

Validation of LMD-ZT model with ETEX-1 experiment

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Abstract

We present here validation of LMD-ZT model in various configurations using the result of the first European Tracer EXperiment (ETEX).

The LMD-ZT model has been used at Laboratoire de Météorologie Dynamique (LMD) in collaboration with Commissariat à l'Énergie Atomique in the frame of the Comprehensive Ban Treaty (CTBT). Coupled to an original inverse approach, it has been used to evaluate ability of the International Monitoring System to detect sub-surface and atmospheric radioactivity.

Introduction

The European Tracer EXperiment (ETEX) was organized by the World Meteorological Organisation, the International Atomic Energy Agency and the European Commission, to test the ability of transport models to predict the dispersion of a cloud of pollutant at continental scales. For the present study, we use results of the first experiment ETEX-1. On October 23 1994, 340 kg of the insoluble gas perfluoro-methyl-cyclo-Hexane (PMCH) were emitted continuously for 12 h starting at 4 p.m. (T0) at the top of the 8 m high tower located in Monterfile, some 30 Km from Rennes in France. The meteorological situation, a strong and maintained westerly to south-westerly flow, was chosen in order to maximize detection at the 168 observing stations mainly located in the north of Western Europe.

Atmospheric dispersion is computed with the transport version of the atmospheric general circulation model of LMD. It includes a zooming capability. Large scale advection is computed based on

a finite volume transport schemes (*Van Leer, 1977, Hourdin et Armengaud, 1999*). The model includes a second order closure for turbulent mixing in the planetary boundary layer and a mass flux representation for a deep convection (*Tiedtke, 1989*). LMD-ZT model can be used in two modes : on-line and off-line. It can be either ran in climatic mode without forcing, or nudged by analysis from operational weather forecast centers.

Simulations and analysis

The ETEX data set (Nodop et al., 1998) is used to evaluate the model performance. The horizontal grid used for ETEX-1 simulations reaches a mean resolution of about 120x150 Km at the center of the zoom over Europe. LMD-ZT is used in two ways : Firstly, a four-day line meteorological simulation is performed. The winds and temperature fields are relaxed toward analysis of the European Center for Medium Range Weather Forecast (nudging). Large scale winds, turbulent mixing coefficients and sub-grid scale convective mass fluxes are averaged in time and archived for the period of the ETEX experiment. The transport model is then used off-line by reading those archives either in forward or in backward mode. In the off-line mode, transport can be computed on a grid twice as fine in each horizontal direction (60x75 Km at the center of the zoom).

Figure 1 shows simulated and observed cloud at 24, 36, 48 and 60 hours after the release beginning. There is a satisfactory agreement between measurements and observations. The model tends to underestimate the values of concentration at southern edge of plume. This feature can be seen clearly in

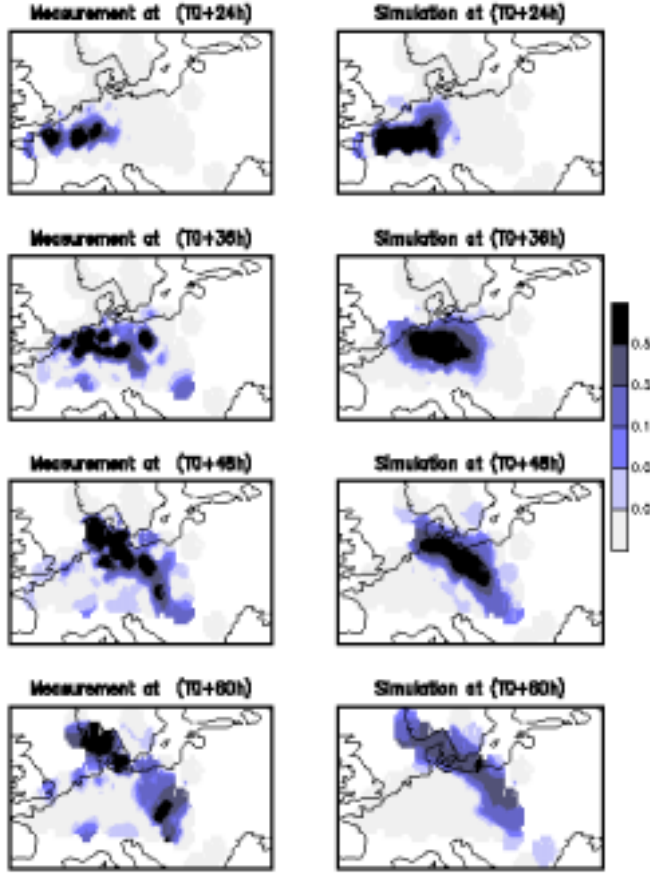


Figure 1: Measured (left) and simulated (right) cloud of PMCH (in ng.m^{-3}) at 24, 36, 48 and 60 hours after the release beginning (T0)

figure 2.

In order to show how our model compare to other models, we have computed the FMT (figure of merit in time) indice for both of the 11 stations retained for model intercomparisons (Graziani et al. 1996). The FMT is originally defined, where the simulated and observed time-series are plotted on the seam graph, as the ratio of the "area" of the common ground (that is the time integration of the lower of the two concentrations at every moment) and the area under the envelope of the two series (that is the time integration of the greater of the two concentration at every moment). The FMT varies from 0% if the two concentrations differ by orders of magnitude or if they do not overlap in time, to 100% when the simulation and observation match exactly.

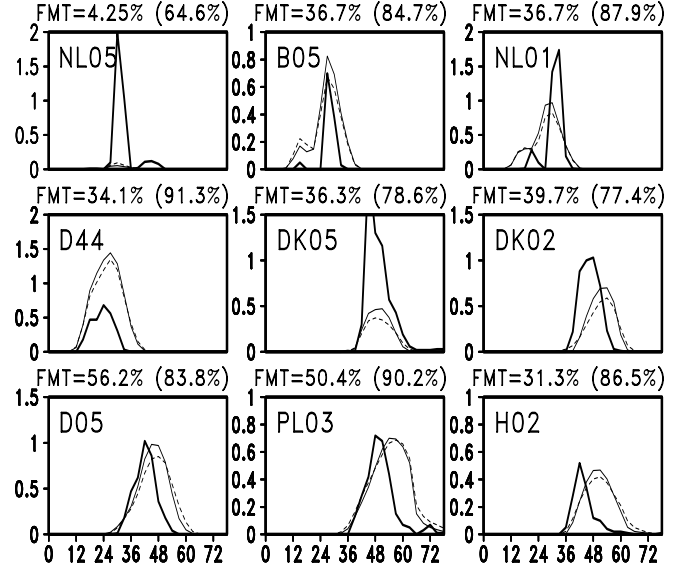


Figure 2: Time evolution of the concentration of PMCH (ng.m^{-3}) as observed (heavy black curve), simulated (thin full curve) and reconstructed with the inverse approach (dashed) at the 9 stations. The FMT (see text for explanations) measures the agreement between observations and direct simulations. Numbers in parenthesis correspond to the FMT computed between forward and backward estimations.

With a mean FMT of about 36 %, our model compares well with the best simulations performed by other models: the mean FMTs never exceed 50 % and are often closer to 20-30 %. This graphic shows also that the result is somewhat better when the grid is refined.

In figure 2, we show also the tracer concentration as reconstructed using backward and forward transport simulations. Backward transport is computed based on the time symmetry of the transport equations as described by Hourdin et al. (Hourdin and Issartel, 2000, Hourdin and Issartel, 2000) The forward and backward estimations do not exactly coincide due to the fact that the time symmetry is not exactly satisfied by the numerical scheme (in particular in the non-linear slope limitation introduced to insure monotony of the finite volume transport scheme). However the difference between direct and backward estimations is must smaller than the difference with observation.

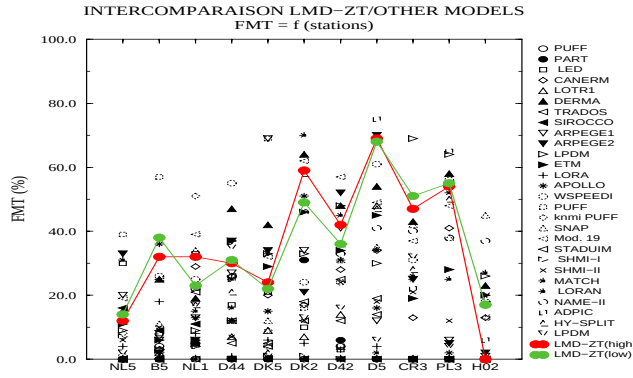


Figure 3: Intercomparison LMD-ZT and other models

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