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Response of the western North Atlantic to seasonal variability in the Southern Ocean

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The huge seasonal variability in Antarctic sea ice distribution and concentration is well known. As a result the air-sea fluxes of heat, freshwater and momentum fluxes are strongly modified seasonally. In this study we conduct two experiments with the NEMO ocean general circulation model at 1 degree horizontal resolution. The first is a control run between January 1989 and December of 1994 forced at the surface by NCEP reanalysis. The second experiment was run for the same period of time as the control run, but all external fluxes from/to the atmosphere south of 30S are replaced by annual mean fluxes. The difference between the two experiments results in anomalies of temperature, salinity and other variables. The anomalies south of 30S are created by differences in the surface fluxes. The anomalies north of 30S are created by the influence of the Southern Ocean (SO) on the northern domain (ND). The SO anomalies can affect the ND in two ways (disregarding possible atmosphere influence):

(i) slow propagation of the anomaly signal by currents and turbulence

(ii) fast wave-like propagation of the anomaly signal.

The propagation speed of such waves could be high. For example the barotropic Rossby waves have a wave speed of about 40 m/s.

The results from the experiments show that the anomaly signal starts propagation in the South Atlantic as a barotropic planetary wave, reaching the equator within the first two days and reaching the North Atlantic in a few days. After the wave reflects from the western boundary temperature anomalies (TA) appear quickly, but with very low amplitude.

However, the amplitude of the TA increases with time. Maximum values of TA occur in an area adjacent to the coast over the Southeast Newfoundland Rise (SNR). The highest values of TA can be observed after two or three years at depths between 90 and 200m: usually between 0.3 to 0.6C and occasionally even above that, up to 0.8C and 1.0C.

Mesoscale patches appear after approx. 5 months with characteristic horizontal scales L of about 200-300 km, increasing to about 500 km after 12 months and to approx. 1000 km after 5 years at the depth of 100 m.

There is a strong correlation between TA and salinities anomalies, which supports the interpretation of a wavelike mechanism for the propagation of the anomaly signal.

In the SNR the very cold and fresh Labrador water meets with very warm and salty water originating from the Gulf Stream. This creates very strong temperature and salinity fronts.

Upon reflection on the western boundary/topography reflected Rossby waves have a shorter

wavelength, than the incident waves. Since the restoring force relates to the beta-term, the particle motion associated with these waves is in the horizontal plane and is perpendicular to the direction of wave propagation. In case of strong horizontal temperature/salinity gradients such motion can result in an enhanced anomaly of temperature/salinity. Interaction of the external planetary wave with topography generates internal modes.

In summary, the huge seasonal cycle in the distribution of Antarctic sea ice and vertical heat/salinity fluxes can influence the western North Atlantic over periods of a few years. The strongest signal is observed near the SNR where the shallow water near the western boundary (bottom) meets strong horizontal temperature/salinity gradients.