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Experimental Study of Gas Dispersion over Complex Terrain

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Abstract: Experimental study of gas dispersion over complex terrain model was performed in VZLU Prague. The terrain model was mounted into a boundary layer wind tunnel and equipped with ground-level gas emission source. Concentration field of the emitted gas was measured using comb suction probe and flame ionization detectors. The results will serve for verification and validation of a new computational dispersion model.

Introduction

The existence of relatively high number of chemical plants in Czech Republic causes an indispensable risk to people living in its neighborhood. Human health and lives can be endangered with many chemical substances stored in the plant areas, e.g. chlorine, ammonia, etc. It is important to know the possible size of an area with lethal concentration of gases in the case of an accident or attack.

The new computational dispersion model, which is being developed in VZLU, is based on numerical simulation of compressible gas flow in the gravitational field and finite volume method of Reynolds-averaged Navier-Stokes equations. The software will use pre-calculated results of flow and dispersion in chosen areas near chemical plants in Czech Republic together with actual meteorological data to estimate the most dangerous area. The estimate will be used by rescue services and firemen to make the rescue action more effective.

The experimental setup and results

The boundary layer wind tunnel (BLWT) in VZLU is an open-circuit wind tunnel with cross section 1.8 m wide and 1.5 m high in test area. The test section for boundary layer development is 13.6 m long and the tunnel is powered with 55 kW fan. Maximal velocity above the boundary layer is 25 m/s, the flow velocity can be measured with hot-wire probes on a traversing mechanism and with a reference Pitot-static tube. The boundary layer simulation has three variants, i.e. agricultural, suburban or urban boundary layer can be simulated in the BLWT according to Eurocode 1 [1].

The terrain model was manufactured from lightweight boards on the basis of a digital terrain model of Liberec city. There is a heating plant with gas tanks near the city center, which presents the possible source of gas leakage. The model was manufactured in scale 1:1500 and presents an area of 9.0 km x 2.4 km in full scale. The modeled area is in northwest-southeast direction along the valley of Lužická Nisa River and contains the heating plant and its densely urbanized neighborhood.

To adjust the incoming boundary layer, lightweight boards covered with 4 mm gravel were mounted ahead of the model in the test section. The boards were glued together in steps, so that a continuous transition from flat plane into the terrain model area was ensured. The terrain model was covered with the same 4 mm gravel in order to increase the aerodynamic roughness. Models of significantly high buildings and housing estates were manufactured too. Other buildings were substituted with the gravel. Part of the terrain model is shown in Fig. 1.

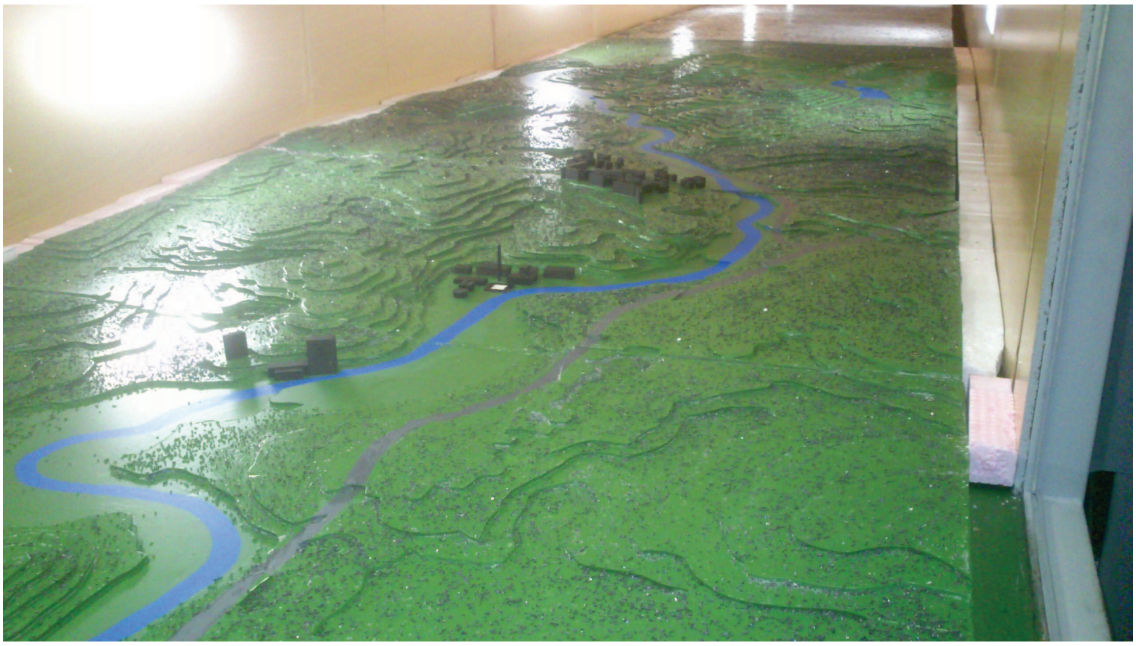

Fig. 1: Front part of the terrain model with emission source (white spot)

Concentration field was measured using suction comb probe, peristaltic pump and four flame ionization detectors (FID). Source emission was air plus ethane as tracer gas dosaged with flow controllers. FID calibration was made with calibration gas mixture with precise concentration 100 ppm of ethane in air. Example of measured longitudinal horizontal concentration profiles for different heights is presented in Fig. 2.

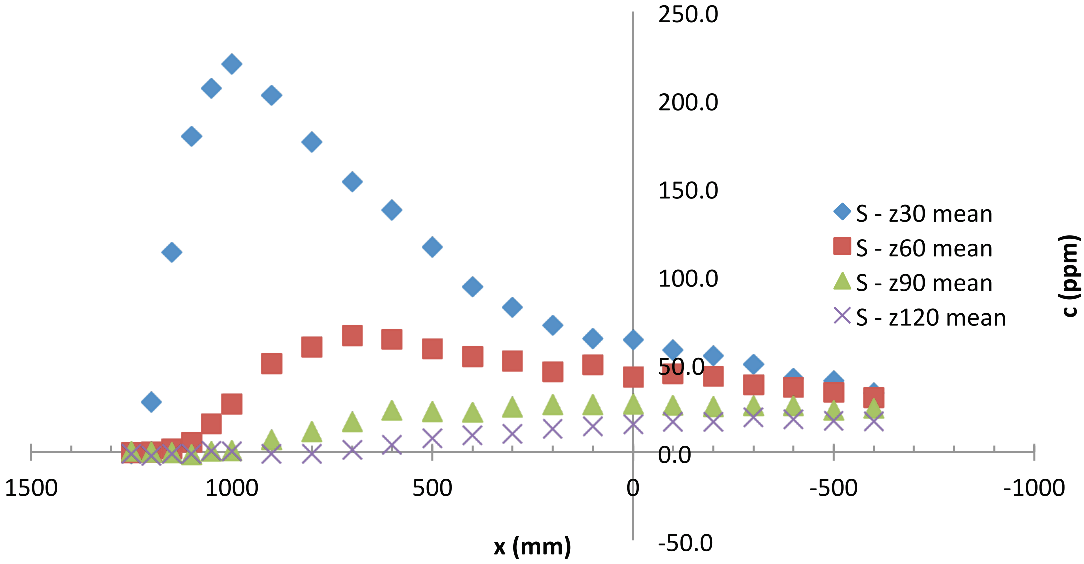

Fig. 2: Horizontal concentration profiles

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References

[1] Eurocode 1: Actions on structures – Part 1-4: General actions – Wind loads (EN 1991-1-4), European Committee for Standardisation, Brussels (2005)