豪州南極海盆における南極底層水の急速かつ持続的な低塩分化

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Rapid and persistent freshening of Antarctic Bottom Water in the Australian-Antarctic Basin

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Antarctic Bottom Water (AABW) production is integral component of thermohaline circulation, which makes an important contribution to storage and transport of heat, carbon and other properties which can influence climate. It is clarified in the recent study that freshening in the benthic layer of Australian-Antarctic Basin is particularly evident among the overall Southern Ocean (Purkey and Johnson, 2013). While freshening implies that there would be sea surface rise due to increased freshwater discharge, it also potentially decreases negative buoyancy force needed for AABW to sink to abyss, namely, it potentially affect the thermohaline circulation. Hence, quantitative and detailed documentation of freshening and its influence is critical for improved understanding of a future climate.

Since after the year 2011, hydrographic observations using a conductivity, temperature, and depth profiler (CTD) were conducted on meridional transect along 110°E, every January, by TR/V Umitaka-Maru. We have examined multi-decadal change in hydrographic condition south of 60°S using the WOCE Hydrographic Program (WHP) and its repeat section on I09S as reference for the year 1995 and 2005. Freshening observed at beginning of 2000s (e.g., Aoki et al., 2005) is still persistent in the recent years (fig. 1) and its bottom intensified feature implies that it is possibly induced by increased fresh water discharge near the formation regions of AABW. Of importance is that a contribution on sea level rise gradually but robustly increasing with time. Sea level rise against 1995, due to freshening, in the layer below 2000 *m* is 3.5 *mm* in 2005, an order smaller than that of thermal contribution (11.0 *mm*). However, in 2013, 2014, 2015, it is 12.9, 13.0, 14.5 *mm*, respectively, and hence, comparable to that of thermal component in the recent year (fig. 2). Although it should be noted that above change were observed at region where newly ventilated AABW locate, and hence, particularly strong signal expected to be observed, this implies that interpretation that haline component of sea level rise is small (Purkey and Johnson, 2013), would be changed in near future.

As for warming, while AABW production might be slowed due to decreases in negative buoyancy by freshening, it is not bottom intensified and non-monotonic with time (fig. 1). Considering such an uncorrelated feature to the observed freshening, over all warming can’t be explained by slowed AABW production. Possible candidate for the cause would be the southward shift of ACC fronts about 60 *km* (circumpolar mean) detected by satellite altimetry data during 1992~2007 (Sokolov and Rintoul, 2009). Southward shift of ACC fronts implies that there would be an adiabatic south ward shift of warm northern water. In fact, adiabatic southward shift (60 *km*) of water mases, which is estimated by using meridional temperature gradient at northern end of study area (60°S), can roughly explain observed overall warming. However, volumetric composition change in temperature, which can’t be explained by adiabatic south ward shift, is also apparent. Namely, in deeper layer below 2000 *m*, volume of water cooler than −0.1℃ decreased and it is compensated by increase in volume of relatively warmer water of −0.1〜0.6℃. Furthermore, in such a way as to correlate with freshening, the change in decomposition becomes evident with time (not shown). Hence, it is also likely that AABW production is slowed with time in the recent year.

In addition, at least around the study area, reported rising trend of sea level, estimated by satellite altimetry during 1992~2007 (Sokolov and Rintoul, 2009), is likely turned to declining after 2008 (fig. 2). Considering tight relation with overall warming, the behavior of ACC fronts would be the next thing to be analyzed for more detailed interpretation of observed warming.

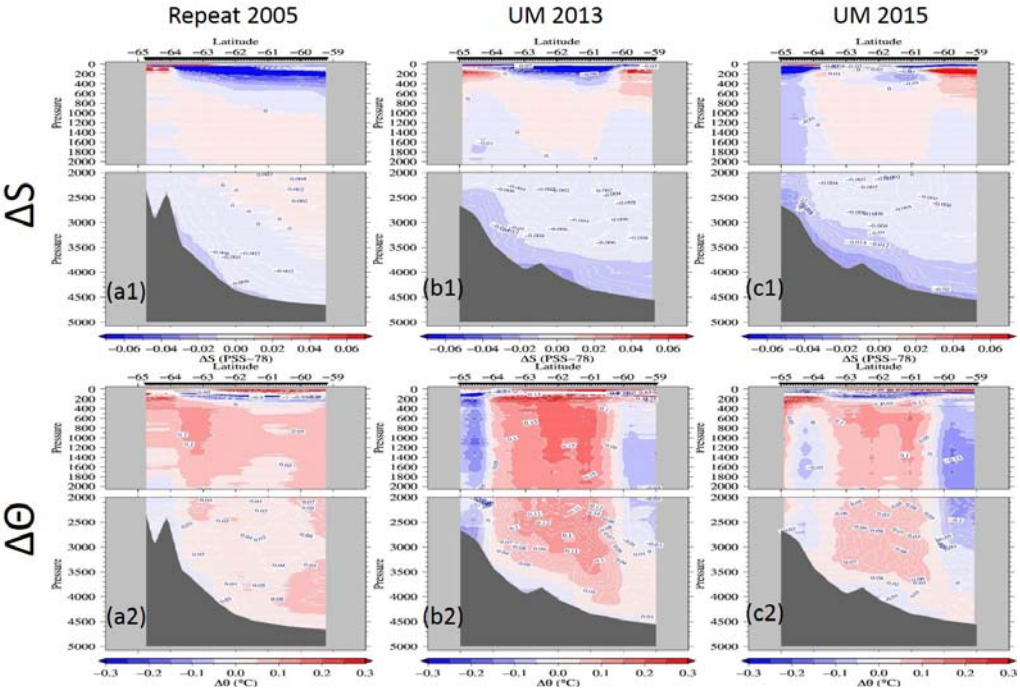

Fig. 1: Difference in salinity (PSS-78) and potential temperature (℃) between 1995 and 2000s.

Panels (a), (b), and (c) show difference between 1995 and 2005, 2013, and 2014, respectively. Panels (1) and (2) show salinity, potential temperature difference, respectively.

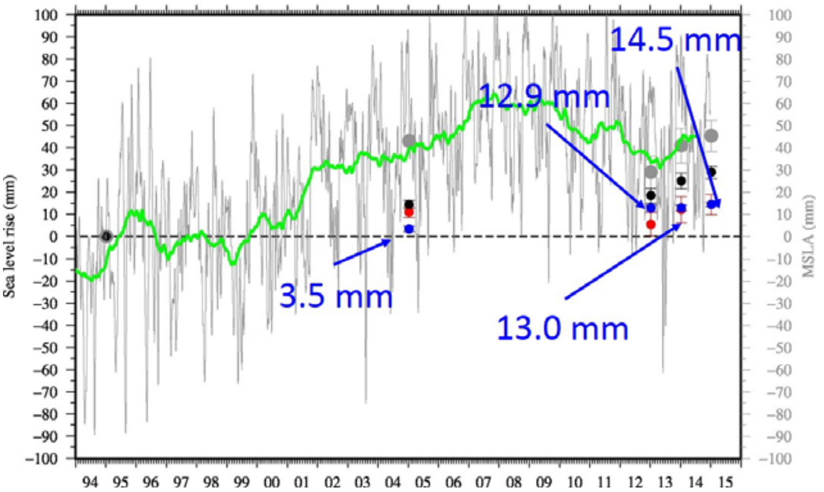

Fig. 2: Change in sea surface height estimated by satellite altimetry and CTD.

Gray and green line are box mean (108~117°E, 59.5~66°S) of level anomaly from satellite altimetry and its annual running mean, respectively. Dots are sea level rise from 1995 estimated from hydrographic data. Blue and red dots indicate contribution of haline and thermal component below 2000 *m*, respectively. Black dots indicate sum of haline and thermal component below 2000 *m*. Gray dots indicate sum of haline and thermal component of whole the water column. Labeled number indicate contribution of haline component below 2000 *m*.

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