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VALUTAZIONE DELL'IMPATTO DELLE EMISSIONI DAL TERMOVALORIZZATORE DI BOLZANO

CARATTERIZZAZIONE DELLE EMISSIONI E DELLA DISPERSIONE A SUPPORTO DI AZIONI DI MONITORAGGIO E DI GESTIONE DI SITUAZIONI CRITICHE

ABSTRACT

The present document summarizes the main outcomes from the technical study entitled: "*Assessment of the impact of the emissions from the incinerator of Bolzano – Characterisation of emissions and dispersion in support of actions for monitoring and management of critical situations*". A full account of the results can be found in the final report of the study (in Italian) available at the web–site of EcoCenter s.p.a (`https://www.eco-center.it/it/attivita-servizi/ricerca-993.html`).

1 Introduzione

The purpose of the study was the assessment of the dispersion processes of pollutants emitted from the incinerator and their ground concentrations within the Bolzano basin.

In mountainous environments, such as Bolzano basin, the numerical modeling of the atmospheric processes is still challenging due to: (*i*) the interaction of wind with the complex topography, (*ii*) the onset of local circulations (*e.g* Giovannini et al., 2014a,b, 2017), and (*iii*) the development of ground–based temperature inversions, which are not always well–captured by models. In order to face these issues, a significant part of the study consisted in:

1. the characterization of typical meteo–climatological processes in the study area;

2. the design and validation of a modeling chain, simulating both meteorological and pollutant dispersion processes, in order to appropriately reproduce the atmospheric processes in the Bolzano basin.

In particular, the meteo–climatological characterization of the area was performed by analyzing data available from permanently operated weather stations, and by performing specific measurement campaigns with more specific devices (SODAR and Doppler Wind–LIDAR). Moreover, high–resolution numerical simulations were run to better characterize atmospheric processes peculiar of the basin, in connection with critical situations for air quality.

Field campaigns were planned and performed to validate the simulated emission–impact scenarios against ground measurements of concentrations of an atoxic, passive gas tracer released from the incinerator: the dataset of ground concentrations was therefore used to calibrate and validate the modeling chain.

The Partners of the study included:

1. EcoCenter S.p.A.: managing society of the incinerator and contractor of the technical study.

2. Eco-Research S.r.l.: analytical laboratory specialized in the detection and determination of environmental pollutants.

3. Atmospheric Physics Group of the Department of Civil, Environmental and Mechanical Engineering of the University of Trento.

4. Environmental Agency of the Autonomous Province of Bolzano, and in particular the Office for Air and Noise and the Physical Chemistry Laboratory.

The study benefitted from the qualified support of the following subjects which were also involved:

1. CISMA S.r.l. for numerical modelling of pollutant dispersion processes, for expertise in this field and previous works on atmospheric processes of the Bolzano basin;

2. Institute of Pharmacological Research "Mario Negri" for the laboratory analyzes required to determine the concentrations of tracer contained in the samples collected during the field campaigns.

The results of this study provided conspicuous insights into the meteo–climatological characteristics of the Bolzano basin and the dispersion processes of the pollutants emitted by the incinerator, even in view of providing a support to the monitoring and management of critical situations.

2 Meteo–climatological characterization of the Bolzano basin

The climatological characterization of the study area was performed both for wintertime and summertime. In particular, meteorological data collected by the ground weather station of Bolzano Ospedale and operated by the Meteorological Service of the Autonomous Province of Bolzano were analyzed. The analysis showed that during nighttime the lower atmosphere in the basin is very stable, while in the central hours of the day the atmosphere is typically weakly convective in winter and very convective in summer. Therefore, during nighttime, the mechanism responsible for the dispersion of the pollutants is the advection by the mean wind, rather than the turbulent diffusion. Conversely, in the central hours of the day, the atmosphere is convective and turbulent mixing is enhanced. This framework is further confirmed by the analysis of vertical profiles of temperature, provided by the temperature profiler (MTP–5HE) installed at the airport of Bolzano. In fact, the analysis of temperature profiles shows that, especially during nighttime, the

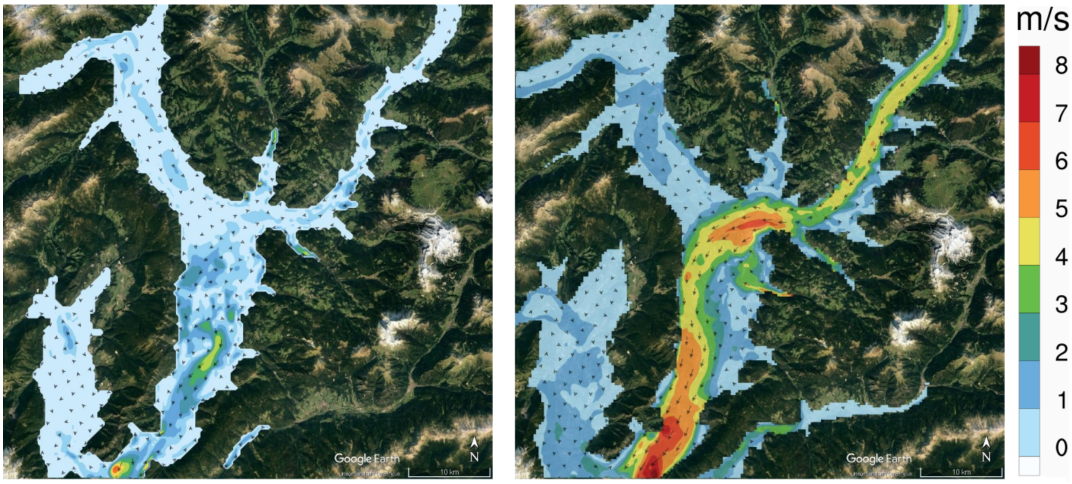

Figure 1: Wind field modeled by the Weather Research and Forecasting Model (WRF) for the event of valley–exit jet occurred in the night between 28–29 January 2017 (map in the background from Google Earth). Both figures refer to the same time, *i.e.* 00 UTC, but at different altitudes: at 10 m above ground level (left) and at 750 m a.s.l. (925 hPa), about 450 m above ground level (right).

stability of the atmosphere within the basin is frequently associated with the development of ground–based temperature inversions. These inversions are confined in the layers close to the ground during summer, but they can extend to higher altitudes (with a thickness of the inversion layer of 400–500 m) and persist for more days during wintertime. In the latter case, the increasing accumulation of pollutants in the lower layers of the atmosphere can determine serious episodes of air pollution peaks.

The wind regime was examined by analyzing both the vertical wind profiles measured by a SODAR, installed on the roof of the incinerator, and by a Doppler Wind–LIDAR, installed on the roof of Palazzo 12 of the Autonomous Province of Bolzano. Data analysis highlighted a wind field with a very complex structure. In fact, especially under fair weather conditions, the wind field of this area is dominated by thermally–driven daily–periodic local circulations in each of the tributary valleys, merging and interacting in the basin.

The most significant local circulation, especially for pollutant dispersion processes, is undoubtedly the drainage wind in the lower layers of the atmosphere from the Isarco Valley. In fact, the nocturnal drainage wind of the Isarco Valley spreads into the Bolzano basin behaving like a valley-exit jet, *i.e.* an organized flow, characterized by a well-pronounced peak of intensity, which can exceed $10\,\mathrm{m\,s^{-1}}$. Doppler LIDAR measurements and high–resolution numerical simulations (Fig. 1) were conducted to better characterize the phenomenon and its interaction with the temperature inversions inside the basin. In particular, the valley–exit jet enters into the basin from East, then it floats above the cold pool of Bolzano (stable layer of atmosphere that stagnates on the city) at about 450 m from the ground and it channels southward into the Adige Valley. Under these conditions, the wind field into the cold pool is almost null and decoupled from the one above. Therefore, pollutants emitted at ground level remain confined in the lower layers of the atmosphere and are not removed from the valley–exit jet. The situation is different for pollutants emitted from the chimney of the incinerator. In fact, the plume can rise higher than the temperature inversion, as a result of a combination of factors, *i.e.* (*i*) the elevation of the chimney, (*ii*) the buoyancy of the plume due to its high temperature, and (*iii*) the vertical exit speed at the chimney mouth.

3 Numerical simulations of pollutants dispersion processes.

In order to properly simulate the dispersion processes of the pollutants released by the chimney of the incinerator, a modeling chain was composed with meteorological and air–quality models. The models are internationally recognized as at the state–of–the–art for the modeling of atmospheric processes at local scale over complex terrain. The modeling chain, described in Chapter 2 of the final report, was composed by the meteorological model WRF (Weather Research and Forecasting Model) and by the CALMET/CALPUFF dispersion model. In order to improve the reliability of the simulated scenarios for the Bolzano basin, specific measurement campaigns were organized including the release of a passive tracer. In this way, direct observations of the ground deposition of the smokes emitted from the chimney were allowed. The experiments included the release of a passive tracer from the chimney of the incinerator, whose concentrations were measured on the ground at different points in the Bolzano basin and in the nearby valleys.

The campaigns were carried out on 14 February 2017 and allowed to collect 79 samples of air containing different concentrations of the tracer. The concentration of the tracer into the collected samples were determined with great accuracy by means a high–resolution mass spectrometer at the laboratories of Eco–Research. The obtained dataset was used to calibrate the model. In particular, the available information were used to identify the best configuration of the CALPUFF model, in order to properly reproduce the tracer releases. This configuration, identified through a statistical approach by comparing measurements against the simulated scenarios, was then used for the different applications required by the technical study, *i.e.* the simulation of the annual average concentration maps and the simulation of the maps of concentrations associated to potentially critical scenarios.

The results of the experiments also represent a valuable dataset for the study of the dispersion processes on complex terrain. In fact, the uniqueness and the detail of the collected data (meteorological and concentration) are of great scientific interest at international level.

The first application of the calibrated, WRF/CALPUFF modeling chain was the simulation of the dispersion of pollutants contained in the smokes of the incinerator over an entire year. For this application, the year 2016 was chosen as a reference year, as meteorologically representative for the study area and well documented in terms of meteorological measurements and emissions from the chimney. The simulation of meteorological fields for the entire year 2016 was obtained by running the meteorological model WRF, whereas the simulation of the dispersion processes was performed by using the (calibrated) CALPUFF model. Then the analysis of the simulations allowed to obtain the following maps of concentrations at ground level:

1. average annual concentration (see Technical Report, Appendix 1);
2. maximum hourly concentrations (see Technical Report, Appendix 2);
3. maximum daily concentrations (see Technical Report, Appendix 3).

The maps were obtained for all the pollutants in the smokes regulated by law. The reliability of these results is very high. In fact, they were obtained from models, internationally recognized for applications in complex terrain and, in addition, the modeling chain was calibrated using data from the field campaigns performed during the experiments in the Bolzano basin.

4 Monitoring of the deposition of pollutants

The annual concentrations at ground level (see Technical Report, Cap. 5) show a very weak impact of the emissions of the incinerator, when compared with other emissions inside the Bolzano basin.

The simulations, aimed at providing information about the positioning of a permanent monitoring network of the emissions, actually, have shown that the concentration due to the emissions from the chimney of the incinerator are so low that they can not by measured, for PM_{10}, and they cannot be distinguished from the background, for NO_x. Indeed,

1. for PM_{10} (map in Figure 2), the maximum annual simulated concentration is $0.01\,\mu g\,m^{-3}$, to be compared with an environmental background of $17\,\mu g\,m^{-3}$

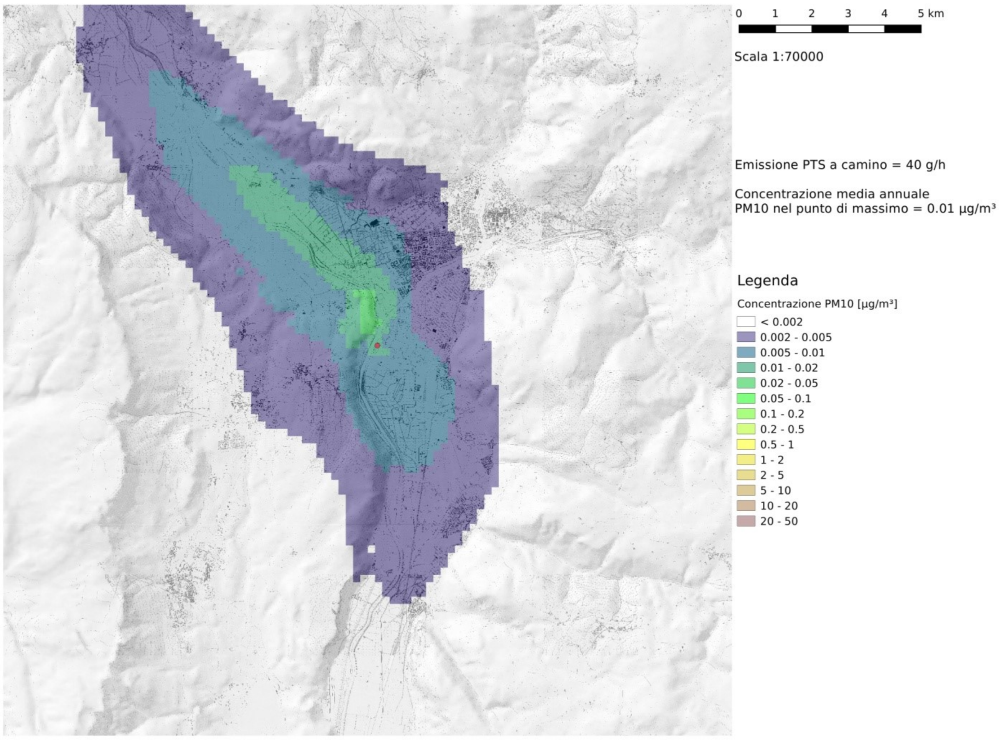

Figure 2: Simulated annual concentrations of PM_{10} at ground level in the Bolzano basin.

(evaluated on the basis of the data collected at the air quality station in Piazza Adriano in Bolzano) and a legal limit of $40\,\mu g\,m^{-3}$;

2. for the NO_2 (map in Figure 3), the maximum annual simulated concentration is $0.36\,\mu g\,m^{-3}$, to be compared with an environmental background of $31.3\,\mu g\,m^{-3}$ (always referred to the data of the air quality station of Piazza Adriano in Bolzano) and a legal limit at $40\,\mu g\,m^{-3}$.

The same result was obtained for the other pollutants emitted by the incinerator. In fact, the ground concentrations of these species were found to be so small that they cannot be properly measured or that their origin cannot be properly identified.

5 A modeling chain to predict the dispersion of pollutants for the incinerator

The modeling chain implemented for this study, besides of for planning purposes, can also be used to support to operations of the civil protection during emergencies. For this reason, the calibrated modeling chain was used to reconstruct the concentration fields determined by hypothetical or accidental releases from the chimney of the incinerator (Technical report, Chapter 6). In fact, given the variability of

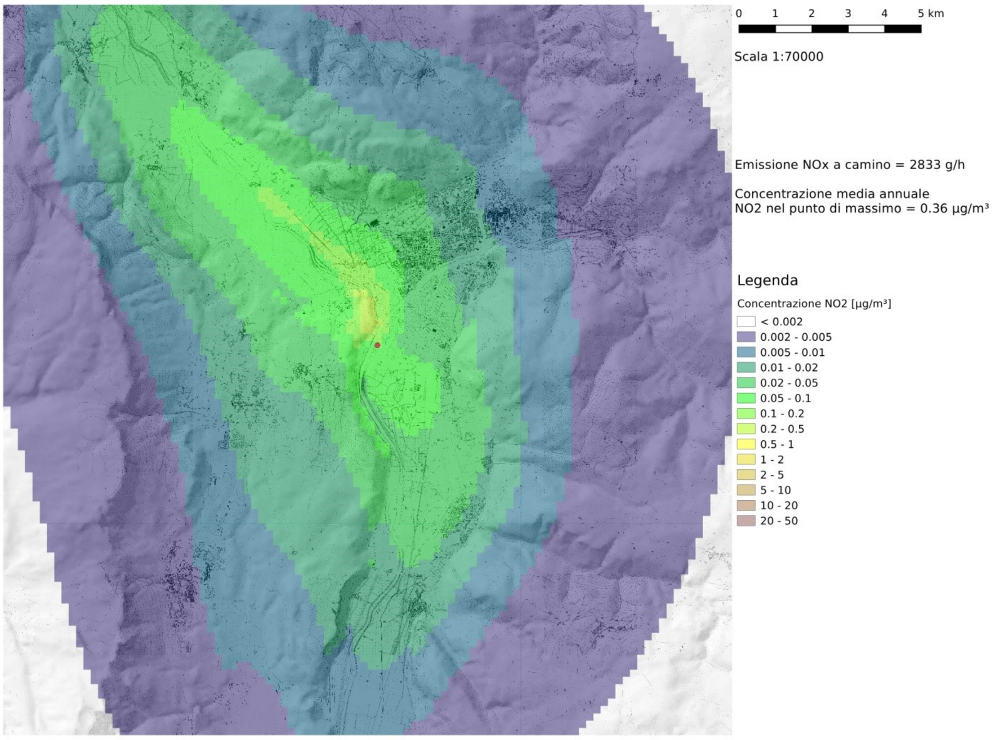

Figure 3: Simulated annual concentrations of NO_2 at ground level in the Bolzano basin.

the wind field in this area, both at daily and at seasonal scale, it was decided to identify some critical cases in which high concentrations of pollutants could reach highly–populated areas. The obtained results (Technical Report, Appendix 4) show a significant increase in concentrations at the ground level, in connection with increased emissions at the chimney. The implemented modeling chain can be made operative in real time with very short run times, to support interventions in case of accidental events that can determine releases of pollutants significantly higher than the danger thresholds.

References

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