Estimation of mechanical increase in sea ice thickness due to sea ice rafting using AMSR-E and AMSR2 derived sea ice velocity data

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In recent years, the zonal ice band formed by rafted sea ice has often remained in coastal regions in the Arctic Ocean, even in the end of summer and blocks the Arctic Sea Route. In the present study, we assumed that mechanical increase in sea ice thickness due to sea ice rafting caused by convergence of sea ice motions is an key factor of the formation mechanism of such heavy sea ice bands, and developed a method to estimate the mechanical increase in sea ice thickness using satellite-derived sea ice velocities calculated from AMSR-E and AMSR2 data in 200-2011 and in 2013-2015. We also examined influences of mechanical increases in sea ice thickness on sea ice conditions in spring, which is an essential precondition of sea ice variations in the subsequent summer.

Mechanical increases in sea ice thickness due to sea ice rafting were estimated along Lagrangian sea ice trajectories that were tracked backward from 1 May to 1 November in the preceding year. Once sea ice rafting is caused by convergent sea ice motions, the increased sea ice thickness does not decrease even under influences of divergent sea ice motions. To take into account such non fluid-like properties of sea ice motions, in our estimation method, we assumed that mechanical increases occur in the case that the following two conditions were satisfied: (1) sea ice concentration (SIC) after a time interval of about 1 day exceeded 100 % due to the convergence of sea ice motions. (2) A parameter calculated from satellite-measured brightness temperature, a proxy of the sea ice type, fell below the threshold. Along Lagrangian sea ice trajectories, the amount of SIC that exceeded 100 % was integrated as the mechanical increase in sea ice thickness. The second condition enables us to estimate mechanical increases of only relatively thick sea ice such as multi-year ice by excluding the convergence of new ice that does not contribute to mechanical increase in sea ice thickness from the integration.

As a result, spring sea ice with large mechanical increases in sea ice thickness during winter tended to distribute in the subsequent spring in the following regions: the Alaskan coastal region, the East Siberian Sea near the Wrangel and New Siberian Islands and the region around the Franz Josef Land, which are known as choke-point of the Arctic Sea Route. With decreasing in advections of multi-year ice that traveled from the northern Canada Basin to the Atlantic sector along the sea ice Beaufort Gyre and the Transpolar drift stream, the amount of rafted sea ice in spring decreased around the Franz Josef Land. On the other hand, in the Pacific sector, spring sea ice thickness with large sea ice rafting during the preceding winter distributed in the Alaskan coastal region near Pt. Barrow and the East Siberian Sea even in the AMSR2 period during 2013 to 2015. These results suggest that spring sea ice conditions in these coastal regions was preconditioned by both sea ice rafting and redistributions of multi-year ice during the preceding winter.