Mapping of active frazil for coastal polynyas in the Northern Hemisphere, with estimation of sea-ice production

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Coastal polynyas, persistent thin ice areas, are important as regions of high sea-ice production and associated brine rejection in the polar oceans. Dense water caused by the high sea-ice production in the coastal polynyas contributes to the formation of intermediate water and maintenance of cold halocline layer in the North Hemisphere. Because of the importance of sea-ice production in coastal polynyas, several studies have developed an algorithm that derives thin ice thickness from satellite microwave radiometers, and estimated ice production based on a heat flux calculation using the ice thickness. In these algorithms, ice thickness of <20 cm is empirically estimated by utilizing negative relationship between the ice thickness and PR (a ratio of the horizontally to vertically polarized brightness temperatures). However, this relationship has a large scatter and depends on regions. Thin ice regions are classified roughly into two ice type areas: active frazil area, which is a mixture of open water and frazil/grease ice formed by turbulent conditions, and thin solid ice area, which is an area of nearly uniform thin ice. Recently, Nakata et al. (2019) indicated that the PR-thickness relationships are clearly different between the two ice types. They have also proposed a new thin-ice algorithm of AMSR-E that discriminates the two ice types by the linear discriminant method. This algorithm, which discriminates the ice type, can be applied to global oceans. In this study, we applied the algorithm to ice-covered oceans in the Northern Hemisphere (the Arctic Ocean, Bering Sea, and Sea of Okhotsk), and made the mapping of active frazil and sea ice production by taking account of ice type. We used 36 and 89 GHz TBs of AMSR-E Level 2A global swath data with the footprint size of 14 km ×8 km and 6 km ×4 km, respectively. For the mapping, we used landfast ice mask by Iwamoto et al. (2014) in the Arctic Ocean and by Ohshima et al. (2020) in the Bering Sea. Sea-ice production is calculated from a heat flux calculation using the derived ice thickness and ERA5 atmospheric data. Then, we created daily data of ice type and sea-ice production during winter (September-May) for the period 2002-2011. Nakata et al. (revised) showed that the active frazil region has an occurrence rate of >0.3 for most of the major polynyas in the Southern Ocean. By contrast, our climatological mapping for the Northern Hemisphere shows that the occurrence rate of active frazil does not exceed 0.3 in all the 29 polynyas except for the North Water and North East Water polynya. This can be explained by relatively weak offshore winds, compared with the case of the Southern Ocean. We could estimate sea ice production for all the coastal polynyas in the Northern Hemisphere, by using the unified thin ice algorithm that discriminates the ice type.

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