Two recirculations in the Australian-Antarctic Basin revealed by improved ice-free monthly absolute dynamic ocean topography using CryoSat-2 radar altimeter

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The bottom melting of ice sheet and the supression of Antarctic bottom water (AABW) formation have been reported [e.g., Williams *et al*., 2016; Kusahara and Hasumi, 2013]. The key driver of both phenomena is thought to be the warm and salty Circumpolar Deep Water (CDW). The transport of CDW and its access to continental shelf break area should depend on the ocean circulation. The ocean circulation in the seasonal sea ice zone, however, is still unclear due to the difficulty of hydrographic observation covering regions of interest. To elucidate the ocean circulation, absolute dynamic ocean topography (ADT) is one of the important parameters. Recently, Mizobata et al. [2016] developed ice-free monthly-mean ADT in the Arctic Ocean using the measurements of the CryoSat-2 (CS-2) radar altimeter, and now several works show similar products in the Southern Ocean [e.g, Armitage et al. 2018]. Unlike the Arctic Ocean, ADT products in the Southern Ocean faces the problem on the spatial interpolation. The distance between the orbits of the polar orbiting satellites like CS-2 becomes larger as going to the lower latitudes. The continental shelf and shelfbreak areas in the Southern Ocean locate around 64S or higher so that the distance between the orbits, i.e., the spatial resolution of original dataset is sometimes not enough due to smaller Rossby radius comparing to it in lower latitude ocean. Also CS-2 only cannot covers the mid-latitude ocean where the Antarctic Circumpolar Current (ACC) flows. To reveal the ocean circulation in both shelf area and offshore basin area (40S-70S), we developed "Ice-free" Monthly ADT using the measurements of satellite altimeters, CS-2/SIRAL (Geophysical Data Record, BASELINE-C) and Jason-2 (AVISO/CorSSH products), based on the methods described in Mizobata *et al*. [2016]. Also we employed the interpolation method with a topographic constraint scheme (TCS) proposed by Shimada *et al*. [2017] to overcome "interpolation" problem. Developed dataset still has uncertainty which will be due to the accuracy of radar altimeter retrieval. Then we applied the empirical orthogonal functions (EOF) to reduce noises and to understand the variability of the ocean circulation field. Although the dataset we developed covers entire Southern Ocean but this study mainly focuses on the Australian-Antarctic Basin (A-A Basin) to avoid the discussion diverging.

Our products reconstructed by using dominant EOF modes, show that the clockwise circulations locate along 63.5S latitude line from 0E to 150E. In the A-A Basin, Bindoff et al. [2000] showed relatively widely distributed "ACC recirculation gyre" from 90E to 110E. But our product show that two recirculation gyres stationary locates at the eastern side of the ridge around 107E and 115E. Those recirculations indicate that there are many possible routes of poleward CDW transport more than expected. Unsolved question is what controls the variability of recirculation field. Through the comparative study, the correlation between First EOF mode of ADT explaining 16% variance and Southern Annular Mode (SAM) index turns out -0.4, i.e., weak sensitivity to atmospheric forcing related to SAM.

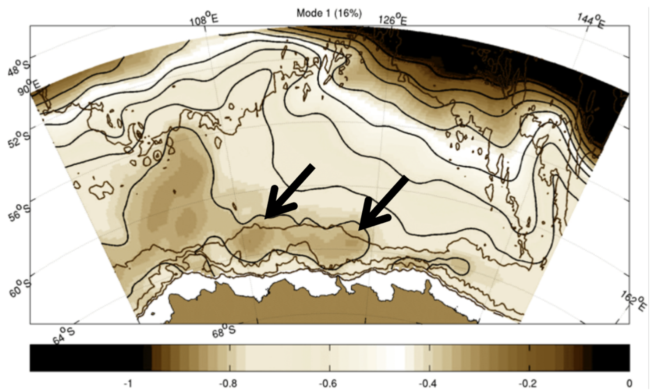

Fig. 1: First EOF of ADT in the A-A basin

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