



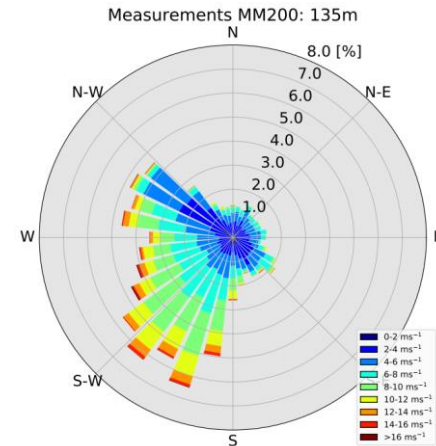
Benchmarking of Microscale Models: The Kassel Blindtest

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Tobias Klaas, Paul Kühn – Fraunhofer IEE

02.04.2019 – NEWA Final Workshop – Wind Europe 2019, Bilbao

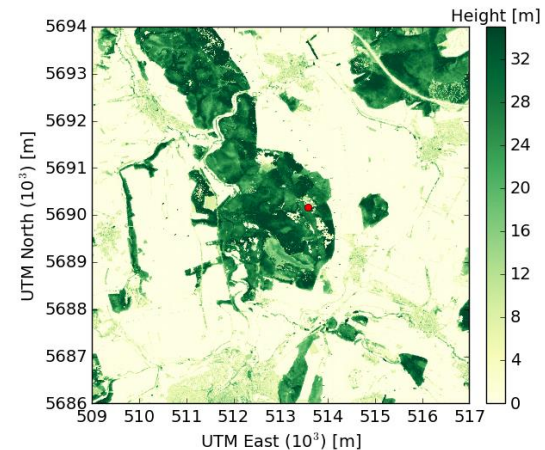
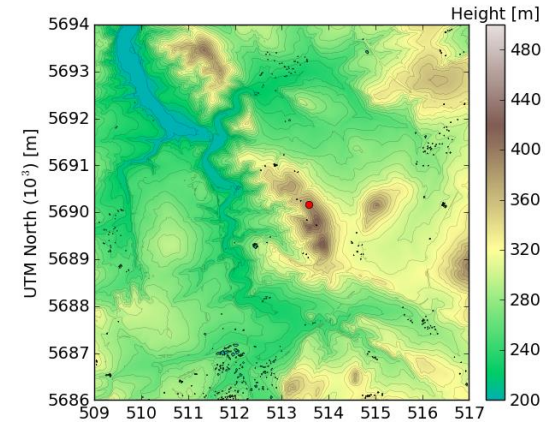
The Kassel Rödeser Berg Experiment

- Forested hill in central Germany
 - Mildly complex terrain 250-500m
 - Forest height 20-35m
- Focus on flow along main wind direction [south-westerly]
 - 2 tall met masts
 - 6 vertical profilers
 - 9 lidar wind scanners
- Measurement campaign in 2016-2017
 - Full campaign (masts only): Nov. 2016 - Oct. 2017
 - Intense campaign: Oct. 2016 - Jan. 2017



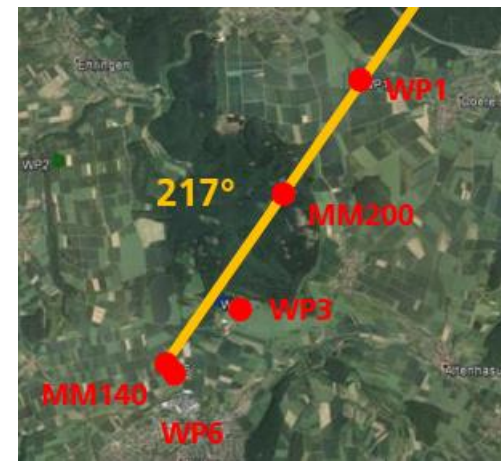
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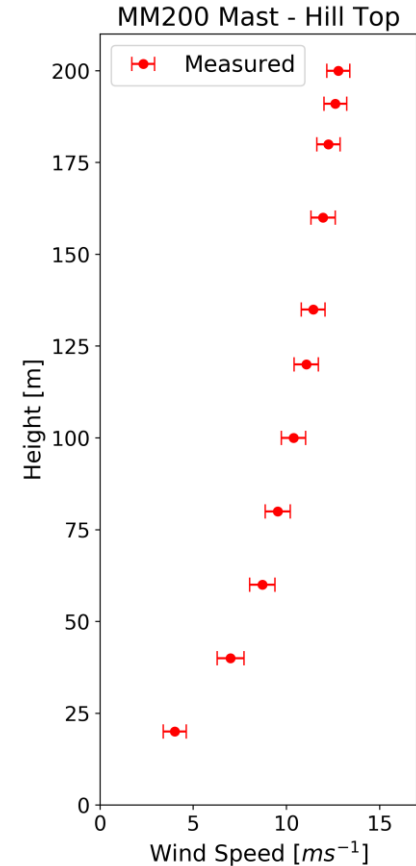
The Rödeser Berg Blind Tests

- Two Phases:
 - Phase 1: Flow across the hill → Finished
 - Phase 2: Transfer wind statistics → Still running
 - Target group: all CFD (LES + RANS) models applied in wind energy research and industry
- Phase 1: Flow across the hill
 - Focus on flow along main wind direction – single common flow cases
 - Analysis of wind and turbulence profiles and vertical planes
 - Different atmospheric stratifications: Neutral + 2 stable cases
- *Provided Data:*
 - Detailed terrain and forest data
 - Wind profile and stability measurement on top of hill



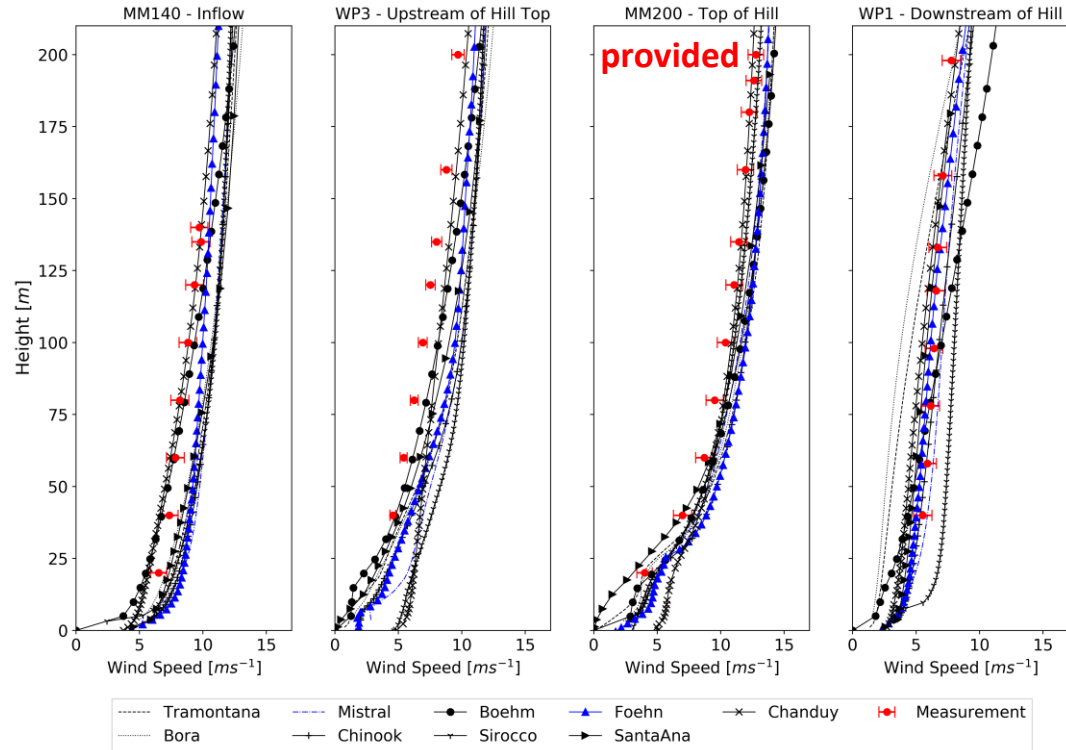
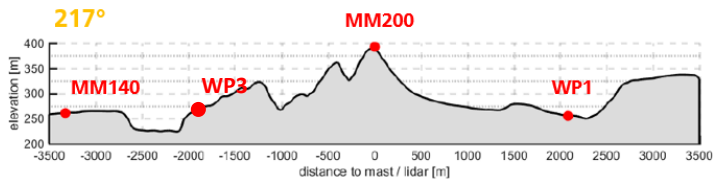
Blind Test Phase 1 – Flow Across Hill - Neutral

- Provided Data:
 - Wind Profile measurement on Hill Top
 - 17.11.2016 – around noon
 - Neutral Stratification: $L \sim 4000\text{m}$
 - Wind Direction: ~ 220 degree (almost exactly along transect)
- Neutral case: 7 Participants, 3 from industry
 - 10 different models (RANS and LES)



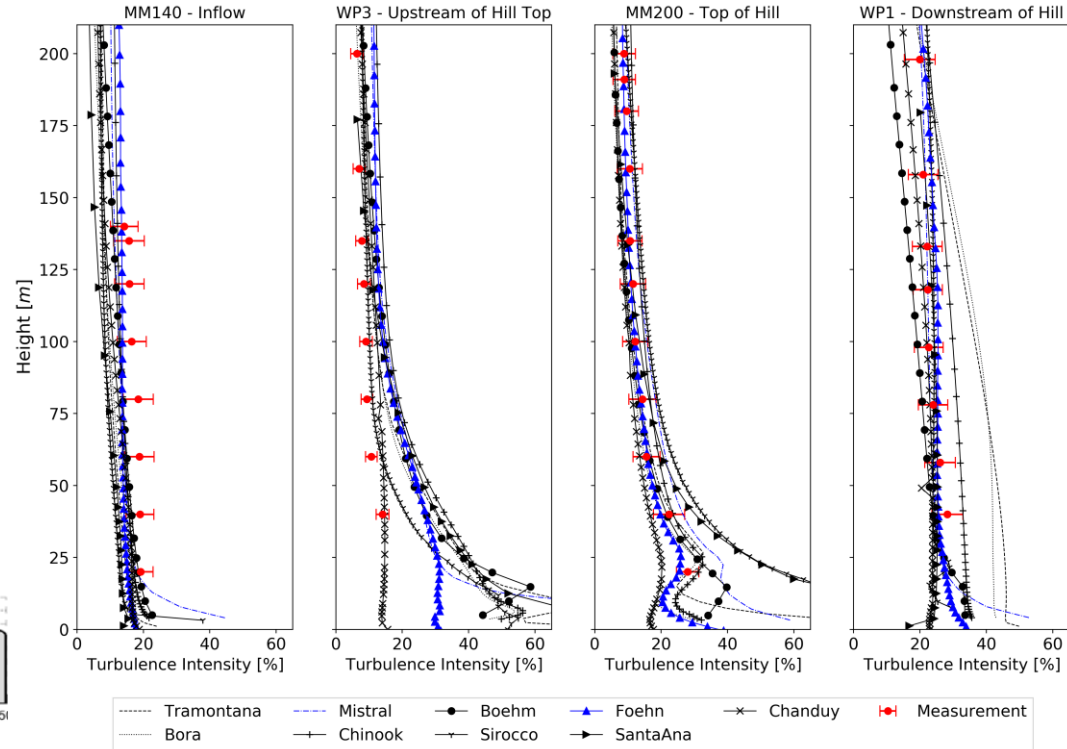
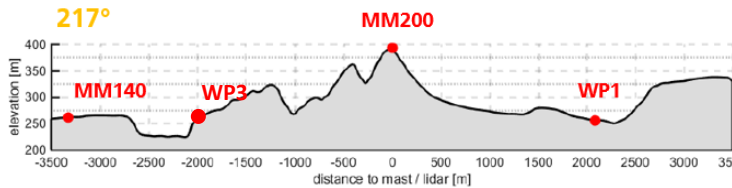
Blind Test Phase 1 – Flow Across Hill - Neutral

- Neutral Stratification
- Wind Speed
- Correct modelling of forest is very critical
- **LES** models do not outperform **RANS** for this mildly complex site



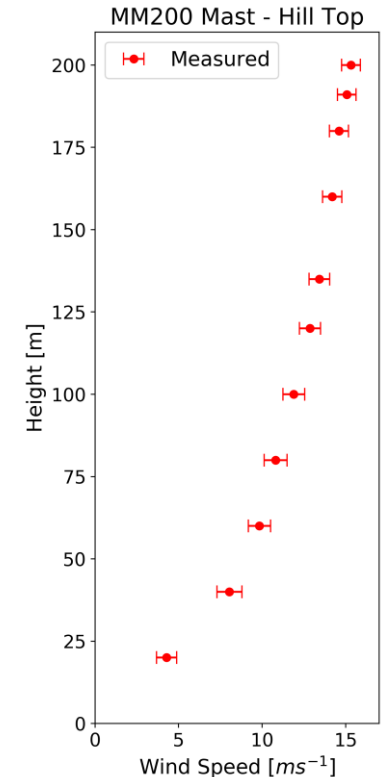
Blind Test Phase 1 – Flow Across Hill - Neutral

- Neutral Stratification
- Turbulence Intensity
- Large differences especially in lower altitudes (in the forest)



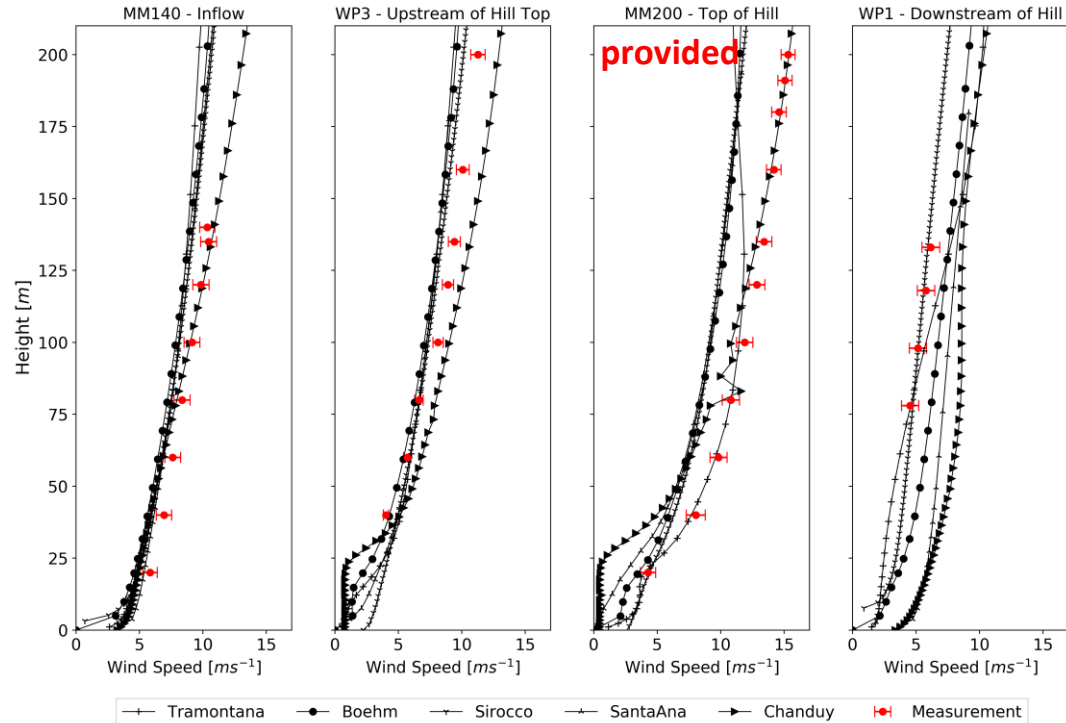
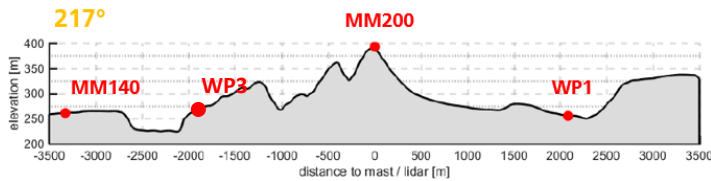
Blind Test Phase 1 – Flow Across Hill – Slightly Stable

- Provided Data:
 - Wind Profile measurement on Hill Top
 - 18.11.2016 – around 16:00-17:00
 - Slightly Stable Stratification: $L \sim 350\text{m}$
 - Wind Direction: ~ 210 degree
- Slightly stable case: 5 Participants, 3 from industry
 - 5 different models (all RANS)



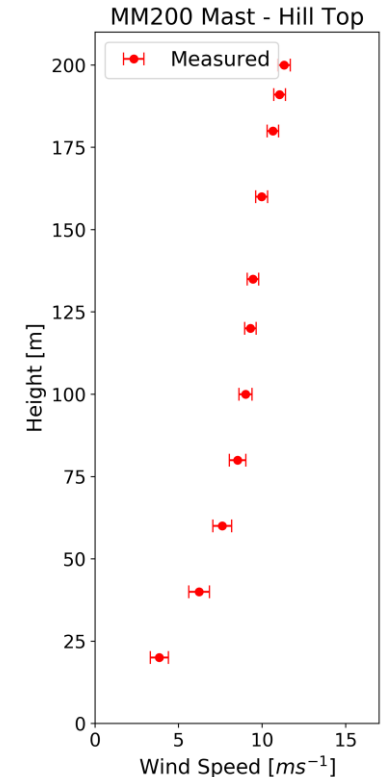
Blind Test Phase 1 – Flow Across Hill – Slightly Stable

- Slightly Stable Stratification
- Wind Speed
- Inflow is well represented by all models
- Wake of the hill shows large differences



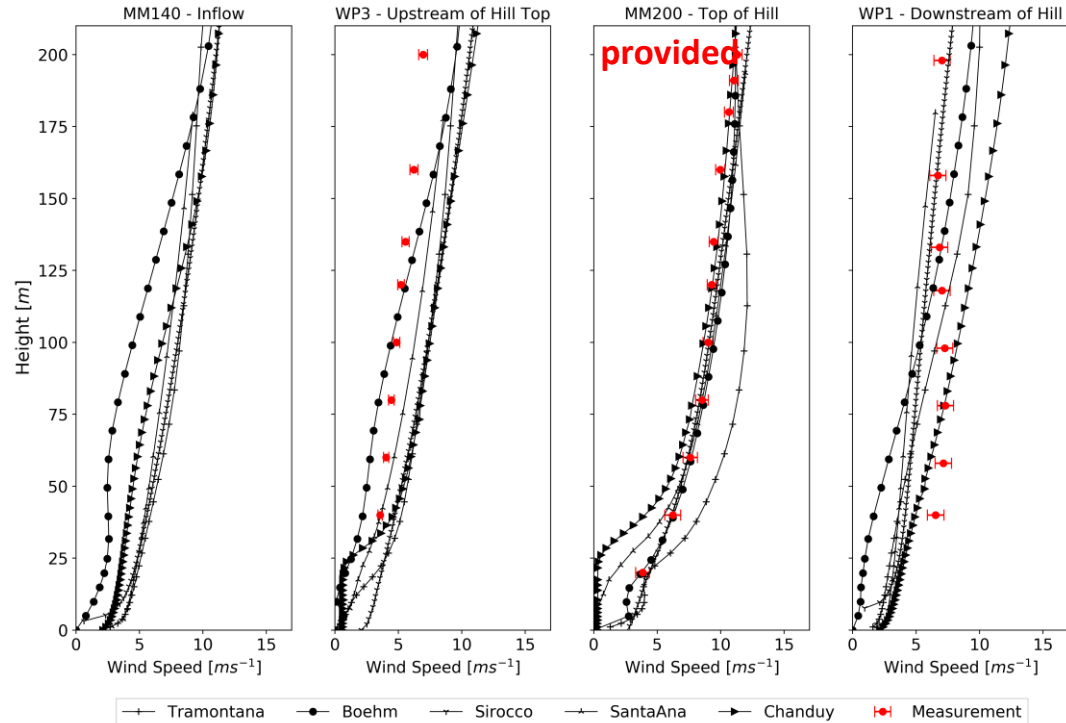
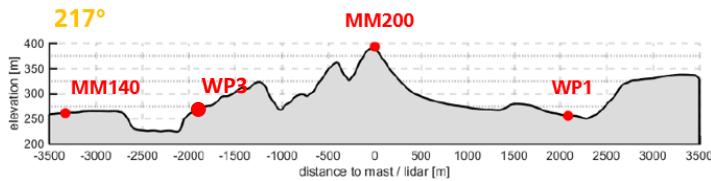
Blind Test Phase 1 – Flow Across Hill – Stable

- Provided Data:
 - Wind Profile measurement on Hill Top
 - 09.12.2016 – around 04:00 AM
 - Stable Stratification: $L \sim 250\text{m}$
 - Wind Direction: ~ 220 degree at 120m
- **Stable case:** 5 Participants, 3 from industry
 - 5 different models (all RANS)



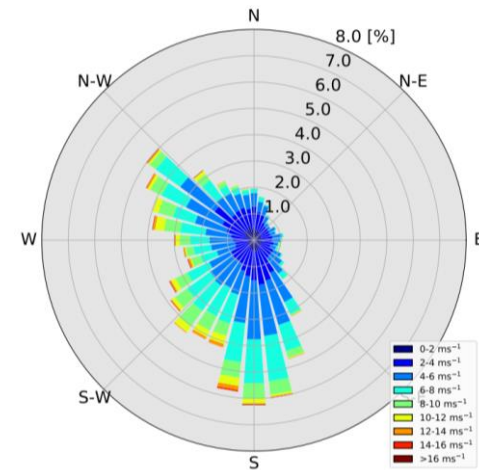
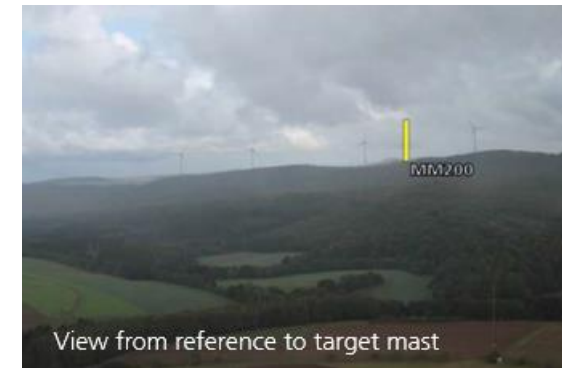
Blind Test Phase 1 – Flow Across Hill – Stable

- Stable Stratification
- Wind Speed
- Inflow is well represented by all models
- Wake of the hill shows large differences



Outlook: Blind Test Phase 2 - AEP

- One year time series from two masts in complex terrain
- Task: Transfer the wind statistics from one site to another
- Provided: time series from one met mast
- Benchmark is coordinated via: <https://thewindvaneblog.com/>



Participation is still possible (until end of April), feel free to contact us and participate!

Conclusions

- Two rounds of blind tests base on Kassel Rödeser Berg Experiment
 - Phase 1: flow across hill in main wind direction (finished)
 - Phase 2: statistics and annual energy production (still open and running)
- Lidars (scanners and profilers) are well suited for high-fidelity model benchmarking and development
- Kassel blind tests will be available as regular benchmarks for model development in the future

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Acknowledgements



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- The Swedish Energy Agency (Sweden)
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Questions?

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Photo by Nicholas Doherty on Unsplash

Thank You for Your Attention

