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

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Introduction

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 and 4 SODAR.
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 Meteorological Models (MetM): ECMWF model (IFS), 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.

Short description of the Network

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 beside figure. 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.

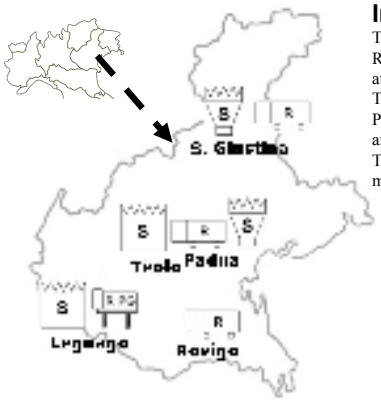
The measuring sites are:

•flat and rural (Legnago),

•flat and urban (Padua and Rovigo),

•on smooth hills (Teolo),

•in a closed valley with very very light winds and strong inversions (S. Giustina, Val Belluna).



Instrumental data set

The 3 MTP5-HE Radiometers (**R** in left figure) are manufactured by Attex in Russia and distributed by Kipp & Zonen. It recieves radiation emitted by the atmosphere in 1 channel (molecular oxyigen).
The HATPRO radiometer (**RPG** in left figure) is manifactured by Radiometer Physics GmbH. It recieves radiation emitted by the atmosphere in 14 channels and converts this data to profiles for themperature and humidity.
The SODAR (**S** in left figure) are two PCS2000-24 and two PCS2000-64 manifactured by Metek.

	SODAR (S)				MTP5-HE (R)			HATPRO (RPG)
	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	0.75	0.73	0.66	0.85	0.97	0.7	0.79	0.63

MetM analysis data set

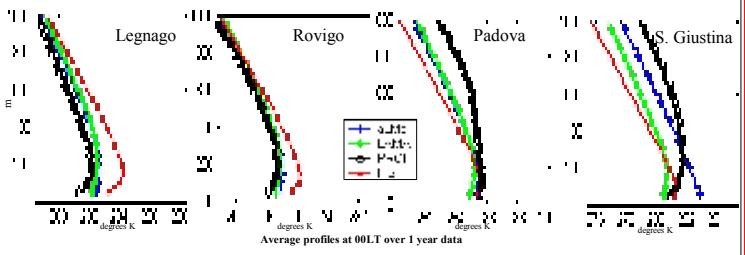
The MetM analysis uesed are extracted form the operational database of ECMWF (**IFS** model), ARPA-SIM (Cosmo Model, **LAMI** suite) and MeteoSwiss CSCS (Cosmo Model, **aLMo** Suite). All data are given at the models levels, then interpolated on the vertical coordinate of the instrument measurement (20m for wind and 50m for temperature). **The IFS model is a Global Model with analysis stored at ECMWF with time resolution of 6 hours whilst Lokal Modell 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
Vertical lev. <1000m	11	13	9	14	10
Temp. Resol.	6h	1h	1h	1h	1h

SCORES FOR TEMPERATURE

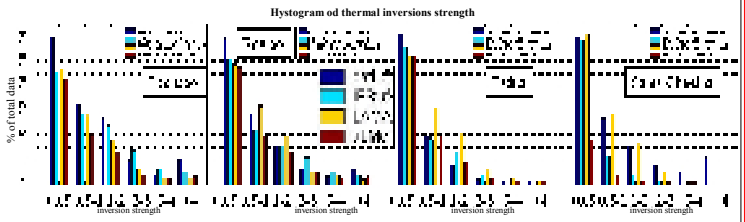
	Padova			Legnago			Rovigo			S. Giustina		
	IFS	LAMA	aLMo	IFS	LAMA	aLMo	IFS	LAMA	aLMo	IFS	LAMA	aLMo
distance to obs. (km)	13.9	2.9	2.9	22.3	3.8	3.8	18.7	4.3	4.3	9.9	2.2	6.4
# data	1409	8315	8455	918	5405	5539	1031	5972	6145	1156	6810	6913
BIAS (°)	-2	-1.2	-1.5	1.4	0.7	0.5	0.1	-0.2	-0.5	-2.5	-2.2	-0.9
RMSE	**2.5**	**1.8**	**2.1**	**2.6**	**2.3**	**2.2**	**2.6**	**2.7**	**2.7**	**10.3**	**10**	**9.9**
R	0.99	0.99	0.98	0.94	0.95	0.94	0.94	0.95	0.95	**0.7**	**0.71**	**0.69**

MetM analysis show:
• **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
• **big RMSE** 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**.



Average profiles at 00LT over 1 year data

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**.



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.**

Scores for statistical verification

To evaluate the performance of the MetM wind and temperaure prifiles field we calculated the statistical parameters reported below, where $p_o(s,t)$ and $p_o(s,t)$ is the temperature or wind intensity calculated and observed on the station s at the time t, ntot(s) is the total number of observations on station s.

For the wind direction we also consider the following statistical indices: %30° and %60° (% cases with wind direction in agreement within 30° and 60°, respectively); DIST takes into account both wind intensity and direction (u(t,s) and v(t,s) wind vector components).

$$BIAS(s) = \frac{\sum_t (p_c(s,t) - p_o(s,t))}{ntot(s)}$$

$$RMSE(s) = \frac{\sqrt{\sum_t (p_c(s,t) - p_o(s,t))^2}}{\sqrt{(ntot(s)-1)}}$$

$$DIST(s) = \frac{\sum_t \sqrt{((u_c(t,s) - u_o(t,s))^2 + (v_c(t,s) - v_o(t,s))^2)}}{ntot(s)}$$

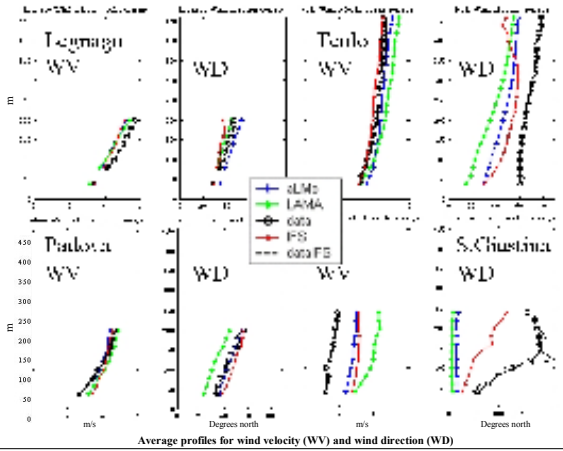
Definition of statistics

SCORES FOR WIND

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 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	0.3	0.03	-0.39	-0.41	-0.38	-0.27	0.52	0.3	1.49	2.26	1.2
RMSE	**2.28**	**2.36**	**2.31**	**2.53**	**2.47**	**2.5**	**2.49**	**2.72**	**2.56**	**2.87**	**4.42**	**3.07**
R	0.58	0.61	0.62	0.6	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	3.1	3.35	3.45	3.18	3.27	4.12	3.16
Perc30	0.46	0.53	0.5	0.51	0.57	0.57	0.46	0.47	0.51	0.22	0.19	0.2
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

MetM analysis for wind show:
•(exluding S. Giustina) **not significant differences between models** even when the topography is not very simple as in Teolo;



Average profiles for wind velocity (WV) and wind direction (WD)

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.

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 **does not show that there is 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 improvements in complex topography are probably possible with LAM at higher resolution (2km), which for Lokal Modell is going to be operative.
The use of SODAR data on case studies 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.