

Application of a new evaluation guideline for microscale flow models

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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 : normalized deviation

W : total deviation

n : Number of data points evaluated

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

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

$$N_i = 0 \quad \text{else}$$

The Model MISCAM

- Three-dimensional non-hydrostatic flow model.
- k - ε turbulence closure, modifications by *Kato & Launder* (1993) and *Lopez* (2002) applied.
- Simple numerical schemes, model runs on standard PC.
- > 50 users in Europe.

Results of Consistency Checks

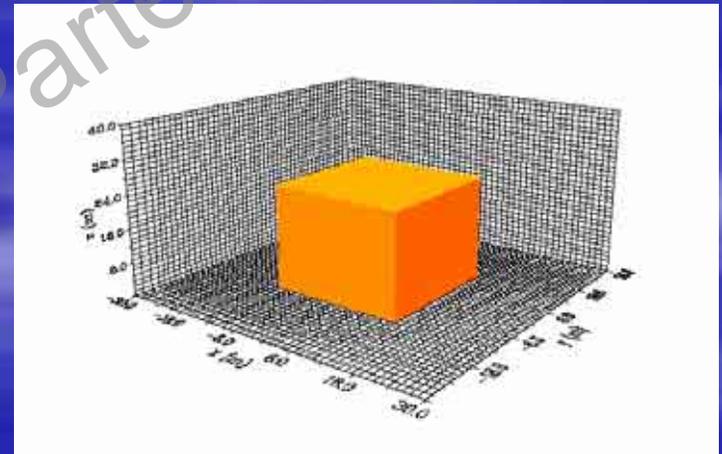
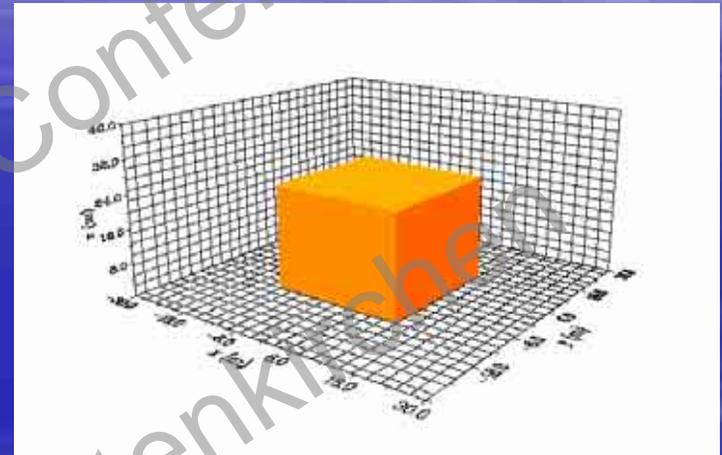
- Scalability
 - Flow over two-dimensional beam
 - Simulations for two inflow velocities, 10 m/s (O_i) and 1 m/s (P_i), normalisation of results
- Criteria for successful evaluation:
 $W = 0.01$; $D = 0.05$; $q_{u,w} \geq 0.95$
- Results for MISCAM:
 $q_u = 0.99$; $q_w = 1.00$

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

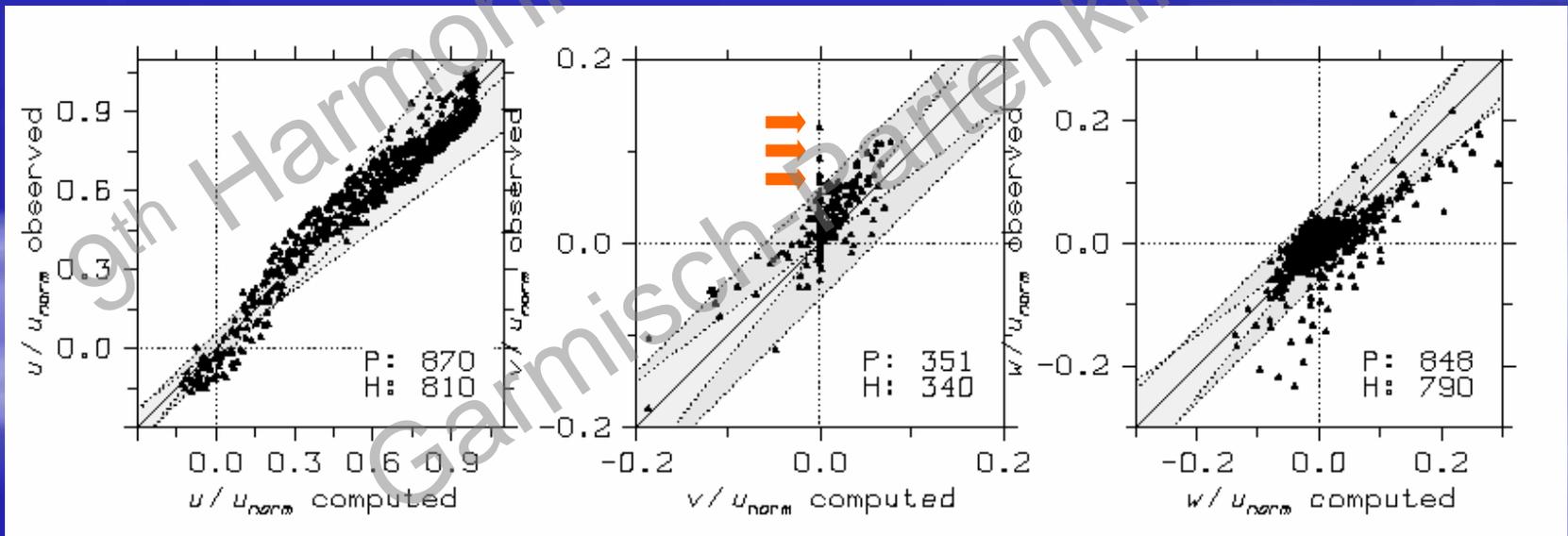
Results of Consistency Checks

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



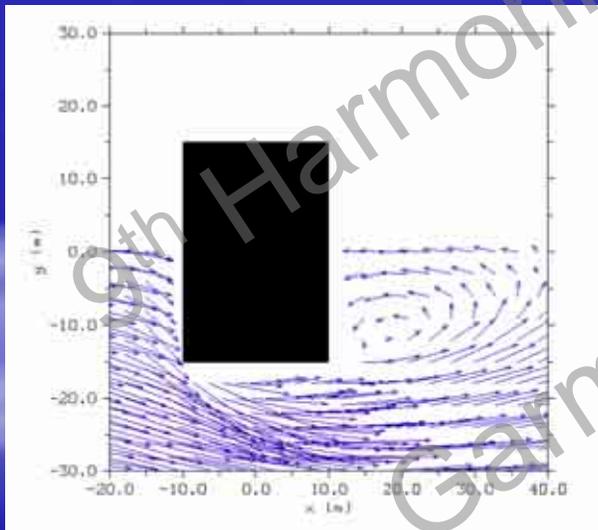
Comparison to wind tunnel data

- Case C3: Flow around a cube
- Criteria: $W = 0.06$; $D = 0.25$; $q_{u,v,w} \geq 0.66$
- Result: $q_u = 0.93$; $q_v = 0.97$; $q_w = 0.93$

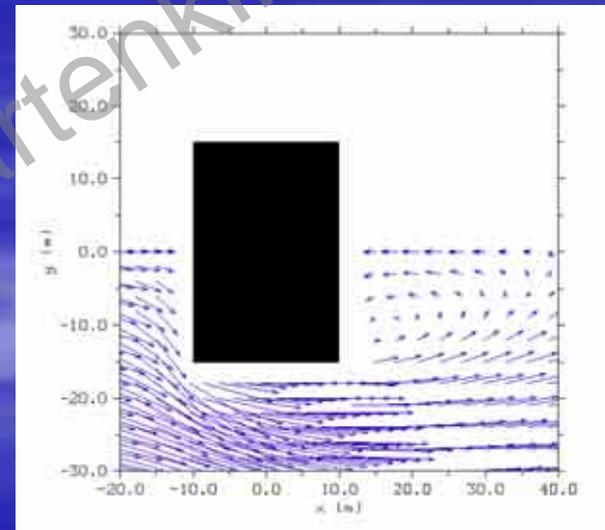


Comparison to wind tunnel data

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



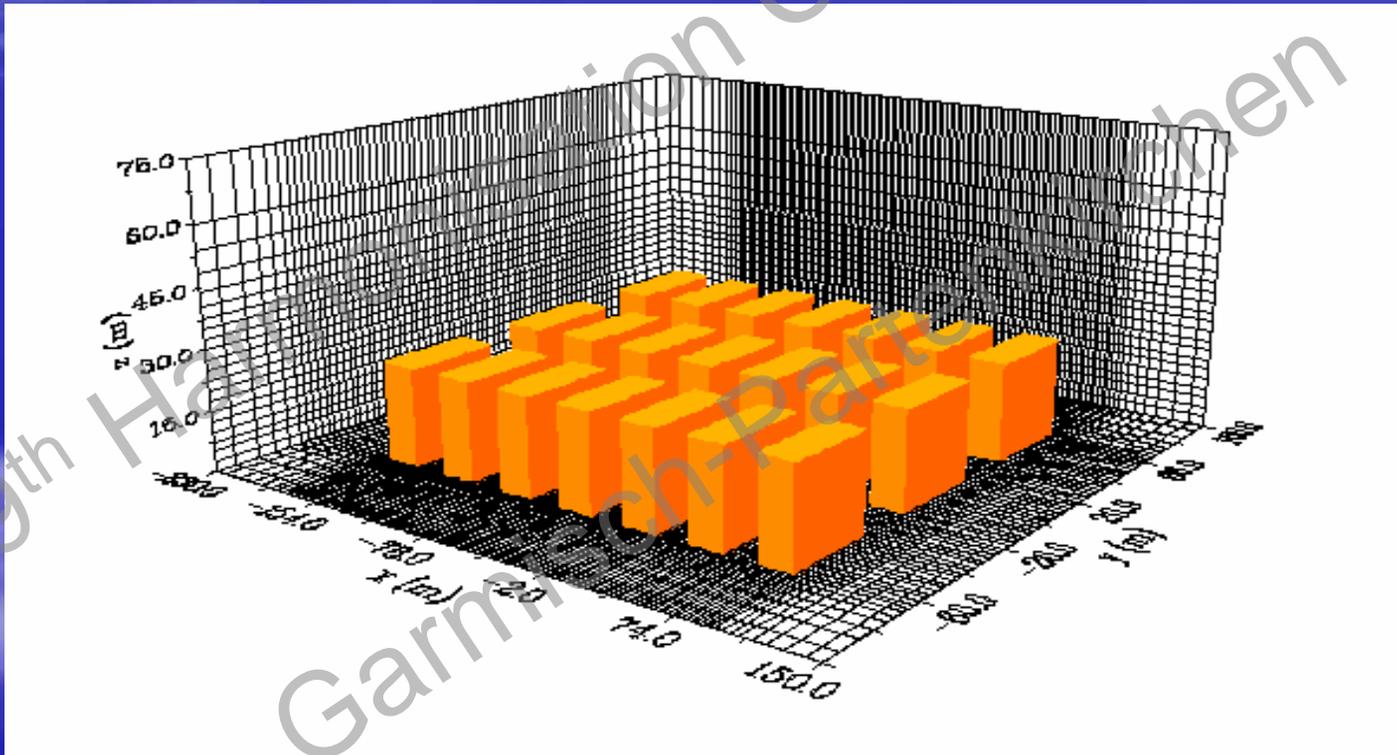
OBS



SIM

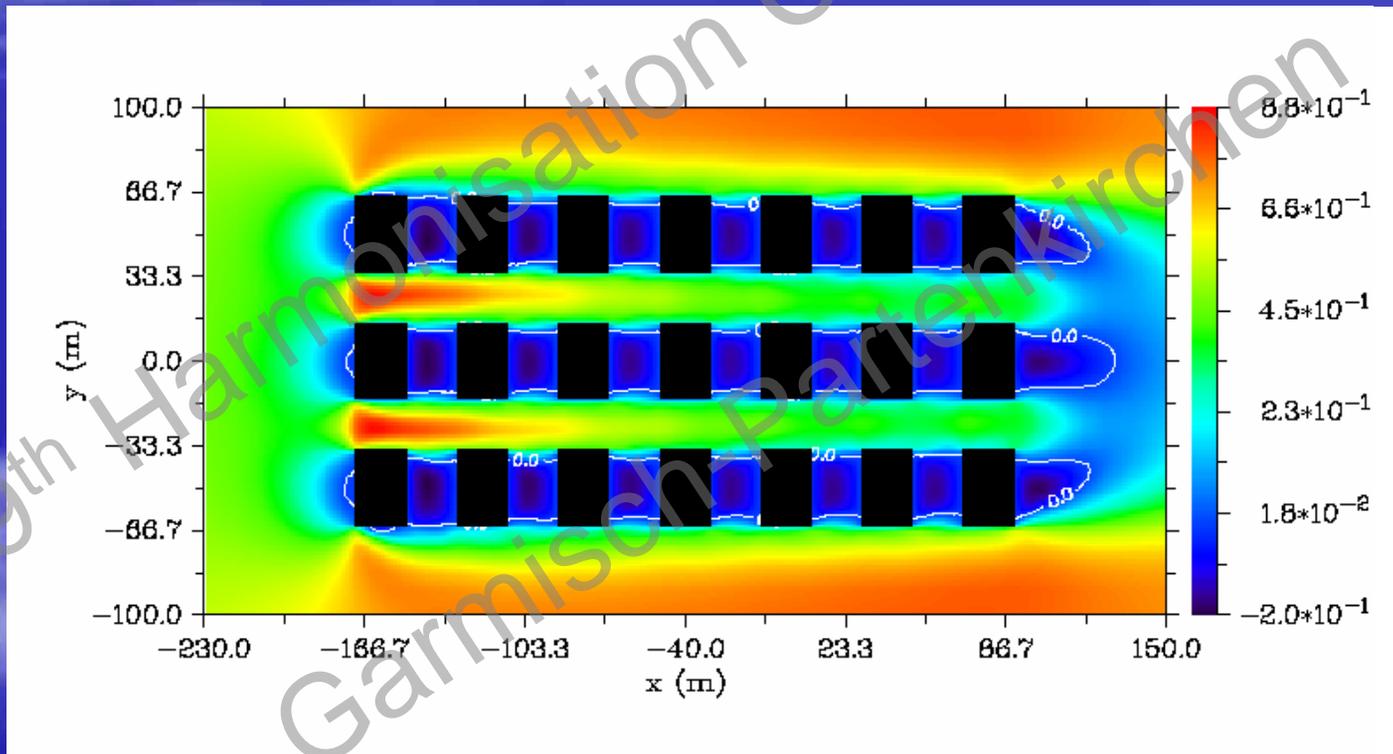
Comparison to wind tunnel data

- Case C6: Array of rectangular obstacles



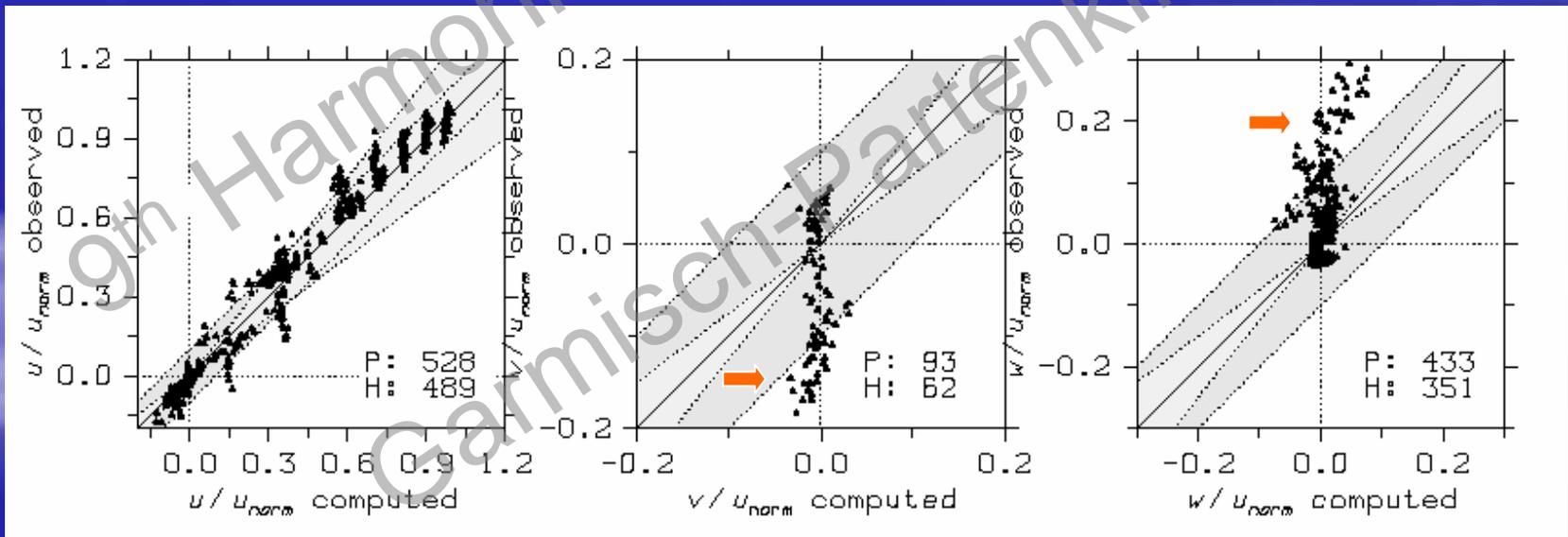
Comparison to wind tunnel data

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



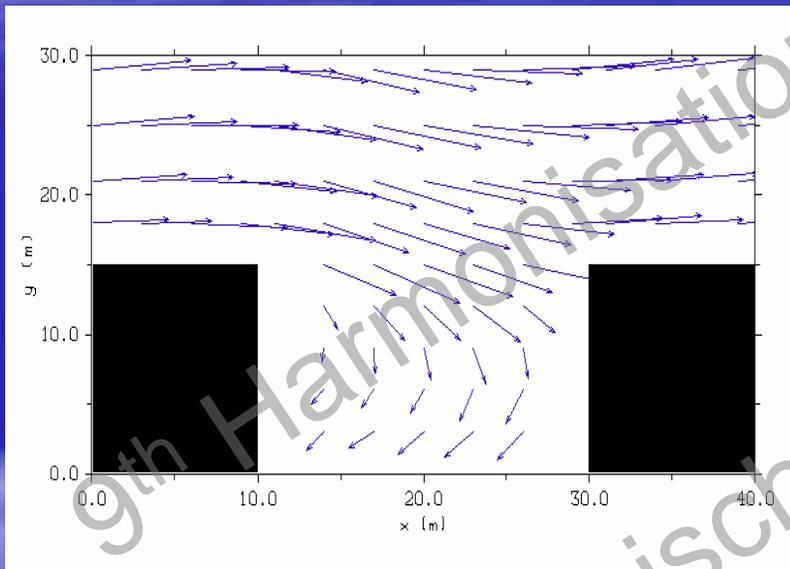
Comparison to wind tunnel data

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

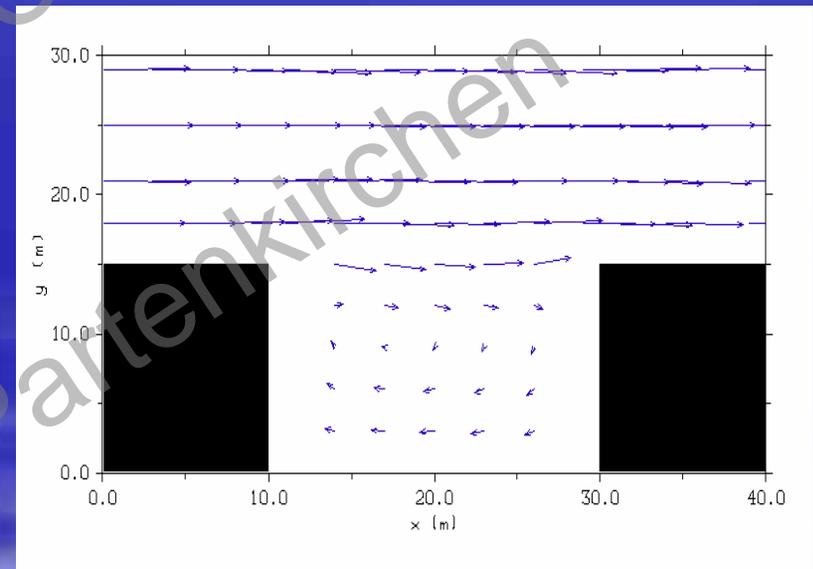


Comparison to wind tunnel data

- 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

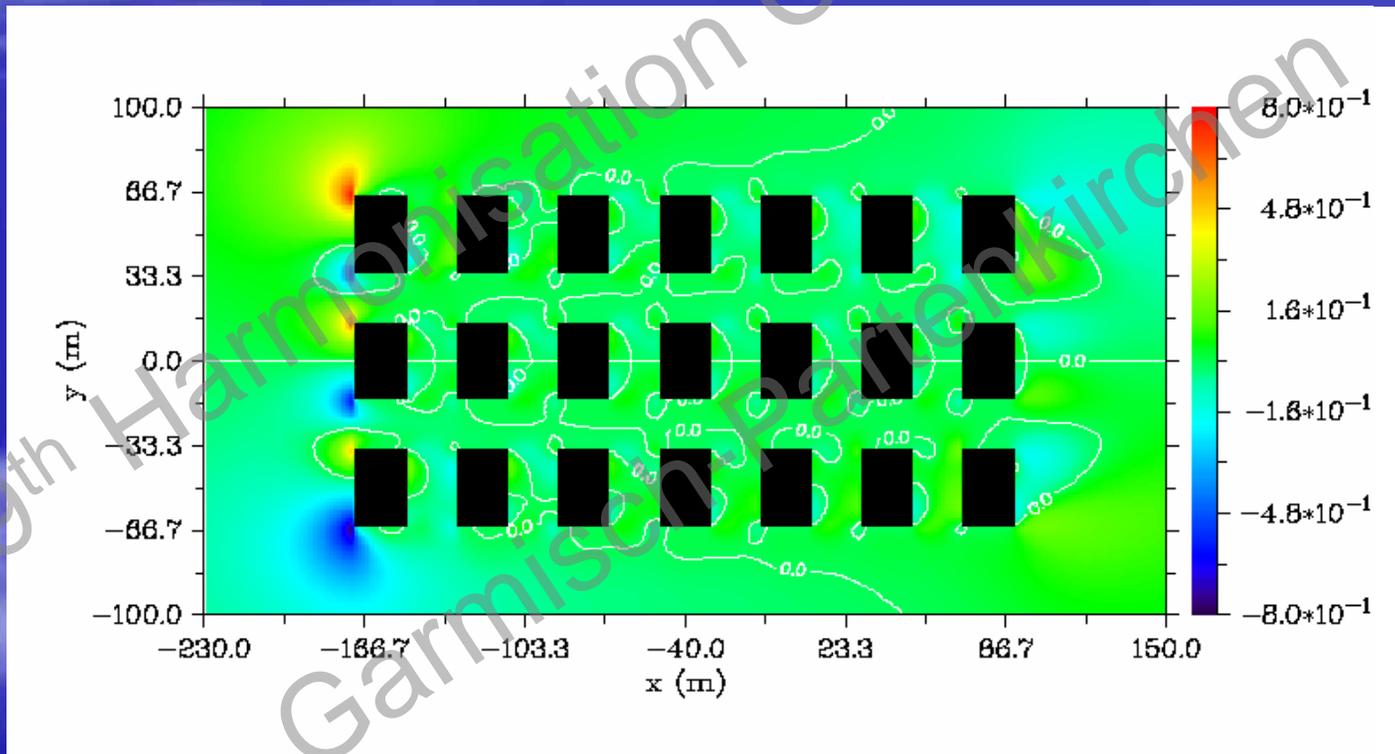
I would like to thank the
members of the VDI working group
for many valuable discussions

...

and everyone here for listening!

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

