Geophysical Research Abstracts
Vol. 12, EGU2010-12080, 2010
EGU General Assembly 2010

Uncertainty characterization and quantification in air pollution models. Application to the CHIMERE model

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Prev'Air is the French operational system for air pollution forecasting. It is developed and maintained by INERIS with financial support from the French Ministry for Environment. On a daily basis it delivers forecasts up to three days ahead for ozone, nitrogene dioxide and particles over France and Europe. Maps of concentration peaks and daily averages are freely available to the general public. More accurate data can be provided to customers and modelers. Prev'Air forecasts are based on the Chemical Transport Model CHIMERE.
French authorities rely more and more on this platform to alert the general public in case of high pollution events and to assess the efficiency of regulation measures when such events occur. For example the road speed limit may be reduced in given areas when the ozone level exceeds one regulatory threshold.
These operational applications require INERIS to assess the quality of its forecasts and to sensitize end users about the confidence level. Indeed concentrations always remain an approximation of the true concentrations because of the high uncertainty on input data, such as meteorological fields and emissions, because of incomplete or inaccurate representation of physical processes, and because of efficiencies in numerical integration [1].
We would like to present in this communication the uncertainty analysis of the CHIMERE model led in the framework of an INERIS research project aiming, on the one hand, to assess the uncertainty of several deterministic models and, on the other hand, to propose relevant indicators describing air quality forecast and their uncertainty.
There exist several methods to assess the uncertainty of one model. Under given assumptions the model may be differentiated into an adjoint model which directly provides the concentrations sensitivity to given parameters. But so far Monte Carlo methods seem to be the most widely and oftenly used [2,3] as they are relatively easy to implement. In this framework one probability density function (PDF) is associated with an input parameter, according to its assumed uncertainty. Then the combined PDFs are propagated into the model, by means of several simulations with randomly perturbed input parameters. One may then obtain an approximation of the PDF of modeled concentrations, provided the Monte Carlo process has reasonably converged.
The uncertainty analysis with CHIMERE has been led with a Monte Carlo method on the French domain and on two periods : 13 days during January 2009, with a focus on particles, and 28 days during August 2009, with a focus on ozone.
The results show that for the summer period and 500 simulations, the time and space averaged standard deviation for ozone is 16 μg/m3, to be compared with an averaged concentration of 89 μg/m3. It is noteworthy that the space averaged standard deviation for ozone is relatively constant over time (the standard deviation of the timeseries itself is 1.6 μg/m3). The space variation of the ozone standard deviation seems to indicate that emissions have a significant impact, followed by western boundary conditions.
Monte Carlo simulations are then post-processed by both ensemble [4] and Bayesian [5] methods in order to assess the quality of the uncertainty estimation.

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