DePreSys version 2: a new version of the Met Office Hadley Centre Decadal Prediction System

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Met Office Hadley Centre

Session S4, International workshop on seasonal to decadal prediction, Toulouse, 15th May 2013

Introduction

- Reminder of Met Office Decadal Prediction System (DePreSys)
- Design of DePreSys v2
- Comparison of skill and sources of differences
- Next steps
- Conclusions

Existing DePreSys – version(s) 1

- Global coupled climate model - HadCM3
  - 2.5˚(lat) x 3.75˚(lon) atmosphere
  - 1.25˚ x 1.25˚ ocean
- GHGs, aerosols, ozone, solar, volcanic
- Initial condition information to predict natural internal variability:
  - Atmosphere: ERA winds, temperature and mslp
  - Ocean: global covariance temperature and salinity reconstruction
- Assimilate as anomalies to reduce model drift
- 10 year ensemble hindcasts over several decades (DePreSys) vs control (NoAssim)
- Original ensemble, perturbed parameter version, CMIP5 ensemble

Smith *et al*. *Science*, 2007

New DePreSys – version 2

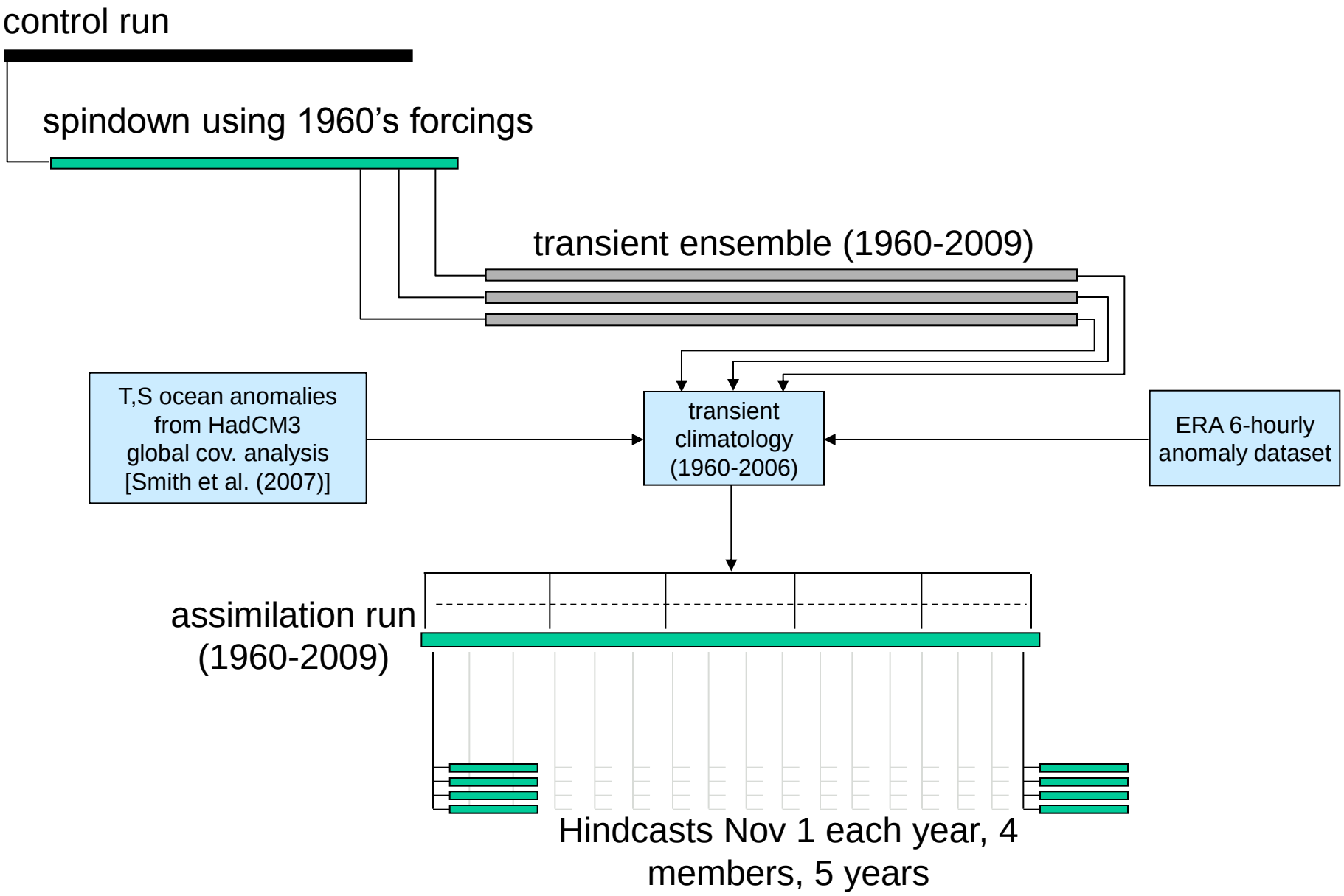
What is different ...

- New climate model – HadGEM3
  - 1.25˚(lat) x 1.875˚(lon) atmosphere
  - 1˚ x 1˚ NEMO ocean
  - New dynamical core, physical parameterisations

... and the same

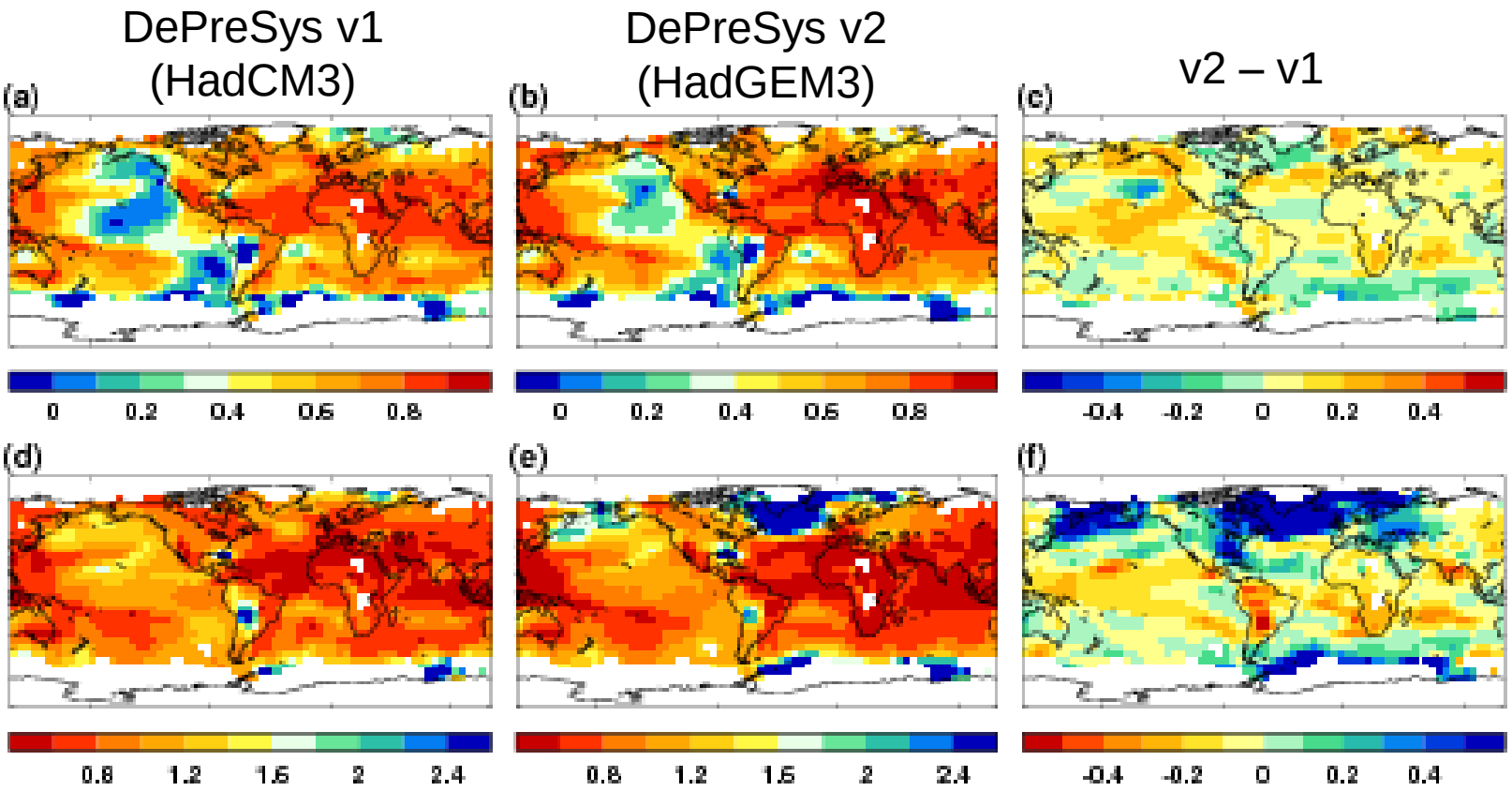
- Initial condition information to predict natural internal variability
  - Atmosphere: ERA winds, temperature
  - Ocean: global covariance temperature and salinity reconstruction (HadCM3 covariances)
- Anomaly initialisation

DePreSys v2 system workflow



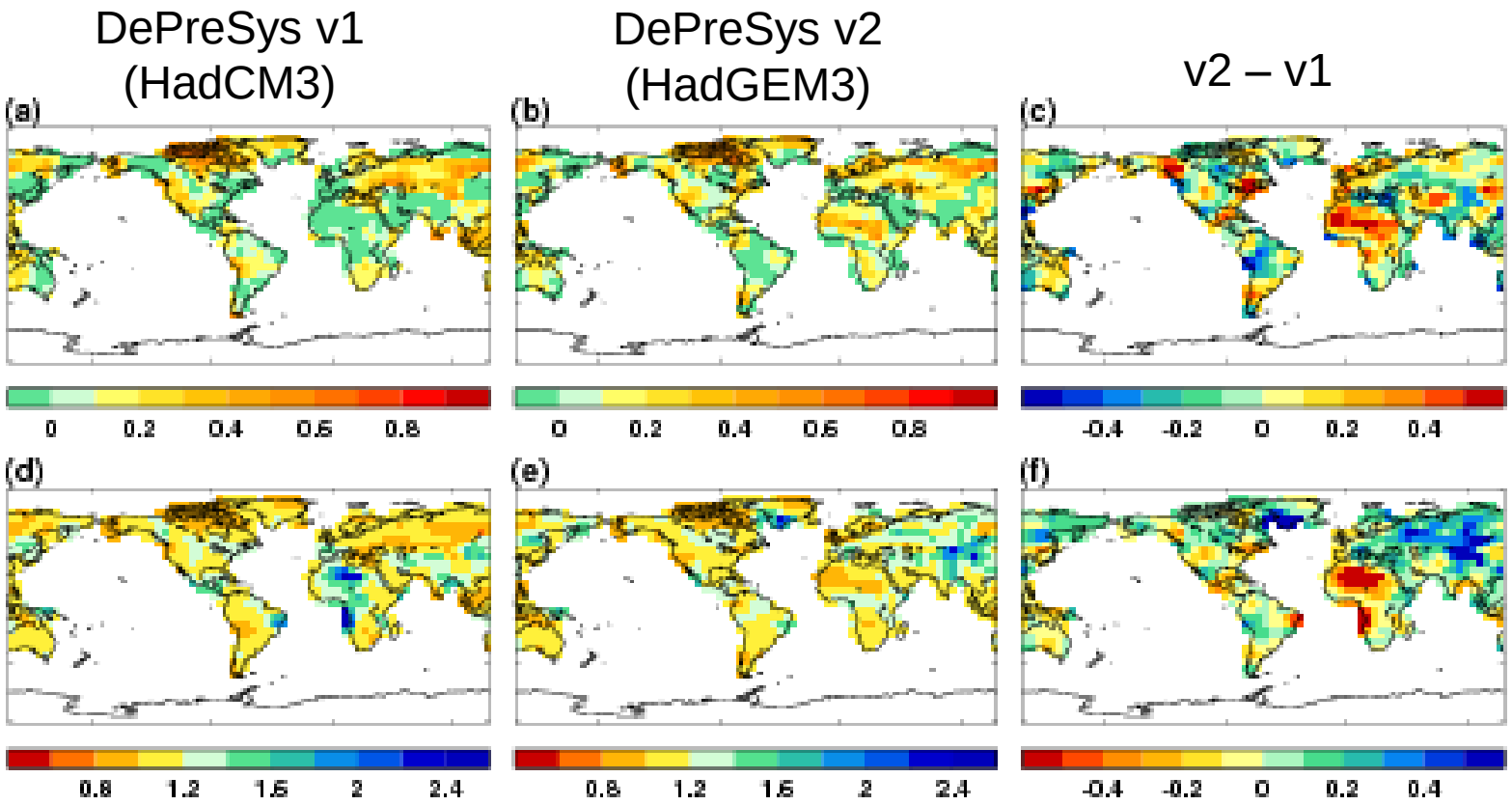
DePreSys v1 vs v2 skill

Global T in years 2-5 vs HadCRUT3, 1960-2009



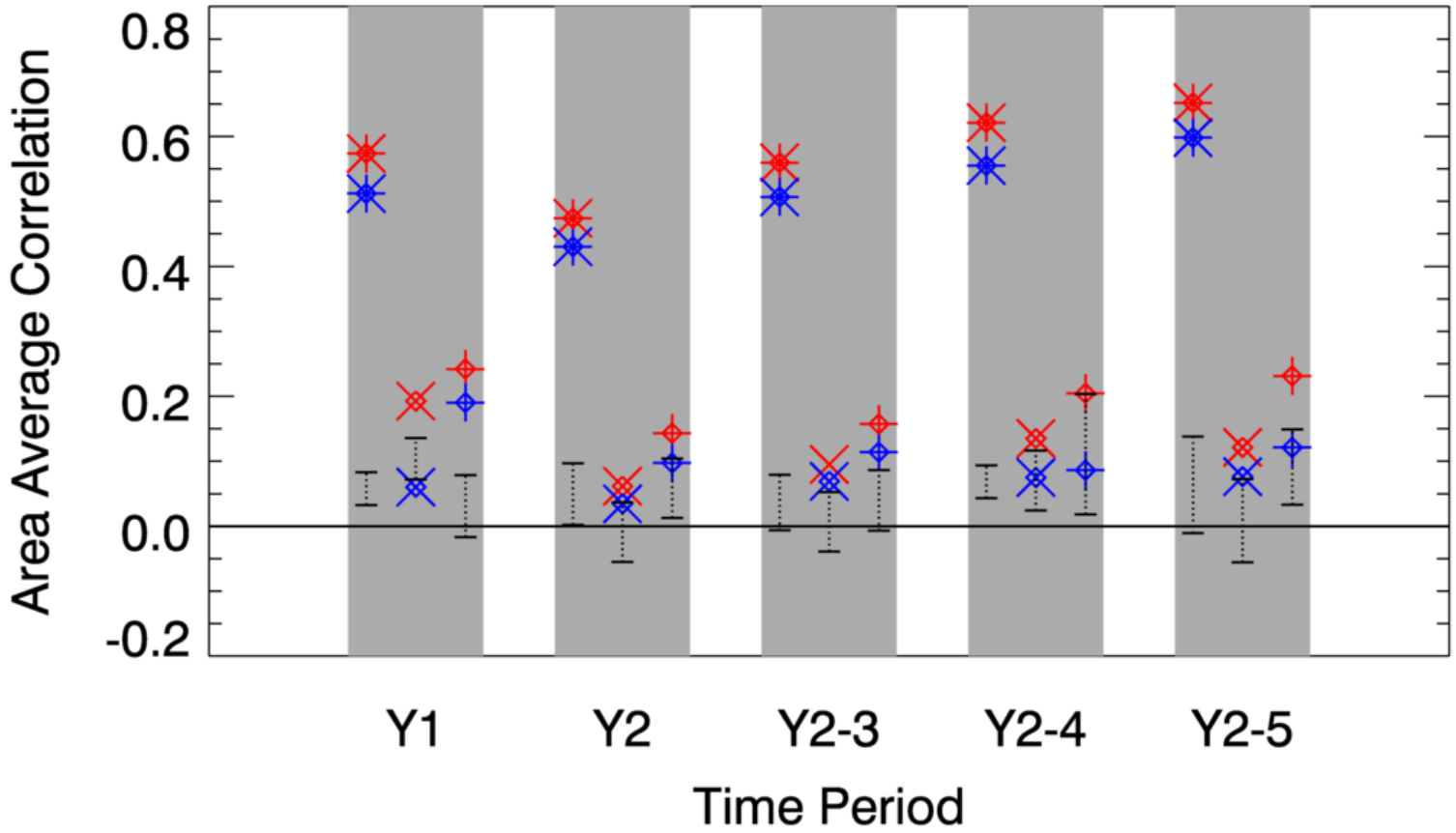
DePreSys v1 vs v2 skill

Global precip in years 2-5 vs GPCC, 1960-2009



Summary of global statistics

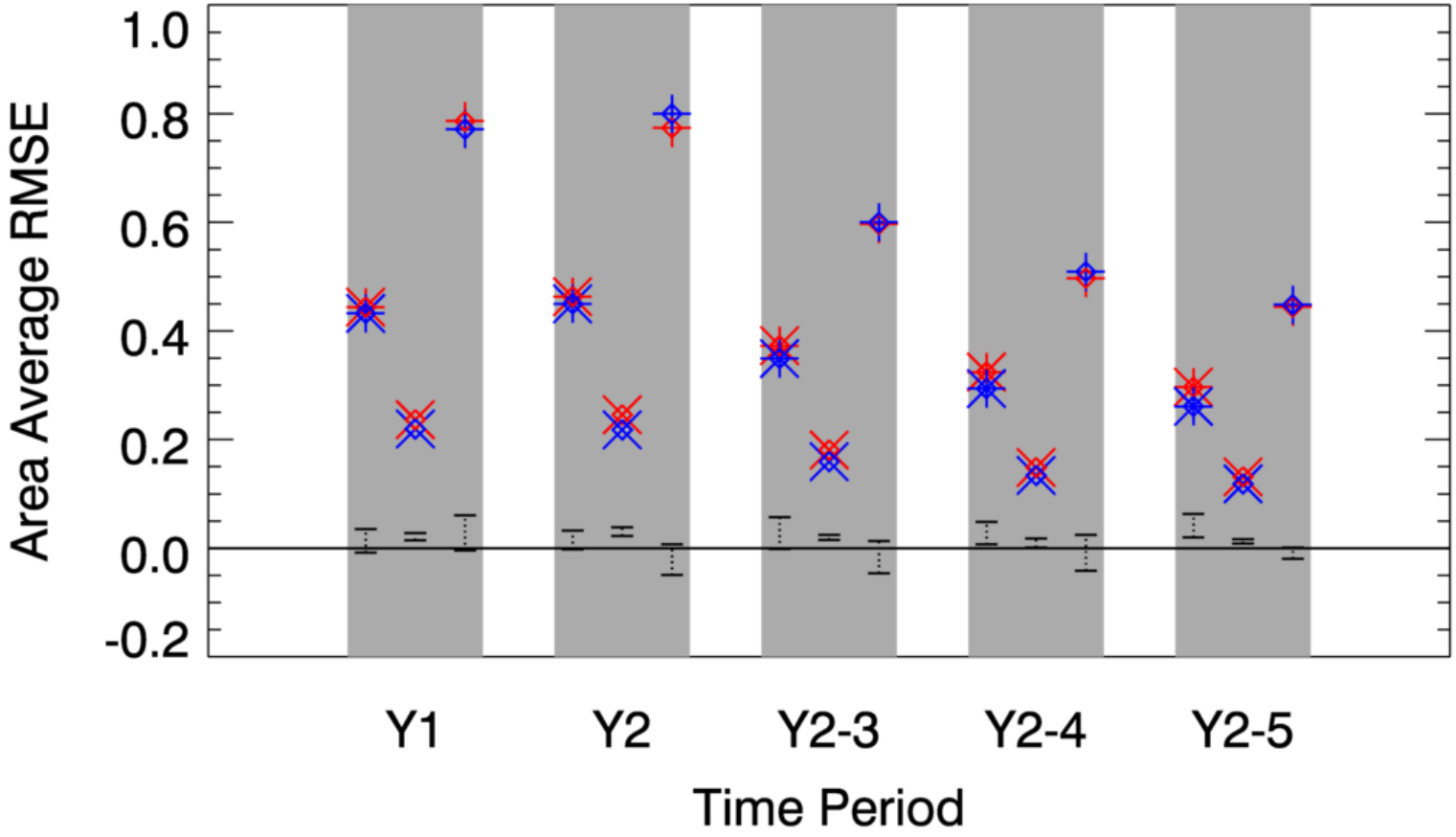
DePreSys v2 vs DePreSys v1



* = Temperature x = Precipitation + = mslp (wrt HadSLP2)

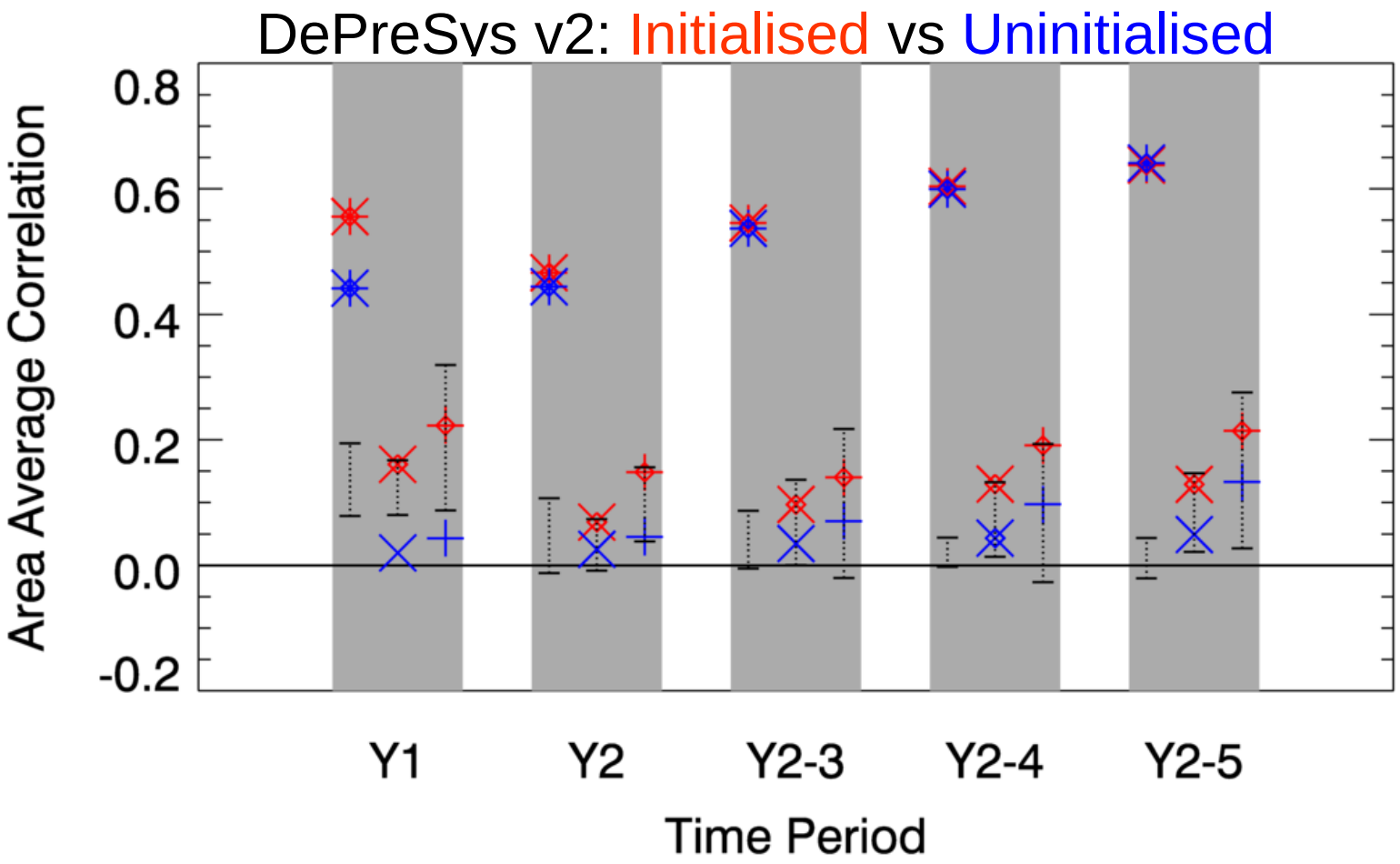
Summary of global statistics

DePreSys v2 vs DePreSys v1



* = Temperature x = Precipitation + = mslp (wrt HadSLP2)

Sources of skill: initialisation



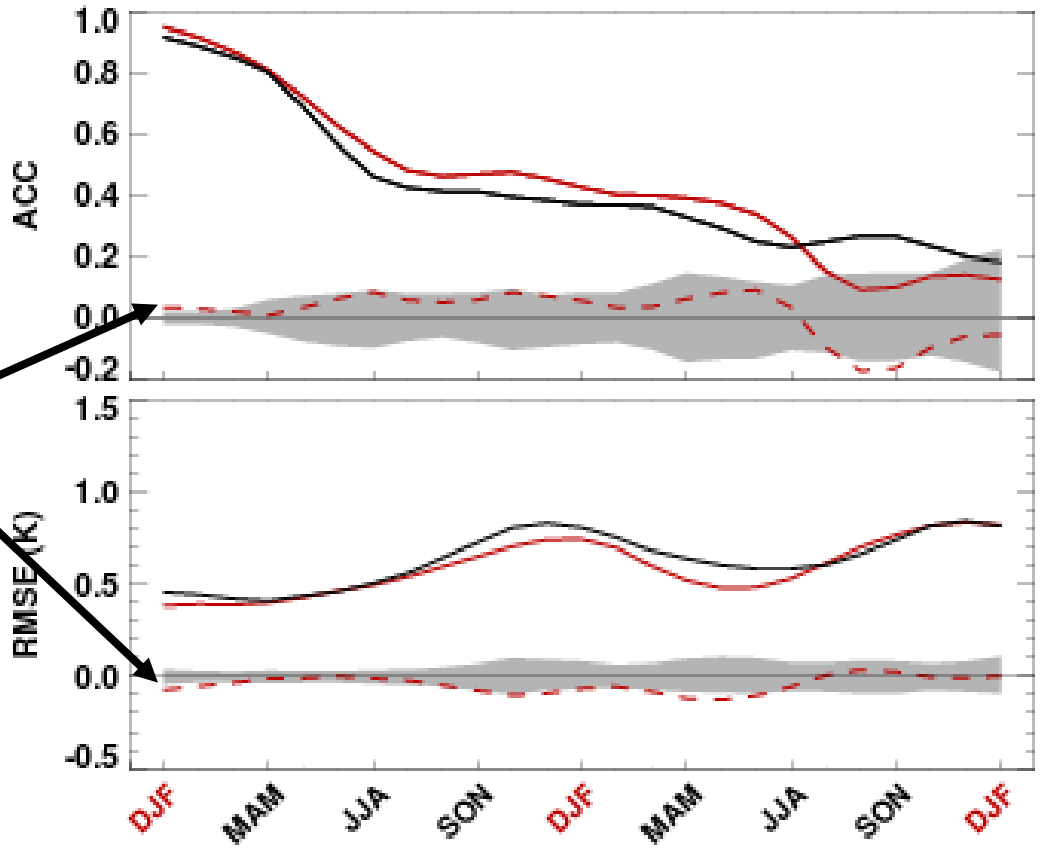
* = Temperature x = Precipitation + = mslp (wrt HadSLP2)

Initialised skill: ENSO variability

Nino4: **DePreSys v2** vs **DePreSys v1**

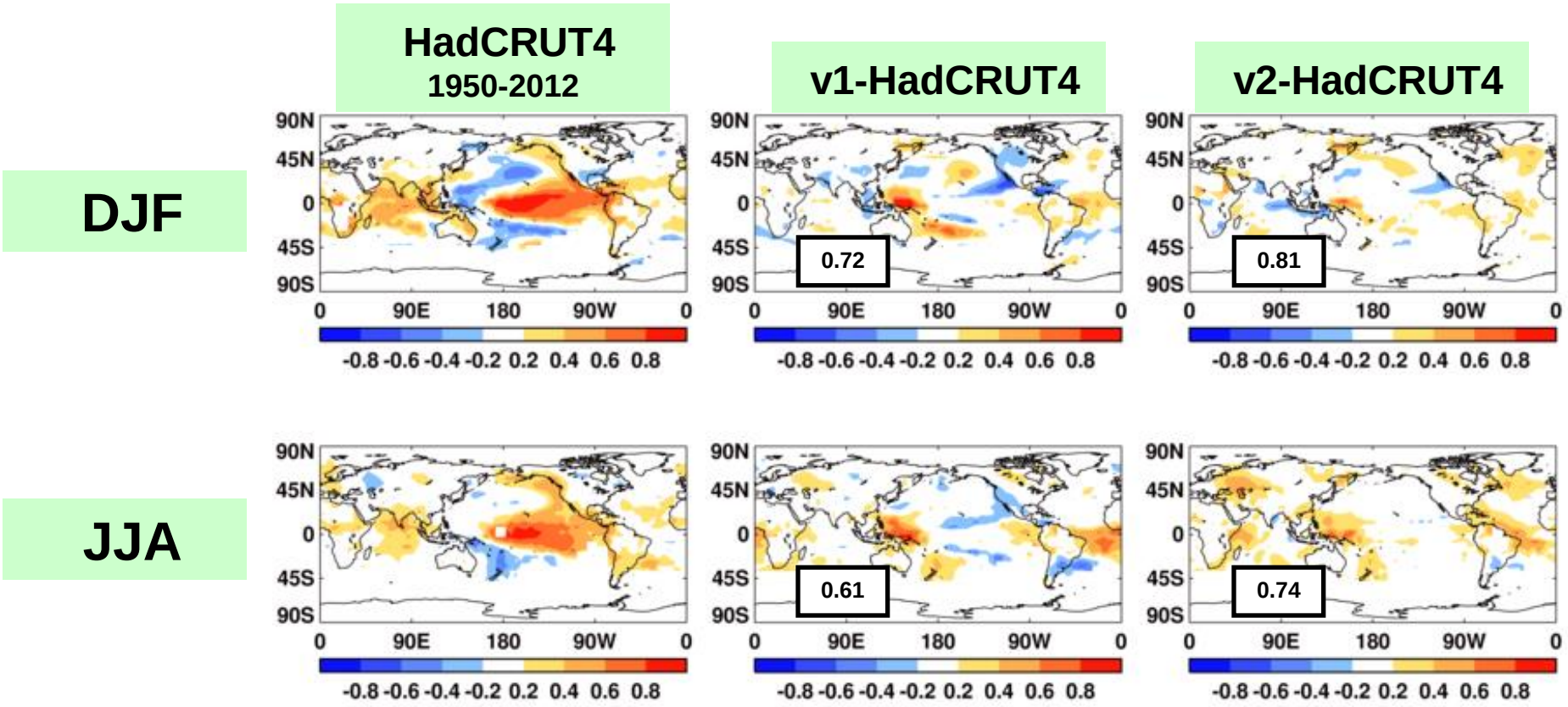
(4/4 members) (4/10 members)

v2 - v1



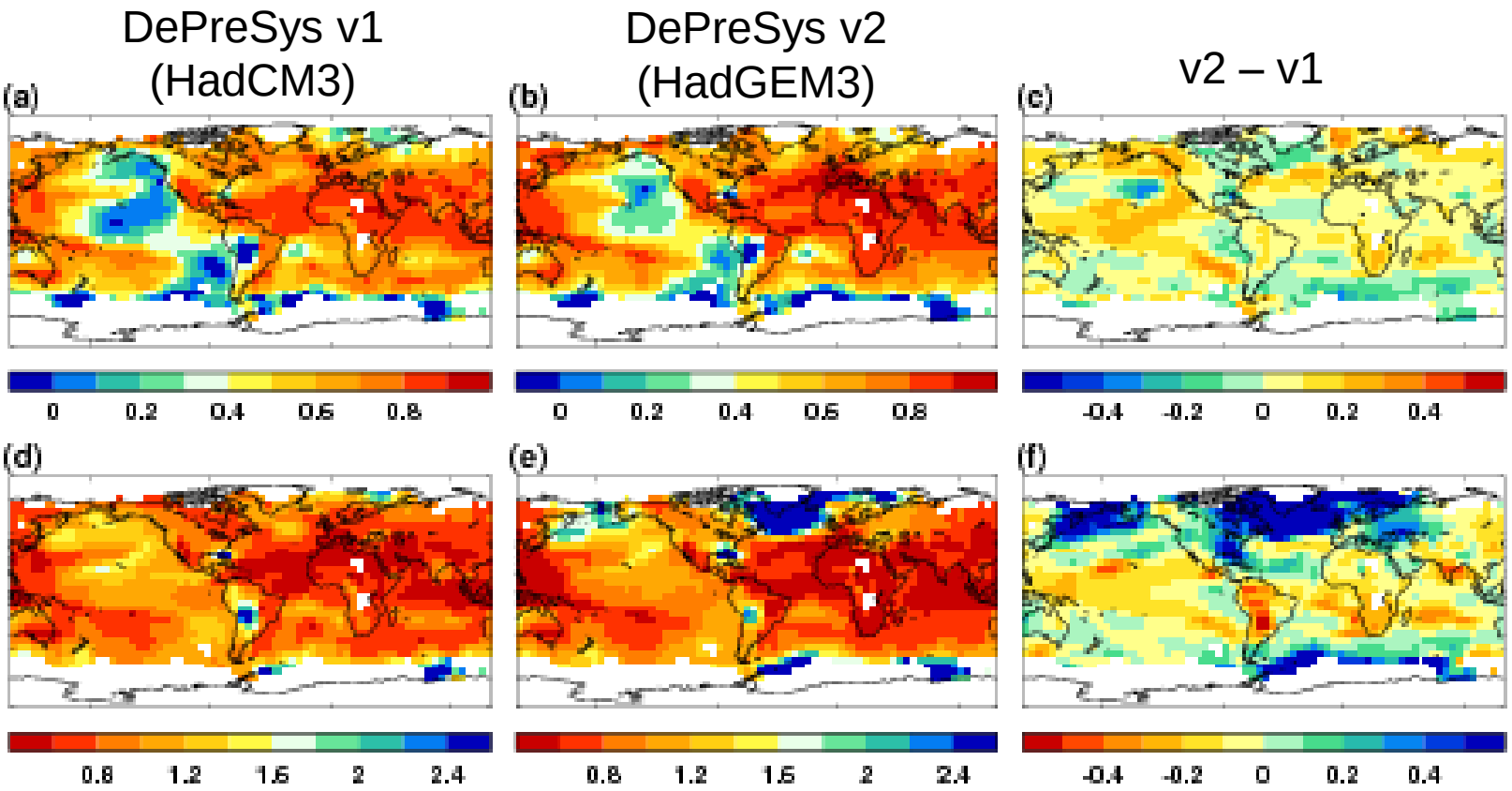
Initialised skill: ENSO teleconnections

Correlation <Nino4, T1.5m>
All start dates and lead times, 4 members



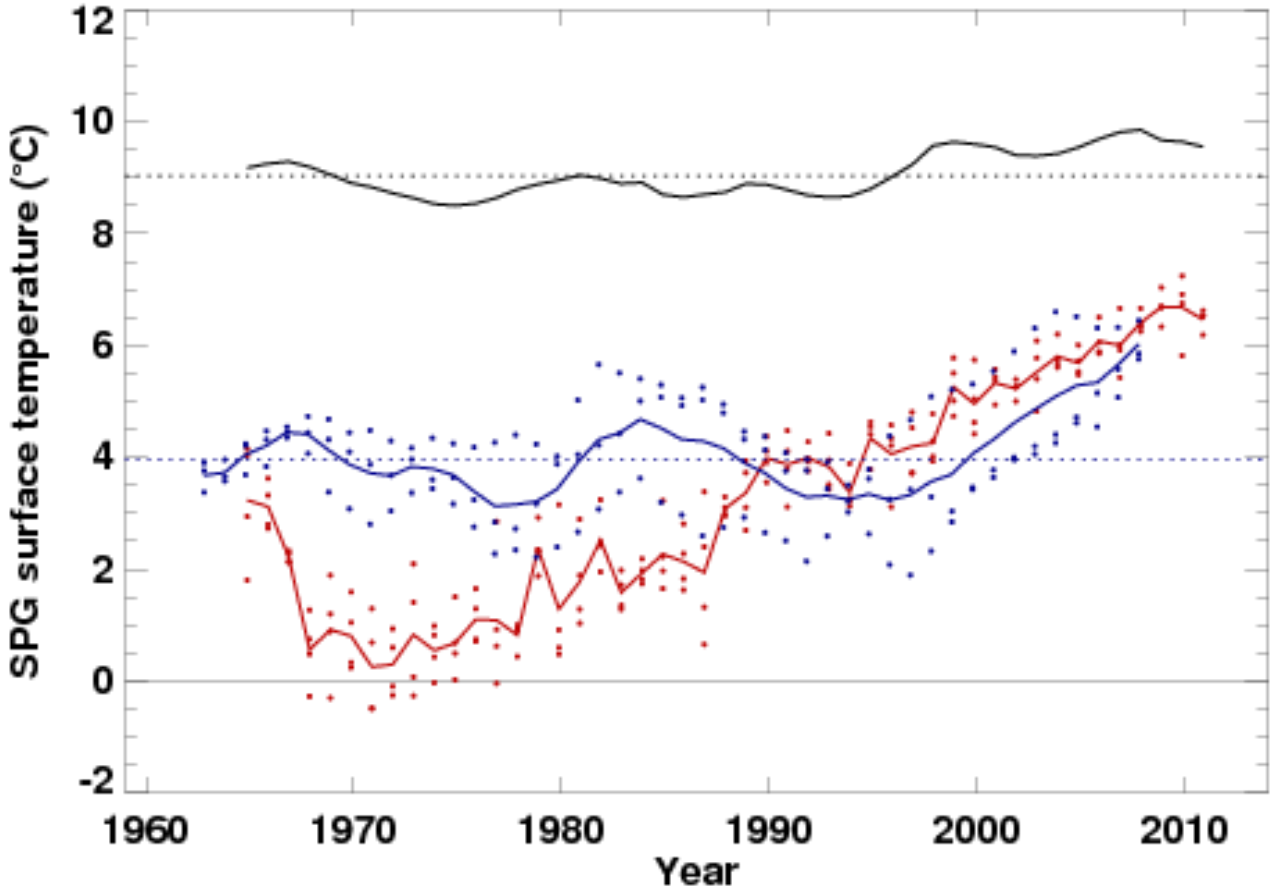
DePreSys v1 vs v2 skill

Global T in years 2-5 vs HadCRUT3, 1960-2009



Errors in the Sub-Polar Gyre

Surface Temperature years 2-5
20°-50° W, 48°-60°N



HadISST

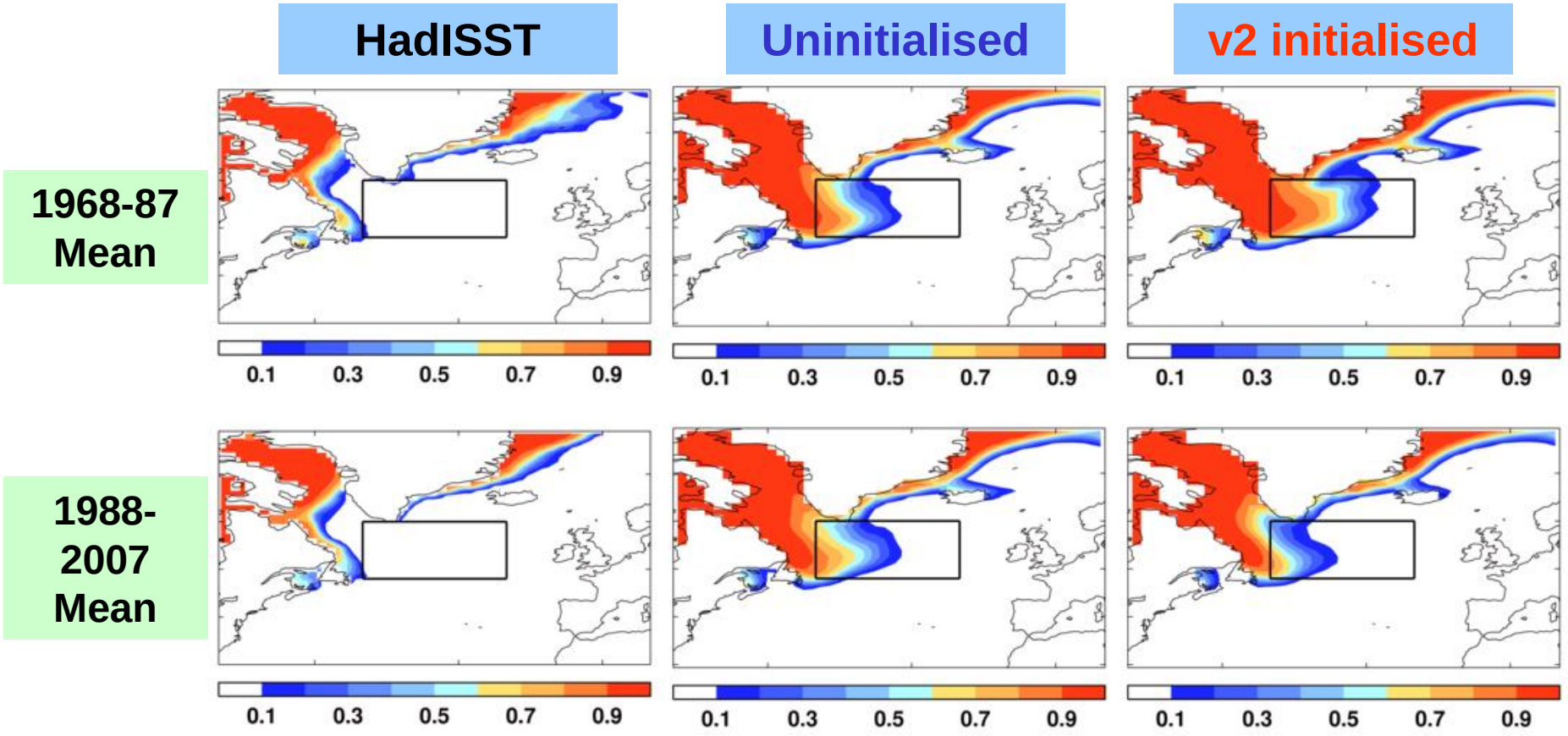
Transients (uninitialised)

v2 initialised ensemble

Errors in the Sub-Polar Gyre

Met Office

Sea ice concentration years 2-5



Skill of detrended hindcast, y1-5

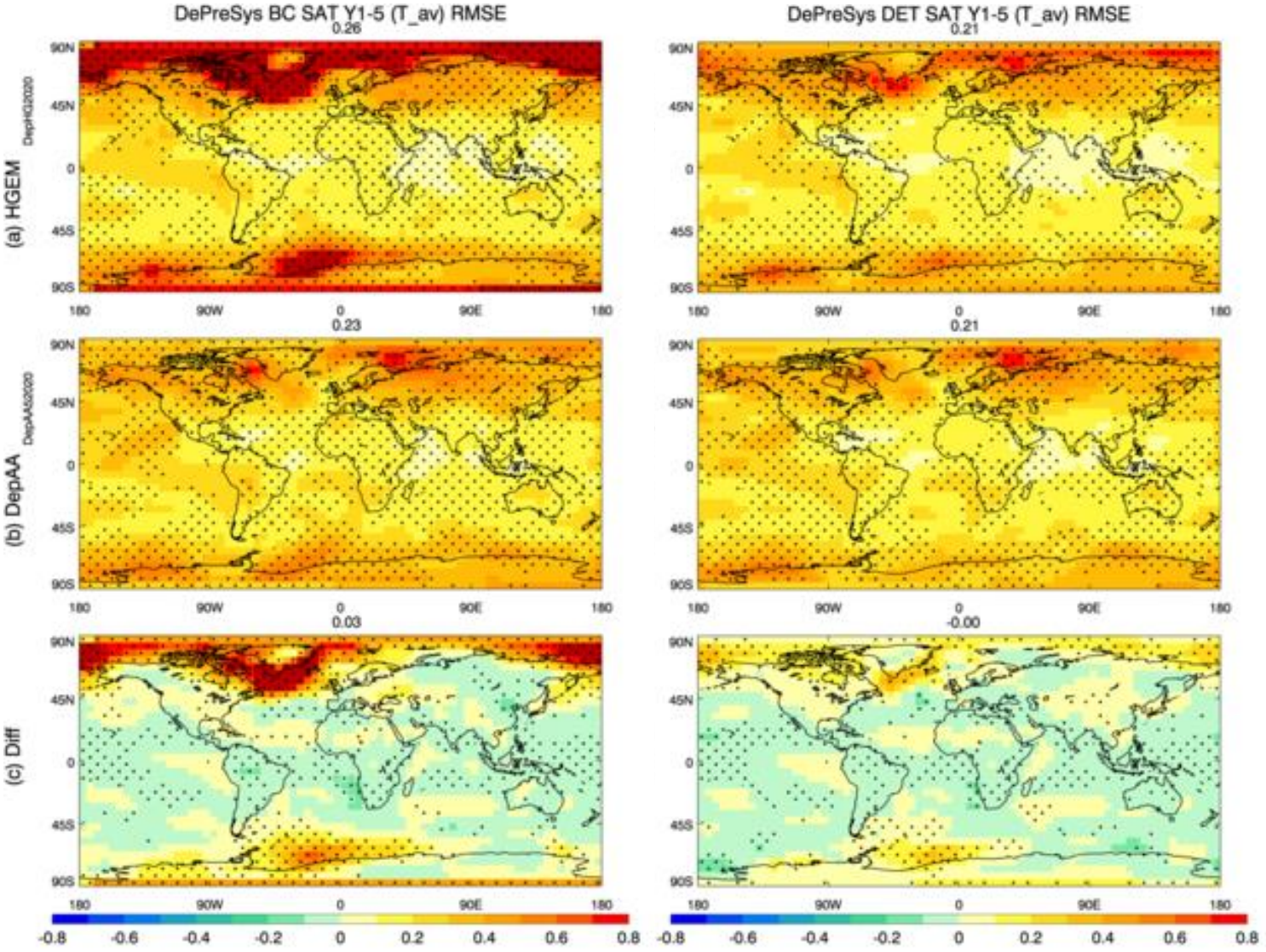
RMSE

RMSE detrended

v1

v2

v2-v1

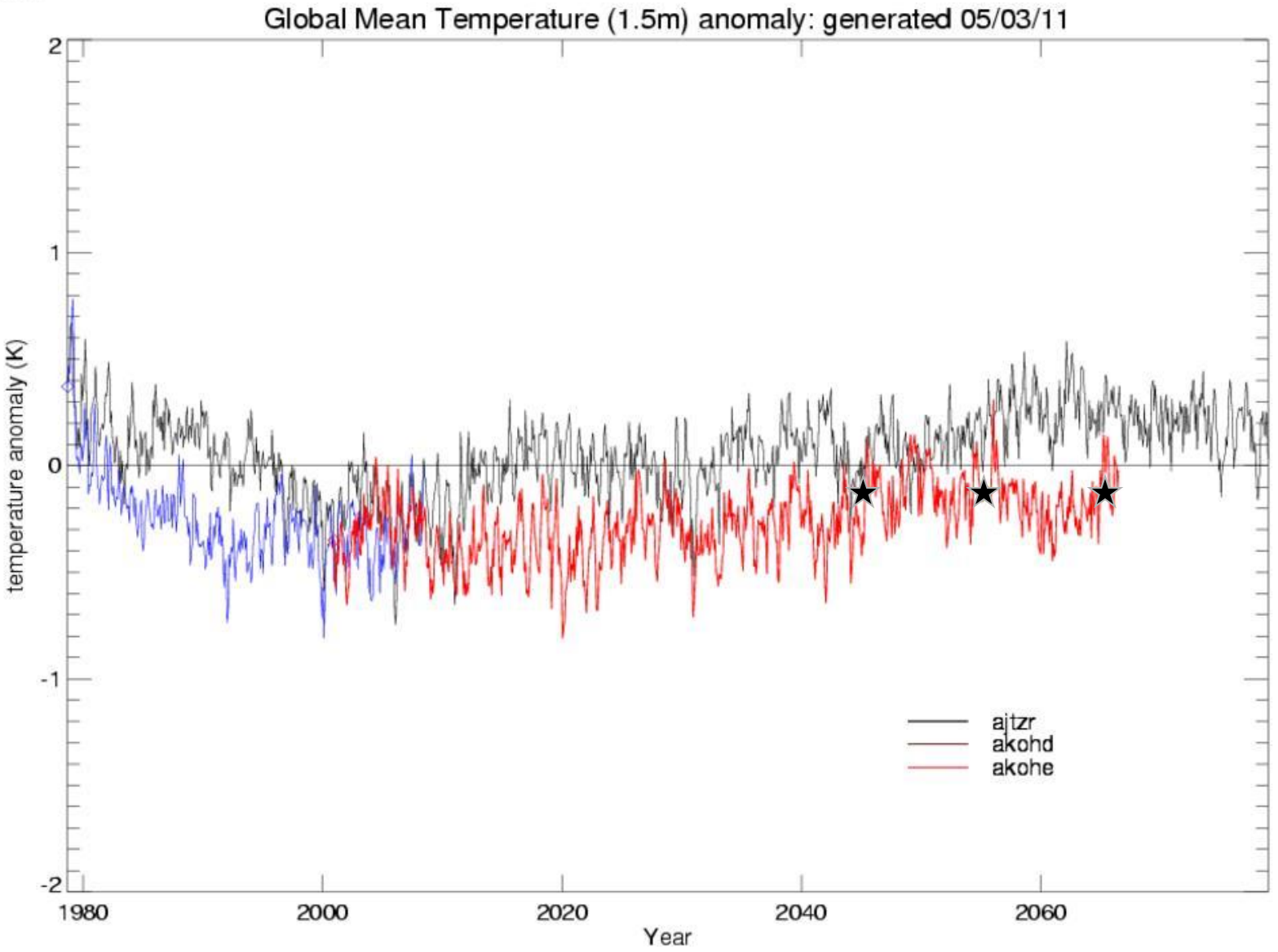


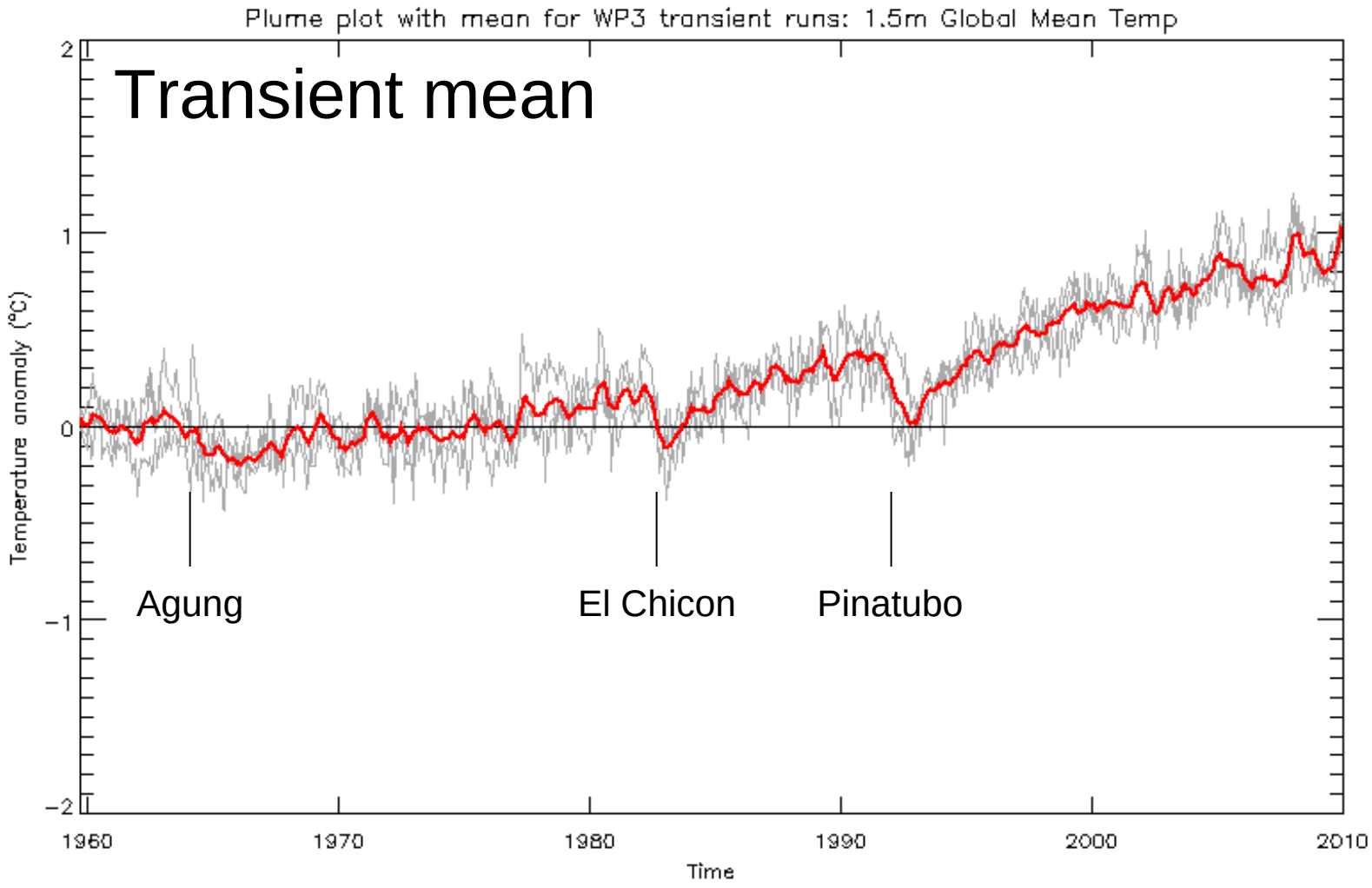
cf Kharin et al. 2012 GRL

Conclusions

- A new decadal prediction system – DePreSys2 – has been produced based on the HadGEM3 model
- This model has better resolution and a better representation of a range of climate processes
- Decadal prediction skill (measured over years where initialisation gives most benefit) is improved in the new system
- Much of the improvement comes in the tropics. In years 1-2 this is related to improved simulation of ENSO and its teleconnections.
- After year 2, improvement comes from the boundary conditions (most likely aerosols).
- Lower skill in high-latitude regions related to large trends due to sea-ice feedback as a result of model biases.
- Work will soon begin on implementing a system using a higher resolution version of HadGEM3.

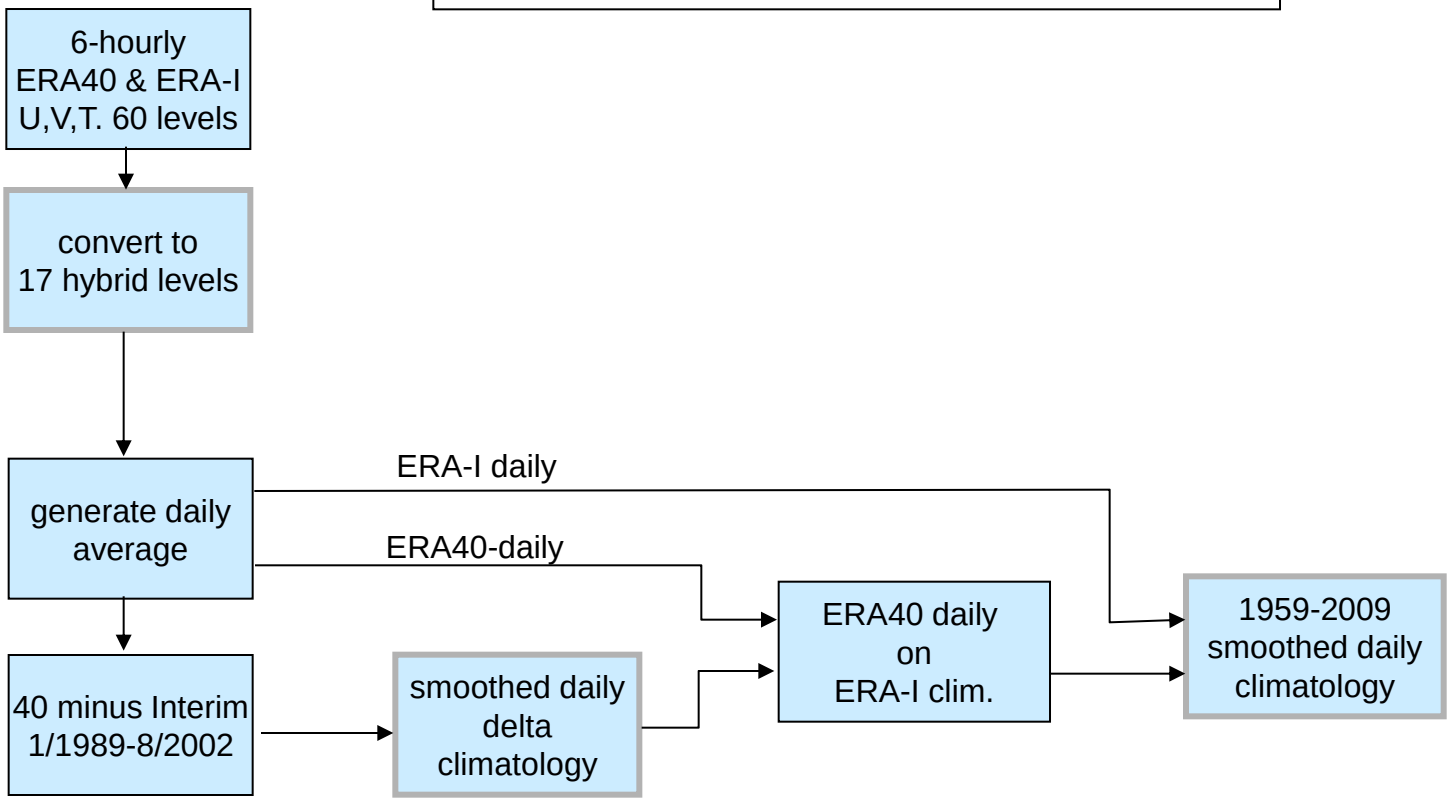
Spindown global mean temp.




Plume plot with mean for WP3 transient runs: 1.5m Global Mean Temp
Transient mean
Temperature anomaly (°C)
2
1
0
−1
−2
Agung
El Chicon
Pinatubo
1960
1970
1980
1990
2000
2010
Time

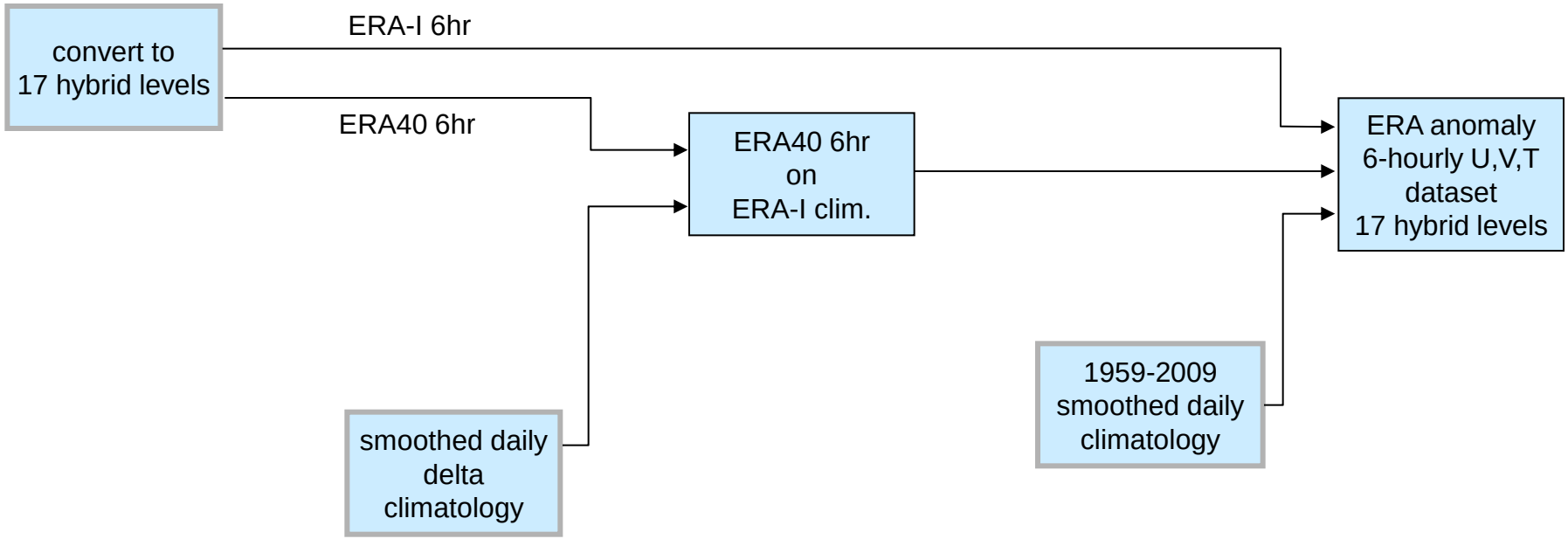
DePreSys-like ERA anomaly dataset – used as input to assimilation run

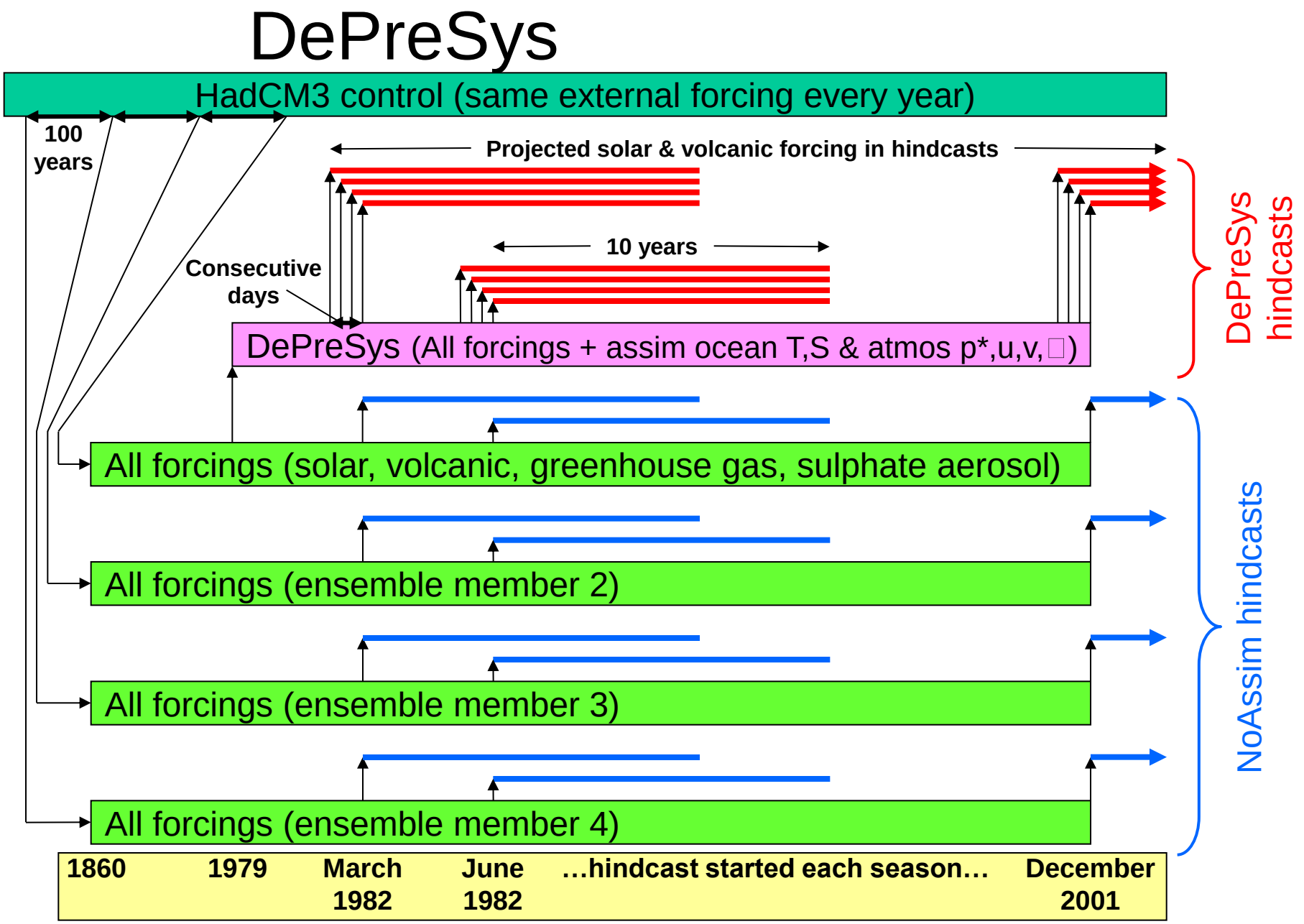
Step 1: create 1959-2009 ERA climatology



DePreSys-like ERA anomaly dataset – used as input to assimilation run

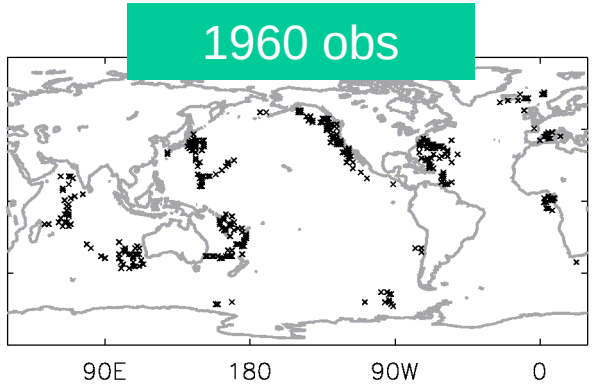
Step 2: create 1959-2009 ERA anomaly dataset

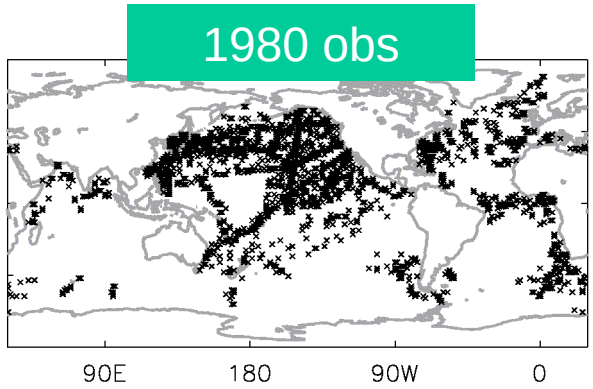



DePreSys
HadCM3 control (same external forcing every year)
100 years
Projected solar & volcanic forcing in hindcasts
10 years
Consecutive days
DePreSys (All forcings + assim ocean T,S & atmos p*,u,v,□)
DePreSys hindcasts
All forcings (solar, volcanic, greenhouse gas, sulphate aerosol)
All forcings (ensemble member 2)
All forcings (ensemble member 3)
All forcings (ensemble member 4)
NoAssim hindcasts
1860
1979
March 1982
June 1982
…hindcast started each season…
December 2001

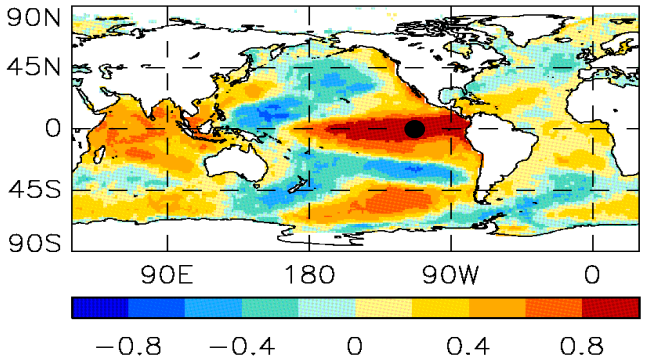
Analysis of historical ocean data

- Need hindcasts to assess likely skill of forecasts
- Problem with very sparse subsurface ocean observations
- Can we use optimal interpolation to reanalyse historical ocean data?

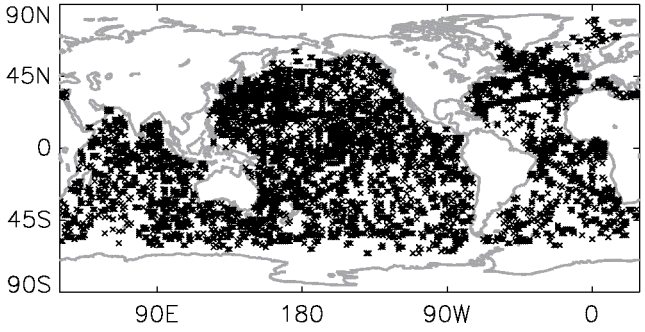




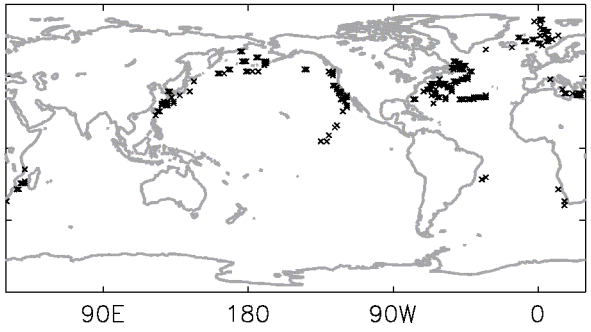
Correlation of SST anomalies with SST at 120^{0}W on the Equator (HadISST, January)



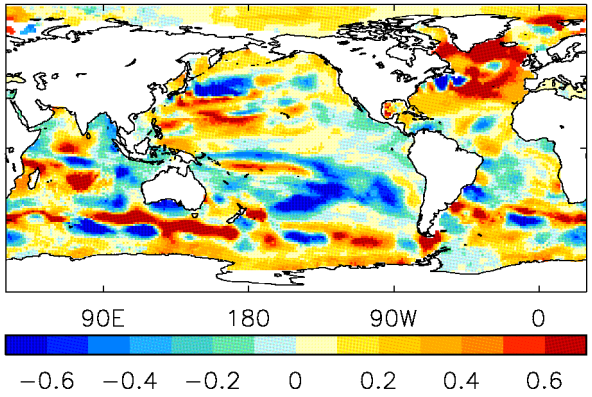
June 2007



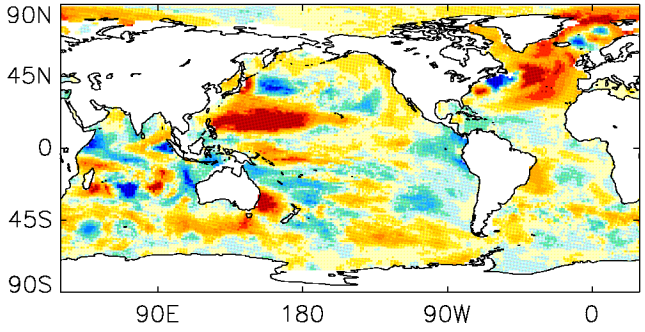
June 1960



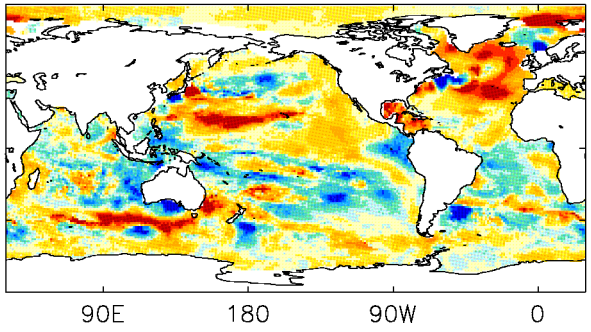
All obs



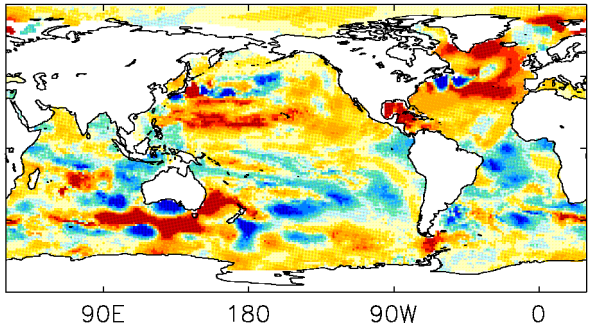
HadCM3 covariances



Iter01

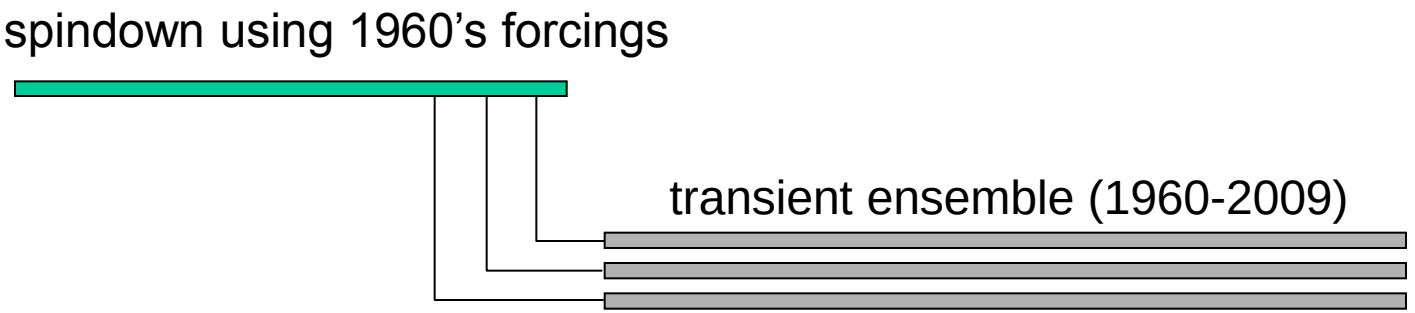


Iter03



T,S OI using model covar → 47y reconstruction to 2006 → recompute covar → iterate

Transient runs



Includes:

Solar (Lean) and volcanic (Sato) forcings

Historic evolving CMIP5 fields

CO2, CH4, NO2, CFC12, HFC134A, O3, sulphur, soot, biomass, OCFF

Run for 50 years

→ Produced model climatology

Assimilation run

Input data

ocean:

HadCM3 GCA 6-hourly anomalies + trans. clim.

fields: T, S, sea-ice-conc.

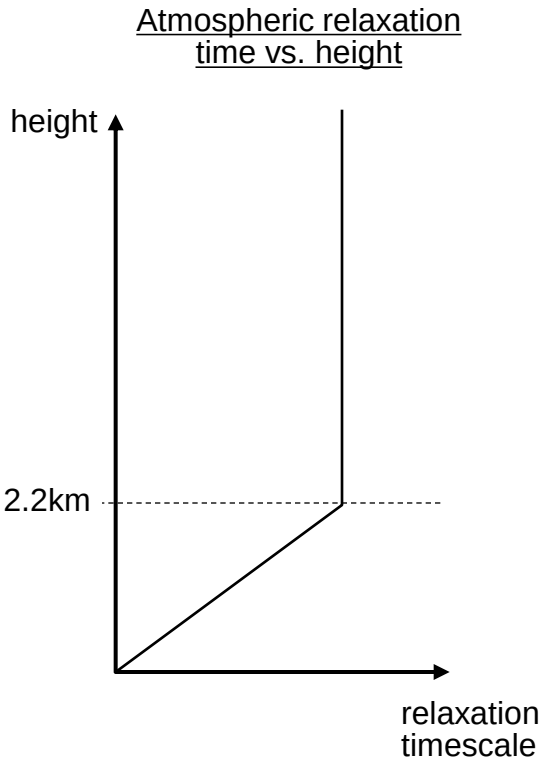
NEMO relaxation scheme

atmosphere:

ERA 6-hourly anomalies + trans. clim.

fields: U, V, T

UM relaxation scheme (6-hour timescale)



Run duration

1960-2009

Output

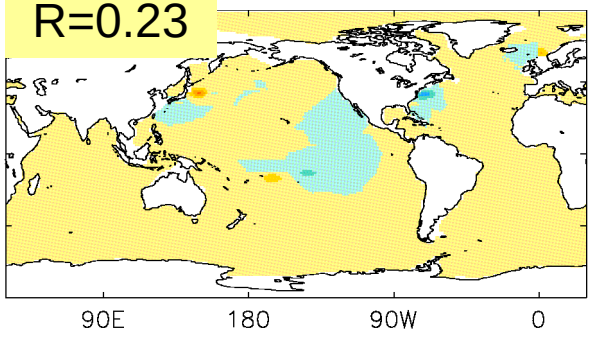
Global Covariances: Reconstructed model T(300m) from Jan 1953 obs locations

Parameterised covariances

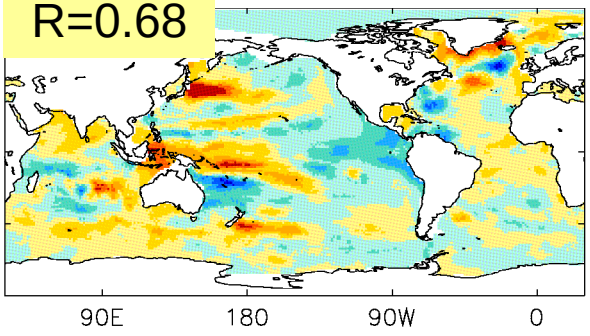
Using actual covariances in multivariate OI

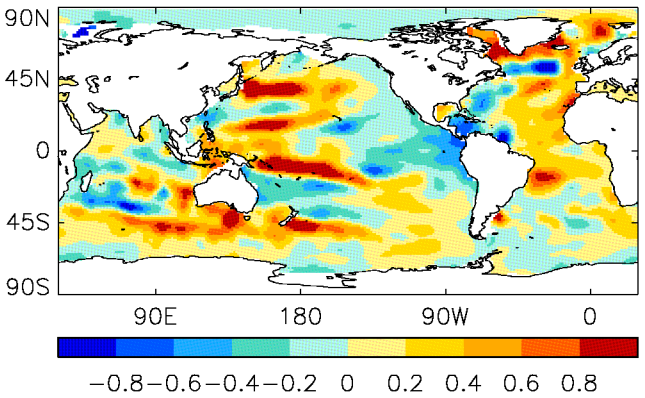
Truth

R=0.23

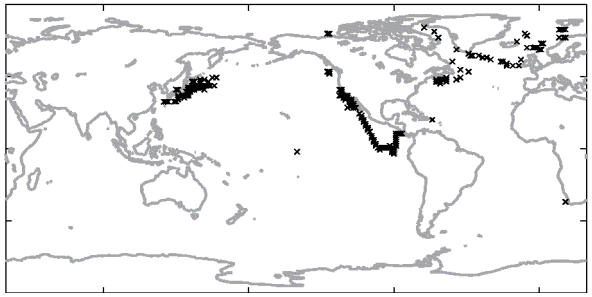


R=0.68





Observations: Jan 1953

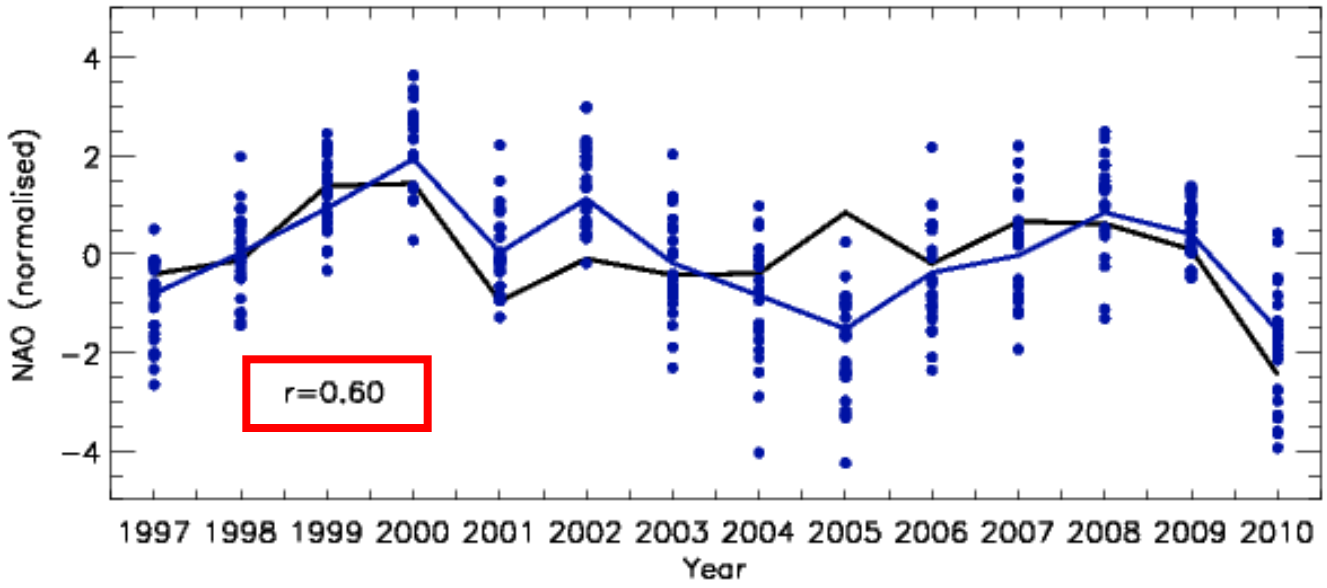


If covariances are known, accurate re-analysis of historical sub-surface temperature and salinity appears to be possible.

Obs covaraiances are not well known so we use GCM to approximate them.

Seasonal Predictability of the Winter NAO

Retrospective winter forecasts from Nov 1



Scaife *et al*. 2013

Skilful prediction of the winter NAO months ahead, correlation 0.6 (significant at the 98% level)

Current operational seasonal systems ~0.2 and not sig.

Represents major step forward in predictability

Amplitude is still too small – model coupling too weak?

SEE POSTER Z297 (Anna Maidens) FOR MORE DETAILS