COMPARISON WIND-TUNNEL EXPERIMENT WITH LES MODELLING OF ATMOSPHERIC DISPERSION OVER COMPLEX TERRAIN

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Summary
We present the results from application study concerning of atmospheric dispersion modelling over open-cut coal mine and its surrounding topography by means of wind-tunnel and computational fluid modelling – large eddy scale simulation (LES). The study has main objective to predict the air quality in populated areas with respect to prevailing wind direction. Simultaneous point measurement of two velocity components and concentrations by Laser Doppler Anemometry (LDA) and Fast Flame Ionization Detector (FFID), respectively, was performed during wind-tunnel experiment. The velocity and concentration field obtained from wind-tunnel measurements are compared with those from LES. The impact of complex topography and especially surface roughness on passive pollutant dispersion was observed. The comparison revealed that LES has a big potential to predict atmospheric dispersion processes occurred at complex terrain topography.

Introduction
The physical modelling of atmospheric dispersion above extensive complex topography like open-cut coal mine excavation in wind-tunnels results in very small scales. At scales smaller than 1:5000 some of the similarity criteria for atmospheric dispersion modelling can't be met. The problems with two-phase flow modelling arise as well because e.g. threshold or terminal velocity ratio can't be fulfilled. Hence, for this case the computational modelling is very helpful. For future quantitative validation of computational model including two-phase flow modelling over complex terrain we compared the results with those from wind-tunnel experiment.

Methodology and Results
For wind-tunnel model the appropriate area (5 x 5 km) of scale 1:3300 was selected according to wind-tunnel dimensions and previous study (Nosek et. al, 2012). In order to observe the pollutant dispersion from coal mine excavation the selection area includes a necessary part of the coal mine topography with respect to future coal mine expansion and surrounding populated areas. We used simultaneous point measurements of two velocity components and concentration by two dimensional optical fibre Laser Doppler Anemometry (LDA) and Fast-response Flame Ionization Detector (FFID), respectively (see Fig. 1), developed by Kukacka et. al (2012). As a computational model the LES numerical model CLMM (Charles University Large-eddy Microscale Model) was used, see Fuka and Brechler (2011). The model uses large eddy simulation for the turbulent flow and solves the incompressible Navier-Stokes equations using the fractional step method.

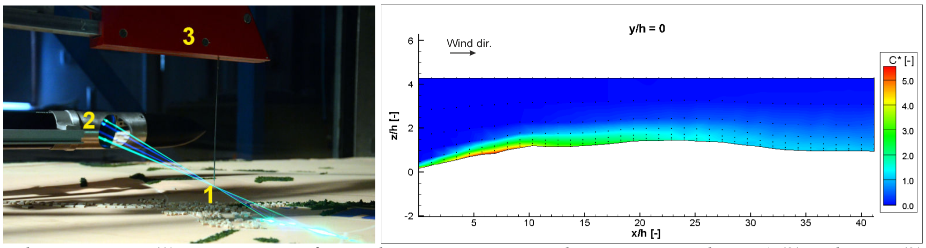

Fig.1 Left: simultaneous point (1) measurement of two velocity components and concentrations by LDA (2) and FFID (3), respectively, during the wind-tunnel experiment; Right: dimensionless concentrations measured at vertical plane parallel to wind direction.

Conclusions
Comparison of results from wind-tunnel experiment with those from LES revealed the following main effects of complex terrain topography and especially surface roughness pollutant dispersion: 1) the highest concentration values are kept within the mine cavity and 2) the plume centre was shifted by magnitude of one mine depth to the north from point source origin. Hence, the LES model was qualitatively validated.

Acknowledgement
Authors acknowledge financial support of project TA01020428 of Technology Agency of the Czech Republic. This work was carried out with institutional support RVO: 6138899

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