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NUMERICAL INVESTIGATION OF THE WEDDELL SEA DEEP WATER MASSES BEHAVIOR: PRELIMINARY RESULTS

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1. INTRODUCTION

The study of oceans and atmosphere has acquired significant importance to explain the climate variability and climate change. Currently, researchers have used diverse oceanic and atmospheric models to carry out forecasts and try to understand the climate variability and change. Water masses acquire their signatures from atmospheric processes and are therefore excellent indicators of alterations in climatic conditions (Leffanue and Tomczak 2004). Several studies describe the vertical distribution of the hydrographic parameters (potential temperature (θ), salinity) and the water masses based on real observations (e.g. Fahrbach et al. 2004; Kerr et al. 2005). However, these are limited in temporal and spatial coverage. Models are excellent tools to understand oceanic behavior through the 3-dimensional representation of the physical fields but these fields needs to be extensively validated.

This work aims to inter-compare the behavior of simulated deep water masses (below 500m depth) between different models output and the real pattern observed in the oceans, such as that obtained with the WOCE program data. The main objective here is to understand how the ocean internal variability and the interactive ice-model will affect the representation of current oceanic characteristics.

2. METHODOLOGY

Optimum Multiparameter (OMP) analysis (Tomczak and Large 1989) was used to trace the deep water masses in the Weddell Sea (Antarctica). This is the main source region for the global deep and bottom water masses (Orsi et al. 1999). The few available parameters, limited the number of water masses that can be separated with the method.

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The following water masses were considered: Warm Deep Water (WDW), Weddell Sea Deep Water (WSDW) and Weddell Sea Bottom Water (WSBW). Thermohaline index parameters (Table I) used to run OMP were obtained from the NODC/NOAA historical hydrographic dataset for the study area (Figure 1). These are based on the definitions of Robertson et al. (2002). Three different model outputs (Table II) have been analyzed in three different meridional sections (020, 030, 040°W; Figure 1). Only some of them are presented.

Table I – Source water types (SWT), parameters and weights for OMP input.

SWT / Parameter	WDW	WSDW	WSBW	Weight
θ (°C)	0.5	-0.3	-0.9	11.5
Salinity	34.70	34.66	34.64	11.5

Table II – Models output analyzed.

Model	Acronyms	Type	Forced with
POP3	POP	ocean only (1°x1°)	observed 43 years of NCEP/NCAR winds with corrected fluxes over ice-covered regions (Large and Yeager, 2004)
POP3	POP302	ocean only (1°x1°)	repeat annual cycle of observed NCEP/NCAR winds and fluxes
POP3	POP401	ocean model coupled to an interactive ice-model (1°x1°)	repeat annual cycle of observed NCEP/NCAR winds and fluxes

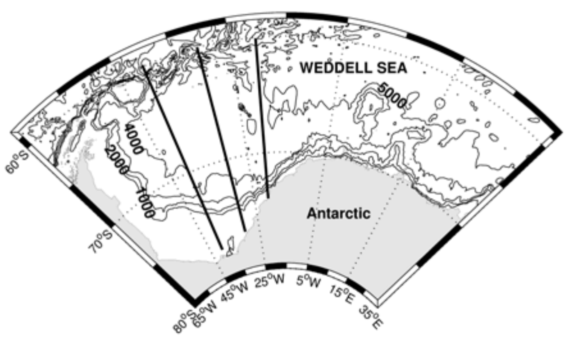

Figure 1 – Models sections position selected.

3. RESULTS AND DISCUSSION

The preliminary results show a good correlation between the present observed WOCE distribution (see Figure 2 in Kerr et al. 2005) and the results obtained by POP401 (Figure 2), indicating the importance of including an ice-model in order to represent the dense water masses. Although the analyzed sections are not the same, we can observe in the output of POP401 the occurrence of the WDW up to 2000m deep, WSDW occupying the layer between 1500-3500m with contribution higher than 50% and WSBW confined in the deep oceanic basin (Figure 2). This distribution is similar to that described in the scientific literature.

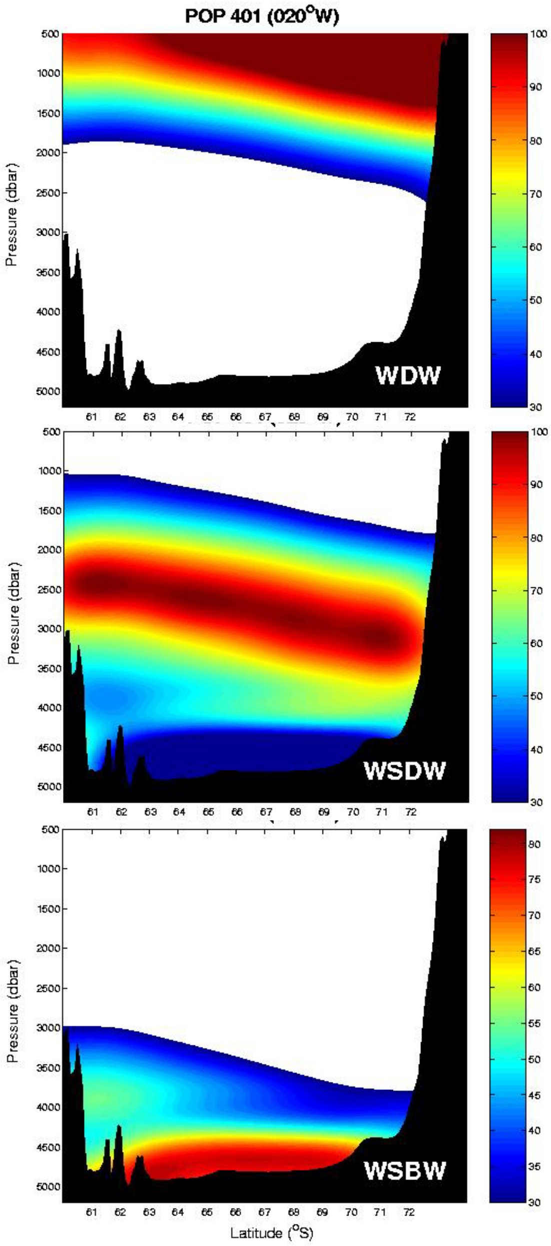

Figure 2 – Weddell Sea water masses distribution based on POP401 output at section 020ºW.

The analysis of the other two ocean-only models (POP and POP302) reveals an overestimation of the WSBW. POP output results are not shown. The water masses distribution obtained for the POP302 simulation results is presented in Figure 3. Furthermore, while the WDW core is well defined, one can observe that WSDW distribution is underestimated with respect to field observations. This may be associated with the parameters indices used, possibly the salinity indices.

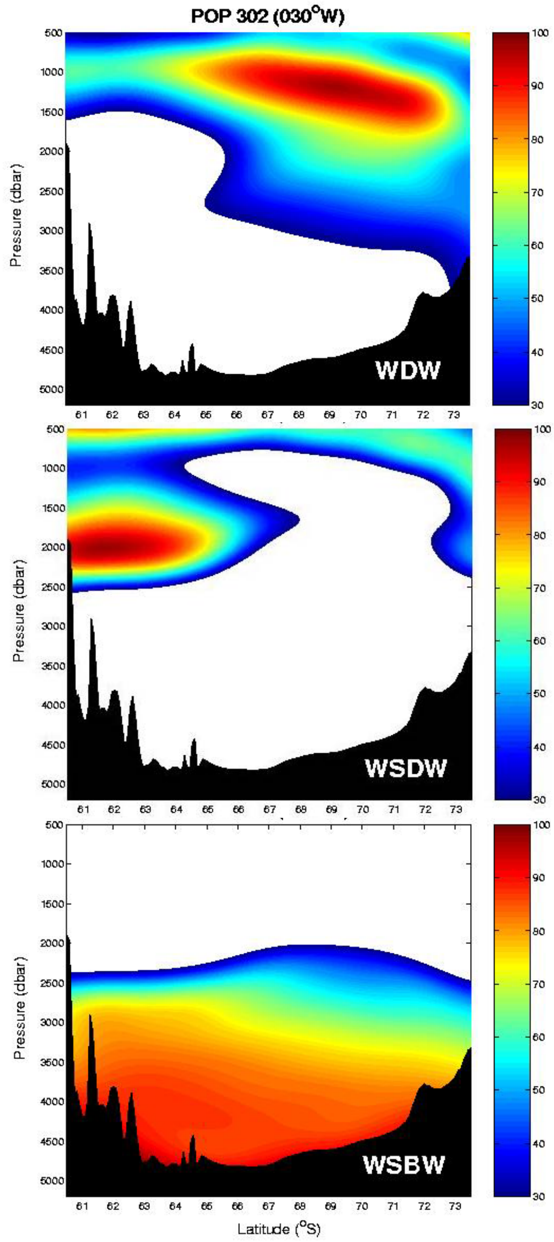

Figure 3 – Weddell Sea water masses distribution based on POP302 output at section 030ºW.

The analysis for the POP401 results shows a good representation of the water masses distribution. Nonetheless, care has to be taken in the interpretation of these results: the POP401 temperature profile (Figure 4) shows values slightly higher (~0.2ºC) than those observed in the real oceans. The temperature profile obtained with the POP302 results (Figure 4), on the other hand, shows values similar to the real ocean. The distribution of the water masses is traced by the OMP analyses really well, despite slightly different absolute values of temperature.

The salinity profiles presented by the different simulations have values with fewer gradients. Furthermore, the indices values that differentiate the water masses are too near.

Results may be improved if a different definition for source water type (SWT) is used within the OMP analysis. Thus, the TS structure for each case has to be examined.

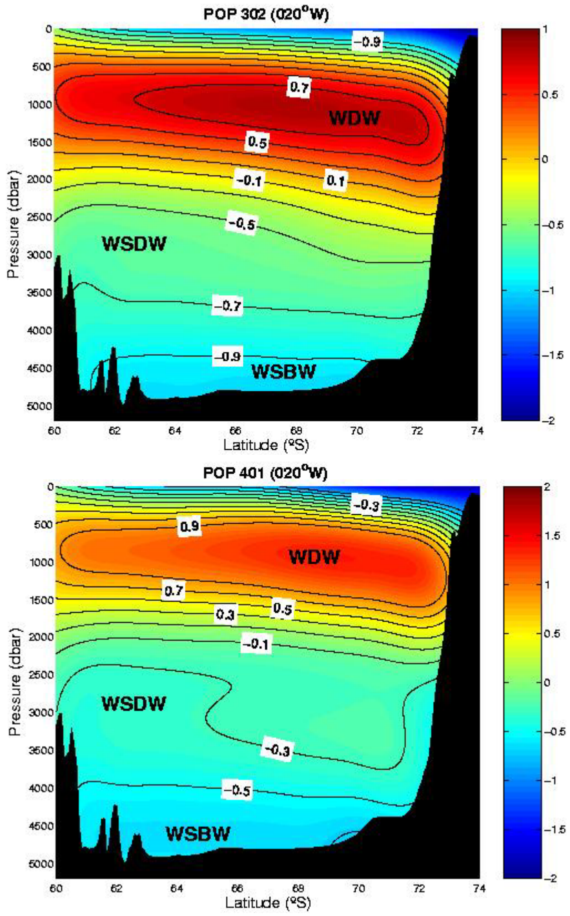

Figure 4 – Temperature profile extracted by output POP302 (upper) and POP401 (bottom).

Considering the sub-sampling in the WOCE data, model output is also compared to the SODA ocean assimilation product (Carton et al. 2000a; 2000b). The water masses distribution based on these dataset (not shown) reveals a very good resemblance with the real pattern observed in the Weddell Sea.

4. CONCLUSION

Improvement of the physics associated with oceanic processes represented by numerical models is the constant object of intense research. The preliminary results presented in this work show the importance of the inclusion of the sea ice dynamics in order to increase the representation of the deep water masses in the Weddell Sea and the performance of OGCMs.

However, some alterations in the SWT index parameter probably will modify the water masses distribution estimated from model simulations. Potential temperature and salinity indices have to be adjusted in order to account for model biases instead of using historical hydrographic data, to calculate the SWT. The limitation to solve for different water masses with the OMP method may be resolved if more parameters (e.g. oxygen and nutrients) could be obtained from the models.

5. ACKNOWLEDGMENT

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