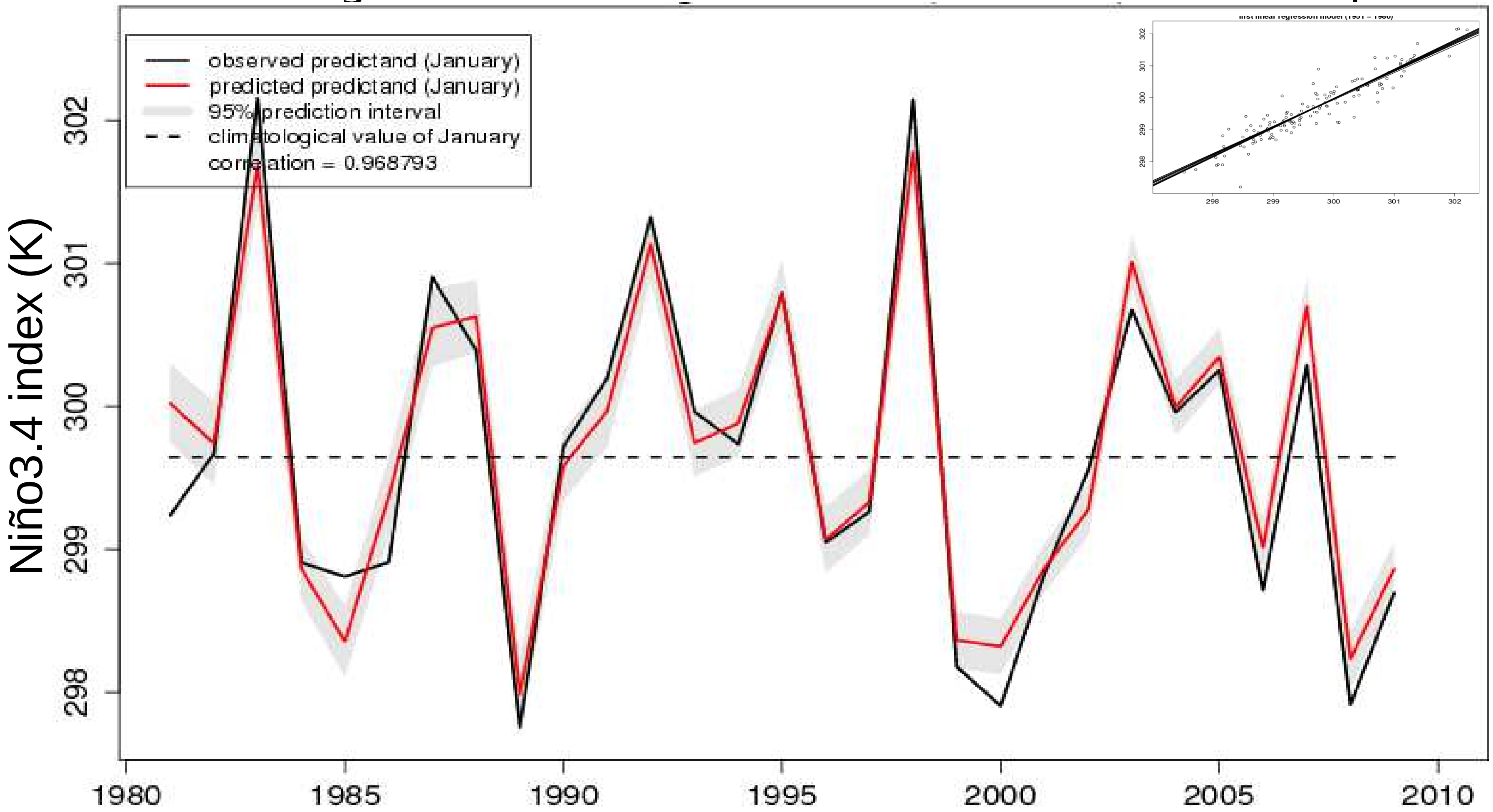
- **ECMWF System 3**
  - Seven forecast months, 11-member ensemble hindcasts with a coupled ocean-atmosphere-land system
  - Atmospheric resolution:T159L62
  - Ocean resolution: zonal of 1.4º and a meridional of 0.3º (within 10º of the equator), to 1.4º polewards of 30º, 29 vertical levels

- **NCEP CFSv2**
  - Nine forecast months, 24-member (Nov 29) ensemble hindcasts with a coupled ocean-atmosphere-land system
  - Atmospheric resolution: T126L64
  - Ocean resolution: horizontal resolution of 0.25º (tropics) to 0.5º northwards and southwards of 10ºN (ºS), 42 vertical levels

- **Statistical forecasts**
  - Based on persistence, lagged regression in forecast mode

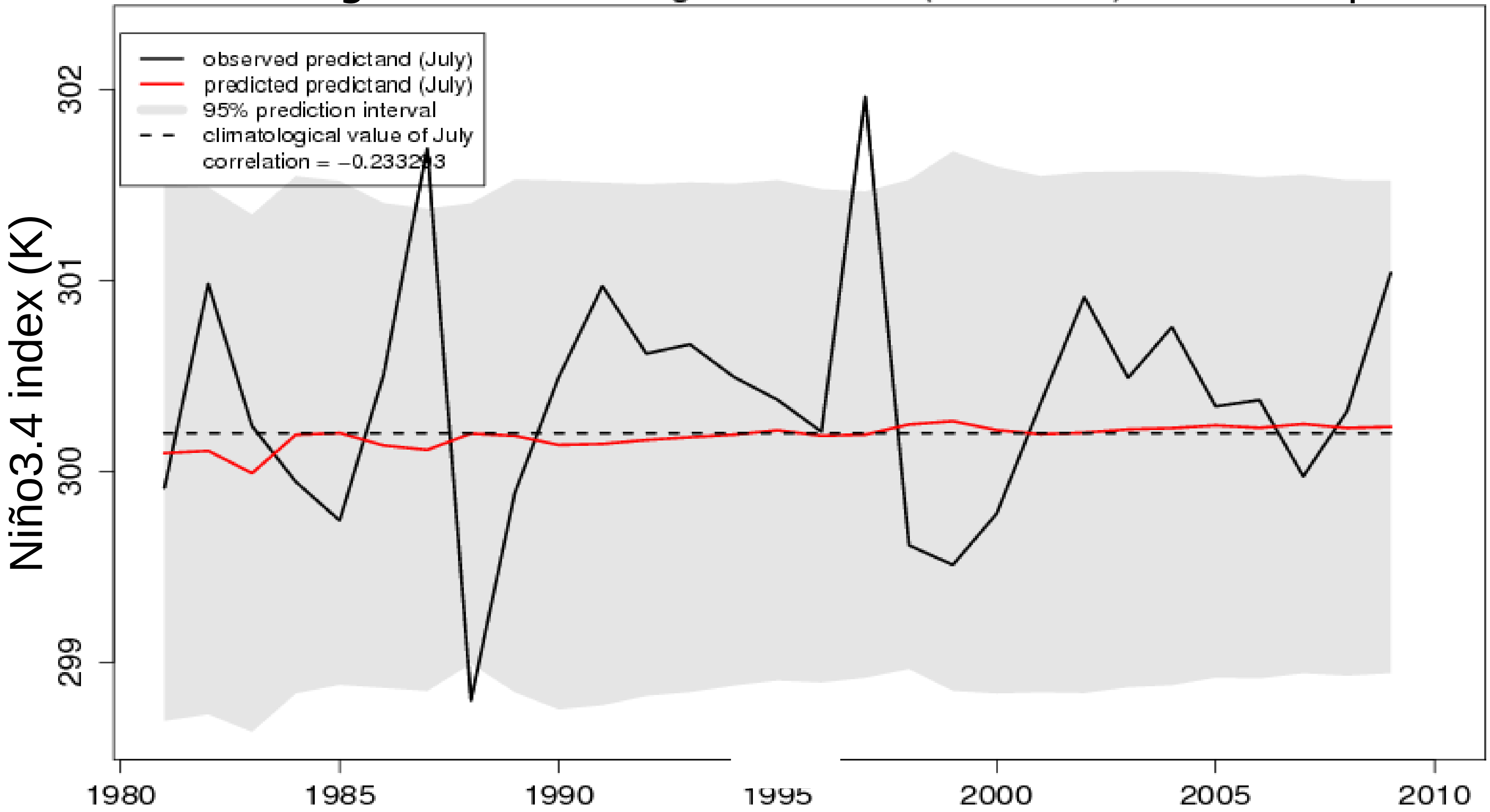
Seasonal empirical forecasts

HadISST Niño3.4 index (5ºS-5ºN, 170ºW-120ºW) in forecast mode.
December predicting January over the period 1981-2009
First linear regression model uses data for the 1951-1980 period.

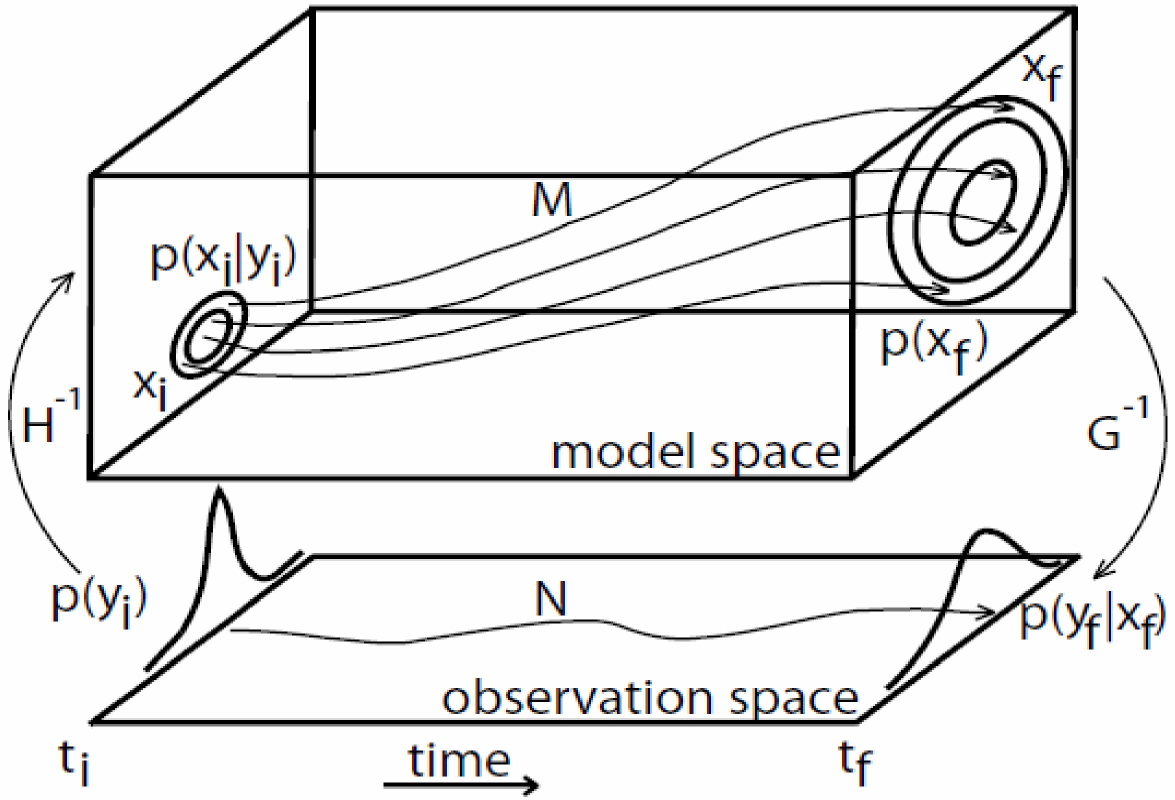


Seasonal empirical forecasts

HadISST Niño3.4 index (5ºS-5ºN, 170ºW-120ºW) in forecast mode.
December predicting July over the period 1981-2009
First linear regression model uses data for the 1951-1980 period.



Calibration and combination

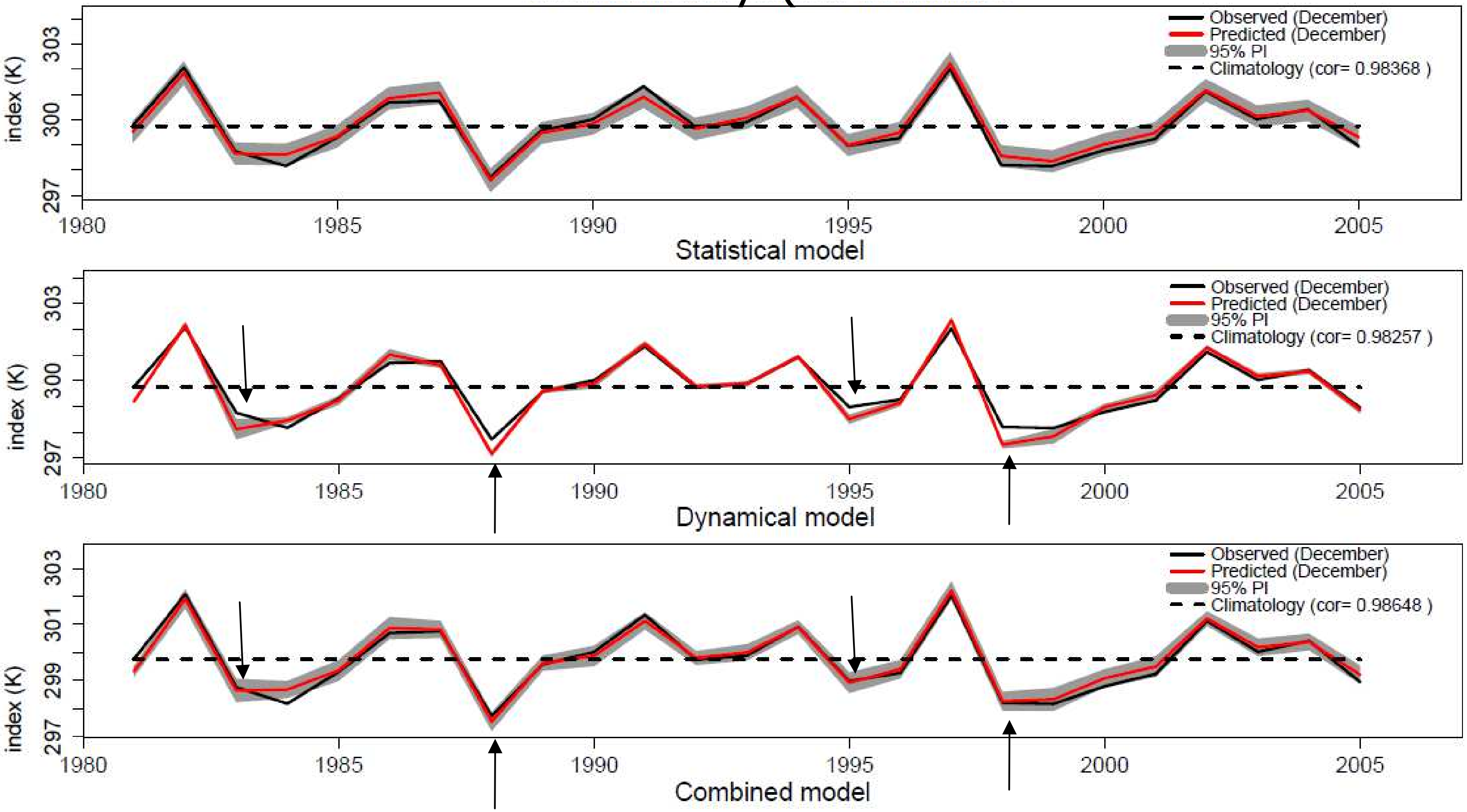


Forecast assimilation (Stephenson et al., 2005): y for observations and x for model output.

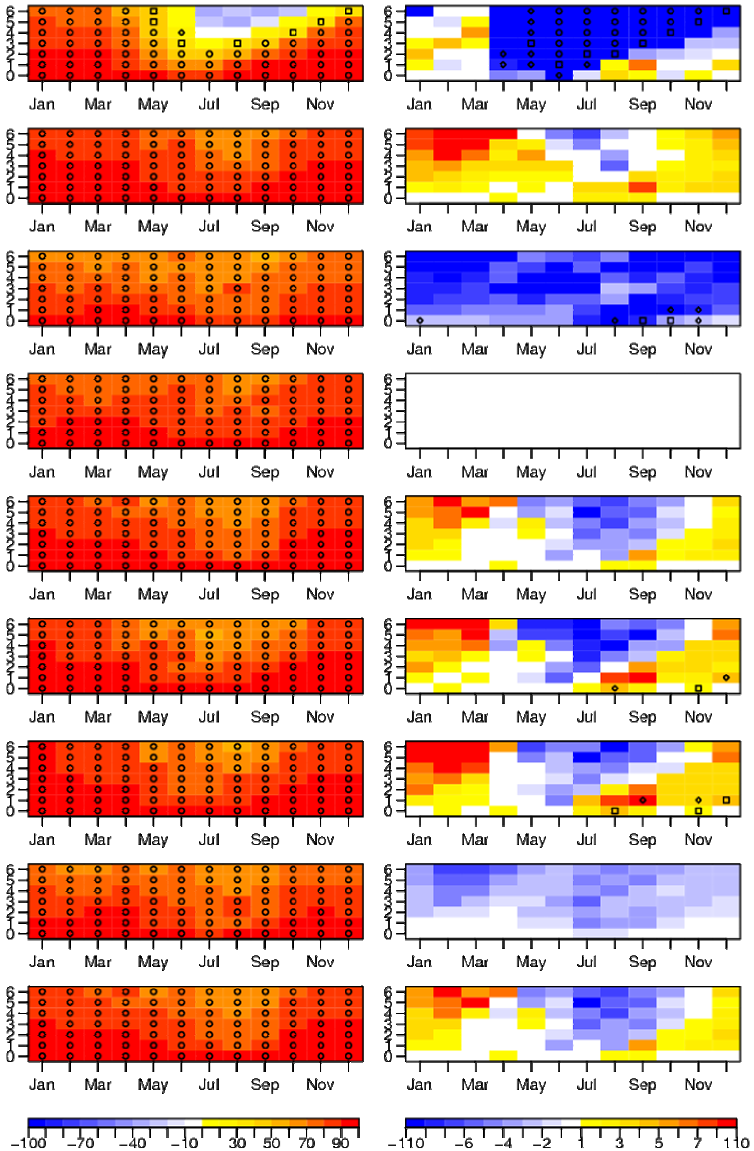
Calibration and combination

Seasonal forecasts of December Niño3.4 ERSST (five-month lead) with a persistence-based statistical model, the ECMWF System 3 forecast system (dynamical) and the combination of the two.

Improvement in forecast uncertainty (events marked with the arrows).

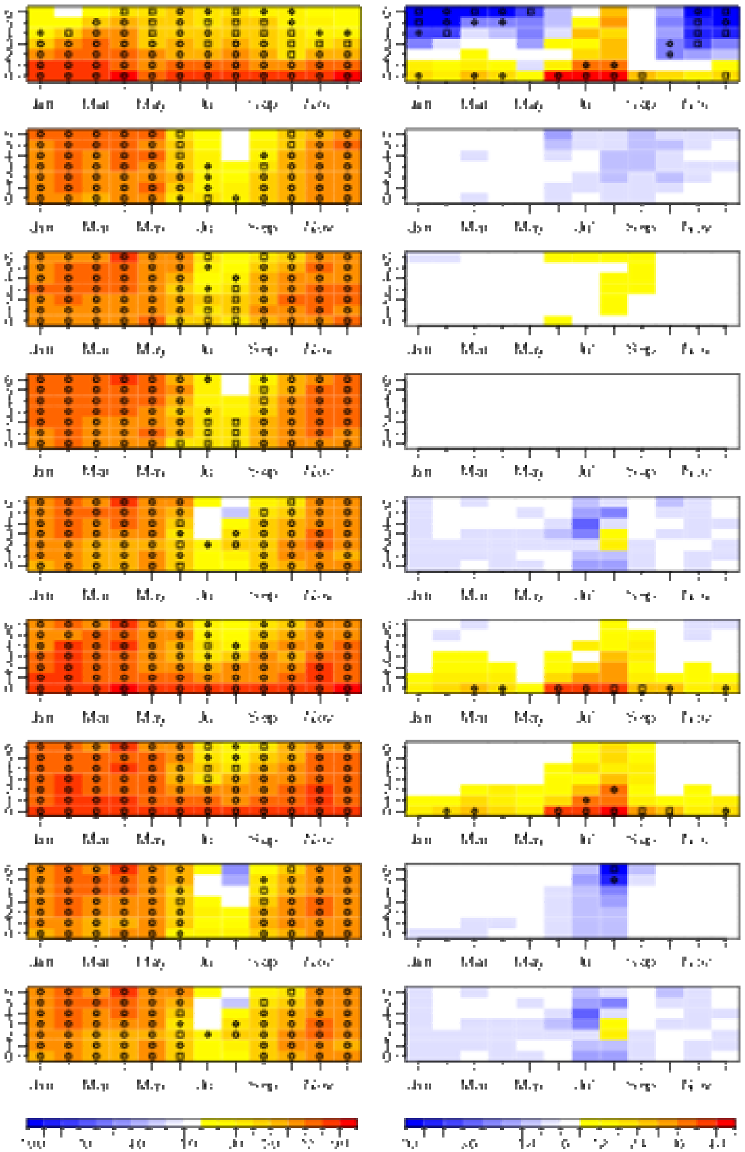


Calibration and combination



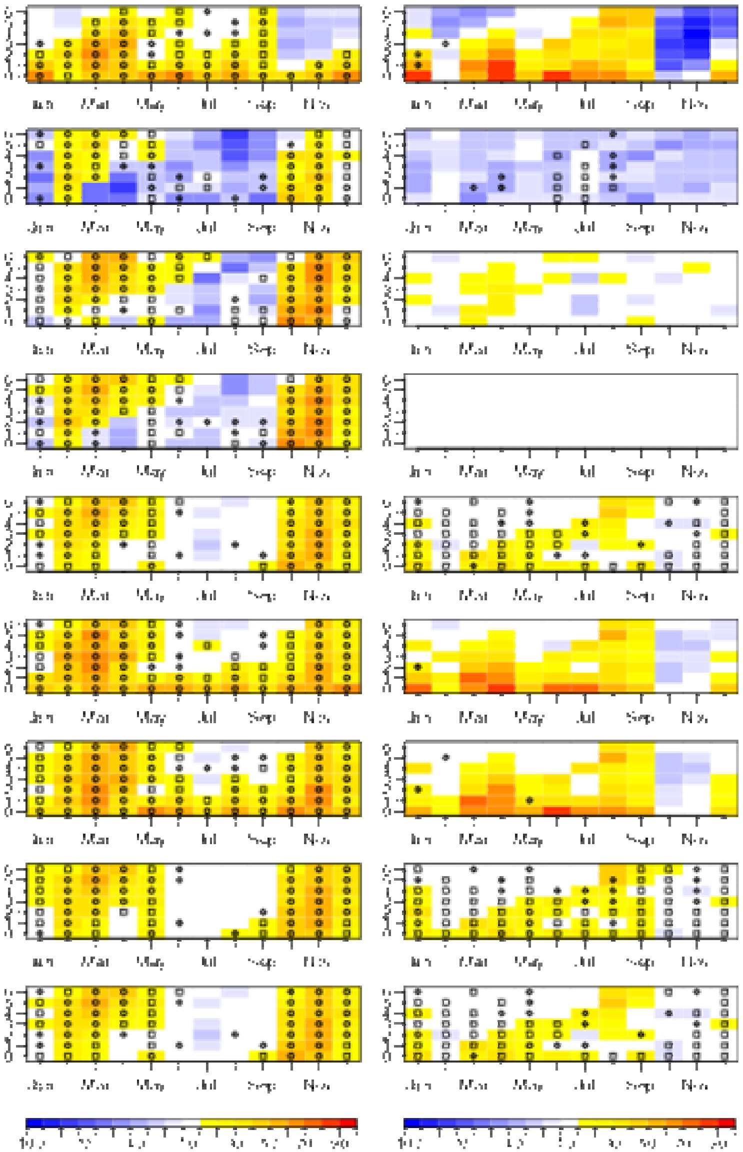
(Left column) Correlation as a function of target month (horizontal) and lead time (vertical) for seasonal predictions of the Niño3.4 index (5ºS-5ºN, 170ºW-120ºW) for (from top to bottom) the statistical model, System 3, CFSv2, the simple multi-model (equal weighting), multiple linear regression (with two dynamical systems), forecast assimilation with climatology as a prior, forecast assimilation with the statistical model as a prior, regression on the first principal component and multiple linear regression using principal components. Hindcasts verified over the period 1981-2009. (Right column) Difference in correlation between each system and the simple multi-model.

Calibration and combination



(Left column) Correlation as a function of target month (horizontal) and lead time (vertical) for seasonal predictions of the western tropical Indian ocean index (10ºS-10ºN, 50ºE-70ºE) for (from top to bottom) the statistical model, System 3, CFSv2, the simple multi-model (equal weighting), multiple linear regression (with two dynamical systems), forecast assimilation with climatology as a prior, forecast assimilation with the statistical model as a prior, regression on the first principal component and multiple linear regression using principal components. Hindcasts verified over the period 1981-2009. (Right column) Difference in correlation between each system and the simple multi-model.

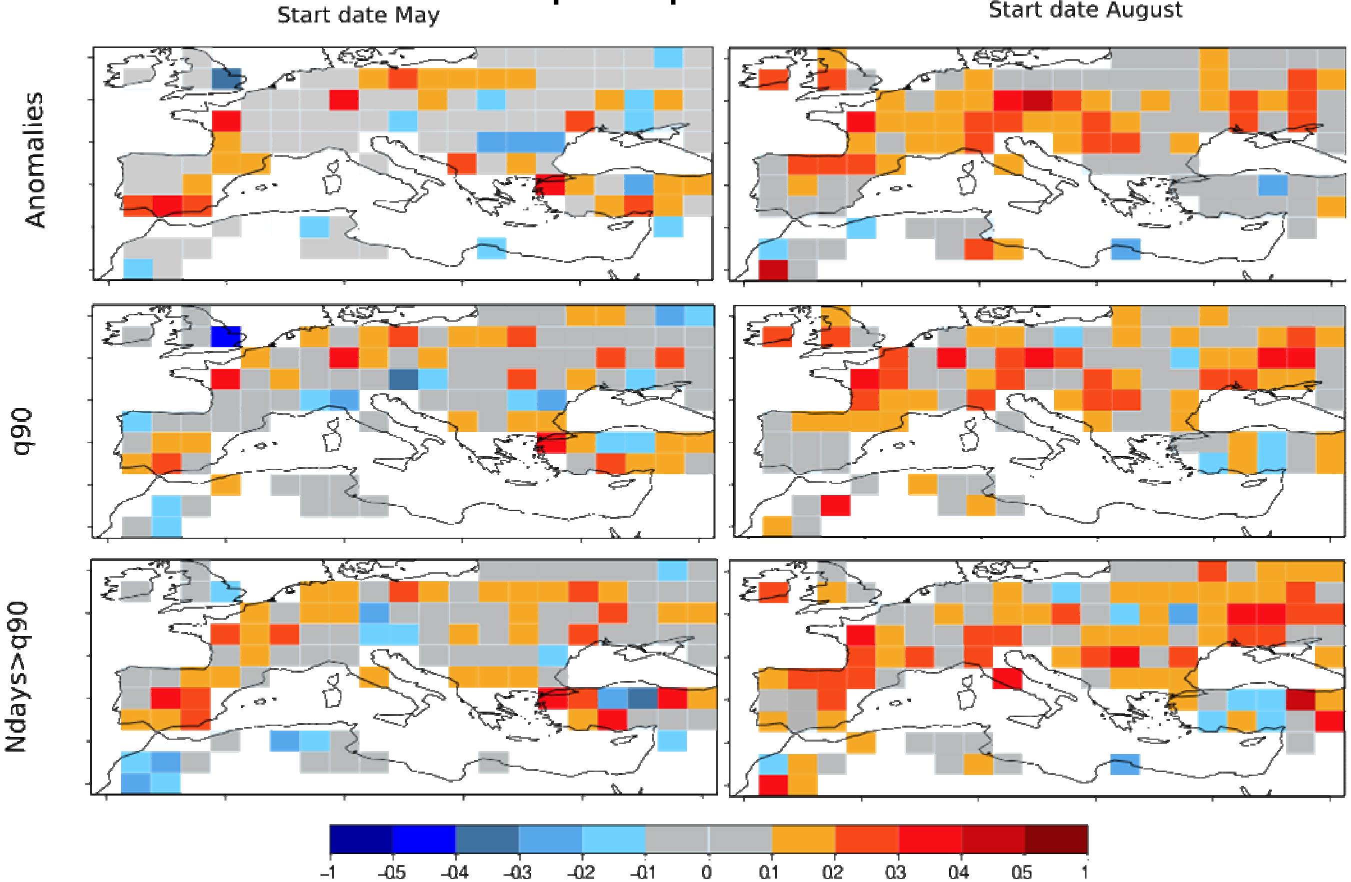
Calibration and combination



(Left column) Brier skill score as a function of target month (horizontal) and lead time (vertical) for seasonal predictions of the western tropical Indian ocean index (10ºS-10ºN, 50ºE-70ºE) being above the upper tercile for (from top to bottom) the statistical model, System 3, CFSv2, the simple multi-model (equal weighting), multiple linear regression (with two dynamical systems), forecast assimilation with climatology as a prior, forecast assimilation with the statistical model as a prior, regression on the first principal component and multiple linear regression using principal components. Hindcasts verified over the period 1981-2009. (Right column) Difference in BSS between each system and the simple multi-model.

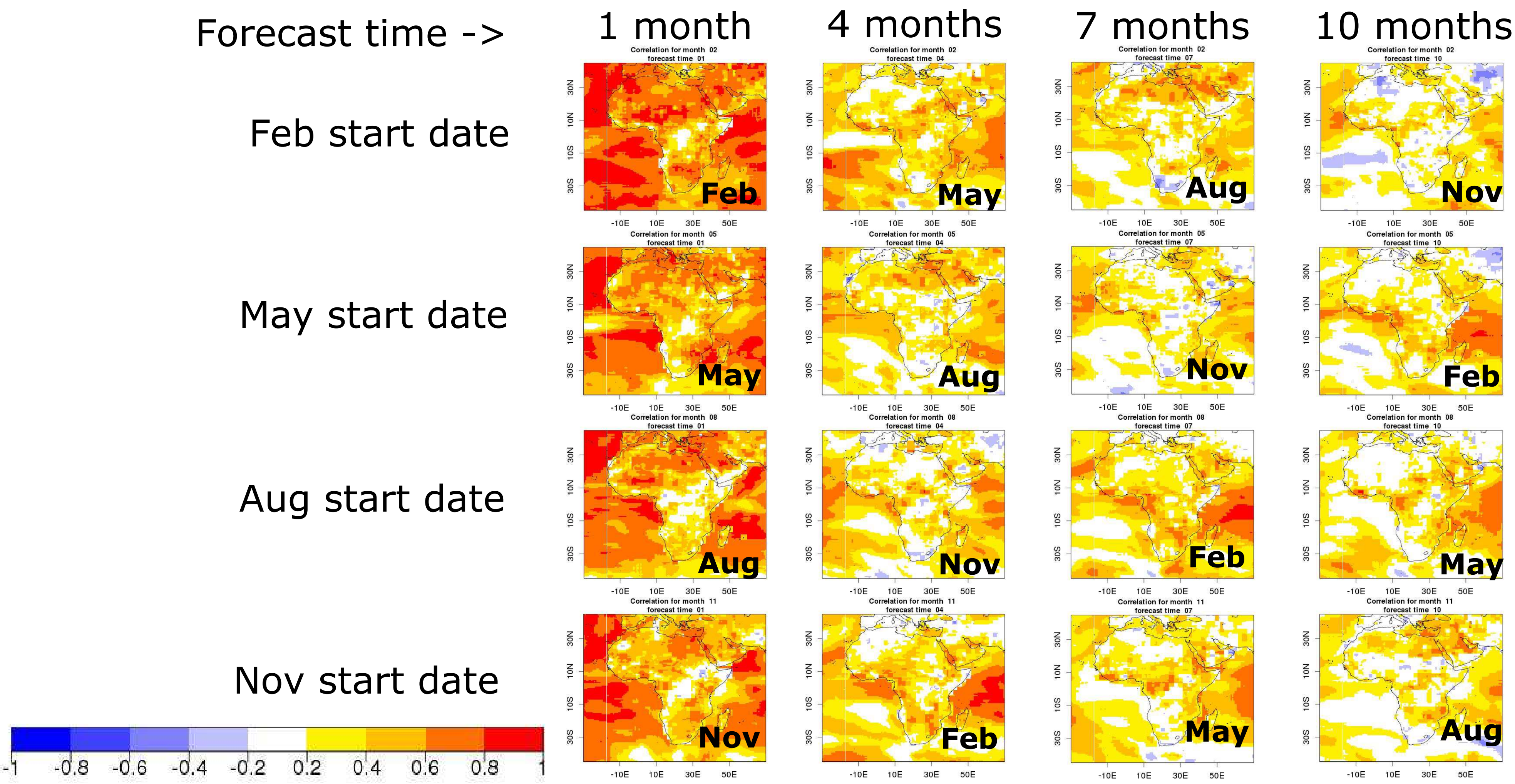
Seasonal prediction: extremes

Ensemble-mean correlation of August (top row) monthly-mean precipitation anomalies, (middle row) 90th monthly percentile and (bottom row) number of days with precipitation above the 90th climatological percentile from DePreSys_PP hindcasts initialized in May (left) and August (right). Hindcasts over 1960-2005, nine members. Reference precipitation from the EObs dataset.



Seasonal forecasts: up to one year

Ensemble-mean correlation of near-surface air temperature for ECMWF System 4 over 1981-2010. GHCN and ERSST are used for reference..



Seasonal forecasts: up to one year

Ensemble-mean correlation of precipitation for ECMWF System 4 over 1981-2010. GPCP is used for reference..

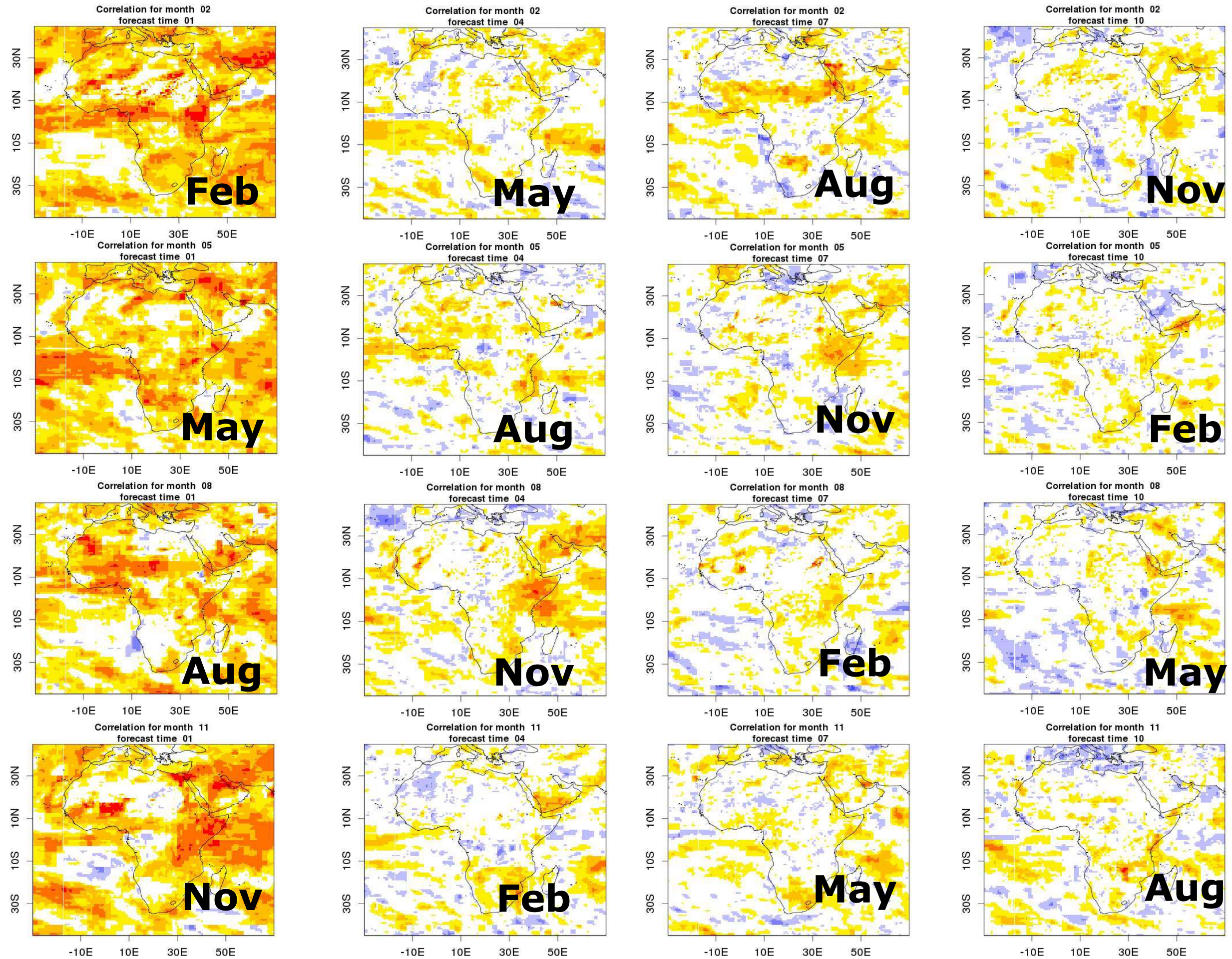
Forecast time -> 1 month | 4 months | 7 months | 10 months

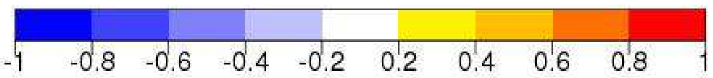
Feb start date

May start date

Aug start date

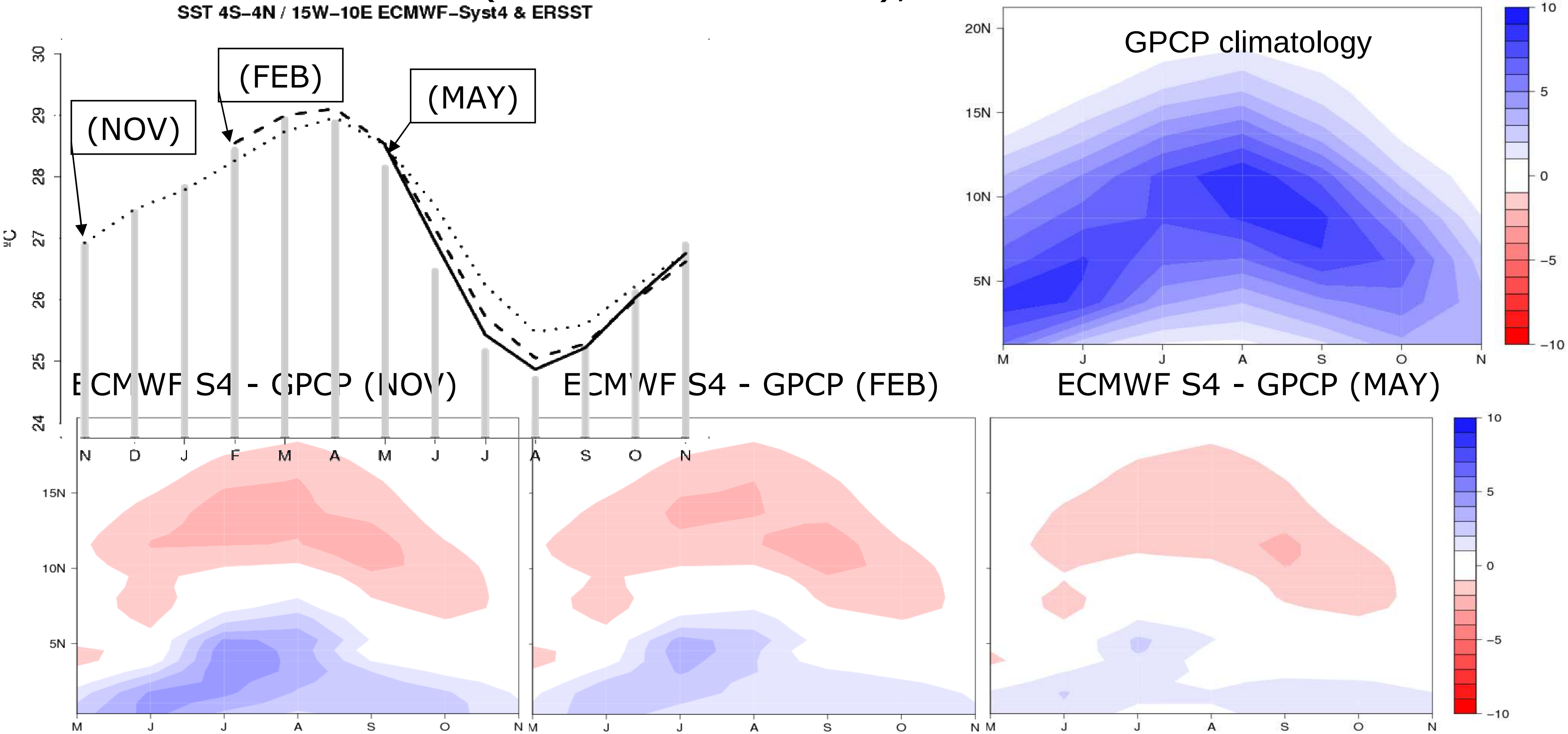
Nov start date





Seasonal forecasts: WAM

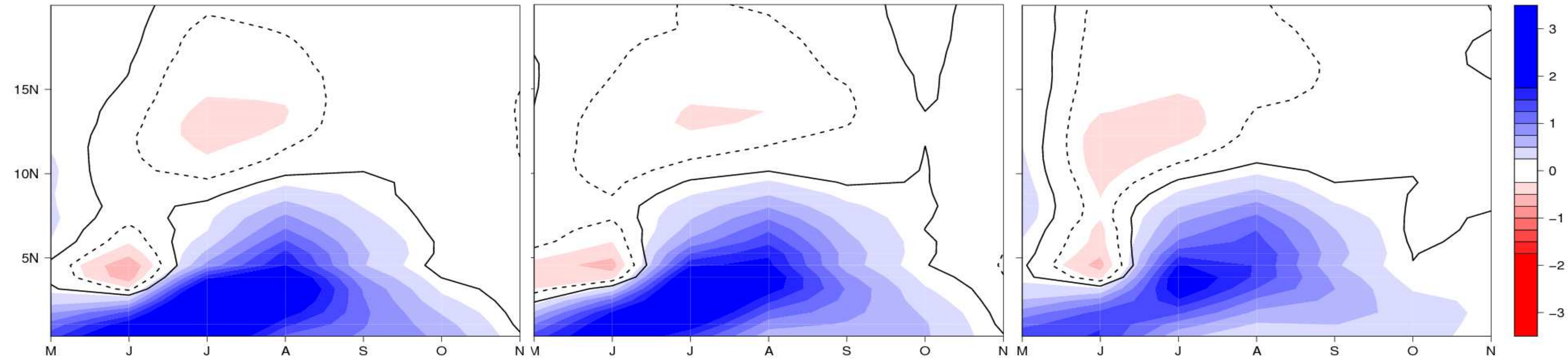
Averaged precipitation over 10ºW-10ºE for the period 1982-2008 for GPCP (climatology) and ECMWF System 4 (systematic error) with start dates of November (6-month lead time), February (3) and May (0).

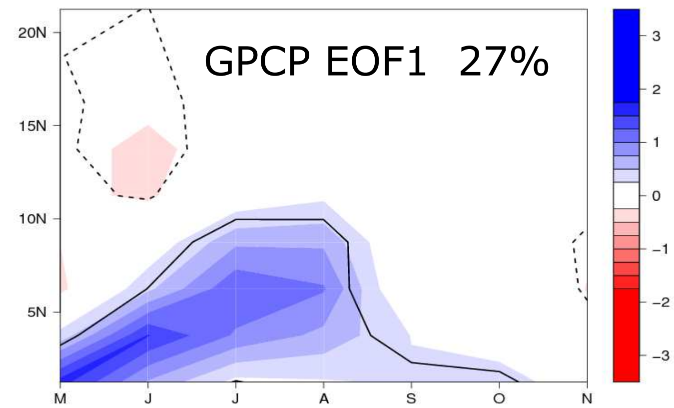


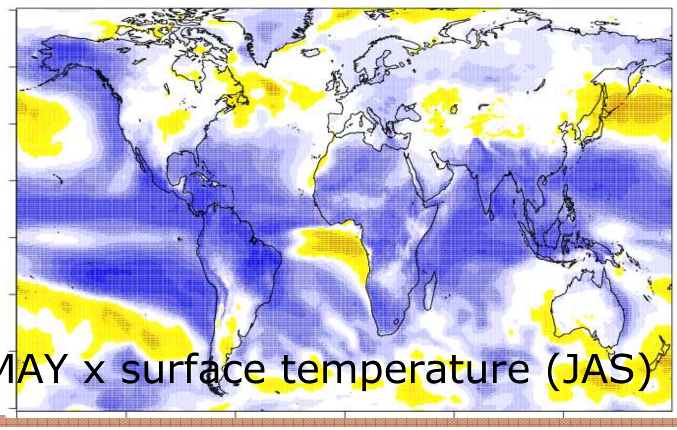
Seasonal forecasts: WAM

Leading EOF of the interannual variations of the meridionally-averaged System 4 precipitation over 1982-2008, corresponding to the Guinean rainfall regime and the Atlantic-Pacific SST link.

EOF 1-NOV 39% EOF 1-FEB 38% EOF 1-MAY 30%





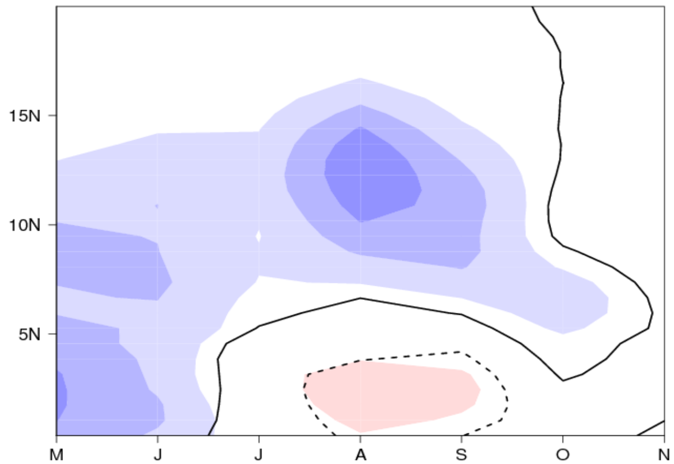


PC1-MAY x surface temperature (JAS)

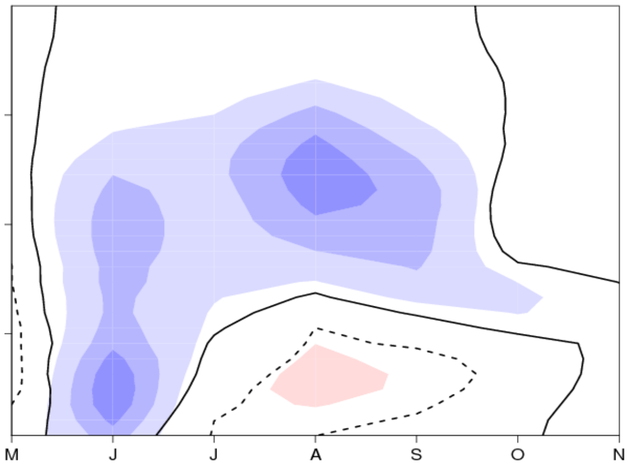
Seasonal forecasts: WAM

Second EOF of the interannual variations of the meridionally-averaged System 4 precipitation over 1982-2008, corresponding to the Sahelian rainfall regime and the inter-hemispheric (AMO, IPO) SST link.

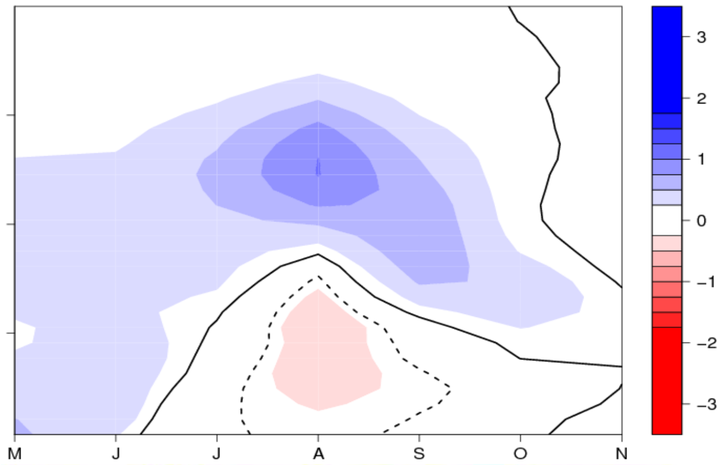
EOF 2-NOV 10%

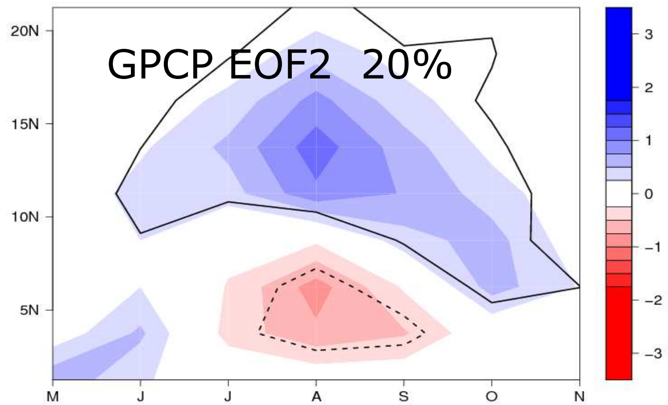


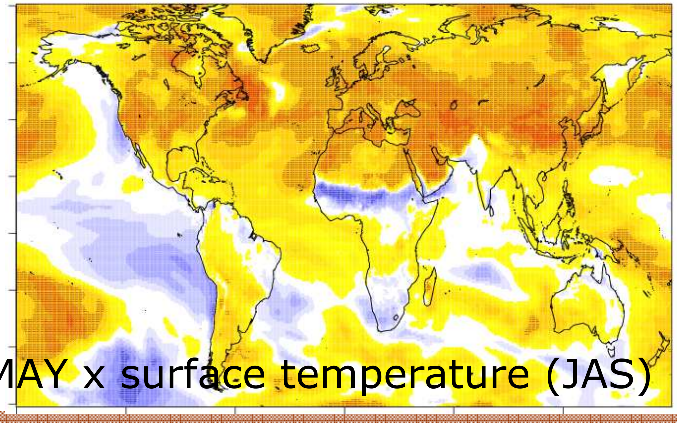
EOF 2-FEB 10%



EOF 2-MAY 11%



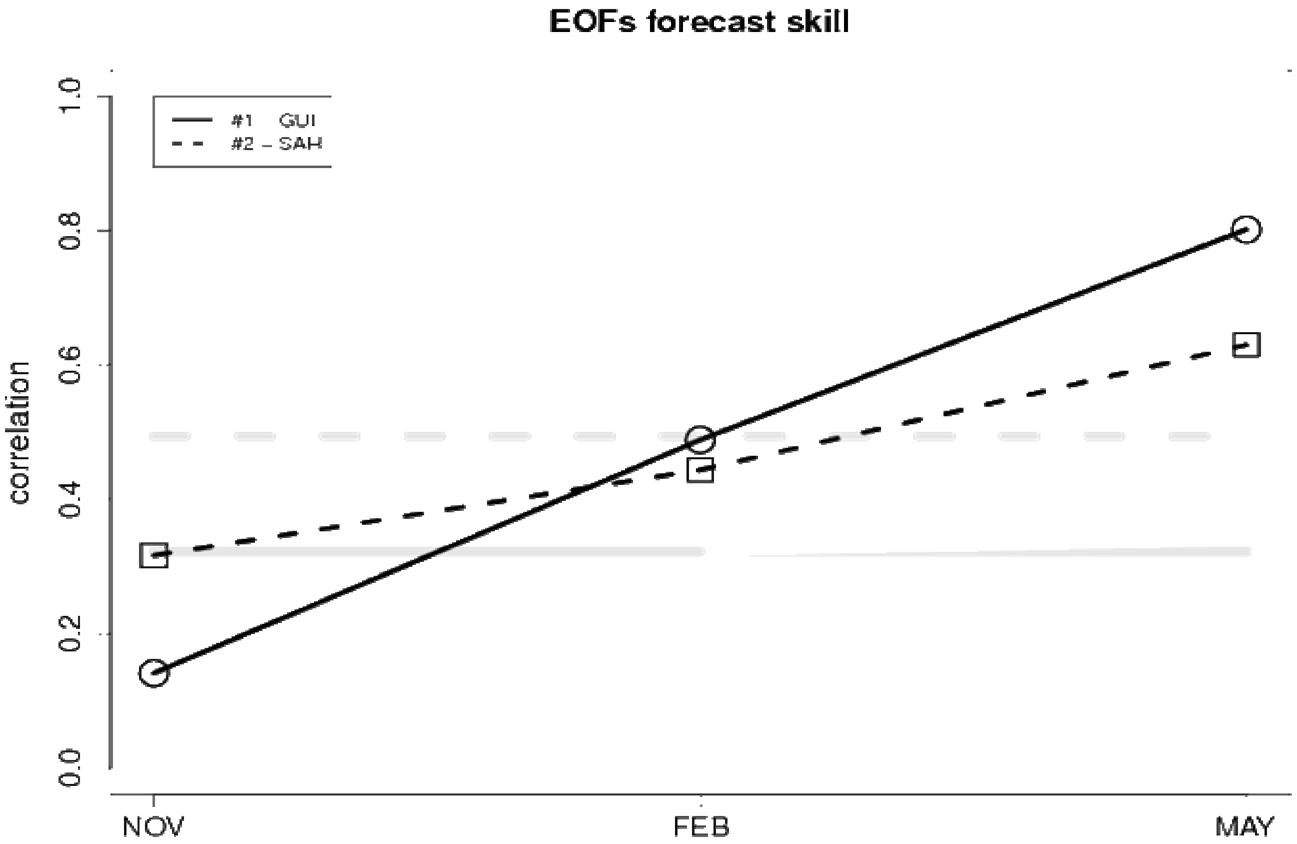




PC2-MAY x surface temperature (JAS)

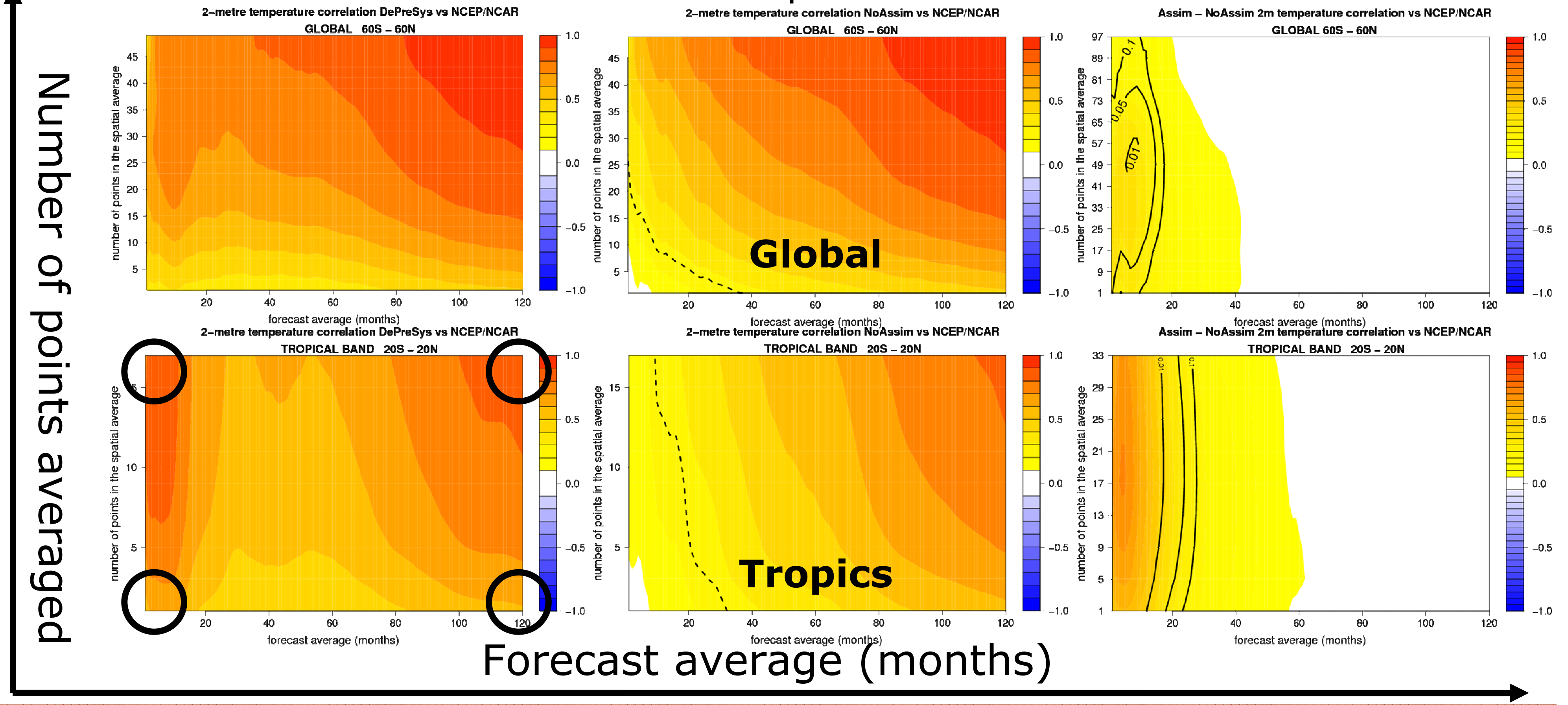
Seasonal forecasts: WAM

Ensemble-mean anomaly correlation coefficient between the GPCP and ECMWF System 4 meridionally-averaged precipitation two leading modes for the different start dates (hindcast period 1982-2008); the horizontal grey lines show the 95% confidence level.



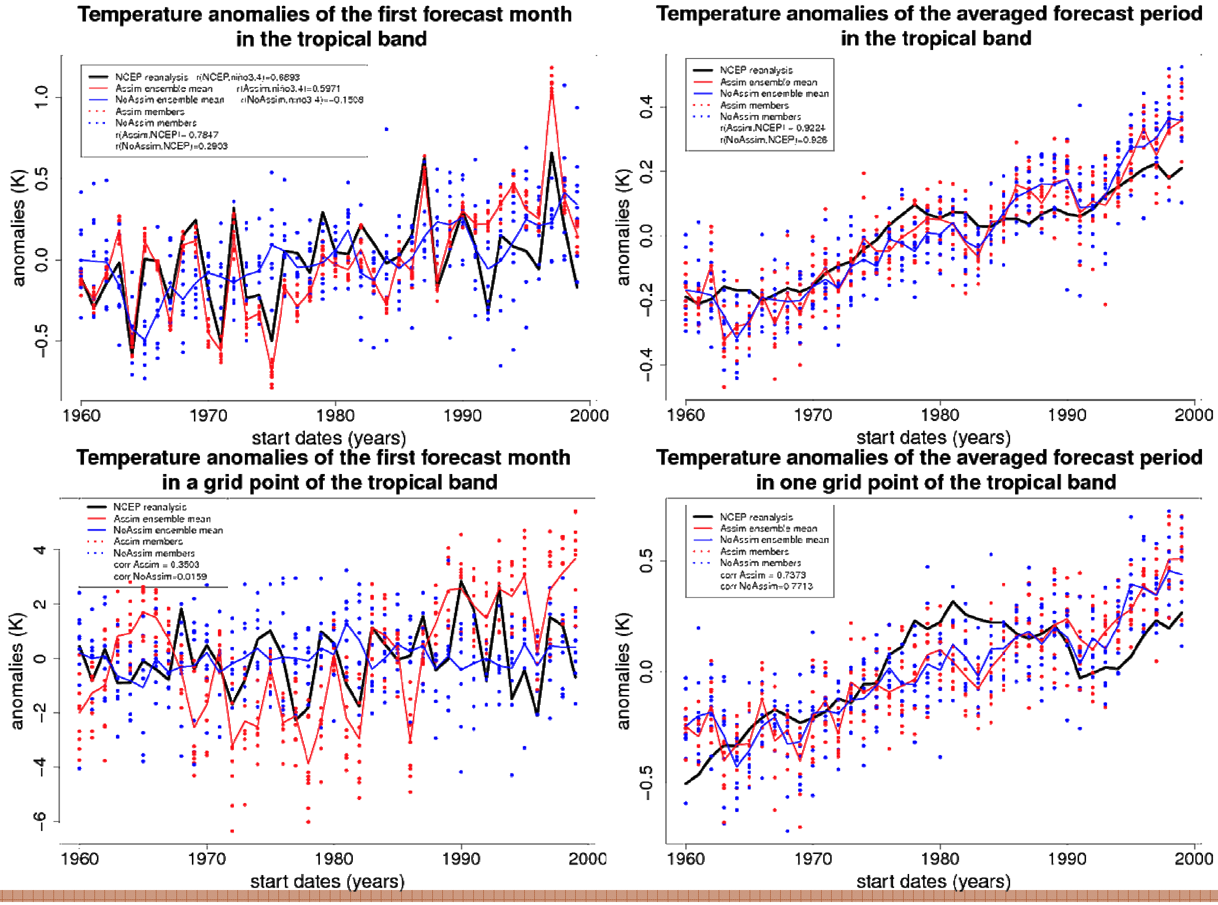
Spatio-temporal dependence of skill

Ensemble-mean correlation 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). Hindcasts over 1960-2005 (nine members) have been used and the reference dataset is NCEP R1. Black lines represent the confidence interval.



Spatio-temporal dependence of skill

Near-surface air temperature of the DePreSys_PP Assim (red) and NoAssim (blue) hindcasts (1960-2005) and the NCEP R1 (black) for different degrees of averaging along the forecast time and spatial dimensions. Solid lines for the ensemble-mean predictions and dots for the individual members, where nine different DePreSys versions have been used to build the ensemble.



CMIP5 decadal predictions

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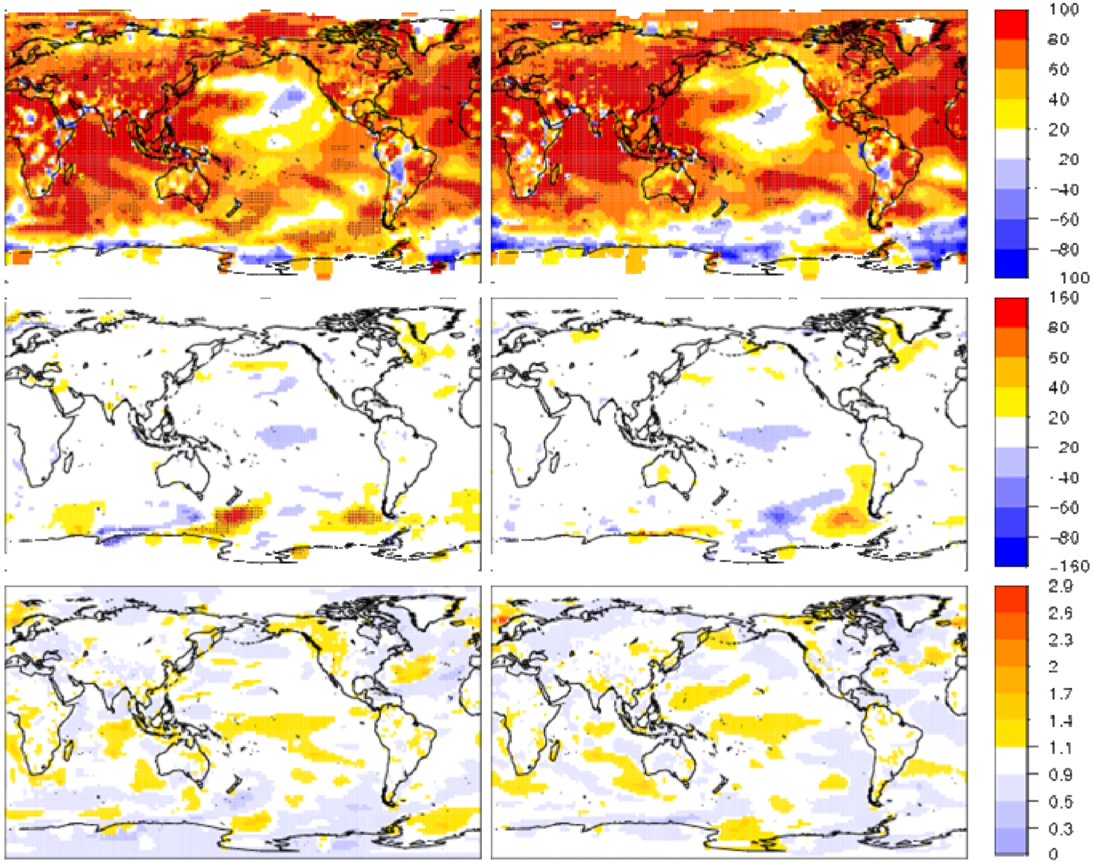
(Top) Near-surface temperature multi-model ensemble-mean correlation from CMIP5 decadal initialised predictions (1960-2005); (middle) correlation difference with the uninitialised predictions; (bottom) spread ratio of 2-5 year (left) and 6-9 year (right) wrt ERSST and GHCN.

Init ensemble-mean correlation

Init minus NoInit ensemble-mean correlation difference

Spread ratio between Init and NoInit



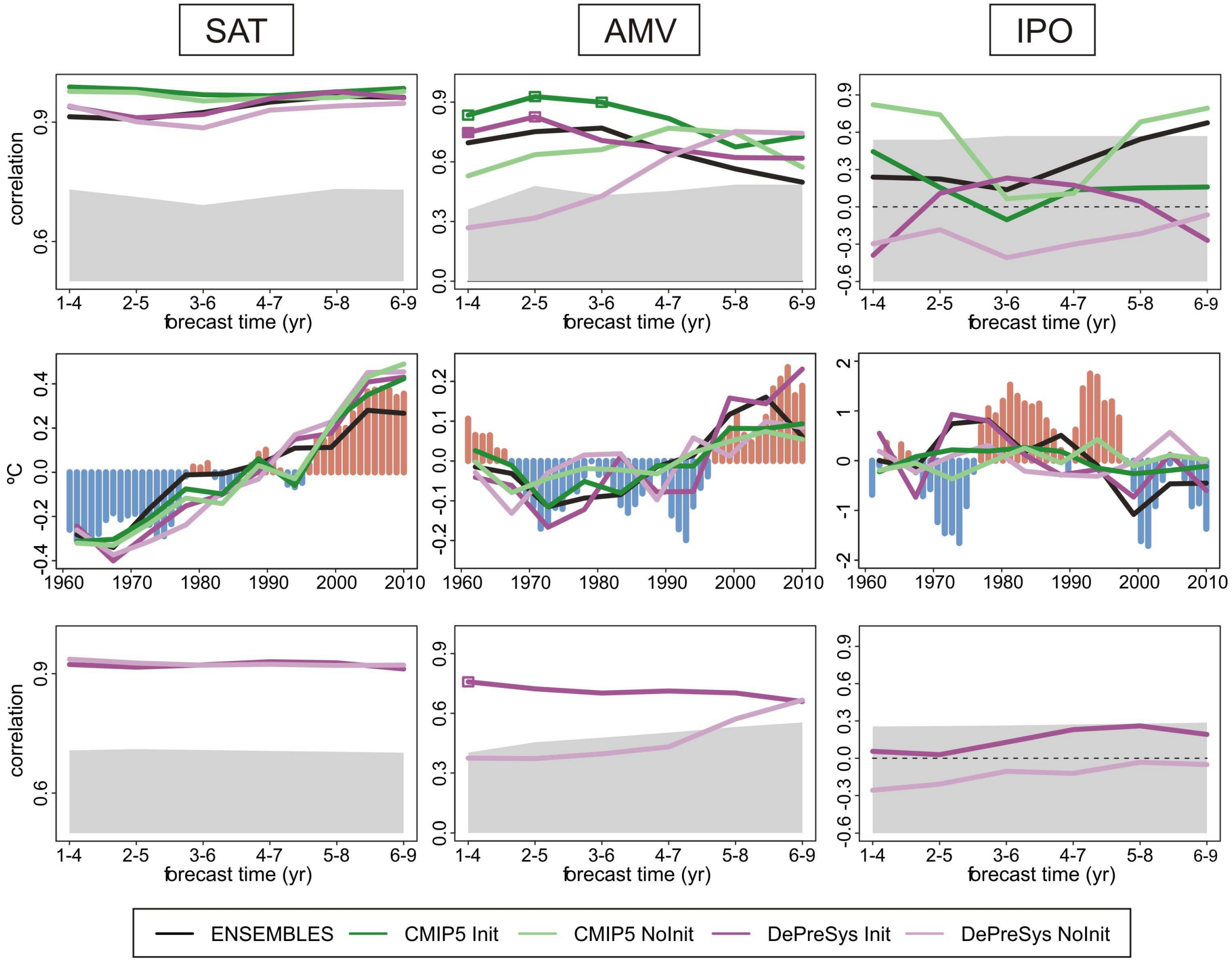
CMIP5 decadal predictions

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 level.

Ensemble-mean correlation

Time series

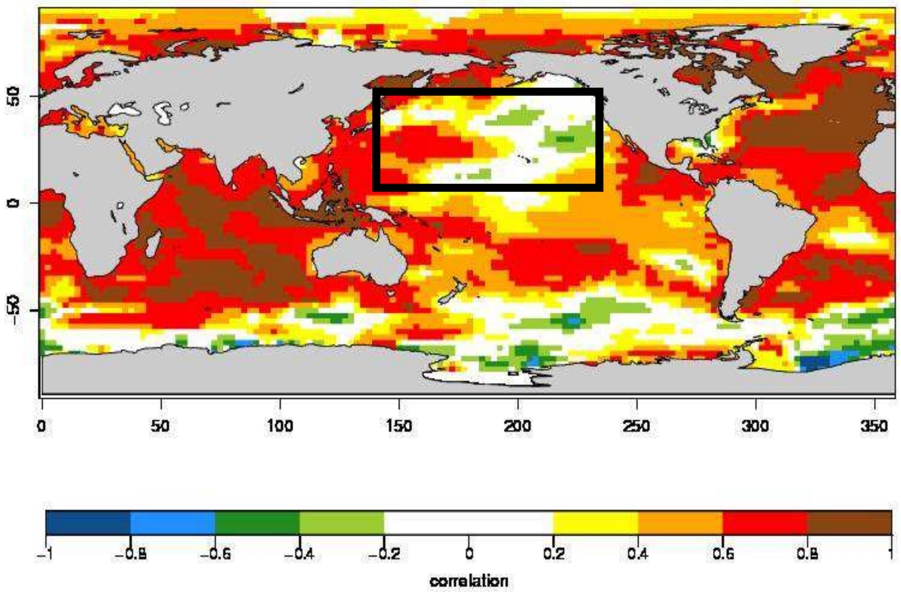
Ensemble-mean correlation (1 year start date interval)



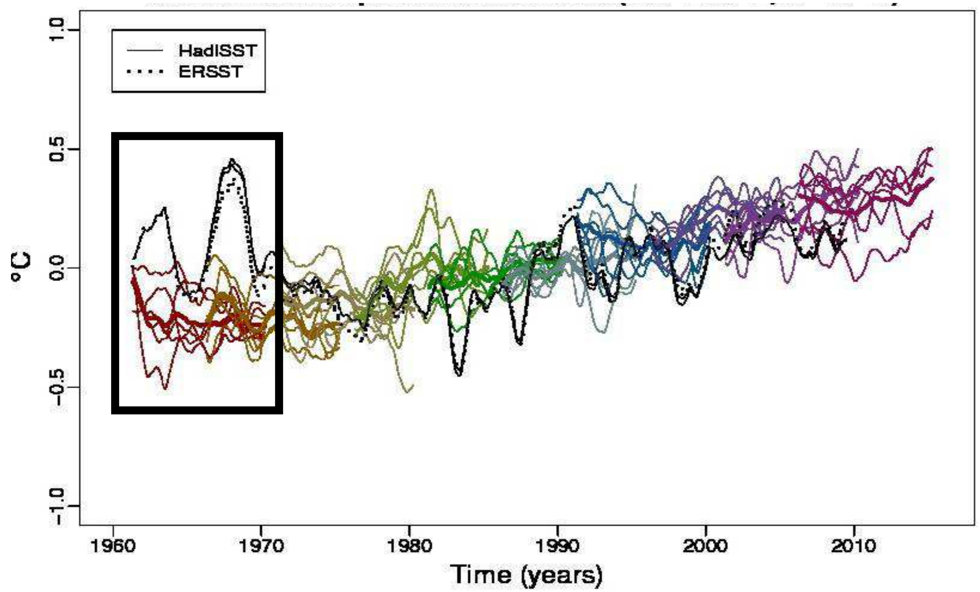
North Pacific decadal prediction

(Left) Multi-model (ENSEMBLES, DePreSys_PP and EC-Earth) 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.



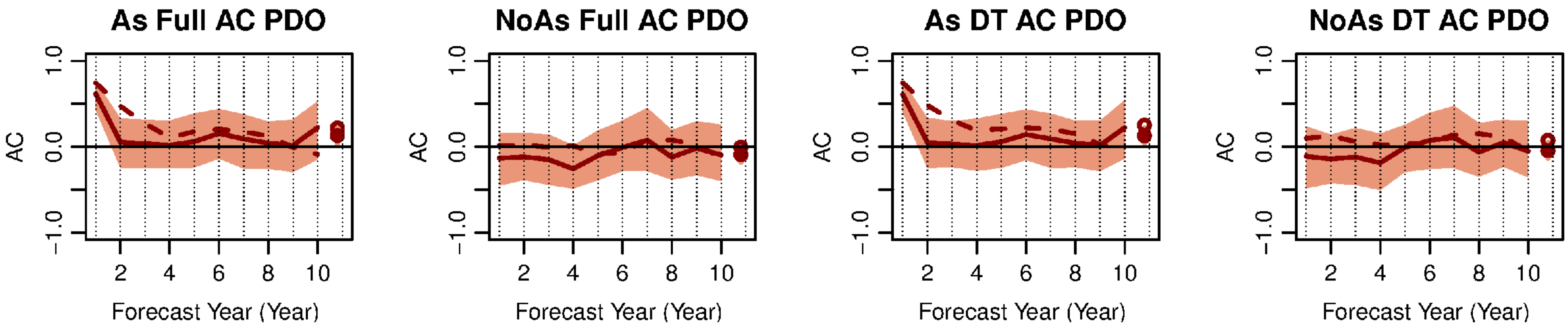
SST anomalies (155-235°E, 10-45°N)



Guémas et al. (2012)

PDO decadal prediction

Skill of the decadal predictions of the Pacific decadal oscillation (PDO) from DePreSys_PP Assim and NoAssim (left) and the corresponding detrended data (right). The PDO is estimated as projections on the ERSST leading EOF in the North Pacific. Bootstrap confidence intervals are drawn in pink. Dashed lines correspond to estimates of perfect predictability. Dots at the end of each panel show the average skill along the forecast time.



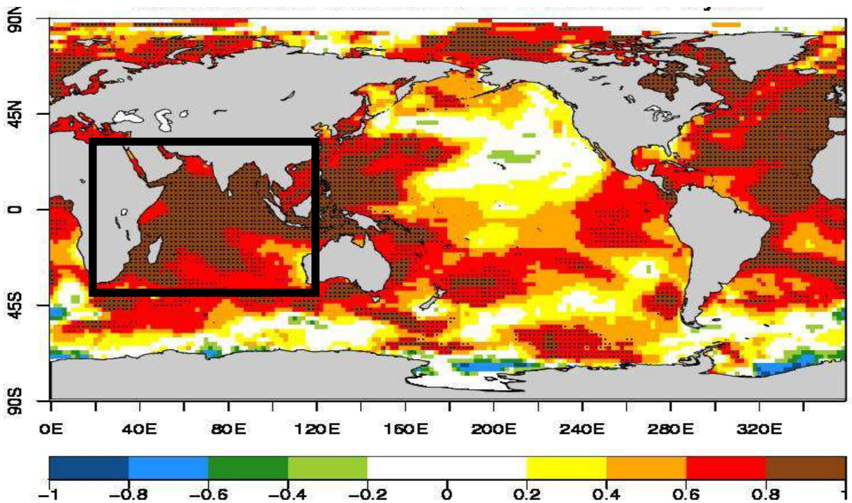
Lienert et al. (2012)

Indian ocean decadal prediction

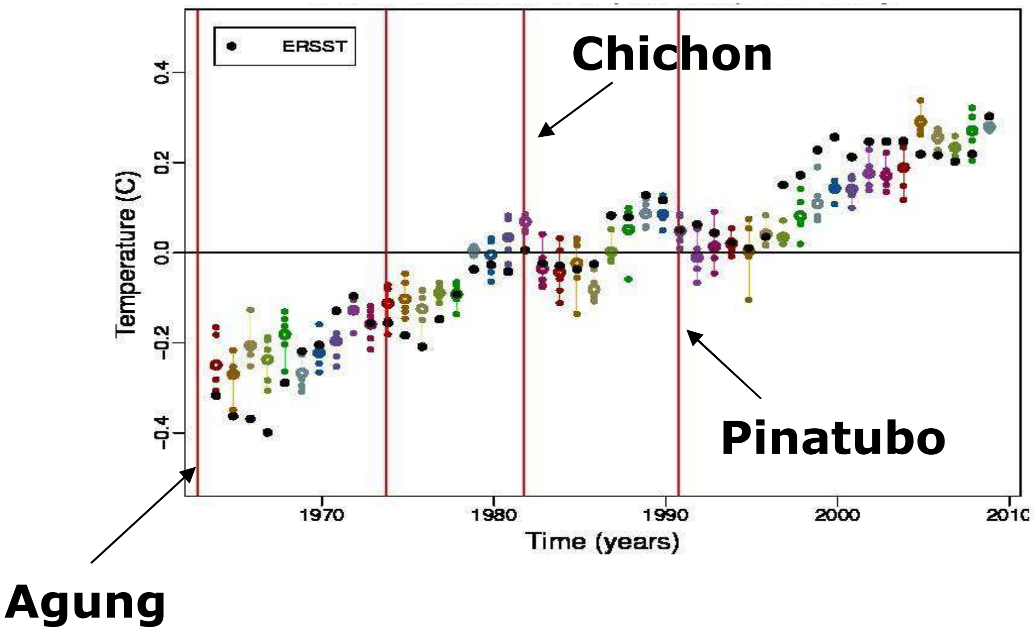
(Left) Multi-model (CMIP5) ensemble-mean correlation of SSTs for the average of the 2-5 forecast years. Ten start dates over 1960-2005 have been used. (Right) Time series of averaged SSTs over the black box, with the reference drawn in black and the 2-5 year EC-Earth decadal forecasts with each ensemble 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 the volcanic aerosol.

CMIP5 SST correlation skill 2-5 years



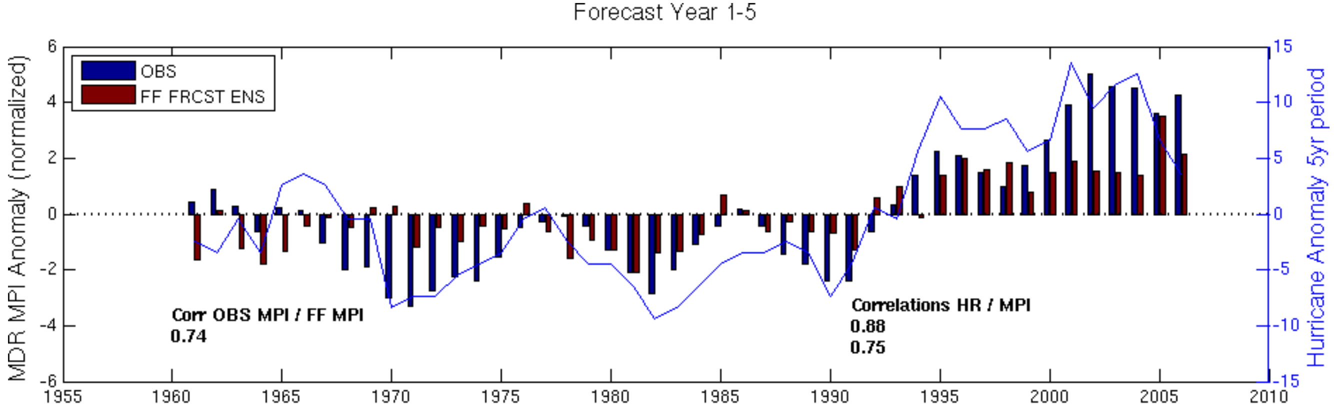
SST anomalies (20-120°E, 40°S-30°N)

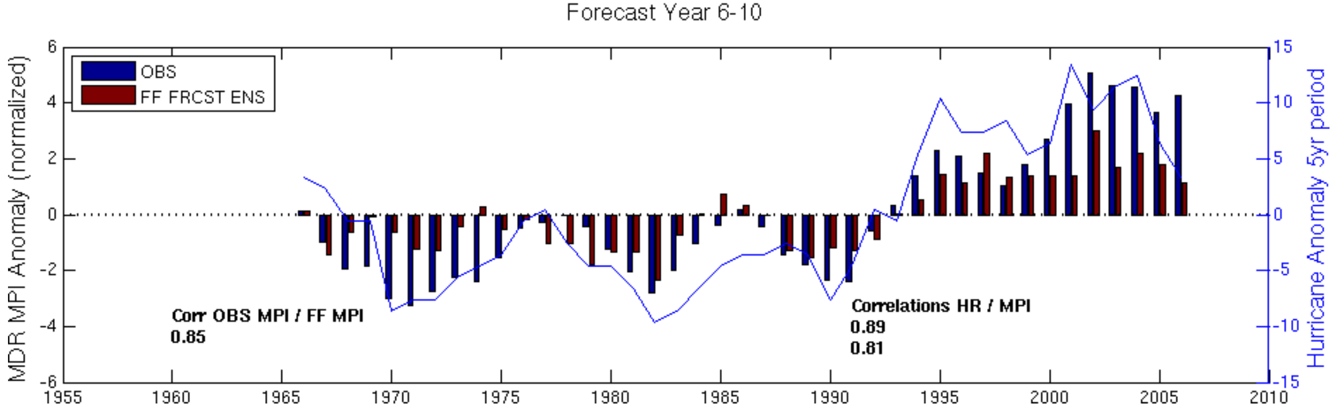


Guémas et al. (2012)

Tropical cyclones

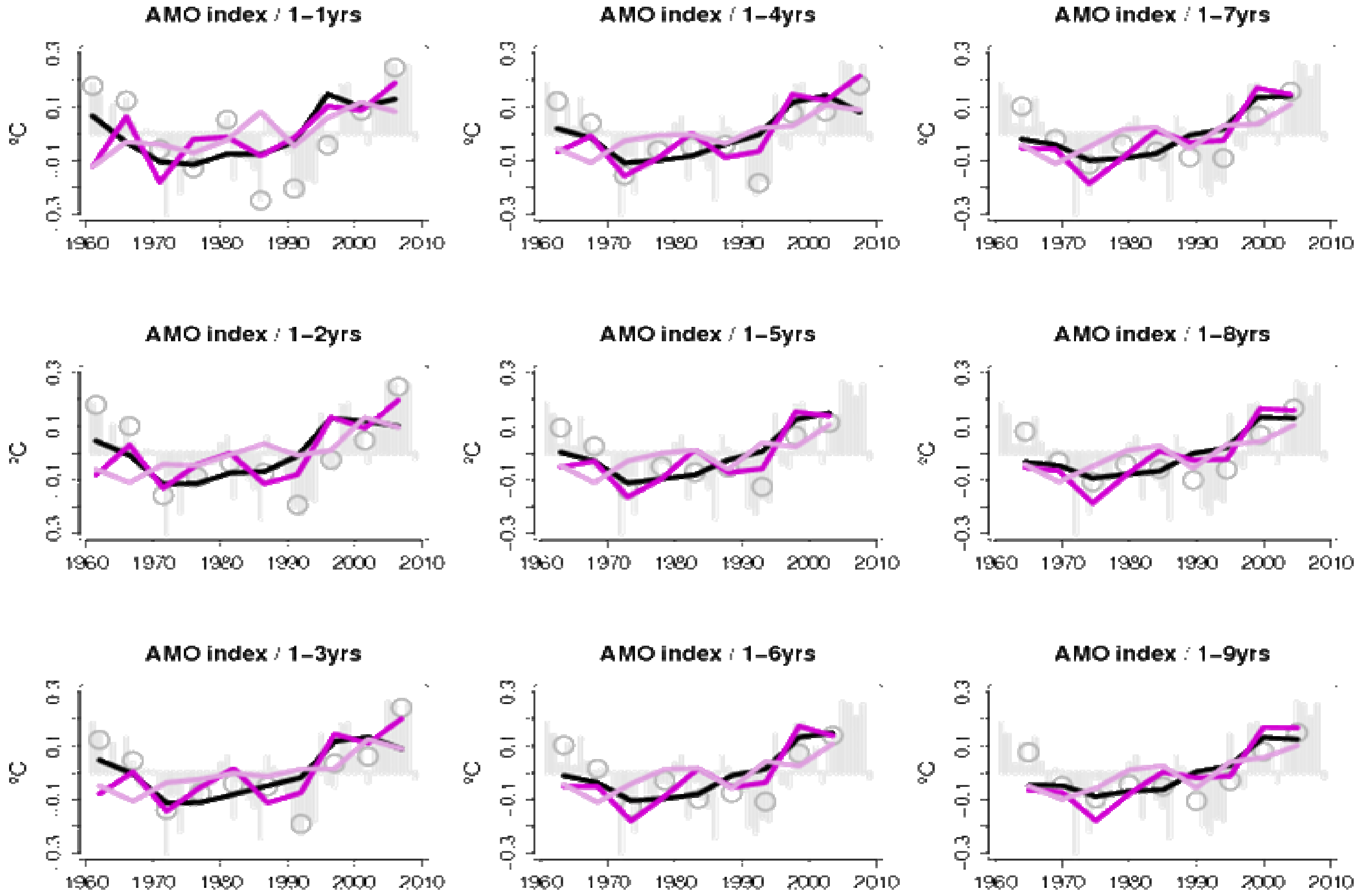
Maximum potential intensity (a measure of cyclone instability) in the main development region from ERA (red bars) and the EC-Earth decadal predictions (blue bars) for the first (top) and last five (bottom) forecast years. The five-year average hurricane number is also drawn (blue line).





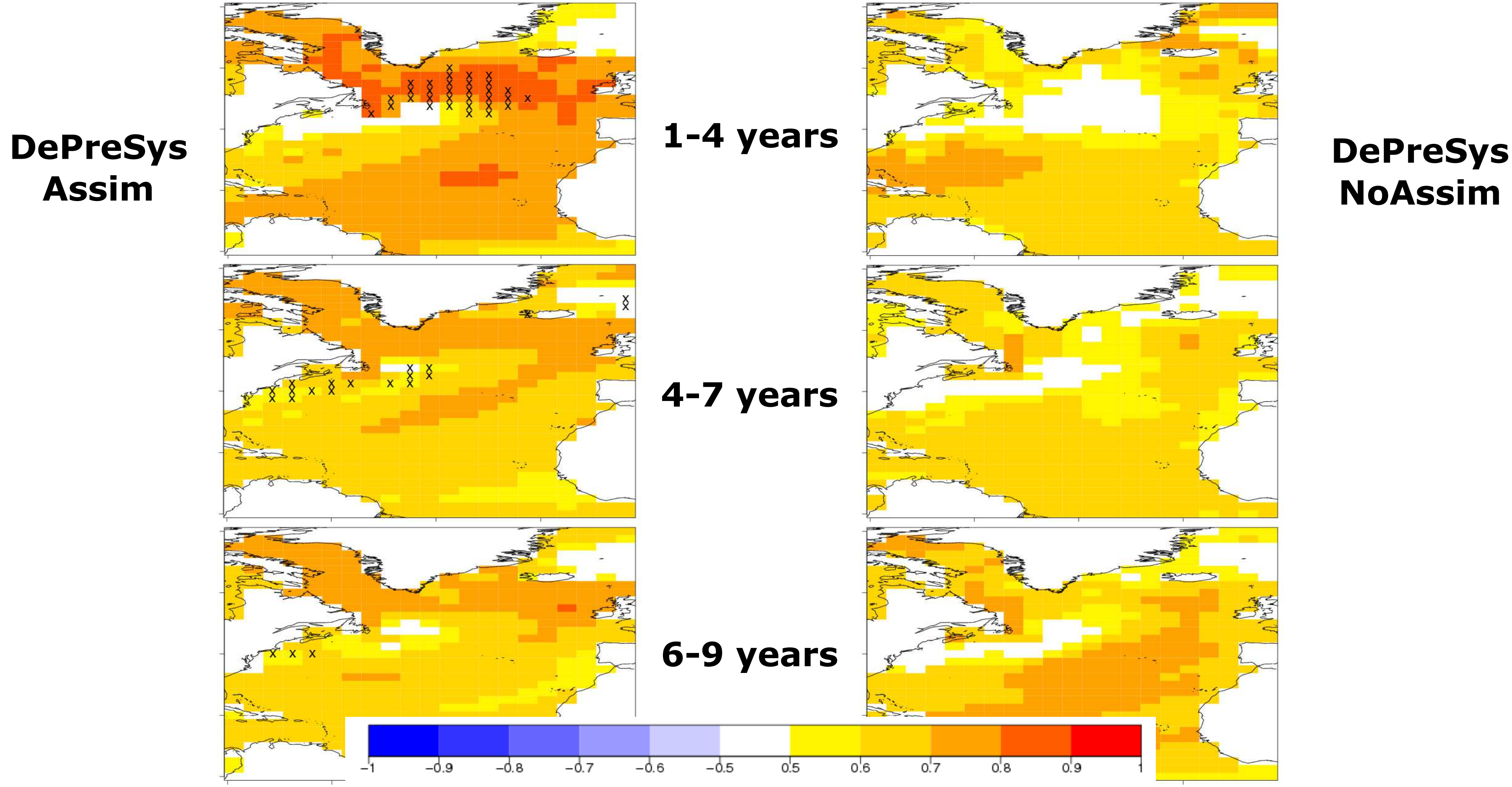
AMV: effect of forecast averaging

Effect of averaging along the forecast time of the annual AMO for the ENSEMBLES multi-model (black), DePreSys-Init (purple), DePreSys-NoInit (pink) and ERSST.



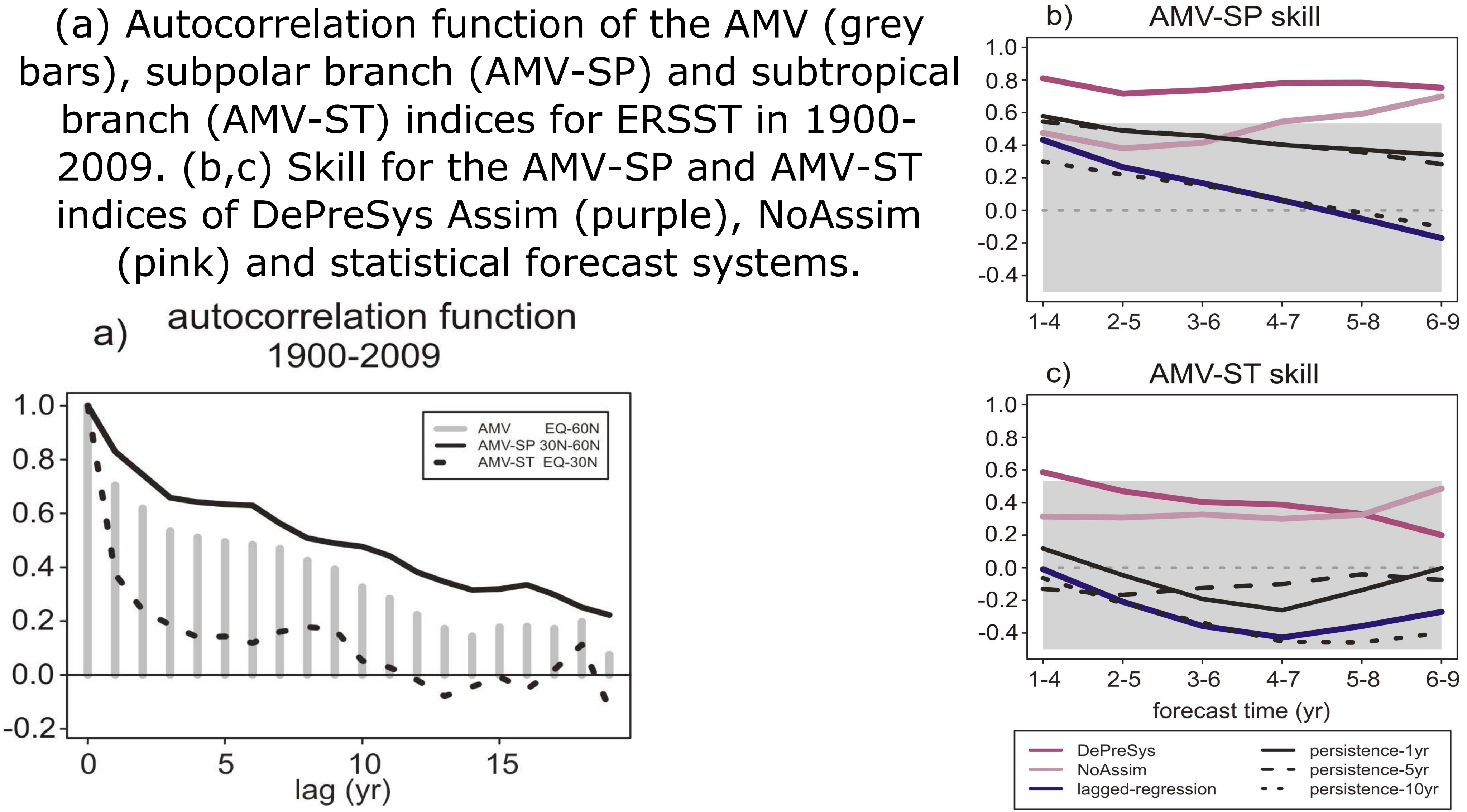
AMV skill

Correlation maps of ensemble-mean SST anomalies with the observed (ERSST) AMV index for different forecast averages.



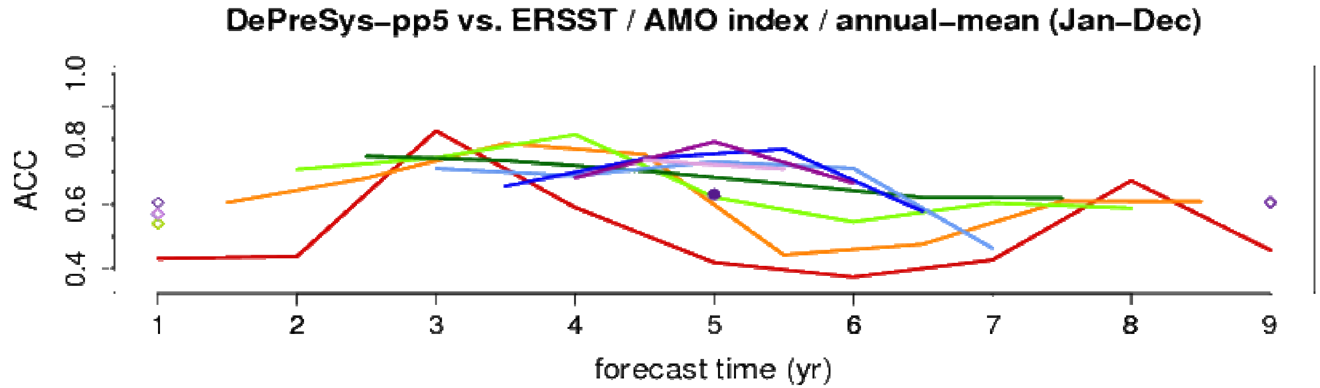
AMV skill

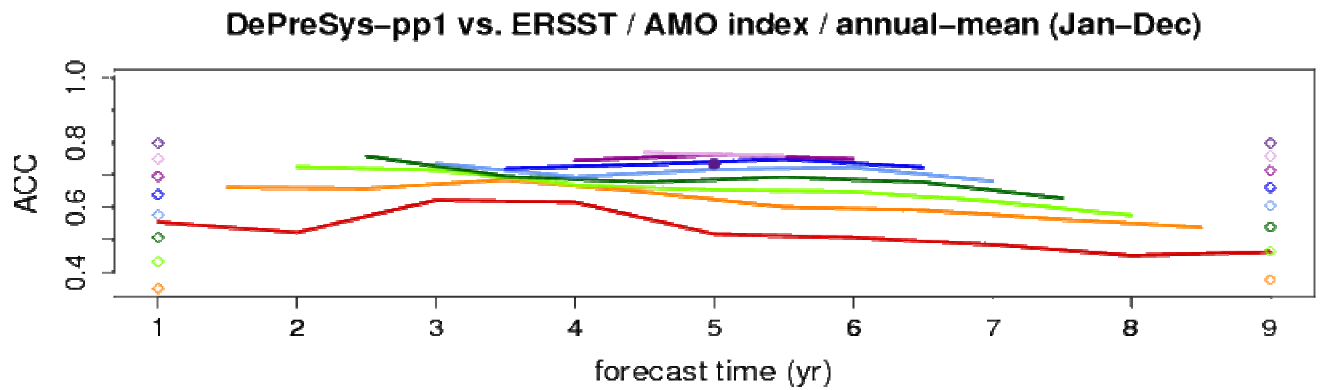
(a) Autocorrelation function of the AMV (grey bars), subpolar branch (AMV-SP) and subtropical branch (AMV-ST) indices for ERSST in 1900-2009. (b,c) Skill for the AMV-SP and AMV-ST indices of DePreSys Assim (purple), NoAssim (pink) and statistical forecast systems.



Influence of start date frequency

Ensemble-mean correlation for annual AMV between DePreSys-Init and ERSST with 5-year (top) and 1-year (bottom) intervals between start dates. Each colour shows the result for a different degree of averaging, from red (one year) to purple (nine years).



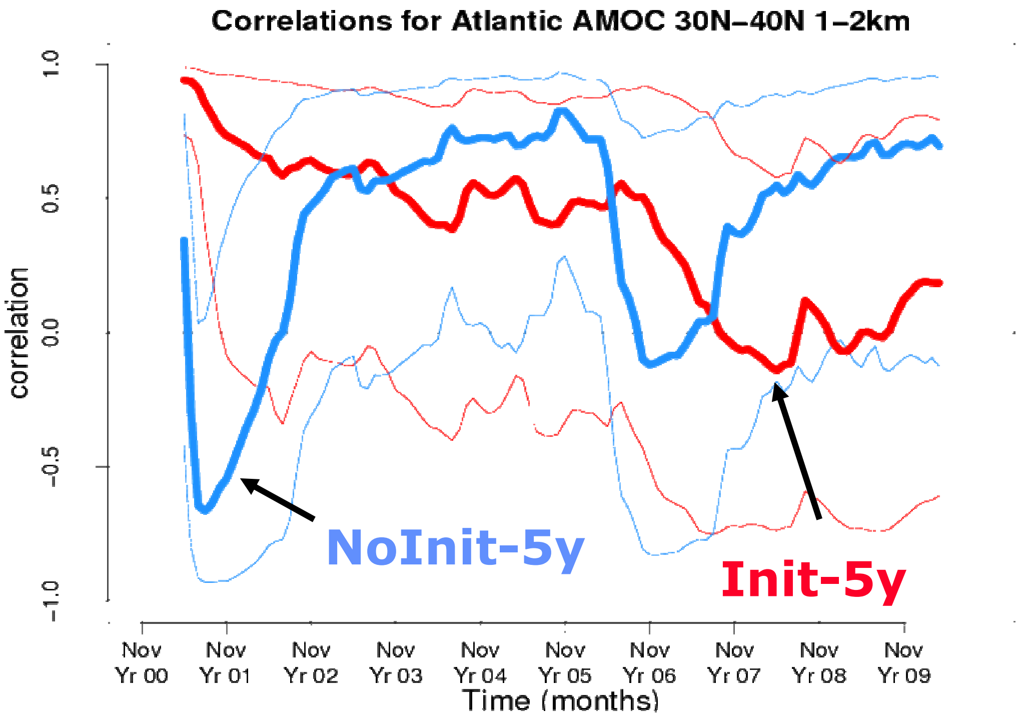


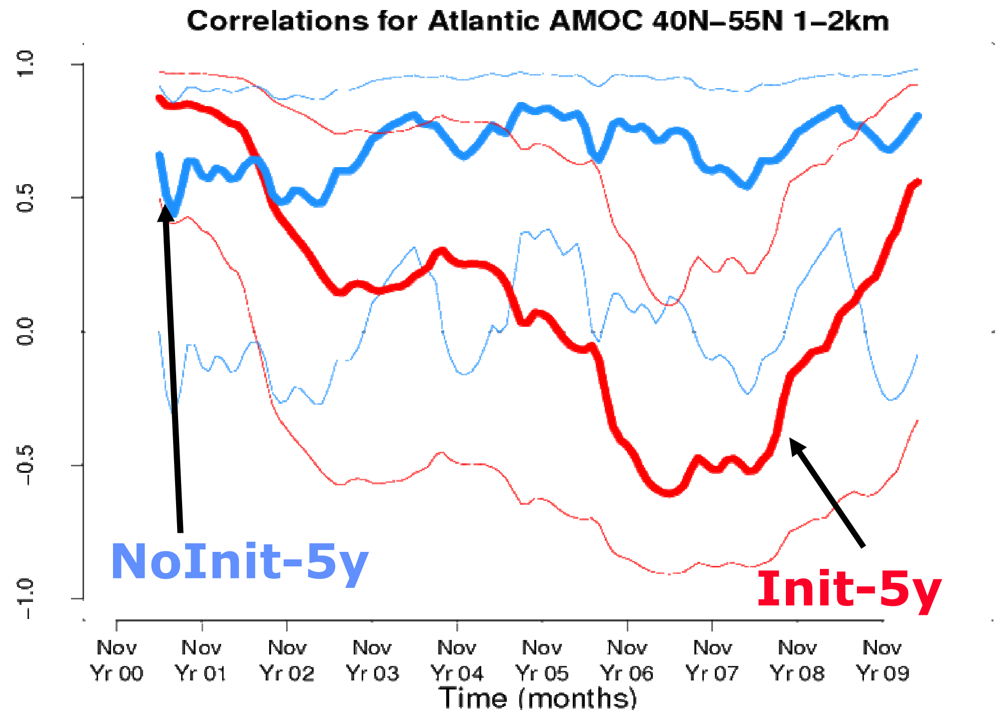
García-Serrano and Doblas-Reyes (2012)

Influence of start date frequency

Ensemble-mean correlation of the Atlantic meridional overturning circulation averaged over (left) 30º-40ºN and (right) 40º-55ºN and 1 to 2 km from the initialised (red) and historical (blue) EC-Earth v2.3 decadal hindcasts over 1960-2005 started once every five years. NEMOVAR-S4 has been used for reference. Results are for a 12-month running mean. Thin lines represent the 95% confidence intervals.

The results are noisy and there is a large uncertainty in the skill.

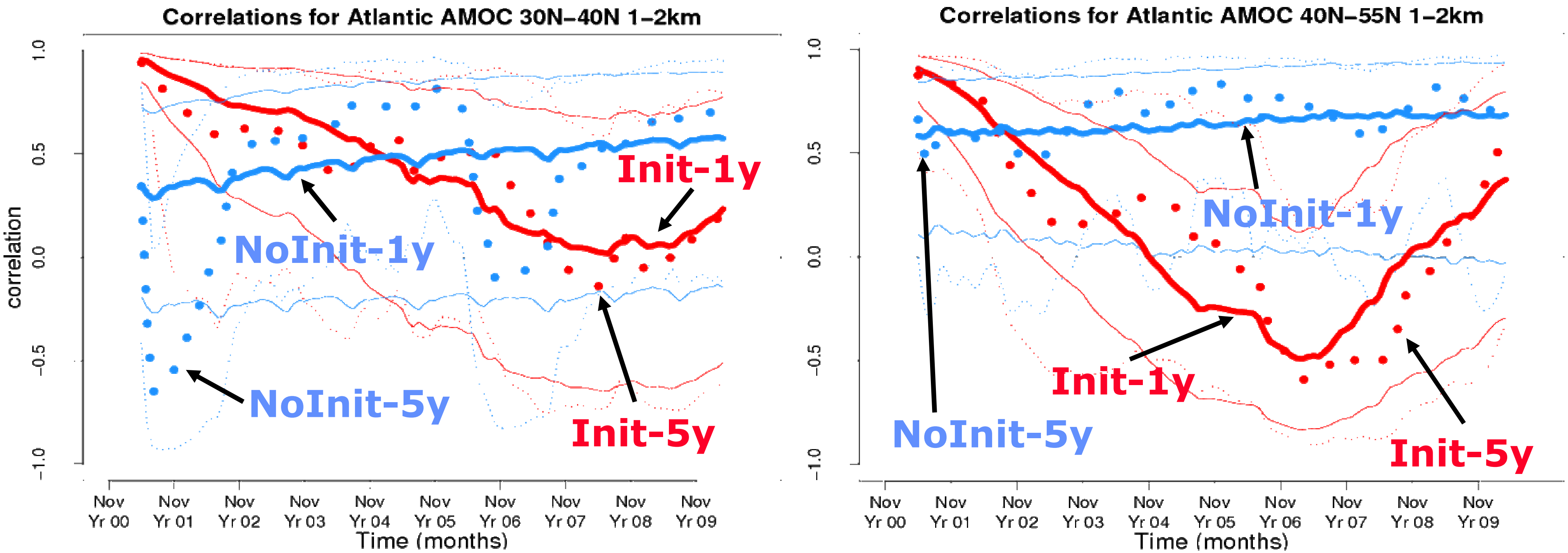




Influence of start date frequency

Ensemble-mean correlation of the Atlantic meridional overturning circulation averaged over (left) 30º-40ºN and (right) 40º-55ºN and 1 to 2 km from initialised (red) and historical (blue) EC-Earth v2.3 decadal hindcasts over 1960-2005 started once every year. NEMOVAR-S4 has been used for reference. Results are for a 12-month running mean. Thin lines represent the 95% confidence intervals.

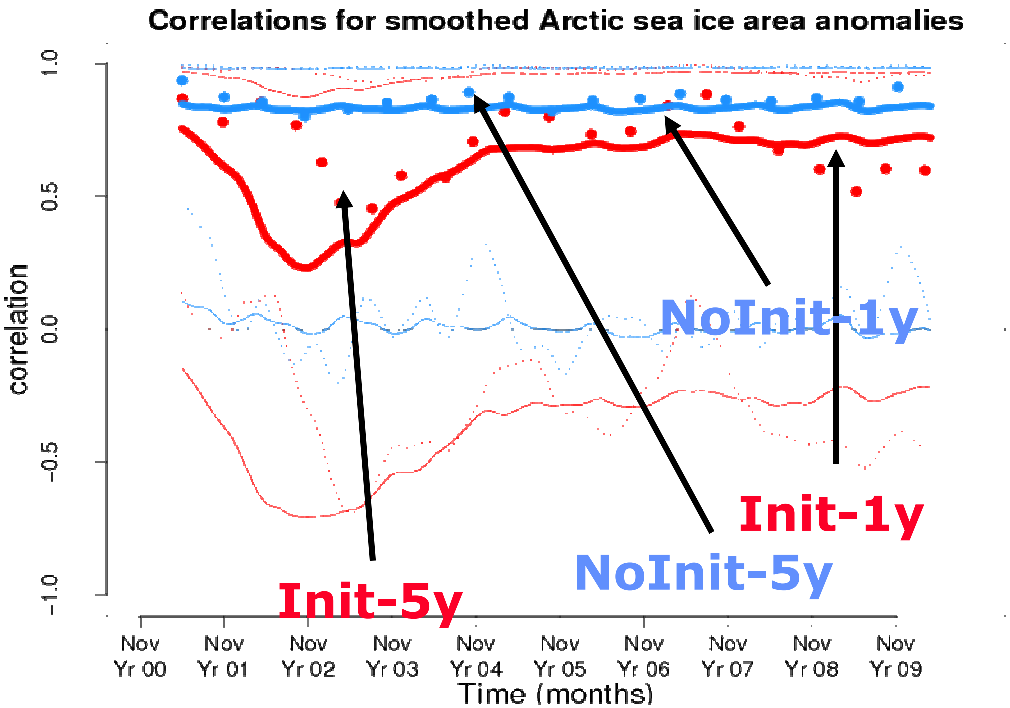
The significant AMOC skill up to forecast year three could not be identified with a five-year start date frequency.

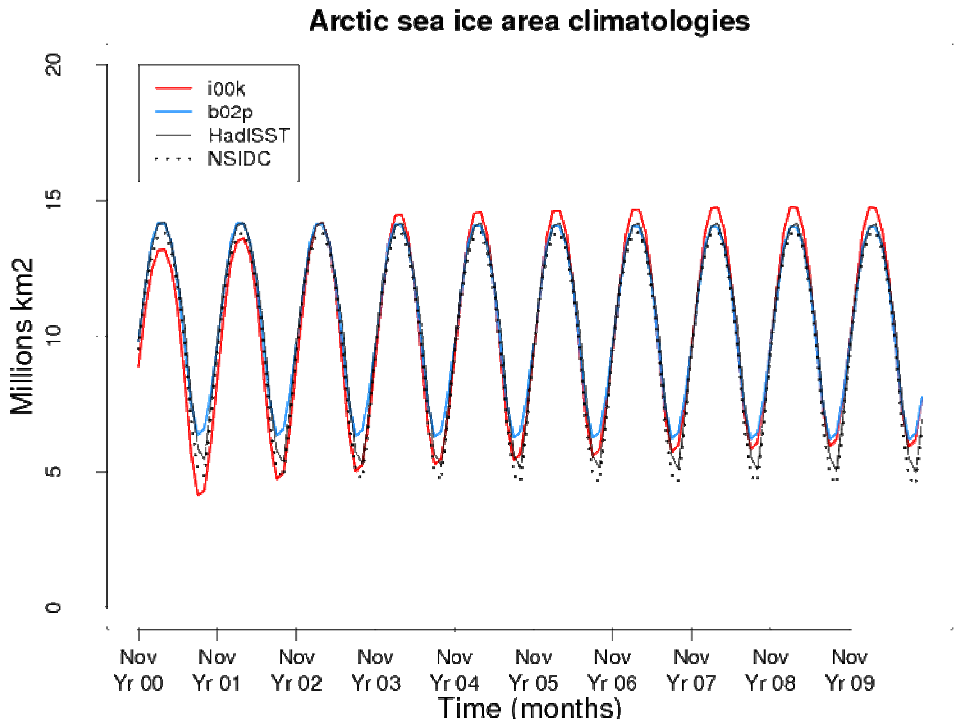


Influence of start date frequency

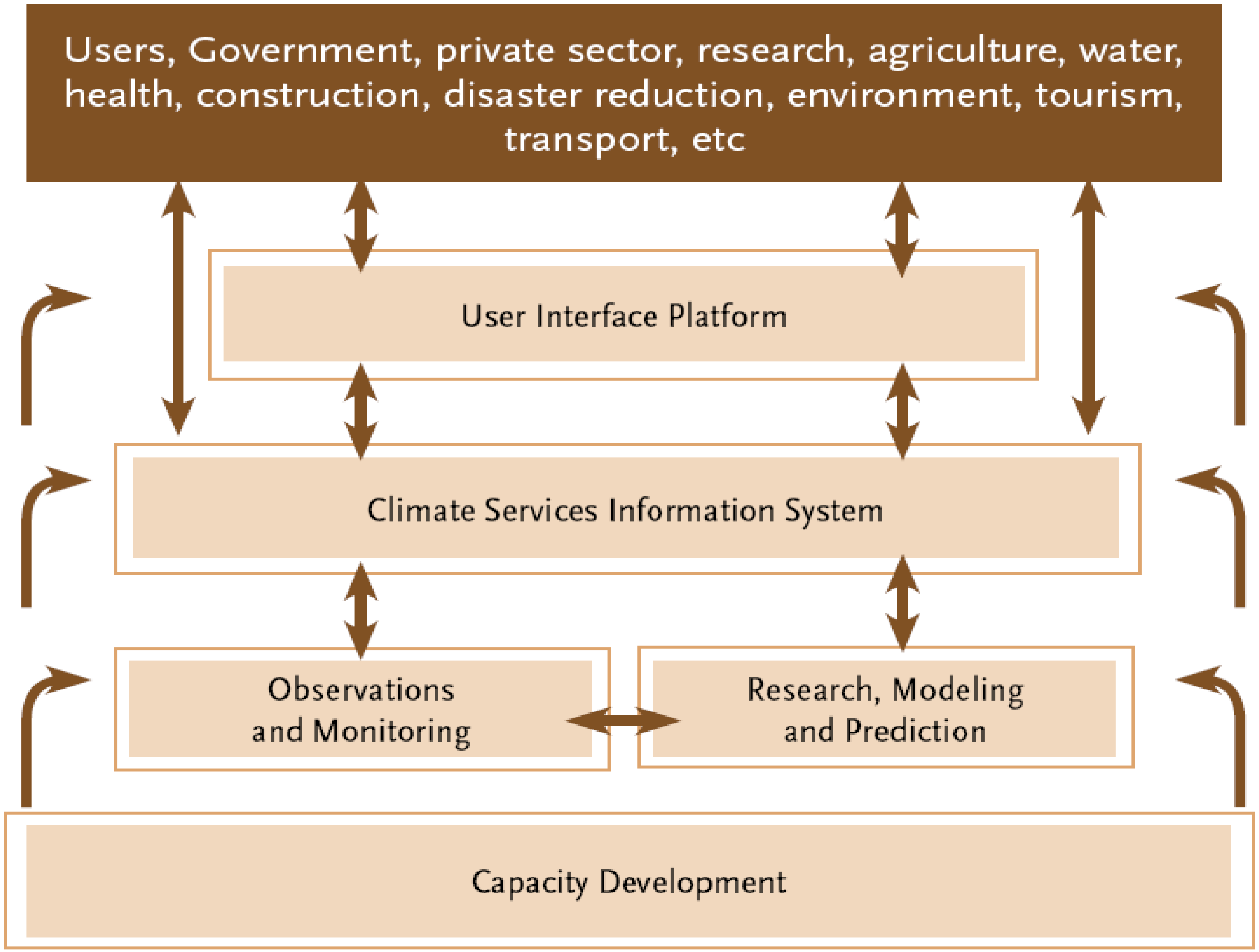
(Left) Ensemble-mean correlation of the Arctic sea-ice area from the initialised (red) and historical (blue) EC-Earth v2.3 decadal hindcasts over 1960-2005 started every year and every five years. HadISST has been used for reference. Results are for a 12-month running mean. Thin lines represent the 95% confidence intervals. (Right) Climatologies as a function of the forecast time.

Low skill in the initialised runs, likely linked to the initial shock. Need for improved initialisation.





Global framework on climate services



CLIMRUN WP7

Aim: Illustrate how climate information can play a role in developments and management in the energy sector.

We seek to reduce the risk for investors and facilitate long-term planning and decision-making for renewable energies and the associated smart-grid.

Partner case-study countries:

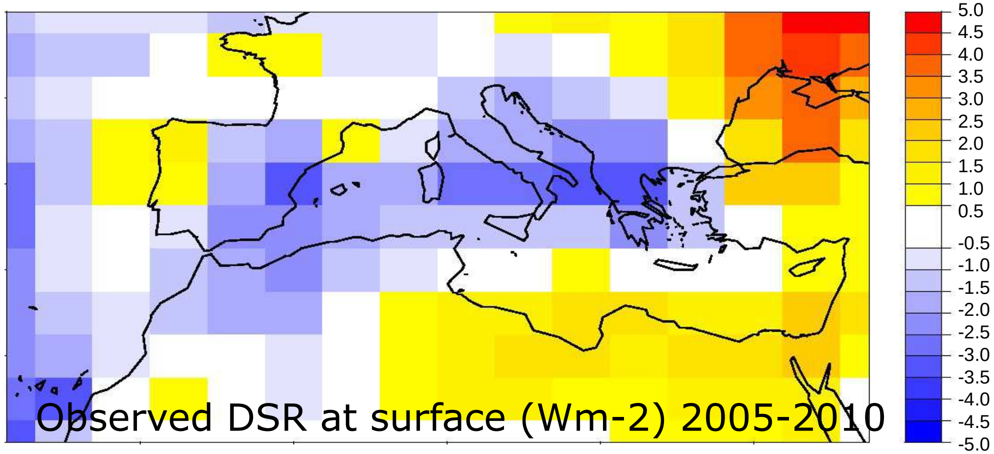
IC3

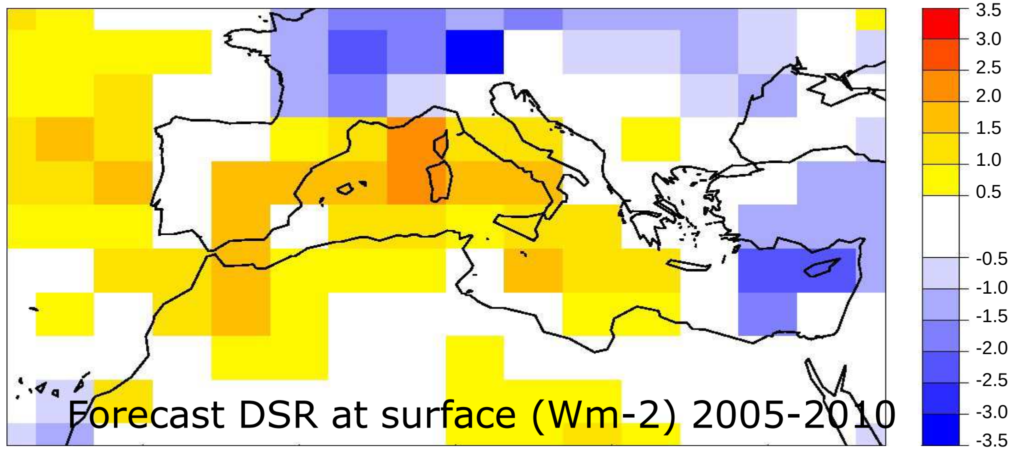
EEWRC

DHMZ

ENEA, PIK

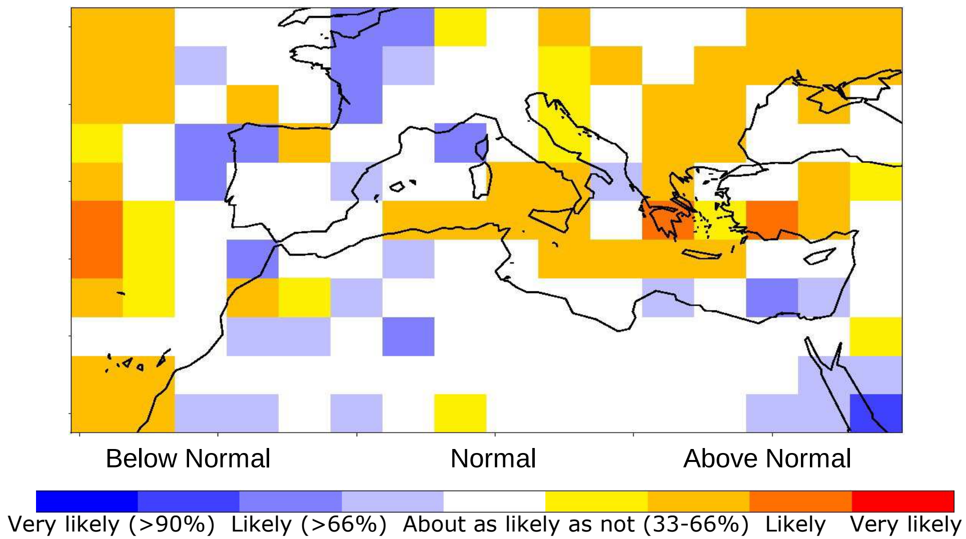
Climate services: renewable energy



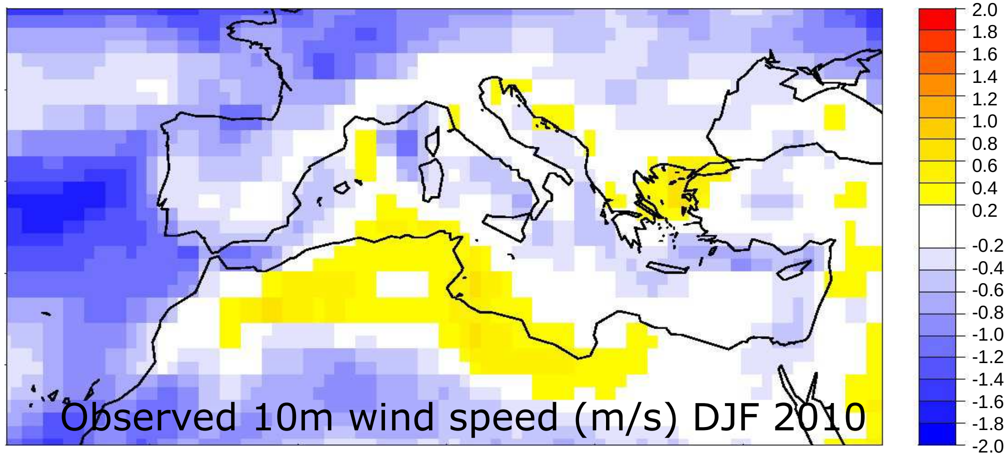


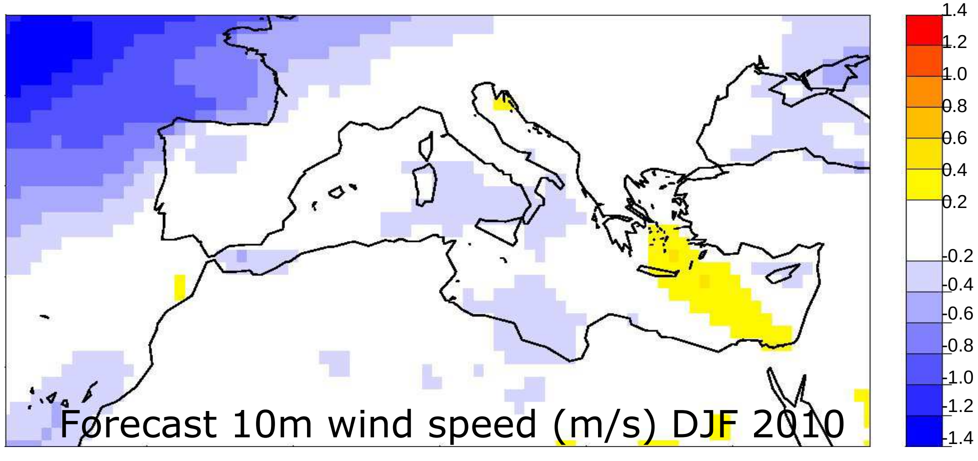
Decadal predictions of surface downward solar radiation from DePreSys_PP for the Nov 2005 start date, with the climatology computed from 1960-2005. Reference from ERA Interim.

Probability most likely tercile (%) 2005-2010



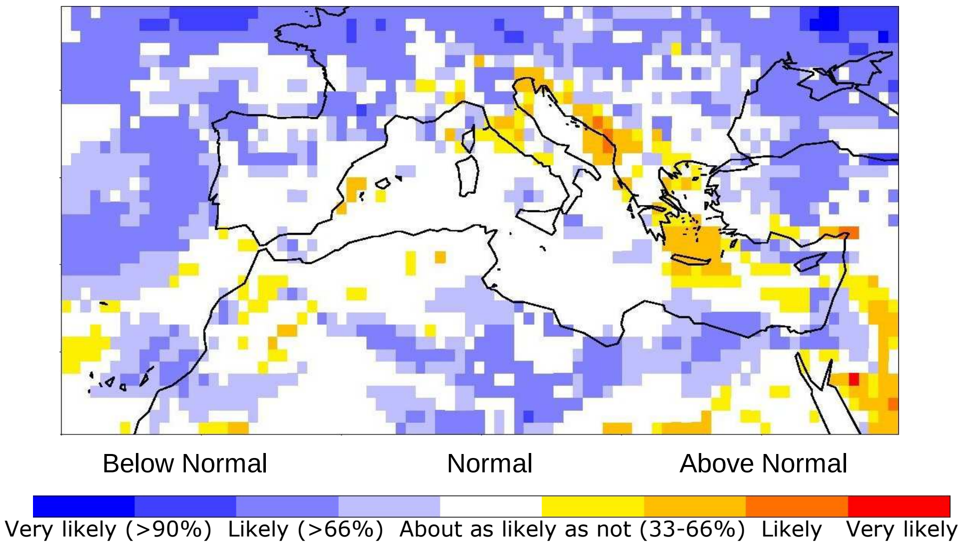
Climate services: renewable energy





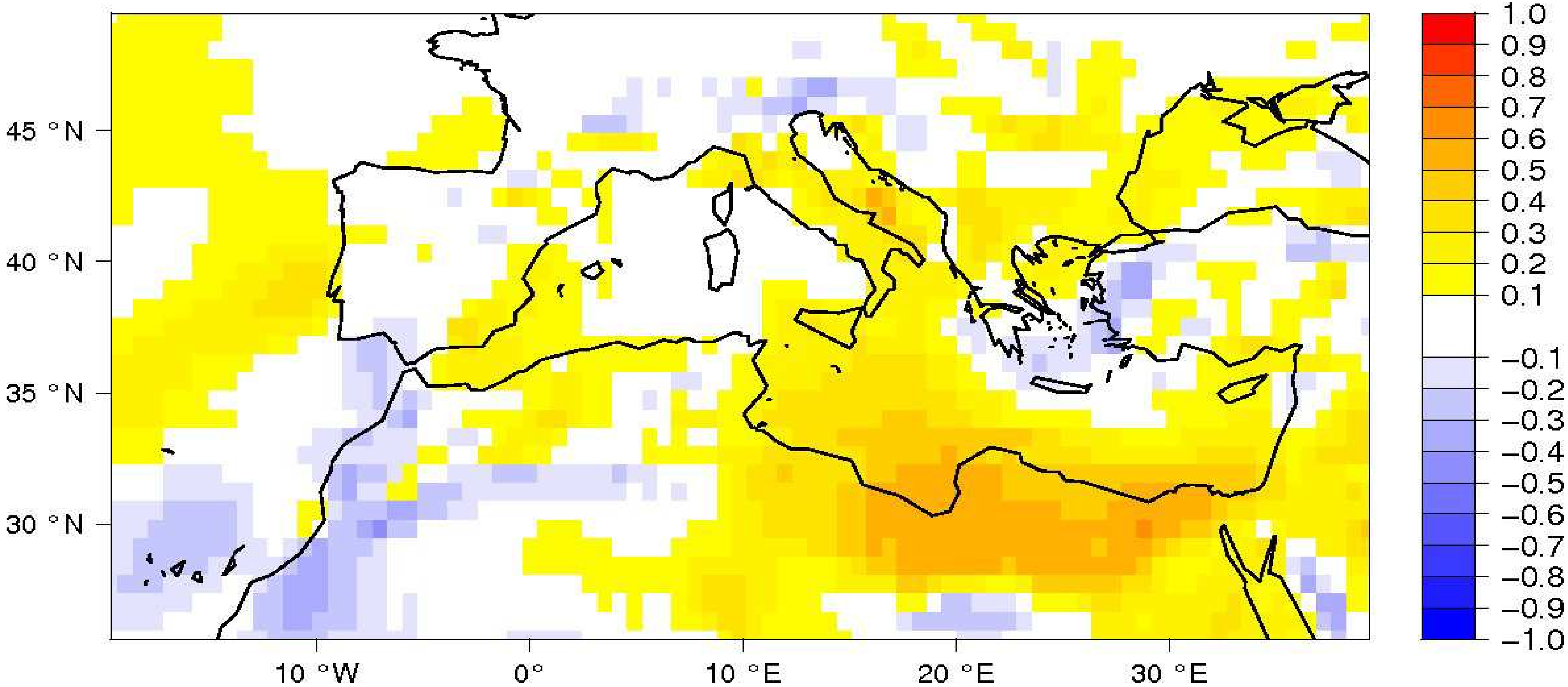
Seasonal predictions of 10-metre wind speed from ECMWF System 4 for the Nov 2010 start date, with the climatology computed from 1981-2010. Reference from ERA Interim.

Probability most likely tercile (%) DJF 2010



Climate services: renewable energy

Ensemble-mean correlation of one-month lead DJF 10-metre wind speed from ECMWF System 4 computed from hindcasts over 1981-2010. Reference from ERA Interim.



Climate services: renewable energy

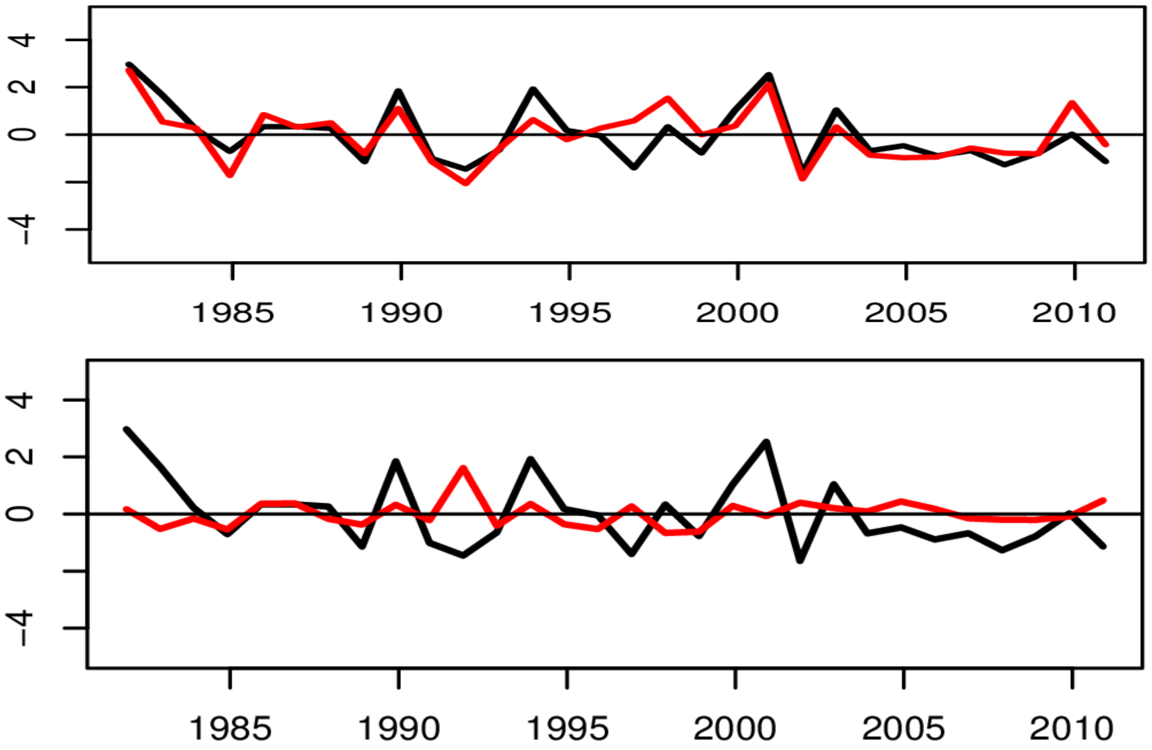
Downscaling of December 10-metre wind speed (m/s) for a point over Northwest Spain computed using the four leading EOFs of MSLP. Downscaled (red) and reference (black) time series.

Predictors from ERA Interim

Corr 0.8

Predictors from System 4 (Nov start date)

Corr 0.1



Summary

- Calibration and combination of seasonal predictions can improve their accuracy and reliability if coefficient estimates are robust.
- There is skilful information in seasonal predictions beyond the first six months (including the Sahel precip), although systematic error problems increase with forecast time.
- North Atlantic and Indian Ocean show skilful decadal predictions, with contributions from the variable radiative forcing and internal variability.
- West African monsoon and North Pacific SSTs show low or zero decadal skill. The systematic error plays a large role.
- Emerging climate services have to make climate forecast information readily available and understandable.