A Method of Predicting Sea Ice Boundary Conditions for the One-month Ensemble Prediction System

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1. Introduction

A method of predicting daily sea ice distribution was developed to determine sea ice boundary conditions for JMA's one-month ensemble prediction system (EPS), which employs an atmospheric global circulation model (AGCM). Sea ice distribution for the coming month is predicted based on initial sea ice concentration (SIC) anomalies in ocean grids and initial sea ice extent (SIE) anomalies in the Northern and Southern Hemispheres with reference to the method proposed by Mizuta et al. (2008). The skill of these sea ice distribution predictions is better than that of the climatological distributions used in JMA's current operational one-month EPS.

2. Data and sea ice area definition

The SIC used to predict sea ice distribution comes from satellite-based daily data sets covering the period from 1986 to 2010 as analyzed by JMA (Ishii et al. 2005), and the horizontal resolution is 0.25 degrees.

Ocean grids with SIC values exceeding 55% are defined as sea ice areas and others are defined as open sea based on the SIC threshold of sea ice grids in the AGCM. The climatological sea ice presence frequency for each grid is determined from 31-day running means of daily presence frequency for the period between 1986 and 2010.

3. Procedure for daily sea ice prediction

Daily sea ice distribution is predicted using a combination of persistent initial SIC anomalies observed in ocean grids and persistent initial SIE anomalies in the Northern and Southern Hemispheres. The procedure for such prediction is described below and presented as a diagram in Fig. 1.

Initial date

Initial sea ice distribution is determined by identifying ocean grids as either sea ice or open-sea types based on the SIC threshold (55%). Initial SIC anomalies in ocean grids and initial SIE anomalies in the Northern and Southern Hemispheres are also calculated.

Lead times of less than 14 days

With lead times of less than 14 days, SICs predicted for ocean grids are assumed to be persistent initial anomalies, which requires the addition of initial SIC anomalies to daily climatological SICs. Ocean grids are identified as either potential sea ice or potential open-sea types based on the SIC threshold (55%). Sea ice distribution is then predicted by adjusting the potential distribution so that the initial SIE anomalies in each hemisphere persist, which means that potential sea ice (open-sea) grids with lower (higher) climatological frequency are modified to open-sea (sea ice) grids.

Lead times of more than 15 days

With lead times of more than 15 days, sea ice distribution is predicted by adjusting the previous day's distribution so that initial SIE anomalies in each hemisphere persist. In other words, the predicted SIE anomaly is made equal to the initial anomaly by correcting sea ice and open-sea grids based on climatological presence frequencies. During the sea ice development (melting) season, previous open-sea (sea ice) grids with higher (lower) frequencies are converted to sea ice (open-sea) grids.

4. Verification

Equitable threat scores were used to verify the accuracy of sea ice distribution predictions. Figure 2 shows such verification based on four methods involving the use of persistent initial SIC anomalies, persistent initial SIE anomalies, a combination of both, and sea ice climatologies. The combined method is the most skillful except for January due to sparse Antarctic sea ice distribution, which exacerbated the scale of estimation errors.

5. Summary and future plans

In this work, a method of predicting sea ice boundary conditions for JMA's one-month EPS was developed. The approach was found to provide sea ice distribution values that correspond to the results of actual analysis. Daily sea ice distributions predicted using this method are to be introduced in the next update of JMA's one-month EPS. Arctic sea ice retreat related to global warming (IPCC 2007) is also expected to be taken into account, and the skill of one-month EPS prediction is expected to improve.

References

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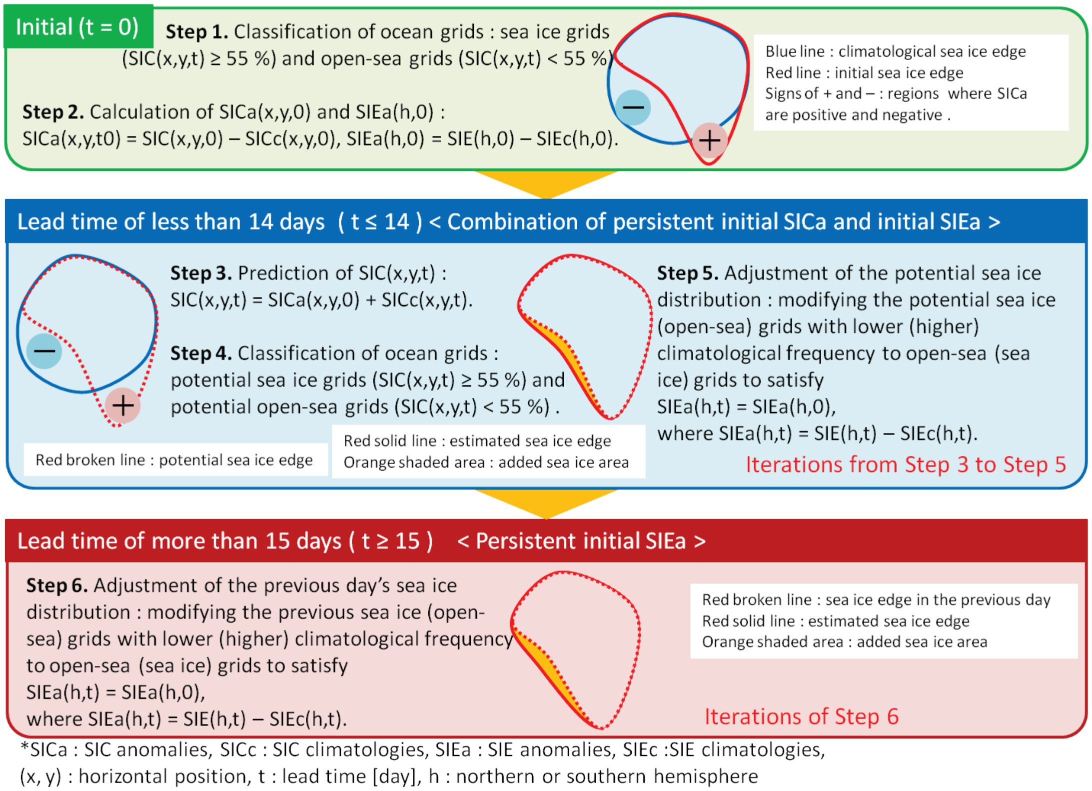

Fig. 1 Summary of sea ice prediction method

In Step 5, the potential SIE anomaly is smaller than the initial anomaly. Step 6 is for the sea ice development season.

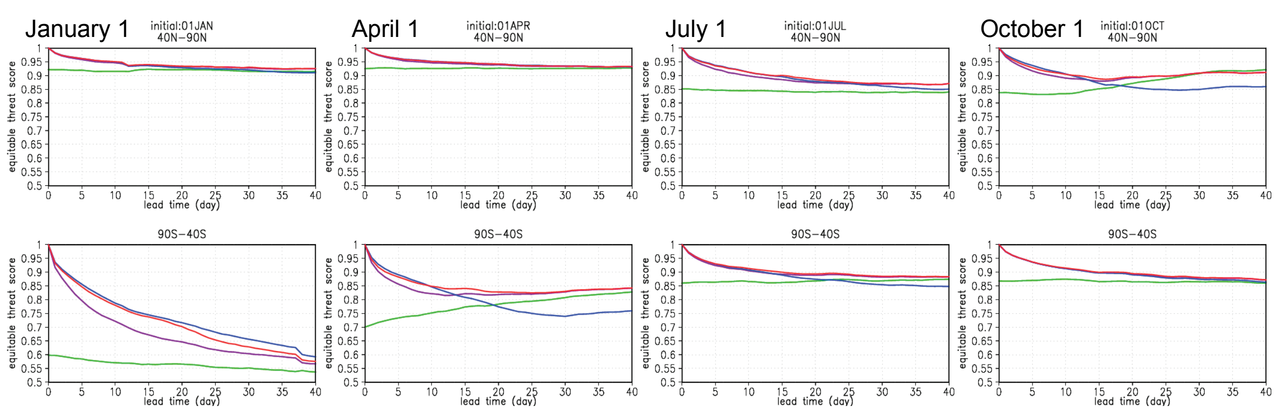

Fig. 2 Equitable threat scores for sea ice distribution predicted using four methods

The x-axis shows the lead time from the initial date, and the y-axis shows the equitable threat score. Scores are calculated for the period from 1986 to 2010, and the initial dates (from left to right) are January 1, April 1, July 1 and October 1. The upper figures are for the Arctic and the lower ones are for the Antarctic. The red, blue, purple and green lines show scores based on the proposed method, persistent initial SIC anomalies, persistent initial SIE anomalies and climatological distributions, respectively.