MONITORING POPS IN A COMPLEX ENVIRONMENT: THE ROLE OF MODELLING

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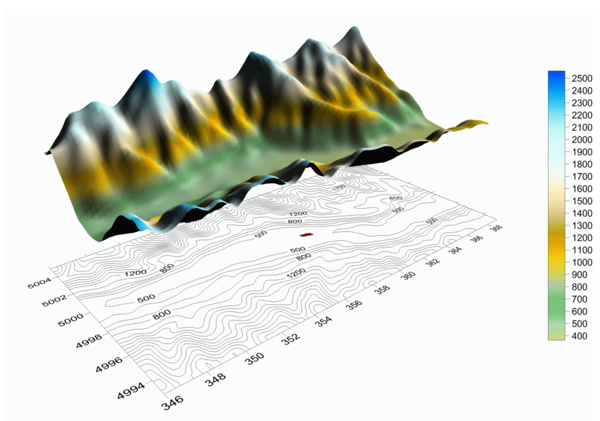
CASE STUDY

We present the case of a steel foundry located in an alpine valley, which provides a good test case for assessing the capabilities of the three-dimensional lagrangian model SPRAY to correctly describe fall-out patterns of persistent organic pollutants (POPs) both in terms of concentrations in the air and depositions on the ground when the terrain complexity is high.



Topography of the area of interest. The red spot indicates the position of the industrial area.

Pollutants mass emission rates were defined after analyzing data registered by the CEM installed on the main stack (45 m tall with a 6.6 m diameter).
Six flue gas 2008 samples were considered in order to define PCDD/Fs and PCBs concentrations for an average scenario and a "worst case" scenario (using the maximum concentration value). We assumed micropollutants are emitted in solid phase (Knight Merz, 2004), adsorbed on particles, testing two particle sizes, fine (1 μm) and coarse (4 μm).

METHODS

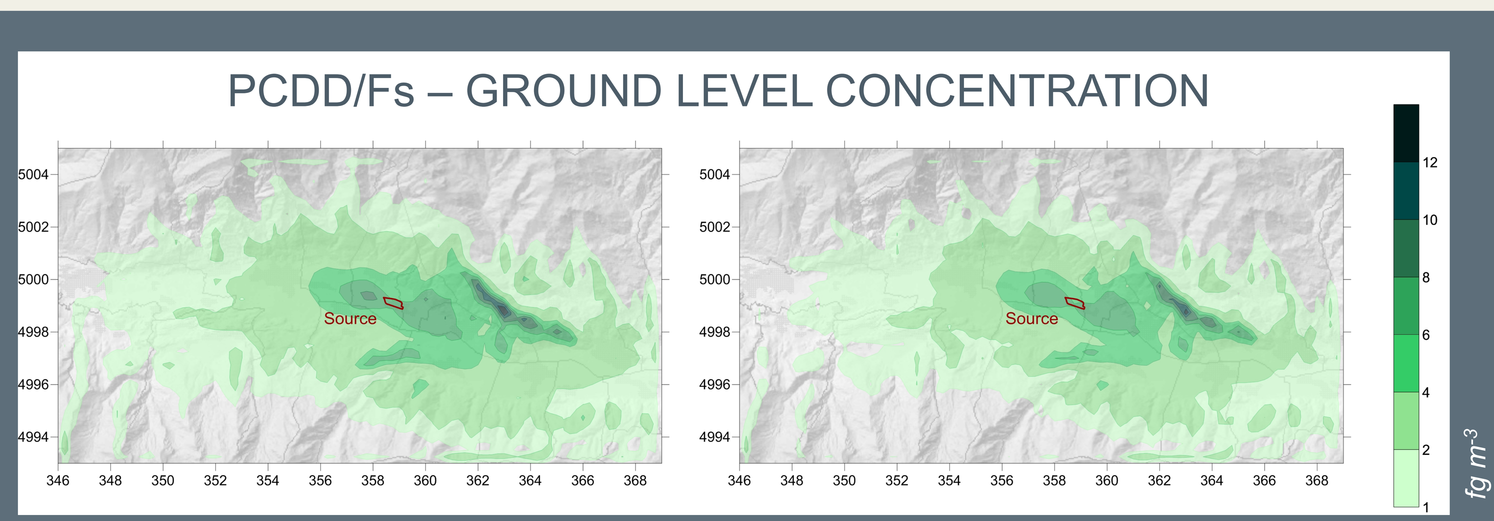
The numerical simulation was conducted in a domain of size 23x12 km^2, on a grid with horizontal step size of 250 m. The vertical grid is formed by 25 levels up to 10800 m above ground.

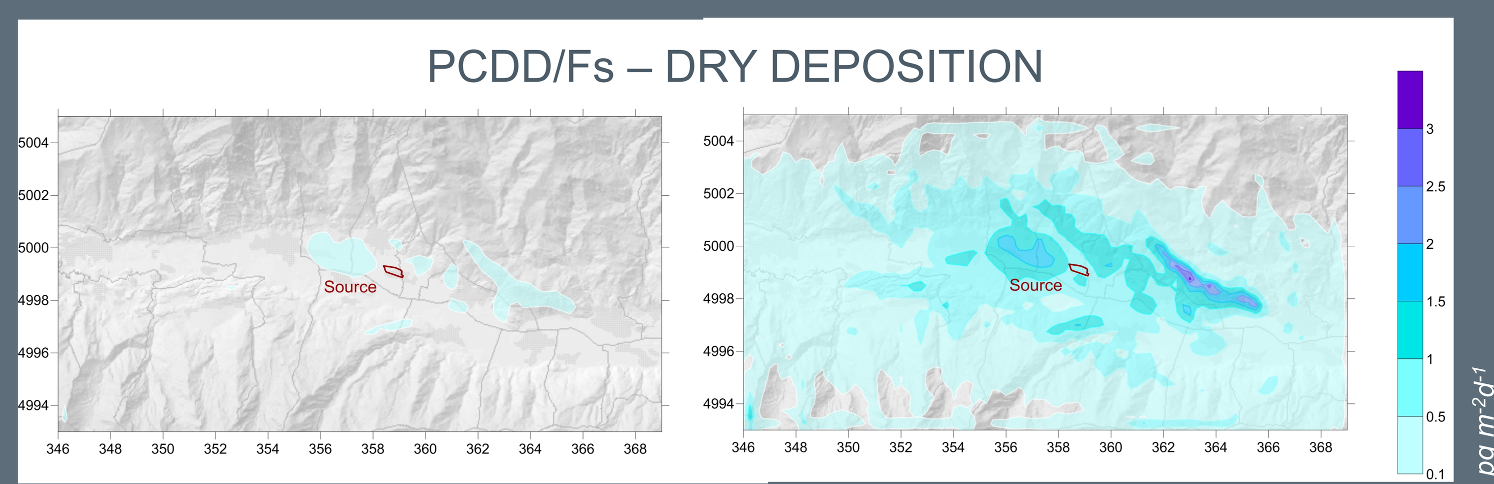
8761 hourly 3D meteorological fields have been derived with the mass-consistent model Swift/Minerve (Aria Technologies, 2001), from an original 2005 dataset at 1 km resolution (by Arpa Piemonte), through a downscaling procedure.

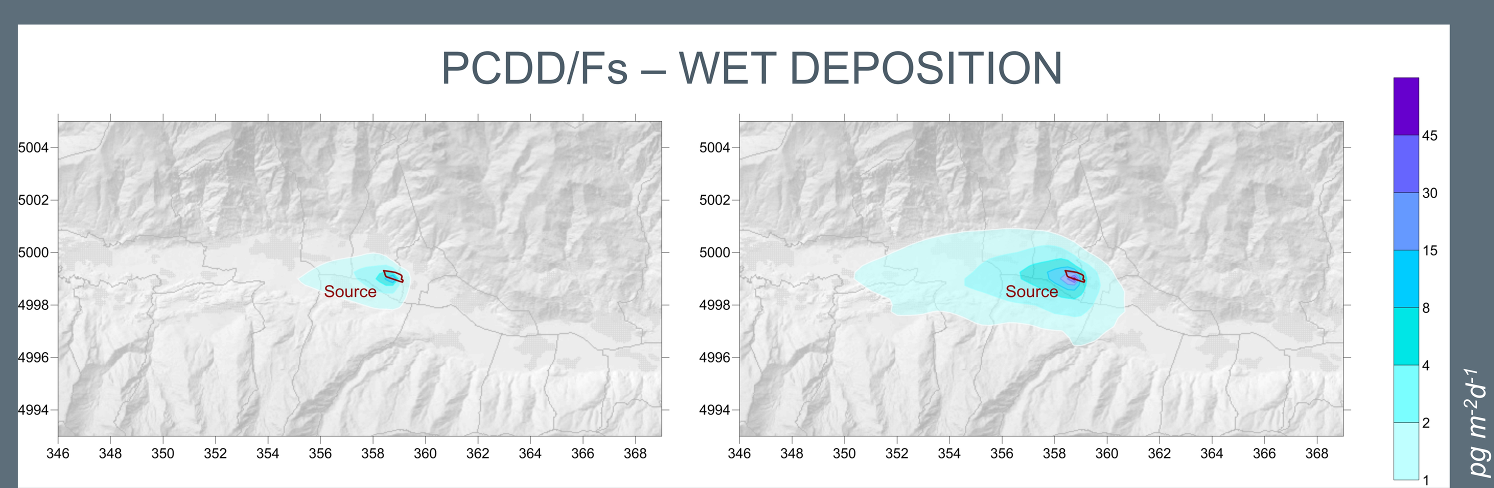
Two-dimensional hourly turbulence scale parameters and size-dependent deposition velocities were calculated by the code SurfPro (Silibello, 2006).

Lagrangian model SPRAY (Thomson, 1987; Ferrero and Anfossi, 1998; Tinarelli, 2007) with a plume rise algorithm (Anfossi et al., 1996) was employed to simulate dispersion. Dry deposition module is based on a removal mechanism derived from a solution of the Fokker-Planck equation (Boughton et al., 1987), in which the probability of mass removal depends on the deposition velocity. Wet deposition is modelled as a time-dependent exponential decay, with a decaying coefficient proportional to the precipitation rate through a species-dependent washout coefficient.

RESULTS







Yearly means for PCDD/Fs ground level concentrations, dry and wet depositions in the average scenario. On the left, results are obtained under the assumption that PCDD/Fs are adsorbed on particles of size 1 μm; on the right, the size is 4 μm.

Due to wind channelling, close to the emitting source there are two main spots, in the NW and SE directions. The maximum value (14.8 fg m^{-3} for 1 μm size and 13.7 fg m^{-3} for 4 μm size) occurs on the mountain side 4 km eastwards.
The amount of dry deposited dioxins on a square meter per day is almost negligible in the case of fine particles (at most 0.27 pg m^{-2} d^{-1} as yearly mean), reaching for coarser particles 3.15 pg m^{-2} d^{-1}. Wet depositions are centered on the industrial area and have limited spatial extension, with values greater than 2 pg m^{-2} d^{-1} only occuring on a small region elongated 1 km westward from the plant (4 km for coarser size).

COMPARISON WITH EXPERIMENTAL DATA

In 2006, the plant was granted with the IPPC permit and a major monitoring campaign on its environmental impact was started. During 2008, both total depositions and air concentrations of PCDD/Fs and PCBs were measured in four sites near to the plant. The siting choice favoured residential and industrial area and it wasn't based on a preliminary study.

In each site, a bulk collector was placed in order to obtain three monthly samples of total depositions during spring (March/April), summer (June/July) and fall (October/November) season.

SITE	POLLUTANT	SIZE	AVERAGE SCENARIO	WORST CASE SCENARIO	MONITORING 2008
BORGONE	PCDD/F (pg-TEQ m^{-2}d^{-1})	1 μm	0.5	1.2	1.1
		4 μm	2	4.7	
	PCB (ng m^{-2}d^{-1})	1 μm	1.9	8.2	11.4
		4 μm	7.4	32	
BRUZOLO	PCDD/F (pg-TEQ m^{-2}d^{-1})	1 μm	0.6	1.5	1.3
		4 μm	2.4	5.6	
	PCB (ng m^{-2}d^{-1})	1 μm	2.3	9.9	6.8
		4 μm	8.9	38	
SAN DIDERO	PCDD/F (pg-TEQ m^{-2}d^{-1})	1 μm	0.7	1.7	2.3
		4 μm	2.9	6.8	
	PCB (ng m^{-2}d^{-1})	1 μm	2.6	11	14
		4 μm	11	47	
VILLAR FOCCHIARDO	PCDD/F (pg-TEQ m^{-2}d^{-1})	1 μm	0.5	1.1	2.5
		4 μm	1.7	4	
	PCB (ng m^{-2}d^{-1})	1 μm	1.8	7.7	10.2
		4 μm	6.3	27	

Comparison between the numerical results and the measures of total (wet and dry) depositions of PCDD/Fs and PCBs in four monitoring sites.

CONCLUSIONS

The comparison with experimental data shows an overall good agreement both for PCDD/Fs concentrations and depositions, even if a supplementary numerical simulation driven by 2008 meteorology would provide a more precise comparison on correspondent time periods.

As for PCBs, further investigation is needed to understand the causes for the underestimation found both in concentrations and depositions, by checking on local activities, by sampling more frequently the industry flue gas and by defining a background level of PCBs concentrations in the area.

The relevant features of the fallout patterns suggest the need of additional monitoring far from urbanized areas, possibly in pasture land where deposition is high and POPs could effectively enter in the food chain.

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