New findings of Antarctic Bottom Water: Ongoing warming/freshening and a discovered AABW source

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1. Discovery of a missing source of Antarctic Bottom Water

Antarctic Bottom Water (AABW) is the cold, dense water that occupies the abyssal layer of the global ocean, accounting for 30−40% of its mass (Johnson, 2008). The production of AABW is a key process in the global overturning circulation, representing a significant sink for heat and CO_2. It is currently recognized that AABW is formed in the Weddell Sea, the Ross Sea and off the Adélie Coast (Orsi et al., 1999). A fourth variety of AABW has been identified in the eastern sector of the Weddell-Enderby Basin (Meredith et al., 2000). However, its production has never been observed, nor its exact dense shelf water (DSW) source located. Recently, satellite-derived estimates of seaice production suggest that the Cape Darnley Polynya (65°−69°E), located northwest of the Amery Ice Shelf, has the second highest ice production after the Ross Sea Polynya (Tamura et al., 2008). As such, this polynya is promoted as a strong candidate for DSW source of the AABW identified in the Weddell-Enderby Basin. As part of the Japanese International Polar Year program, we conducted mooring observations in 2008−2009 offshore from the Cape Darnley Polynya, and revealed that the enhanced sea-ice production in this polynya is the missing source of the AABW (Ohshima et al., revised). Moored instruments observed overflows of newly formed AABW, about 300 m thick and bottom-intensified, cascading down the canyons north of Cape Darnley. This result is novel because this AABW is produced purely from sea-ice production without the assistance of an ice shelf and/or large storage volume on the continental shelf, in contrast to the traditional paradigm. We suggest that 6−13% of the circumpolar total of DSW, the precursor to AABW, is ventilated here. As such, Cape Darnley Bottom Water should now be incorporated into the global assessment of the meridional overturning circulation (MOC) and its variability.

2. Ongoing warming and freshening of Antarctic Bottom Water

Recent several studies have revealed ongoing warming and freshening of AABW. In the Weddell Sea, AABW have all exhibited warming trends since 1990 (Fahrbach et al., 2011), and in addition, glacier melt has freshened shelf water near the deep-water formation regions (Hellmer et al. 2011). Also in the Ross Sea, shelf water and bottom water have freshened over the past 50 years (Jacobs and Giulivi 2010). Finally, bottom waters off the Adélie Coast have cooled and freshened on isopycnals between the mid-1990s and mid-2000s (Aoki et al. 2005, Rintoul, 2007). Further, warming of AABW has also occurred along its spreading paths outside of the Southern Ocean (Purkey and Johnson 2010). Most recently, a direct impact of glacier change on AABW has been realized. After the calving of the Mertz Glacier Tongue in 2010, Tamura et al. (2012) revealed the significant decrease of sea ice production in the Mertz Polynya, which is the DSW source of the Adélie Land Bottom Water. This abrupt change could result in ultimately decreased DSW export and AABW production from this region for the coming decades. All these changes imply a global-scale contraction of AABW, suggesting a possibility of a global scale slowdown of the bottom, southern limb of the MOC.

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