1.24 APPLICATION AND DEVELOPMENT OF THE OFIS MODEL WITHIN THE FRAMEWORK OF CITYDELTA

Nicolas Moussiopoulos and Ioannis Douros
Laboratory of Heat Transfer and Environmental Engineering, Aristotle University Thessaloniki, Box 483, 54124 Thessaloniki, GREECE

INTRODUCTION

As a step towards its further evaluation and development, the Eulerian photochemical dispersion model OFIS was applied to various European cities within the framework of CityDelta (*URL1*). The OFIS model is a robust tool that allows an adequate description of urban scale transport and transformation processes of air pollutants and therefore the establishment of more accurate source-receptor relationships in urban areas at a very low computational effort.

The comprehensive input and monitoring data provided by the CityDelta community for a number of European cities, has set solid ground for the validation and further development of the basic concept of the OFIS model, allowing at the same time the realisation of a series of sensitivity analysis tests with respect to various model parameters such as the spatial and temporal resolution of the emissions used, the model cell size and the update frequency of meteorological input. More specifically, the latest development has revealed considerable improvement in the model performance when gridded emissions inventories are used instead of disaggregated ones as well as when 3-hourly values are used for the meteorological and boundary conditions input that drives the model, instead of daily ones. Additional improvement was achieved with the use of an appropriate parameterisation for wet removal of particulate matter (scavenging).

MODELLING TOOL

The OFIS model belongs to the European Zooming Model (EZM) system, a comprehensive model system for simulations of wind flow and pollutant transport and transformation (*Moussiopoulos N*., 1995) and was developed to serve a twofold aim; (i) allowing authorities to assess urban air quality by means of a fast, simple and still reliable model and (ii) refining a regional model simulation by estimating the urban subgrid effect on pollution levels.

OFIS was derived from the more sophisticated EZM core models. Being closely related to the 3D photochemical dispersion model MARS/MUSE (*Moussiopoulos N., P. Sahm and C. Kessler,* 1995), OFIS simulates concentration changes due to the advection of species and chemical reactions in each cell of the computational domain. The concentration values outside this domain are assumed to coincide with the regional background concentrations used for the calculation of the boundary conditions.

The computational domain of the original model version consists of a two-layer gridded strip with a length of the order of 200 km and a width defined by the city size, with the city in the centre. The strip is oriented along the prevailing wind direction, altering every day. The computational domain of the model for a specific day with a prevailing wind from SW is illustrated in figure 1. The first vertical layer extends up to 90m, while the second one extends up to the mixing height, thus varying with time. The restriction to this computational domain results in a high computational speed and a low output file size. For prescribing the time evolution of the mixing height as well as of the turbulent exchange coefficient between the two layers, a 1D version of the non-hydrostatic meteorological model MEMO (*Kunz R. and N. Moussiopoulos*, 1997) is utilised. Emission data are inserted into the model in the form of integrated urban, suburban and rural totals for each pollutant species. Biogenic emissions also are taken into account for rural areas. Due to the modular structure of OFIS, chemical transformations can be treated by any suitable chemical reaction mechanism, the default being the EMEP MSC-W chemistry.

The use of gridded emission inventories is one of the major improvements that have been incorporated into the OFIS model. Emissions can now be calculated for each OFIS cell by properly taking into account the emission density of the underlying fine-scale inventory. Secondly, the modified OFIS version which is under consideration here, can take advantage of the improved frequency (3-hourly values) by which boundary conditions and meteorological data from larger scale models usually become available. More specifically, OFIS will now perform a 5 hour run for each 3-hour frame, utilising one hour as a pre-run and reserving the last hour for purposes of blending with the calculated concentrations at the beginning of the next 3-hour frame. Thirdly, an appropriate parameterisation for wet removal (*Scott B.C.,* 1979), an important physical process especially with regard to particulate matter, is now part of the model and is evaluated along with the aforementioned changes. For the purposes of this study, boundary conditions originated from the EMEP model, while meteorological data from the ALADIN project (*URL1*).

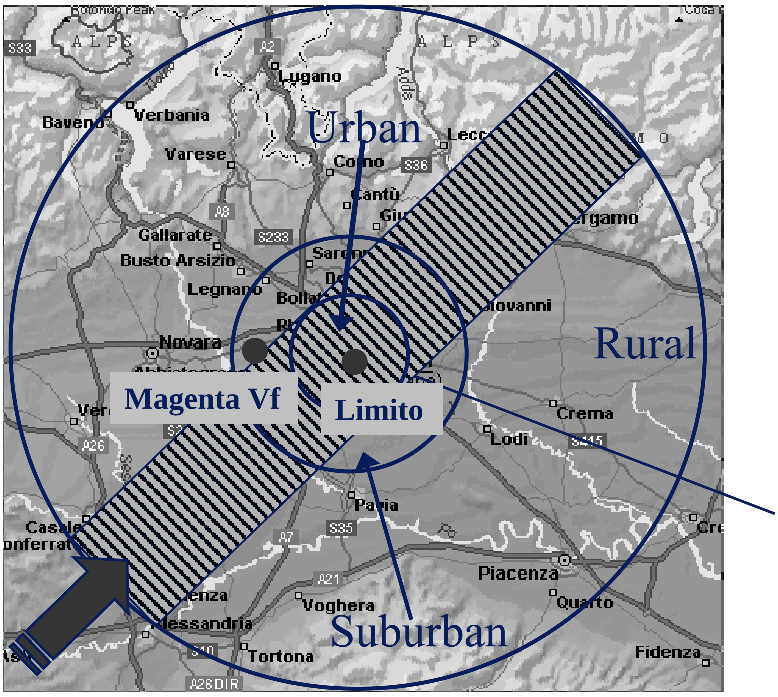


Figure 1. OFIS computational domain (gridded strip) and geographic distribution of emissions to three areas of different emission density: urban, suburban and rural. The area depicted here is that of Milan, where one can also see the locations of the two stations of interest, Magenta Vf. and Limito.

RESULTS

Results are presented for the city of Milan. Two representative monitoring stations of the greater area of Milan were chosen for the purposes of evaluation of the performance of the model at urban and non-urban environments. In figure 1 we can see where each of the stations examined is located with regard to the city. The evaluation of the model's performance is considered with use of statistical indices such as the NMSE (normalised mean square error), the BIAS and the correlation coefficient. We focus our study on three different pollutants, namely NO_2, O_3 and PM_{10} and the comparison is performed between the old version of the model (OFIS), the new version of the model (OFIS_new) and the 3D fine scale model MUSE which run at a horizontal resolution of 5 km, except for the case of PM_{10} where the comparison is only between the two OFIS model versions since there where no PM calculations available from MUSE. The simulations were performed for a 6-month summer period (April-September) for the gaseous pollutants (NO_2 and O_3) and a full calendar year for the case of PM_{10}. The results are shown in figures 2 to 4.

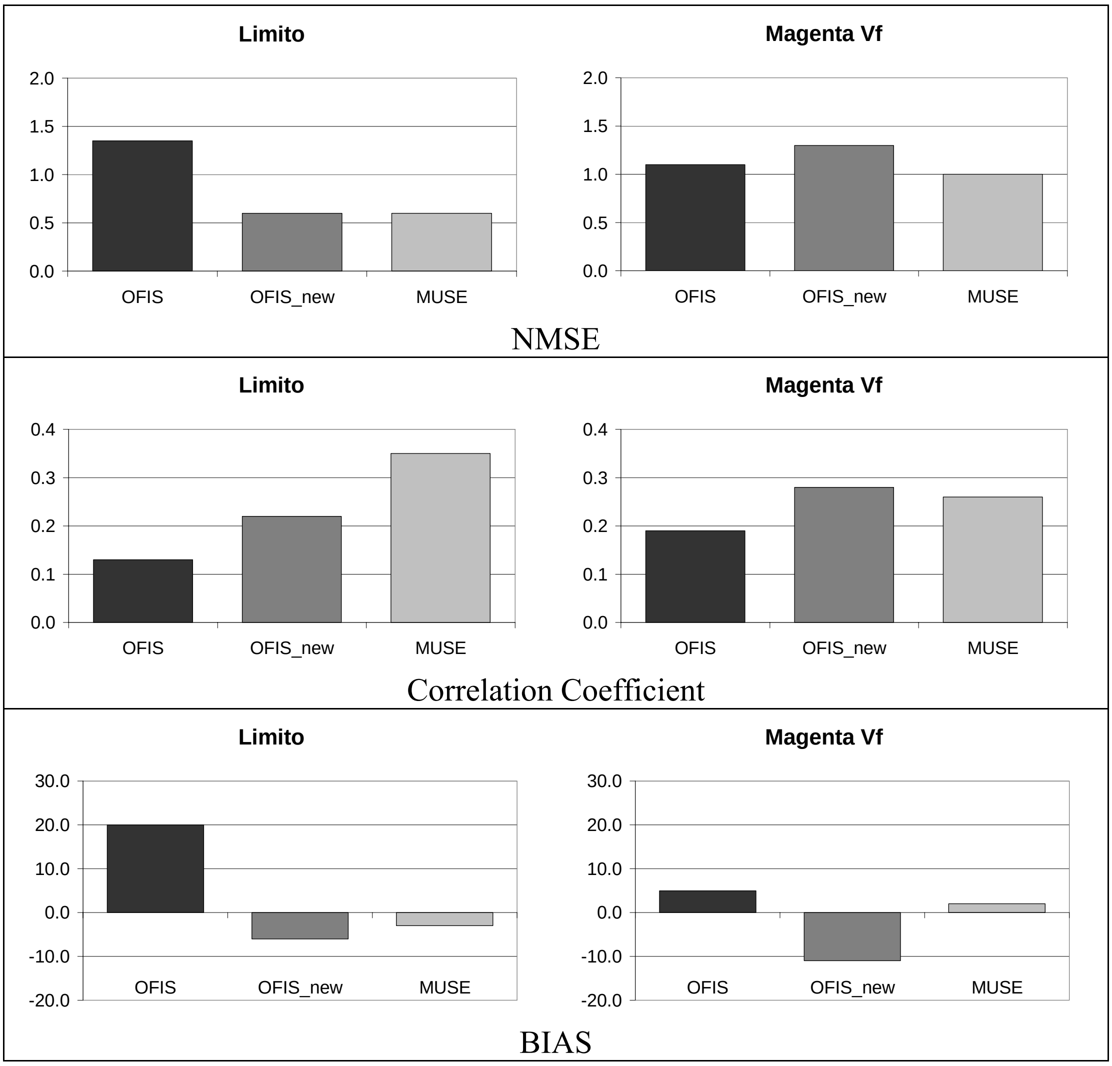


Figure 2. Statistical evaluation of model results for NO_2. BIAS units are in ppb.

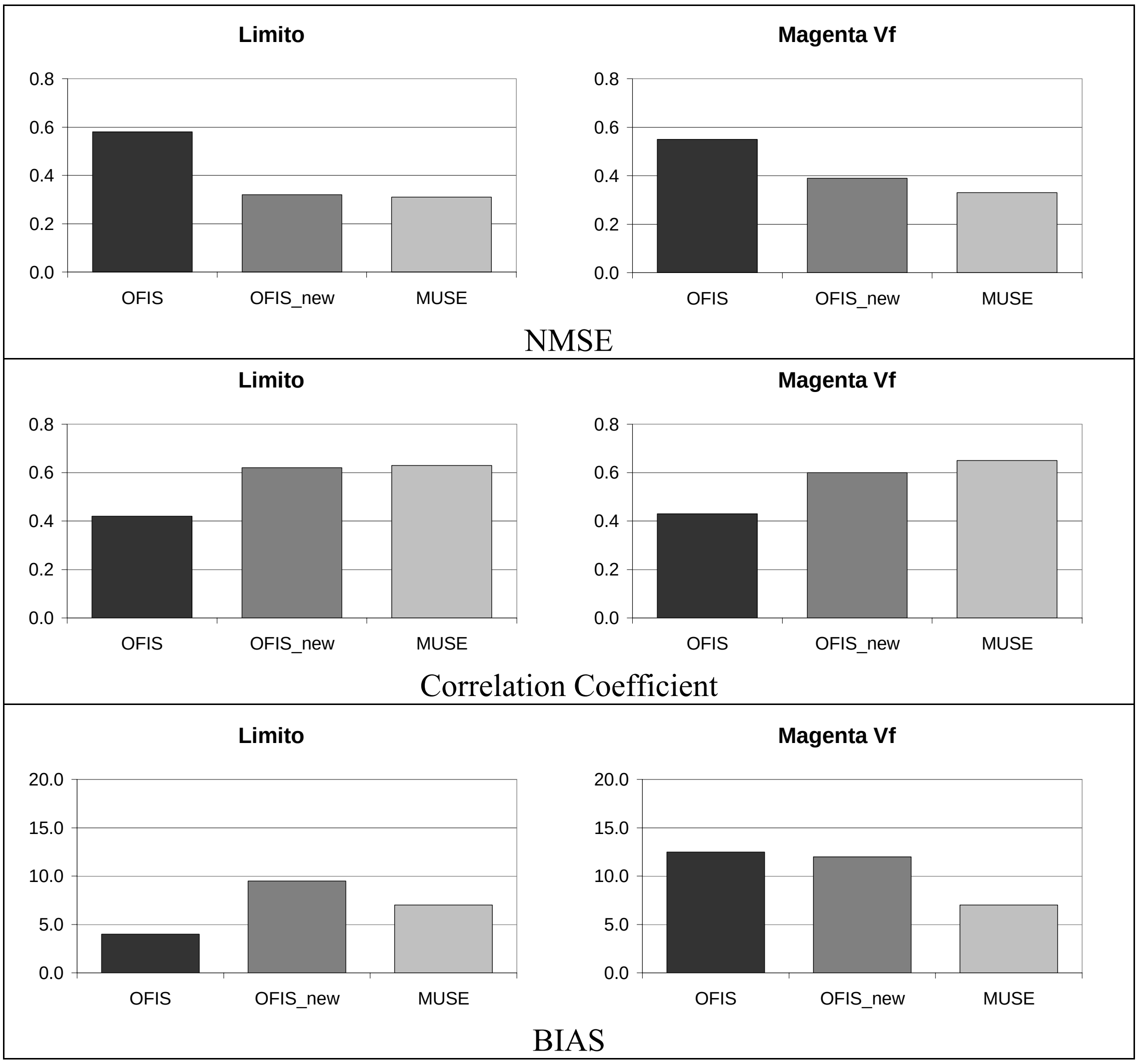
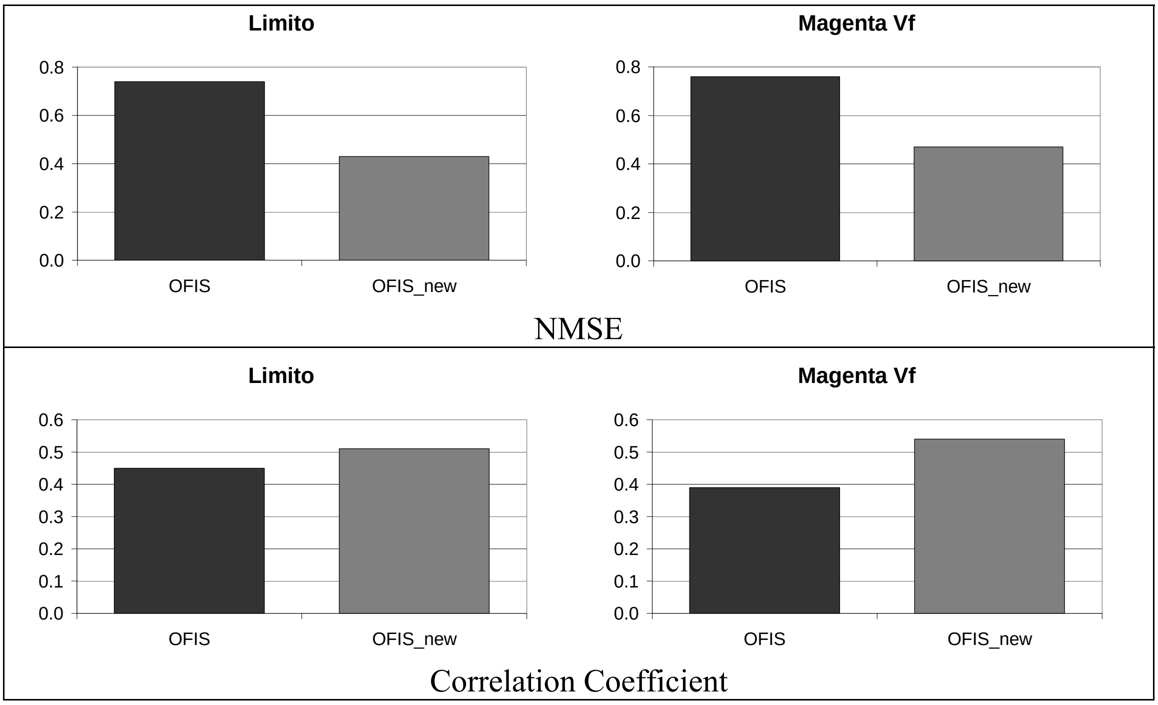


Figure 3. Statistical evaluation of model results for O_3. BIAS units are in ppb.



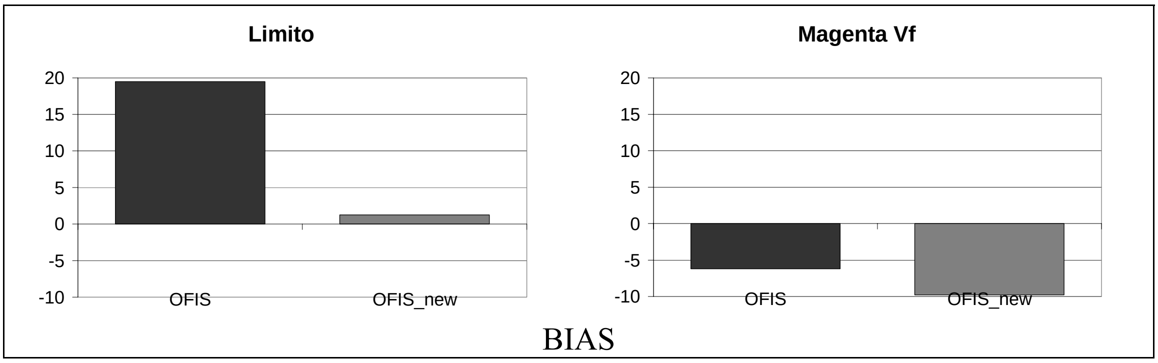


Figure 4. Statistical evaluation of model results for PM_{10}. BIAS units are in μg/m^3.

What is evident from the figures above is a considerably better performance of the new model compared to the old one. Although the 3D model expectedly performs better in most occasions, the new version of OFIS is remarkably close in some of them. More specifically, there seems to be an overestimation of emissions density in urban areas in the old model, which used to lead to significant overestimations of NO_2 concentrations. This situation is now reversed and the results reveal a behaviour very similar to that of the 3D model.

The improvement achieved in the correlation coefficient is appreciable for all pollutants. This is mostly associated with the better treatment of the input boundary conditions and meteorology data and the subsequent refinement of the 3-hourly time frame scheme that is now operational in the model. The significant overestimation of PM_{10} concentrations in the urban station of Limito is also alleviated, as a presumable effect of the wet removal process that was taken into account. A tendency for underprediction of PM_{10} concentrations in suburban and rural areas is not alarming considering the inherent uncertainties of primary PM emissions and the physico-chemical processes involved in their consideration in a model. A notable improvement is also achieved with regard to the results of the regional scale model which provides OFIS with boundary conditions, especially for the case of PM_{10}.

CONCLUSIONS

A new version of the OFIS model is evaluated against the older version of the model and a fine scale 3D model. The study reveals a considerable improvement in the performance of the new model compared to the older one. The comparison with the 3D model in particular, reveals good evidence for the validity of the OFIS model concept, since in many cases the performance of the two models are on a par.

REFERENCES

Kunz R. and N. Moussiopoulos, 1997: Implementation and assessment of one-way nesting technique for high resolution wind flow simulations. *Atmospheric Environment*, **31**, 3167-3176.

Moussiopoulos N., 1995: The EUMAC Zooming Model, a tool for local-to-regional air quality studies. *Meteorology and Atmospheric Physics*, **57**, 115-133.

Moussiopoulos N., P. Sahm and Ch. Kessler, 1995: Numerical simulation of photochemical smog formation in Athens, Greece - a case study. *Atmospheric Environment,* **29**, 3619-3632.

Scott, B. C., 1979: Parameterization of sulphate removal by precipitation. *J. Appl. Met.*, **17**, 11375-11389.

URL1: http://rea.ei.jrc.it/netshare/thunis/citydelta/