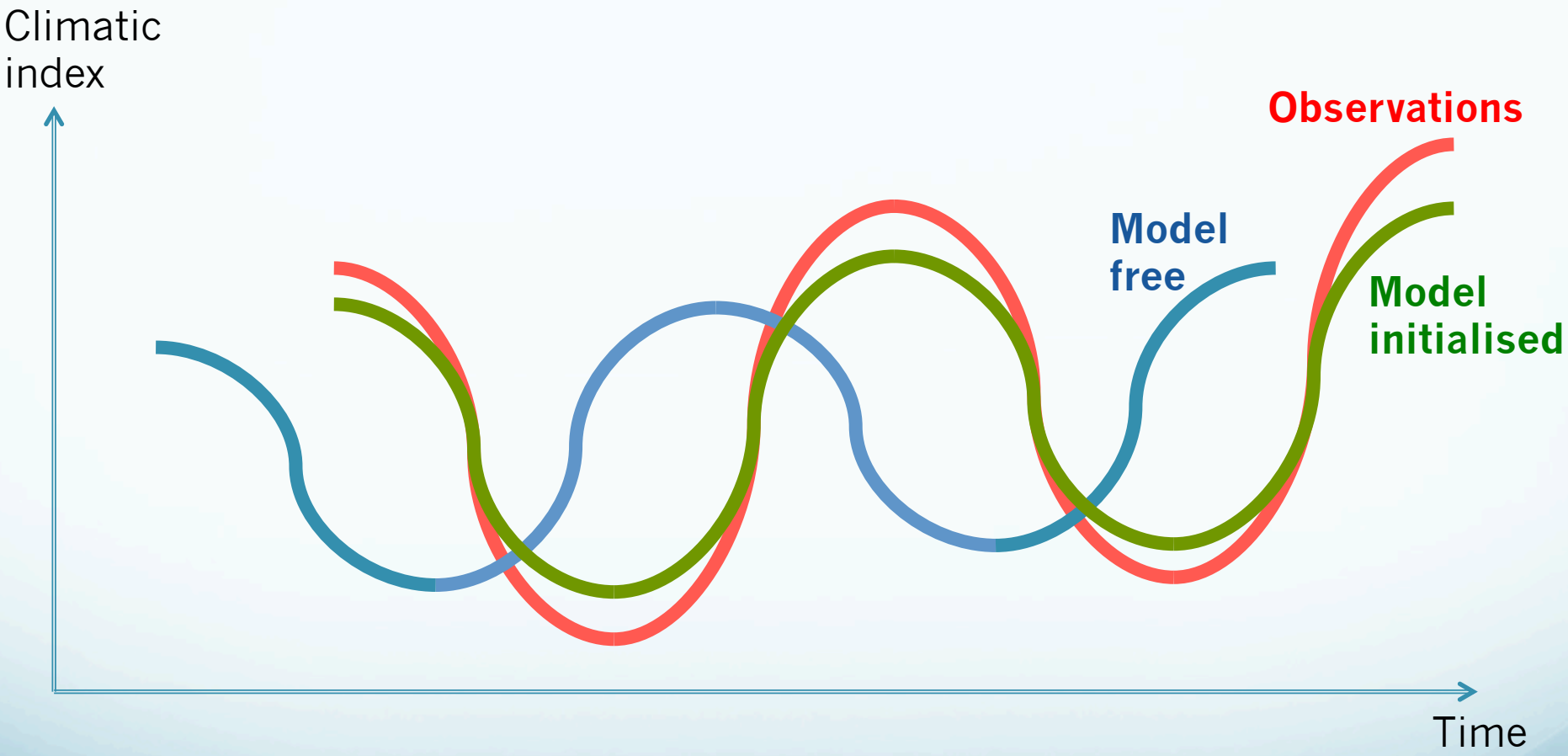
Initialisation of the AMOC in the IPSL-CM5 model over the last 60 years

Didier Swingedouw, Juliette Mignot, Sonia Labetoule, Eric Guilyardi

What do we expect from initialisation?



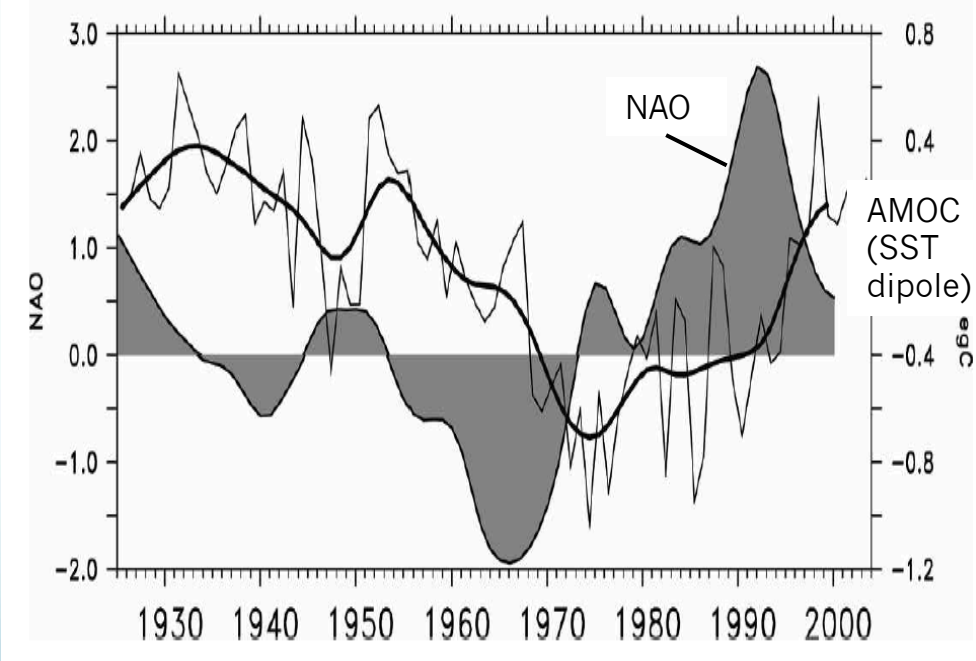
Assumptions:

1. **Climatic oscillations correctly represented in model (frequency, amplitude)?**
2. **There exist ways to phase the two signals using coupled models?**

AMOC in recent years

- Latif et al. 2006: NAO forces the AMOC through heat flux in the Labrador Sea
- Keenlyside et al. 2008: initialisation through SST anomalies allow to capture this mechanism
- Other mechanisms in the North Atlantic? Salinity?

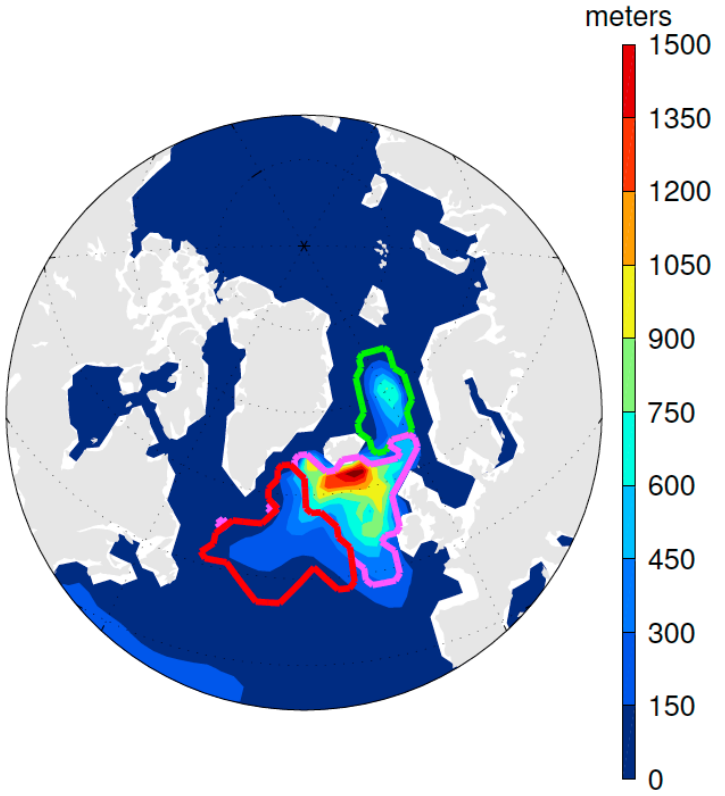
NAO and AMOC indexes
(Latif et al. 2006)



Tool: IPSL-CM5 coupled model

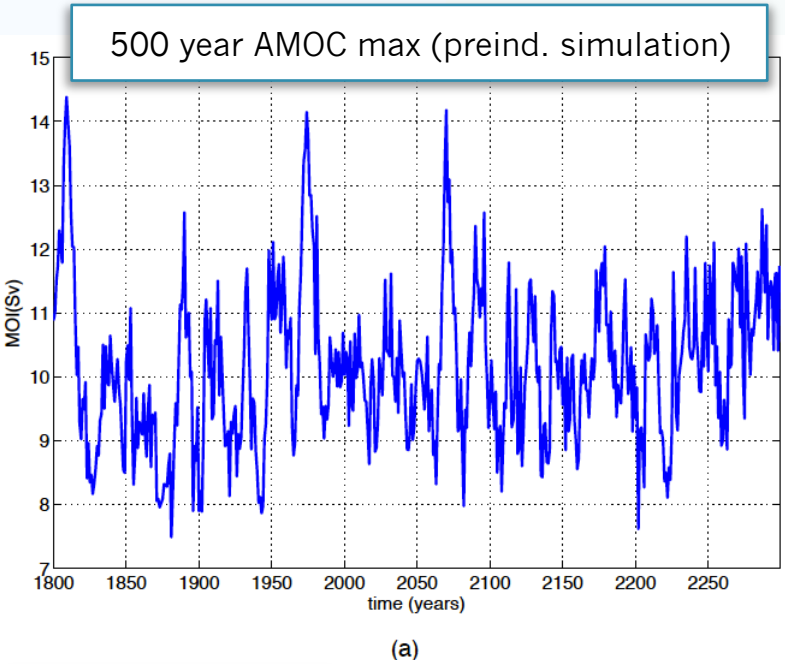
- Low resolution version of the model
  - Ocean: NEMO-ORCA2 (149x182xL31)
  - Atmosphere: LMDz (96x96xL39)
  - Sea ice: Lim2
  - Biogeochemistry in the ocean: PISCES
- Important biases to be kept in mind
  - Only 10 Sv of AMOC
  - Almost no convection in the Labrador Sea

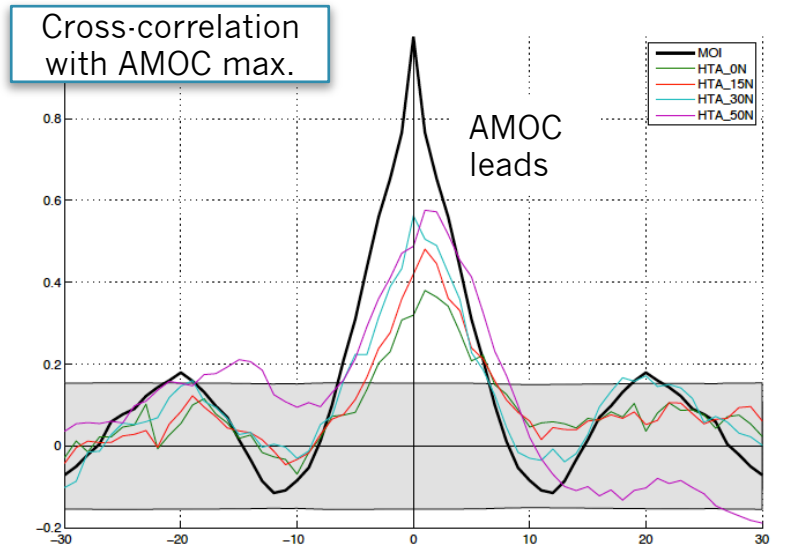
Mixed layer depth in JFM



Decadal variability in the IPSL-CM5 model

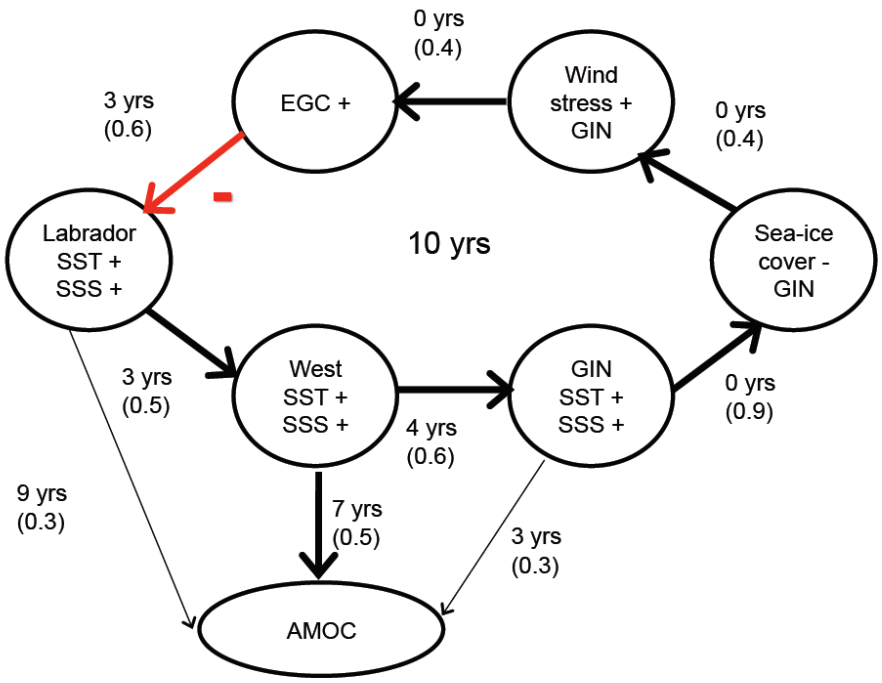
- 20-year cycle for the AMOC
- Impact on the ocean heat transport at different latitudes in the Atlantic Ocean

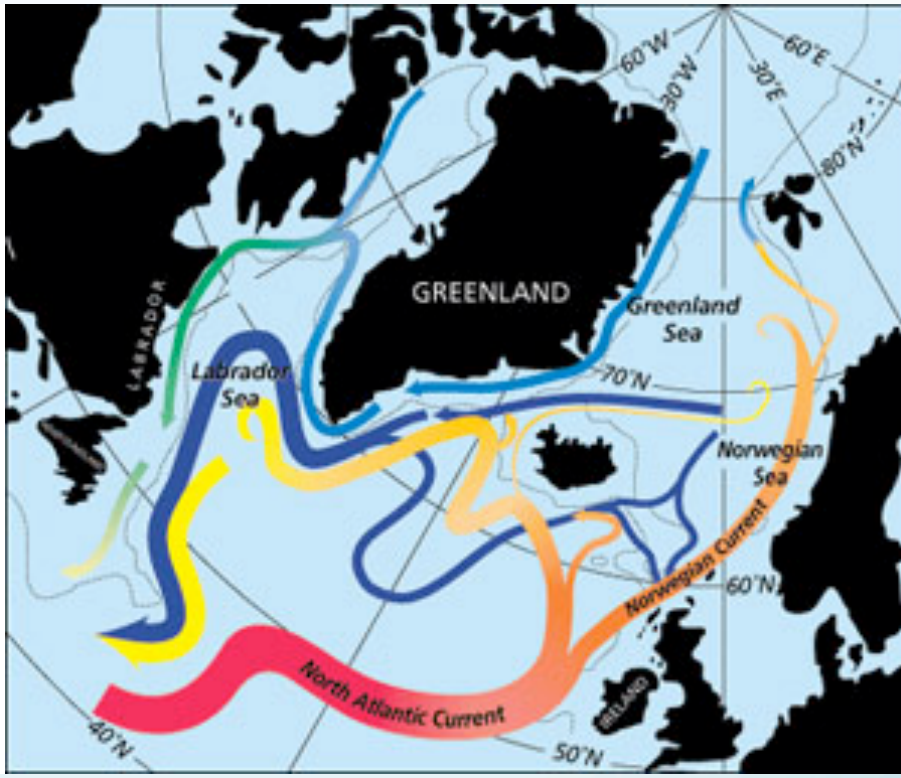




Escudier et al. in prep.

20-yr cycle mechanisms





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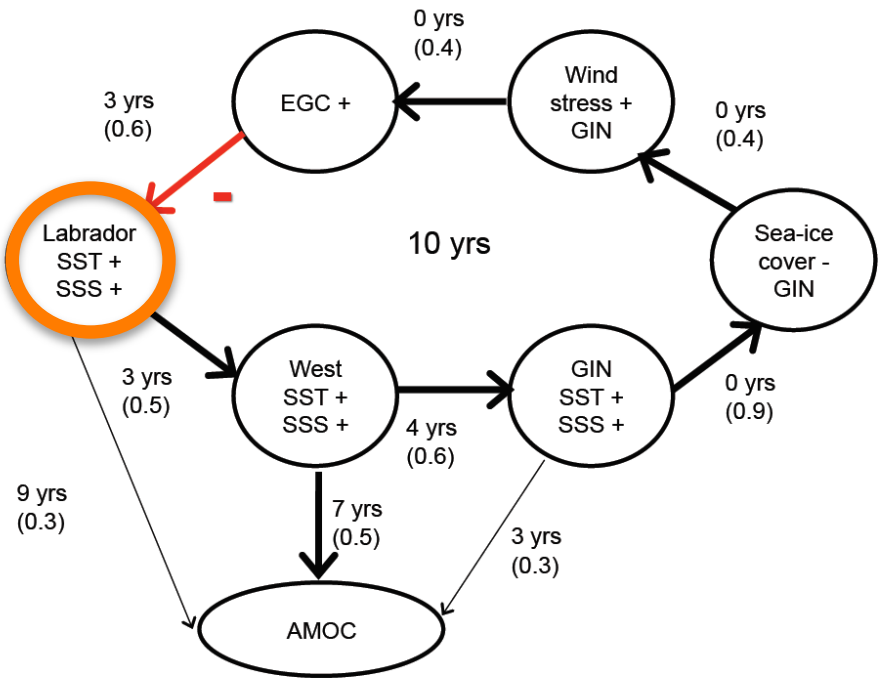
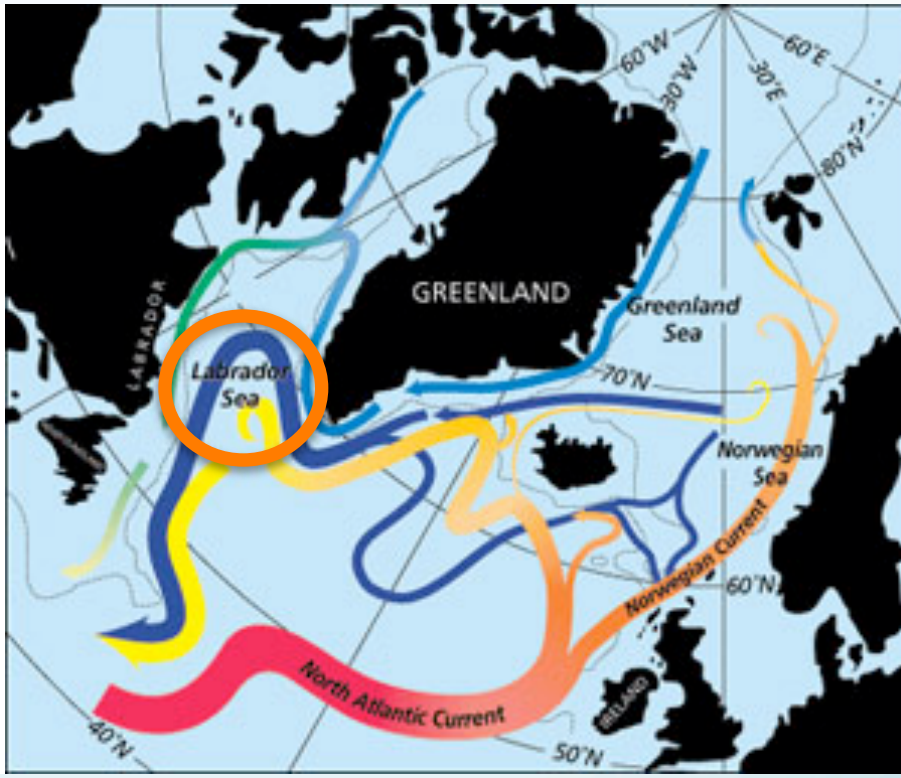
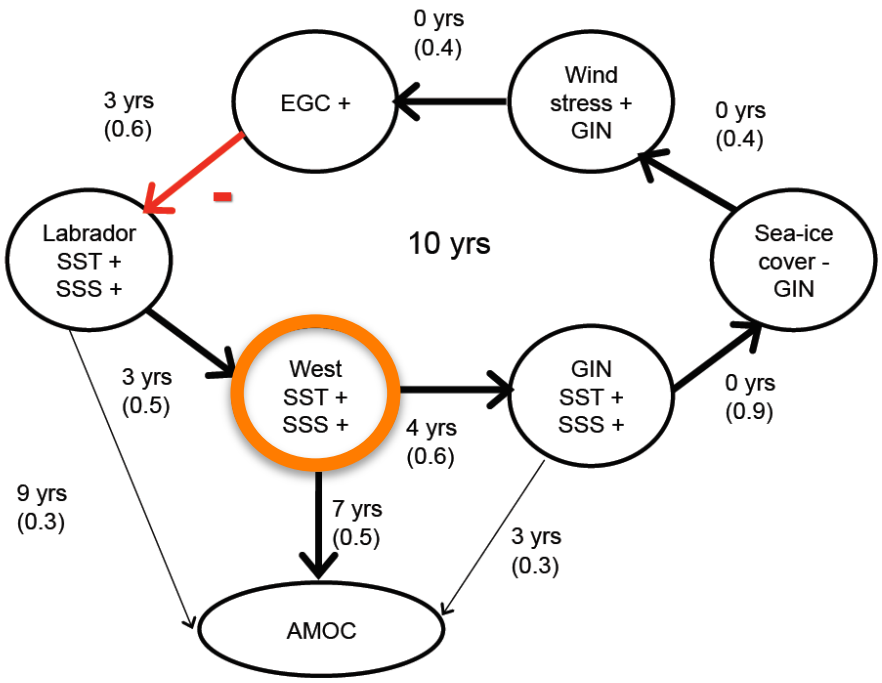
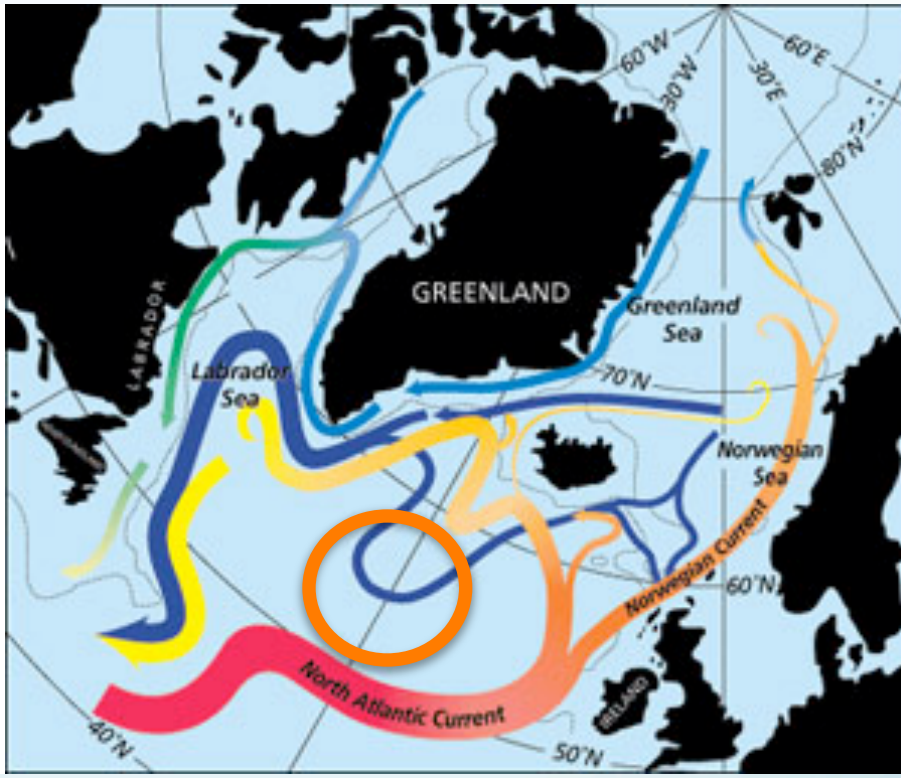




20-yr cycle mechanisms





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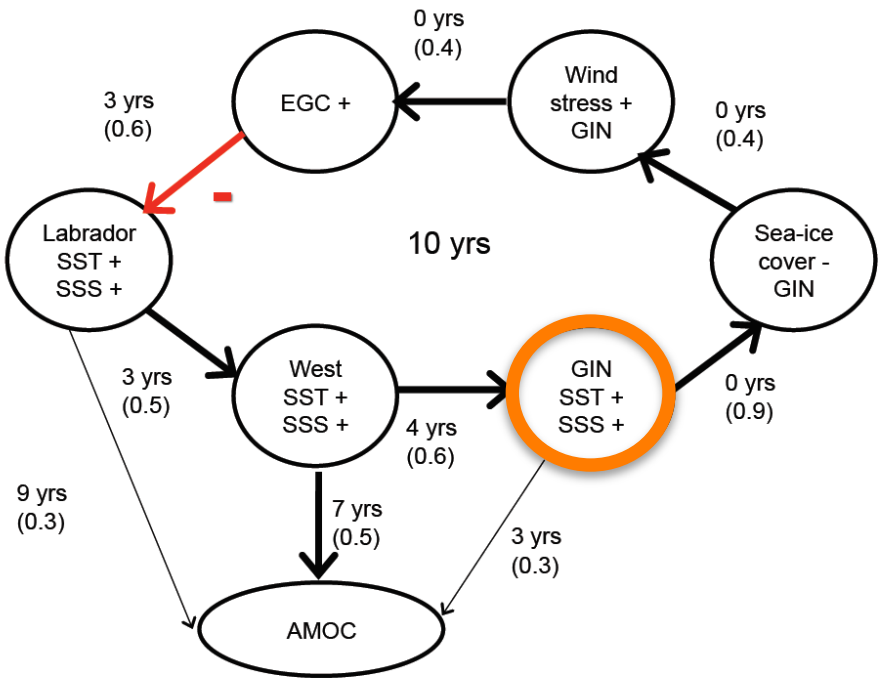
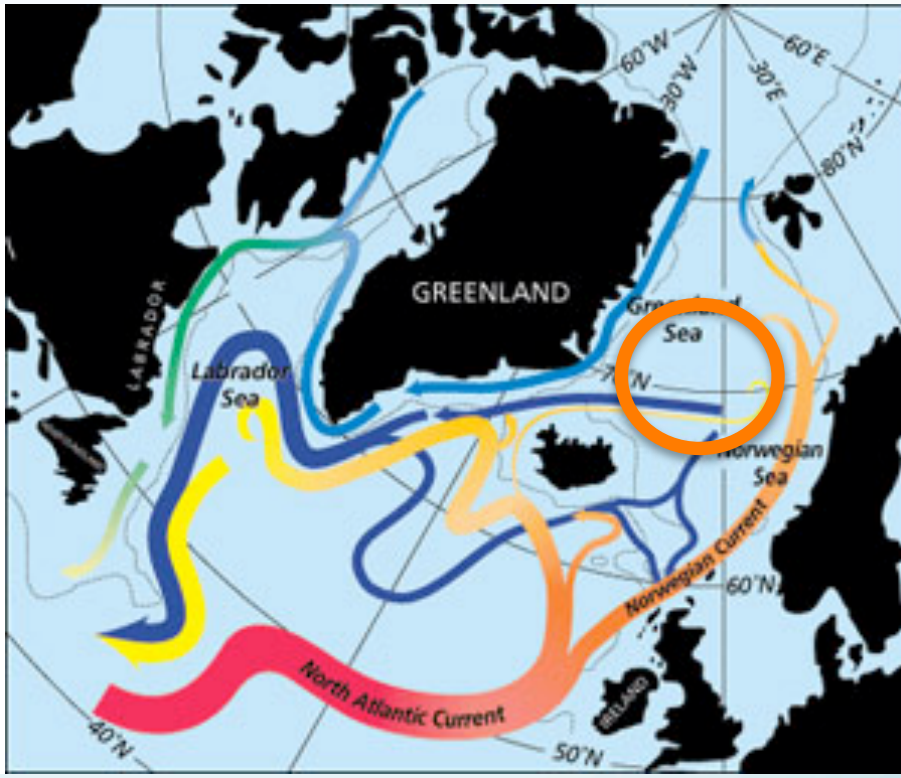
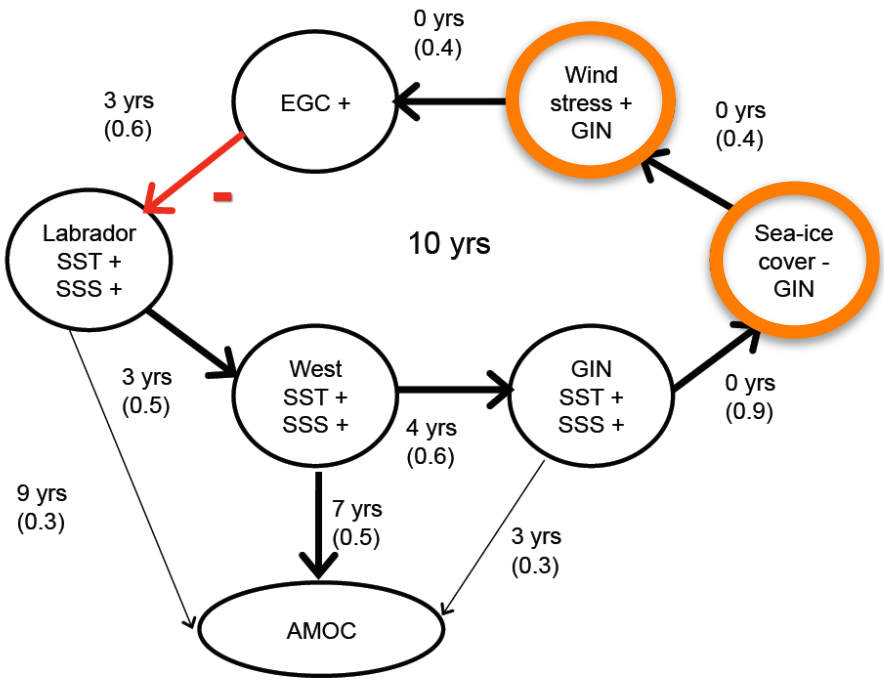
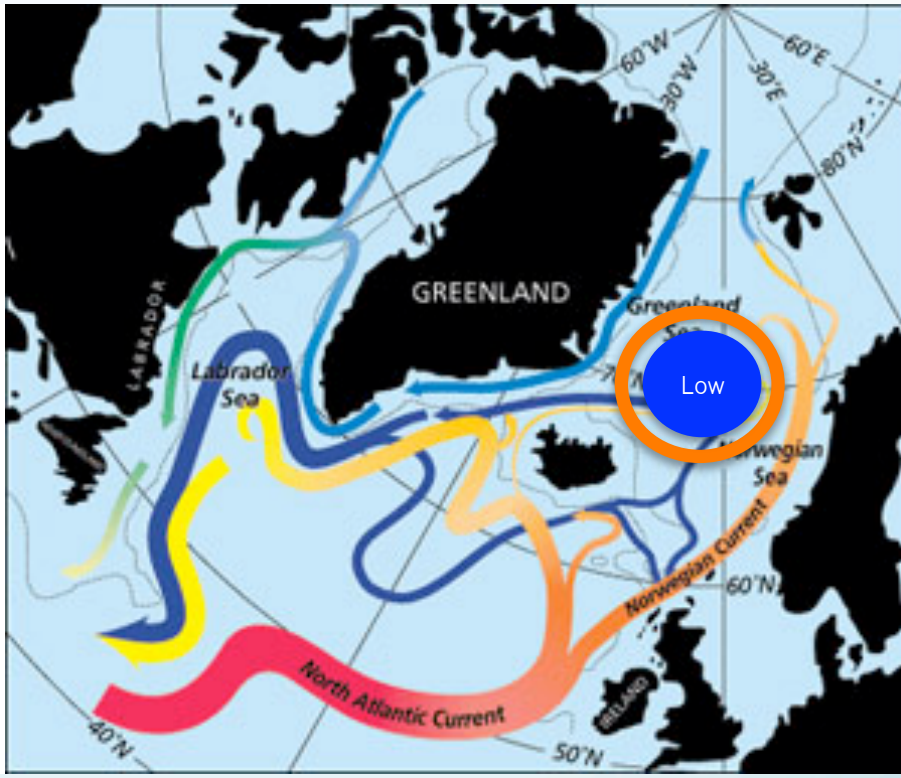


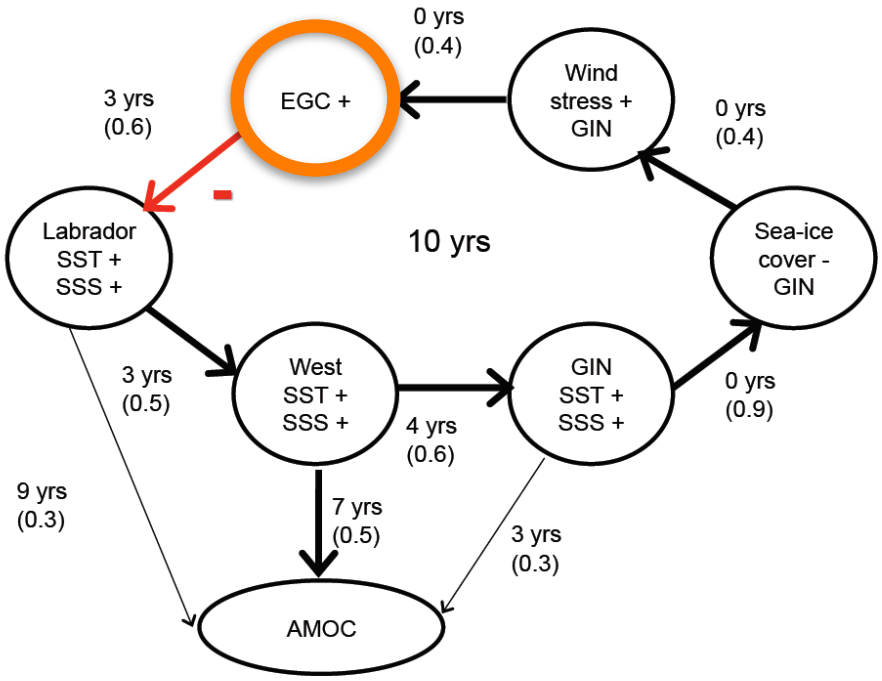


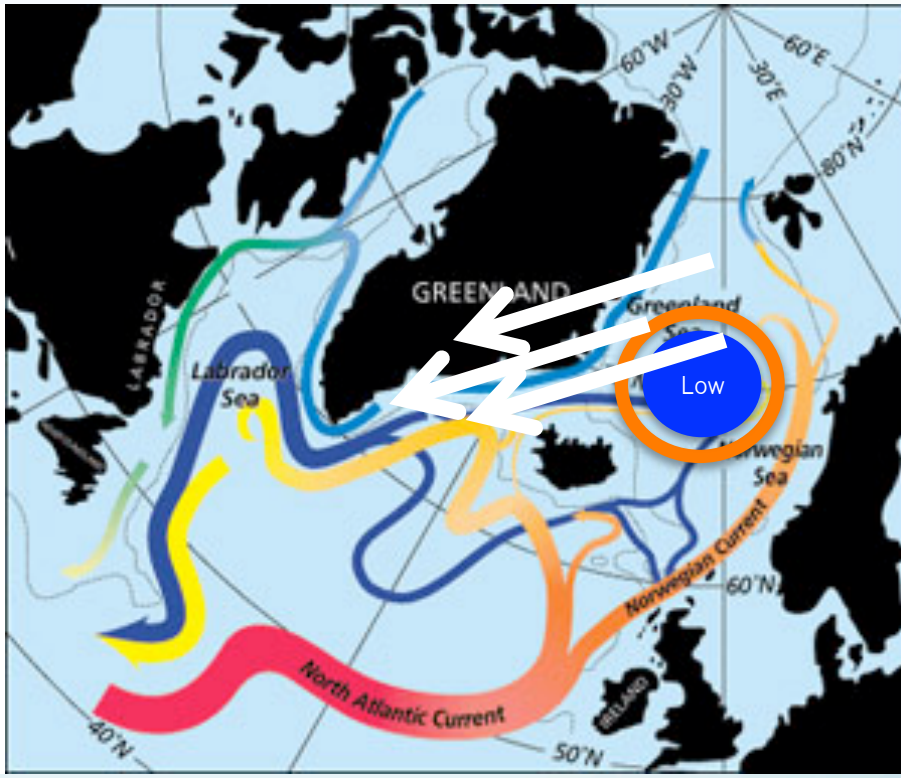
20-yr cycle mechanisms



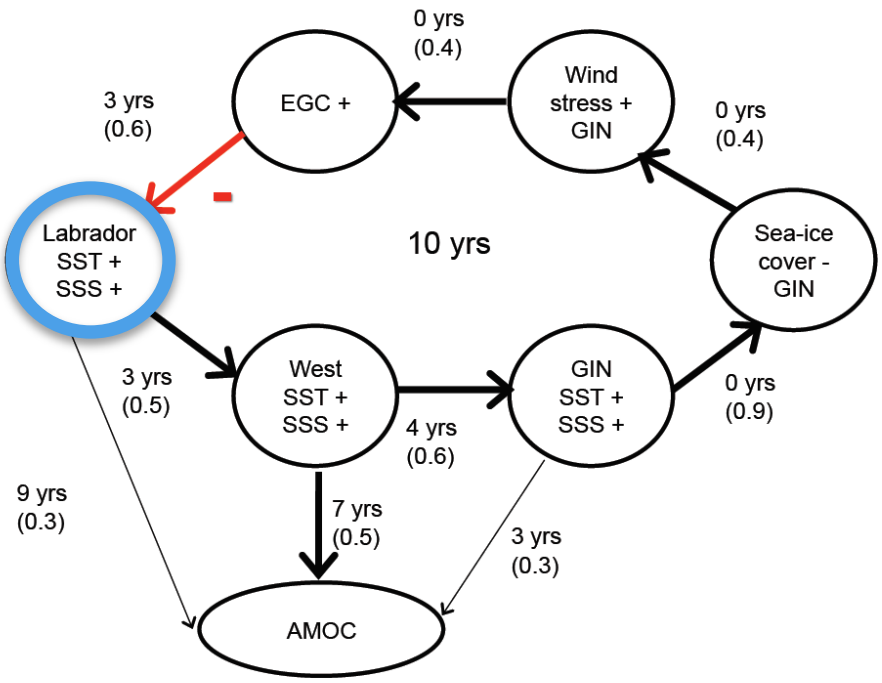


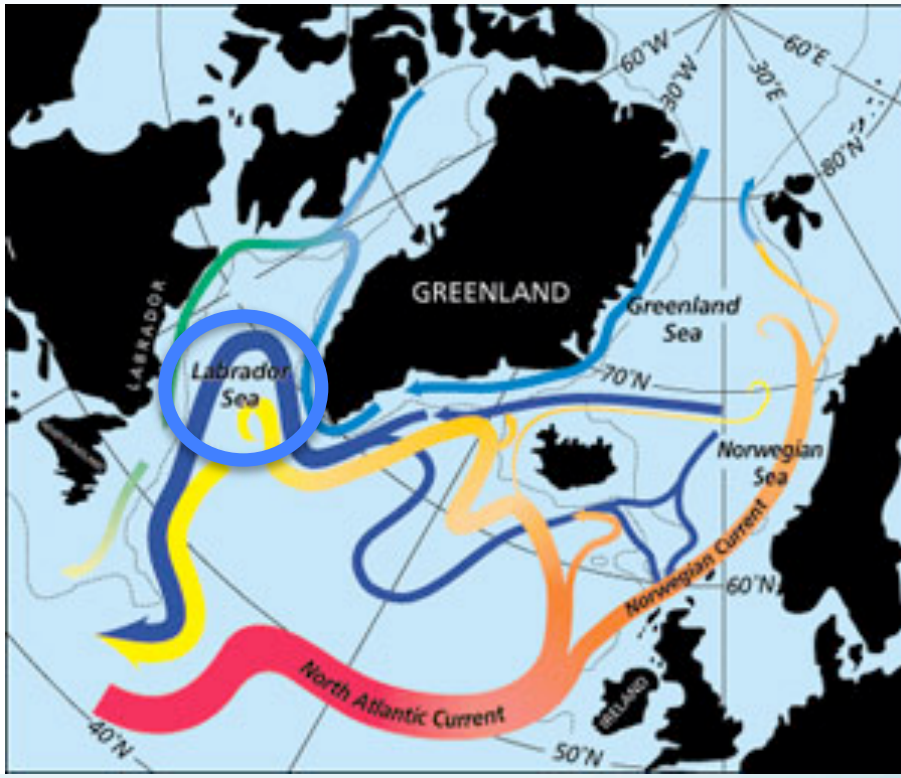
20-yr cycle mechanisms



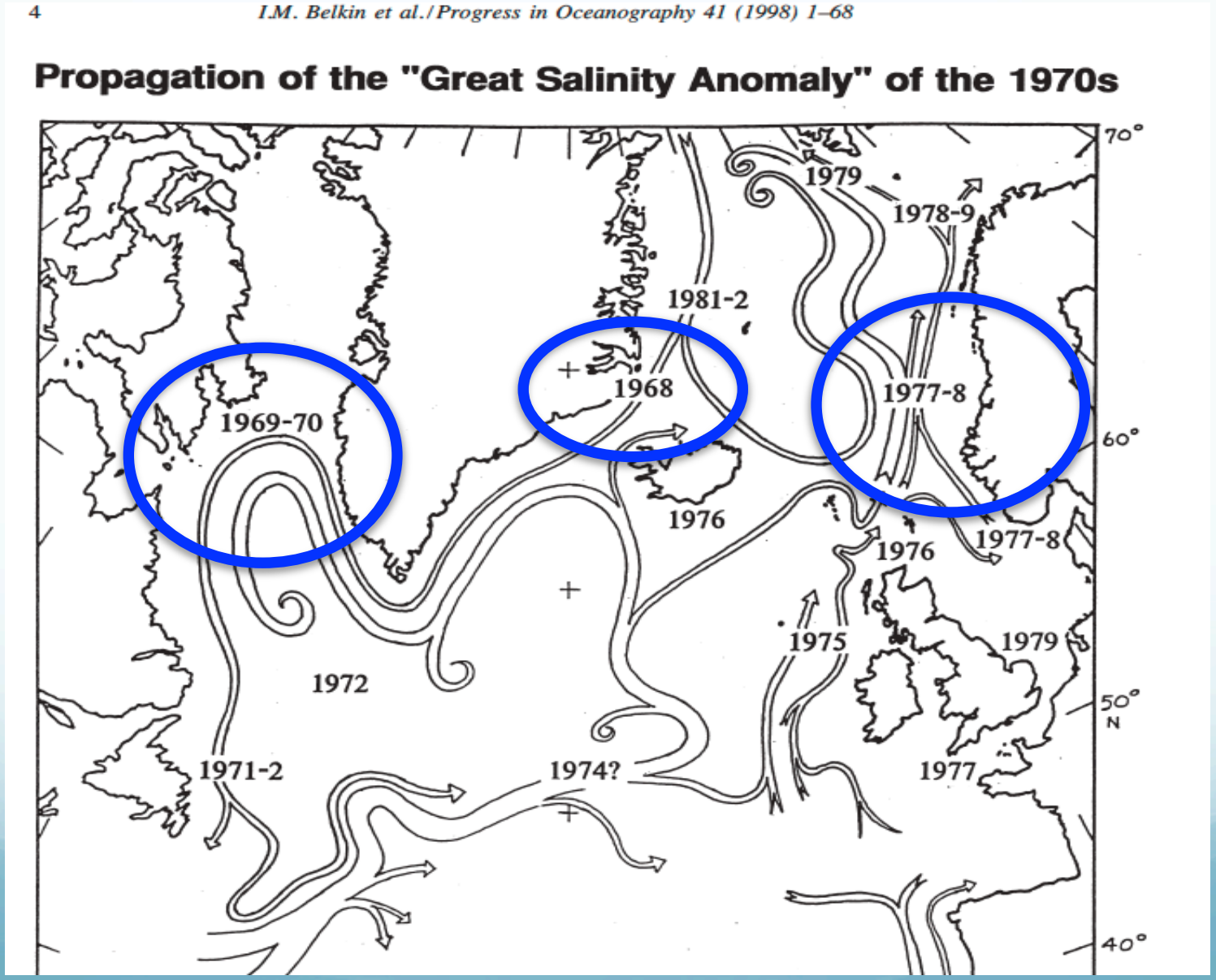


20-yr cycle mechanisms



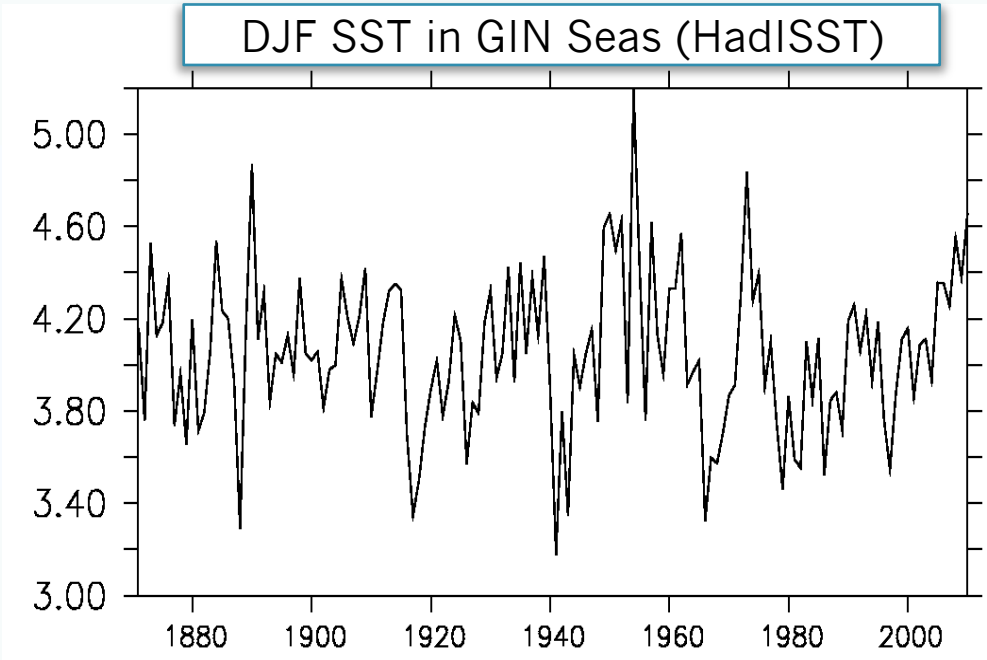


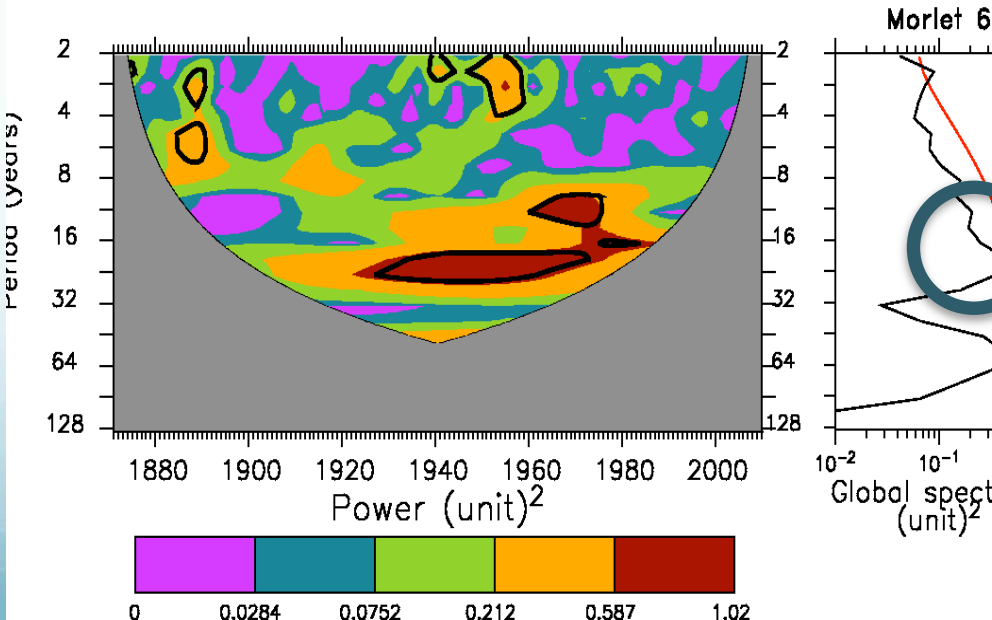
Agreement with GSAs anomalies?



A 20-yr cycle in the subpolar gyre?

- Very few data on this time scale (for AMOC, SSS)
- First clue: 20-yr variability in the GIN Seas in HadISST
- We assume that this cycle is not totally unrealisitic in the real ocean
- Step 2: can we phase observed and modeled AMOC?



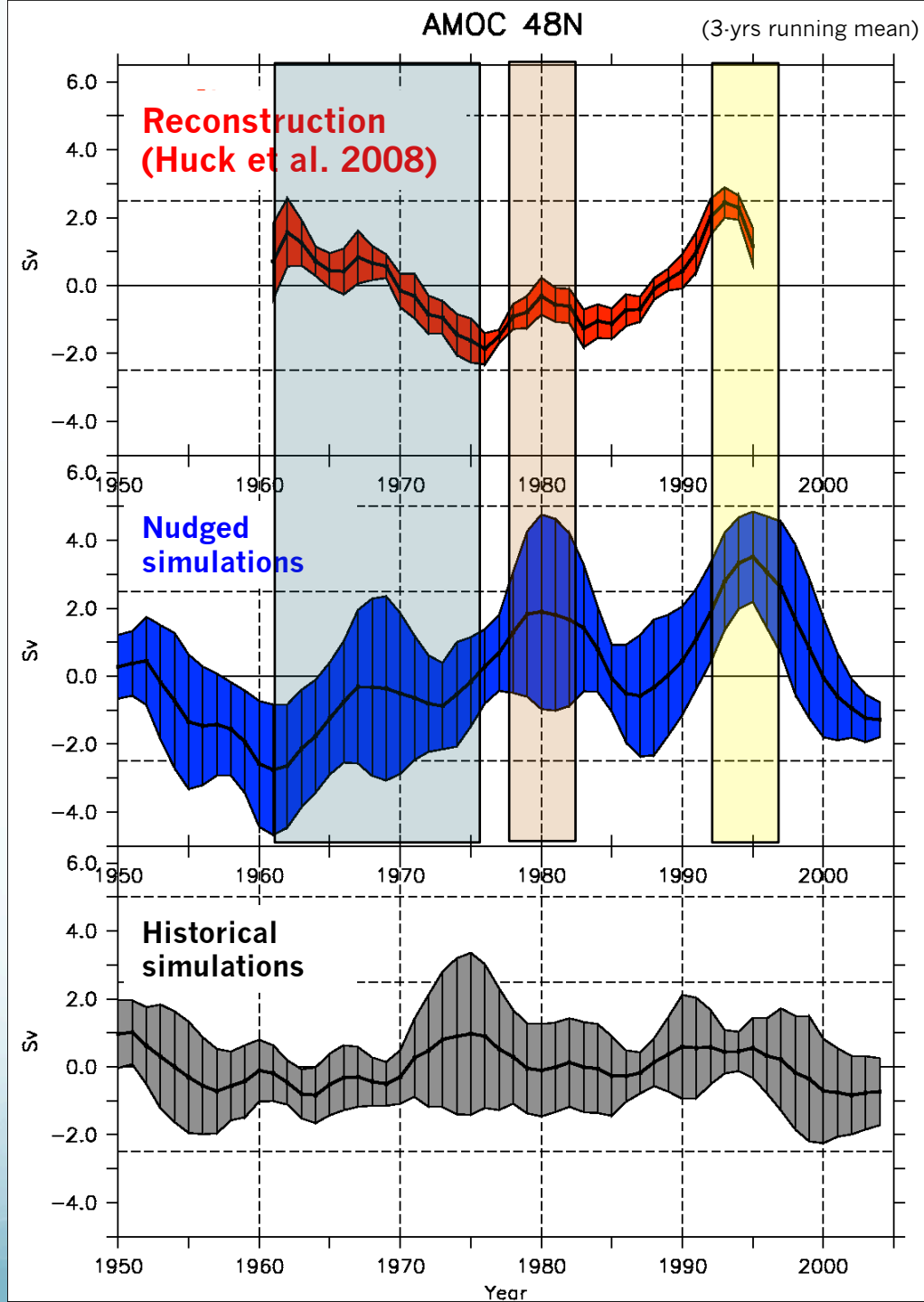


Experimental design

- We initialise the IPSL-CM5 with **SST anomalies** (Reynolds) superimposed on each historical simulation over the period **1949-2005:** 5-members ensemble (different initial conditions)
- With one of the initialised members, we launch a 3-members ensemble every 5 years (with white noise on SST)
- We include historical radiative forcing

AMOC Initialisation

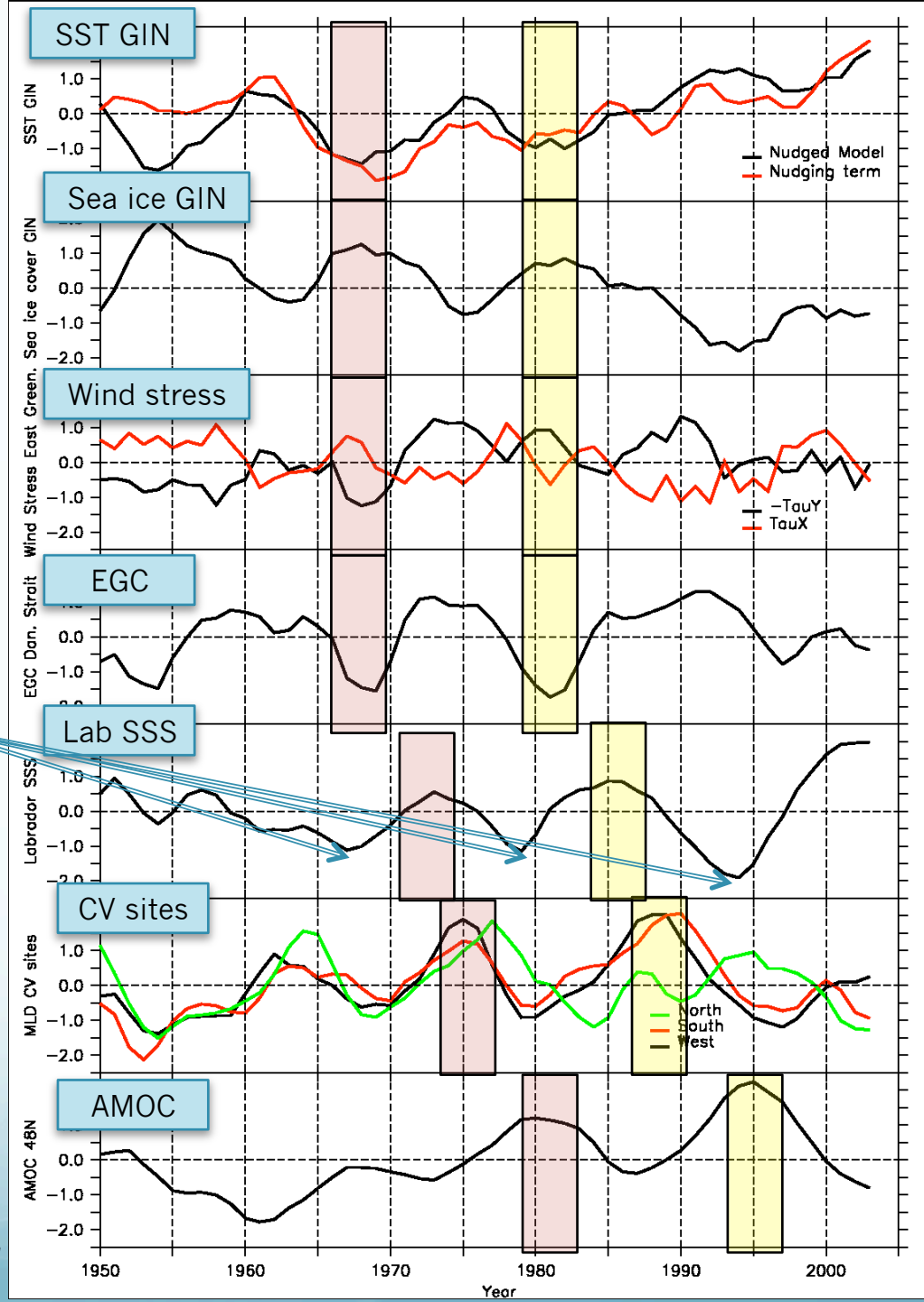
- Reconstruction of the AMOC using NODC hydrographic data (Huck et al. 2008)
- 5-members ensemble of nudged simulations and control-historical ones
- 5-members historical simulations as control
- Agreement apart from 1980



Mechanisms

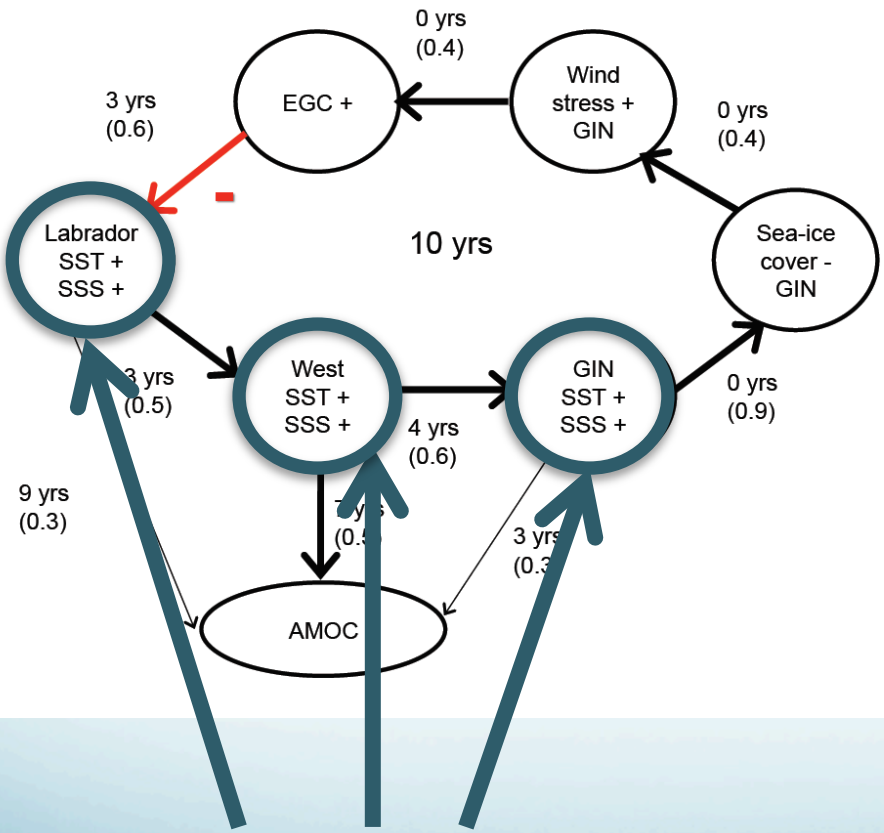
- ⇒ GIN seas SST
- ⇒ GIN seas ice cover
- ⇒ Wind stress
- ⇒ EGC
- ⇒ SSS Labrador Sea
- ⇒ CV sites
- ⇒ AMOC

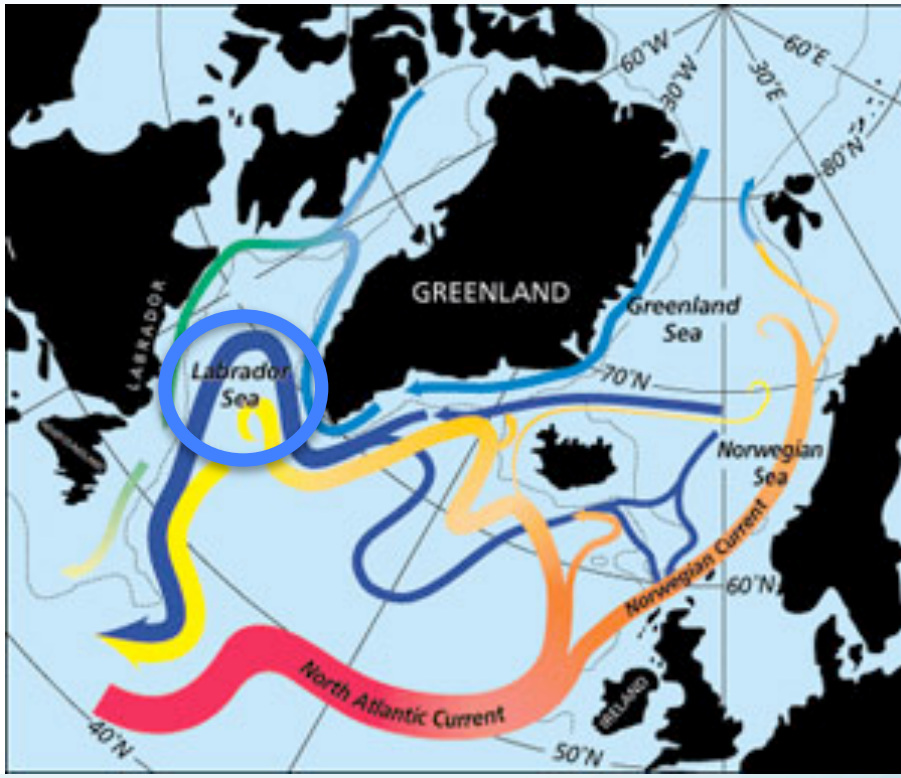
GSAs!
(1970, 82, 90 Sundby & Drinkwater 2007)



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

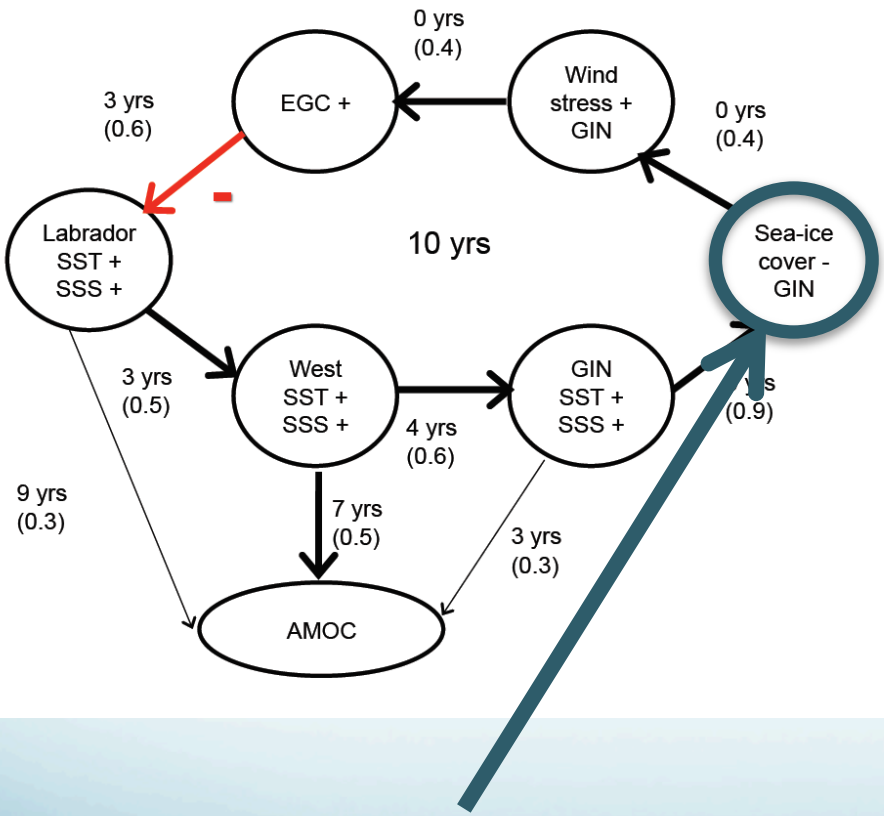
20-yr cycle for the AMOC

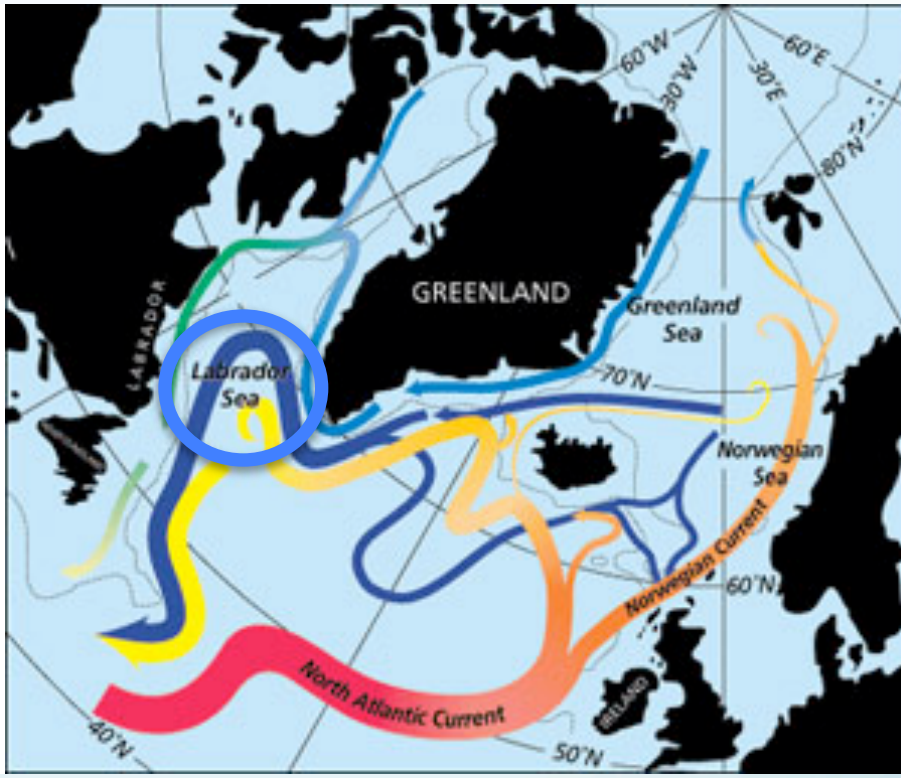




Nudging in SST

20-yr cycle for the AMOC

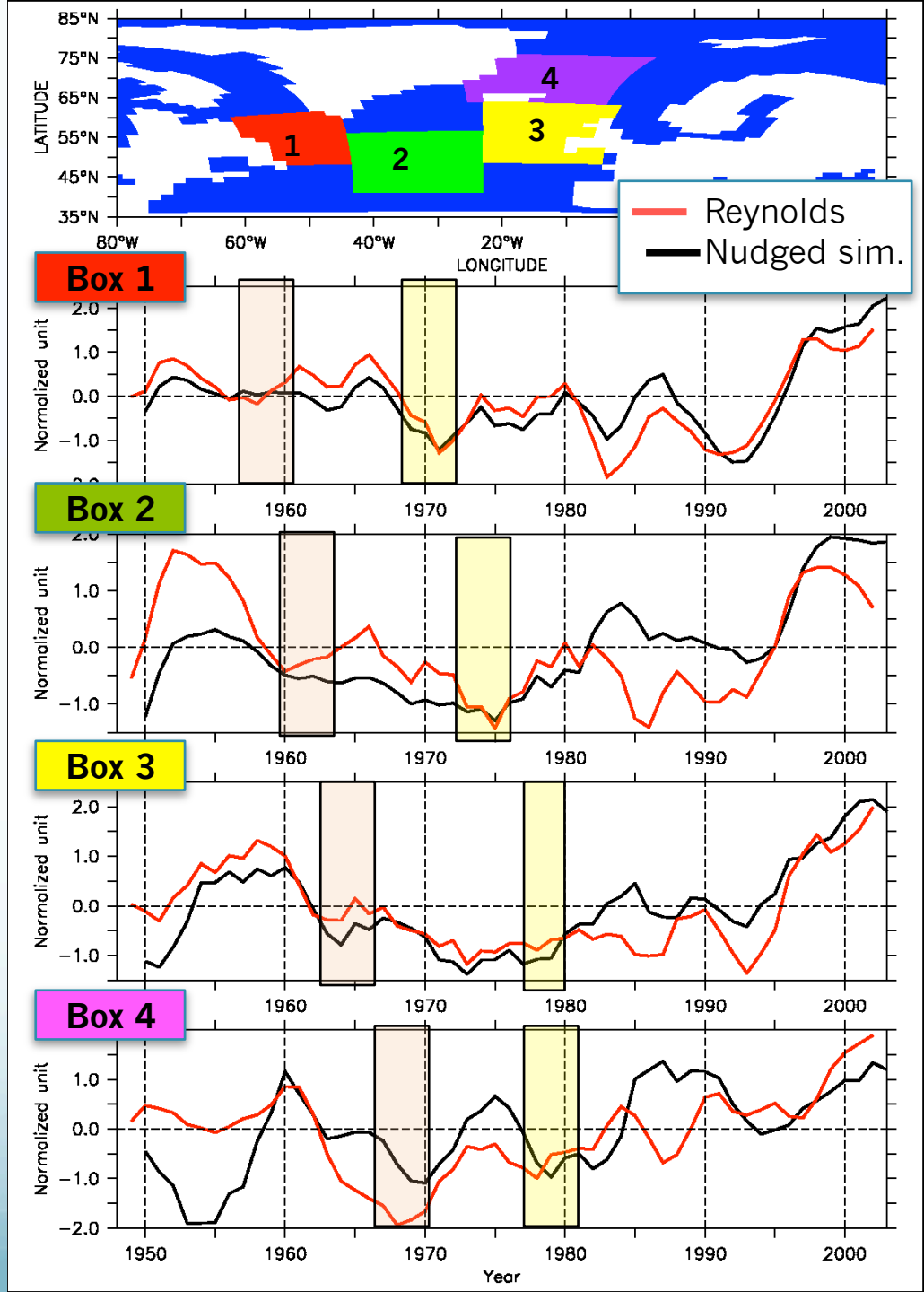




Nudging in SST

Propagation of SST anomalies

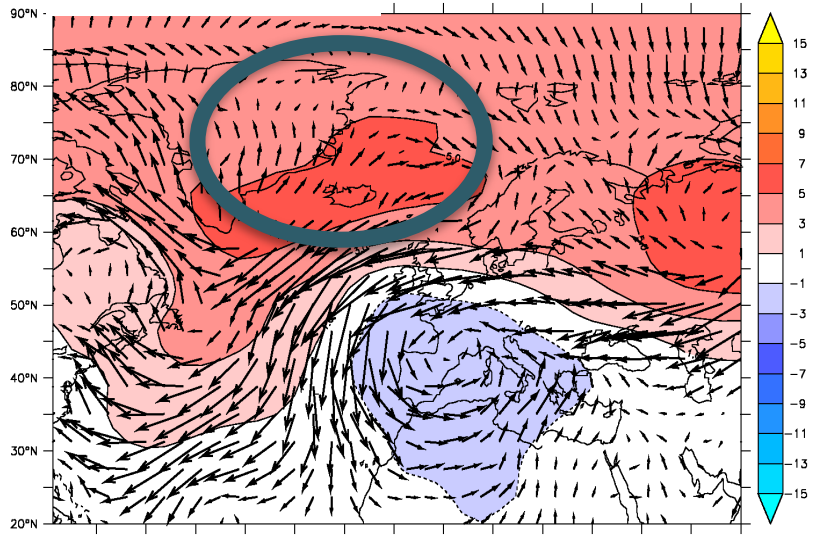
- ⇒ We follow the mininimum of SST along the gyre
- ⇒ 8 years between Labrador and GIN
- ⇒ True in the model (known)
- ⇒ And in the Reynolds data!



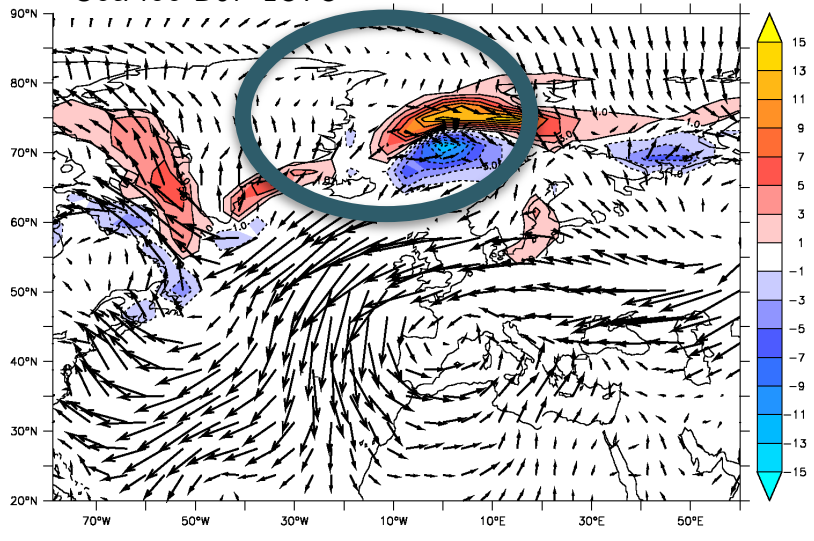
Air-sea ice interactions in 1979-80

Nudged simulations

SLP DJF 1979

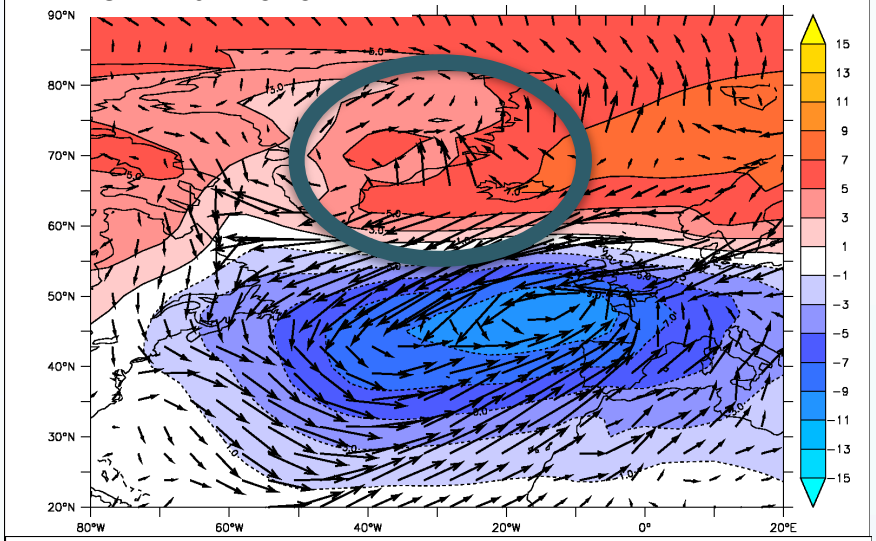


Sea ice DJF 1979

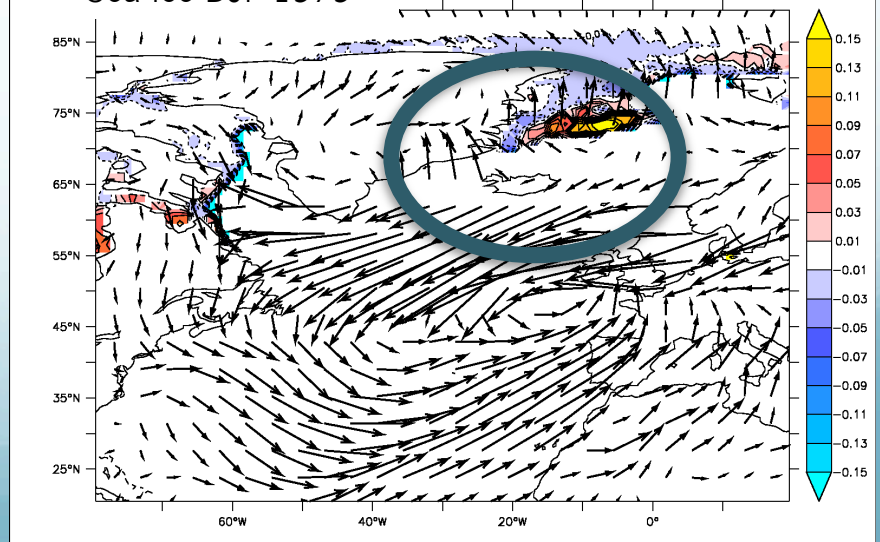


NCEP

SLP DJF 1979

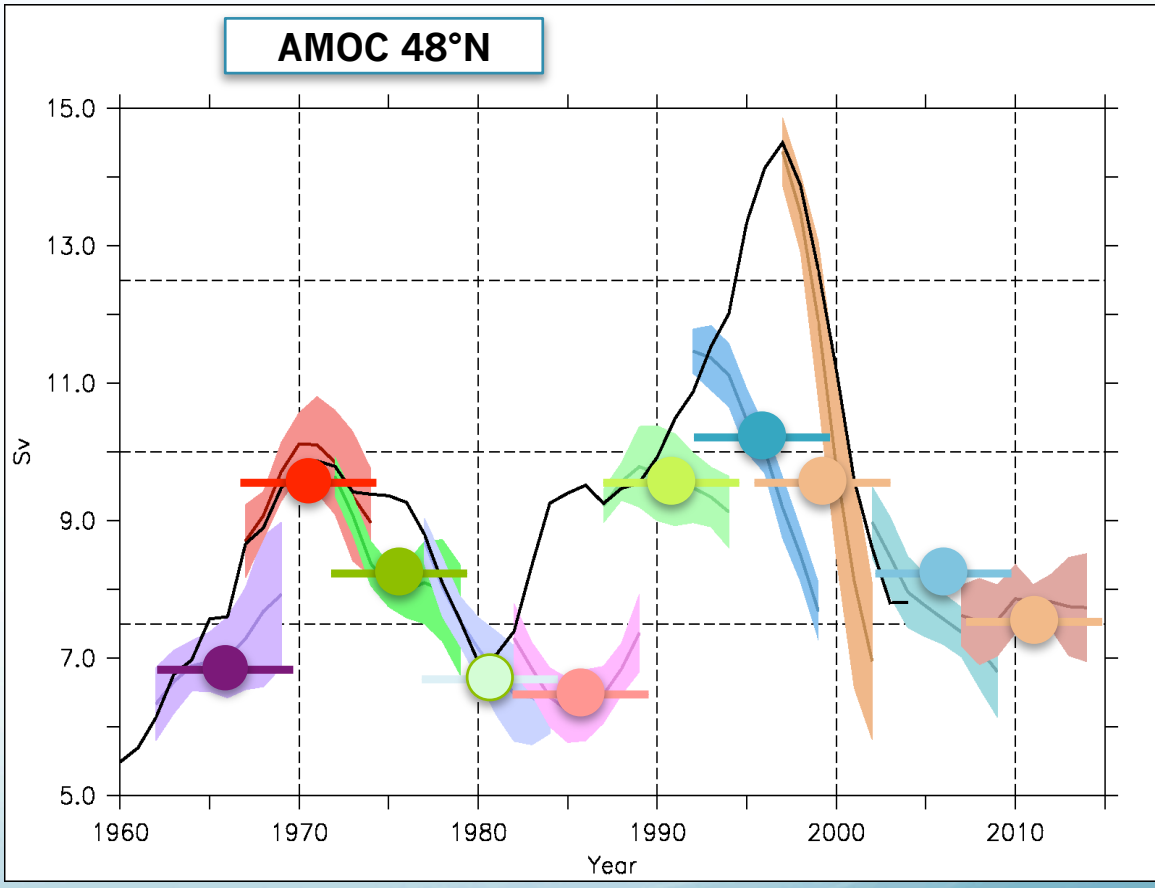


Sea ice DJF 1979



Hindcasts

- Only one member of the nudged ensemble (planned to apply to each)
- 3-members ensemble of free run
- Good predictive skill for the AMOC in perfect model analysis (Persechino et al., in prep.)
- 90's max. missed



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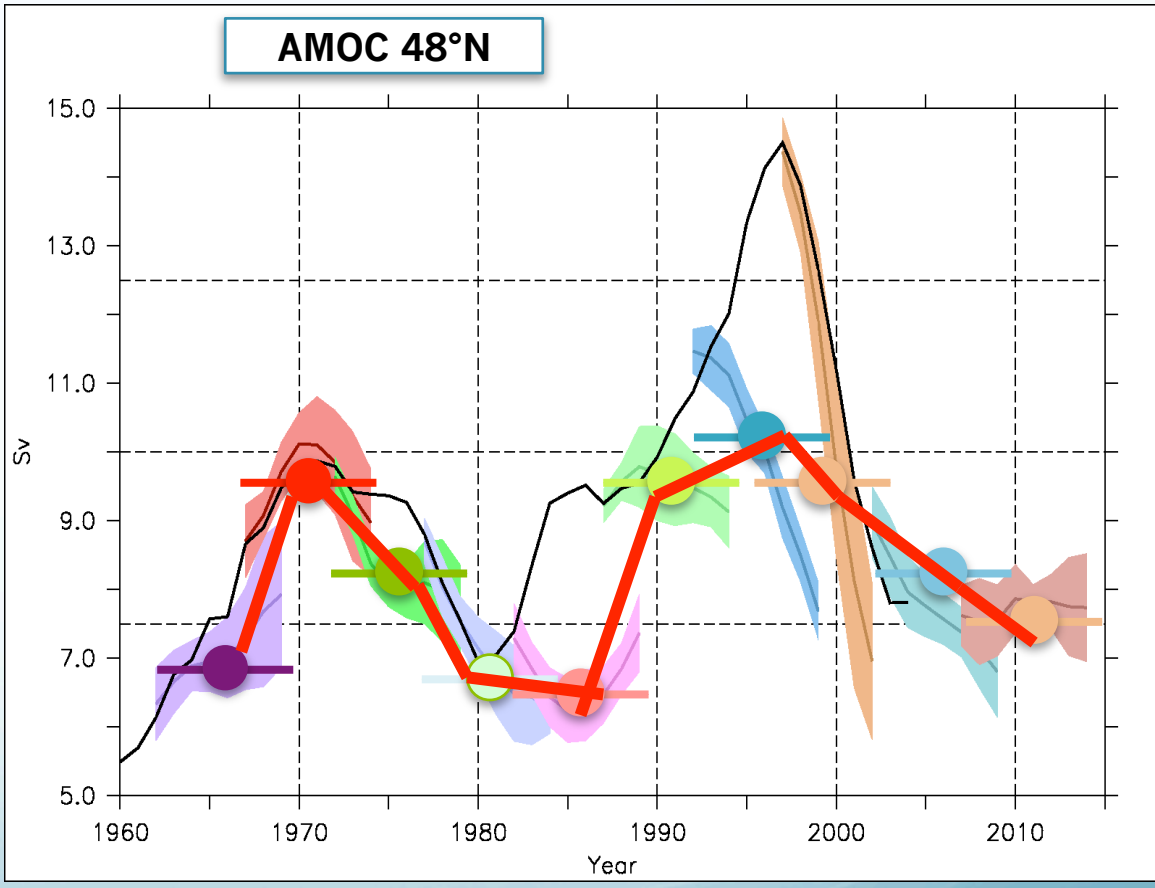
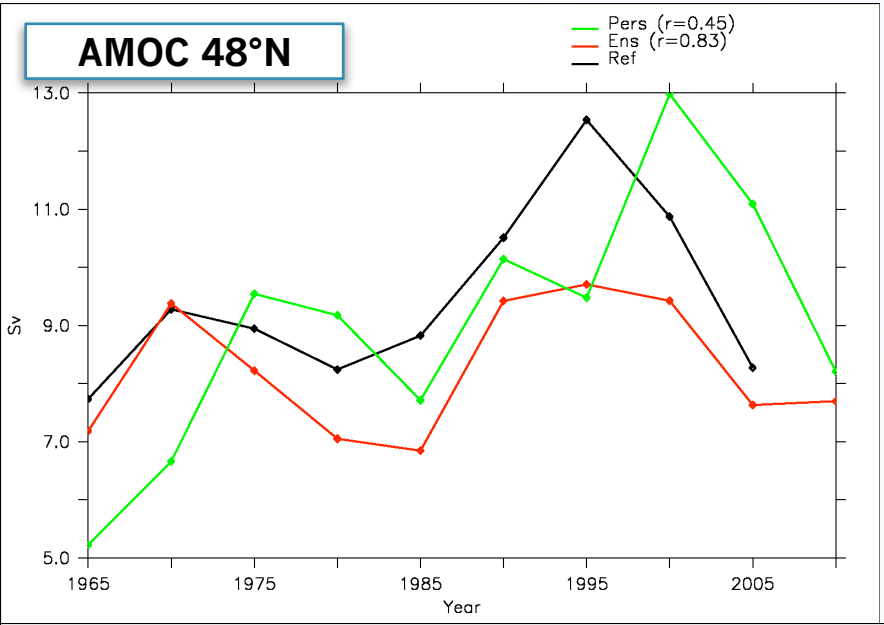
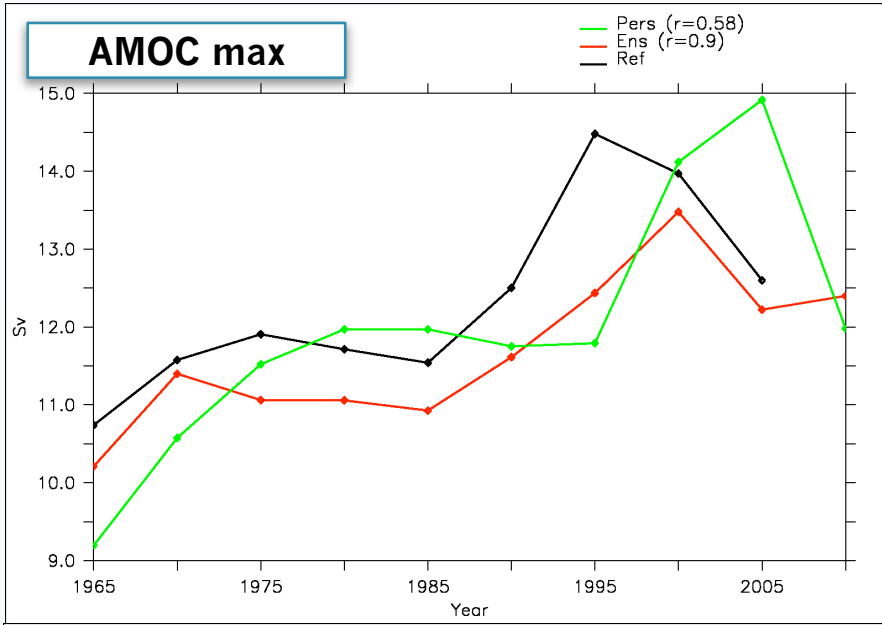
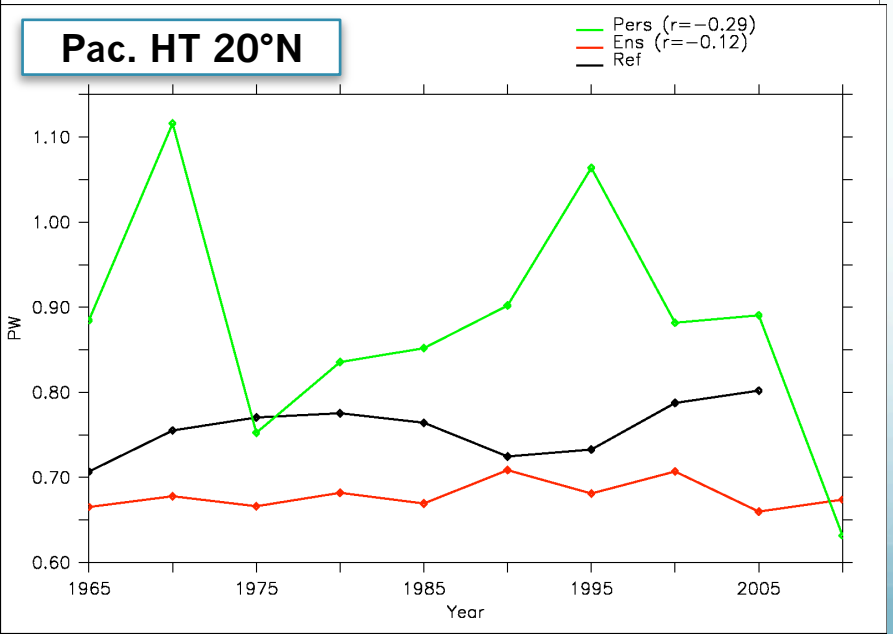
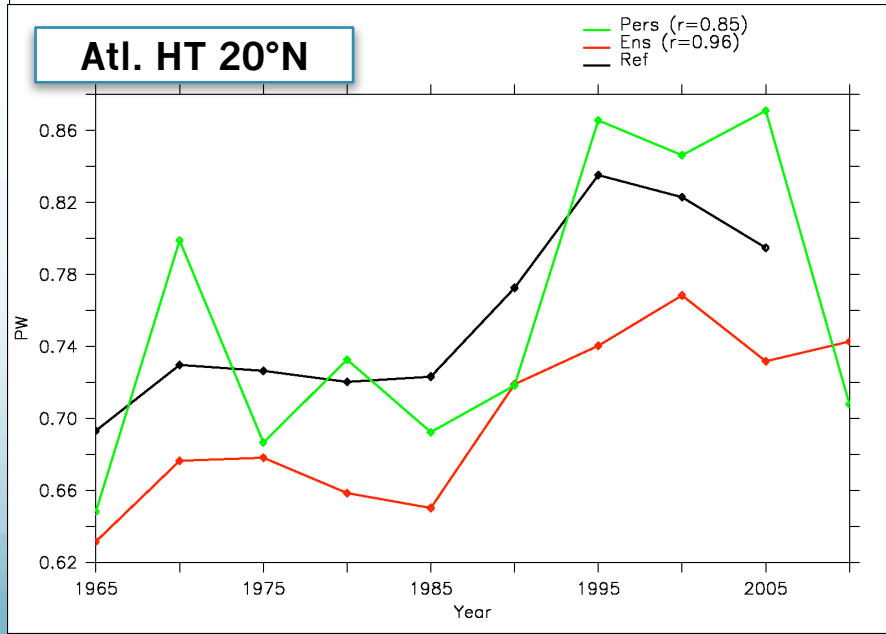


Hindcasts

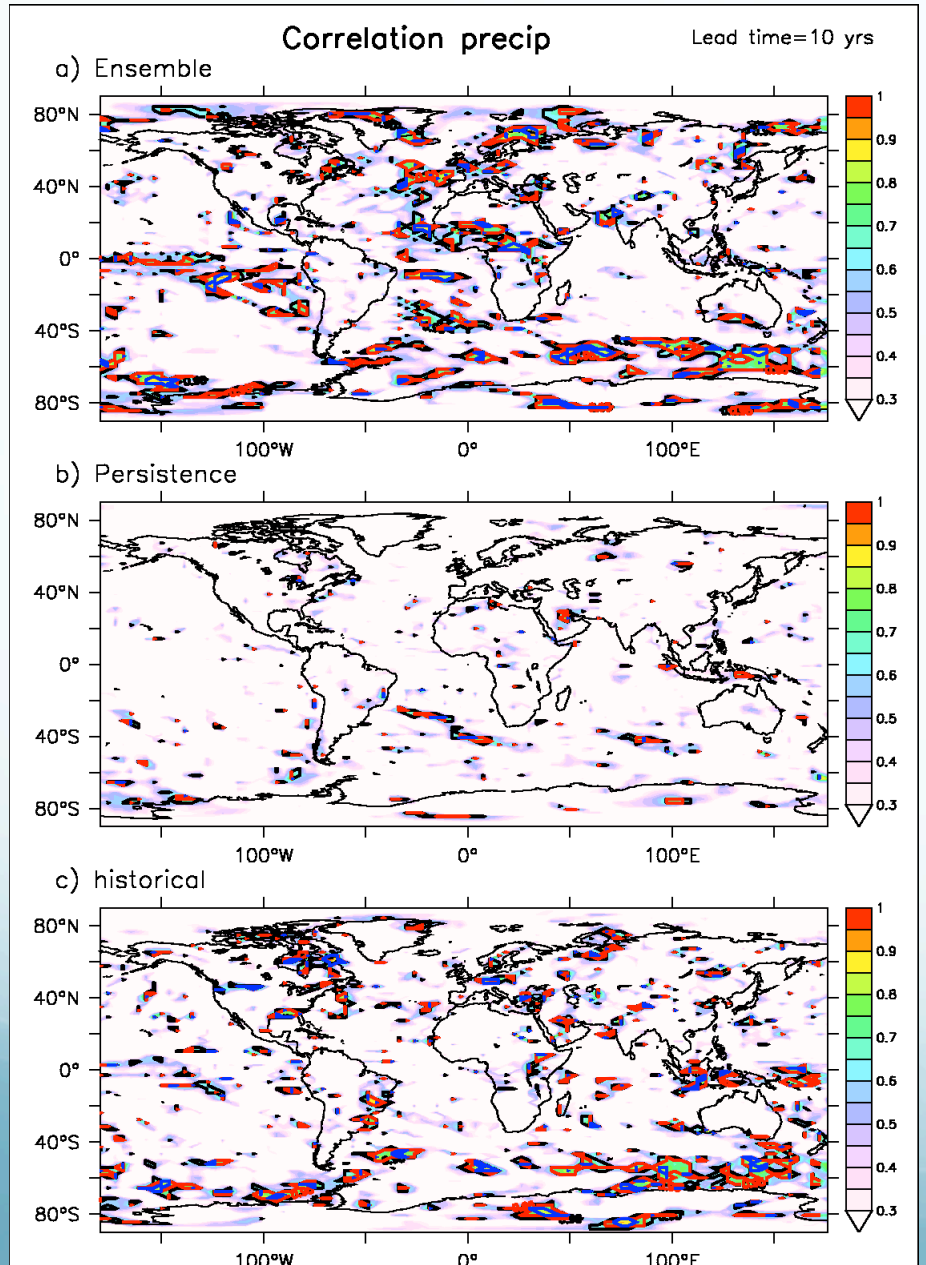

AMOC 48°N
Pers (r=0.45)
Ens (r=0.83)
Ref
13.0
11.0
9.0
7.0
5.0
Sv
1965
1975
1985
1995
2005
Year

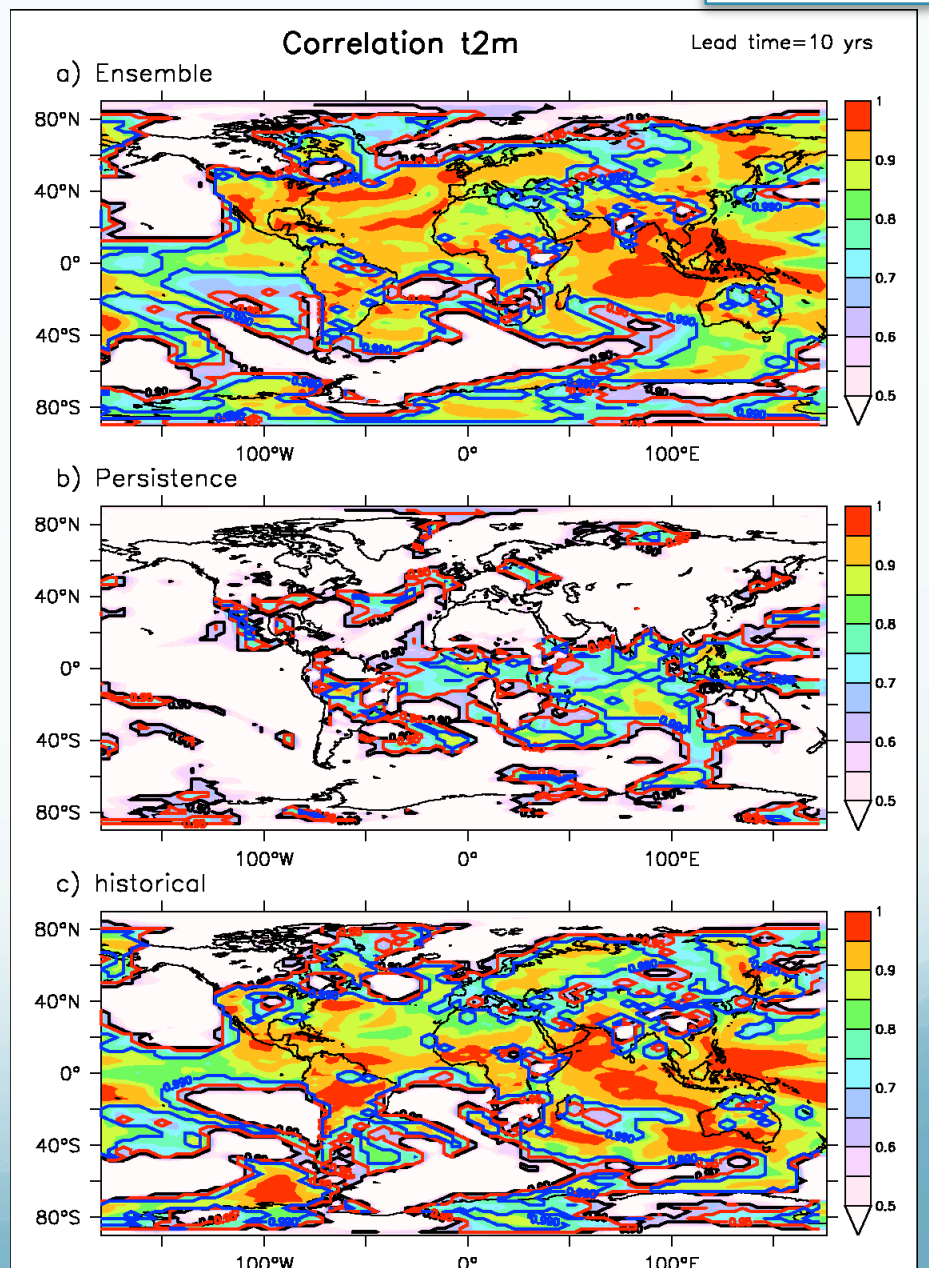

AMOC max
Pers (r=0.58)
Ens (r=0.9)
Ref
15.0
14.0
13.0
12.0
11.0
10.0
9.0
Sv
1965
1975
1985
1995
2005
Year


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

Hindcasts





Student test

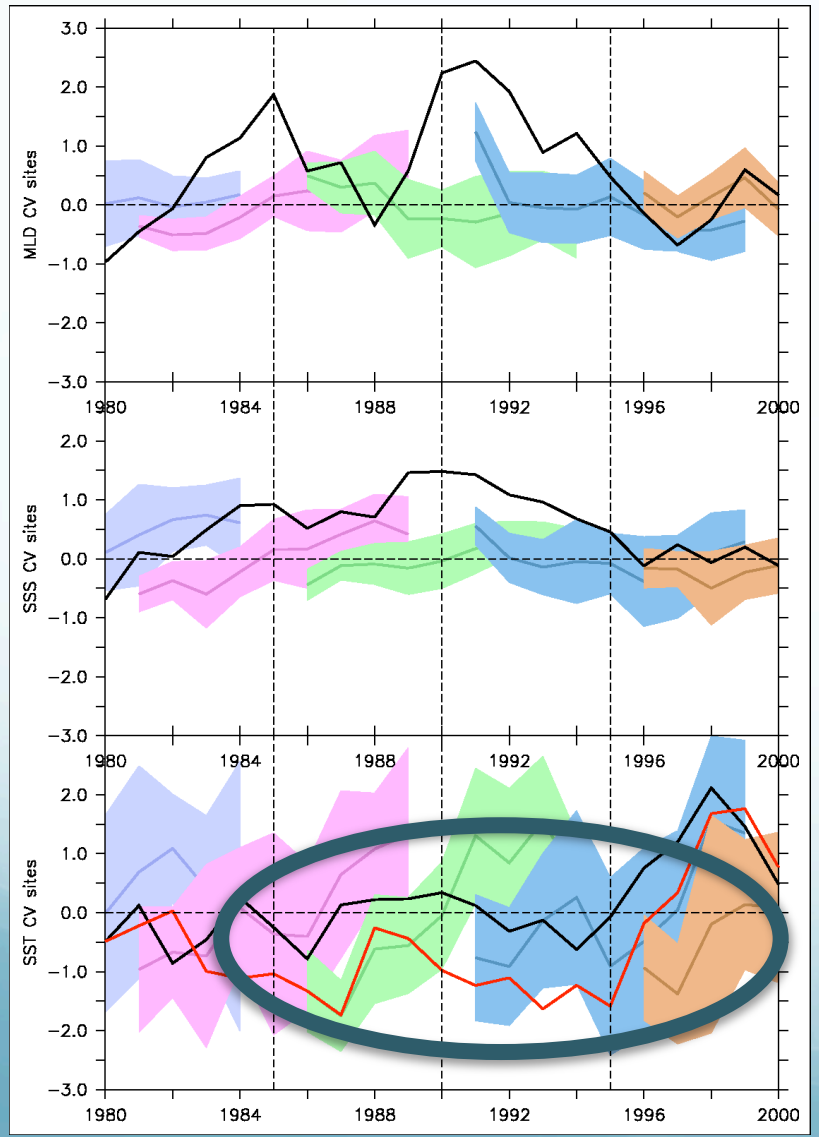
90%
95%
99%

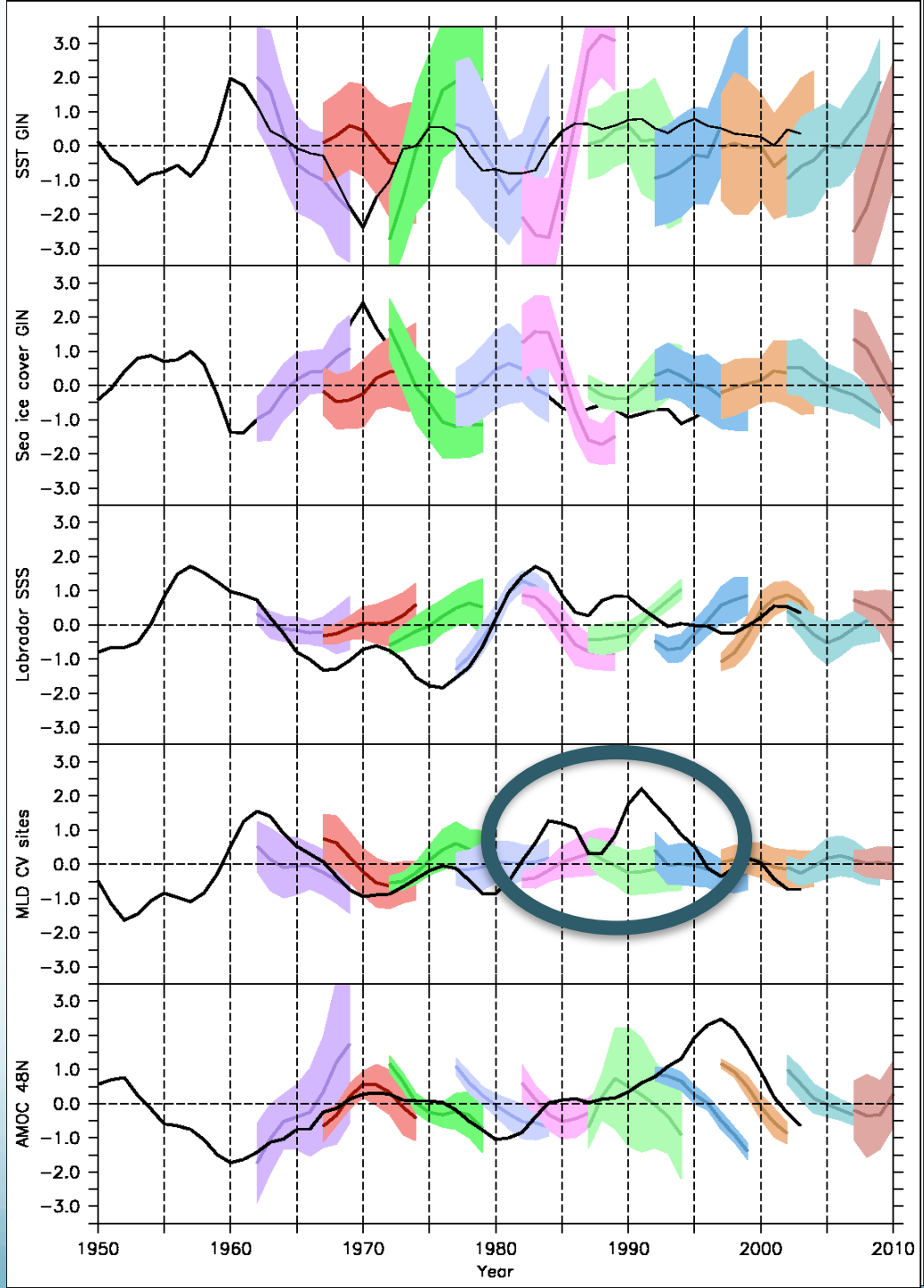
Conclusions

- Surprising agreement with data given the biases in the North Atlantic in the IPSL-CM5 model!
- A different (complementary) story from Latif et al.: an ocean-sea ice-atmosphere coupled mechanism in agreement with GSAs and initialised after 30 years using only Reynolds SST
- Nevertheless, in the 90s the cooling of the SPG related to high NAO played a role and may explain the very high AMOC max (not captured by free simulations)
- Correct predictive skill in the North Atlantic and Europe
- More results in Mignot et al. Poster
- The problem of sea ice cover: Servonnat et al. talk

Thank you

Why do we miss the 1990s peak?





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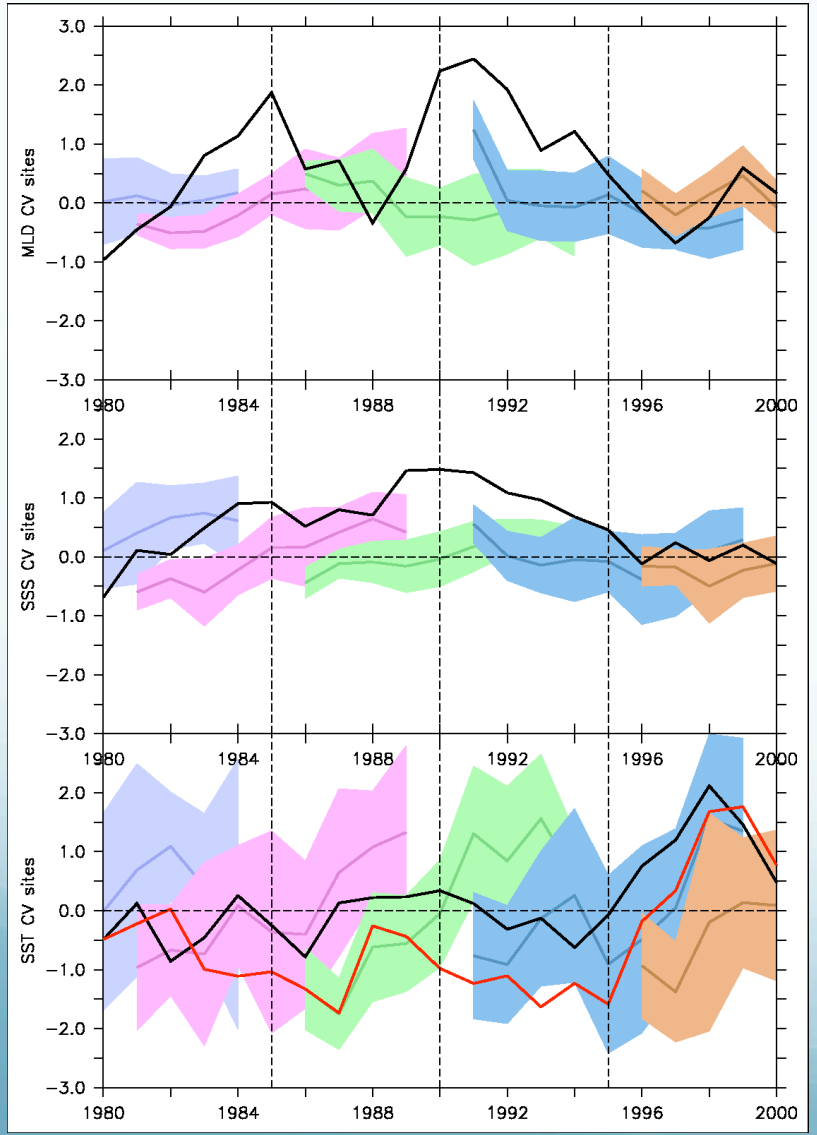

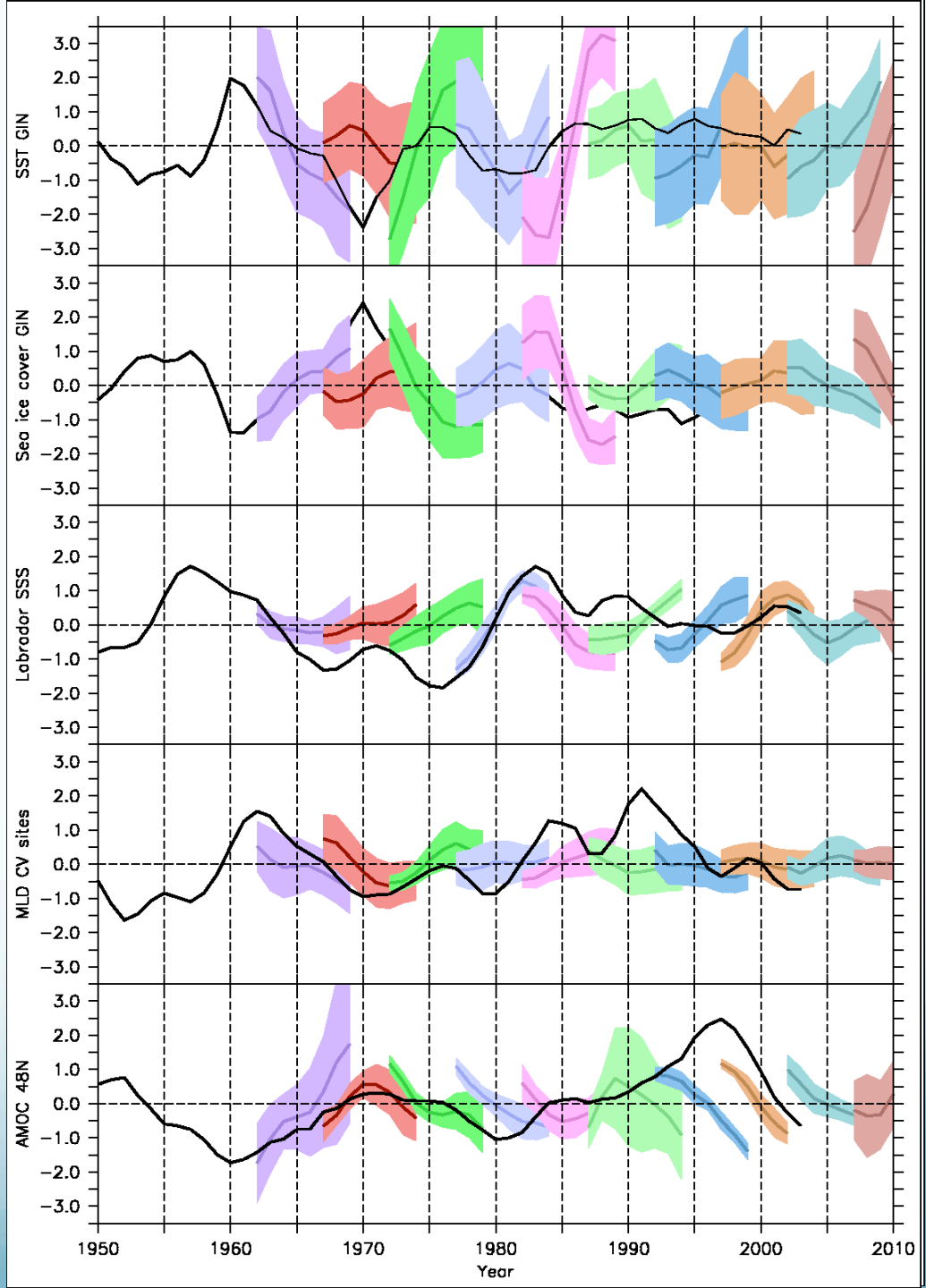

Future

Figure T2M global et SST par bassin