LARGE EDDY SIMULATION OF POLLUTION DISPERSION FROM HIGHWAYS WITH NOISE BARRIERS

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Model CLMM

- LES CFD model developed in-house for research purposes by the authors of this study
- Incompressible Navier-Stokes equations, optionally with Boussinesq approximation for temperature stratification
- Parallelized using OpenMP (MPI or coarrays planned)
- Object oriented features from Fortran 2003/08, mainly for geometric computations on complex datastructures concerning the
- Finite volume method on a uniform Cartesian grid
- Second order central spatial discretization
- Third order Runge-Kutta method in time
- Third order non-oscillatory method for advection of scalars

Problem description

- Set-up as requested by the Road and Motorway Directorate (RMD) of the Czech Republic
- 6 m high noise barriers placed on one or both sides of the highway located in a flat terrain
- passive scalar volume sources from the ground to 2 m height representing the exhaust gas pollution mixed by the traffic
- The scalar source strength represented typical NOx emmissions on the highway as supplied by the RMD with the total intensity of 0.902 $g.s^{-1}.km^{-1}$.
- No chemical processes considered.
- Synthetic turbulent inlet using the method of Xie and Castro (Fl.Turb.Compust. 2008). The mean flow profile is logarithmic with the reference wind speed 5 m/s in 10 m height and normal to the higway.
- The compatational domain has dimensions 400 m × 40 m × 64 m with horizontal resolution 0.5 m and vertical resolution 0.25 m.

Results

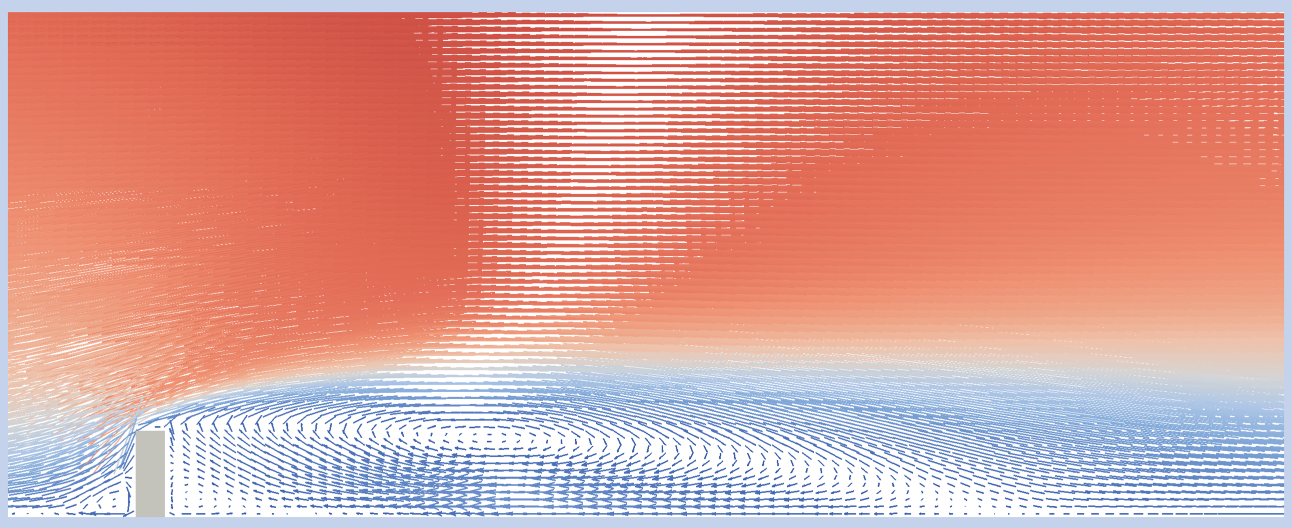

Fig. 1. The time-averaged flow behind one 6 m tall noise barrier.

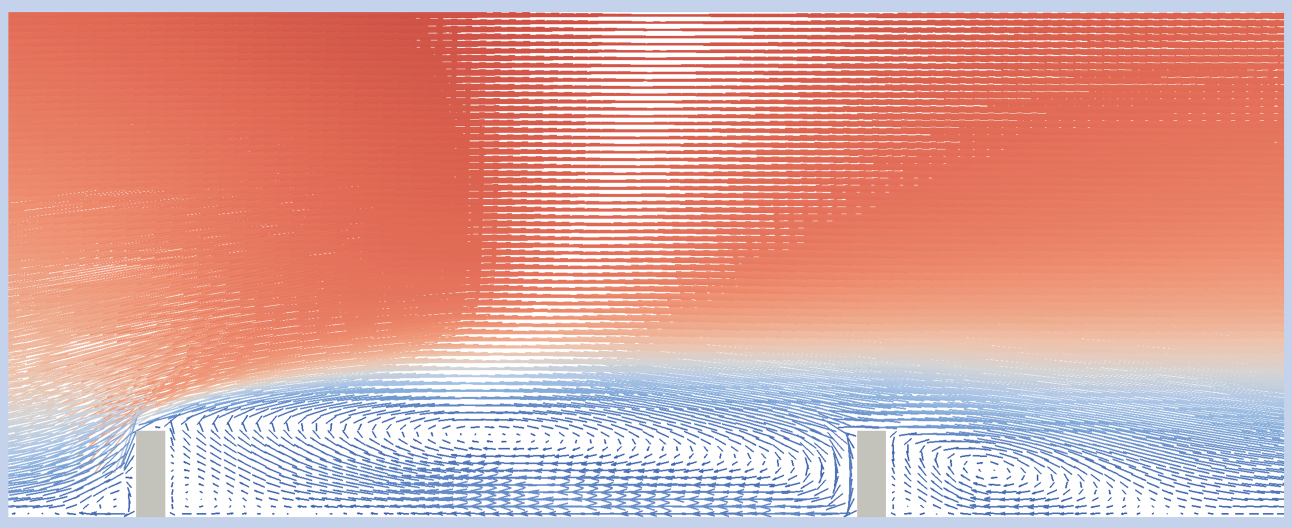

Fig. 2. The time-averaged flow behind two 6 m tall noise barriers with 25 m distance between them.

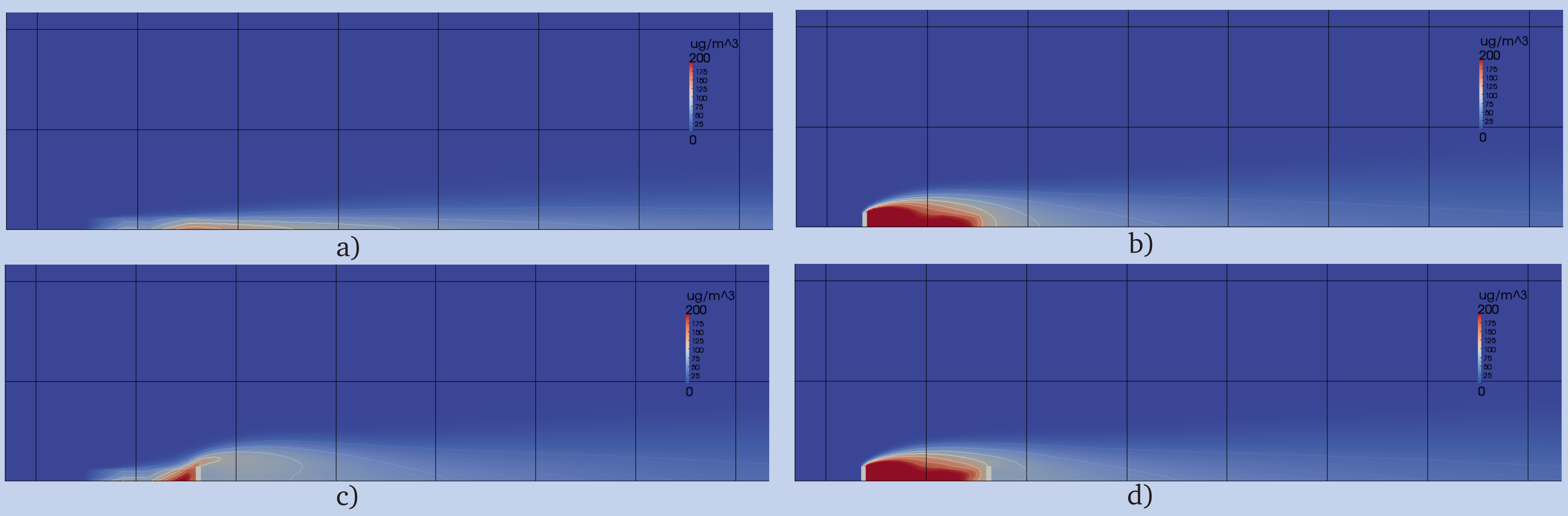

Fig. 3. The time-averaged concentrations of the tracer in the four configurations. The grid lines denote every 20 m. a) no barrier, b) upwind barrier, c) downwind barrier, d) both barriers.

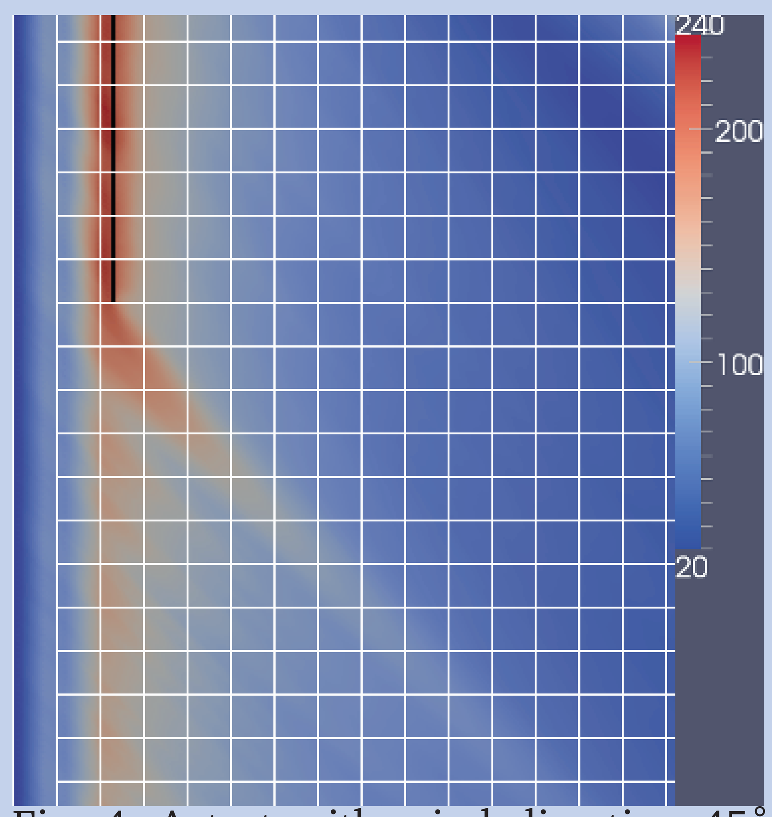

Fig. 4. A test with wind direction 45° from the highway and one downwind barrier. The wind speed and source are not changed.

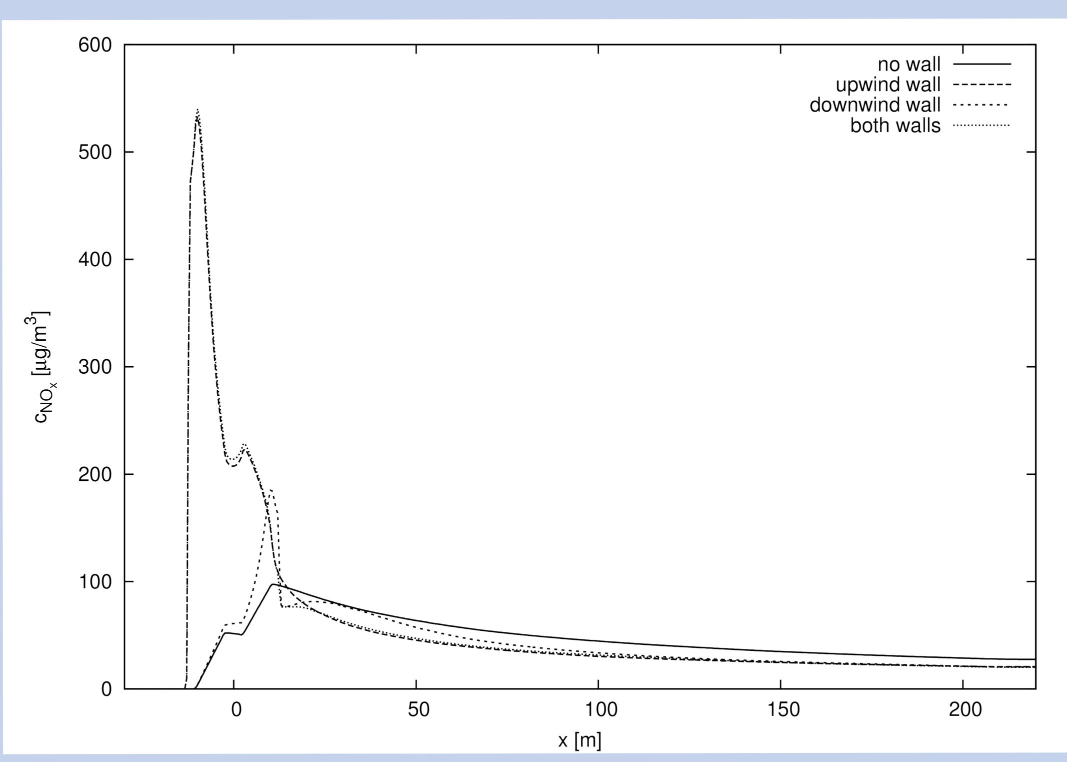

Fig. 5. The tracer concentrations in 1.5 m as a function of distance from the higway centreline.

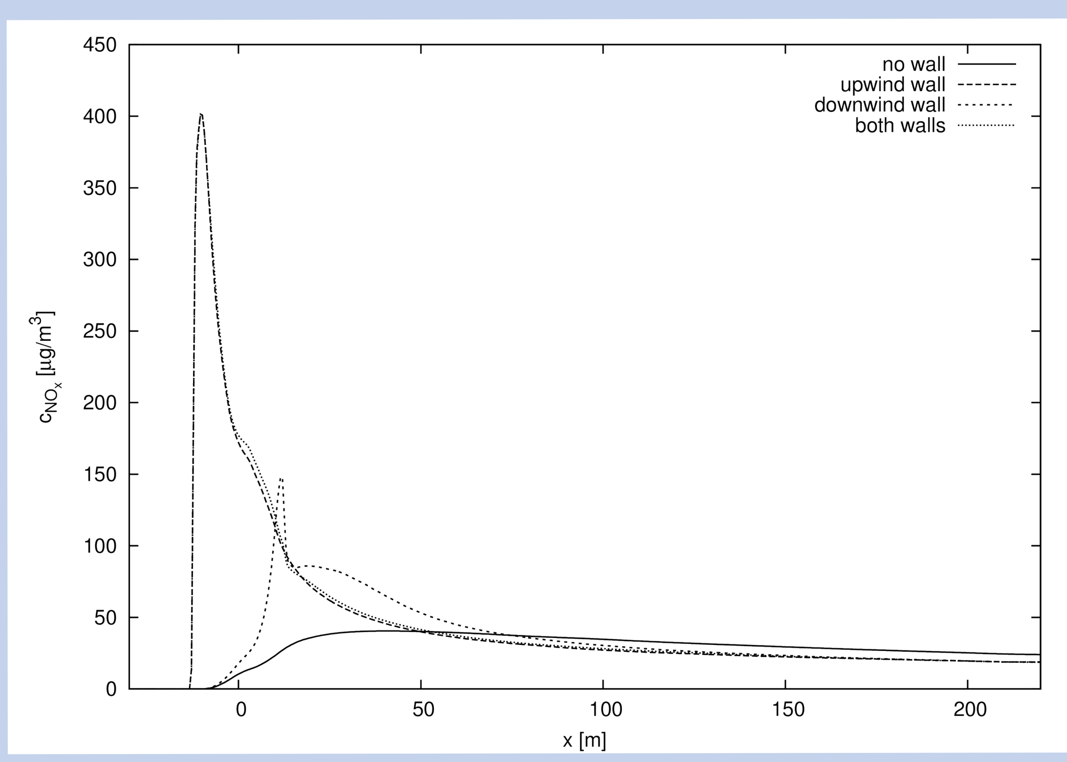

Fig. 6. The tracer concentrations in 3 m as a function of distance from the higway centreline.

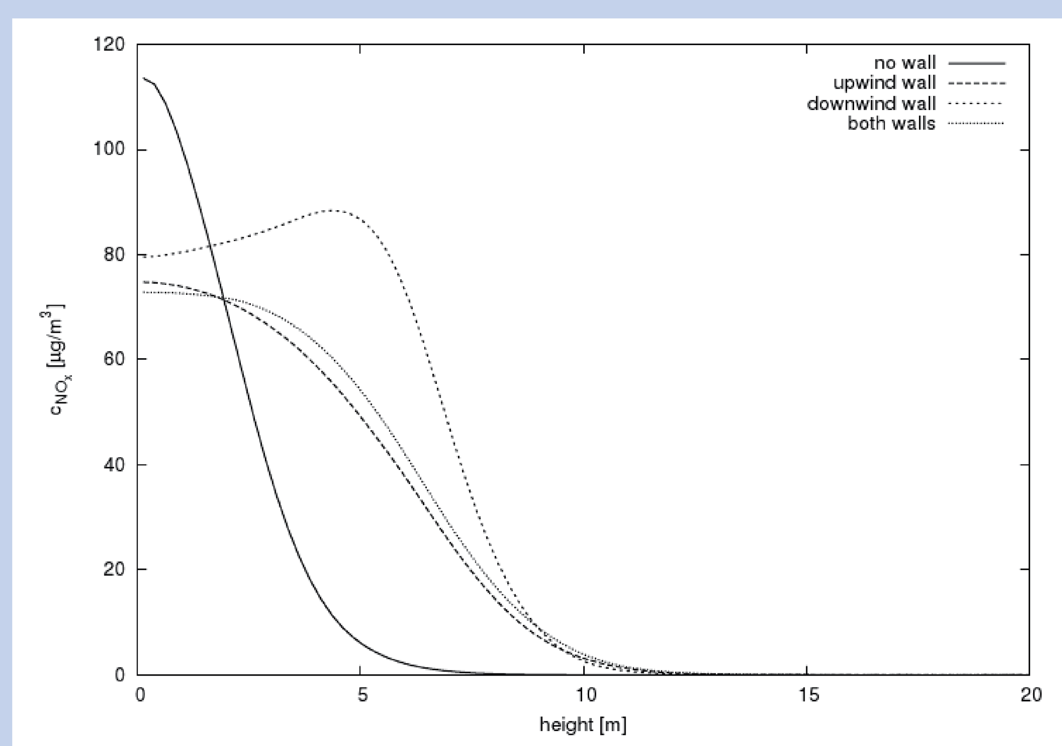

Fig. 7. The vertical profile of the concentrations at distance from the centreline of 22.5 m (10 m from the location of the downwind barrier).

Conclusions

The computation showed better dispersion of pollutants upwards with the noise barriers. However, on must be careful, because the ideally flat terrain, which was requested by the RMD for this study is not very representative. Therefore any obstacle can increase the diffusion by increasing the turbulence levels. We tried to use realistic value of the roughness length for the incoming turbulence, but still there was 150 m of flat terrain, where the synthetic turbulence fully developed. Also, there was little between the cases with two barriers and with the upwind barrier only, because the length of the recirculation region coresponds almost exactly to the distance of the barriers.

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