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Modeling of intermediate layer circulation and iron circulation in the Sea of Okhotsk and the North Pacific

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The Sea of Okhotsk is now recognized as a primary iron source region to the western North Pacific. Iron is mixed into Dense Shelf Water (DSW) on the northern shelf together with sediments when DSW is formed as a result of brine rejection from sea ice. DSW is transported southward the East Sakhalin Current in the intermediate layer off Sakhalin, and finally flows out into the Pacific through the Kuril straits, supplying iron to the western North Pacific. In this talk, we first discuss tracer experiments including CFCs using a regional model developed at Institute of Low Temperature Science, Hokkaido University. Second, iron transport processes in the North Pacific are discussed using a biogeochemical model developed at Central Research Institute of Electric Power Industry.
We have constructed an ice-ocean coupled model that covers the northwestern North Pacific including the Sea of Okhotsk based on Iced COCO ver. 3.4. The horizontal resolution is 0.5 degree. The model represents circulations and intermediate layer features in the Sea of Okhotsk reasonably. Using the regional model, a tracer experiment and chlorofluorocarbons (CFCs) simulations were performed. In the tracer experiment, tracer is injected in winter in the northwestern shelf in the Sea of Okhotsk to trace DSW formed there. Tracer is transported southward along Sakhalin Island and flows out
into the Pacific through the Kuril Straits. In the CFCs simulation, CFC distribution comparable to an observation is represented. Two areas are identified where CFCs enter the intermediate layers; one is polynya along the northern coast of the Sea of Okhotsk, and the other is found around the Kuril Islands. The former is caused by brine rejection in winter, and the latter is due to strong tidal mixing. The CFC flows out to the North Pacific Ocean along the Oyashio front and spreads to the subarctic gyre.
Next, a biogeochemical model (called BEC), coupled to an ocean general circulation model, was used to discuss transportation processes of iron. The resolution of the model is about 1 degree. Both atmospheric (dust) iron source and sedimentary iron source were considered. The BEC model represents seasonal variation of phytoplankton bloom well. Iron distribution was also well represented. The maximum concentration is found in the intermediate layer around 600 m. At surface, relatively high concentration is seen in the western North Pacific, which supports high seasonal phytoplankton bloom there. We conducted two additional experiments; one includes dust source only (DST), while the other includes sedimentary source only (SED). The SED experiment causes intense intermediate layer maximum in both subtropical and subpolar gyres, while the DST experiment represents weaker maximum in the subtropical gyre. Contribution of DST and SED to primary production is then estimated. In the western North Pacific where the pathway of the outflow from the Sea of Okhotsk is present, SED contribution to primary production is comparable to DST contribution where subsurface iron outcrops, suggesting significance of the SED source from the Sea of Okhotsk.

Keywords: Dense Shelf Water, iron circulation, Okhotsk Sea, Intermediate layer