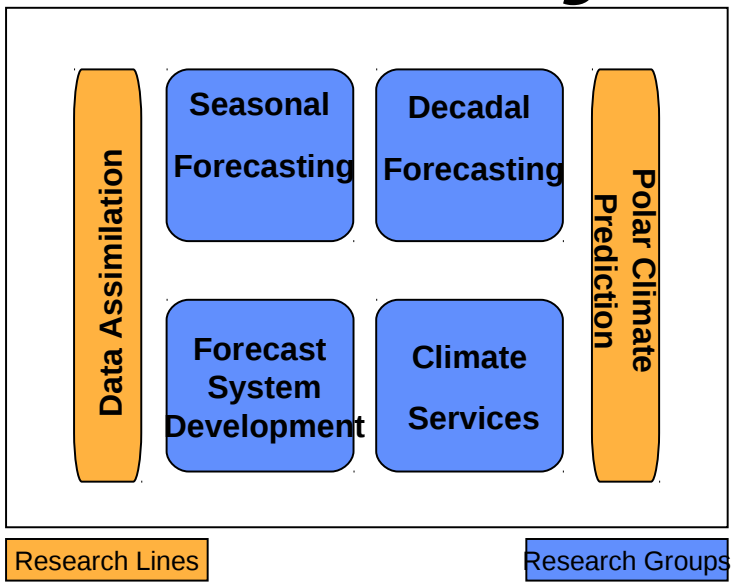
Seasonal-to-decadal climate prediction in the Atlantic sector

CFU team, IC3, Barcelona

Chloé Prodhomme

Climate Forecasting Unit



SEVENTH FRAMEWORK PROGRAMME

SPECS
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

PREFACE

CFU Team

- ***Francisco J Doblas-Reyes***
- ***Muhammad Asif: EC-Earth***
- ***Pierre-Antoine Bretonnière: SPECS data***
- ***Louis-Philippe Caron: tropical cyclones***
- ***Melanie Davis: climate services***
- ***Neven Fuckar: Arctic sea ice***
- ***Virginie Guémas: sea ice, XXIst century hiatus***
- ***Omar Bellprat: extreme events***
- ***Domingo Manubens: autosubmit developer***
- ***Oriol Mula-Valls: system administrator***
- ***Aida Pintó: prediction of extremes***
- ***Chloé Prodhomme: Sources of seasonal skill***
- ***Mar Rodríguez: SPECS manager***
- ***Luis Rodrigues: seasonal climate predictability***
- ***Gabriela Tarabanoff: secretary, climate services***
- ***Verónica Torralba: climate services***
- ***Nube Gonzalez-Reviriego: climate services***
- ***Danila Volpi: initialisation, decadal prediction***
- ***Robin Weber: initialisation in simple models***

Objectives:

1) ***Development of s2d prediction capability***
2) ***Forecast quality assessment***
3) ***Downscaling of probabilistic forecasts***
4) ***Climate services***

We share on request:

1) ***Autosubmit***
2) ***Sea-ice restarts***
3) ***R diagnostic functions***

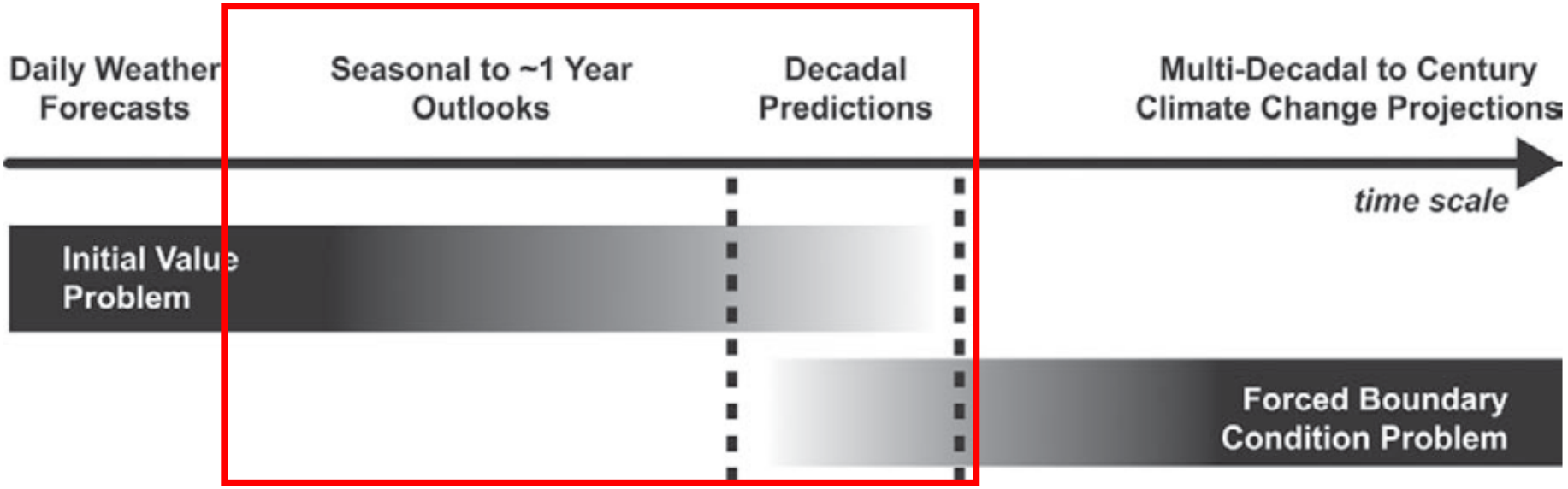
We run on:

1) ***Marenostrum (Spain)***
2) ***ECMWF***
3) ***Lindgren (Sweden)***
4) ***ARCHER (UK)***
5) ***Our local cluster***

http://www.ic3.cat ***http://ic3.cat/wikicfu***

Climate time scales

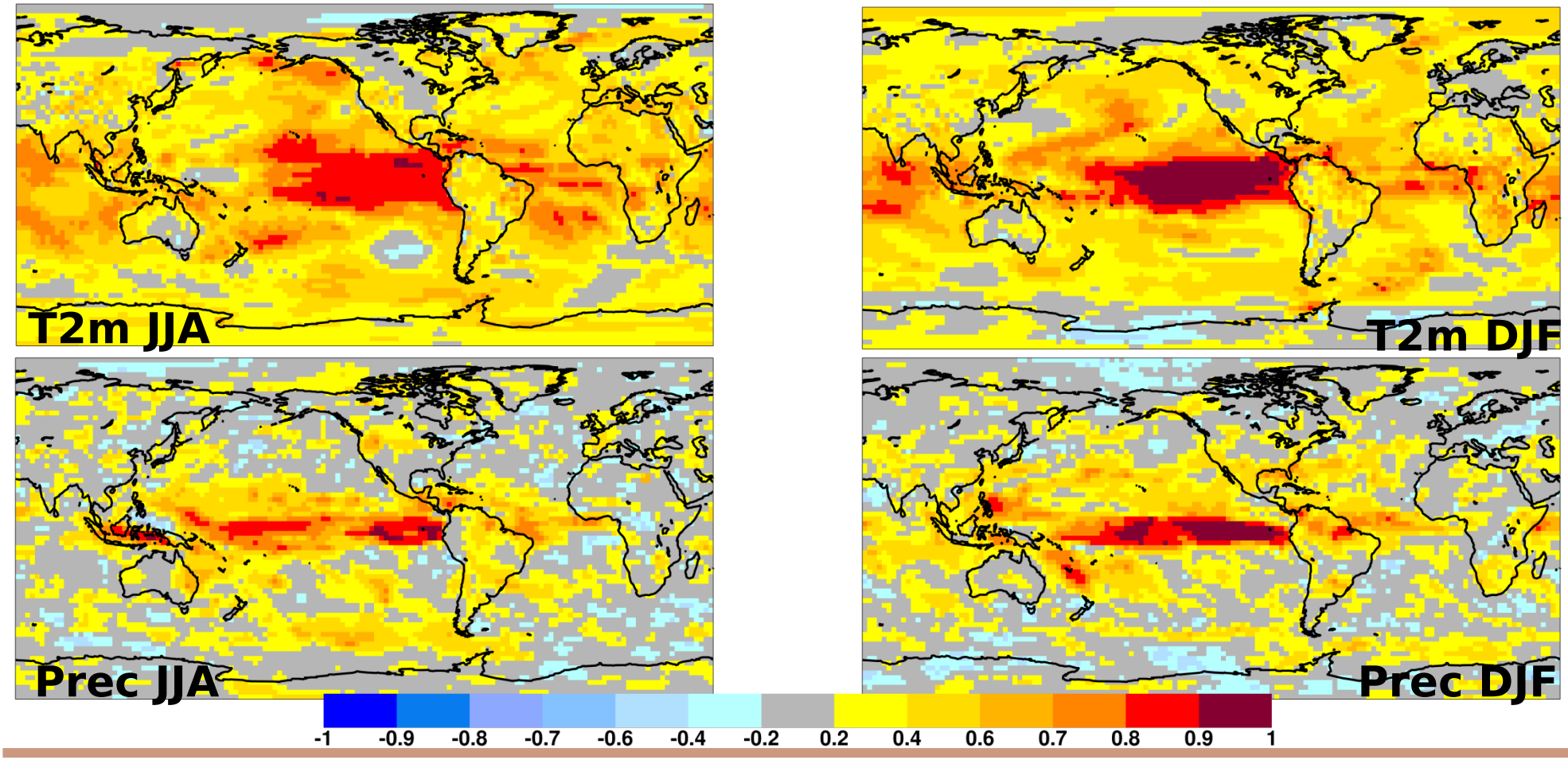
Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialization and systematic comparison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



Meehl et al. (2009)

Typical seasonal forecast skill

Correlation of the ensemble mean for the ENSEMBLES multi-model (45 members) wrt ERA40-ERAInt (T2m over 1960-2005) and GPCP (precip over 1980-2005) with 1-month lead.



Some open fronts

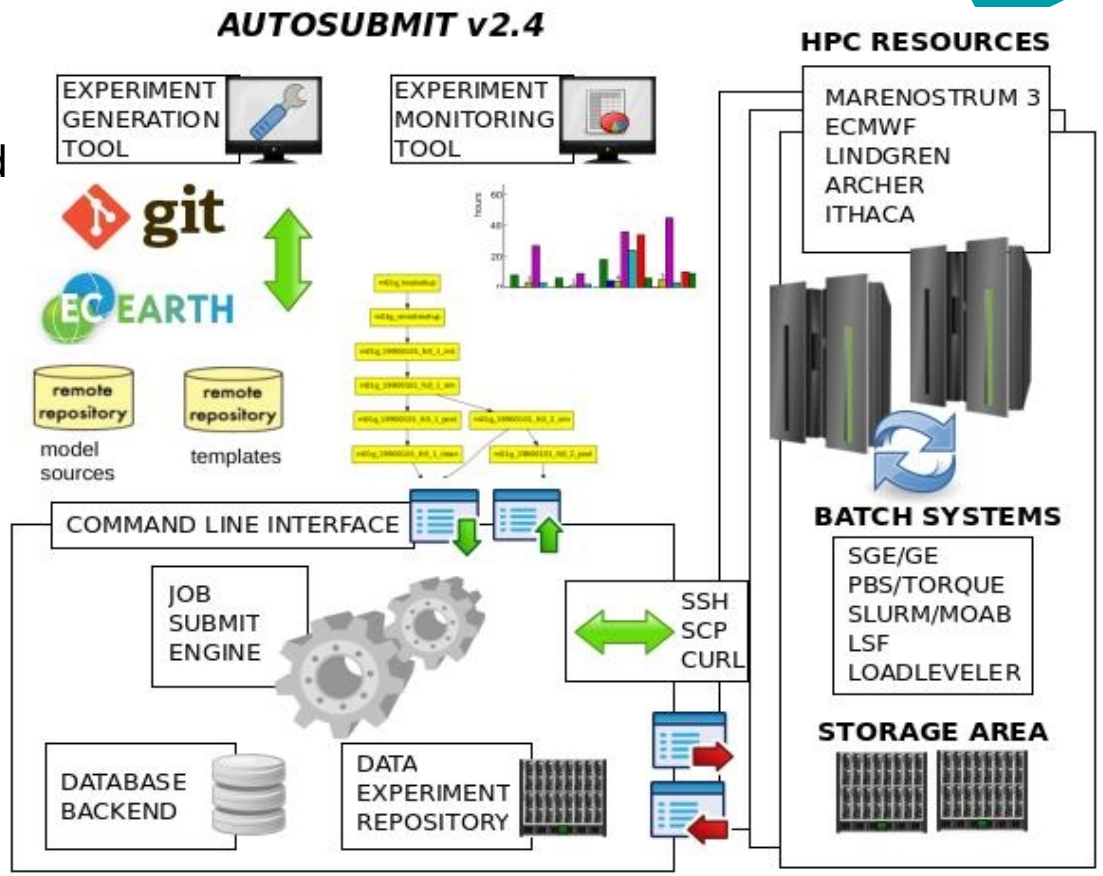
- Work on initialisation: initial conditions for all components (including better ocean), better ensemble generation, etc. Link to observational and reanalysis efforts.
- Model improvement: leverage knowledge and resources from modelling at other time scales, drift reduction. More efficient codes and adequate computing resources.
- Calibration and combination: empirical prediction (better use of current benchmarks), local knowledge.
- Forecast quality assessment: scores closer to the user, reliability as a main target, process-based verification.
- Improving many processes: sea ice, projections of volcanic and anthropogenic aerosols, vegetation and land, ...
- More sensitivity to the users' needs: going beyond downscaling, better documentation (e.g. use the IPCC language), demonstration of value and outreach.

Autosubmit

Autosubmit acts as a wrapper to run a climate experiment on a HPC. The experiment is a sequence of jobs that it submits, manages and monitors. When a job is complete, the next one can be executed.

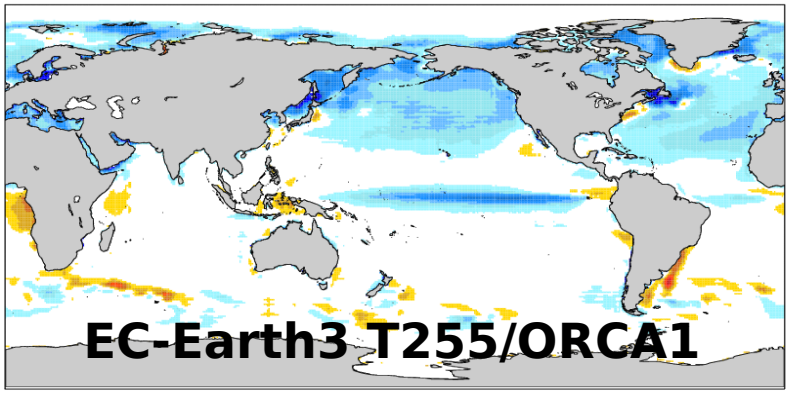
- Divided in 3 phases: ExpID assign, experiment creation, run.
- Separation experiment/autosubmit cod
- Config files for autosubmit and experiment.
- Database to store experiment information.
- Common templates for all platforms.
- Recovery after crashes.
- Dealing with a list of schedulers and communication protocols.

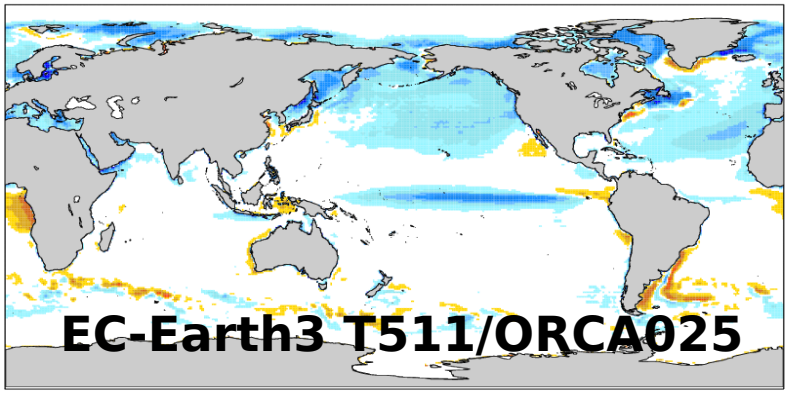
Each job has a colour in the monitoring tool: yellow=completed, green=running, blue=pending, etc.

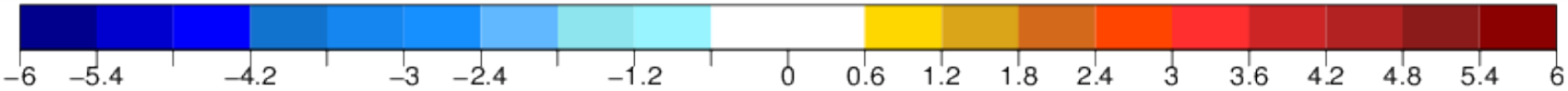


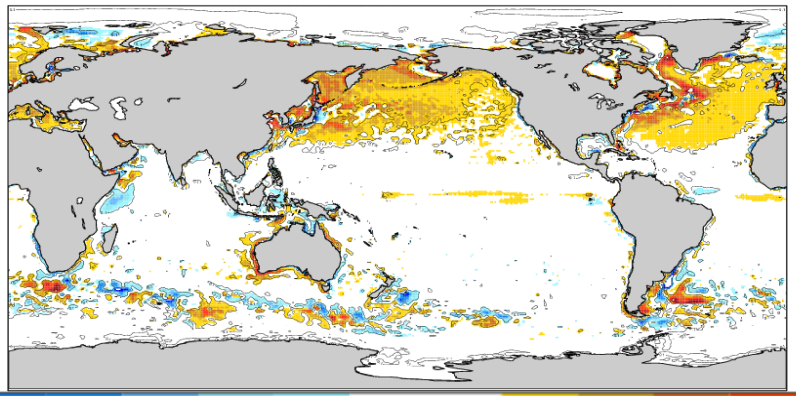
Increase in resolution: mean climate

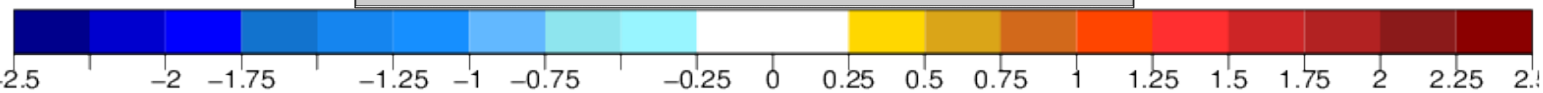
Mean SST (K) systematic error versus ERAInt for JJA one-month lead predictions of EC-Earth3 T255/ORCA1 and T511/ORCA025. May start dates over 1993-2009 using ERA-Interim and GLORYS initial conditions.



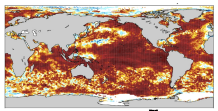








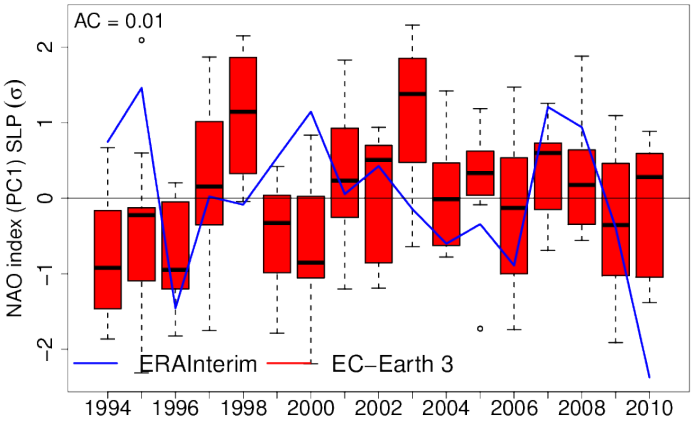
C. Prodhomme (IC3)



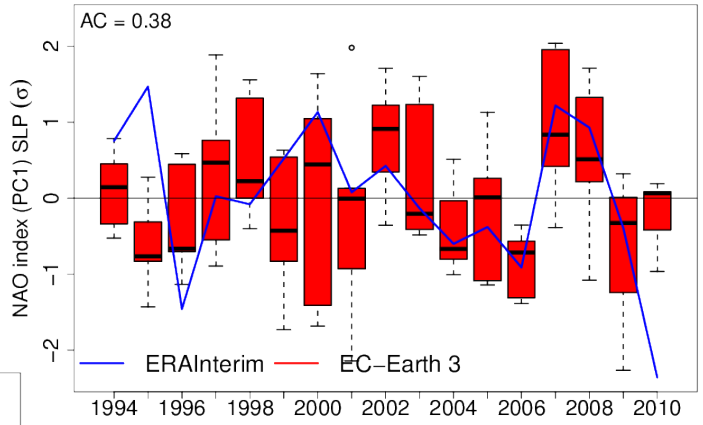
Predicting NA atmospheric circulation

Predictions of DJF NAO with **EC-Earth3 low and high resolution** and ECMWF S4 started in November over 1993-2009 with ERA-Interim and GLORYS initial conditions and five-member ensembles. Correlation of the ensemble mean on top left.

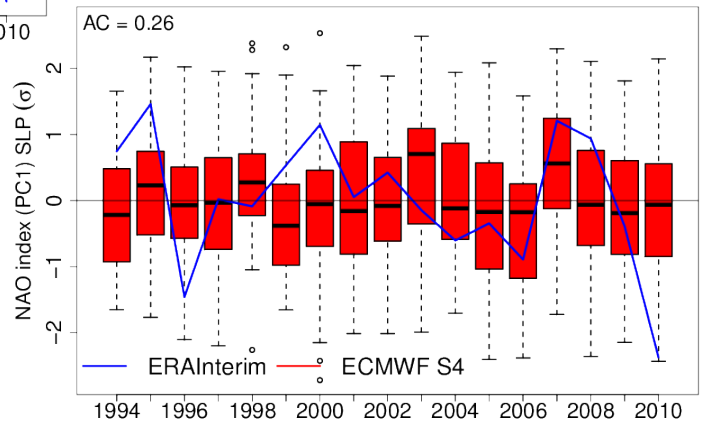
EC-Earth3 T255/ORCA1



EC-Earth3 T511/ORCA025



ECMWF S4



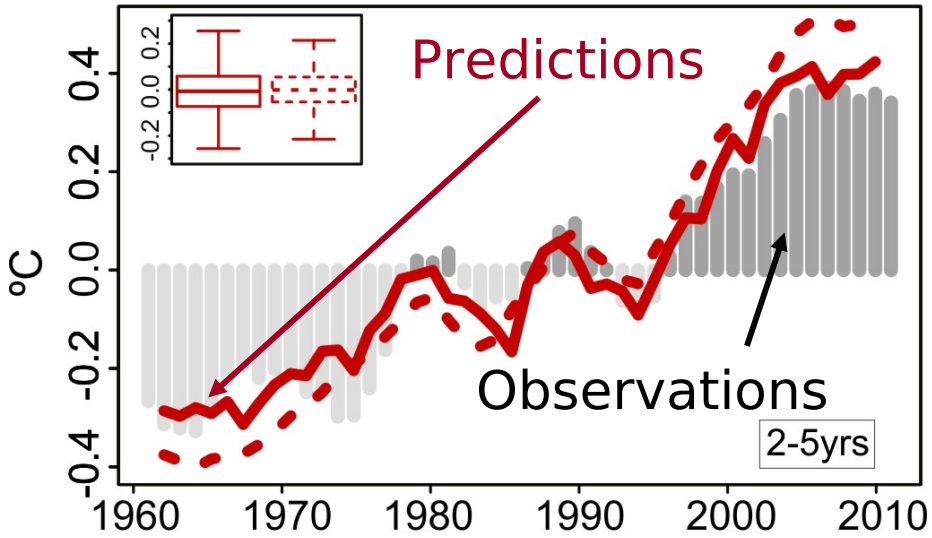
Batté et al. (2014)

HiResClim

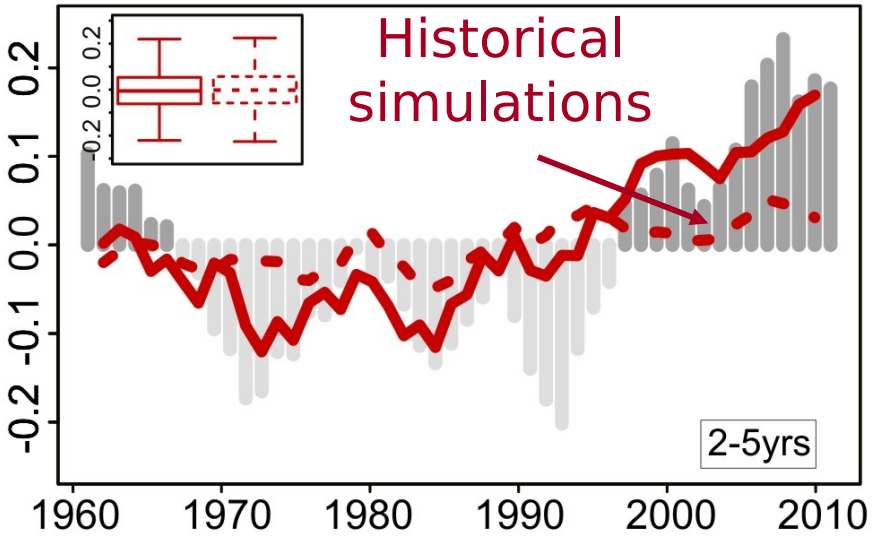
CMIP5 decadal predictions

CMIP5 decadal predictions. Global-mean t2m and AMV against GHCN/ERSST3b for forecast years 2-5. **The initialised experiments reproduce the GMST trends and the AMV variability and suggest that initialisation corrects the forced model trend and phases in some of the internal variability.**

Global mean surface atmospheric temperature



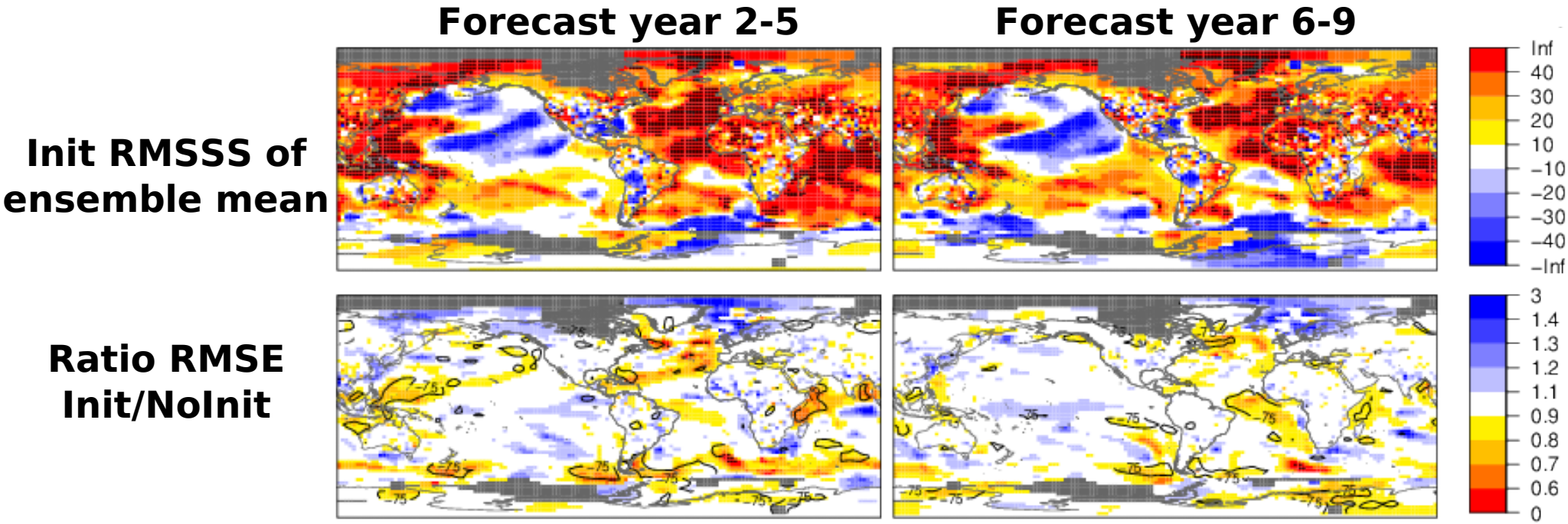
Atlantic multidecadal variability (AMV)



Doblas-Reyes et al. (2013)

Impact of initialisation in CMIP5

(Top row) Root mean square skill score (RMSSS) of the ensemble mean of the initialised predictions and (bottom row) ratio of the root mean square error (RMSE) of the initialised and uninitialised predictions for the near-surface temperature from the multi-model CMIP5 experiment (1960-2005) for (left) 2-5 and (right) 6-9 forecast years. Five-year start date interval.



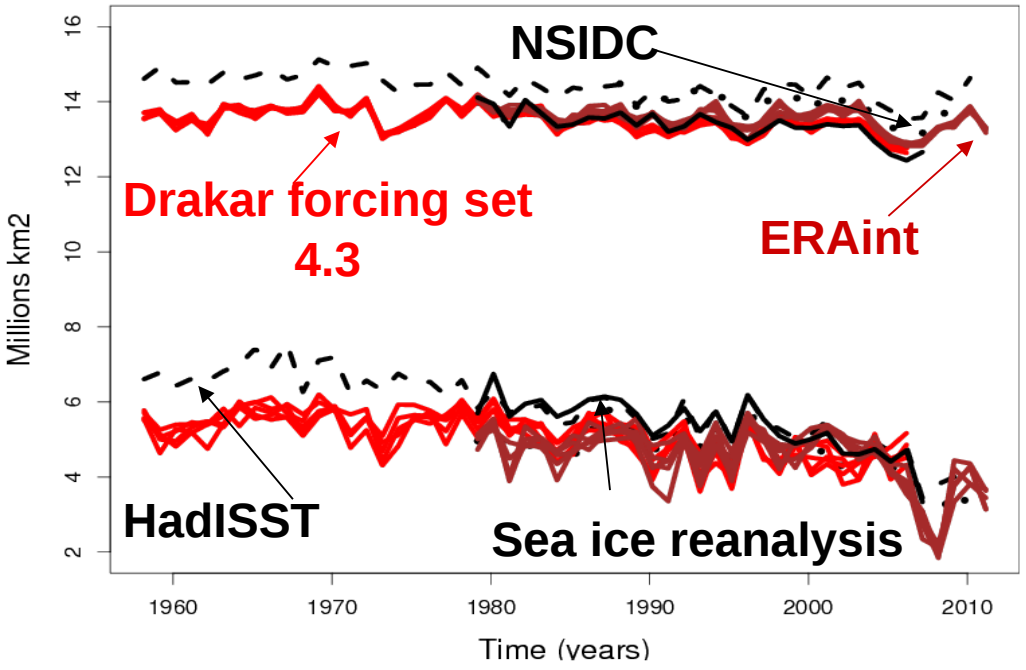
Doblas-Reyes et al. (2013)

Initial conditions: sea-ice reconstructions

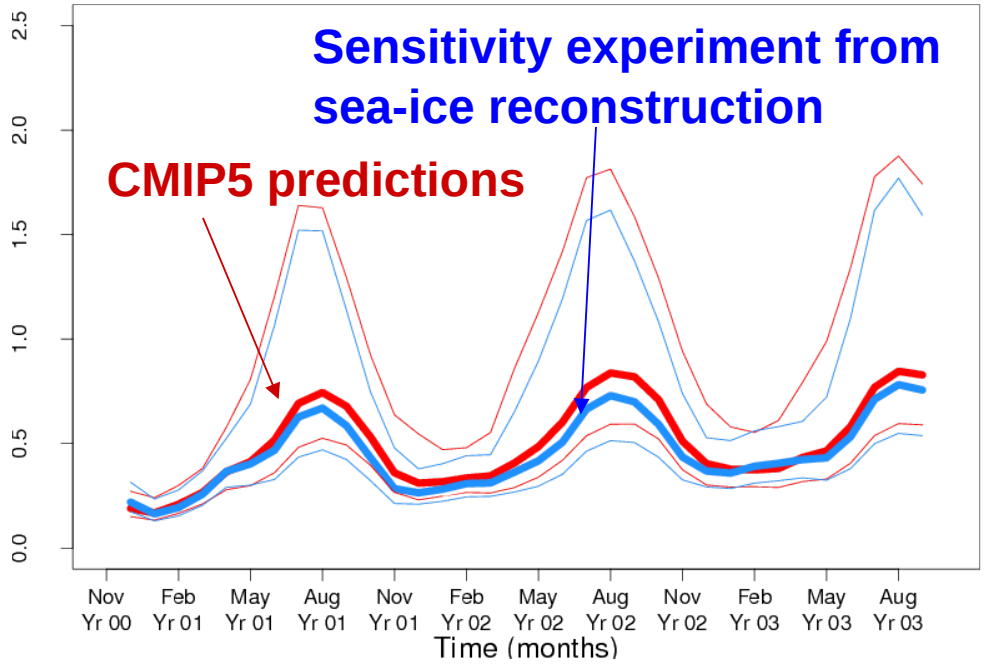
Sea ice simulation constrained by ocean and atmosphere observational data

Arctic sea ice area

March and September reconstruction



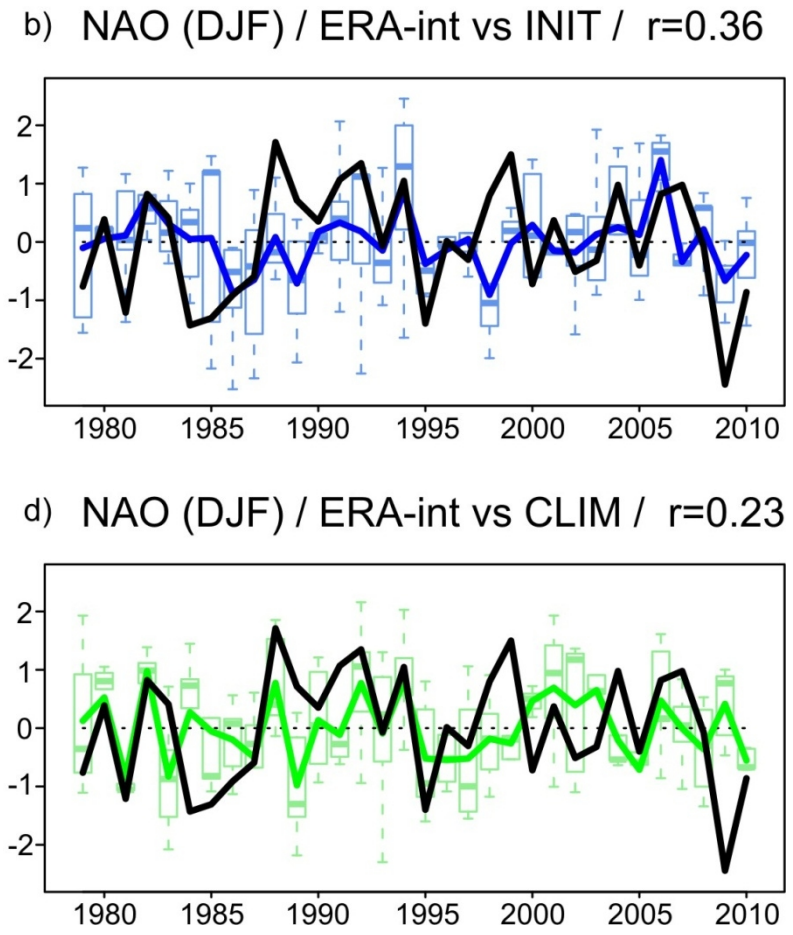
Root Mean Square Error of predictions



Guemas et al. (2014)

Predicting NA atmospheric circulation

Predictions of DJF NAO with EC-Earth2.3 started in November over 1979-2010 with ERAInt and ORAS4 initial conditions. Two sets, one initialised **with realistic (top) and one with climatological (bottom) sea-ice initial conditions**.

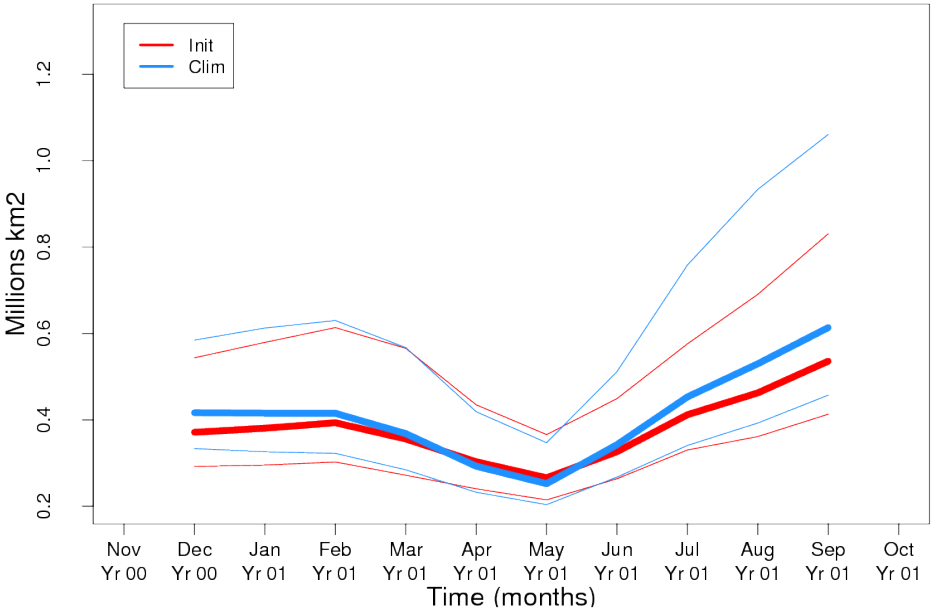


J. García-Serrano (IPSL)

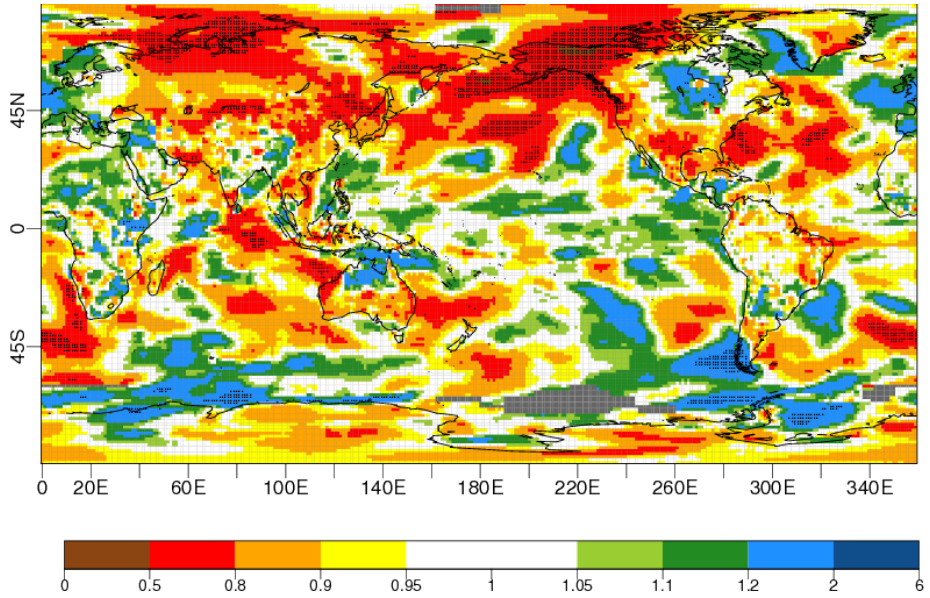
Impact of initialisation: Sea ice

Predictions with EC-Earth2.3 started every November over 1979-2010 with ERAInt and ORAS4 initial conditions, and a sea-ice reconstruction. Two sets, one initialised with realistic and another one with climatological sea-ice initial conditions. Substantial reduction of temperature RMSE in the northern high latitudes when using realistic sea-ice initialisation.

RMSE Arctic sea-ice area



Ratio RMSE Init/Clim hindcasts 2-metre temperature (months 2-4)

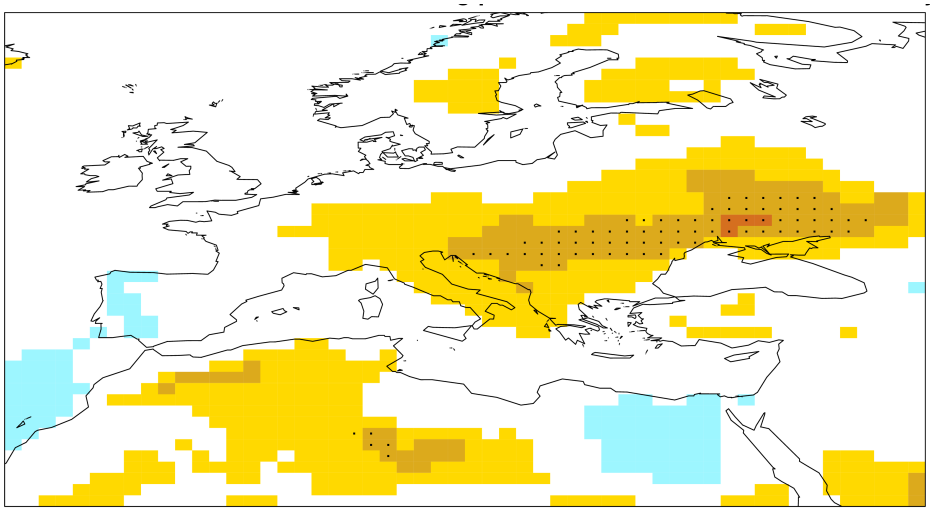


Guemas et al. (2014)

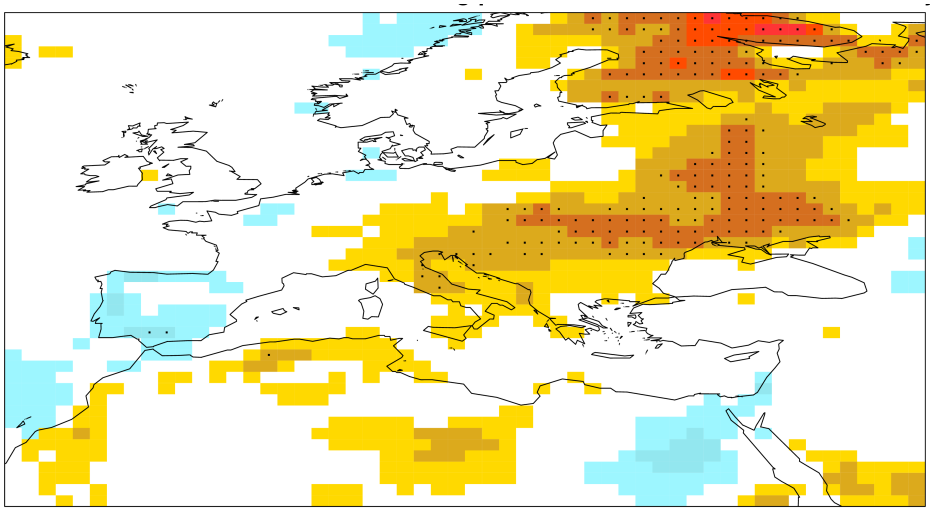
Impact of initialisation: Land surface

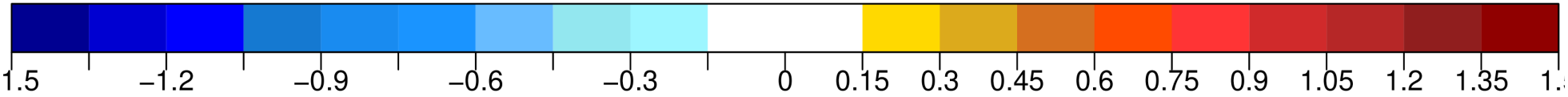
Difference in the correlation of the ensemble-mean near-surface temperature from two experiments, one using a realistic and another a climatological land-surface initialisation. Results for EC-Earth2.3 started every May over 1979-2010 with ERAInt and ORAS4 initial conditions and a sea-ice reconstruction.

INIT-CLIM mean T



INIT-CLIM T max

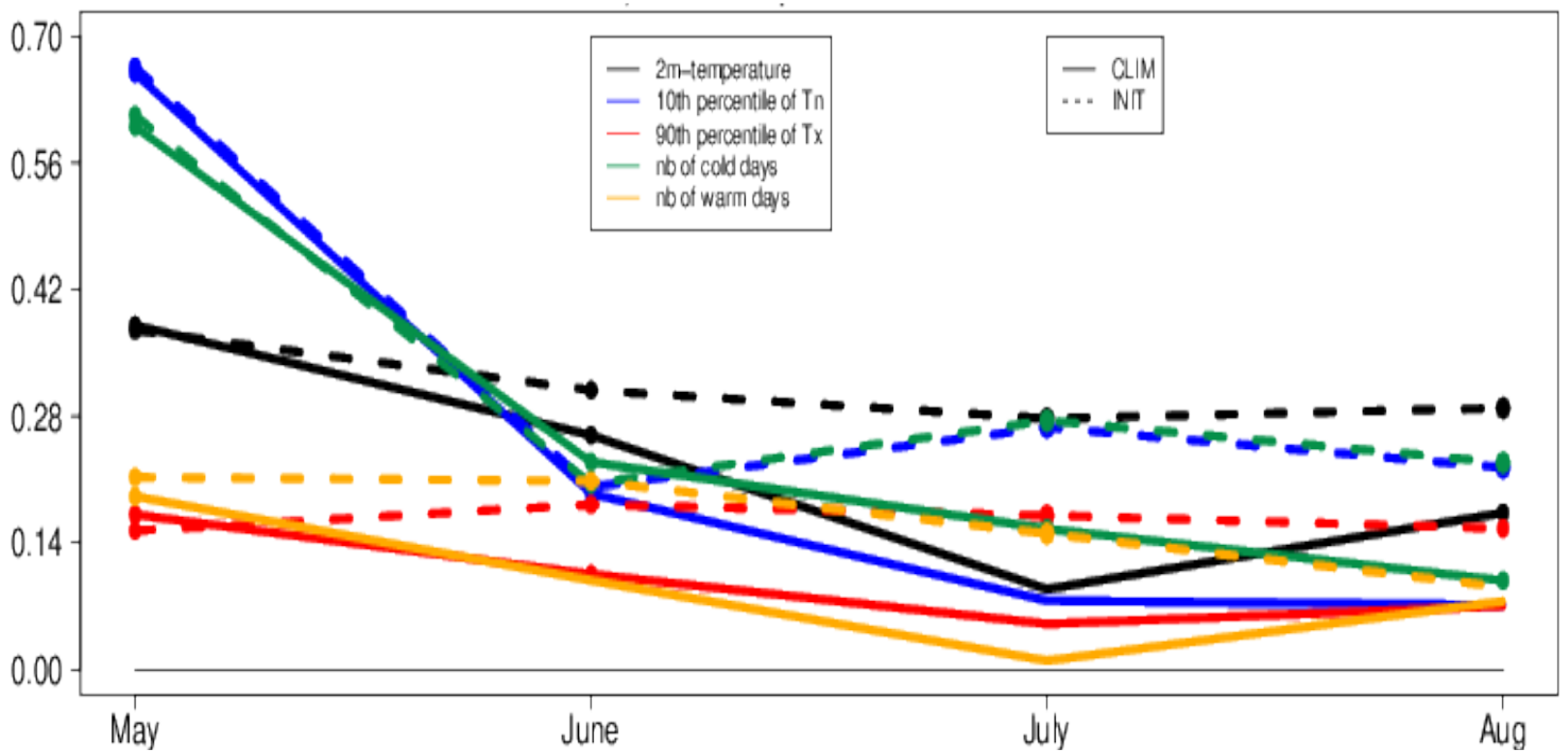




C. Prodhomme (IC3)

Impact of initialisation: Land surface

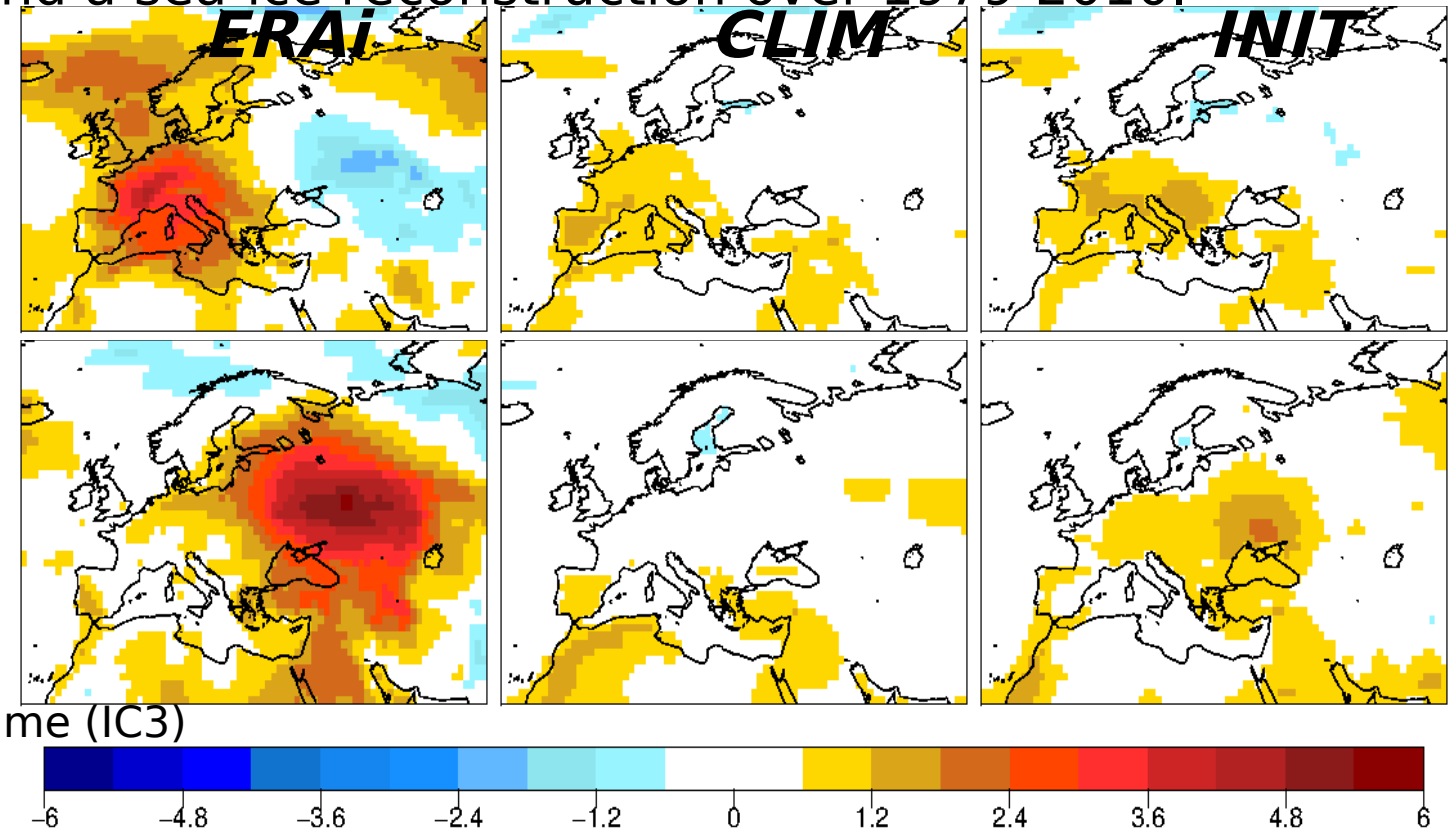
MACC of the ensemble-mean for several temperature variables from experiments with a realistic (dashed) and a climatological (solid) land-surface initialisation. Results for EC-Earth2.3 started in May with initial conditions from ERAInt, ORAS4 and a sea-ice reconstruction over 1979-2010.



C. Prodhomme (IC3)

Impact of initialisation: Land surface

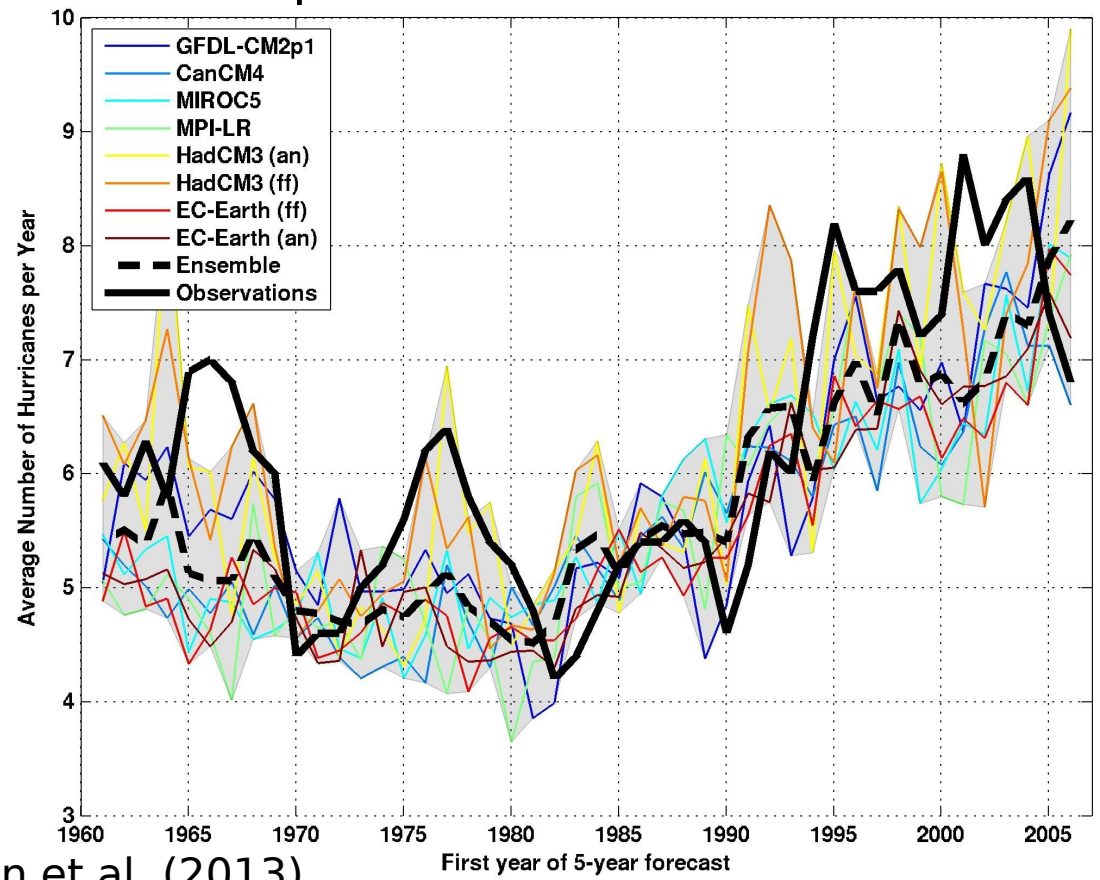
JJA precipitation in 2003 (top row) and near-surface temperature in 2010 (bottom row) anomalies from ERAInt (left) and experiments with a climatological (centre) and a realistic (right) land-surface initialisation. Results for EC-Earth2.3 started in May with initial conditions from ERAInt, ORAS4 and a sea-ice reconstruction over 1979-2010.

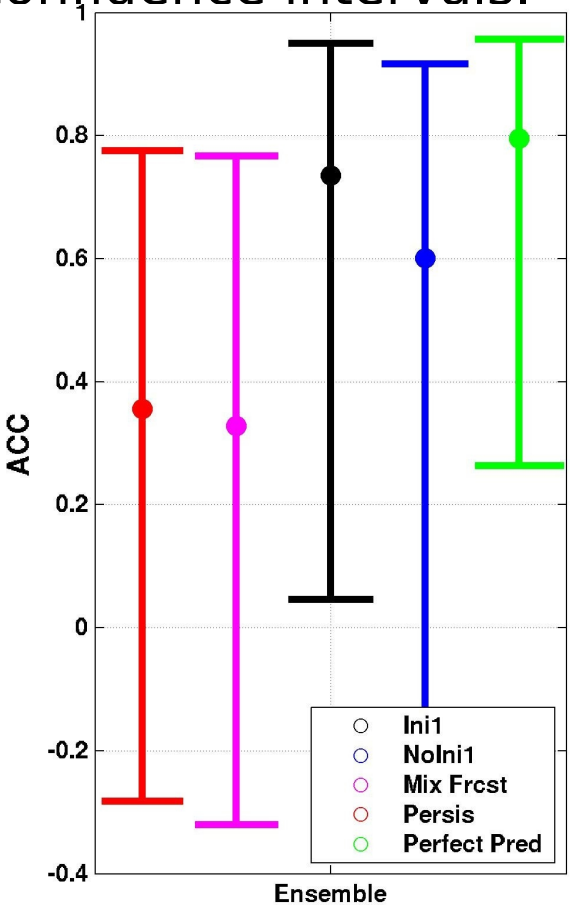


C. Prodhomme (IC3)

Hurricane frequency prediction

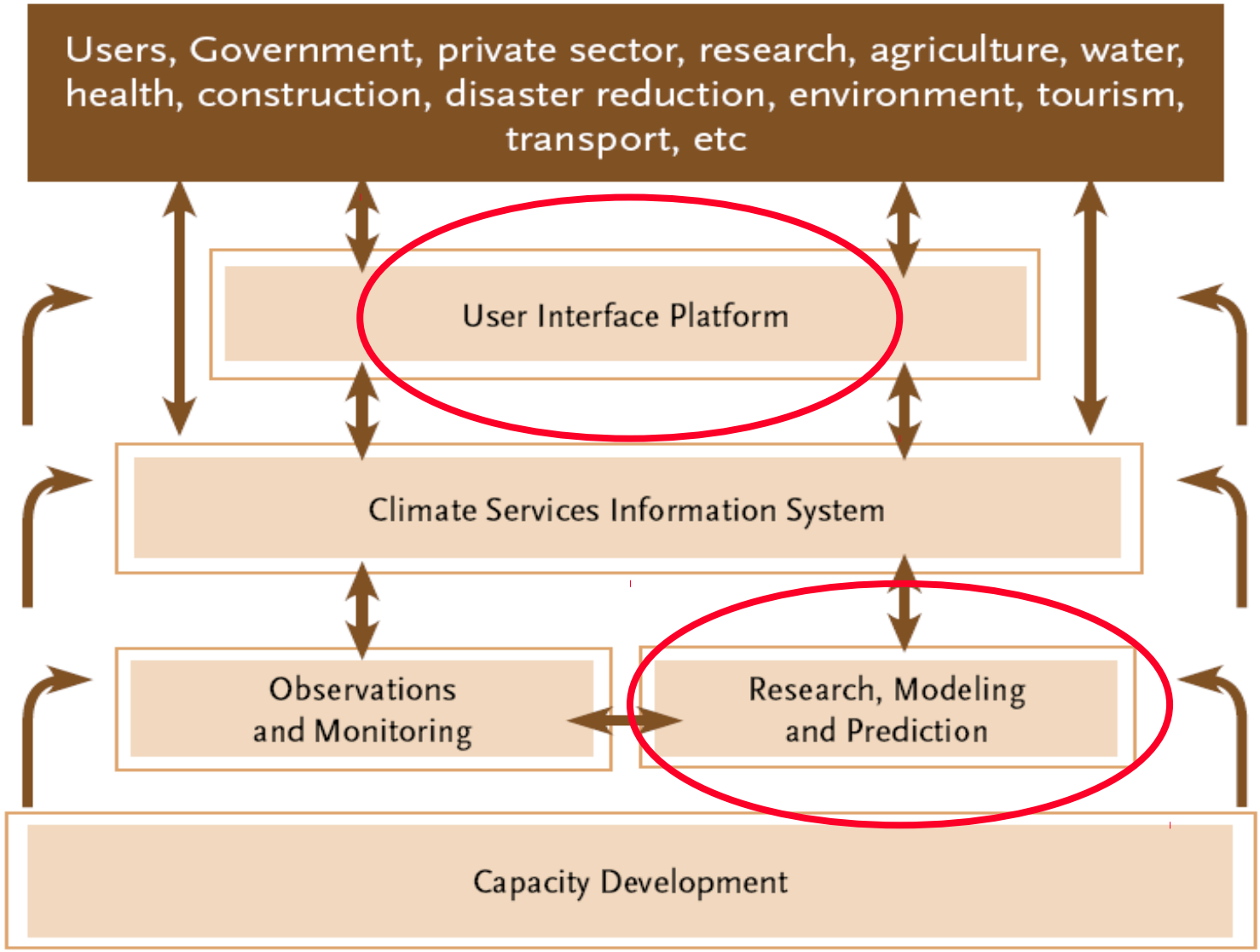
Average number of hurricanes per year estimated from observations and from the CMIP5 multi-model decadal prediction ensemble (forecast years 1-5). The correlation of the ensemble mean for the initialized, uninitialized and statistical predictions are shown with the 95% confidence intervals.





Caron et al. (2013)

Global framework on climate services



Some of the things missing

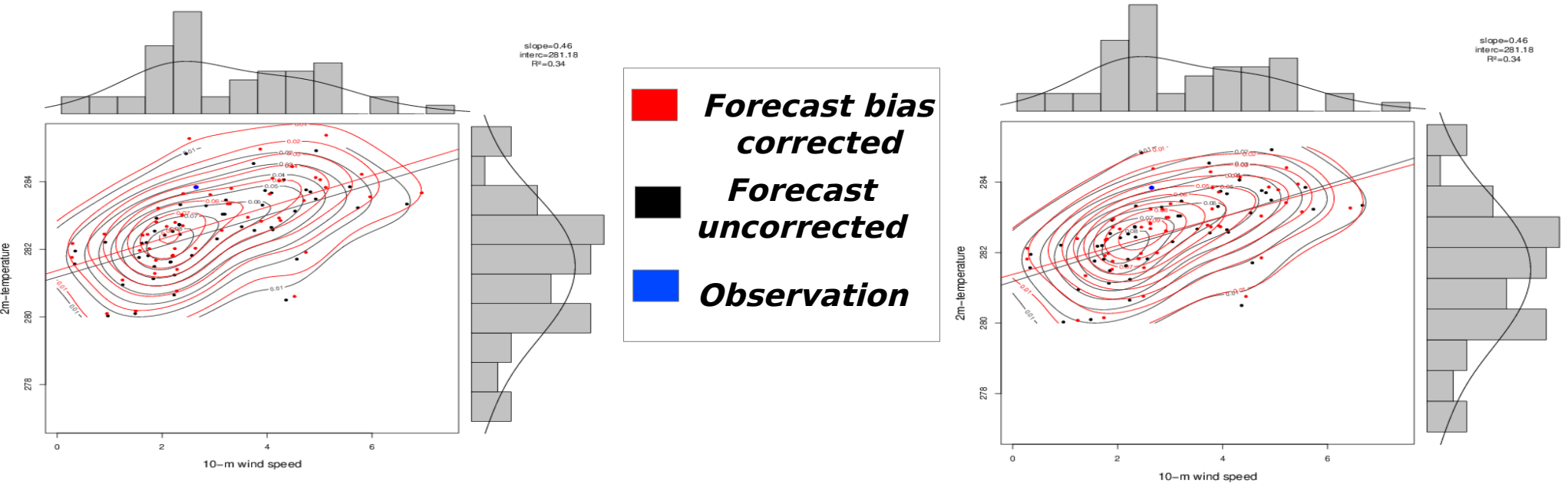
- Understanding of the impact models, and the best way to adapt them to the useful climate information available
- Bias correction
- Calibration and combination
- Downscaling, when necessary
- Documentation (follow the IPCC calibrated language), demonstration of value and outreach
- The EUPORIAS project, working alongside SPECS, is considering solutions to address some of these problems.

Bias correction

Bias correction is necessary, but it can also impact the skill. Bias-corrected ECMWF S4 forecasts for November with start date in November over 1981-2012. One-year-out cross-validation applied.

Method 1: Simple

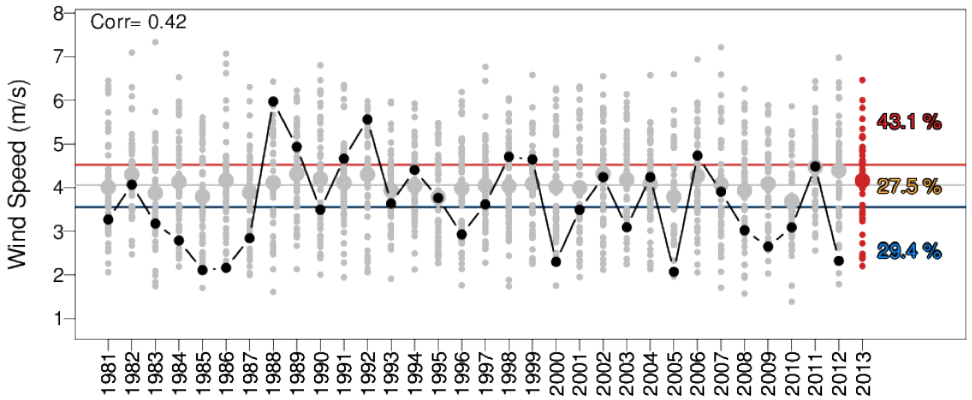
Method 2: Percentile Matching

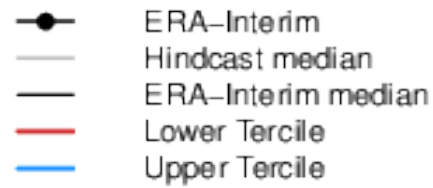


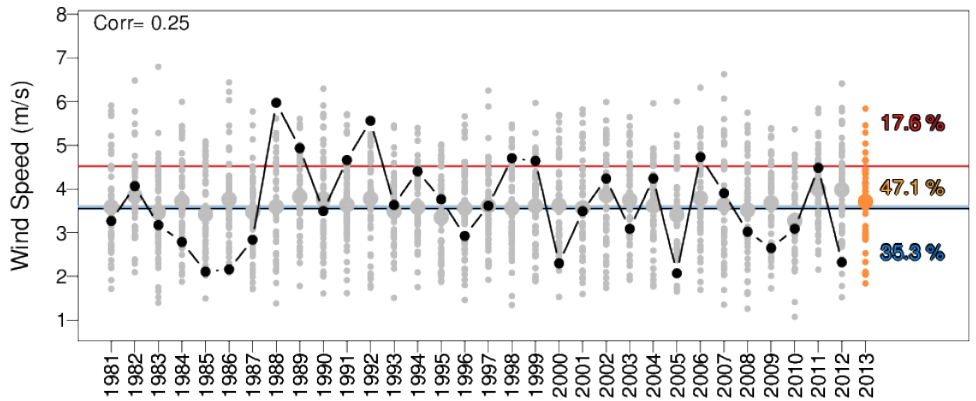
V. Torralba (IC3)

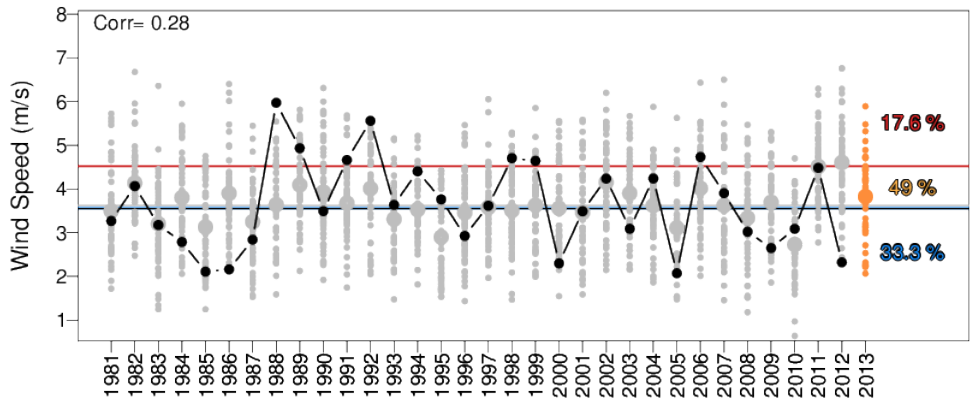
Bias correction and calibration

Bias correction and calibration have different effects. ECMWF S4 predictions of 10 m wind speed over the North Sea for DJF starting in November. Raw output (top), bias corrected (simple scaling, left) and ensemble calibration (right). One-year-out cross-validation applied.









V. Torralba (IC3)

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