Application of a new evaluation guideline for microscale flow models

J. Eichhorn
Institute for Atmospheric Physics
University of Mainz, Germany
Overview

- The guideline
- The model MISCAM
- Results of consistency checks
- Results of comparisons to wind tunnel data
- Discussion
The Guideline

- **VDI 3783/9 „Environmental Meteorology – Prognostic microscale windfield models – Evaluation for flow around buildings and obstacles“**

- **Topics addressed:**
  - Scalability, stationarity, homogeneity, independance on grid resolution
  - Accuracy in comparison to measurements
Evaluation method

- In each case, agreement between model results ($P_i$) and some reference data ($O_i$) must be quantified.
- Definition of hit rate $q$ in terms of:

$$D: \text{normalized deviation}$$
$$W: \text{total deviation}$$
$$n: \text{Number of data points evaluated}$$

$$q = \frac{1}{n} \sum_{i=1}^{n} N_i$$

$$N_i = 1 \quad \text{for} \quad \left| \frac{P_i - O_i}{O_i} \right| \leq D \quad \text{or} \quad |P_i - O_i| \leq W$$

$$N_i = 0 \quad \text{else}$$
The Model MISCAM

- Three-dimensional non-hydrostatic flow model.
- Simple numerical schemes, model runs on standard PC.
- > 50 users in Europe.
Results of Consistency Checks

- **Scalability**
  - Flow over two-dimensional beam
  - Simulations for two inflow velocities, 10 m/s ($O_i$) and 1 m/s ($P_i$), normalisation of results

- **Criteria for successful evaluation:**
  \[ W = 0.01; \quad D = 0.05; \quad q_{u,w} \geq 0.95 \]

- **Results for MISCAM:**
  \[ q_u = 0.99; \quad q_w = 1.00 \]
Results of Consistency Checks

- Stationarity
  - Same configuration
  - Simulation of stationary wind field \((O_i)\)
    and with number of timesteps doubled \((P_i)\)
- Criteria as above
- Results as above
Results of Consistency Checks

- Grid resolution
- Flow around a cube
- Grid spacing 2.5 m ($O_i$) and 1.25 m ($P_i$)
- Criteria:
  \[ W = 0.05; \quad D = 0.05; \quad q_{u,v,w} \geq 0.95 \]
- Results:
  \[ q_u = 0.99; \quad q_v \approx 1.00; \quad q_w = 0.99 \]
Comparison to wind tunnel data

- Case C3: Flow around a cube
- Criteria: \( W = 0.06; D = 0.25; q_{u,v,w} \geq 0.66 \)
- Result: \( q_u = 0.93; q_v = 0.97; q_w = 0.93 \)
Comparison to wind tunnel data

- Case C5: Flow around a rectangular block
- Criteria: \( W = 0.07; D = 0.25; q_{u,v,w} \geq 0.66 \)
- Result: \( q_u = 0.78; q_v = 0.88; q_w = 0.86 \)
Comparison to wind tunnel data

- Case C6: Array of rectangular obstacles
Comparison to wind tunnel data

- Wind component $u$ (m/s) at $z = 12$ m
Comparison to wind tunnel data

- **Case C6**: Flow around an array of obstacles
- **Criteria**: $W = 0.10; D = 0.25; q_{u,v,w} \geq 0.66$
- **Result**: $q_u = 0.93; q_v = 0.66; q_w = 0.81$
Comparison to wind tunnel data

- An explanation?

**OBS**

**SIM**
Discussion

- MISCAM fulfils the criteria of VDI 3783/9.
- Consistency checks are most useful for model developers.
- Fulfilment of evaluation criteria does not imply perfect agreement with wind tunnel data.
- Failure to fulfil the criteria, however, is a hint to model errors.
Discussion

- Critical evaluation of data sets is mandatory.
- Data sets for more complex situations are necessary.
- An analogous guideline for microscale dispersal models seems worthwhile.
Acknowledgements

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Comparison to wind tunnel data

- Wind component $v$ (m/s) at $z = 12$ m
Comparison to wind tunnel data

- Wind component $w$ (m/s) at $z = 12$ m