Applications of the 3I System to NOAA-10/11 over China Area

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1. INTRODUCTION

The Improved Initialization Inversion (3I) system like the International TOVS Processing Package (ITPP) has been made available by LMD to the general remote sensing community. At present, many remote sensing centers throughout the world have used the ITPP and 3I packages to produce atmospheric temperature and moisture profiles from the NOAA satellites. Some research centers have gained the experiments with the ITPP and 3I systems over the oceans, antarctica and their local regions.

At SMC, the TOVS operational processing system has been established based on the ITPP and the NESDIS TOVS operational processing system (Dong,1988, Zhang,1989). But the statistic regression algorithm(REG) is still used to produce the atmospheric temperature and moisture profiles. However, China has a large area, the topographic features in China are very complex. And the local climates in the different regions are quite different, the temperature and moisture near the surface change so rapidly during a day and night. So it is difficult to improve the accuracies of temperature and moisture profiles retrieved from the current TOVS processing system due to the limitation of the re-retrieval algorithm. For these reasons, many users much more concern about the 3I system to be suitable for China area or not. Thus, we have applied the 3I method to NOAA-10 TOVS data in the summer, autumn and winter time of 1988. The preliminary results (Zhang,1989) have been obtained by using the 3I old version (Scott ,1988).

After that, the 3I system has been improved twice (as I know). One of the major improvements is about the temperature variance/covariance matrices which are used in the inversion procedure (Chedin,1989). The improved 3I system has 120 matrices (3 air masses, 2 surface emissivities, clear/cloudy cases, and 10 viewing angles) instead of 12 matrices in the old version. Another major improvement is about the TIGR data set. The original TIGR data set was computed by using the NOAA-8 response functions. But the new one is computed from the NOAA-11 response functions.

In order to understand the new 3I system and the new TIGR data set to be suitable for China area, we apply both of the new 3I version and the new TIGR data set to NOAA-10 and NOAA -11 TOVS 1b data which are processed by the TOVS operational processing system, respectively. The comparisons with the radiosondes have been performed to assess the quality of temperature and moisture profiles. Also, the thickness and temperature analysis fields associated with the conventional ones are displayed. The experiment on incorporating ITPP simultaneous retrieval algrithm into the 3I system has been studied. The details on the descriptions above are given in the following sections.

2. APPLICATIONS OF THE 3I SYSTEM TO NOAA-10/11 OVER CHINA

2.1 Apply the New 3I System to NOAA-10 with the Old TIGR

As mentioned above, we have used the old 3I system to produce temperature profiles from the NOAA-10 TOVS data in the summer, autumn and winter of 1988. Based on the preliminary results we obtained, on the average the 3I-retrieved temperatures are a little bit better than REG retrievals. In order to know how the new 3I system works over China area the selected NOAA-10 two passes have been processed by using the new 3I version. The first pass is covering the east of

China at 23 GMT of Oct. 5,1988, and the part of the pass is over the sea, where the severe storm was just in life and caused the heavy rain and strong winds. The second pass is covering the west of China at 02 GMT of Aug. 27,1988, and the most of the pass is over the plateau region.

Comparisons with the radiosondes for the two passes have been performed and are shown in the Fig.1. The matched satellite sounding and the radiosonde space and time windows are about 100 km and 3 hours, respectively. From the Fig.1, it can be seen that the baises for the two passes are about -2k - 1.5k, and negative for the most levels. This indicates that the 3I-retrieved temperatures are colder than the conventional ones. The standard deviations (STD) are less than 2k except for the levels near the surface and around the tropopause. (The RMS is similar to STD.) That means that the retrieved temperatures near the surface and tropopause have a little noise. Also, the standard deviations for the pass over the east is smaller than that over the west. Compared with the results from the old 3I version (Zhang,1989), the results from the new 3I version have a little improvements.

It should be noticed that the 3I system offers two inversion models. One is with using the forecast data, the other is without using the forecast data. At present, the model we used is without the forecast data. Probably this is a reason that the results we got near the surface are poorer than normal.

Fig.2 shows the 1000-500 mb thickness and 500 mb temperature analysis fields for the pass of Aug.27,1988. The corresponding 500 mb height and temperature fields from the synoptic chart are displayed in Fig.3. From the Fig.2-3, we can see that both of the thickness and temperature fields have a good agreement with the synoptic chart, especially in the region (50° - 70°N). The center of the low in the Fig.2a is coincident with that in the Fig.3a. And the cold air centers (-28°C) for the Figs.2b and 3b are identical. Unfortunately, there are few data or no data in the region (40°-20°N) over the plateau due to effects of the high elevation or heavy clouds. So the local small systems could not be displayed in the Fig.2a. But for the higher layer or level thickness or temperature fields you will find that satellite soundings can provide the more useful information over the plateau region.

Fig.4 presents the 500 mb 3I-retrieved temperature field for the pass of Oct.5,1988, and the corresponding conventional one from the synoptic chart. From the Fig.4, it can be seen that the thermal structures for both of the 3I retrievals and radiosondes are quite similar, especially in the region (30° - 60°N). Due to the effects of the severe storm over the region (30° - 20°N), there are few soundings over there. In the Fig.4b, it can be found the center of the cold air (-24°C), but no one in the Fig.4a. All of the problems may be caused by the limitation of the TOVS instruments and maybe can be resolved by using the ATOVS instruments in future.

2.2 Apply the New 3I System to NOAA-11 with New TIGR

In order to assess the quality of the temperature and moisture profiles derived from the NOAA-11 TOVS data by using the new TIGR data set, the 18 passes from April 1 to 5,1990 (in the Spring time) have been processed by using the new 3I version. Comparisons with the conventional data for the temperature and relative humidity profiles have been made zone by zone from 70° - 10°N (60° - 160°E), which is divided into 3 zones: zone 1 (70° - 50°N), zone 2 (50° - 30°N), and zone 3 (30° - 10°N). The collocated space and time windows between the soundings and radiosondes are about 100 km and 6 hours. The temperature statistics are made level by level (15 levels). But the relative humidity statistics are made for three layers (1000-800 mb, 800-500 mb, 500-300 mb). Also, in order to make comparisons with the temperature profiles produced by the TOVS operational processing system (REG) for the same passes, the similar statistics for the REG have been performed associated with the 3I temperature statistics.

Fig.5 shows the temperature statistics for the 18 passes and 3 zones, where (a) is for zone 1, (b) for zone 2, and (c) for zone 3. It can be seen from the Fig.5 that the baises for both of the 3I and REG are about -2k - 2k at the most levels for the 3 zones. However, the baises of the 3I for the 3 zones are negative at the most levels. While the baises of the REG for the zone 1 (70° - 50° N) are positive at the most levels, for the zone 3 (30° - 10° N) are negative at the most levels, and for zone 2, they are just in between.

The standard deviations (STD) of the 3I and REG for the 3 zones are quite similar (2k - 3k), especially for zone 2. For zone 1, the STD of the REG is smaller than that of the 3I. While for zone 3, the 3I's STD is smaller than the REG's. The STD near the surface is greater than 3k, some times, it can reach to 5k. This important standard deviation is probably caused by the so big time window (6 hours) between the satellite observations and the radiosondes.

The comparisons between the 3I-retrieved relative humidities and the conventional ones are listed in the table 1. From the table 1, we can see that the baises for the 3 zones are about 5-10%, the standard deviations are varying from 20% to 25% which is similar to the results got from ECMWF (Chedin, 1989).

3. EXPERIMENT ON INCORPORATING THE ITPP RETRIEVAL ALGORITHM INTO THE 3I SYSTEM

As you know, one of the 3I system major features is applying the pattern recognition approach to obtain the best initial guess solution through the TIGR data set. But the temperature and moisture profiles are retrieved separately.

However, one of the major features of the ITPP is taking the simultaneous physical retrieval algorithm to obtain the temperature and moisture profiles in one step. In order to take both of the major features of the 3I and ITPP and put them into the one system, the experiment has been made to take the simultaneous retrieval algorithm instead of the original retrieval algorithm of the 3I (called the modified 3I system, ie. 3IM). The transmittances used in the inverson procedure are taken from the TIGR data set. The comparisons with the conventional analyses for the experiment from the NOAA-10 TOVS data (7 days) in February,1990 are shown in the table 2.

From the table 2, we can see that the results of the 3I (old version) and the 3IM are quite similar, and better th than those of the REG and the simultaneous retrieval method (use the climate data as the first guess). This indicate that the accury of the retrieval temperatures for the physical algorithm is more dependent on the the first guess. It should be noticed that the modified 3I system only takes about 3/4 CPU time of the original 3I system for the same run (Zhang,1990).

4. SUMMRY

The improved 3I system and the new TIGR data set have been applied to NOAA-10/11 TOVS data. The results from the new 3I system for NOAA-10 are a little bit better than the old one. The standard deviations of the 3I retrieved temperatures and relative humidities are about 2-3k and 20-25%, respectively. The thickness and temperature fields of the 3I retrievals have a good agreement with the conventional ones for the large scale system, but the small scale system are smoothed out. The 3I system and the TIGR data set can be used to process the NOAA satellites data over China area, but the accuracy of the retrievals are limited due to the limitation of the samples in the TIGR data set.

5. REFERENCES

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Table 1. The relative humidity statistics (3I-Radiosondes) from NOAA-11 TOVS data in April 1-5,1990.

Zone	Zone 1 (70°-50° N)			Zone 2 (50°-30° N)			Zone 3 (30°-10° N)		
Layer (mb)	1000 -800	800 -500	500 -300	1000 -800	800 -500	500 -300	1000 -800	800 -500	500 -300
NO.	223	181	40	213	180	151	33	18	22
Bais	4.1	0.7	2.3	-1.8	3.3	-1.0	1.2	0.7	7.1
STD	20.3	18.4	18.1	21.1	19.8	19.6	18.3	17.8	16.6
RMS	20.7	18.5	18.2	21.2	20.1	19.7	18.4	17.9	19.9

Table 2. The temperature statistics (RMS) for the 3I, 3IM, REG and the simultaneous retrieval method from the NOAA-10 TOVS data in February of 1990(7 days).

Pressure (mb)	3I	3IM	REG	ITPP
1000	2.7	2.8	3.1	3.3
850	3.0	3.1	3.5	3.5
700	2.6	2.5	2.7	2.5
500	2.7	2.4	2.6	2.7
400	2.5	2.6	2.1	2.7
300	2.4	2.5	2.2	2.6
250	2.6	2.6	2.9	2.8
200	2.5	2.6	2.9	3.7
150	2.4	2.5	3.1	3.4
100	2.3	2.3	2.8	2.9
70	2.0	2.1	2.4	2.8
50	2.5	2.5	2.7	2.8
30	2.8	2.7	2.5	3.4
20	2.9	2.8	3.4	3.4
10	3.2	3.1	3.6	3.9

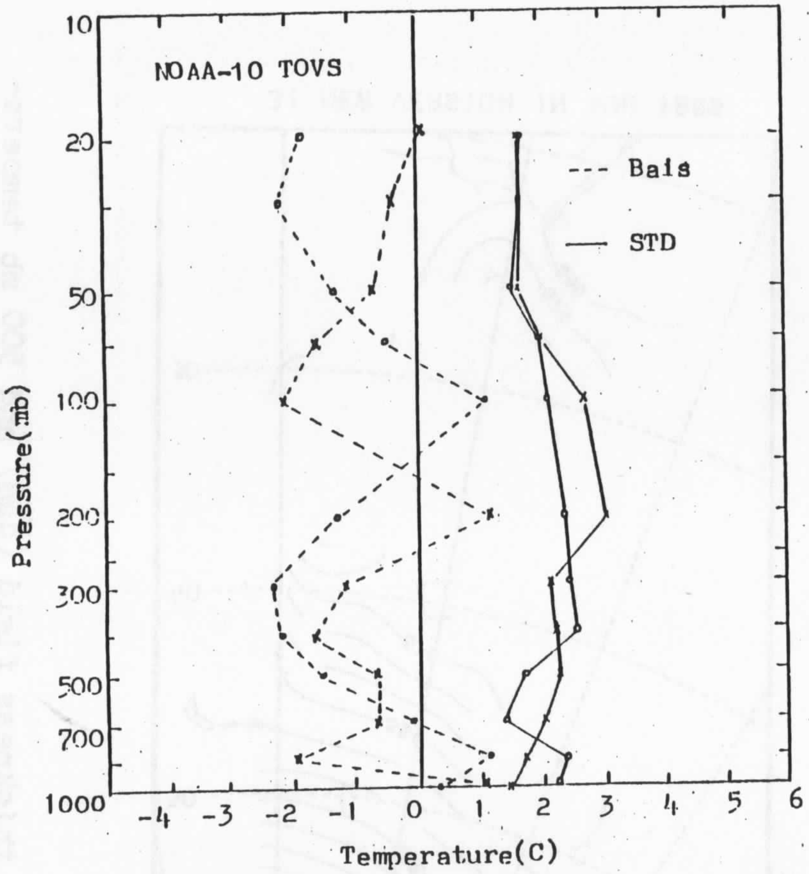

Fig.1 The temperature statistics of the 3I (3I- Radfosondes) from NOAA-10 TOVS data for the passes of Aug. 27,1988,02GMT (--X--) and Oct.5, 1988,23GMT (--o--).

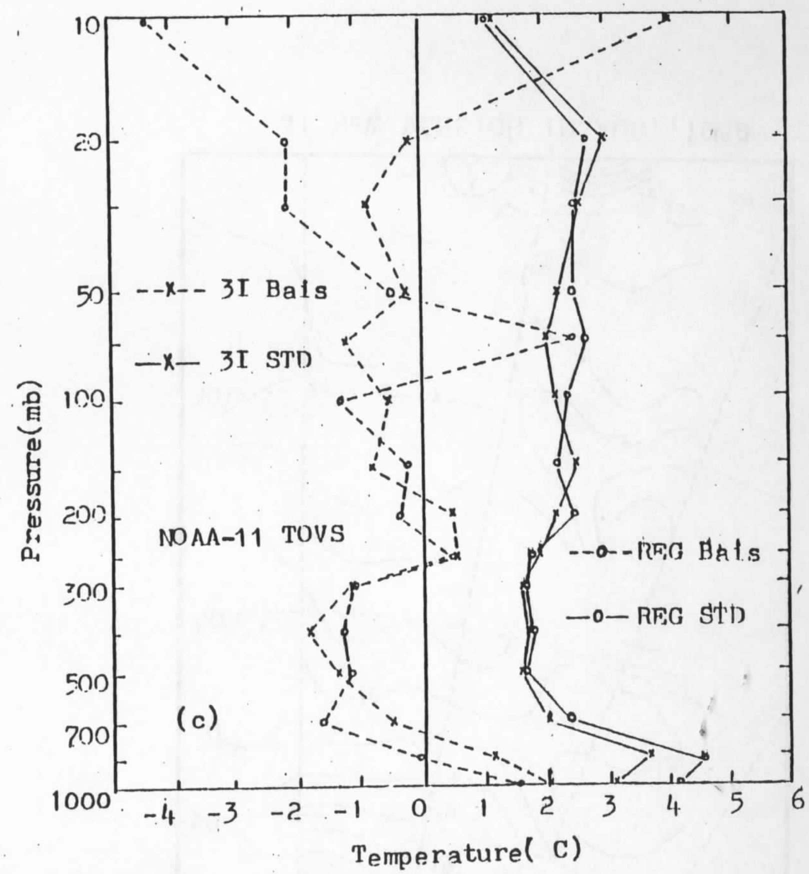

Fig.5 (continue)

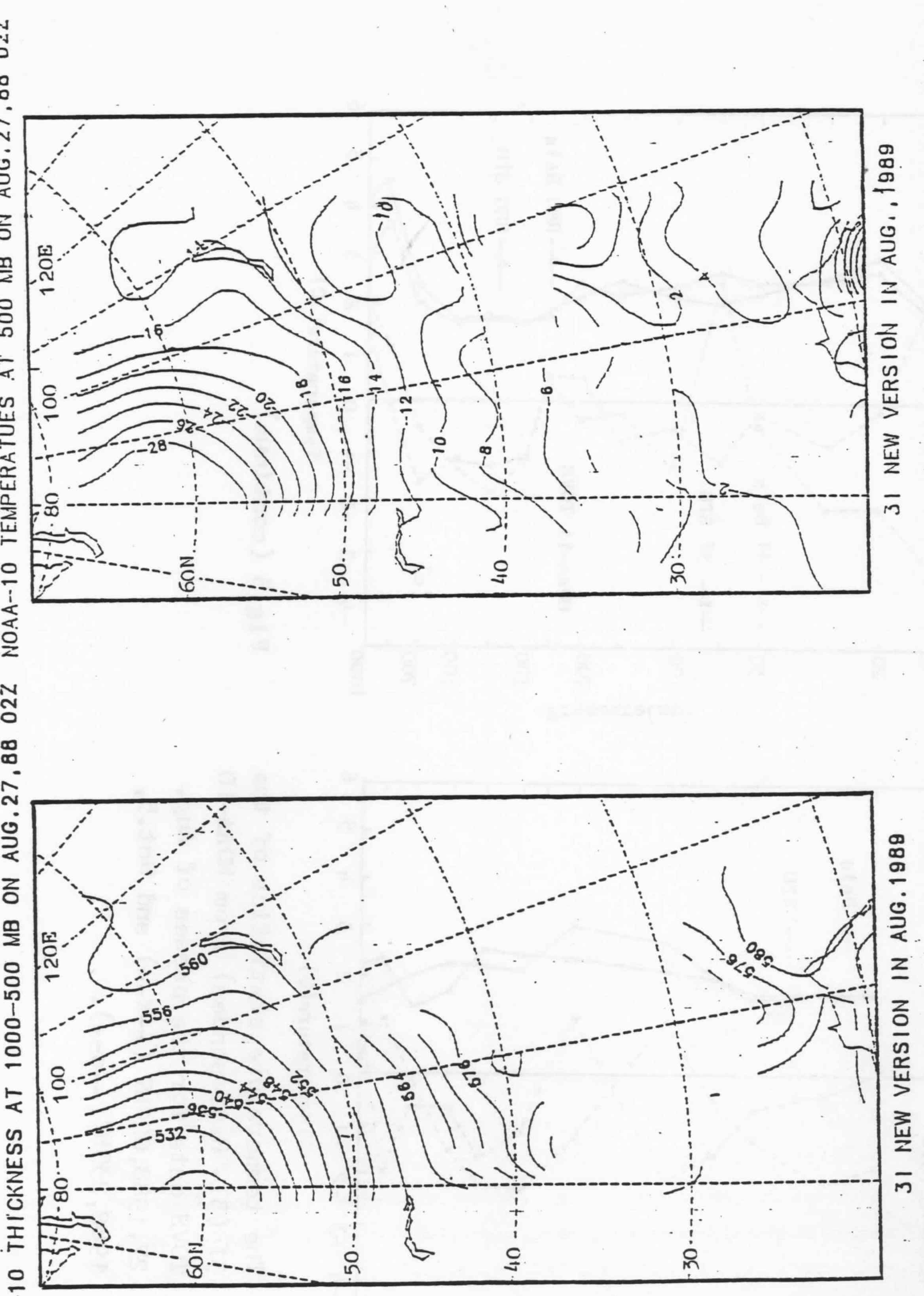

Fig.2 1000-500 mb thickness field (dam) and 500 mb temperature field (C) from NOAA-10 TOVS data on Aug.27,1988, 02GMT.

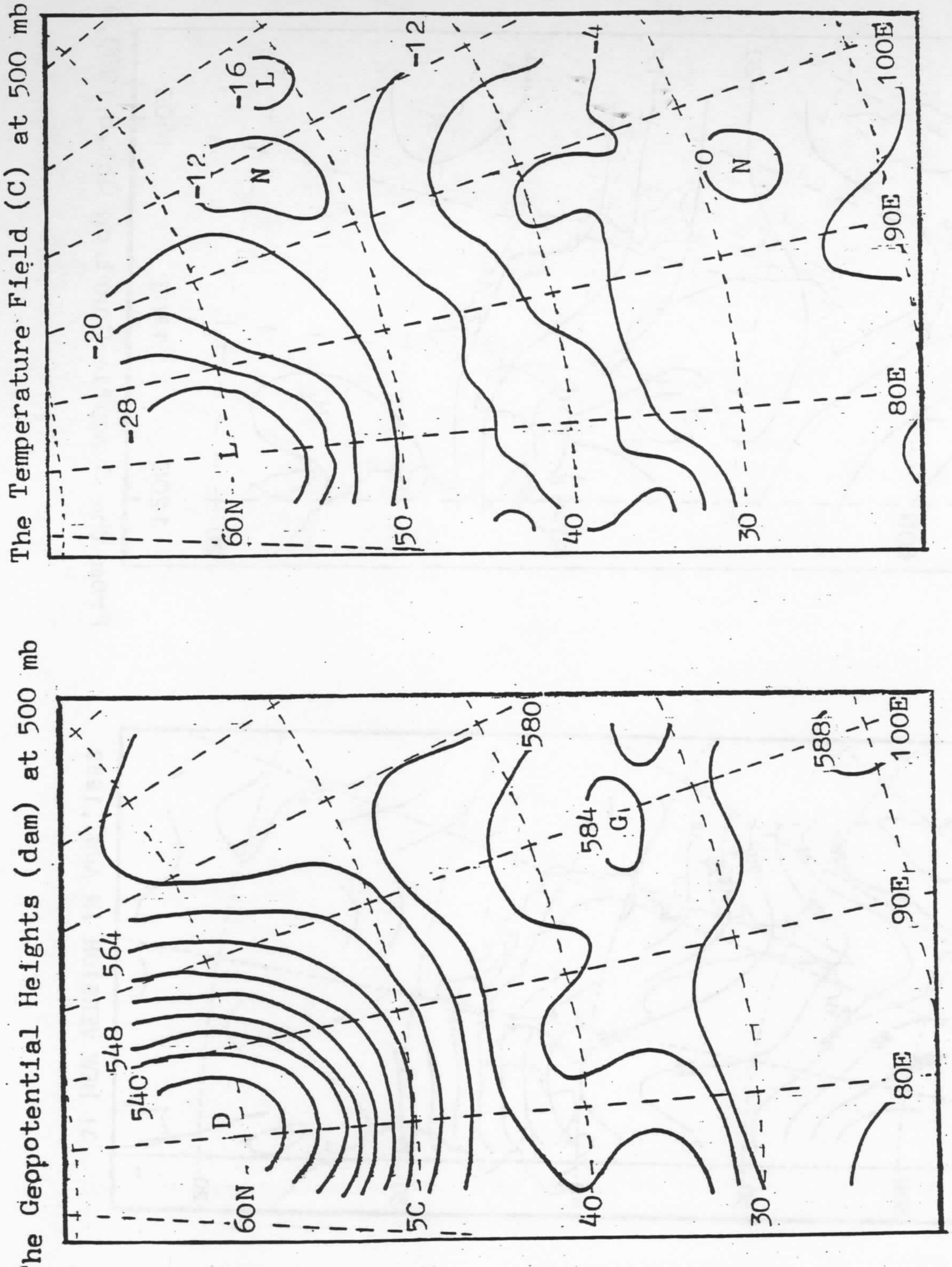

Fig.3 500 mb geopotential height (dam) and temperature (C) fields from the synoptic chart on Aug.27,1988,00GMT.

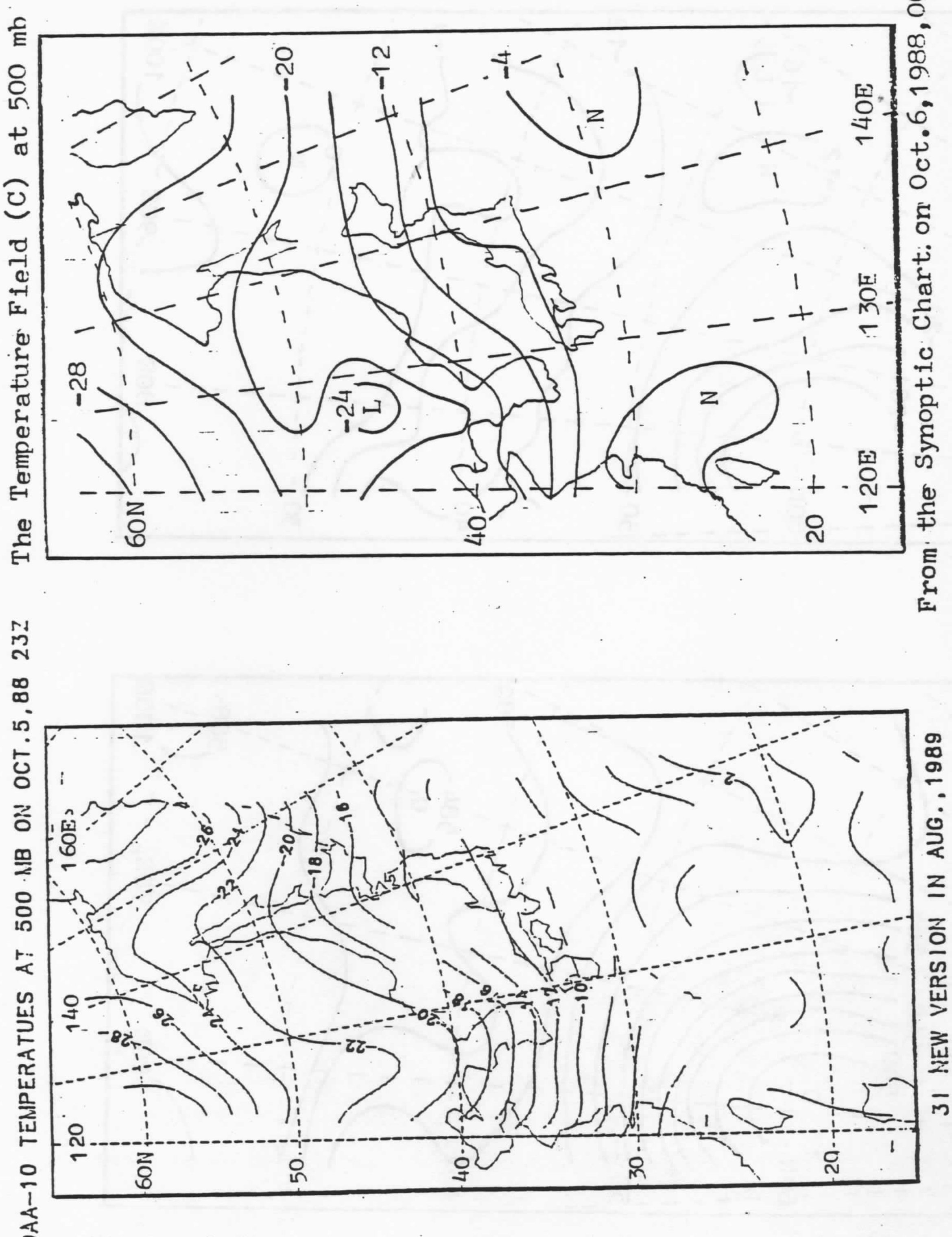

Fig.4 500 mb temperature fields (C) from the NOAA-10 3I retrievals on Oct.5,1988,23GMT and the synoptic chart on Oct.6,1988,00GMT.

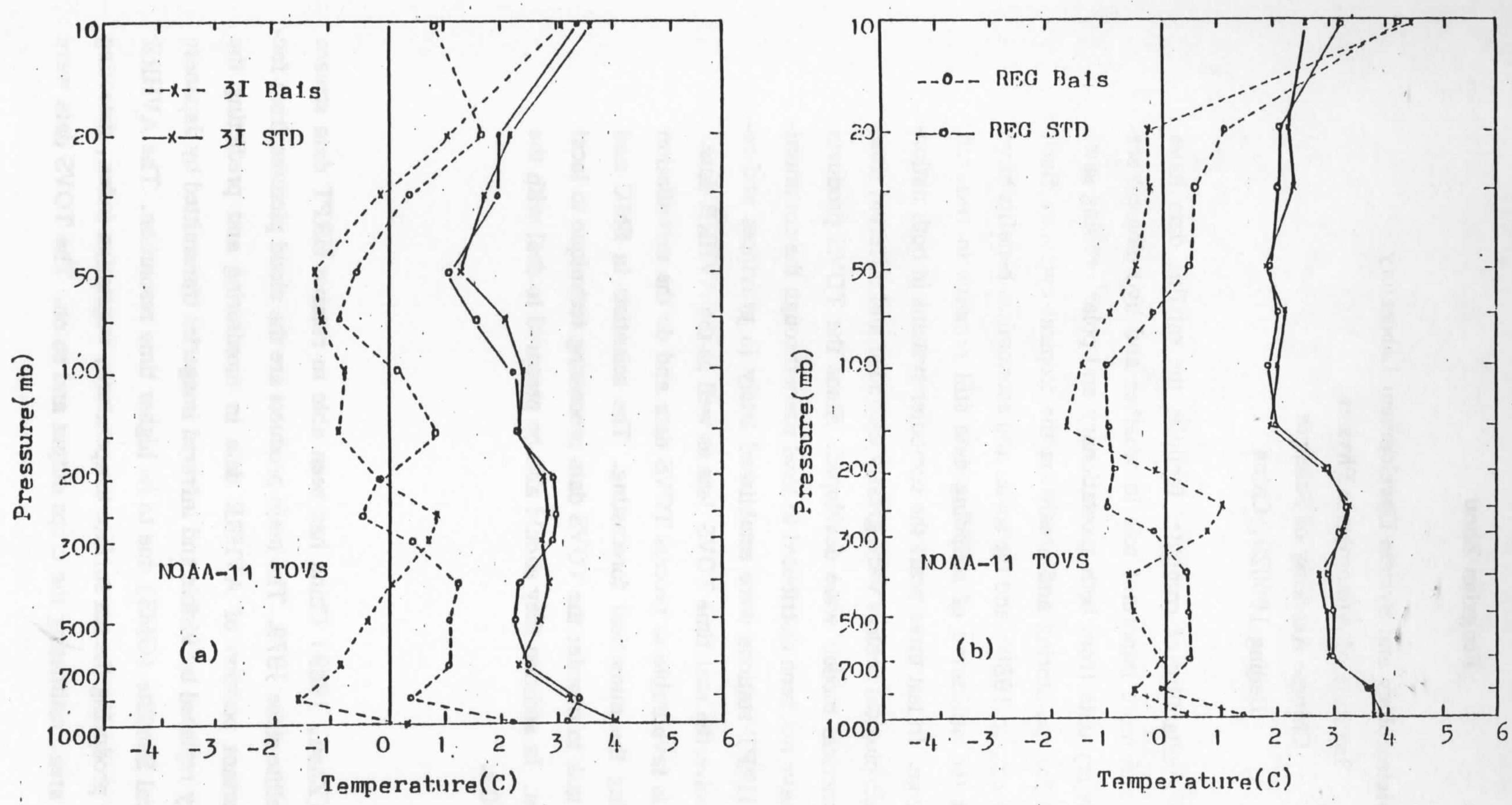

Fig.5 The temperature statistics for the 3I and REG (Retrievals-Radiosondes) from the NOAA-11 TOVS data in April 1-5,1990 (18 passes). Where (a) is for zone 1 (70°-50°N), (b) for zone 2 (50°-30°N), and (c) for zone 3 (30°-10°N).

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