ON THE DISTRIBUTION AND VARIABILITY OF THE MAIN WATER MASSES ALONG THE PRIME MERIDIAN IN THE WEDDELL SEA, ANTARCTICA*

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Introduction

The complex interaction among ocean, atmosphere and ice in Antarctica affects the global oceanic circulation. Researchers have been highlighting the importance of the oceans in climate variability and climate change, where the water masses act as important reservoirs of heat, salt and dissolved gases (1). The water masses acquire their signatures from atmospheric processes and are therefore excellent indicators of alterations in climatic conditions. Weddell Sea (WS) have an extreme importance for the global ocean circulation, because of its western and southwestern continental shelfs occurs the formation of great volume of Antarctic Bottom Water, responsible for ventilation and consequent renewal of the bottom waters in all oceans, due mainly to accentuated interaction among atmosphere, ocean and ice (2; 3; 4).

Recently, besides the traditional methods used for water masses analysis, other methods have also been used more frequently providing new tools for water masses study, such as: numerical modelling, that is capable to identify formation areas and possible water masses pathways; and inverse methods capable to extract information on the water masses from different groups of hydrological and chemical data, as nutrients and other tracers. In this last group is included the Optimum Multiparameter (OMP) analysis method (5), which will be used in this work.Thus, the present study aims to describe the distribution and variability of the main water masses present in the WS along the prime meridian.

Metodology

OMP analysis is based on the supposition that the mixing processes that involve the water masses are linear processes and affect all parameters equally (5). OMP estimates the best contributions of all source water types (SWT) for each sample and allows to evaluate the spatial and structural distributions of the water masses. The oceanic circulation can be later iferred by the distribution of those water masses. Only two physical restrictions exist for the employment of the method: the first is that the contribution of all SWT has to be sum 100%, in other words, is considered the mass conservation, and second that this contribution cannot be negative.

We apply OMP analysis to the NODC/NOAA historical dataset, and consider the following parameters as tracers: potencial temperature, salinity and dissolved oxigen. The following water masses were considered: Warm Deep Water (WDW), Weddell Sea Deep Water (WSDW) and Weddell Sea Bottom Water (WSBW). The index parameters used to characterize the SWT representative of the water masses are presented in Table 1.

SWT/Parameter	WDW	WSDW	WSBW	Weight
Potencial temperature (°C)	0,5	-0,3	-0,9	11,5
Salinity	34,70	34,66	34,64	11,5
Dissolved Oxigen (µM)	212	234	263	11,9
Mass Conservation	**	**	**	11,9

Table 1 - Source water matrix (SWT and parameter definitions for model input).

Results and Discussion

We analyzed four transects along the Greenwich Meridian for years 1984, 1986, 1992 and 1996. In 1984, WDW presented contribution higher than 70% above 1000 m of the water column (Fig.1A). WSDW was faintly present with contribution lower than 50% between 1500 and 2000 m (Fig.1B). WSBW was present to the north and south of Maud Rise (64°S-67°S), with contribution varying between 70-100% and 70-80% below 3000 m (Fig.1C), respectively, although the literature suggests that WSBW does not occur south of the Maud Rise (Fig. 2). This was the only year analyzed that showed a strong contribution of this water in this area. The year of 1986 presented a smaller contribution (>60%) of WDW above 1000 m (Fig.1D). The WSDW core (>70%) was present between 1000-3000 m (Fig.1E). WSBW only obtained significant contribution (>70%) below 3000 m (Fig.1F). In 1992, WDW presented similar distribution than year 1984 (Fig.1G). WSDW was more strongly marked than year 1984, between 1000-3000 m with contribution higher than 70% (Fig.1H). WSBW below 3500 m contributed for more than 70% (Fig.1I). In 1996, WDW was present above 1000 m with contribution higher than 70% (Fig.1J). WSDW presented a larger distribution than the previous years with contribution higher than 70% between 1500-3000 m (Fig.1L). WSBW had more restricted distribution than the previous years, reaching more than 60% only below 4000 m (Fig.1M).

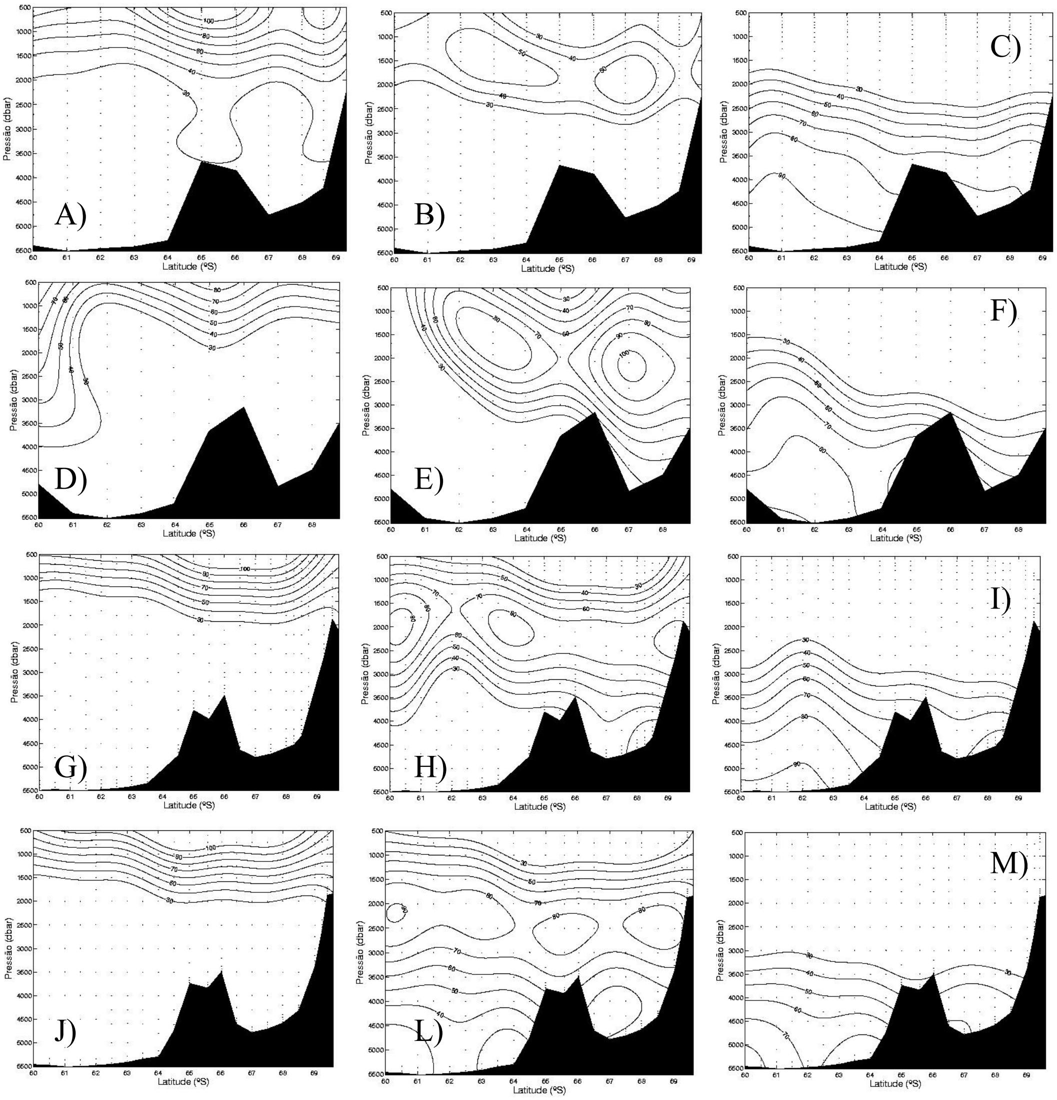

Figure 1 – Distribution (%) of WDW (A, D, G, J), WSDW (B, E, H, L) and WSBW (C, F, I, M) at years 1984, 1986, 1992 e 1996, respectivally.

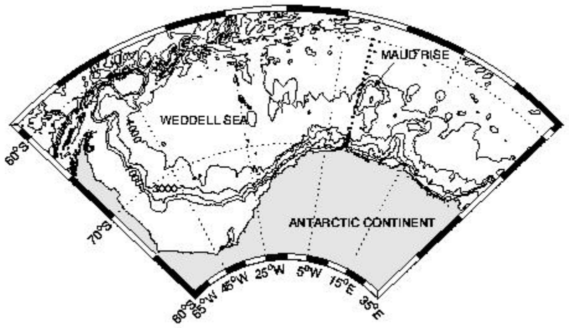

Figure 2 – Location of the hydrographic sections across the Weddell Gyre along the prime meridian.

A substantial warming of WDW occurred along the Greenwich meridian following the Weddell Polynya of the 1970s (6). The mean warming of WDW along this section was of ~0.032 °C per decade, comparable to the warming of the Antarctic Circumpolar Current (ACC). That suggests the variation in the inflow as possible explanation for cooling event between 1984 and 1989, and a warming event between 1989 and 1992 (6). Cooling during the late 1990s is probably related with the reappearence of a polynya close to Maud Rise (6). The cooling effect was discussed by Gordon (7), and the subsequent warming was described by Robertson *et al.* (8) and Fahrbach *et al.* (9). The WDW properties along the prime meridian vary in temporal and spacial scales. However, the northern end (60-62 ºS) display small changes in long term, that could represent an estimate of the temporal and spatial variations (6), as it can be observed in the distribution of WDW in figure 1 (A,G, J). Smedsrud (6) found a mean thickness of WDW of ~1040 m in this section in 1977, varying between 1350-1380 m from 1984 to 2001. This indicates a mean thickness of WDW about 1600 m between 64 ºS and 69 ºS in 1984 as found in this work. The changes in the WDW thickness is probably caused by variation in the water mass lower limit (6).

WSDW salinity seems to show a rising trend, wich is accompanied by a slight increase of the area occupied by WSDW (9). These authors still report that WSDW variation in potencial temperature over 12 years at the prime meridian were within 0.008 °C. For the WSBW, the same authors (9) show a clear warming trend, where the warming rate was highest in the second half of the 1990 decade, and indicating a decreased in the section area occupied by WSBW. These increase/decrease in the area occupied by WSDW/WSBW may be shown by the WSDW/WSBW distribution obtanied through OMP analysis.

Conclusion

OMP analysis is shown as an excellent tool for water masses mixing studies, consequently, for the distribution and the variability of the water masses in the study area. Besides, we can verify the good reply of the method to estimates the thickness (section area) ocuppied for the water masses, being just considered the contribution of each water mass. The warming trend in the ACC, reported in the literature, was also observed in the data analyzed here and is probably related to variations in atmospheric forcing conditions. Changes in its source waters (WDW) would also lead to changes in WSDW and WSBW properties.

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