ANALYSIS OF EFFECTS AFTER TYPHOON 8115 IN COASTAL AREA AND FIELDS IN HOKKAIDO, NORTHERN JAPAN, USING LANDSAT MSS DATA

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Abstract

Based on Landsat MSS data taken consecutively after typhoon 8115 which brought heavy rainfall over Hokkaido and subsequent flood, coastal phenomena and feasibility of detecting flooded area were investigated assisted with areal photos taken immediately after the previous flood.

It was found there exist fairly complicated meso-scale phenomena such as counter currents along the coast of eastern Hokkaido. In a small bay the existence of local circuration generated perhaps due to the effect of coastal shape and ocean current was observed also.

Several experiments reveal that MSS band 4 and 5 imageries are effective to detect sea surface phenomena.

Detecting flooded area in mid-eastern plain of Hokkaido was fairly difficult from the MSS imagery analysis.

I. Introduction

Recently the utilization of remotely sensed data by satellites has been increasing year by year and a lot of papers have been published in many countries including Japan.

Tsuchiya, one of the authors, et al.[1] indicated examples of sea surface phenomena around Japan revealed by airborne MSS, Landsat MSS, Landsat RBV and Geostationary Geometrological Satellite of Japan(GMS) data.

Regarding sea surface phenomena, Munday et al.[2] reported about the detection of oil slicks and oil spill by MSS and MSC. In 1980, Ochiai reported the effectiveness of airborne MSS and Landsat RBV camera in the detection of oil slicks in coastal area in Japan [3]. As early as 1973, Pirie et al.[4] and Klemas et al.[5] studied suspended substances and coastal processes based on Landsat MSS data. As to oceanic front, Mun and Gordon[6] carried out a fine study based on Landsat MSS data, while Pierson et al.[7] made a good analysis based on Landsat MSS and SKYLAB EREP data.

For the detection of expanding patterns of river effluents from the river, Tsuchiya et al.[8] reported a result of digital analysis around Ishikari Bay in Hokkaido based on Landsat MSS and

Landsat RBV camera data.

In this paper, indicated are water surface phenomena near the coast and effects in not only coastal area but also fields after Typhoon 8115 which landed in Hokkaido, northeast one of four main islands of Japan, on August 23 in 1981. In the analysis of the phenomena and the effects, Landsat MSS data of August 25, two days after the typhoon,were mainly utilized.

The water surface phenomena and the effects in coastal area concerned are on a front of muddy river water in the sea, counter currents to the ocean current, bay current variation in a small bay and a clear water flow through a swamp into a muddy lake.

II. Analysis of Coastal Phenomena as Revealed by MSS Data

It is recognized that in the imageries of Landsat MSS band 4 and 5 of August 25, radiance of sea water near the coastal line is greater than those of September 30, 1981 and the high radiant area is much more widespread(See Photo 1 and 2). The high radiant pattern in the coastal area is thought to be mostly muddy river water into the sea after the heavy rainfall caused by Typhoon 8115.

The following four phenomena are observed in Landsat MSS imageries of August 25 and also of September 30;

A front of muddy water 10 to 35 kilo-meters at sea along the coastal line
Water flows along the coast of the Tokachi Plain(Indicated in Fig.1) and mixing with the flows of the opposite direction near Kombumori(Indicated in Fig.1 also)
Muddy water pattern in Akkeshi Bay(Indicated in Fig.1) suggesting clockwise flows
Water flows into Lake Akkeshi at the river mouth

The results of analtsis of phenomena listed above are described in the following paragraphs.

II.1 Front of Muddy Water

According to the sea truth data, a sharp change of salinity from 24 ‰ to 32 ‰ takes place at off the mouth of the Tokachi River (Indicated in Fig.1) where deapth is in the range from 50 to 120 meters(See Fig.2 and 3).

Also according to the measurement data of water volume of the Tokachi River at the points A and B(indicated in Fig.1), water amount of the river remarkably increased on 23 and 24 of August(See Fig.4).

Judging from the two facts above, the pattern of water is considered to be that by rivers in the Tokachi Plain.

It is recognized from the imageries of MSS band 4 of August 25 that a front of muddy water coincides with the iso-line of around 200 meters' depth(Photo 1 and Fig.2).

On the other hand, the front of muddy water on September 30 approximately coincides with a 70 meters depth contour line. Therefore the front of muddy water move forward or backward in accordance with volume of discharged river water into the sea, where an ocean current must have some effect on the formation of the front.

II.2 Water Flows along Coast

The ocean current flows from northeast to southwest off both Akkeshi Bay and the coast of the Tokachi Plain(See Fig.5). On the other hand, the water flows around the river mouth prove that the direction of current along the coast near the Tokachi Plain is from southwest to northeast. Therefore a meso-scale counter current is

thought to exist as is shown by a thick arrow in Fig.5, and it is observed in MSS band 4 imagery on August 25 that the current from southwest along the coast mixes with that from northeast near Kombumori(See Photo 1).

II.3 Bay Current

Clockwise rotation of muddy water in Akkeshi Bay is recognized in MSS imageries on both August 25 and September 30. Especially, extremely muddy water rotation is observed in the former imagery.

Multi-temporal comparison of Landsat MSS data shows the feature of water flows change according to tide or season(Photo 3). In winter, water in the bay is clearer, and the flowing pattern of ice there is obviously different from that of muddy water in summer. Bay current is considered to be affected by the ocean current off Akkeshi Bay.

II.4 Clear Water Flowing into Lake

According to MSS band 4 and 5 imageries on both August 25 and September 30, relatively clear water flowing into Lake Akkeshi(Indicated in Fig.1), while the lake is not clear owing to high plankton density (See Photo 3 (a) and (b)). Water of the river is not muddy even immediately after the typhoon though that of other rivers contain plenty of mud.

III. Detection of Flooded Area

An attempt was made to detect the flooded area in the Tokachi Plain from Landsat imageries taken two days after Typhoon 8115 which passed over Hokkaido on August 23 and caused flood in the area.

Unfortunately the area in the MSS imageries taken before the flood were entirely covered with cloud, so the scenes which were applicable to the analysis were only those of August 25 and September 30, 1981 after the flood was over.

It was not easy to detect the flooded area due to the following reasons;

a) The flood caused by Typhoon 8115 was not so great.
b) The surface condition changed between August 25 and September 30, which makes multi-temporal analysis difficult. For example, at the beginning of September a spring wheat farm, where wheat was reapt at the end of July, was digged, and potatoes were cropped for crop rotation almost at the beginning of September.
c) A part of the area concerned was covered with thin cloud which makes digital analysis difficult.

To clear the difficulties above, color areal photos(Photo 6 and 7) were greatly effective. The photos were taken not after Typhoon 8115 but on around August 7, four days after previously passed Typhoon 8112 which caused great and widespread flood in Hokkaido. There is a good reason to assume that flooded area by heavy rainfall of the previous typhoon may be flooded again by the rainfall of the present typhoon, Typhoon 8115. Thus it is reasonable to make use of the areal photos taken on around August 7, 1981.

In fact, correspondence of traces of submergence between areal photos and Landsat MSS false color images(band 4, 5 and 7) was recognized(See Photo 5 and 7).

The analized areas are shown in Fig.1 and Photo 4 and 5.

Using Landsat digital image data analysis system, the spectral characteristics(See Fig.6) of the sites interpreted as flooded area (See Photo 5) in Landsat image on August 25 were computed and the flooded area was classified.

IV. Concluding Remarks

The forgoing analysis indicates the followings;

i) Landsat Mss band 4 and 5 black-and-white imageries, including two-band composite false color imageries (e.g. blue and green for band 4 and red for band 5), are effective for the detection of meso-scale coastal phenomena such as a front of muddy river water discharged into the sea, a counter current near a coast, bay current variation in a small bay and clear water flows into a muddy lake.

ii) Small-scale flood in fields, such as less than a few hundred square meters in area, can be detected. Especially, MSS false color imageries(blue, green and red for band 4, 5 and 7 respectively) and the color areal photos after flooding were valid in the analysis.

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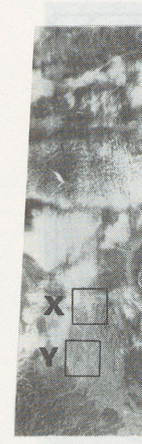

Photo 1 L

Photo 2

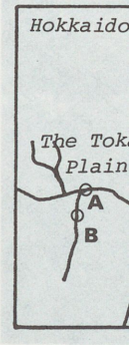

Fig.1 Ma
Note: A
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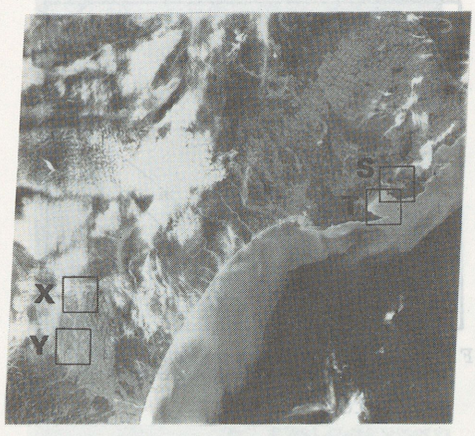
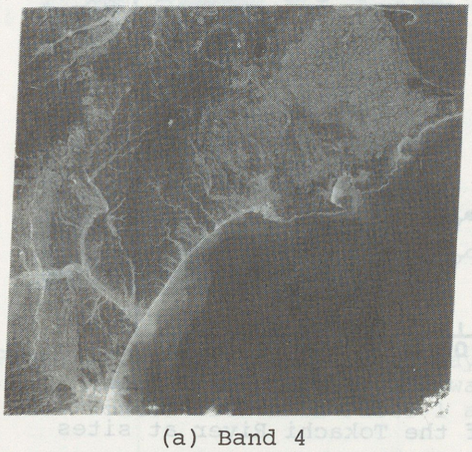
F



(a) Band 4

(b) Band 5

Photo 1 Landsat MSS imageries of eastern part of Hokkaido (WRS path 114 and row 30) on Aug. 25, 1981



(a) Band 4

(b) Band 5

Photo 2 Landsat MSS imegeries of eastern part of Hokkaido (WRS path 114 and row 30) on Sep. 30, 1891

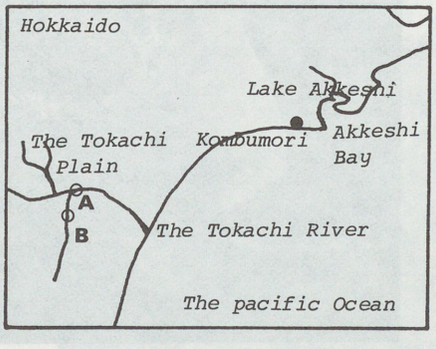


Fig.1 Map of eastern Hokkaido
Note: A & B; Sites of river water measurement (See Fig.4)

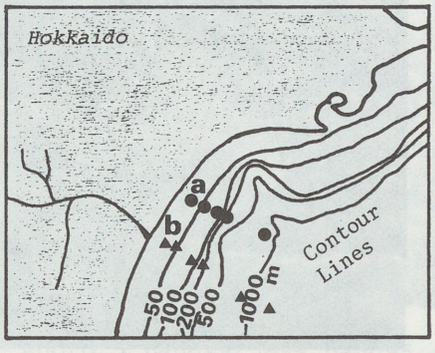


Fig.2 Contour map of sea depth
Note: a & b ; Sites of salinity measurement (See Fig.3)

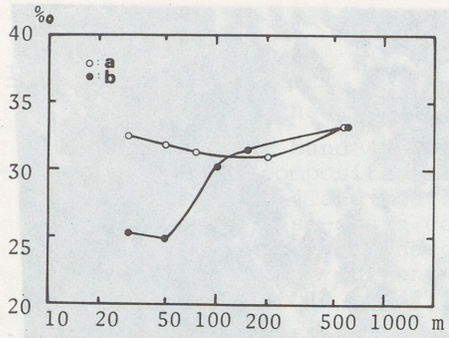


Fig.3 Relationships between salinity and sea depth at sites a and b (See Fig.2)

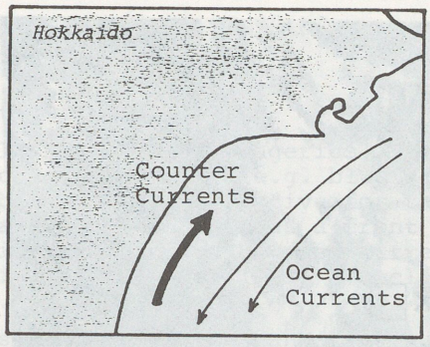


Fig.5 Ocean currents and counter currents off eastern Hokkaido

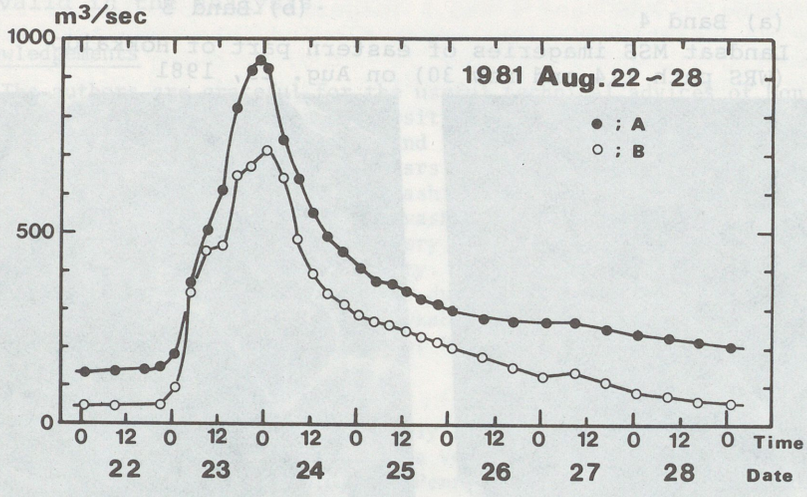
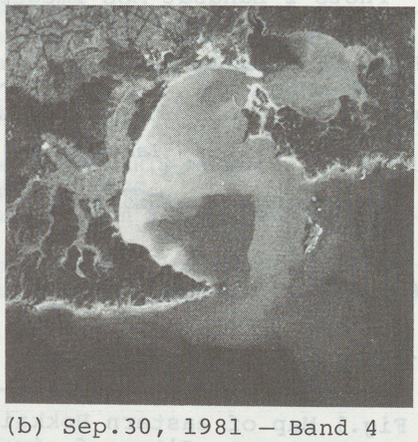


Fig.4 Water volume variation of the Tokachi River at sites A and B (See Fig.2)

(a) Aug.25, 1981 — Band 4



(b) Sep.30, 1981 — Band 4

Photo 3 Feature Variations of bay current in Akkeshi Bay (Indicated with T in Photo 1) and water pattern in Lake Akkeshi (Indicated with S in Photo 1 also)

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Photo 3 Fea wit cat

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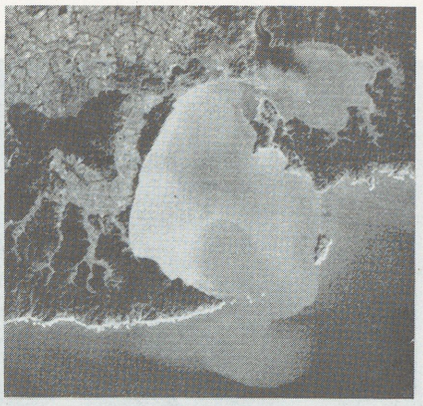
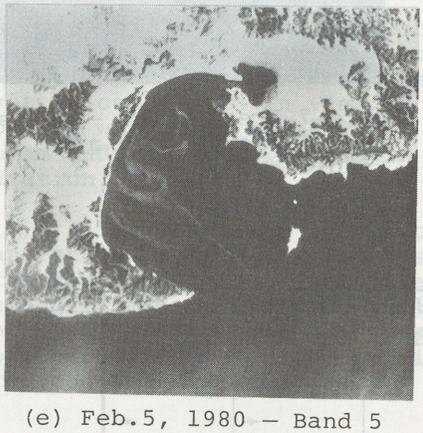
(c) Oct.4, 1980 — Band 4



(d) Nov.5, 1981 — Band 4



(e) Feb.5, 1980 — Band 5

(f) Feb.22, 1890 — Band 5

Photo 3 Feature Variations of bay current in Akkeshi Bay (Indicated with T in Photo 1) and water pattern in Lake Akkeshi (Indicated with S in Photo 1 also)

Photo 4 Landsat MSS band-5 imagery of site X in Photo 1

Photo 5 Landsat MSS band-5 & -7 imagery of site Y in Photo 1 — Sites 1 through 5 are flooded area reconized.

Photo 6 Areal photo – Sites 1 through 3 are flooded area indicated in Photo 5.

Photo 7 Areal photo – Sites 4 and 5 are flooded area indicated in Photo 5.

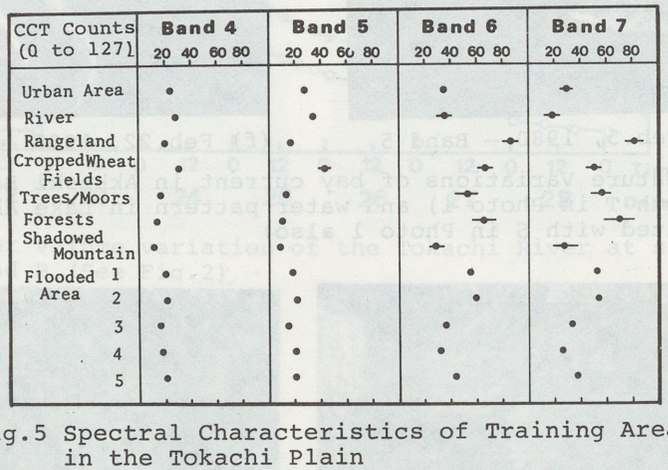


Fig.5 Spectral Characteristics of Training Area in the Tokachi Plain

Note: Flooded area 1 through 5 are indicated in Photo 5.