Estimation of thin ice thickness and discrimination of ice type from AMSR2 passive microwave data

*Kazuki Nakata[1], Tamaru Naoya[1], Sohey Nihashi[2], Kay I. Ohshima[3]

1. Remote Sensing Technology Center of Japan, 2. National Institute of Technology, Tomakomai College, 3. Institute of Low Temperature Science, Hokkaido University

Antarctic coastal polynyas (thin ice and/or low ice concentration area) are areas of high ice production due to huge heat loss to the atmosphere. Dense water formed by the high ice production is a significant source of Antarctic Bottom Water. Thin ice thickness algorithms that use satellite passive microwave data have been developed to detect coastal polynyas and estimates thin ice thickness on a daily timescale. In these algorithms, ice thickness of <20 cm is empirically estimated based on a negative correlation relationship between polarization ratio (PR) of brightness temperatures (TBs) and ice thickness (hi). However, the dispersion of the data points of PR-hi relationship was relatively large. Nakata et al. (2019) revealed that two thin ice types (active frazil and thin solid ice) cause this dispersion using AMSR-E data (2002-2011). They detected these ice types based on a PR-GR (Gradient Ratio) relationship. And thin ice thickness was estimated from PR-hi relationships for each ice type. This new thin ice algorithm can improve the accuracy of the thin-ice thickness estimation. In this study, we have examined whether this new algorithm can apply to data from AMSR2 which the successor of AMSR-E. The footprint size of AMSR2 is improved by about 85% from AMSR-E in spite of the frequency channels are the same. By adding AMSR2 data, thin-ice thickness, ice type, and ice production data set with a higher spatial resolution can be obtained from 2002 to the present.
We use TBs at 36 and 89 GHz from AMSR2 Level 1B data. The footprint sizes are 12 km ×7 km and 5 km × 3 km, respectively. Ice thickness for comparison with AMSR2 PR is derived from clear-sky thermal infrared images by MODIS with a spatial resolution of 1 km. Backscatter images acquired by C-band SAR (C-SAR) on the ESA’s Sentinel-1 satellite with a spatial resolution of 90 m are used to validate two thin ice types. We use these satellite data obtained at Ross Ice Shelf and Cape Darnley polynya areas.
AMSR2 PR-hi relationships for two ice types differs clearly as in Nakata et al. (2019). We estimate ice thickness using lines that best fit into the AMSR-E PR-hi relationships (Nakata et al., 2019) using AMSR2 data. And then, mean bias and root-mean-square error (RMSE) of the data points from the lines are calculated. The errors are slightly larger than the cases of AMSR-E data. When ice thickness is <10 cm, mean bias and RMSE for active frazil are -2.0 and 1.0 cm, respectively, while those for thin solid ice are -6.2 and 9.8 cm, respectively. For ice thickness of 10-20 cm (only for thin solid ice), the bias and RMSE are -5.9 and 9.9 cm, respectively. We also have confirmed that two ice types can be detected using AMSR2 data by a method for AMSR-E data proposed by Nakata et al. (2019). The results of this study indicate that the new thin ice algorithm for AMSR-E data can apply to the AMSR2 data.

Keywords: Thin ice thickness, Ice type, AMSR2, Coastal polynya

