PERFORMANCE OF DIFFERENT MODELS TO EVALUATE ATMOSPHERIC DISPERSION IN CALM WIND CONDITIONS

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ABSTRACT

This study investigates the performance of different air pollution dispersion models in calm wind conditions. The models have been applied to two case studies: the cities of Modena and Reggio Emilia, both placed in the Po river valley (Northern Italy), an area characterized by prevailing weak winds conditions. The emission sources are the municipal waste incinerator of Modena and the Turbo Gas plant of Reggio Emilia. Total suspended particulate (TSP) concentration levels are estimated by three models: the Gaussian Industrial Source Complex (ISC3) and WinDimula 3.0 models, and the langrangian particle model SPRAY. The performances of the models have been compared.

DISPERSION MODELS

SPRAY (Tinarelli, G. et al., 1998) is a 3D lagrangian stochastic particle dispersion model able to simulate air pollution dispersion and deposition-decay phenomena in non homogenous, non stationary conditions and over complex topography (Thomson, D.J., 1987).

The model WinDimula 3.0 (Cagnetti, P. and M.C. Cirillo, 1982; Cirillo, M.C. et al., 1986) is an atmospheric multisource Gaussian steady-state dispersion model of non reagent pollutants generated by point, line and area sources.

The dispersion model ISC3 is a steady-state Gaussian model allowing to assess pollutant concentrations from point, area and volume sources.

CASE STUDIES

The cities of Modena and Reggio Emilia are located in the central part of the Po river valley (Northern Italy), an area characterized by flat topography and prevailing conditions of weak winds, often occurring in autumn and winter seasons. Wind calm conditions (i.e. wind speed lower than 2 m/s) occurred for about 78% of the simulation time in Reggio Emilia and about 30% in Modena site (Database CALMET-SIM).

Modena

The model domain is 15x15 km², with resolution of 100 m; the center of the domain is in the emission source. The domain origin (S-W corner) is located at cartographic coordinates (464663; 4942233)m (UTM33-WGS84). The simulation period spans over one year from October 1st, 2006 to September 30th, 2007.

The simulations were performed using meteorological data acquired by Osservatorio Geofisico of the University of Modena and Reggio Emilia (Modena, Italy) and meteorological data simulated by CALMET model provided by the Emilia-Romagna Meteorological Service.

RESULTS

The average concentration levels and concentration maps at the ground obtained from one-year-long simulation runs resulted very similar for the three models, for this reason the subsequent analysis involved the simulation results for a shorter time length.

CONCLUSIONS

In wind calm conditions the advective transport is reduced and the pollutants are homogeneously distributed over the whole mixed layer depth, where they accumulate also very close to the source. The lagrangian simulation describes more satisfactorily this situation: the size and the shape of the plume are mainly determined by the turbulent mixing and the concentration field at ground level is more uniform. The area covered by the lagrangian plume at ground level is lower than the Gaussian plume surfaces and also the maximum concentration values calculated by SPRAY are lower. These results confirm that ISC3 and WinDimula are mainly suitable for climatologic application over long time period; ISC3 has not to be applied during wind calm conditions, WinDimula performs better than ISC3, while SPRAY gives the most reliable simulation of the air quality deterioration due to pollutant emission in wind calm conditions.