

ICE & ROCKS III Zadar 5th and 6th May 2010

Round Robin Numerical Flow Simulations in Wind Energy

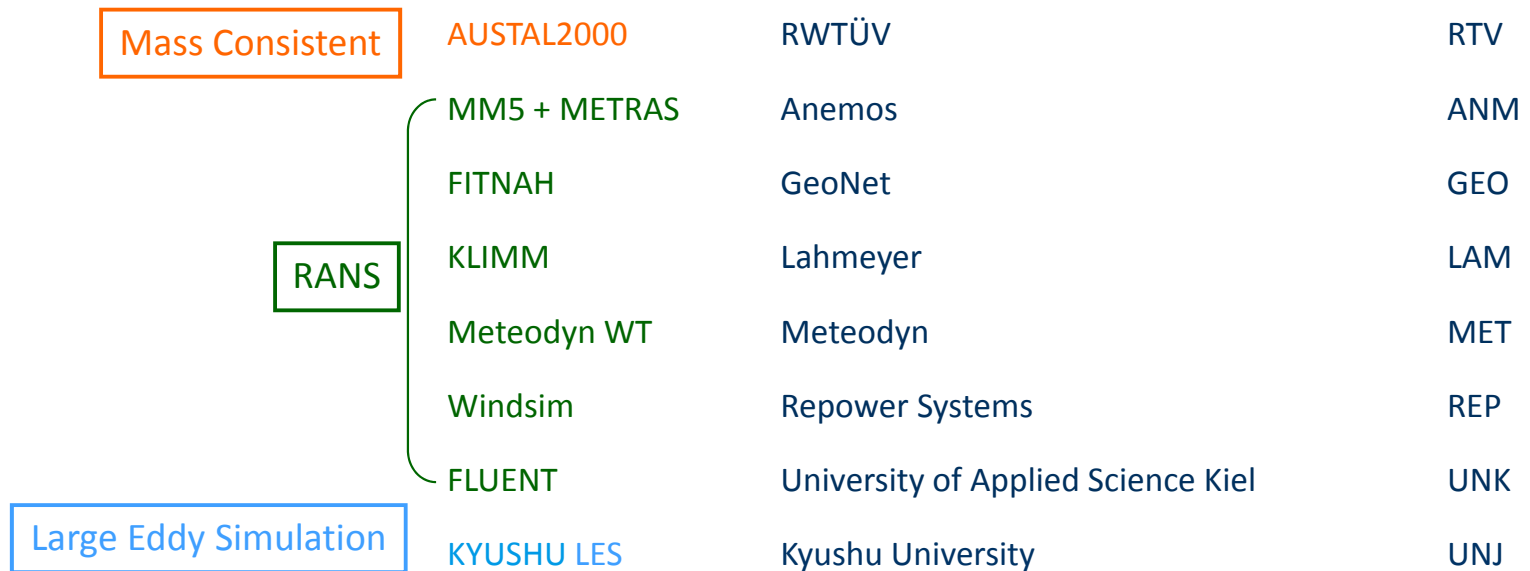
Francesco Durante
DEWI GmbH

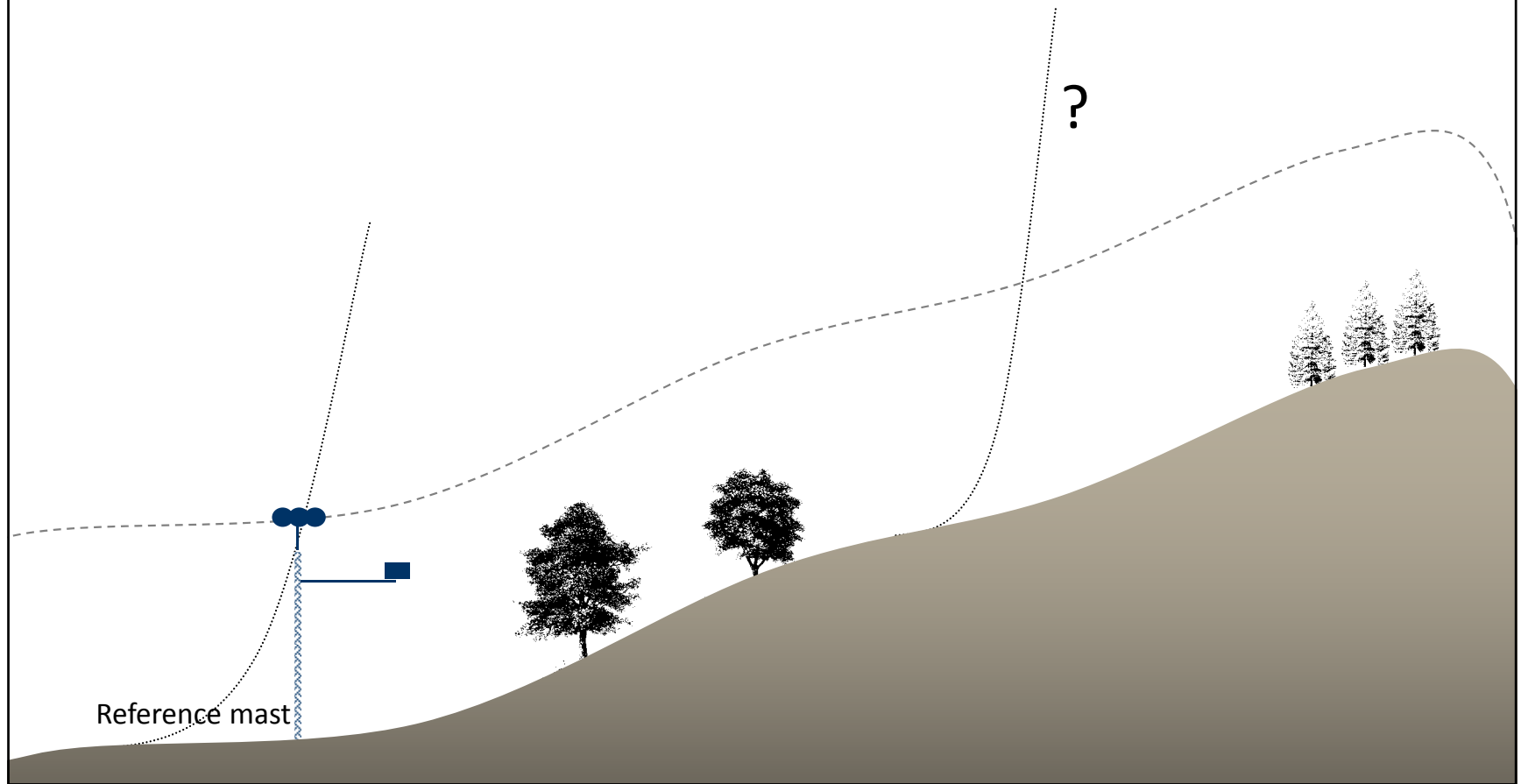
► SITE ASSESSMENT . WIND TURBINE ASSESSMENT . GRID INTEGRATION . DUE DILIGENCE . KNOWLEDGE . CONSULTANCY

- Overview of the Project
- The participants and the models
- The test site
- Wind measurements
- Set-up of the test
- The results
- Conclusions

Why research on Numerical Simulation for wind energy?

- A systematic evaluation of models and methods applied to wind energy is still missing.
- The uncertainty of the extrapolation methods in complex terrain are not well known.

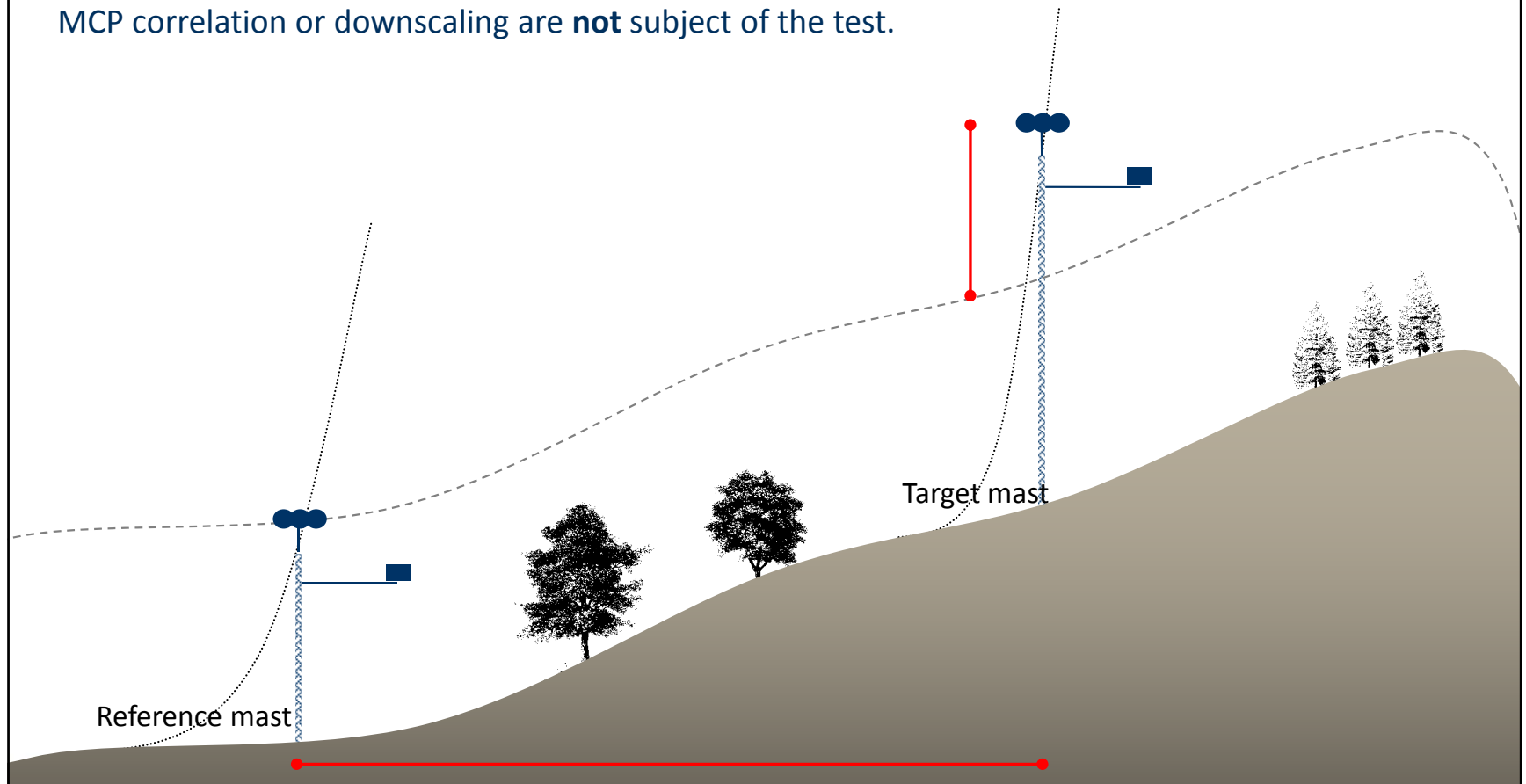




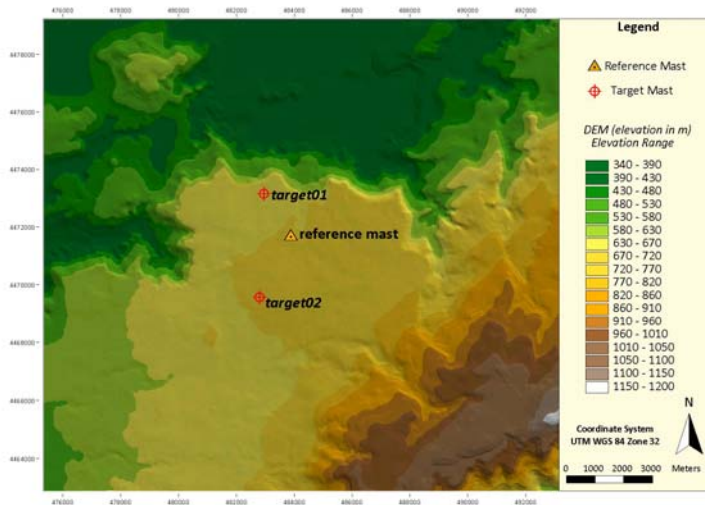
▸ The site

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The focus of the research was on **extrapolation of measurements at site**
MCP correlation or downscaling are **not** subject of the test.

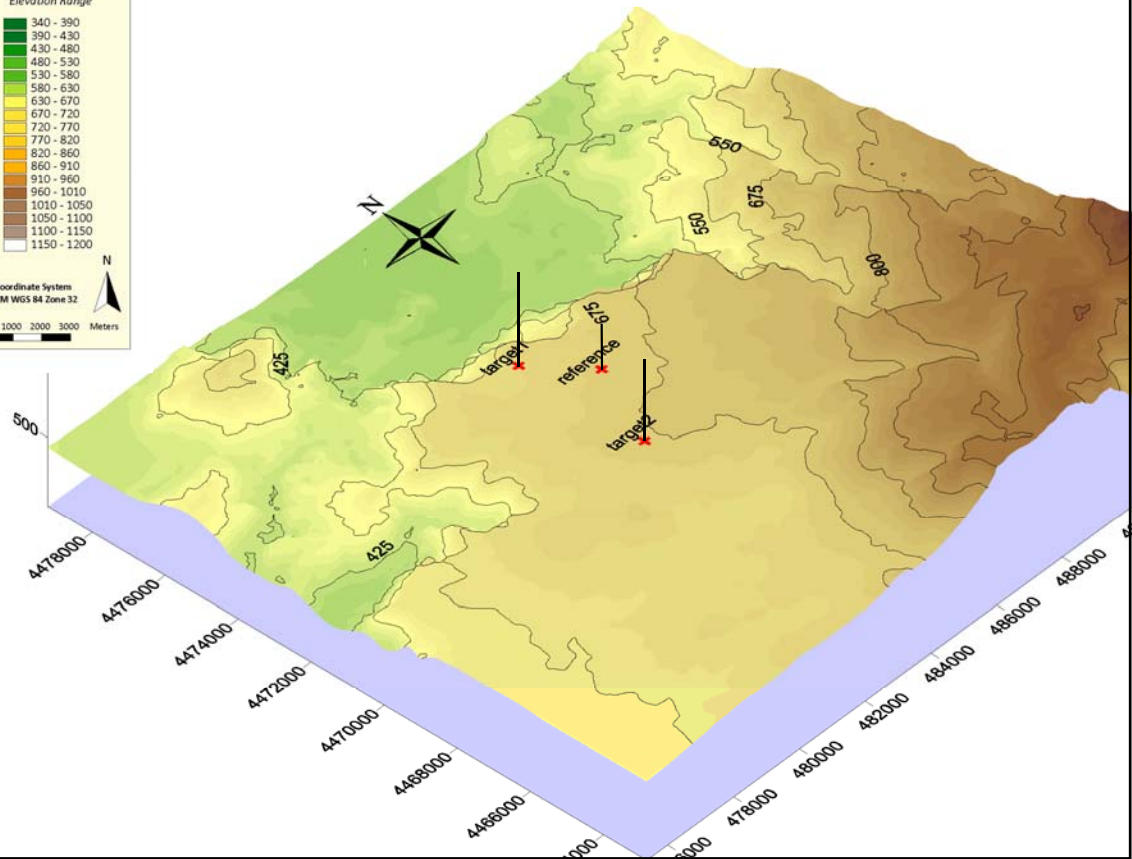


▸ The site



Distance between masts:

- Reference Mast → Mast 1 ~ 1700 m
- Reference Mast → Mast 2 ~ 2400 m



▸ Wind Measurements

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REFERENCE MAST

- Thies First class 43 m a.g.l.
- Wind vane: thies compat, 42 m a.g.l.
- Individual (Measnet) calibration
- Logger: Wicom CM
- Boom lenght: 1.4 m



TARGET MAST 1

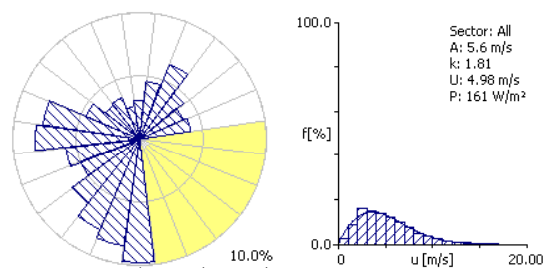
- Thies First class 80 m (a.g.l.)
- Wind vane thies compat 78 m (a.g.l.)
- Individual (Measnet) calibration
- Wind vane boom 245°



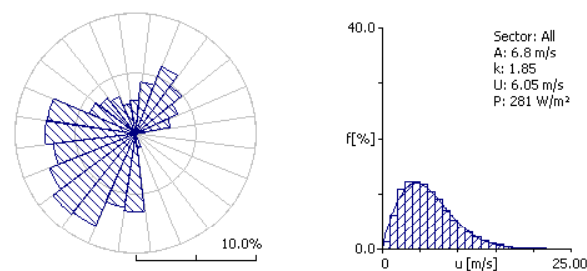
TARGET MAST 2

- Thies First class 80 m (a.g.l.)
- Wind vane thies compat 78 m (a.g.l.)
- Individual (Measnet) calibration
- Wind vane boom 226°

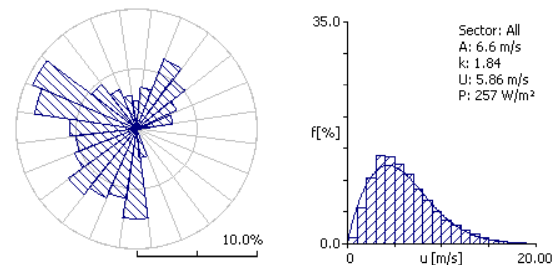
Wind direction between $[83^\circ - 172^\circ]$ filtered out to avoid mast-shading effects



Reference mast

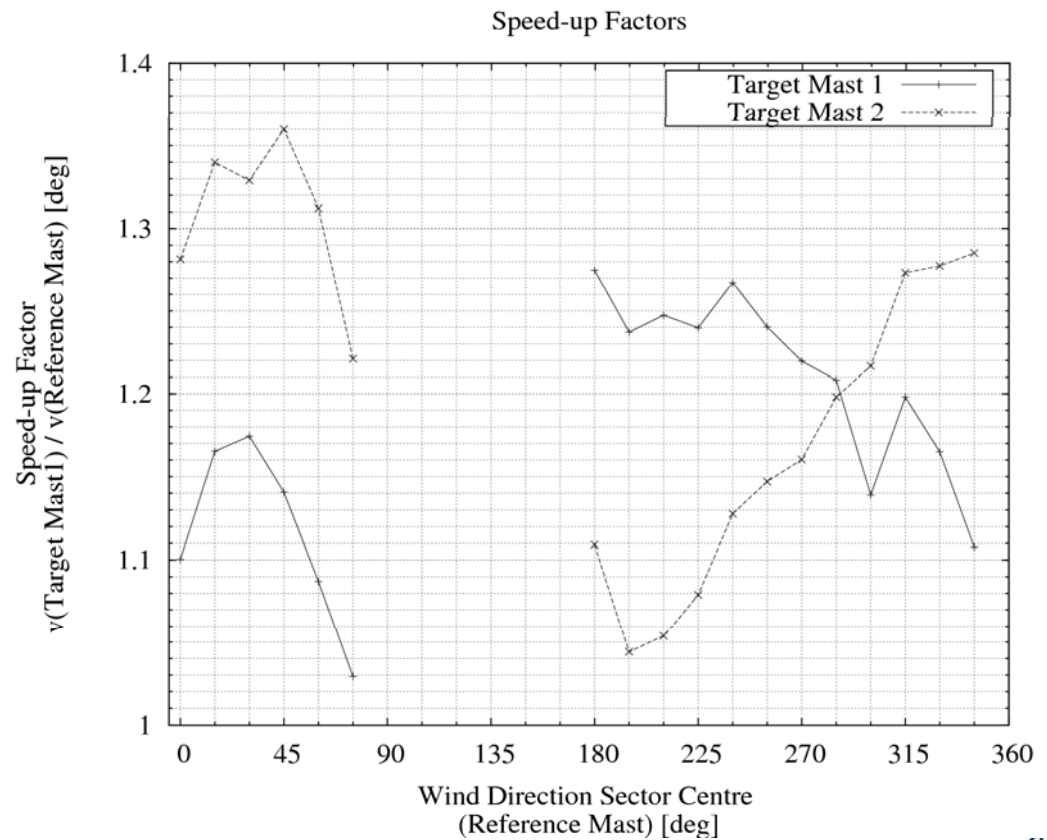


Target mast 1



Target mast 2

High speed-up factors for a medium-complex terrain



The participants got:

- Elevation for an area close to the site (resolution 10m)
- Elevation for the β -mesoscale area (resolution 90 m)
- Land cover (and z_0) for the area close to the site
- Land cover for the β -mesoscale area
- Atmospheric soundings from the nearest airport (about 120 km from the site)
- Reanalysis data for pressure levels surface levels
- Wind time series at the reference mast for all sectors
- „Directional time series“ at the reference mast for 24 sectors (15° each)

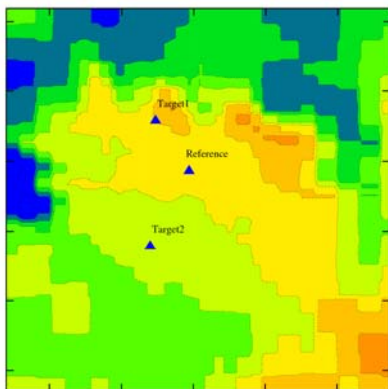
The participants calculated:

- Mean Wind speed at the target mast
- Mean Wind speed for an horizontal terrain following surface (at 40m , 60 m, 80m)
- Wind Statistics for the two target masts
- Directional wind statistics

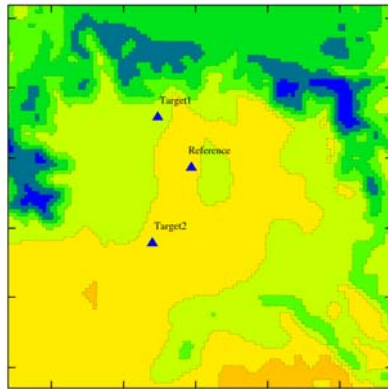
Limitations:

- Only a subset of models which are currently used for wind energy
- Single test
- Uncertainty in the input data (e.g. wind data, terrain data, information about atmospheric stability, etc.)

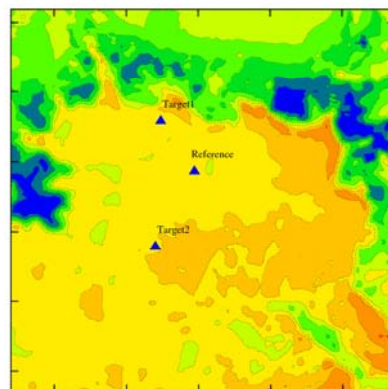
ANM 80 m - Mean Wind Speed [m/s]



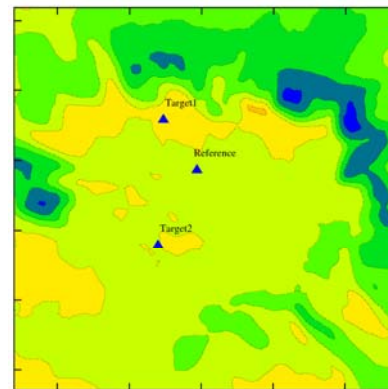
GEO 80 m - Mean Wind Speed [m/s]



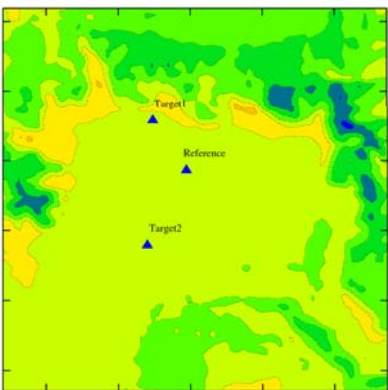
LAM 80 m - Mean Wind Speed [m/s]



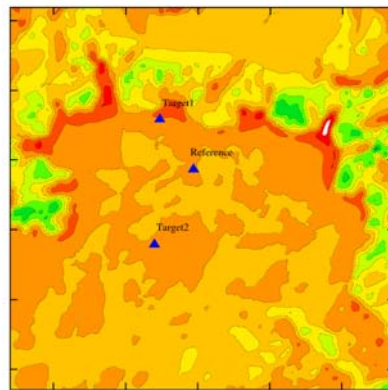
MET 80 m - Mean Wind Speed [m/s]



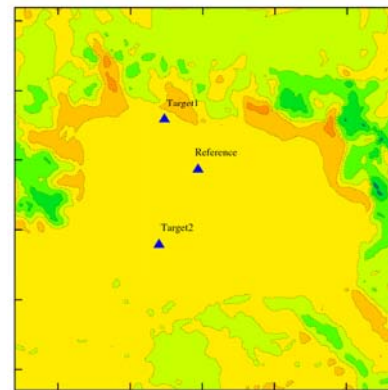
REP 80 m - Mean Wind Speed [m/s]



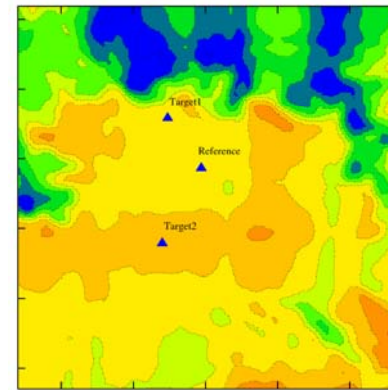
RTV 80 m - Mean Wind Speed [m/s]



UNJ 80 m - Mean Wind Speed [m/s]

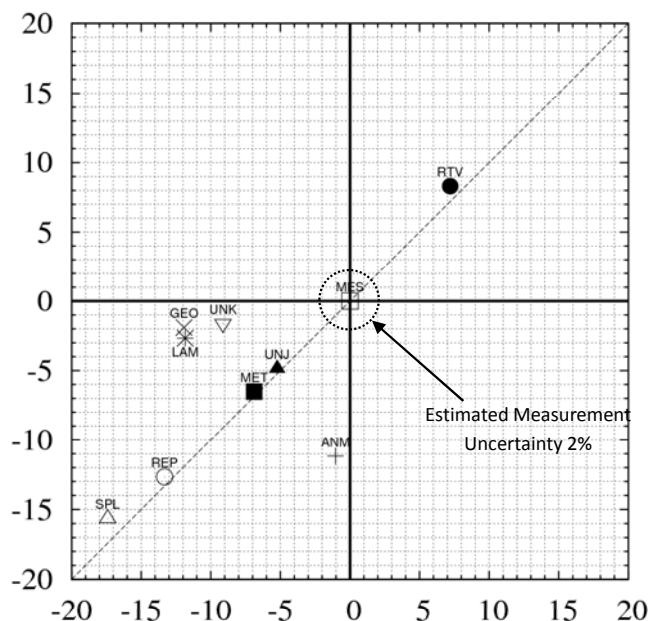


UNK 80 m - Mean Wind Speed [m/s]

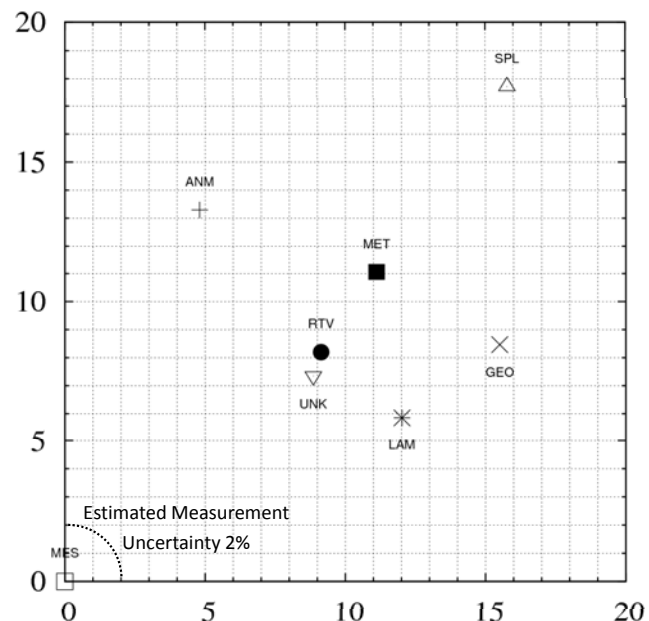


m/s

Mean Wind Speed Error [%]

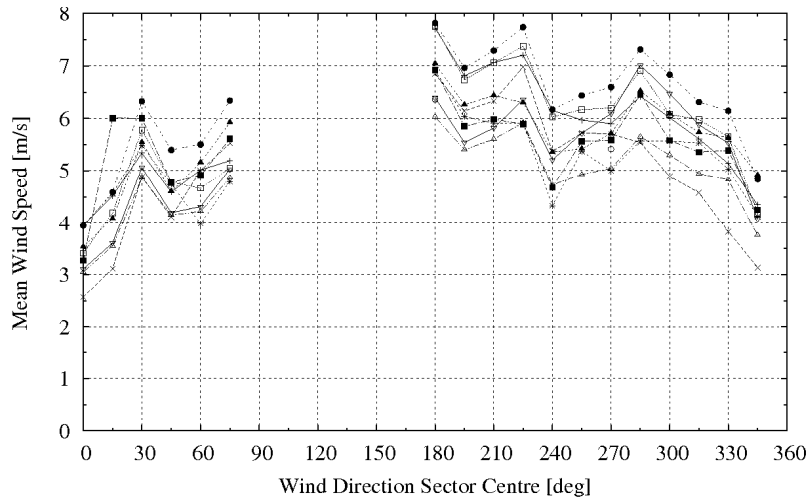


Mean absolute Error [%]

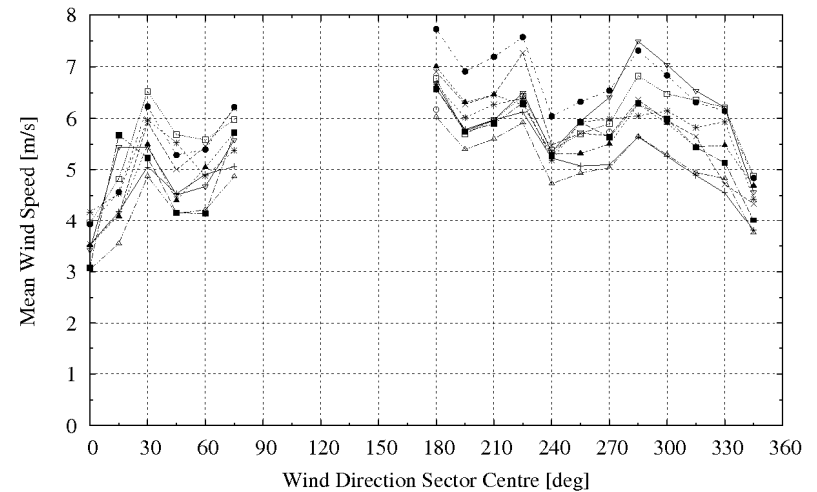


ANM	-----+-----	LAM	-----*-----	MET	-----■-----	RTV	-----●-----	UNK	-----▼-----
GEO	-----x-----	MES	-----□-----	REP	-----○-----	SPL	-----▲-----		

Target Point 1 - Mean Wind Speed

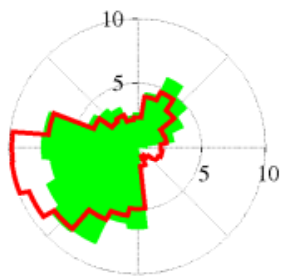


Target Point 2 - Mean Wind Speed

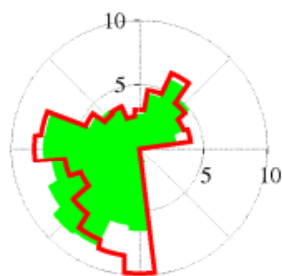


Result: Wind Direction at Target Mast 1

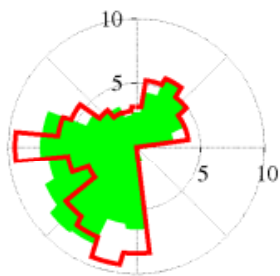
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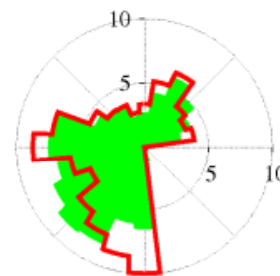
ANM - Target Mast 1



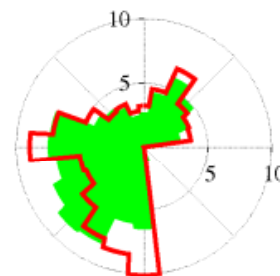
GEO - Target Mast 1



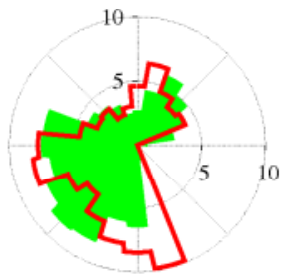
LAM - Target Mast 1



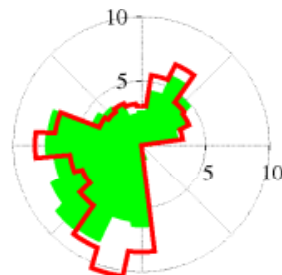
MET - Target Mast 1



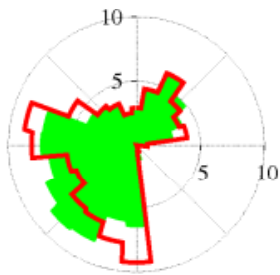
REP - Target Mast 1



RTV - Target Mast 1



UNJ - Target Mast 1

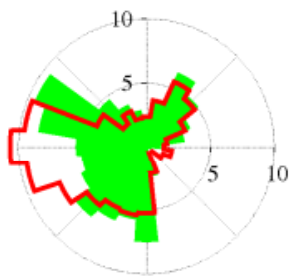


UNK - Target Mast 1

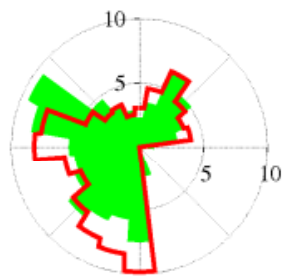
 Measured Distribution
 Modelled Distribution

Results: Wind Direction at Target Mast 2

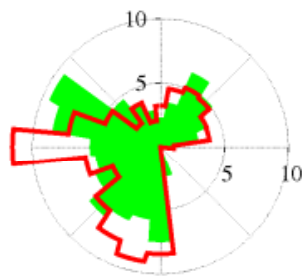
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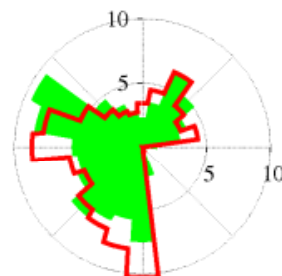
ANM - Target Mast 2



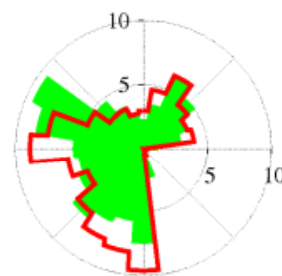
GEO - Target Mast 2



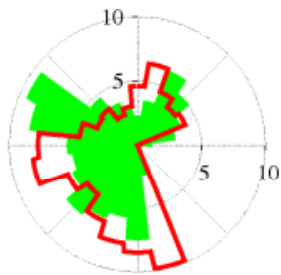
LAM - Target Mast 2



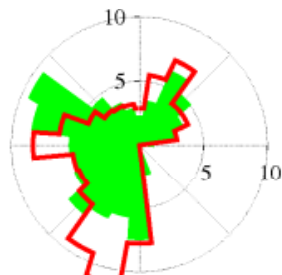
MET - Target Mast 2



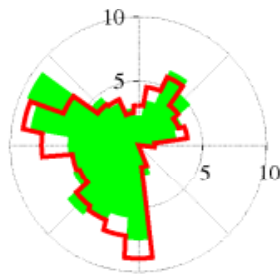
REP - Target Mast 2



RTV - Target Mast 2



UNJ - Target Mast 2

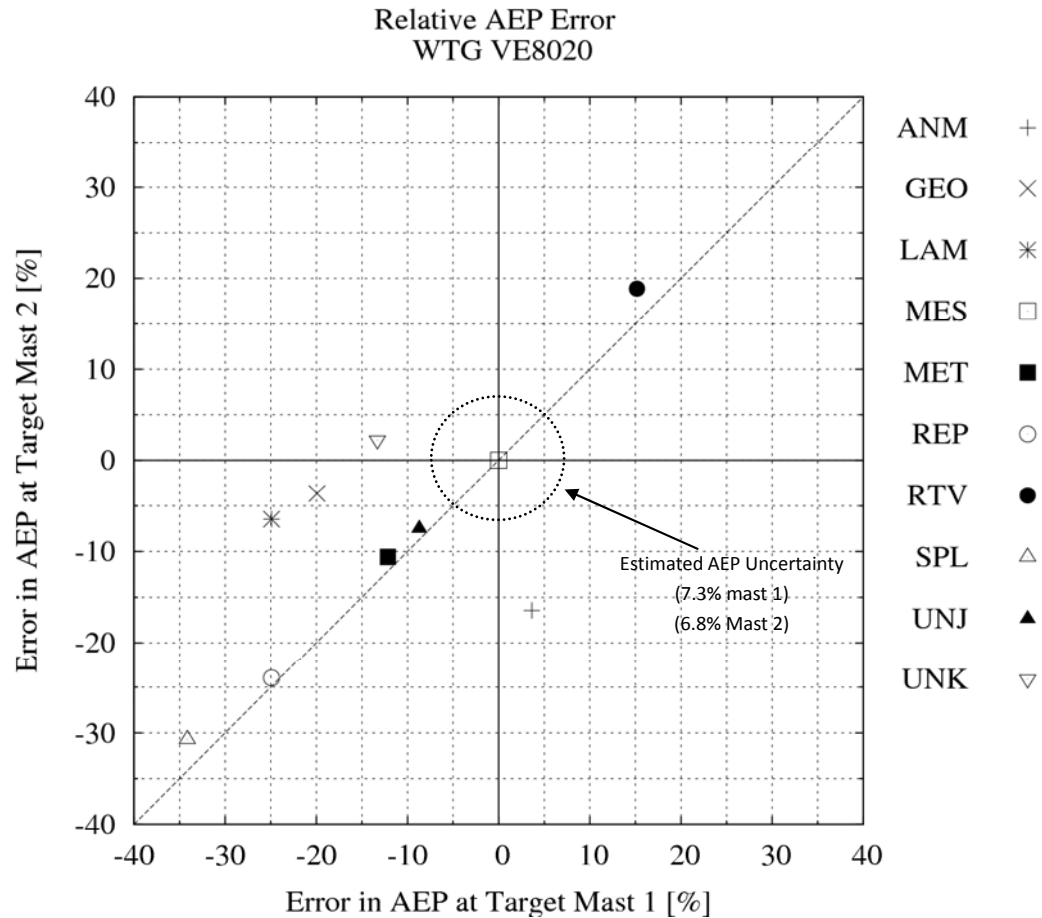


UNK - Target Mast 2

 Measured Distribution
 Modelled Distribution

Results: Single Turbine Energy Yield (Vestas V80 2.0MW)

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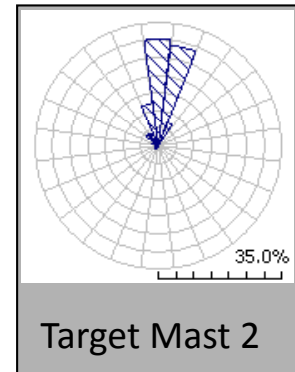
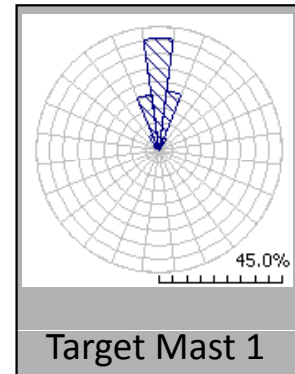
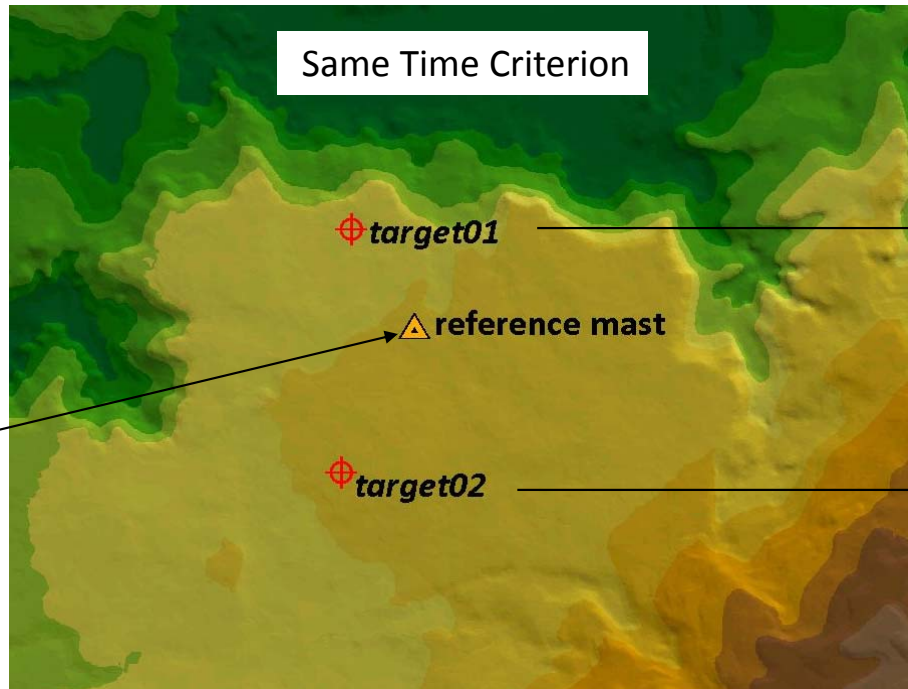
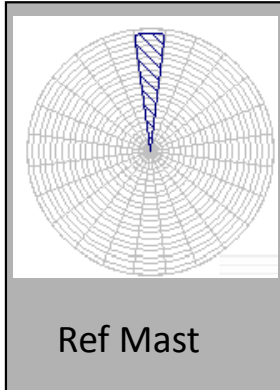
- Large quantitative and qualitative differences
- Sectorwise results often show that important meteorological effects are not sufficiently modelled.
- Tendency towards underestimation of vertical wind speed increase.
- Strong need for harmonization of the applied simulation procedures



The Participants

- Anemos Gesellschaft für Umweltmeteorologie mbH
- CeBeNetwork GmbH
- GEO-NET Umweltconsulting GmbH
- Lahmeyer International GmbH
- Meteodyn
- RWTÜV SYSTEMS GmbH
- Technical University KIEL, Faculty of Mechanical Engineering
- Kyushu University
- REpower Systems AG

Example:
North Sector
at Reference Mast



Problems:

- No sector-wise Data from UNJ
- Only 2 Sectors from REP
- Method not fully applicable to ANM

The participant “SPL” (SIMPLE)

- It is an additional virtual participant
- It simply takes the wind conditions at the reference mast
- It does not perform any kind of horizontal or vertical extrapolation

Target Point 1 - Percentage Error in Mean Wind Speed

