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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Lorenzo Morselli

Overview

Introduction

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

Objective

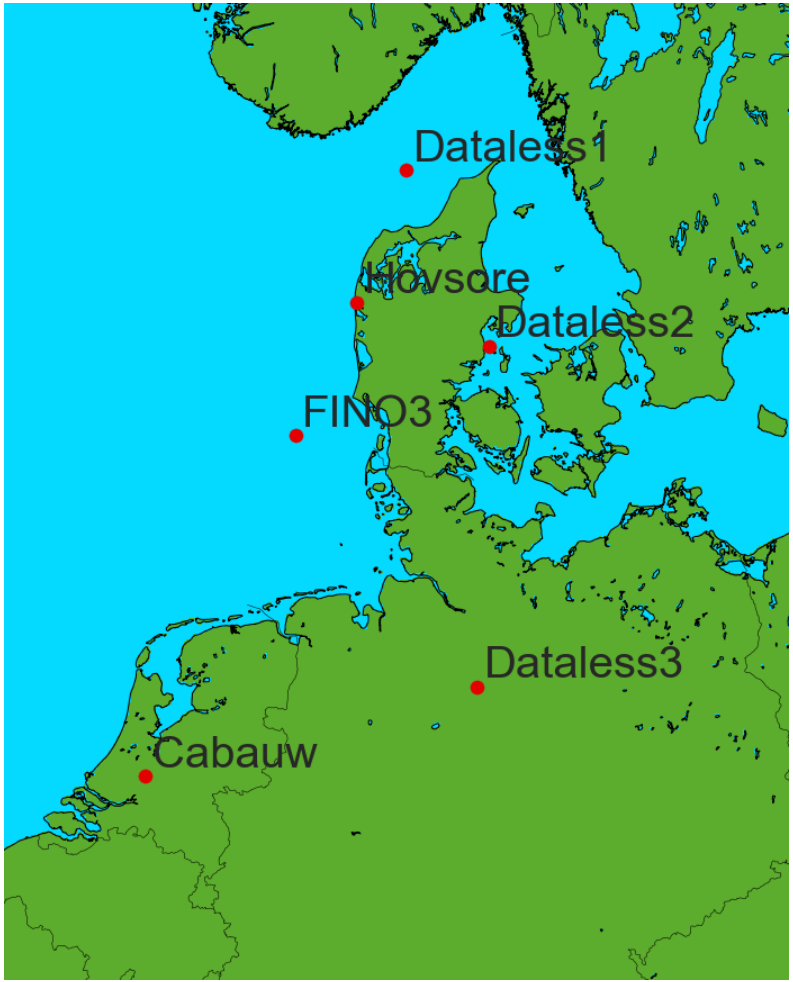
- To highlight common issues with mesoscale models
- To identify weaknesses and strengths for further evaluation of uncertainties

Question to be answered

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

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:
  - Model name
  - Model version
  - Grid spacing (horizontal and vertical)
  - Forcing (Boundary data)
  - Surface roughness
  - and more…



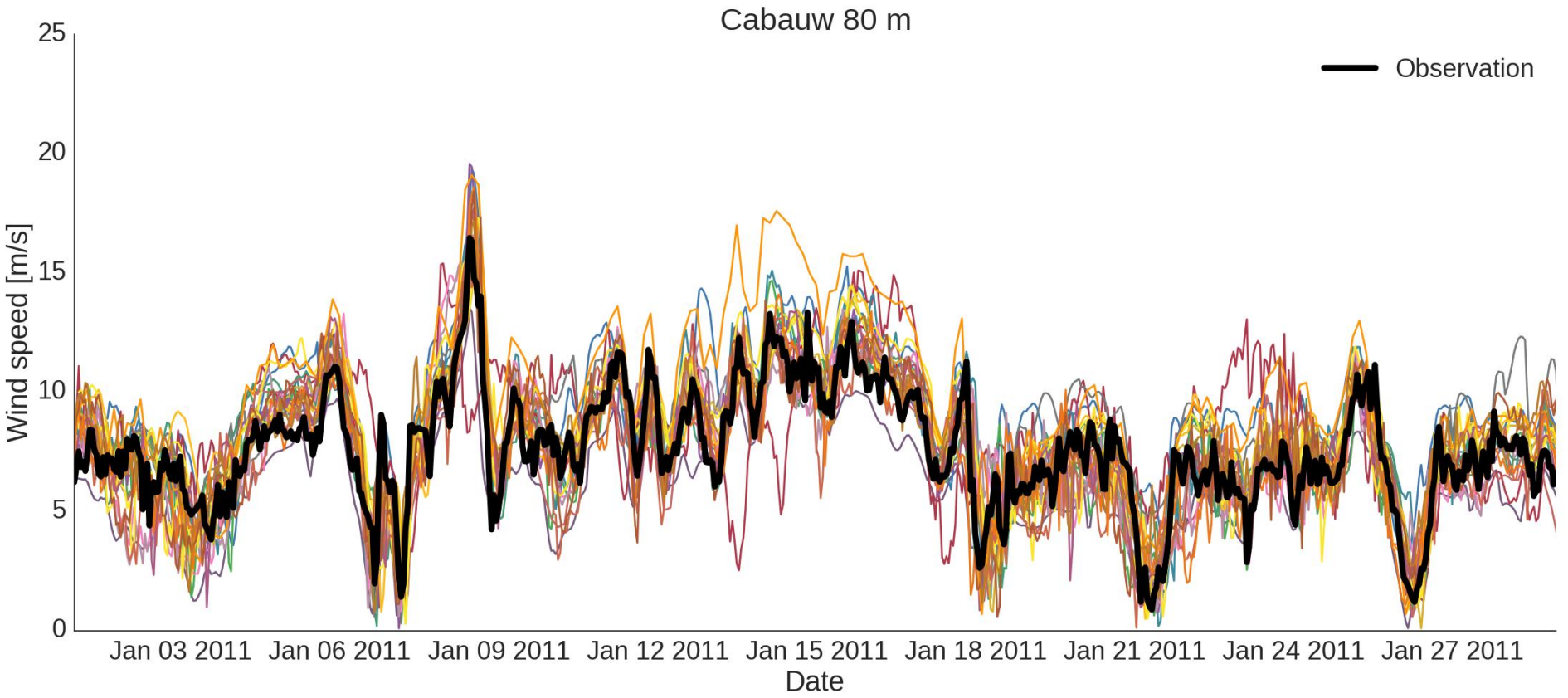
Participants:

- 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:

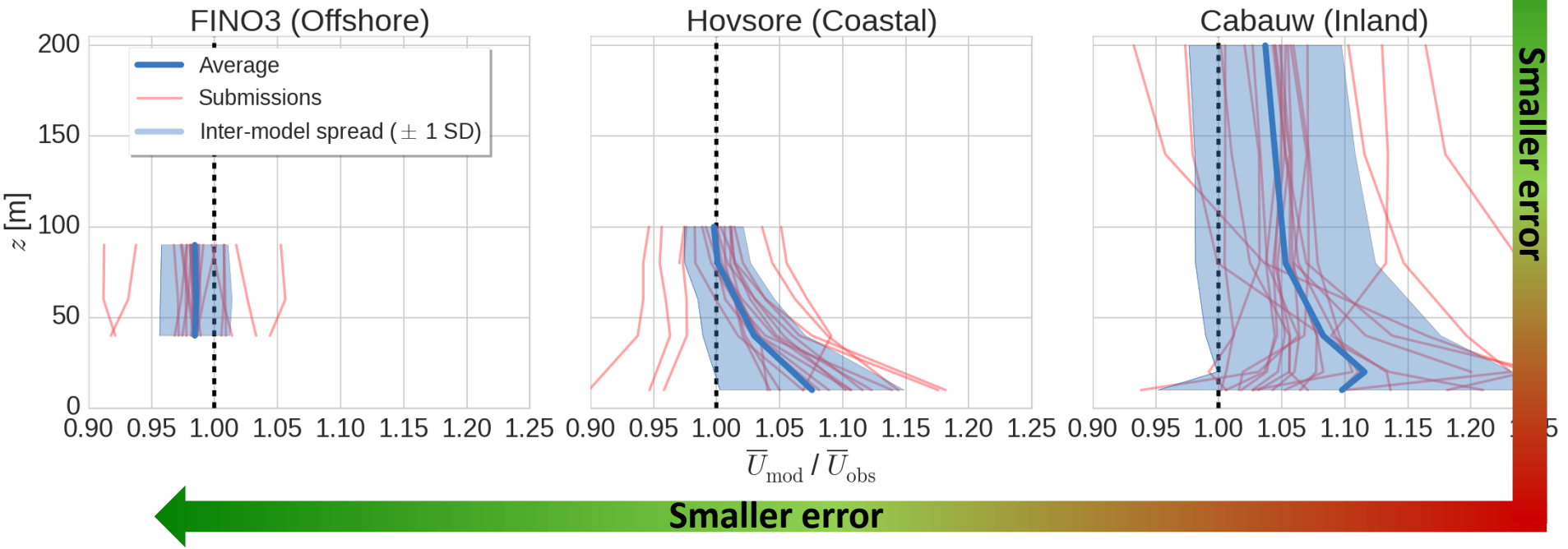
- Harmonie37h1.1
- HIRLAM, v6.4.2
- Met Office v8.4
- MM5
- RAMS 6.0
- SKIRON 6.9
- WRF v3.0.1
- WRF v3.1
- WRF v3.2.1
- WRF v3.3.1
- WRF v3.4
- WRF v3.5.1
- WRF v3.6
- WRF v3.6.1

First impressions… wind speed at Cabauw (80 meters)



1st order statistics – mean wind speed

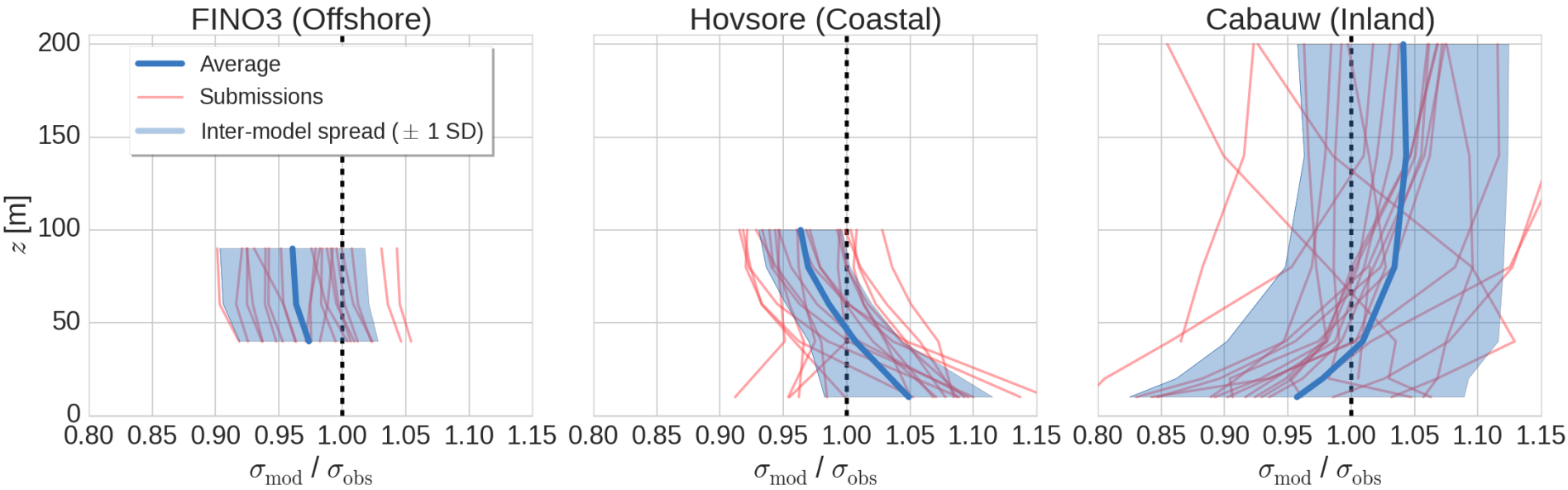
- Smaller errors offshore and aloft, larger inland and near the surface
- Same pattern for inter-model spread



1st order statistics – standard deviation

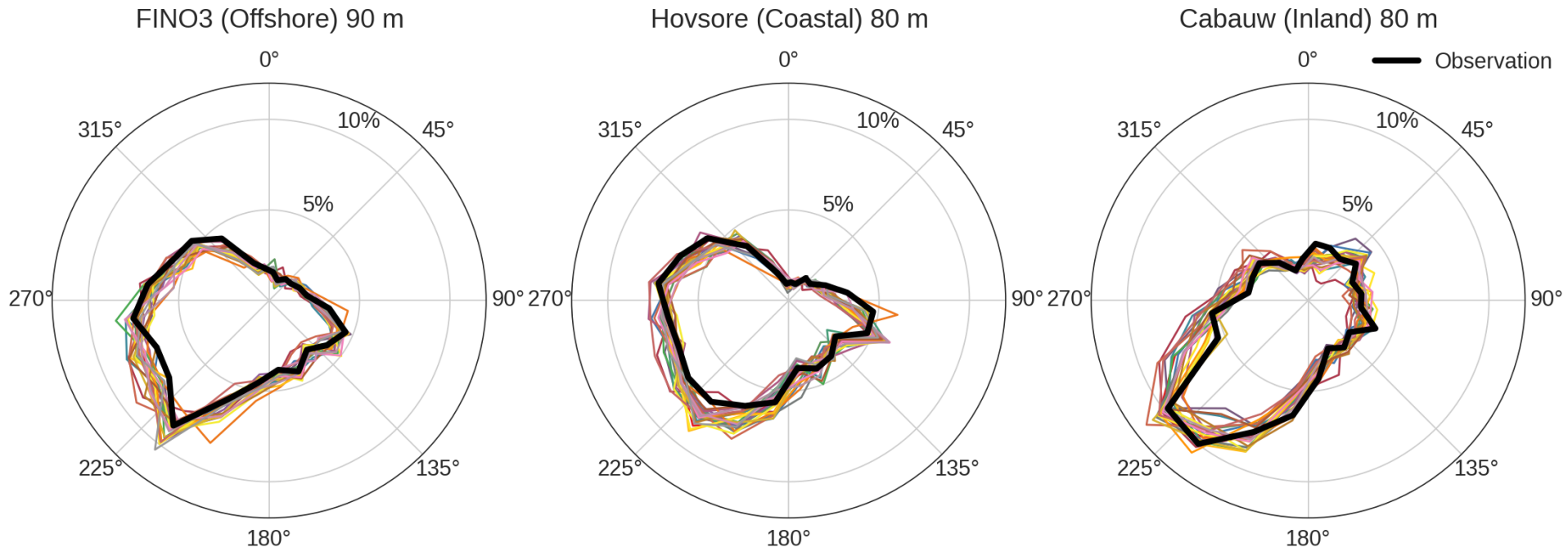
- Underprediction offshore
- Near surface: overprediction at Høvsøre, underprediction at Cabauw
- Greater inter-model variance inland

$$\sigma = \sqrt{\frac{1}{N}\sum_{t=0}^{N_t}(U_t - \bar{U})^2}$$



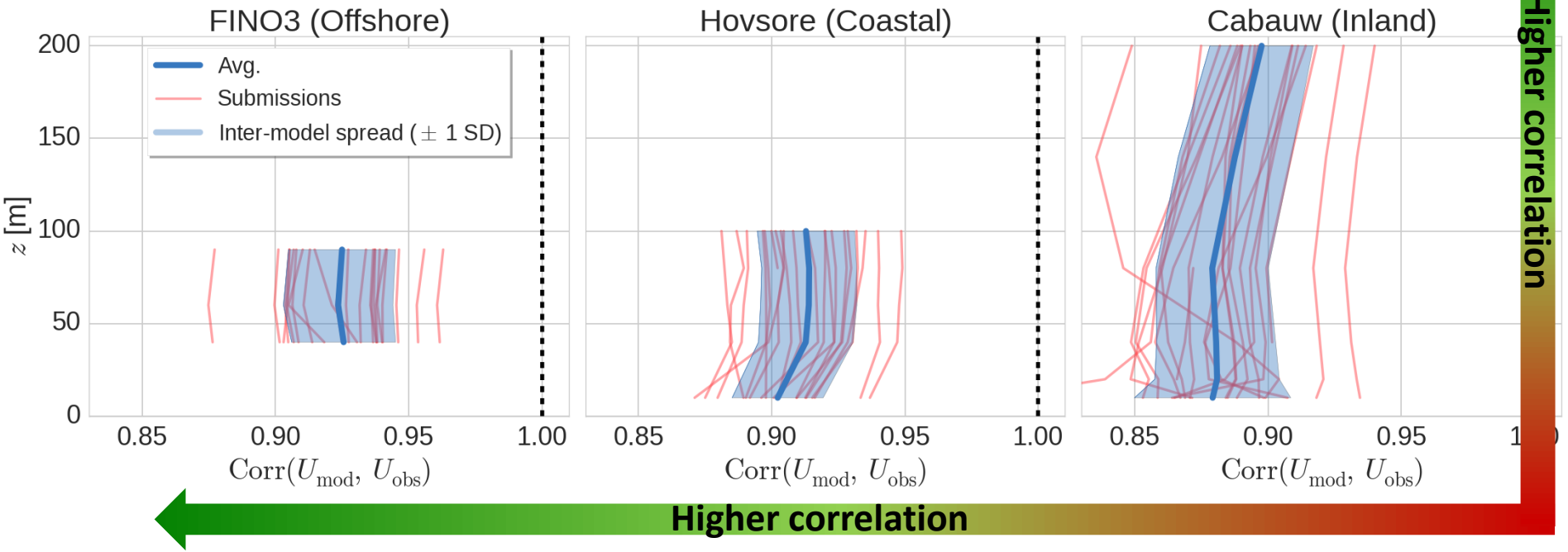
Direction wind rose

- 24 direction sectors
- Wind directions are well captured



2nd order statistics - Correlation

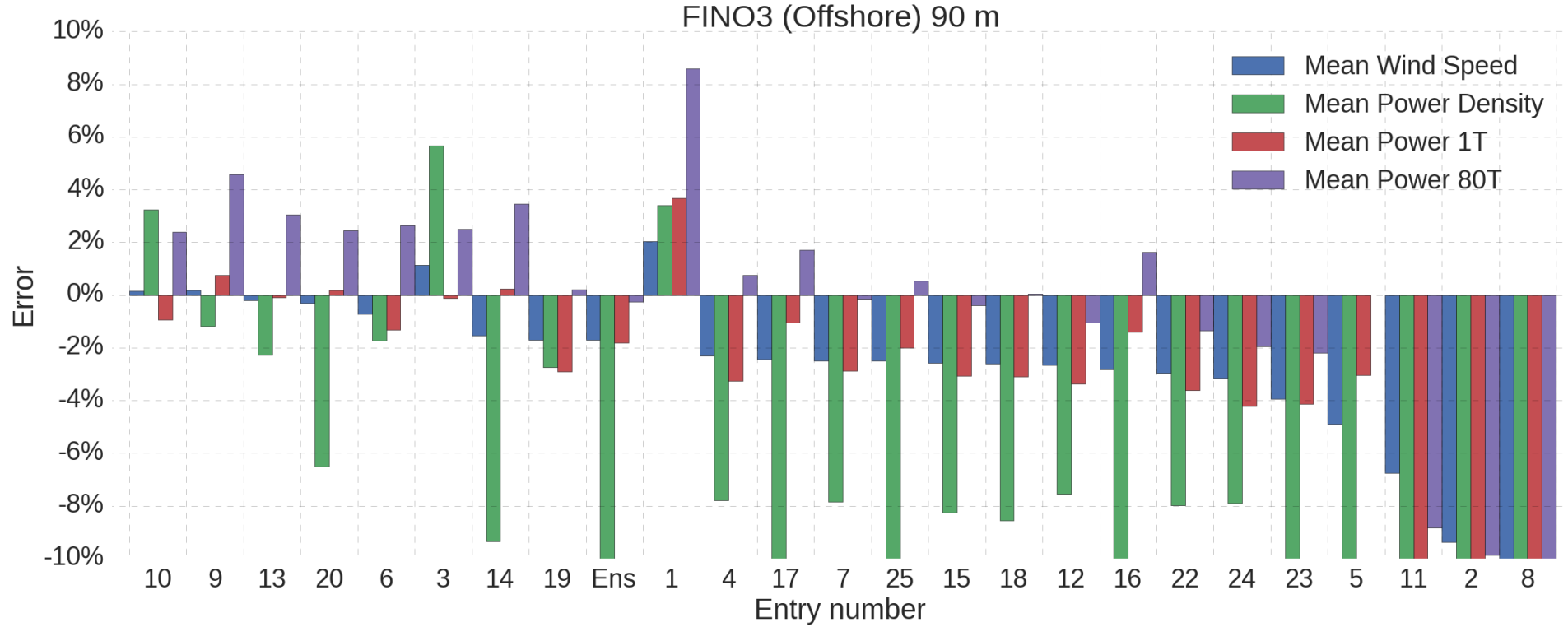
- Generally high correlation > ≈ 0.85
- Higher correlation offshore and aloft, lower onshore and near the ground



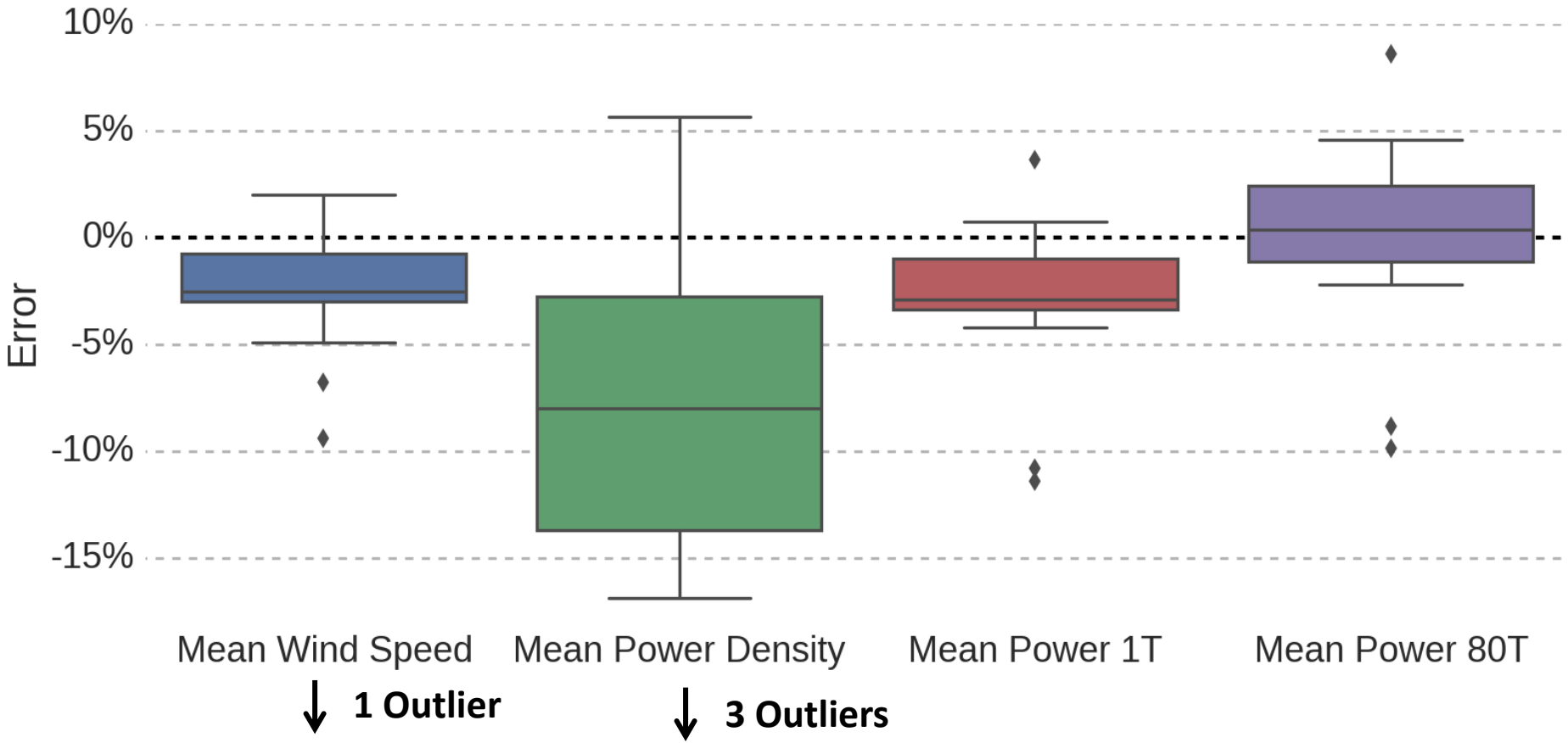
Applying mesoscale data for wind energy – FINO3 90 m

Power curve: Vestas V80 (2 MW)

Wind farm: Horns Rev 1
Wake calculation using WAsP



Applying mesoscale data for wind energy – FINO3 90 m

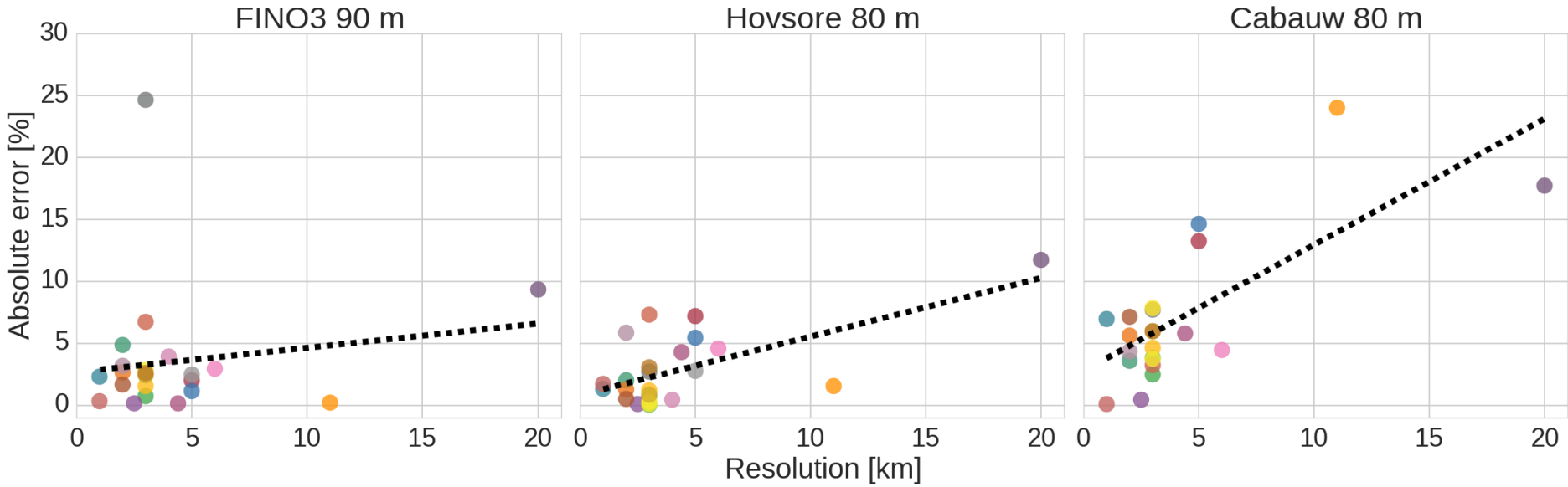


Can we link the model setup to performance?

- Number of vertical level
- Forcing data
- Surface roughness
- PBL scheme

} Inconclusive – too little data

- Resolution: Yes – some evidence



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:
http://www.ewea.org/events/workshops/wp-content/uploads/2015/06/Hahmann_MesoBenchmark_V2.pdf