High-resolution simulation of stack pollutant emissions

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

(1) LaCàN, Matemàtica Aplicada 3, UPC | (2) University Institute SIANI, University of Las Palmas de Gran Canaria

Abstract

A three-dimensional air pollution model for the short-term simulation of emission, transport and reaction of pollutants is presented. In the finite element simulation of these environmental processes over a complex terrain, a mesh generator capable of adapting itself to the topographic characteristics is essential, A local refinement of tetrahedra is used in order to capture the plume rise. Then a wind field is computed by using a mass-consistent model and perturbing its vertical component to introduce the plume rise effect. Finally, an Eulerian convection-diffusion-reaction model is used to simulate the pollutant dispersion.
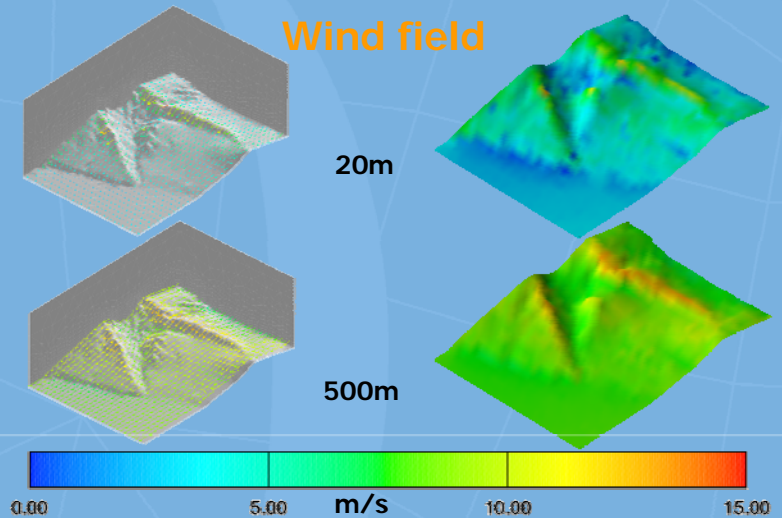
Algorithm

1. Construct an adaptive tetrahedral mesh of the domain
2. Wind field simulation from experimental or forecasting data
3. Wind field modification including the plume rise effect
4. Air pollution simulation from stack emission data

3D FE Mesh

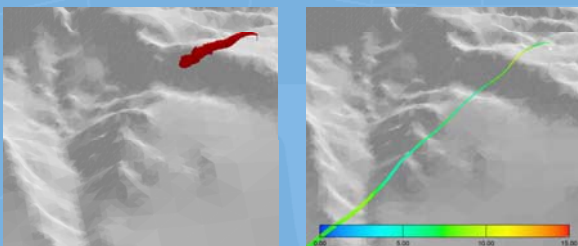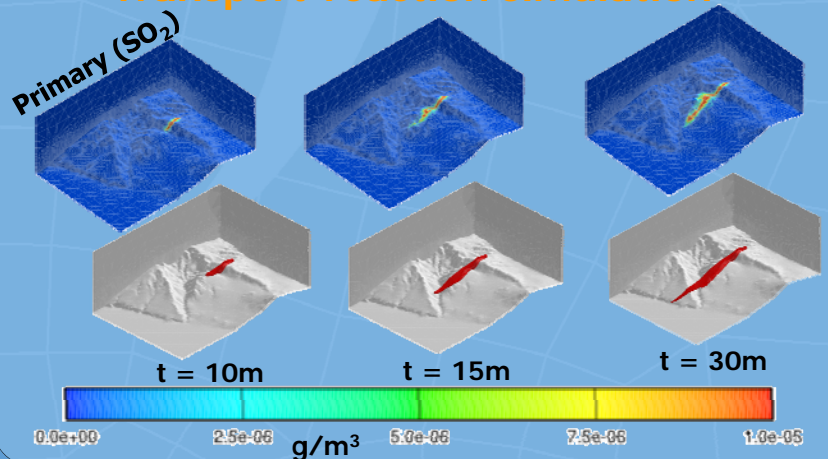- Adapted to topography
- Including punctual emissaries

Wind field

20m

500m

0.00   5.00   m/s   10.00   15.00
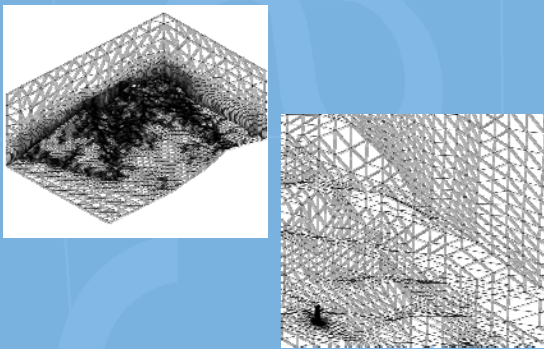
Plume rise and refinement

- Mesh refinement to capture plume rise
- Wind perturbation to get plume rise

Transport-reaction simulation

Primary (SO$_2$)

t = 10m   t = 15m   t = 30m

0.0e+00   2.5e-06   5.0e-06   g/m^3 7.5e-06   1.0e-05

Conclusions

We have introduced a new methodology for solving air pollution problems over a complex terrain. The adaptive three-dimensional mesh generation discretizes domains defined over complex terrains. The mass-consistent model obtains an ambient wind field that takes into account the complex orography. The local mesh refinement along the Gaussian plume, allows to perturb the ambient wind field to introduce the effect of the pollutant emissions. The convection-diffusion-reaction equation obtains the values of concentration for all the pollutants.

References

A. Oliver, G. Montero, R. Montenegro, E. Rodríguez, J.M. Escobar, A. Pérez-Foguet "Adaptive finite element simulation of air pollution over complex terrains ", submitted to Environmental Modelling and Software (2011)