Application of PBL Profiling Network to Air Quality in the Po-Valley Region Veneto Italy - Elements of an NWP Model Validation

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Introduction: A recently installed a boundary layer profiler network, which consists of one HATPRO radiometer, three MTP5-HE radiometers and four PCS-2000 SODAR is discussed. Six of these profilers are installed in flat terrain, while two are located in the major Alpine Valley Val Belluna. In this paper we will analyze the quality of the profiler data, and illustrate how these instruments depict the peculiar Po Valley PBL climate, which is well known to induce frequent air pollution episodes. Furthermore, we apply these data to validate the PBL representation of the Italian and the Swiss suites of the COSMO Model, i.e. LAMI and aMLo, as well as the Integrated Forecast System (IFS) of ECMWF, in terms of wind and temperature profiles.

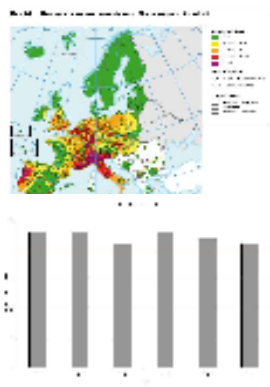


Fig 1-2 Last data from EEA (march 2007) Ozone map of number of days with exceedance information threshold – Annual Day Average of PM10 from all Air Quality station in Veneto Region

DOCUP Project:
In response to the frequent air quality emergencies in the North-Eastern Italian region Veneto, (see Fig. 1-2), 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 passive radiometers "R" and SODAR "S" for air quality monitoring purposes. The network, co-funded by the European Union, Italy, and the region of Veneto, is the first of its kind in Italy.

Sites:
The measuring sites are: flat and rural ("VR" Legnago," VE" Concordia S.), flat and urban ("PD" Padua and "RO" Rovigo), in a closed valley with very light winds and strong inversions ("SG" S. Giustina, Val Belluna).

Data set
The present analysis spans two years of data split in two periods:
2006 (1 April 2005 – 31 March 2006) 2007 (1 April 2006 – 31 March 2007).
The Sodar data used for model verification are from 1 May 2006 - 31 March 2007

Homogeneity condition & Grid interpolation
As none of the radiometers are collocated with a radio sounding, the times at which the soundings of Milano and Bologna are close in the lowermost kilometre, i.e. the temperature difference is smaller than 2K, were chosen for comparison.
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 50m spacing up to 1000m. For the HATPRO the grid was adapted to reach 10'000m, while for the Sodars the comparison with the model analyses was performed on a 20m grid with a vertical range of some 200m.

			
Type	Radiometer MTP5HE	Radiometer HATPRO	Sodar Metek 200-64
Number	X3	x1	x4
NameSite	RRO - RSG RPD	RVR	SVE - SPD SVR - VSG
	Made Attex in Russia and distributed by Kipp & Zonen. It receives radiation emitted by the atmosphere in 1 channel (molecular oxygen).	Product by RPG. It receives radiation emitted by the atmosphere in 14 channels and converts this data to profiles for temperature and humidity.	The SODAR are two portable PCS2000-24 and two re-locable PCS2000-64 manufactured by Metek, new version with flat array.
Vertical resolution	50 m	Varible 50 m low levels 500 m upper level	20 m
Time resolution	5 min	20 min	15 min
Vertical range	1000 m	10.000 m	200-400 m
2006	75:97 %	54 %	61:83 %
2007	60:97 %	63 %	66:85 %

Radiometer-Radiosounding Comparison Temperature

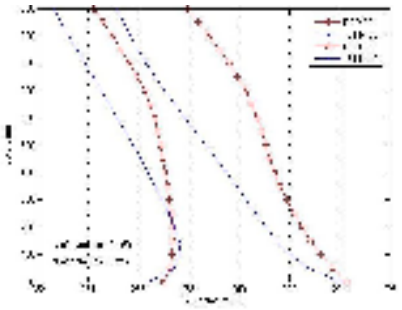


Fig. 3 Radiometer Padua Vs Radiosounding 16144 Bologna (~97 km) in Homogenety conditions

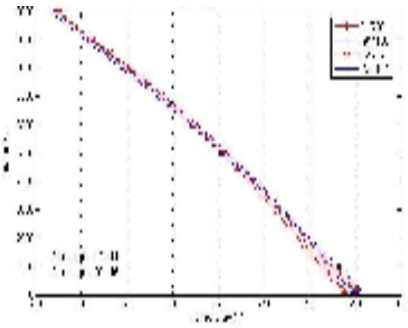


Fig. 4 Radiometer Legnago RVR Vs Radiosounding 16144 Bologna (~74 km) in Homogeneus condition

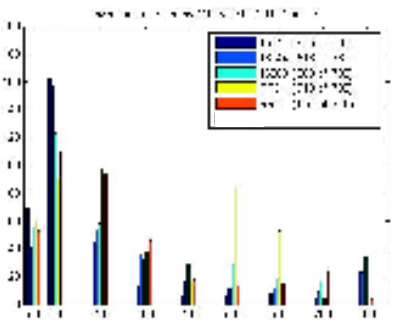


Fig. 5 Histogram of the height of temperature inversions (m) The legend includes the number of available profiles with a maximum of 730.

Profiler (Radiometer/Sodar - NWP Comparison Temperature

Fig. 6 Good correlation (R) in Padua, Legnago and Rovigo, whilst it is not so good for S. Giustina; Important BIAS in Padua and S. Giustina as can be also seen in next figure, but this can be related to the instrument site setting

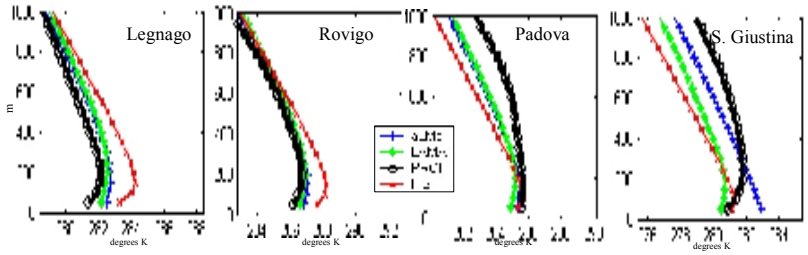
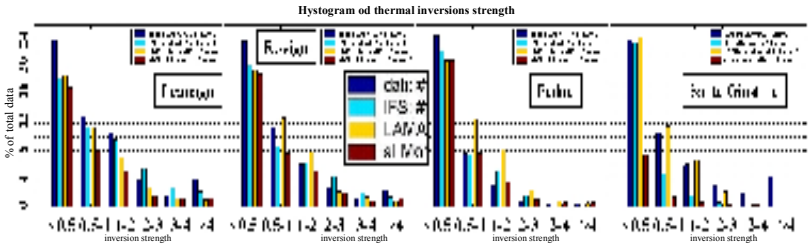


Fig.7 Histograms for the inversions distribution show that all MetM underestimate the strength of the strongest inversions, which happen mostly in S. Giustina and Legnago; in these cases LAMA is doing better then IFS whilst aLMo is performing the worse.



Total inversion time ①

The radiometers' data report 37% of total time with inversions in Padua, 49% in Rovigo and 60% in Legnago. This variability in not well reproduced in the LM model data, that give inversion always around 45% of the time for LAMA and 35% for aLMo. The IFS model is doing better, with 37% of the time with inversion in Padua, 44% in Rovigo, 51% in Legnago.

Wind ②

The availability of SODAR data is normally decreasing very rapidly with the height therefore for the wind the verification is limited for all sites to about 200m, except SVE (440m).
The results include BIAS in the range of 0.2-0.4 m/s with RMSE in the order of 2.5 m/s, values that become significantly worse for the valley station S. Giustina. As to wind direction, percentage of success within 30° is around 50%, within 60° is abound 75% for the stations in the plain, again with significantly worse values for the valley station.

Conclusion

Radiometer vs Radiosounding

With Temperature

- ❑ RRO Cold BIAS 00/12 / RPD ever warm BIAS - worse with the high (<1K low levels / ~3K high levels) Fig. 3
- ❑ RVR Excellent (<1K) upper level until 10 km, good in the low level (<2K) (but…few cases) Fig. 4
- ❑ ¾ of inversion are under 200m -trend with high have good correlation R - Fig. 5

Radiometer vs NWP

With Temperature

- ❑ BIAS <1K RVR RRO ~2K RPD RSG – RMSE 2K RVR RRO RPD ~ 10 RSG
- ❑ Total inversion time: Radiometer spatial difference Models C-I and C-CH no! IFS better (Box①)
- ❑ Inversion Strength: underestimate big inversion (RSG, RVR), general good agreement weak inversion / IFS better of C-I and C-CH Fig.7
- ❑ Thermal gradient C-CH weak gradient for every site, IFS inversion excessive

With Wind

- ❑ Wind Velocity BIAS 02-04 m/s / RMSE general 2.5 / SSG valley worst (Box②)
- ❑ Wind Direction number of success: In the plain general 30° ~50% - 60° ~75%, in valley worse

Discussion

- ❑ These resoults should be analysed in the light of the radiometer errors, bearing in mind that the model analyses are expected to be quite close to the radio soundings. Indeed, the comparison between radiometers and radio soundings show that both bias and RMSE are of the same order as the model analysis error for RPD, and less than 1K larger for RVR and RRO.
The opposite sign in the bias is due to the fact that the reference for the model verification is the set of profilers while for the profiler evaluation is against the radio soundings.

References

Ferrario, M. E., A. M. Rossa, D. Pernigotti, M. Sansone, A. Benassi, 2006. Presentation and first assessment of a radiometer network in the Italian region Veneto. *Proc. of the Int. Conf. on Urban Climate, Goteborg, 10-16 June 2006*, 288-291.

Pernigotti, D., A. M. Rossa, M. E. Ferrario, M. Sansone, and A. Benassi, 2007: Influence of ABL stability on the diurnal cycle of PM10 concentration: Illustration of the potential of the new Veneto network of MW-radiometers and SODAR. *Submitted to Meteorologische Zeitschrift, ISARS 06 Special Issue (accepted)*.

Putaud, J.-P., F. Raes, R. Van Dingenen, E. Brüggemann, M.-C. Facchini, S. Decesari, S. Fuzzi, R. Gehrig, C. Hüclin, P. Laj, G. Lorbeer, W. Maenhout, N. Mihalopoulos, K. Müller, X. Querol, S. Rodriguez, J. Chneider, G. Spindler, H. ten Brink, K. Tørseth, A. Wiedensohler, 2004 : A European aerosol phenomenology-2: chemical characteristics of particulate matter at kerbside, urban, rural and background sites in *Europe--Atm. Env.* **38**, 2579 - 2595.