Local Scale Finite Element Modelling of Stack Pollutant Emissions

R. Montenegro*, A. Oliver+, E. Rodríguez*, J.M. Escobar*, G. Montero* and A. Pérez-Foguet+

*University Institute for Intelligent Systems and Numerical Applications in Engineering (SIANI), University of Las Palmas de Gran Canaria, Spain, http://www.dca.iusiani.ulpgc.es/proyecto2012-2014/

+Laboratori de Càlcul Numèric (LaCàN), Universitat Politècnica de Catalunya–BarcelonaTech, Spain, http://www.lacan.upc.edu/

Numerical simulation of pollutant transport and reaction on atmosphere has been the result of important advances in the last thirty years. However, nowadays it remains as a scientific challenge. Key analysis are related to acid rain, ozone, particle matter and toxic emissions. Air quality modelling systems mainly involve three components: emissions, meteorology and convection-diffusion-reaction of pollutants.
Conventional air quality models uses Lagrangian or Eulerian 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 [1,2]. This effect is included by perturbing the vertical component of the resulting wind field along the bent plume trajectory. Wind measurements are used to compute the interpolated wind field. Chemical reactions have been solved using a condensed pseudo-first-order chemical scheme model (RIVAD) involving four species with non-linear chemistry. To solve this problem we apply an Strang splitting and a second order Rosenbrock time integration scheme (ROS2). The linearised numerical solution is obtained using stabilized finite elements with least squares and a Crank-Nicolson time integration. The discretization of the stack geometry allows to define the stack pollutant emissions as boundary conditions, and dry deposition is also included as a boundary condition. A previous description of the proposed procedure can be found in [3].

Acknowledgements: This work has been supported by the Spanish Government, Ministerio de Economía y Competitividad, and FEDER, CGL2011-29396-C03-01; and by CONACYT-SENER (Fondo Sectorial CONACYT SENER HIDROCARBUROS), grant contract: 163723.

References

[1] 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, 36, 3–10 (2005).

[2] 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, 98, 548–558 (2010).

[3] A. Oliver, G. Montero, R. Montenegro, E. Rodríguez, J.M. Escobar, A. Péez-Foguet, *Adaptive finite element simulation of stack pollutant emissions over complex terrains*. Accepted for publication in Energy (2012).