Medium-range prediction of the Arctic sea ice

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INTRODUCTION

The summer Arctic sea-ice extent has decreased in this several decades. This reduction has accelerated maritime transport using the Arctic sea route. Sea ice prediction is essential to realize safe and sustainable use of the route. Especially, medium-term forecast looking several months ahead is necessary to determine whether or not the shipping route through the Arctic will be navigable.

The Arctic Ocean is nearly fully covered by sea ice until April or May, after which time interannual differences in ice area become noticeable. One possible cause of the interannual difference of ice retreat is ice thickness in spring before the start of melting. However, observations of ice thickness are insufficient in their spatial and temporal coverage, observation period or their accuracy to resolve the interannual difference of the thickness. Recently, Krishfield et al. (2014) shows the way to derive the daily sea ice thickness from the satellite microwave data.

To estimate the spatial distribution of spring ice thickness, we focus on the winter ice motion and redistribution. Our prediction is basing on the relationship between the ice thickness in spring and ice area in the following summer. We predict the summer ice area based on this relation.

DATA

We prepare a daily ice-velocity product on a 60 km resolution grid for 2003-2015, calculated from data of the satellite microwave sensors Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E) and AMSR2. The procedure for detecting ice motion is based on the maximum cross correlation method (Kimura et al., 2013). Ice thickness is calculated from AMSR-E and AMSR2 images using the algorithm by Krishfield et al. (2014). This study also uses satellite derived daily ice concentration on a 10 km resolution grid, distributed by Arctic Data archive System (https://ads.nipr.ac.jp/index.html).

METHOD OF ICE PREDICTION

To investigate the dynamic redistribution of sea ice during winter, movement of particles spread over the ice area is calculated. About 20000 particles having initial ice thickness are arranged at an interval of 30 km over the ice area on December 1 of each year. Daily displacement of the particles is calculated from the satellite derived ice velocity on one-day time steps up to April 30.

Provisional ice thickness on April 30 is estimated by 1) particle density only, 2) particle density multiplied by the initial ice thickness, 3) particle density multiplied by the initial ice thickness only in the thick-ice (>1.5m) area. We found the highest correlation between the spring ice thickness and summer ice cover in the case of 3. We can predict the summer ice area based on the relationship between the provisional ice thickness and summer ice area. Based on the analysis, first report of the summer ice prediction showing the ice concentration map for July 1 to September 11 is released in May on our website.

The medium-term forecast looking several months ahead should be useful for safe and efficient use of the Arctic sea route. As a next step, we are trying to predict the ice thickness distribution.

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