1.30 AN EVALUATION GUIDELINE FOR PROGNOSTIC MICROSCALE WIND FIELD MODELS

K. Heinke Schlünzen[1], Wolfgang Baechlin[2], Harald Brünger[3], Joachim Eichhorn[4], David Grawe[1], Rainer Schenk[5] and Christof Winkler[6]

[1] Meteorological Institute, Centre for Marine and Climate Research, University of Hamburg, Germany,[2] Ingenieurbüro Lohmeyer, Germany,[3] VDI Düsseldorf, Germany,[4] Institute for Atmospheric Physics, Johannes Gutenberg-University, Mainz, Germany,[5] IBS Wettin, Germany,[6] Ingenieurbüro Winkler Würselen, Germany

INTRODUCTION

Obstacle resolving microscale wind field models are frequently used to simulate the flow fields within the obstacle layer. Building effects are treated explicitly within these models, topography as well as temperature and humidity effects are considered. Prognostic equations are solved for wind, and quite frequently for temperature and humidity as well. Turbulent mixing coefficients are calculated on-line and in dependence of stratification, obstacle distance and surface roughness. Typical domain sizes of these models are between several hundred meters and a few kilometres, the horizontal resolution is in the order of metres. The models are sometimes used as a meteorological pre-processor for transport models.

1. General evaluation
   - Comprehensibility
   - Documentation
     - Short description
     - Extended description
     - Users manual
     - Technical reference
2. Scientific evaluation
   - model equations
   - parameterisations
   - boundary conditions
3. Validation
   - Evaluation for selected cases
     - Specification of test cases
     - Evaluation criteria and error tolerances
   - Grid specification
   - Additional on-line quality tests
4. Evaluation protocol
5. Demands on model set-up and control of model results
   - Demands on model grid structure
   - Quality control of model results
   - Evaluation of model results

Figure 1. Structure of the model evaluation guideline.

Despite their frequent application an overall evaluation guideline has not been available up to now for this type of models. In the framework of the German Association of Engineers, VDI, a group has been working on an evaluation guideline in the previous years. This guideline shall serve two purposes:

- It shall allow to evaluate the performance of single models.
- It shall allow to compare model performance of different models and thereby to distinguish general model shortcomings (and thus deficits in our scientific understanding) from single model deficits.

EVALUATION GUIDELINE

The evaluation guideline is based on general ideas on model evaluation by the *Model Evaluation group (1994)*, a conceptual idea for mesoscale models by *Schlünzen (1997)* and a first evaluation concept for microscale models by *Panskus (2000)*. The evaluation guideline for obstacle resolving microscale models (*VDI, 2004*) consists of five parts (Figure 1).

The general evaluation (Part 1) includes criteria on model documentation, publications and, more general, on the comprehensibility of the model. The scientific evaluation (Part 2) specifies the necessary model equations and parameterisations as well as boundary and initial conditions. To give some examples, necessary model qualities are:

- The calculation of all three wind components from prognostic equations.
- The use of the continuity equation or the anelastic approximation.
- The simulation of continuous fluxes (with respect to stratification and/or height).
- The calculation of the fluxes close to the boundaries directly or by employing wall functions.
- The symmetry of the Reynolds stress tensor.
- The explicit treatment of buildings.
- The consideration of building roughness.
- The possibility to use a non-uniform grid in three dimensions.

The validation (Part 3) is the most relevant part of the evaluation. A number of test cases is specified (Table 1) and comparison data are given. These are either taken from other model results (test cases a1, a3, b-2, b-7, b-8, c2), from analytic solutions or plausibility checks (test cases b-1, b-7, c1, c2) or from wind tunnel data (test cases c1, c3, c4, c5, c6). No field data are used, since the flow field within the urban canopy layer is by far too complex. There are no observed wind field data that reflect the complex flow structures adequately. In contrast, wind tunnel data that include a sufficient amount of measurement points are available and have specifically been compiled for model evaluation (CEDVAL, 2001). To receive numerical model results that are comparable with the wind tunnel data, Coriolis force and stratification effects need to be neglected in the numerical model. In addition, the incoming wind and turbulence profiles need to be adjusted to the one used in the wind tunnel measurements. To ensure comparability with the wind tunnel data, the model set-up and initialisation are described in the guideline.

Table 1. Test cases for model evaluation and comparison data sets (M: model results, A: analytic solution or plausibility check, W: wind tunnel data).

Test case	Kind of building	Tested quality	Comparison data set
a1	quasi 2d building	Scaling	M a1-1
a2	quasi 2d building	Stationarity	M a1-2
a3	1 building	Grid size dependence	M a3-1
b-1	no building	Development of boundary layer	A b-1
b-2	no building	Direction of incoming flow	M b-1
b-7	no building	Coriolis force	A b-7, M b-1
b-8	no building	Coriolis force and direction of incoming flow	M b-7
c1	quasi 2d building	Advection, turbulence	W c1, A c1
c2	quasi 2d building	Advection, turbulence	M a1-2, A c2
c3	1 building	Advection, turbulence	W c3
c4	1 building	Direction of incoming flow	W c4
c5	1 building	Width of building	W c5
c6	several buildings	Flow interaction between buildings	W c6

For validating the model results a hit rate q is defined (eq. 1), which defines the percentage of model results O_i within an allowed range D from measured data P_i. D accounts for the relative uncertainty of the comparison data. Only those differences are counted that are above a threshold value W which describes the repeatability of the measured data. For comparison with wind tunnel data a hit rate of $q > 66\ \%$ is demanded, while comparisons with model results or analytic solutions demand a hit rate of $q > 95\ \%$.

$$q = \frac{N}{n} = \frac{1}{n}\sum_{i=1}^{n} N_i \quad \text{with } N_i = \begin{cases} 1 \text{ for } \left|\frac{P_i - O_i}{O_i}\right| \le D \text{ or } \left|P_i - O_i\right| \le W \\ 0 \text{ else} \end{cases} \qquad (1)$$

Part 3 of the guideline also specifies the grid structure to be used for the different test cases. The evaluation protocol (Part 4) summarizes the evaluation results of the previous three parts.

To consider results of new model simulations and thus allow a continuous model evaluation, the evaluation guideline defines in Part 5 demands on the model set-up and model performance. This part of the guideline is to be used, when applying the model to regions and cases that were not already checked in the test cases of Part 3 of the guideline. In Part 5 the grid structure to be used and the evaluation to be made are also given. This part of the guideline can not be applied ahead by a model developer, but needs to be employed by every model user for every model run in a new area, to ensure that a new model result is realistic.

RESULTS

The evaluation guideline has been applied by several modelling groups to check the usability of the guideline itself. Results of the application of the evaluation guideline (parts 1 to 4) are presented during the conference by *Eichhorn (2004)* for the microscale model MISKAM (*Eichhorn et al., 19*88). *Grawe et al. (2004)* demonstrate the use of Part 5 of the guideline by comparing results of the microscale model MITRAS (*Schlünzen et al., 2003*) with wind tunnel data.

CONCLUSIONS

The guideline is currently in review in Germany and will probably be available in an English version in summer 2005. The European-wide application of the guideline could help to distinguish general microscale model shortcomings (and thus deficits in our scientific understanding) from single model deficits by intercomparing the performance of several prognostic microscale wind field models.

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