Observation of the Bo-hai, China by NOAA/AVHRR and MOS1/MESSR

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1 Introduction

The Bo-hai is attracting attention again. It is said that the oil field, which was discovered in the Liaodong Bay last year(1987), will be the largest one in China at present. Aside from oil resource, the Bo-hai has been involved in many troubles due to its geographical position. Its importance is much increasing economically and politically.

Long range observations of atmospheric and oceanographic phenomena are essential for the development of the coast and mining of underground mineral resources, but there is no systematic satellite observation of the Bo-hai.

It is said that the Liaodong Bay is the southern limit in the northern hemisphere where drift ice is seen. The oceanographic conditions in the Liaodong Bay, therefore, must be very severe in winter owing to drift ice as well as wild weather.

Fujii and Ishimori(1987) studied the drift ice in the Liaodong Bay using LANDSAT MSS images from 1982 to 1986. In spite of their effort and others, the freezing process of the sea is still not clear. Therefore, time series data are most desirable for the observation of the sea features, freezing and melting processes in particular.

In order to confirm the features of the bay onshore and offshore, the authors used here NOAA/AVHRR data along with MOS1/MESSR data.

2 Features of the Liaodong Bay

2.1 Observation by NOAA/AVHRR

It is difficult to collect LANDSAT time series data through seasons since the quality of the data absolutely depends on the weather conditions in addition to its long recurring interval. every week.

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On the contrary, NOAA satellite scans the same spot twice a day and returns to the previous trajectory It is, therefore, expected that NOAA is more useful than other satellites for time series analysis. The spatial resolutions of the exsisting satellites are depicted in Fig.1

A set of the time series data of NOAA, which covers early December 1986 to late March 1987, was prepared. The data used to demonstrate the drift ice are listed in Table 1 along with those of MOS1.

Table 1 Data of satellites

satellite	date	row/path
NOAA	Dec.10,'86	
NOAA	Jan. 8,'87	
NOAA	Jan.28,'87	
NOAA	Feb.25,'87	
NOAA	Mar. 5,'87	
NOAA	Mar.25,'87	
MOS1	Apr.22,'87	33/63W
MOS1	Dec.26,'87	33/63W
MOS1	Jan.17,'88	31/64W

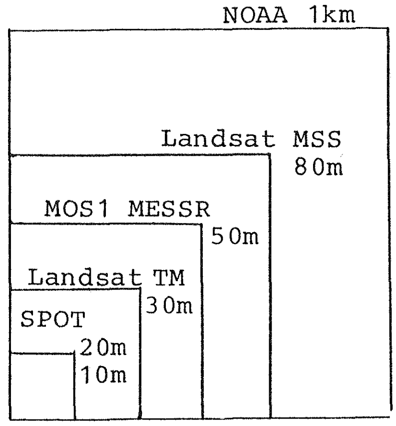

Fig.1 Spatial resolution

Figs.2(a)-(f) are color composite images consisting of three bands except other two thermal images(refer to next page). In this case, the differential operation was conducted prior to image enhancement.

No drift ice is seen in Fig.2(a), while the bottom of the bay looks ice-bounded in Fig.2(b). The drift ice probably generates through the remarkable change of the water level between full and ebb tides under the circumstances (Fujii and Ishimori, 1987).

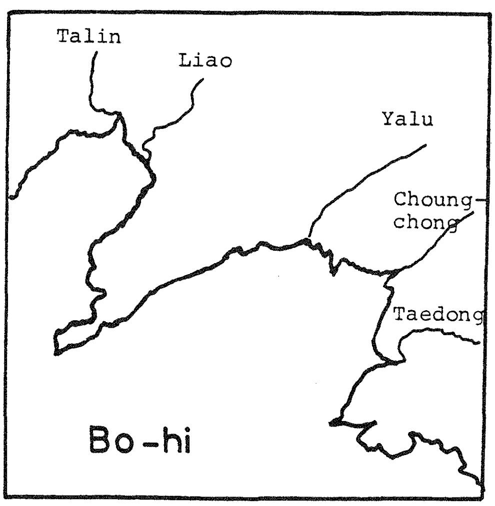

Fig.3 Geography of the Bo-hai and locations of the rivers influential on drift ice.

In Fig.2(c), the drift ice is extended as long as 100km to the center of the bay, but its root is at the bottom of the bay. This fact suggests that the drift ice is still developing, so that the bay looks as if it is ice-bounded. The drift ice can

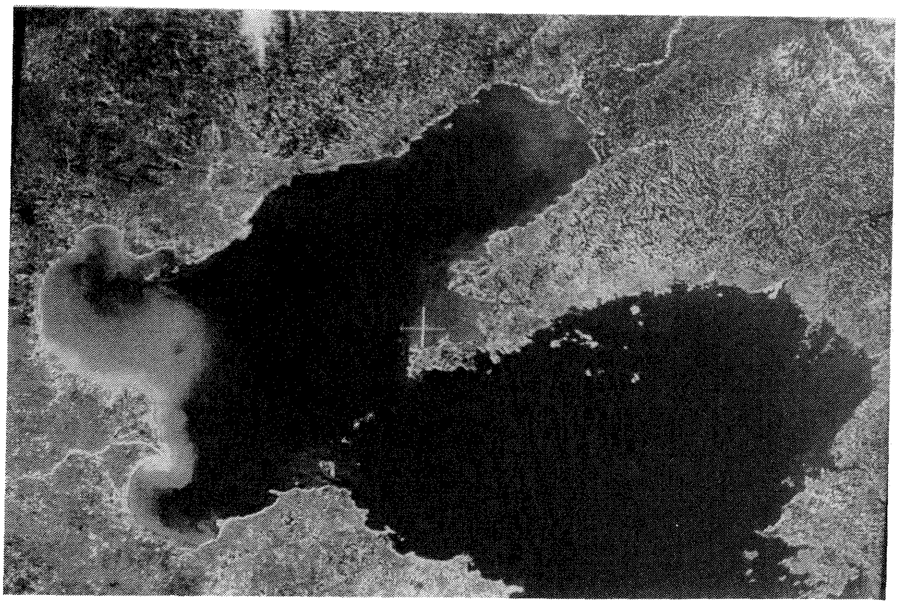

Fig.2(a)
Dec.10,'86

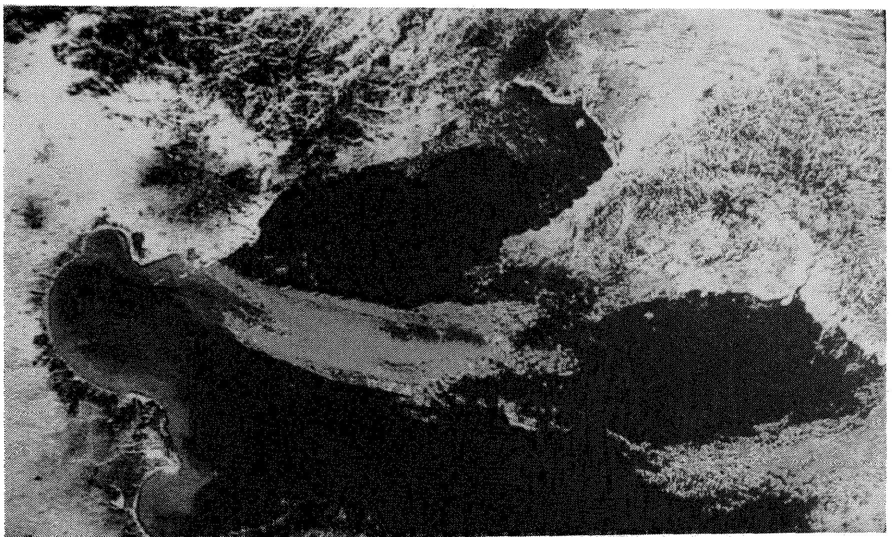

Fig.2(b)
Jan.8,'87

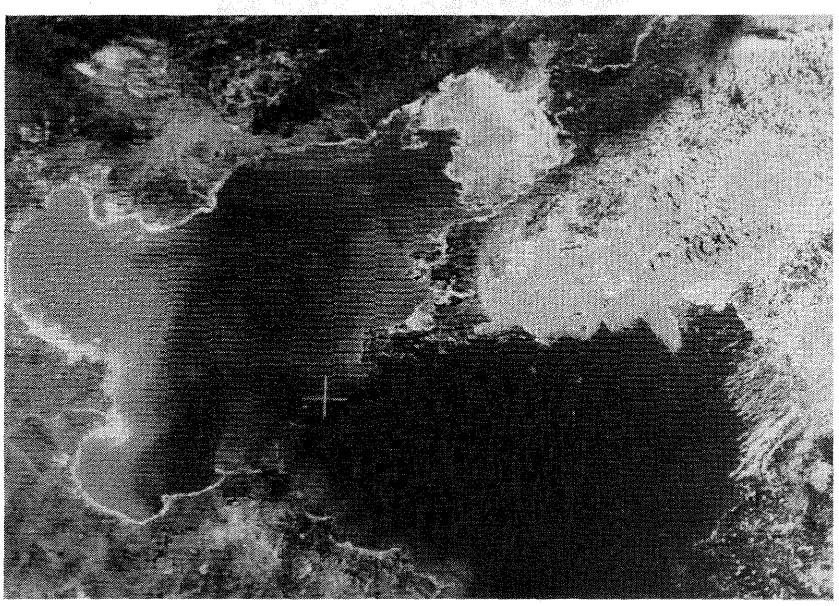

Fig.2(c)
Jan.28,'87

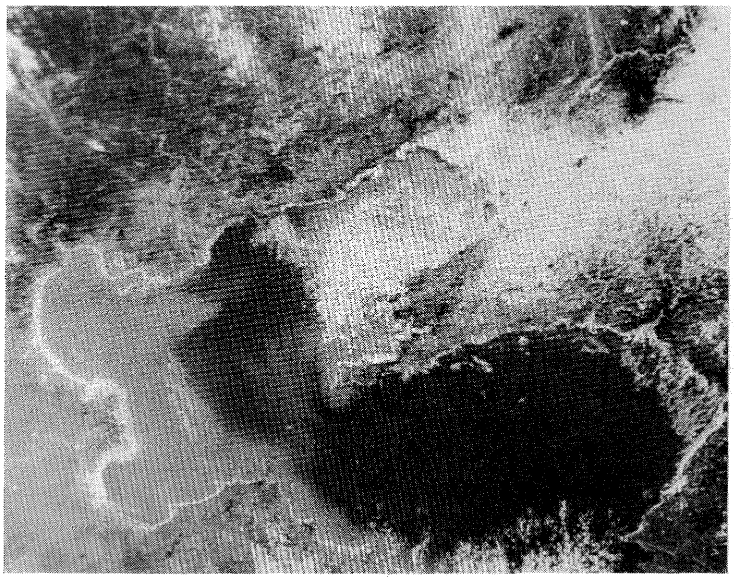

Fig.2(d)
Feb.25,'87

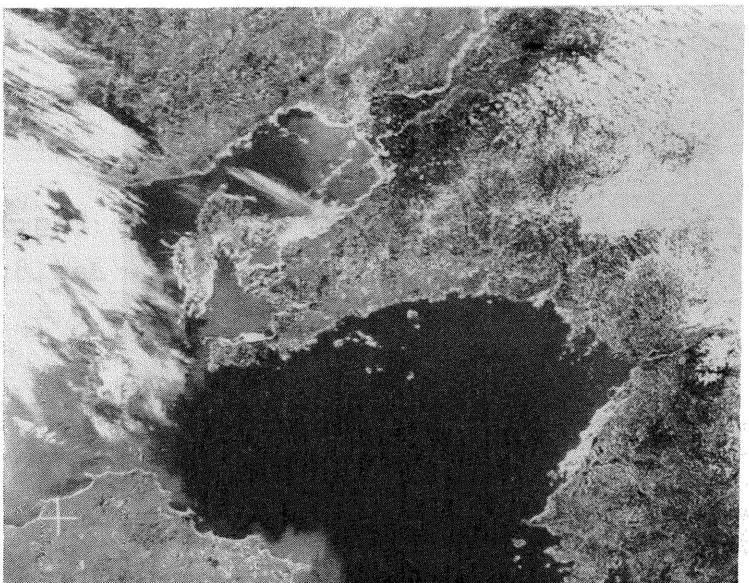

Fig.2(e)
Mar. 5,'87

Fig.2(f)
Mar.25,'87

barely been seen in the West Korean Sea but its origin is supposed to be the Yalu River or the Choung-Chong River. Fig.3 shows the locations of these big rivers.

There also can be seen some pieces of the drift ice in the West Korean Sea in Fig.2(d). However, there is no ice at the bottom of the bay and a huge lump of the drift ice is going out of the Liaodong Bay. This fact indicates that the generation of the drift ice from the Liao River is completely exhausted.

In Fig.2(e), most of the drift ice is melted except a couple of pieces at the upside of the Liaodong peninsula. There is another scene of the same date as Fig.2(e) but 1986, and it also shows that here is the right spot where the survived ice pieces finally disappears. The schematic is shown in Fig.4.

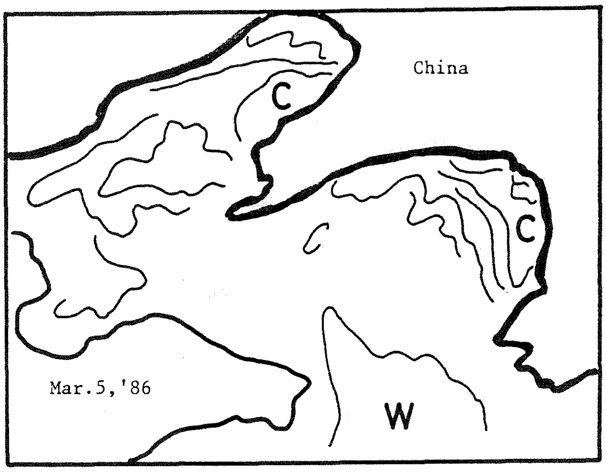

Fig.4 Contour of surface temperature of the Bo-hai.
C: cold water
W: warm water

In Fig.2(f), there can be seen no ice piece in the Bo-hai. Instead, we can see a pattern which suggests a trace of turbid water from the Liao River. It must be due to the stream of the melted snow. The pattern is extended one week later (not shown here).

Fig.5(a)-(c) show the changes of the surface temperature. The gray scale indicates a relative temperature and it is proportional to the density. As expected, it can be seen that the temperature gradient is ramarkably steep in Fig.5(a) where no drift ice is existing, while the temperature patterns become quite monotonous in Figs.5(b) and (c) where the bay is packed with the drift ice.

2.2 Observation by MOS1/MESSR

The MOS1 data are now available for general usage. The spatial resolution of MESSR is sufficient to observe features of sea and land.

Fig.6 shows that the drift ice around the mouth of the Talin River(Dec 16, 1987). Its size is about 70km wide and 20km long. As shown in Fig.2(b), the drift ice is growing at the time of this season and its pattern can be seen more clearly in Fig.6.

Fig.7 shows the mouth of the Yalu River(Jan.17, 1988). There are many pieces of the drift ice along the coast. These

Fig.5(a)
Dec.10,'86

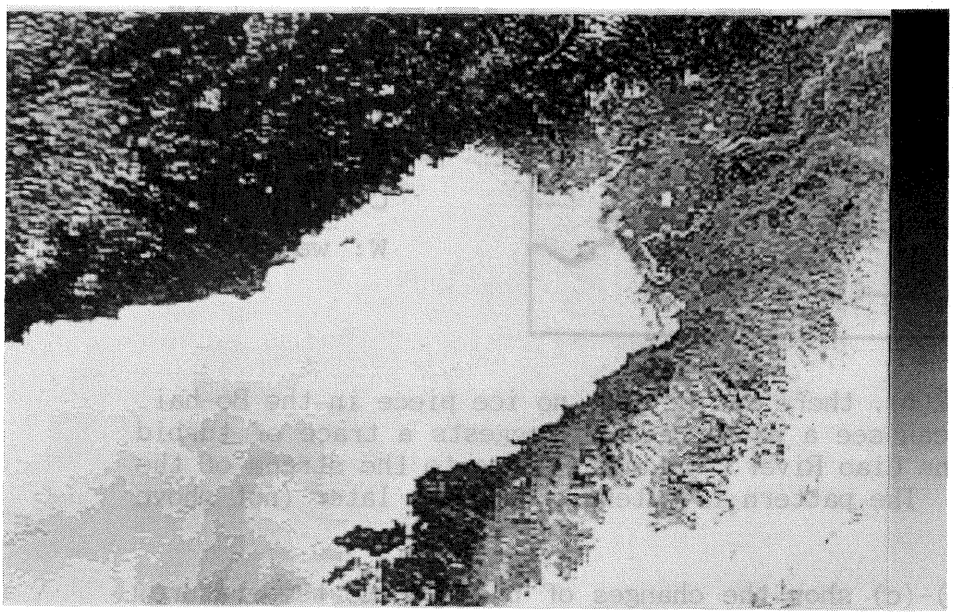

Fig.5(b)
Jan.28,'97

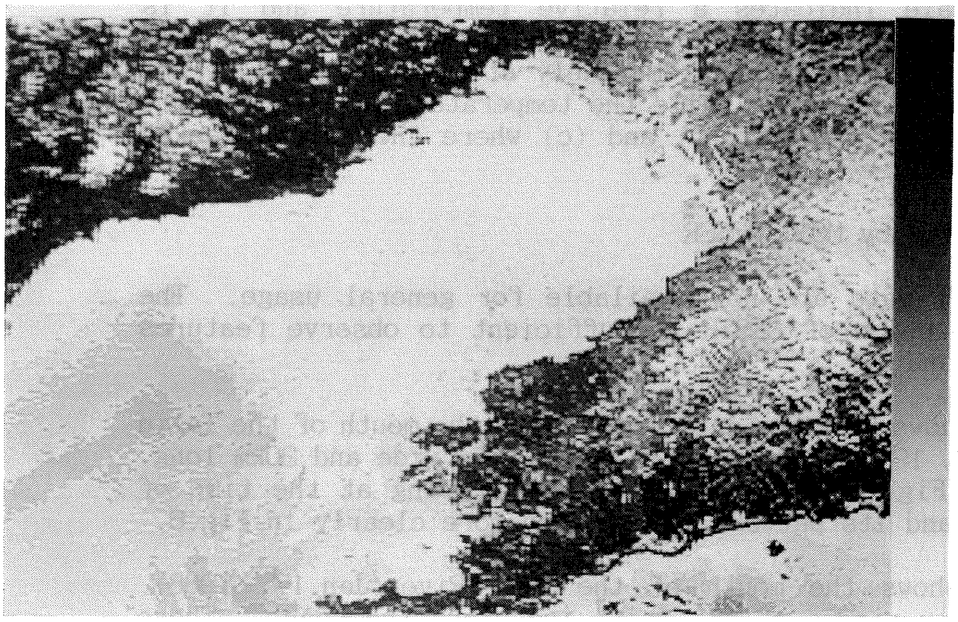

Fig.5(c)
Feb.25,'87

Fig.6 Mouth of the Liao Rever. Dec.16 (1987)

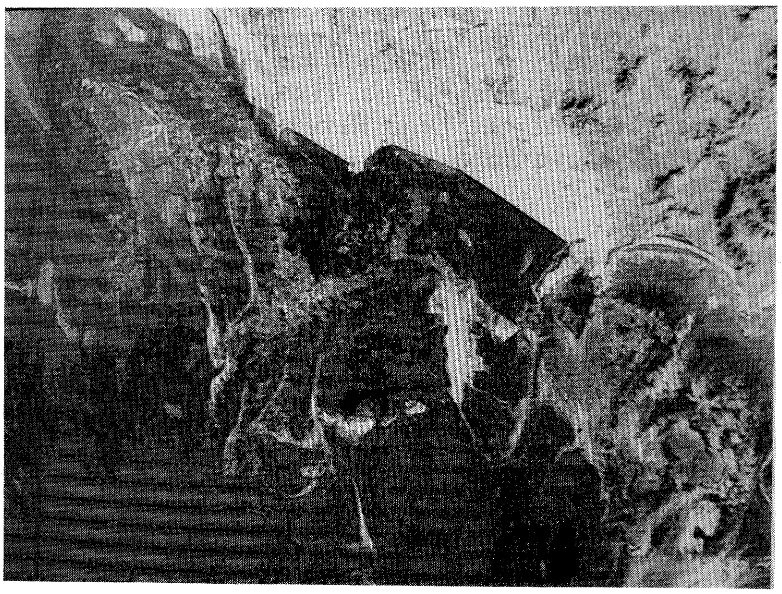

Fig.7 Mouth of the Yalu Rever. Jan.17 (1988)

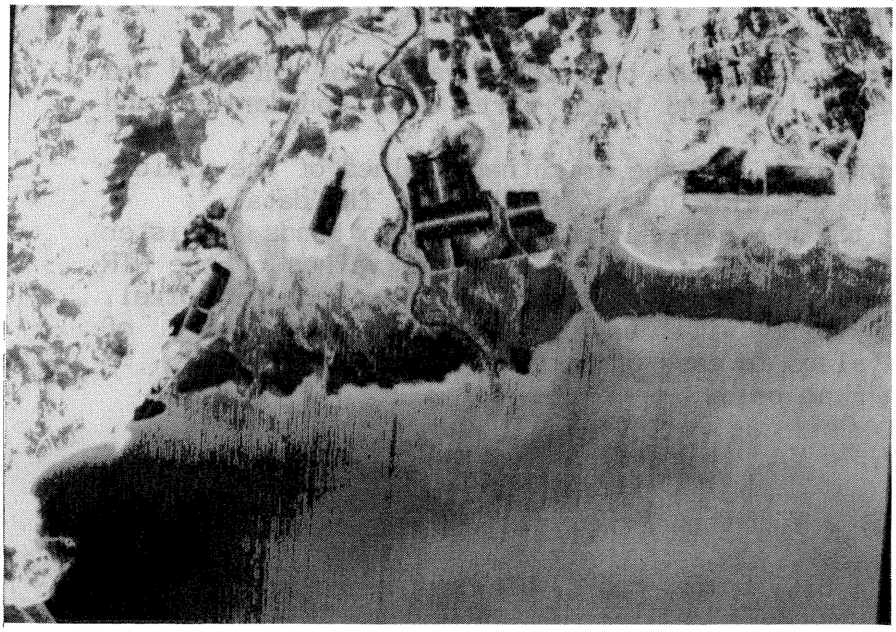

Fig.8 Salt field in the bottom of the Liaodong Bay. Apr.22 (1987)

ice pieces may be driven to the center of the West Korean Sea and exhausted around the sopt shown in Fig.2(e) and Fig.4. As demonstrated here, the MOS1 data are very useful when they are used in connection with NOAA time series data.

Aside from underground mineral resources, the shore of the Bo-hai is expected to be productive since it is very shoaling and the change of the water level between full and ebb tides is outstandingly large. As expected, the MOS1 data have revealed that there are many salt fields on the shore of the Bo-hai. Fig.8 shows salt fields near the Liao River(Apr.22, 1987).

Prior to the present study, the salt field in Korean peninsula was examined by SPOT images. In the SPOT images, white staight lines in black patches in Fig.8 divide into dotted lines which indicate piles of sand particles coated by white salt particulates. The surface of the salt fields in Fig.8 was estimated by the most likelihood method. It is as large as $6km^2$.

In addition to the salt field, another MOS1 imagery has revealed that there are huge facilities like fish firm or sea weed firm in the east side of the Liao River , but it is still under investigation(not shown here).

3 Histgram saparation in visible band of NOAA data

Fig.9 shows a model in which two spectral informations are used to compose a new single band image. Let us call this flag model hereafter(Yano et al., 1987). The new band usually consists of near infrared red(NIR) information of 1 bit and visible or thermal information of 7 bit. NIR of 1 bit is placed in the position of the most significant bit(MSB) and behaves as a *flag*. By doing so, boundary between land and water in visible or thermal image becomes much clearer than original images. As an example, we demonstrate how to deal with the NOAA data by a personal computer.

1. Find the threshold of the brightness values of infrared red data, at which land and water parts make boundaries, and register it as V_{th}.
2. Find the minimum V_{min} of the brightness values of the visible or thermal image. This value is a bias of the data.
3. By scanning the whole pixel matrices of two bands, register every V_{ir} and V_r which are the brightness values of the NIR and visible or thermal bands for a certain pixel, respectively. it will usually make 512×400 pairs of brightness values in case of personal computer.
4. Make a flag F as below.

   If $V_{ir} < V_{th}$, then F=0

   If $V_{ir} \geqq V_{th}$, then F=1

5. By adding F(1 bit) to (V_r-V_{min})(7 bit), it reduces to V_c, that is,

$$V_c=F\times2^7+(V_r-V_{min})$$

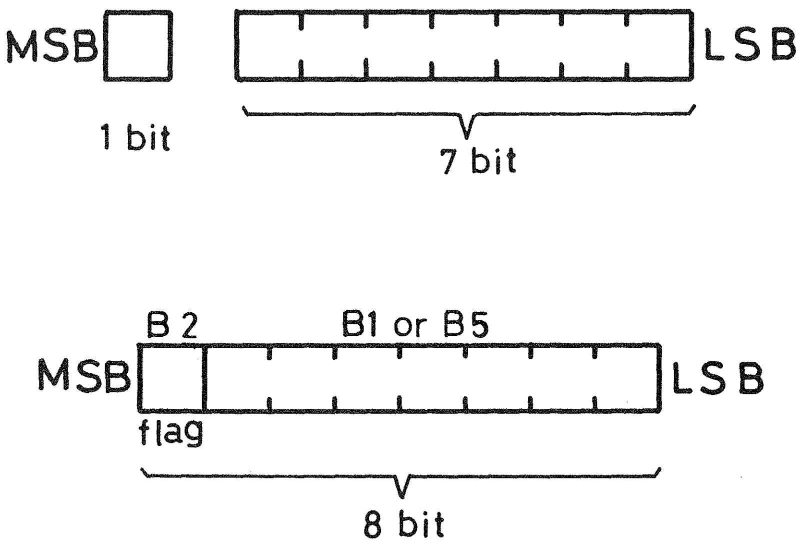

Fig.9 Schematic of falg model

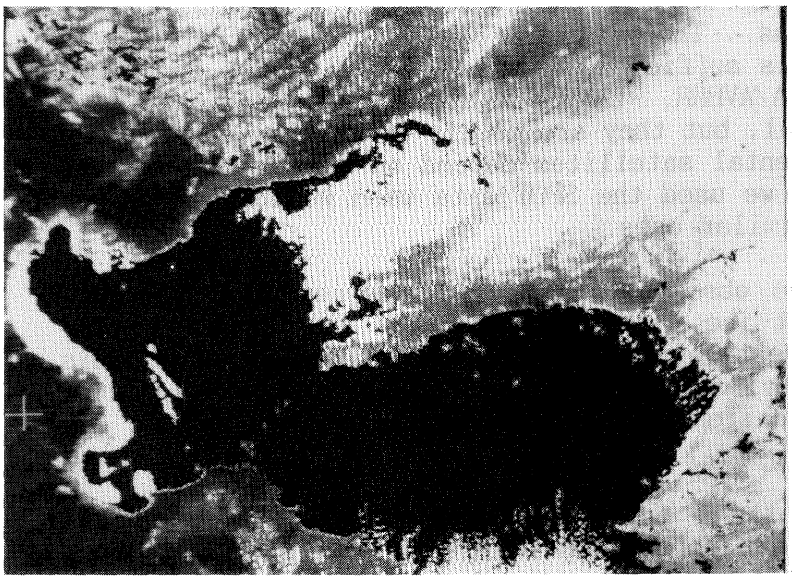

Fig.10(a) Ch.1 without flag

Fig.10(b) Ch.1 with flag

Thus, transformed image data are characterized as follows.

If $0 \leqq V_c < 127$,

then it reflects informations of water part

If $127 \leqq V_c \geqq 255$,

then it reflects informations of land part.

Fig.10(a) shows the original image of Ch.1(visible), while Fig.10(b) shows the image transformed by the flag technique. The latter image is remarkably improved.

4 Discussion and conclusion

It should be stressed that the NOAA data are indespensable for time series observations and that their results are more fruitful when supported by other satellites having better spatial resolutions. The spatial resolution of MOS1/MESSR is about 50m and it is sufficient enough to make up for the rough resolution of NOAA/AVHRR. LANDSAT TM data and SPOT data also can be supplemental, but they are costly in certain cases. The choice of supplemental satellites depend on the purpose of the study. Actually, we used the SPOT data when we identified the salt field from similar ones.

The satellite observations have first revealed the life cycle of the drift ice in the Bo-hai. The same approach will be applied to investigations of analogous phemomena. In this case, a supplemental satellite will be needed in both aspects, that is, identification and classification, if the latter one is necessary.

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MOS1 data used here were received and processed by Earth Observation Center National Space Development Agency of Japan.

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