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Finite element local air quality modeling of punctual emissions

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ABSTRACT

This paper presents an air pollution model for local scale simulations around punctual sources (up to few tens of kilometers). It is based on the application of the finite element method and it uses unstructured meshes to discretize three-dimensional atmospheric domains. Discretization is adapted to terrain features, including description of basic geometry of major sources. Model follows an Eulerian approach, instead of usual Lagrangian strategies of local dispersion models [1,2]. Eulerian approach facilitates the simulation of nonlinear chemistry coupling among two or more plumes.

Pollutant transport – reaction is computed in two phases: First, wind is interpolated from given data, and then, a convection – diffusion – reaction problem is solved for a given time interval. As a first approach, wind is considered constant during convection – diffusion – reaction problem. Wind velocity field is approximated to measured or predictive data of some control points using a consistent mass model. The model incorporates plume rise effect of punctual sources [3,4], and discretization can be refined to follow the plume rise.

Two chemical models are considered: A two-species lineal model and the RIVAD model, which involves four species and non-linear chemistry. Linear problems are solved with *Crank-Nicolson* time integration scheme applied to the computation of nodal concentrations and *Least Squares* approximation of spatial operators. *Strang* splitting and *ROS2* time integration scheme are used for nonlinear problems.

The proposal has been tested with two examples with meshes of around 20000 elements and 5000 nodes: One and two chimneys (200 meters of height each) in a flat domain (of 18 by 18 square kilometers). Transport and reaction of pollutants with linear and nonlinear models have been computed

and compared with results of simplified models. Interactions of pollutant plumes in the example with two sources are analyzed in detail. A realistic simulation in a complex terrain has also been computed (part of La Palma island, in the Canary Islands, with a mesh of more than 150000 elements and 30000 nodes). Accurate and credible results have been obtained (see Figure 1). The approach have shown to be efficient in both simple and complex terrains.

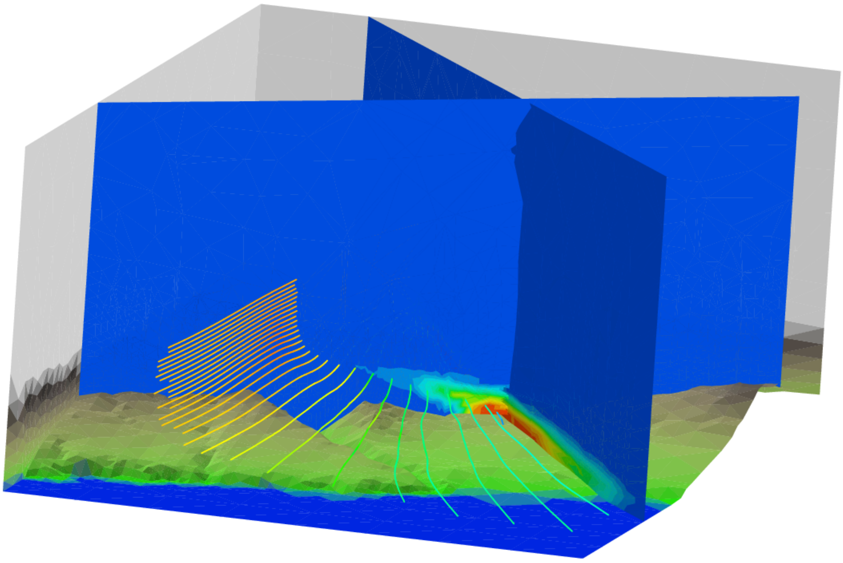

Figure 1: Plume concentrations on 2 sections and wind streamlines

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