APPLICATION OF A NETWORK OF MW-RADIOMETERS AND SODAR FOR THE VERIFICATION OF METEOROLOGICAL FORECASTING MODELS

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Abstract

The Centro Meteorologico di Teolo (CMT) of the Regional Agency for Protection and Prevention of the Environment of the Veneto Region (ARPAV) has recently installed on its territory a boundary layer profilers network, which consists of four passive microwave radiometers (1 Radiometer Physics GmbH, 3 Kipp & Zonen) and 4 SODAR (Metek).

In the framework of the contribution of ARPAV to the COST728 this paper will present the application of the radiometers and SODAR data for the verification of profiles of temperature and wind for various MetM: ECMWF model, COSMO Model in the Italian (LAMI) and Swiss (aLMo) Suite. In this paper comparisons of profiler data acquired in the year May 2005-April 2006 with the analysis made with the MetM are presented. In particular, the potential of the profiler network to detect and characterize the ability of MetM to describe the PBL for pollutant dispersion applications is discussed.

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 and four SODAR for air quality monitoring purposes. The instruments are all located in Veneto, as reported in Figure 1. The network, in the framework of the project DOCUP (D*OCumento Unico di Programmazione*) co-funded by the European Union, Italy, and the region of Veneto, is the first of its kind in Italy. The Profilers data have more time and vertical resolution when compared to radio-sondings, which allows for a great value of these data for MetM verification in the Planetary Boundary Layer (PBL), i.e. for the region where all application for pollutant dispersion modelling take place.

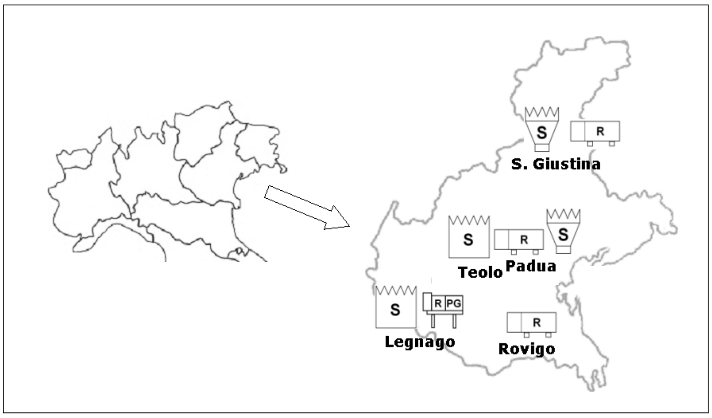

Figure 1: Profiler Network on north/east Italy

2. DATA SET

The MetM analysis uesed are extracted form the operational database of ECMWF (IFS model), ARPA-SIM (Cosmo Model, LAMI suite) and MeteoSwiss CSCS (Cosmo Model, aLMo Suite). All data are given at the models levels, then interpolated on the vertical coordinate of the instrument measurement. The IFS model is a Global Model with analysis stored at ECMWF with time resolution of 6 hours whilst Lokal Moedell is a Limited Area Model (LAM) with analysis stored at ARPA-SIM and CSCS with 1h time resolution.

	IFS till 31/02/06	IFS	LAMI till 25/1/06	LAMI	aLMo
Horiz. Resol.	0.5° (50km)	0.25° (25km)	7km	7km	7km
Vertical lev.	60	91	35	40	45
V. lev <1000m	11	13	9	14	10
Temp. Resol.	6h	1h	1h	1h	1h

Tab. 1: Some details on the MetM used for verification

The 3 MTP5-HE Radiometers ("R" in figure 1) are manufactured by Attex in Russia and distributed by Kipp & Zonen. As shown in Kadygrov et al. (2005) this instrument reports a good agreement within 0.5-0.8K with a co-located radio sounding found in Payerne, Switzerland, on 63 profiles. Ferrario et al (2006) confirmed this data for the ARPAV MTP5-HE radiometers. All instruments are set to have the first level at 50m.

The radiometer ("RPG" in figure 1) is manifactured by Radiometer Physics GmbH. It recieves radiation emitted by the atmosphere in 14 channels (molecular oxygien and water vapour lines) and converts this data to profiles for themperature and humidity (T. Rose et al.,2005) via neural algorithm optimized for the measuring site. The instrument installed in Legnago makes also a vertical scan every 20' for temperature to increase vertical resolution (50-75m up to 2000m) in the PBL, where the declared accuracy is 1K.

The SODAR ("S" in figure 1) are two PCS2000-24 and two PCS2000-64 manifactured by Metek. This is well known technology (I. Antonious et al., 2003) and the manifacturer declared accuracy of the data is of 0.3m/s for wind intensity and 5-8° for wind direction. This kind of instrument have always the problem of the vertical range, which is dependent by the atmospheric stability, giving a strong decrase on the number of sampling incrising the altitude. All SODAR are set with first level at 40m and temporal resolution of 15'.

	SODAR				MTP5-HE			HATPRO
	Padova	S.Giustina	Legnago	Teolo	Padova	S.Giustina	Rovigo	Legnago
Vert. resol	20m	20m	20m	20m	50m	50m	50m	50-75m
Temp.resol	15'	15'	15'	15'	5'	5'	5'	20'
V. range	200m	220m	200m	440m	1000m	1000m	1000m	2000m
#data	75%	73%	66%	85%	97%	70%	79%	63%

Tab. 2: Some parameters on instruments settings and data availability, Vertical range for SODAR is the altitude were availability go down to 30% of the one of first level (40m)

The measuring sites are flat and rural (Legnago), flat and urban (Padua and Rovigo), on smooth hills (Teolo) and in a closed valley with very very light winds and strong inversions (S. Giustina, Val Belluna).

3. SCORES FOR TEMPERATURE

As reported in the works made in the framework of the FUMAPEX Project (S. Jongen and G. Bonafè, 2006; B. Fay et al.,2005) a good simulation of the thermal profile in the levels near ground is very important for air quality assessment purposes.
The MW-Radiometers can be very useful in assessing the ability of MetM analysis to simulate the temperature profile in the PBL. The results reported in Tab.3 show that the models' analysis is good for correlation (R) in Padua, Legnago and Rovigo, whilst it is not so good for S. Giustina; the BIAS is quite important in Padua and S. Giustina as can be also seen in Fig. 2, but this can be related to the instrument site setting (see M.E. Ferrario et al., 2006); the RMSE is big in all sites and in the case of Legnago and Rovigo (where the BIAS is small) this can be partially related to the inability of models to correctly simulate the temperature in the lowest levels. To confirm this the statistical scores in the first 300m for Rovigo and Legnago were calculated, giving a slightly grater RMSE.

	Padova			Legnago			Rovigo			S. Giustina		
	IFS	LAMA	aLMo	IFS	LAMA	aLMo	IFS	LAMA	aLMo	IFS	LAMA	aLMo
distance	13.9	2.9	2.9	22.3	3.8	3.8	18.7	4.3	4.3	9.9	2.2	6.4
# data	1409	8315	8455	918	5405	5539	1031	5972	6145	1156	6810	6913
BIAS (°)	-2.0	-1.2	-1.5	1.4	0.7	0.5	0.1	-0.2	-0.5	-2.5	-2.2	-0.9
RMSE	2.5	1.8	2.1	2.6	2.3	2.2	2.6	2.7	2.7	10.3	10.0	9.9
R	0.99	0.99	0.98	0.94	0.95	0.94	0.94	0.95	0.95	0.70	0.71	0.69

Tab. 3: Average of statistical parameter from 50m to 1000m above ground, 'distance' is the distrance from model point to the radiometer site.

Number and strength of nocturnal inversions are particular important for pollutant dispersion, expecially in the PO-Valley (S. Jongen and G. Bonafè, 2006). 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. The Fig. 1 show the histograms for the inversions distribution, showing that all models underestimate the strength of the strongest inversions, which happen mostly in S. Giustina and Legnago; in these cases LAMA is doing better then IFS whils aLMo is performing the worse.

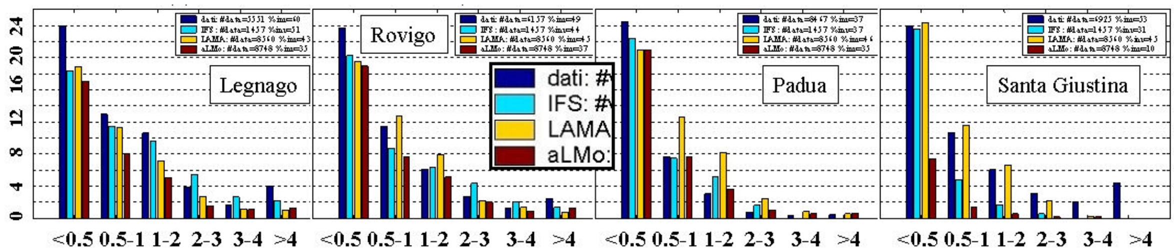

Fig. 1: Histogram of temperature inversion strength (maxT(50,1000)-T(50)) in degrees in % on the total data.

Fig. 2 confirms that in all sites LAMA and IFS report the inversion of midnight, whilst for aLMo this is allways too weak or absent as in the case of S. Giustina.

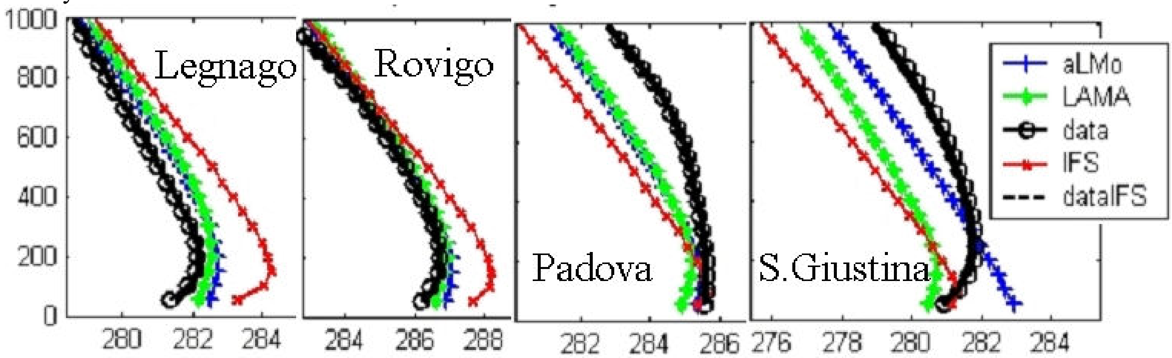

Fig. 2: Average temperature profile for 00UTC for various stations and models

4. SCORES FOR WIND

The availability of SODAR data is normally decreasing very rapidly with the height, as can be seen in Tab. 2 on the vertical range, therefore for the wind the verification is limited for all sites to about 200m, except for Teolo where the vertical range goes up to 440m.

	Padova			Legnago			Teolo			Sgiustina		
	IFS	LAMA	aLMo	IFS	LAMA	aLMo	IFS	LAMA	aLMo	IFS	LAMA	aLMo
distance	14.2	3.5	3.5	21.9	4.3	4.3	22.3	2.8	2.9	9.4	2.6	6.8
#data min	337	2155	2190	307	1817	1851	357	2094	2149	353	2052	2110
BIAS	0.21	0.30	0.03	-0.39	-0.41	-0.38	-0.27	0.52	0.30	1.49	2.26	1.20
RMSE	2.28	2.36	2.31	2.53	2.47	2.50	2.49	2.72	2.56	2.87	4.42	3.07
R	0.58	0.61	0.62	0.60	0.66	0.66	0.59	0.61	0.63	0.09	0.05	0.06
DIST	3.12	2.92	2.91	3.37	3.11	3.10	3.35	3.45	3.18	3.27	4.12	3.16
Perc30	0.46	0.53	0.50	0.51	0.57	0.57	0.46	0.47	0.51	0.22	0.19	0.20
Perc60	0.71	0.75	0.74	0.73	0.76	0.77	0.65	0.69	0.71	0.39	0.38	0.38

Tab. 4: average for statistical scores from 40m to 'vertical range' of SODAR (see tab. 2). 'distance' is the distance in km from model point to SODAR, '# data min' is the number of data available at the 'vertical range' height, 'DIST' is the vectorial distance of model from data averaged over the year. Perc30 and Perc60 are the number of success of the model predicting the wind direction in a range of 30° and 60°.

The data reported in Tab. 4 and in Fig. 3 show that there are not significant differences between models even when the topography is not very simple as in Teolo. The case of S.Giustina has to be considered apart as it is in a closed valley, where all models do very bad in analyzing both wind intensity and direction; in particular LAMA analysis does particularly bad, probably because the grid point of the model is not the best for representing that valley. The results are not very different compared with the results obtained in Pernigotti et al. (2005) where the verification for wind was carried for one year with the surface stations, only RMSE seems to be grater when using the wind profile (about 1.5m/s for surface stations, around 2.5 m/s here).

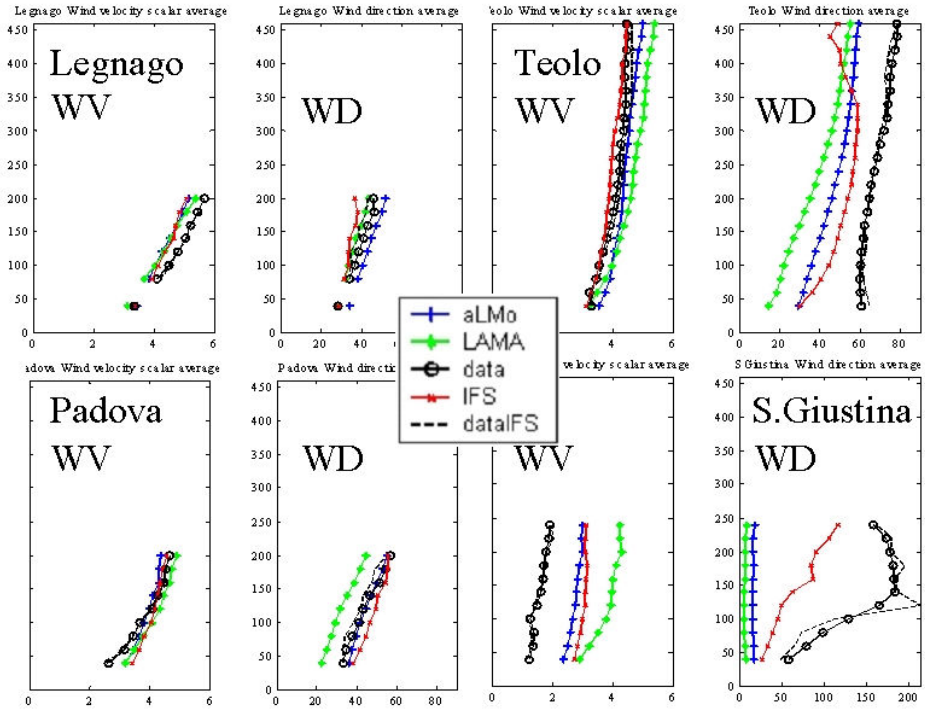

Fig. 3: profiles for annual scalar average for wind intensity (m/s) ;vectorial average for wind direction

5. CONCLUSIONS

The present study show the potential use of the network of profilers for the verification of MetM, especially for air quality application.

The results for wind show that there is not a clear and significant improvement on the long-term analysis with the use of a LAM model instead of a Global Model nor in the flat nor in a mountains valley. Further improvement in complex topography are probably possible with LAM at higher resolution (2km), which seems to be achievable for Lokal Modell in the near future. The use of SODAR data on case study could possibly give more hints on the ability of models in reproducing the wind temporal variability.

The result for temperature profile and inversion analysis is quite surprising, giving that IFS seems to be more able to reproducing the variability of the PBL even in a flat terrain, which could be explained with the grater vertical resolution of this GM compared with LM.

6. AKNOWLEDGMENTS

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