A New Microwave Temperature Profiler – First Measurements in Polar Regions

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Introduction

Temperature inversions are a ubiquitous feature of the high latitude atmospheric boundary layer (ABL). In Polar Regions, the temperature inversion is a complicated phenomenon involving interactions between surface radiative cooling, subsidence and warm air advection. In the period 1997-2002, several microwave temperature profilers were used to measure temperature inversion parameters at one of the three sites of the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Program, located at the North Slope of Alaska (NSA). These instruments provided continuous, unattended observation of the ABL thermal structure. However, the vertical resolution was not large enough to measure the low-level lifted inversions, which were observed in the spring period by radiosondes. In 2001, the Russian scientific production company ATTEX, in cooperation with the Dutch Company Kipp & Zonen, produced a new microwave temperature profiler for Polar regions, MTP-5P (P stands for Polar), with improved vertical resolution.

Temperature Profiler MTP-5 for Polar Research

Regular radiosonde sounding cannot cover the needs in sufficient data set because it is normally does four times a day so, for 6 hour periods; the assumption of coincidence is accepted as valid. But for investigation of the internal ABL physics in Polar Regions such an assumption looks like very questionable. The main evidence of that is in fast changes of the air temperature at the ground level (Lettau 1979). More frequent radio sounding could be a solution although the remote sensing of ABL temperature profiles more cheaper and reliable option. The first attempt of such investigations in Polar conditions took place during the August 1996 (Kadygrov et al. 1997). MTP-5 was installed on the top of main building of the Geophysical Institute, Fairbanks, Alaska. Comparisons with radiosonde data gave good coincidence. The fact is that that device was able to detect lifted inversion with the base from 100 to 200 m. It means that due to Kahl (1990) analyses of Alaskan Arctic coast ABL we can potentially detect about 59% of lifted inversions and about 40% of lifted inversions are out of our detectable range. However for some applications it is needed to have more good vertical resolution.

The MTP-5P (P-means Polar) has an antenna beam width of 0,5° and vertical resolution at lowest altitude about 10 m in contrast with MTP-5 with beam width of 6,0° and vertical resolutions at lowest altitude about 50 m. The common view of MTP-5P with back cover and inside meteoprotection is presented at Figure 1.

Figure 1. Meteorological temperature profiler MTP-5P

Comparisons and Simulations

Unique technical properties give an opportunity to retrieve temperature profiles with very high height resolution. The examples of simulation of elevated inversions and large temperature gradients in the surface layer are presented at Figures 2 and 3. Big circle – simulated temperature profile, little circle – retrieved curve, triangle – the temperature profile retrieved for 6° antenna beam.

During autumn 2001 it has been tested in Moscow region and compared with radiosondes. An example of the comparison is presented on Figure4.

The radiosonde data are presented by circle and MTP-5P retrieved data are presented by triangle at the Figure 4.

MTP-5P have been tested in Italy by Rome IFA-CNR and compared with Vaisala external sensor data since December 2001. One of illustration of these experiments is presented at Figure 5.

Figure 6 demonstrates the fine structure of atmospheric temperature retrieved by MTP-5P during the Italian testing experiment.

Temperature Profile Measurement at Antarctic Plateau

During the austral summer of 2002 the MTP-5P operated at the French-Italian Antarctic plateau station of Dome Concordia (75°06′S, 123°24′E, alt. 3280 m) Figure 7. The mean annual temperatures observed at this site are below -50°C. The MTP-5P gave the ability to have continuous measurements of the ABL temperature profiles above the Antarctic plateau for the first time. These measurements allow us to calculate some parameters of the temperature inversion such as the height of inversion base, the inversion depth and temperature difference across the inversion.

Figure 2.

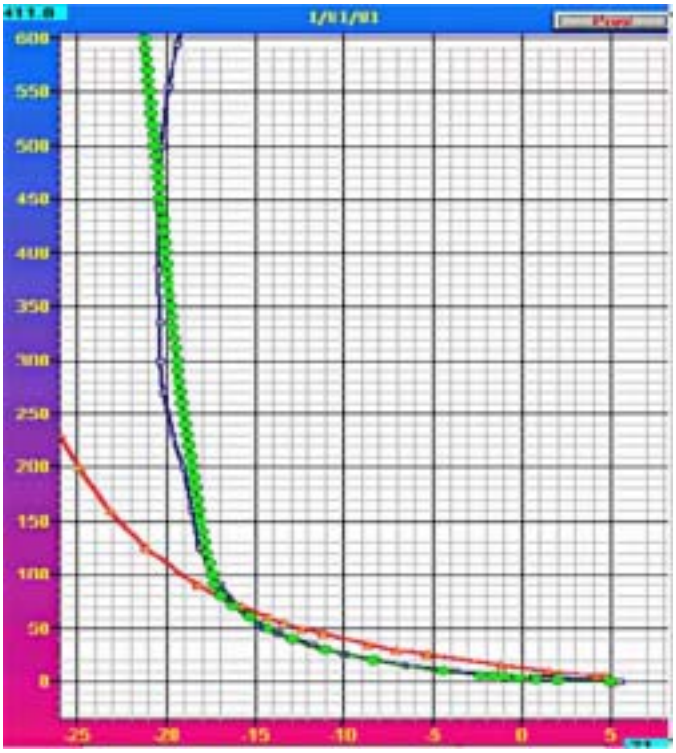

Figure 3.

Figure 4.

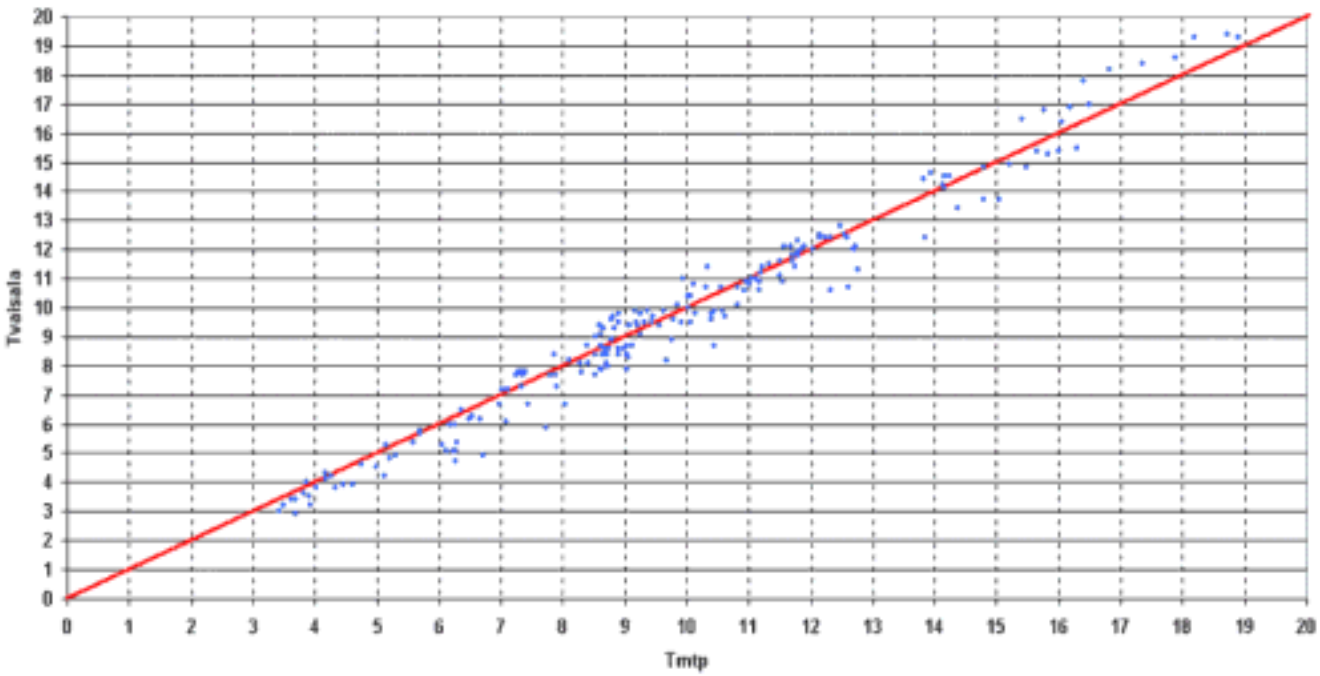
01/03-31/03/02 Tor Vergata, Italy
Tvaisala and Tmtp during the calibration period 02:00-03:00
197 points
Tvaisala
Tmtp
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Figure 5.

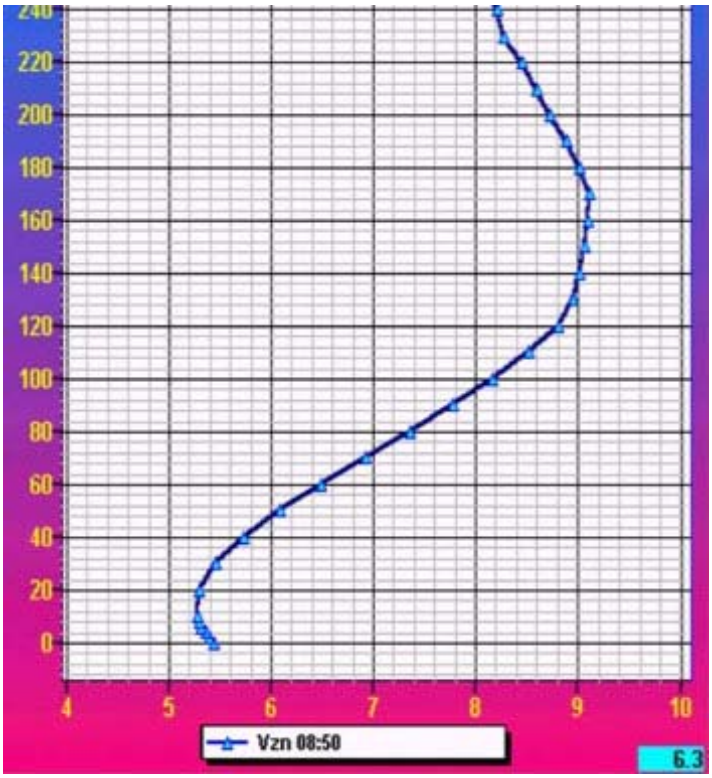

Figure 6.

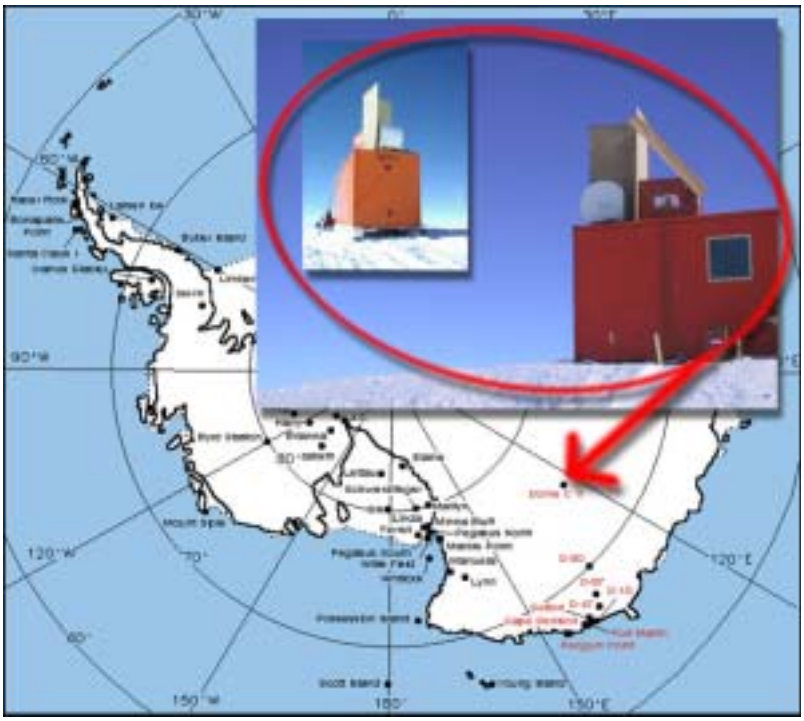

Figure 7.

The temperature profile measurements were provided from November 18 to December 17, 2002. MTP-5P was in normal operational mode within the whole period of observations. At Figure 8 are shown the typical measured by MTP-5P temperature profile for a "day" time (sun angle about 30°), and at Figure 9 is the same for a "night" time (sun angle about 5°). More detail analysis of the measured data and it's comparison with the model data will be ready later, at about the middle of 2003.

Conclusion

Involving of unattended remote system MTP-5P in investigation of ABL features gave an opportunity to obtain continuous data in various weather conditions and geographical regions.

The preliminary analysis of the MTP-5P data from Antarctica showed that it would be a suitable and promising instrument to measure the ABL temperatures in Polar Regions.

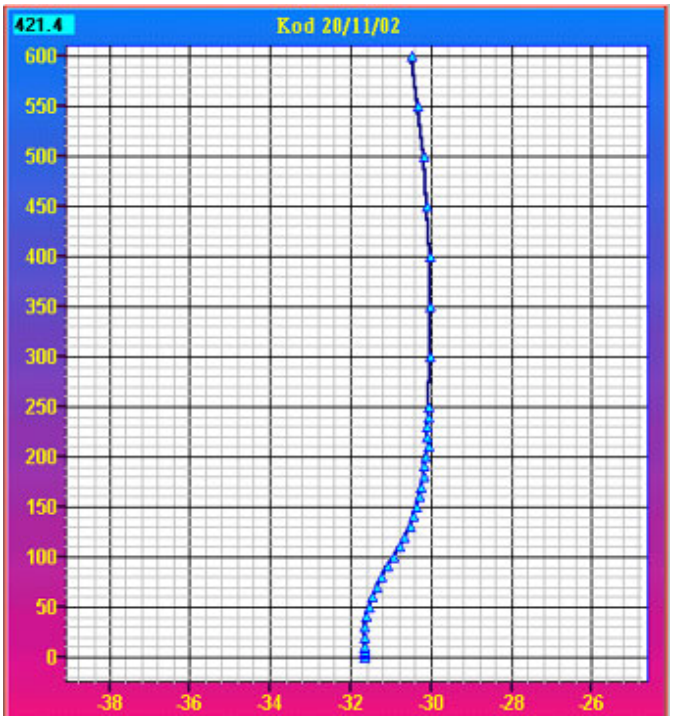

Figure 8.

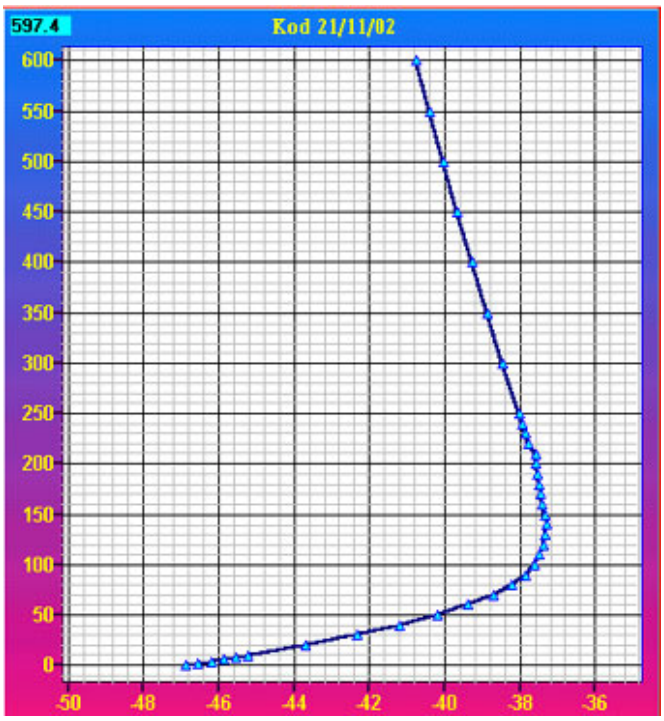

Figure 9.

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