High resolution modeling efforts : impact on the North Atlantic circulation

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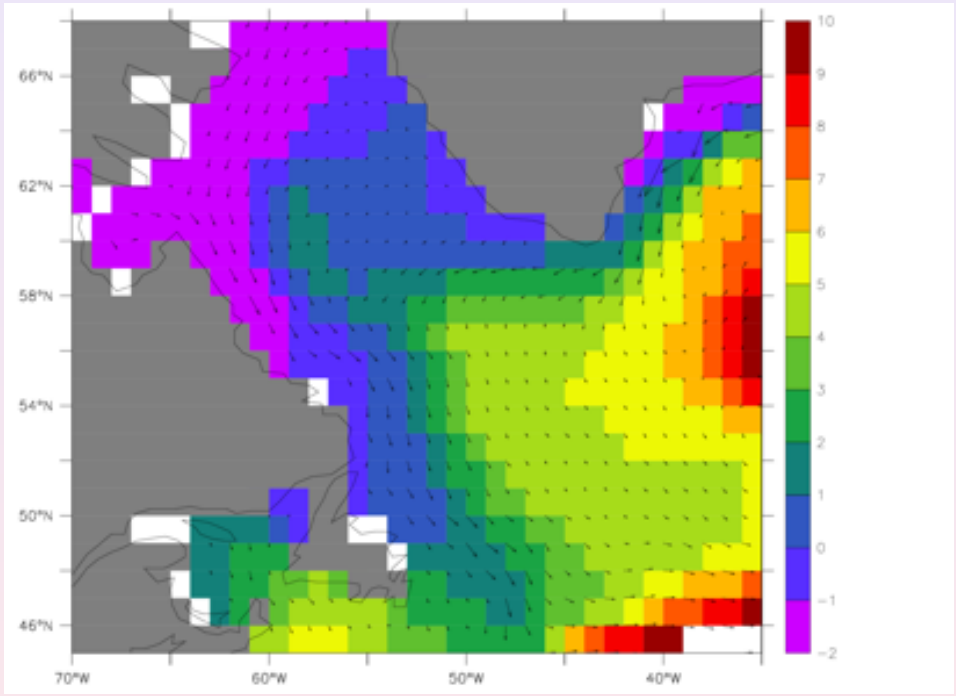
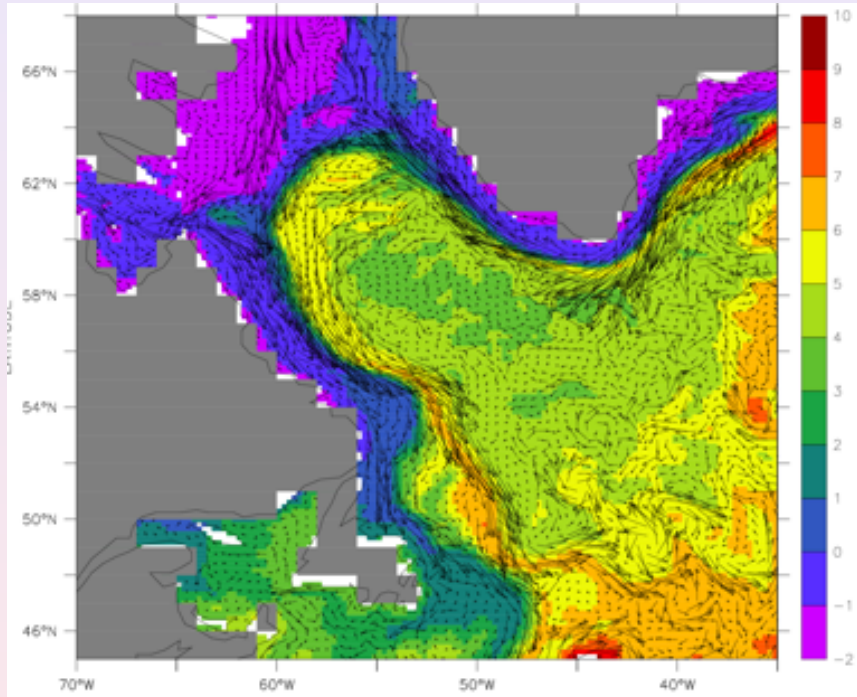
Clearly resolution does matter

Surface currents

GFDL CM2.1



GFDL CM2.4



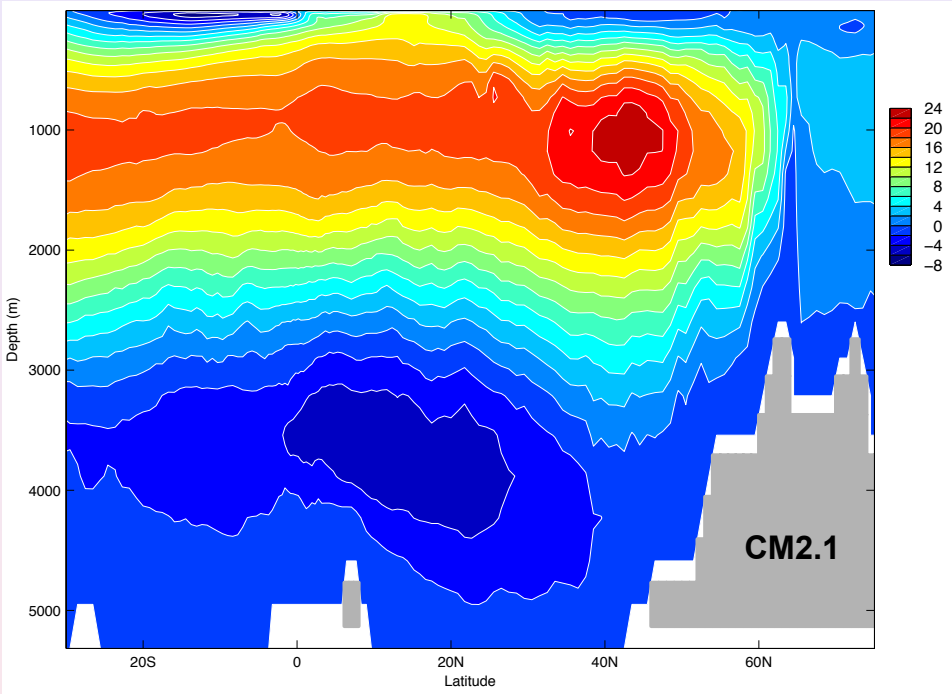
$\Longrightarrow$ GFDL CM2.1 was one of the best coupled models for Atlantic simulations in AR4. Yet western boundary currents were not well resolved.

$\Longrightarrow$ With a resolution as high as 10 km at high latitudes, better representation of all the subpolar gyre currents (Labrador, West Greenland, East Greenland)

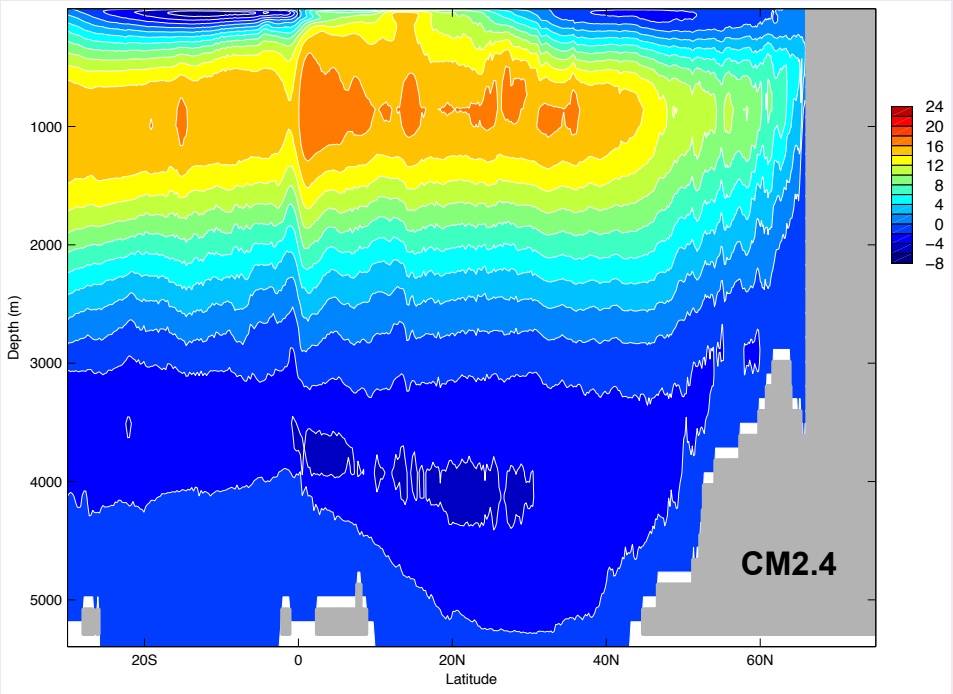
$\Longrightarrow$ More realistic DWBC and AMOC

Atlantic Meridional Overturning Circulation

GFDL CM2.1



GFDL CM2.4

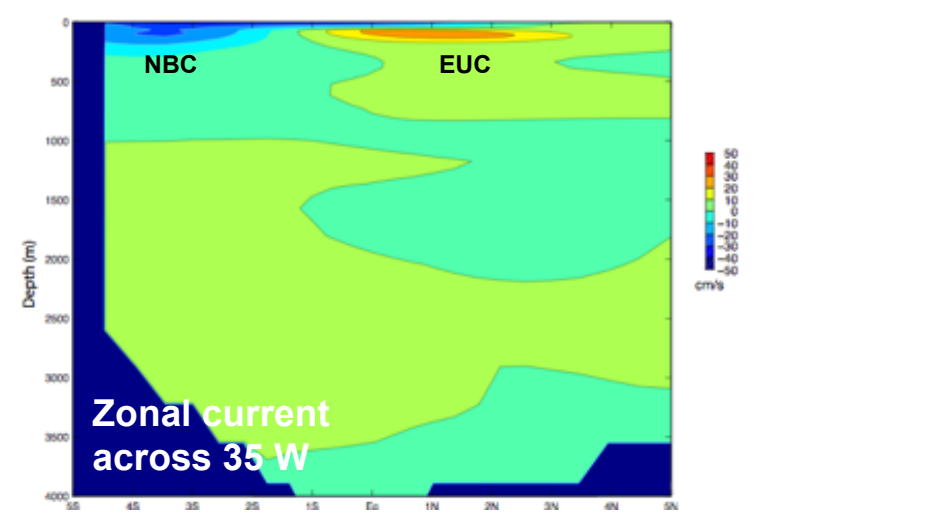


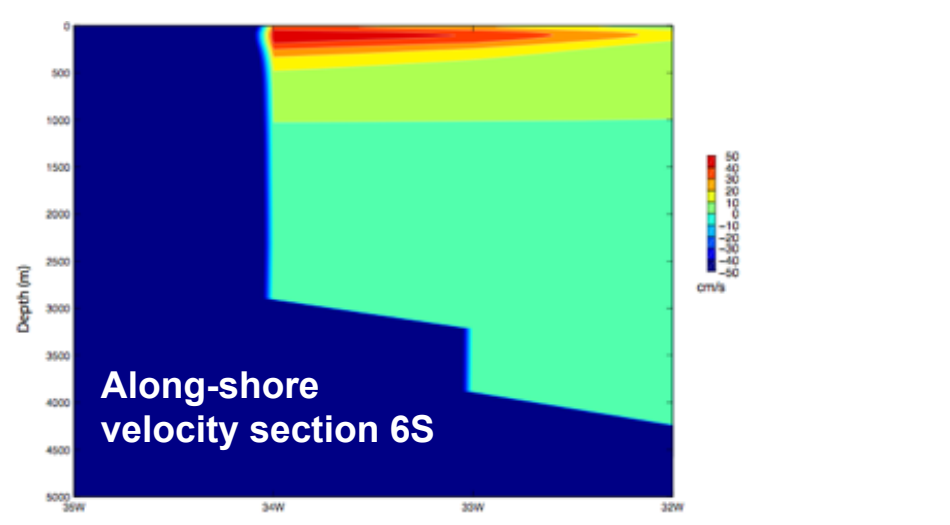
$\Longrightarrow$ Weaker NADW in CM2.4, closer to observed estimations

$\Longrightarrow$ Sharp equatorial separation : processes that were not resolved before like North Brazil Current

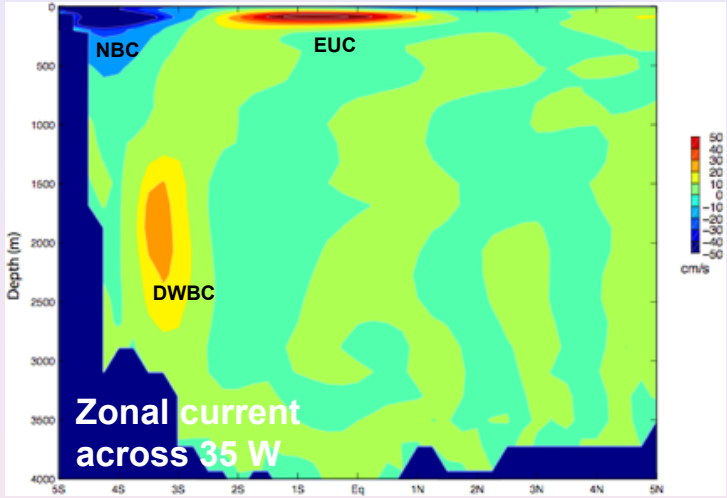
The North Brazil Current

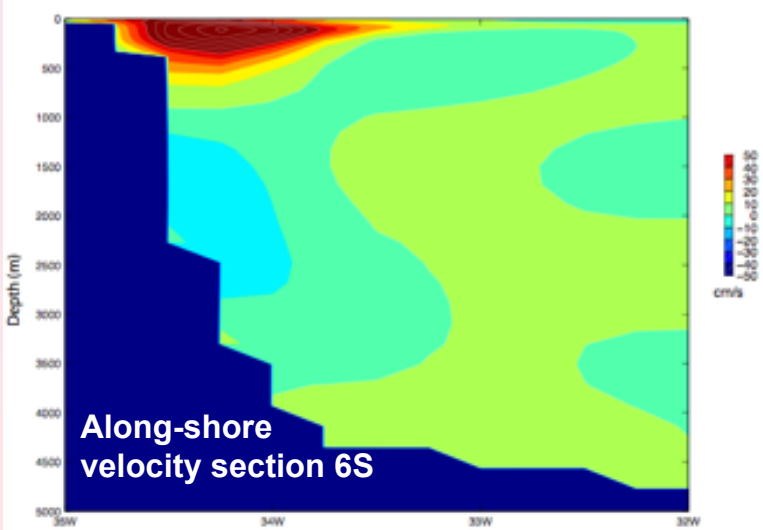
GFDL CM2.1





GFDL CM2.4

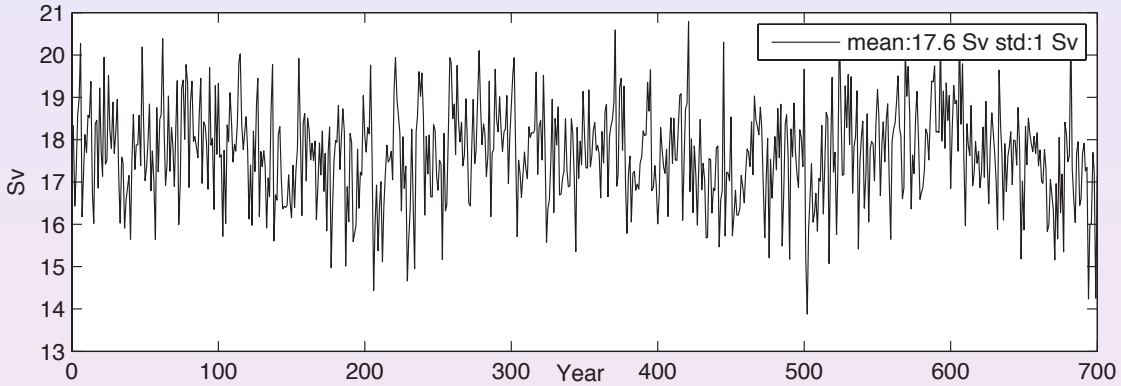




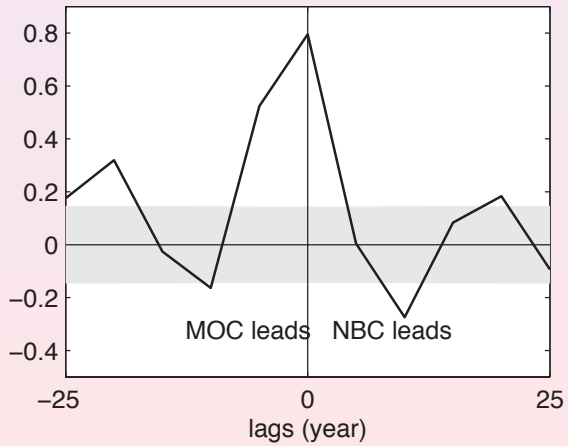
$\Longrightarrow$ Clear improvement with resolution

North Brazil Current, a proxy of the MOC ? (*Zhang and McPhaden* 2009)

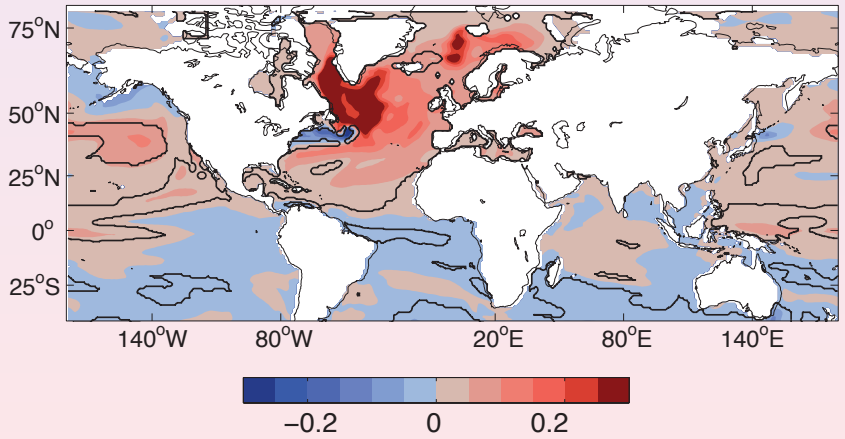
NBC index : meridional transport at 6 S-35 W over the upper 1200 m



Correlated with the MOC : good indicator of its variability

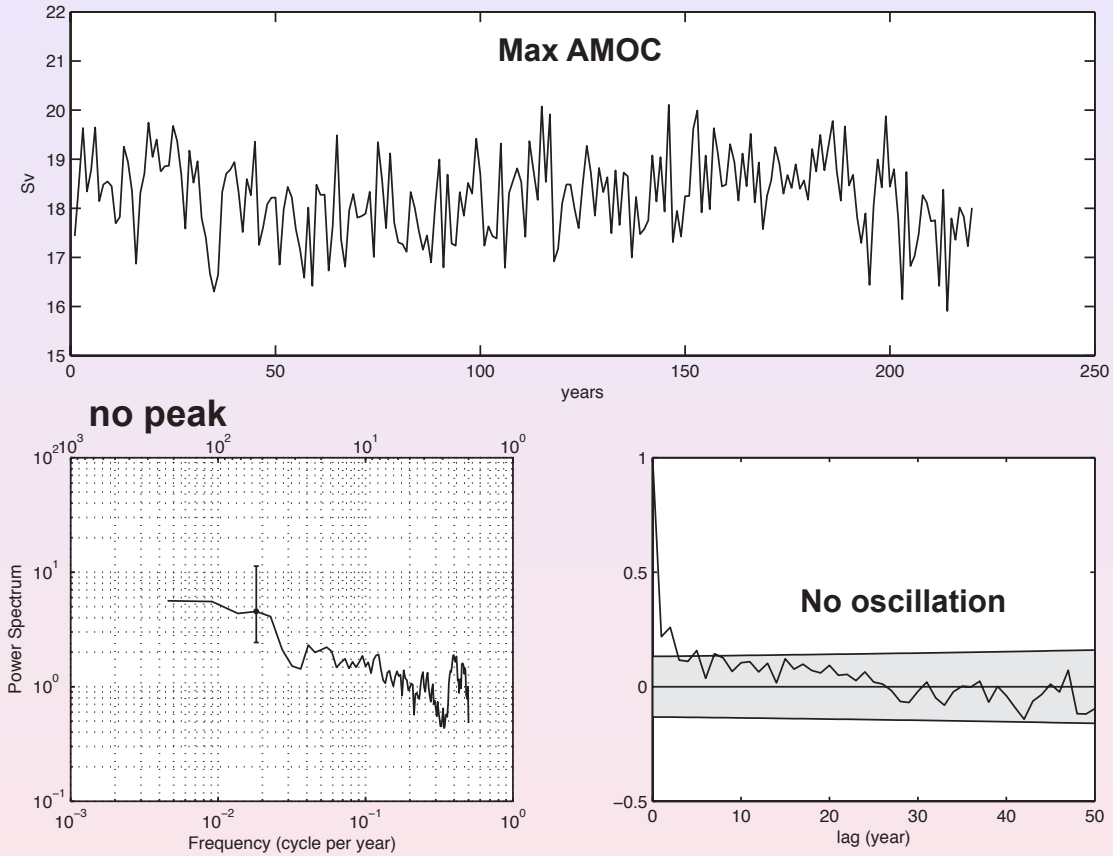


Surface signature similar to the AMV



$\Longrightarrow$ The NBC could povide a derived AMOC transport time series. It was largely observed and could be used for decadal predictability

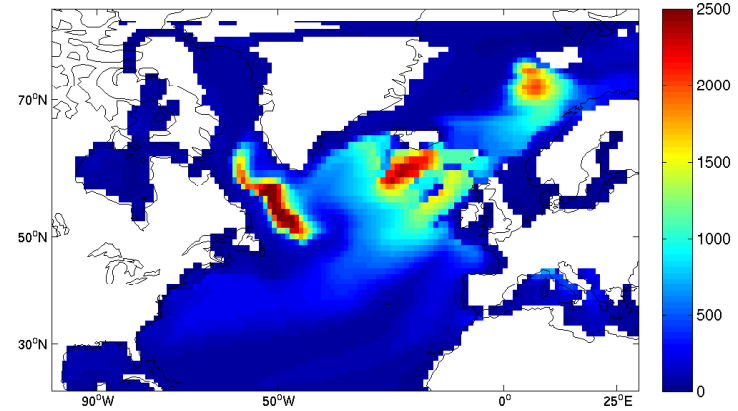
Lack of low-frequency fluctuations in CM2.4

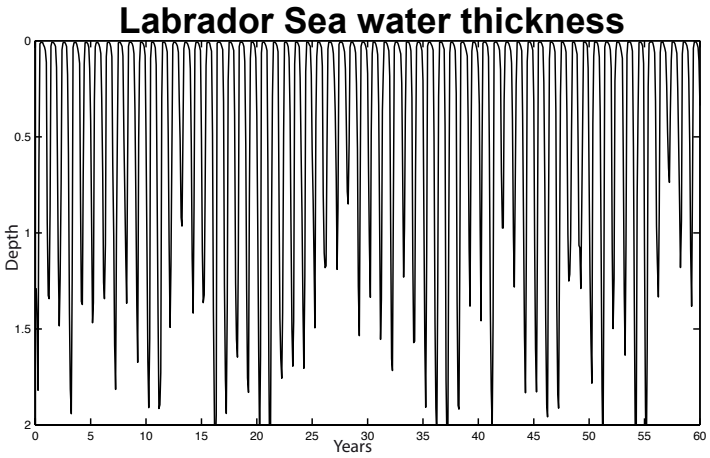


1. Decadal variability and predictability sensitive to resolution
2. Need to identify the mechanisms of variability. Challenging effort while increasing resolution

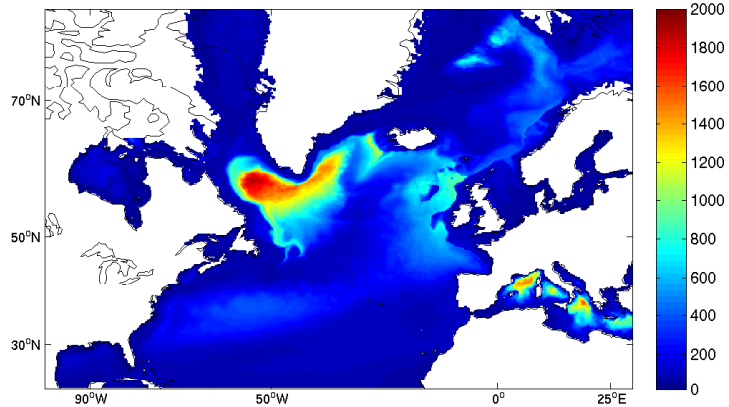
Winter Mixed layer depth

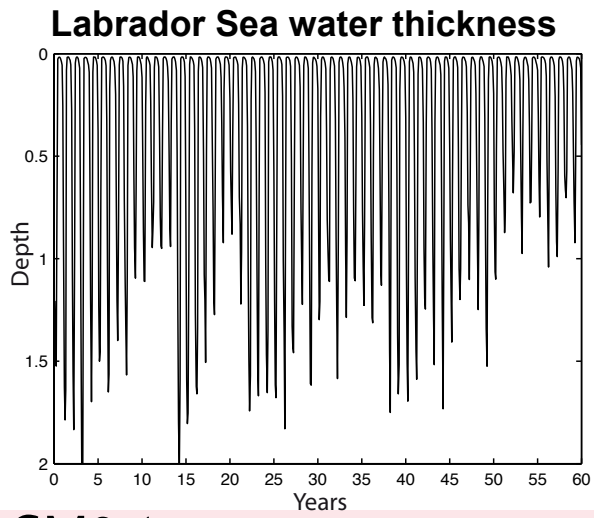
GFDL CM2.1





GFDL CM2.4



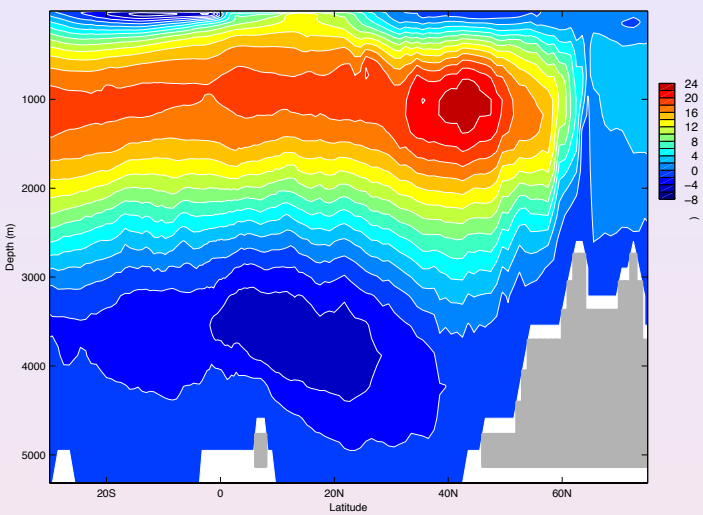


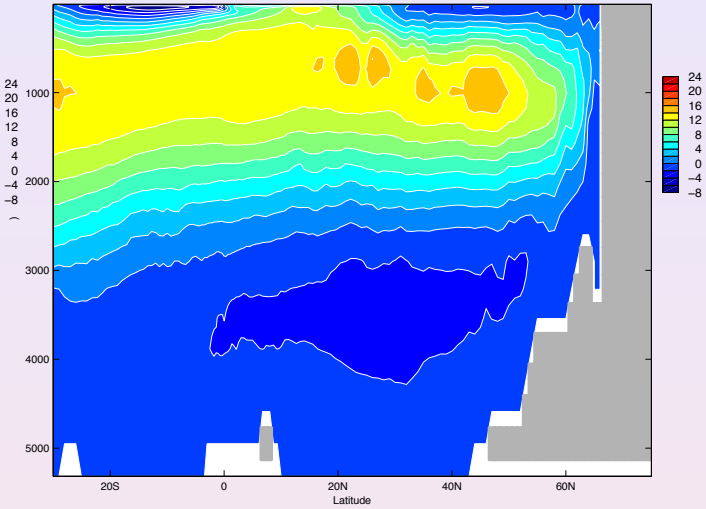
$\Longrightarrow$ Strong convection in the Labrador Sea in CM2.1

$\Longrightarrow$ Dominates MOC variability in CM2.4 too, but with a different phase lag.

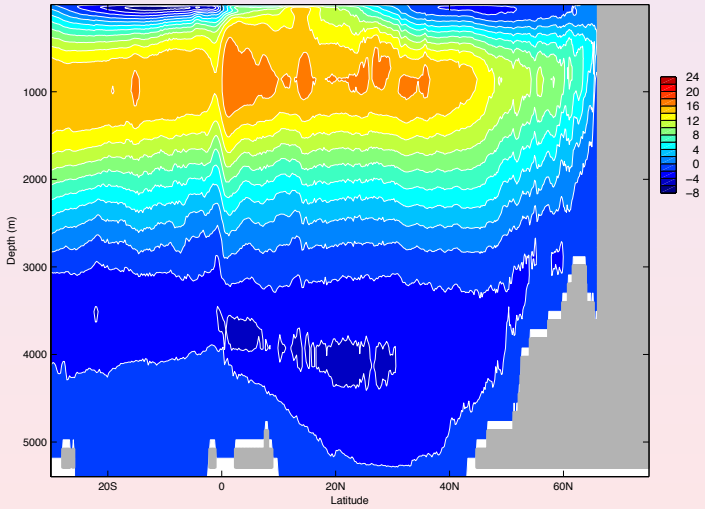
The atmosphere plays an important role

CM2.1
2° X 1°





CM2.3
1° X 1°

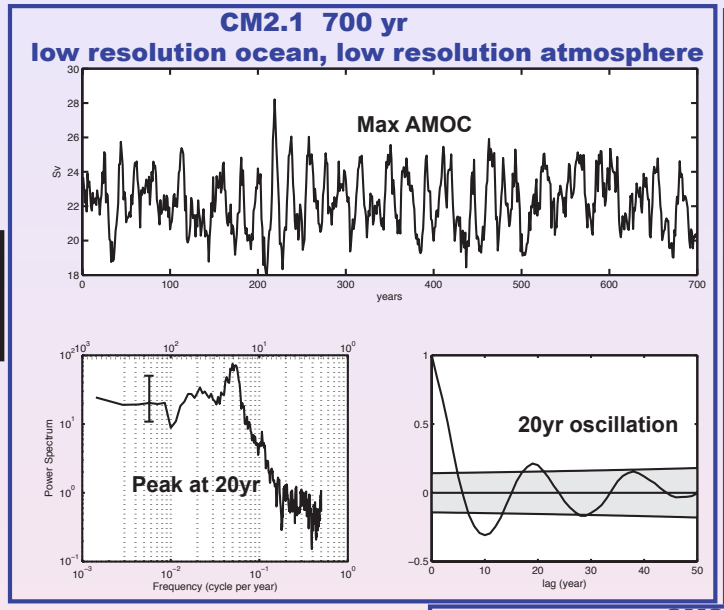


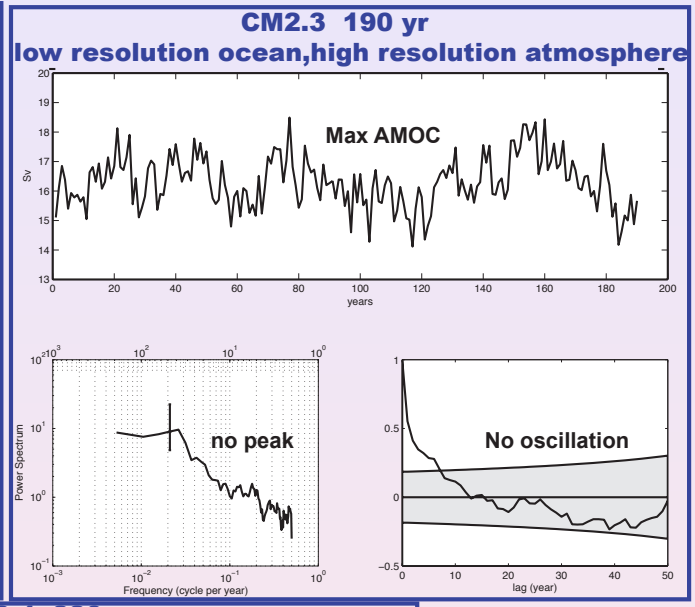
CM2.4
1° X 0.25°

$\Longrightarrow$ Different AMOC amplitude, different location of the maximum

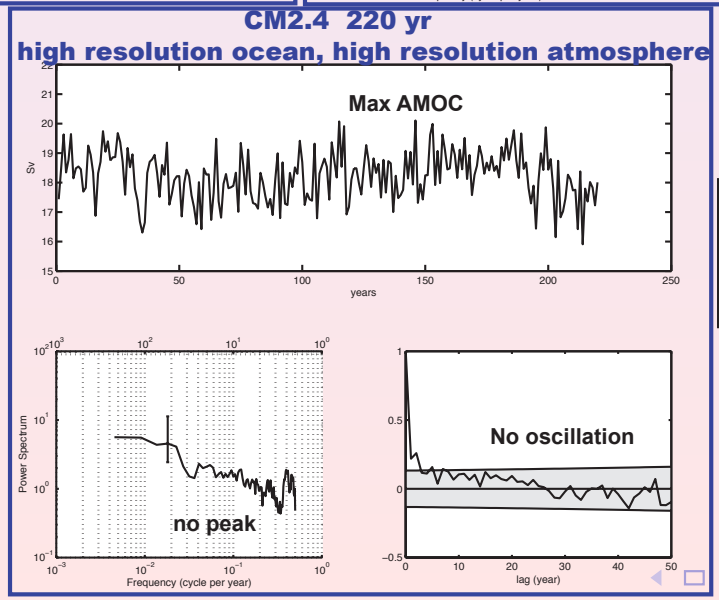
AMOC variability in different GFDL coupled models

CM2.1
2° X 1°





CM2.3
1° X 1°



CM2.4
1° X 0.25°

Conclusion

1. Important features of the North Atlantic circulation improve with resolution
   - More realistic subpolar gyre
   - Better representation of the western boundary currents
   - Tropical currents/undercurrents resolved

   $\Longrightarrow$ Holds promise for future monitoring and prediction of the AMOC
2. However issues are raised
   - Large biases in the mean circulation remain
   - Decadal variability and predictability might be sensitive to model resolution

$\Longrightarrow$ High resolution is necessary but not sufficient. The challenge is to understand the mechanisms