ESTIMATION OF SEA ICE CONCENTRATION IN THE SEA OF OKHOTSK USING PALSAR POLARIMETRIC DATA

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1. INTRODUCTION

The extent of sea ice is related to local as well as global climate change, because sea ice acts as an insulator between air and seawater. It is very important to monitor an extent and volume of sea ice in order to understand global climate changes. Since the microwave remote sensing is expected to play an important role in monitoring sea ice in cryosphere due to its all weather capabilities, the data from microwave radiometer are mainly used in sea ice monitoring so far. However, the microwave radiometer data have been used limitedly in the Sea of Okhotsk, because the spatial resolution is not good enough for regional sea ice monitoring. If the SAR data can be applied to monitor sea ice in the Sea of Okhotsk, the spatial resolution problem will be solved and greatly contributed to operational sea ice monitoring.

The objective of this research is mainly in estimating sea ice concentration from Phased-Array L-band SAR (PALSAR) polarimetric data. This paper shows the results of estimating sea ice concentration from PALSAR data acquired in 2008 and 2009. AMSR-E sea ice concentration is also used to verify the result of sea ice concentration derived from PALSAR data.

2. TEST SITE AND PALSAR DATA

The Sea of Okhotsk is located in the most southerly region of the Northern Hemisphere, where sea ice exists only during wintertime. Our test site is located between Hokkaido and Sakhalin islands in the southern region of the Sea of Okhotsk. Most of sea ice found in this region has the thickness less than 1m. Based on ice core structure analysis, it is suggested that the dynamical ice growth process under turbulent conditions such as frazil ice formation and floe accumulation are the dominant contributors to thick ice growth in this region [1].

The Japan Aerospace Exploration Agency (JAXA) launched PALSAR aboard the Advanced Land Observing Satellite (ALOS) in January 2006. Although the ALOS has been observing the Sea of Okhotsk more than three years, there were a few PALSAR polarimetric data acquired in the Sea of Okhotsk in the sea ice growing season so far, because of the confliction with Japan Coast Guard ScanSAR requirements. Three polarimetric observations were finally conducted in our test site during 2008 and 2009 wintering periods.

3. ESTIMATION OF SEA ICE CONCENTRATION

Since the backscatter from open water depends on sea surface roughness caused by wind, it is generally difficult to recognize sea ice area by using the methods based on the backscattering coefficient. Our previous research showed that the scattering entropy of open water gives consistently low value in wide range of incidence angle, because the surface scattering is dominant in open water. On the contrary, the scattering entropy of various sea ice gives higher value than that of open water [2]. Therefore, we propose that the scattering entropy is used to distinguish sea ice from open water.

In order to determine a threshold for detecting open water from scattering entropy data, we compared the values of scattering entropy for various sea ice types with AMSR-E data as well as MODIS data. Based on the results of similar research [3], in which AMSR-E sea ice concentration was compare with RADARSAT-1 and MODIS imagery, we tried to determine the threshold of scattering entropy to detect sea ice area. As the result, a threshold of the scattering entropy to divide sea ice from open water is determined. Extracted sea ice area from PALSAR polarimetric data is given in Fig. 1.

4. COMPARISON OF SEA ICE CONCENTRATIONS BETWEEN PALSAR AND AMSR-E

In order to verify our method for deriving sea ice concentration from PALSAR data, we used well-known AMSR-E sea ice concentration data, which are distributed routinely by NSIDC. Sea ice concentration derived from PALSAR data has originally the spatial resolution of 50m, because the scattering entropy is calculated in the area of 8 pixels in azimuth by 4 pixels in range direction on level 1.1 data. Since AMSR-E sea ice concentration is 12.5km, which is 250 times as large as that of PALSAR's, there, is a big difference in spatial resolution of sea ice concentrations derived from PALSAR and AMSR-E data. The number of sea ice pixels within 12.5 km squared area was converted to PALSAR sea ice concentration.

The comparison of sea ice concentration between PALSAR and AMSR-E is given in Fig. 2. Although the consistency in derived sea ice concentrations is about 60 percent, we found some differences especially in AMSR-E low concentration area. Since we can recognize sea ice cover in backscattering image as well as scattering entropy image, we suppose that there is thin sea ice existing which AMSR-E cannot detect.

5. CONCLUSION

A method to estimate sea ice concentration from PALSAR data was proposed and applied to relatively thin sea ice area in the Sea of Okhotsk. This method is based on the finding in our previous research by using airborne L-band SAR data, in which the scattering entropy has consistently low in open water area. AMSR-E sea ice concentration was used to verify our proposed method. The difference in two sea ice concentrations was found especially in AMSR-E low concentration area. The high resolution backscattering and scattering entropy images give us an idea that there is some difficulty in AMSR-E to detect very thin sea ice in the Sea of Okhotsk.

6. ACKNOWLEDGMENT

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7. REFERENCES

[1] T. Toyota, K. Baba, E. Hashiya, and K. I. Ohshima, "In-situ ice and meteorological observations in the southern Sea of Okhotsk in 2001 winter: Ice structure, snow on ice, surface temperature, and optical environments," Polar Meteorol. Glaciol., vol. 16, pp. 116-132, 2002.

[2] H. Wakabayashi, T. Matsuoka, K. Nakamura, and F. Nishio , "Polarimetric Characteristics of Sea Ice in the Sea of Okhotsk by Airborne L-Band SAR, " IEEE Trans. on Geosci. and Remote Sens. vol. 42, no. 11, pp. 2412-2425, Nov. 2004

[3] J. F.Heinrichs, D. J.Cavalieri, and T. Markus, "Assessment of the AMSR-E sea ice concentration product at the ice edge using RADARSAT-1 and MODIS imagery," IEEE Trans. on Geosci. and Remote Sens. vol.44, no.11, pp. 3070-3080, Nov. 2006.

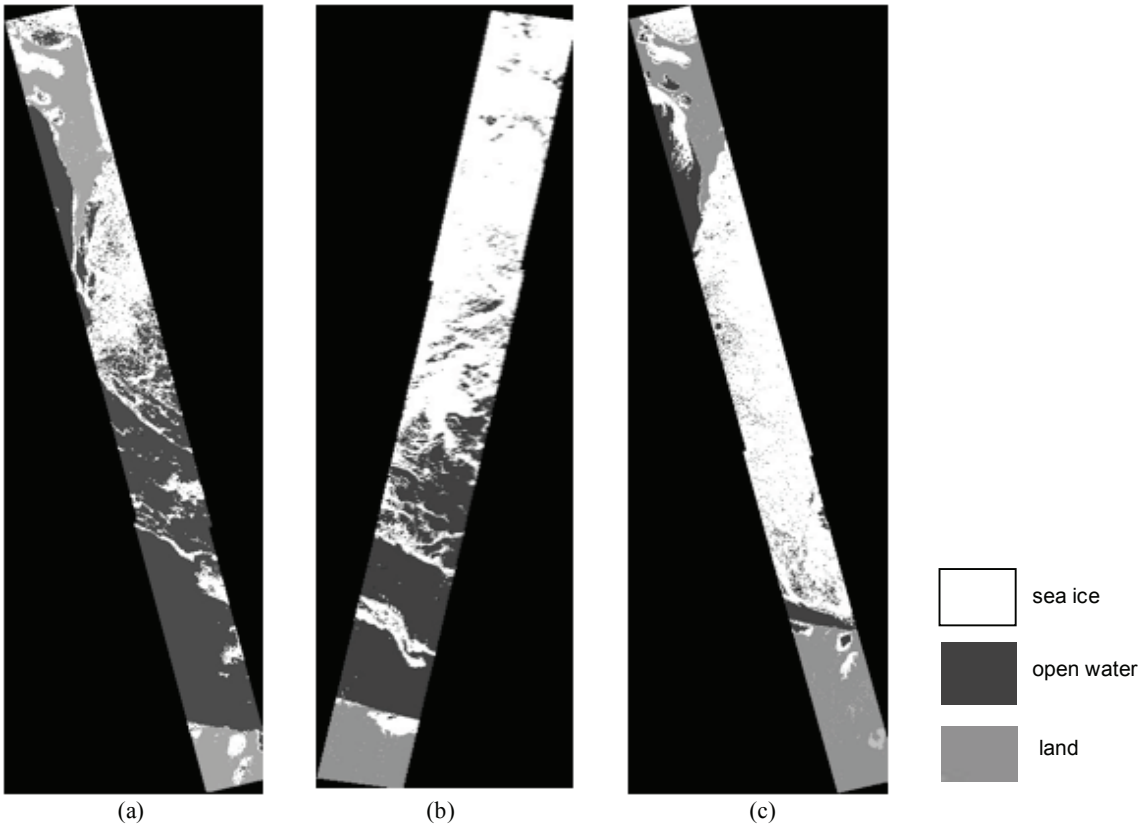

Fig.1. Extracted sea ice area from PALSAR polarimetric data.
(a) 2008/02/15, (b) 2008/02/17, (c) 2009/02/17

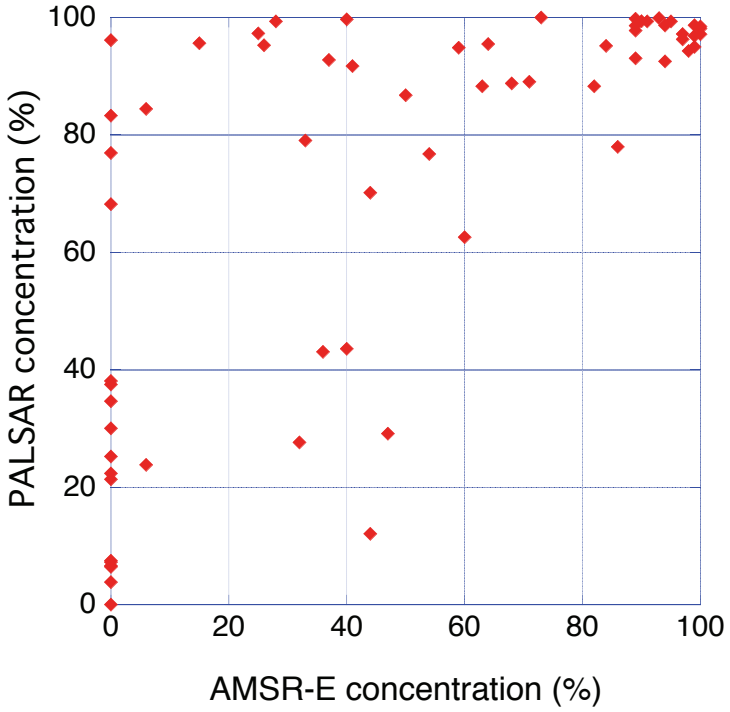

Fig.2. Comparison of sea ice concentration between PALSAR and AMSR-E.