Mechanism of sea-ice production variation in Amundsen Sea Polynya

*Sohey Nihashi[1], Kouta Mine[1], Kazuki Nakata[2]

1. National Institute of Technology, Tomakomai College, 2. RESTEC

A coastal polynya is an area of high ice production and dense water formation. This dense water is a major source of the Antarctic Bottom Water. Since winter polynya is a difficult site to observe, the mechanism of polynya formation and variation had not been understood well. About ten years ago, an algorithm was developed that uses satellite passive microwave data to detect polynyas and estimates thin ice thickness on a daily timescale. The satellite data revealed the detailed distribution and variation of polynyas (e.g., Tamura et al., 2007; 2008). Use of AMSR-E/AMSR2 data with a finer spatial resolution (about 5-6 km), can reveal the more detailed spatial distribution of polynyas. For example, it was revealed that most of coastal polynyas form on the west side of landfast ice (fast ice: stationary sea ice attached to coastal features such as shoreline and grounded icebergs). This close relationship indicates a vital role of fast ice for formation and variation of coastal polynyas (Nihashi and Ohshima, 2015; Nihashi et al., 2017). The Amundsen Sea Polynya (ASP), located in West Antarctica, is the third largest ice production area and is formed on the west side of fast ice protruding into the ocean. Thwaites Glacier adjacent to the fast ice has been suggested that a rapid melting occurs in recent decades (Rignot et al., 2008; Milio et al., 2019). Grounded icebergs that act as anchor points play an essential role in the formation of fast ice protruding into the ocean. Since the sources of an iceberg are glacier and ice sheet, the rapid melting possibly affects the formation and distribution of fast ice and accordingly adjacent polynyas.

In this study, we compare the ice production in the ASP with atmospheric parameters and fast ice extent to investigate factors for causing ice production variation. Ice production estimated from heat flux calculation with daily thin ice thickness from AMSR-E/AMSR2 data (Nihashi and Ohshima, 2015; Nihashi et al., 2017) is used. For fast ice, monthly extent detected from AMSR-E/AMSR2 data is used. We also use ice production estimated using thin ice thickness by an improved algorithm in which ice types (active frazil and thin solid ice) are considered (Nakata et al., 2019). As atmospheric data, we use ERA5.

Ice production is positively correlated with wind speed regardless of daily or monthly data with the coefficient of 0.54-0.73. Here, we use a wind component with the highest correlation; components of the wind vector are projected in all directions of every 1˚ from 0˚ (northerly wind) clockwise to 360˚, and then, correlation coefficients are calculated. The wind component is oriented to the west rather than to the offshore (north) against the land. This is a direction towards the offshore against the shoreline defined by both the land and fast ice. This result supports the analysis using only AMSR-E data (Nihashi and Ohshima, 2015). If ice production in which thin ice types are considered is used, the wind component is oriented toward further west when active frazil is dominant. This direction is to the offshore against the fast ice. Further, active frazil tends to form along fast ice. On the other hand, the wind component is northward (to the offshore against land) when thin solid ice is dominant. Multiple regression analysis is performed on the ice production using air temperature, wind speed, and fast ice extent averaged over the freezing season (May-August). Ice production can be explained by these parameters with R=0.77. This indicates that ice production in the ASP before the satellite observation era can be reproduced to some extent from atmospheric data by using this regression line. The results presented in this study suggest that fast ice plays a vital role in the formation and variation of the ASP. Continuous monitoring of Antarctic coastal polynyas and fast ice from passive microwave satellite sensor is quite meaningful understanding climate change.

Keywords: Antarctic Ocean, coastal polynya, Amundsen Sea Polynya

