



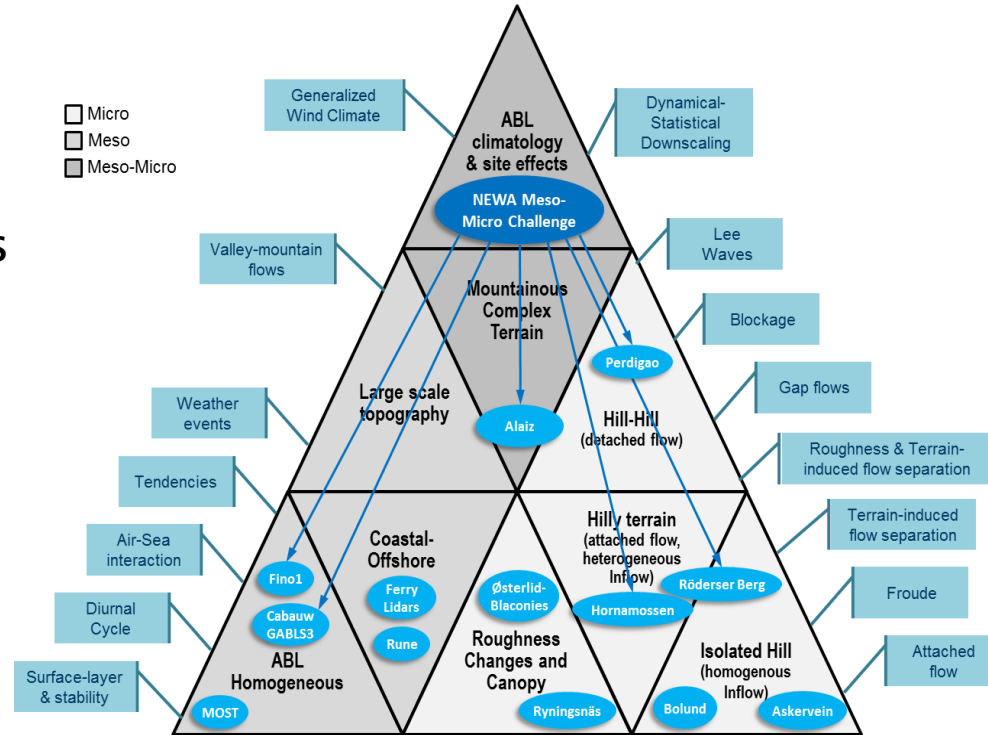
# Validation of meso- and micro-scale models: results from the NEWA benchmarks

Dr. Martin Dörenkämper, Dr. Bernhard Stoevesandt, Dr. Julia Gottschall – Fraunhofer IWES  
Dr. Björn Witha – ForWind Universität Oldenburg  
Tobias Klaas, Dr. Paul Kühn – Fraunhofer IEE

05.07.2019 – ForWind – Wind Physics Symposium 2019, Windlab Oldenburg

# Overview

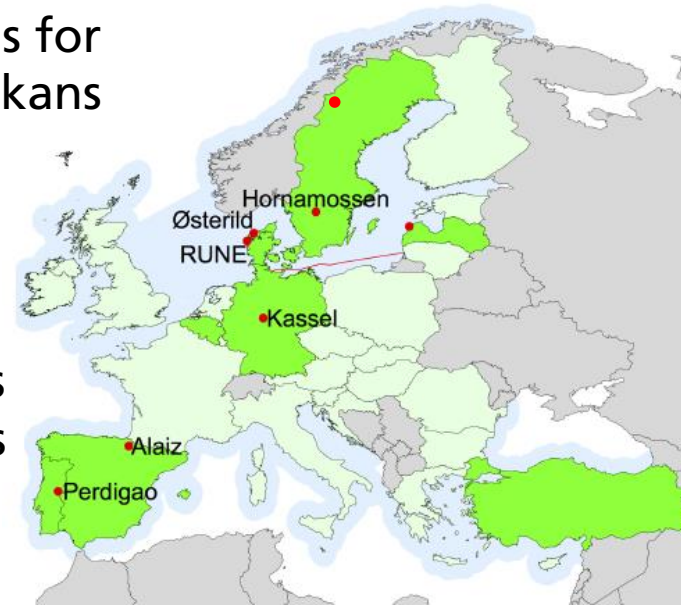
- The NEWA Experiments
- Kassel Rödeser Berg Benchmarks
  - Results Round 1
  - Outlook Round 2
- Ferry Lidar Benchmark
- Conclusions & Outlook



*Sanz Rodrigo et al. (2019)*

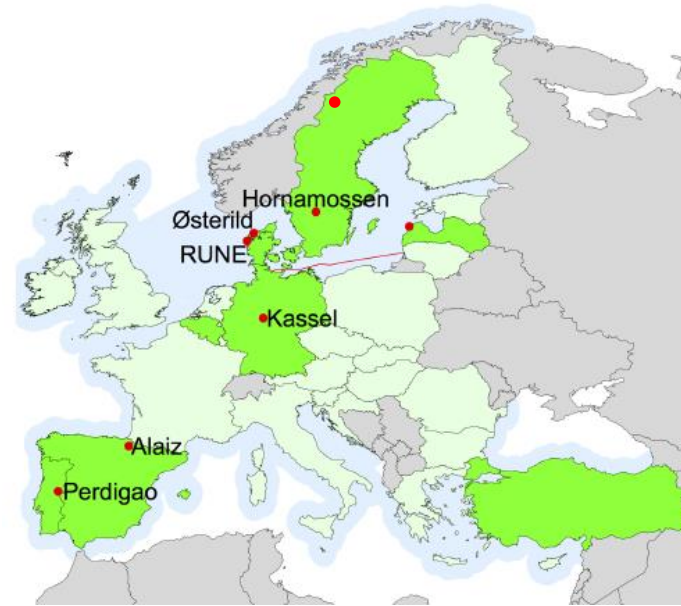
# The NEWA Experiments

- New European Wind Atlas project focused on:
  - Generation of a meso- and microscale atlas for all EU countries + Switzerland/Norway/Balkans
  - Development of advanced methods for downscaling of wind resources
  - Several large-scale experiments with lidars and wind scanners to validate flow models commonly used in wind energy applications



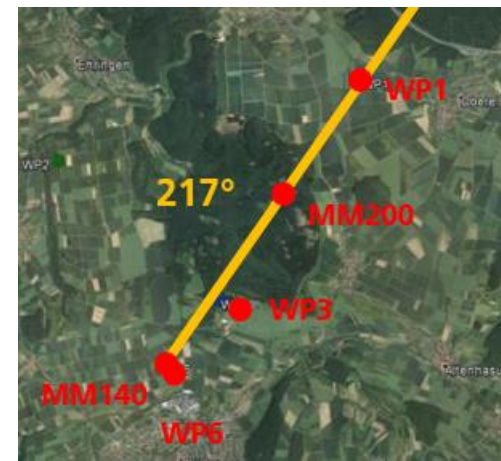
# The NEWA Experiments

- **Northern Experiments**
  - Ferry Lidar (2017)
  - Coastal Experiments (2015/2016)
  - Forested flat terrain (2017/2018)
- **Kassel Rödeser Berg (2016-2017)**
  - Forested hill in mildly complex terrain
- **Perdigao (2017-2018)**
  - Flow across a forested double ridge
- **Alaiz (2018-2019)**
  - Very complex terrain



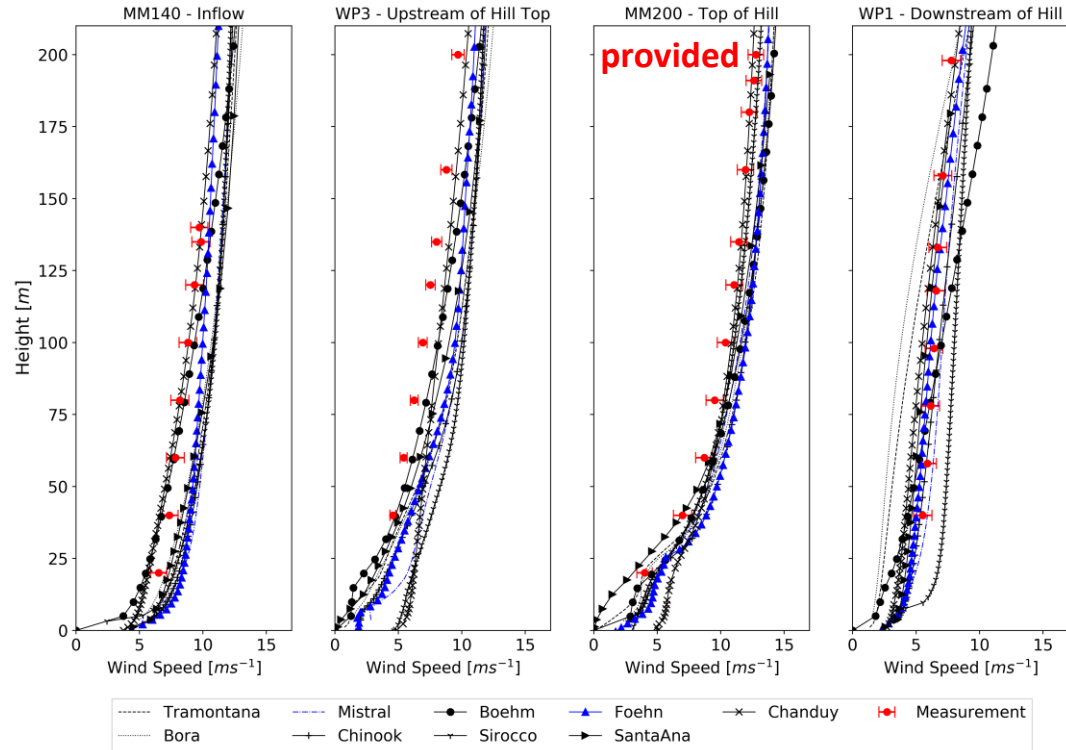
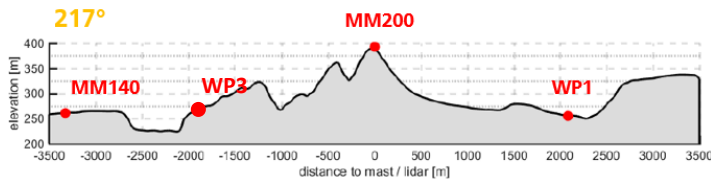
# The Rödeser Berg Blind Tests

- 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



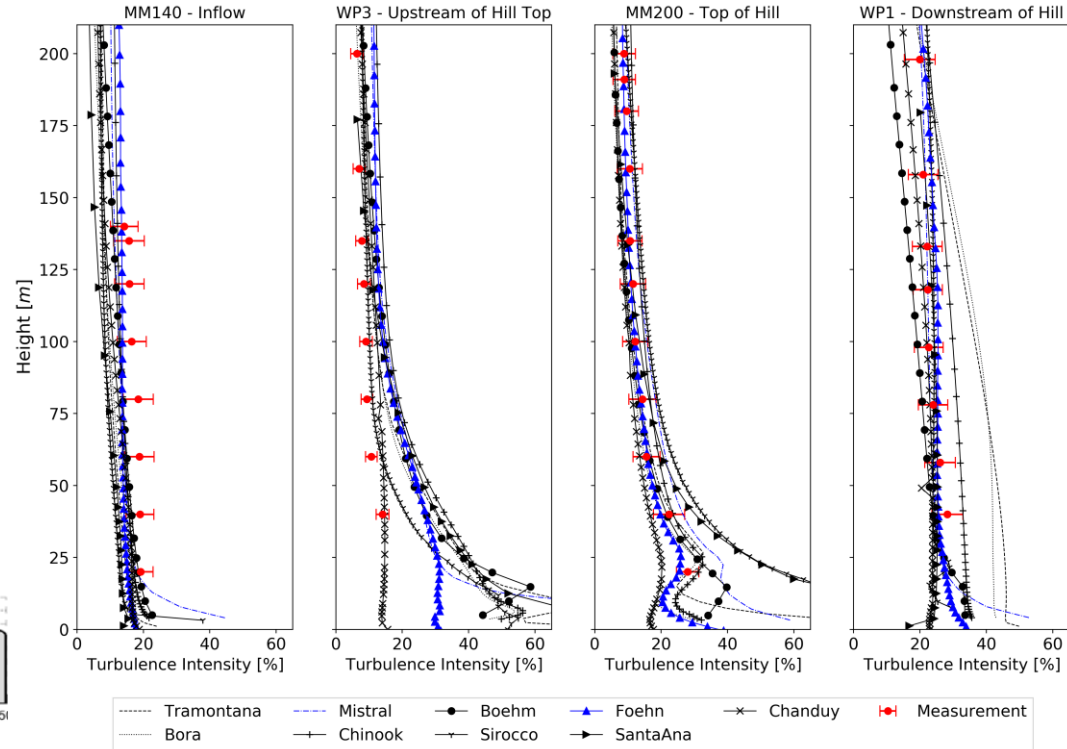
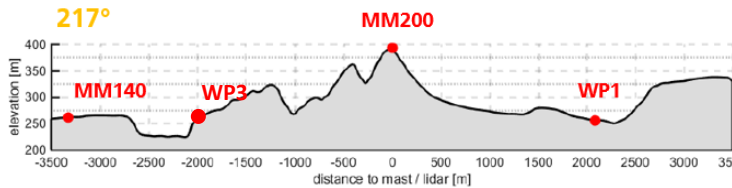
# Blind Test Phase 1 – Flow Across Hill - Neutral

- 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

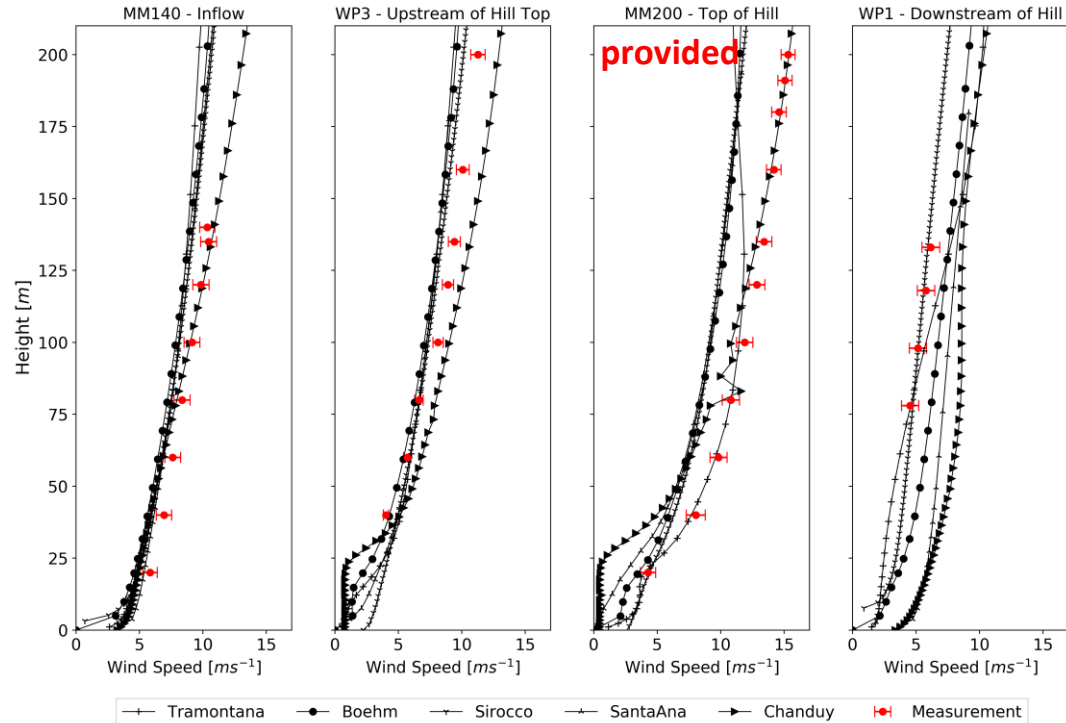
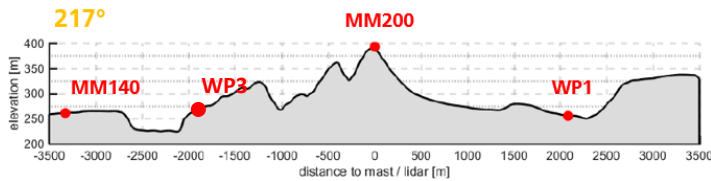
- Neutral Stratification
- Turbulence Intensity
- Large differences especially in lower altitudes (in the forest)





# Blind Test Phase 1 – Flow Across Hill – Slightly Stable

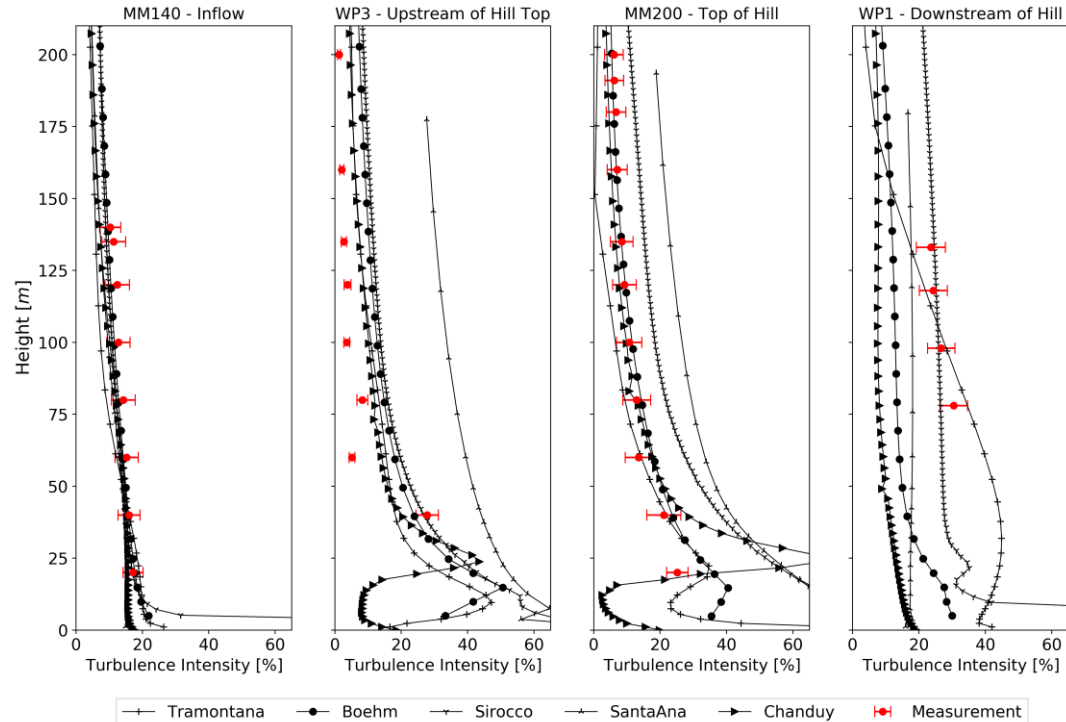
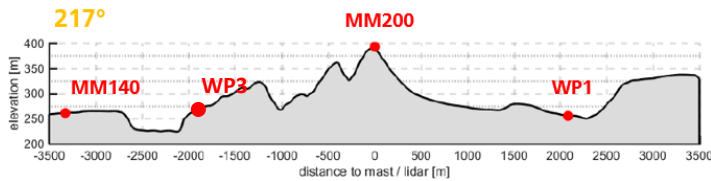
- Slightly Stable Stratification
- Wind Speed
- Inflow is well represented by all models
- Wake of the hill shows large differences





# Blind Test Phase 1 – Flow Across Hill – Slightly Stable

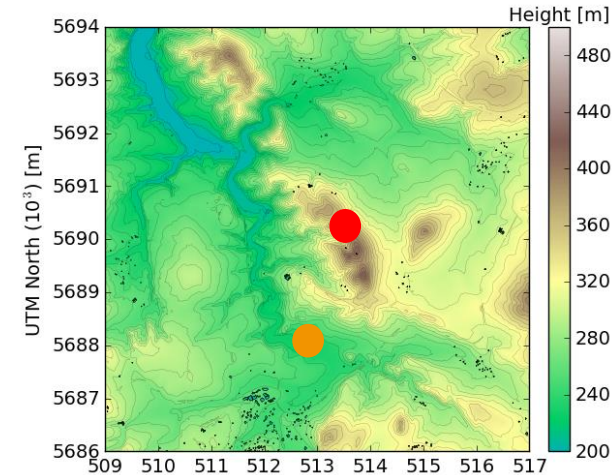
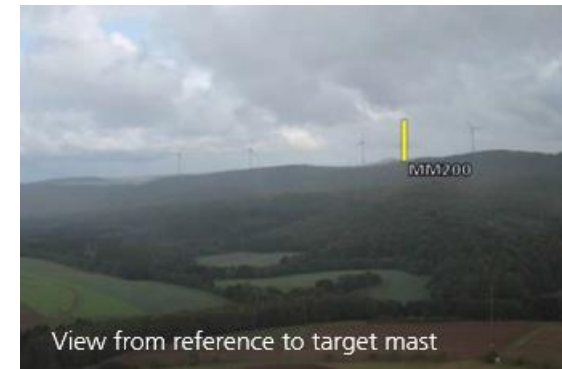
- Slightly Stable Stratification
- Turbulence Intensity
- Inflow is well represented by all models
- Wake of the hill shows large differences



# Blind Test Phase 2 - AEP

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

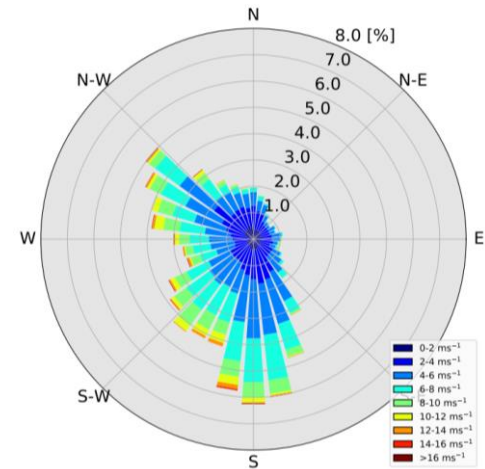
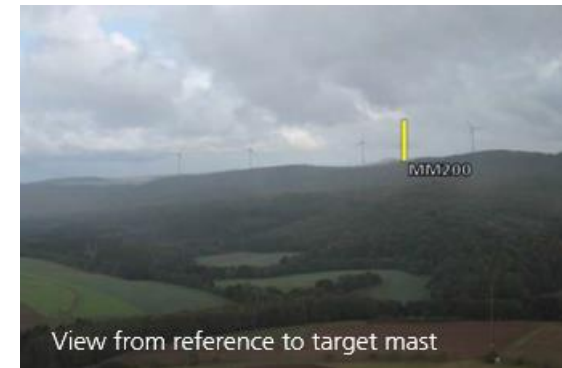
**Participation is still possible, feel free to contact us and participate!**



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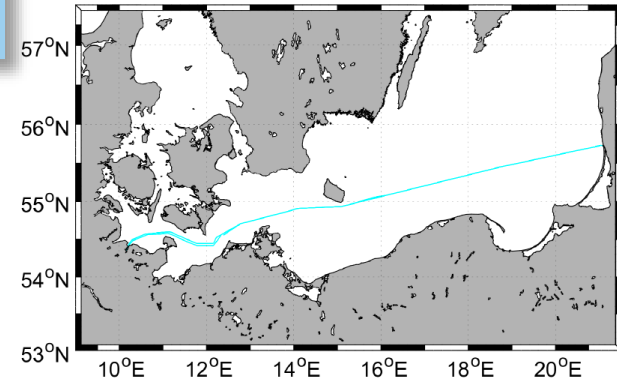
**Participation is still possible, feel free to contact us and participate!**



# Ferry Lidar Experiment

- Fraunhofer IWES ship lidar system installed on regular ferry travelling through the Southern Baltic Sea between Germany and Lithuania
- Measured vertical wind profiles continuously between February and June 2017

J. Gottschall et al. (2018): The NEWA Ferry Lidar Experiment: Measuring Mesoscale Winds in the Southern Baltic Sea, *Remote Sens.*, **10**, 1620



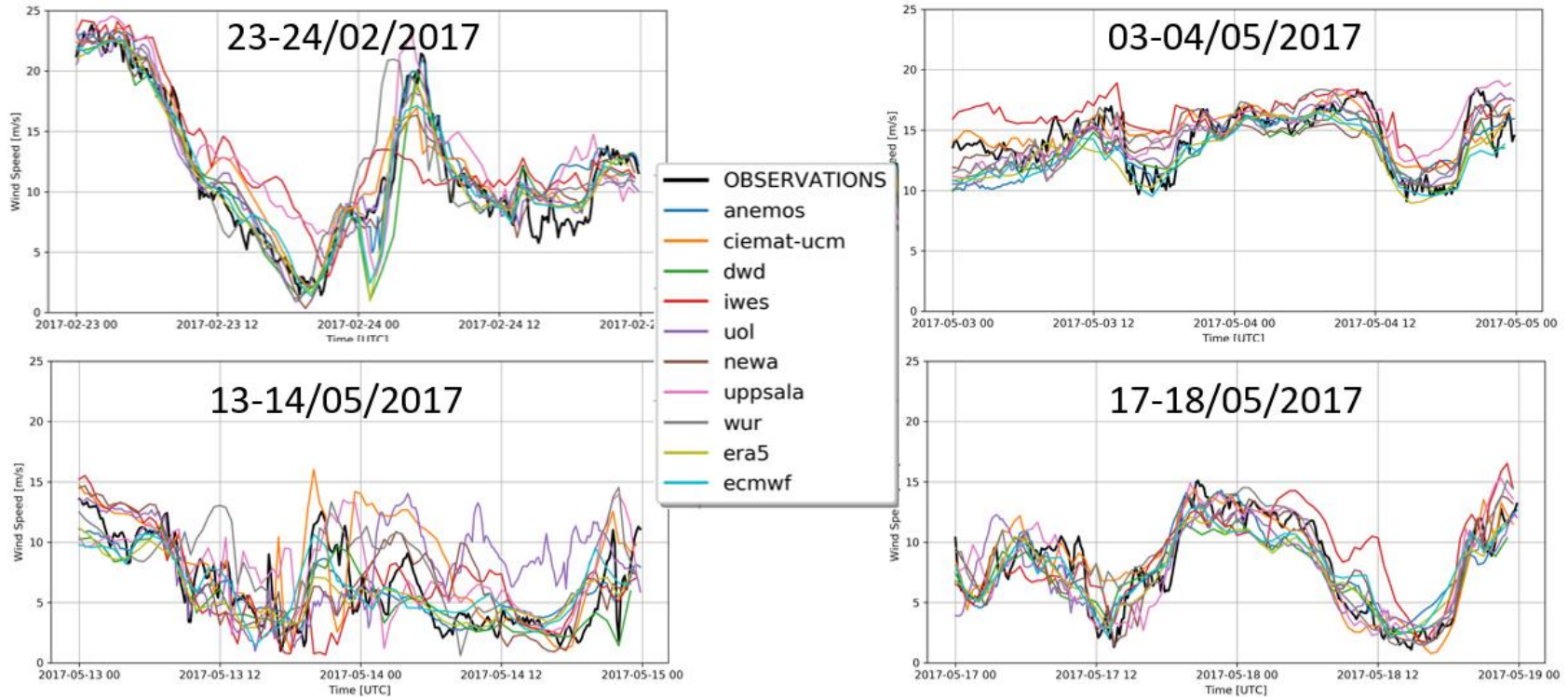
# Ferry Lidar Benchmark

- Intended for mesoscale meteorological models (meso- $\alpha$ , meso- $\beta$  scale)
- Objectives of the benchmark:
  - To assess how well today's mesoscale models can reproduce the wind conditions offshore and in coastal areas (Southern Baltic Sea)
  - To gain experience with this unique kind of data (moving wind profiles) and explore its strengths and weaknesses.
- Blind test → Best practice and further setups
- <https://thewindvaneblog.com/the-newa-ferry-lidar-benchmark-bd79009afb26>

# Participants of Ferry Lidar Benchmark

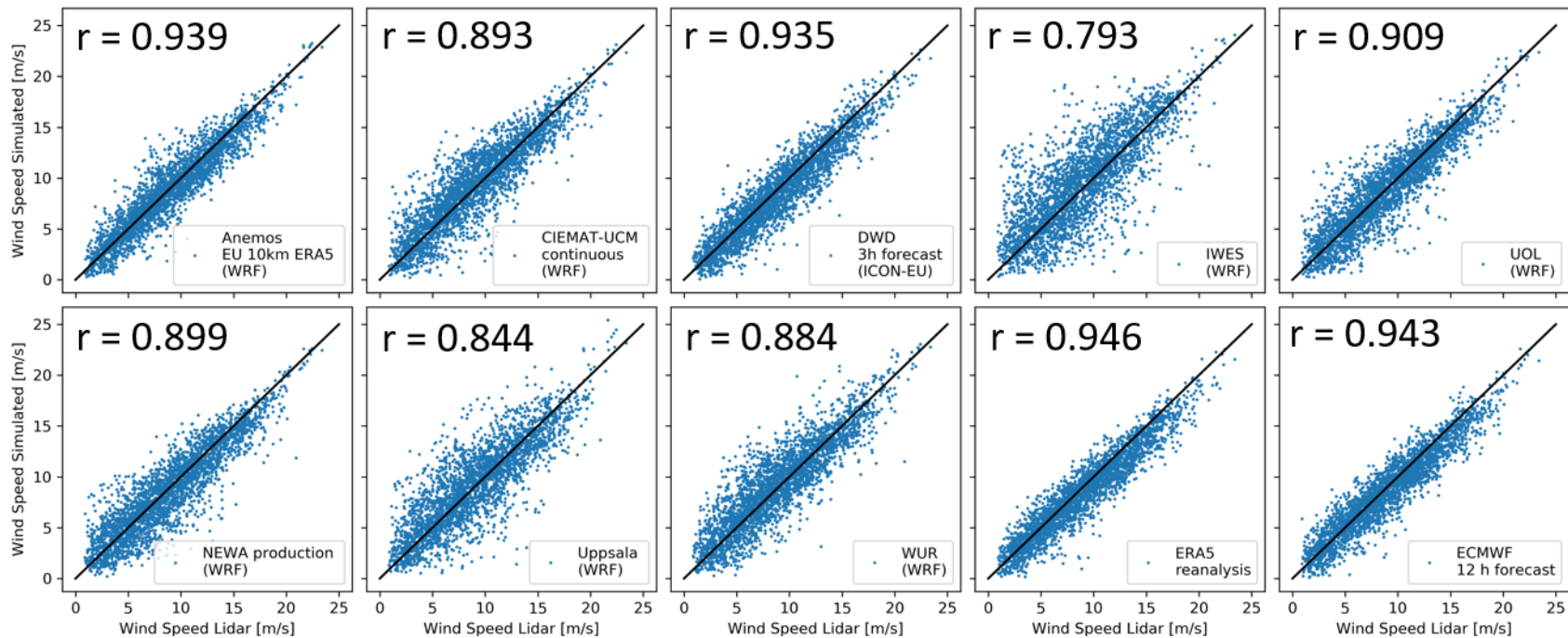
participant	model (version)	resolution	dyn. forcing	SST	PBL-SL	sim. Length
anemos	WRF 3.7.1	10 km	ERA5	ERA5	YSU-MO	continuous
ciemat-ucm	WRF 3.6.1 mod.	3 km	ERA5	OSTIA	MYNN-MYNN	continuous
dwd	ICON-EU 3 h forecast	6.5 km	ICON	NCEP	Raschendorfer-Raschendorfer	3 h
iwes	WRF 3.6.1	2.1 km	MERRA2	OSTIA	MYNN2-MYNN	10 d (+24h)
newa	WRF 3.8.1 mod.	3 km	ERA5	OSTIA	MYNN-MYNN	7 d (+24h)
uol	WRF 3.8.1 mod.	3 km	ERA5	OSTIA	MYNN-MO	7 d (+24h)
upsala	WRF 3.8.1	3 km	ERA-Interim	ERA-Interim	MYNN2-MYNN	1 d (+12h)
wur	WRF 3.9.1.1	3 km	ECMWF oper	ECMWF oper	MYNN-MYNN	1 d (+24h)
ecmwf	IFS 12 h forecast	~11 km				12 h
era5	ERA5 reanalysis	~30 km				

# Time Series on Different Days



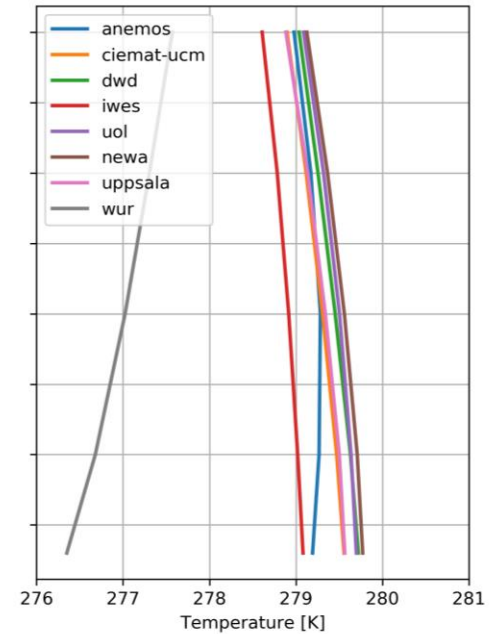
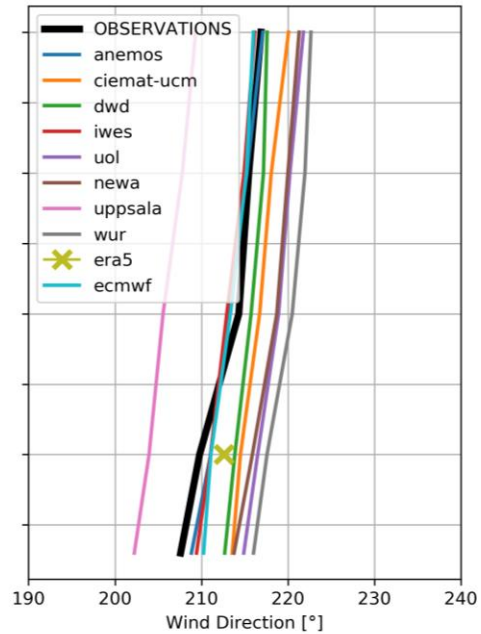
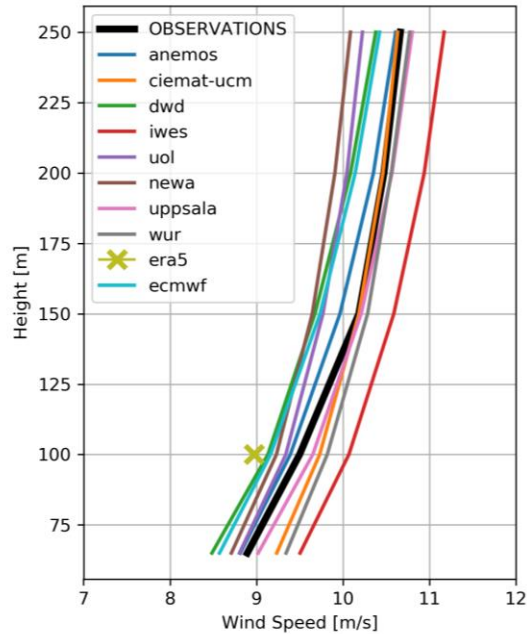


# Overall Performance



- Hourly averages

# Average Vertical Profiles



# Conclusions & Outlook

- Several rounds of public benchmarks released within NEWA project
- German sub-project: Kassel and Ferry Lidar benchmarks
- 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)
- Results not yet published in journal papers, will follow within next months
- More microscale benchmarks to come using data from the very complex terrain experiments of **Perdigao** and **Alaiz**

# Acknowledgements

**Many thanks to all technicians and also benchmark participants!**



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- Department of Economy, Science and Innovation Flemish Government (Belgium)
- Danish Energy Authority (Denmark)
- Federal Ministry for the Economic Affairs and Energy, on the basis of the decision by the German Bundestag (Germany)
- Latvijas Zinatnu Akademija (Latvia)
- Fundação para a Ciência e a Tecnologia (Portugal)
- Ministerio de Economía y Competitividad (Spain)
- The Swedish Energy Agency (Sweden)
- The Scientific and Technological Research Council of Turkey (Turkey)



# Questions?

Martin Dörenkämper - [martin.doerenkaemper@iwes.fraunhofer.de](mailto:martin.doerenkaemper@iwes.fraunhofer.de)

Bernhard Stoevesandt – [bernhard.stoevesandt@iwes.fraunhofer.de](mailto:bernhard.stoevesandt@iwes.fraunhofer.de)



Photo by Nicholas Doherty on Unsplash

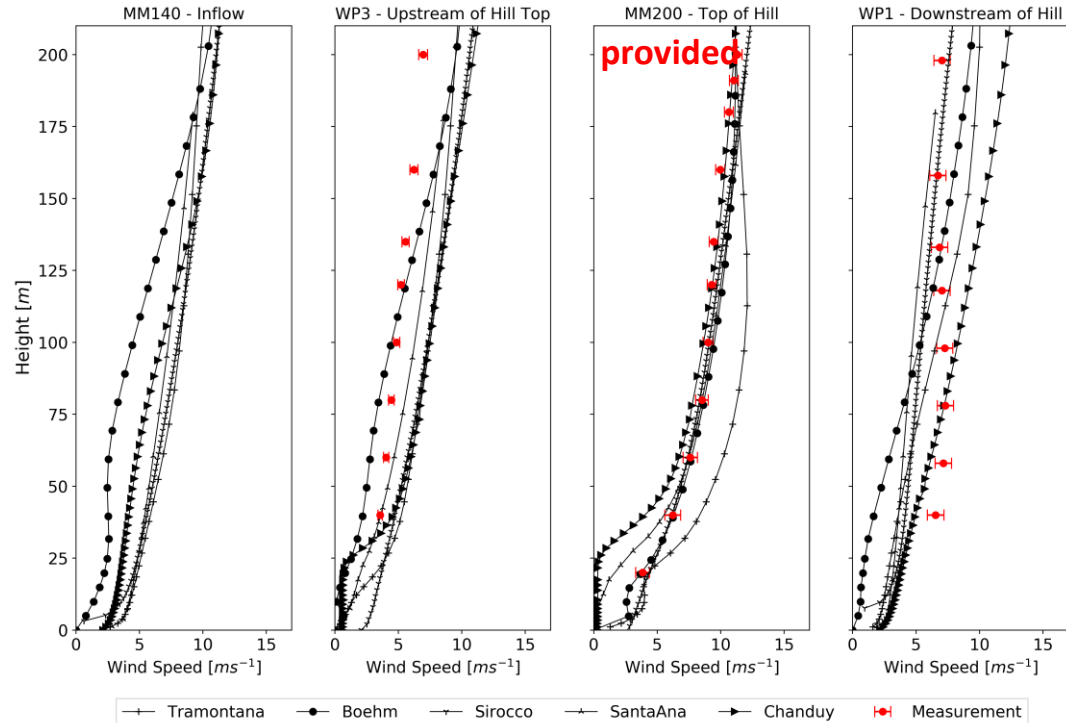
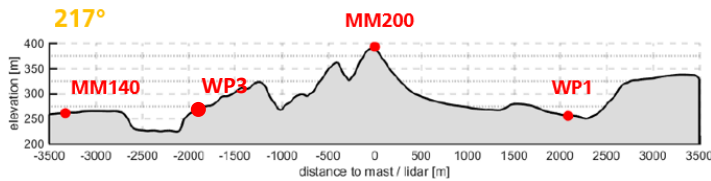


# Thank You for Your Attention



# 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





# Blind Test Phase 1 – Flow Across Hill – Stable

- Slightly Stable Stratification
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