PRESENTATION AND FIRST ASSESSMENT OF A RADIOMETER NETWORK IN THE ITALIAN REGION VENETO

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Abstract

The Centro Meteorologico di Teolo (CMT) of the Regional Agency for Protection and Prevention of the Environment of the region Veneto (ARPAV) has recently installed a network of four passive radiometers for air quality monitoring purposes. In this paper comparisons of profiler data acquired in the year April 2005 until March 2006 with the neighbouring radio soundings of Bologna San Pietro Capofiume are presented, as well as with a pseudo profile constructed in the surroundings of a particular profiler. In particular, the potential of the profiler network to detect and characterize thermal inversions is discussed.

Key words: Boundary layer, profiler, radiometer

1. INTRODUCTION

The Centro Meteorologico di Teolo (CMT) of the Regional Agency for Protection and Prevention of the Environment of the region Veneto (ARPAV) has recently installed a network of four passive radiometers for air quality monitoring purposes. Three of these instruments allow to profile temperature up to 1000m above ground, while one is more powerful in that it ranges up to 10km and measures also humidity variables. However, data of this latter have not yet been included in this analysis. The instruments are all located in Veneto, two in the city centres of Padua and Rovigo, respectively, one in the remote rural site of Legnago, and one in the Alpine Valley of Belluno (Fig. 1). The network, in the framework of the project DOCUP (documento unico di programmazione) co-funded by the European Union, Italy, and the region of Veneto, is the first of its kind in Italy.

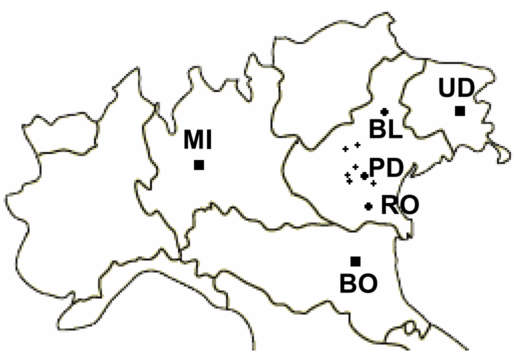

Fig. 1: Map of Northern Italy with the location of the radio sounding stations (squares), the MTP5-Hes (thick crosses), and the automatic surface stations used for the pseudo profile (thin crosses).

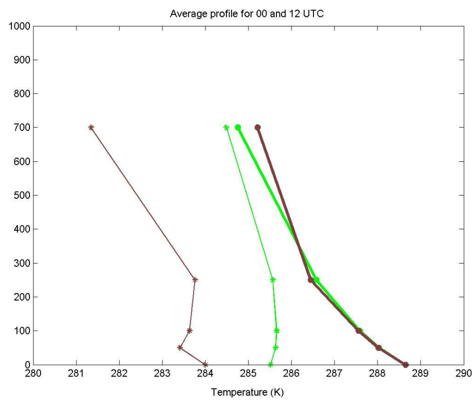

Fig. 2: Comparison of the MTP5-HE radiometer in Padova with a pseudo profile constructed in the rural surroundings of Padova. Average temperature profiles for the radiometer are shown for 00UTC (thick ‘x’) and 12UTC (x), and for the pseudo profile for 00UTC (squares) and 12UTC (o).

The radiometers on which we focus here are MTP5-HE instruments, manufactured by Attex in Russia and distributed by Kipp & Zonen. The MTP5-HE is a well proven and robust instrument. As a matter of fact, the instruments nominally measure temperature with an accuracy of 0.3K from 0 to 500m and 0.4K from 500-1000m, 0.8/1.2K in cases of inversions. First installations and validation studies date back to 1996 and comprise comparisons with lidars, radio soundings, RASS, pseudo profiles and foreacast models (see enclosed references). For example, Kadygrov et al. (2005) report a good agreement within 0.5-0.8K with a collocated radiosounding found in Payerne, Switzerland on 63 profiles. In another recent study of markasub ag (2004) good quality was ascribed to the MTP5-HE in comparison with a pseudo profile for a test period of four days.

In this paper we present a first analysis of our MTP5-HE network on a data set of a full year. Section 2 briefly describes the data set and the chosen approach, while section 3 reports the results. A summary and outlook is given in the final section.

2.Data set and approach

The data set used in this study spans the year from 1 April 2005 until 31 March 2006, for which the availability of the MTP5-HE was 97%, 75%, and 78% for the sites of Padova, Rovigo, and Santa Giustina, respectively, for 00 and 12UTC. For the comparison exercise the radio sounding stations of Milano Linate and Bologna San Pietro Capofiume were used, as was a pseudo profile constructed with a total of six surface stations, four in the surroundings of Padua, two on the nearby Alpine chain (see Fig. 1).

As none of the radiometers are collocated with a radio sounding, we have chosen a set of time steps for which the soundings of Milano and Bologna are close in the lowermost kilometer, i.e. the temperature difference is smaller than 2K. These are taken as conditions of homogeneity for which we can assume that the radiometers of Padua and Rovigo should be reasonably close to the radio soundings. All data have been interpolated on a vertical grid with levels 0, 50, 100, 150, 250, 700, 1000m, i.e. close to the levels on which radio sounding data is measured.

3. Results

3.1. MTP5-HE versus radio soundings

Fig 3 shows the comparison between the MTP5-HE RO and the Bologna radio sounding for the 170 time steps (53 for 00UTC, 117 for 12UTC) for which the radio soundings of Milano and Bologna show good agreement. As a matter of fact, the agreement of the two measurements at 00UTC is excellent, while for 12UTC there is an overall warm bias of the radiometer of about 1K throughout the profile. The linear regression yields $y = -0.08 + 0.9998x$ with a correlation of 0.99. The agreement between the MTP5-HE PD with the same radio sounding exhibits a warm bias, both for 00 and 12UTC and a linear regression $y = -16.5 + 1.056x$ with a correlation of 0.98.

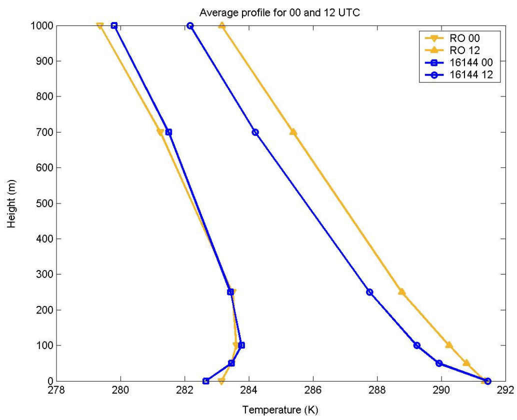

Fig. 3: Comparison of the MTP5-HE radiometer in Rovigo with the Bologna radio sounding for homogeneous conditions (see text). Average temperature profiles for the radiometer are shown for 00UTC (Δ) and 12UTC (∇), and for the radio sounding for 00UTC (squares) and 12UTC (o).

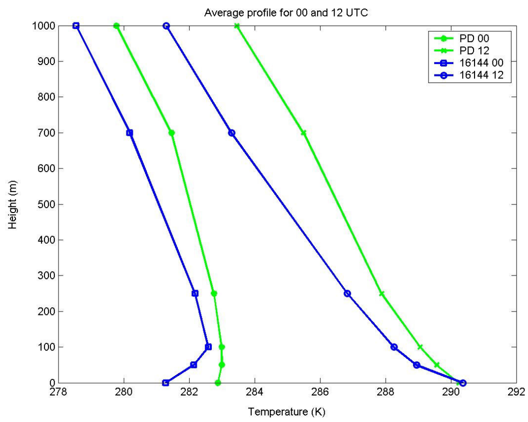

Fig. 4: As in Fig. 3 but for the radiometer in Padova.

3.2. Inventory of Po Valley inversions

Thermal inversions, especially during winter, are conducive to pronounced pollution spells in the Po Valley, as the keep the pollutants from being dispersed and close to the ground. Figures 5 and 6 show an inventory of inversions as seen by the radio soundings of Milano and Bologna, and the radiometers. There is a general agreement of having most inversions with relatively small temperature differences, i.e. below 1-1.5K, while most inversions have an inversion height of 200m. The urban radiometer of Padova exhibits more weak inversions, while the pseudo profile has a large number of inversions with strengths above 2K. However, the pseudo profile features always (except once) an inversion at 00 and 12UTC, an issue that deserves further analysis. There is an impressive number of very strong inversions (dT > 4K) as seen by the Bologna radio sounding, a station located in a agricultural area. This number is only partially confirmed by the close-by Rovigo radiometer. The isolated peak in the histogram of the inversion heights stems from the vertical grid which has be adapted to the heights on which radio sounding observations are available.

Figs. 7 and 8 show the yearly distribution of the number of inversions and average inversion parameters for the radio sounding of Milano and the MTP5-HE radiometer of Padova. These sites report what agrees well with common experience in the Po Valley, i.e. that number and strength of the inversions peaks during the cold season, while a minimum is reached during summer. However, other sites, e.g. radio sounding of Bologna, does feature very strong inversions in the months of May and June (not shown).

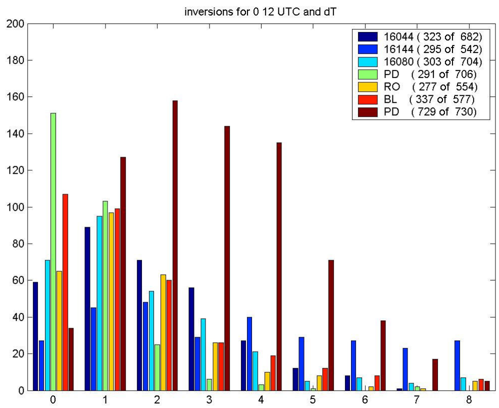

Fig. 5: Histogram of the temperature difference (K) of the Po Valley inversions for the period 1 April 2005 - 31 March 2006 as seen by the three available radio soundings (UD 16044, BO 16144, and MI 16080), the three MTP5-HE radiometers and the Padova pseudo profile (lowermost 'PD'). Sample sizes are denoted in brackets.

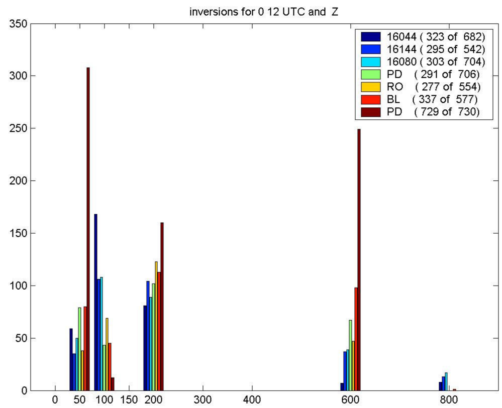

Fig. 6: As in Fig. 5 but for inversion height (m).

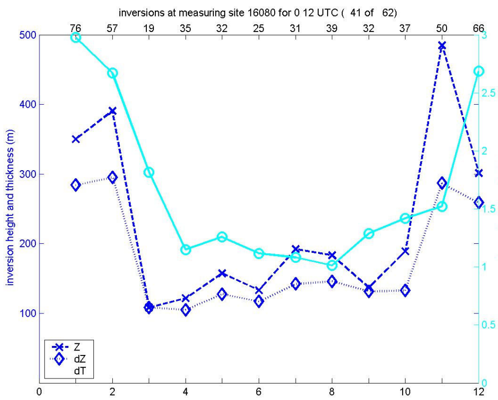

Fig. 7: Monthly distribution of the inversion parameters temperature difference dT (o, continuous line), inversion height Z (x, dashed line), and thickness of the inversion layer dZ (diamonds, dotted line) for the period 1 April 2005 - 31 March 2006 as seen by the radio sounding station Milano (MI 16080). Number on the lower x-axis denote the months of the year, the numbers on the upper x-axis the occurrences in the respective month.

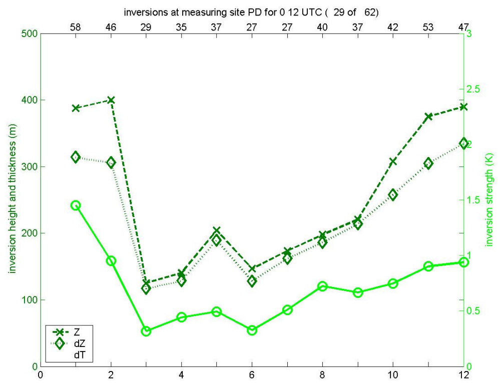

Fig. 8: As in Fig. 7 but for the MTP5-HE in Padova.

3.3. Urban temperature signature

Padova is a small to medium-size city for Po Valley standards with more than 200'000 inhabitants. The MTP5-HE radiometer is actually installed in the centre of Padua on the top of a building and should therefore 'see' the city climate in terms of temperature, which is expected to be quite distinct from the rural climate. Fig. 2 shows the comparison between the Padua radiometer and a pseudo profile constructed in the rural surroundings of the city for the four lowermost levels, while the two uppermost stations are located on the southern fringe of the pre-alpine chain, located some 50km north of Padua. At 00UTC the city profile exhibits a clear warm bias at all levels, largest at the ground and monotonically decreasing with height. At 12UTC, however, there is still a warm bias in the lower half of the profile, while in the upper half there is a distinct cold bias now. This is consistent with a warmer city center relative to the rural surroundings and a possible surface effect of the higher stations as opposed to the free boundary layer probed by the radiometer.

4. Summary and outlook

In this study a first analysis of the recently installed MTP5-HE radiometer network in the north Italian region Veneto has been presented. Overall, the radiometer bears a good potential to continuously monitor the thermal properties of the boundary layer, whereas only the 00 and 12 UTC measurements have been used so far. The main findings are summarized in the following:

- the MTP5-HE radiometers work very efficiently and reached levels of data availability of 97%, 75%, and 78% for the sites of Padova (PD), Rovigo (RO), and Belluno Santa Giustina (BL);
- there is a very good agreements between the MTP5-HE in Rovigo with the radio sounding in Bologna for the night-time in homogeneous conditions, i.e. when the Milano and Bologna radio sounding profiles are close;
- the MTP5-HE in Padova exhibits a distinct warm bias w.r.t. to the Bologna radio sounding for the same conditions;
- a first inventory of thermal inversions has been made; distribution of inversion height and strength seems to feature a significant spatial variability, e.g. Padova city vs. Bologna radio sounding (rural);
- comparison of the MTP5-HE in Padova with a pseudo profile constructed in the rural surroundings is consistent with an urban temperature signature, with a clear warm bias at night-time and a warm bias in the lower half of the profile during day-time; the cold bias aloft is thought to reflect the near-surface air which is warmer than the free boundary layer.

As opposed to the radio soundings which are available only twice or four times per day, the radiometers continuously monitor the thermal properties of the boundary layer. This temporal frequency has not been exploited in this study, but is planned for the near future. For example, build up and break-down of thermal inversions can be studied in some detail and put in relation with particulate matter concentrations.

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