Paper E 14B

APPLICATION OF ERTS DATA TO THE DETECTION OF THIN CIRRUS AND CLEAR AIR TURBULENCE

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ABSTRACT

The feasibility of detecting a thin cirrus and clear air turbulence from ERTS MSS data is explored. The result of analyses indicates that a thin cirrus not shown in a conventional meteorological satellite picture can be revealed in ERTS MSS picture. It is also found that the core of jet stream can be located with high accuracy from ERTS pictures and the possible area of clear air turbulence can be predicted if the data of the quality of ERTS data are available in real time.

1. INTRODUCTION

One of the most difficult problems in the interpretation of operational meteorological satellite pictures is the detection of a thin cirrus. One can hardly expect to succeed in detecting a thin cirrus in a picture taken from a meteorological satellite. The main reason is its low reflectivity.

In addition to its shortness of life time and small horizontal scale, clear air turbulence is another difficult problem to find due to invisible phenomenon. According to pilots who have encountered clear air turbulence (hereater abbreviated to be CAT) cirrus is often observed near the area of CAT.

Based on the pictures of meteorological satellites Viezee (1966) pointed out that CAT is generally found where cirrus is found near a jet stream while Ishizaki (1971) made a classification of clouds appearing in aerial photographs. Both of these studies are worthy of special attention, however the former is handicapped in its resolution and poor detectability of cirrus while the latter in the limitation of field of view and difficulty of locating the position and also measuring the horizontal extension.

ERTS has a great advantage compared with a conventional meteorological satellite in that it can respond differential reflectivity of the surface of materials in different spectrum. It has been prooved that the data of multiple spectral scanner can reveal various physical characteristics which an ordinary picture can not show in addition to its extraordinary high resolving power and accuracy in location. Taking advantage of this feature of ERTS an attempt is made to explore the feasibility of detecting cirrus and CAT from ERTS' pictures.

2. THE STUDY OF DETECTING A THIN CIRRUS FROM ERTS' PICTURE

In Fig. 1 (a), (b), (c) and (d) are shown a part of central Japan and its neighbouring sea as seen by four channels of MSS on board ERTS. It can be seen triangular wavy clouds in the pictures. Our main interest is to find the type of these clouds. Comparing four pictures one can easily find the difference in the appearance i. e. with the increase in the wave length, the clouds gradually become thinner and finally diminishes in MSS 7, or in the picture with the longest wave length. The surface weather map covering the area in the picture show the clouds as observed from the surface are mostly high cloud of cirrus as is indicated in Fig. 2. A synoptic pressure pattern is also indicated in Fig. 3 which shows a severe tropical storm with the central pressure of 990 mb is located to the south of the area.

The vertical distribution of air temperature and dew points together with the winds at Hamamatsu (47681), Shionomisaki(47778) and Hachijojima (47678) (the locations are indicated in Fig. 5) are shown in Fig. 4. Both Hamamatsu and Shionomisaki soundings show low humidity throughout the layer, which suggests that the clouds in the pictures will be fairly thin with fine structure. It is also seen from the pictures, weather maps and vertical distribution of air temperature and dewpoint at Hachijojima that the cloud becomes thicker towards south. From these analyses it can be concluded that a thin cirrus which is generally invisible in an ordinary meteorological satellite picture can be well detected in an ERTS picture.

3. THE STUDY OF CLEAR AIR TURBULENCE(CAT)

3.1 CLEAR AIR TURBULENCE OF AUG. 29, 1972

There were clear air turbulence in the northern Japan as is indicated in Fig. 6 which is made from the reports of pilots. Both B-727

and T-33 met moderate turbulence above Tsugaru Strait between 00h 45m(Z). Another T-33 encountered a weak turbulence between Niigata and Misawa, too. The same plane reported cirrus. The level of the flight was around 25,000 ft above Tsugaru Strait and around 23,000 ft between Niigata and Misawa.

3.2. ERTS PICTURES SHOWING CAT AREA

The ERTS' pictures covering the CAT area are shown in Fig. 7 (A), (B), and (C). Fig. 7 (A) is MSS 4 covering the southern Hokkaido. The small white dots over the inland area are all fair weather cumulus. The significant clouds are the larger clusters of clouds with fuzzy fibrous appearance trailing southward to the west of Tsugaru Peninsula and northward above Misawa area. It is interesting to notice that over the area to the east of Hakodate are seen very thin white cloud with wavy appearance. The surface weather observation at Hakodate (Fig. 8) indicates clear weather. If these white wavy ones are clouds, they are indication of wave motion. The area to the south of Fig. 7(A) is shown in Fig. 7 (B) and (C). Large cloud clusters are seen to the north of Ojika Peninsula with fuzzy appearance. The clouds in the inland are above the Shiragami mountain range orienting from west to east and Hachikoda mountains running from north to south. Other interesting clouds in the pictures are those located to the northwest and southwest of Ojika Peninsula with clear cut trail extending toward west. The appearance of these clouds suggest strong vertical moition embedded in strong horizontal wind with a large vertical shear. In reference with the study in the previous section, the surface weather map shown in Fig. 8, it is considered that these clouds are cirrus. However, they are different from the so called fair weather cirrus with rather uniform thickness. The fact that the clouds are fairly white even in MSS 7 (Fig. 7C) indicates that the clouds are fairly thick. The cirrus may have originated from convective acitivity and there would be large up and down draft over the area. The spacing of the clouds to the west of Tsugaru Peninsula ranges from 6.5 to 13 kms while the spacing of large clusters of clouds to the north west of Ojika Peninsula is approximately 17 kms. These fact suggest there may have been gravity wave motion with the period of Brunt-Vaisala.

3.3. METEOROLOGICAL ANALYSIS

The surface weather map of 00Z Aug. 29, 1972 is shown in Fig. 8 which indicates that the area of CAT is in the periphery of a migrating high. Most of stations in Tohoku District reported cirrus fibratus or

some indication of cirrus floccus. Towering cumulus is reported by Fukaura weather station thus static stability of the amosphere was not good in the norther Tohoku district.

In order to see the wind distribution at the flight level of the planes, 300-mb chart is made and is shown in Fig. 9 in which the contours at 60-gpm interval are drawn in broken lines while the isotachs at 20-kt inverval are drawn in solid lines. The jest stream axis is shown in a thich solid line which sharply curves cyclonically above northern Tohoku Dirstrict. The vorticity at the area of CAT reaches as large as the order of 10 sec . The cross section analysis along 140°E meridian is shown in Fig. 10. The isotherms at 5°c interval and isotachs at 20-kt interval are drawn in broken and solid lines respectively. The thick solid lines are frontal surface.

The figure indicates that the jet core is located at the level of approximately 250-mb level above Misawa area and the planes encountered CAT within the frontal layer where the vertical wind shear is the maximum. The value in this case is as large as 10 /s.

4. CONCLUDING REMARK

The previous analyses lead to the following conclusion. A thin cirrus can be successfully detected from ERTS MSS data and the features of clouds can be also known from the pictures of different spectrum. The possible CAT area can be found from the particular apperance of cirrus.

References

Ishizaki, H., 1970: Clouds. All Nippon Airways.

Viezee, W., 1966: TIROS viewed jet stream cloud pattern in relation to wind, temperature and turbulence. Stanford Research Inst.

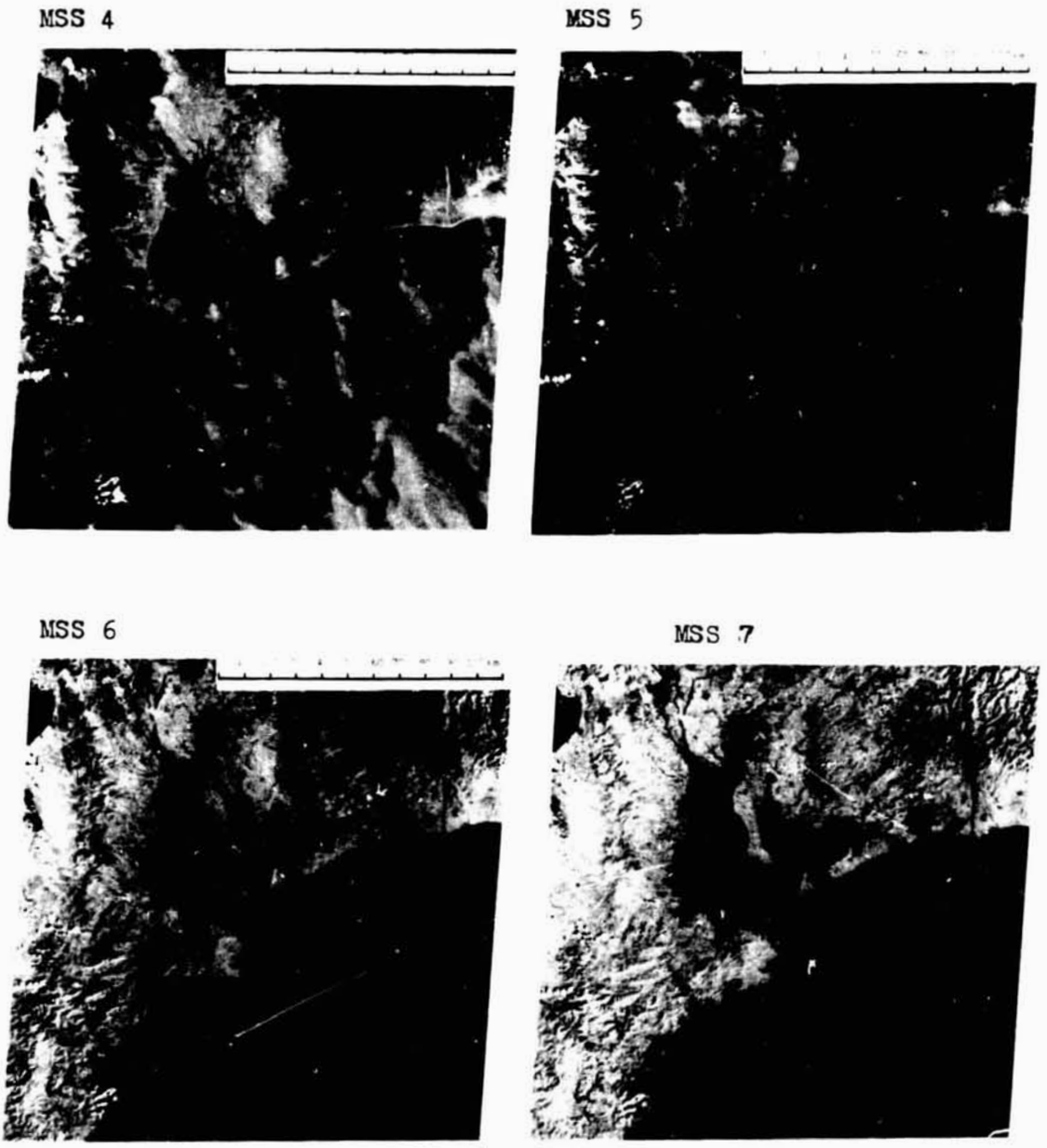


Fig. 1 Pictures of MSS, ERTS showing clouds as seen in different spectrum. 0059(Z) Oct 05, 1972.

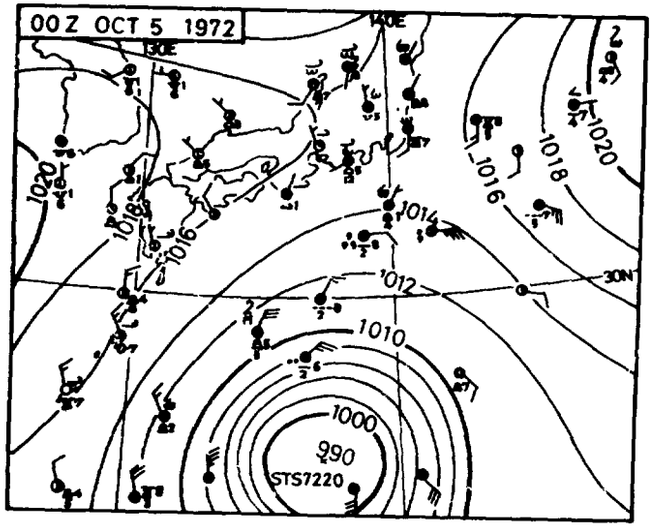


Fig. 3 The surface weather map at 00)4) Oct 5 1972

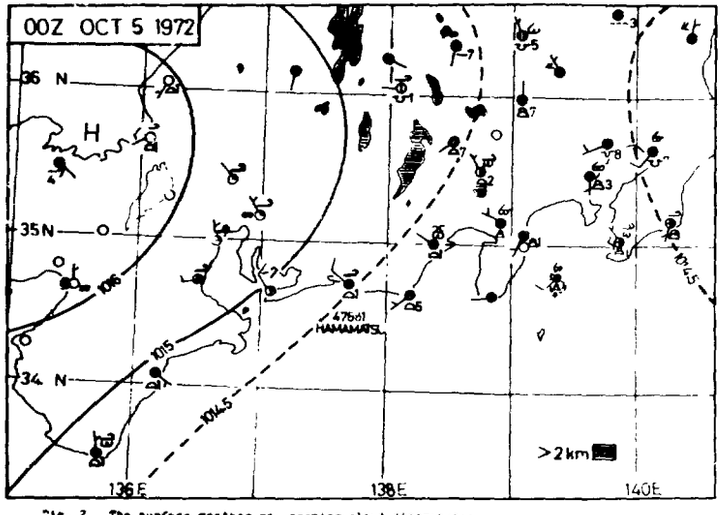


Fig. 2 The surface weather map, showing cloud distribution in central part of Japan 00(4) Oct 5, 1972.

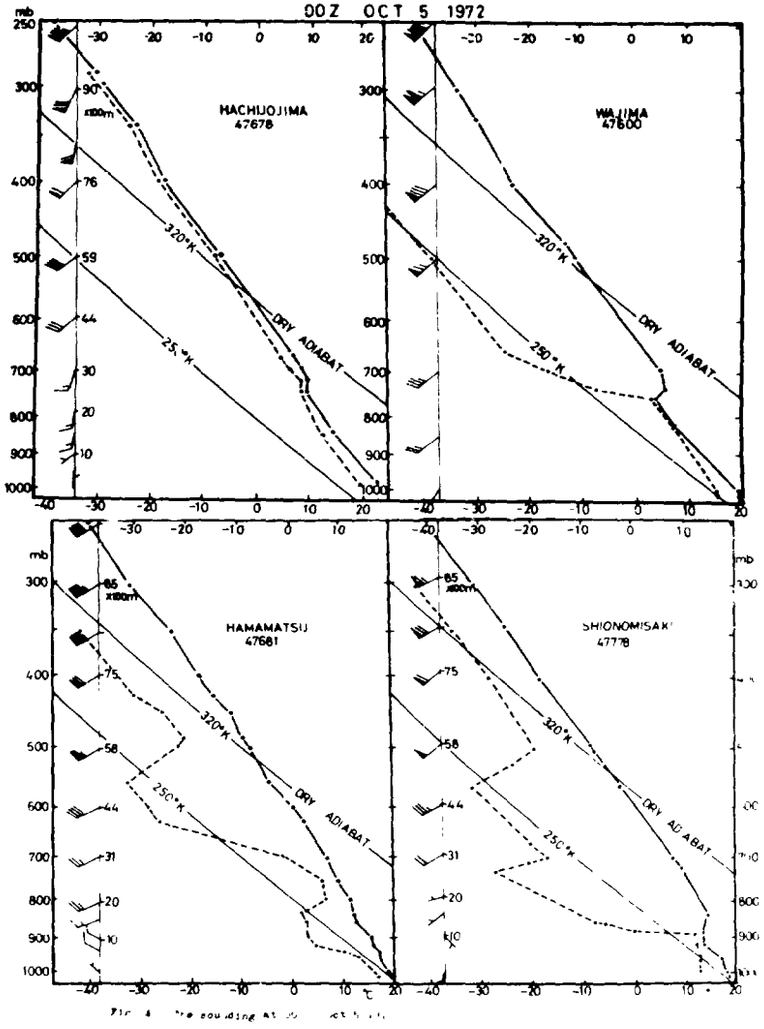


Fig. 4 The sounding at 00 Oct 5 19..

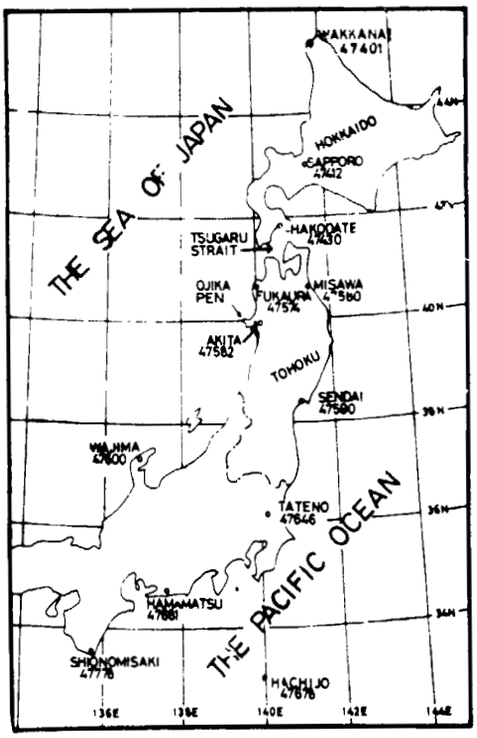


Fig.5 The map of Japan with weather stations.

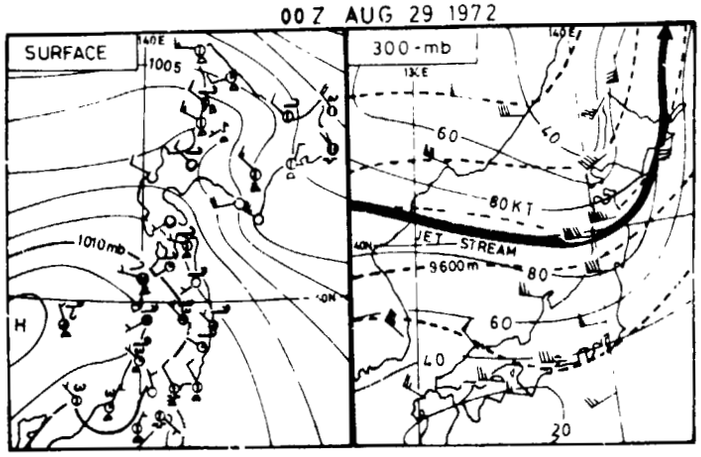


Fig. 8 The surface weather map, 00(Z) Aug 29 1972.

Fig. 9 300-mb chart at 00(Z) Aug 29 1972.

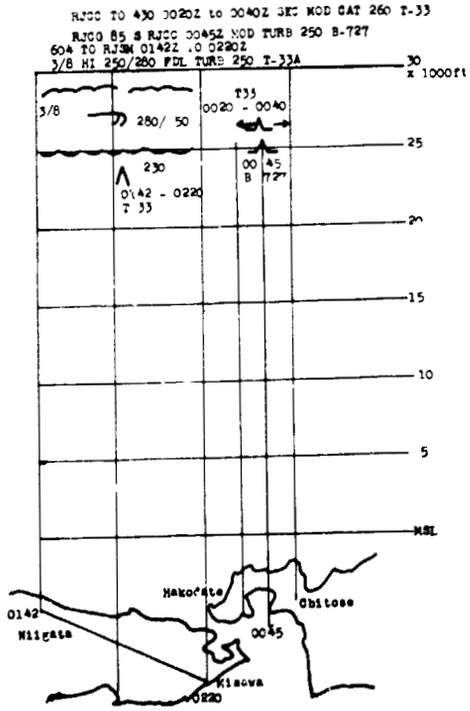


Fig.6 The flight cross section made from pilots' reports

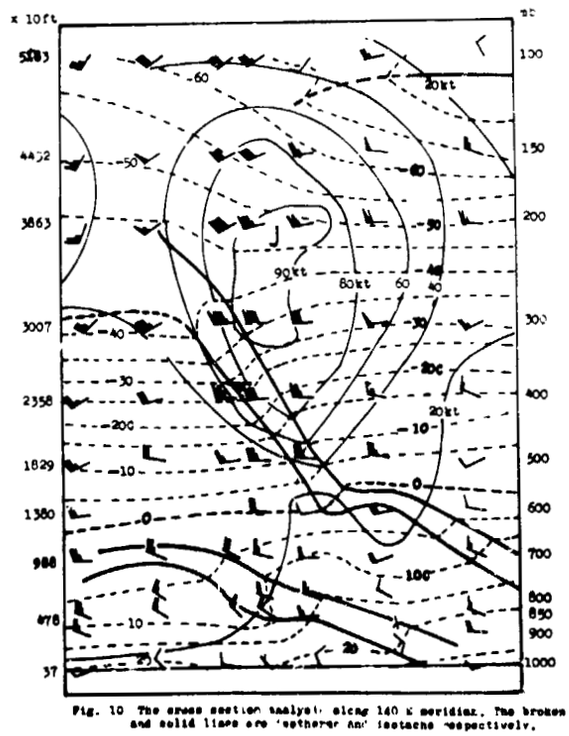
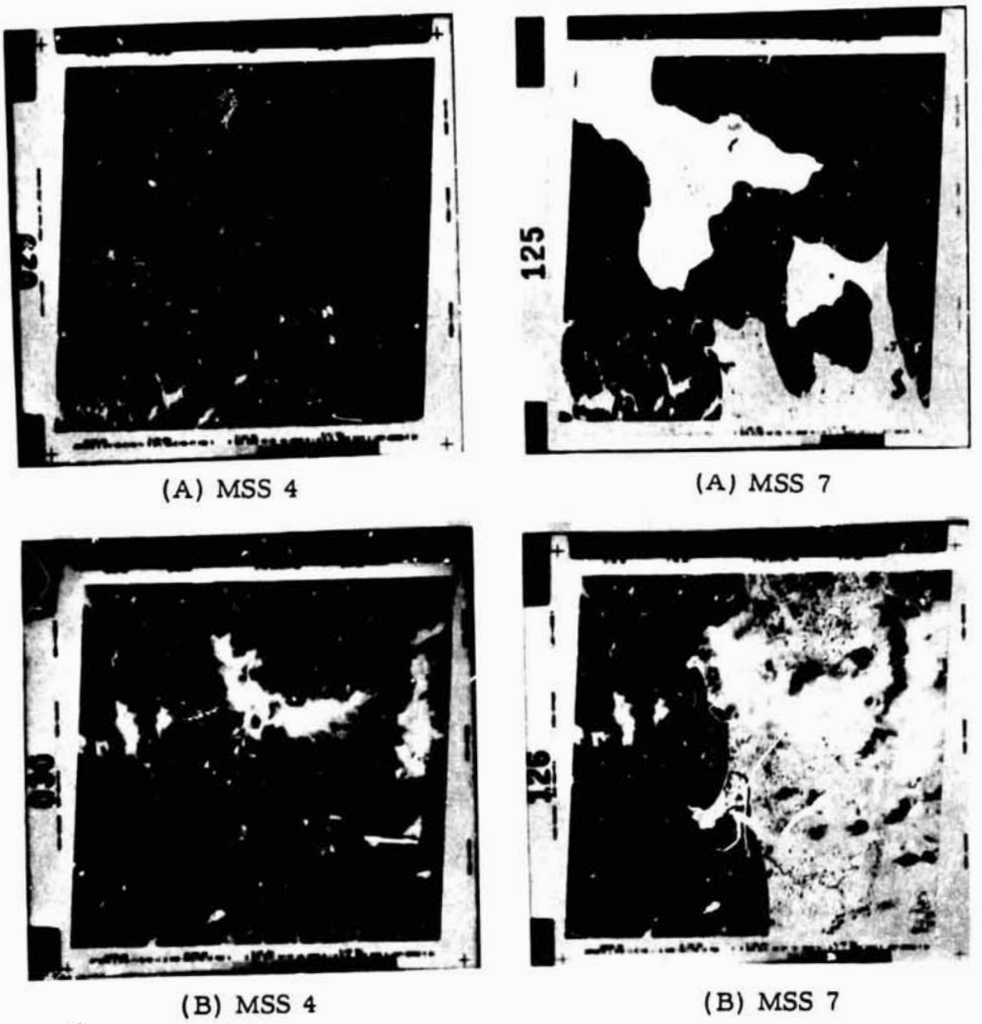


Fig. 10 The cross section analysis along 140 E meridian. The broken and solid lines are isotherm and isotachs respectively.



(A) MSS 4 (A) MSS 7

(B) MSS 4 (B) MSS 7

Fig. 7 ERTS pictures showing the clouds on the day CAT was reported
(A) 00520 (Z) Aug. 29, 1972
(B) 00522 (Z) Aug. 29, 1972