Study on detecting thin sea ice area from satellite images

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Abstract：

In order to verify the possibility of detecting thin sea ice area from satellite images, authors are collecting multi-stage remote sensing data of sea ice for the passed few years. This paper describes about the comparison of thin sea ice images acquired from different platforms.

1. Introduction

The thermal flux from the thin sea ice to the air is 10 to 100 times larger than that of the thick sea ice(Maykat, 1978). Thus, monitoring of thin sea ice is quite important for the study of global warming. Since the albedo of thin sea ice changes with it's thickness, visible & near infrared sensors onboard satellites may monitor the thickness differences of thin sea ice. However, since thin sea ice areas consist of various sea ice types, such as Nilas, Pancake ice, Young ice, the explanation of the areas are not easy. For example, algorithm difference of estimating sea ice concentration from satellite passive microwave sensor often appears in thin sea ice area (Cho et al., 1998). In order to verify the possibility of detecting thin sea ice area from satellite images, the authors are collecting multi-stage remote sensing data of sea ice for the passed few years (Cho et al, 2003).

2. Multi-stage remote sensing

Recently, various satellite sensors are becoming available for sea ice monitoring. However, the information of which we can acquire with each sensor changes according to the spacial resolution and spectral bands of each sensor. Various types of sea ice are randomly distributed in certain sea ice zone, and the sizes of which are different from one type to another. For example, the diameter of typical pancake ice may be 20 cm, while the diameter of typical medium floe could be 200m or more. These situations are making it difficult to monitor sea ice condition from space. In order to verify the possibility of extracting thin sea ice information from remotely sensed data, preparation of multi-stage remote sensing data set for comparing sea ice images of various sensors including in-situ data is very important. The multi-stage remote sensing which authors are performing consists of observations from ships, low altitude airplanes, and satellites (See Figure 1).

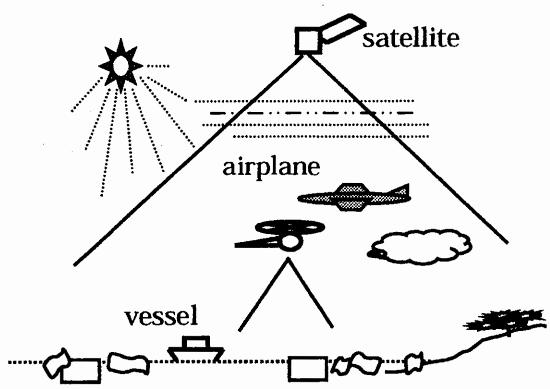


Figure 1. Muti-stage remote sensing of sea ice.

2.1 In-situ measurement

In-situ measurement is most important and most difficult. Since various types and scales of sea ice are often randomly distributed, the area for the measurement should carefully be selected. In this study, in-situ measurement consists of sea ice thickness measurement, spectral measurement, and photographing.

(1) Sea ice thickness measurement from an icebreaker

The authors have developed a system to measure sea ice thickness using stereo cameras equipped on a ice breaker(Cho et al. 2002). Figure 2 shows the concept diagram of the system. The sea ice thickness can be estimated with the error of 1.5cm when the stereo cameras are equipped 2.5m above the sea level.

(2)Spectral measurement

Spectral measurement of sea ice using radiometer is quite difficult. The condition of sea ice surface changes from one place to another. In order to compare the spectral data with satellite data, it is important to perform the spectral measurement at several points within certain area and calculate the averaged value.

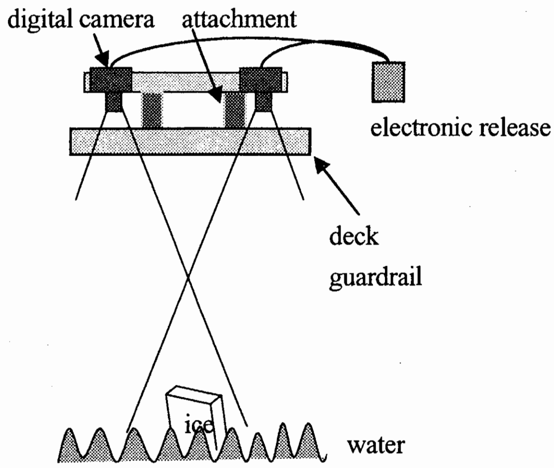


Figure 2. Stereo pair imaging system for sea ice thickness measurement.

(3) Photographing

In-situ images taken from ships and from land are important information for understanding the condition of the sea ice.

2.2 Aerial observation

Observations from low altitude helicopter/airplane provide very high resolution images of sea ice which are necessary for connecting in-situ measurement data with satellite observation. Multi-spectral imager observation from an airplane is quite useful. But even a digital camera imaging from a Cessna give us useful information for identifying in-situ measurement location on the satellite images.

2,3 Satellite observation

Satellite observation gives us wide view of sea ice. However there is always limitation for extracting detailed sea ice information from low/middle special resolution satellite images. High resolution satellite images such as of IKONOS may cover the gap between low/middle special resolution satellite images and aerial/in-situ images of sea ice.

3. Comparison of multi-stage remote sensing images of sea ice

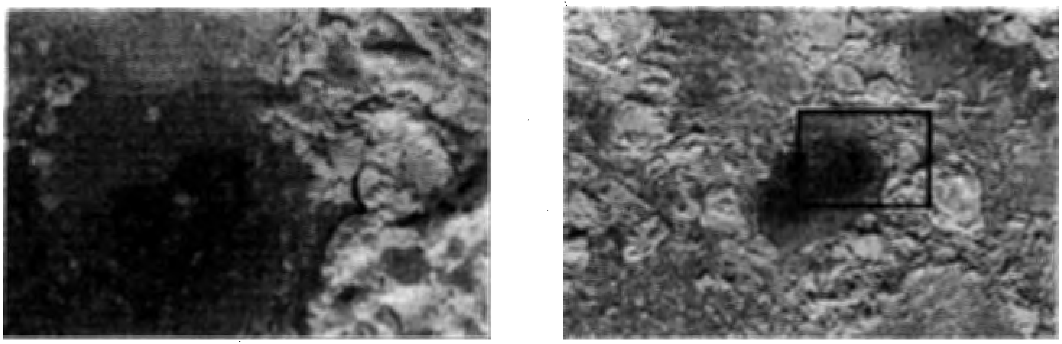
3.1 Aerial images

(1) Images from a remote control helicopter

An experimental flight using a remote controlled(RC) helicopter was performed by Dr. Yoshiaki Honda's group of CERES of Chiba University in March 2000 along the coast of Hokkaido. Figure 3 show example images of sea ice area taken by the digital camera onboard the helicopter. The high resolution aerial images give us detailed information on sea ice condition and distribution. Even though the digital camera is only a color camera, the images give us good information on the condition of sea ice.

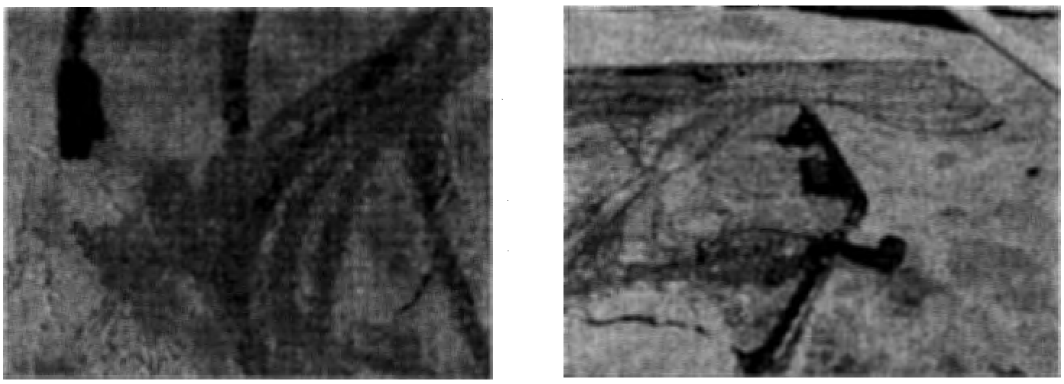
(2) Images from a Cessna

Figure 4 shows images of the icebreaker and it's surrounding sea ice area taken when the ice thickness measurement was performed on the icebreaker on March 6, 2003.



(a) Resolution : 4mm (altitude: 15m)　　　(b) Rresolution : 16mm (Altitude: 60m)

Figure 3. Images from the hericopter.



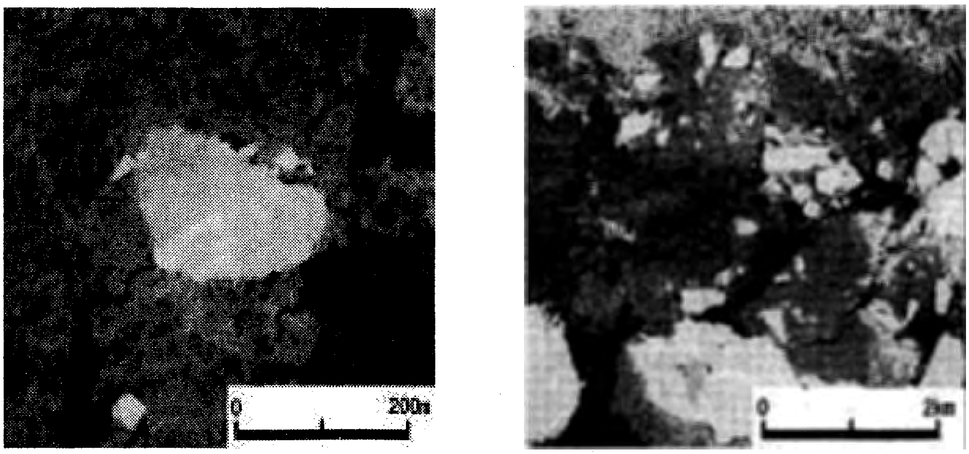
(a) Garinko-2 and it's trajectory (Resolution:35cm)　(b) Monbetsu Bay and trajectories of Garinko-2

Figure 4. Aerial images of sea ice from a Cessna (Altitude: 150m)

3.2 Satellite Images

(1) IKONOS

Recently, 1m or higher resolution satellite images of IKONOS, OrbView-3, Quickbird etc. are becoming available. On March 10, 2000, IKONOS observation was performed over the Sea of Okhotsk. Figure 5 shows a part of the IKONOS image in different resolution. (a) is the original 1m resolution image and (b) is the averaged 10m resolution image. The images strongly suggest the advantage of using 1m resolution satellite images for thin sea ice identification.



(a) Resolution : 1m (original)　　　(b) Resolution : 10m (10x10 averaged)

Figure 5. IKONOS images of the Sea of Okhotsk(March 10, 2000)　© Japan Space Imaging

(2) Landsat-7/ETM

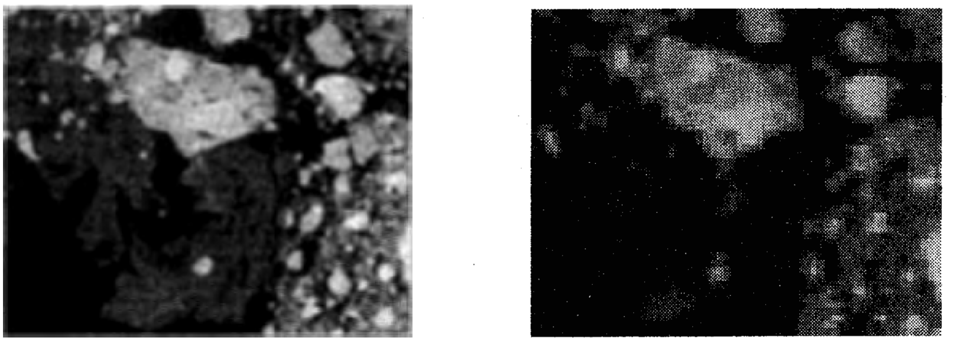
The Landsat-7 observation over Hokkaido was performed on March 6, 2003. Figure 6 shows the ETM panchromatic image of Monbetsu Bay. The trajectories of the icebreaker Garinko-2 can clearly be seen on the image. By using the GPS data of the icebreaker, the in-situ sea-ice measurement data can easily be plotted on a map and overlay on the ETM imagery.

(3) Terra/MODIS

The Figure 8 shows the comparison of NOAA/AVHRR image with MODIS image. The advantage of 250m resolution of MODIS is clear.

Resolution:15m

Figure 6. Landsat/ETM image



(a) Terra/MODIS image(Resolution:250m) (b)NOAA/AVHRR image(Resolution:1km)

Figure 8. Comparison of MODIS image and AVHRR image.(April 3, 2003)

5. Conclusion

The multi-stage remote sensing images of sea ice around Monbetsu Bay have been collected and compared. Even though the images are not all simultaneously collected, the images strongly suggest the importance of multi-stage remote sensing for sea ice. Our next step is to collect various multi-stage remote sensing data in same time to verify the possibility of detecting thin sea ice area from satellite images. This experiment was performed under the science project of the General Research Organization of Tokai University Educational System.

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