VOLUME TRANSPORT VARIABILITY IN THE NORTHWESTERN WEDDELL SEA SEEN IN A GLOBAL OCEAN MODEL (OCCAM)

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1. ABSTRACT

Our aims focus to better understanding the physical processes (e.g. bottom water formation and variability; Antarctic Slope Front variability) around the Antarctic margins and also the linkage between the continental shelf and slope hydrography variability with changes observed in adjacent deep ocean, as part of the International Polar Year – SASSI (UK) and SOS-Climate (Brazil; www.goal.furg.br) projects. To tackle these questions several sections around the Antarctic continent (Fig. 1) are under investigation from high resolution ocean models and observations. Here, we show only preliminary results of the northwestern Weddell Sea.

2. INTRODUCTION

The Synoptic Antarctic Shelf-Slope Interactions Study (SASSI) project has conducted multidisciplinary studies on the continental shelf and slope at Antarctic margins during the International Polar Year (IPY-2007/09). In summary, during the IPY several countries contributed to SASSI project with short synoptic transects that were undertaken circumpolarly and radiated outwards across the Antarctic continental shelf and slope. One of those is the high sampled WOCE SR4 hydrographic section starting near the tip of the Antarctic Peninsula across the Weddell Sea, which is one of the main areas of Antarctic Bottom Water (AABW) export to the global oceans. As part of the SASSI project and because of the high spatial-temporal resolution available, we have chosen to analyze the 1/12° simulation obtained with the Ocean Circulation and Climate Advanced Modelling (OCCAM) model to investigate the temporal variability of AABW (i.e. Weddell Sea varieties) volume transport in the northwestern Weddell Sea (NWS; Fig. 1).

3. STUDY AREA

The Weddell Sea is the main source area of dense AABW that fills the world oceans at deeper levels [1] contributing to the deeper branch of the meridional overturning circulation. AABW is a mixture of different source waters, which involve sea ice formation and brine rejection, deep convection, entrainment waters and other complex processes of the ocean, atmosphere, and cryosphere [2, 3], occurring on the western and south shelf-slope margins due to interactions between cold and salty shelf waters (e.g. High Salinity Shelf Water and Ice Shelf Water) with warm and salty intermediate waters (e.g. Warm Deep Water – WDW, Modified WDW, and Circumpolar Deep Water). Two AABW regional varieties contribute with cold and dense waters export from the NWS: (i) Weddell Sea Deep Water (WSDW) with potential temperature (θ) between 0°C and -0.7°C and (ii) Weddell Sea Bottom Water (WSBW) with θ>-0.7°C [4]. Here, we investigated the volume transport of AABW varieties with neutral density (γ^n) >28.26 $kg.m^{-3}$ (i.e. enclosing both WSDW and WSBW [1, 5]).

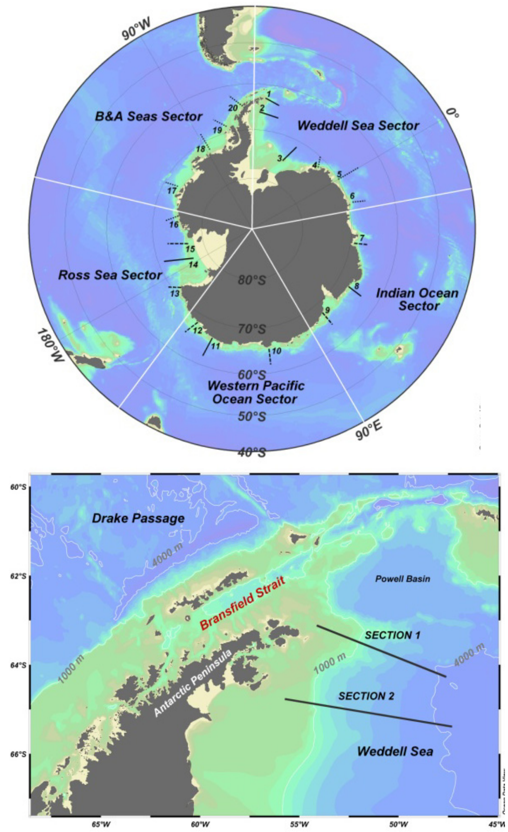

Figure 1. Southern Ocean map showing the sections selected to be investigating around the Antarctic margins for each regional sector (up). Model sections analyzed and discussed here in the northwestern Weddell Sea (bottom).

4. MODEL DATA

This work is based on the simulated results obtained from the high spatial resolution 1/12° eddy-resolving version of the OCCAM model. Although this study focuses on the NWS, OCCAM is a global ocean general circulation model (OGCM) of the Bryan-Cox-Semtner type [6, 7, 8] coupled with a dynamic-thermodynamic sea ice model [9]. There are 66 levels in the vertical, whose thickness increases approximately from 5 m at the surface to 205 m for the deepest layer. The minimum depth is 2.5 m, and the maximum depth is 6365 m. The bathymetry is constructed from references [10] and [11]. The model was run during 20 years, corresponding to the time interval from 1985 to 2004. Details about the model forcing are obtained in references [12] and [13].

5. RESULTS AND DISCUSSION

The mean total full depth cumulative volume transport obtained was respectively 28.6 ± 8 Sv (1 Sv = 10^6 m^3s^{-1}) and 28.7 ± 10 for section 1 (i.e. the western part of the WOCE SR4 section) and section 2 (Fig. 2a, b), this is somewhat lower than the transport (i.e. 46 ± 8 Sv) obtained during the summer 2007 cruise of the Antarctic Drift Experiment Link to Isobaths and Ecosystems (ADELIE) project [14]. On the other hand, this is the mean volume transport considering all the simulated years (i.e. 1988-2004). It is not unexpected that the bottom layer volume transport is also underestimated by the model (i.e. 11.6 ± 4 Sv – section 1 and 10.7 ± 4 Sv – section 2; Fig. 2a, b). The same is true for the volume transport obtained only for the main currents and fronts (i.e. Antarctic Coastal Current – CC; Antarctic Slope Front – ASF; and Weddell Front – WF) present in the NWS. This could be probably associated with the weaker current velocity representation by OCCAM model in the Weddell Gyre [15].

The monthly variability of the total volume transport, considering both the entire section and only the γ^n layers >28.26 $kg.m^{-3}$, shows the maximum (minimum) transport occurring in June (January). Comparing with the results from reference [16], there is a delay of one month in the model. However, the monthly variability of the total volume transport in the model is in phase with sea ice fraction monthly average (not shown) in the Antarctic Peninsula sector (Fig. 1). The annual variability of the total volume transport of section 1 is not in phase with the sea ice parameters (not shown). In contrast, the annual average of the bottom volume transport is ~2 years lagged with both the sea ice fraction and the sea ice thickness variability. Other parameters (as the wind patterns) are under investigation to try to explain these findings.

This is a preliminary study that focuses on better understanding the temporal variability of the bottom water volume transport from the Weddell Sea to the global oceans. Historical and recent (i.e. 2005, 2008-09) hydrographic data (from the Brazilian SOS-CLIMATE project) sampled in the western part of WOCE SR4 section is under investigation and will be used to compare the results with that obtained by model simulation. Thus, additional work is still in progress.

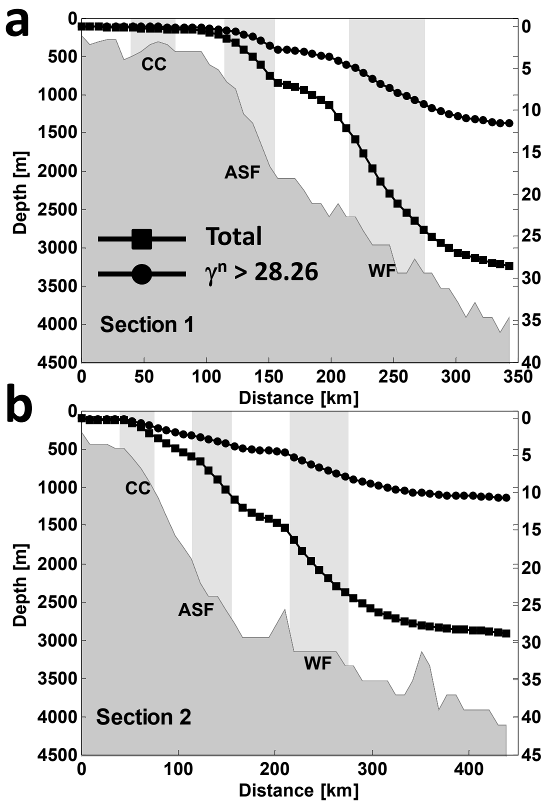

Figure 2. Mean full depth (square) and bottom (circle) cumulative volume transport for each section (as indicated). Grey rectangles indicating the zone of the Antarctic Coastal Current (CC), Antarctic Slope Front (ASF) and Weddell Front (WF).

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