18th International Conference on
Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes
9-12 October 2017, Bologna, Italy

SENSITIVITY OF THE CAMX PHOTOCHEMICAL MODEL TO METEOROLOGICAL AND EMISSION PARAMETERISATION AND ITS EFFECTS ON FORECAST OF PM10 ACUTE POLLUTION EVENTS. APPLICATION AND INTERCOMPARISON OF TWO MODELLING SYSTEMS IN THE VENETO REGION.

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Abstract: ARPAV and RSE are running CAMx model version 6.3 on the Po Valley with the same resolution (4 km^2) but different extent of the domain, emission and meteorological input. The two operational modelling systems have been compared on a set of meteorological and air quality stations over the Veneto region. One of the most critical episode of PM10 occurred in the last ten years was selected for the present intercomparison. Models showed some systematic differences that can be mainly ascribed to the different meteorological input.

Key words: *CAMx, photochemical modelling, PM10 forecasting* **.**

INTRODUCTION

In the period from the end of January and the first days of February 2017, extremely high PM10 concentrations were recordered by monitoring stations located in Po Valley. Some preliminary results of the comparison between two forecast systems against the measurement performed in the urban background sites of Veneto Region are shown. The two modelling systems implement the same version of the CAMx model, with the same grid resolution (4 km), but driven by different meteorological models. Main objective of the work is to evaluate the effect of different meteorological characterisations and modelling setup on the forecast performance of CAMx model, for an acute PM10 episode over the Veneto Region domain.

MODELLING SETUP

Both the Regional Air Observatory of the Environmental Protection Agency of the Veneto Region (ARPAV) and the RSE have implemented an operational modelling chain based on CAMx model (Ramboll Environ, 2016). The model version currently implemented is the 6.3 (March 2016).

The RSE modelling system is designed to provide air quality forecasts, up to three days ahead, over the whole Italian Peninsula by means of CAMx. The computational domain extends over a 1136 x 1448 km^2 area and it was defined in Conical Conformal Lambert projection with 284x362 grid cells of 4 km horizontal resolution. The vertical grid includes 14 vertical layers up to 11 km. Meteorological fields arise from the Weather Research and Forecasting (WRF) meteorological model driven by the GFS operational data, operated daily by the American National Centers for Environmental Prediction (NCEP). WRF was setup using the same horizontal grid step as for CAMx, but adopting a slightly increased dimension domain. Vertical turbulence coefficient (kv) was recalculated using O'Brien scheme (O'Brien, 1970) by means of a specific processor.

Chemical boundary conditions are provided by the French air quality forecasting and monitoring system Prev'Air based on the CHIMERE model (http://www2.prevair.org/).

Emission inventories have been spatially and temporally disaggregated using SMOKE, for both national (ISPRA) and regional (INEMAR) based Italian inventories. Temporal disaggregation was based on monthly, daily and hourly profiles deducted by CHIMERE model and EMEP model from Institute of Energy Economics and the Rational Use of Energy (IER) project named GENEMIS (Pernigotti et al., 2013). Moreover emissions of foreign countries included in the computational domain are derived by the EMEP dataset available over a regular grid of 50x50 km^2. SeaSalt emission pre-processor and the MEGAN model are adopted in order to account for the natural emissions.

The ARPAV system produces, on a daily basis, air quality forecasts up to 72 h. The computational domain consists of an area 250 x 230 km^2 wide, covering the whole Veneto Region and part of the neighbouring regions. The horizontal grid is defined in terms of UTM coordinates and consists of 64 x 59 cells with 4 km resolution. The vertical grid includes 10 levels terrain following: the bottom level is 20 m (cell face) and the top level is 3000 m high. The meteorological input is based on the forecasts provided daily by COSMO-LAMI model, with a resolution of 7 km. The interpolation on the CAMx grid and the estimation of micrometeorological variables are perfomed by the CALMET processor run in NO-OBSERVATIONS mode; in this mode the local scale adjustments are performed over the "first guess" field supplied by the LAMI meteorological model. CALMET provides, beside wind and temperature three dimensional variables, also a set of two dimensional variables including the micro-meteorological variables required for the evaluation of turbulent diffusivity (Obukhov length, friction velocity etc). Variables describing the aqueous phase of the atmosphere (water vapour content, cloud/rain water content and cloud optical depth) are computed separately by a devoted processor starting from the basic fields. Vertical turbulence coefficient (kv) has been calculated using the algorithm adopted in the Community Multiscale Air Quality (CMAQ) modeling system.

As with the RSE system, boundary conditions are provided by the Prev'air system. The anthropogenic and Volatile Organic Compunds (VOC) biogenic emissions dataset is obtained from the local emission inventory and refers to the 2010 year. Point and grid sources are computed by a devoted processor developed by ARPAV. A specific CAMx preprocessor is also used to compute the sea salt contribution.

In both systems, CAMx was run using the CB05 mechanism for homogenous gas phase reactions (Yarwood et al., 2005). The aerosol scheme was based on two static modes (coarse and fine). Secondary inorganic compounds evolution was described by thermodynamic algorithm ISORROPIA (Nenes et al., 1998), while SOAP (ENVIRON, 2011) was used to describe secondary organic aerosol formation. The inorganic aqueous chemistry was reconstructed with RADM-AQ algorithm. Further information can be found in (ENVIRON, 2016). The investigated period spans from 18-January to 7-February 2017.

AIR POLLUTION MODELLING EVALUATION

Air quality forecasts have been verified against measurements collected at background stations of the ARPAV air quality monitoring network. Sites have been grouped in different geografical areas accordingly with their altitude. In Figure 1 measured and estimated mean concentrations for each site are presented for the evaluation period. The two systems are able to capture the observed mean concentrations but with different performances (see Table 1 and 2). Both models underestimate the observed concentrations, with RSE simulation showing a stronger negative bias than ARPAV. The most pronounced differences are in the mountain area, where RSE systematically underestimates, whereas the ARPAV system tends to overestimate the measured values.

In Figure 2 the mean trend of the pollution event for all stations is presented. The comparison with measured and modelled wind speed at the first model level is shown as well. The wind speed measurements are collected at the monitoring stations of the ARPAV Meteorological Centre (CMT) by anemometers located at 10 m above the ground.

A decrement of wind speed is recorded and modelled during the most acute pollution days (from 28 to 31 Jan). In the following days an increment in the wind speed and weather front's passage bring to the end of the pollution episode (see in Figure 3 the average of daily cumulated precipitation measured by the ARPAV meteorological stations).

The ARPAV first level wind field shows on average a better agreement with measurements, bringing to higher PM10 concentrations prediction with respect to RSE simulations.

In Figure 4 the measured and modelled PM10 trends, are compared with the daily maximum PBL height averaged over the meteorological sites. The PBL estimation algorithms used by the two modelling systems bring to a very different results, with a more stable atmosphere in the RSE simulations. However the effect of different PBL heights on modeled concentrations seems to be less relevant than the differences in the wind velocity showed by RSE and ARPAV.

Table 1. PM10 prediction at the monitoring sites -Average concentrations and standard deviation

Altitude	**Station**	**PM10 Average concentrations ($\mu g/m^3$)**			**Standard deviation ($\mu g/m^3$)**		
		Obs	**ARPAV**	**RSE**	**Obs**	**ARPAV**	**RSE**
Coast	IT0448A	58.8	40.5	33.7	43.6	30.5	23.7
	IT0663A	66.2	47.0	37.9	52.6	32.0	27.3
Plain	IT0963A	67.1	62.3	40.5	36.9	34.0	26.2
	IT1177A	59.6	36.4	34.0	40.8	22.2	15.0
	IT1213A	53.6	48.9	40.2	37.4	30.8	27.2
	IT1328A	68.4	50.7	41.9	40.7	29.2	27.5
	IT1343A	66.3	44.3	39.3	48.5	25.4	23.6
	IT1453A	72.1	54.4	39.8	50.8	29.3	27.2
	IT1535A	55.2	45.0	35.2	38.3	23.1	24.8
	IT1590A	60.7	62.3	40.5	34.2	34.0	25.8
Hill	IT1594A	54.8	46.9	36.0	47.8	28.8	23.4
Piedmont	IT1596A	44.0	43.7	39.1	30.7	28.5	21.8
	IT1619A	47.5	53.3	33.6	28.0	27.7	22.5
	IT1790A	21.4	25.0	19.3	21.6	18.7	9.0
Mountain	IT1848A	40.0	37.6	18.3	22.8	25.2	7.0
	IT1870A	53.2	39.3	19.2	24.8	20.8	7.2
	IT1905A	19.3	32.9	13.1	14.2	23.4	5.9

Table 2. PM10 prediction at the monitoring sites – perfomance indicators

Altitude	**Station**	**MB ($\mu g/m^3$)**		**CRMSE ($\mu g/m^3$)**		**R**	
		ARPAV	**RSE**	**ARPAV**	**RSE**	**ARPAV**	**RSE**
Coast	IT0448A	-18.2	-25.1	22.6	23.1	0.9	0.9
	IT0663A	-19.2	-28.3	29.1	30.0	0.9	0.9
Plain	IT0963A	-4.8	-26.6	14.5	16.1	0.9	0.9
	IT1177A	-23.1	-25.5	23.8	30.8	0.9	0.7
	IT1213A	-4.7	-13.4	14.1	16.2	0.9	0.9
	IT1328A	-17.7	-26.4	20.6	24.9	0.9	0.8
	IT1343A	-21.9	-26.9	24.6	28.8	1.0	0.9
	IT1453A	-17.6	-32.2	25.7	26.2	0.9	0.9
	IT1535A	-10.1	-19.9	20.5	20.0	0.9	0.9
	IT1590A	1.6	-20.2	15.6	15.7	0.9	0.9
Hill	IT1594A	-7.9	-18.8	24.9	28.9	0.9	0.9
Piedmont	IT1596A	-0.3	-4.9	13.6	19.9	0.9	0.7
	IT1619A	5.8	-13.9	12.1	17.2	0.9	0.8
	IT1790A	3.6	-2.1	13.3	15.7	0.8	0.7
Mountain	IT1848A	-2.3	-21.6	10.6	19.6	0.9	0.5
	IT1870A	-13.9	-34.0	8.3	20.2	0.9	0.7
	IT1905A	13.6	-6.2	12.6	10.4	0.9	0.7

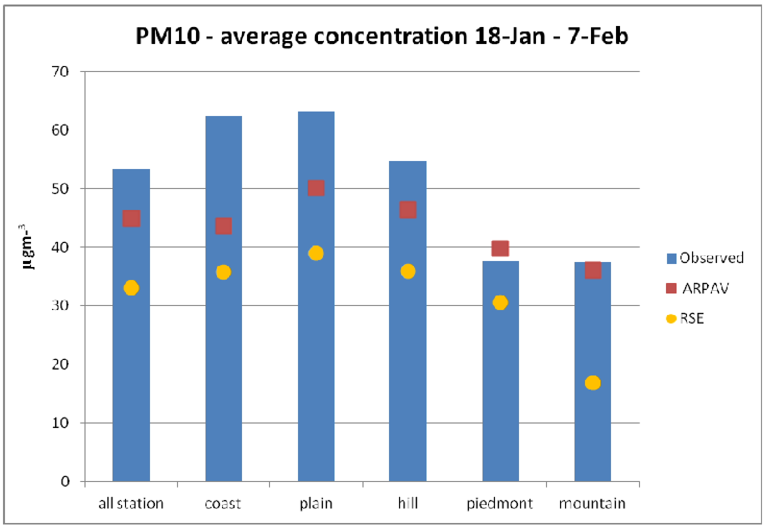

Figure 1. Models vs measurement – average concentrations

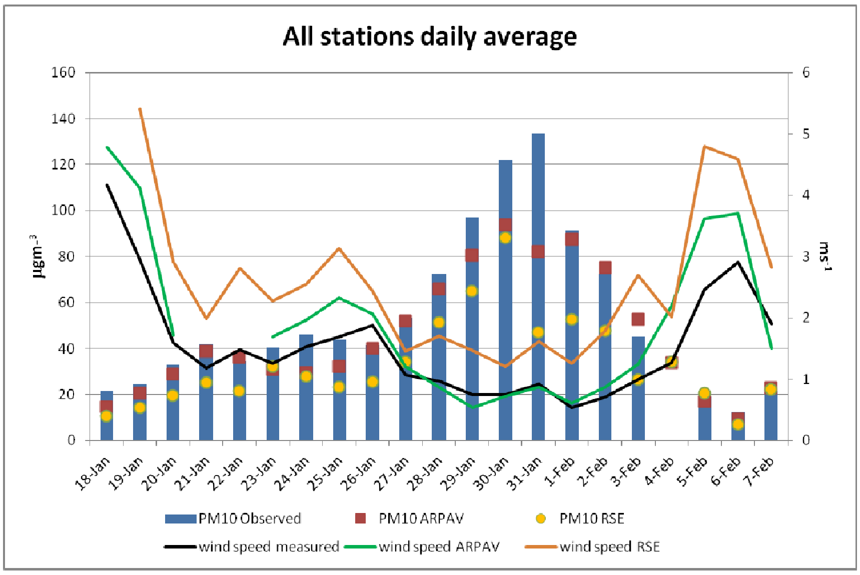

Figure 2. Trend of PM10 and daily average wind speed at the first level – average of all stations

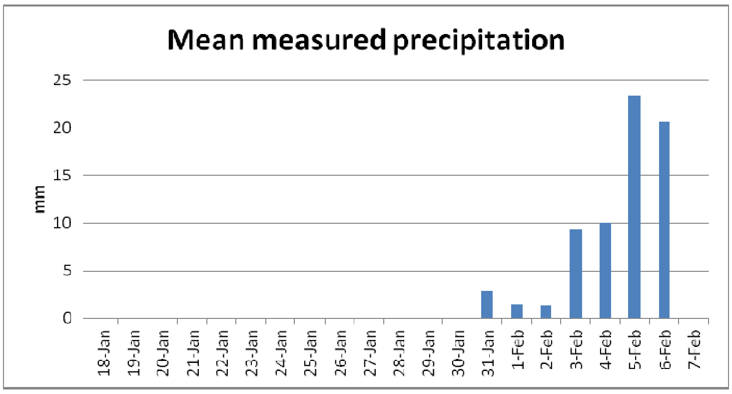

Figure 3. Precipitation in mm: average of the sites of the ARPAV meteorological network

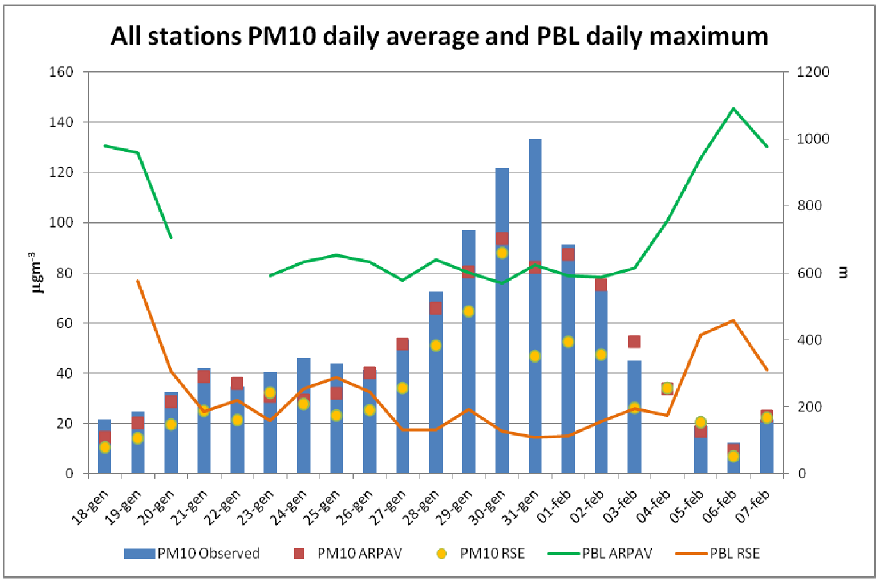

Figure 4. Trend of PM10 and maximum daily PBL height – average of all stations

CONCLUSION

The influence of the different modelling setup and meteorological characterisation on PM10 acute episode forecast has proved to be significant giving rise to differences between the two runs higher than 15 µg/m^3 at several measurement sites. The differences between the two models seems to be related more to the correponding differences in the modelled wind speed, than the PBL height. The evolution of the pollution levels has been correctly reproducted by both systems, even if understimation of very high concentration can be shown. Furher investigations are currently ongoing, particularly in respect to the micrometeorological parameterisation and emission profiles.

The results of this analysis will be used to enhance the capabilities of the two modelling systems in the prediction of acute pollution episodes. An increased level of the model performance is desirable to improve the current procedures to inform local authorities and the citizens.

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