船舶断面観測から推定する南極深層水生成量

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Antarctic Bottom Water production estimated by hydrographic observations

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The shelves around the Antarctica are the source region for the Antarctic Bottom Water (AABW), which is widely observed in near-bottom depths in the world oceans. The outflow of AABW comprises the deepest branch of the meridional overturning circulation and thus plays an important role in the heat and salt transport by the ocean currents. The outflow of AABW is also believed to be associated with the recently-observed warming in the North Pacific bottom waters (Masuda *et al.*, 2010) via fast wave dynamics. The quantitative estimate of the production rate of AABW is, however, difficult. Among others, paucity of winter *in situ* data, difficulty of sea-ice modelling, lack of reliable air-sea fluxes are the complicating factors. We attempted to indirectly estimate the production of AABW using the hydrographic data surrounding the Antarctica (Fig.1) using the box inverse modelling approach.

The present inverse model is different from the previous ones in (1) constraining the 1000-m depth velocity by the geostrophic flow estimated by the drift data of the Argo floats (Katsumata and Yoshinari, 2010) and (2) having a separate “surface box” with a depth of 300 m, representing the near-surface mixed layer. The water exchange between the surface box and the interior represents subduction and upwelling, and is part of the solution.

Using the hydrographic data from 1987 to 2009, it is estimated that the average subduction, through the 300-m depth, with the neutral density greater than 1028.2 kgm^{-3} (our definition of AABW) is about 10 Sv (1 Sv = 10^6m^{3}s^{-1}) in the Atlantic sector and 2 Sv in the Australian sector. The hydrographic lines shown in Fig.1 were occupied at least twice, once in the WOCE era (from 1987 to 1996) and later in the 2000s (2003 to 2009), making it possible to estimate the variability over the decades. The AABW production estimated for these two periods show considerable reductions although these estimate suffer from rather larger uncertainties with the results not statistically significant. The air-sea fluxes do not show clear trends over the two sectors, but the reduction is consistent with the result discussed in Masuda *et al.* (2010).

For numerical general circulation models, the shelves are known as one of the most difficult regions to accurately reproduce, particularly for models without sea ice, due mainly to the lack of reliable air-sea flux products. The estimated AABW production rates vary amongst the models and do not provide a unified estimate.

With the present data, the indirect methods cannot narrow down these ballpark estimates and efforts should be continued to monitor this important region.

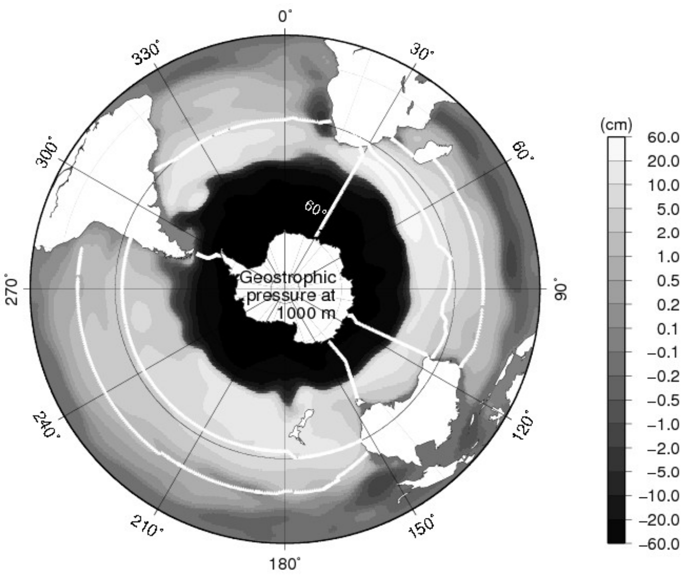

Figure 1. Hydrographic lines used in the box inverse model. The background shade shows the geostrophic pressure (roughly equivallent to the streamline) at 1000 dbar in cm of water column estimated by the drift data of the Argo floats.

References

Katsumata, K., and H. Yoshinari, Uncertainties in global mapping of Argo drift data at the parking level, Journal of Oceanography, 66,553-569, 2010.

Masuda, S. and coauthors, Simulated rapid warming of abyssal North Pacific Waters, Science, 329, 319-322 , 2010.