アイスタイプを考慮した薄氷厚アルゴリズムの開発

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Estimation of thin ice thickness discriminating ice type from AMSR-E passive microwave data

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In Antarctic coastal polynyas, high production of sea ice occurs due to huge heat loss to atmosphere, resulting in the formation of dense water, precursor of Antarctic Bottom Water. Detection of thin ice area and estimation of ice thickness are inevitable for the calculation of sea-ice production. Several studies have developed algorithms for estimation of the thin ice thickness from brightness temperature (TB) of satellite passive microwave sensor [e.g., Martin et al., 2005; Nihashi and Ohshima, 2015]. In these algorithms, ice thickness of less than 20 cm is empirically estimated by utilizing negative correlation between the ice thickness and a ratio of the horizontally to vertically polarized TBs (PR).

Thin ice (polynya) areas are classified roughly into two types. One is active frazil type: a mixture of open water and frazil/grease ice areas. This type is formed under strong wind condition. The other is thin solid ice type: nearly uniform thin ice covered area. This type is formed under relatively calm condition. It has been speculated that difference in these ice types causes reduced accuracy of the ice thickness algorithm because the two ice types likely show quite different microwave characteristics. In this study, we examined the PR-thickness relationship on these two types separately, and developed the thin ice algorithm discriminating the ice type.

We used 36 GHz and 89 GHz TBs data of Advanced Microwave Scanning Radiometer for EOS (AMSR-E, the resolution of 12.5 and 6.25 km, respectively), MODerate resolution imaging Spectroradiometer (MODIS, the resolution of 1 km) data and the Advanced Synthetic Aperture Radar (ASAR, the resolution of 150 m) data, obtained from the major three polynya around the Antarctica (Ross Ice Shelf polynya (RISP), Ronne Ice Shelf polynya (RONP) and Cape Darnley polynya (CDP)). We estimated sea ice thickness for the AMSR-E footprint using MODIS and ERA-interim atmospheric data. After thin ice areas are divided into the two types from the ASAR data, we examined the AMSR PR-MODIS ice thickness relationship for each ice type.

The result shows the clear difference of PR-thickness relationship between the two ice types. The exponential fitted curves for active frazil and thin solid ice types are similar to those of Martin et al. [2005] and Nihashi and Ohshima [2015], respectively. We considered that the difference of PR-thickness relationship is caused by the presence or absence of open water fraction. Because the ratio of open water in sea-ice region is largely reflected in gradient ratio (GR) of 36 and 89 GHz vertically polarized TBs, the two types can be clearly discriminated by the PR-GR plane. Based on these, we have developed a new thin ice algorithm in which polynyas are classified into the two ice types by a linear discriminant method. Sea ice thickness is estimated from the fitted exponential curve of PR-thickness relationship for each ice type. Using this algorithm, daily ice type and ice thickness for the three polynyas have been estimated during April-November in 2003-2010. Sea-ice production has been also estimated by heat flux calculation using the ice thickness and ERA-interim atmospheric data.

It is found that the occurrence frequencies of the two polynya types are largely different among the three polynyas. In the CDP, frazil type is more predominant, compared with other two polynyas. In previous algorithms, ice thickness was overestimated because the PR-thickness relationship is similar to that of the thin solid ice type. Therefore, sea-ice production in the CDP with high occurrence frequency of active frazil type is calculated to be about 1.5 times as that of previous studies.

References

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