

Global view of sea ice production and its linkage with dense/deep water formation

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Global overturning circulation is driven by density differences: water sinks in dense water formation areas and then gradually upwells in other areas. Saline water rejected during sea-ice formation is the main source of dense water, and thus sea-ice production is a key factor in the overturning circulation. Due to the difficulty in observation, sea-ice production and its interannual variability has not been well understood. We have developed an algorithm to estimate sea ice production globally from satellite data with heat flux calculation. Global mapping of sea-ice production demonstrates that the production rate is particularly high in the Antarctic coastal polynyas, in contrast to the Arctic ones. This is consistent with the formation of Antarctic Bottom Water (AABW), the densest water which occupies the abyssal layer of the global ocean. The Cape Darnley polynya (65°–69°E) is found to be the second highest ice production area, suggesting a source of AABW. Recent Japanese IPY observations revealed that this is the missing (fourth) source of AABW. In the region off the Mertz Glacier Tongue (MGT), the third source of AABW, sea-ice production decreased by as much as 40%, due to the MGT calving in early 2010. Recent observations suggested a significant reduction in AABW there, likely caused by the decrease in sea-ice production. Overturning in the North Pacific extending to the intermediate layer originates from sea-ice production in the Okhotsk coastal polynyas and is suggested to have weakened during the past 50 years. Our estimate shows a significant decrease of sea-ice production in the polynyas, likely resulting in weakening of North Pacific overturning. These demonstrate the strong linkage between variabilities of sea-ice production and bottom/intermediate water. The mapping has also provided the surface boundary condition and validation data of heat- and salt-flux for various ocean and coupled models.