OXYGEN FINGERPRINTS OF VARIABILITY IN THE ATLANTIC MERIDIONAL OVERTURNING CIRCULATION

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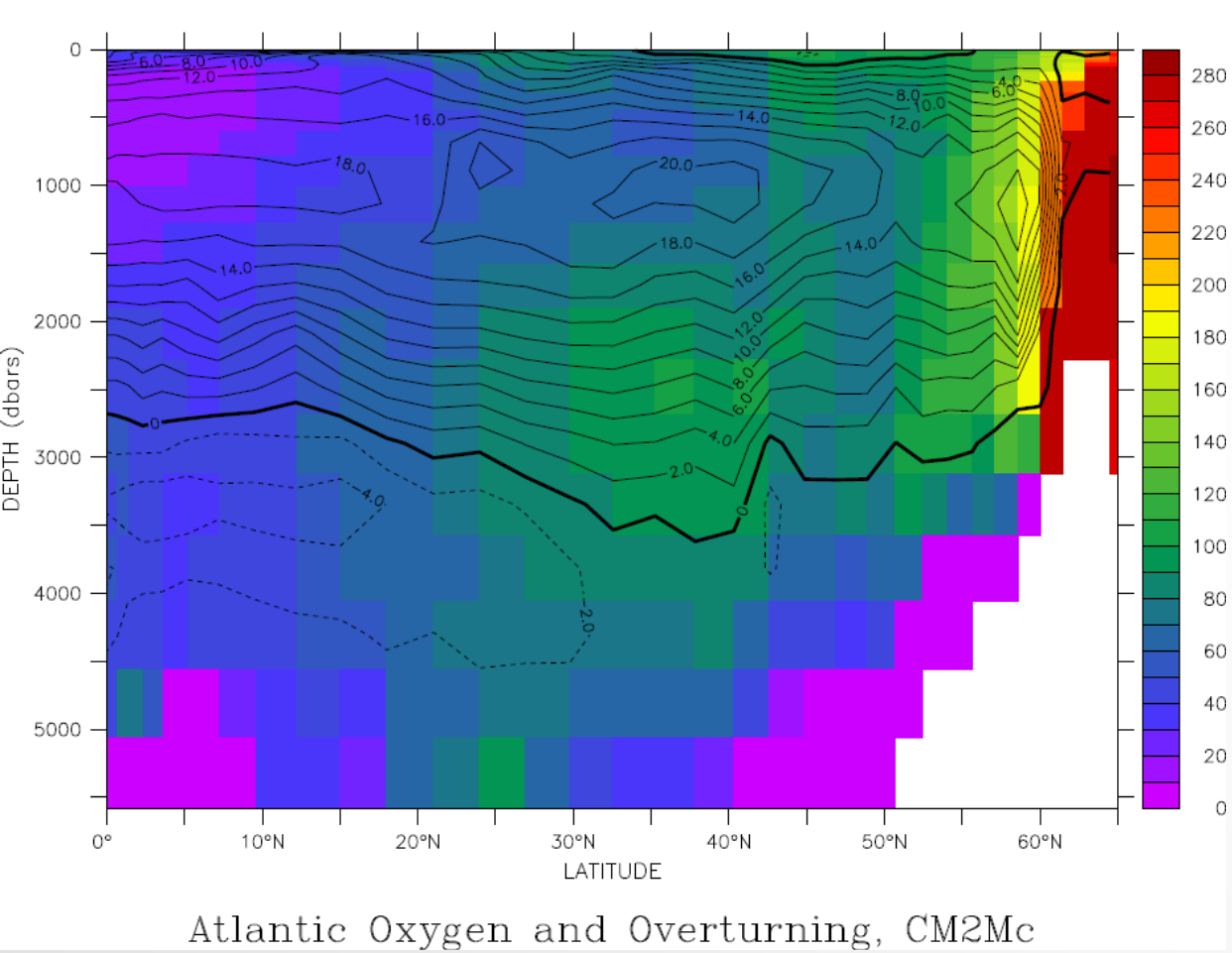
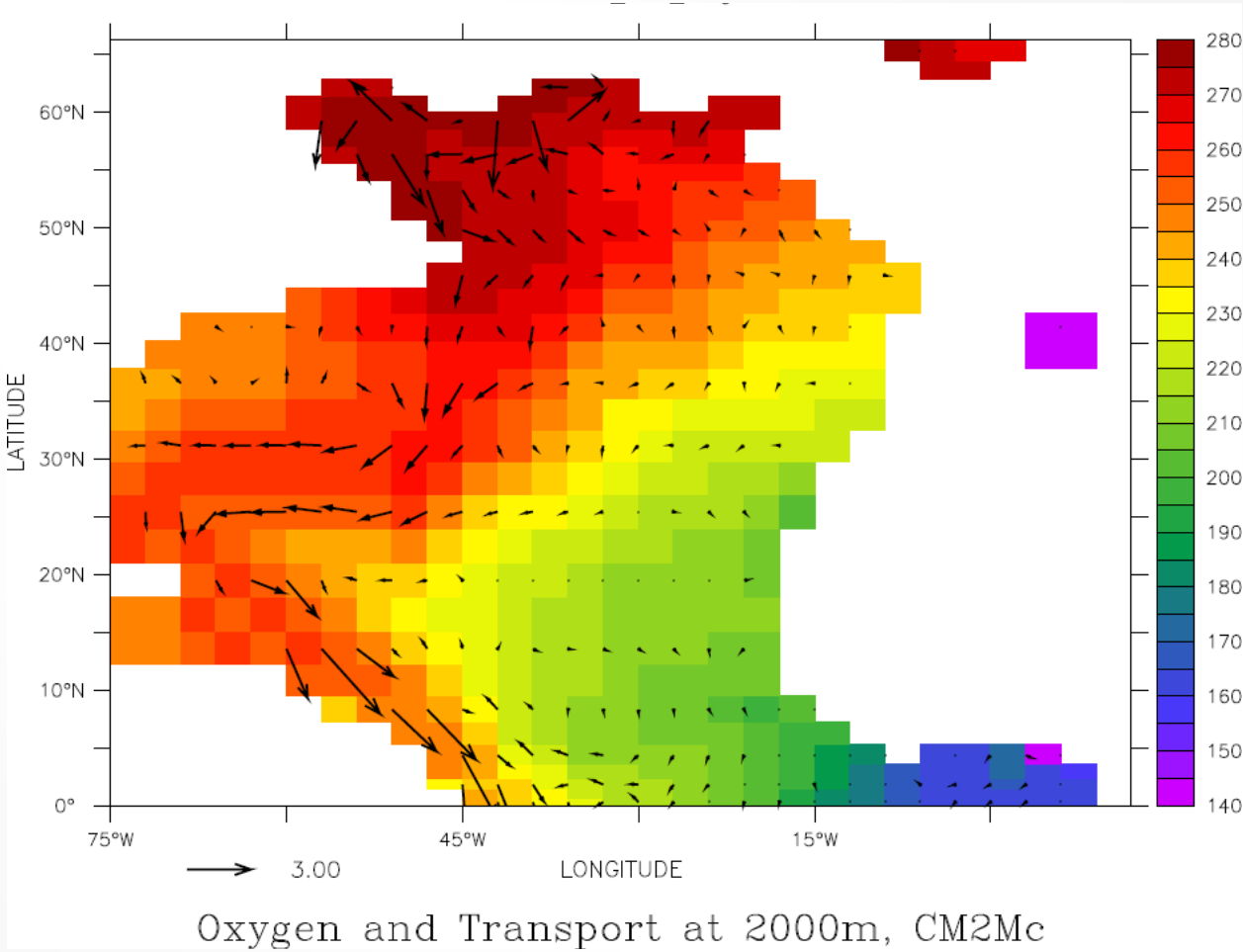
BACKGROUND

- Direct time series measurements of the AMOC are limited due to challenges in measuring the overturning
- Find data that correlates with overturning and has a longer time series
  - Transient tracers – Oxygen Concentration
- Hypothesize that a snapshot of transient tracers is a better measure of low frequency variability in the overturning than snapshots of the overturning itself

OVERTURNING IN THE ATLANTIC: COARSE-RESOLUTION GFDL MODEL



Atlantic Oxygen and Overturning, CM2Mc

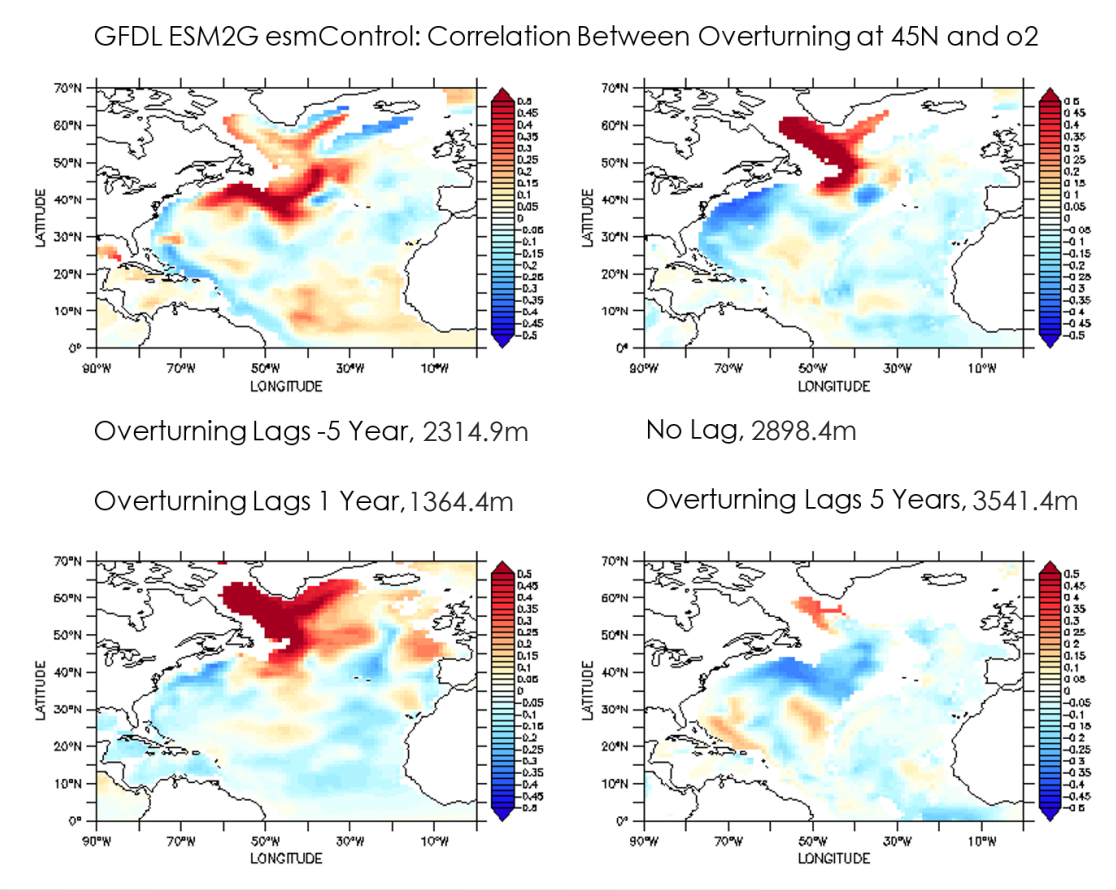


Oxygen and Transport at 2000m, CM2Mc

OBJECTIVES & DATA COLLECTION

- Can oxygen concentration be used to describe ocean overturning
  - at different latitudes?
  - in different models?
  - Is correlation with overturning consistent?
  - Is o2min data sufficient?
- Data obtained from ESGF P2P and GFDL data portals
  - Oxygen variable used:
    - from ESGF database, *o2min*
    - from GFDL database, *o2 – dissolved oxygen concentration*

GFDL ESM2G: esmControl



GFDL ESM2G esmControl

In GFDL ESM2G…

Very high correlations between oxygen and annually smoothed overturning at 45N seen in Northwest Atlantic

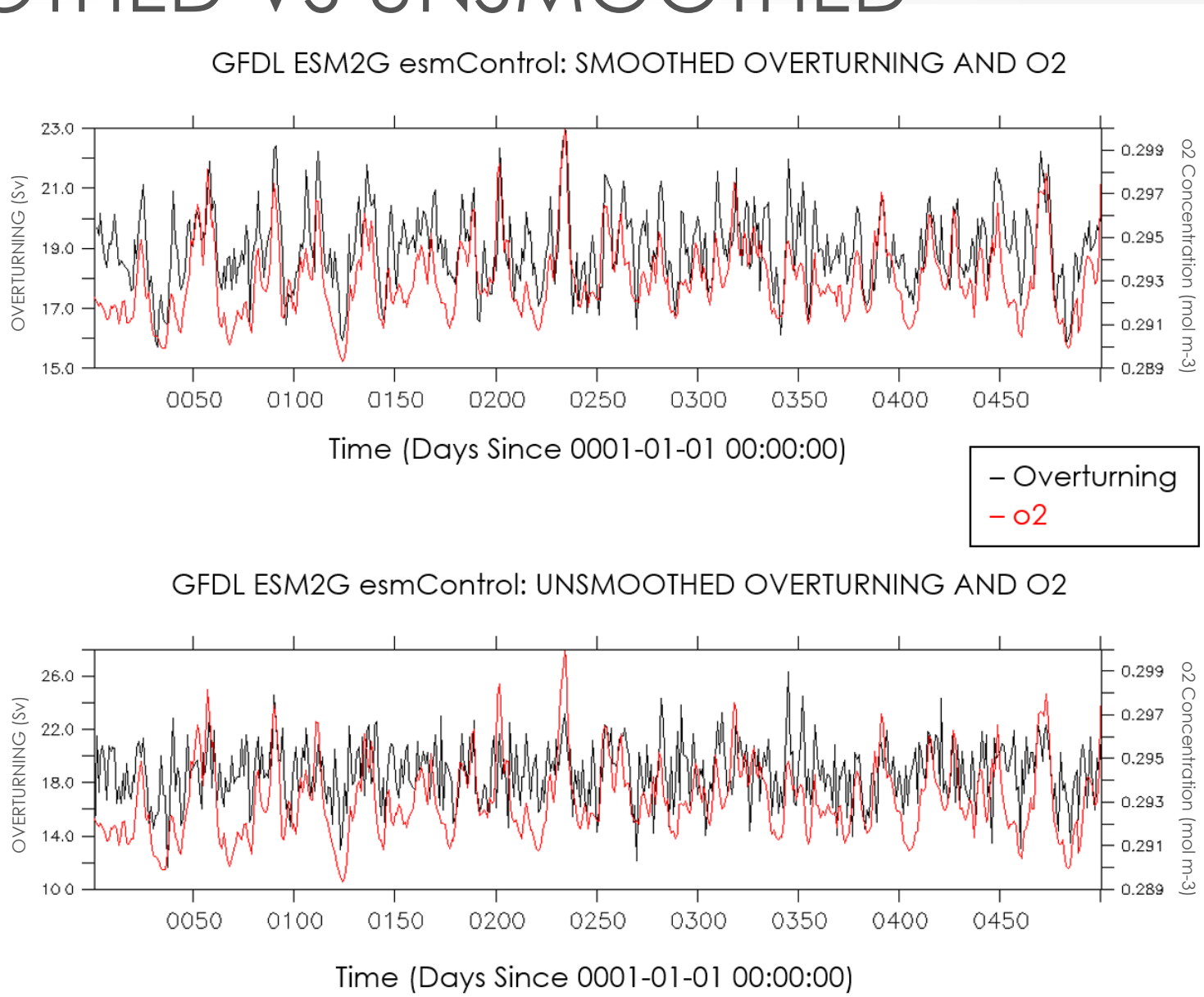
Biggest correlation seen with 1 year lag.

TIME SERIES: SMOOTHED VS UNSMOOTHED OVERTURNING

Oxygen Smoothed over Labrador Sea

Top: overturning is smoothed: R=0.731

Bottom: overturning unsmoothed: R = 0.445

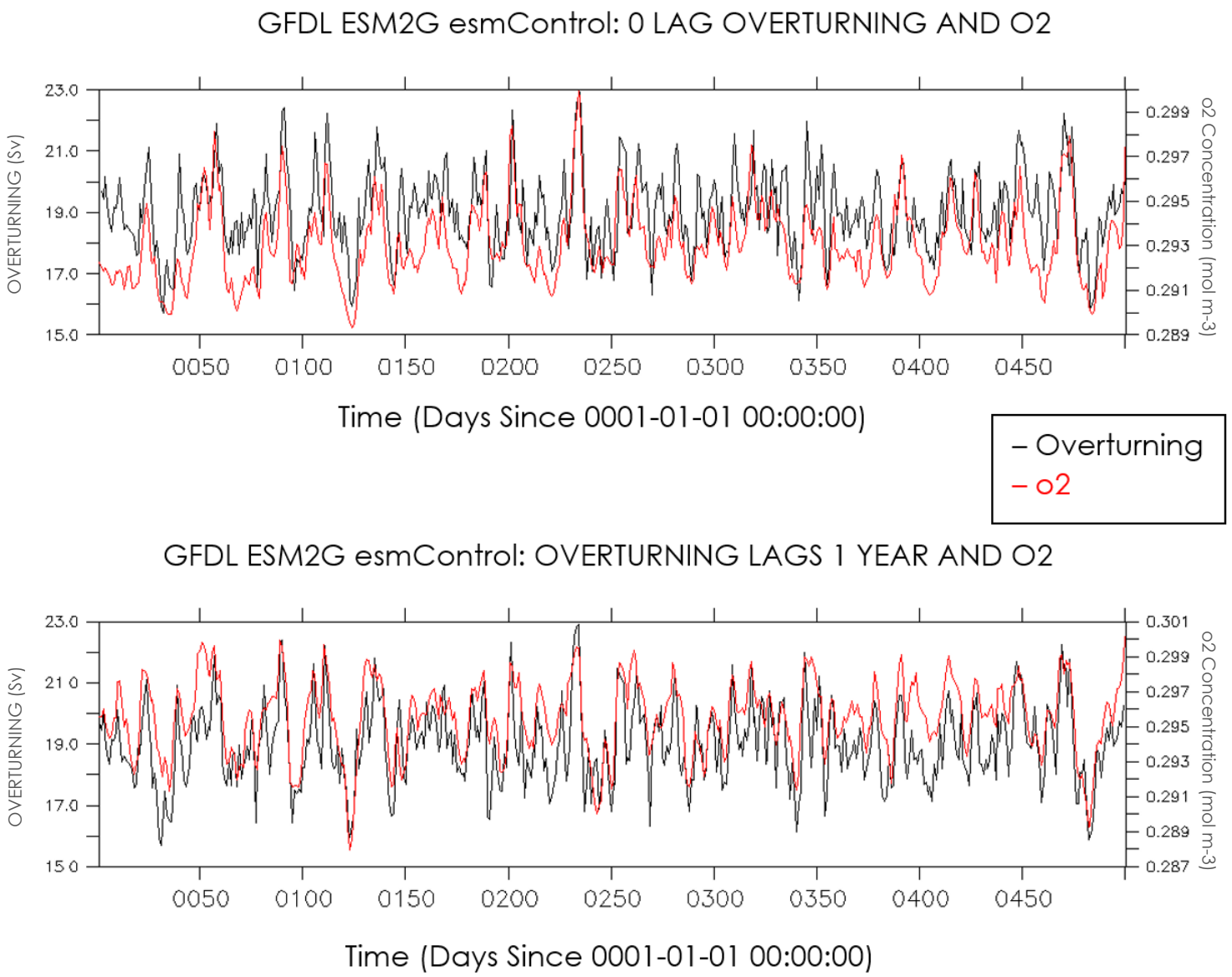


TIME SERIES: OVERTURNING LAGS 1 YEAR

Oxygen smoothed over Labrador Sea

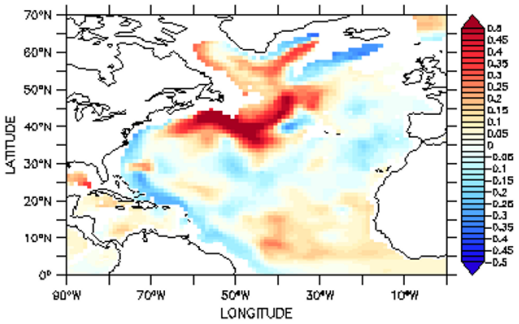
Top: no lag:
R = 0.731

Bottom: overturning lags 1 year:
R = 0.780

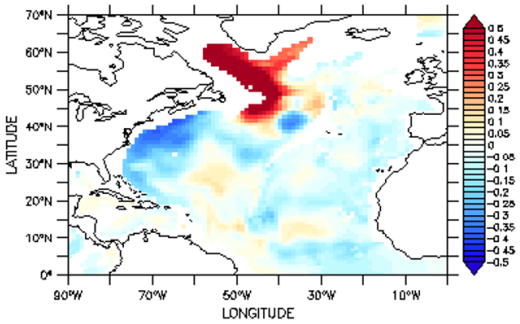


esmControl: GFDL ESM2G and ESM2M

GFDL ESM2G esmControl: Correlation Between Overturning at 45N and o2

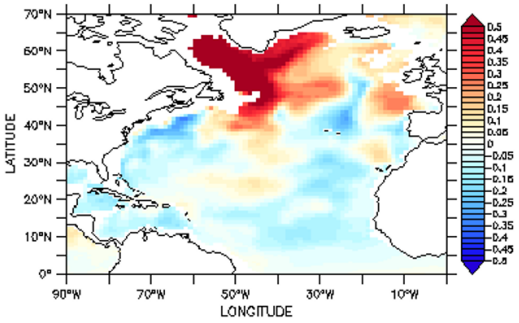


Overturning Lags -5 Year, 2314.9m

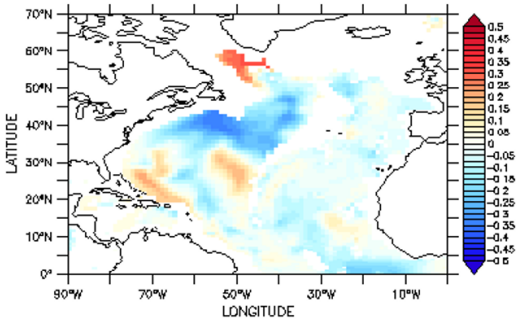


No Lag, 2898.4m

Overturning Lags 1 Year, 1364.4m

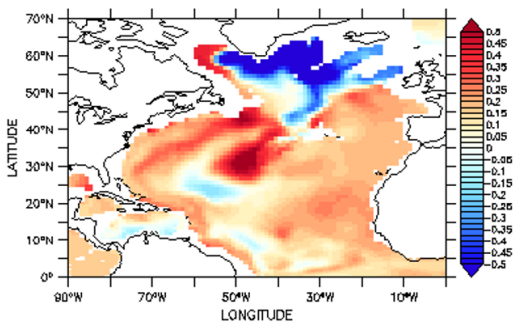


Overturning Lags 5 Years, 3541.4m

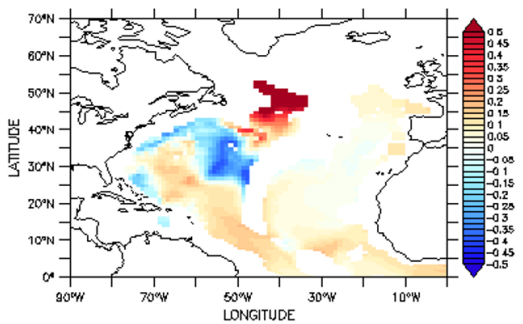


GFDL ESM2G esmControl

GFDL ESM2M esmControl: Correlation Between Overturning at 45N and o2

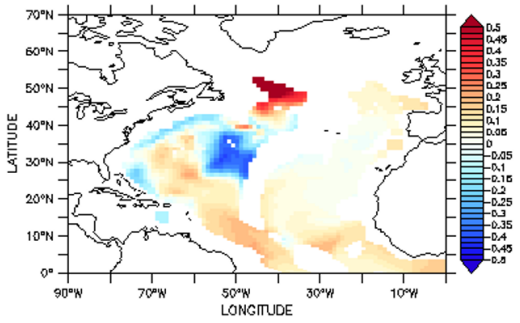


Overturning Lags -5 Year, 2048.8m

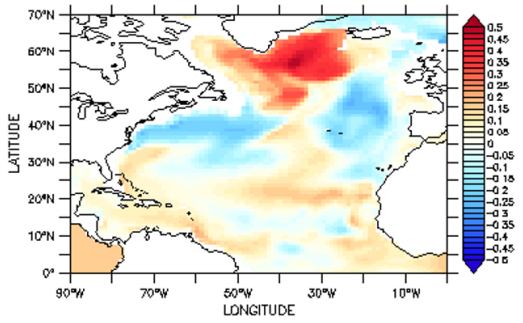


No Lag, 4230.6m

Overturning Lags 1 Year, 4230.6m



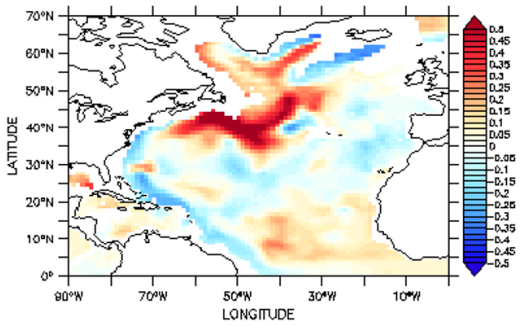
Overturning Lags 5 Years, 858.4m



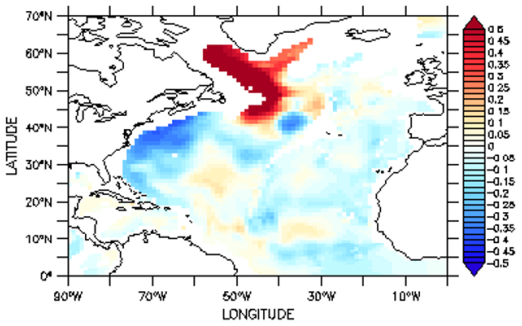
GFDL ESM2M esmControl

ESM2G esmControl: o2 and o2min

GFDL ESM2G esmControl: Correlation Between Overturning at 45N and o2



Overturning Lags -5 Year, 2314.9m



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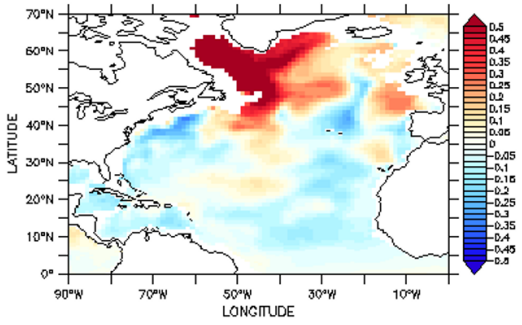
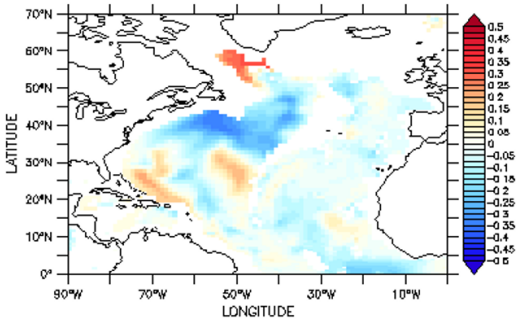
Overturning Lags 1 Year, 1364.4m

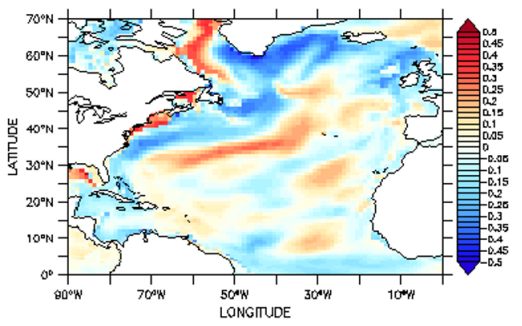


Overturning Lags 5 Years, 3541.4m

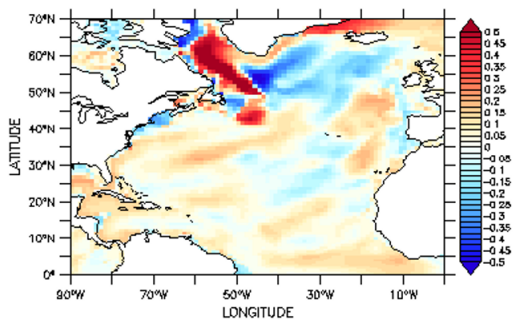


GFDL ESM2G esmControl o2

GFDL ESM2G esmControl: Correlation Between Overturning at 45N and o2min

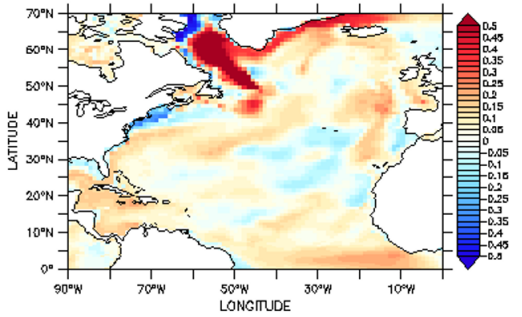


Overturning Lags -5 Year

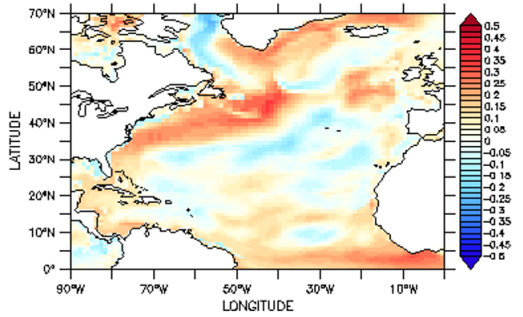


No Lag

Overturning Lags 1 Year



Overturning Lags 5 Years

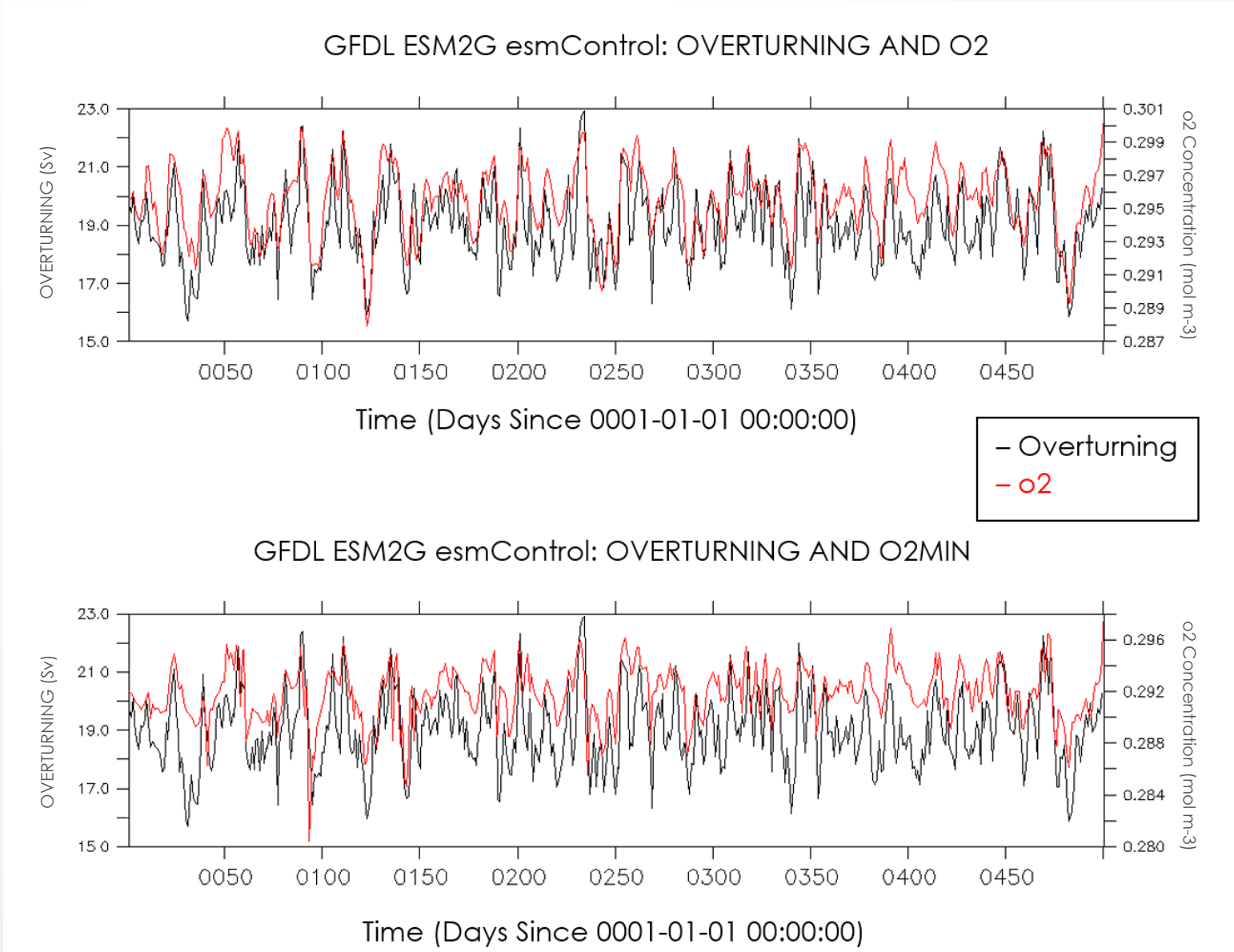


GFDL ESM2G esmControl o2min

TIME SERIES: o2 Concentration vs o2Min

Top: o2 concentration at optimal depth and lag: R = 0.780

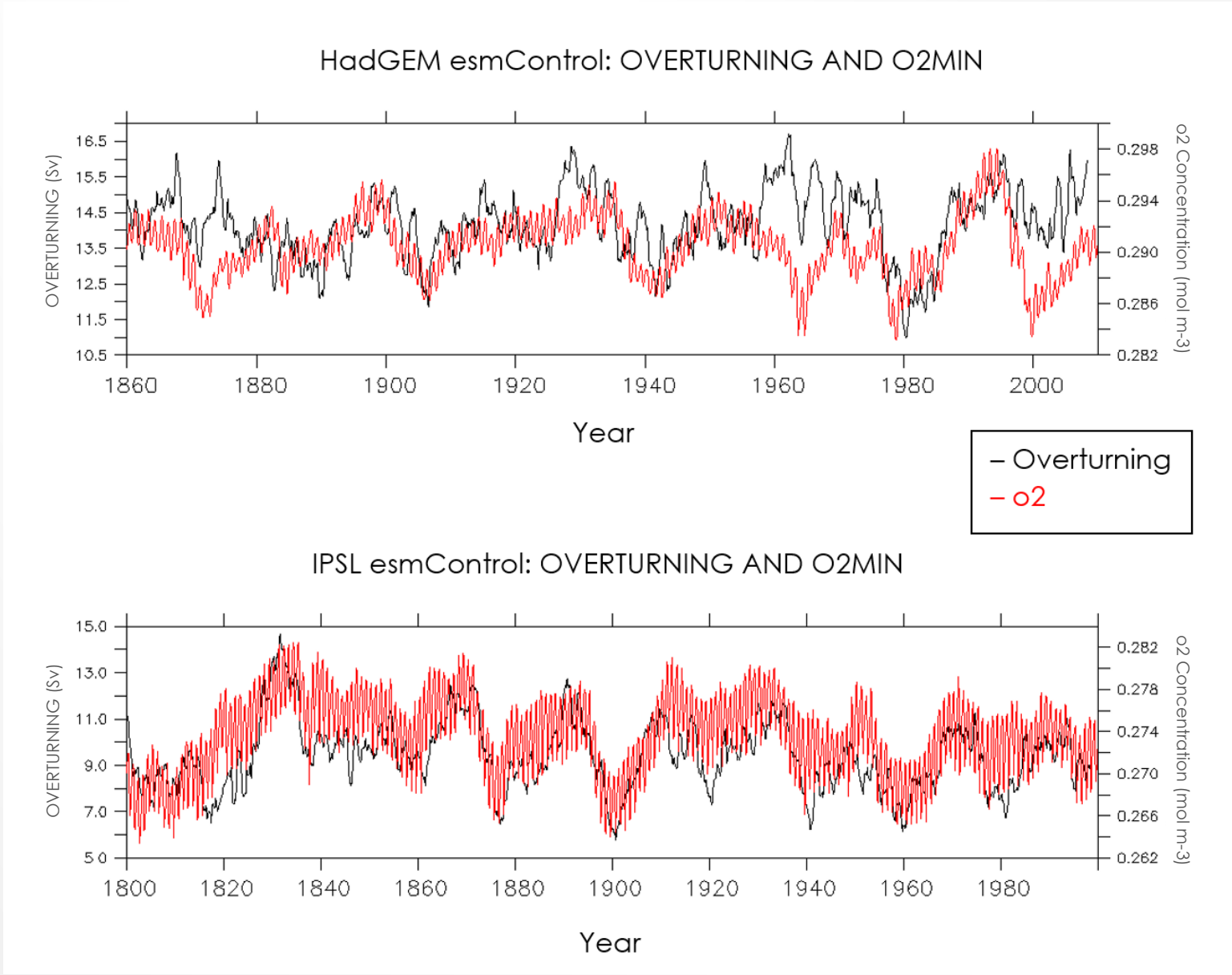
Bottom: o2min at optimal lag: R = 0.658



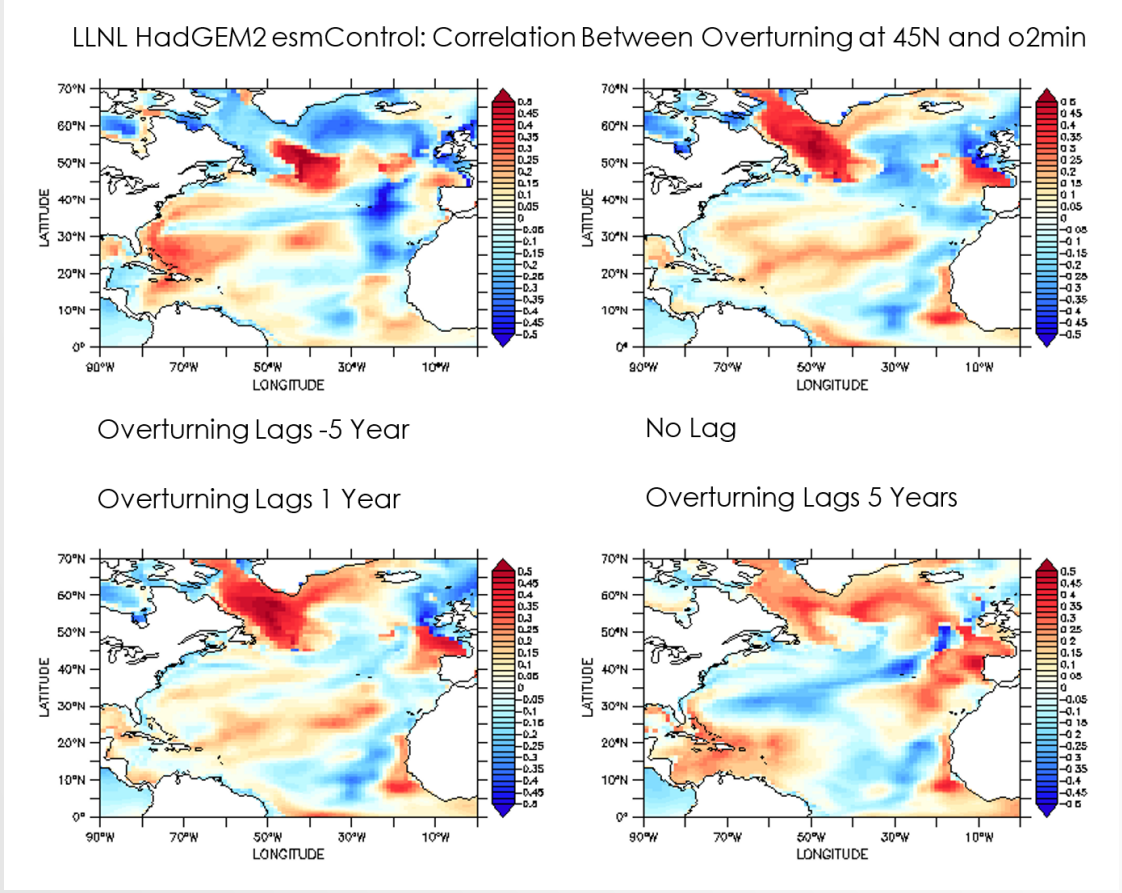
TIME SERIES: HadGEM2 vs IPSL CM5

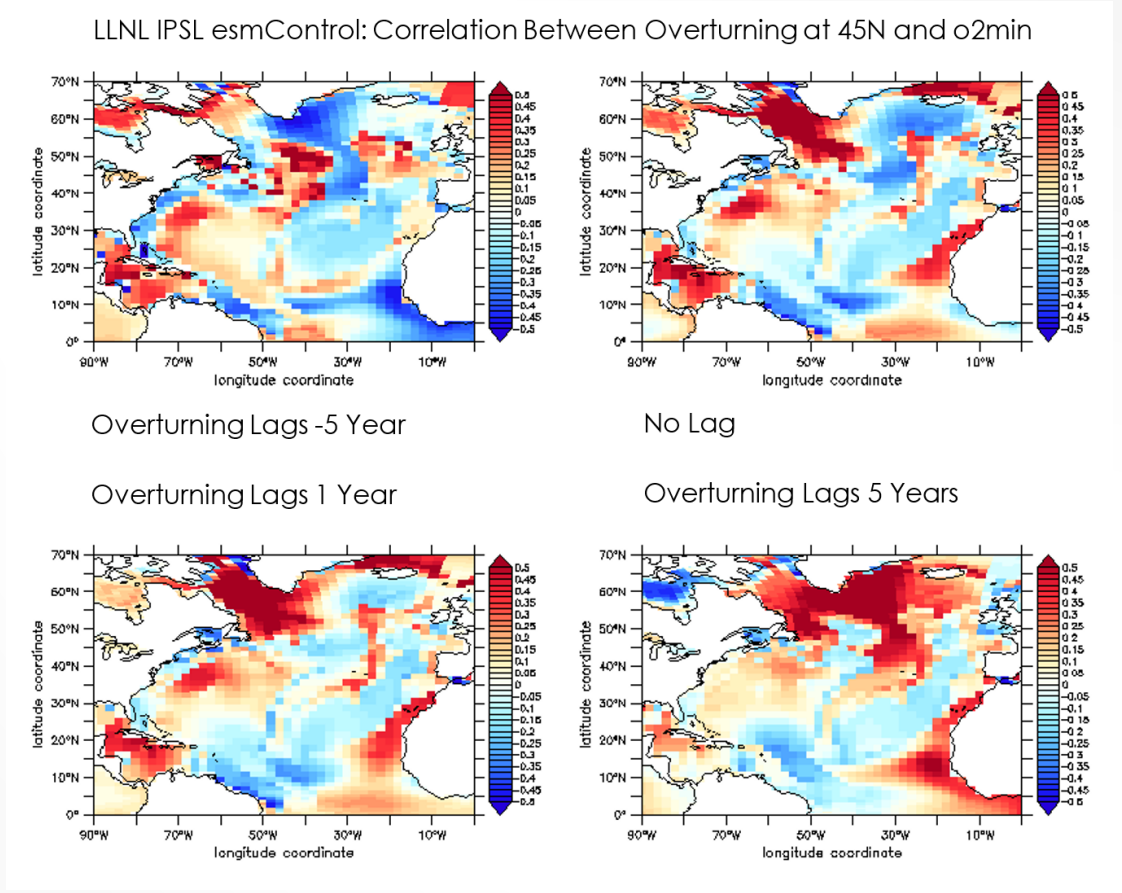
Top: HadGEM at optimal depth and lag: R = 0.304

Bottom: IPSL at optimal depth and lag: R = 0.580



esmControl: HadGEM2 and IPSL



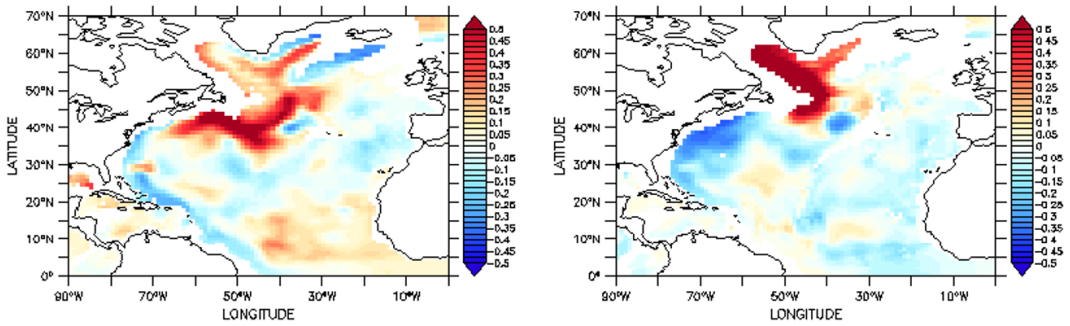


HadGEM2 esmControl

IPSL-CM5 esmControl

GFDL ESM2G: esmControl and esmHistorical

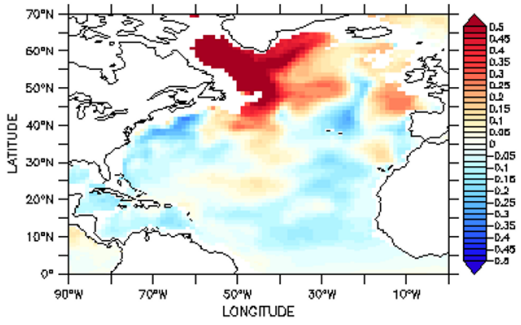
GFDL ESM2G esmControl: Correlation Between Overturning at 45N and o2



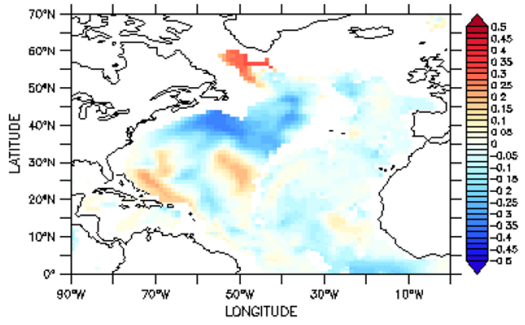
Overturning Lags -5 Year, 2314.9m

No Lag, 2898.4m

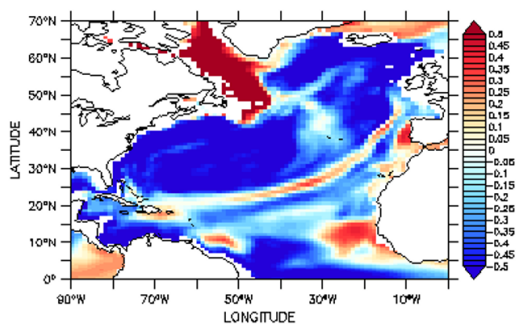
Overturning Lags 1 Year, 1364.4m



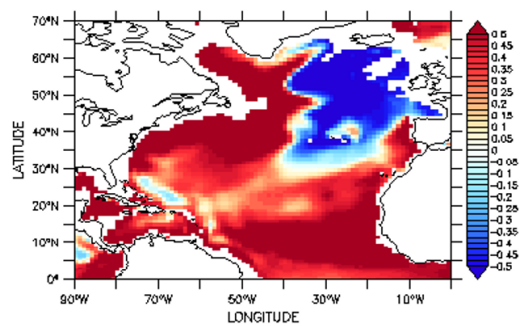
Overturning Lags 5 Years, 3541.4m



GFDL ESM2G esmHistorical: Correlation Between Overturning at 45N and o2

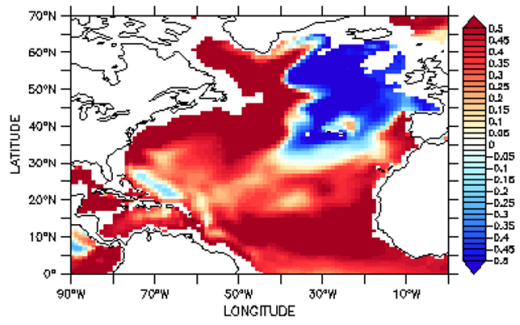


Overturning Lags -5 Year, 298.3m

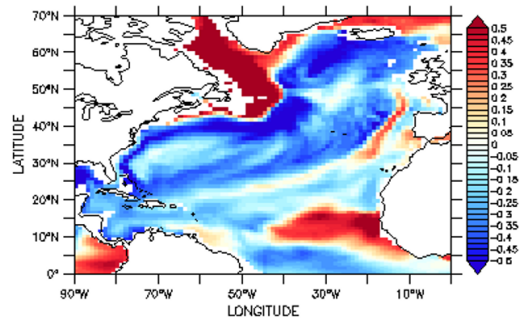


No Lag, 1573m

Overturning Lags 1 Year, 1573m



Overturning Lags 5 Years, 384.6m



GFDL ESM2G esmControl

GFDL ESM2G esmHistorical

OBSERVED TRENDS

- Smoothed overturning results in higher correlation with o2 and o2min than unsmoothed correlation
- Maximum correlation occurs
  - when overturning lags o2 or o2min by 1 year
  - when depth is below 384.6m
- Labrador Sea shows high correlation across models
- o2min correlation with overturning is not as high as o2 correlation with overturning
  - However, o2min correlation does show areas of high correlation and effects of lags

DISCUSSION

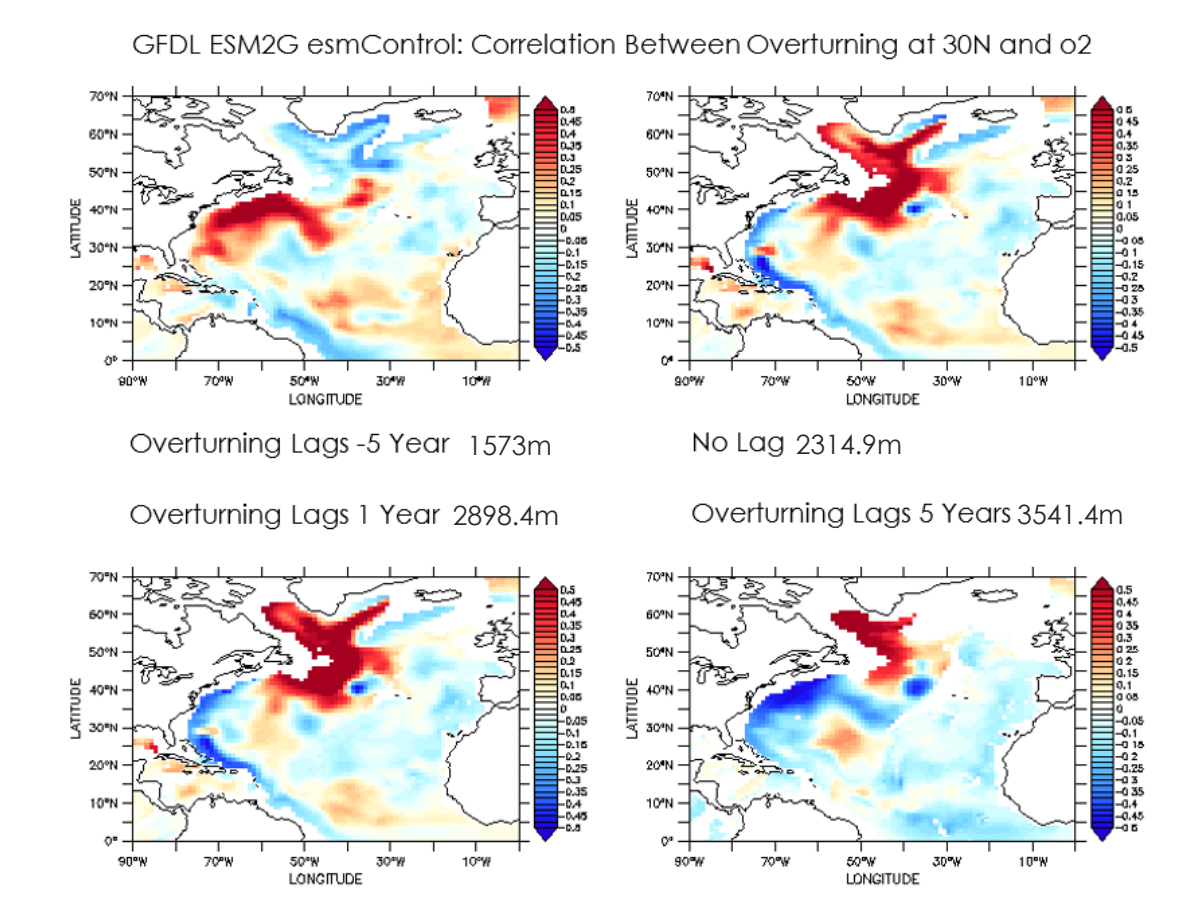
- Are the models robust?
  - Correlation between overturning and oxygen concentration shows similar signals across models
  - But signals are different outside Labrador Sea.
  - ESM2M and ESM2G (same atmosphere, sea ice, biology, different ocean) show different signals.

CONCLUSION & FURTHER DIRECTION

- Oxygen shows promise as index of overturning circulation…
- …But primarily in Labrador Sea.
- Profiling oxygen floats can add important information to oxygen
- Examining observed oxygen changes in GLODAP dataset.

QUESTIONS?

OVERTURNING AT 30N



TIME SERIES: OVERTURNING LAGS 5 YEARS

Top: no lag
Bottom: overturning lags 5 years