An Improved Version of the Microscale Flow Model MISCAM - Evaluation according to VDI Guideline 3783/9

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Outline

- The Model MISCAM
- VDI Guideline 3783/9
- Results of the Evaluation
- Discussion
- Outlook

MISCAM – up to version 5.x

- Threedimensional non-hydrostatic flow model
- *k*-ε turbulence closure, modified as suggested by *Kato & Launder* (1993) and *Lopez* (2002)
- Simple numerical procedures, runs on standard PC
- ~ 100 implementations in Europe

MISCAM – version 6

- Optional: Use of predictor corrector advection scheme (*MacCormack*, 1969) for momentum transport
- Optional: Use of corrected upstream scheme (MPDATA, *Smolarkiewicz*, 1989) for transport of scalars (k, ε)
- Minor bug fixes

VDI guideline 3783/9

Prognostic microscale wind field models

- Evaluation for flow around buildings and obstacles
  - General evaluation
    - Traceability
    - Documentation
  - Scientific evaluation
    - Completeness of model equations
    - Requirements on grid structure etc.

VDI guideline 3783/9

Prognostic microscale wind field models

- Evaluation for flow around buildings and obstacles
  - Validation
    - Consistency checks
    - Comparison to wind tunnel data
  - Final evaluation

Consistency checks

- Homogeneity
- Scalability
- Grid resolution
- Grid orientation
- Steady state





Consistency checks

Steady state:

Upstream advection acted as an accelarator of the overall convergence towards a steady solution

⇨ need to modify internal steady state criterion

⇨ ~15% increase of number of time steps ⇨

Consistency checks

- Homogeneity ☺
- Scalability ☺
- Grid resolution ☺
- Grid orientation ☺
- Steady state ☺

Comparison to wind tunnel data - all data points

	Hit rate % (required according to guideline: 66)			
Test case	u	v	w	
C1 (Beam)	86	./.	96	☺
C3 (Cube, 270°)	94	98	93	☺
C4 (Cube, 225°)	85	76	81	☺

Comparison to wind tunnel data - all data points

	Hit rate % (required according to guideline: 66)			
Test case	u	v	w	
C5 (Cuboid)	77	90	87	☺
C6 (Array of obstacles)	92	68	81	☺

Comparison to wind tunnel data - near field

	Hit rate % (required according to guideline: 66)			
Test case	u	v	w	
C1 (Beam)	70	./.	88	☺
C3 (Cube, 270°)	90	96	88	☺
C4 (Cube, 225°)	76	62	66	☹

Comparison to wind tunnel data - near field

	Hit rate % (required according to guideline: 66)			
Test case	u	v	w	
C5 (Cuboid)	74	86	79	☺
C6 (Array of obstacles)	n.a.	n.a.	n.a.	

Comparison to wind tunnel data

Asymmetry of distribution of hit rates (C4):

- Wind tunnel inflow direction deviates from diagonal orientation (223° instead of 225°)
- Change of results for inflow direction 223°:

	Hit rate % (required: 66)			
C4 (Cube, 223°)	u	v	w	
All data points	85 ⟶ 84	76 ⟶ 81	81 ⟶ 81	☺
Near field	76 ⟶ 76	62 ⟶ 68	66 ⟶ 67	☺

Comparison to wind tunnel data

Array of obstacles (C6):

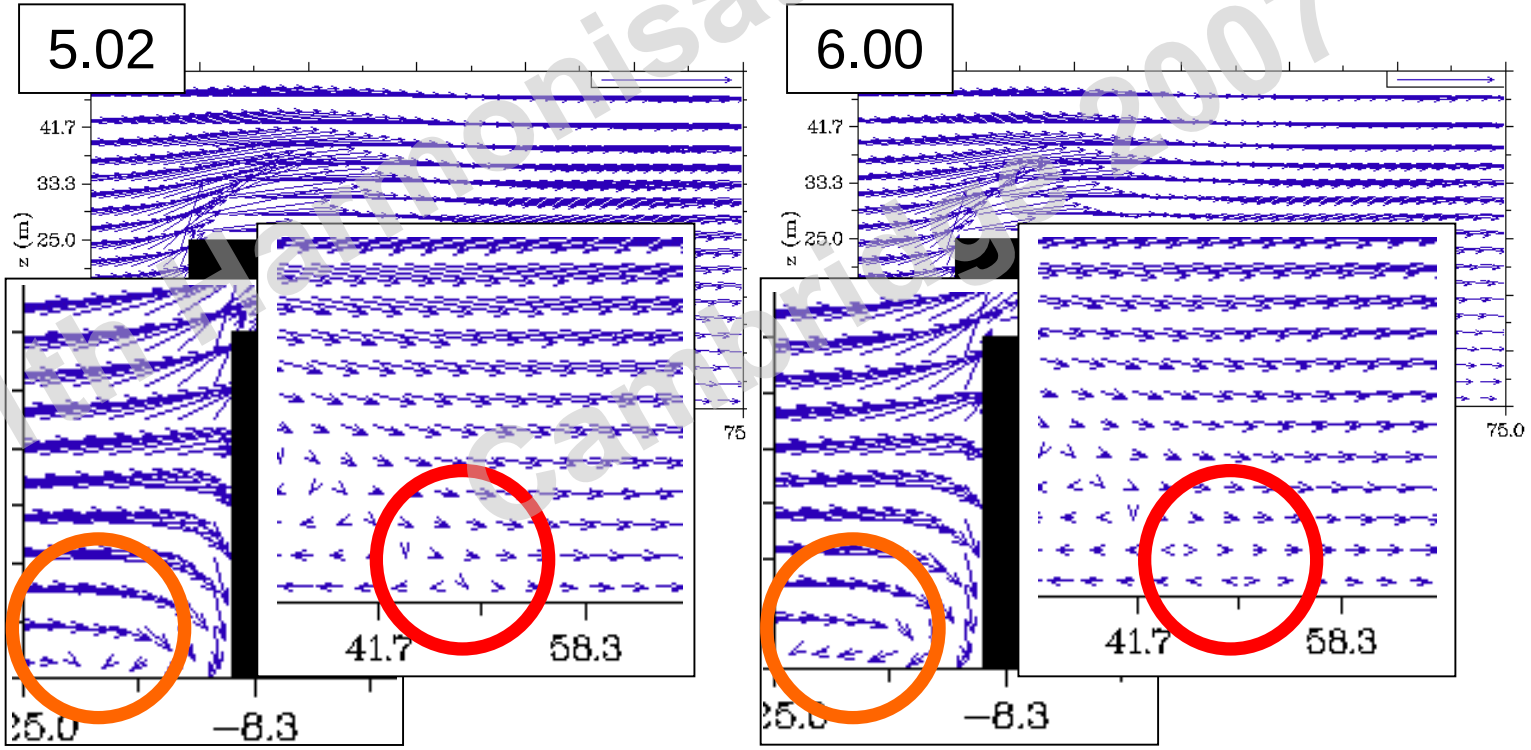
– Speculation!
  Wind tunnel inflow probably not in x-direction

– Model run for inflow direction 250° gives:

	Hit rate % (required: 66)			
Test case	u	v	w	
C6 (array of obstacles)	92 → 93	68 → 84	81 → 81	☺

Comparison 5.02 ↔ 6.00, qualitatively

Cuboid, 270° (C3)



Comparison 5.02 ↔ 6.00, hit rates

	Hit rates % (5.02)			
Test case	u	v	w	
C1 (Beam)	86 (87)	./.	96 (95)	☺
C3 (Cube, 270°)	94 (93)	98 (97)	93 (93)	☺
C4 (Cube, 225°)	85 (84)	76 (76)	81 (81)	☺

Comparison 5.02 ↔ 6.00, hit rates

	Hit rates % (5.02)			
Test case	u	v	w	
C5 (Cuboid)	77 (77)	90 (88)	87 (86)	☺
C6 (Array of obstacles)	92 (93)	68 (67)	81 (81)	☺

Discussion

- Improvement of advection schemes results in marginal improvement of simulates flow field.
- Flow separation at building edges still not reproduced satisfactorily .
- Both MISCAM versions fulfill requirements of the guideline only after correction of inflow profile for case C4.
- No significant deviations between evaluation results for version 5 and 6.
- Users are advised to use version 6 due to higher credibility of results.

Discussion

- Quality of wind tunnel data must be carefully evaluated
- Model developers are advised to carry out validations beyond the requirements of the guideline
- An additional guideline for dispersal models is still missing but is considered necessary

Outlook

- Evaluation results of other developers?
- Alternative data sets?
- Revision of the guideline should include an evaluation of the turbulence closure.
- A comparison of complete wind vectors might be more meaningful than the point by point comparisons of Cartesian wind components.