

# DUST GENERATION AND DISPERSION (PM10 E PM2.5) IN THE AOSTA VALLEY: ANALYSIS WITH THE FARM MODEL

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## INTRODUCTION

The Aosta Valley is one of the deepest and longest valleys of the Alps. It is surrounded by high chains of mountains reaching more than 3000-4000 metres, and, on its western side, it faces the Mont Blanc. The bottom of the valley has an average height of 600 metres. The valley axis is prevalently oriented west-east: this maximises the shading effects of mountains on the bottom of the valley, enhancing differences in radiation, flow and turbulence over mountain slopes. The high level of naturalness is an important resource for the region, but also an element of vulnerability. In the last years, some stations in the urban area of Aosta failed to comply with the maximum number (35) of exceedances of PM10 daily human health protection limit, (50 µg/m<sup>3</sup>). This fact urged us to investigate the dust origin and dispersion by means of a modelling code.

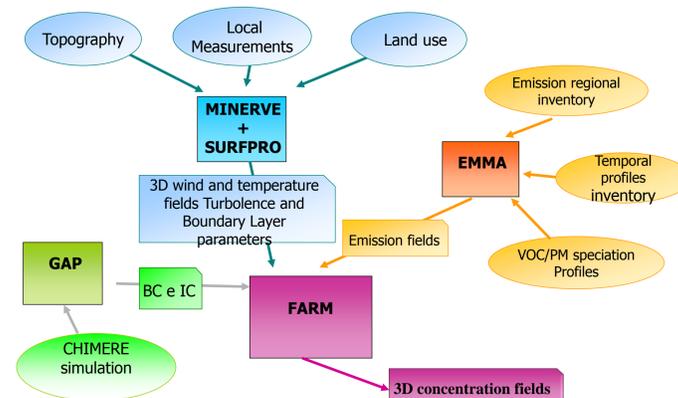
## DOMAINS DEFINITION AND EPISODES SELECTION

To investigate the effect of local and distant sources and describe processes dominated by scales larger than the city scale, a nested approach considering two domains was adopted. The background domain covers all territory of the Aosta Valley (111 x 71 cells at 1 km spacing) and the domain that includes the urban area of Aosta (69 x 29 cells at 250 m spacing).

Two periods were selected: the first episode (09-16 January 2006) was representative of winter condition of atmospheric stability, characterised by high concentrations of pollutants, and the second one (12-14 and 24-28 June 2007) characterised by typical summer conditions.

## THE MODEL

The simulations were performed using the regional emission inventory for the year 2005. Meteorological analyses were produced starting from the data provided by the ARPA monitoring network, using MINERVE diagnostic model and SURFPRO turbulence processor. The dispersion and the chemical evolution of the pollutants were simulated by the flexible air quality regional model (FARM) which was derived from STEM-II. FARM is a three-dimensional Eulerian model dealing with the transport and the multiphase chemistry of pollutants in the atmosphere. Gas-phase reactions are described by means of SAPRC-90 (Carter, 1990) whereas the aero3 aerosol module (Binkowski, 1999) is employed for particulate matter. The second module is based on a modal approach, whereby particle size distributions are represented as the superposition of three lognormal sub-distributions or modes: Aitken, accumulation and coarse mode.



## CONCENTRATION MAPS

The outputs obtained by the FARM model were three-dimensional maps of concentrations of major pollutants. The pollutants taken into account were: NO<sub>x</sub>, NO<sub>2</sub>, SO<sub>2</sub>, O<sub>3</sub>, PM10 and PM2.5 and maps of concentrations were produced for each pollutant on the urban and regional scale

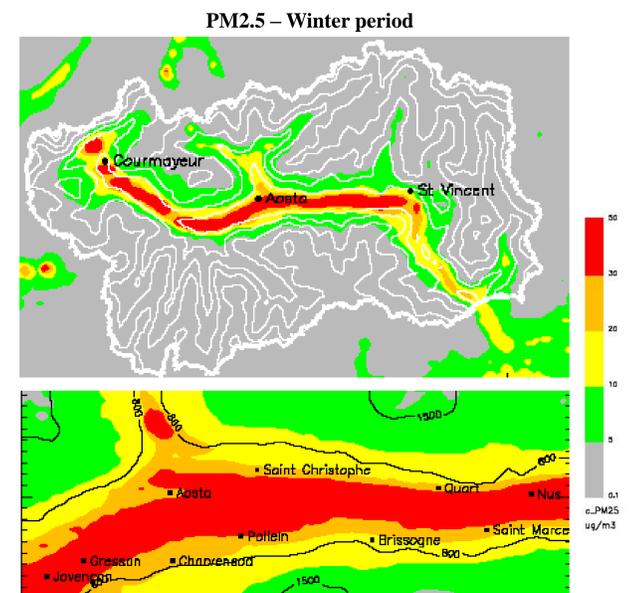


Figure 1. PM2.5 concentration maps during winter episode in the whole region and in the urban area of Aosta

## GASEOUS POLLUTANTS

We analysed in the first place the calculated concentrations of gaseous pollutants, which are decisive also to PM prediction, because they are precursors of secondary particulate matter.

The air quality data obtained through the ARPA monitoring network were used to evaluate the performance of the modelling system.

To quantitatively evaluate the modelling results for the two episodes, the Fractional Bias (FB) as well as a standard statistical measure were considered. Values of FB between -0.5 and 0.5 suggest good results. Figure 2 summarizes FB values for each station and gaseous pollutant.

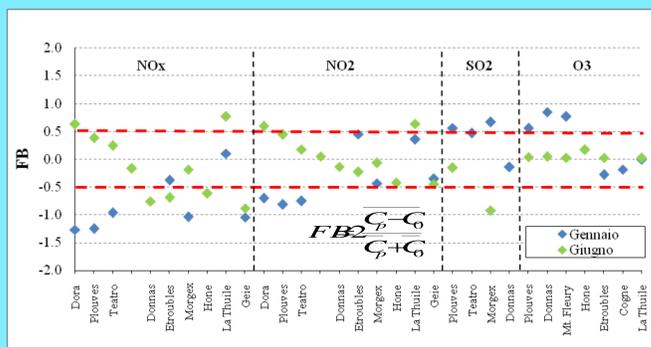


Figure 2. Fractional Bias of gaseous pollutants simulation for each measurement station

## EMISSION FACTORS FOR PM10

For PM simulations we used two different emission factors (EFs) for vehicles, in order to find out the best one:

- **IIASA EFs**, the most used, emission factors developed by the Austrian Institute IIASA;
- **Lohmeyer EFs**, Lohmeyer and co-workers calculate PM10 as a sum of all emissions for primary sources (exhaust pipe, vehicle parts and road abrasion) and those from material deposited on the road (resuspension).

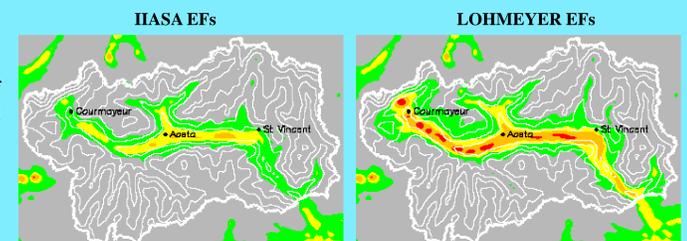
Road	Highway			National road			Regional road			Urban					
	Vehicle	Commercial light	Commercial heavy	Commercial light	Commercial heavy	Motor Bike	Commercial light	Commercial heavy	Motor Bike	Commercial light	Commercial heavy	Motor Bike			
PM IIASA	0.1	0.14	0.61	0.1	0.15	0.91	0.1	0.14	0.88	0.1	0.12	0.22	1.18	0.13	
PM10 Lohmeyer	0.1	0.34	17.2	0.1	0.5	11.6	0.001	0.1	0.3	11.6	0.001	0.08	0.27	7.54	0.001

Concentration maps confirmed that the urban area of Aosta and the whole central valley are affected by relatively high concentrations, particularly during the winter season.

As we can see in Figure 3, the values of PM10 concentration are higher for the Lohmeyer EFs.

## CONCENTRATION MAPS OF PM10

### PM10 – Winter period



### PM10 – Summer period

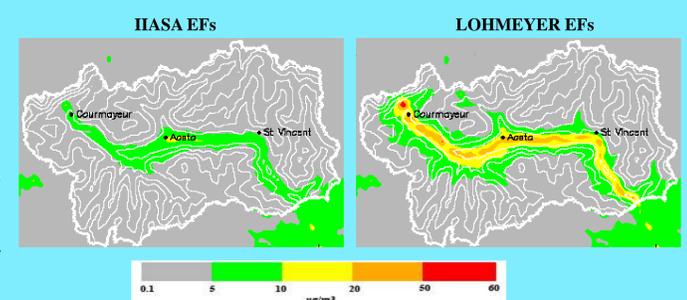


Figure 3. Comparison between concentration maps of PM10 obtained with IIASA EFs and Lohmeyer EFs

## PM10 CONCENTRATIONS

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Figure 4 gives the FB values for the urban station of the Quartiere Dora in the summer period, it is evident the better performance of Lohmeyer EFs in urban domain.

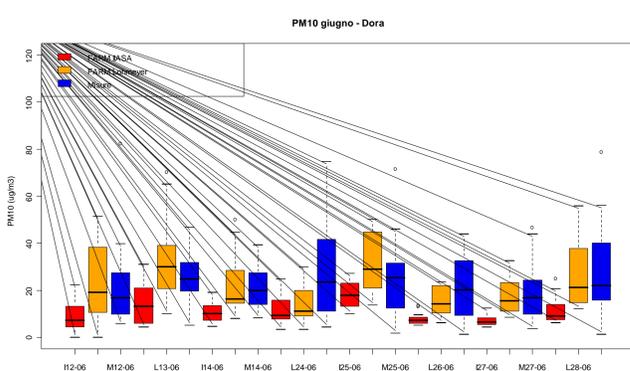


Figure 4. Boxplots of the comparison between concentration calculated with two FEs and measured at the Quartiere Dora station during summer episode

For quantitative evaluation, also for PM10 we calculated the FB:

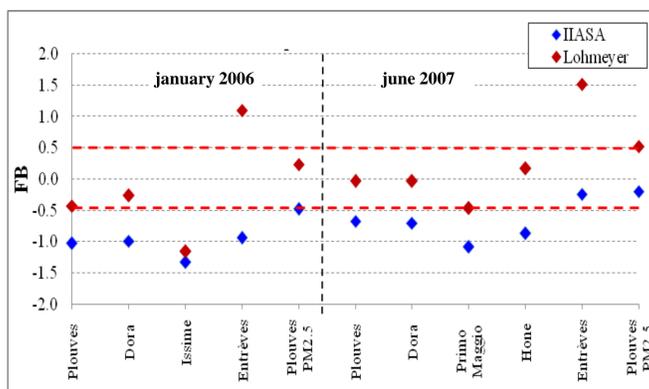


Figure 5. Fractional Bias of PM10 simulation for each measurement station

The IIASA EFs tend to under-predict the observed values over all domain, especially during the winter period. The concentration values obtained with Lohmeyer EFs are closer to the observed values, but some critical situations remain:

- during winter period concentrations are underestimated in the rural stations, probably because the emissions of domestic heating are also underestimated, especially the PM produced by wood combustion,
- in the highways areas, where there are many heavy goods vehicles, the concentrations are widely overestimated, because the Lohmeyer EFs for these vehicles are too high.

## Chemical characterisation of PM10

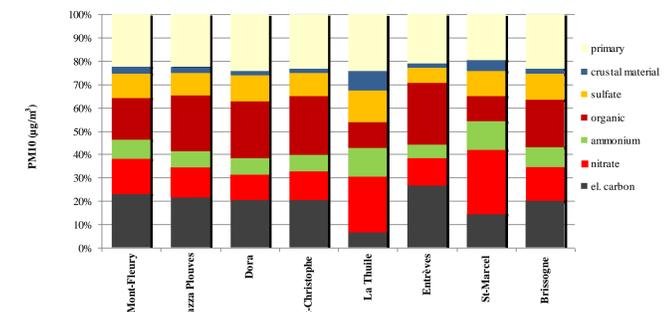


Figure 6. Chemical composition of PM10 for each measurement station in the winter episode

The analysis of the dust chemical characterisation gives that in the urban and traffic areas the main contributors to the PM10 mass concentration are the fractions derived from combustion, like primary, organic and elemental carbon, whereas in the rural station nitrate and crustal fractions are more relevant (Figure 6).

## CONCLUSIONS

FARM code was used in order to investigate the origin and dispersion of PM10 and PM2.5 in the alpine region of the Aosta Valley. The model well predicts concentrations of gaseous pollutants. PM model results obtained with IIASA EFs revealed the tendency to under-predict the observed values, that is why we tried to use a different emission factor for vehicles (Lohmeyer factor). The new results were good for the urban and suburban areas, but some critical situations need more study.