An evaluation guideline for prognostic microscale wind field models

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- Purpose of guideline
- Structural details
- Results and conclusions

Purpose of Guideline

- Allow a quantitative model evaluation.
- Evaluation of models for simulations of the flow fields within the urban canopy layer.
- Hints for improvements of models.
- Evaluation of the performance of single models.
- Comparison of model performance from different models and thereby detection of general model shortcomings (and thus deficits in our scientific understanding) in contrast to single model deficits.

Structure of Guideline

1. **General evaluation**
2. **Scientific evaluation**
3. **Validation**

Σ **Evaluation Protocol**

Model developer

5. **Control steps** ➡ Model user

1. General evaluation

- Comprehensibility
  - Documentation must be available
  - Source code open for inspection
  - Three publications in refereed journals
- Documentation
  - Short model description
  - Extended model description
  - User manual
  - Technical reference

2. Scientific evaluation

- All three wind components calculated from prognostic equations.
- Use of continuity equation or the anelastic approximation.
- Calculation of continuous fluxes
(with respect to stratification and/or height).
- Direct calculation of the fluxes close to rigid boundaries or employment of wall functions.
- Symmetry of the Reynolds stress tensor.
- Explicit treatment of buildings.
- Consideration of building roughness.
- .....

3. Validation

- Model evaluation for selected cases
  - Specification of test cases
  - Evaluation criteria
- Specification of grid structure
- Additional on-line tests
  - No 2 Δt-oscillations
  - mass conservation
  - no exceedance of threshold values
  - ...

Test cases

	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	Dependence on 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

Evaluation measure

Hit rate q:

percentage of model results P_i within an allowed
- relative difference D and
- absolute difference W from measured data O_i.

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

Comparison with:

- wind tunnel data q > 66 %
- model results or analytic solutions q > 95 %.

4. Evaluation protocol

Compiles all evaluation results on one page

5. Control steps by model user

- Specification of grid structure.
- Quality control of model results.
  - No 2 Δx-oscillations (inspection of cross sections).
  - check of „independence“ of model results from resolution and model area size (5% differences allowed).
  - check model results for plausibility and –whenever possible- quantitatively compare with measurements and results of other models.
- Documentation of model evaluation and model limitations.

Guideline fulfills its purpose

- Allows a quantitative model evaluation. (Hit rates)
- Evaluation of models for simulations of the flow fields within the urban canopy layer.
(models MIMO, MISKAM, MITRAS were used)
- Hints for improvements of models
(e.g. coding error by test cases of type b detected).
- Evaluation of the performance of single models.
(all models were tested independent)
- Comparison of model performance from different models and thereby detection of general model shortcomings (and thus deficits in our scientific understanding) in contrast to single model deficits.
(up to now mainly shortcomings in data sets)

Conclusions and results

• The application of the guideline by several modelling groups showed its usability.

• The guideline is in national review and will be available in English in summer 2005.

• Results of the application of the evaluation guideline (part 5) can be seen on the poster 1.31 by *Grawe et al.* for the microscale model MITRAS.

• Results of the application of the evaluation guideline (part 3) are presented in the following talk by *Eichhorn* for the microscale model MISKAM.

Thank you for your attention