Understanding the Centennial O_2 Changes in the North Atlantic Ocean simulated by the CMIP5 Earth System Models

Tagklis F. [1] , Bracco A. [1] , Ito T. [1] ,

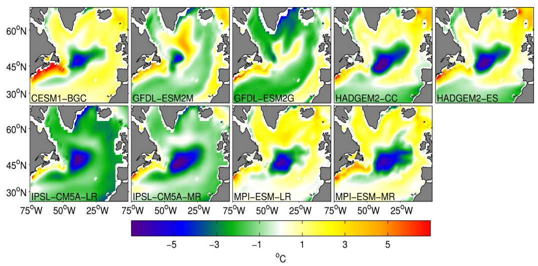
1.School of Earth and Atmospheric Sciences, Georgia Institute of Technology

OBJECTIVES

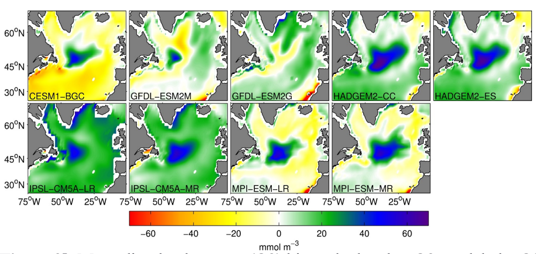
Oxygen is fundamental for aerobic life in the ocean, and a decrease in oxygen levels could adversely affect marine organisms and ecosystems. It is not yet well understood what drives uncertainties in O2 projections in the North Atlantic. Here we investigate the mechanisms driving the regional trends of dissolved oxygen in the North Atlantic Ocean as simulated by the Earth System Models from CMIP5 under the RCP8.5 scenario.

MODEL EVALUATION

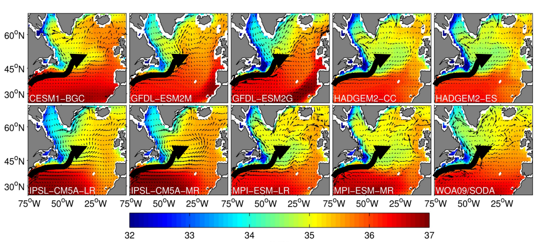
Common patterns of model biases emerge in temperature (T) and dissolved oxygen (DO). The representation of the ocean circulation in the ESMs is responsible for the model biases in T, S and O2 distributions (Figure 3).



[**Figure 1**]: Mean temperature (T) bias calculated as T-modeled – T-observed (from WOA09) over the period 1975-2005 depth averaged between 0 and 700 m.

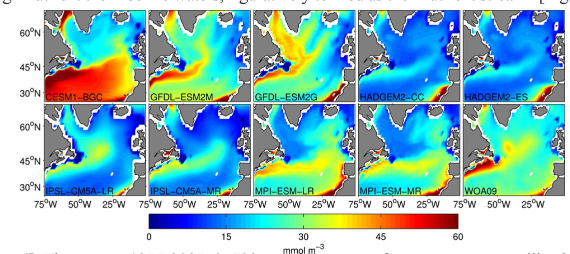


[**Figure 2**]: Mean dissolved oxygen (O2) bias calculated as O2-modeled – O2-observed (from WOA09) over the period 1975-2005 depth averaged between 0 and 700 m.



[**Figure 3**] Time-mean salinity S for the period 1975-2005, averaged over 0–700 meters, with superposed the depth-averaged velocity vectors for all the models and the observations (WOA09/SODA).

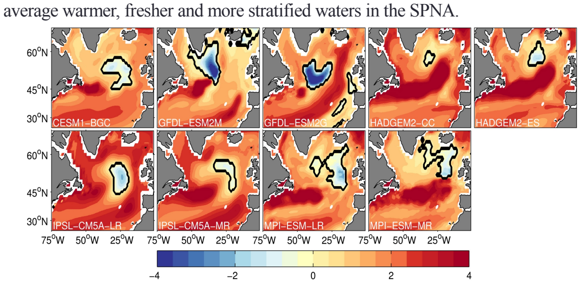
The apparent oxygen utilization (AOU) climatological distribution appears relatively homogeneous over the subtropical and subpolar region (~30 mmolm-3), with maximum values found along the east coast of North America (~60 mmolm-3) and off the shelf along the pathway of the NAC. The elevated AOU values are associated with the transport of high-nutrient thermocline waters, figuratively termed as the "nutrient stream" [Figure 4].



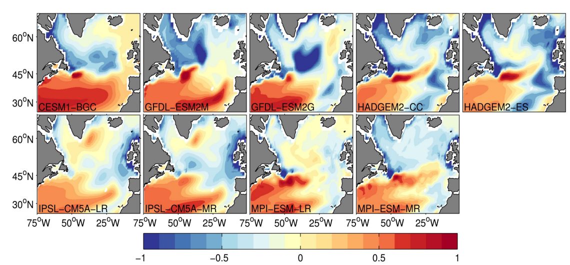
[**Figure 4**]: Time-mean 1975-2005, 0–700 meters average of apparent oxygen utilization (AOU).

CENTENNIAL CHANGE

Centennial changes are quantified by the differences between the 2070 - 2100 and 1975 – 2005 time averages (climatology). Under the RCP8.5 scenario, the models predict on average warmer, fresher and more stratified waters in the SPNA.



[**Figure 5**]: Centennial change of T. All plotted values are 0-700m averages

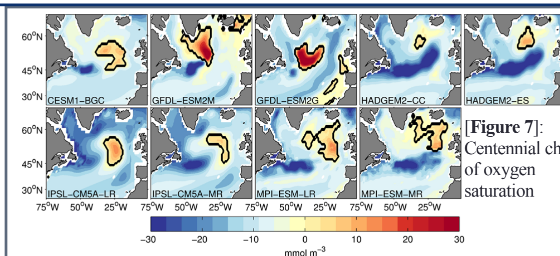


[**Figure 6**]: Centennial change of S. All plotted values are 0-700m averages

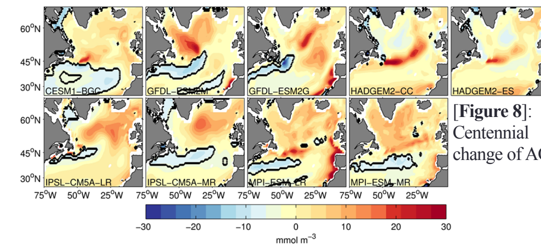
The increasing temperature + freshening (increasing stratification) over this century have important implications for the oxygen budget:

•the reduction of O2 solubility seen by comparing figure 5 with 7.

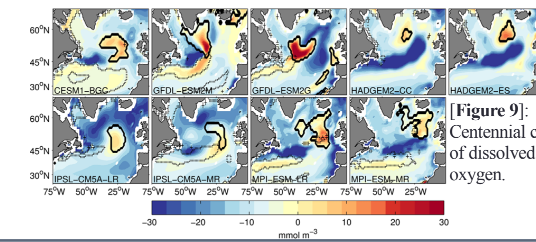
•the suppression of convective mixing at high latitudes that reduces the vertical O2 transport, leading to an increase in AOU (figure 8) and a decrease in O2 in the subpolar gyre in all models (figure 9).



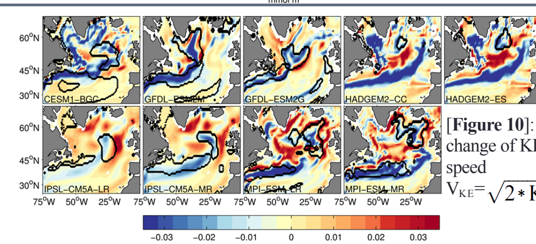
[**Figure 7**]: Centennial change of oxygen saturation



[**Figure 8**]: Centennial change of AOU.



[**Figure 9**]: Centennial change of dissolved oxygen.



[**Figure 10**]: Centennial change of KE cast as a speed $V_{KE}=\sqrt{2*KE}$

- The centennial change of the KE reveals a substantial weakening of the NAC.
- The weakening of the NAC has two consequences:
  - ➢ reduced northward heat transport results in a warming hole in the SPNA, inducing a thermodynamically driven increase in dissolved oxygen.
  - ➢ reduction in the lateral and vertical transport of nutrients being injected in the mixed layer. This in turn induces a lower biologically driven O2 consumption and are responsible for the regional decline in AOU, particularly in the subtropics.

Our analysis suggests a potentially important, coupled physical biogeochemical resistance to the ocean deoxygenation in global warming scenarios.