



Met Office
Hadley Centre



Hadley Centre Decadal Predictions

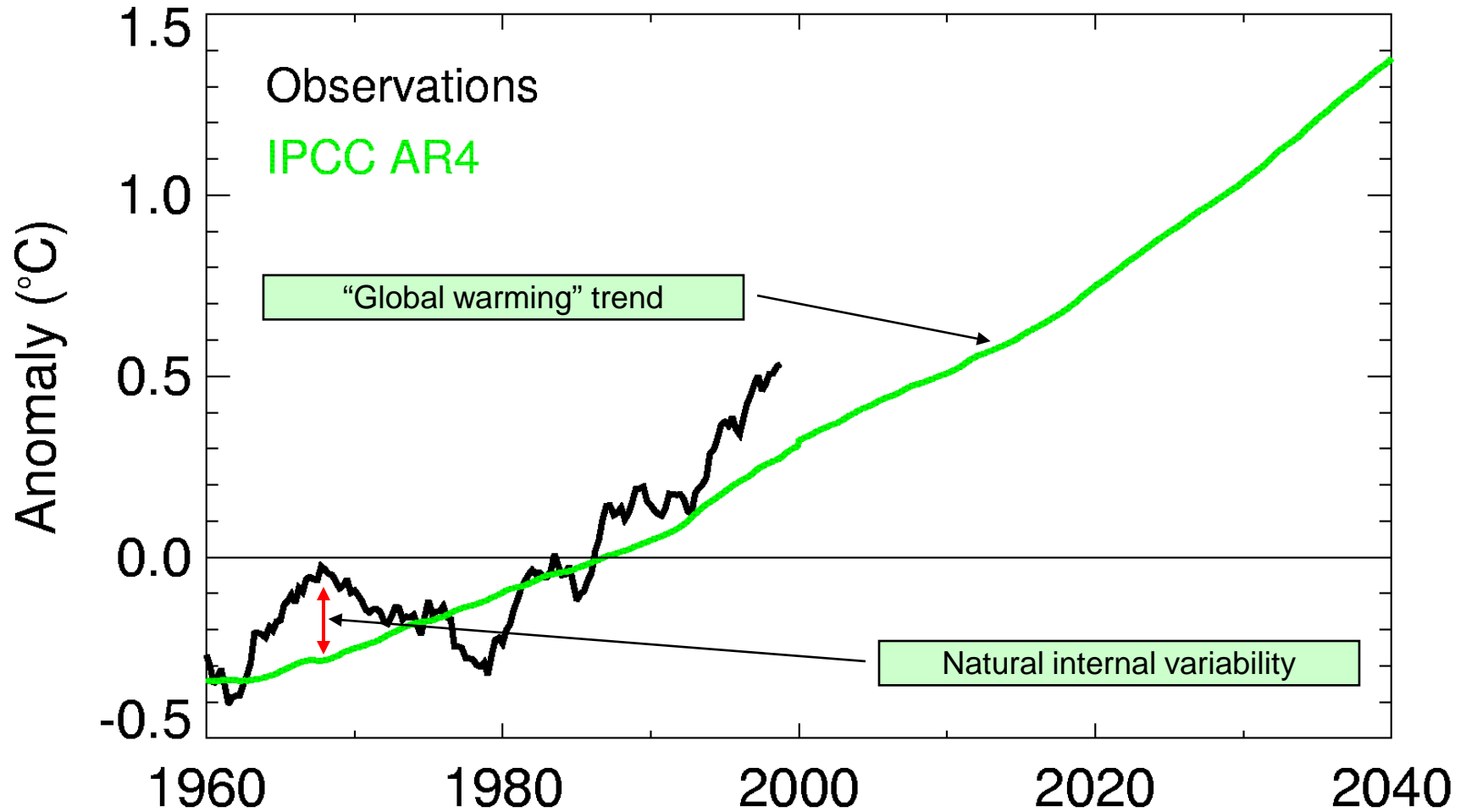
Doug Smith, Nick Dunstone, Rosie Eade, James Murphy, Holger Pohlmann, Adam Scaife



Contents

- The Met Office Decadal Prediction System
 - Initial assessment
- Impact of initial conditions on forecasts from 2007
- Reanalysis of historical ocean observations
 - Needed for hindcasts starting from 1960 etc.
- New hindcasts: preliminary results

UK 9-year mean temperature



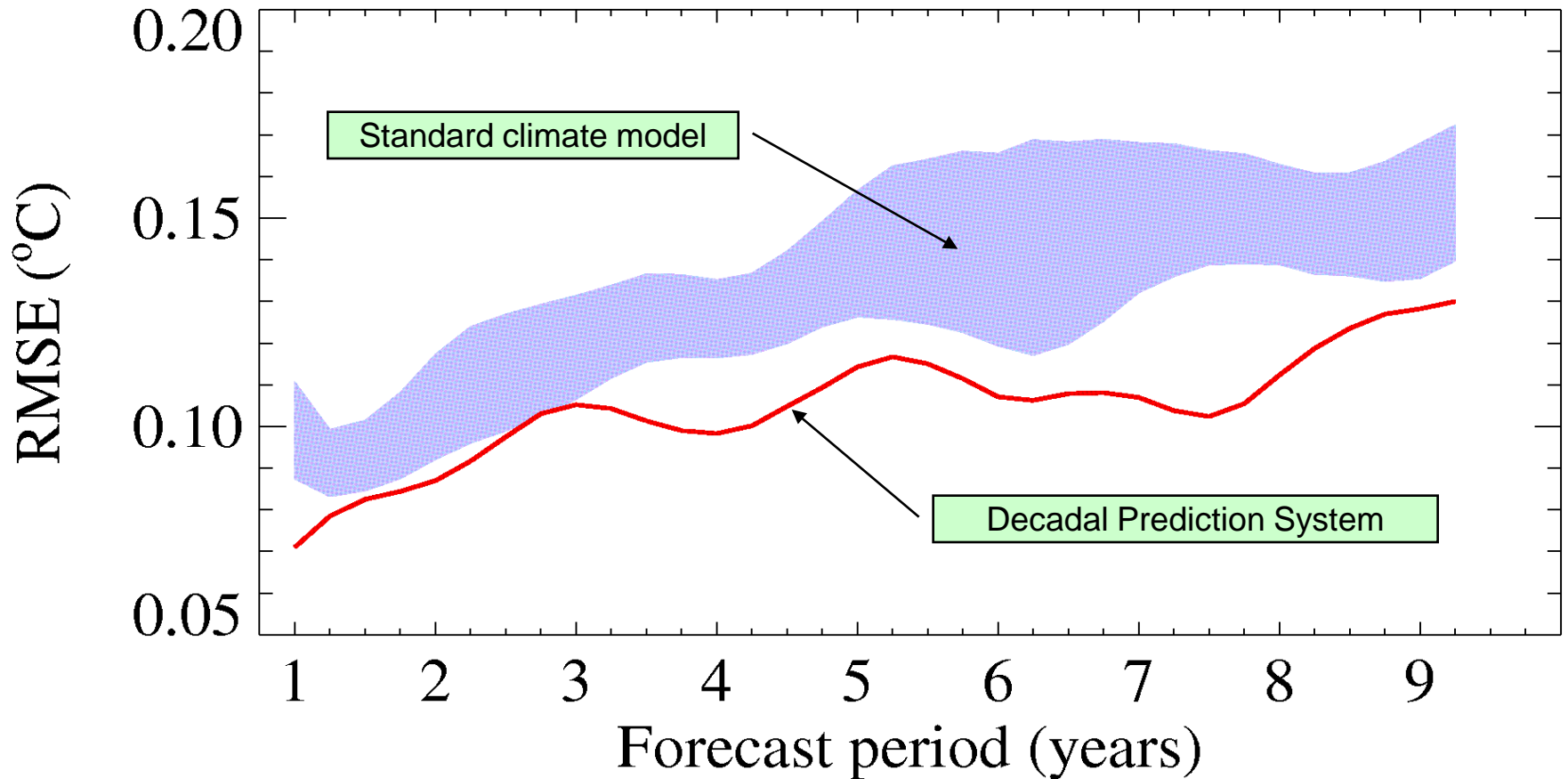
Decadal Prediction System (DePreSys)

- Global coupled climate model (HadCM3)
- Include changes in greenhouse gases and sulphate aerosols (SRES intermediate scenario)
- Repeat previous 11-year solar cycle in forecasts
- Decay volcanic aerosol from the start of a forecast
- Include initial condition information to predict natural internal variability
 - Atmospheric winds, temperature and surface pressure
 - Ocean temperature and salinity
- **Assimilate as anomalies to avoid model drift**

Hindcast experiments to assess skill

- Hindcasts started from 1st March, June, September and December in each year from 1982 to 2001 (20 years x 4 seasons = 80 start dates)
- Each hindcast is 10 years long
- 4 ensemble members
- **Key issue:** Do we achieve additional skill by starting the model from observed initial conditions ?
- Test by making a new set of hindcasts (NoAssim) parallel to DePreSys
- NoAssim includes the same external forcings as DePreSys but omits the assimilation of observed initial conditions.

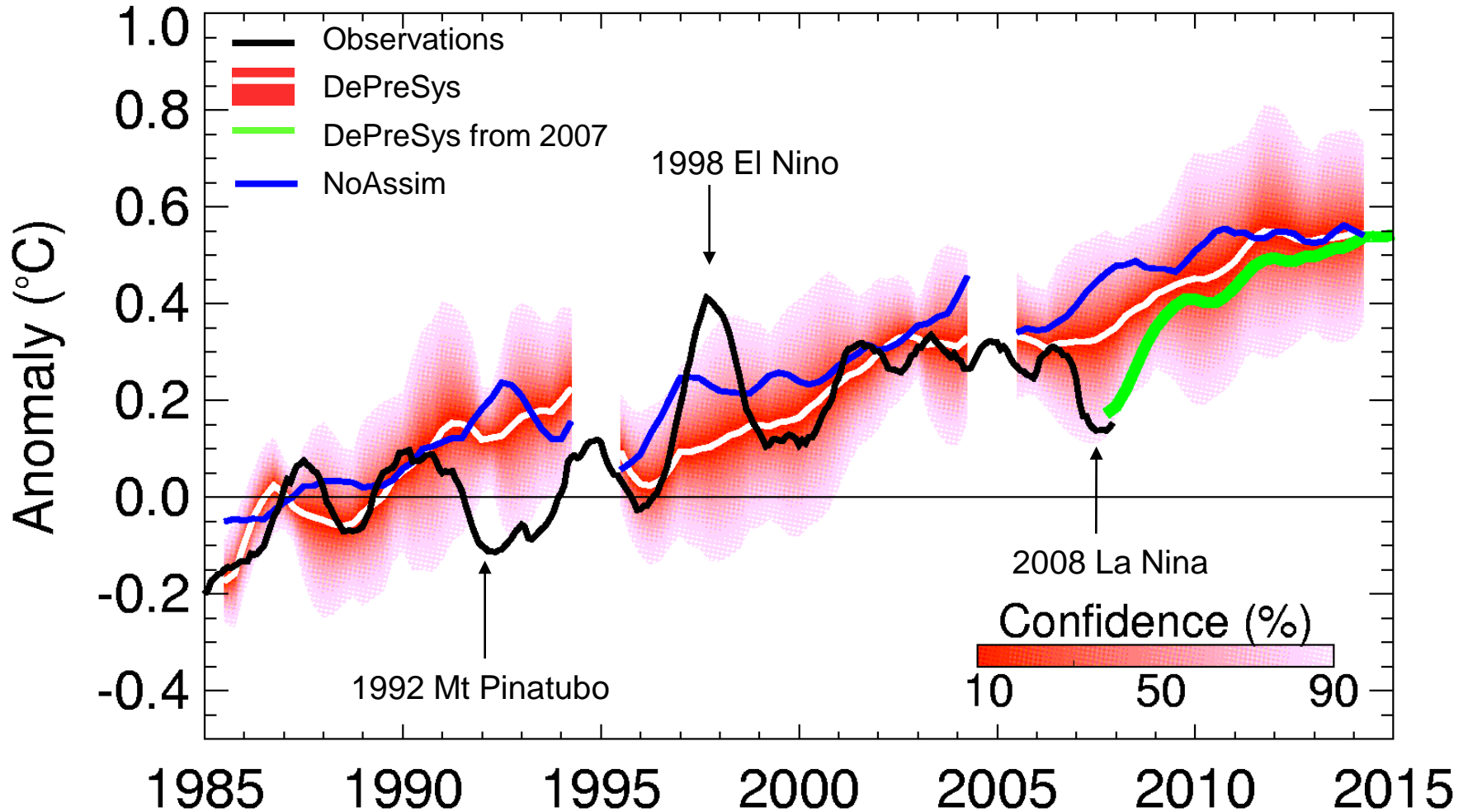
Improved skill of global annual mean surface temperature



Global annual mean surface T

2014 predicted to be 0.3°C warmer than 2004

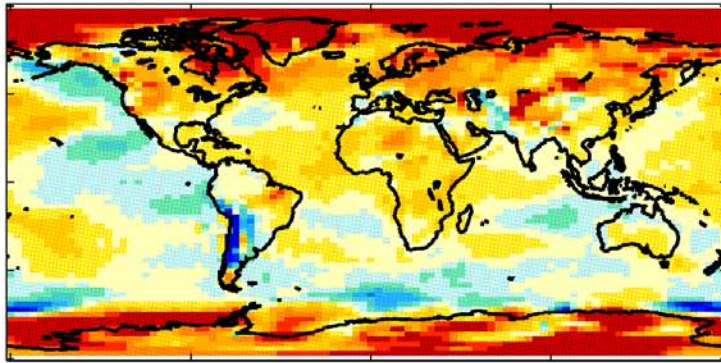
Half of years after 2009 predicted to be hotter than 1998



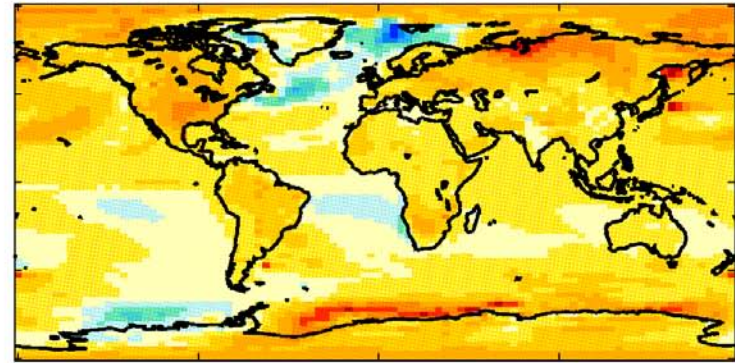
Assessment of forecast from June 2005

Temperature anomalies (wrt 1979-2001) for the period June 2005 to Nov 2008

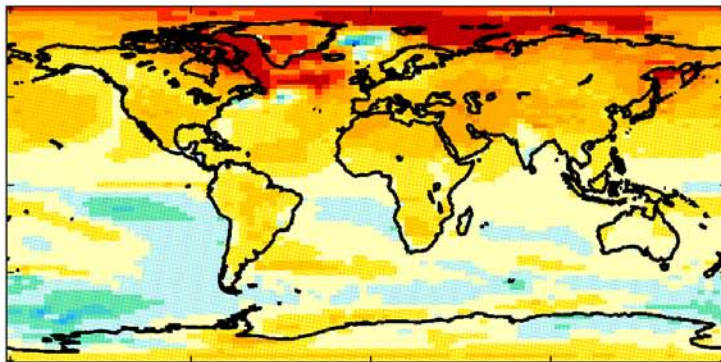
NCEP



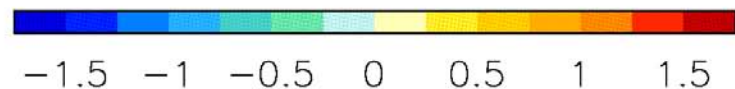
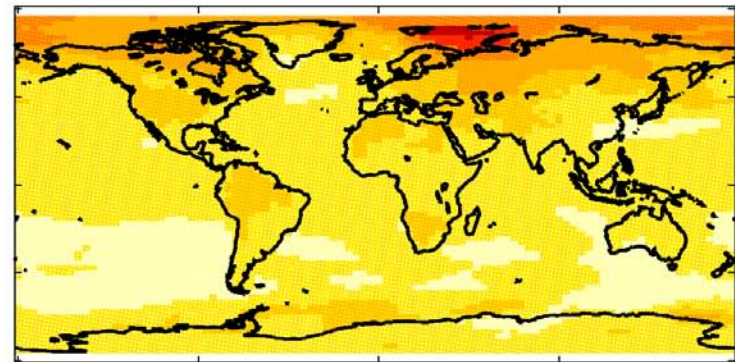
NoAssim



DePreSys



IPCC AR4





Contents

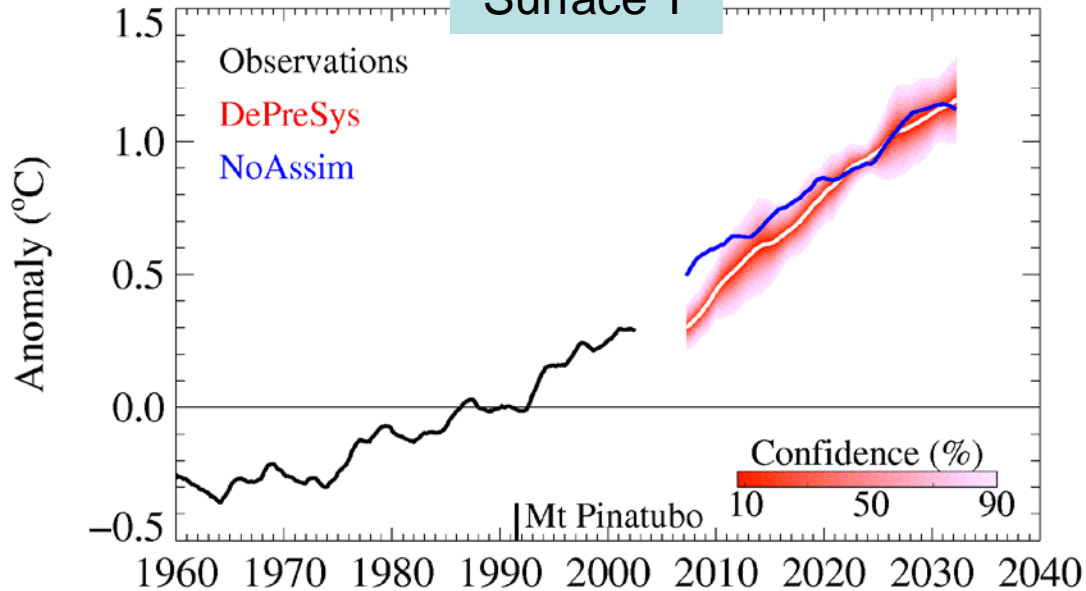
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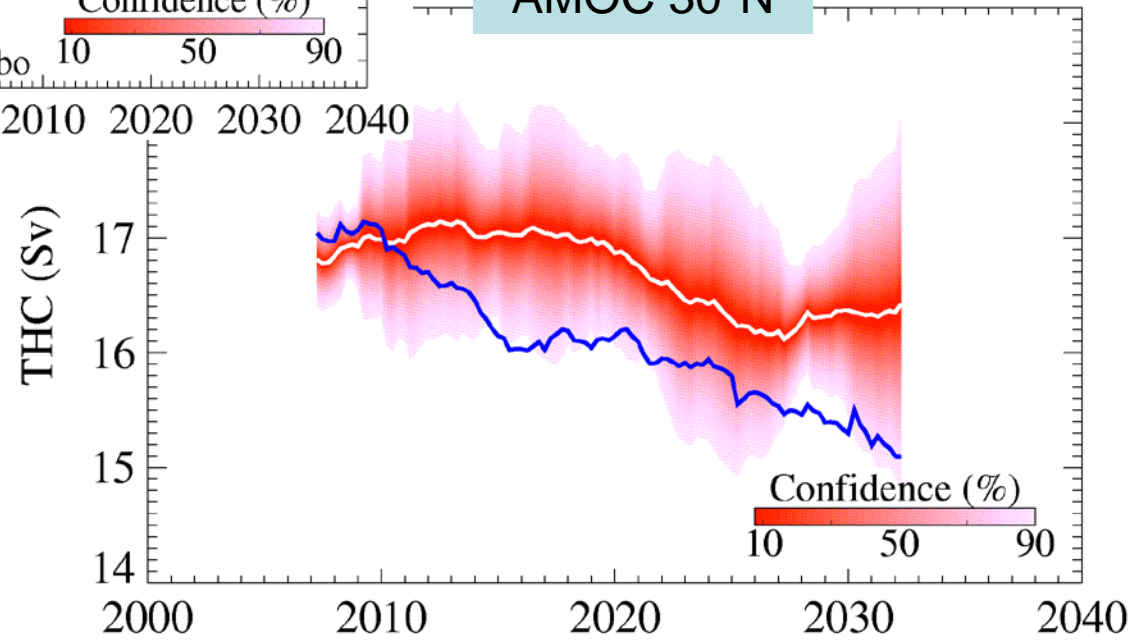
30 year forecasts from Mar 2007

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Surface T



AMOC 30°N



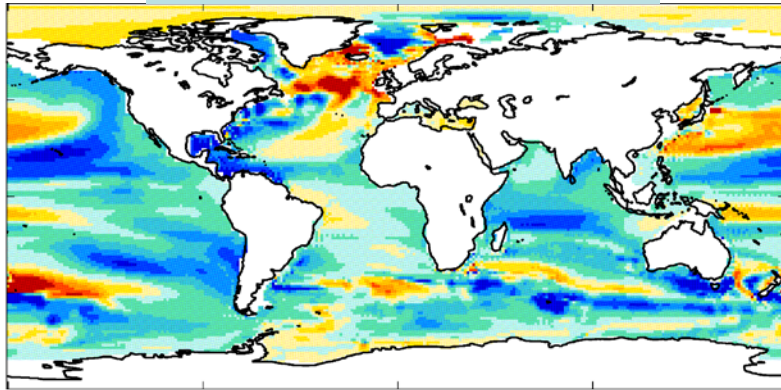
- 5-year means
- 10 members DePreSys
- 4 members NoAssim



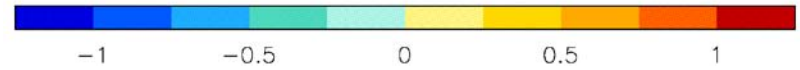
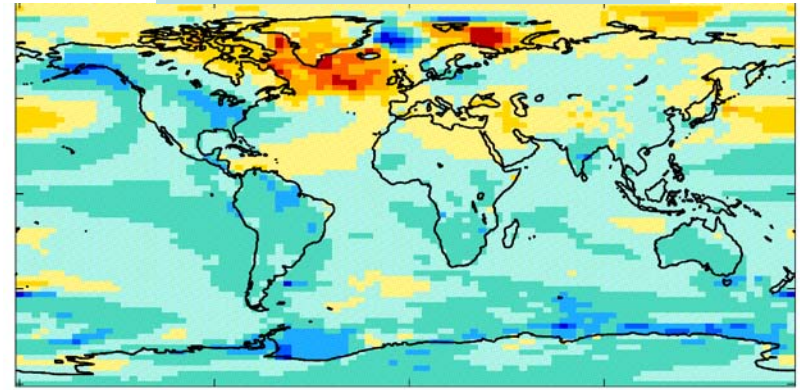
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Impact of initial conditions on the coming decade (2007-2017)

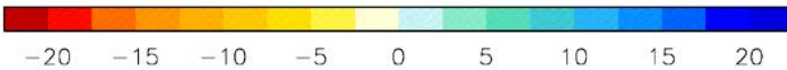
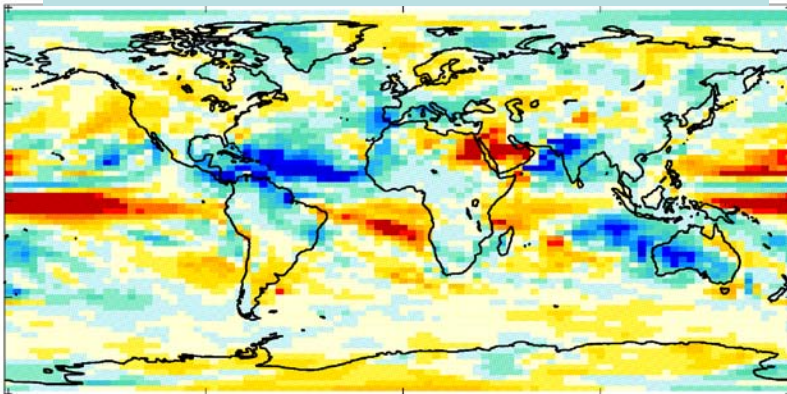
360m upper ocean T



Surface T



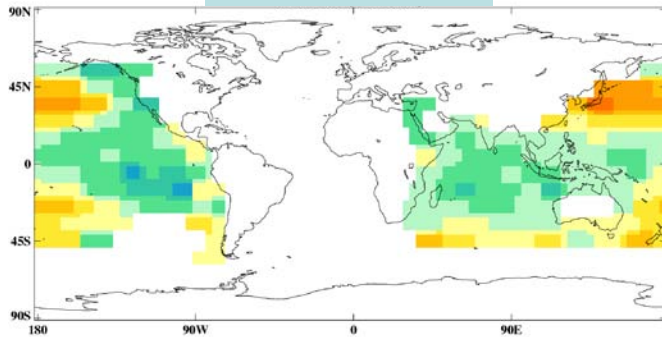
Precip (% of 1979-2001 mean)



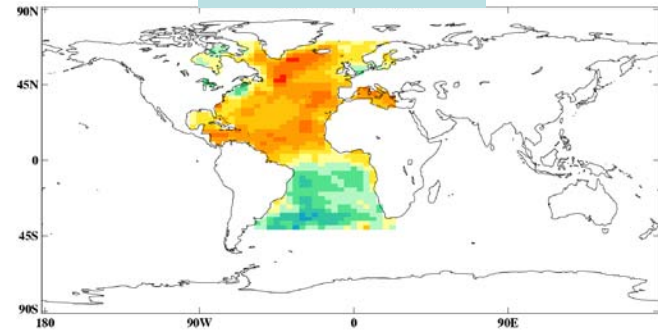
- Mar 2007 to Feb 2017
- DePreSys - NoAssim

Impact of initial conditions on PDO and AMO

PDO

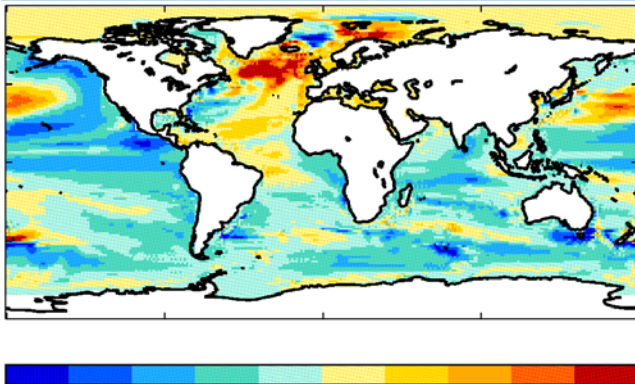


AMO



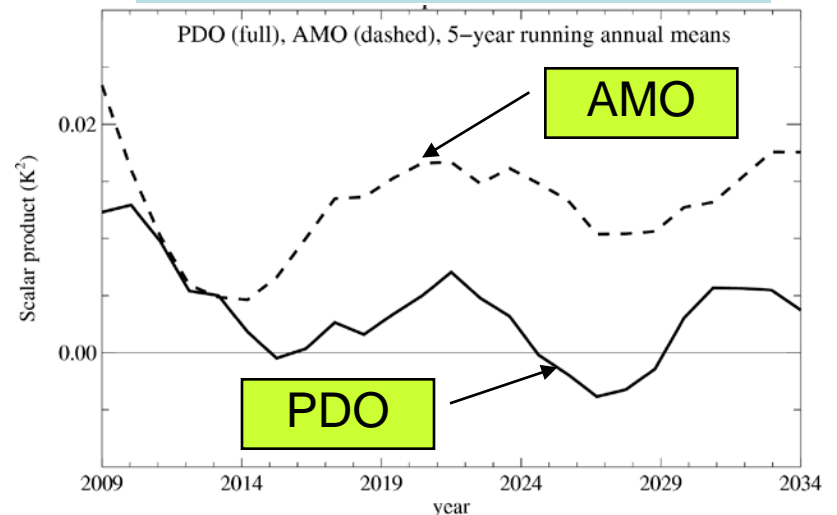
DePreSys – NoAssim

110m ocean T, 2007-12



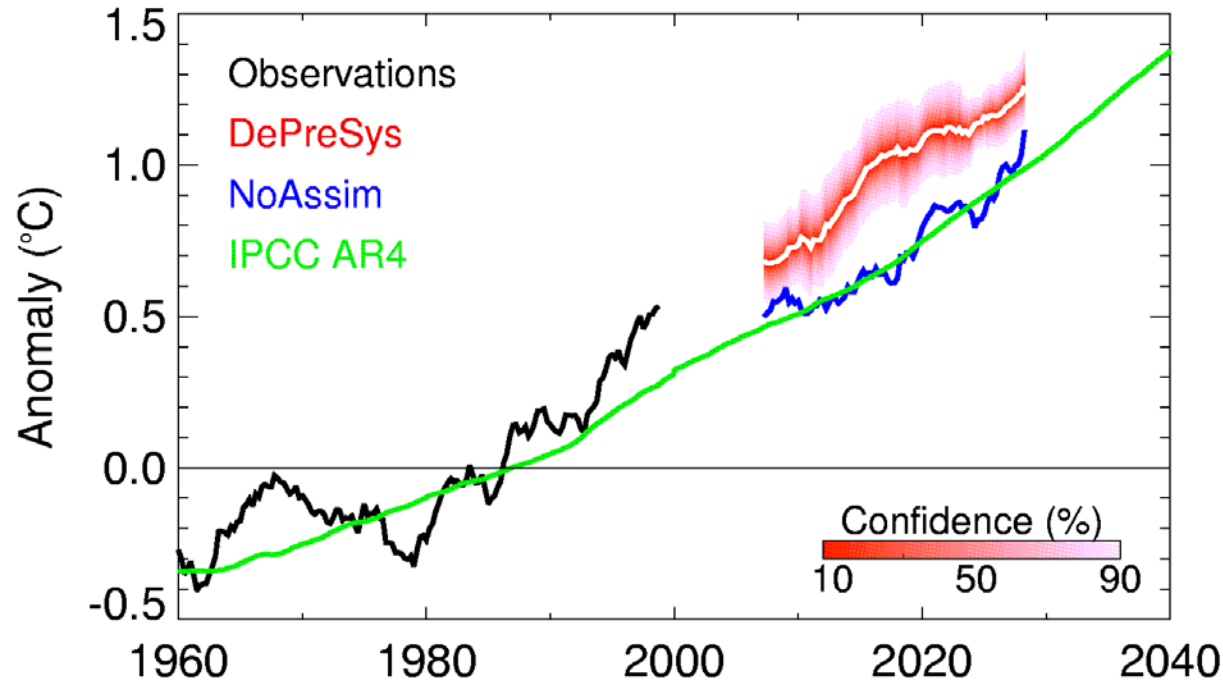
-1 -0.5 0 0.5 1

DePreSys – NoAssim

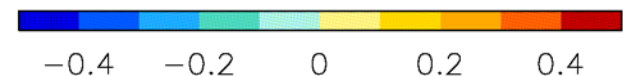
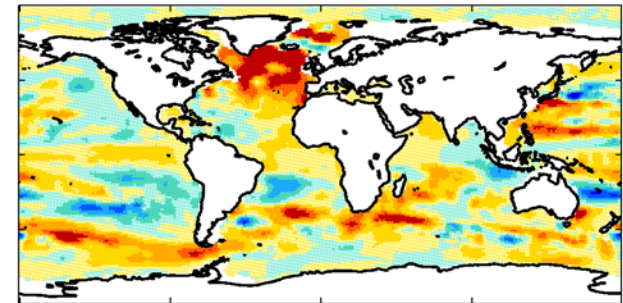


30 year forecasts from Mar 2007: UK 9-year mean T

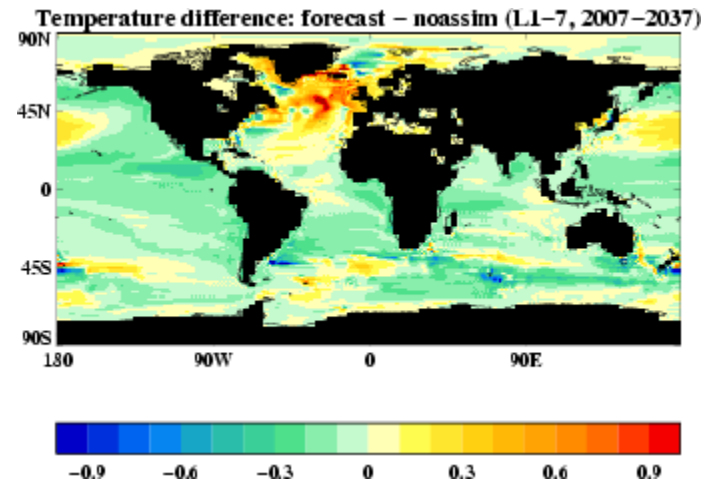
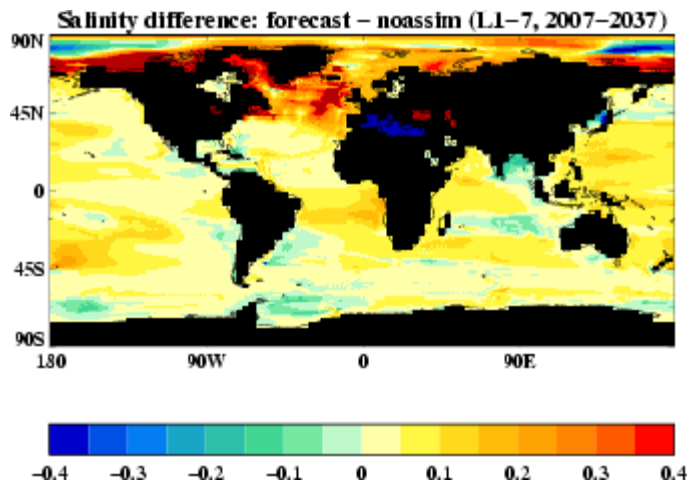
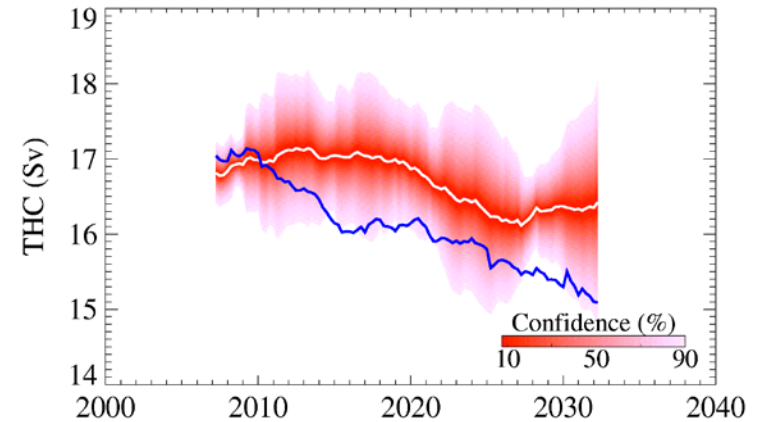
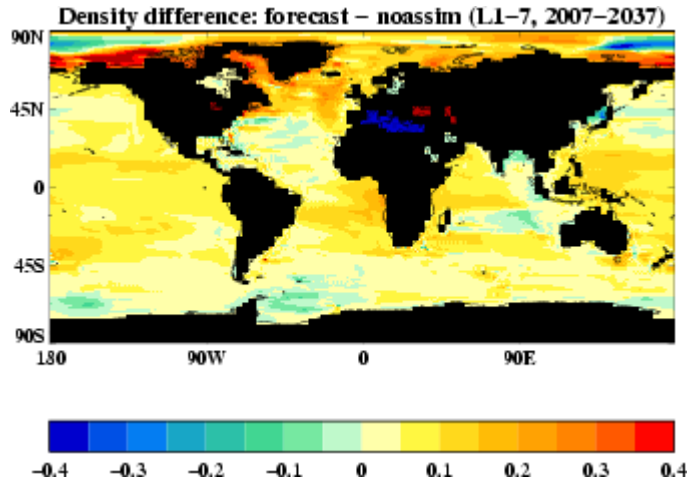
UK 9-year mean T



360m ocean T, March 2007



Salinity initialisation likely to be important in explaining maintenance of MOC in DePreSys 30 year forecast





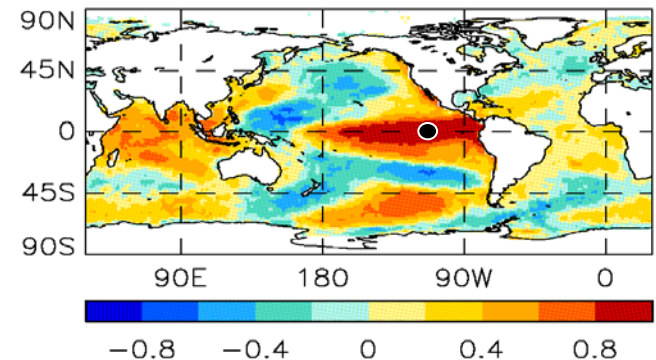
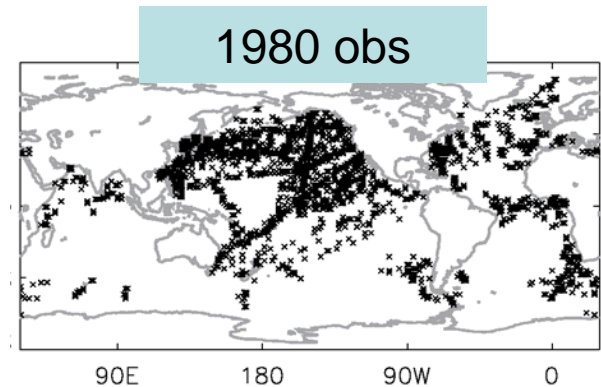
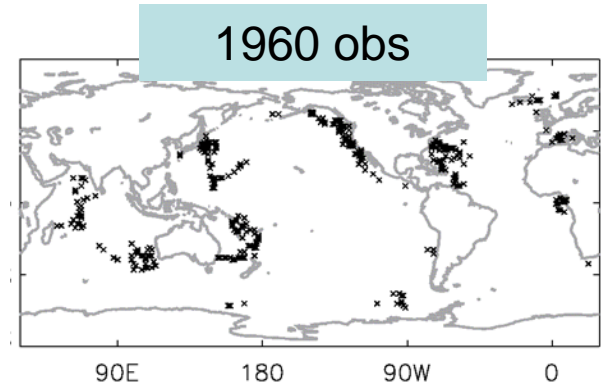
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Analysis of historical ocean data

- 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?

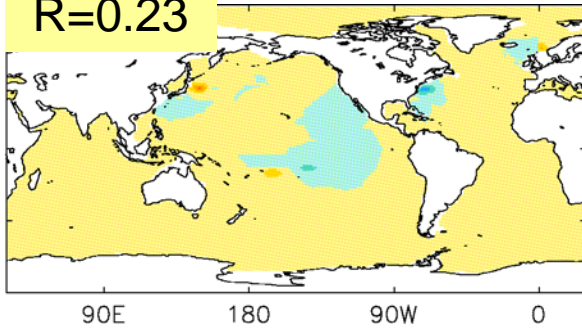
Correlation of SST anomalies with SST at 120°W on the Equator (HadISST, January)



Reconstructed model temperature at 300m from Jan 1953 obs locations

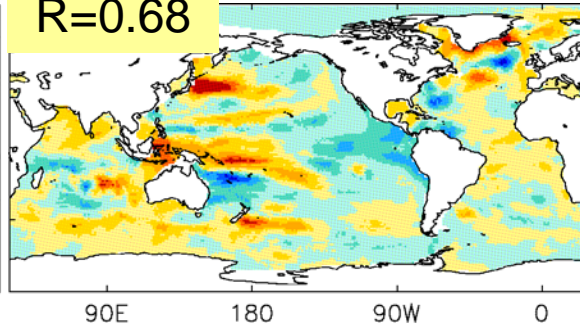
Parameterised covariances

R=0.23

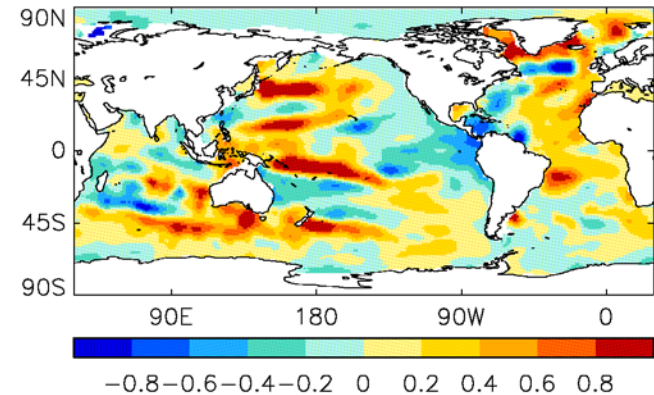


Actual covariances

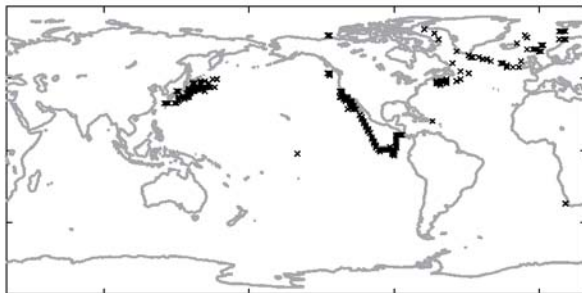
R=0.68



Truth



Observations: Jan 1953



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



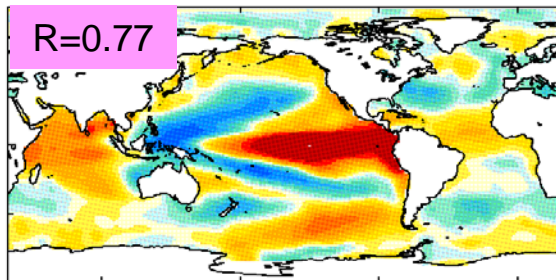
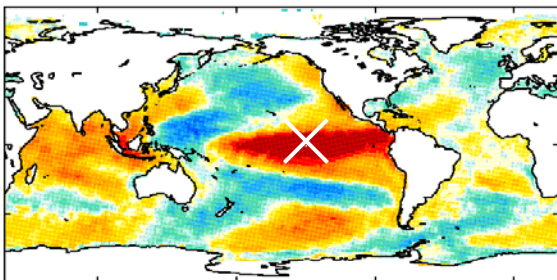
SST anomaly correlations: HadCM3

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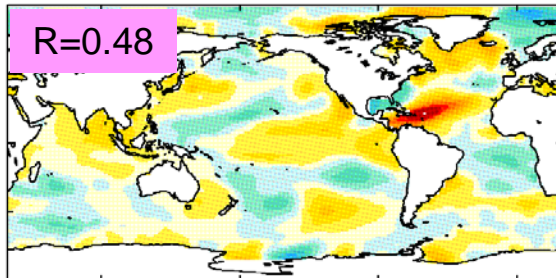
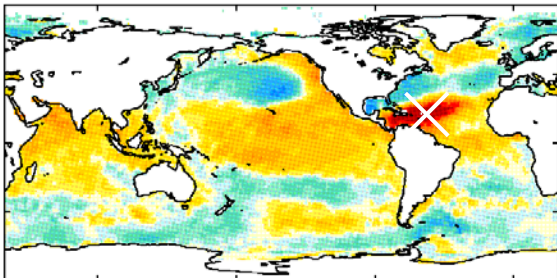
Obs (HadISST)

Model (HadCM3)

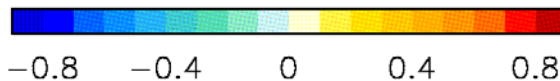
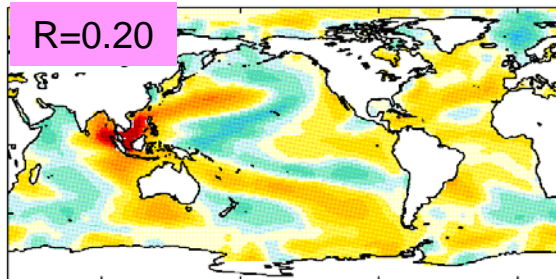
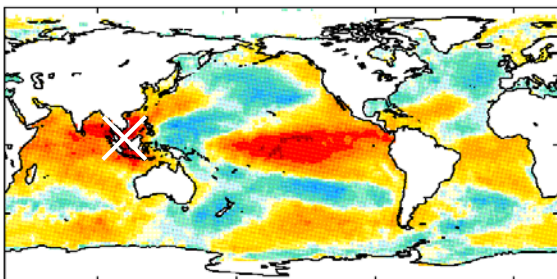
130°W, 0°N



60°W, 20°N



105°E, 5°N





SST anomaly correlations: model ensemble

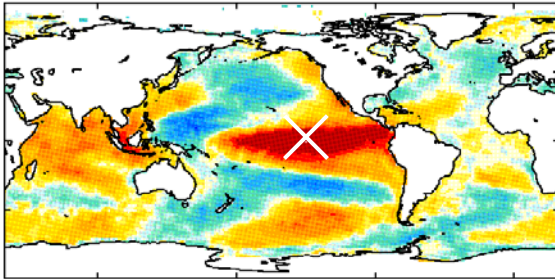
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Obs (HadISST)

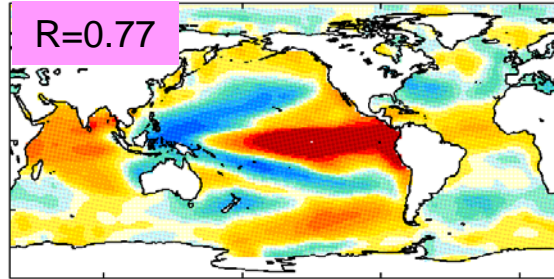
Model (HadCM3)

Model ensemble

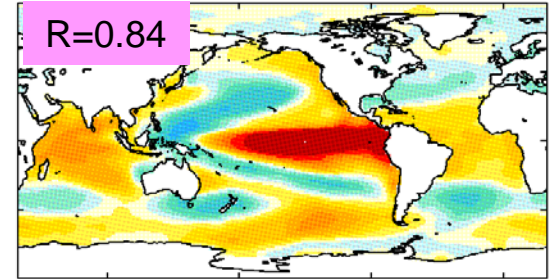
130°W, 0°N



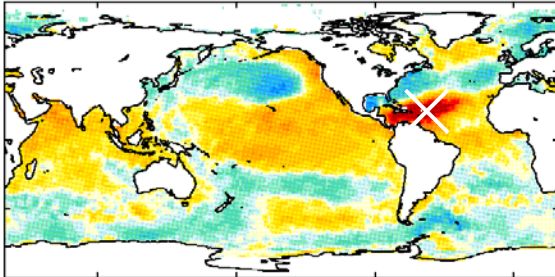
R=0.77



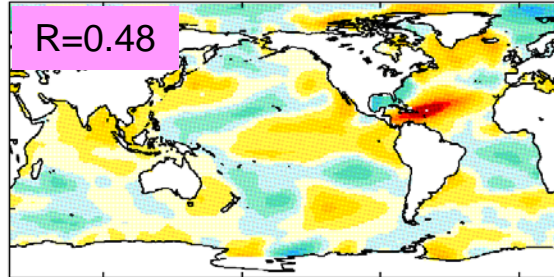
R=0.84



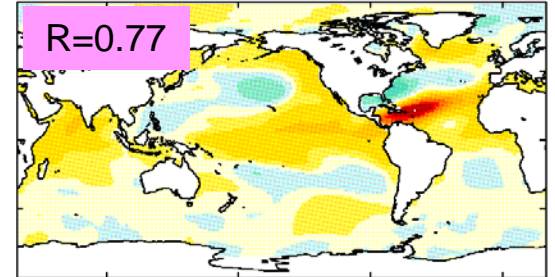
60°W, 20°N



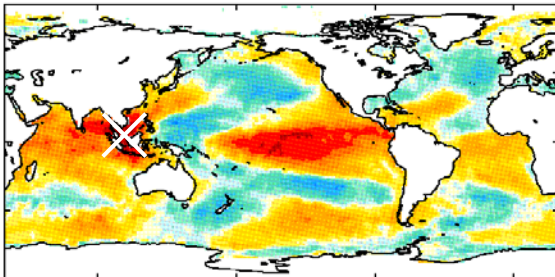
R=0.48



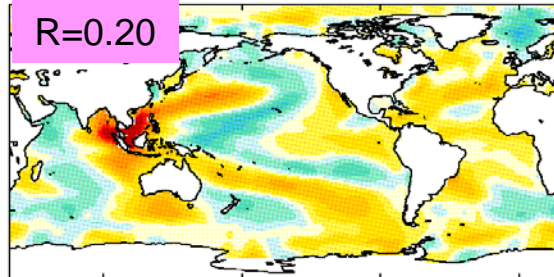
R=0.77



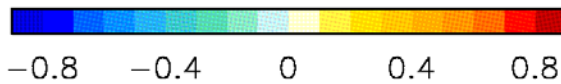
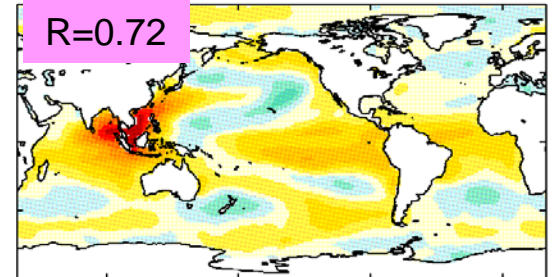
105°E, 5°N



R=0.20

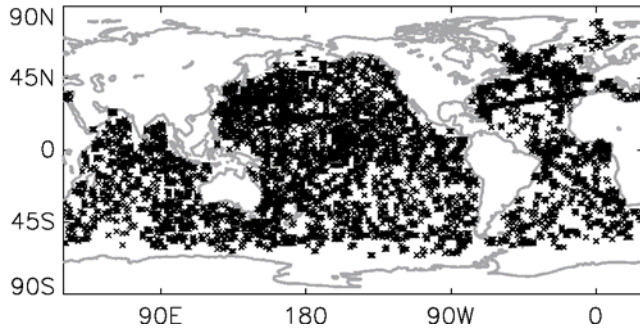


R=0.72

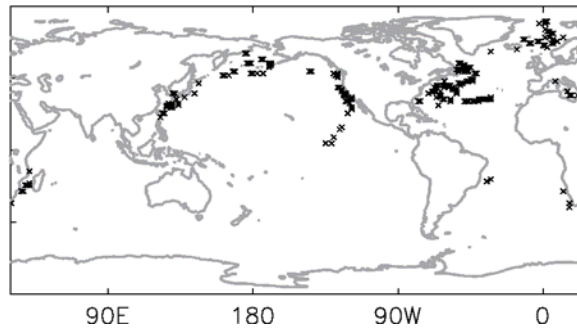


Temperature at 300m : June 2007 from 1960 obs

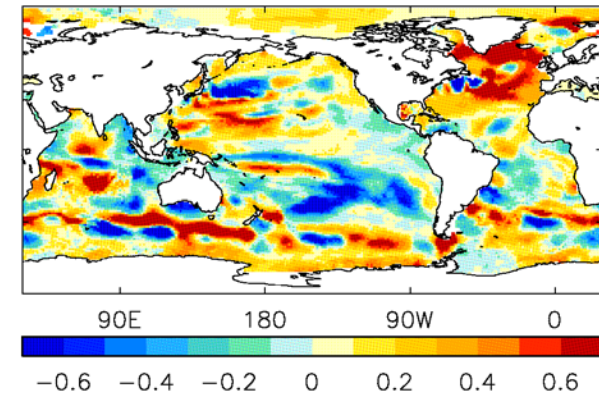
June 2007



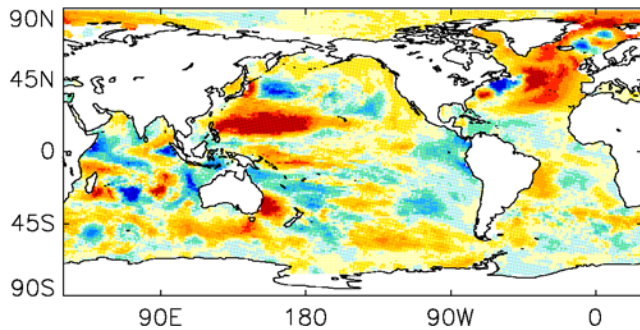
June 1960



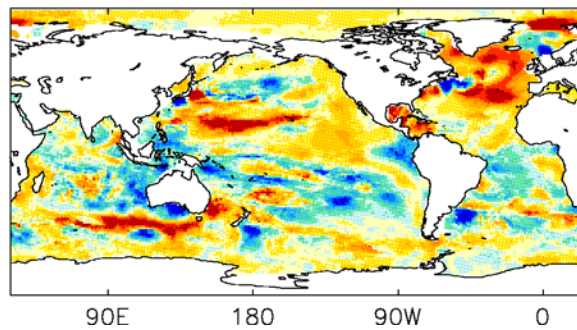
All obs



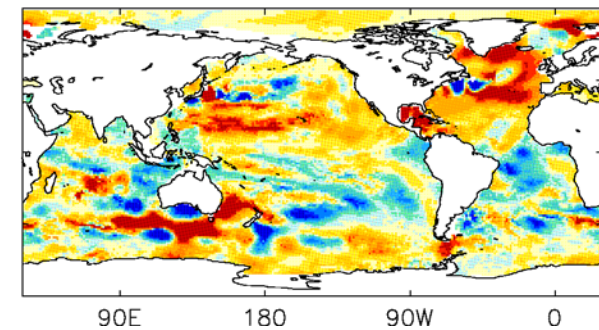
HadCM3 covariances



Iter01

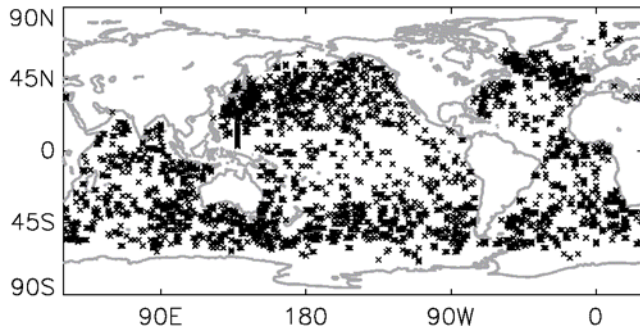


Iter03

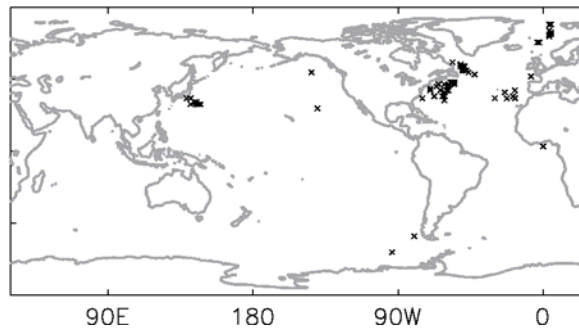


Salinity at 1500m : June 2007 from 1960 obs

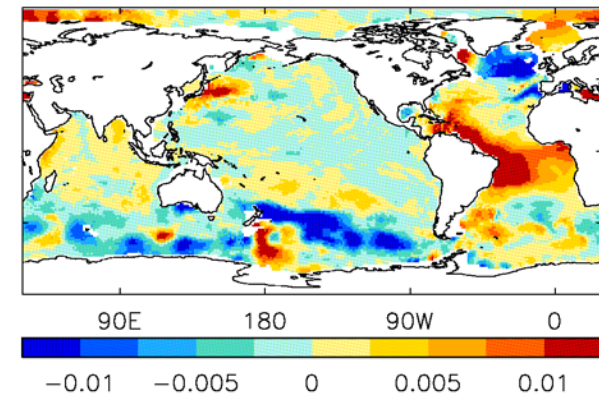
June 2007



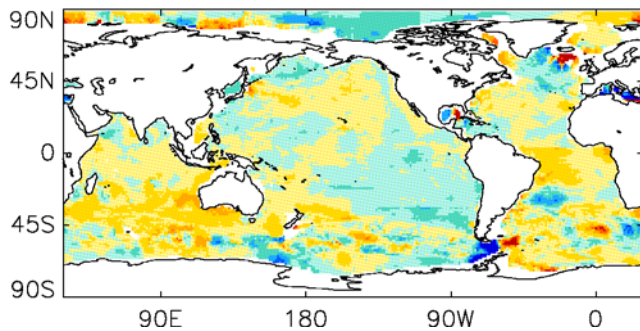
June 1960



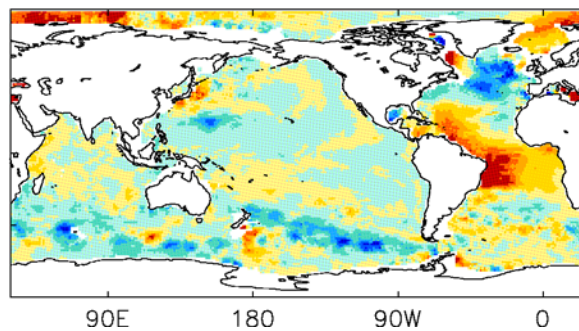
All obs



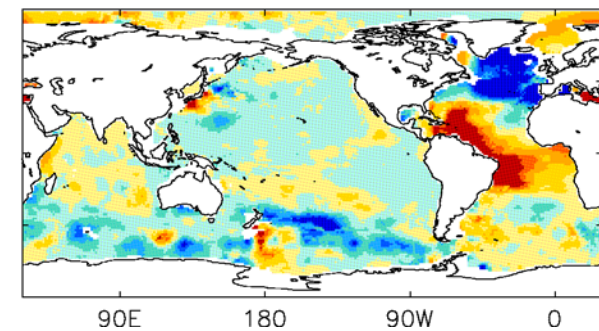
HadCM3 covariances



Iter01

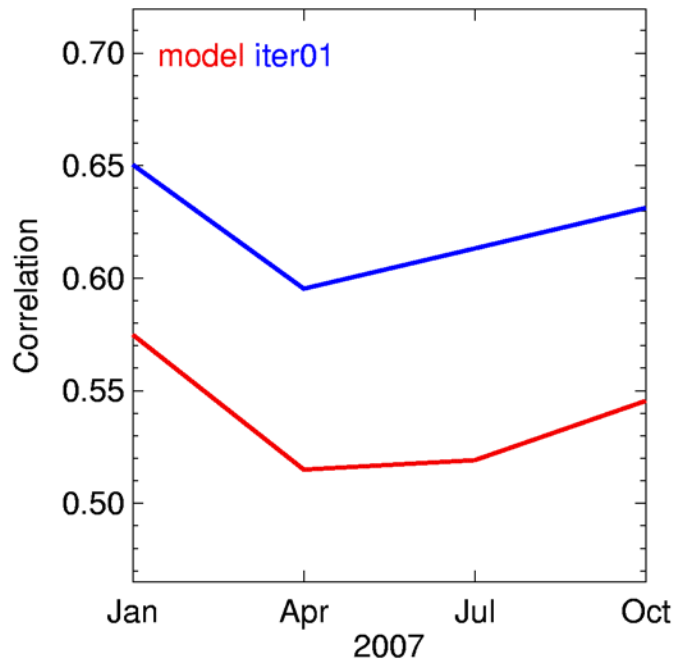


Iter03

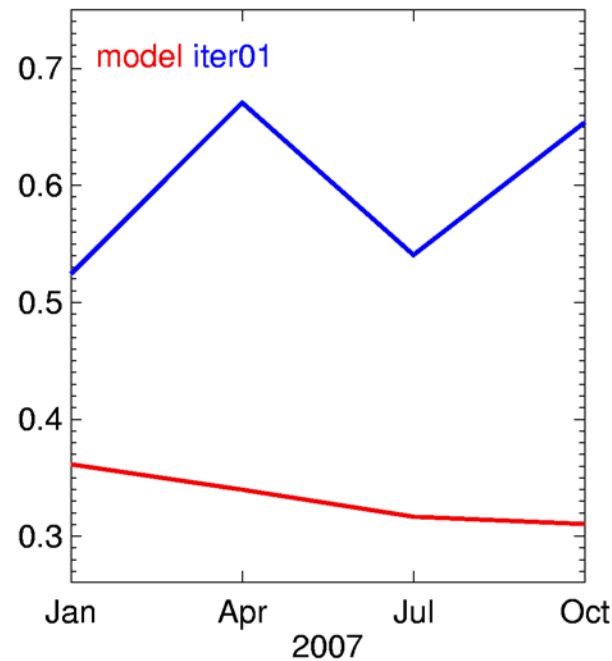


Temperature : reconstruction of 2007 using 1960s obs

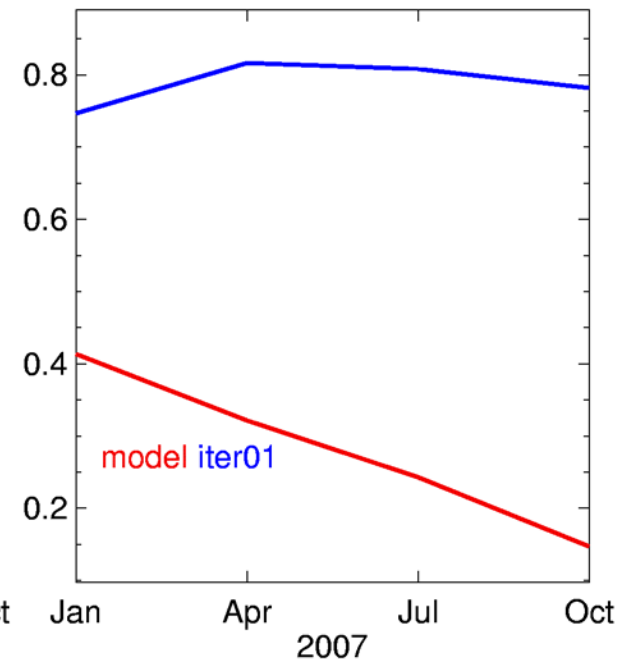
200m



650m



1500m



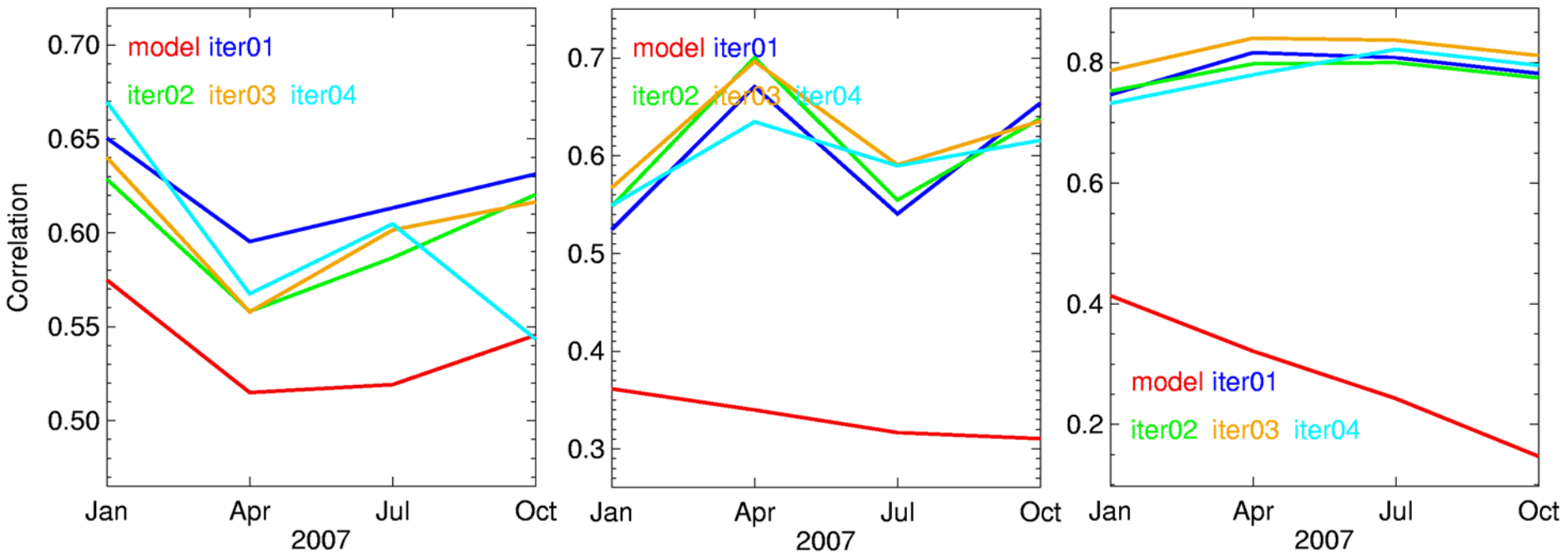
Correlation between analyses using all observations, and analyses using observations sampled at 1960s locations

Temperature : reconstruction of 2007 using 1960s obs

200m

650m

1500m



Correlation between analyses using all observations, and analyses using observations sampled at 1960s locations



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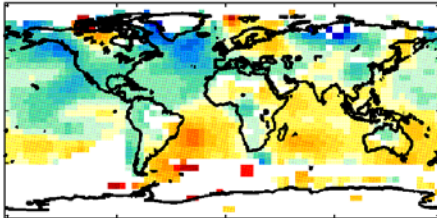
New hindcast experiments

- DePreSys2
 - Start dates Nov 1960, 1965, 1970, ... , 2005
 - 10 ensemble members
 - 10 years long, except 1965, 1975, ..., 2005 extended to 30 years
- DePreSys2 PPE
 - EU ENSEMBLES project, starting each year from 1960 to 2005, 9 members with perturbed model parameters
- Parallel NoAssim experiments

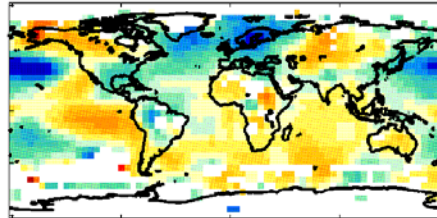
9 year mean surface temperature anomalies

Observations

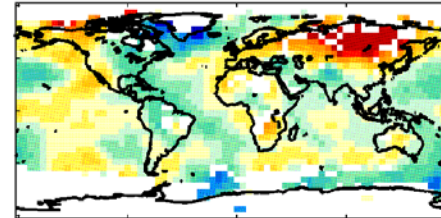
1968–1977



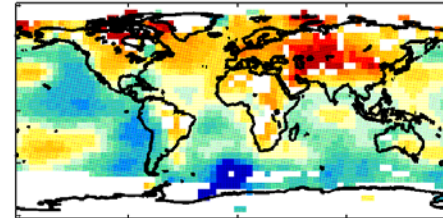
1978–1987



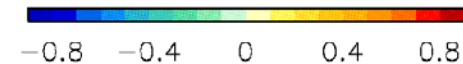
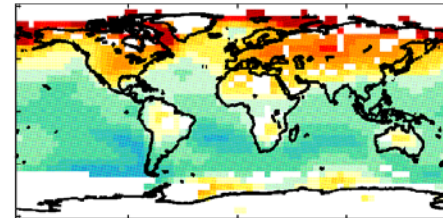
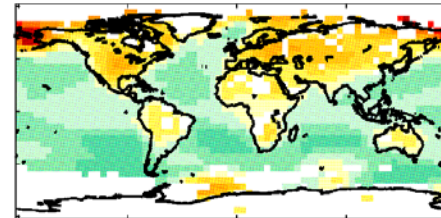
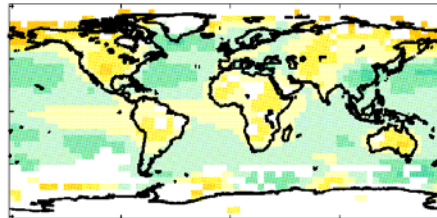
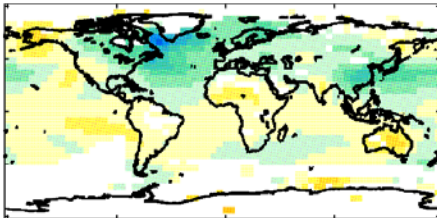
1988–1997



1998–2007

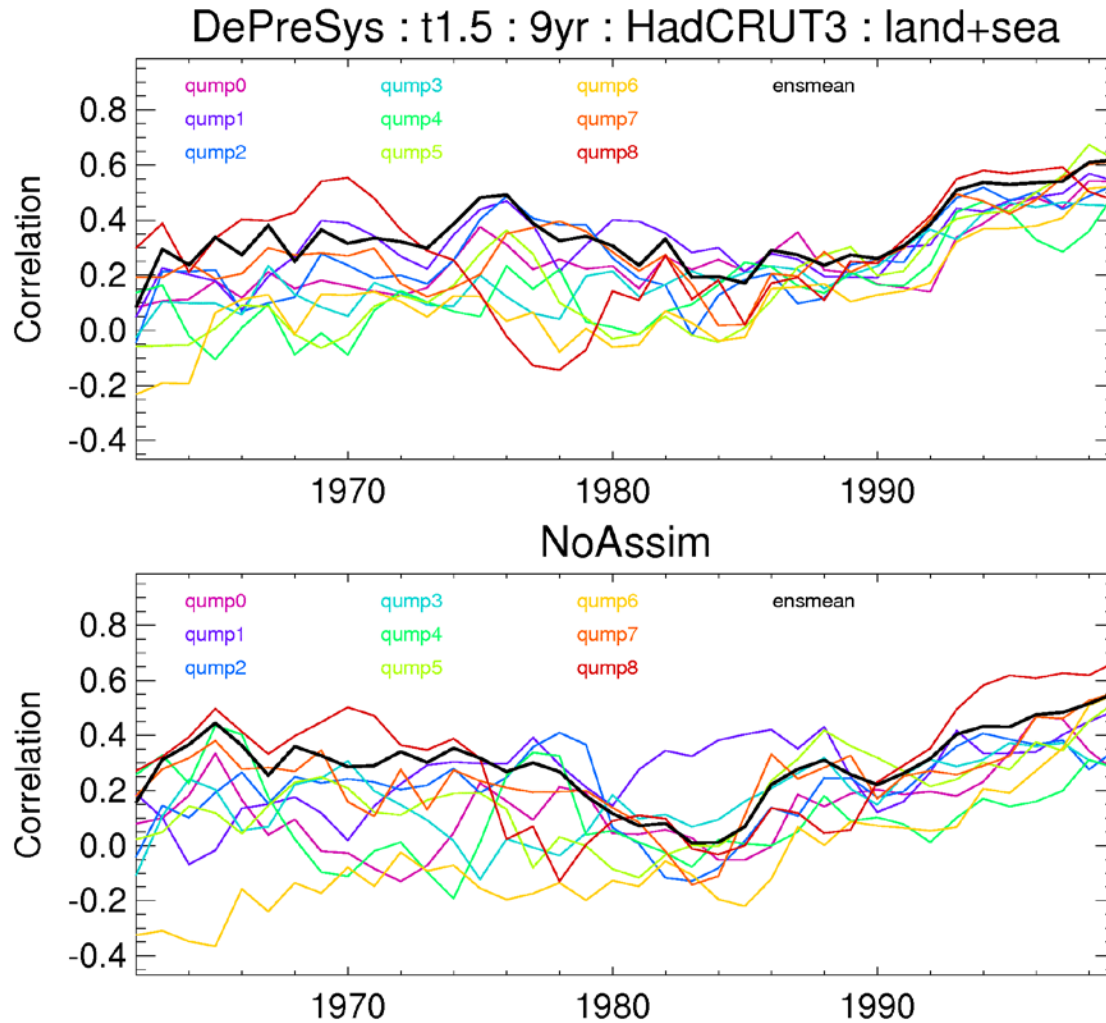


DePreSys

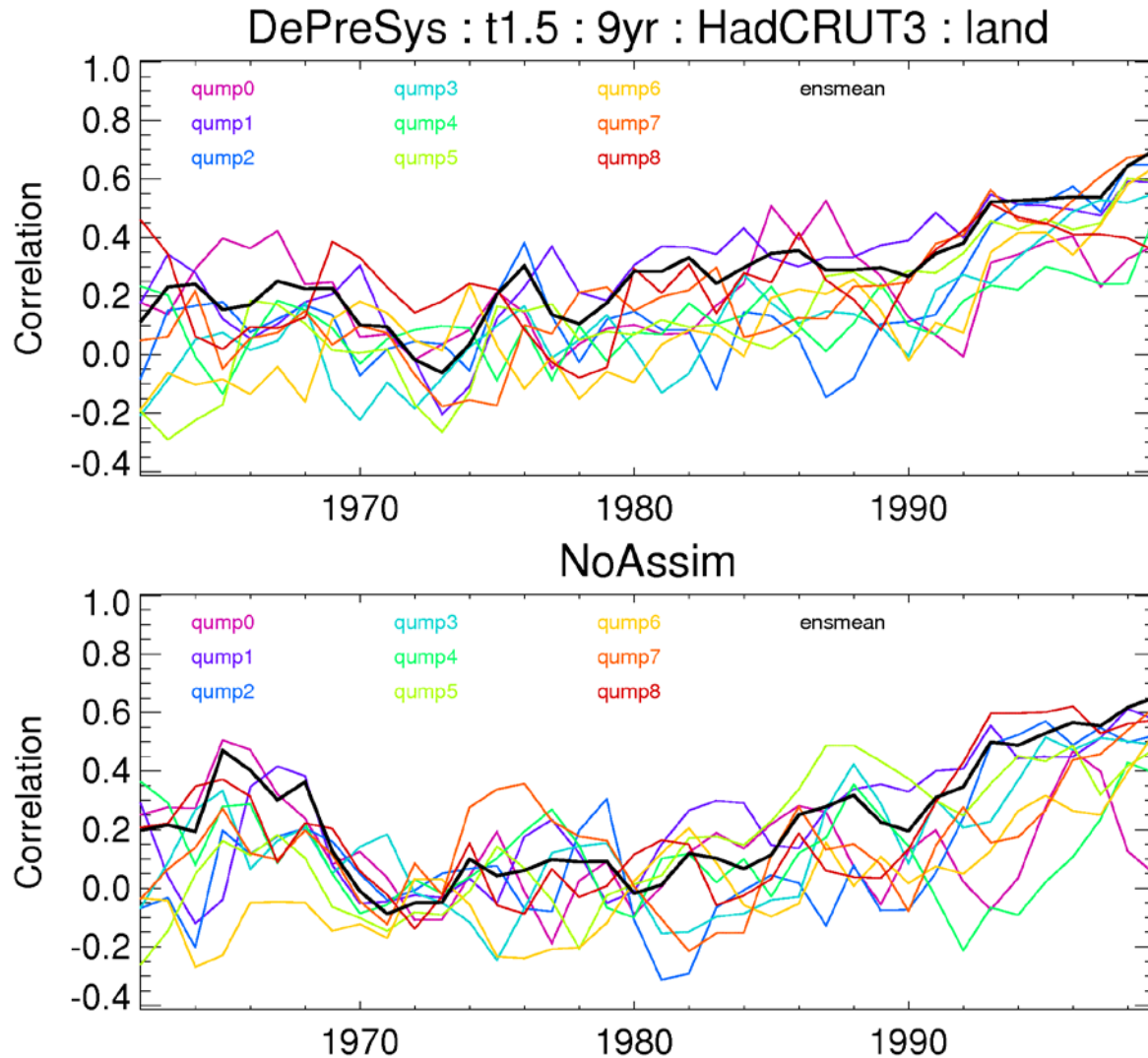


- Anomalies from rolling 30 year climate
- Normalised for zero global mean
- Observations from HadCRUT3
- 15x15 degree lat/lon boxes

Time series of spatial correlation: 9 year mean surface temperature

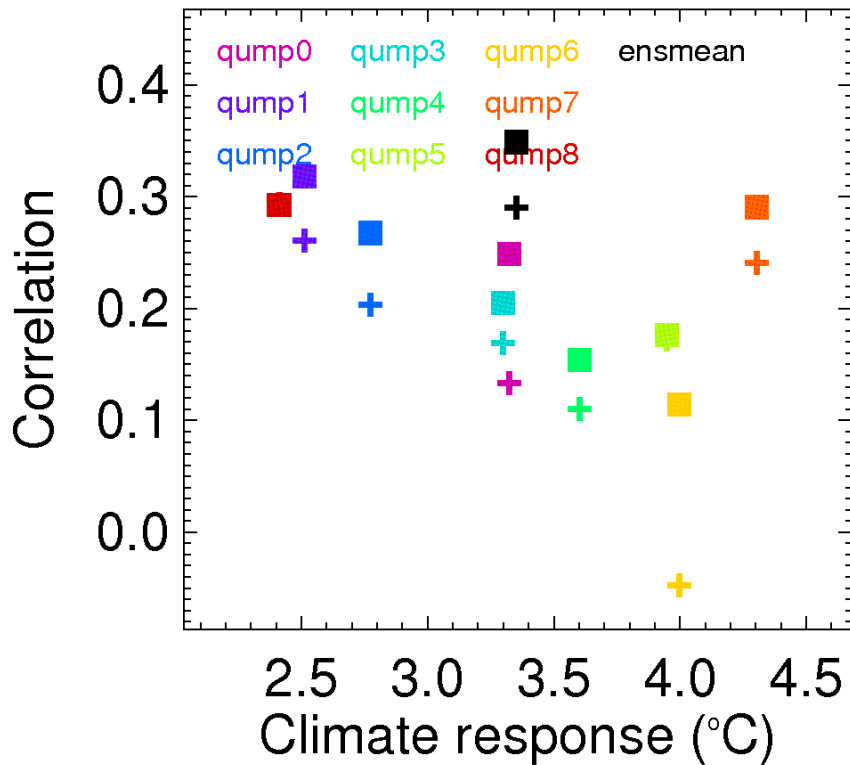


Time series of spatial correlation: 9 year mean surface temperature: land

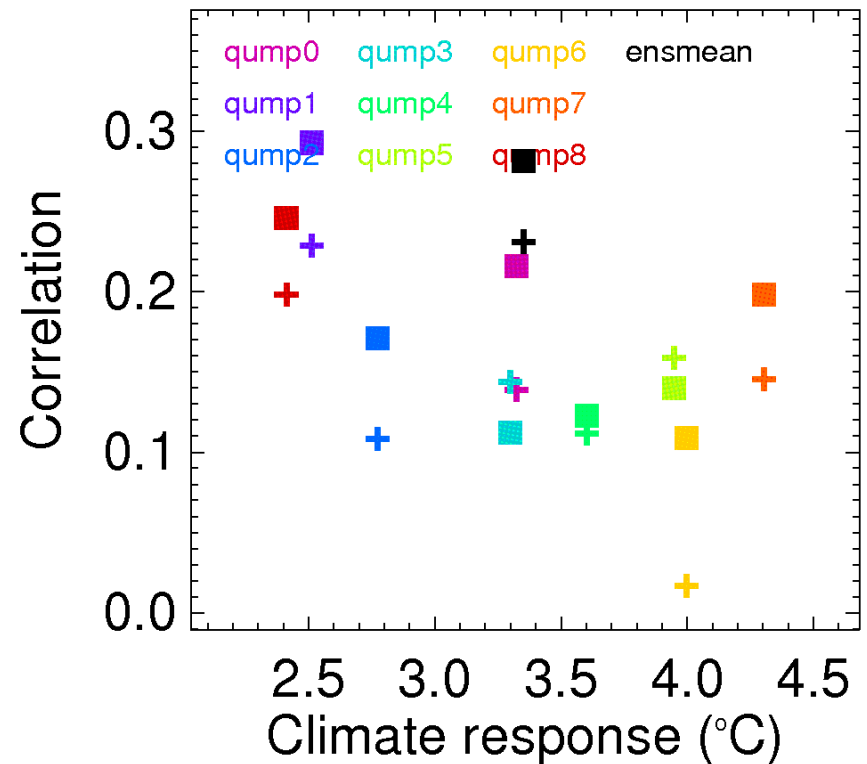


Average spatial correlation: 9 year mean surface temperature

Land + sea

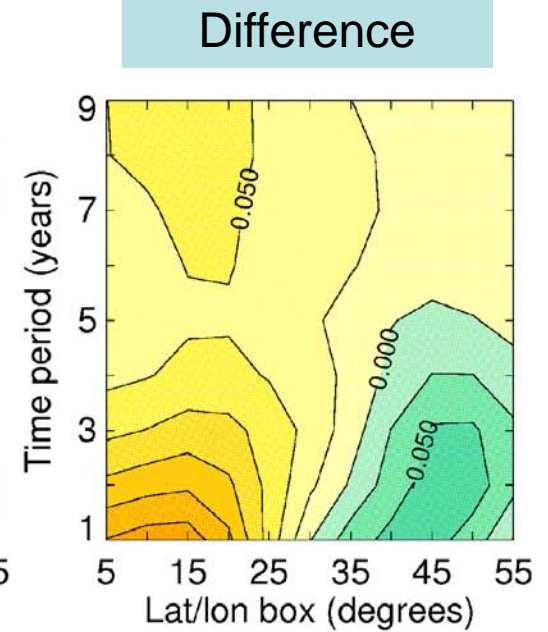
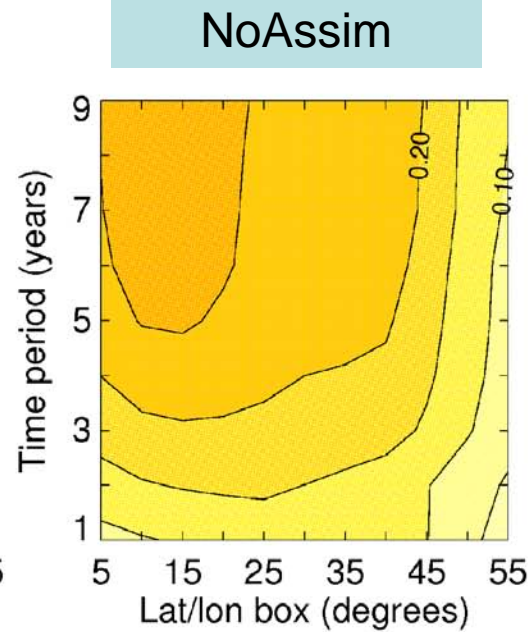
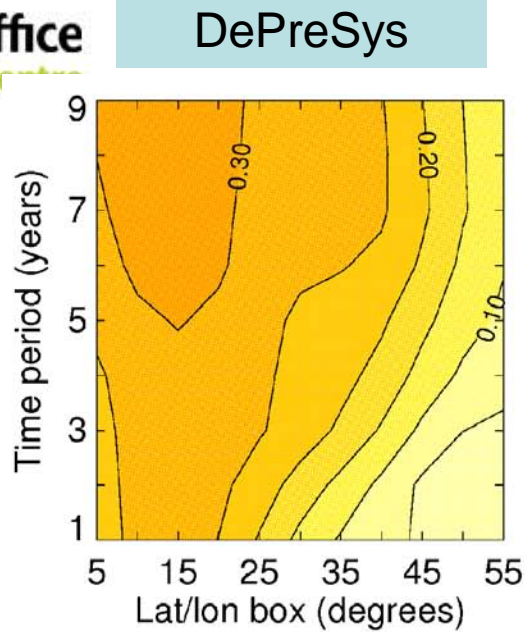


Land only

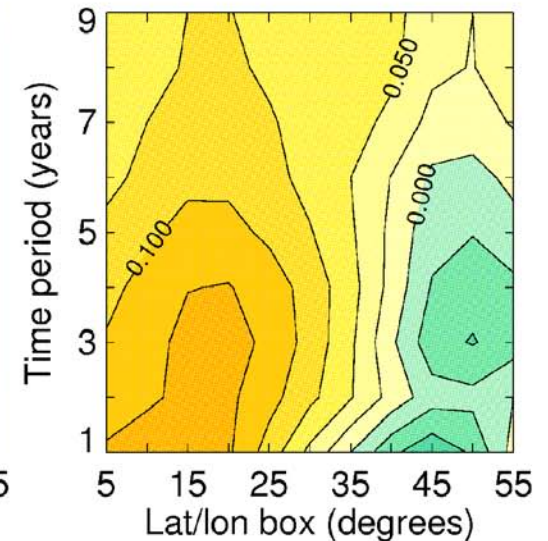
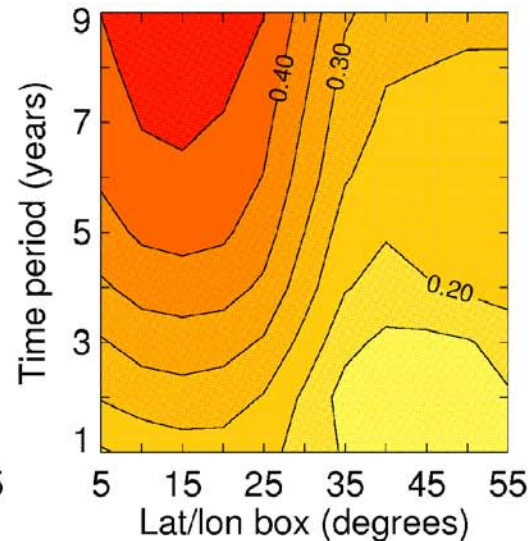
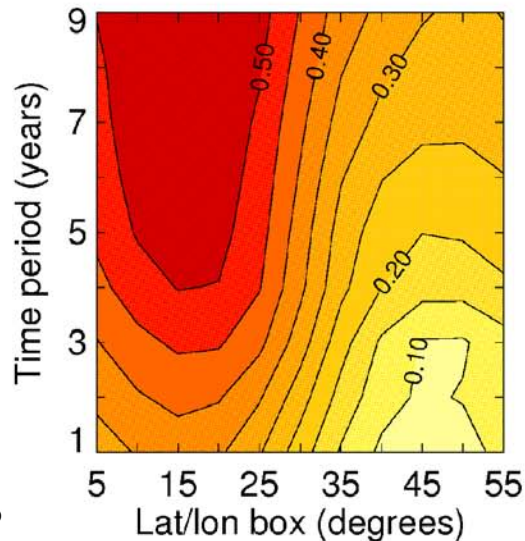


Surface temperature correlation

1960-2005

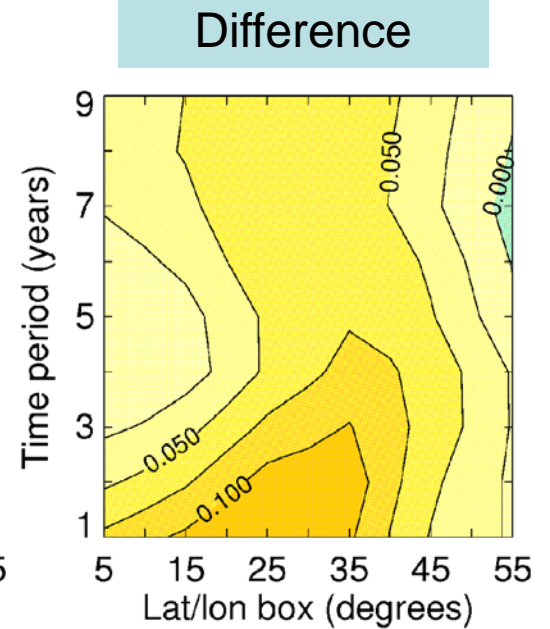
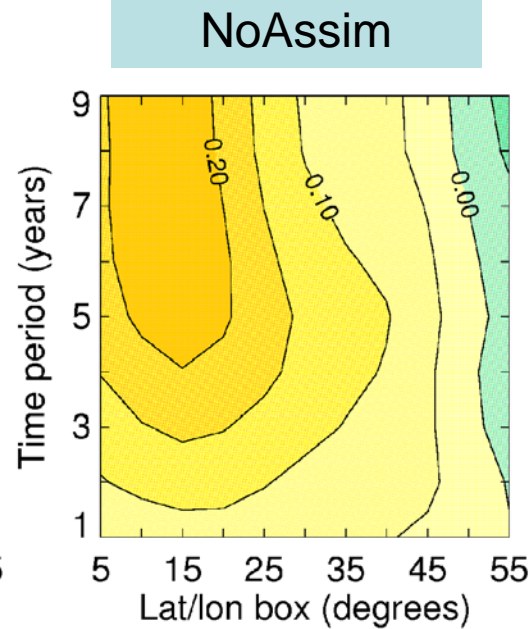
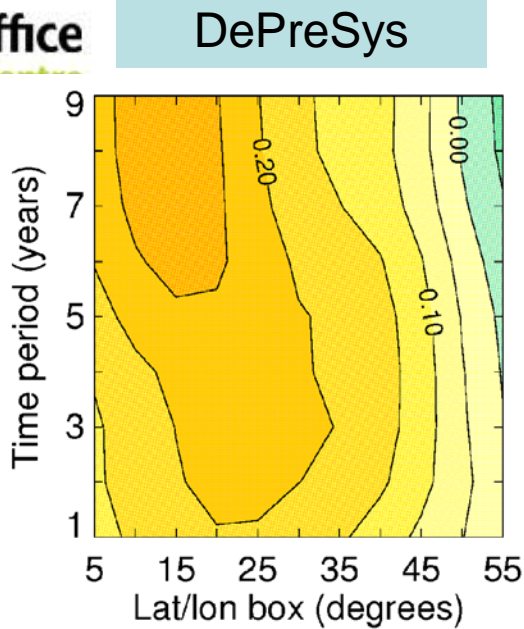


1995-2005

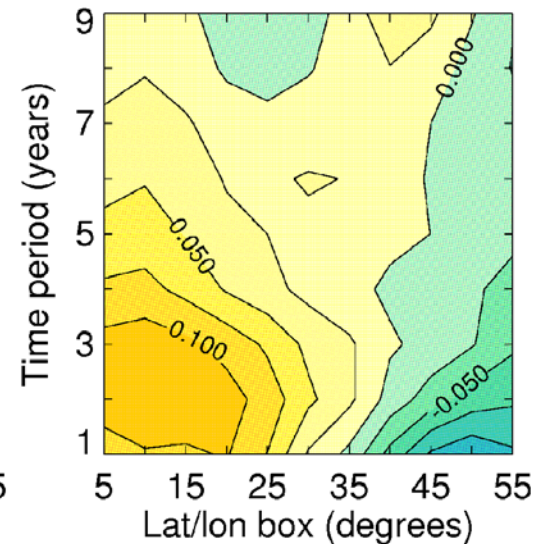
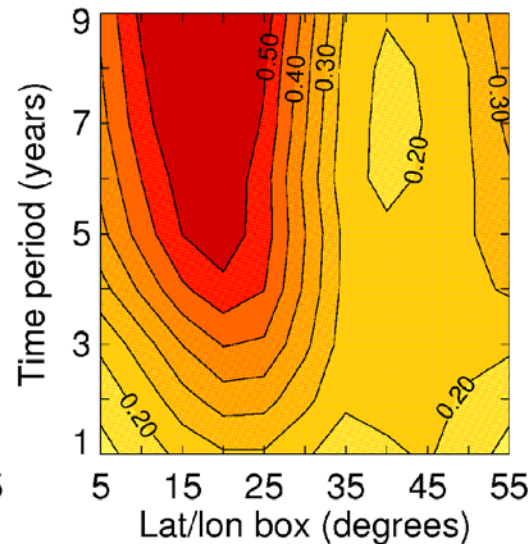
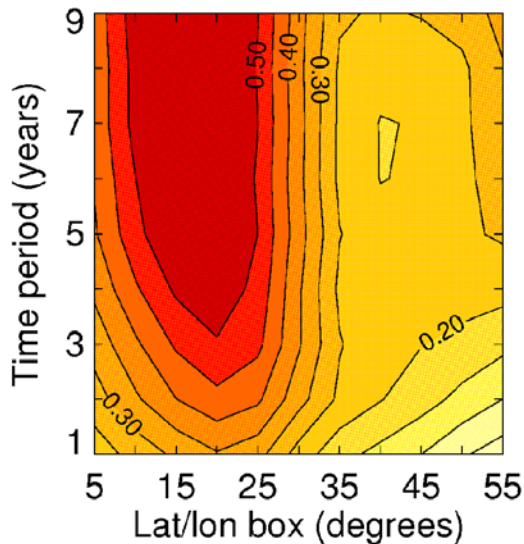


Surface temperature correlation: land

1960-2005

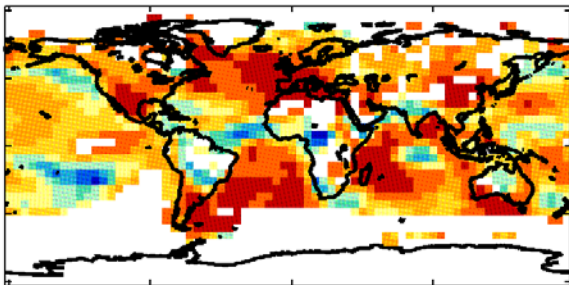


1995-2005



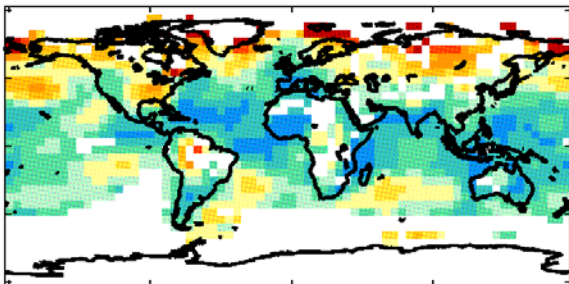
Time series correlation maps: 9 year mean surface temp: 15x15 degrees

t1.5 : HadCRUT3 : 9yr
corr : DePreSys



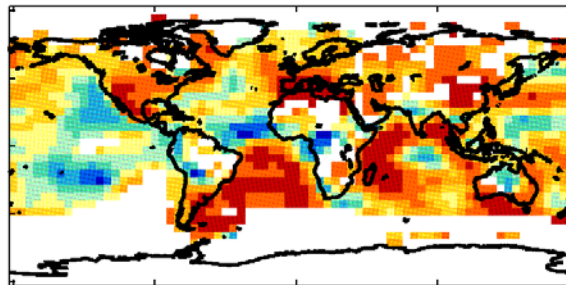
-0.8 -0.4 0 0.4 0.8

rmse : DePreSys



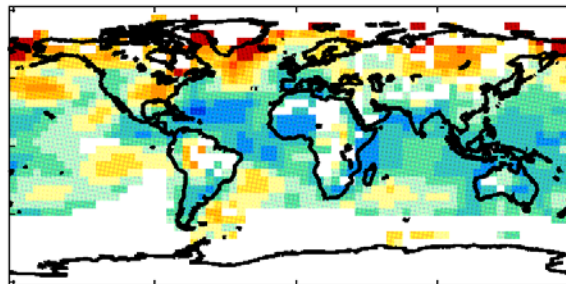
0 0.1 0.2 0.3 0.4 0.5

corr : NoAssim



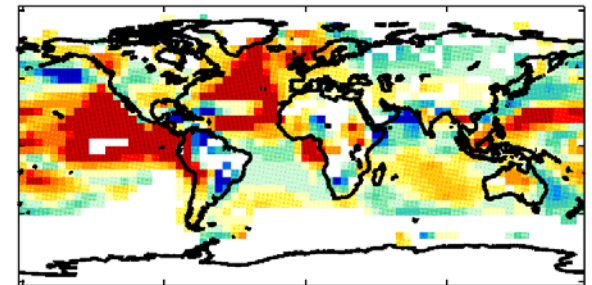
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rmse : NoAssim



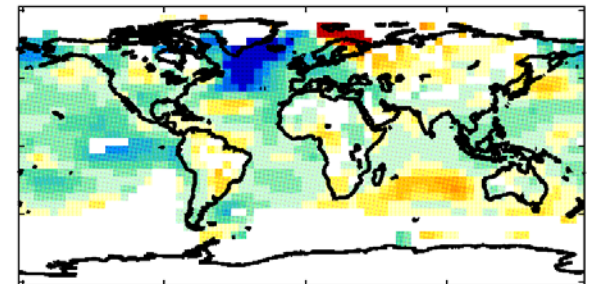
0 0.1 0.2 0.3 0.4 0.5

corr : Diff



-0.4 -0.2 0 0.2 0.4

rmse : Diff



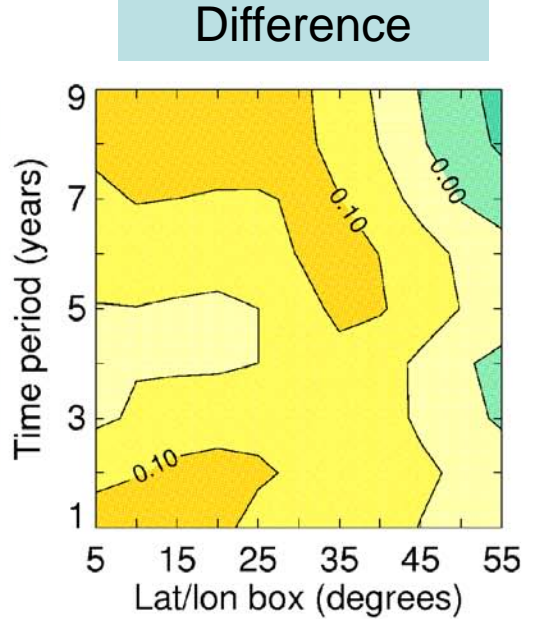
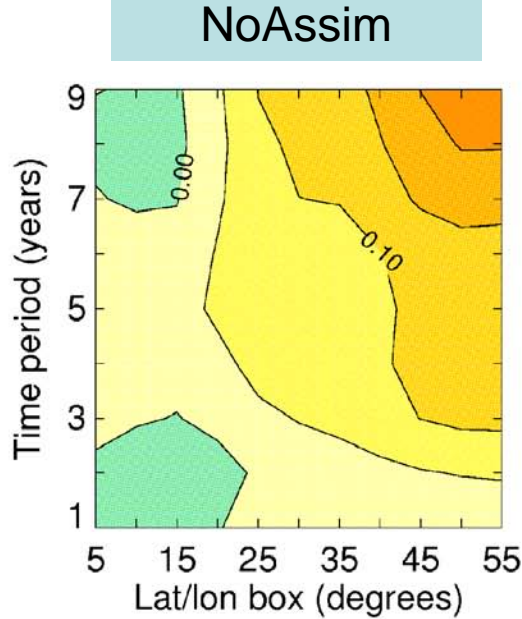
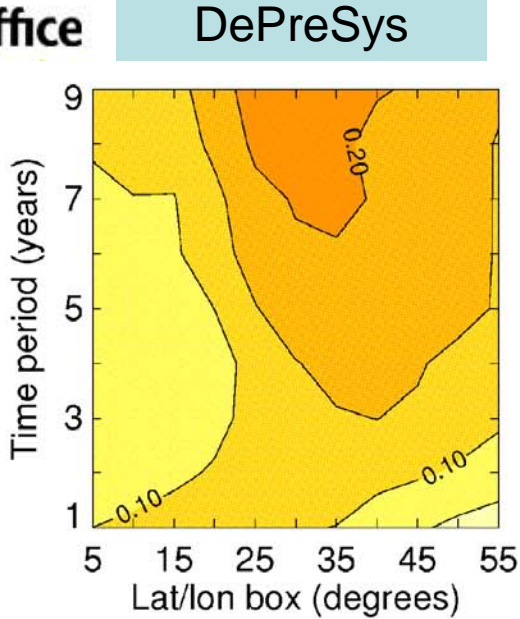
-0.1 -0.05 0 0.05 0.1



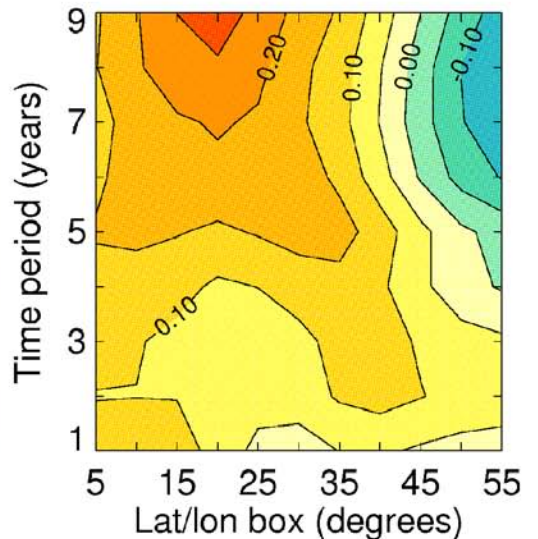
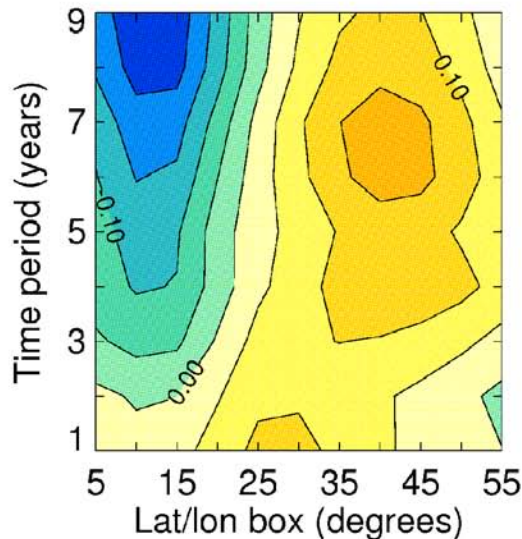
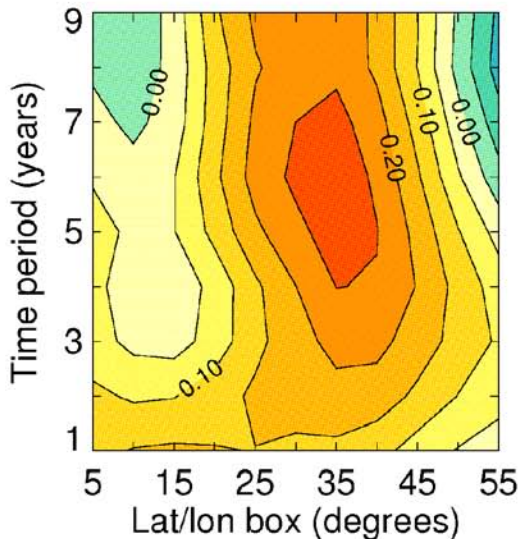
Met Office
Hadley C

Precipitation correlation: land

1960-2005



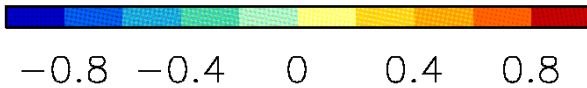
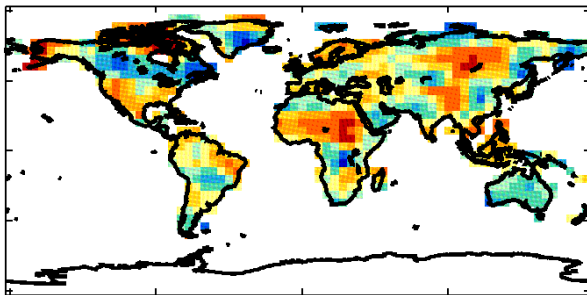
1995-2005



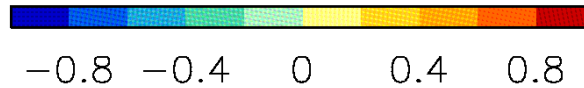
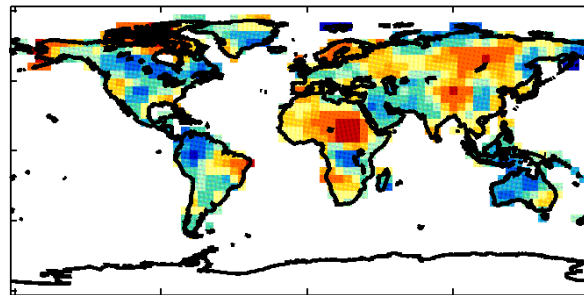


Time series correlation maps: 9 year mean precip: 15x15 degrees

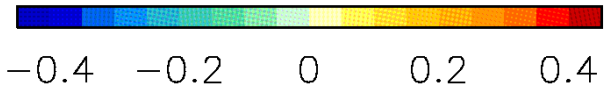
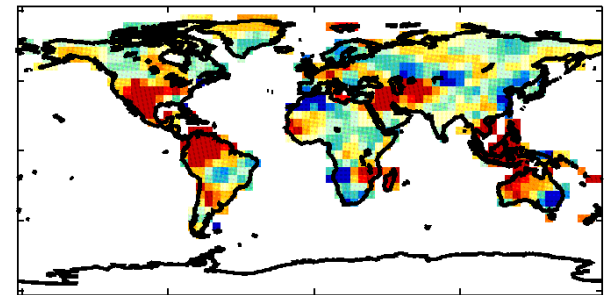
precip : GPCC : 9yr
corr : DePreSys



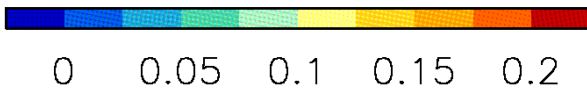
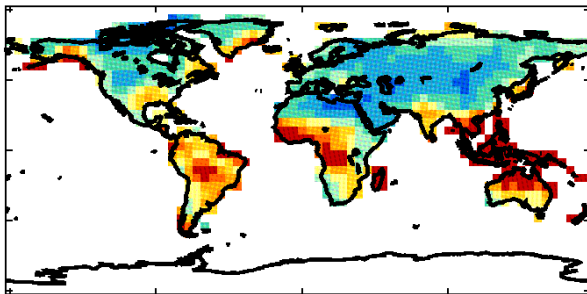
corr : NoAssim



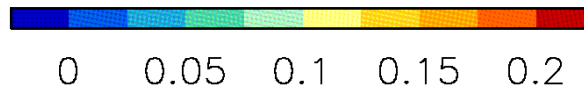
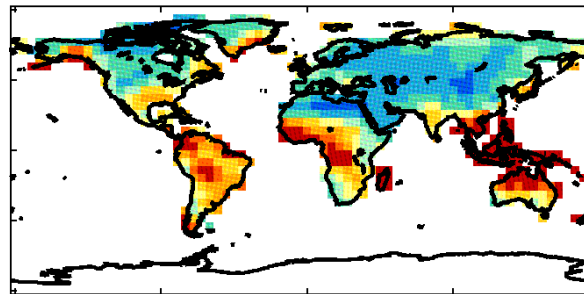
corr : Diff



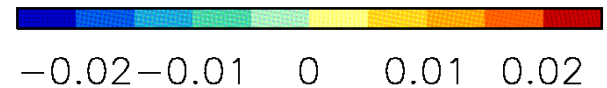
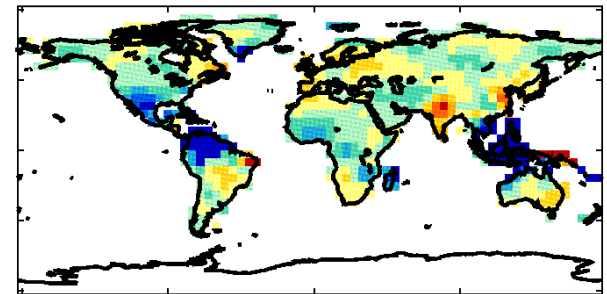
rmse : DePreSys



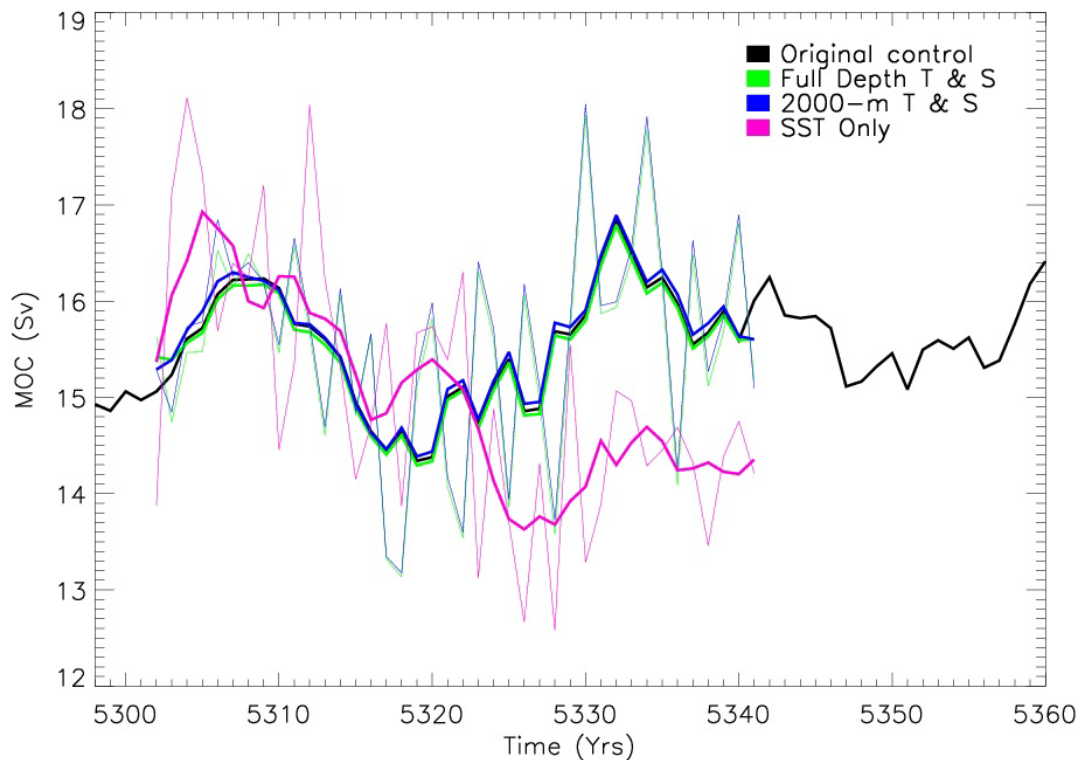
rmse : NoAssim



rmse : Diff

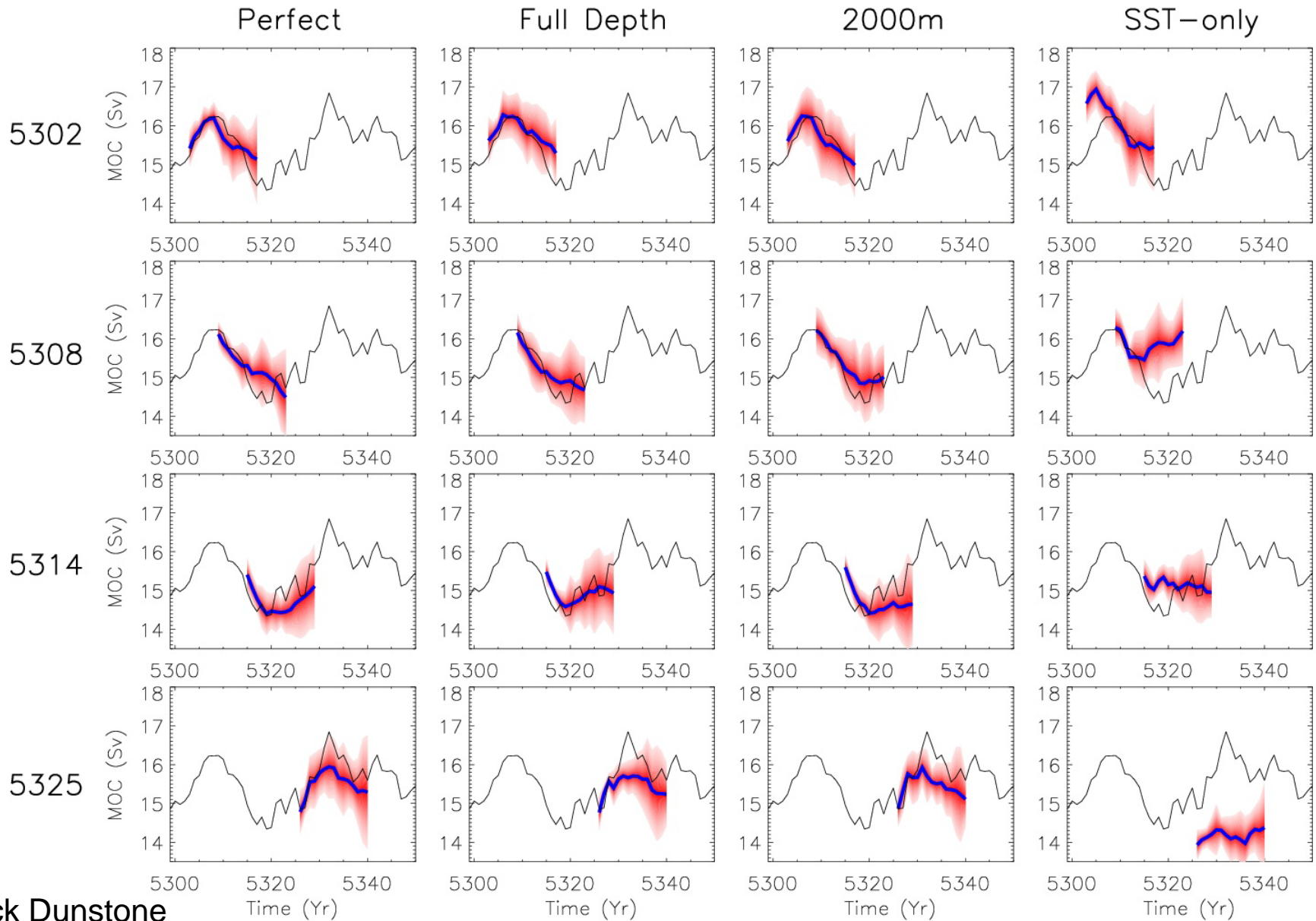


Idealised experiments: assimilation runs



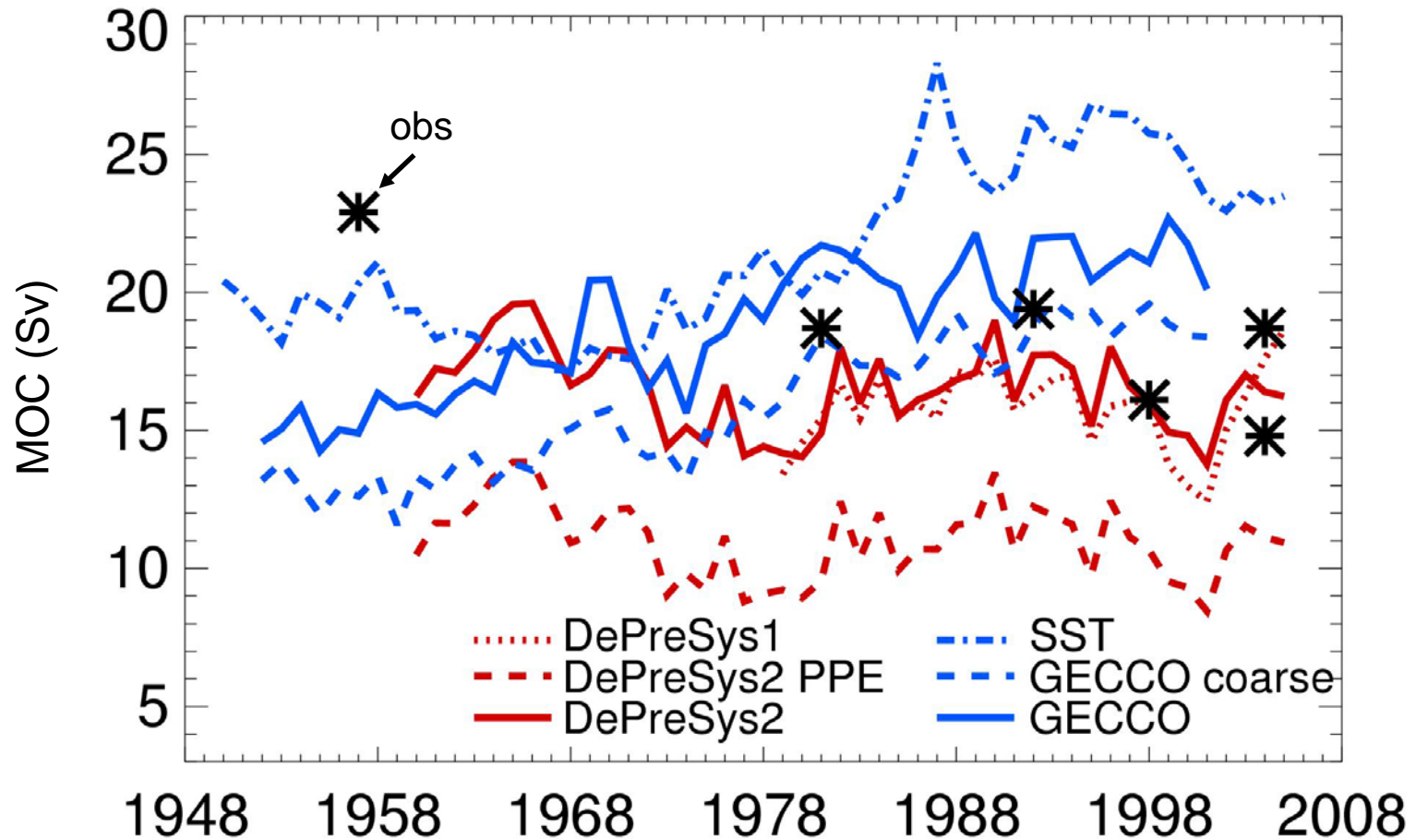
- MOC calculated for a latitude of 30 deg N and a depth of 1000m.
- The experiments that assimilate Full Depth and 2000-m ocean T & S, follow the original control run MOC to high accuracy
- The SST only assimilation experiment deviates from the original control run. The MOC is too strong initially and too weak at later times.

Idealised experiments: Forecasting the AMOC



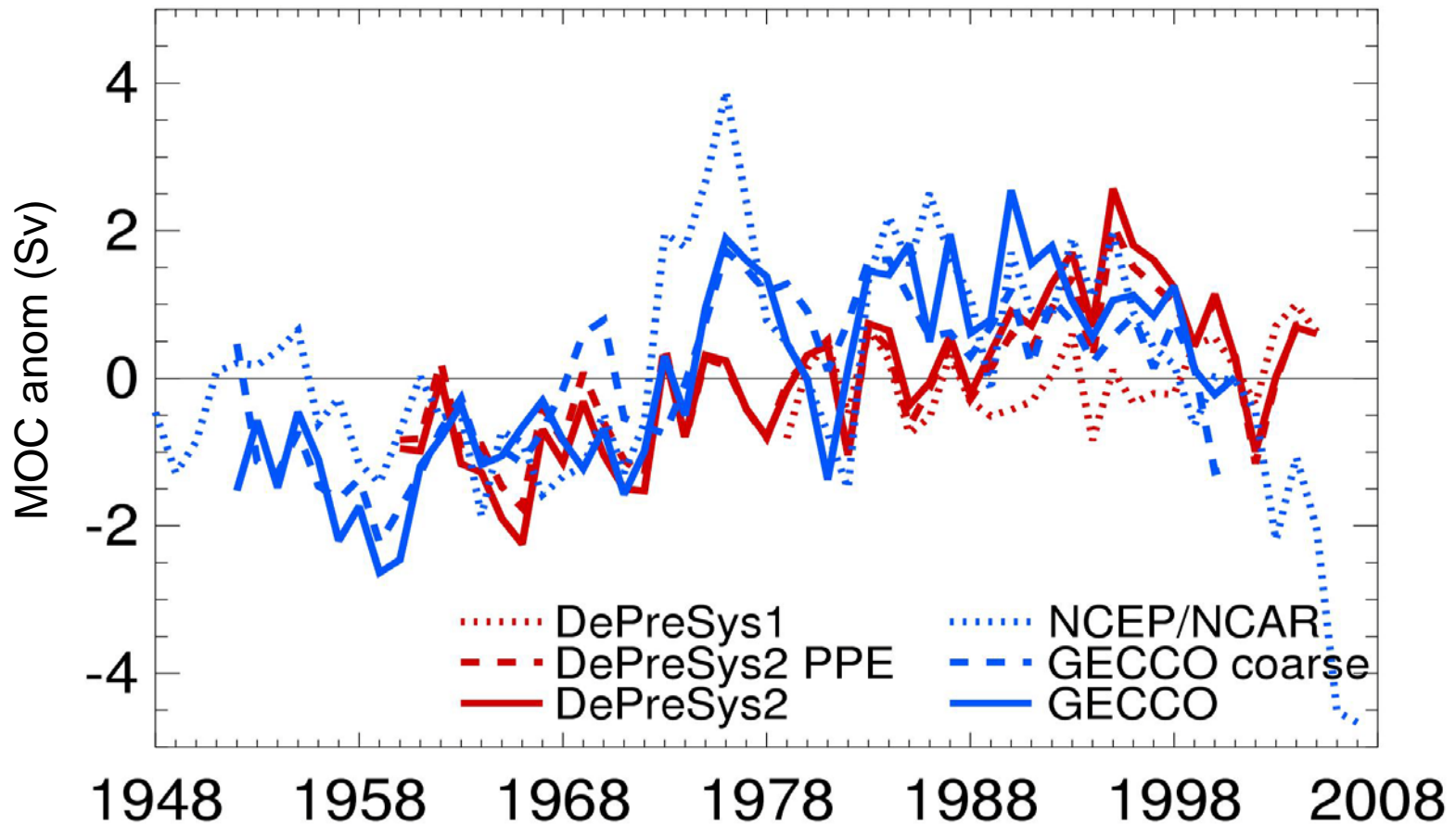
AMOC in Decadal Prediction Assimilation Experiments

Atlantic MOC (25N)



AMOC in Decadal Prediction Assimilation Experiments

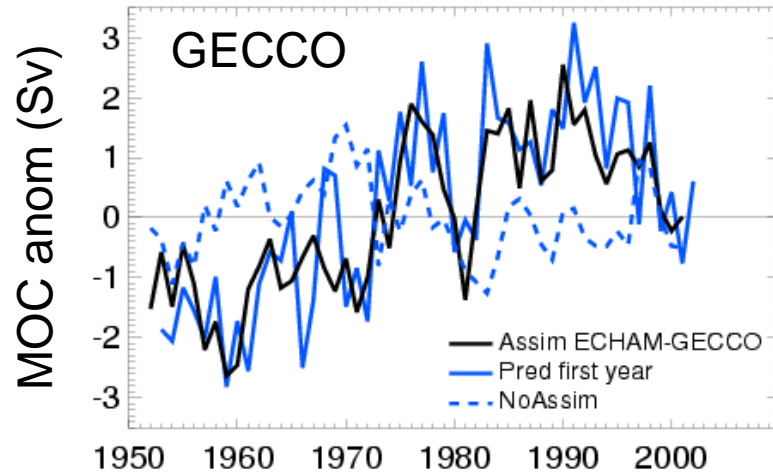
Atlantic MOC (45N)



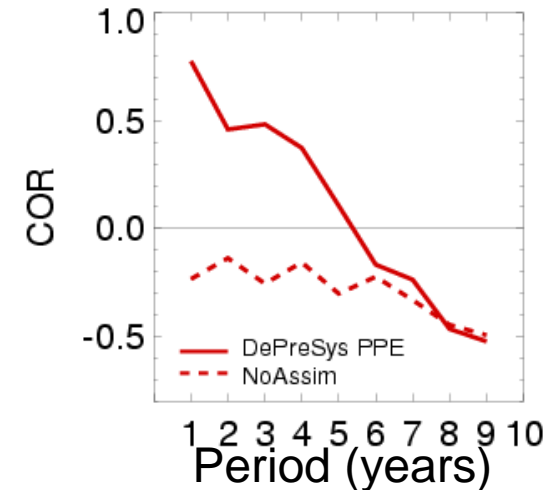
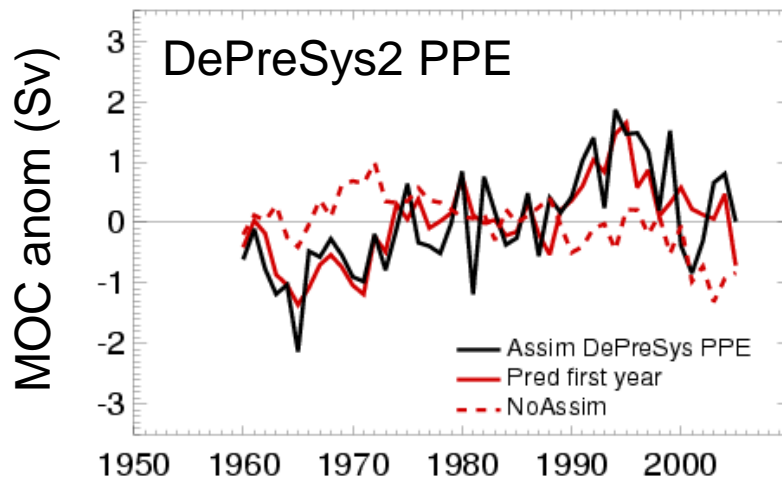
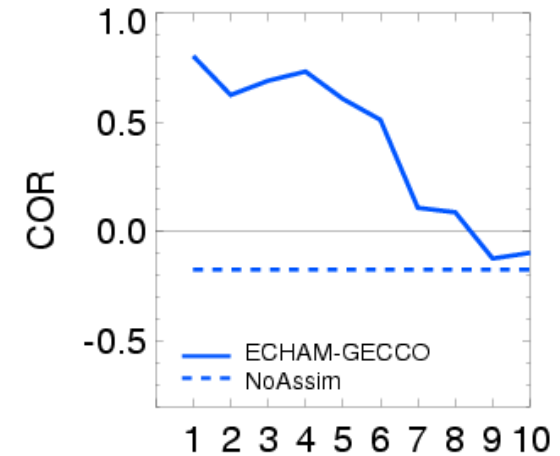
AMOC in Decadal Predictions

Predictability of single years

Atlantic MOC (45N)

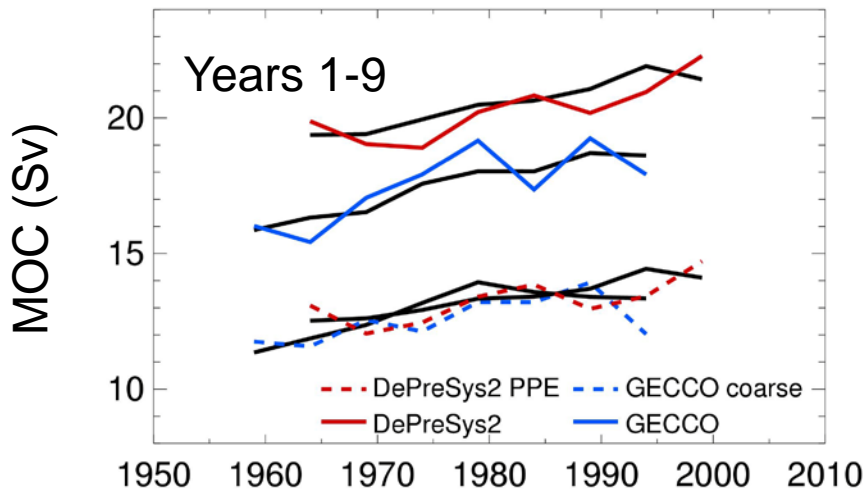
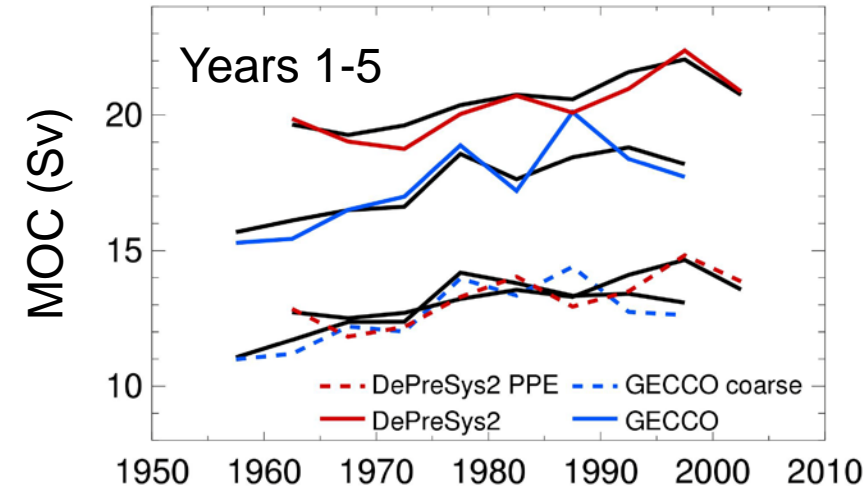


Predictability



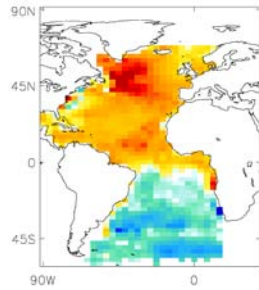
AMOC in Decadal Predictions

Atlantic MOC 45N: multi-year predictability

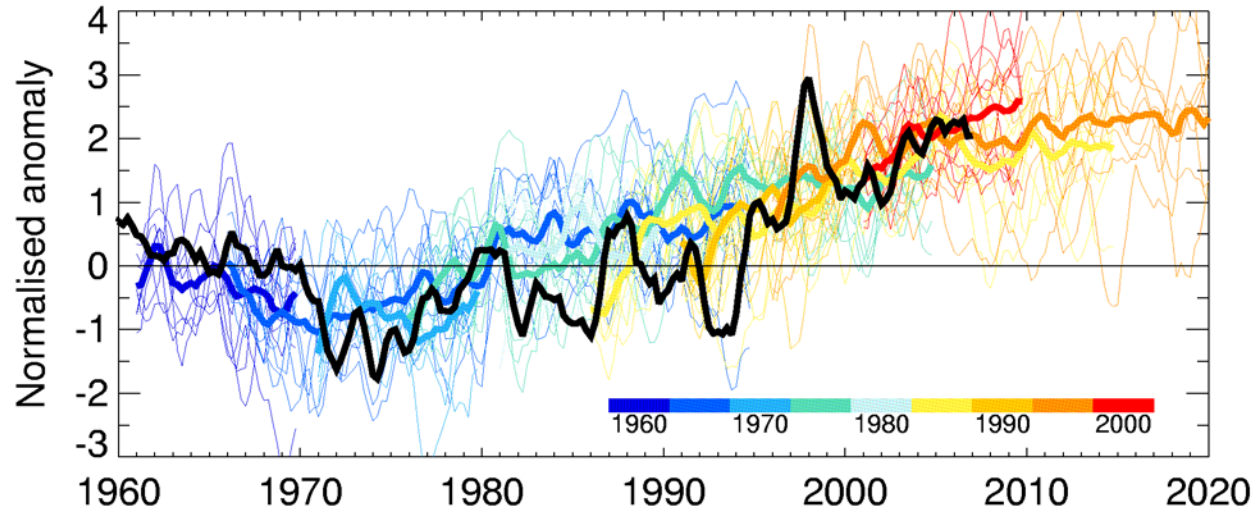


Correlations		
Period (Years)	1-5	1-9
GECCO	0.90	0.84
GECCO coarse	0.90	0.70
DePreSys2	0.94	0.76
DePreSys2 PPE	0.90	0.66

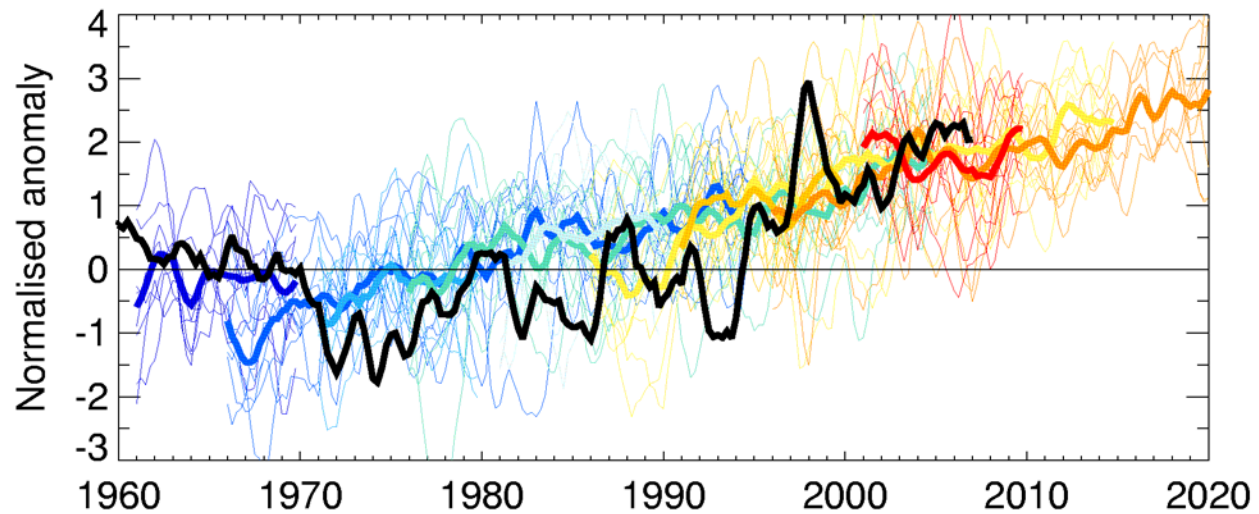
AMO : ENSEMBLES PPE (DePreSys2 PPE)



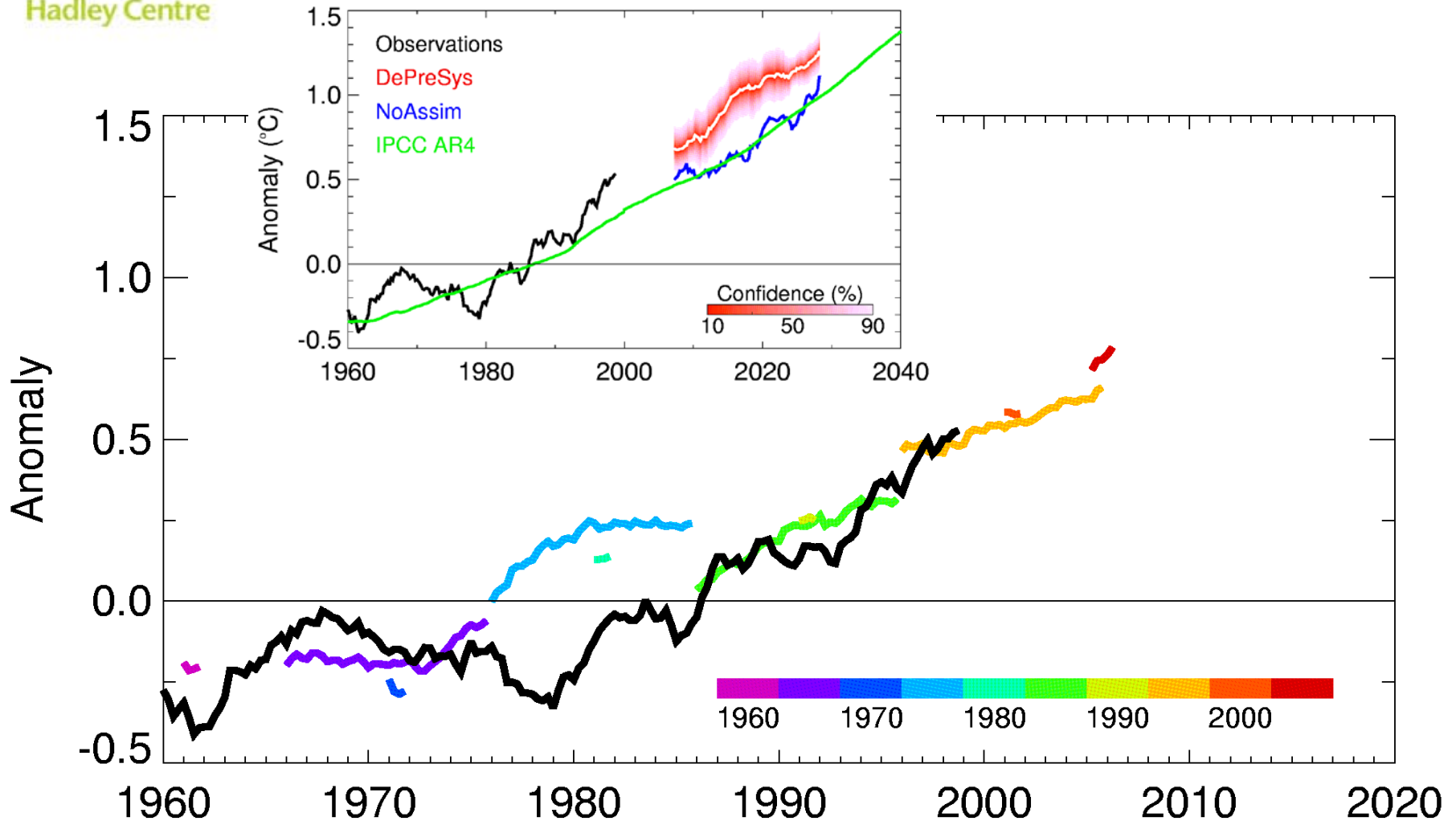
DePreSys



NoAssim



UK 9-year mean temperature: DePreSys2



Summary (1)

- Initial conditions have a significant impact on forecasts of the coming decades
 - AMO, PDO, THC, precipitation, N. European temperature
- Ideally confidence in forecast would be gained by demonstrating skill in hindcasts
 - Problem with lack of historical ocean obs
 - Could forecasts benefitting from Argo be much more reliable than historical hindcasts?
- Increasing trend in spatial anomaly correlation
 - Climate change signal
- Initialised hindcasts generally show improved skill

Summary (2)

- Atlantic MOC predictable in idealised experiments by initialising with upper 2000m T and S (but not SST only)
- Hindcasts show some skill for AMOC (45N) for first few years (assessed against assimilation run)
 - But lack of skill beyond 5 years need further investigation – volcanoes?
- Further analysis needed
 - UK temperature in late 1970s (El Chichon?)
 - What is skill of decadal forecasts made now?



Met Office
Hadley Centre



Questions and answers