Interannual Variability of Ocean Mixing and Biogeochemistry in the North Atlantic Ocean.

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Using illustrations from numerical models and remotely observed data, we examine how interannual variability of upper ocean mixing modulates productivity and air-sea gas fluxes in the North Atlantic. We comment on the contribution of North Atlantic variability on the global scale.

New production in the North Atlantic is modulated on the gyre scale by interannual and decadal changes in convective mixing. Observations have shown that winter mixing is enhanced in the subpolar North Atlantic, and diminished in the western subtropics, during periods of positive North Atlantic Oscillation (NAO) index, and vice versa.

Our models suggest that new and export production behave consistently with the strongest correlation between the NAO index and new production in the subpolar gyre.

Primary production is modulated by variations of both nutrient and light availability (and other factors). Remote observations and numerical models suggest that the North Atlantic “spring bloom” is enhanced in the nutrient limited, subtropical gyre by increased storminess and upper ocean mixing in the bloom period (winter), associated with a low NAO index.

Conversely, the bloom is retarded by increased bloom-period mixing in the light limited subpolar gyre. However, the subpolar bloom occurs in late spring and summer and this season has no systematic, large scale patterns of variability related to the NAO index. Hence interannual variability of the bloom in the subtropical gyre shows a clear relationship with year-to-year changes in meteorological forcing but the subpolar bloom does not.

In contrast to the expectation for new production, we suggest that there will be a signature of the NAO in the subtropical bloom, but not the subpolar. This can be tested as the time-series of remote ocean colour observations is extended.

Air-sea fluxes of CO_2 and O_2 in the North Atlantic are also modulated by the variability of convective mixing. The dominant effect is the year-to-year change in the exposure of carbon rich, oxygen depleted waters of the thermocline. Local changes in new production have less impact, partly due to light limitation in the subpolar gyre.

The response of the air-sea flux of CO_2 to changes in winter mixing is damped due to its long air-sea equilibration timescale, but there is a significant, basin-scale, interannual variability of air-sea O_2 flux. In a global biogeochemical model the interannual variability of the global, annual flux of O_2 across the sea surface feels contributions of comparable magnitude from the Tropical Pacific and North Atlantic. Variability of the annual CO_2 flux is dominated only by the Tropical Pacific. The global O_2 flux, and its North Atlantic contribution, are significant for interpretations of trends in atmospheric O_2/N_2 which are used to infer the oceanic and terrestrial sinks of fossil fuel CO_2. These methods presently assume that there is no net annual flux of O_2 across the sea surface.