Temperature and moisture profiles over Mongolian region from NOAA/TOVS satellite data

N. Tsengel, Z. Batjargal
Institute of Meteorology and Hydrology (IMH),
National Agency for Meteorology and Hydrology and Environmental Monitoring (NAMHEM),
Mongolia

Abstract

Numerical weather prediction models, in addition to wind profiles, need temperature and moisture profiles with radiosonde type accuracy. But current satellite systems are unable to satisfy this requirement. At the same time the existing global upper-air sound network can not provide high temporal and spatial resolution data, particularly over the ocean and over the some part of Asia, like Siberia and territory of Mongolia. In this regard it is necessary to develop a methodology using alternative source of information like TOVS type data. The International TOVS Processing Package (ITPP-4) developed by the University of Wisconsin, USA, was used for retrieving temperature and moisture profiles. In the physical retrieval method as a initial "first guess" temperature profile have been used the climatological data. This paper discusses the evaluation of accuracy of TOVS temperature and dew point temperature retrievals through a comparative study against radiosonde measurements over the Mongolia and neighboring regions. IMH has developed a PC based radiosonde/TOVS data extraction and analysis program. Vertical profiles of atmospheric thermodynamic parameters (temperature, dew point temperature, geopotential height, etc.) can be displayed at selected geographical points.

Introduction

Three dimensional data of air temperature, humidity and geopotential heights etc. which show physical characteristics of atmosphere, are necessary for nowcasting and forecast the state of atmosphere. Sounding of the atmosphere by balloon-borne radiosonde instrument has increased our knowledge of the vertical structure of atmosphere. But these sounding are available on a limited scale over land area and are particularly absent over vast oceanic area. At present time, for instance, over the vast area of Mongolia these are only 5 upper air sound stations with only one observation in a day. Similar situation take place in the Central Asia including South part of Russia and West and north west parts of China. In this regard it is necessary to create additional or alternative source of the data.

Air temperature and dew point temperature retrievals from TOVS data, received in real time at Information and Computer Centre (ICC) of the NAMHEM, are currently obtained by ITPP-4 software package, using the climate data base as first guess field for the retrieval,

running on MicroVAX-4000 computer, being part of the system for reception and processing of satellite data.

Data processing

Total data processing is a man independent system. The TIP data are extracted from the HRPT-data-stream. The preprocessing and retrieval processing of the TOVS data are accomplished on MicroVAX-4000. Navigation parameters are taken from the GTS-TBUS message. The whole processing time, beginning with the first reception of satellite data, is around 45 minutes. The results are routed to the MiGDAS-Interactive Graphics System, where they can be displayed together with all the other available meteorological information.

Statistical analysis for temperature and dew point temperature with radiosondes

The collocation area has an upper left edge with coordinates 60^0N/80^0E and a lower right edge at 35^0N/125^0E which includes territory of Mongolia. We have collocated retrieval results with radiosonde data in space of 70 km and in time of 2.5 h. HRPT ground receiving station in ICC can cover contiguous orbits (A, B and C) passing through west part, east part of Mongolia and whole Mongolia. Table 1 and 2 show basic statistics (mean bias, rms error and correlation coefficient) of satellite temperature profiles and dew point temperature profiles compared with the matched radiosonde data for 6 days 12 overpasses of September in 1996.

Table 1. Statistics of satellite retrieved temperatures, September, 1996

Pressure [hPa]	A (West pass)			B (East pass)		
	# of cases	M. Bias [oK]	rms [oK]	# of cases	M. Bias [oK]	rms [oK]
1000	7	2.16	4.11	32	1.49	3.25
850	48	1.70	5.80	108	0.55	2.94
700	78	0.48	2.83	119	0.64	2.26
500	88	1.40	2.24	120	1.87	1.89
400	86	1.73	2.71	119	1.57	2.21
300	86	1.14	2.64	117	1.31	6.42
250	84	0.78	4.64	116	-0.21	3.42
200	84	2.58	2.65	115	1.78	2.15

Table 2. Statistics of satellite retrieved dew point temperatures, September, 1996

Pressure [hPa]	A (West pass)			B (East pass)		
	# of cases	M. Bias [oK]	rms [oK]	# of cases	M. Bias [oK]	rms [ok]
1000	7	7.09	6.89	32	-6.18	4.29
850	48	5.53	11.01	108	3.64	7.05
700	78	12.18	11.24	119	14.11	12.31
500	88	31.74	13.13	120	34.97	12.52
400	82	42.05	10.41	119	44.16	12.56
300	70	52.78	9.53	109	55.53	10.93

It is clearly on the overall concepts as the following:

The accuracies of retrieved parameters from orbit B are little better in generally little better than those from A at the same pressure levels. The main reason is the complexity of topography in which the other conditions are completely identical. In addition, there are a few machuped radiosonde stations with retrieval in the area covered by orbit A. the arithmetic mean from the table 1-3, retrieval accuracy (rms) of temperature is 3.45^0K for the orbit of A and 3.06^0K for the orbit of B. The accuracy (rms) of dew point temperature is 10.36^0K for the orbit of A and 9.94^0K for the orbit of B.

Table 3 and 4 show the mean bias, rms error and correlation between the TOVS retrieved temperature and dew point temperature soundings and radiosonde data from central orbit over Mongolia for 9 days of August in 1996. The largest differences are near surface and in tropopause region because of the frequent existence of vertical temperature discontinuities. The all types of retrieval give more differences from radiosonde observations in tropopause region (from 400 hPa to 200 hPa) and near surface (up 800 hPa) which are around 7^0K in average. The reason might be the numbers of collocated data points over surface were these numbers relatively less than in the middle troposphere.

Table 3. Statistics of retrieved temperatures, August 1996

Pressure [hPa]	1000	850	700	500	400	300	250	200
# of cases	4	87	131	147	149	146	146	144
M. Bias [oK]	6.79	0.28	1.12	1.33	2.40	-0.53	1.02	1.85
rms [oK]	4.76	6.99	3.24	2.03	9.95	7.34	8.62	2.47
Corr. Coef.	0.88	0.60	0.86	0.93	0.41	0.59	0.46	0.77

Table 4. Statistics of retrieved dew point temperatures, August 1996

Pressure [hPa]	1000	850	700	500	400	300
# of cases	4	85	130	146	148	135
M. Bias [oK]	6.76	-1.40	8.56	29.47	44.70	57.99
rms [oK]	9.01	8.24	8.98	11.88	12.49	11.44
Corr. Coef.	-0.84	0.14	0.21	-0.38	-0.44	-0.37

From the tables, statistical values of differences between TOVS retrieved temperature and dew point temperature and radiosonde measurements are relatively less in the middle troposphere (near 500 hPa) which is main predictor pressure level for weather forecasting. It has been shown that the satellite atmospheric temperature retrievals are in good agreement with radiosonde measurements. TOVS outputs are regarded as an alternative data set for identifing air mass over the Mongolia, especially in the data sparse region.

The program for analysis of Radiosonde/TOVS soundings

The program has been developed using "Visual Basic 4.0" standard software for operational analysis of Radiosonde/TOVS data. It runs interactively with the users in the environment of WINDOWS. Figure 1 and 2 show flow chart of processing program of radiosonde/TOVS soundings and general view of interactive processing of meteorological parameters. The PC-based radiosonde/TOVS data extraction and analysis program can display vertical profiles of atmospheric thermodynamic parameters (temperature, dew point temperature, geopotential height, etc.) can be displayed at selected geographical points. Displayed data can be printed and incorporated into other geographical analysis program. Some printed outputs of the program are shown in Figure 3 and 4.

Conclusions

We have analysed TOVS soundings using ITPP-4 package through a comparative study against radiosonde measurements over the Mongolia and neighbouring regions, which extended between latitude of 35-60^{0}N and longitude of 80-125^{0}E. The comparison of the coincident TOVS/radiosonde observations of temperature show that satellite temperature soundings exhibited rms temperature differences of near 2.6^{0}K in the middle troposphere. There are large differences near surface and upper troposphere. The retrieved dew point temperatures are not comparable to those from upper air sound observations. It has been shown that the satellite atmospheric temperature retrievals are in good agreement with radiosonde measurements. In this regard the TOVS retrieved temperature data could be considered as an alternative data set for identifing weather pattern over the Mongolia or over the other data sparse regions. In addition to this, the program for analysis of Radiosonde/TOVS soundings offer an opportunity to monitor NOAA/TOVS data anytime.

Figure 1. Flow chart of processing program of Radiosonde/TOVS soundings

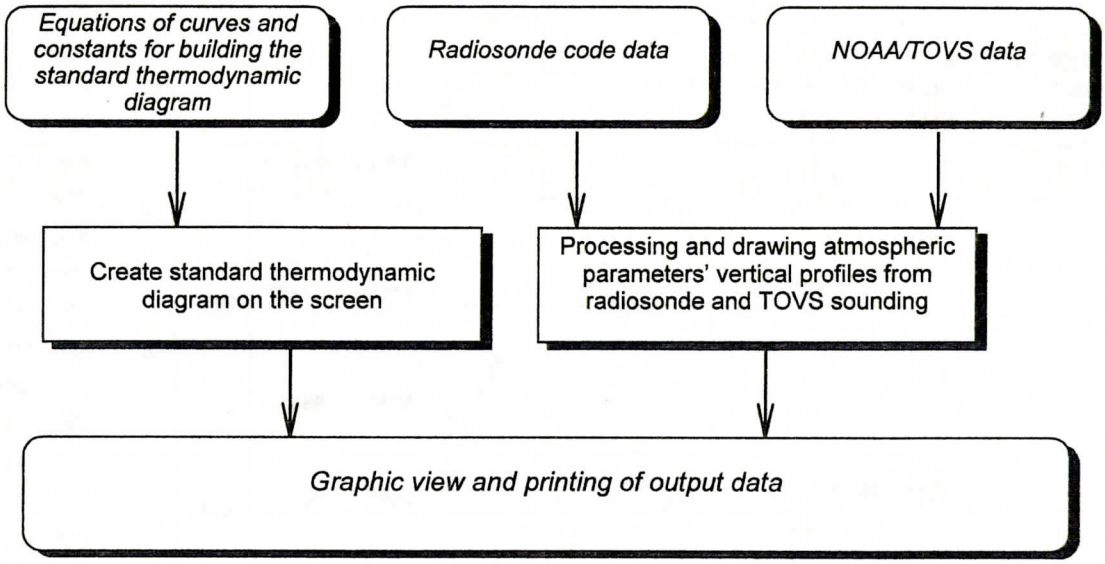
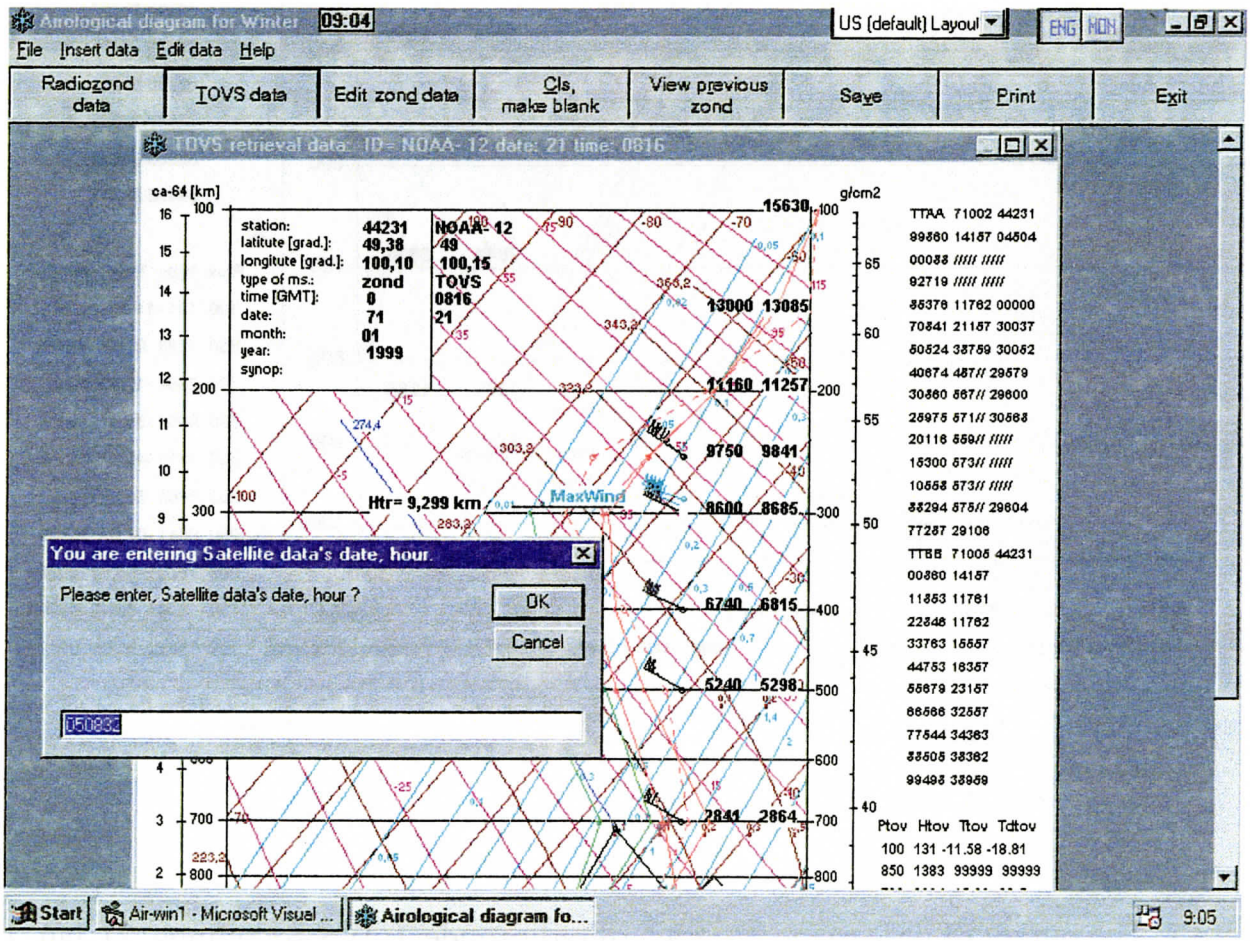


Figure 2. General view of interactive processing of meteorological parameters



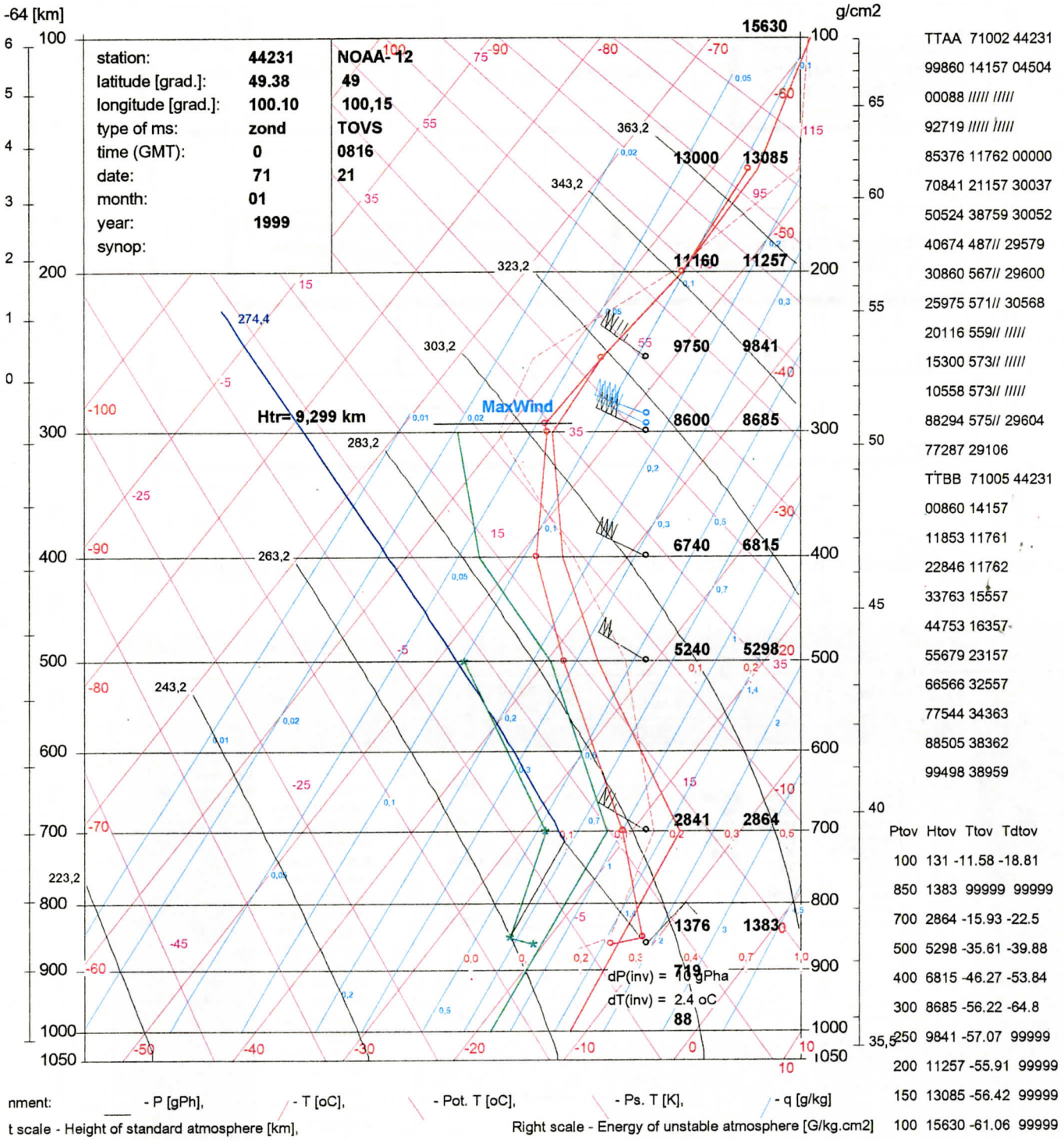


Figure 3. The output of processing program of radiosonde/TOVS soundings, 21 Jan. 1999

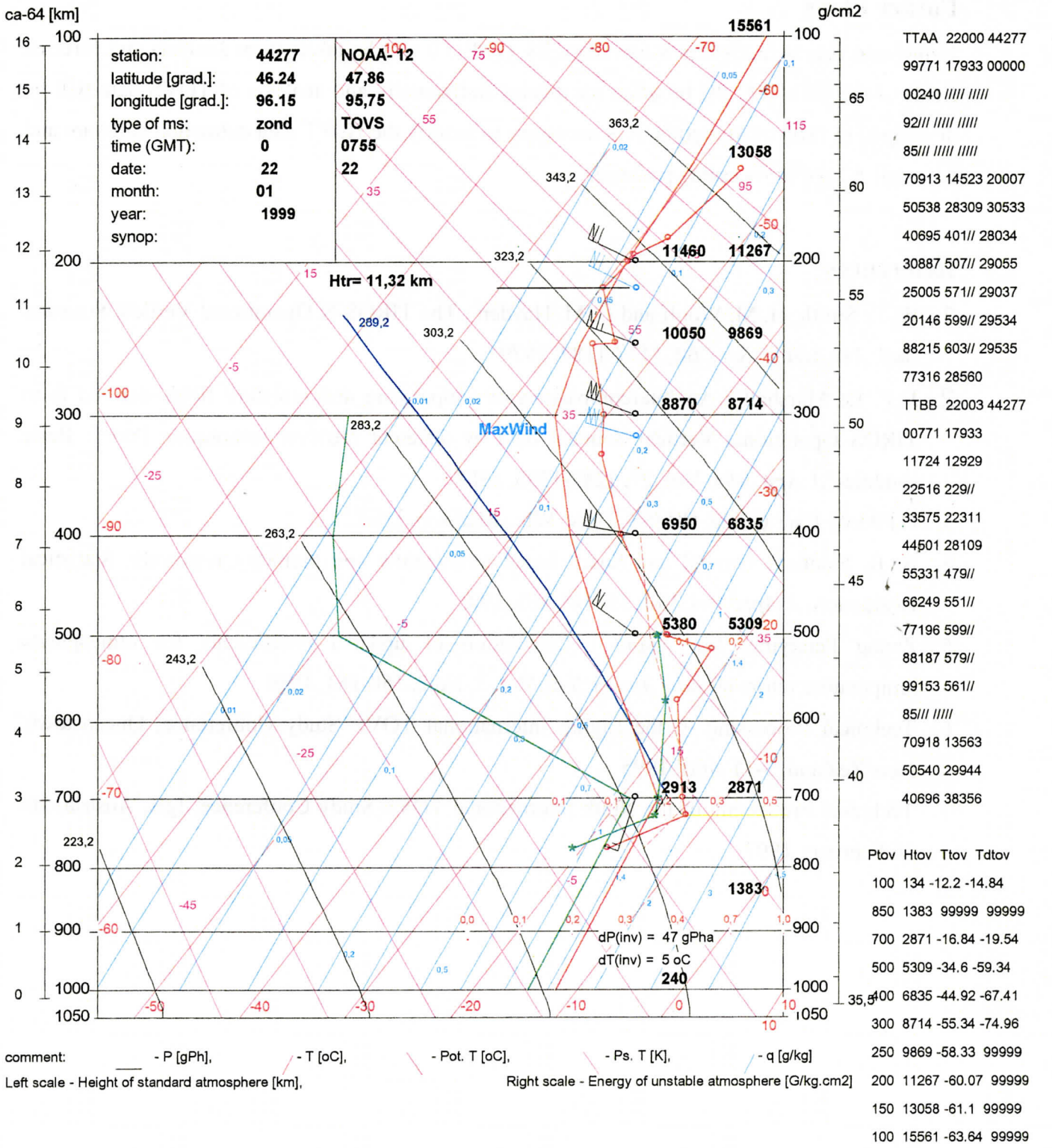


Figure 4. The output of the program, 22 Jan. 1999

Future Plans

In the near future first-guess information for ITPP-5.0 will be taken from analysis and forecast fields of the ECMWF. PC program for display horizontally and analysis of TOVS data will be developed in IMH of Mongolia. It is necessary to modify the HRPT data extraction software and to install ATOVS processing package.

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