

**23rd International Conference on
Harmonisation within Atmospheric Dispersion Modelling
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EXTENDED ABSTRACT

Abstract title: Simulation of dispersion of air pollutants in a street canyon and along a highway using the DALES model

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Abstract text

Air quality in urban environments directly affects the health of a large number of people. Accurate assessment is therefore important. The need for more detailed assessment may arise in urban areas, where high concentrations are often observed. A relatively new development in dispersion modelling is the use of numerical Large-Eddy Simulations (LES). With such simulations, it is possible to focus in more detail on an area and assess the air quality at a high spatial and temporal resolution, i.e. meters and seconds.

Calculations with the Dutch Atmospheric Large-Eddy simulation (DALES) model (Heus et al., 2010) are presented in this work for three case studies. The three case studies considered here are: 1. the concentration gradient of pollutants downstream of a road for which the wind direction is perpendicular to the road; 2. the same configuration as the first case, but with a wall placed downwind of the road; 3. the dispersion of pollutants in a double street canyon, with the wind direction perpendicular to the street canyon and for several different configurations regarding building height (two are shown in this extended abstract). For the first two cases a comparison is made with results from “Standaard Reken Methode 2” (SRM2) (Wesseling, 2015). SRM2 is one of the official dispersion models in the Netherlands, to calculate the concentration of pollutants along roads and motorways. Results from the third case are compared with results from wind tunnel experiments in a similar configuration (CODASC, 2008 and Kim et al., 2005).

The set-up for the first and second case is similar. The domain is rectangular, with a cell size of 5x5x2 m. The simulation is performed for the case of a weak convective atmospheric boundary layer. For the first case, the concentration gradient of the pollutant downstream of the road as calculated with DALES compares well with the calculated gradient obtained from SRM2 (Figure 1). In the DALES model the concentration of a passive tracer (as a proxy for air quality in general) is calculated. The road in the simulation consists of 10 point sources at the lowest level (1 m) of the domain with an emission strength of 1 arbitrary unit/s. The SRM2 calculation uses different units for the emission strength. Hence, in order to compare the gradients, both calculations were scaled to the maximum concentration in the output from each model.

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The scaled concentration at a height of 1.8 m

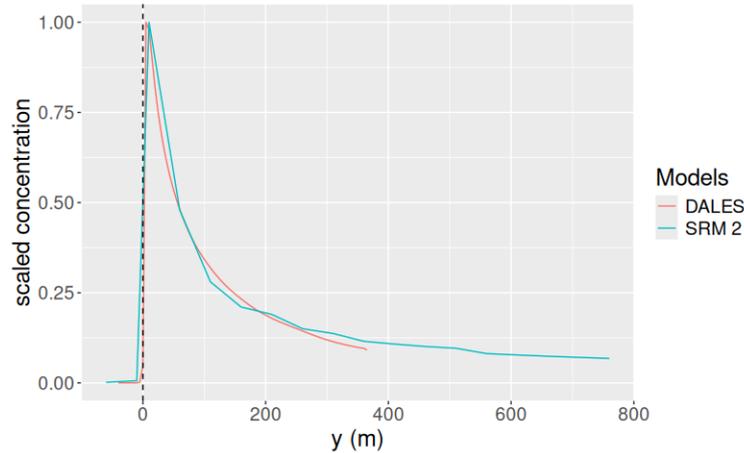


Figure 1 The scaled concentration versus the distance from the wall for DALES and SRM2. The dashed line shows the position of the road.

For the second case, in which a thin wall (height 4 m) is placed downstream of the road, the concentration gradient from the two models deviate (Figure 2). The scaled concentration from DALES decreases less quickly with distance from the wall than the scaled concentration from SRM2 .

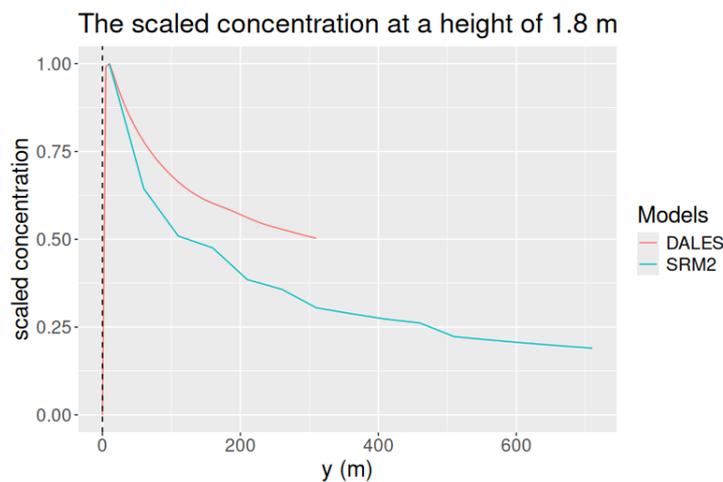


Figure 2 The scaled concentration versus distance of the wall for DALES and SRM2. The dashed line shows the position of the wall. Note that here the distance from the wall is shown, while previously the distance from the road was shown.

Comparing the concentration from DALES for the run with and without the wall (not shown here), it is found that the concentration is higher for the case with the wall. When comparing the concentrations from SRM2 (also not shown here) the opposite is observed. For the third case, the concentration in and around a street canyon, due to traffic emission is studied. The LES simulation is performed for the case of a neutral atmospheric boundary layer. The cell size is 2.9x2.9x2 m. The distance between the buildings is 29 m. Two cases are shown here. For the first case all buildings have a height of 14 m and for the second case the first and third building have a height of 8 m and the second building has a height of 20 m. In both street canyons 16 equidistant point sources with an emission strength of 1 arbitrary unit/s were placed to simulate the emission of road traffic in the

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canyon. The horizontal cross-section at a height of 3 m for a street canyon with equal building height is shown in Figure 3 and the vertical cross section is shown in Figure 4. Because the wind direction is perpendicular to the orientation of the street canyons, a large difference in concentration is obtained between both sides of the street canyon. In Figure 5 the results of the case with unequal building heights is shown. In this configuration, the concentration is higher in the second street canyon than in the first.

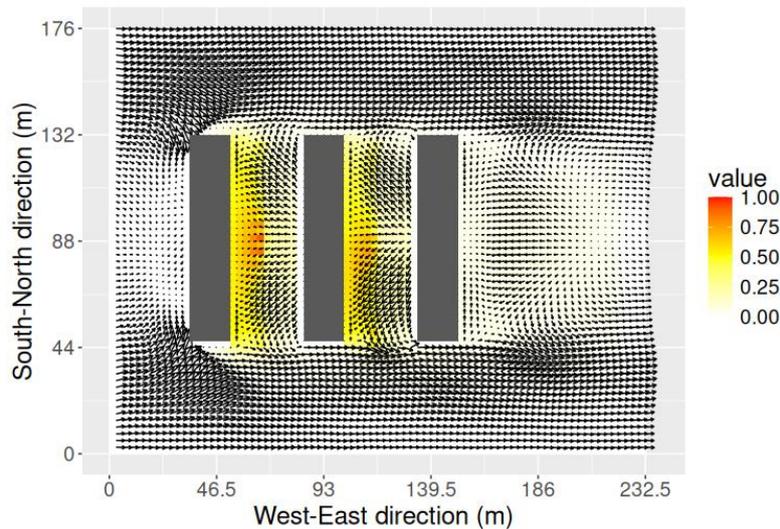


Figure 3 The top view of the two street canyons with a building height of 14 meters. The colour gradient shows the concentration and the arrows show the direction and speed of the wind. The concentration and wind velocity at a height of 3 meters is shown. Both are averaged over the last hour of the simulation.

The flow patterns around the buildings and inside the street canyons as depicted in the figures 3-5 are similar to the patterns found in literature and wind tunnel experiments. Obviously, there is a large variation in the distribution of the concentration over time.

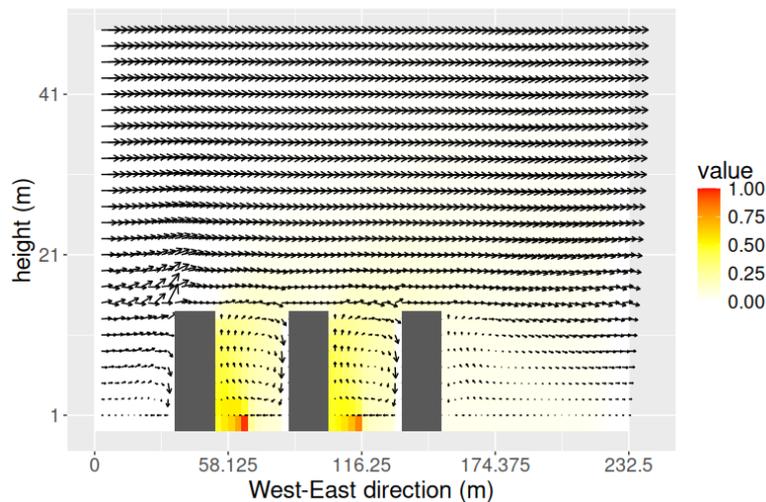


Figure 4 The colour gradient shows the concentration and the arrows show the direction and speed of the wind. The concentration and the wind speed are averaged along the length of the building and are averaged over time for the last hour of the simulation. Here, the building height is 14 meter.

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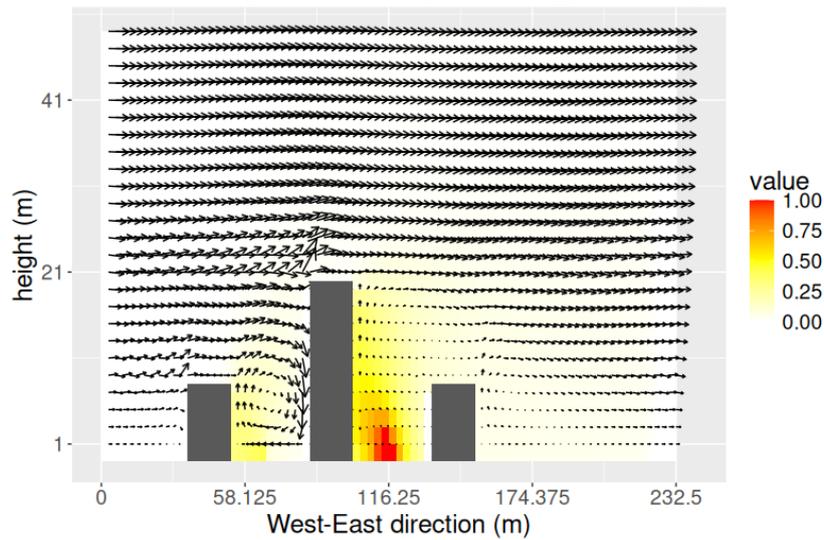


Figure 5 The colour gradient shows the concentration and the arrows show the direction and speed of the wind. The concentration and the wind speed are averaged along the length of the building and over the last hour of the simulation. Here, the building height of the first and third building is 8 meter and the building height of the second building is 20 meter.

To evaluate the results from DALES a qualitative comparison is made with results from wind tunnel experiments. Figure 6 shows the normalized concentration at the inner walls of a street canyon from wind tunnel experiments from the CODASC (2008) database and from the simulations with the DALES model. The distribution of the concentration is quite similar for the upwind wall, but less so for the downwind wall.

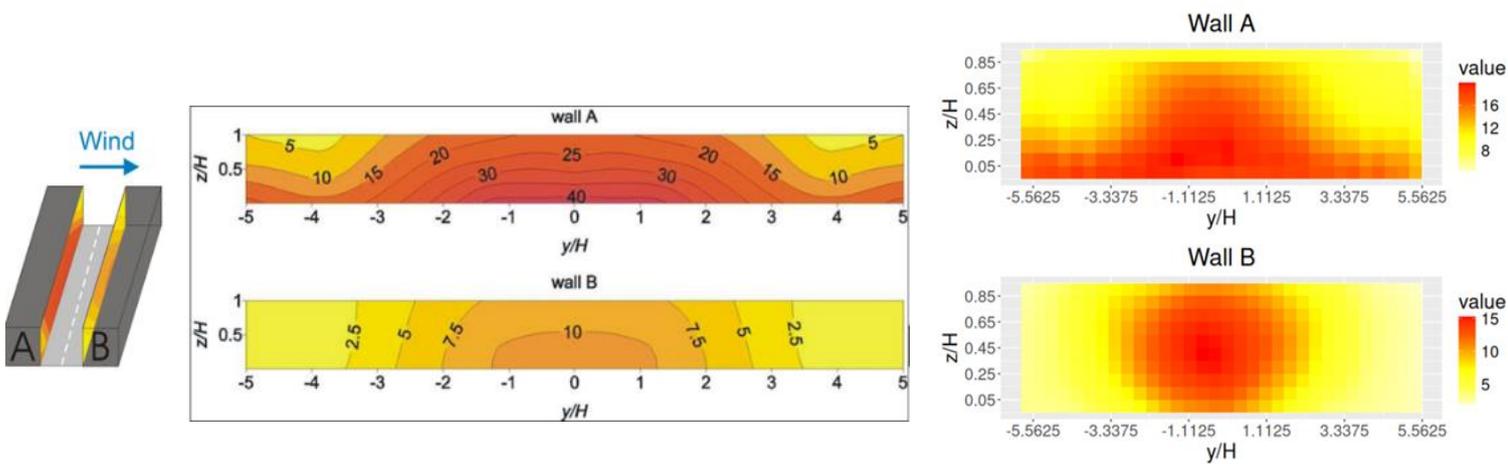


Figure 6 Normalized concentrations at the inner walls (denoted with A and B), respectively). Left: the normalized concentration from the CODASC wind tunnel experiment; right: normalized concentration at the inner walls from the DALES model.

Another qualitative comparison is made for the cross section of multiple street canyons. The wind tunnel results from Kim et al. (2005) are compared to the results from DALES in Figure 7. The results look similar, however there are some differences. The plume obtained from DALES fans out more upwardly than the plume in the wind tunnel. In the second street canyon the normalized concentration obtained from DALES is highest on the East side of the canyon, whereas the normalized concentration from the

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wind tunnel experiment is highest at the West side. Finally, the normalized concentration windward of the first building is higher for the wind tunnel results.

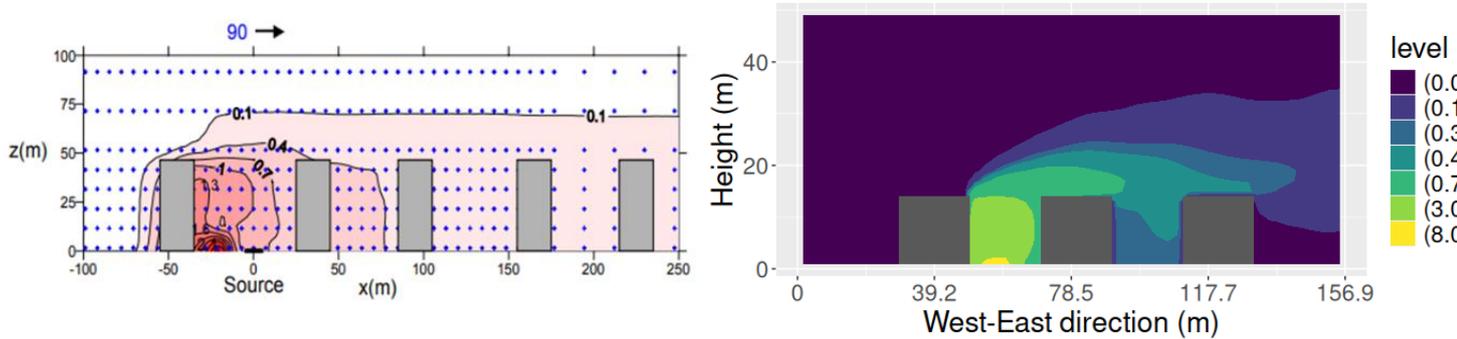


Figure 7 Left: The normalized concentration obtained from wind tunnel experiments in a street canyon with a width to height ratio of 1.39 (Kim et al., 2005) Right: The normalized concentration obtained from DALES in a street canyon with a width to height ratio of 1.45

Conclusions

The DALES model can simulate concentrations of pollutants at a high temporal and spatial resolution. This makes it very suitable tool for modelling the flow and concentrations of pollutants along roads, motorways and inside street canyons.

Here, we have presented simulations for DALES for three different applications. The third application is the most complicated one, in which the dispersion of pollutants is modelled in a double street canyon. The results of these calculations are quite similar to measurements found in literature from wind tunnel experiments.

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