Comparison of the results of two air quality models in the simulation of a turbogas cogeneration plant PM emissions

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INTRODUCTION
The aim of this study is to compare the outputs of two different models for estimating primary PM10 pollutant concentrations caused by a turbogas cogeneration plant emissions, using the same meteorological input datasets.

MODELS
- ADMS-Urban (version 3.0) is an advanced Gaussian dispersion model with a normal Gaussian distribution in stable and neutral conditions. The vertical dispersion is approximated by two different Gaussian distributions in a convective boundary layer. Furthermore, ADMS applies up-to-date physics using parameterizations of the boundary layer structure based on the Monin-Obukhov length and the boundary layer height;
- LAPMOD is a Lagrangian particle model, that simulates dispersion of pollutants by releasing a large number of particles for each source at each time step and following their motion. Particles motion is the resulting effect of the mean wind field and the turbulent diffusion. The particles randomly get induced by turbulence in Markovian processes.

CONTEXT
The study has been carried out for a domain that contains Imola (Italy) a medium town (68,862 inhabitants) in the Po Valley (Northern Italy) which is one of the most polluted areas in Europe, near the Apennine Mountains. A combined cycle gas turbine (CCGT), coupled with district heating, has been built. The plant, located in the urban area, has a capacity of up to 80 Megawatts of electricity and 80 Megawatts of thermal energy.

EMISSIONS PLANT
The emissions of the CCGT plant have been considered as two point sources (Table 1). Emission rates in both models are the hourly data measured by the continuous monitoring system of the plant. The PM10 values are extremely low.

<table>
<thead>
<tr>
<th>Source</th>
<th>Height of stack (m)</th>
<th>Diameter of stack (m)</th>
<th>Exit temperature (°C)</th>
<th>Exit velocity (m/s)</th>
<th>PM10 ap/y (Mg/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TG1</td>
<td>50</td>
<td>3</td>
<td>120</td>
<td>10</td>
<td>0.005</td>
</tr>
<tr>
<td>TG2</td>
<td>50</td>
<td>3</td>
<td>120</td>
<td>10</td>
<td>0.038</td>
</tr>
</tbody>
</table>

Table 1: Sources and emissions parameters

METEO DATASET
The meteorological input (2010) for both models was derived from a high resolution analysis dataset, built with the limited area meteorological model COSMO (Consortium for Small-scale MGoodelling www.cosmo-model.org). COSMO was run at 7 km horizontal resolution in continuous assimilation mode, with all available GTS data being ingested with a nudging technique; moreover a set of parametric schemes was used to estimate the most important turbulence parameters, such as mixing height and Obukhov length.

ADMS-Urban was forced with surface and turbulent parameters at the COSMO grid point closer to the emitting point. The high resolution three-dimensional meteorological fields required by LAPMOD were produced with the meso-consistent meteorological pre-processor Calmet, driven with data from 9 COSMO grid cells surrounding the domain of study.

OUTPUT DATA
The output of both models has been calculated according to a long-term simulation, in which the concentrations have been estimated on the nodes of a grid formed by 100*100 points, with 50 m horizontal resolution, covering the whole 5x5 km² domain. In order to calculate temporal concentration series, receptor points have been chosen at different distances from the stack (Figure 2), along the prevailing wind directions: SW, WNW and W.

GRID ANALYSIS
Output values, including percentiles, resulting from long-term average ADMS-Urban calculations are a sequence of very low values. These values are related to stable conditions in particular in the fanning case or when the receptor is located upwind. Data distribution (Figure 8) is asymmetrical and the average is higher than the 90th percentile. Conversely LAPMOD estimates surface concentrations in stable conditions and also upwind, because it can simulate a particles accumulation with weak winds and a backward path when the wind direction is variable. Anyway the values are very low yet, but some orders of magnitude larger than ADMS.

REFERENCES