Simulating wind energy resources with mesoscale models: Intercomparison of state-of-the-art models

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Simulating wind energy resources with mesoscale models: Intercomparison of state-of-the-art models

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### Overview

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- EWEA mesoscale models benchmarking exercise
- Intercomparison study of mesoscale models
- Wind energy community submits their model output
Overview

• Data submission facilitated by EWEA ensuring anonymity of participants
• ‘Raw’ mesoscale output for 6 sites in Northern Europe
• Hourly data for all of 2011
• Wind speed, direction, temperature, and humidity, surface fluxes.
• Many vertical levels 10-200 m.
• A lot of metadata:
  o Model name
  o Model version
  o Grid spacing (horizontal and vertical)
  o Forcing (Boundary data)
  o Surface roughness
  o and more…
Participants:
- 3E (Belgium)
- Anemos GmbH (Germany)
- ATM PRO (Belgium)
- CENER (Spain)
- CIEMAT (Spain)
- DEWI (Germany)
- DTU Wind Energy (Denmark)
- DX Wind Technologies (China)
- EMD International (Denmark)
- ISAC-CNR (Italy)
- KNMI (The Netherlands)
- Met Office (United Kingdom)
- Noveltis (France)
- RES Ltd. (United Kingdom)
- Statoil ASA (Norway)
- University Oldenburg (Germany)
- Vestas (Denmark)
- Vortex (Spain)

Models:
- Harmonie37h1.1
- HIRLAM, v6.4.2
- Met Office v8.4
- MM5
- RAMS 6.0
- SKIRON 6.9
- WRF v3.0.1
- WRF v3.1
- WRF v3.2.1
- WRF v3.3.1
- WRF v3.4
- WRF v3.5.1
- WRF v3.6
- WRF v3.6.1
First impressions... wind speed at Cabauw (80 meters)
1st order statistics – mean wind speed

- Smaller errors offshore and aloft, larger inland and near the surface
- Same pattern for inter-model spread
1st order statistics – standard deviation

- Underprediction offshore
- Near surface: overprediction at Høvsøre, underprediction at Cabauw
- Greater inter-model variance inland

\[ \sigma = \sqrt{\frac{1}{N} \sum_{t=0}^{N_t} (U_t - \bar{U})^2} \]
Direction wind rose

- 24 direction sectors
- Wind directions are well captured
2nd order statistics - Correlation

- Generally high correlation \( > \approx 0.85 \)
- Higher correlation offshore and aloft, lower onshore and near the ground
Applying mesoscale data for wind energy – FINO3 90 m

Power curve: Vestas V80 (2 MW)
Wind farm: Horns Rev 1
Wake calculation using WAsP

FINO3 (Offshore) 90 m

- Mean Wind Speed
- Mean Power Density
- Mean Power 1T
- Mean Power 80T
Applying mesoscale data for wind energy – FINO3 90 m

- Mean Wind Speed: 1 Outlier
- Mean Power Density: 3 Outliers
- Mean Power 1T
- Mean Power 80T
Can we link the model setup to performance?

- Number of vertical level
- Forcing data
- Surface roughness
- PBL scheme
- Resolution: Yes – some evidence

Inconclusive – too little data

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**Graphs:**

- FINO3 90 m
- Hovsøre 80 m
- Cabauw 80 m

**Axes:**

- Absolute error [%]
- Resolution [km]
So?

• How good are simulated time series from mesoscale models?
• How is the model setup related to performance?

Summary

• Distribution of wind directions (Wind rose) well captured
• Smaller mean wind speed errors and higher correlation offshore and aloft
• Overprediction of mean wind speed near the surface inland
  • Misrepresentation of surface characteristics?
• Variance of wind speed underpredicted offshore
• Some evidence that higher resolution is linked to a lower mean wind speed errors
• Inconclusive evidence for others factors – too little data

Thank you for your attention!

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Some early results from this exercise was presented in Juli, see: