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Introductions of New Satellite Observation Techniques for Sea Ice Growth and Transport in the Arctic (Extended Abstract)

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Abstract: This study presents some results on sea ice changes in the Arctic and surrounding seas by archiving new data set and applying new approach of analyses. Sea ice motion, sea ice type or ice thickness data were obtained by the satellite remote sensing. Combinations of satellite observations of ice thickness and ice motion enable estimation of ice volume transport, which is important for investigating energy transport, salinity anomaly due to ice formation and melting.

1. Introduction

Recently, thinning of sea ice in the Arctic became great concern and many attempts have been done to investigate it. Although cryosphere can indicate significantly the environmental changes, observations in the remote and cold area are difficult. Sea ice has important roles for atmosphere-ocean interaction as sea ice controls heat and material exchanges.

There are still lack of data and observation systems in the higher latitudes. One of the useful techniques is the satellite remote sensing.

Approach of sea ice research

This report introduces combined analysis of new algorithms for sea ice investigation.

Available algorithms are observing ice thickness, ice motion and under-ice oceanic condition. Figure 1 summarizes analysis attempted in the present study.

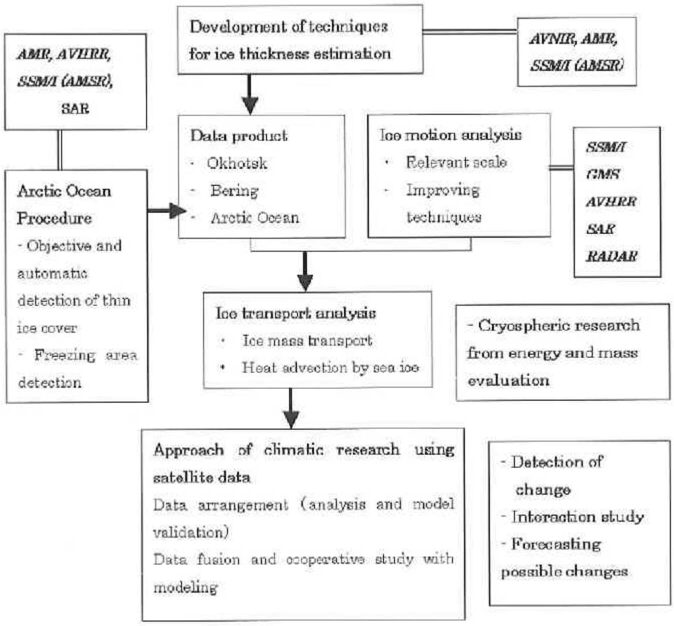

Fig. 1. Flow of possible analysis combining sea ice motion, sea ice type or ice thickness data.

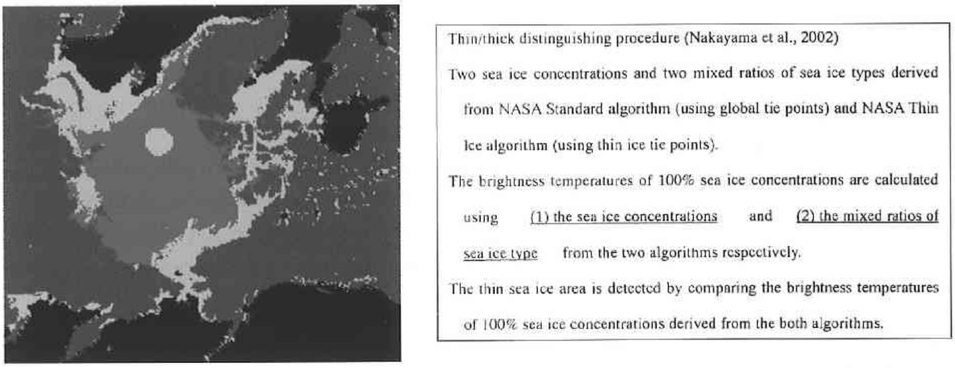

Fig. 2. Thick (red) and thin (blue) ice distributions (Nakayama *et al.*, 2002)

Examples of ice thickness estimation

For the studying ice growth and decay, ice thickness change is important information (Enomoto, 1996). Time series of large scale data is useful for analysis.

New satellite observation techniques for estimating sea ice growth in the seasonal sea ice area have been developed. Figure 2 shows an example of ice thickness variation in the Northern Hemisphere (Nakayama *et al.*, 2002).

Figure 3 shows an example of ice thickness indication in the Sea of Okhotsk estimated from passive micro wave data, based on Tateyama and Enomoto (2001) and

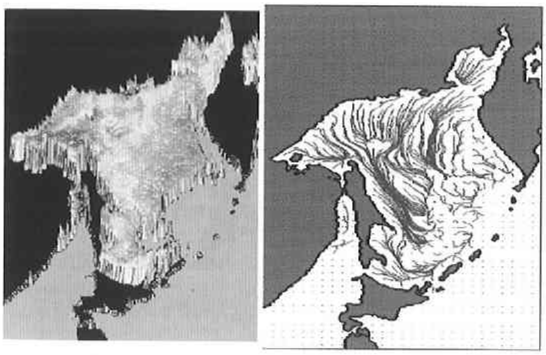

Fig. 3. Sea ice thickness variations in Mar. 2001 (right) and mean ice flow pattern (left) in the Sea of Okhotsk.

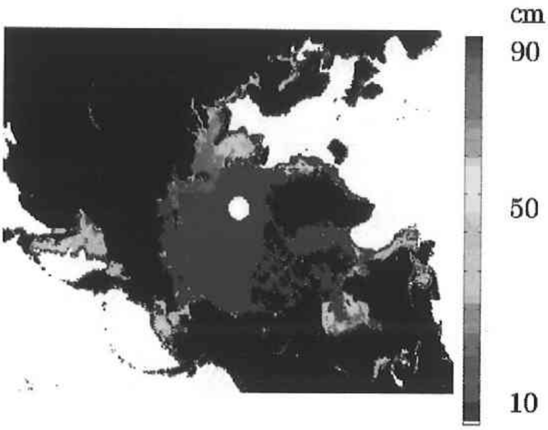

Fig. 4. Ice thickness distribution in the seasonal sea ice area.

Tateyama *et al.* (2002). Mean ice flow was also indicated in Figure 3. Sea of Okhotsk is covered by thin ice and sensitive for climatic conditions. Seasonal sea ice area in the Arctic can be investigated from a point of ice growth characteristics, by using these techniques.

Figure 4 shows an example of distinguishment of thin ice region and then ices thickness estimation to focus detail of regional ice thickness distribution.

Ice motion and Oceanic Current

One of the characteristics of sea ice compared to the other cryospheric components is its movement. Ice replacement is important information to study sea ice fluctuations. Interactions among the ice motion-wind-oceanic current will be investigated by new approaches of ice motion analysis (Kimura and Wakatsuchi, 2000).

Examples of estimations of oceanic current under sea ice by subtracting wind effect

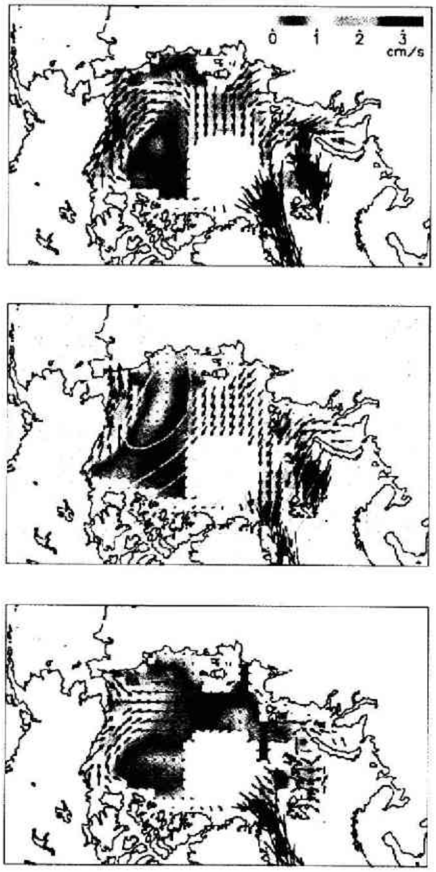

Fig. 5. Ice drift, wind component and Oceanic current based on the algorithm of Kimura and Wakatsuchi (2000).

from the ice drift were introduced in Figure 5. This shows the mean pattern of winter circulation. A clockwise circulation off Canada can be observed (Beaufort Gyre). Transpolar drift stream is visible as a stream to Atlantic Ocean through the North Polar region.

Ice motion analysis and ice thickness estimation provides ice advection data, thus the cause of ice condition changes will be analyzed from the thermal condition and dynamics of sea ice.

Summary

Newly developed sea ice observation techniques by satellite were introduced:

—Sea ice motion, sea ice type or ice thickness data can be obtained by the satellite remote sensing.

—Combinations of satellite observations of ice thickness and ice motion enable estimation of ice volume transport, which is important for investigating energy transport, salinity anomaly due to ice formation and melting.

—These analyses enable monitoring of sea ice from the point of energy and mass analysis.

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