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Coupling mesoscale air quality models with finite element computation of dispersion at local level

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Mesoscale Air Quality models are able to simulate pollutant emission emitted from chimneys or industrial areas. CMAQ (Community Multiscale Air Quality) model is one of the most used. It includes the Plume-in-Grid (PinG) model to simulate local emission sources and their influences in the mesoscale. Because of the several limitations of PinG model, in this paper a different approach is proposed. Dispersion at local level is computed using the Finite Element method.

Following steps are proposed to couple one-way CMAQ and a Finite Element solver. First, a discretization (mesh) of the overall domain, covering a minimum of two by two horizontal cells of CMAQ, is computed. This unstructured and three-dimensional mesh should include all topographic and built elements of interest and with desired geometric precision. Domain mesh is computed from a Digital Terrain Model (DTM) of the area of interest. Terrain is meshed using a background mesh [1] and prescribing element size based on terrain curvature [2]. After that, meshes of a set of layers at different heights are computed smoothing curvature recursively. Layers are fixed following the CMAQ-layer approach, but not restricted to it. Smoothing curvature is important in order to increase horizontal element size in upper layers. Finally a three-dimensional mesh based on meshes of layers is computed.

After that, wind field from CMAQ is interpolated to the Finite Element mesh. Interpolation scheme incorporates a correction of CMAQ description of terrain, which has a very low precision (adequate for mesoscale but not for local scale). Then, the influence of the plume rise is added to the wind field and the domain is re-meshed to capture expected influence of initial plume rise. Formulas from Briggs [3] are used to model plume rise. Finally, all CMAQ data needed at local level (as initial and boundary conditions, and different distributed parameters) is interpolated and a Finite Element convection-diffusion-reaction solver is used to simulate the local dispersion problem. Numerical solver splits transport (convection-diffusion) and reaction. Transport is solved with a conjugate gradient method [4], while the reaction solver is the same used by CMAQ.

Main advantages and limitations of proposed approach are analyzed with an example of CMAQ tutorial.

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