Interannual Climate Prediction at IC3

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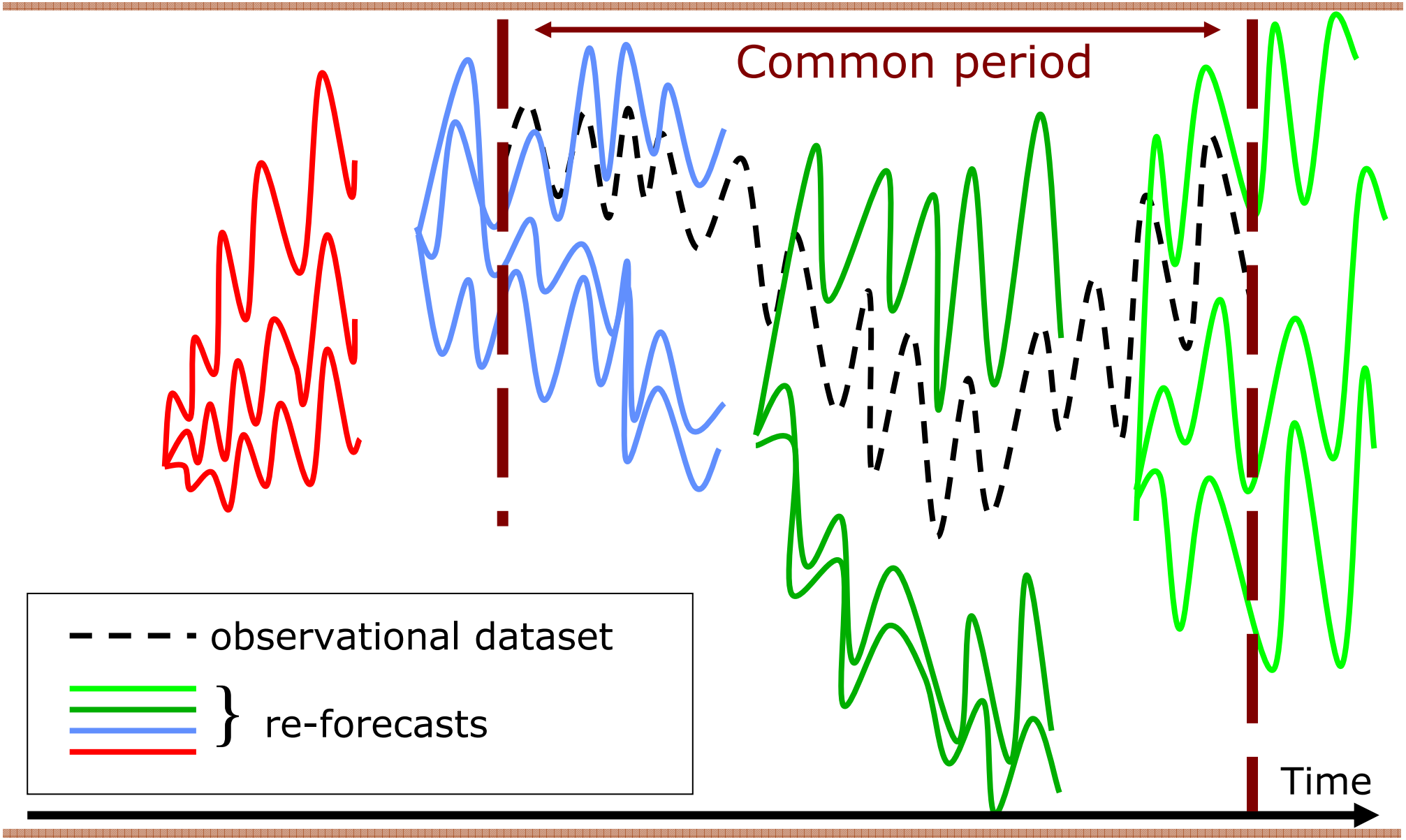
Outline

- Decadal experiment benchmarking
- CMIP5 decadal experiments
- Impact of sea-ice initial conditions in interannual forecasts
- Generation of sea-ice initial conditions
- Summary

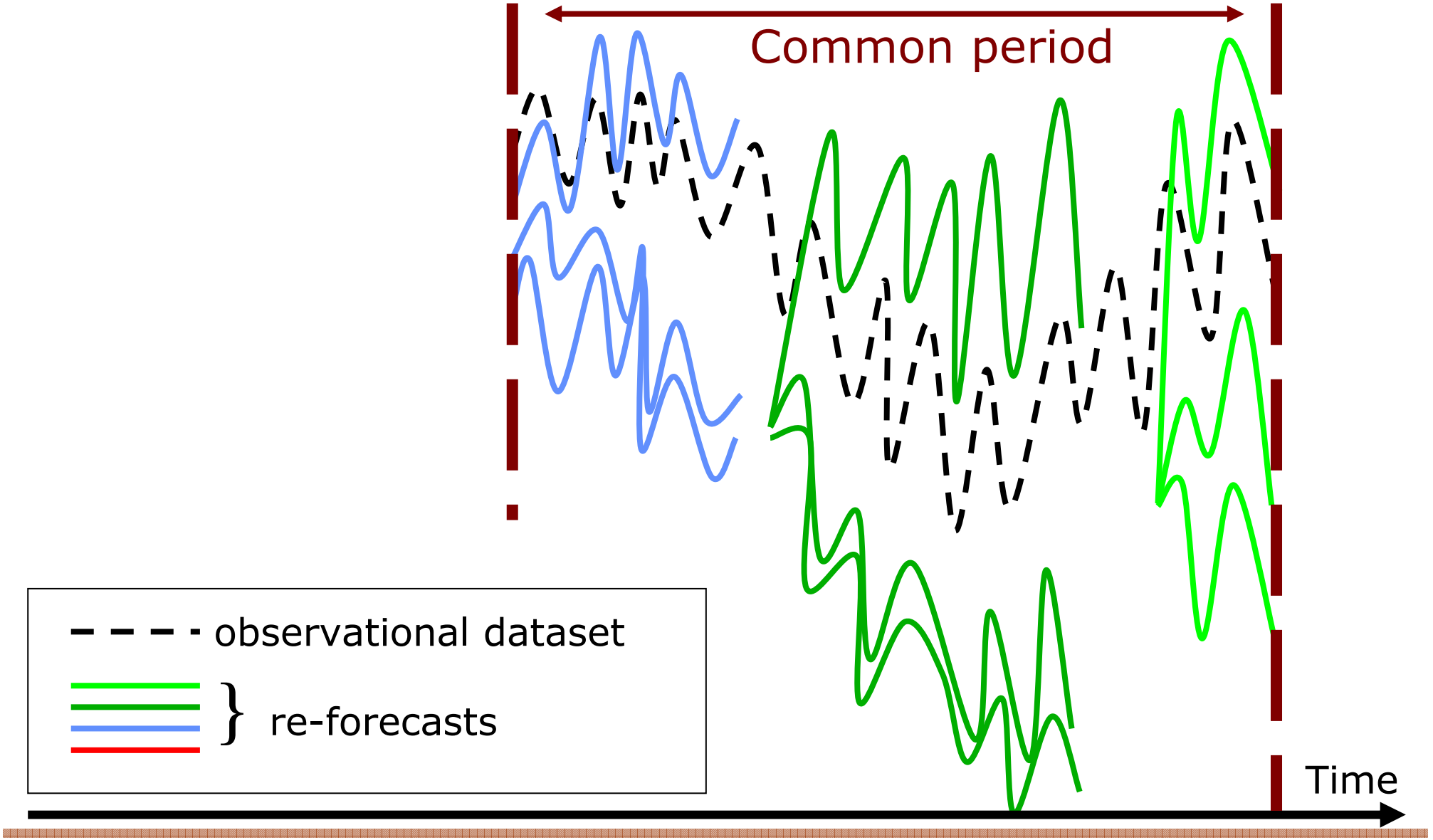
Formulating climate predictions

- Near-term climate predictions should make use of information about both anthropogenic climate change and natural decadal variability
- Empirical models
  - Characterize the observed variability of the past
  - Relies on reasonably good and long observational datasets
- Long-term climate change simulations
  - Ensembles of historical simulations and long-term projections, preferably multi-model
  - All bells and whistles forcings, but no initial-condition information
- Initialized predictions
  - Made with coupled Earth System Models with initialization of the climate system, particularly the oceans
  - Include observed and projected changing atmospheric composition

Estimating the climate



Estimating the climate



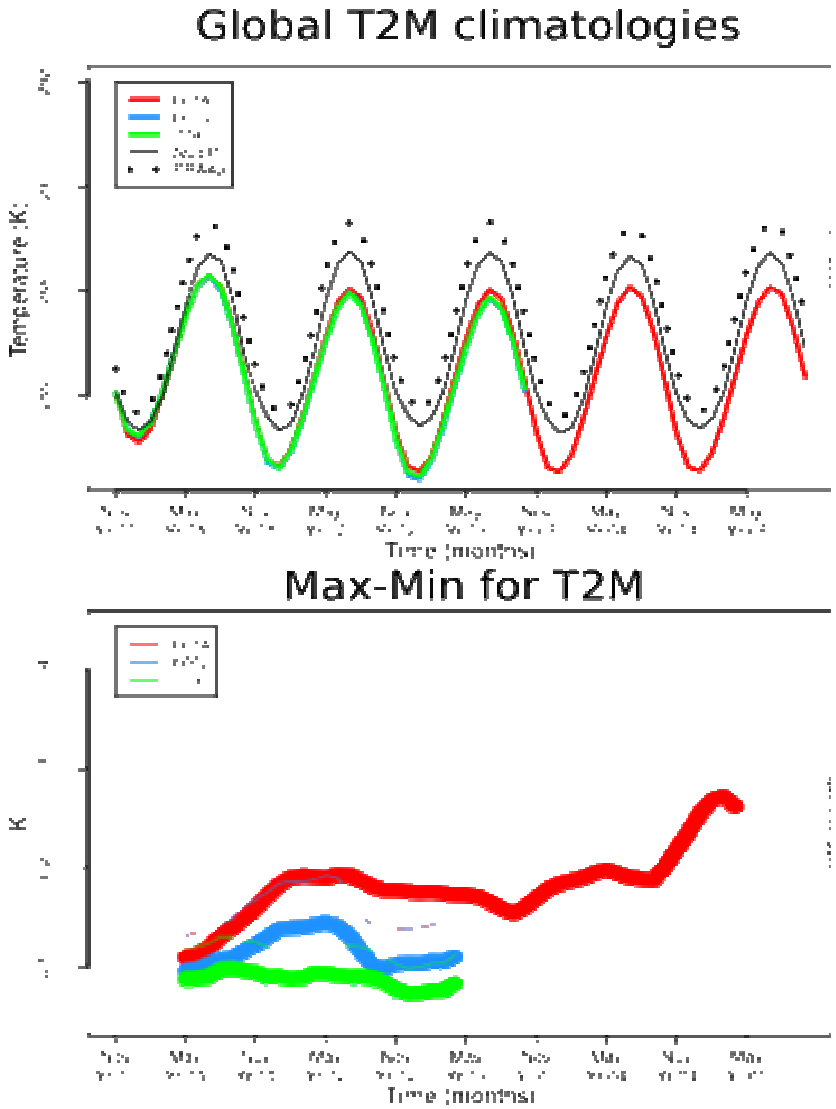
Benchmark of decadal experiments

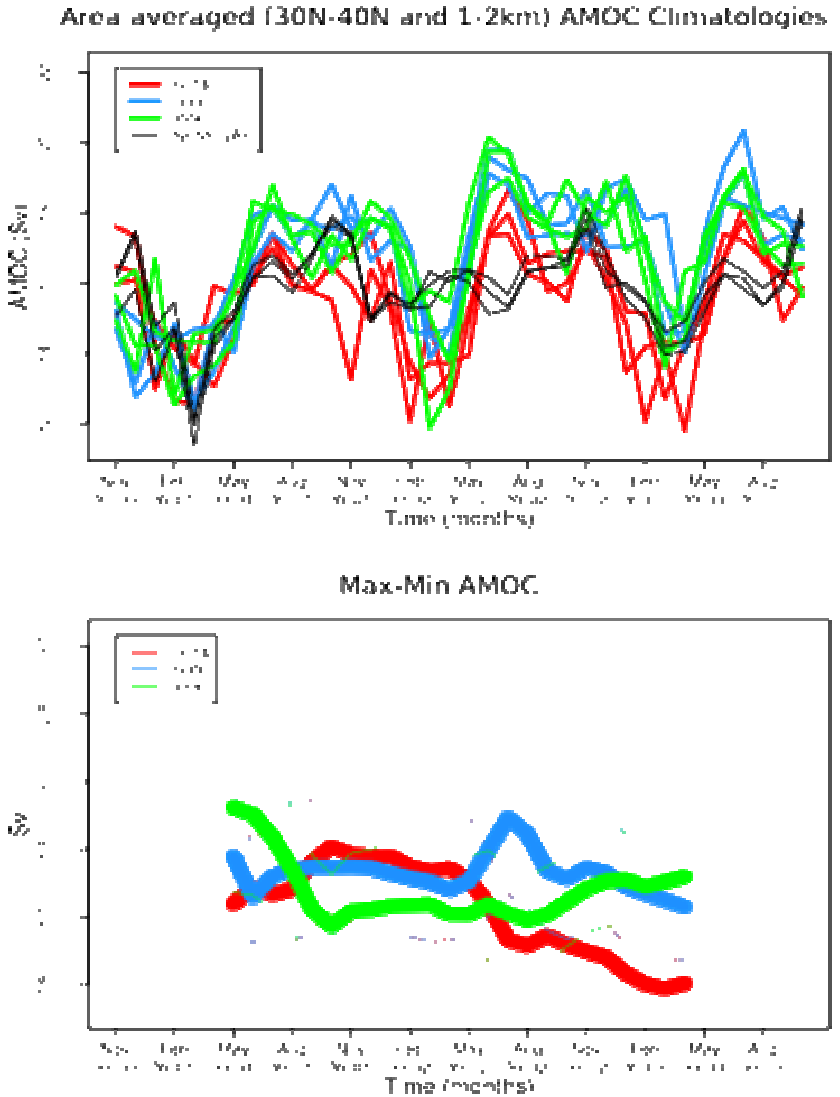
EC-Earth decadal experiments on different platforms: four start dates (1st Nov 1960, 1970, 1980, 1990), 3 members, same atmospheric ics

Experiment ID	Platform	Ocean initial conditions
b014 (v2.2)	Marenostrum	NEMOVAR-COMBINE
b00u (v2.3)	Marenostrum	NEMOVAR-S4
i00k (v2.3)	Ithaca	NEMOVAR-S4

- b014 and b00u use different ocean ics, version and same platform
- b00u and i00k use same ics, version and different platforms
- Variables used in the comparison:
  - Near surface temperature (T2M)
  - Sea-ice area (SIA) for both Arctic and Antarctic
  - Global ocean heat content (OHC) for 0-300m
  - Area averaged (30ºN-40ºN and 1-2km deep) Atlantic Meridional Overturning Circulation (AMOC)

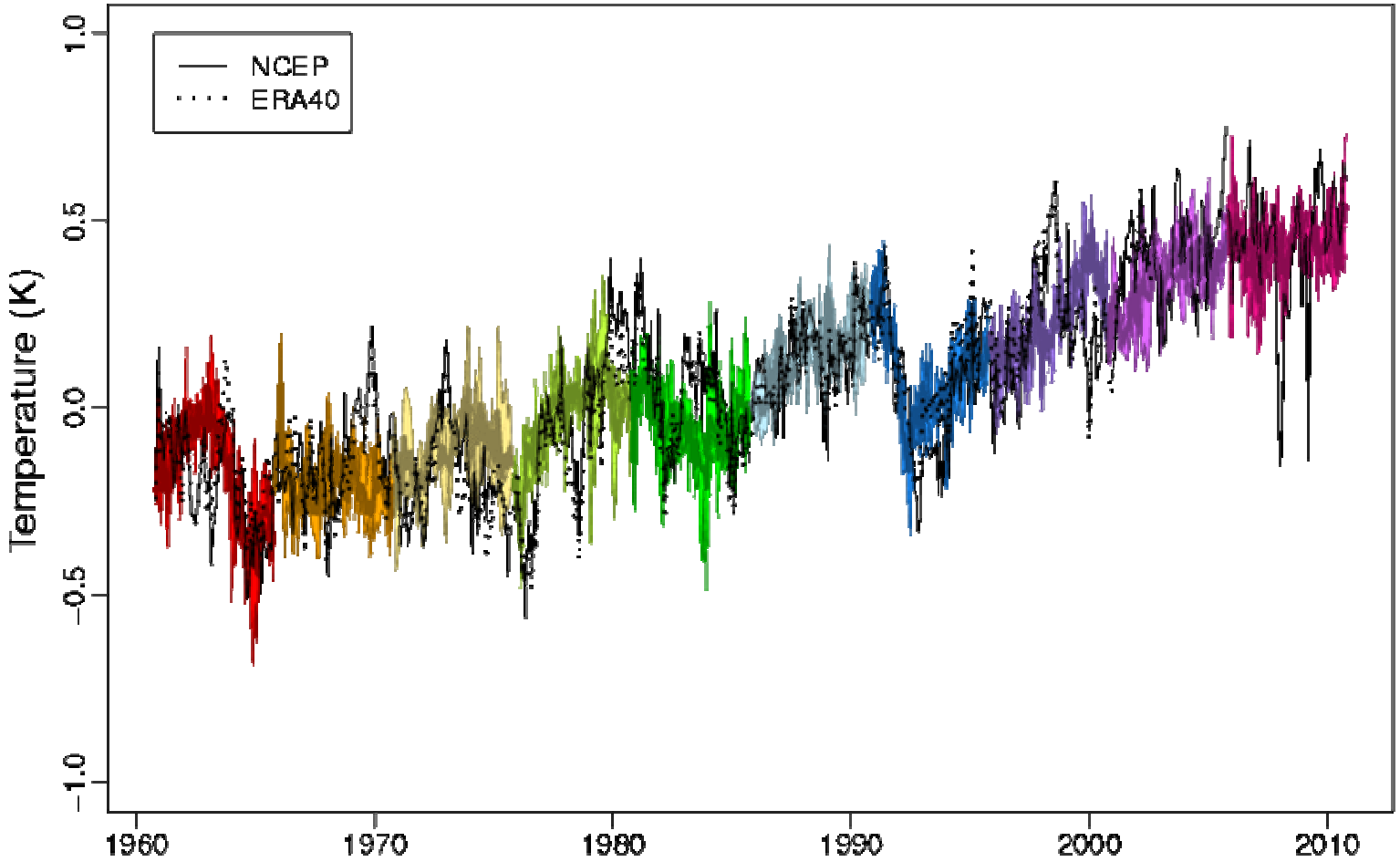
Benchmark of decadal experiments





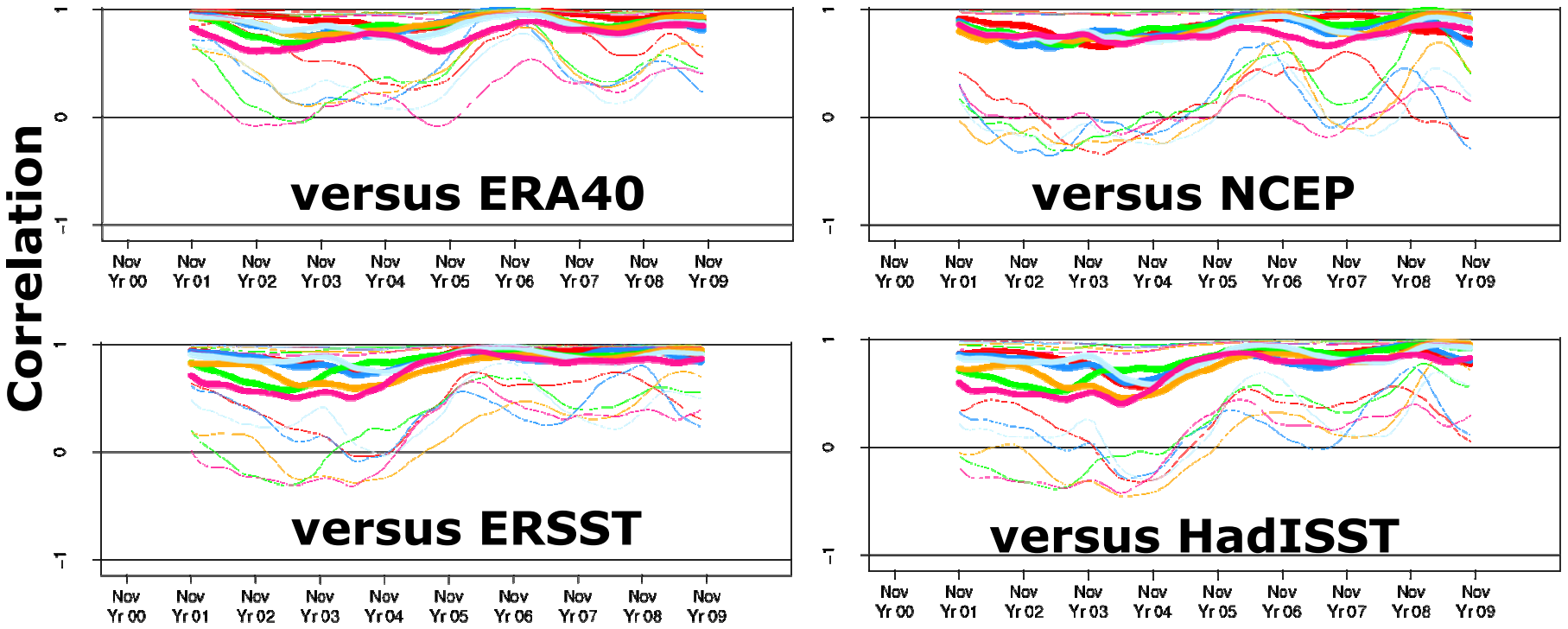
CMIP5 decadal experiments

Global-average near-surface air temperature ensemble (three members) re-forecasts performed with EC-Earth v2.3 over 1960-2005 (IC3, full initialization).



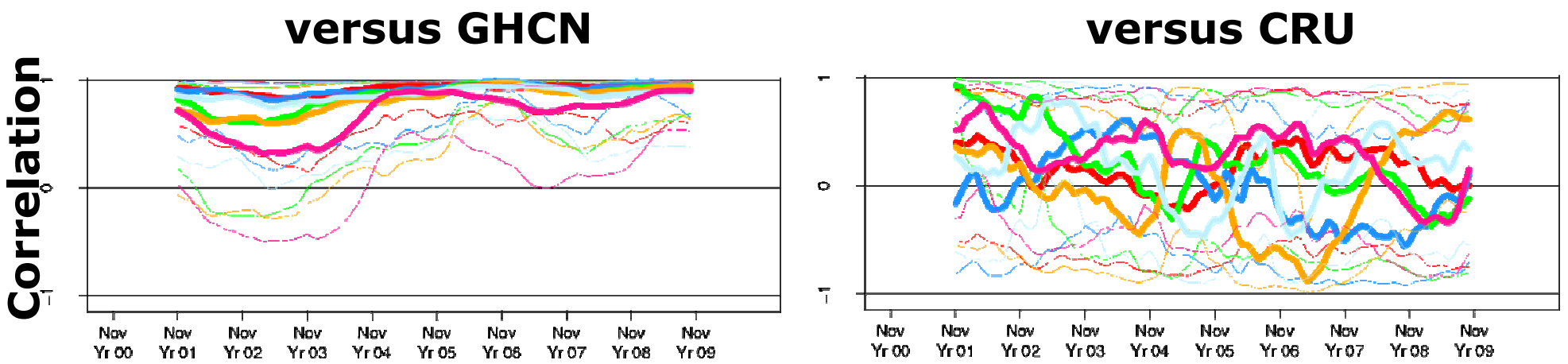
CMIP5 decadal predictions

Ensemble-mean correlation (and 95% confidence intervals) for EC-Earth (5), IFS/HOPE-33R1 (3), CERFACS (3), IfM (3), HadGEM2 (3), DePreSys_PP (9) global-average near-surface air (top row) and sea surface (65ºN-60ºS, bottom row) temperature re-forecasts (two-year running mean applied) over 1960-2005.



CMIP5 decadal predictions

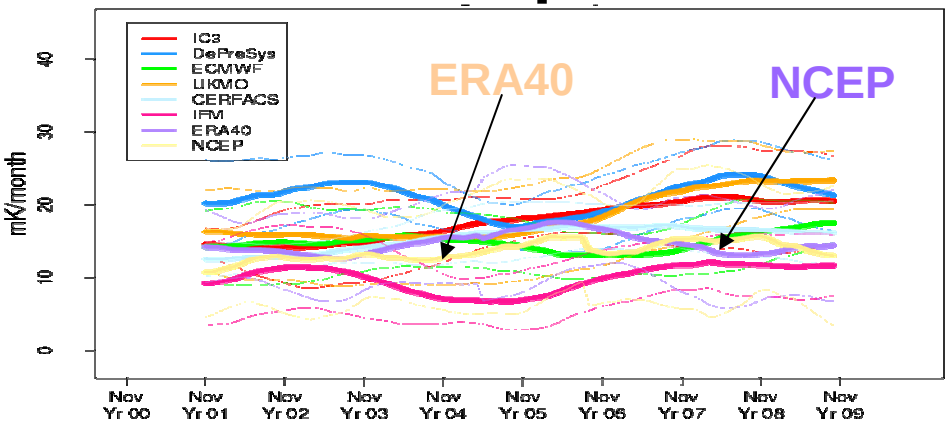
Ensemble-mean correlation (and 95% confidence intervals) for EC-Earth (5), IFS/HOPE-33R1 (3), CERFACS (3), IfM (3), HadGEM2 (3), DePreSys_PP (9) land-average temperature (left) and precipitation (right) re-forecasts (two-year running mean applied) over 1960-2005.



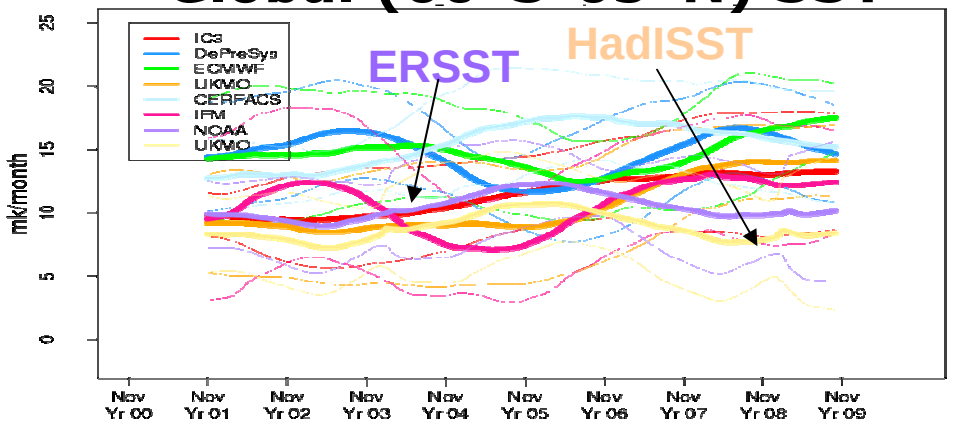
CMIP5 decadal predictions

Linear trends (and 95% confidence intervals) for EC-Earth (5), IFS/HOPE-33R1 (3), CERFACS (3), IfM (3), HadGEM2 (3), DePreSys_PP (9) re-forecasts (two-year running mean applied) over 1960-2005.

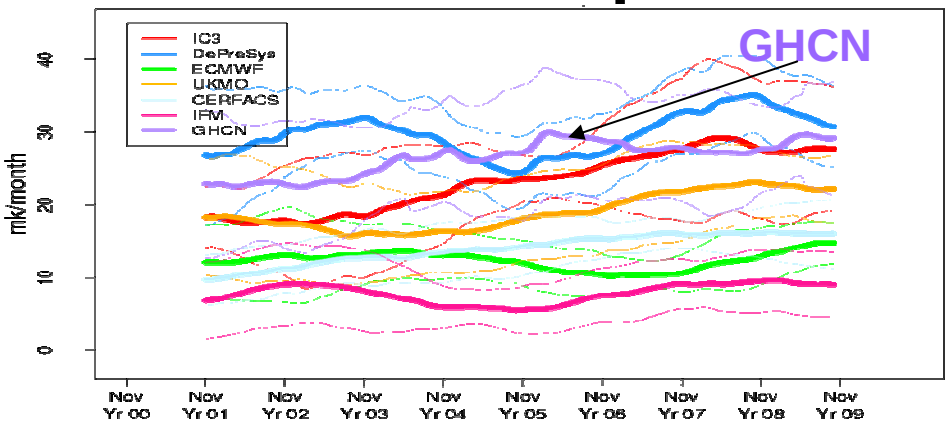
Global temperature



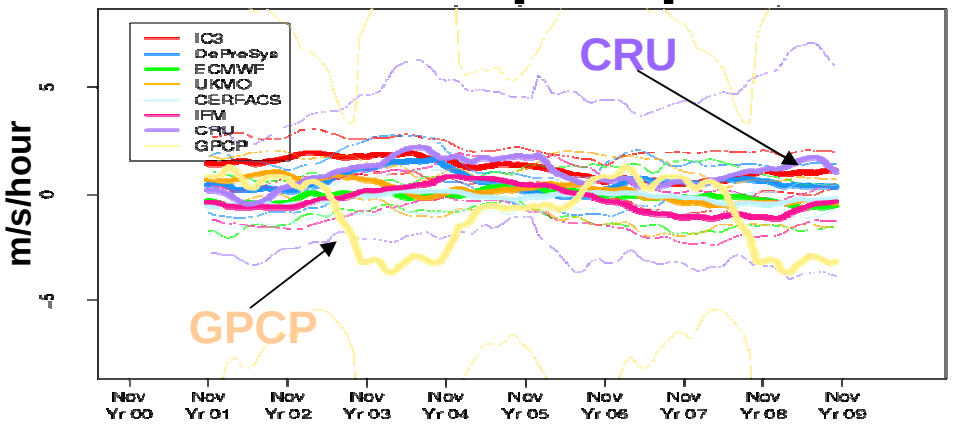
Global (60°S-65°N) SST



Global land temperature



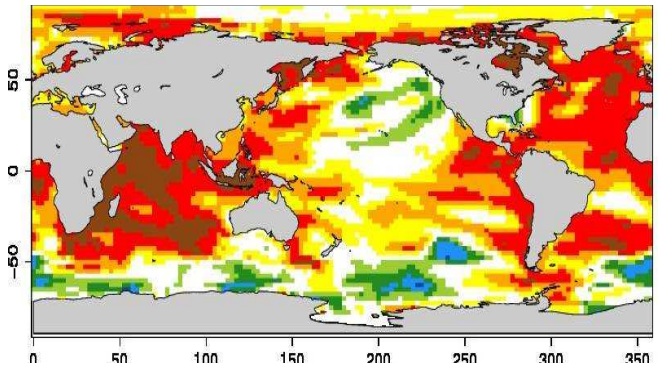
Global land precipitation



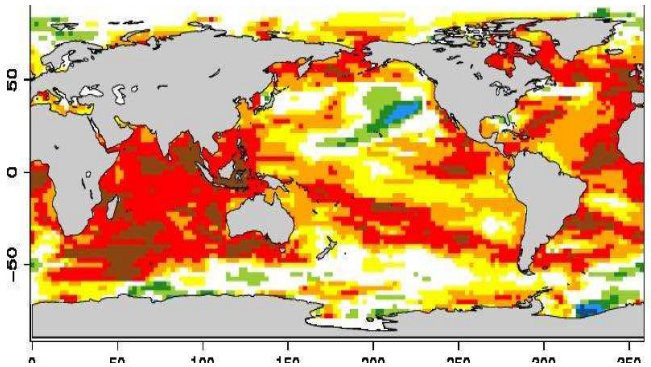
CMIP5 decadal predictions

Single-system ensemble-mean correlation for decadal forecasts (2-5 year average) of SSTs (1960-2005) wrt ERSST.

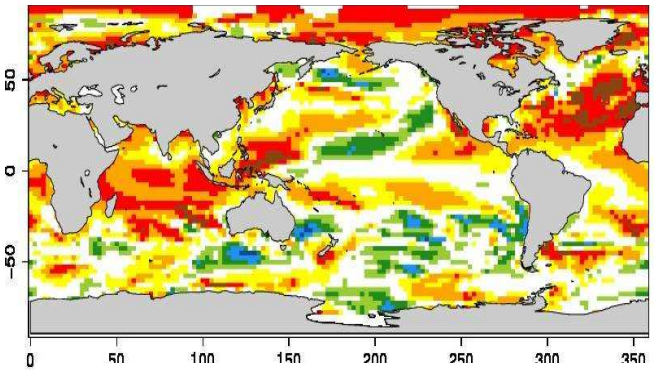
CERFACS



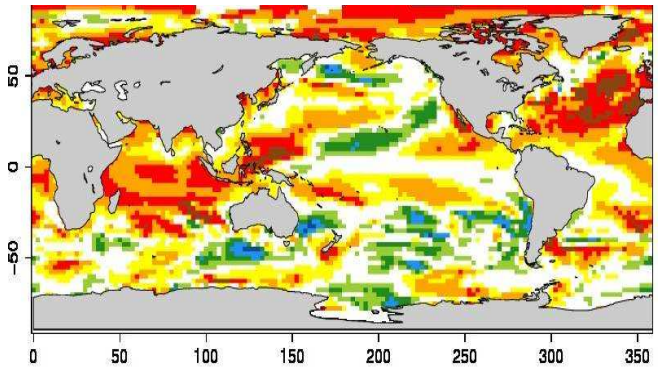
UKMO



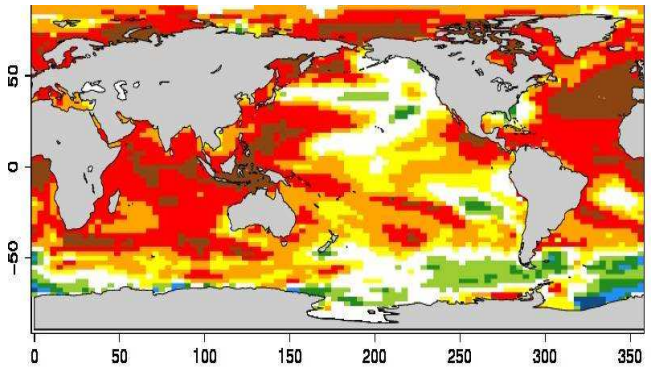
IFM-GEOMAR



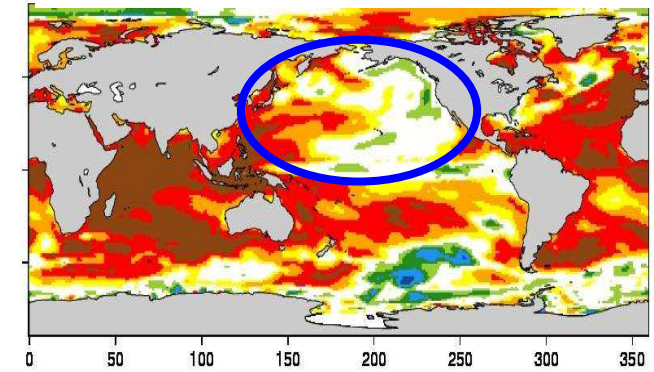
ECMWF

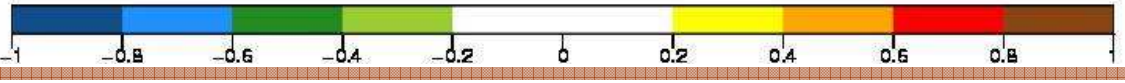


DePreSys



EC-Earth

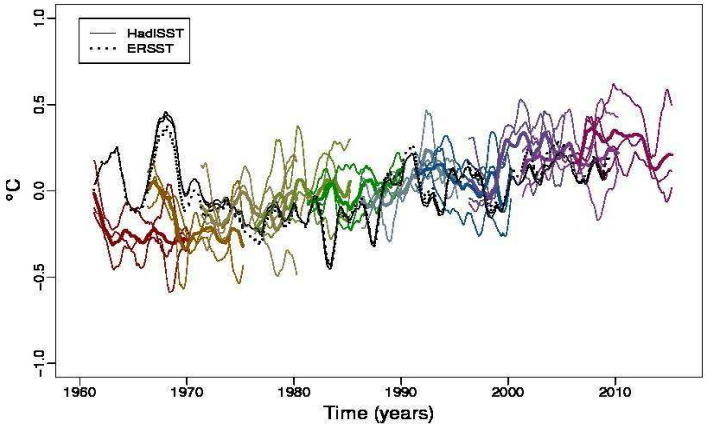




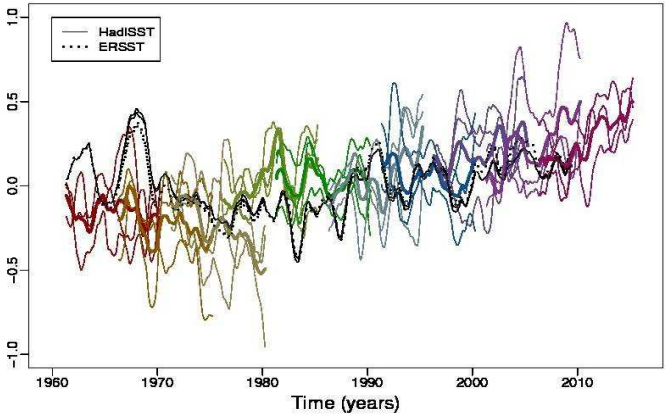
North Pacific SST decadal predictions

Area-averaged North Pacific (155º-235ºE, 10-45ºN) SST anomalies for different re-forecast sets initialized on the 1st of Nov. over 1981-2005.

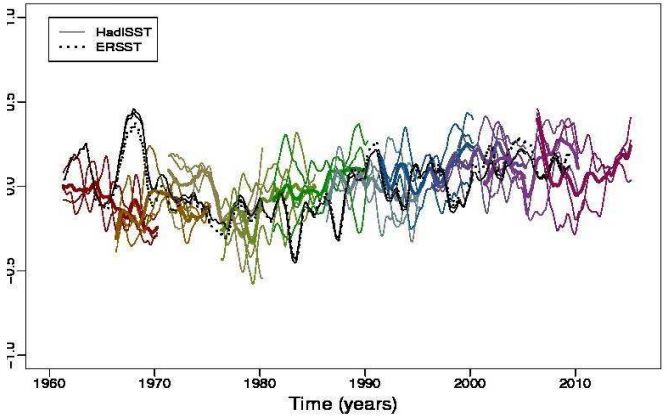
CERFACS



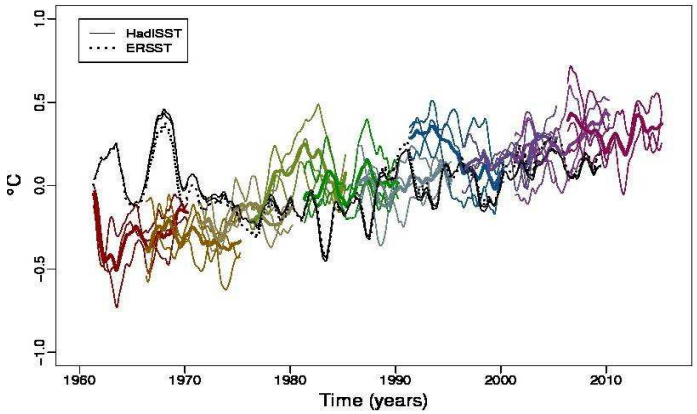
UKMO



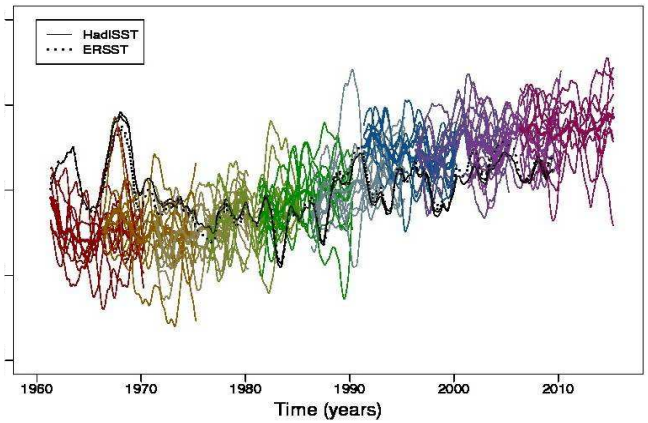
IFM-GEOMAR



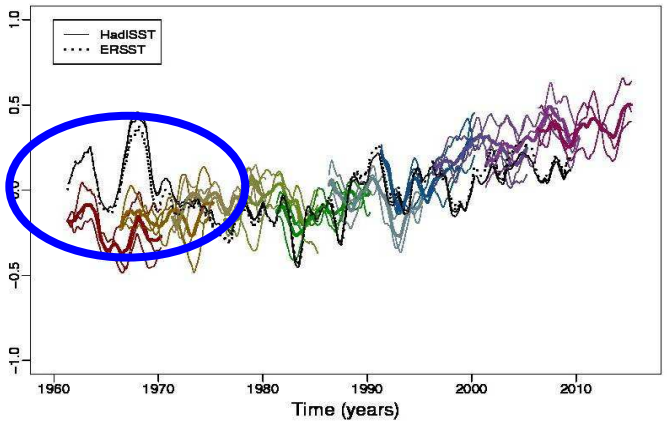
ECMWF



DePreSys

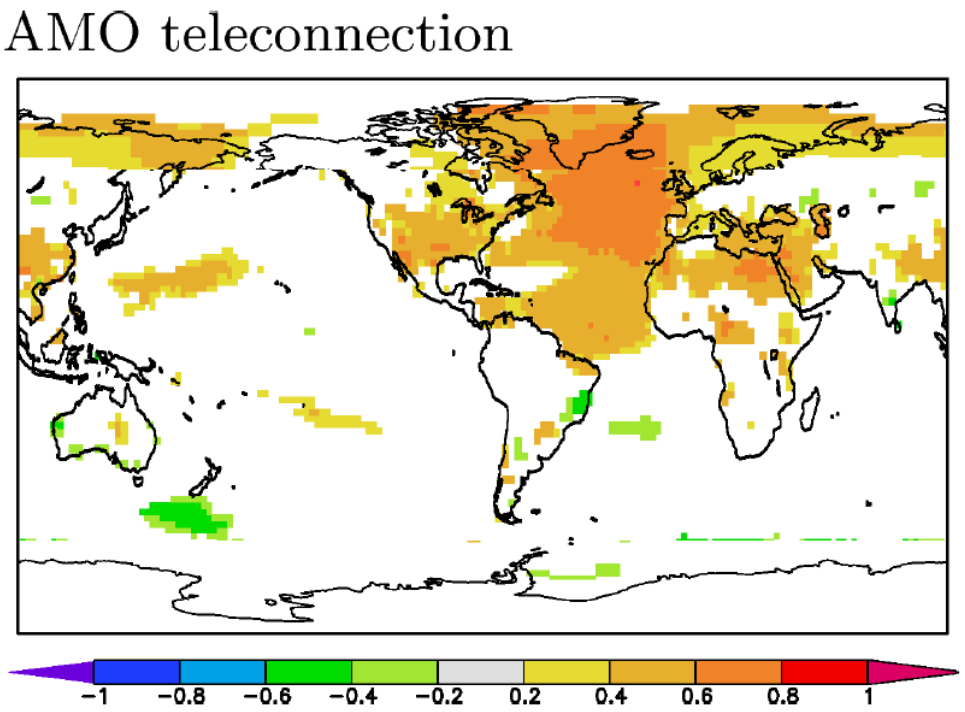


EC-Earth

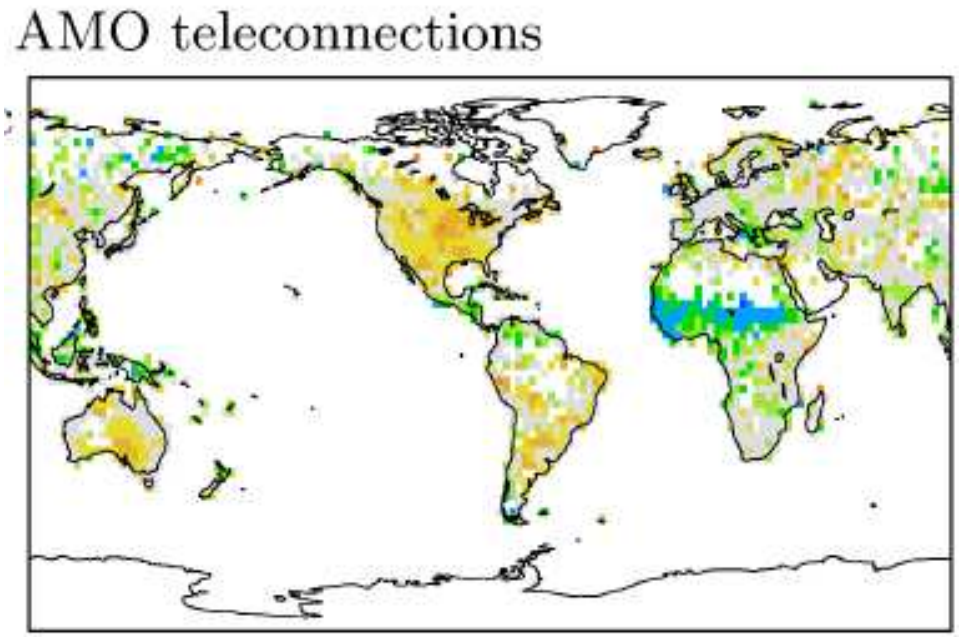


Modes of variability: AMO

Observed AMO teleconnections.



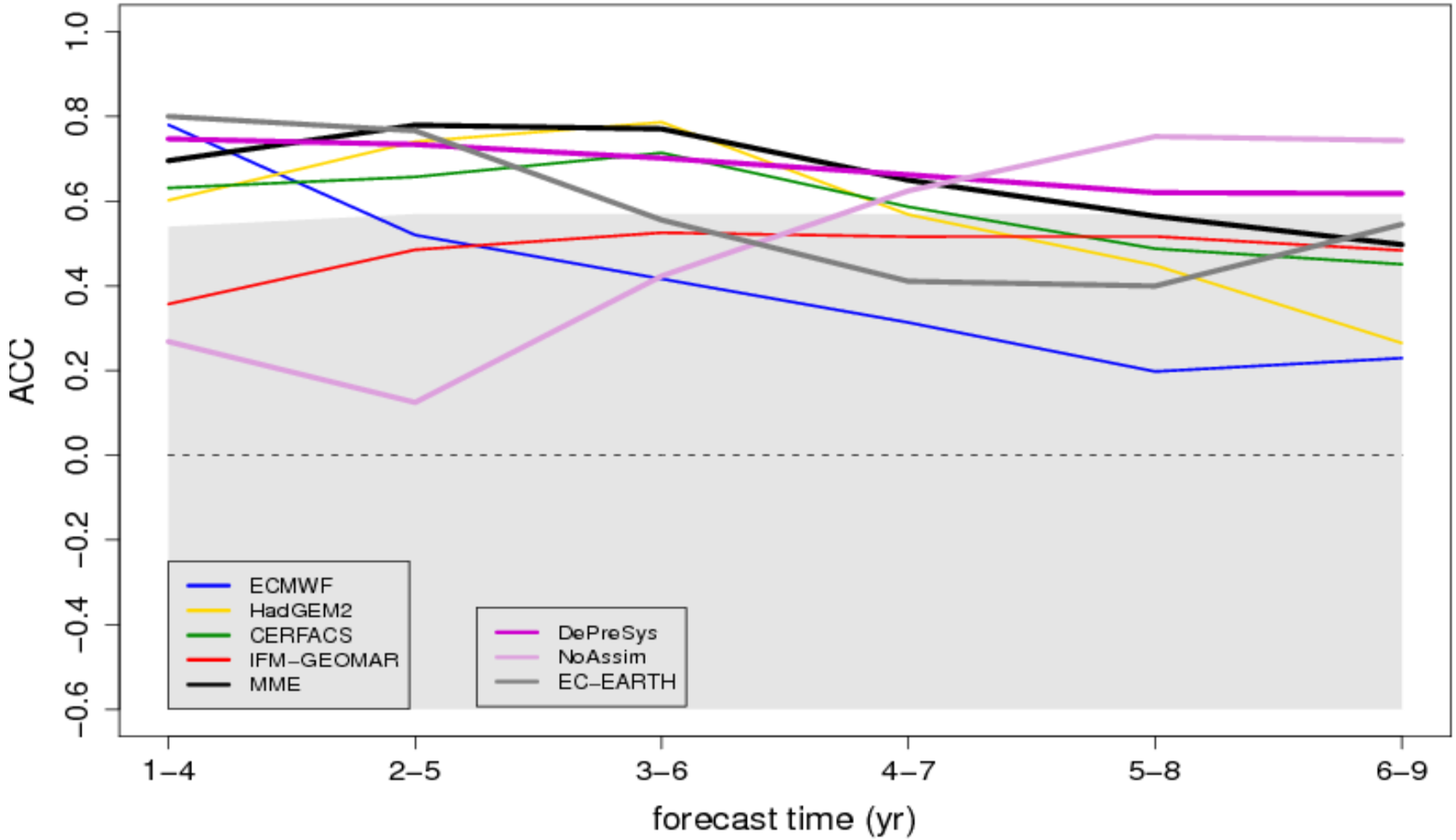
Temperature



Precipitation

AMO decadal predictions

Ensemble-mean correlation of four-year running mean AMO ENSEMBLES re-forecasts wrt the ERSST index.

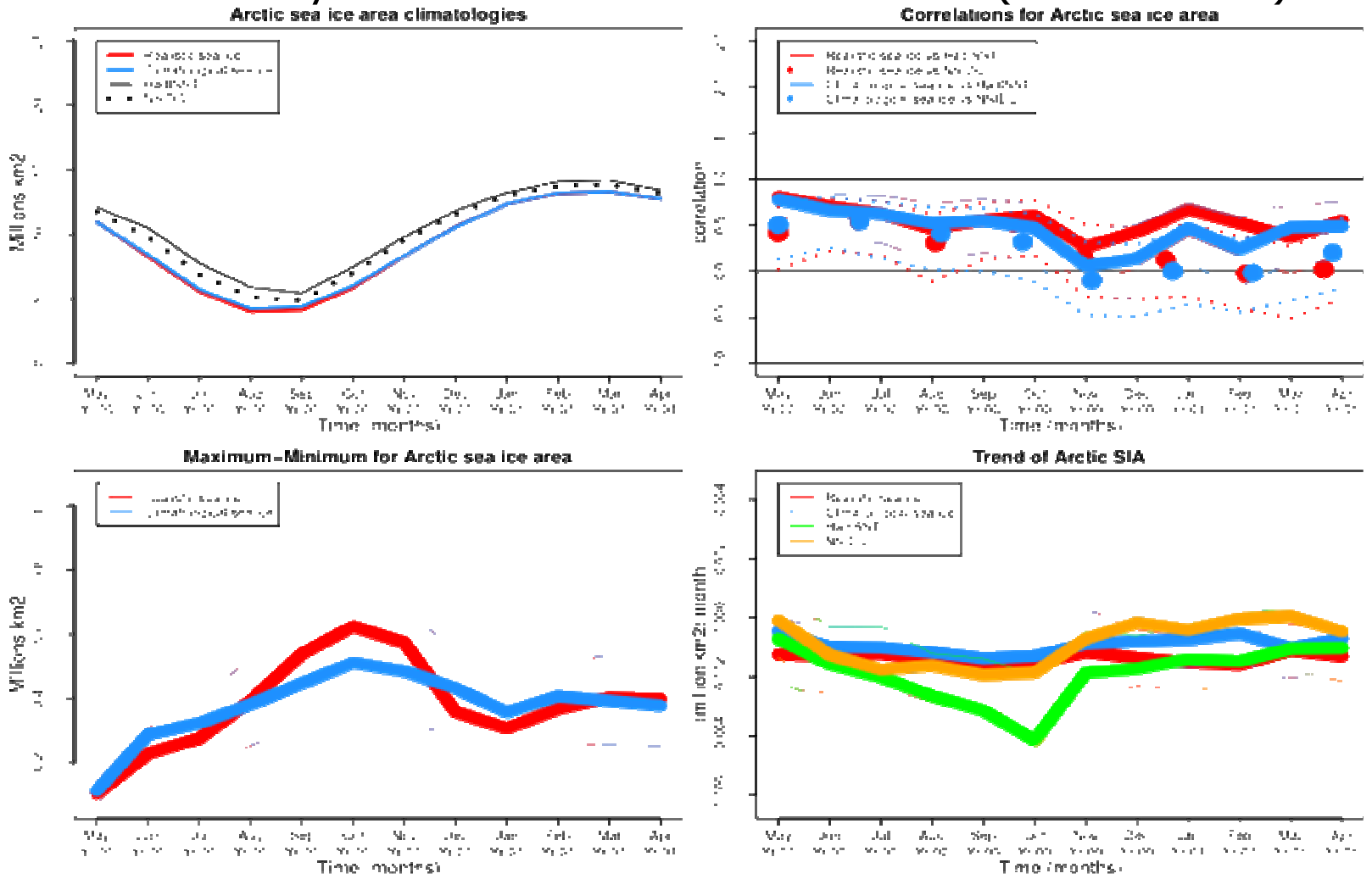


Sensitivity to sea-ice ics

- Objective: test the relevance of initializing the sea-ice component in seasonal forecasting.
- One-year long, three-member ensemble experiments over 1981-2005 with EC-Earth 2.3.
- May and November start dates, ERA40/Int atmospheric ics, NEMOVAR-S4 ocean ics, sea-ice ics from a single NEMO/LIM2 run using DFS4.3 (from Bert Wouters, KNMI).

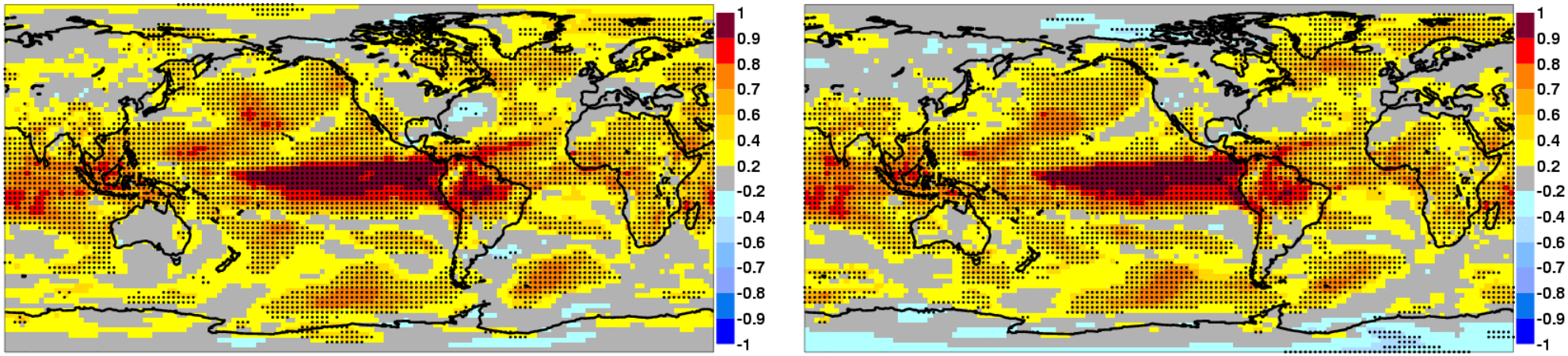
Sensitivity to sea-ice ics

Arctic sea-ice area from realistic and climatological sea-ice ics hindcasts for the May start dates over 1981-2005 (3 members).



Sensitivity to sea-ice ics

Ensemble-mean correlation for boreal winter near-surface temperature of the realistic (left) and climatological (right) sea-ice ics hindcasts for Nov. start dates over 1981-2005 (3 members). Dots represent correlations statistically significant with 95% confidence.

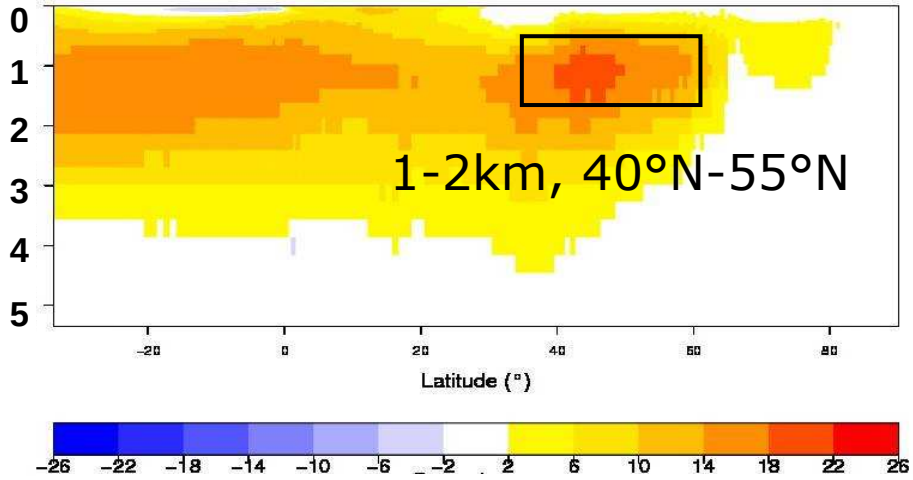


Generation of sea-ice ics

- Objective: generate almost real-time ensembles of sea-ice initial conditions for the different NEMO versions.
- Tests with NEMO3.2/LIM2.
- For all runs: SST and SSS restoring (-40W/m2, -150 mm/day/psu).
- Forcings: 1958-2006 DFS4.3 or 1979-2010 ERA-Interim.
- Spin up: start from Levitus T and S climatology, 3 metre sea-ice in Arctic, 1 metre sea-ice in Antarctic.
- Nudging towards NEMOVAR with a time scale of 360 days below 800 metres and 10 days above except in the mixed layer, excluding 1ºS-1ºN.
- Future plans: use DFS5, wind stress perturbations.

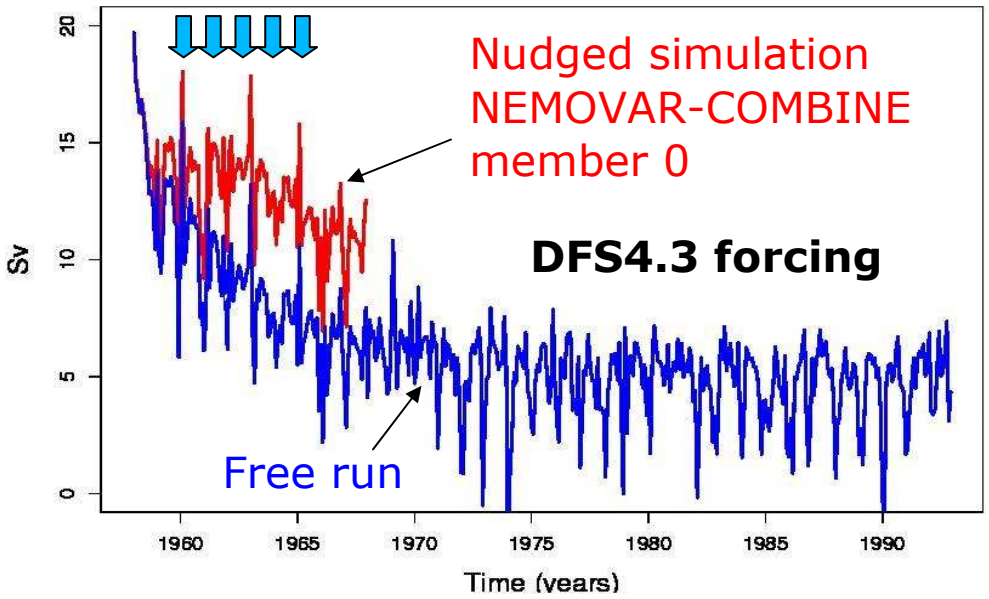
Generation of sea-ice ics

NEMO3.2/LIM2 simulations: Atlantic Meridional Overturning Circulation

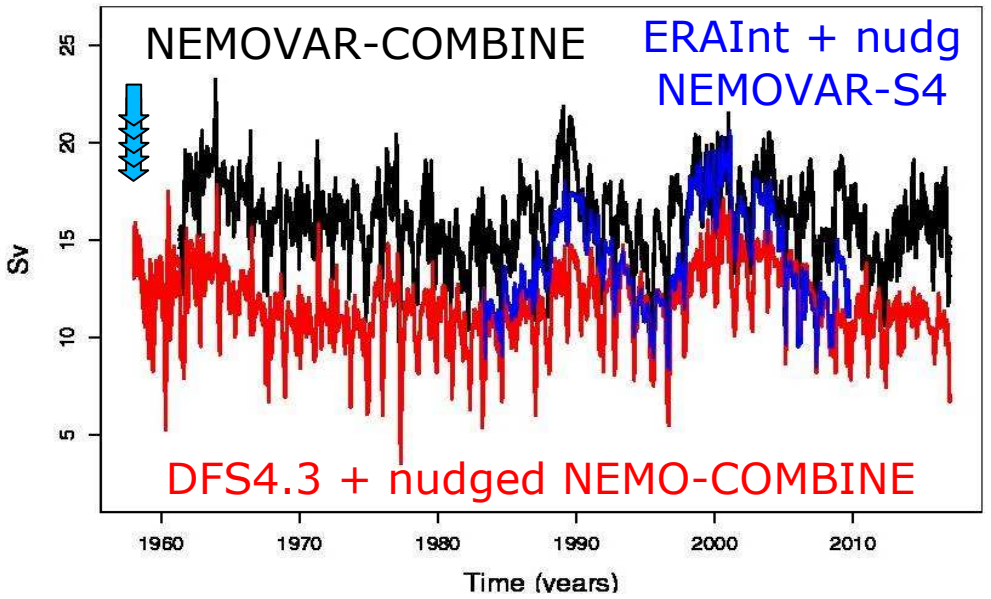


NEMOVAR-COMBINE climatology (Sv)

Spin-up: averaged (1km-2km, 40°N-55°N) streamfunction



Historical simulations

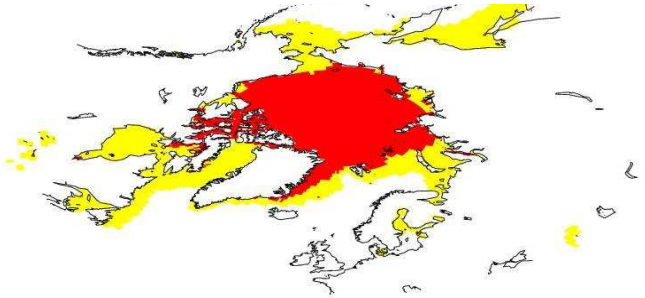


Generation of sea-ice ics

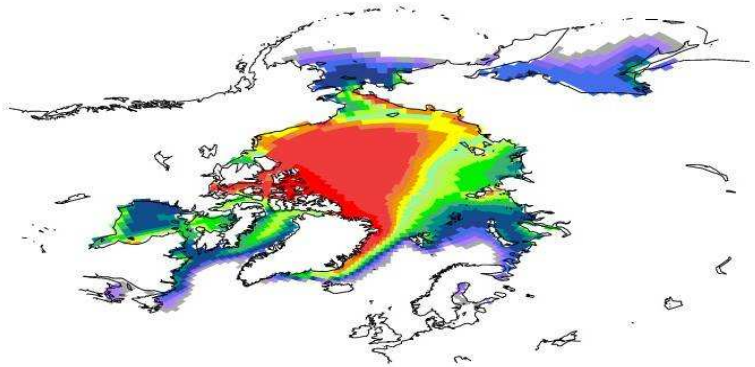
NEMO3.2/LIM2 simulations: Arctic sea-ice cover

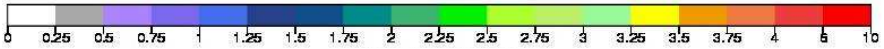
DFS4.3 + NEMO-COMBINE

March/September HadISST sea ice cover >10%

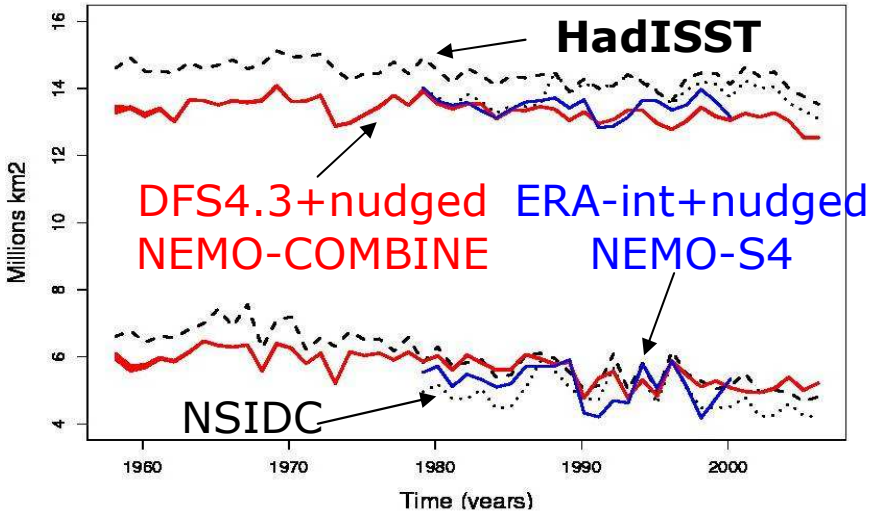


March sea ice thickness (m)

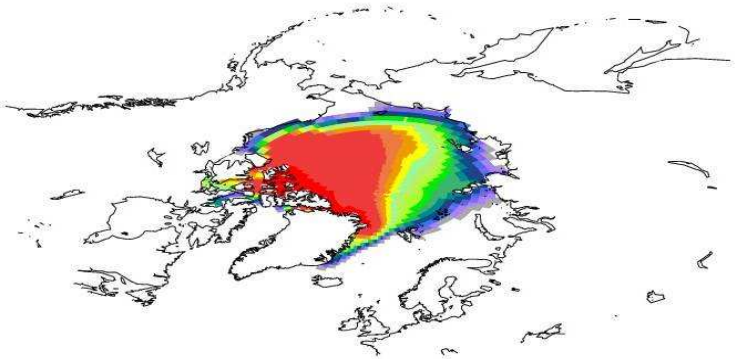


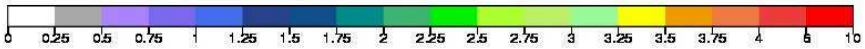


March/September Arctic sea ice area



September sea ice thickness (m)



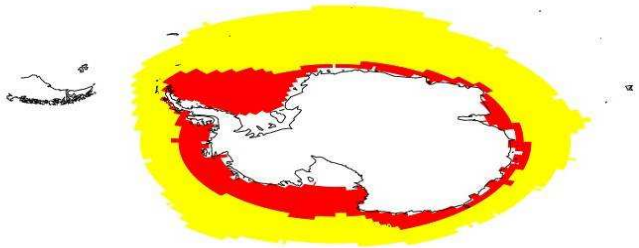


Generation of sea-ice ics

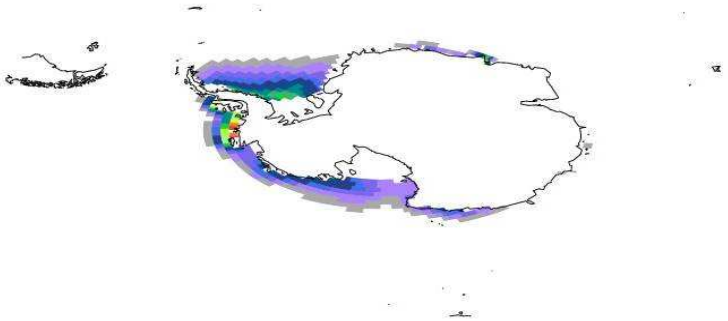
NEMO3.2/LIM2 simulations: Antarctic sea-ice cover

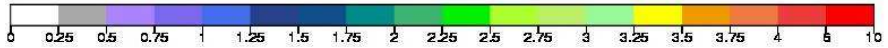
DFS4.3 + NEMO-COMBINE

March/September HadISST sea ice cover >10%

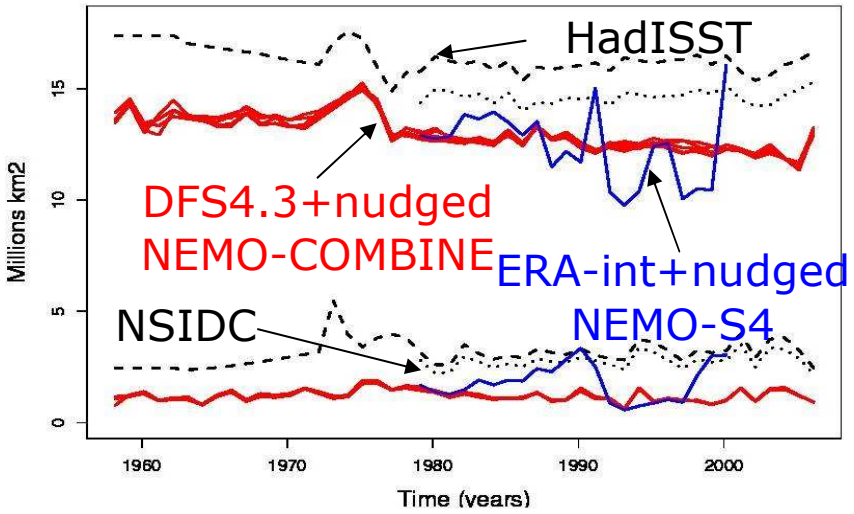


March sea ice thickness (m)

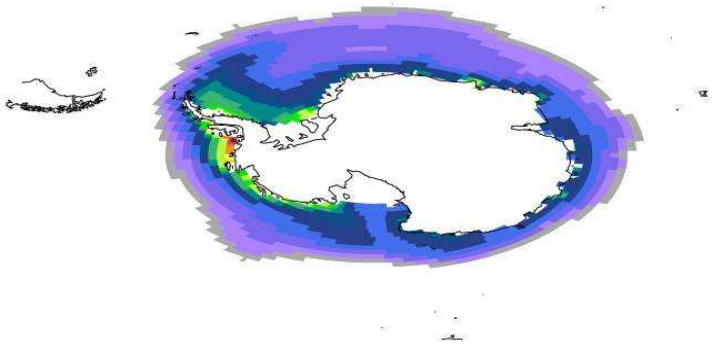


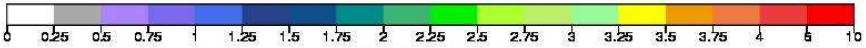


March/September Arctic sea ice area



September sea ice thickness (m)





Summary

- Benchmarks of decadal experiments suggest substantial differences among platforms, but still scientific equivalence of the experiments.
- EC-Earth performs as well, if not better, than the ENSEMBLES and DePreSys decadal hindcasts. Significant skill is found for SST and near-surface temperature (mainly North Atlantic and Indian Ocean) and AMO. A large portion is due to the “trend”.
- Simple reference forecasts (e.g. persistence) and an ensemble of historical simulations (CMIP5 NoAssim experiment) is needed to test the impact of initialization.
- Little sensitivity to the sea-ice ics has been found.
- Ensembles of sea-ice restarts are available after 2006.