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MONITORING AND MODELLING ACTIVITIES TO EVALUATE THE DEPOSITION AT GROUND OF POLLUTANTS IN THE VICINITY OF THE AOSTA CITY

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Abstract: The Regional Environmental Protection Agency (ARPA) of the Aosta Valley (Northern Italy) has performed an intensive measuring campaign during the period November 2007 – November 2008. The deposition of several atmospheric contaminants (metals, IPA, PCB, PCDD/F) in the conurbation of the city of Aosta, have been controlled. The monitoring network has been designed to possibly evaluate the effects that the existing local emission sources (road traffic, domestic heating and a big steel plant) may have on different zones of the city. Every monitoring site measured wet and dry deposition through bulk deposimeters, able to determine the presence of both metals and organic micro pollutants. This monitoring activity has been supported by a modelling study, in order to better characterize the spatial impact of the dioxins emitted by the big steel plant over the urban area. Two simulations have been performed covering the period February-March and August-September 2008, during two of the monitoring displacements. The Lagrangian Particle Model Spray has been used at local scale, driven by local meteorological observations previously assimilated by the Swift/SurfPro diagnostic pre-processor. The steel plant's stacks have been assumed to be the only source of particulate matter that transports dioxins. Surface concentrations have been carried out considering different aerosol diameters, and computing total, dry and wet deposition fluxes. Results have been compared with the available measurements. Simulation results show a satisfactory reproduction of the data collected by the monitoring network and allow a spatial reconstruction of the impact generated by the plant emissions.

***Key words:** Air quality modelling, urban and industrial air pollution, dioxin depositions.*

INTRODUCTION

Aosta Valley is a small Italian region located in the alpine domain close to the NW national boundary. Its main town, Aosta, lies in a basin surrounded by the mountains. This can affect the air quality, especially during the winter season.

Close to the town centre there is a steel factory. ARPA (the Regional Agency for Environmental Protection) of Aosta Valley performed two different studies in order to analyse the dioxin depositions derived from its furnaces: a monitoring campaign using deposimeters and a dispersion model simulation.

THE MONITORING CAMPAIGN

A sampling station made up of two bulk type deposimeters for the collection of both dry and wet deposition was installed in each monitoring site. The deposimeter consisted of two containers of rectangular cross section (Fig. 2), one is made out of plastic for the determination of metals and anions and the other made out of glass for the determination of organic micropollutants (HPA, PCDD/F, PCB).

These deposimeters were exposed to the environment over one month periods. The sampling was repeated for 13 consecutive months from June 2006 to July 2007. Each exposure period was intended to collect the sample, providing a thorough cleaning of the inner surface and collecting the aqueous solution of washing to be submitted for laboratory analysis.

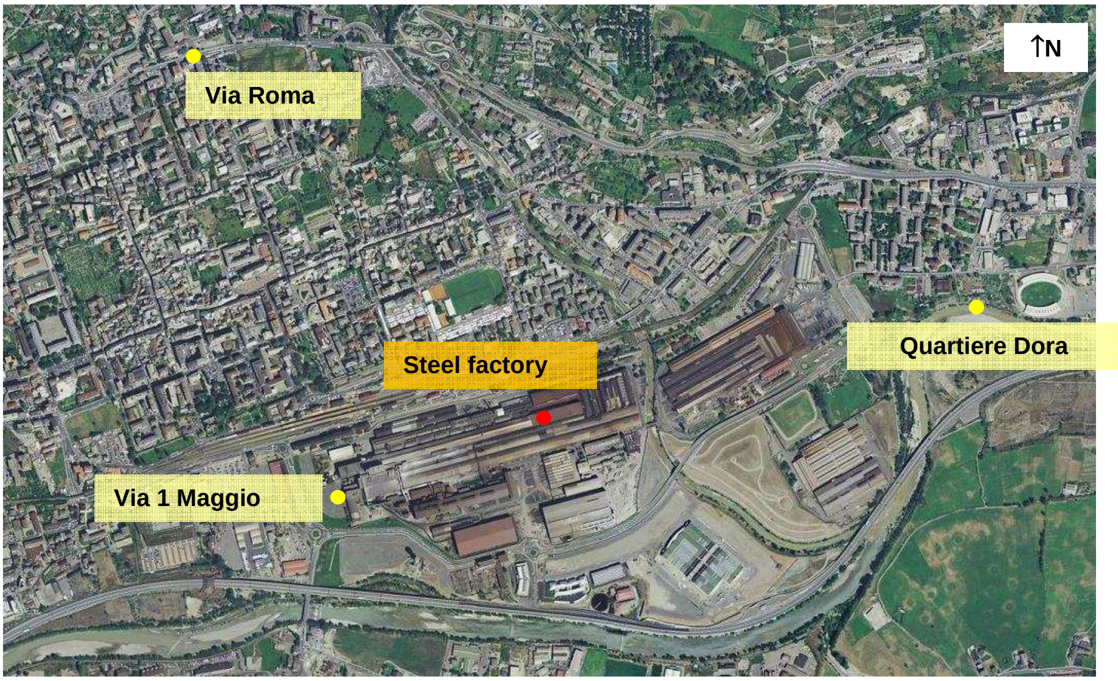

Figure 1. The monitoring deposimeters located in Aosta town.

Fig. 2 – Monitoring stations: Via 1 Maggio (left) and Chanversod (right)

Samples were divided into 17 congeners of dioxins and furans and 12 other types (PCB-DL) in accordance with the World Health Organization (WHO) standards.

Table 1 shows the average values of deposition of dioxins and furans, expressed as equivalent toxicity (TEQ), derived from the sum of the products of toxic equivalency factors for individual congeners (TEF_i) and their concentrations (C_i) according to the formula:

$$I - TEQ = \sum_i (C_i \cdot TEF_i)$$

Table 1 – Results of the deposimeter campaigns: deposition of PCDD / F detected in the monitoring sites

Deposimeter sites	Distance to source (km)	Direction to source	Campaign Feb-Mar pg /(m^2d)	Campaign Aug-Sep pg /(m^2d)	Annual average: Nov. 2007 – Nov. 2008
Via Primo Maggio	0.6	S	0.89	1.75	0.92
Piazza plouves	0.7	N	0.61	1.10	0.89
Via Roma	1.2	N	0.81	0.48	0.99
Quartiere Dora	1	E	1.01	6.33	3.05
Sarre	6	W	0.77	0.59	1.58
Charvensod	1.3	S	0.49	0.73	0.68
St. Christophe	2.4	E	0.46	1.77	1.32
Senin	2.6	NE	1.66	1.00	1.02
St. Marcel	9.4	E	1.64	1.83	1.09
Villefranche	6.8	E	0.51	0.68	0.70
Jeanceyaz	5	NE	0.46	1.45	0.79
Villair	5	E	1.22	0.45	0.77
Pollein	4	E	0.41	1.14	0.81

The values reported in the urban area of Aosta (the first four in the table) range between 0.89 and 3.05 pg/(m^2d) and are comparable with the levels measured in other Italian cities. In the other suburban sites the depositions measured are about 1 pg/(m^2d).

THE DISPERSION MODEL SIMULATIONS

The Lagrangian dispersion model SPRAY (Arianet, 2001) has been used to perform two dispersion and deposition simulations in order to both check the reliability of the code to reconstruct ground depositions and to know which areas are most affected by this kind of pollution. The periods analyzed are the two campaigns of February - March and of August – September 2008.

For the input of emissions, we only considered the steel factory stacks and we calculated them using the stack parameters, the flow data and the dioxin concentrations measured at the top of the chimney, provided by the factory management. Dioxins are supposed to be emitted by the solid particle phase, the particle size distribution is not well known and represents one of the uncertainties of the problem.

Meteorological analyses were performed according to the data provided by the ARPA monitoring network, using SWIFT diagnostic model and SURFPRO turbulence processor, using the data available by a local network on hourly basis.
One computational grid was considered: the urban and the suburban areas of Aosta (20 x 10 km, with 125 m horizontal resolution).The dry deposition is evaluated by SPRAY model through a removal mechanism proportional to a dry deposition velocity coefficient calculated by SURFPRO model; the wet one is based on a particle-size dependent washout coefficient.
Different particle diameters have been tested for the particulate matter transporting the dioxins, the smallest diameter among 1µ, 2µ and 5µ shows the best fit with the measureddata.

Figures 3 and 4 show the dry and wet depositions fields modeled in the two campaign periods.

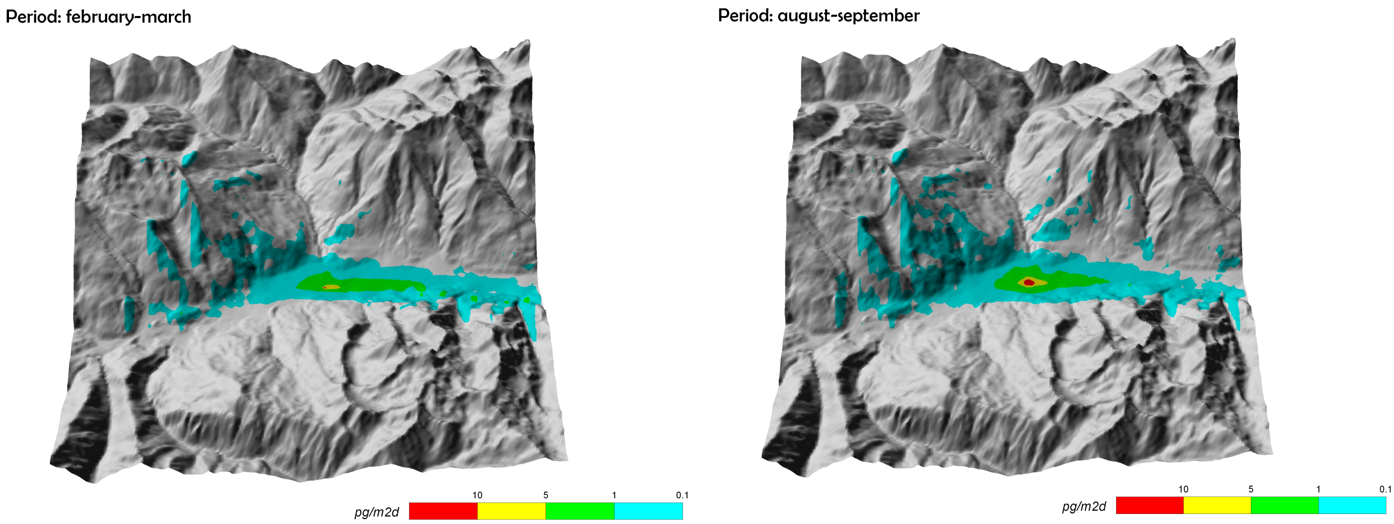

Fig. 3 – Dry dioxin depositions calculated by SPRAY model

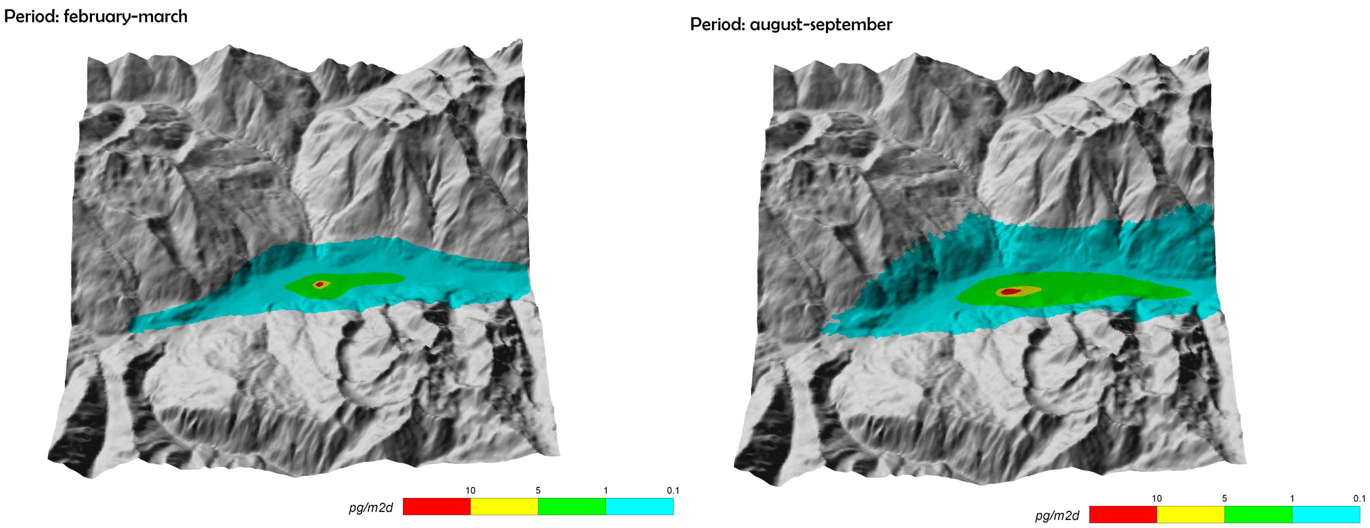

Fig. 4 – Wet dioxin depositions calculated by SPRAY model

The SPRAY model gives a good representation of the dioxin depositions. The period August-September is confirmed with the highest values. The maps show that the impact area is located in the East side of Aosta with an extension towards the East due to the breeze/wind direction.

By comparing the observed values of the deposimeters and the values calculated by the model shown in the fig.5 and 6, it is evident that the model tends to over-predict the deposition near the source (Primo Maggio and Plouves sites) whereas it gives the best results for the sites more than one kilometer from the steel factory as well as for the Quartiere Dora peak in the second period.

These higher values are especially generated by the wet deposition scheme used by the model that tends to overestimate the effects of the washout process close to the source where the emitted plume is still highly concentrated.

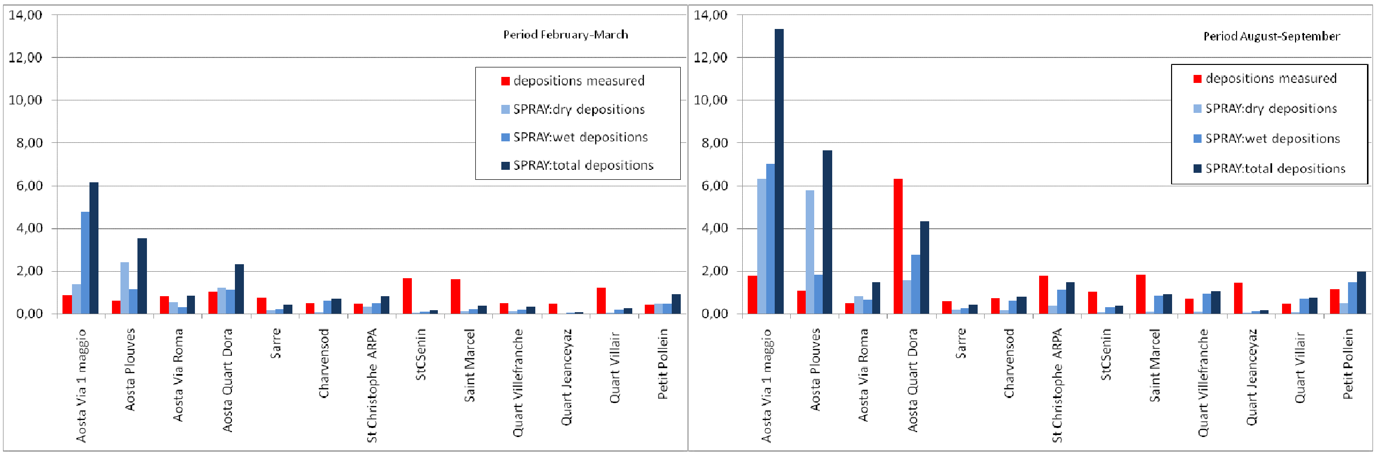

Fig. 5 – Comparison between dioxins depositions observed and calculated by SPRAY model for the two periods

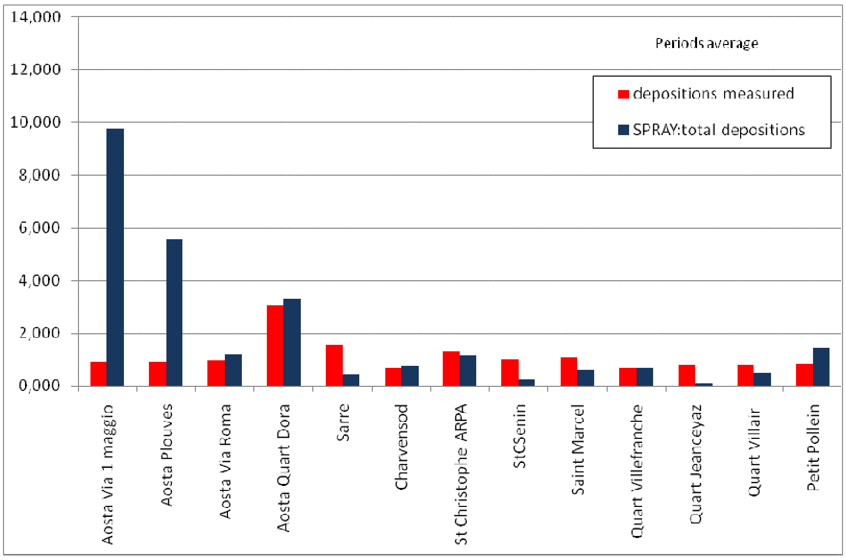

Fig. 6 – Comparison between dioxins depositions observed (yearly average) and calculated (two periods average) by SPRAY model

CONCLUSION

We used the SPRAY code in order to investigate the dispersion and the depositions of dioxins emitted by a steel plant located in the town of Aosta. The model overpredicts depositions of this pollutant in the vicinity of the source and predicts all the other values well, comparing the simulation results with the measurement data provided by a monitoring campaign using deposimeters. Sites located more than one kilometer away from the source give the best results. The quality of these results shows that the modeling system, coupled with a measuring network, is a reliable tool that can help in the spatial reconstruction of the long-range impact in the surrounding of industrial emissions, which is particularly important if the emissions are located close to an urban inhabited environment.

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