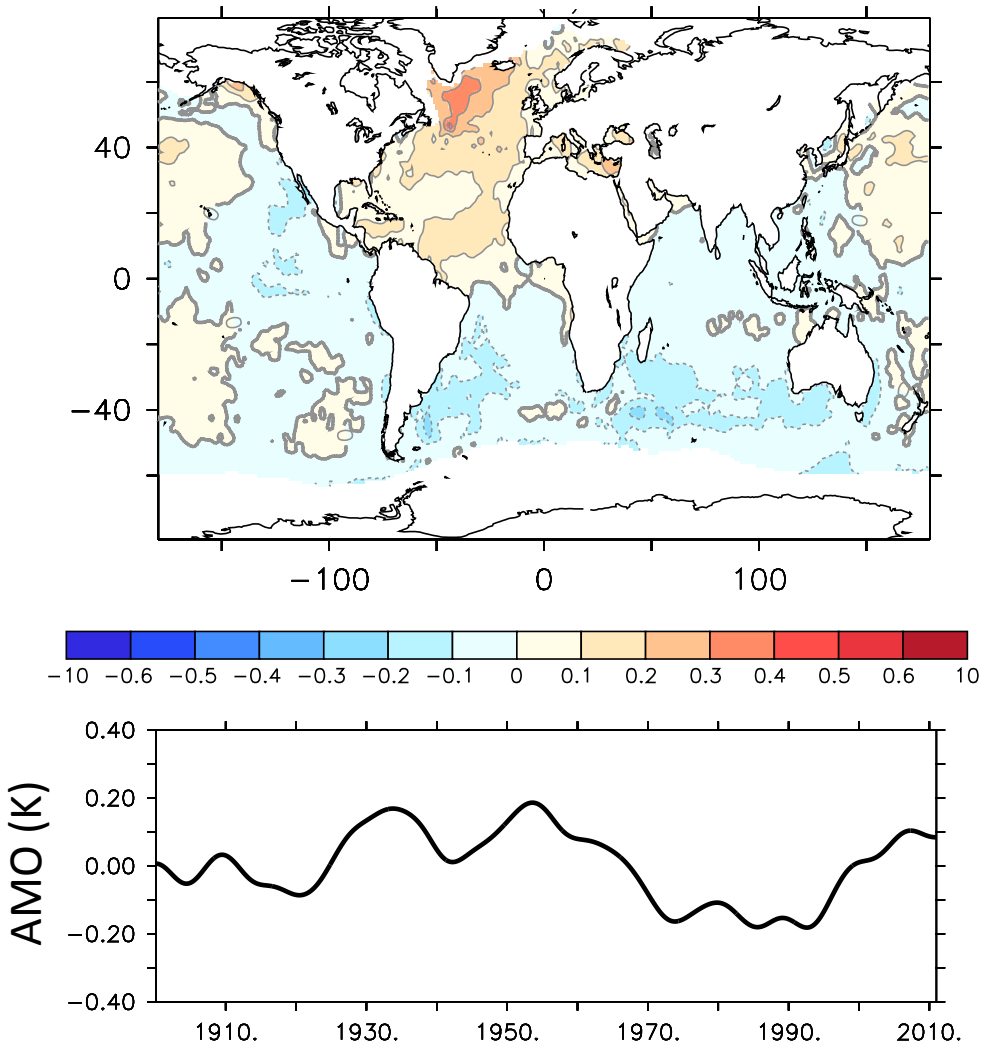
Décomposition de l'influence de l'AMOC sur l'atmosphère dans des simulations avec LMDZ

Guillaume Gastineau[1], Blandine L'Hévéder[2],
Francis Codron[2], Claude Frankignoul[1]

[1]LOCEAN/IPSL
[2]LMD/IPSL

Atlantic decadal climate variability

Atlantic Multidecadal Oscillation (AMO) in K



The climate show some decadal variability over the Atlantic Ocean.

Has been involved for:

-> various climate phenomenon such as tropical cyclone, NAO, rainfall, ect…

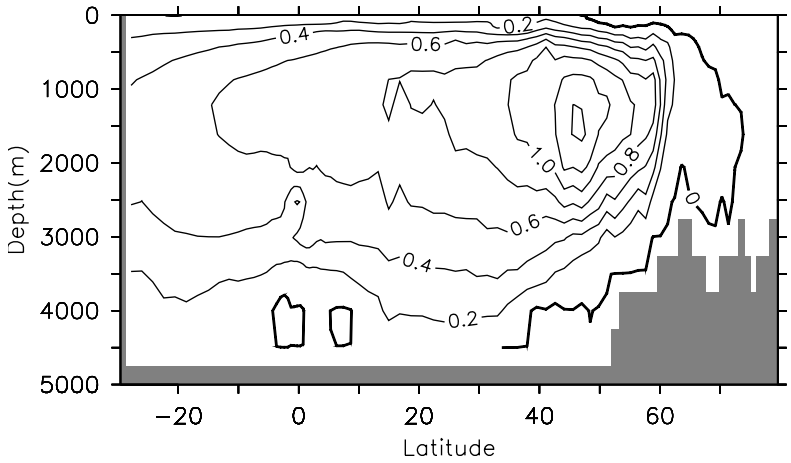
-> potential predictability at decadal scales

Observations limited : coupled models are studied.

-> IPSL-CM5A

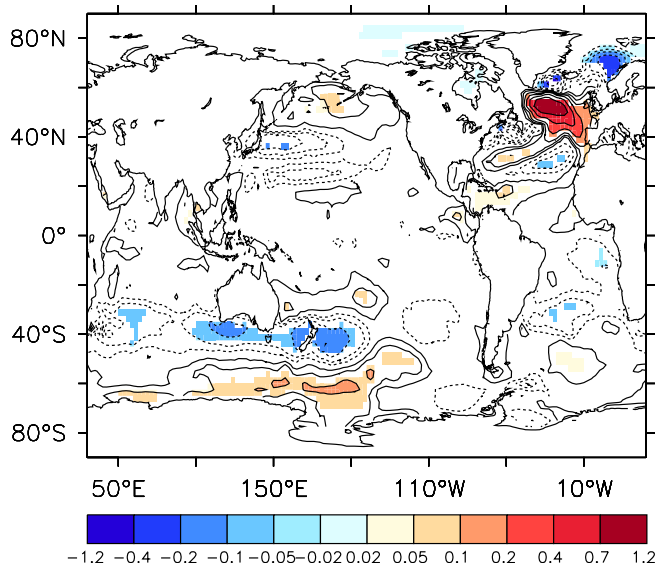
The AMOC in IPSL-CM5A

EOF1 yearly AMOC, in Sv (49%)

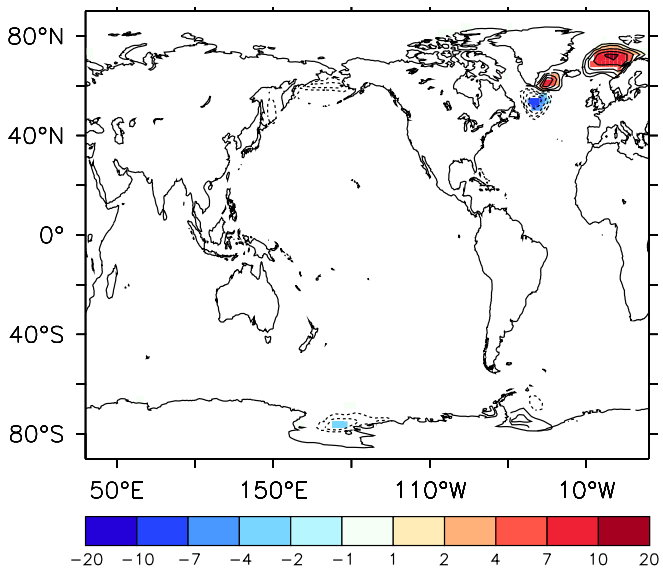


- IPSL-CM5A-LR (low resolution), 500 yr preindustrial control simulation.
- AMOC has a 20yr multidecadal variability in IPSL-CM5A-LR,
- Decadal variability of AMOC linked to subpolar gyre currents (Escudier et al., 2013).

SST (in K) regression onto AMOC-PC1
AMOC leads by 9 yrs

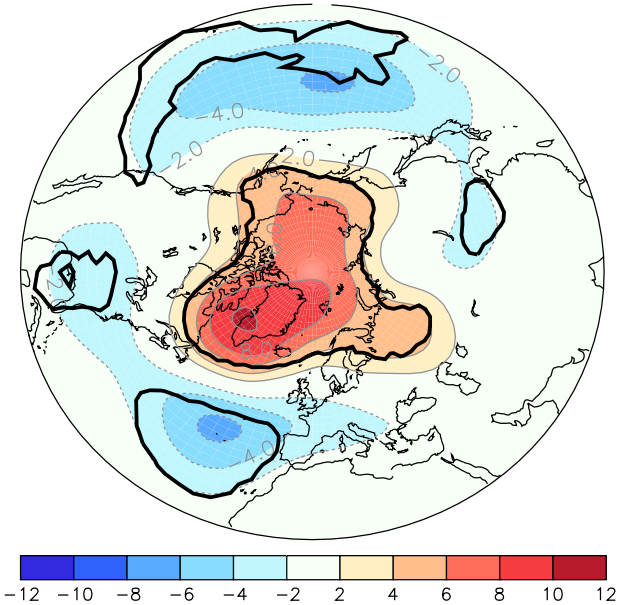


SIC (in %) regression onto AMOC-PC1
AMOC leads by 9 yrs



Atmospheric response to AMOC in IPSL-CM5A

Z500 JFM (in m) regressed onto AMOC-PC1, AMOC-PC1 leads by 9 yr



Gastineau and Frankignoul, *Clim. Dyn.*, 2012

- Role of the meridional SST gradient over the western Atlantic region.

Warm AMO phase

↓

Smaller SST gradient

↓

weaker lower tropospheric baroclinicity

↓

weak storm track and NAO-

<u>Questions:</u> What is the cause of the atmospheric response?
Do sea-ice anomalies play a role?
Does some remote influence from tropics also play a role?

Experimental set-up

-> Ensemble simulation using LMDZ (atmospheric component of IPSL-CM5A-LR) forced by SST, sea-ice and surface sea-ice temperature from the coupled model.

Each member : October 1st - - - - > April 30th

Experiment Name	Ensemble size	SST conditions	Sea-ice
CTRL	75	Climatology	Climatology
ALL	75	Anomalies AMOC+ *everywhere*	Anomalies AMOC+ *everywhere*
N-ATL	75	Anomalies AMOC+ *in Atlantic North of 20°N*	Climatology
N-ATL+SIC	75	Anomalies AMOC+ *in Atlantic North of 20°N*	Anomalies AMOC+ x3 *in Atlantic and Arctic*
$N\text{-}ATL_N$	75	Anomalies AMOC+ in Atlantic North of 45°N	Climatology
$N\text{-}ATL_S$	75	Anomalies AMOC+ between 20°N and 45°N	Climatology

Experimental set-up

Model version :

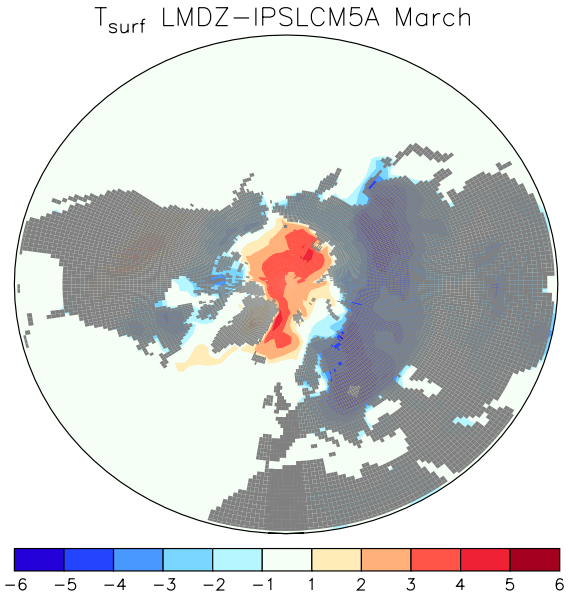
- LMDZOR 96x96 AR4 physics (atmospheric component of IPSL-CM5A-LR)
  -> Simulations performed in local (LOCEAN) and ada (IDRIS)

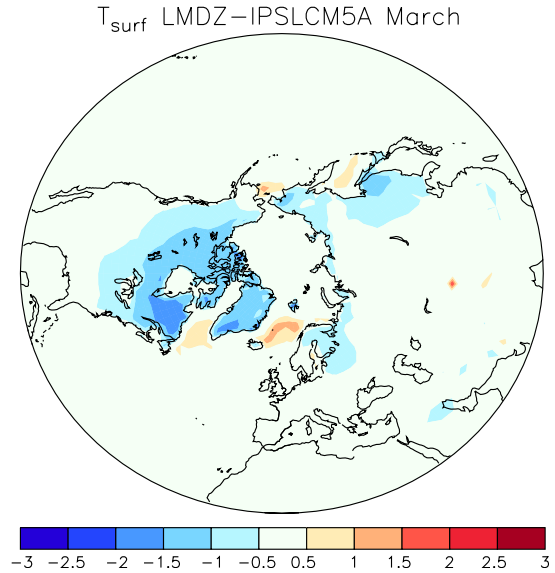
Main issue :

- Difficult to find the same LMDZ as IPSL-CM5A-LR
- Warm bias over sea-ice regions

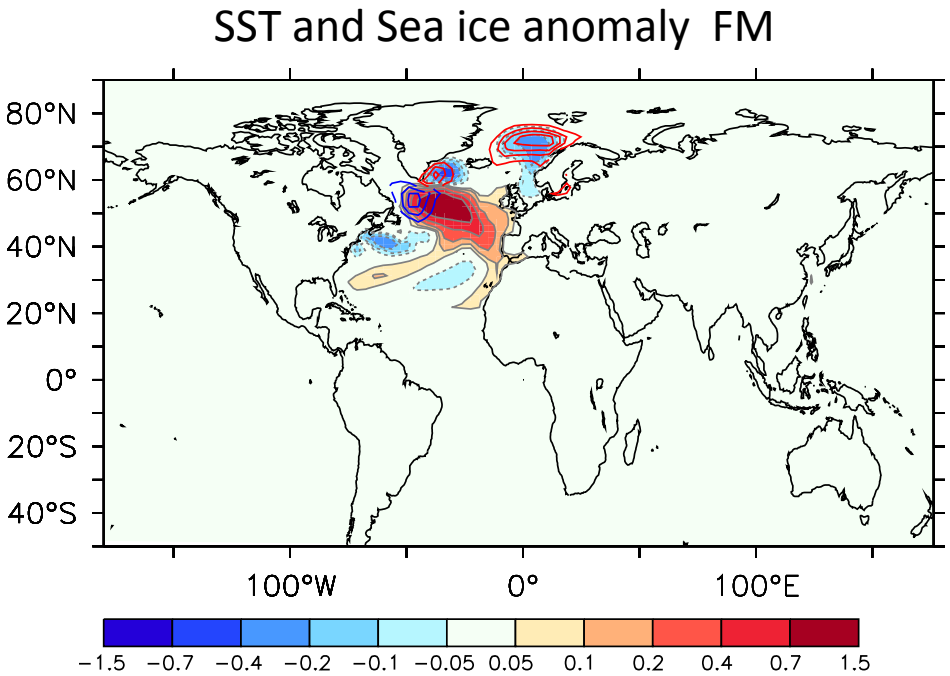
Modification:

- Prescribed temperature over sea-ice through limit.nc



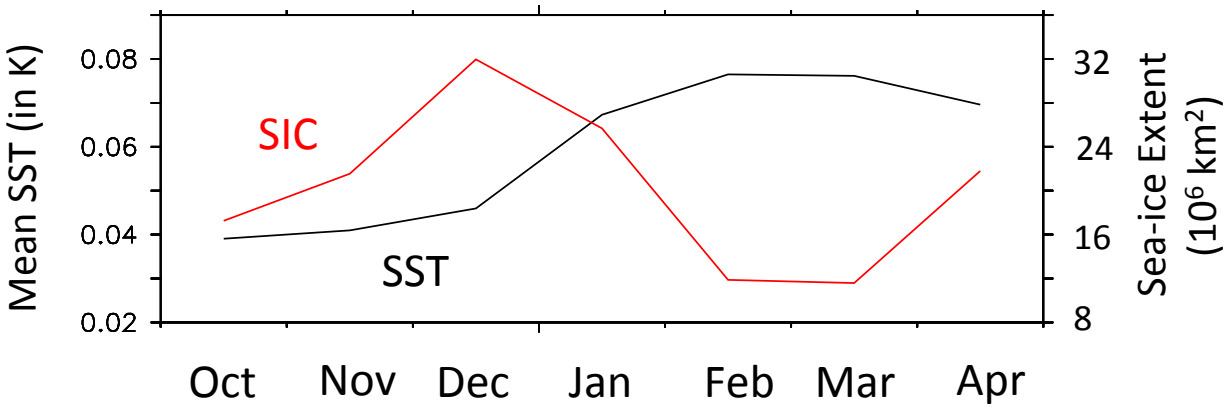


SST boundary condition



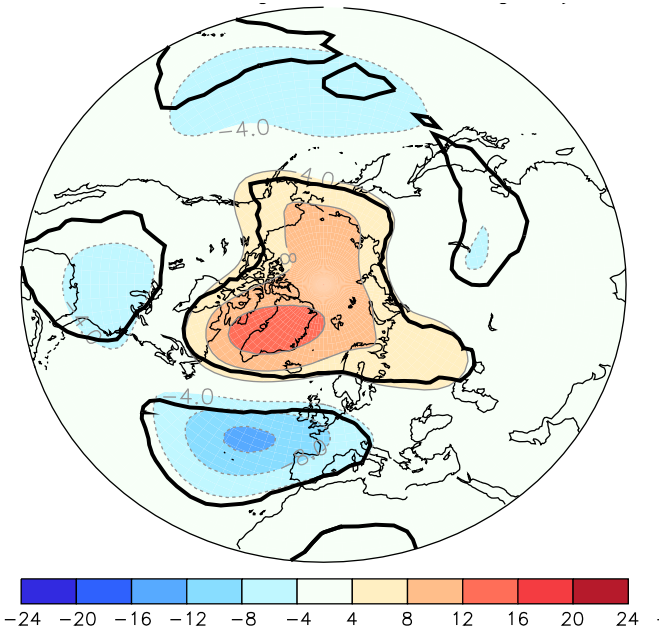
SST and sea ice (SIC) anomaly =
time evolving anomaly given by the regression onto AMOC-PC1 (lag 9 yr)

Focus on the season February-March (FM) when the atmospheric response is maximum.

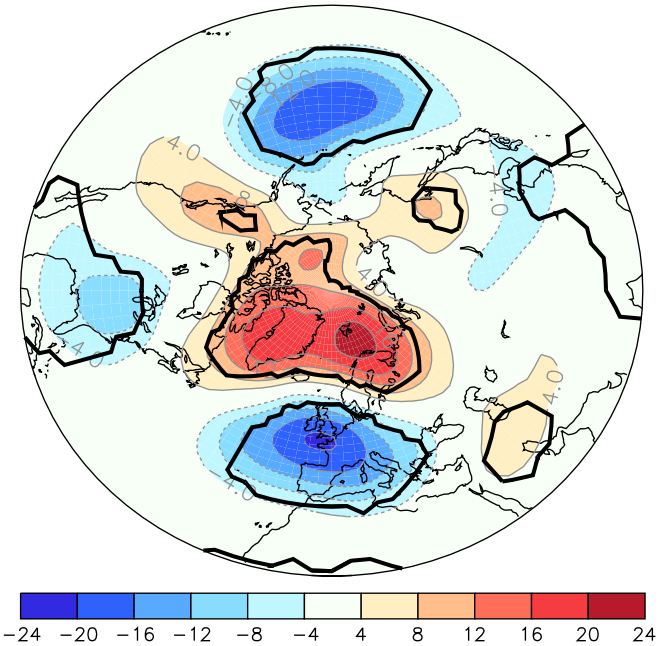


LMDZOR simulations to reproduce IPSL-CM5A

Z500 Regression in FM
for IPSL-CM5A



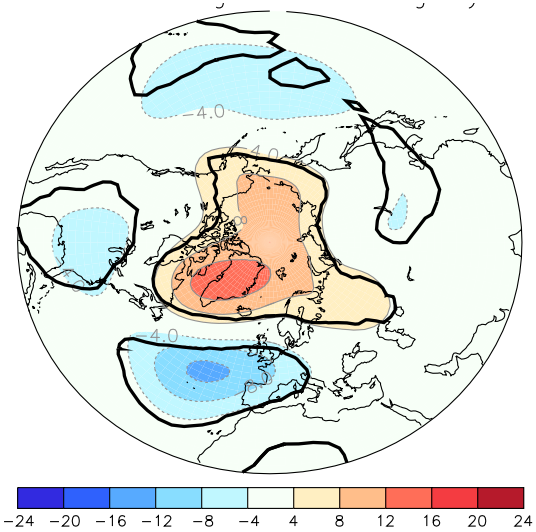
ALL - CTRL



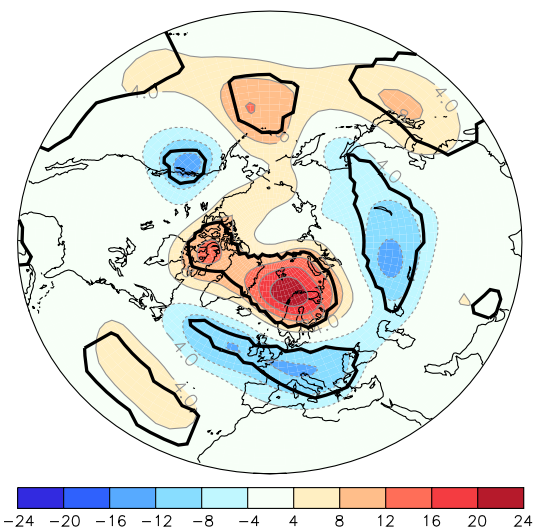
- Similar NAO-like response but slightly overestimated in forced simulation
  - -> SST and SIC forcing are too large in the forced simulation
  - -> 75 members not enough to capture the amplitude of the response
  - -> difference in the mean climate may change the response

Influence of Atlantic SST and Sea ice

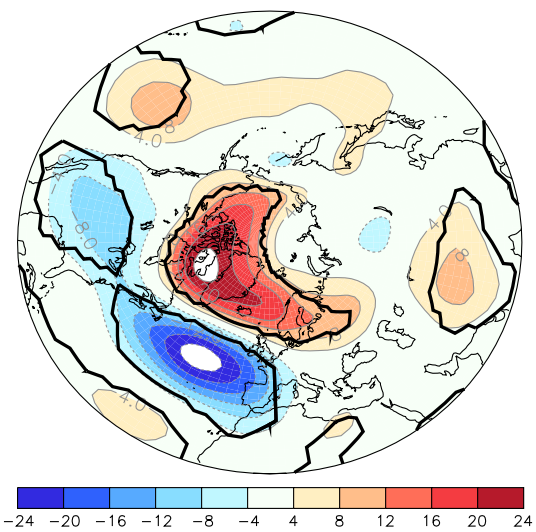
Z500 Regression
IPSL-CM5A



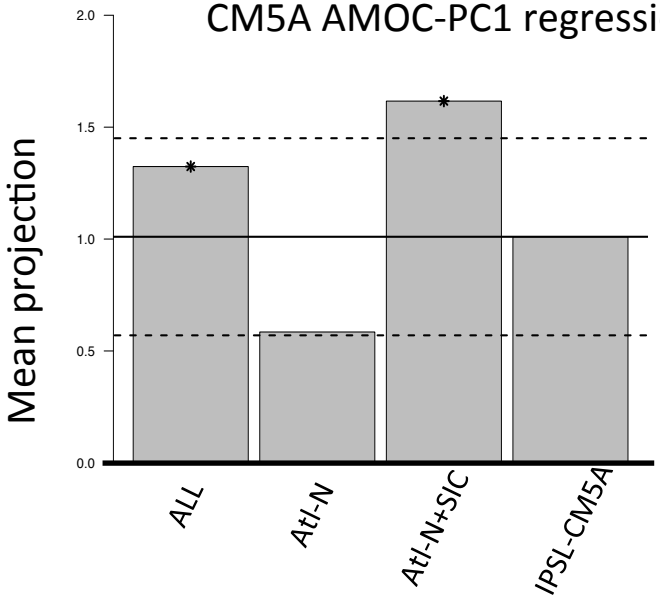
N-ATL - CTRL



N-ATL+SIC - CTRL



Projection Z500 anomalies onto the IPSL-CM5A AMOC-PC1 regression

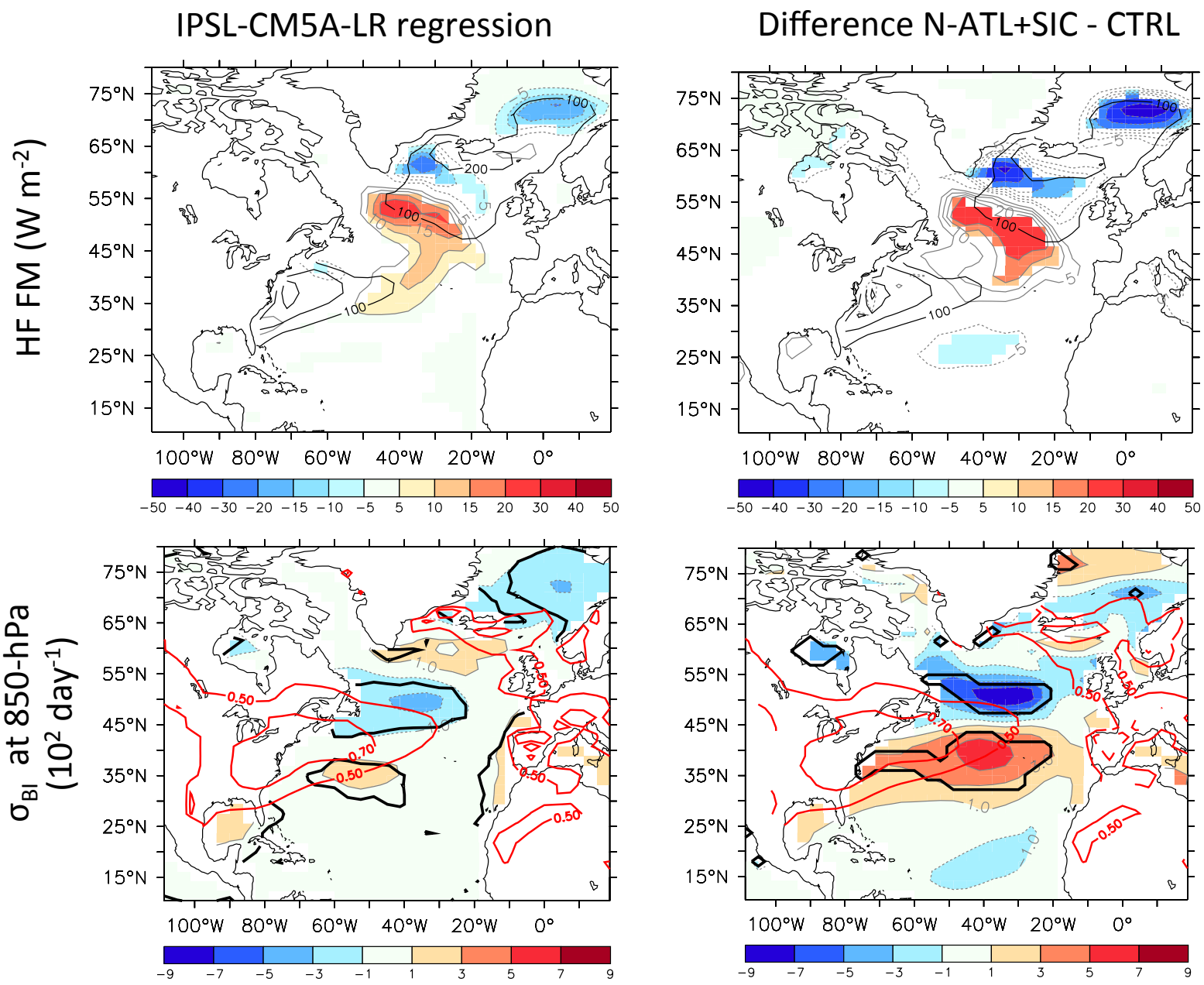


Summary:

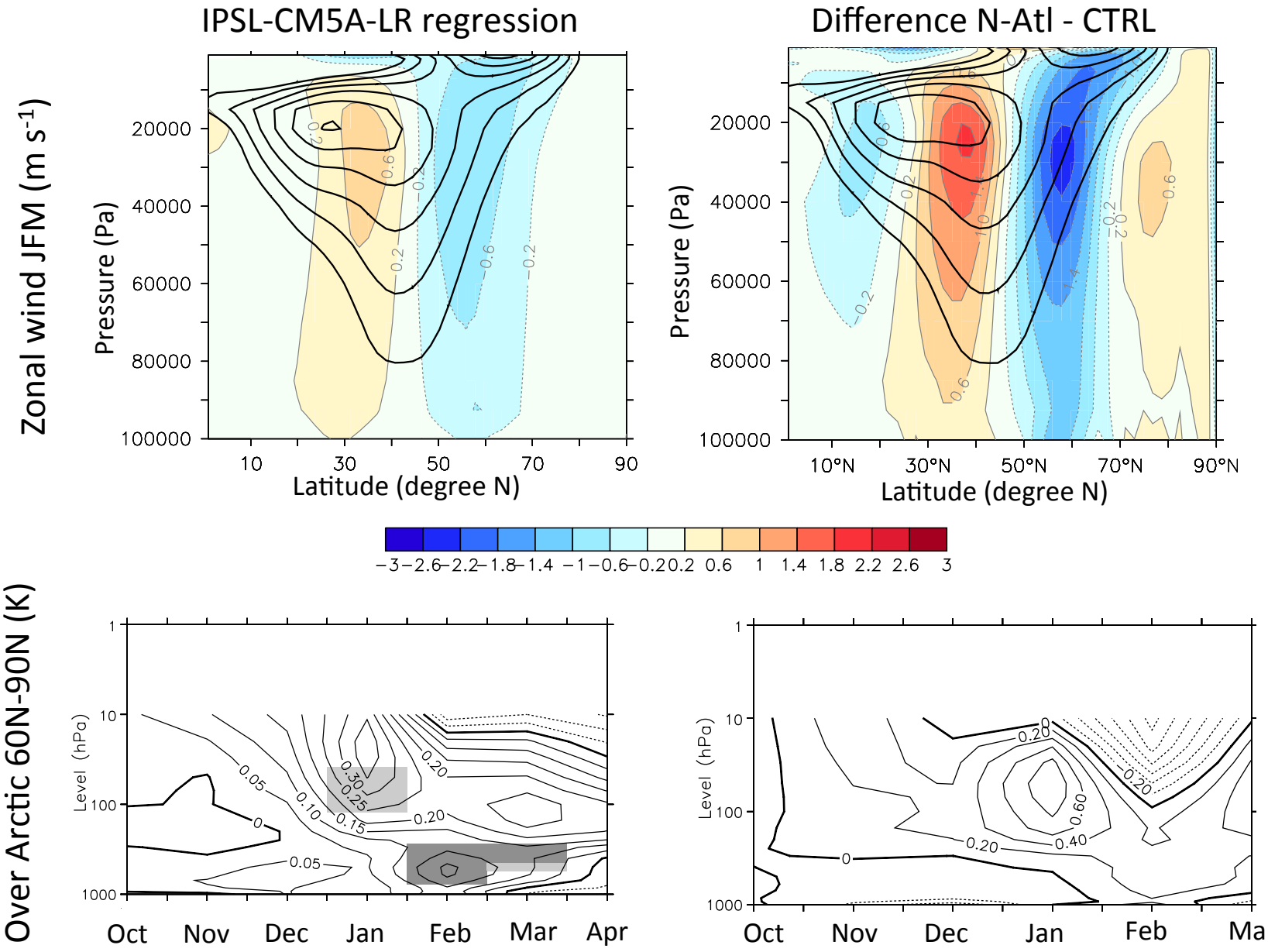
Late winter NAO-like signal seems to be due to :

- midlatitude SST anomalies
- Arctic SIC anomalies

Effect of North Atlantic SST



Stratospheric pathway

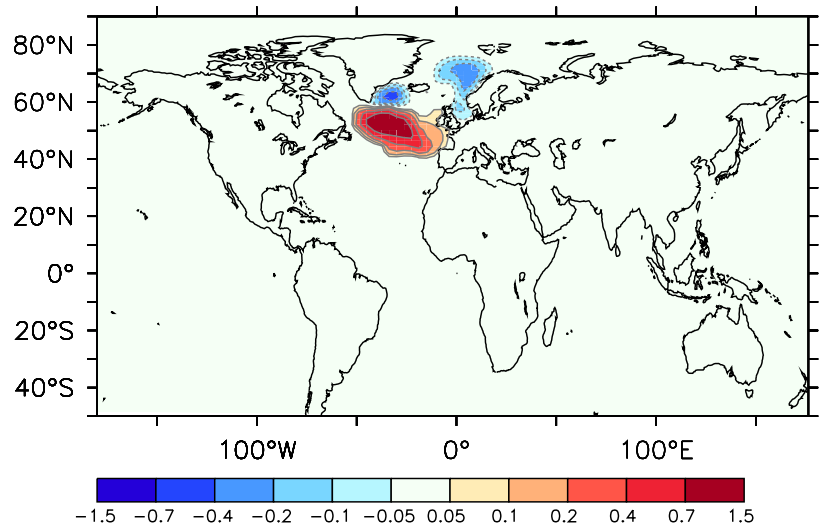


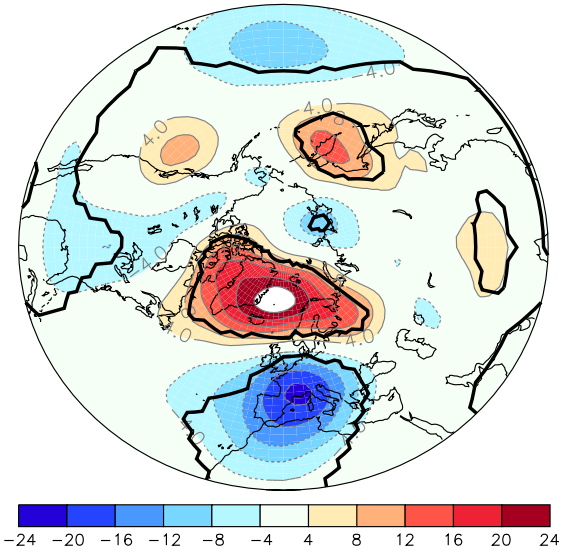
Which region is the most important?

SSTA (in K)

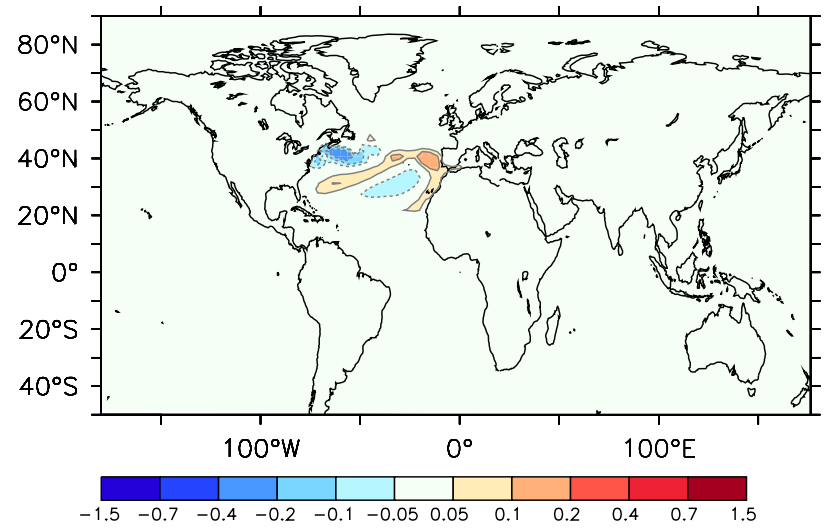
Z500 FM (in m)

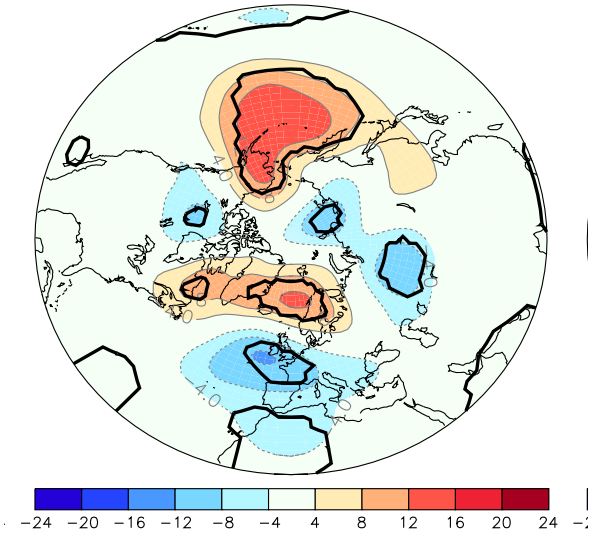
N-ATL$_N$ - CTRL





N-ATL$_S$ - CTRL





Conclusion and discussion

- The SST and sea ice anomalies north of 20°N are the cause of the NAO-like response to AMOC in late winter.

- The atmospheric response to the AMOC is weak and difficult to simulate

- The response to SST anomalies is due to :
  1. The role of the SST onto baroclinicity and the associated jet stream shift
  2. The coupling with the stratosphere that remains to be clarified

- The sea ice and SST both have a comparable effect