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Numerical modelling of air pollution dispersion in an idealized urban area

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Turbulent flow in built-up areas can be very complex, influencing the processes which govern air pollution dispersion. Understanding such phenomena is important because of the increasing interest in local pollution. In order to describe the impacts of buildings on flow and plume dispersion, detailed numerical simulations are performed over an idealized urban area, modelled as regular rows of large rectangular obstacles, and validated with the measurements from a field experiment.

The numerical simulations are performed with the model MERCURE, which is a three-dimensional model adapted to atmospheric flow and dispersion. Its core is a Computational Fluid Dynamics model Code_Saturne (developed by EDF), which can handle complex geometry. Real scale simulations are done at fine resolution, on a flat terrain. The model takes into account the meteorological conditions and uses the k-ε closure to simulate the effects of obstacles on the production of turbulence.

The simulations are evaluated with the result of the Mock Urban Setting Test (MUST), which is a near full-scale experiment. It was designed to support urban dispersion model developpement and validation: it consists of neutral gaz releases in a field of shipping containers in Utah's West Desert at US Army's Dugway Proving Ground (Biltoft, 2001, Yee and Biltoft, 2004).

Several simulations are done for different meteorological conditions, i.e. several upstream wind speeds and directions. The simulated releases are continuous plumes of

neutral tracer, for different source locations. The results are compared with the measurements in terms of dynamics fields (velocity, turbulent energy, shear stress...) as well as concentration fields (means and fluctuations) for different downwind distances. Despite a slight overestimation of concentrations near the source, comparisons are overall satisfying. Sensitivity analyses show a high dependance of plume dispersion on initial meteorological conditions.

References:

Biltoft, C.A.: 2001, Customer report for Mock Urban Setting Test, Rep. no. WDTC-FR-01-121, US Army Dugway Proving Ground.

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