whiffle

RWE-Whiffle VMM Validation

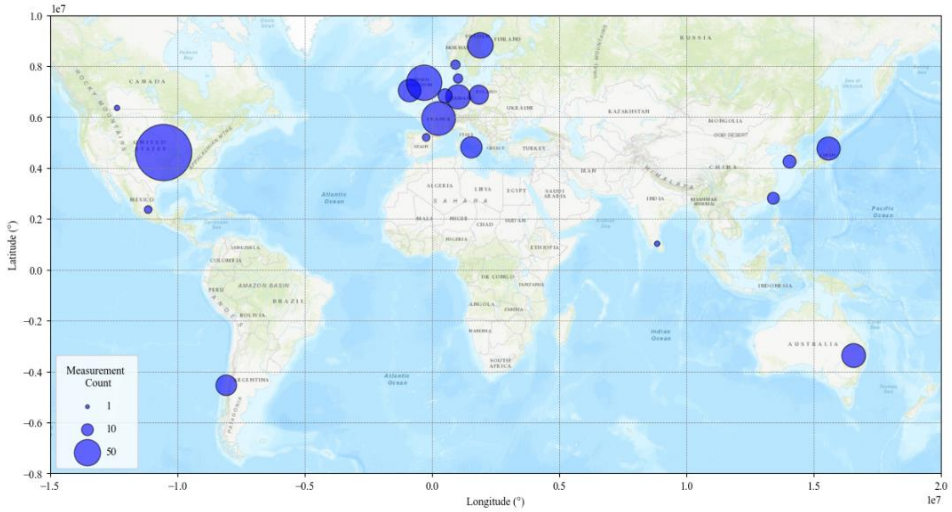
RWE-Whiffle joint validation

Objectives

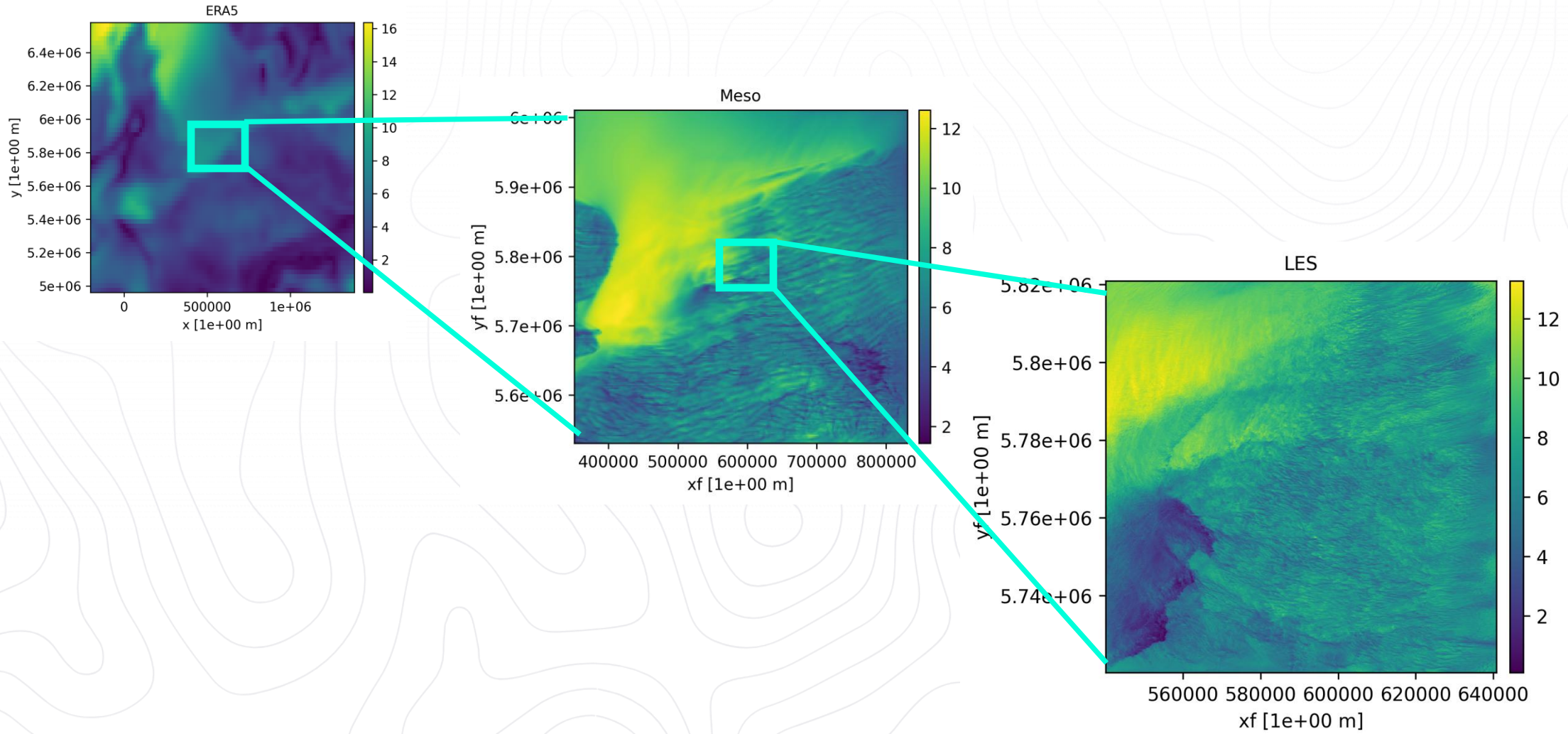
- RWE benchmarks wind modelling data providers to reduce uncertainty of wind resource assessments.
- Whiffle uses validation results for shaping and prioritizing model development roadmap.

Scope

- Unprecedented scale: 170+ sites, 300+ measurement locations
- Meso-scale + LES validation
- Offshore and onshore measurements included
- Single location time series validation + multiple location cross prediction within site

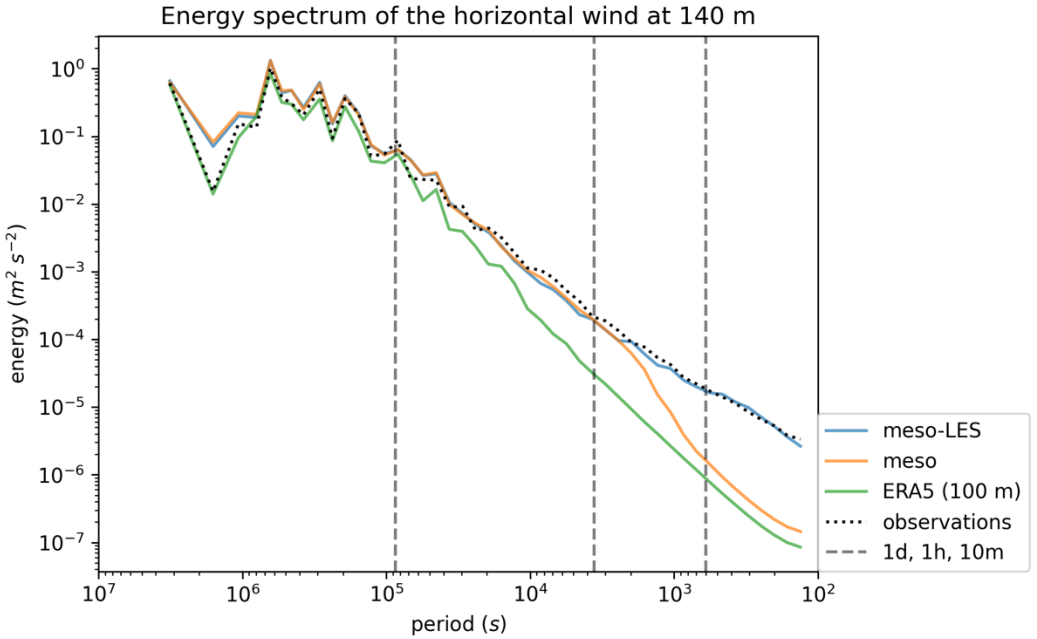


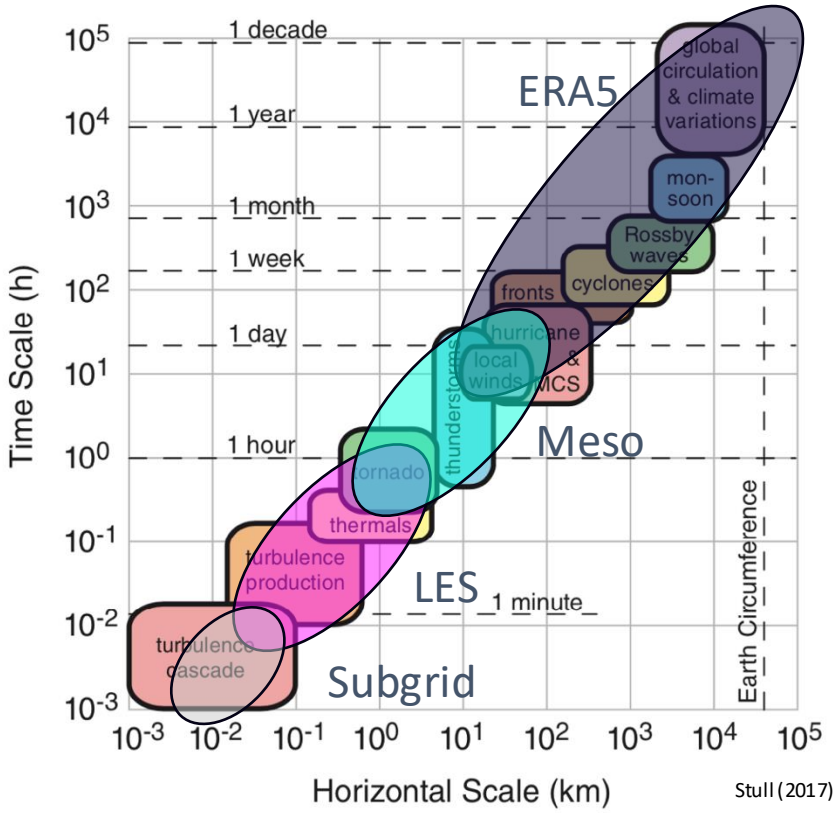
Whiffle Meso and Whiffle LES



Whiffle Meso and Whiffle LES

- Same governing equations and GPU-resident solver
- LES (~1 to 100m resolution)
  - Resolved turbulence up to grid scale
  - Subgrid model for small scale dissipation
- Meso (~1 to 10km resolution)
  - All turbulent mixing parameterized



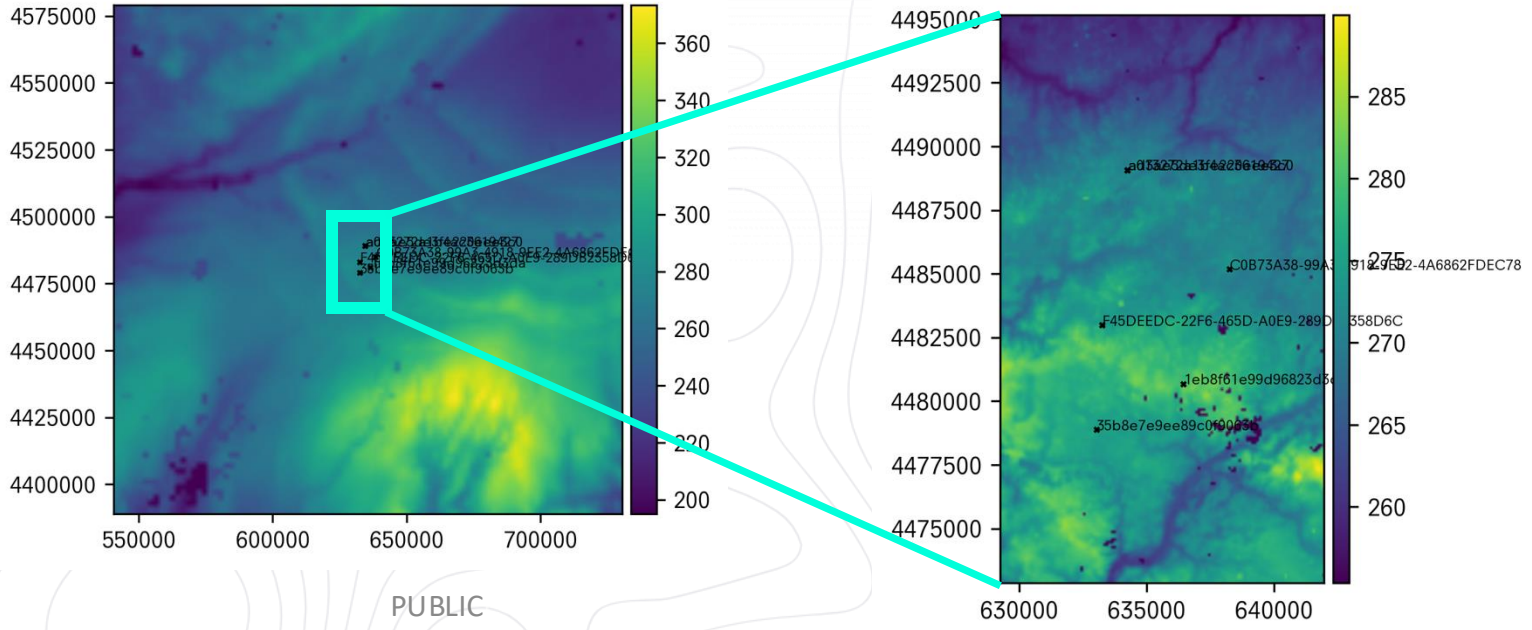


Stull (2017)

Whiffle modelling setup

- Default Whiffle Wind modelling recipe, model version 13
- Meso at 2 km resolution at 256x256 km grid, with 40 m vertical spacing.
- LES at 100 m resolution at site-specific grid of at least 13x13 km, with 25 m vertical spacing.
  - Domain selected around measurement locations with at least 5 km margin
- In total 60K+ 24 hour runs with 6 hour meso/1 hour LES spin-up each for massive parallelization

Example Meso and LES domain setup



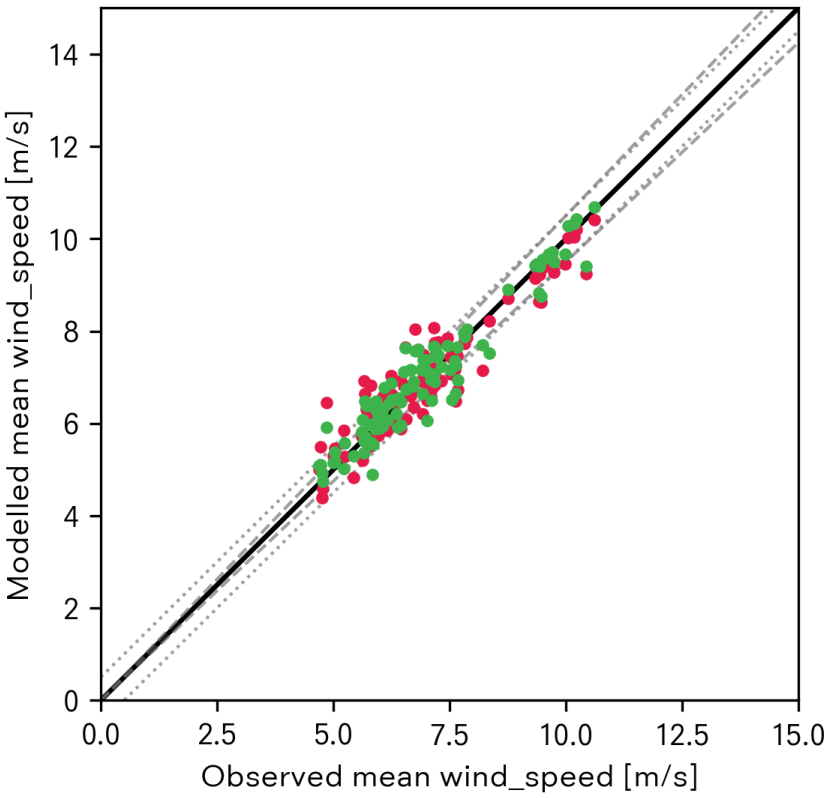
Data selection and filtering

- Site and measurement location (meta)data compiled and validated by RWE.
- For running:
  - Selected ~170 sites of which RWE is allowed to share measurement data with Whiffle.
- For data analysis:
  - Include locations with at least 90 days of overlap between observations and model.
  - Include heights with at least 50% availability.
  - Include timestamps for which all heights have valid measurements.

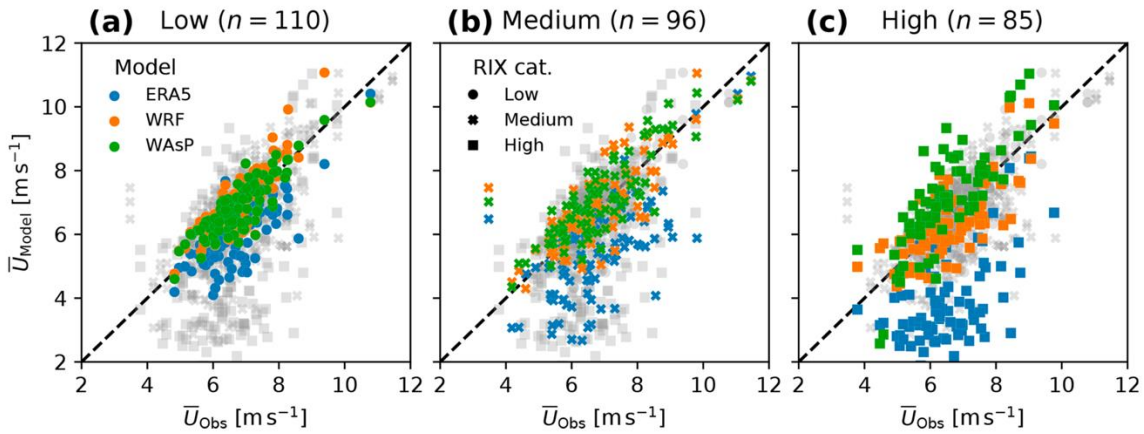
Mean wind speed

Average bias on par with NEWA, substantially lower spread for Whiffle Meso and LES

Whiffle



NEWA for reference

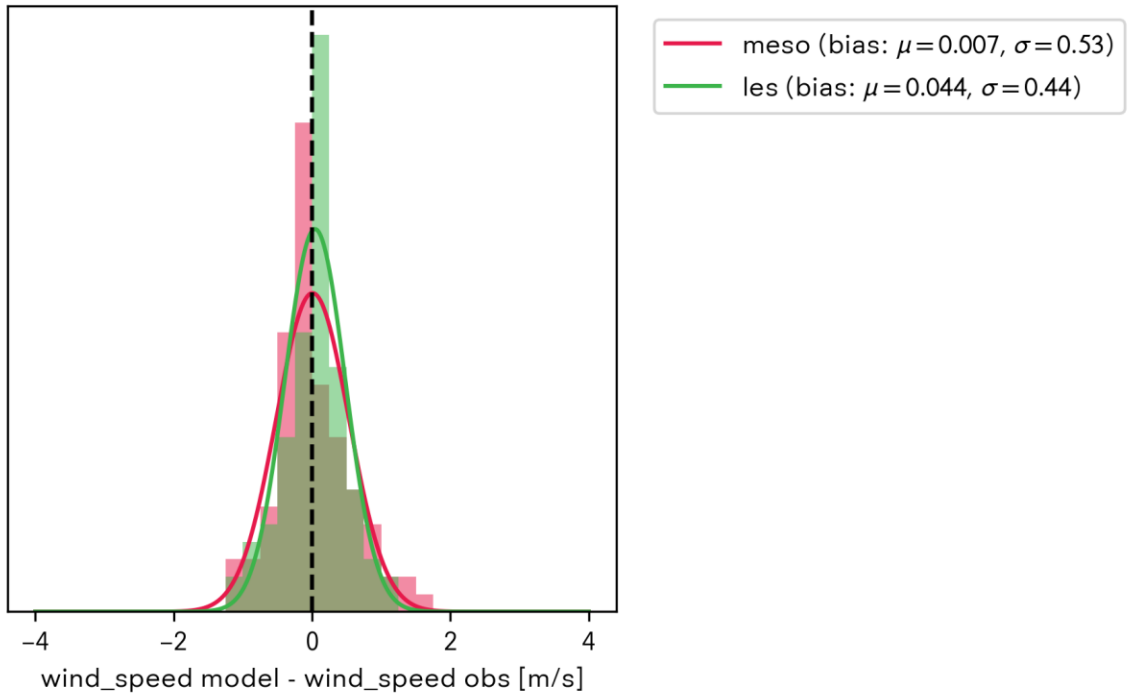


Dörenkämper, Martin, et al. "The making of the new european wind atlas–part 2: Production and evaluation." Geoscientific Model Development Discussions 2020 (2020): 1-37.

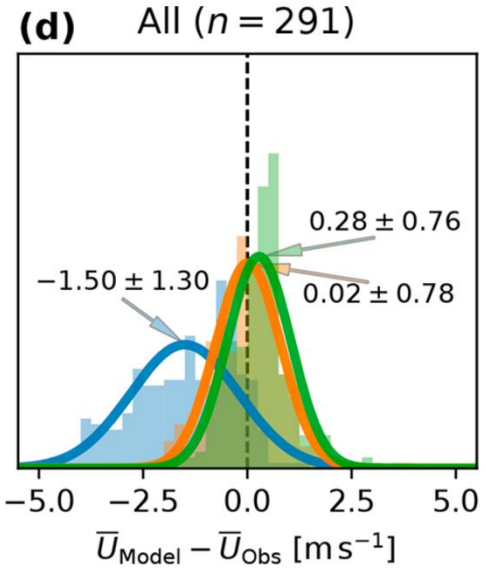
Mean wind speed

Average bias on par with NEWA, substantially lower spread for Whiffle Meso and LES

Whiffle



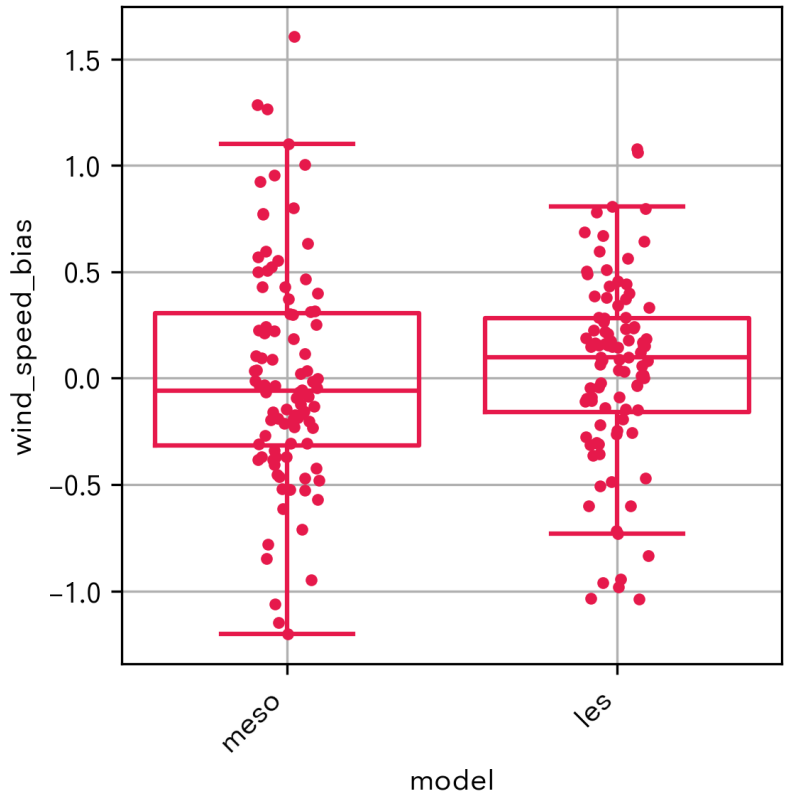
NEWA for reference



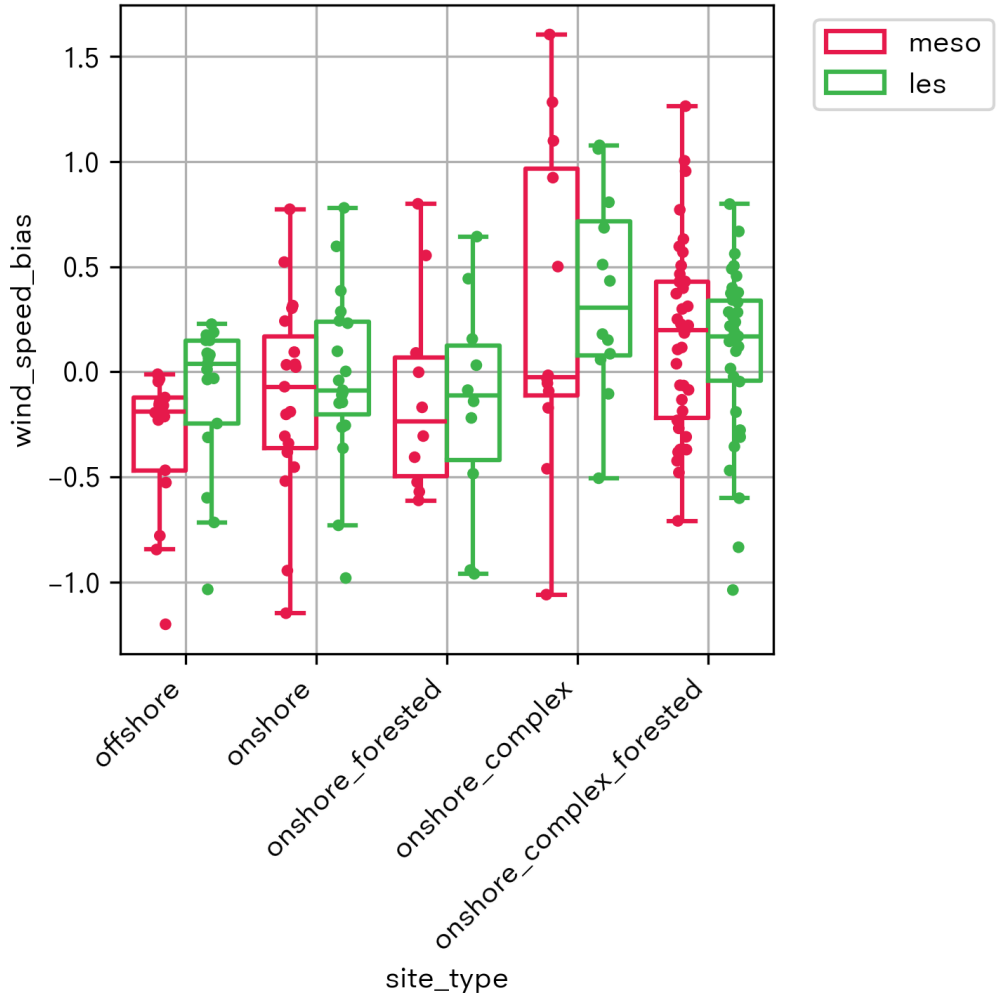
Dörenkämper, Martin, et al. "The making of the new european wind atlas–part 2: Production and evaluation." Geoscientific Model Development Discussions 2020 (2020): 1-37.

Wind speed bias

All sites

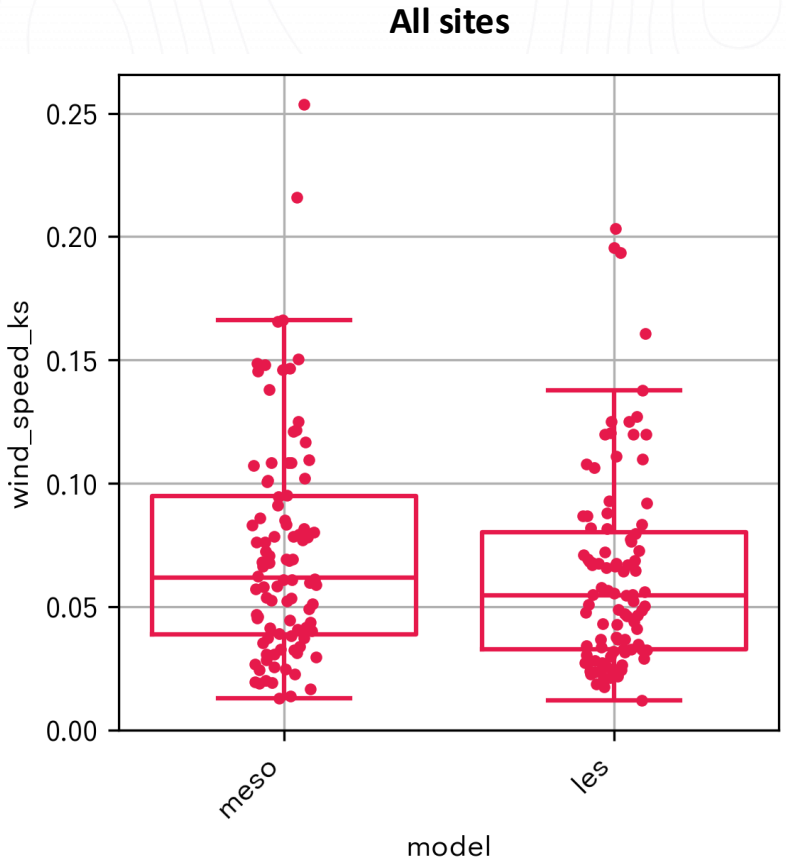


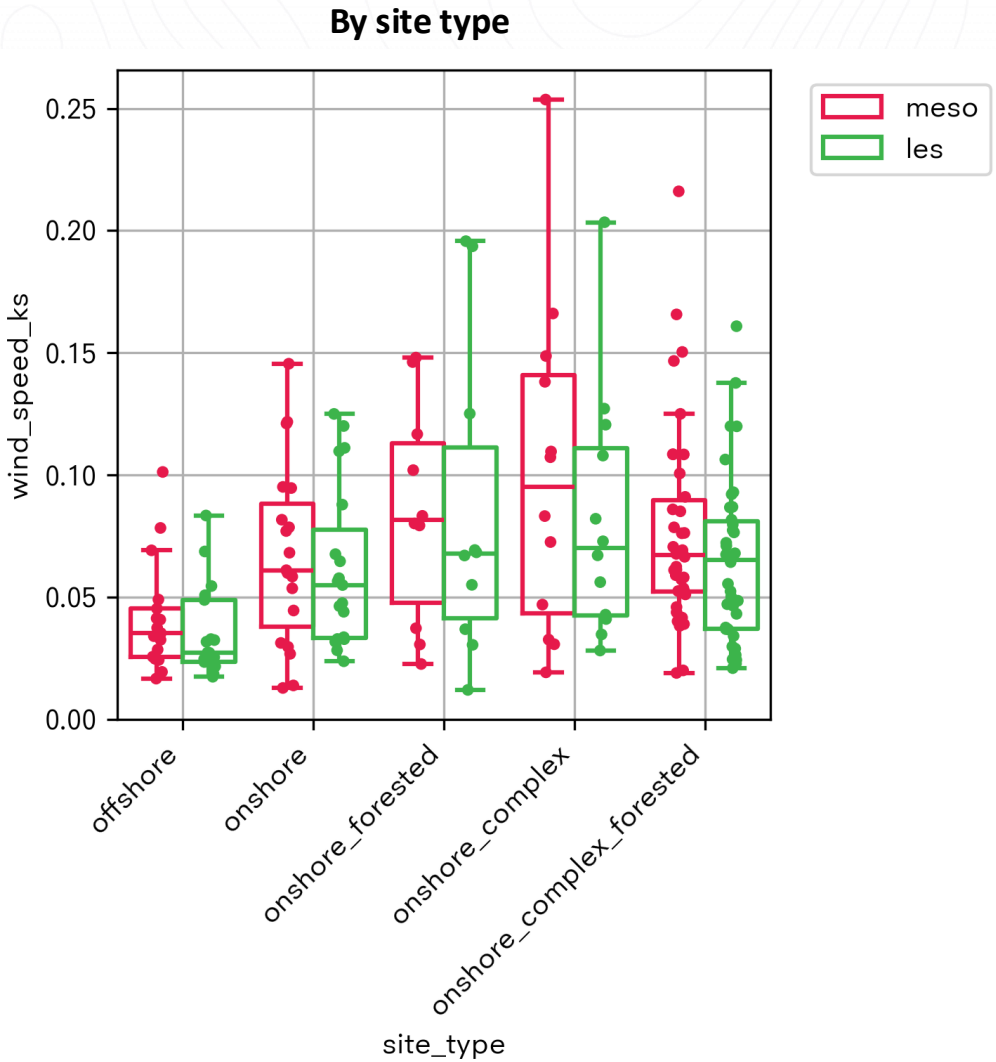
By site type



Wind speed distribution

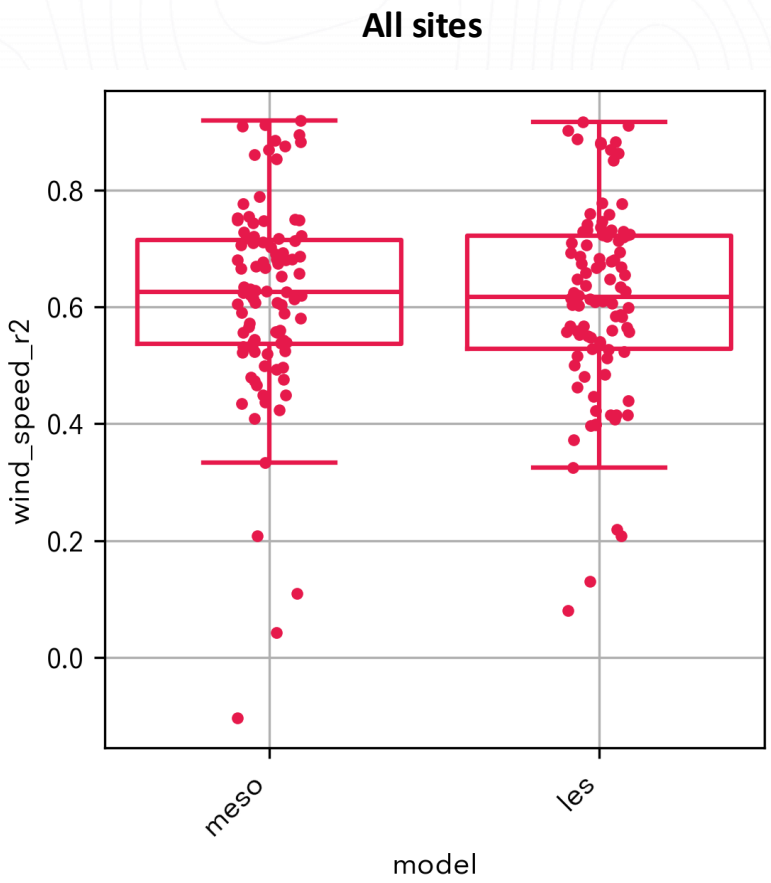
LES shows lower KS-statistic, indicating better match of wind distribution

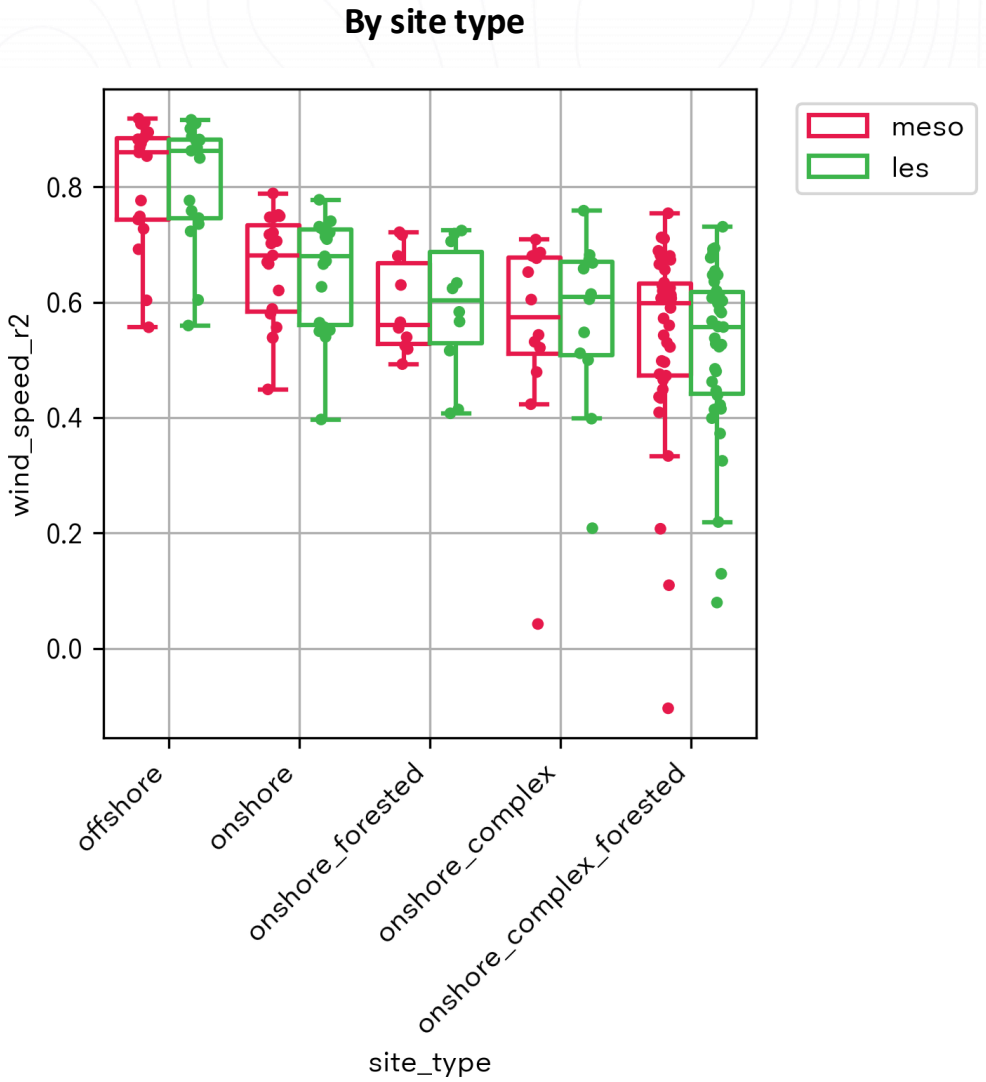




whiffle

Wind speed R2





The scaled power metric

RWE uses the *scaled power* as a proxy for the approximate annual energy production (AEP) modelling error:

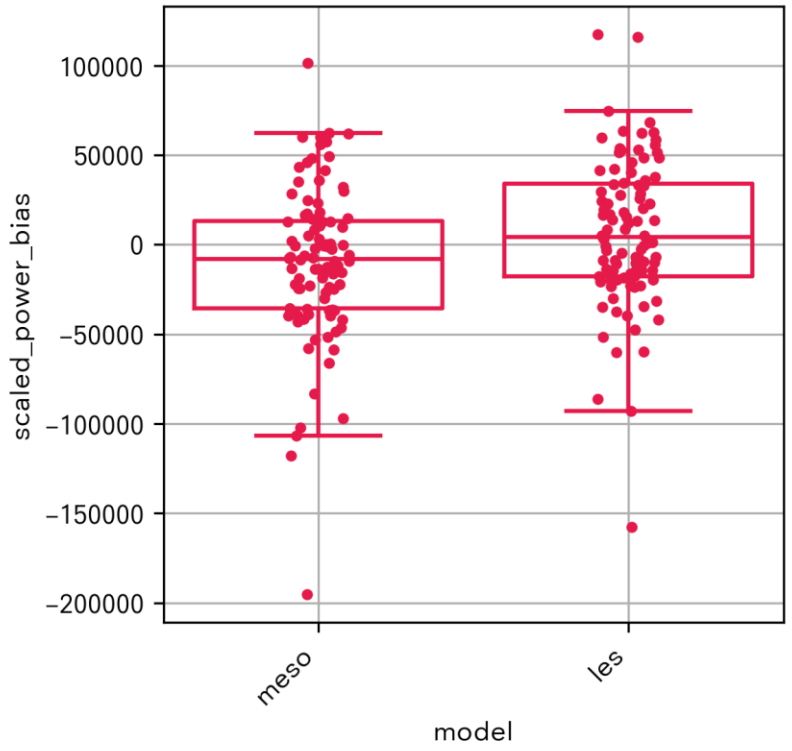
Observed scaled power = power curve evaluated at observed wind speed

Modelled scaled power = power curve evaluated at (modelled wind speed x $\frac{\text{Mean observed wind speed}}{\text{Mean modelled wind speed}}$)

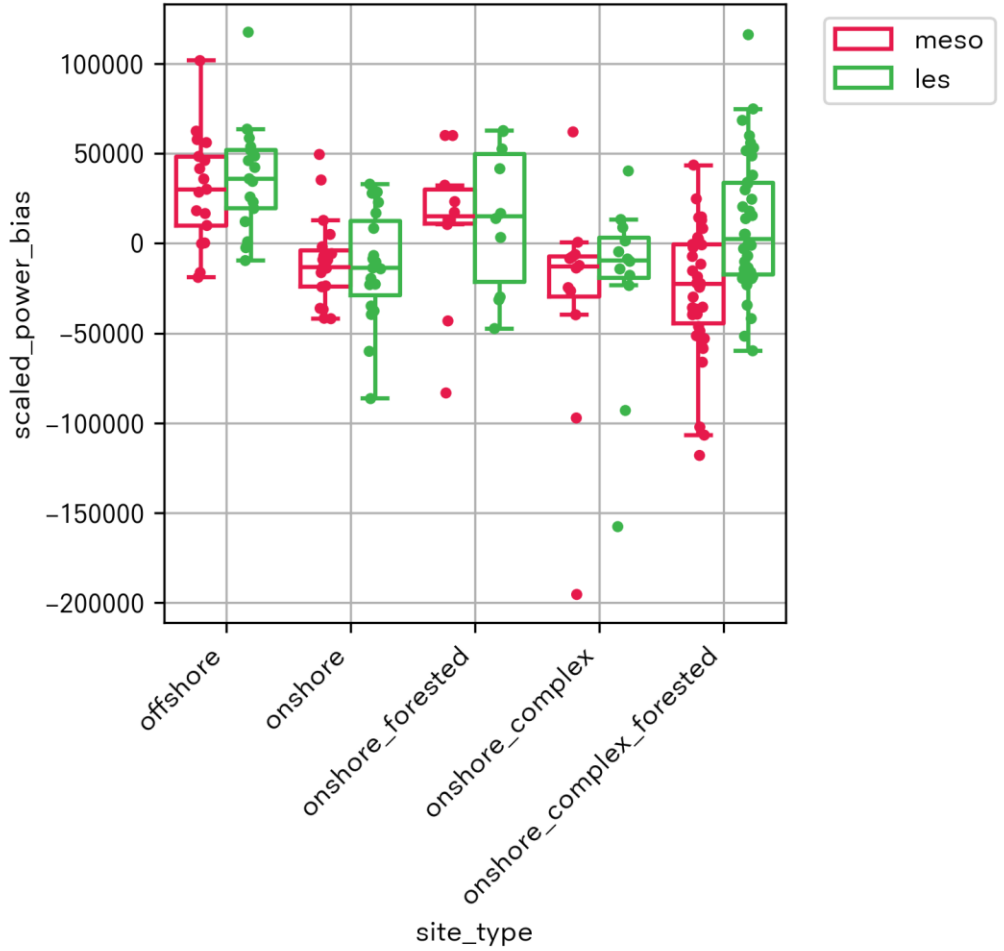
Scaled power bias

Offshore scaled power bias > 0 for Meso and LES: relative overprediction for sub-rated wind speeds?

All sites



By site type



Conclusions and outlook

Whiffle Meso

- Whiffle Meso average bias on par or lower in comparison with NEWA.
- Lower spread around the mean bias: lower uncertainty in wind speed modelling for unseen site.

Whiffle LES

- Slightly higher mean bias but further reduced spread around the mean bias.
- Shows added value over Whiffle Meso mainly in distributional metrics.

- RWE presented results at WindEurope in April 2025 + joint paper planned.