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COMPARISON OF GROUND-LEVEL CENTRELINE CONCENTRATIONS CALCULATED WITH THE MODELS OML, AERMOD/PRIME, MISKAM AND AUSTAL2000 AGAINST THE THOMPSON WIND TUNNEL DATA SET FOR SIMPLE STACK-BUILDING CONFIGURATIONS

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Abstract: In 1990 a comprehensive data set on dispersion behind rectangular buildings was compiled in the US EPA wind tunnel (Thompson, 1993). In this study the data set is used to analyse the performance of several dispersion models with more or less sophisticated approaches for handling building effects. The models are the Danish OML model, the US AERMOD/PRIME model and the German models MISKAM and AUSTAL2000.

THOMPSON'S WIND-TUNNEL DATA

- In 1990 a comprehensive data set on dispersion behind rectangular buildings was assembled in the US EPA wind tunnel, through efforts led by R. Thompson. The data set (around 250 scenarios) systematically analyses the dispersion for a variety of building shapes, stack heights and stack locations.
- An Excel spreadsheet with the Thompson data (also containing the OML and AERMOD model simulation results) is available from the NERI group: atmosphericdispersion.wikia.com/wiki/Thompson_Wind_Tunnel_data

TEST CASES

- From the Thompson data set 3 building cases with 3 stack heights each, in total 9 cases have been selected:
  - o No building
  - o Cubic building
  - o Wide_4 building (crosswind ext. is 4 times the building height)
- Source location: Centred on top of the building, point source.
- Stack height (H_s) above ground: 1, 1.5 and 2 times the building height (H_b).
- Applied wind tunnel scaling factor: 1000.

RESULTS

The dimensionless concentration $c^* = (c u_\infty H_b^2)/Q$ is basis for the discussion. (*c:* measured or simulated concentration, u_∞ : free-stream velocity (4 ms^{-1}) and *Q*: emission rate. The results are depicted in the following figures.

DISCUSSION AND CONCLUSIONS

- It is interesting to note that all of the models have difficulties to reproduce with standard assumptions the measured concentration profiles for the case without building. A possible explanation is that the actual boundary layer profile in the wind tunnel noticeably differed from the standard boundary layer parameterizations as implemented in the models.
- The results for the specific data set of Thompson must be put into context with other validation tests that have been performed for each model in order to evaluate the overall performance of a model. However, this goes beyond the scope of this paper.
- In general, the prognostic procedure of MISKAM seems to be better able to account for details of the flow distortion due to the building as compared to the empirical approaches implemented in AERMOD, OML and AUSTAL2000. On the other hand, a prognostic model like MISKAM requires considerably more user skill and computation time.
- The ability of AUSTAL2000 to apply externally generated wind and turbulence fields in form of a wind field library may open the possibility to apply MISKAM generated fields for longer time series (for example over a complete calendar year), as it is required in regulatory practice.

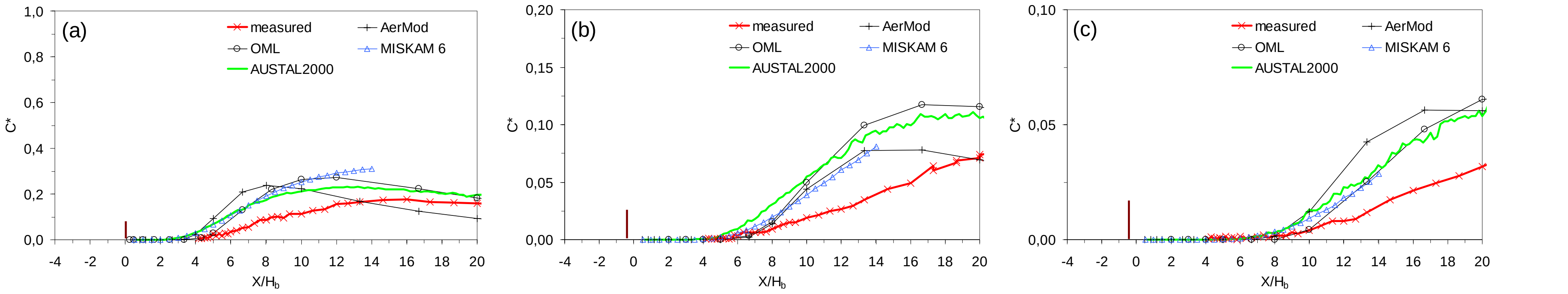

Figure 1. Comparison of measured (red line marked with x) and modelled, along-wind, centreline, dimensionless, ground level concentration profiles for the case **without building**. Stack height divided by building height H_s/H_b: (a) 1.0, (b) 1.5, (c) 2.0.

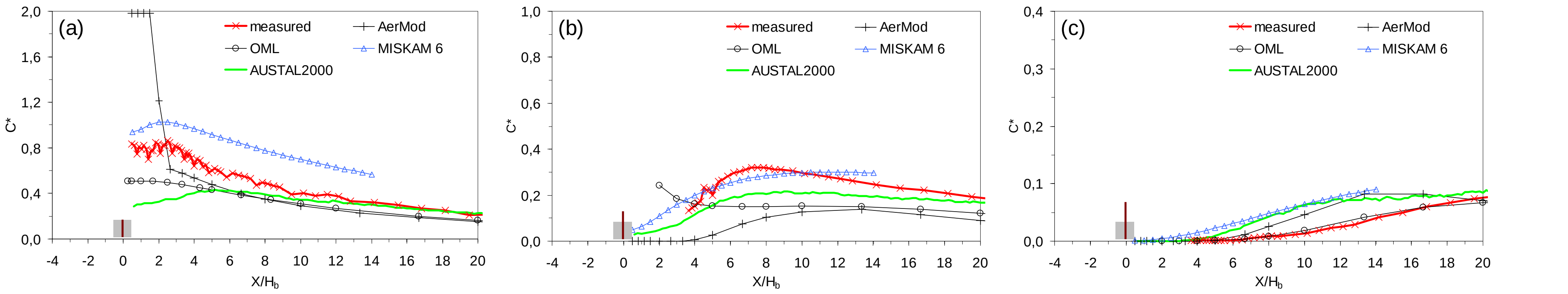

Figure 2. Results for the **cubic building** (axes and stack heights as in Figure 1).

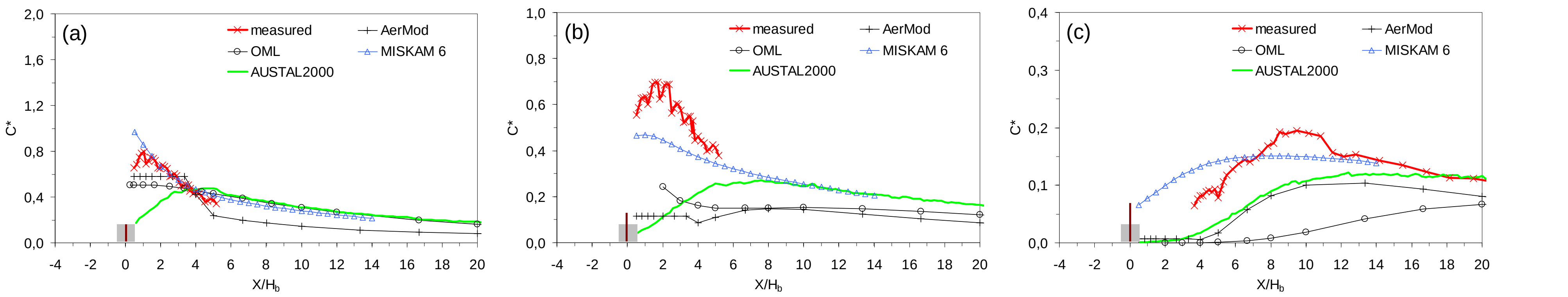

Figure 3. Results for the **wide_4 building**. (axes and stack heights as in Figure 1).

REFERENCES

Donnelly, R.P., T.J. Lyons and T. Flassak, 2009: Evaluation of results of a numerical simulation of dispersion in an idealised urban area for emergency response modelling. *Atmospheric Environment,* **43**, 4416-4423.

Eichhorn, J. and A. Kniffka, 2010: The numerical flow model MISKAM: State of development and evaluation of the basic version, Meteorol. Zeitschrift, 19, 81-90.

Flassak, T and C. Blessing, 2009: Vergleich der Modelle MISKAM und AUSTAL2000 am Anwendungsfall eines U-förmigen Gebäudes. Immissionsschutz, 4/2009, 184-188.

Janicke, U. and L. Janicke, 2004: Weiterentwicklung eines diagnostischen Windfeldmodells für den anlagenbezogenen Immissionsschutz (TA Luft). UFOPLAN 20343256. Dispersion model, wind field model and documentation is provided at http://www.austal2000.de (English/German).

Olesen H.R, R. Berkowicz and P. Løfstrøm, 2007: OML: Review of model formulation. National Environmental Research Institute, Denmark. NERI Techn Report 609, 130 pp, http://www.dmu.dk/Pub/FR609 .

Olesen, H.R., R. Berkowicz, M. Ketzel, P. and P. Løfstrøm, 2009: Validation of OML, AERMOD/PRIME and MISKAM using the Thompson wind tunnel data set for simple stack building configurations, Boundary-Layer Meteorology, 131, 73-83

Thompson, R.S., 1993: Building Amplification Factors for Sources Near Buildings - A Wind-Tunnel Study. Atmospheric Environment, 27A, 2313-2325.

VDI 3945, Part 3, 2000: Environmental meteorology - Atmospheric dispersion models - Particle model, Beuth, Germany

VDI 3783, Part 9, 2005: Environmental meteorology - Prognostic microscale windfield models - Evaluation for flow around buildings and obstacles, Beuth, Germany.