Decadal prediction studies at IPSL

Juliette Mignot, Didier Swingedouw, Sonia Labetoulle, Eric Guilyardi, Aurélie Persechino, Jérome Servonnat

Overview of activities

- Initialisation of coupled system (J. Servonnat, D. Swingedouw, E. Guilyardi, J. Mignot)
  - Surface nudging/forcing
  - Perfect model studies (SST, SSS, wind stress - sea-ice, ...)
- CMIP5 contribution (S. Labetoulle, D. Swingedouw, E. Guilyardi, J. Mignot)
  - using IPSL-CM5A-LR
- Mechanisms for MOC predictability, potential predictability evaluation (D. Swingedouw, A. Persechino, E. Guilyardi, J. Mignot)
- Other predictability studies
  - Ocean biogeochemistry (R. Séférian, L. Bopp)
  - African monsoon (A. Gueye, S. Janicot)
- Seasonal in tropics (B. Vannière, E. Guilyardi)
  - Understand model initial drift

IPSL-CM5 Earth System Model plateform

Biogeochemistry models

Carbon & CO_2 (***Orchidée, Pisces***)

aerosols

O_3

CO_2

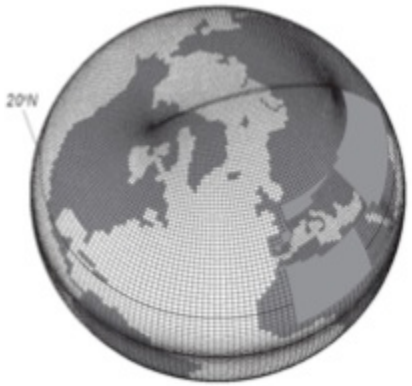
other var.

Physical models

- Atmosphere (***LMDZ***)
- Land surf. (***Orchidée***)
- Coupler (***OASIS***)
- Ocean (***Nemo***)
- Sea-ice (***LIM***)

LR: 96 x 95 x L39
MR: 144x142x39

ORCA2



Natural and anthropogenic perturbations

CO_2 emissions	Other gas	Land use	Solar irradiance	Volcanic aerosols

>1000 yrs piControl

5 members historical simulations

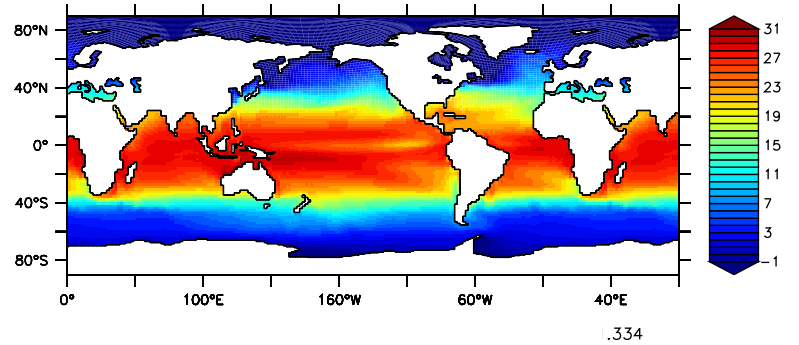
http://forge.ipsl.jussieu.fr/igcmg

SST

SSS

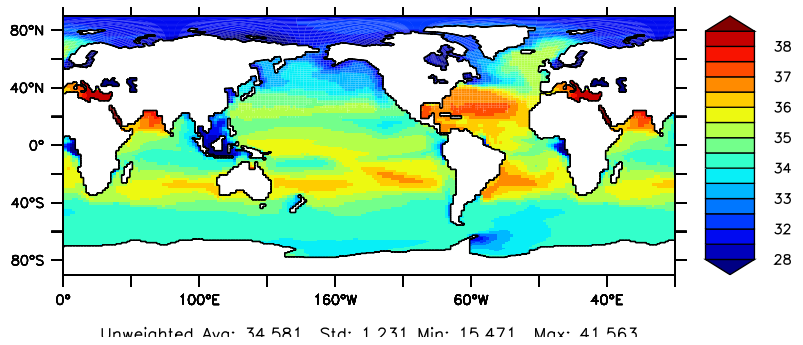
March

IPSLCM5A



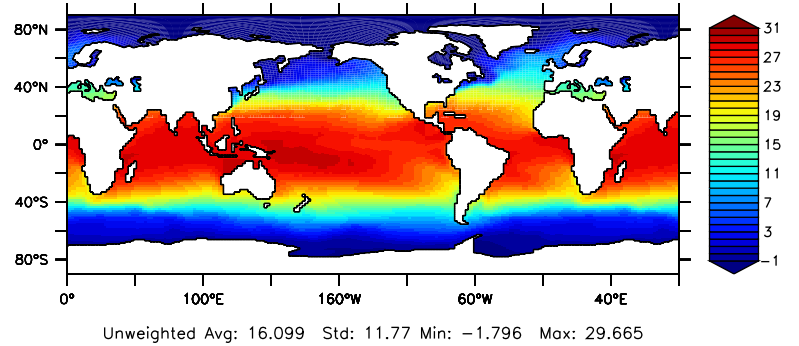
.334

IPSLCM5A



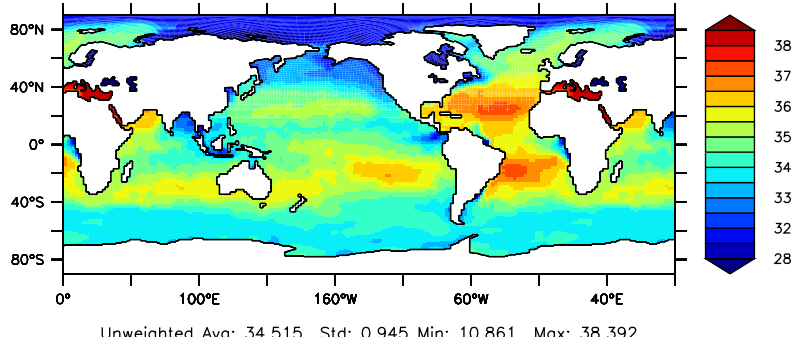
Unweighted Avg: 34.581 Std: 1.231 Min: 15.471 Max: 41.563

HadISST



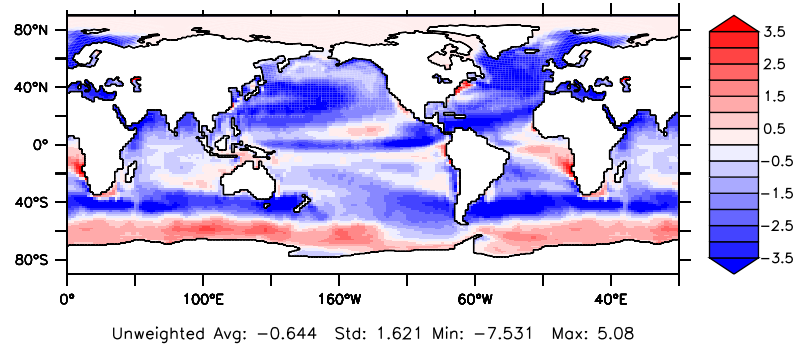
Unweighted Avg: 16.099 Std: 11.77 Min: −1.796 Max: 29.665

Levitus



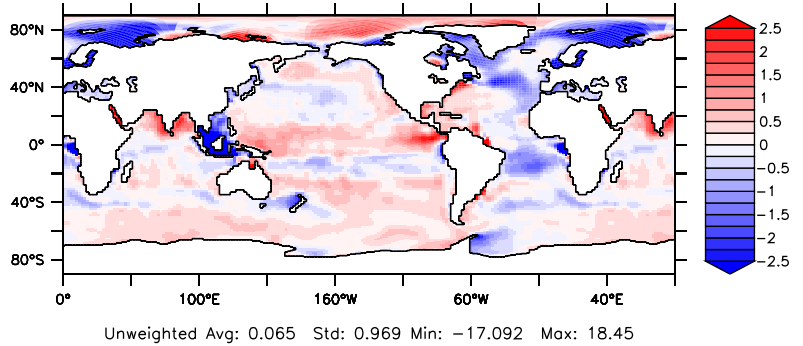
Unweighted Avg: 34.515 Std: 0.945 Min: 10.861 Max: 38.392

IPSLCM5A - HadISST



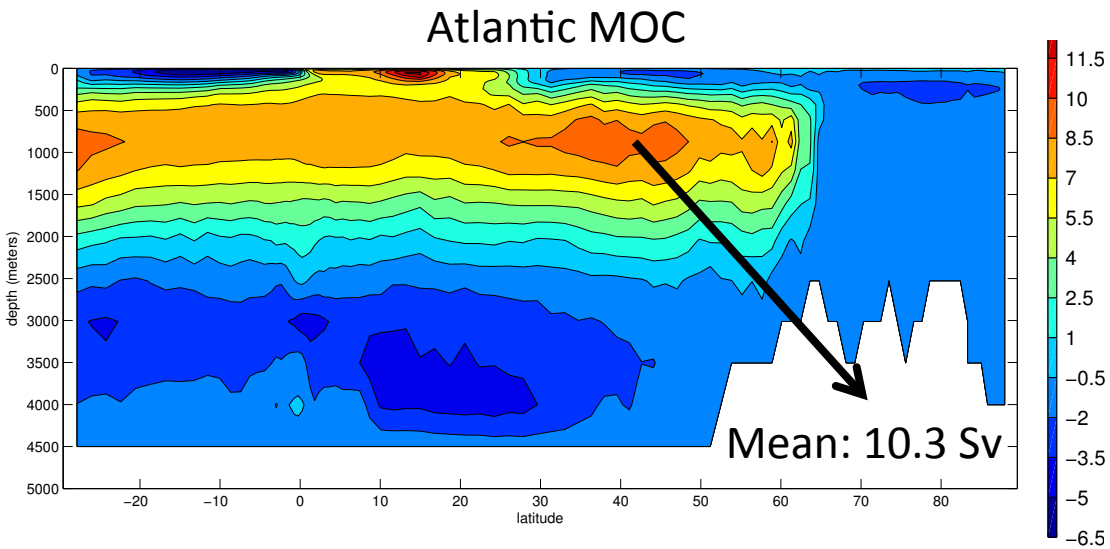
Unweighted Avg: −0.644 Std: 1.621 Min: −7.531 Max: 5.08

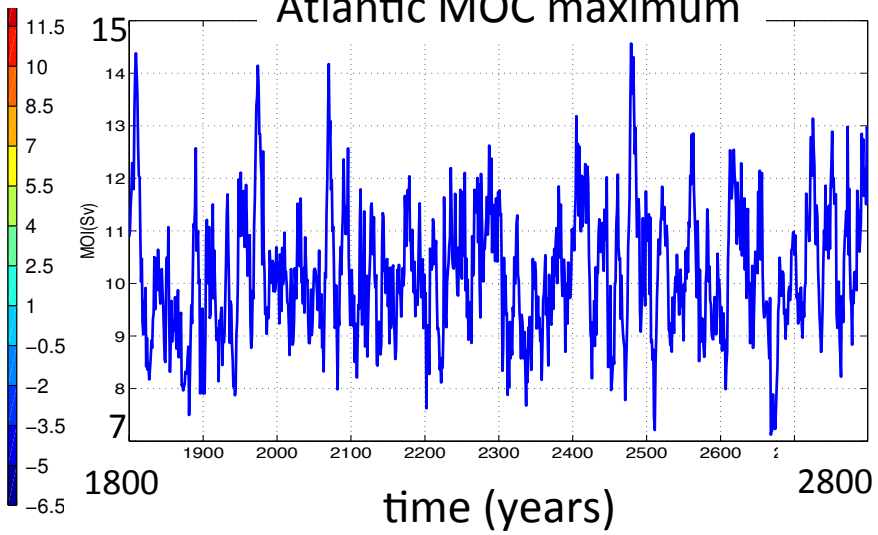
IPSLCM5A - Levitus

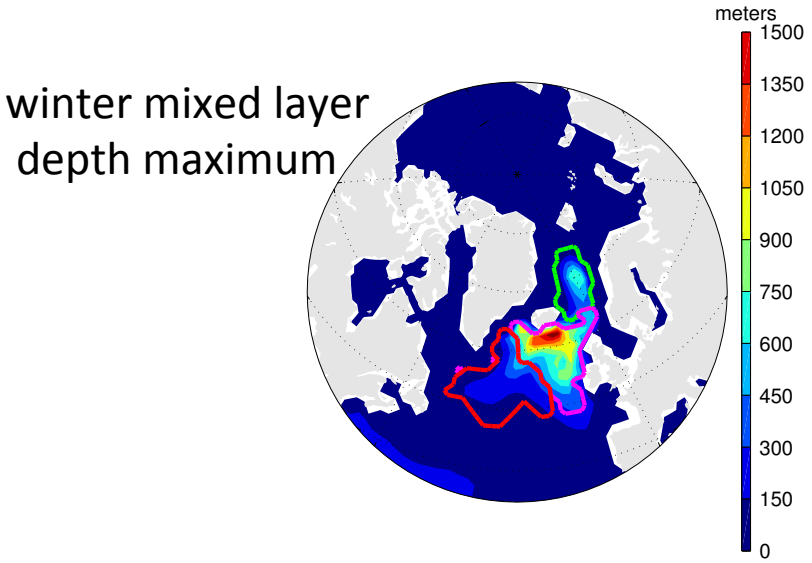


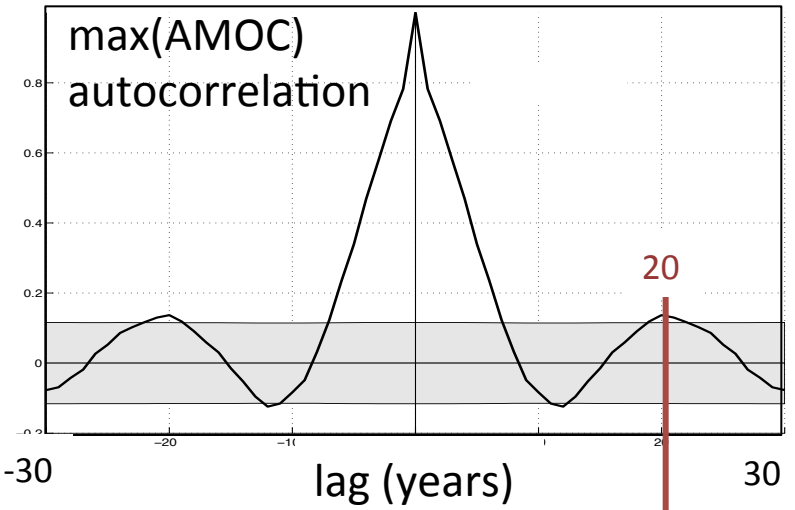
Unweighted Avg: 0.065 Std: 0.969 Min: −17.092 Max: 18.45

Atlantic meridional overturning circulation

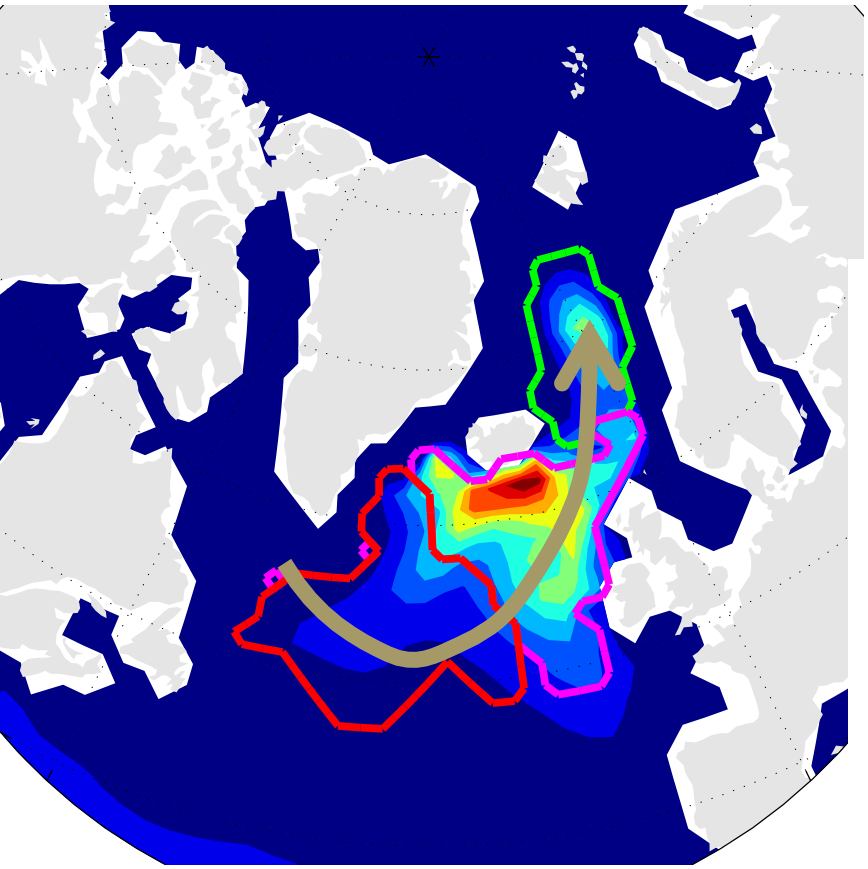








A 20-yr coupled ocean atmosphere sea-ice mode in the subpolar North Atlantic in IPSLCM5A



Escudier, Mignot and Swingedouw, in prep.

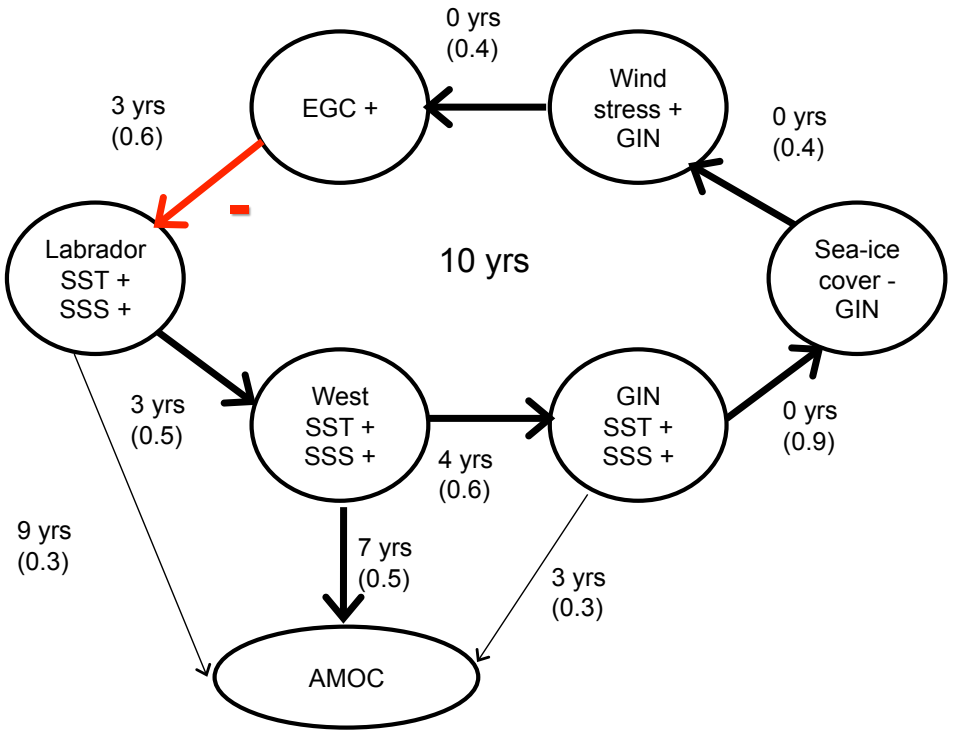
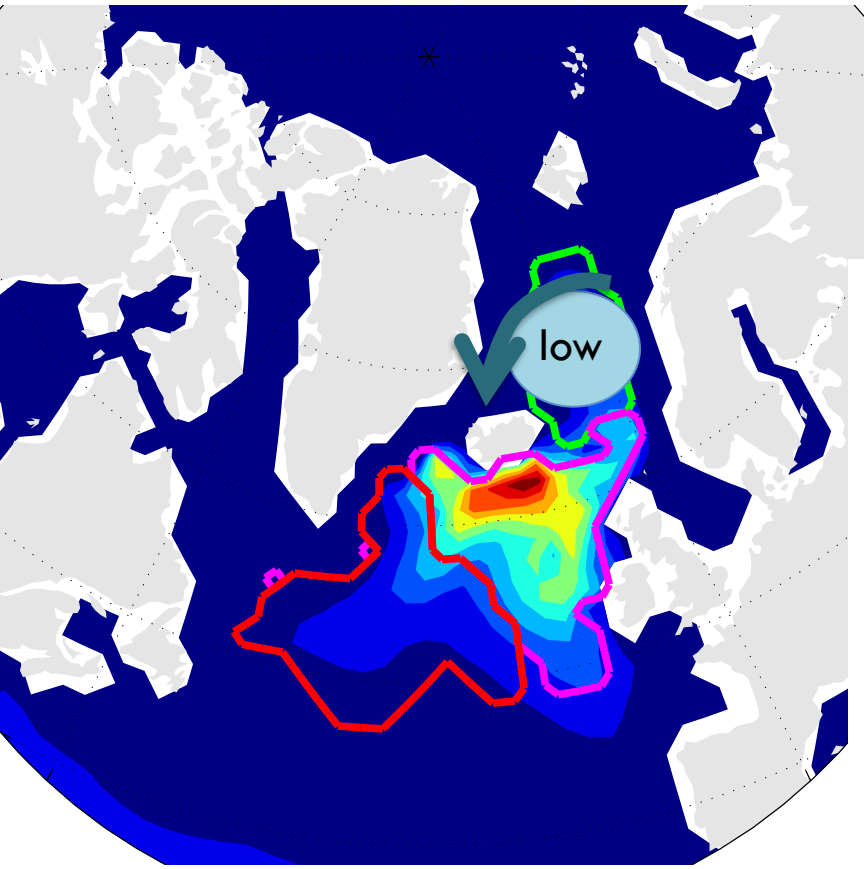


FIG. 11. Schematic vue of the whole mechanism. Estimated time lags (and correlations) are indicated.

A 20-yr coupled ocean atmosphere sea-ice mode in the subpolar North Atlantic in IPSLCM5A



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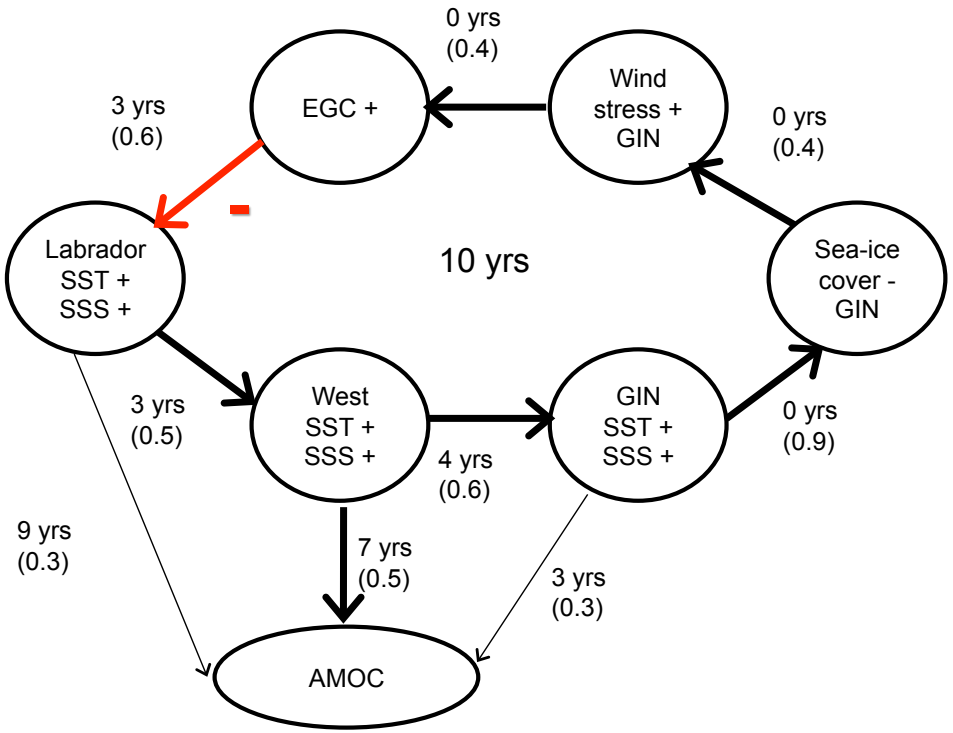

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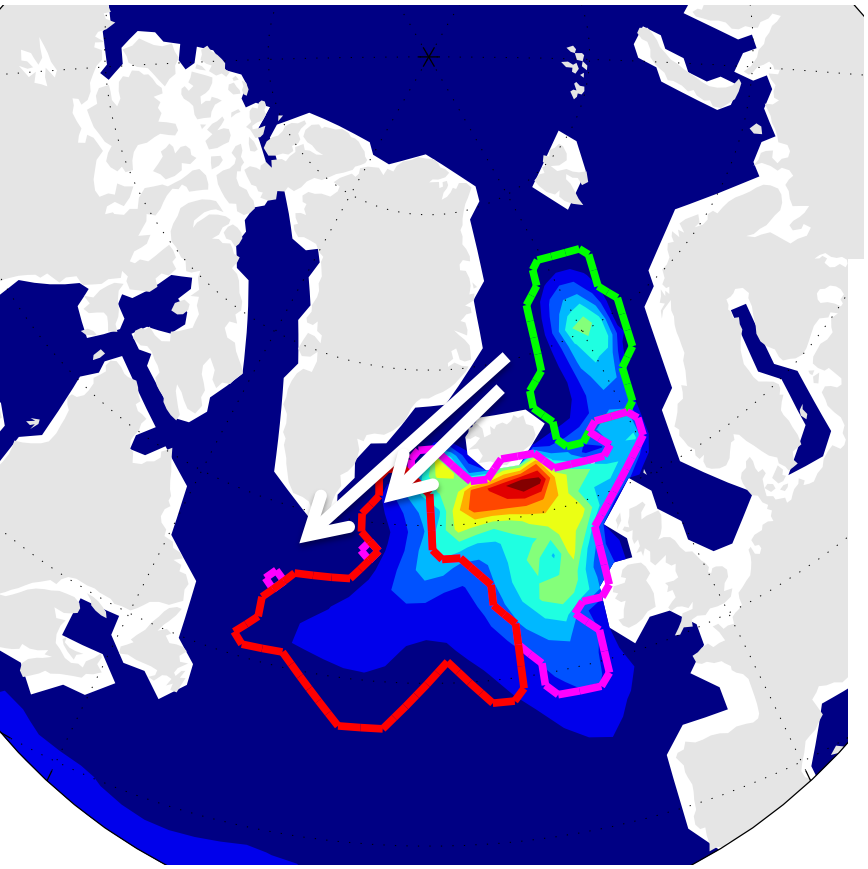
A 20-yr coupled ocean atmosphere sea-ice mode in the subpolar North Atlantic in IPSLCM5A



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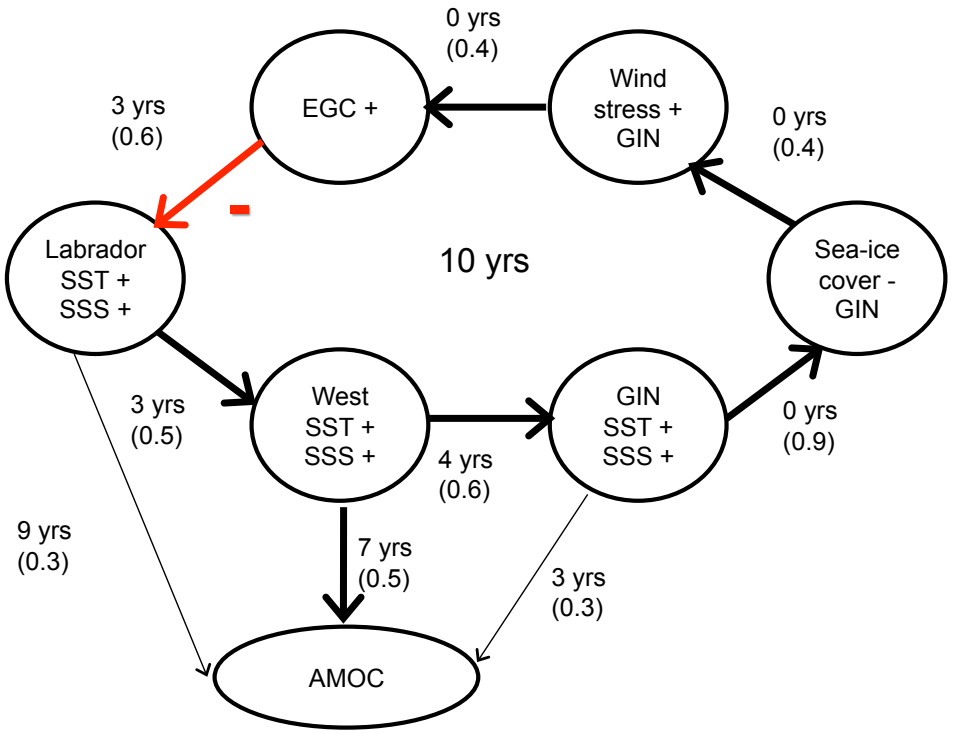

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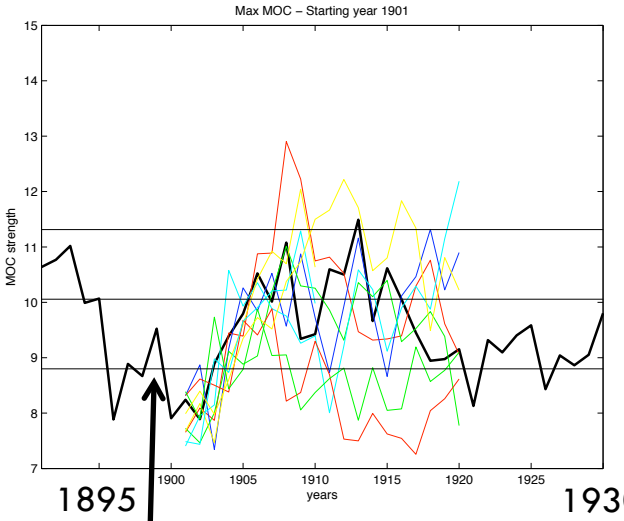
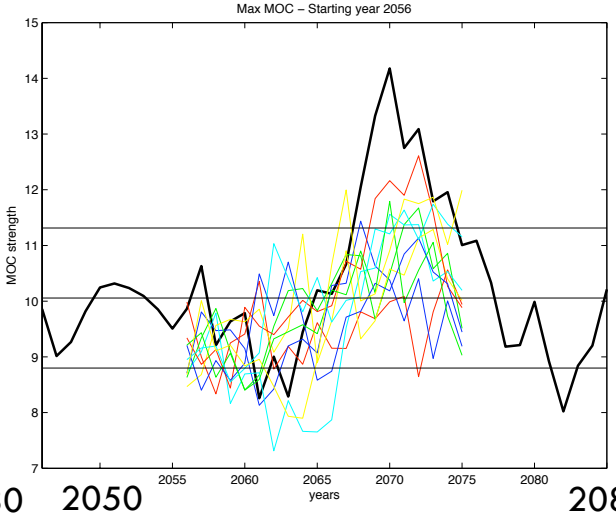
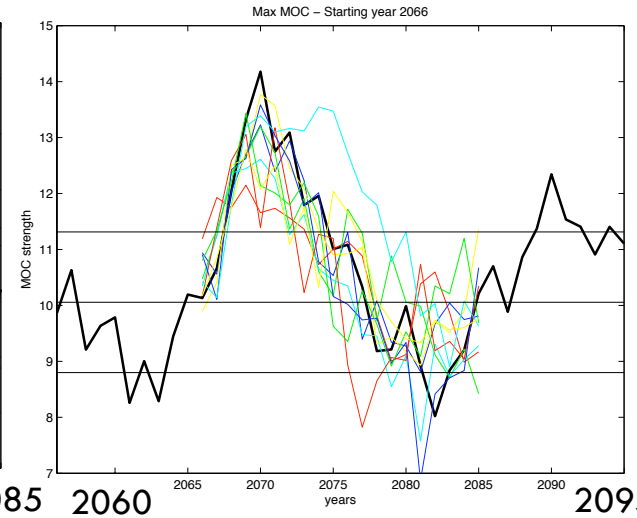
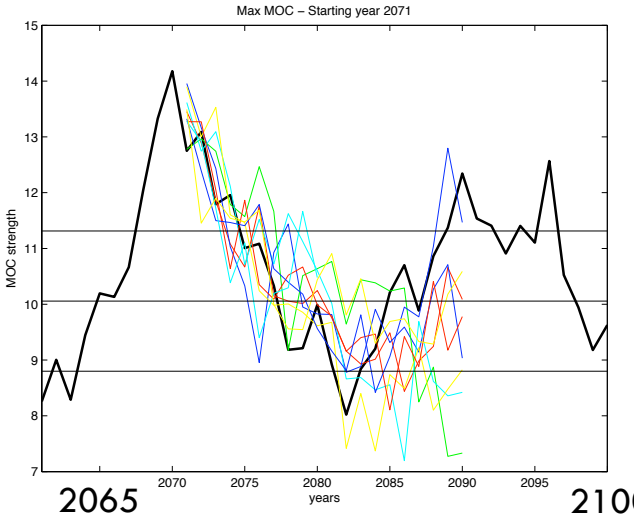
Consequences for potential predictability at decadal timescales?

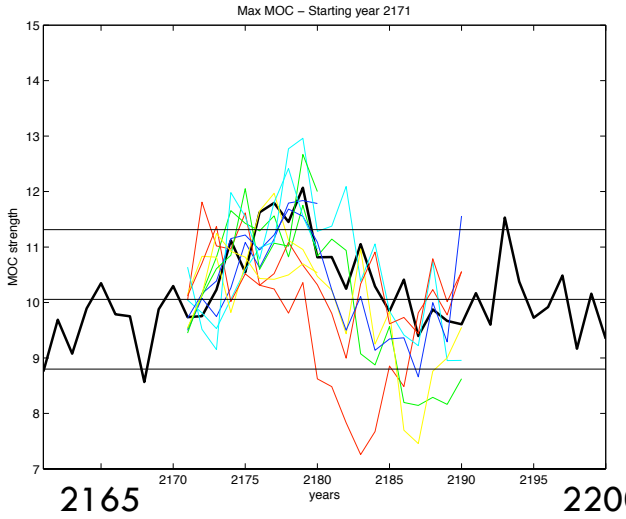




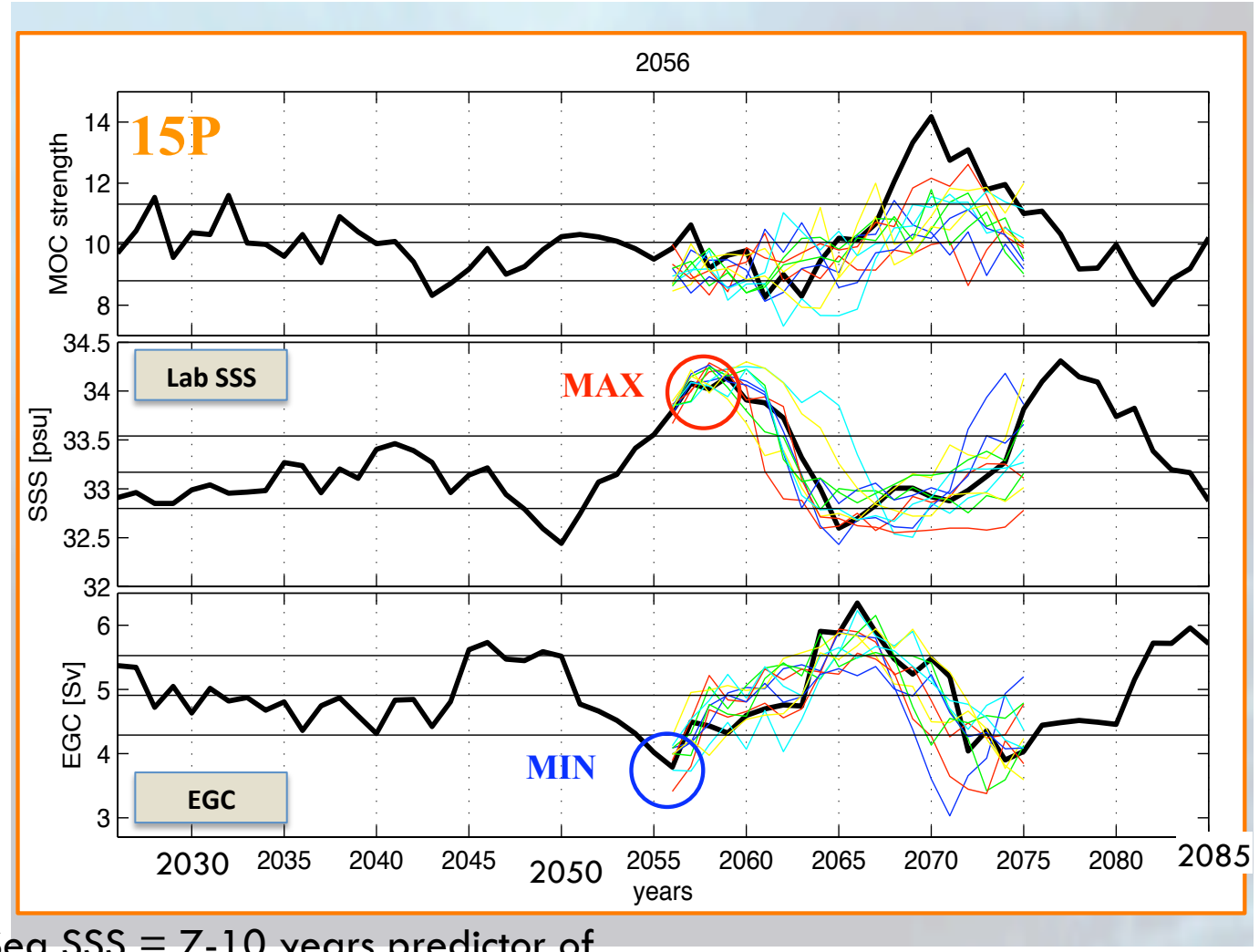


control





Consequences for potential predictability at decadal timescales?

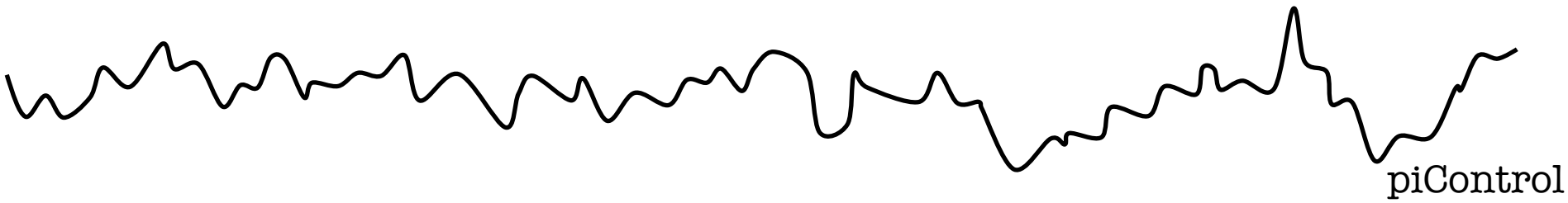


- Labrador Sea SSS = 7-10 years predictor of the AMOC
- EGC = more than 10 years predictor

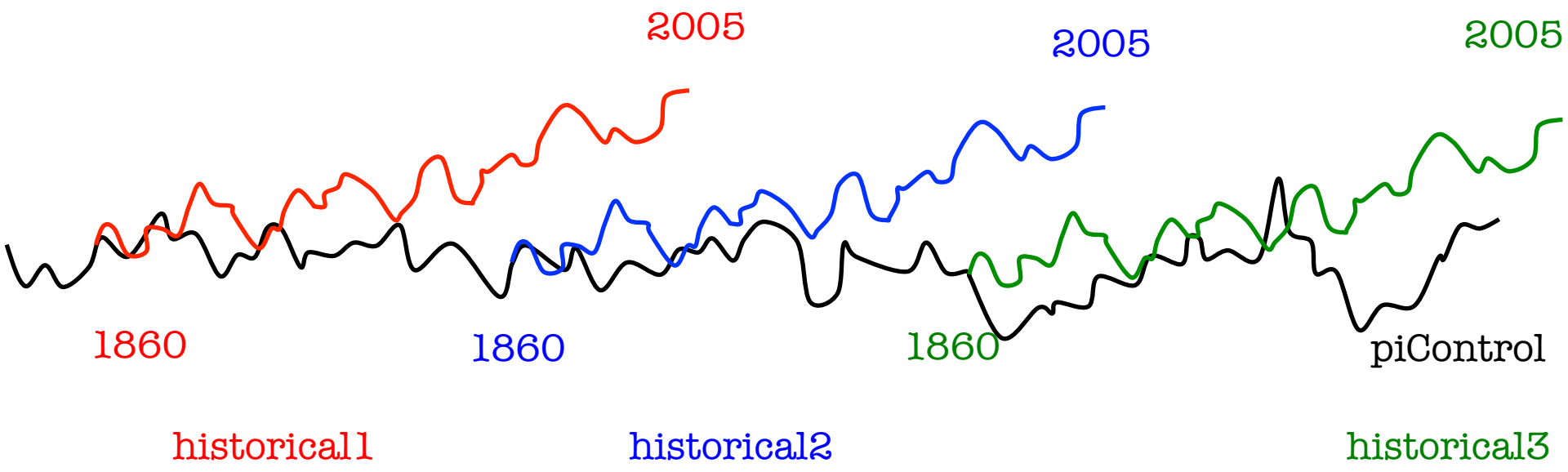
Persechino, Mignot, Swingedouw, Labetoulle, Guilyardi, in prep.

CMIP5 near term exercise at IPSL

CMIP5 near term at IPSL: strategy

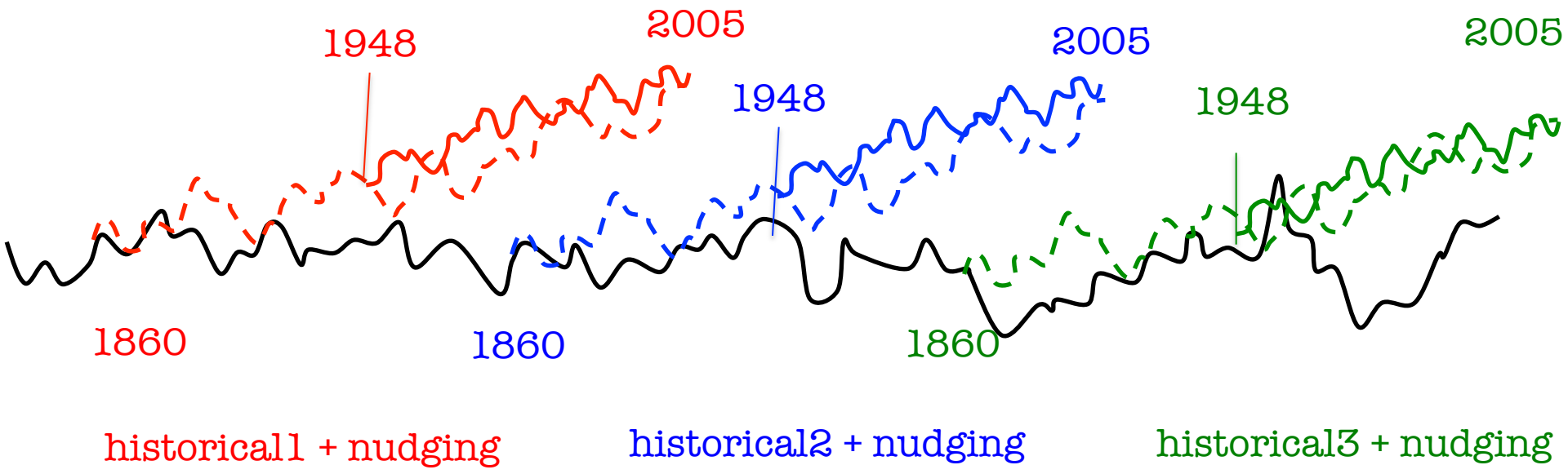


CMIP5 near term at IPSL: strategy



CMIP5 near term at IPSL: strategy

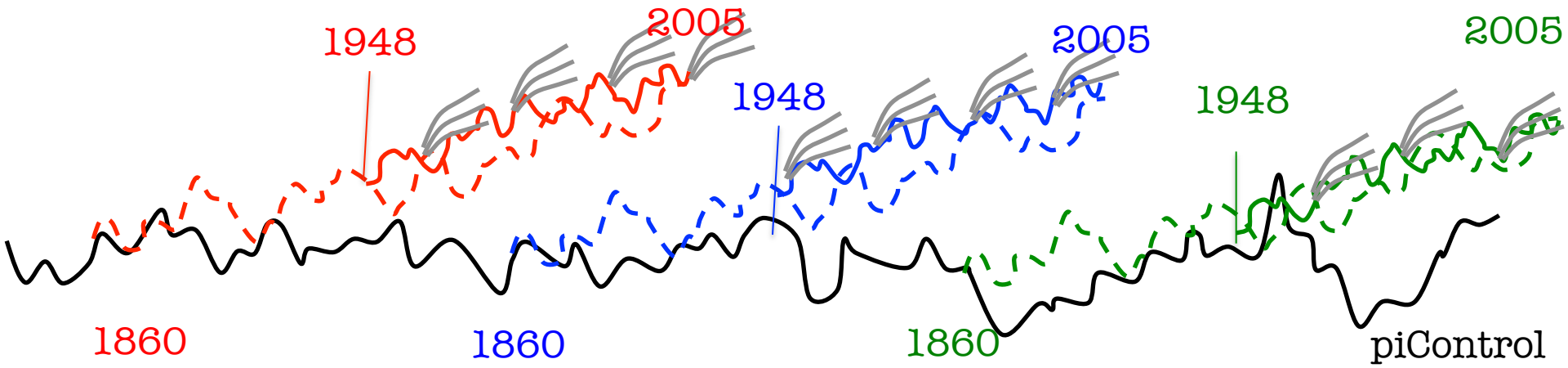
surface restoring $Q_{nudg} = -\gamma(T'_{model} - T'_{obs})$ $\gamma =$ 40 W/m²/K



- 3 initialized simulations from 3 members of the ensemble of historical simulations (long term)

CMIP5 near term at IPSL: strategy

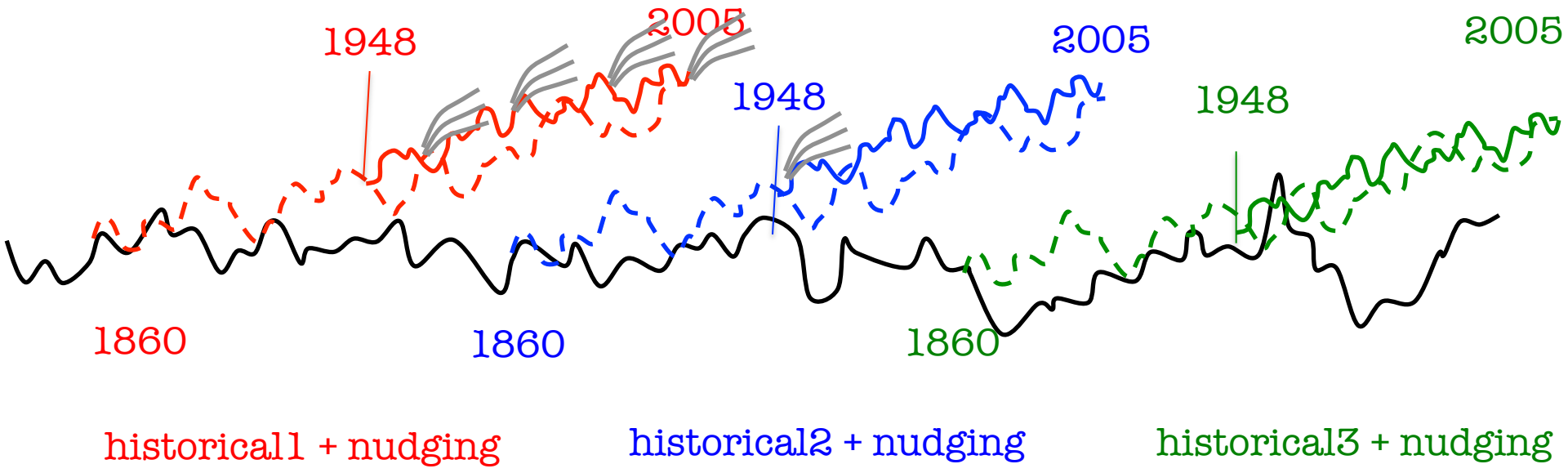
Strategy:



3 free runs with perturbed initial conditions started from 31 dec 1960, 1965, … 2005

Initial perturbation: spatial white noise on SST

CMIP5 near term at IPSL: **status**



1st set hindcasts done - 90%

2nd set in the machine – 50%

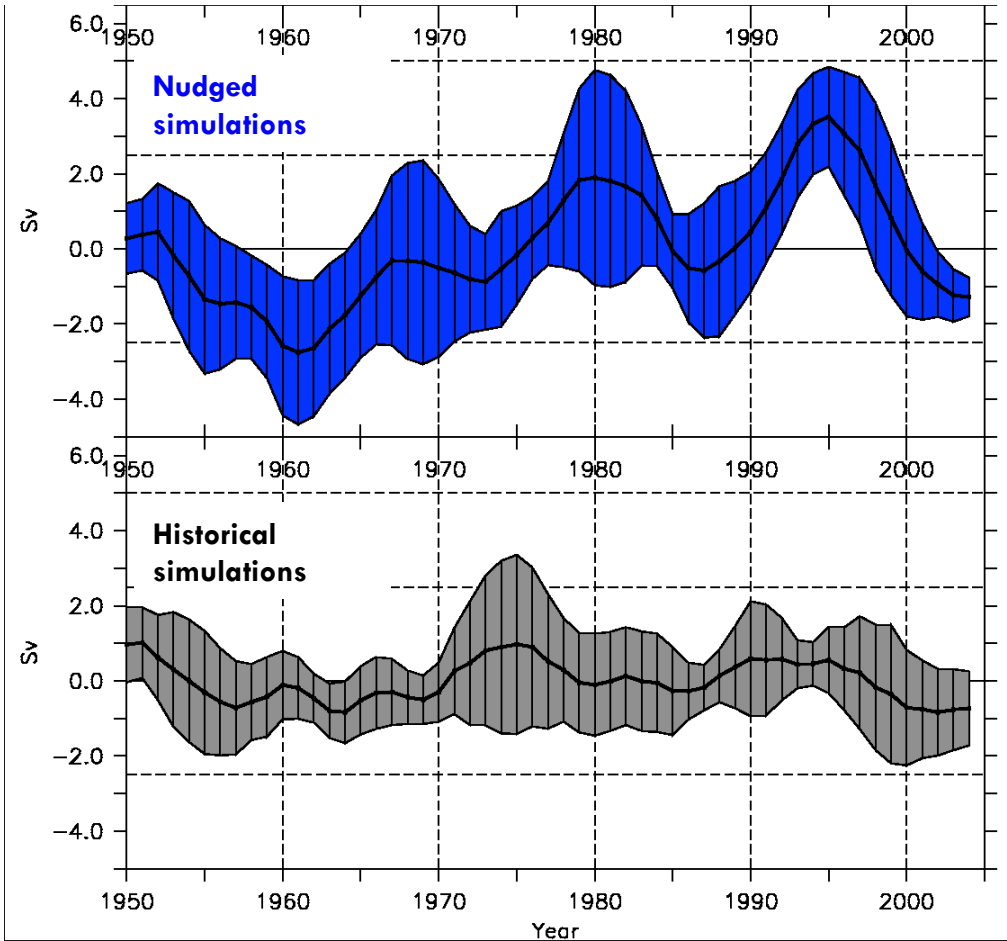
First results on AMOC initialisation

(3-yrs running mean)

AMOC Initialisation

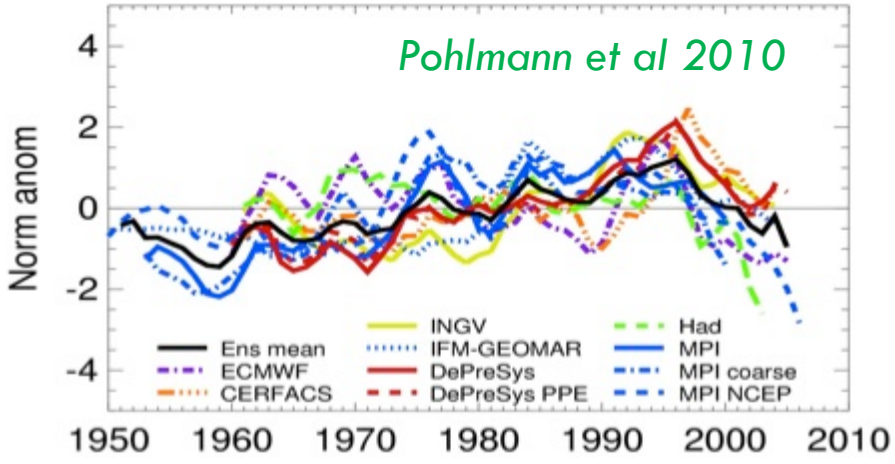
- 5-members ensemble of nudged simulations and control-historical ones
- 5-members historical simulations as control

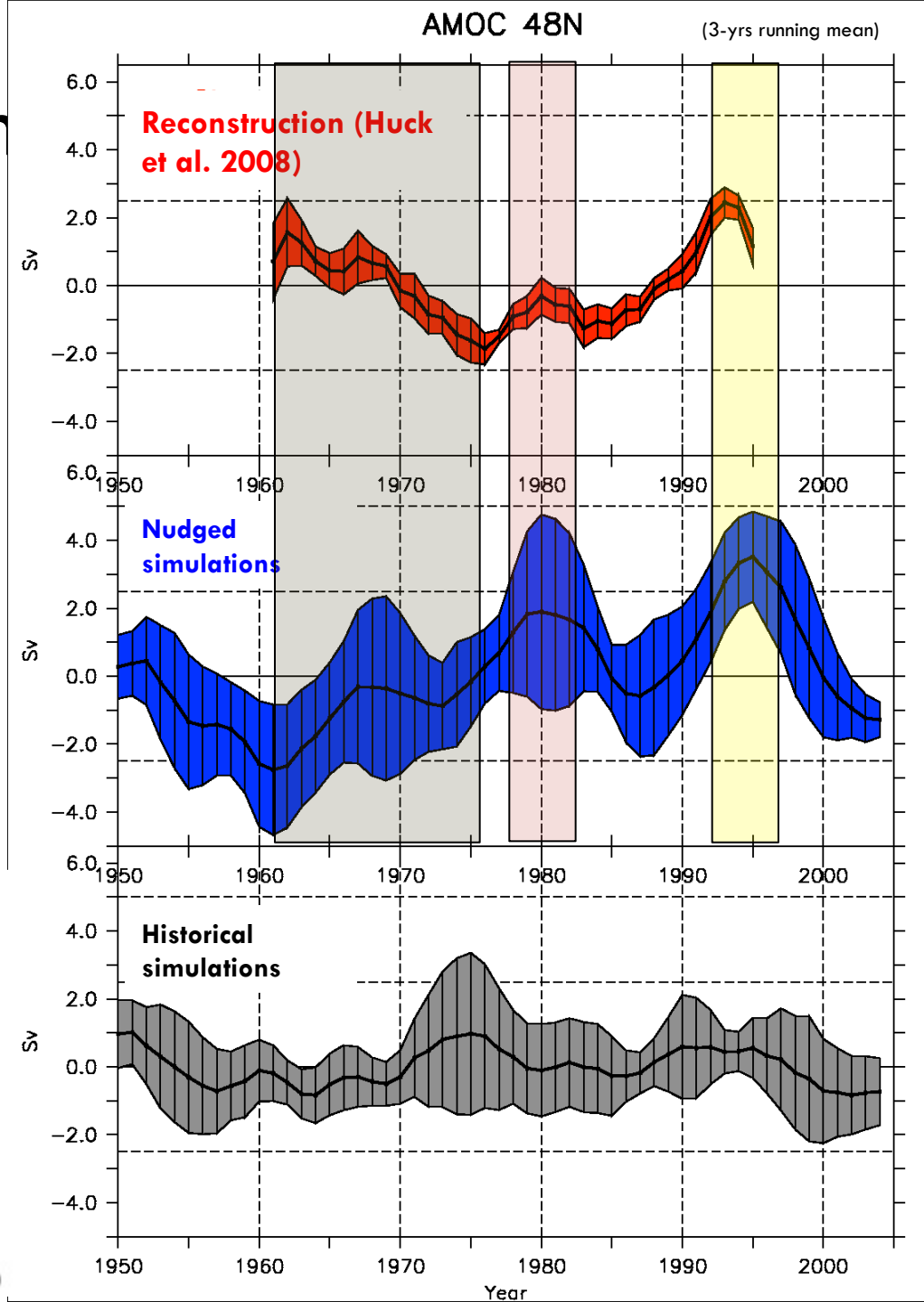
AMOC 48°N



AMOC Initialisation

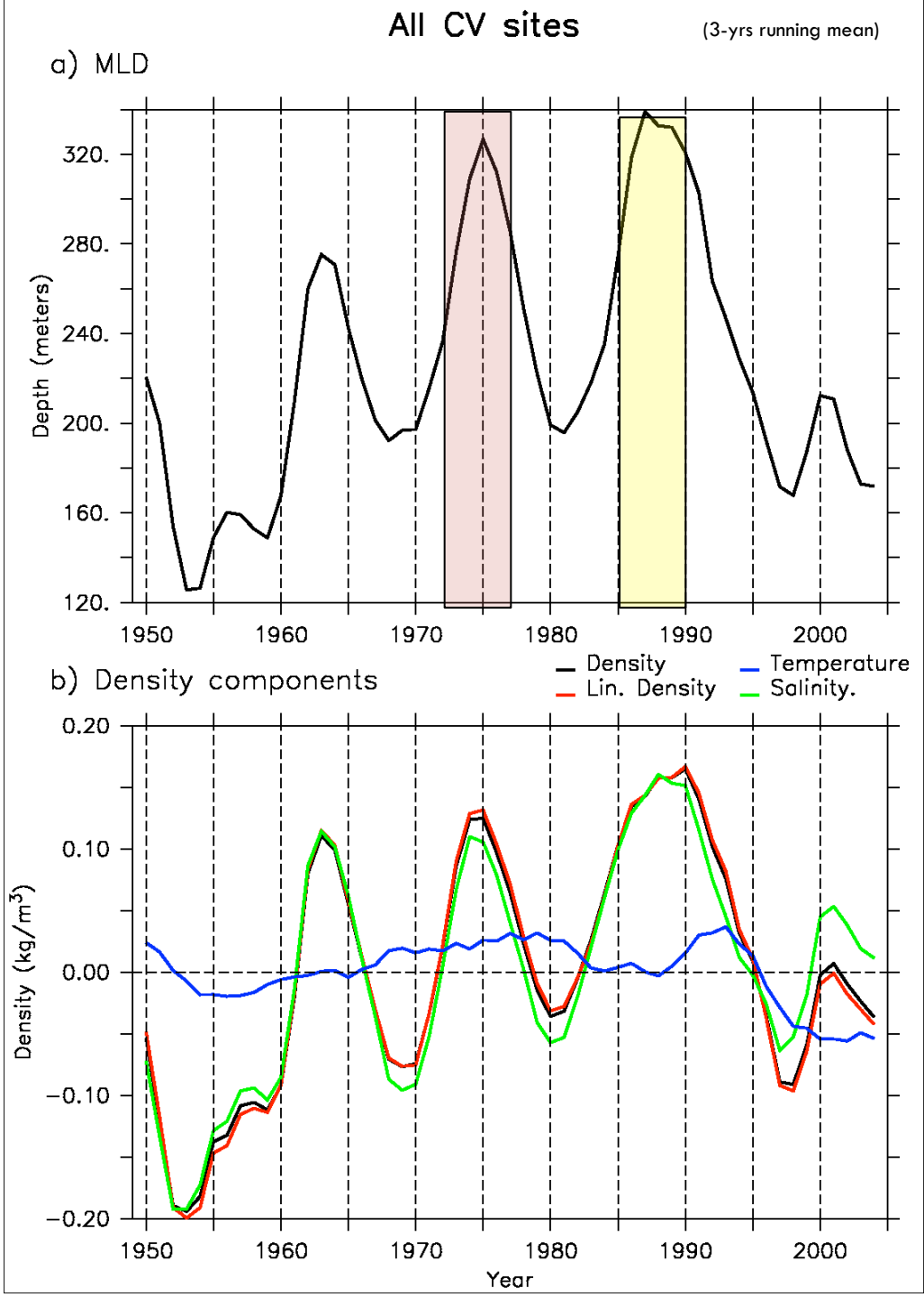
- Reconstruction of the AMOC using NODC hydrographic data (Huck et al. 2008)
- 5-members ensemble of nudged simulations and control-historical ones
- 5-members historical simulations as control





Convection sites response

- Two pics around 5 years before each AMOC max.
- Driven by density at surface, coming from salinity mainly and a slight contribution from SST
- How is SSS initialized?



Mechanisms

⇒ GIN seas SST

⇒ GIN seas ice cover

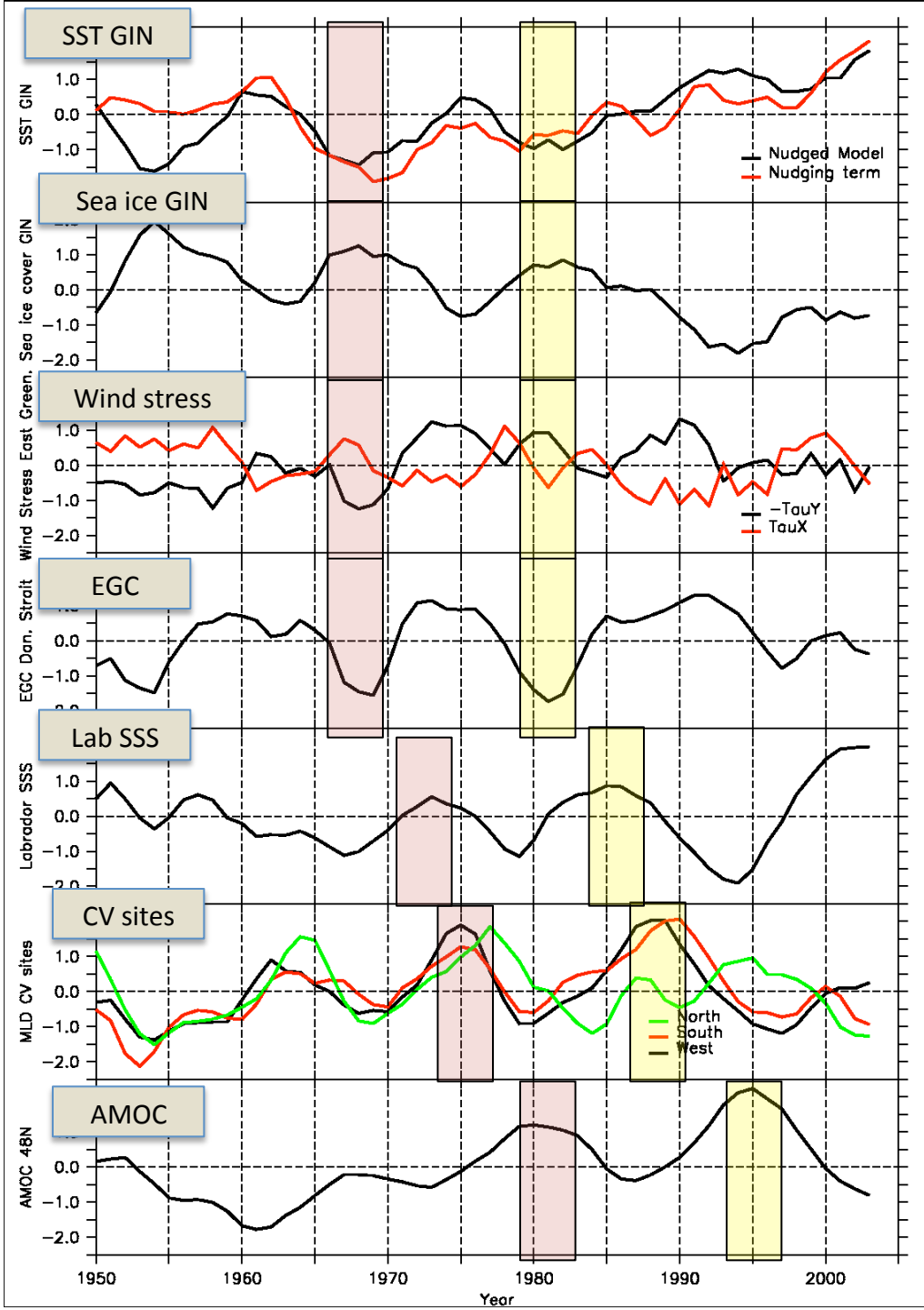
⇒ Wind stress

⇒ EGC

⇒ SSS Labrador Sea

⇒ CV sites

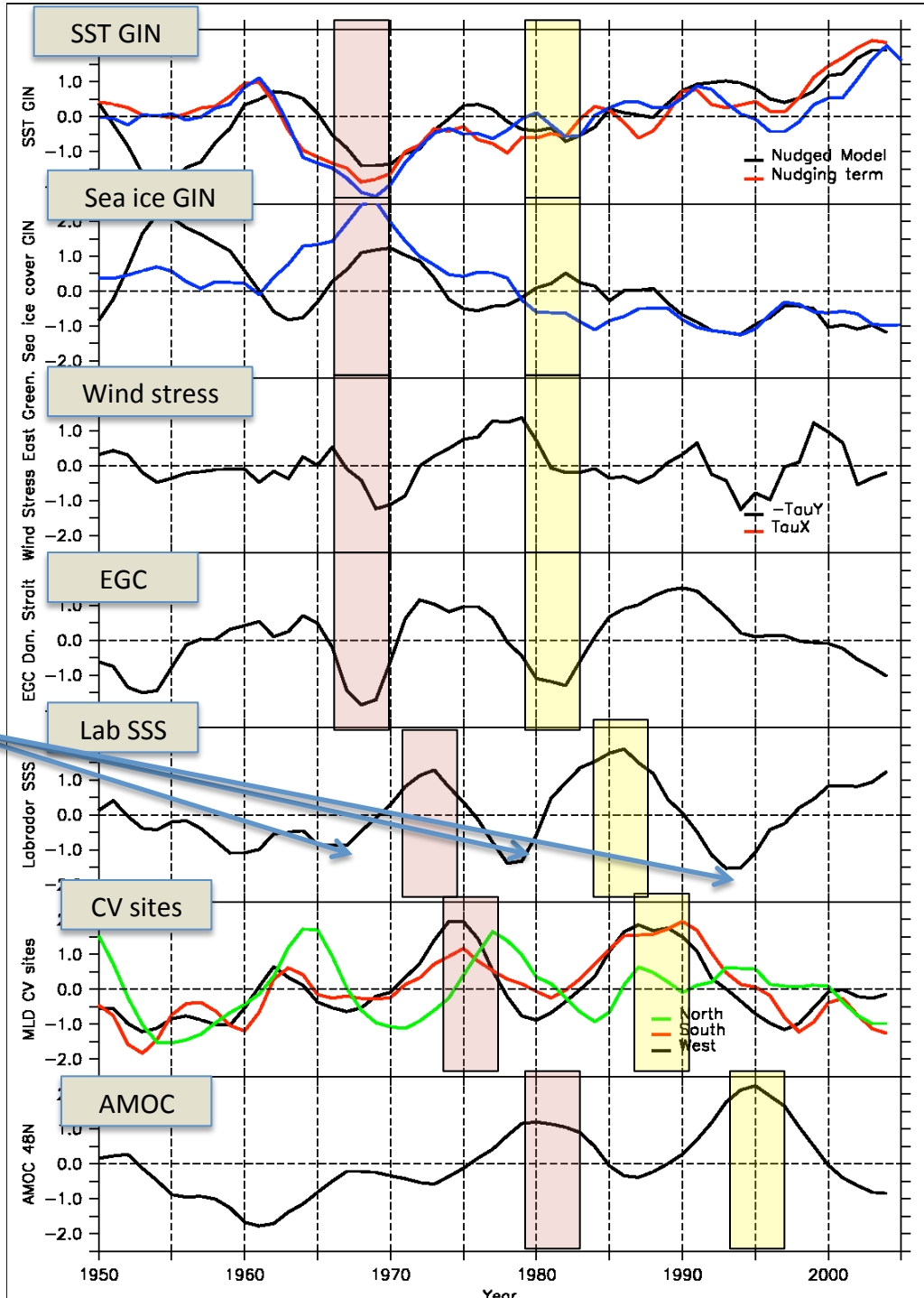
⇒ AMOC



Mechanisms

⇒ HadISST

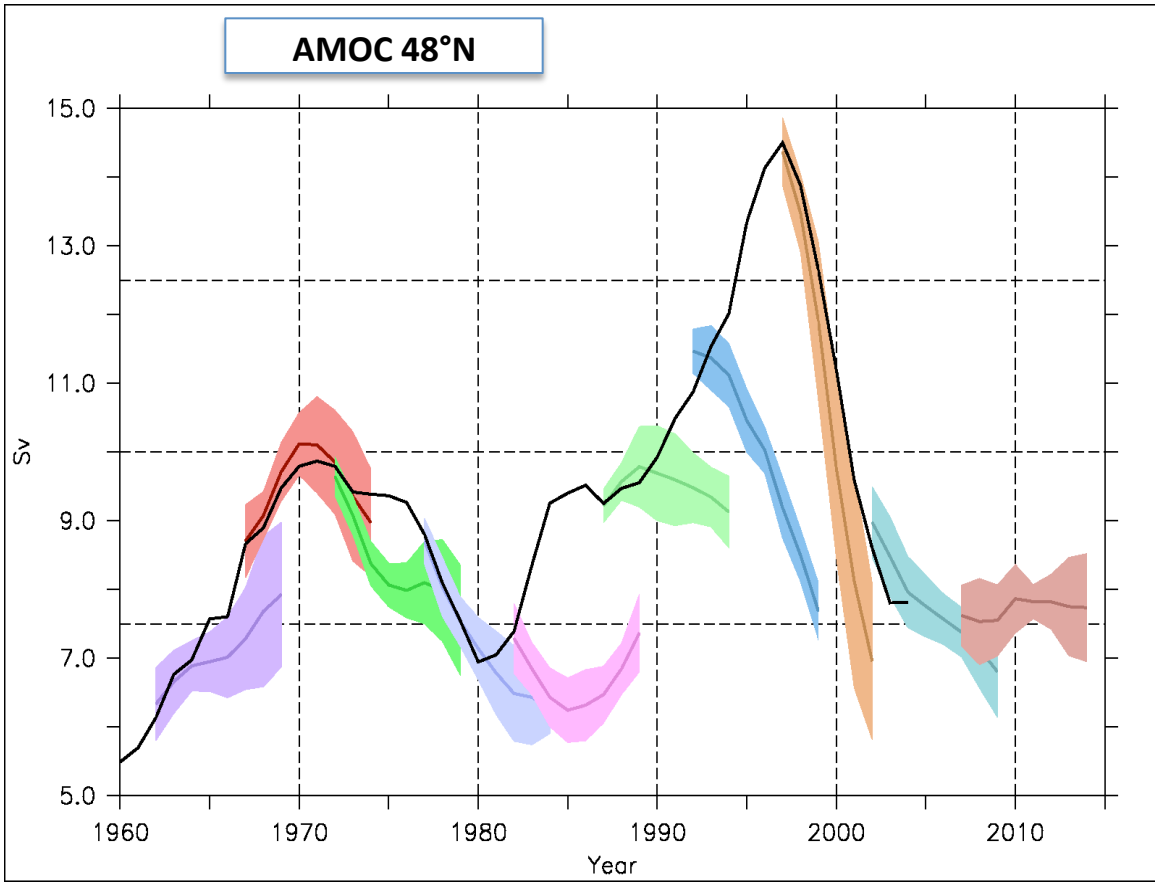
GSAs!
(1970, 82, 90 Sundby & Drinkwater 2007)



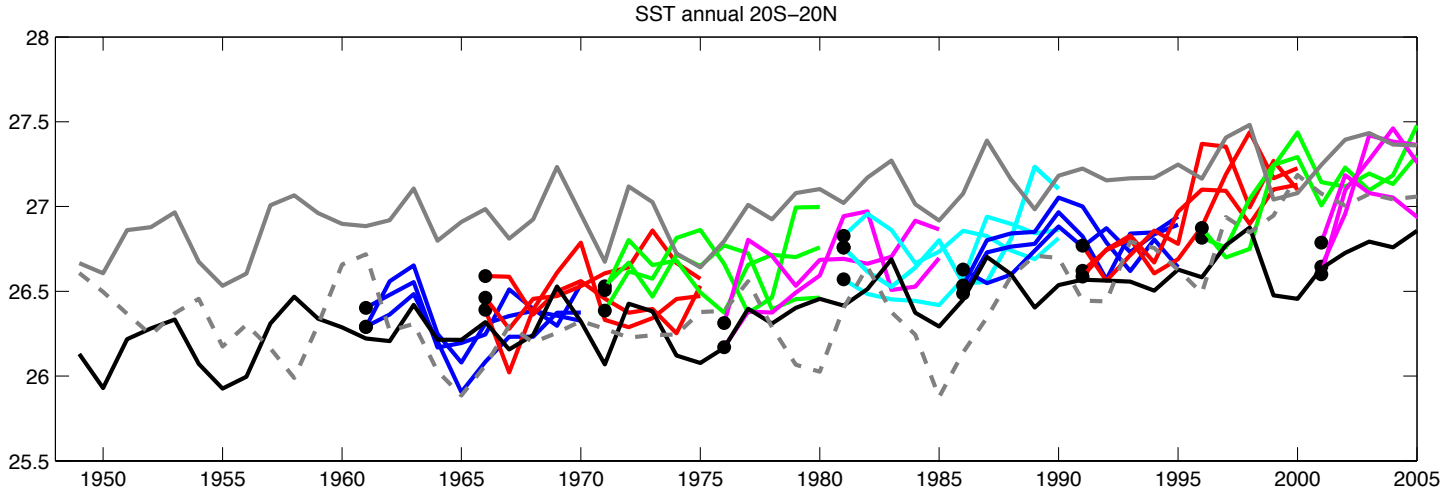
first hindcasts results

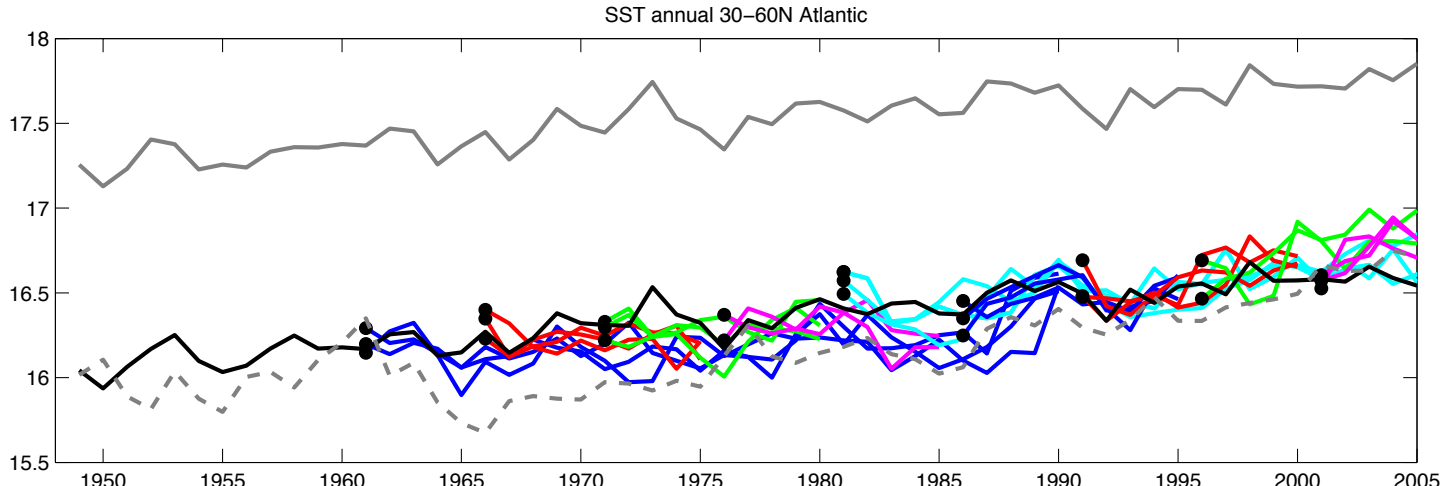
AMOC hindcasts

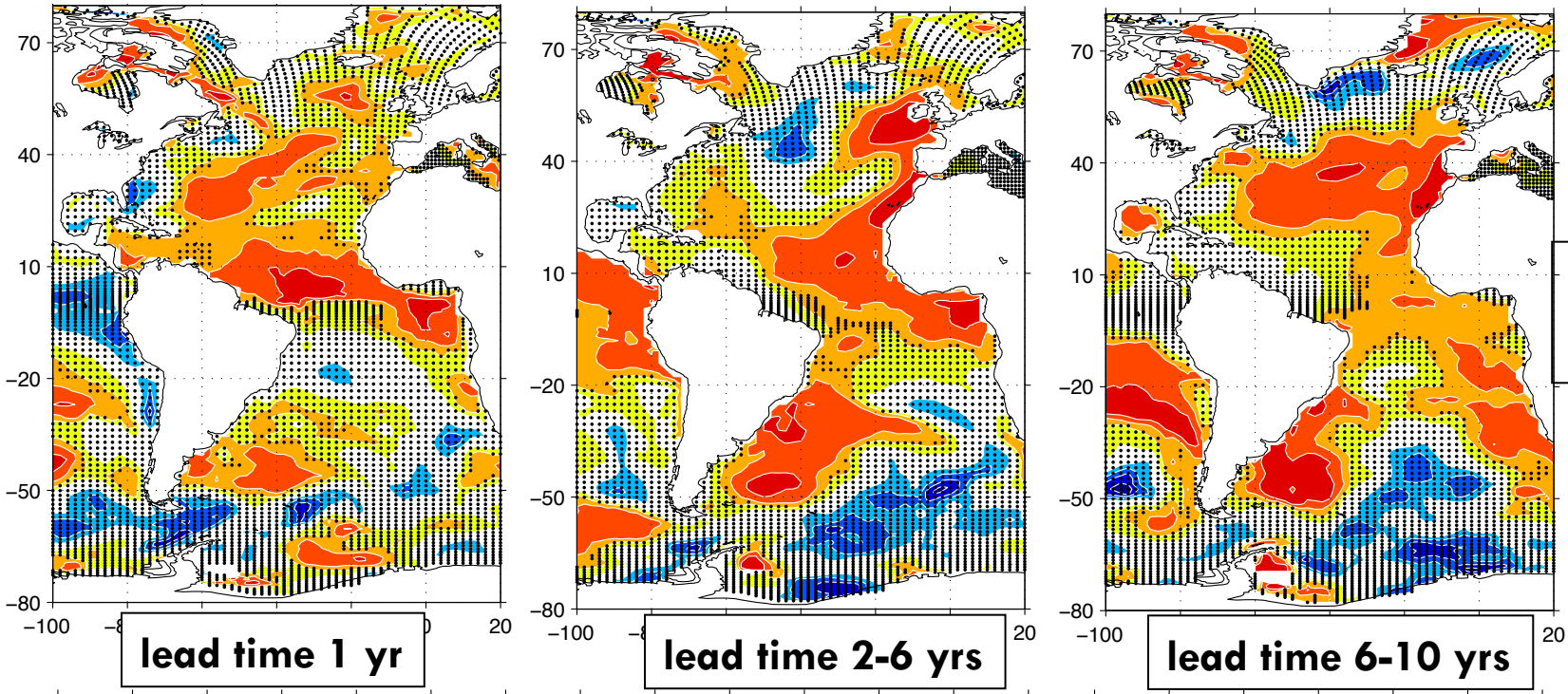
- Only one member of the nudged ensemble (planned to apply to each)
- 3-members ensemble of free run
- 90's max. missed (effect of persistent NAO?)

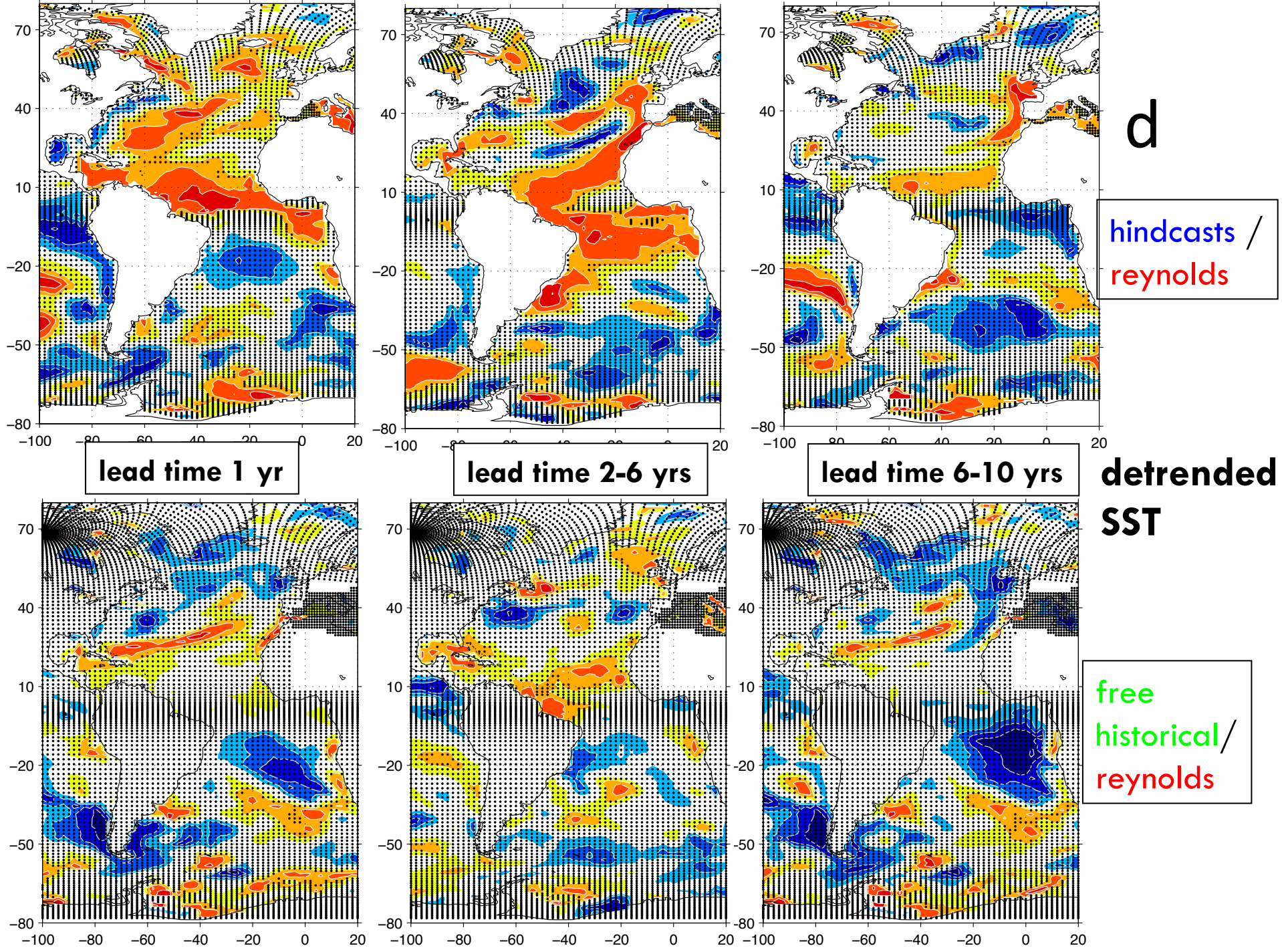


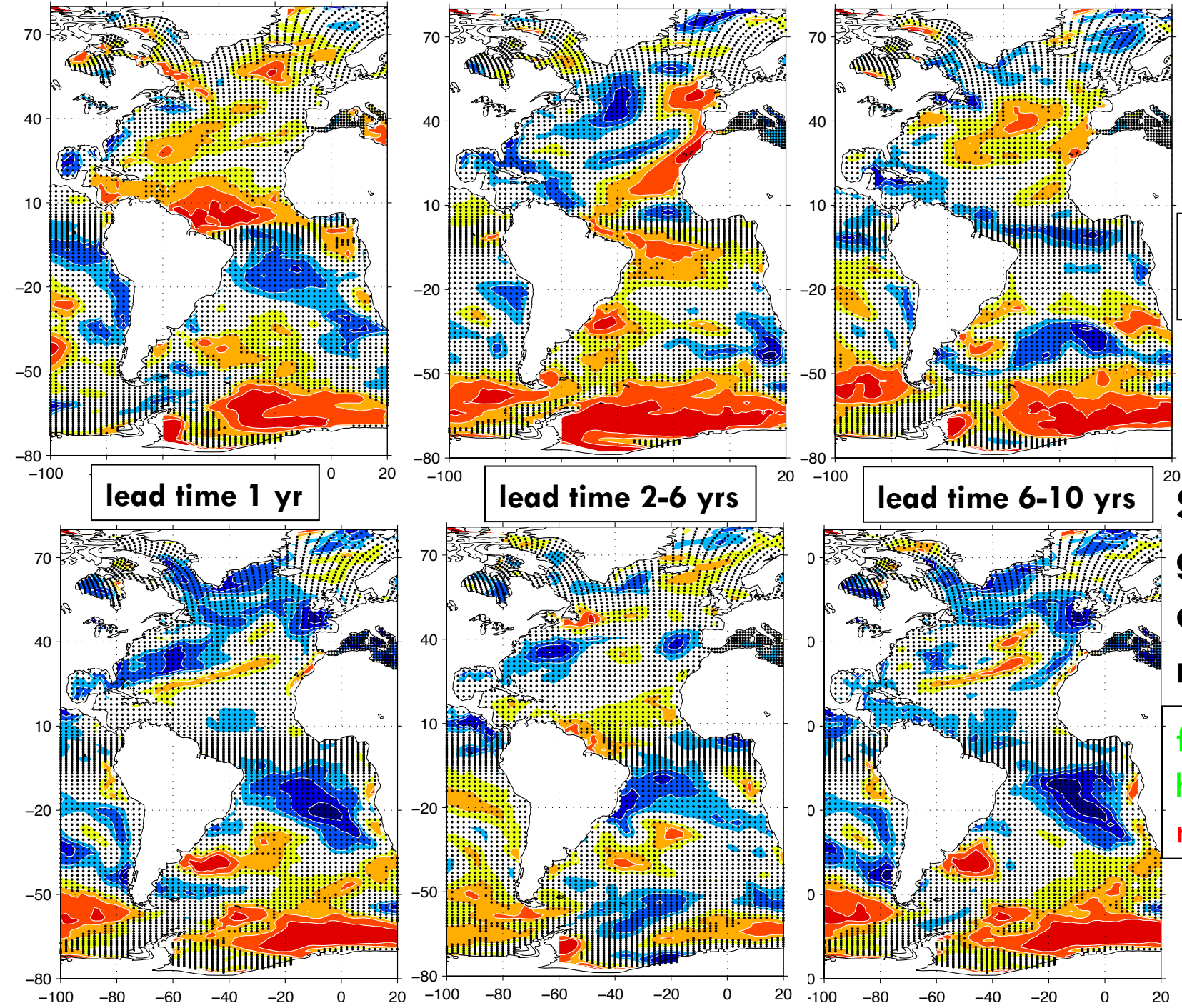
SST


SST annual 20S–20N
28
27.5
27
26.5
26
25.5
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005


SST annual 30–60N Atlantic
18
17.5
17
16.5
16
15.5
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005


lead time 1 yr
lead time 2-6 yrs
lead time 6-10 yrs
hindcasts / reynolds
SST
free historical / reynolds


d
hindcasts /
reynolds
lead time 1 yr
lead time 2-6 yrs
lead time 6-10 yrs
detrended
SST
free
historical/
reynolds


lead time 1 yr
lead time 2-6 yrs
lead time 6-10 yrs
hindcasts / reynolds
SST global average removed
free historical/ reynolds

Conclusions

- In IPSLCM5, AMOC predictability strongly linked to a multidecadal mode of variability
- AMOC initialisation also linked to this mode. Surprising agreement with data given the biases in the North Atlantic in the IPSL-CM5 model?

- not inconsistent with GSAs

- initialised after 30 years using only Reynolds SST

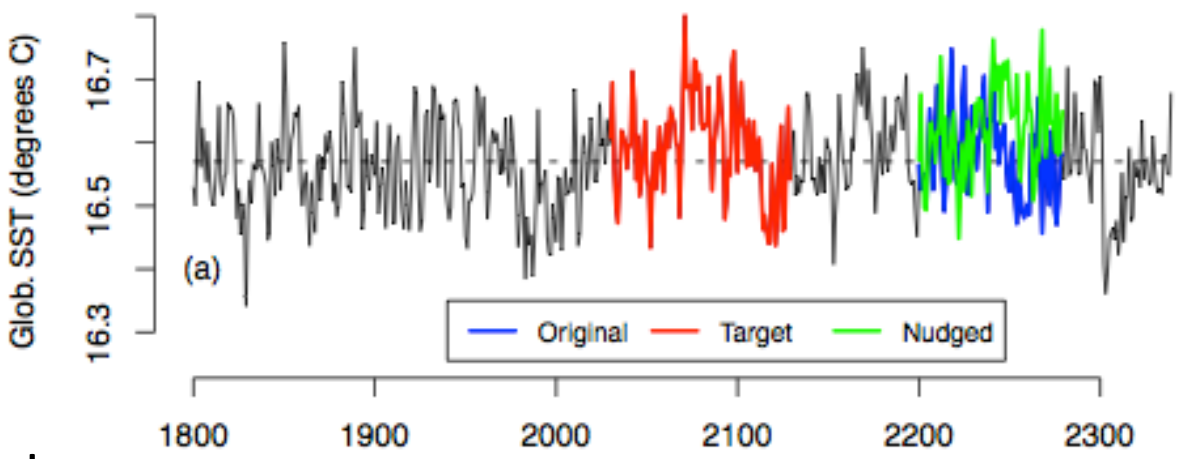
- 1st set of decadal predictions with IPSLCM5A is on the way
- Evaluation of the predictive skill under investigation.
- Some issue about the 1991 starting date

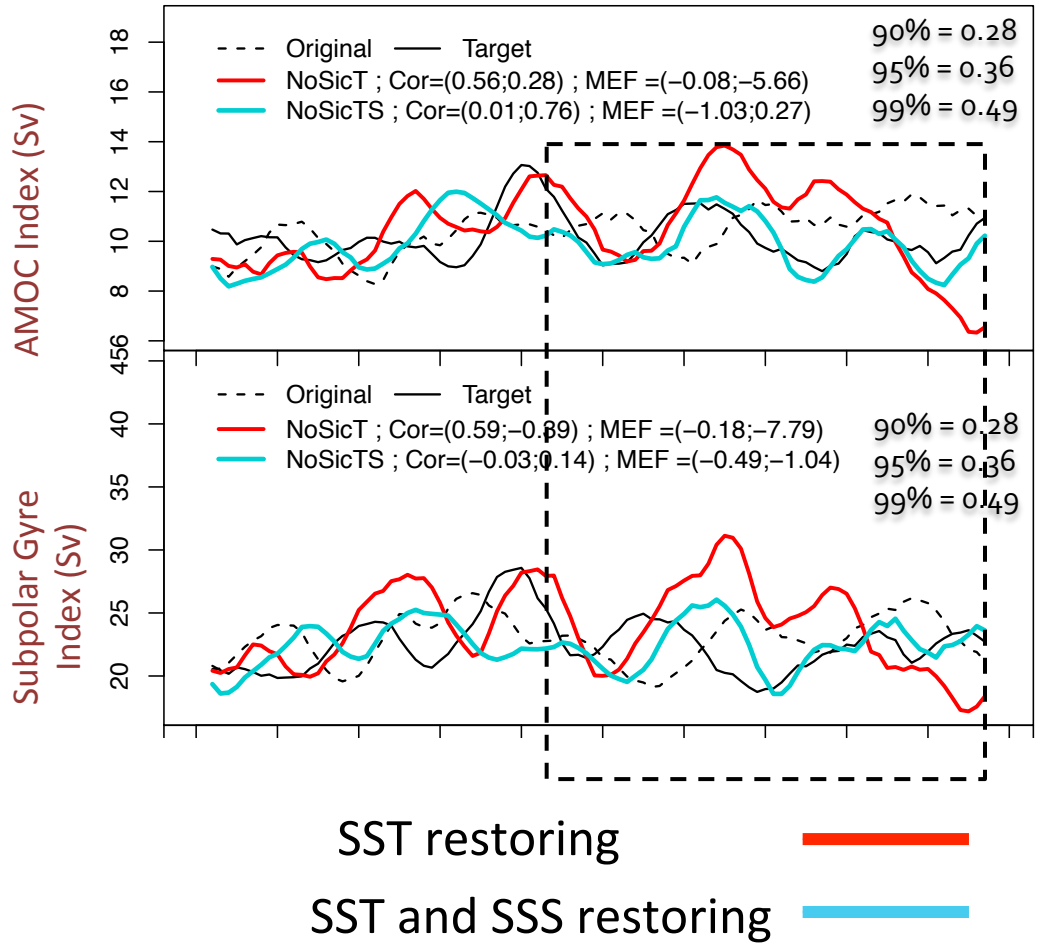
to be continued…

Future work

use perfect model approach to gain insight into initialization strategy

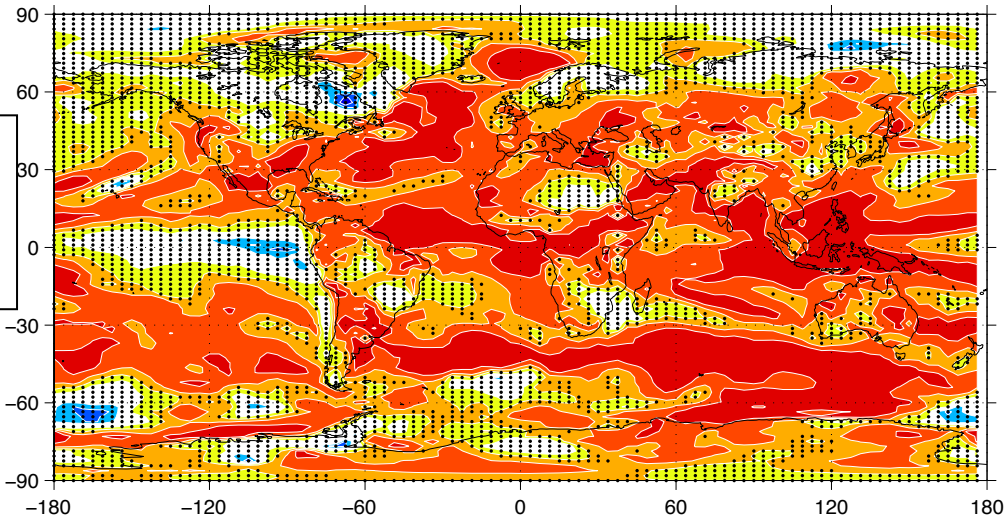
- add compensating freshwater
  flux to compensate temperature anomalies
- initialization through wind (3D atmosphere)



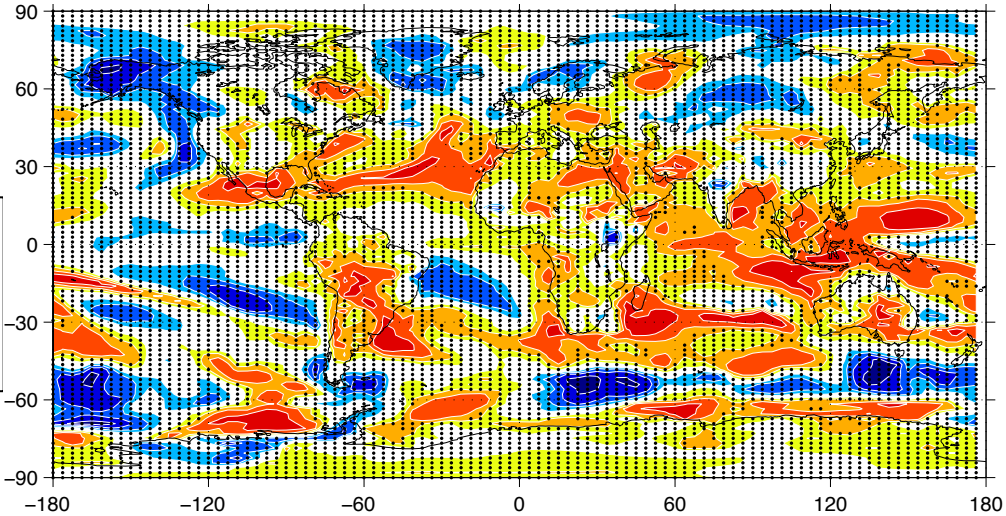


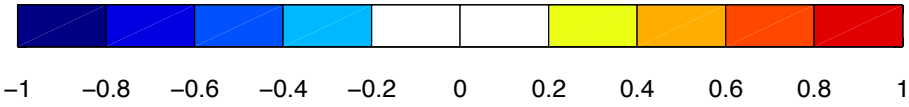
surface temperature lead time 1 yr

correlation
hindcasts /
nudged run

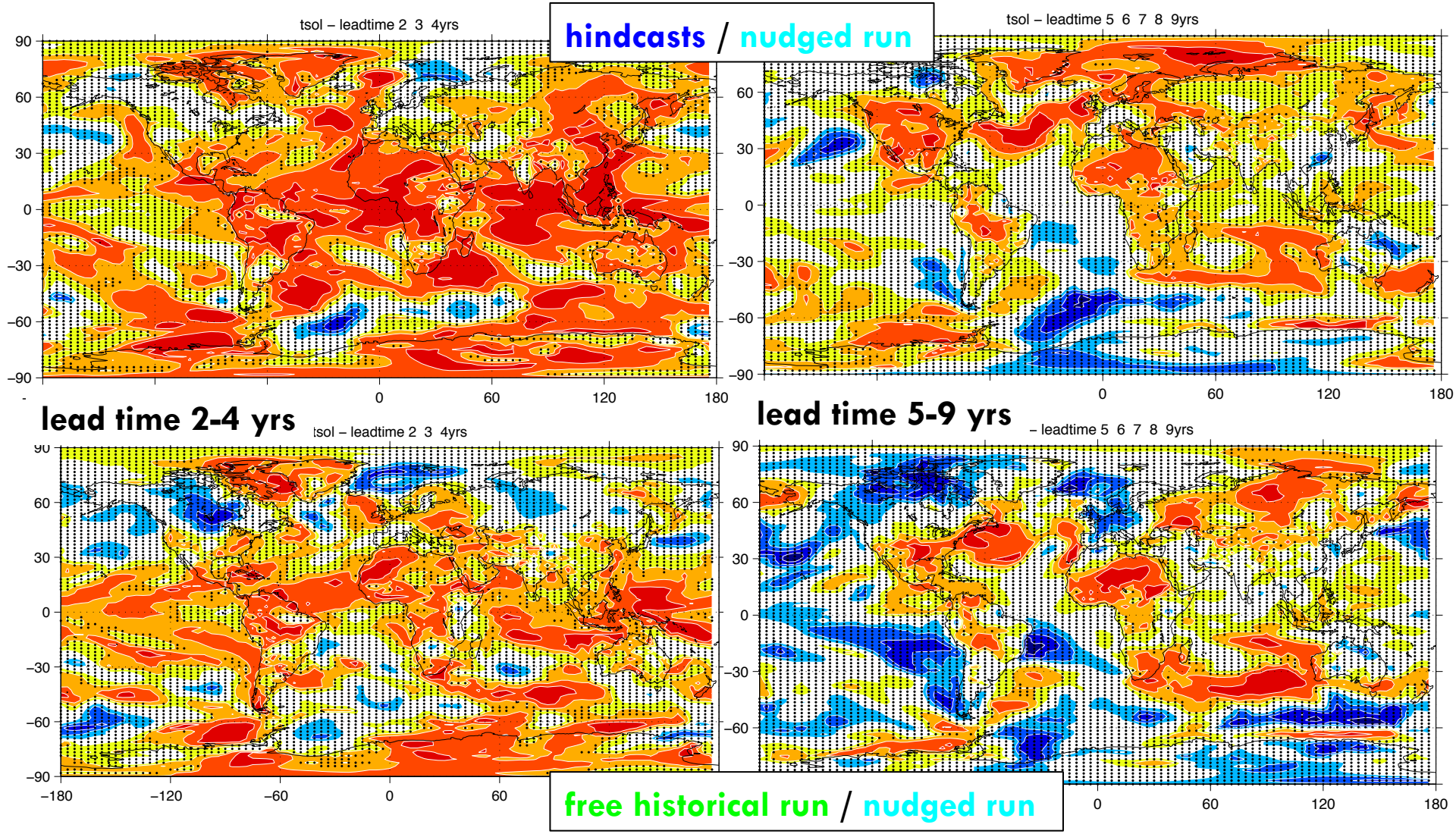


correlation
free historical run /
nudged run

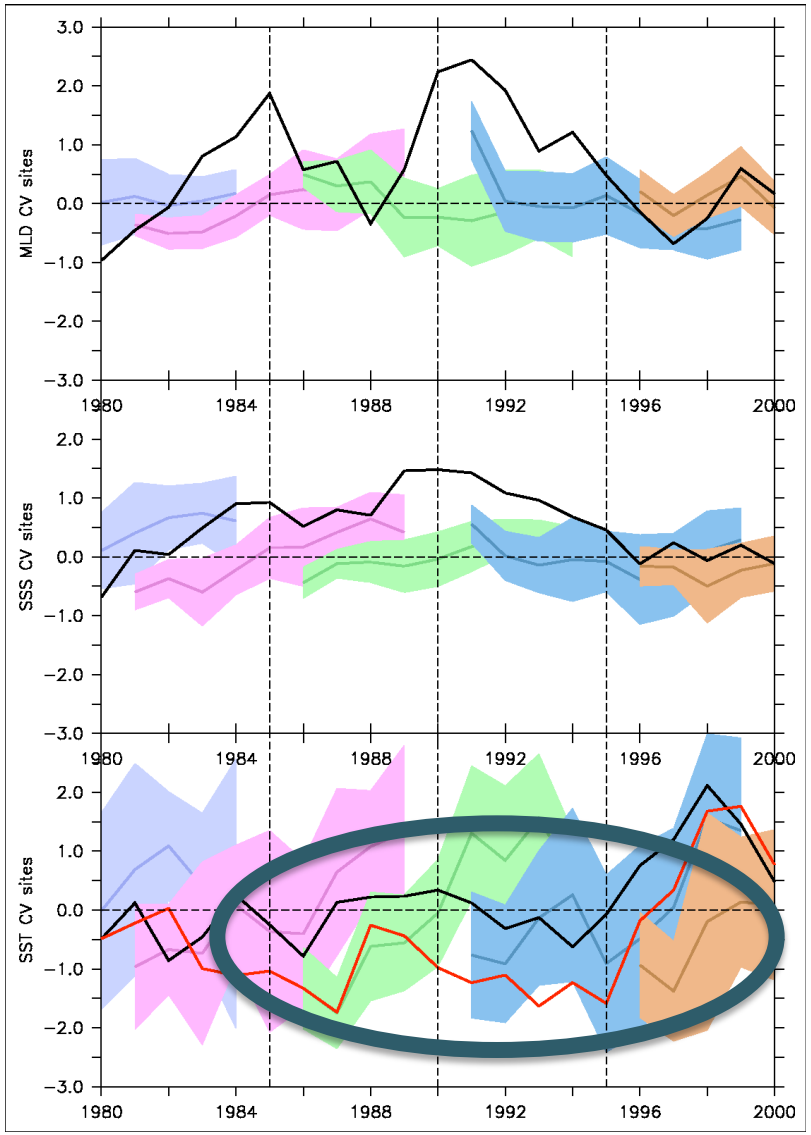


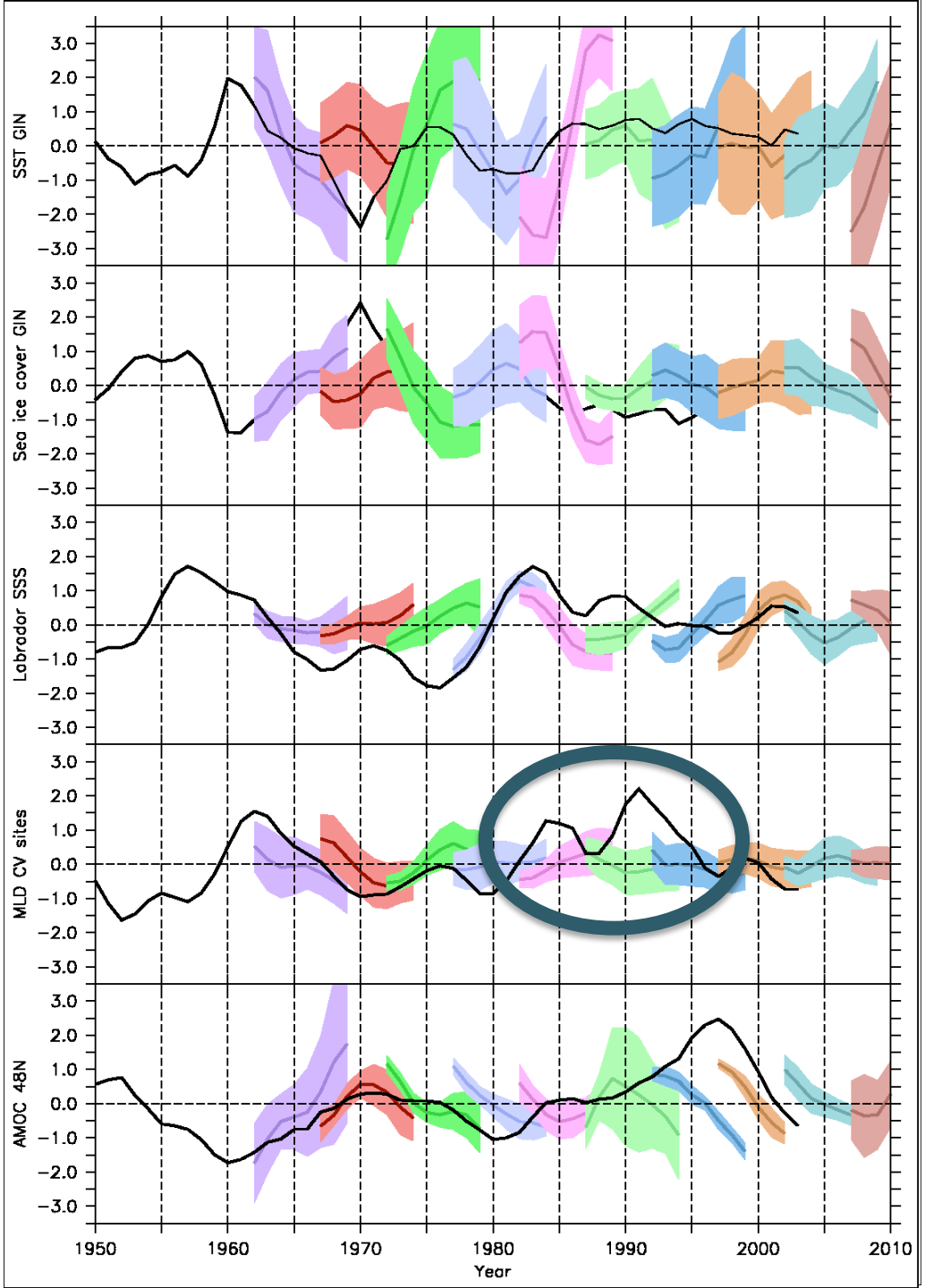


surface temperature

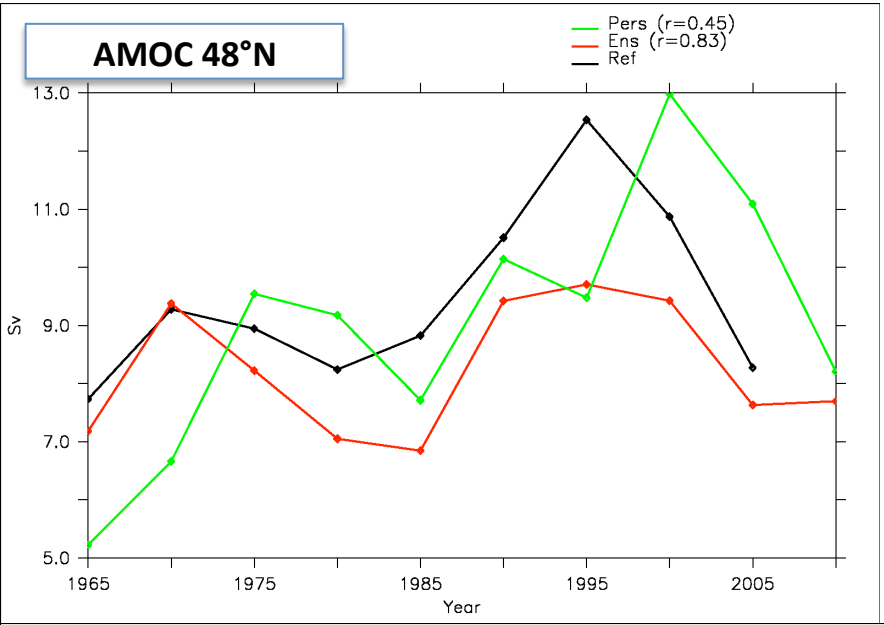


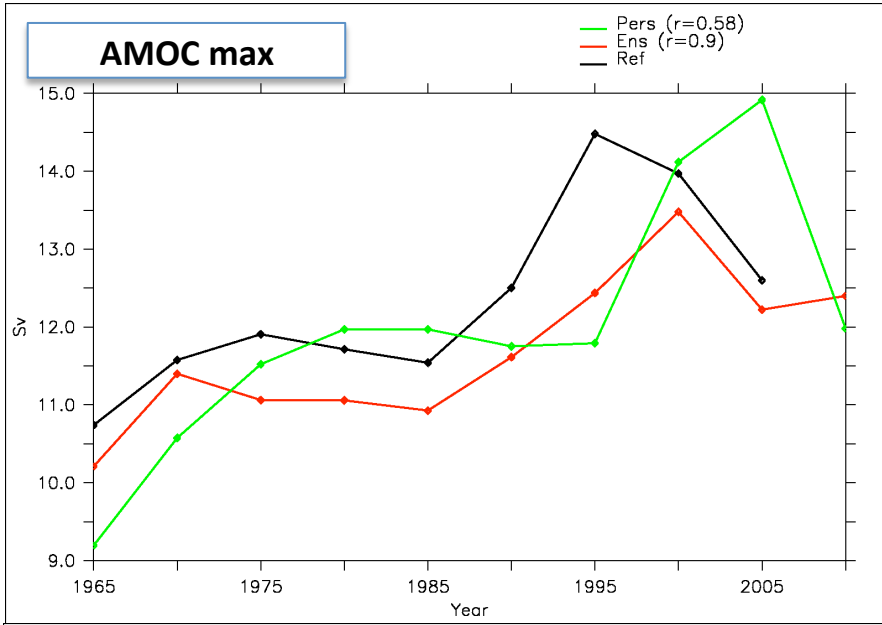
Why do we miss the 1990s peak?

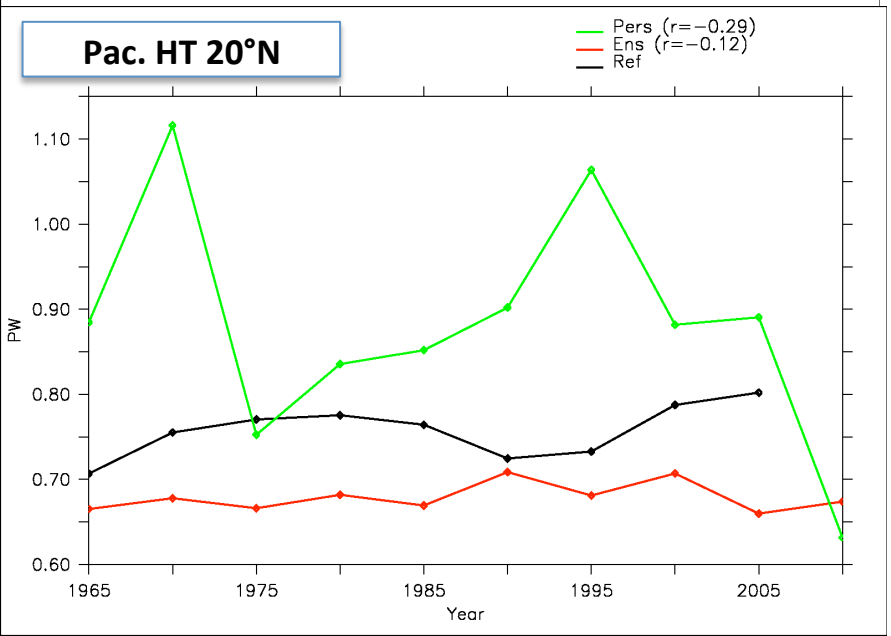


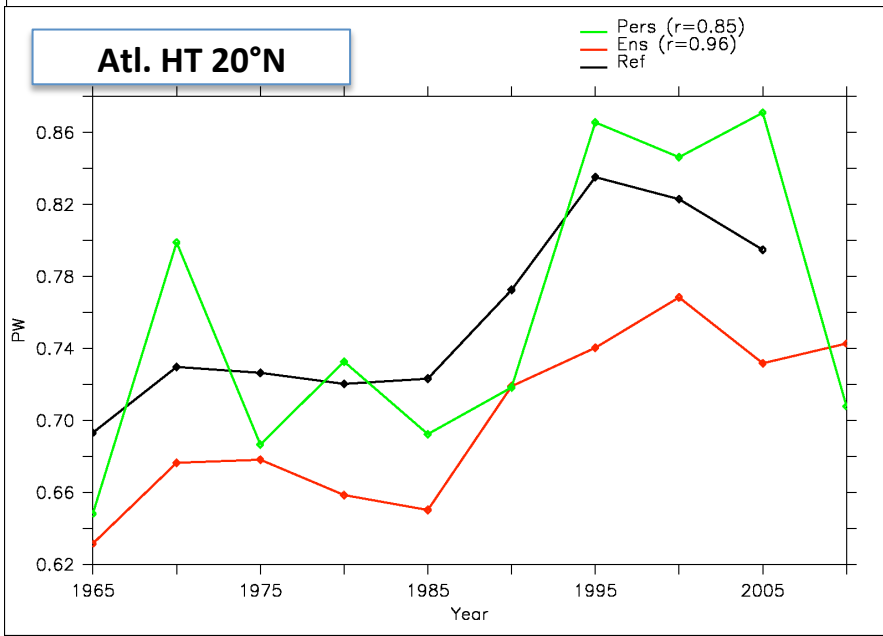


Hindcasts


AMOC 48°N
Pers (r=0.45)
Ens (r=0.83)
Ref
13.0
11.0
9.0
7.0
5.0
Sv
1965
1975
1985
1995
2005
Year

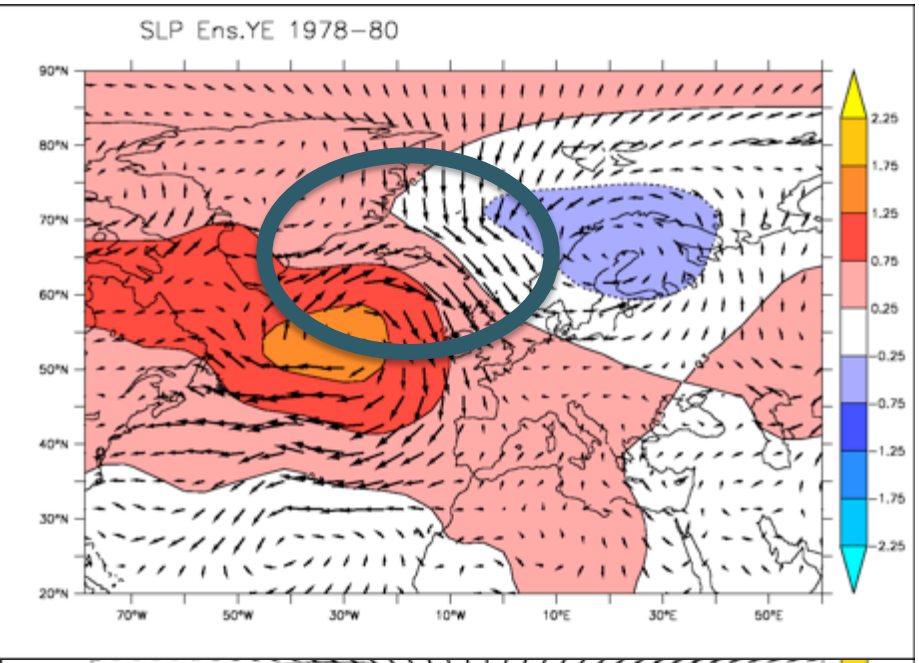

AMOC max
Pers (r=0.58)
Ens (r=0.9)
Ref
15.0
14.0
13.0
12.0
11.0
10.0
9.0
Sv
1965
1975
1985
1995
2005
Year

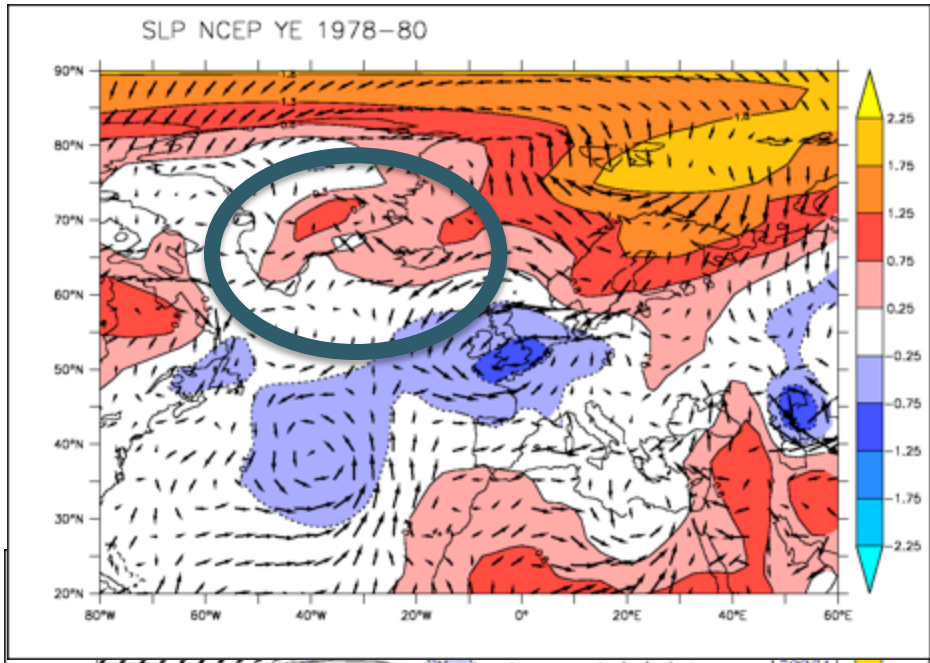

Pac. HT 20°N
Pers (r=−0.29)
Ens (r=−0.12)
Ref
1.10
1.00
0.90
0.80
0.70
0.60
PW
1965
1975
1985
1995
2005
Year

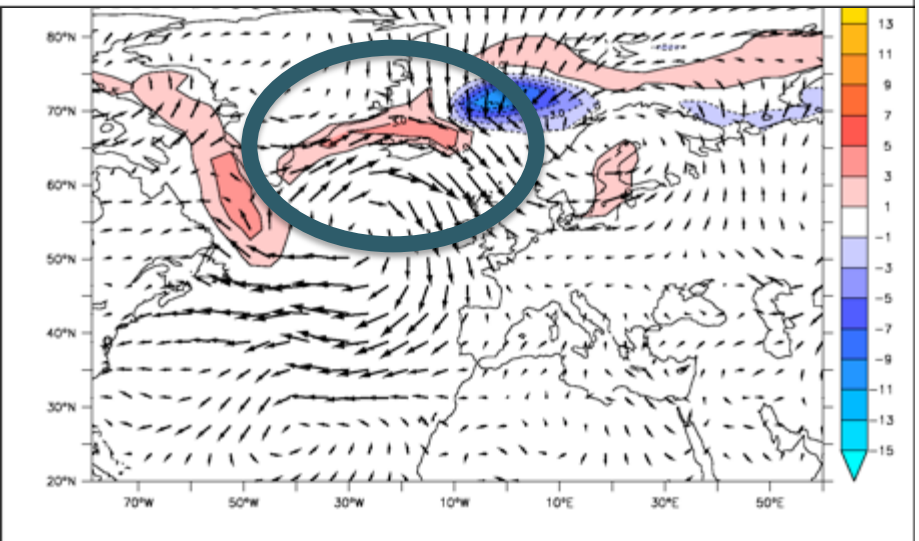

Atl. HT 20°N
Pers (r=0.85)
Ens (r=0.96)
Ref
0.86
0.82
0.78
0.74
0.70
0.66
0.62
PW
1965
1975
1985
1995
2005
Year

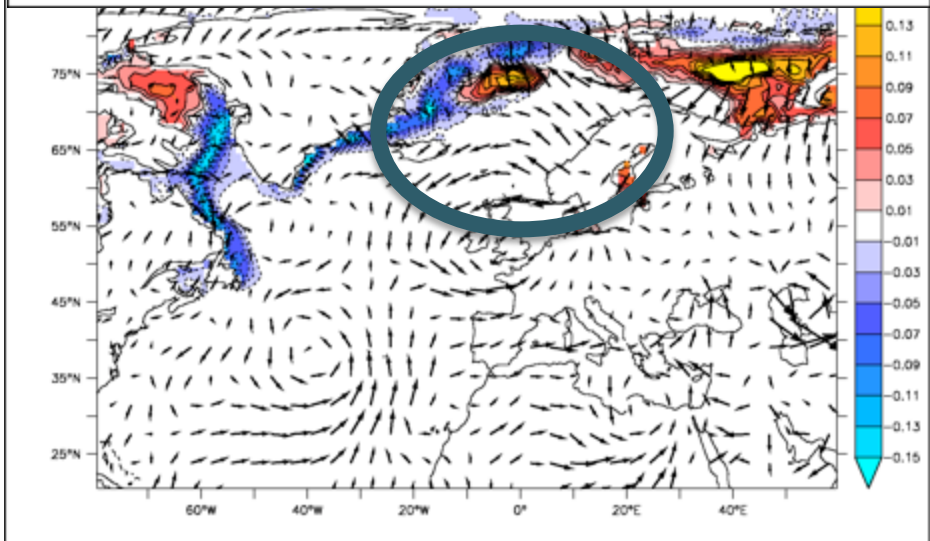
Air-sea ice interactions in 1978-80

Nudged simulations



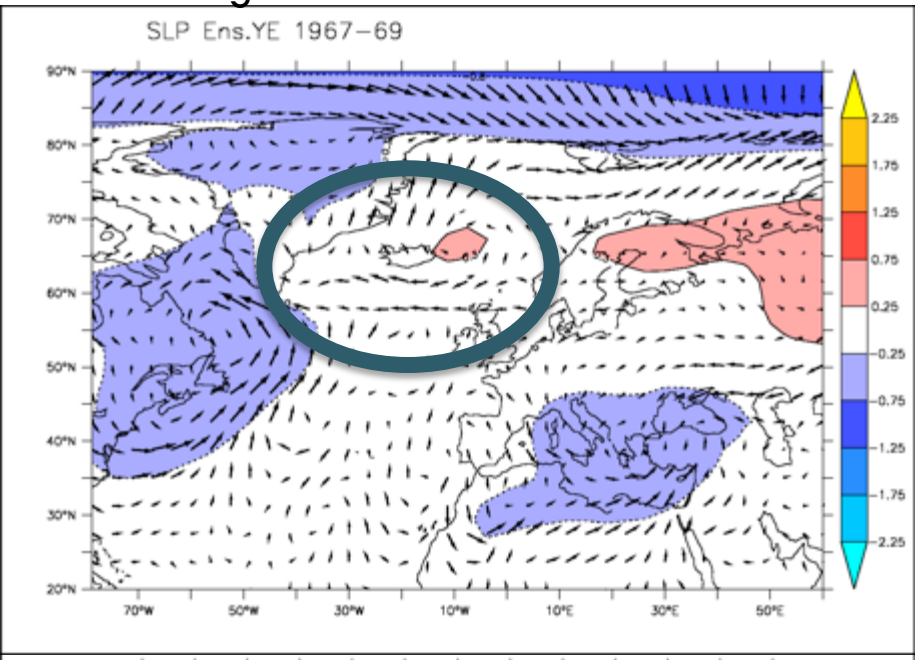


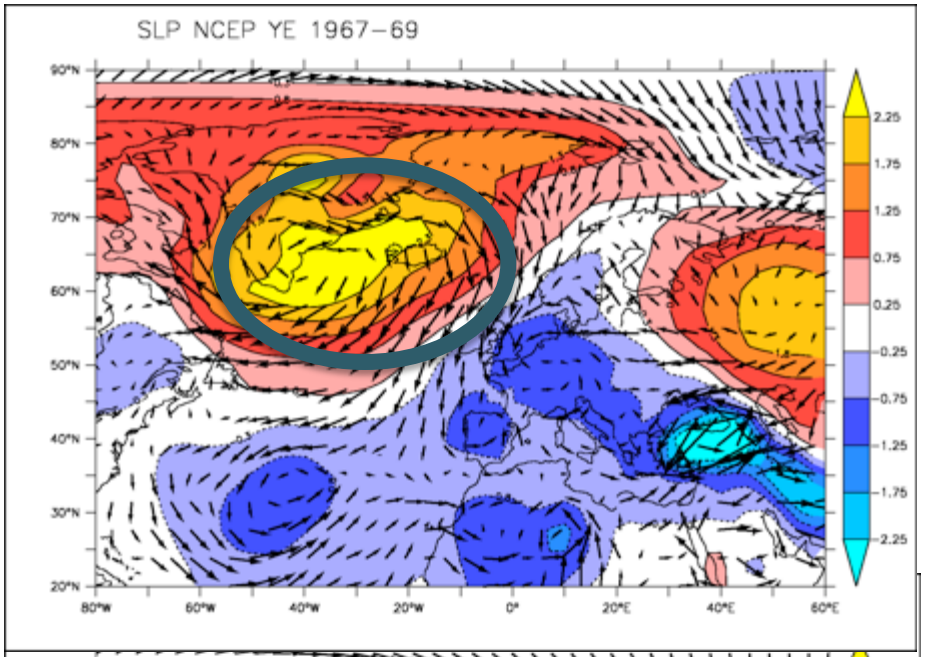


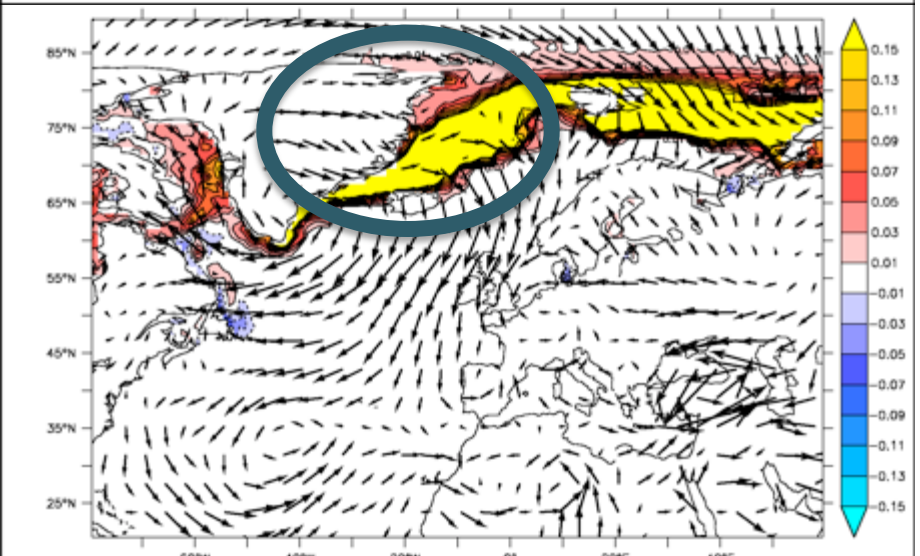


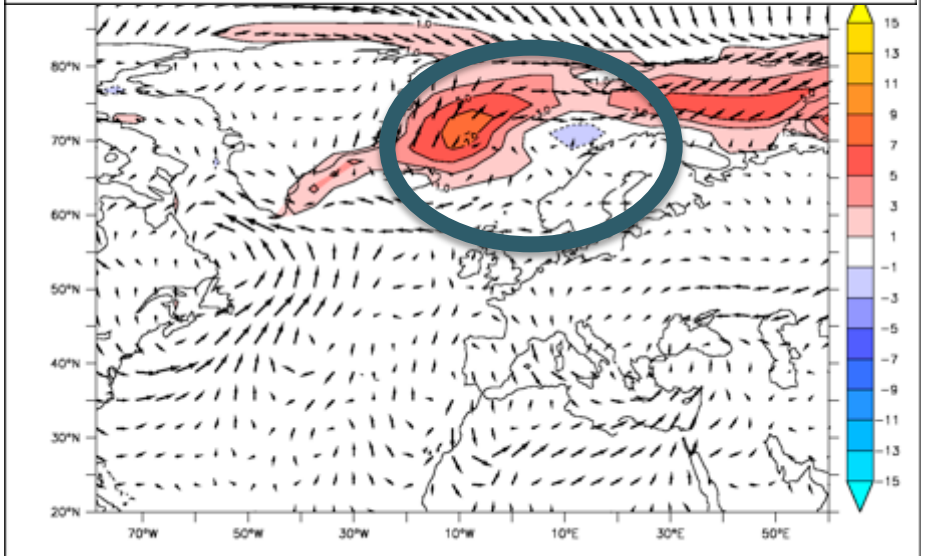
Air-sea ice interactions in 1967-69

Nudged simulations









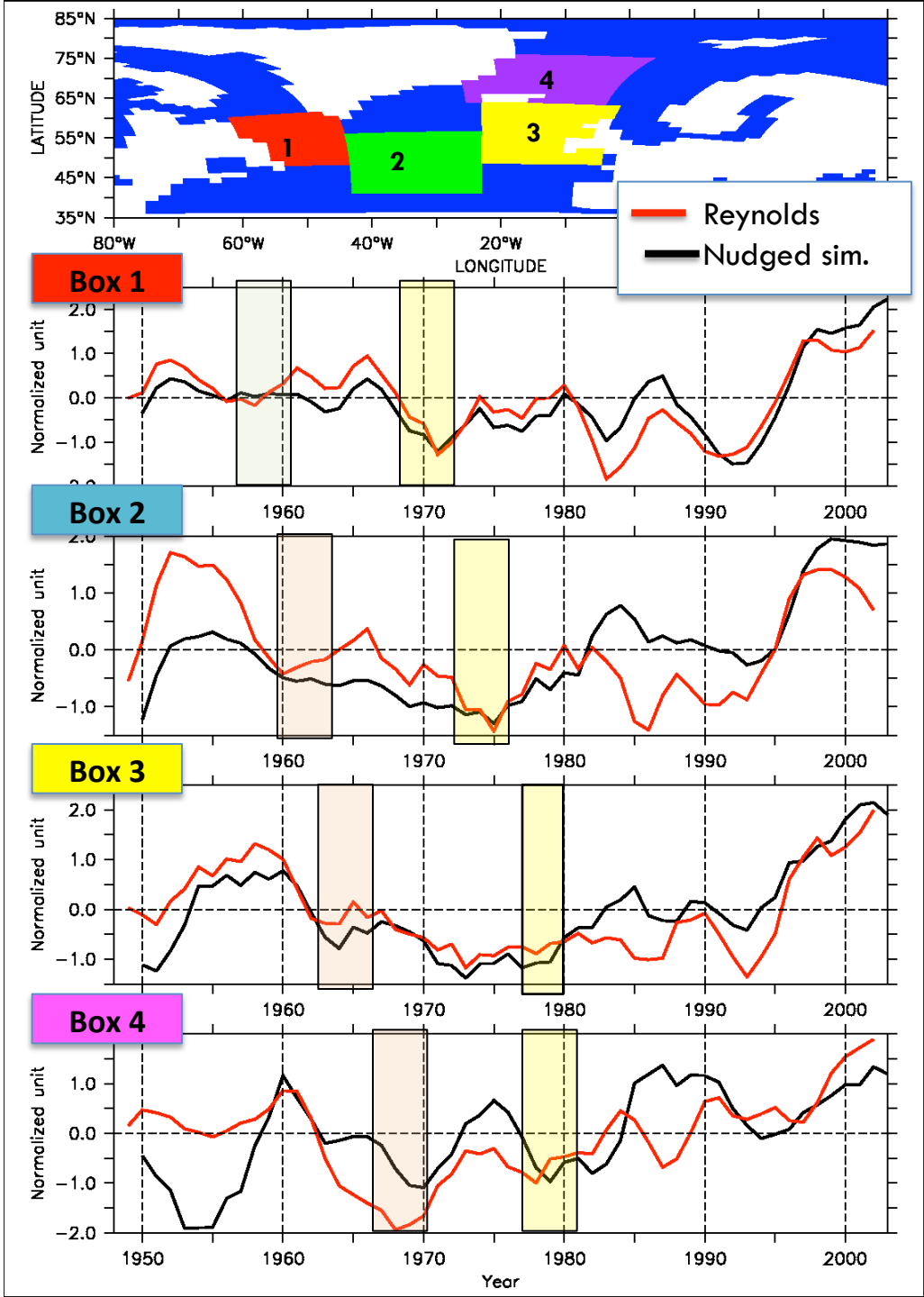
Propagation of SST anomalies

⇒ We follow the mininimum of SST along the gyre

⇒ 8 years between Labrador and GIN

⇒ True in the model (known)

⇒ And in the Reynolds data!

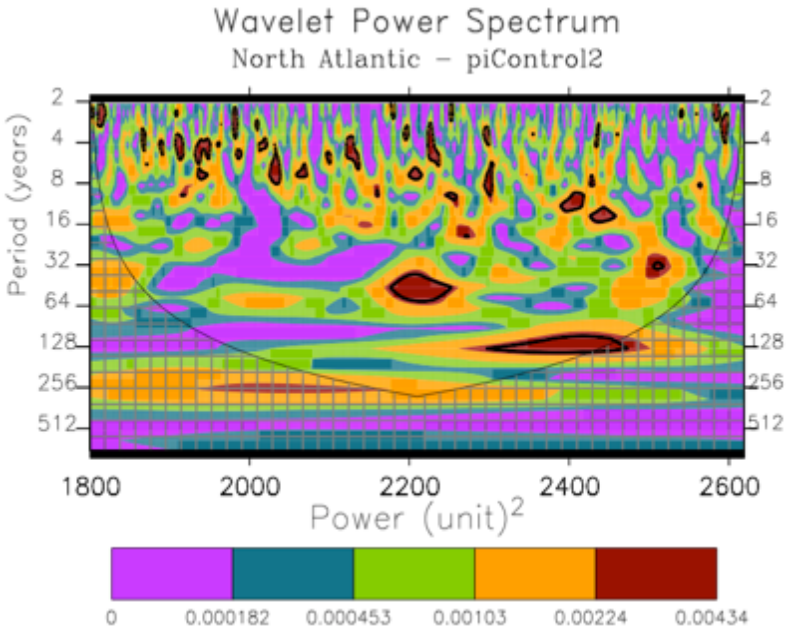


Simulating ocean carbon fluxes at decadal time-scale need online simulations

Séférian, Bopp et al.

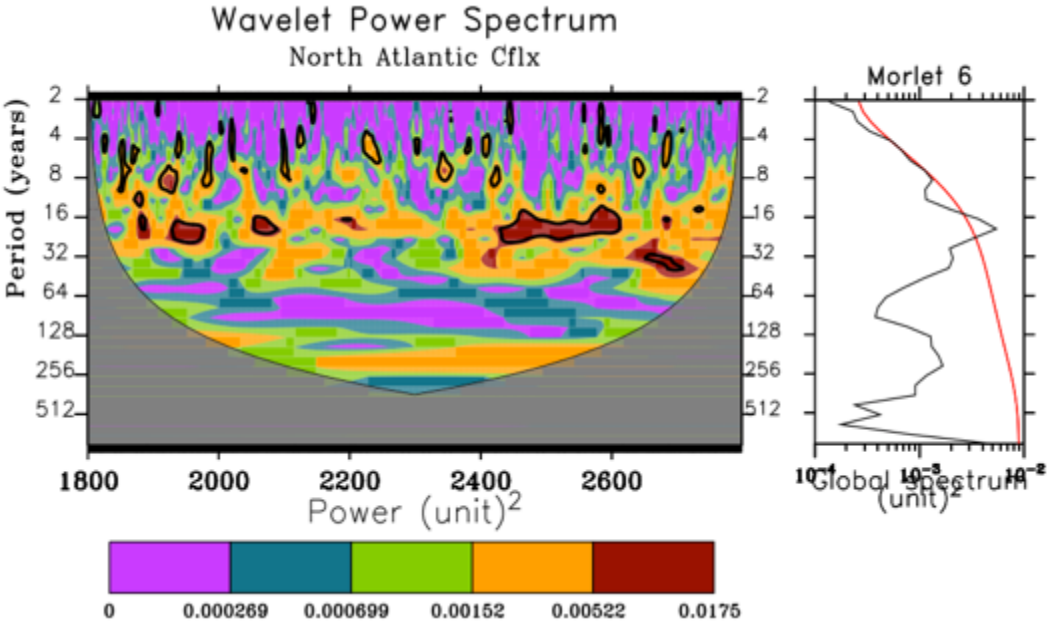
North Atlantic (45-75°N) carbon uptake Wavelet Analysis on preindustrial simulation (1000 years)

Offline simulation
Biogeochemical model
forced by monthly means



No Signal at decadal time-scale

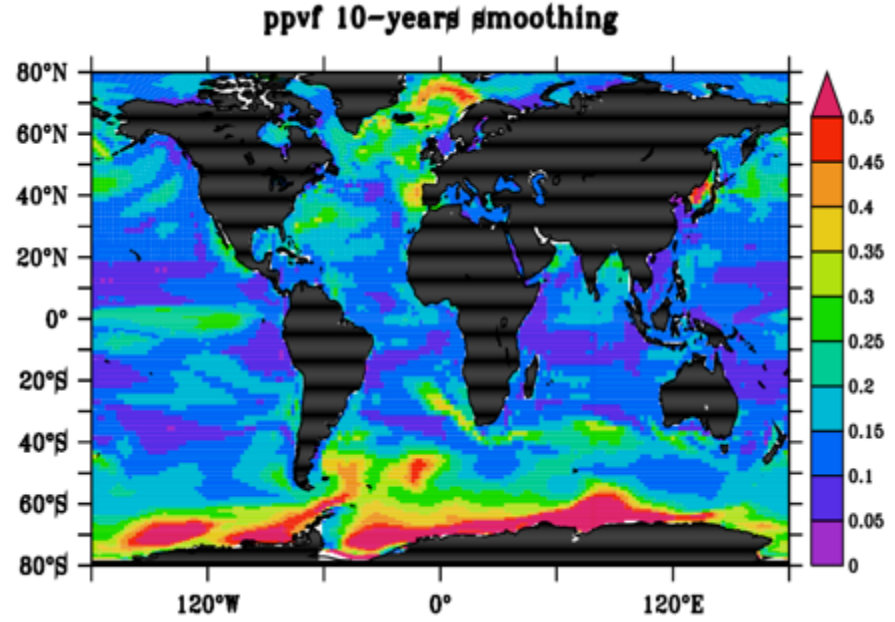
Online simulation
Biogeochemical model
Embedded in coupled climate model



Signal at decadal time-scale

Predictability of ocean carbon fluxes at decadal time-scale

Séférian, Bopp et al.

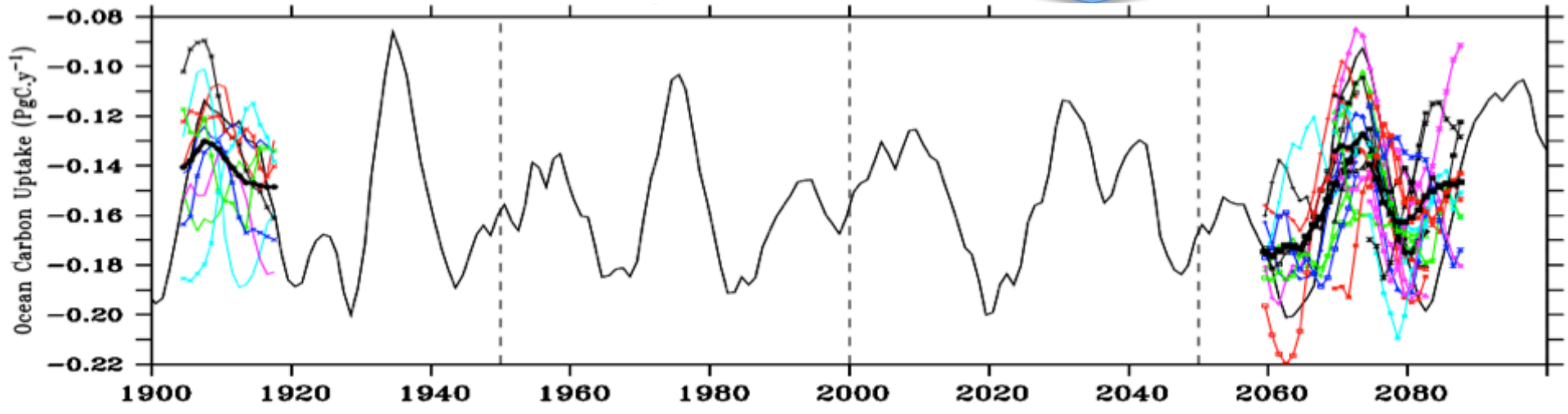


Potential predictability diagnostic (PPVF, Boër et al., 2004)

Perfect Model Approach

Understanding the mechanisms of the decadal predictatibility/variability

Practical predictability diagnostic (e.g., Msadek et al., 2010)

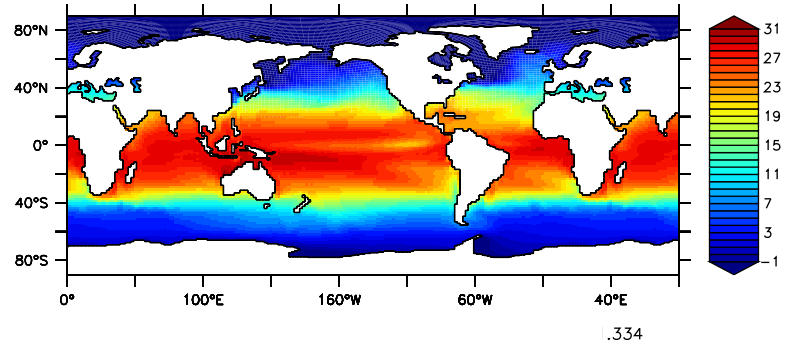


SST

SSS

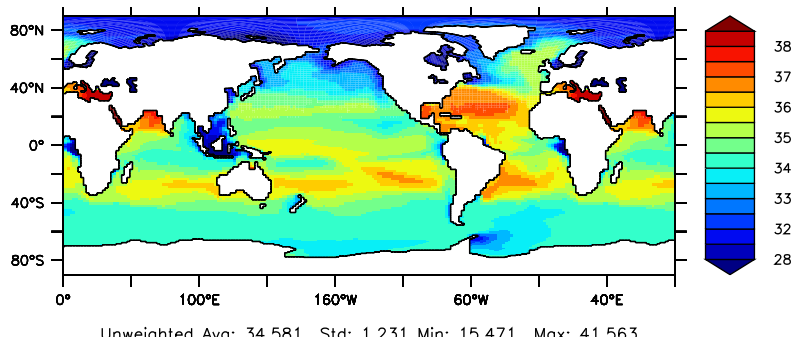
September

IPSLCM5A



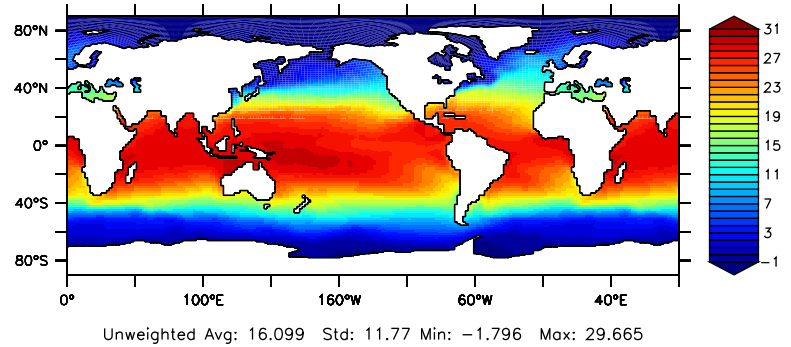
.334

IPSLCM5A



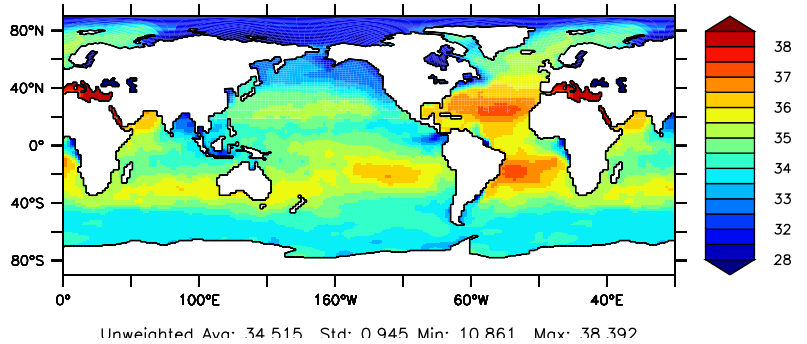
Unweighted Avg: 34.581 Std: 1.231 Min: 15.471 Max: 41.563

HadISST



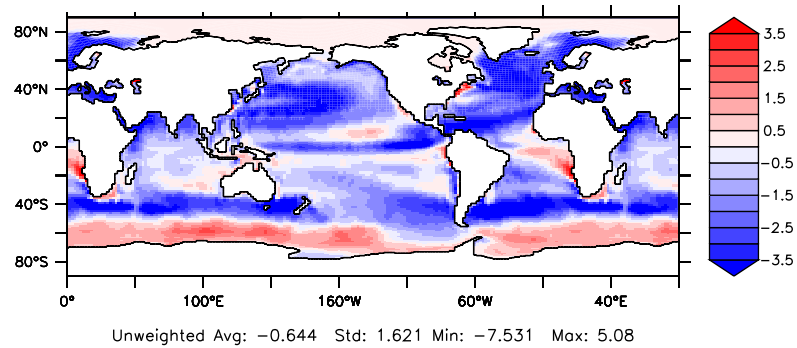
Unweighted Avg: 16.099 Std: 11.77 Min: −1.796 Max: 29.665

Levitus



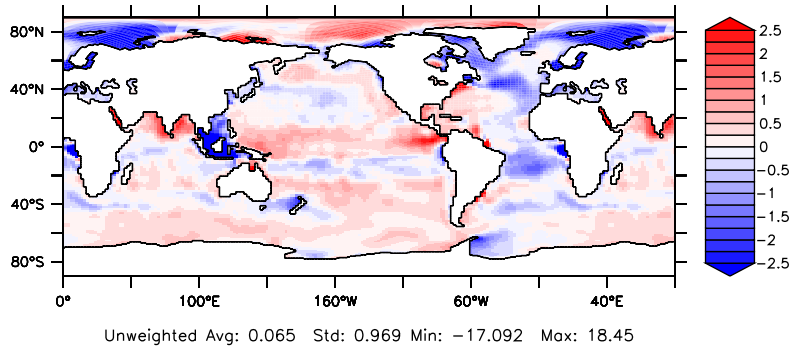
Unweighted Avg: 34.515 Std: 0.945 Min: 10.861 Max: 38.392

IPSLCM5A - HadISST



Unweighted Avg: −0.644 Std: 1.621 Min: −7.531 Max: 5.08

IPSLCM5A - Levitus



Unweighted Avg: 0.065 Std: 0.969 Min: −17.092 Max: 18.45

AMOC maximum in IPSLCM5A control simulations