Impact of Surface Climate Forcing on Interannual Variability of Antarctic Bottom Water in the Weddell Sea

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Abstract:

In broadest terms, Antarctic Bottom Water (AABW) is a dense water mass originating in the polar seas of Antarctica and extending into the global abyssal ocean. Though AABW is formed elsewhere, approximately 60-70% is formed in the Weddell Sea. At hand we have a time series of bottom water potential temperature and velocity dating from April 1999 through January 2007. Of particular interest is the bottom water at mooring M3 near the tip of the Antarctic Peninsula, revealing the coldest and deepest water exported out of the Weddell Gyre. The time series demonstrates consistent seasonal variation, with cold pulses in early winter associated with benthic intensification. However, there are anomalously cold pulses in the years 1999 and 2002 with no marked cold event in the year 2000. It is our goal to understand this interannual variability. Correlations of the potential temperature time series at mooring M3 with climate indices including NINO3.4 and SAM index (defined as difference of zonally averaged sea level pressure [SLP] anomaly at 65°S and 40°S [Gong and Wang, 1999]) peak with indices leading on the order of 14-20 months. Using NCAR-NCEP reanalysis data, maps of correlations of leading SLP anomalies with temperature anomalies at M3 at above mentioned leads are strongly indicative of the spatial patterns of coupled ENSO and SAM impacts, including the summer to fall southeast movement of the pressure center above the Bellingshausen Sea. Due to a strongly out-of-phase relationship between ENSO and SAM amplifying each others effects in the late 1990's (Stammerjohn et al, 2008), we conduct a multivariate EOF analysis of surface forcing including SLP, surface air temperature, surface winds, and sea ice concentration to capture coherent climate variability. The leading mode represents characteristic traits of coupled ENSO and SAM, and is separated nicely from other modes in terms of power, reflecting its unique physical relevance. Its principle component correlates significantly with the time series of temperature anomalies at M3 at a broadly defined 14 month lead, implying a likely relationship between the water mass and surface forcing. Based on surface conditions, lead time, and an approximate mean water velocity of 10 cm/s along an isobath (Gordon et al, 2001) we propose that climate anomalies in the atmosphere and sea ice act upon surface water on the shelf of the Southwest Weddell Sea which ultimately becomes AABW. The path from source to mooring M3 requires a travel time on the order of 8-10 months prior to the cold pulse, fitting with favorable conditions for exporting shelf water (full ice pack and sea-ward winds) in the late winter. To complete the lead time, the water is resident on the shelf for 4-6 months prior to export, implying the initial surface water is shaped by late summer to fall surface conditions of the year prior to cold pulse, which is consistent with observations.