Variability of Antarctic coastal polynyas and their linkage with fast ice revealed from AMSR-E and AMSR2 data

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A coastal polynya is newly-forming thin sea-ice areas formed by divergent ice motion driven by prevailing winds and/or ocean currents. In coastal polynyas, huge amounts of heat flux from the ocean to the atmosphere occur because the heat insulation effect of sea-ice is greatly reduced in the case of thin ice, and accordingly sea ice is formed actively. Dense water formed in Antarctic coastal polynyas with the intense sea-ice production is a major source of Antarctic Bottom Water (AABW), which is a key player in the global climate system.

In Antarctic coastal polynya areas, algorithms that detect the polynya areas and estimate the thin ice thickness from passive microwave satellite data (SSM/I-SSMIS: 1992—present or AMSR-E: 2003—2011) had been developed to estimate the ice and dense water production. Fast ice areas were also detected using the passive microwave data. The spatial (grid) resolution of AMSR-E (about 6 km at 89 GHz) is four times higher than that of SSM/I-SSMIS in the pixel density. This advantage of AMSR-E is critical for the monitoring of the coastal polynyas and fast ice because of their small areal extent (i.e., from 10 to 100 km at most).

The coincident circumpolar mapping of Antarctic coastal polynyas and fast ice from AMSR-E had revealed that most of the polynyas are formed on the western side of fast ice or glacier tongue, indicating an important role of fast ice and glacier tongue in the polynya formation. Because the fast ice and glacier tongue are particularly vulnerable to oceanic and atmospheric conditions, their extent can be changed drastically and suddenly. The change in the fast ice or glacier tongue can cause dramatic changes in sea-ice production in the adjacent polynya and possibly AABW formation, as in the case of the Mertz Glacier Tongue (MGT) calving in 2010. This can potentially contribute to further climate change. Although AMSR-E failed in October 2011, AMSR2, the successor to AMSR-E, was launched in May 2012. The spatial resolution of AMSR2 is improved about 17% from AMSR-E.

This study developed an algorithm which can detect the polynya area and can estimate the thin ice thickness from AMSR2 data, based on a similar method to the AMSR-E algorithm development. Fast ice areas were also detected using AMSR2 data. Ice production in the polynyas was estimated from heat flux calculation using the sea-ice data from AMSR2. In the major polynyas, the AMSR2 ice production was compared with the AMSR-E ice production though a comparison with the SSM/I-SSMIS ice production. The comparison confirmed that the AMSR2 and AMSR-E data with higher spatial resolution can be used for time series analysis of the relationship between coastal polynyas and fast ice for >10 years. For example, maps of annual ice production and fast ice from AMSR2 and AMSR-E can reveal the details of the Mertz Polynya change before and after the MGT calving. Continuous monitoring of the coastal polynyas by the AMSR series is essential for climate-change-related analyses in the Antarctic Ocean.

Keywords: AMSR2, coastal polynyas, fast ice