Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

MIS34-04 Room:414 Time:May 2 15:00-15:15

High resolution Modeling on the Antarctic Bottom Water Formation

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At the Antarctic continental margin, a great amount of dense water is created due to intense cooling and active sea ice formation. A part of this dense water descends down to the depth on the continental slope and provides a source of Antarctic Bottom Water (AABW), the densest water mass of the world ocean. This deep water formation drives and controls the global thermohaline circulation. Thus, quantitative understanding of where and how much such dense water descends to which depth with what water mass property is necessary for discussing the structure and intensity of the global thermohaline circulation and hence the earth's climate.

The AABW formation involves various processes with wider range of spatial and temporal scales, such as turbulent mixing induced by vertical velocity shear of descending dense water, influences of small scale submarine ridges and canyons of O(1) km, the surface buoyancy flux highly controlled by openings and closings of coastal polynyas. It is very difficult to perform a numerical simulation which resolves all of these processes because such simulation requires a huge amount of computational resource. Therefore, modeling studies on the AABW formation have been restricted to very idealized experimental settings. In particular, small scale processes such as turbulent mixing and vertical convection cannot represented by widely used general ocean circulation models with hydrostatic approximation, and a non-hydrostatic model is required. The numerical cost of non-hydrostatic models has been much greater than the hydrostatic models due to the cost of three-dimensional Poisson solver required to diagnose pressure field. To overcome this problem, we developed a non-hydrostatic ocean model with a very numerically-efficient and scalable Poisson solver using the multigirid method. The totla cost of our non-hydrostatic model stays less than twice of that of hydrostatic one even with huge amount of grid cells on massively parallel super computers. With using this newly developed model code and present days computational resources, multi-scale and multi-process modeling on the AABW formation, whose results are competent to be quantitatively compered with direct observations, is becoming a reality.

In our talk, we will introduce the outline of the newly developed numerical model and discuss the results of high-resolution AABW formation simulation with focusing on the effects of small scale topographic features and the turbulent entrainment processes induced by Kelvin-Helmholtz instability.

Keywords: Antarctic Bottom Water, non-hydrostatic model