*Forecasting the weather
- ensemble techniques
in probabilistic weather prediction*

A local scale finite element moldel for stack pollutant dispersion over complex terrains

A. Oliver (1), A. Perez-Foguet (1), E. Rodríguez (2), J.M. Escobar (2), R. Montenegro (2), and G. Montero (2)

(1) LaCàN, Matemàtica Aplicada 3, UPC, Spain ({albert.oliver,agusti.perez}@upc.edu), (2) University Institute SIANI, University of Las Palmas de Gran Canaria, Spain (jescobar@dsc.ulpgc.es, {barrera,rafa,gustavo}@dma.ulpgc.es)

Conventional air quality models uses Lagrangian [1,2] or Eulerian [3] strategies, and the numerical approach is normally obtained by using finite difference schemes. In this paper, we introduce a local scale Eulerian air pollution model that is related to unsteady propagation problems which may be mathematically described by convection-diffusion-reaction equations. We solve the couple problem applying a three-dimensional finite element discretization with unstructured and adapted meshes. The tetrahedral mesh is adapted to the topography and the plume rise. The local area of interest is up to tens of kilometres and it includes the stacks.

The wind field is crucial for the pollutant transport, specially in complex terrain areas. We use a mass consistent model that is solved with the finite element method taking into account the plume rise effect [4,5,6].

Chemical reactions have been solved by two models [7]. The first one is a linear model relating two chemical species and the second one is the RIVAD model involving four species with non-linear chemistry. The numerical solution for the linear problem is obtained using stabilized finite elements with least squares and a Crank-Nicolson time integration. In the non-linear case, we apply a Strang splitting and a ROS2 time integration scheme.

We present several applications of the model. On the one hand, we consider two test problems that involve one and two stacks over a plane terrain. On the other hand, we simulate the pollution that is produced by a stack placed in the Island of La Palma (Canary Island, Spain). Expected results have been simulated in both cases within a reasonably computing time.

References

[1] J.S. Scire, D.G. Strimaitis, R.J. Yamartino, "A Users Guide for the CALPUFF Dispersion Model", Earth Tech. Inc., Concord, MA (2000).

[2] J.F. Hernández, L. Cremades, J.M. Baldasano, "Dispersion modelling of a tall stack plume in the Spanish Mediterranean coast by a particle model", Atmospheric Environment, Vol. 29, pp. 1331–1341, (1995).

[3] R.E. Morris, G. Yarwood, C.A. Emery, G.M. Wilson. "Recent advances in photochemical air quality modelling using the CAMx Model: Current update and ozone modelling of point source impacts" Proc. AWMA (2002).

[4] G. Montero, E. Rodríguez, R. Montenegro, J.M. Escobar, J.M. González-Yuste, "Genetic algorithms for an improved parameter estimation with local refinement of tetrahedral meshes in a wind model", Journal of Wind Engineering and Industrial Aerodynamics, Vol. 36, pp. 3-10 (2005).

[5] J.M. Escobar, E. Rodríguez, R. Montenegro, G. Montero, J.M. González-Yuste. "Velocity field modelling for pollutant plume using 3-D adaptive finite element method", Lecture Notes in Computer Science, Vol. 3037, pp. 642-645 Springer-Verlag (2004).

[6] L. Ferragut, R. Montenegro, G. Montero, E. Rodríguez, M.L. Asensio, J.M. Escobar. "Comparison between 2.5-d and 3-d realistic models for wind field adjustment", Journal of wind Engineering and Industrial Aerodynamics, Vol. 98, pp. 548–558 (2010).

[7] A. Oliver, J.M. Escobar, E. Rodríguez, A. Perez-Foguet. "A. Finite element local air quality modeling of punctual emissions", 8th World Congress on Computational Mechanis and 5th European Congress on Computational Methods in Applied Sciences and Engineering (2008).