NREL
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The SWiFT Benchmarks

Part of IEA Wind Task 31 Phase 3 (2018-2019)
Meeting #7 – WakeBench Meeting in Visby, Sweden

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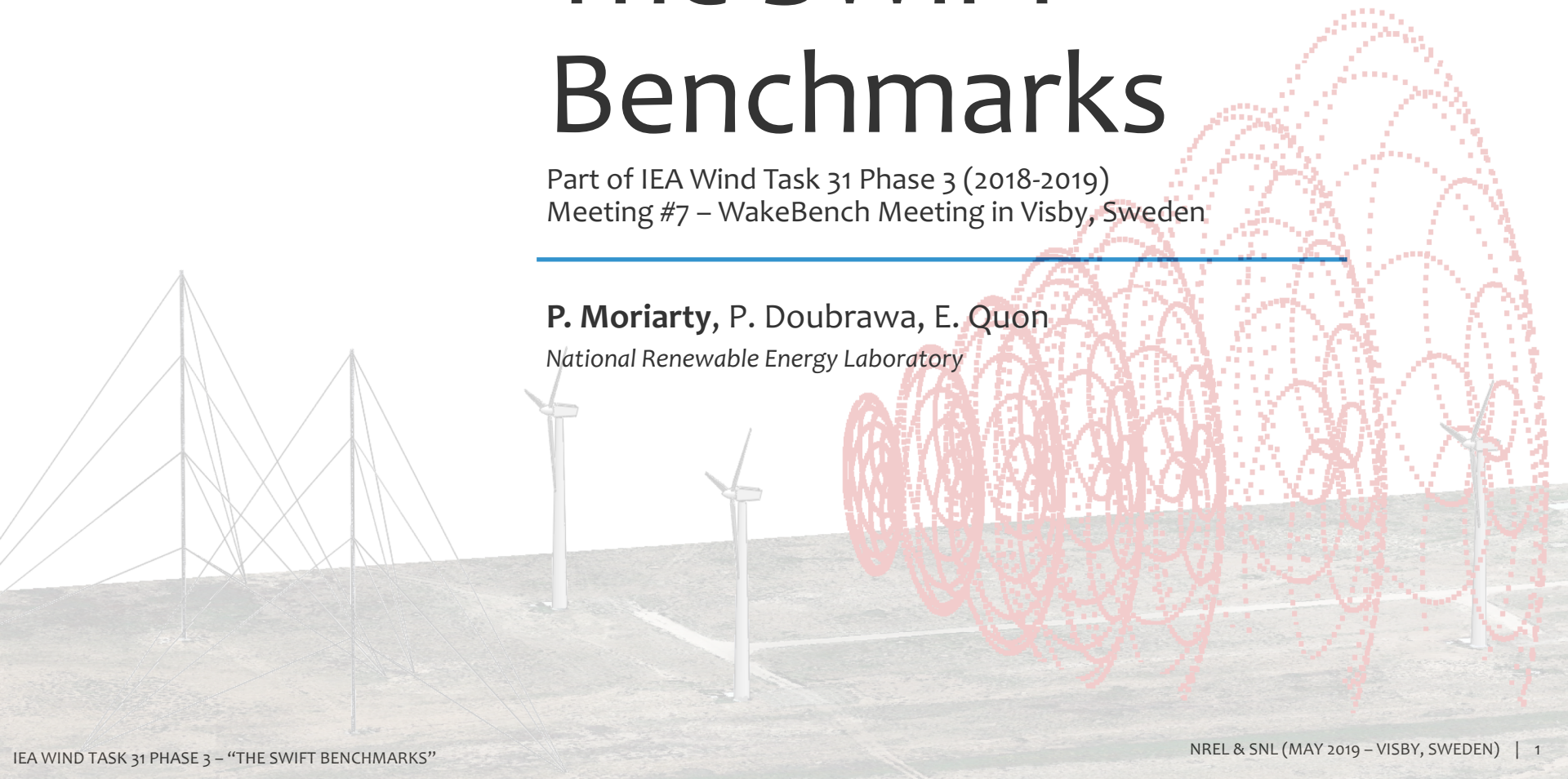
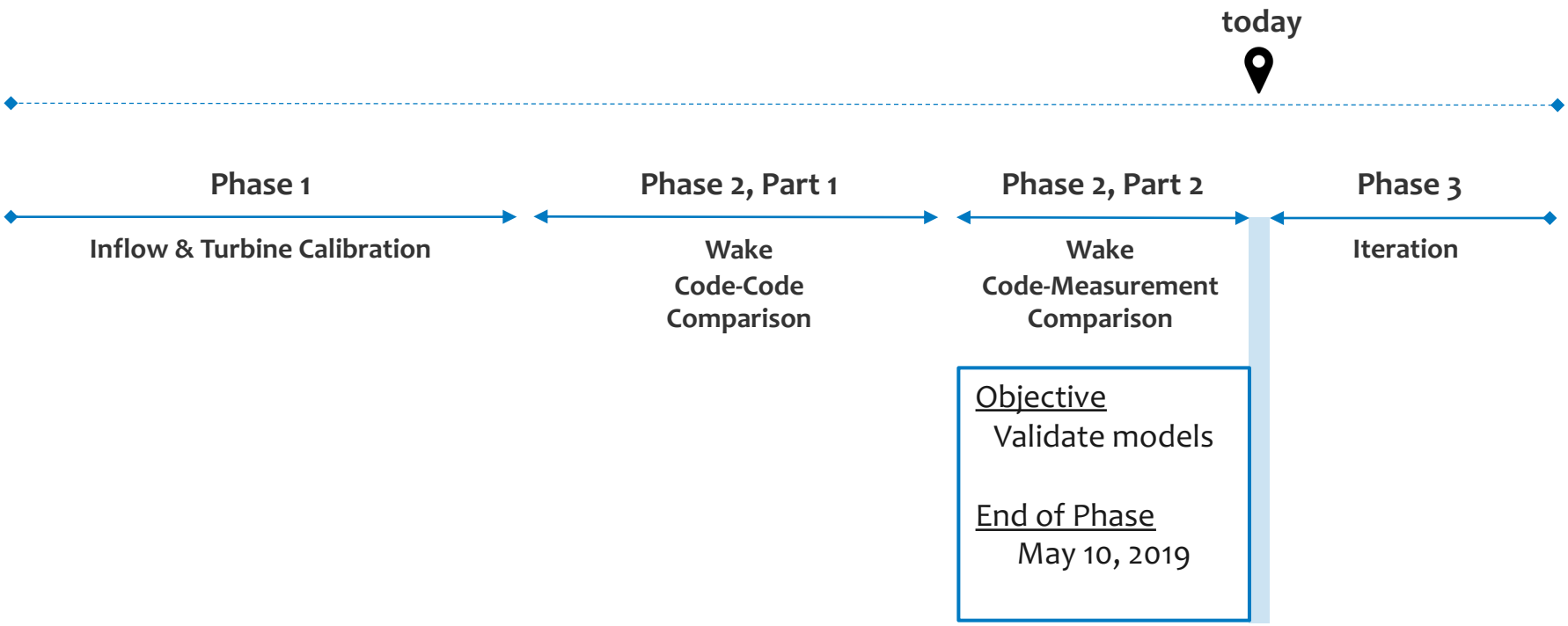
National Renewable Energy Laboratory



Status

More info: https://wakebench-swift.readthedocs.io



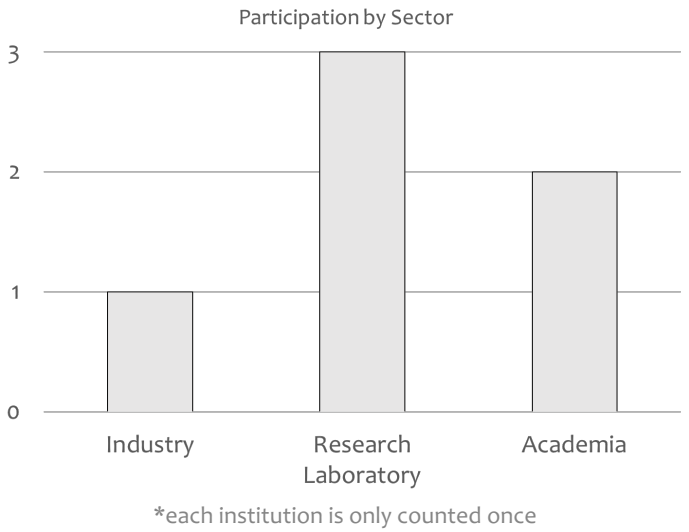
Phase 2

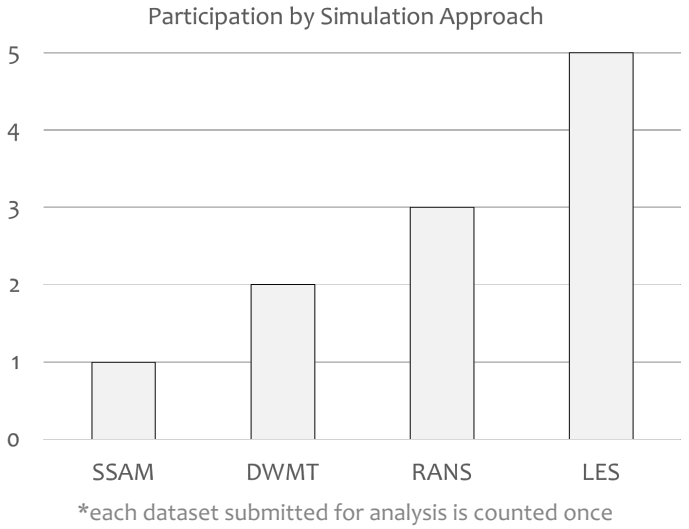
Participation

*Model-Model Comparison

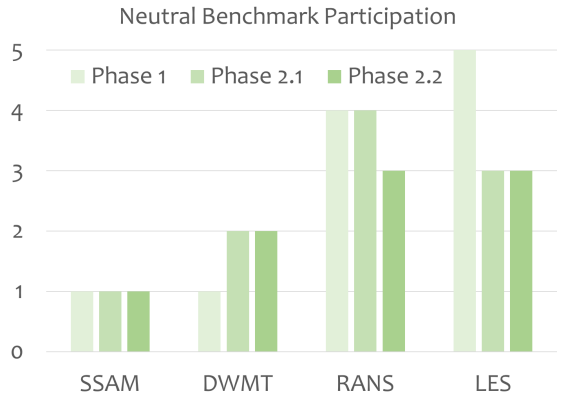
Participation

- 6 institutions currently
- 11 simulation approaches



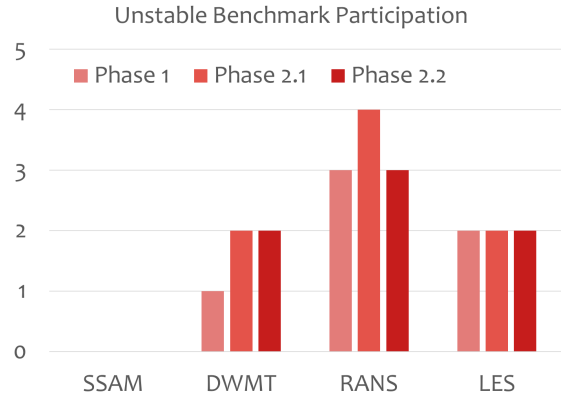


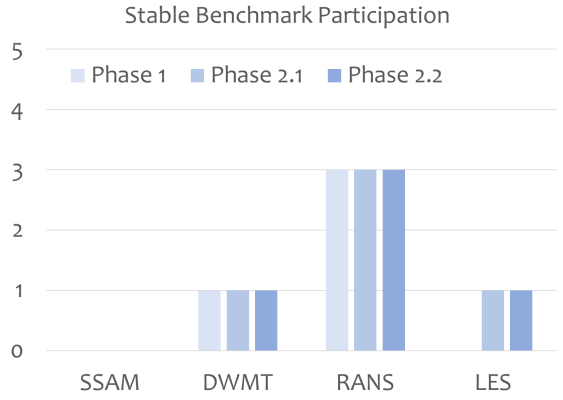
Participation



Hub-height wind speed ~ 8.7 m/s
Hub-height turbulence intensity ~ 10.7 %
Power-law shear exponent ~ 0.14
Stability parameter z/L ~ 0.00

Hub-height wind speed ~ 6.7 m/s
Hub-height turbulence intensity ~ 12.6 %
Power-law shear exponent ~ 0.14
Stability parameter z/L ~ -0.09





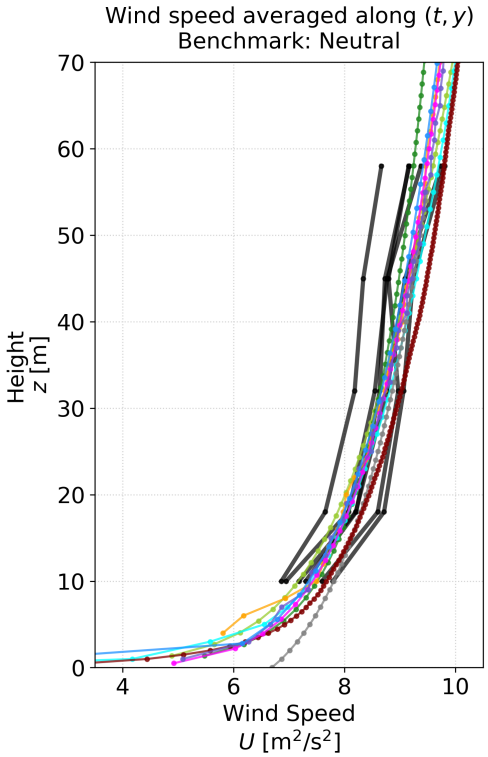
Hub-height wind speed ~ 4.8 m/s
Hub-height turbulence intensity ~ 3.4 %
Power-law shear exponent ~ 0.5
Stability parameter z/L ~ 1.15

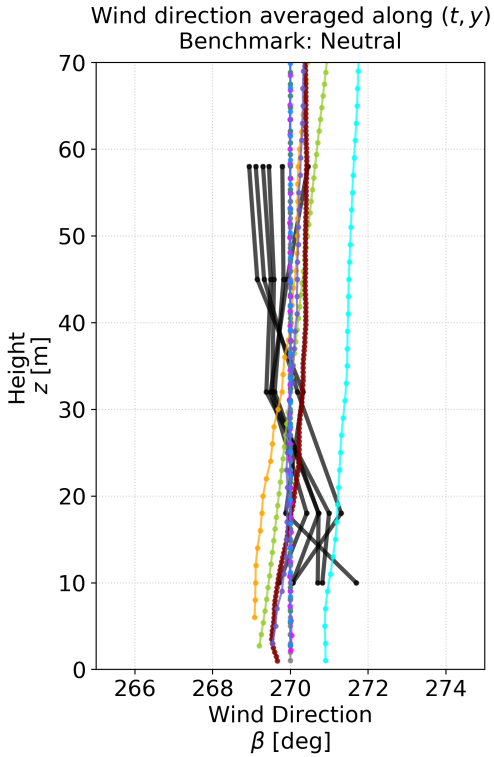
Phase 2: Blind Comparison

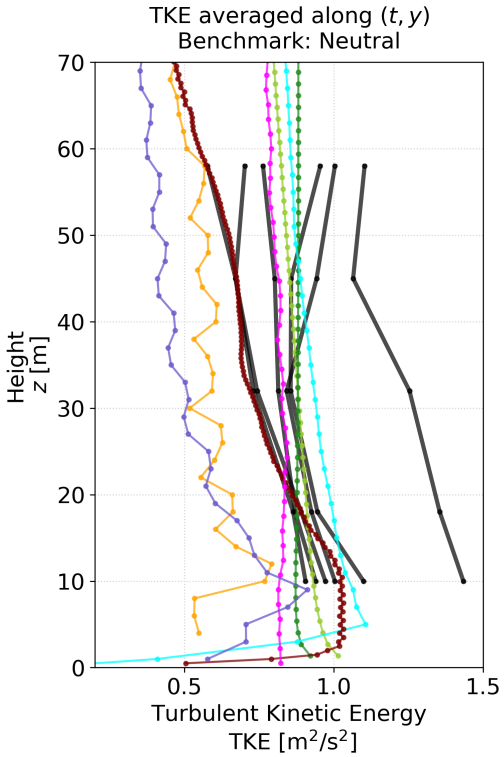
Atmospheric Inflow

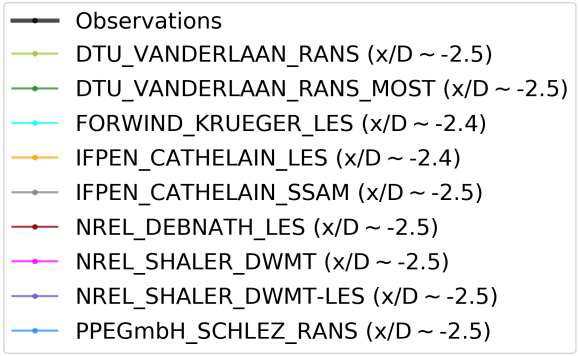
*Model-Model Comparison

Neutral Benchmark

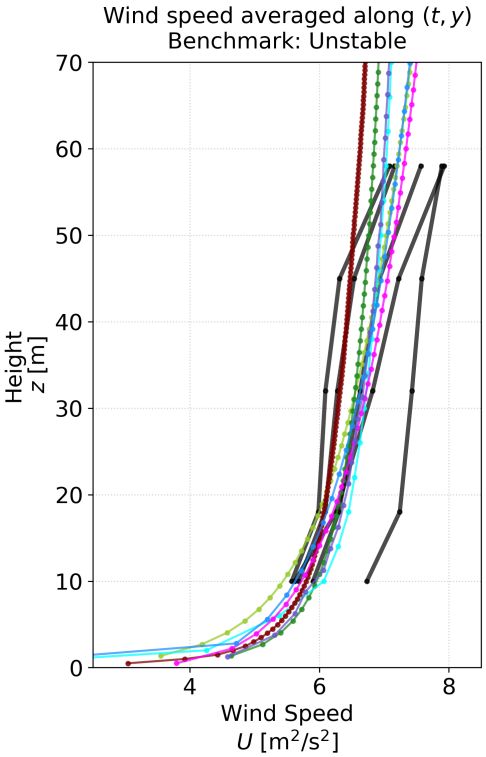


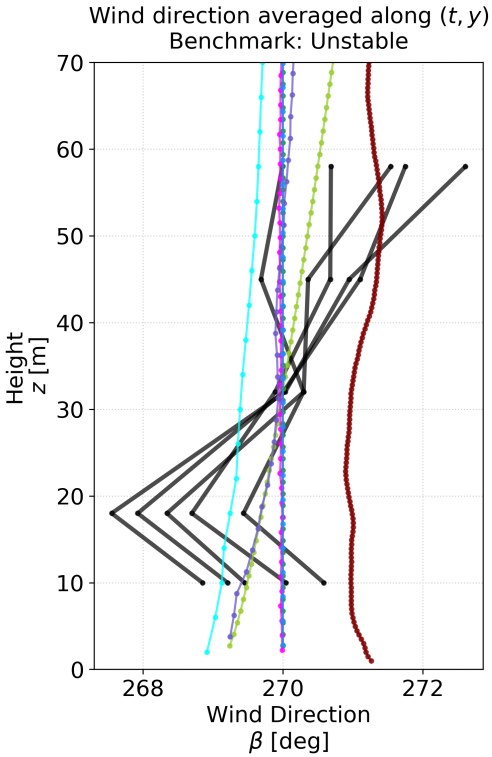


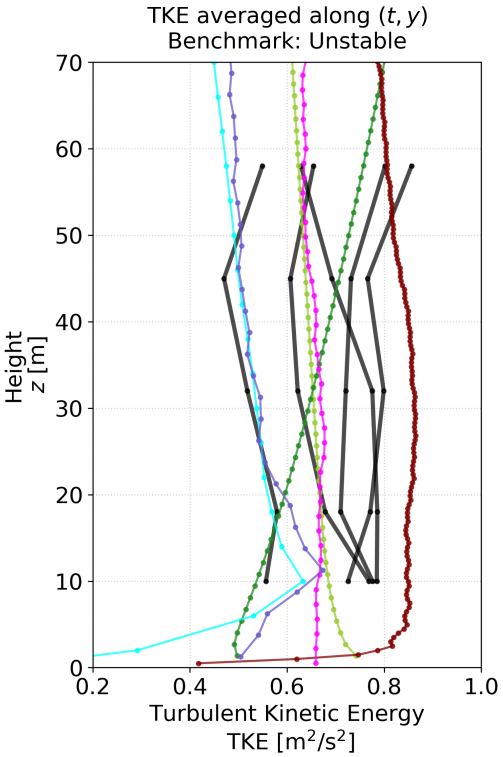


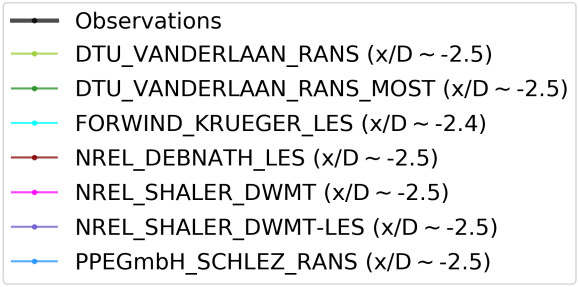


Unstable Benchmark

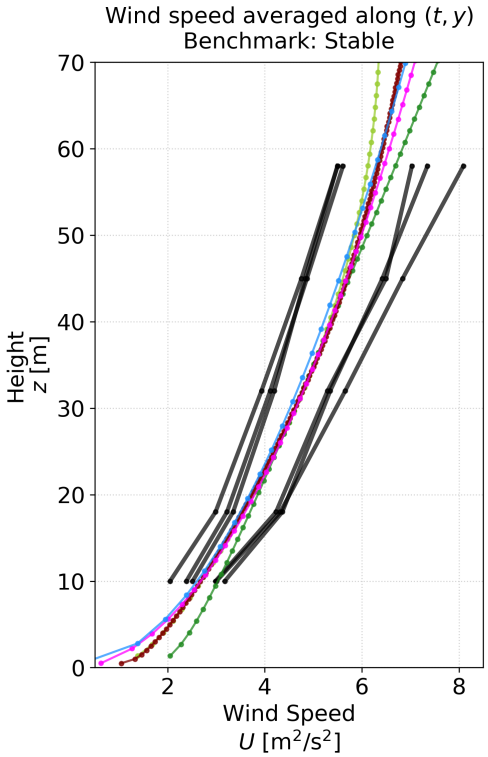


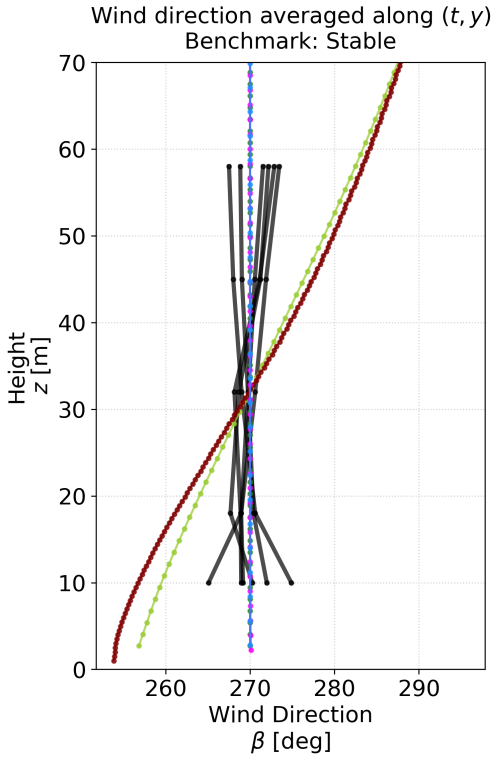


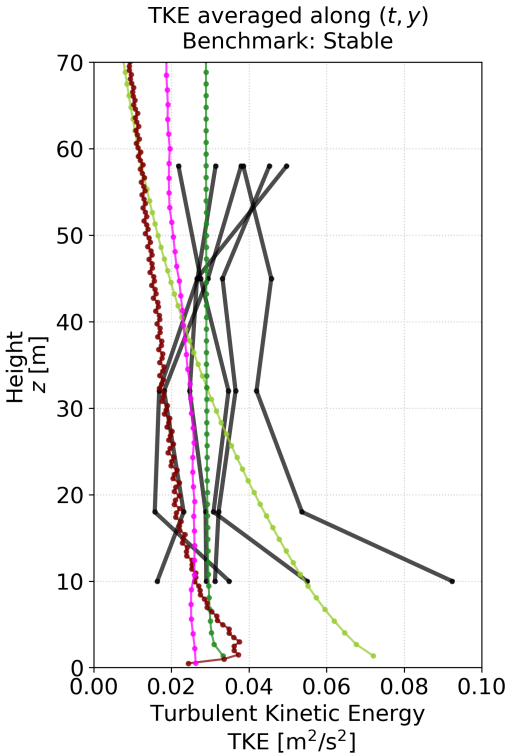


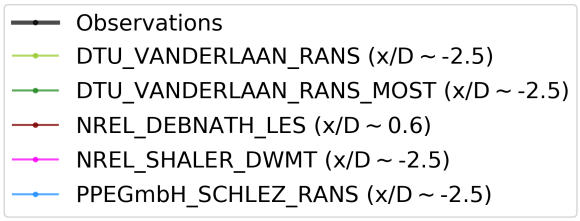


Stable Benchmark







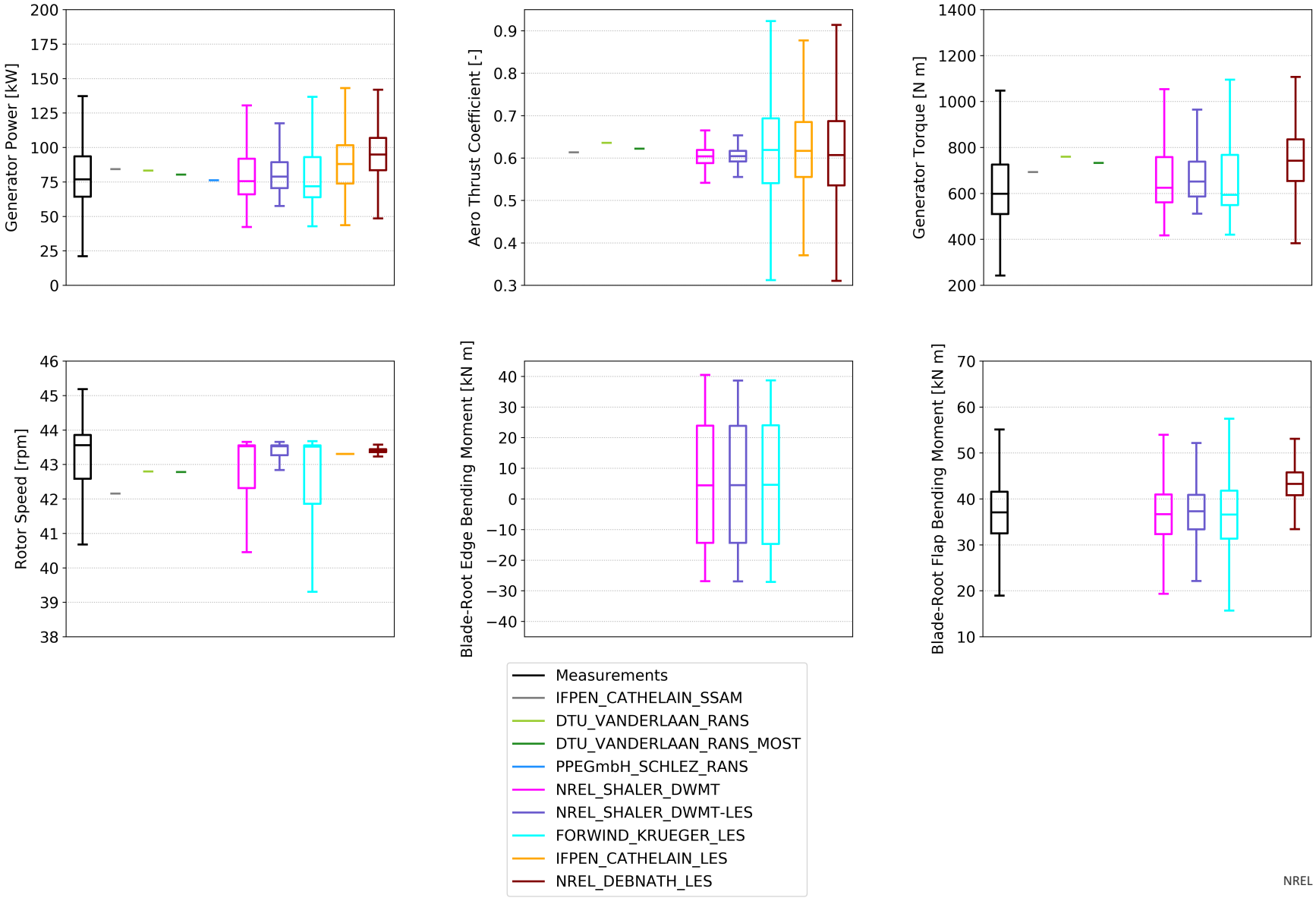


Phase 2: Blind Comparison

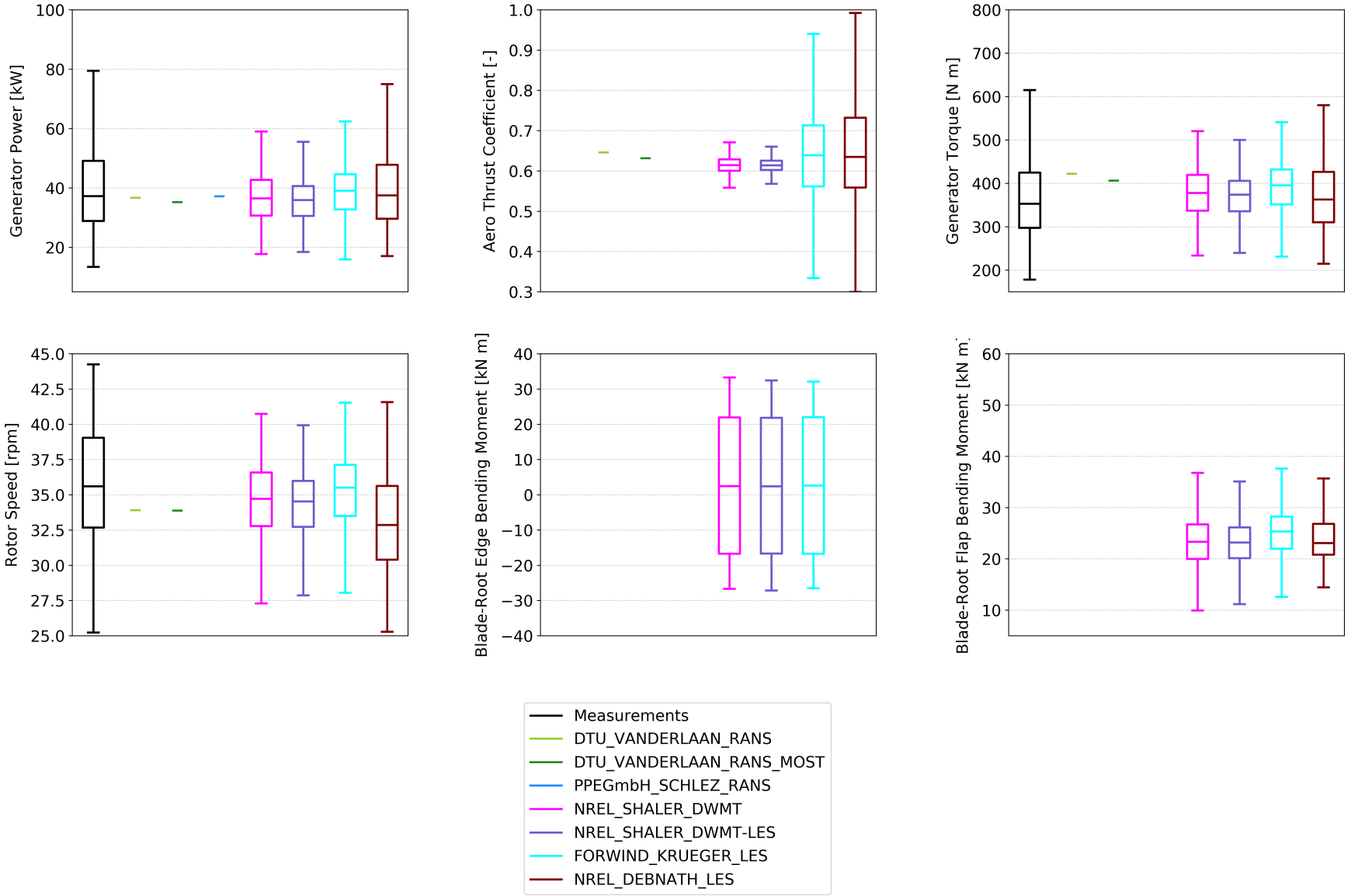
Turbine Response

*Model-Model Comparison

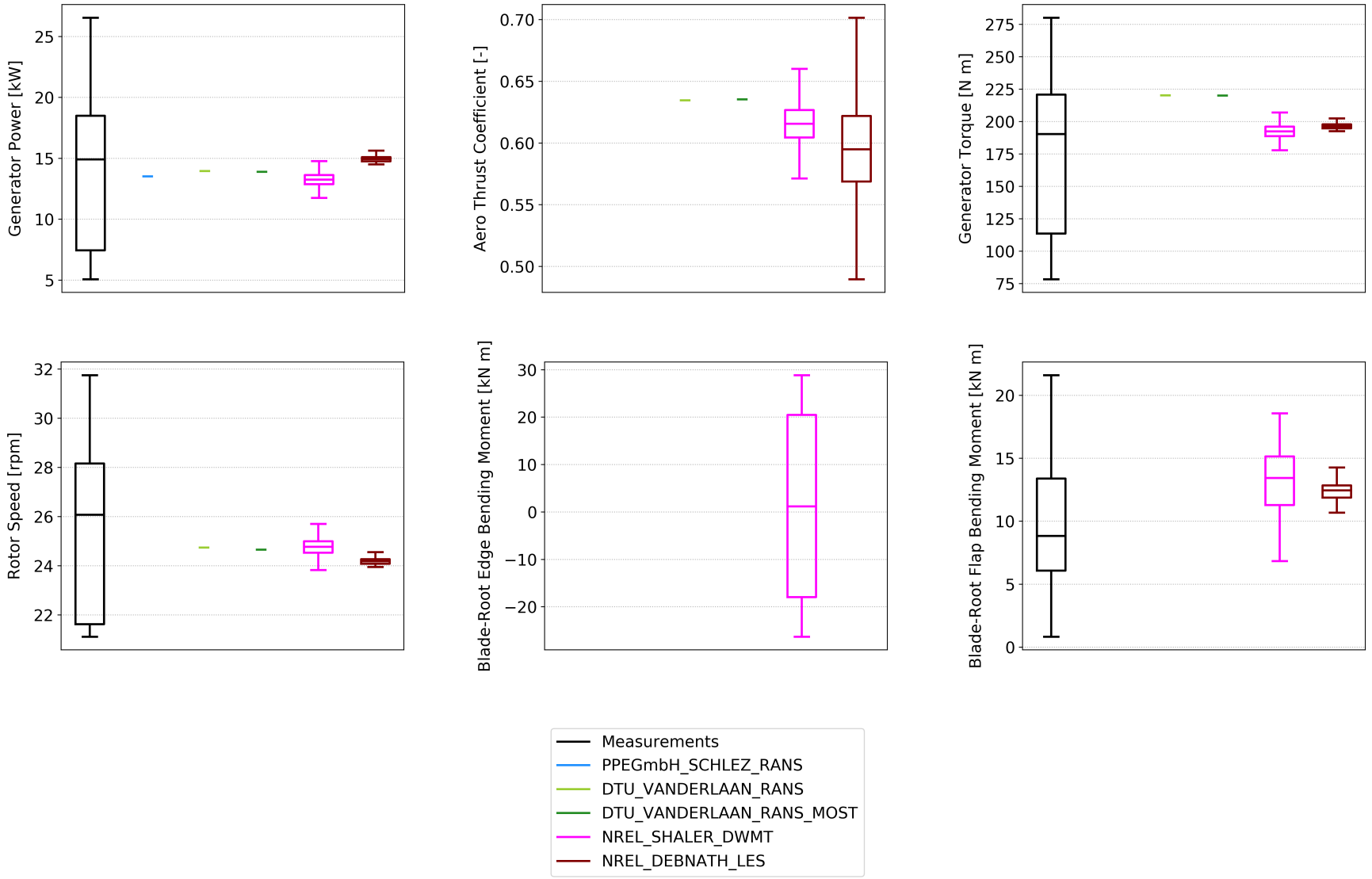
Neutral Benchmark



Unstable Benchmark



Stable Benchmark



Phase 2: Blind Comparison

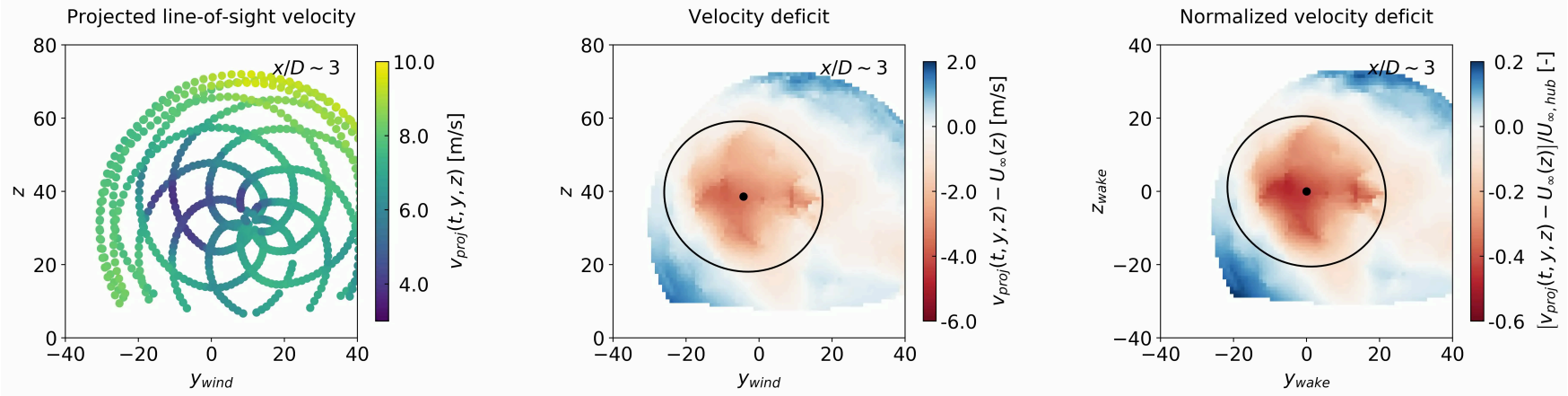
Turbine Wake

*Model-Model Comparison

Processing of lidar wake measurements

DAP: Data Archive and Portal
https://a2e.energy.gov/projects/wake

- Lidar line-of-sight measurements



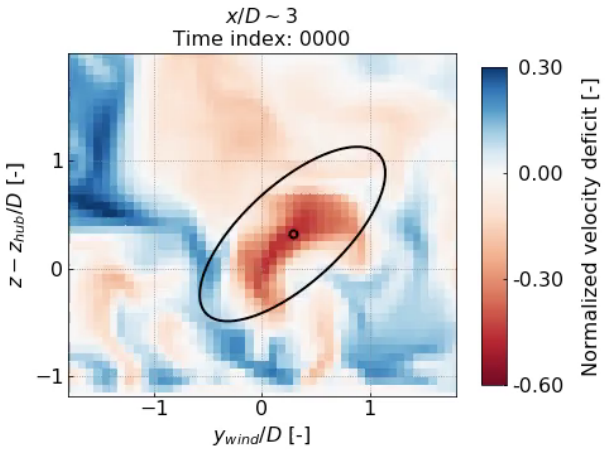
- Interpolation to regular grid
- Computation of velocity deficit
- Identification of wake (2-D Gaussian)
- Estimation of wake center

https://github.com/ewquon/waketracking

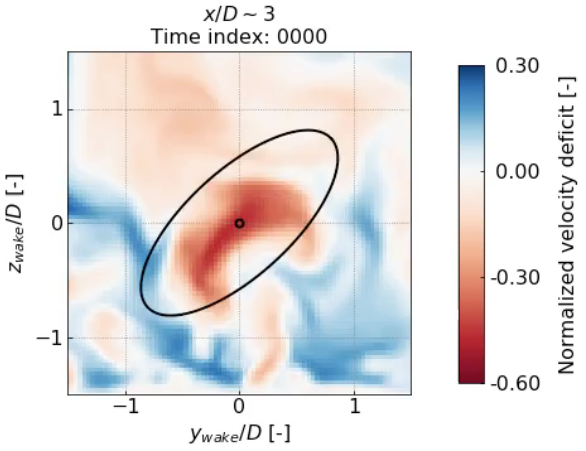
- Translation of each snapshot into meandering frame of reference
- Normalization of deficit relative to U_{hub}

- Time-averaged wake profiles at each x/D
- Statistics of wake center movement

Processing of simulation data

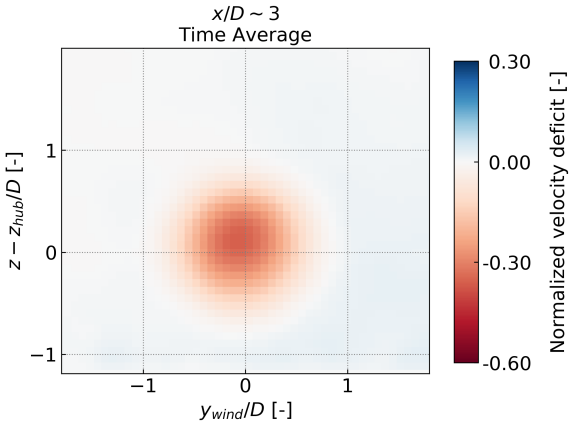


- Computation of velocity deficit
- Identification of wake edge and center

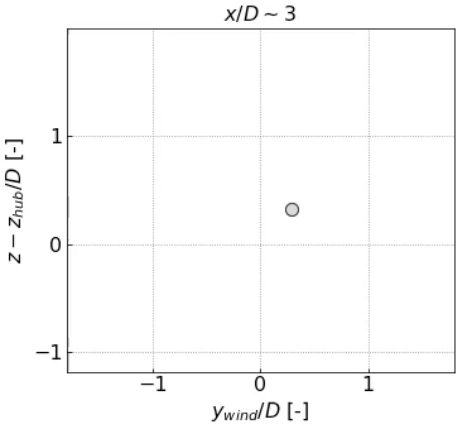


- Translation of each snapshot into meandering frame of reference

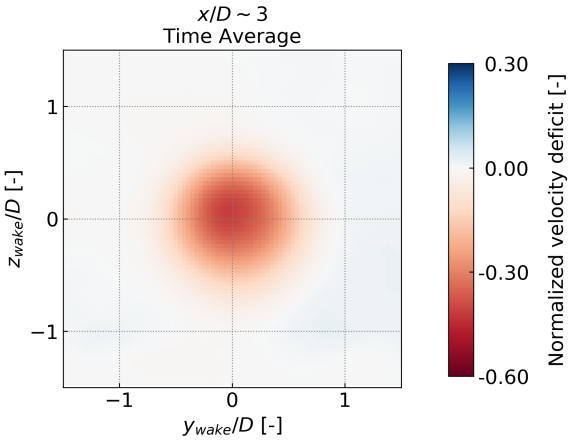
Time average in "fixed" (streamwise) frame



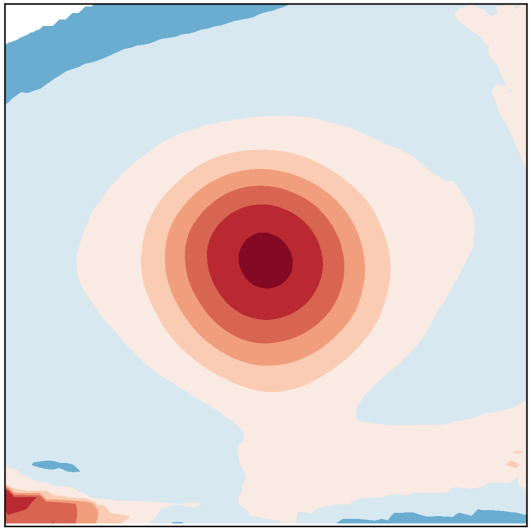
Wake meandering



Time average in meandering (wake) frame



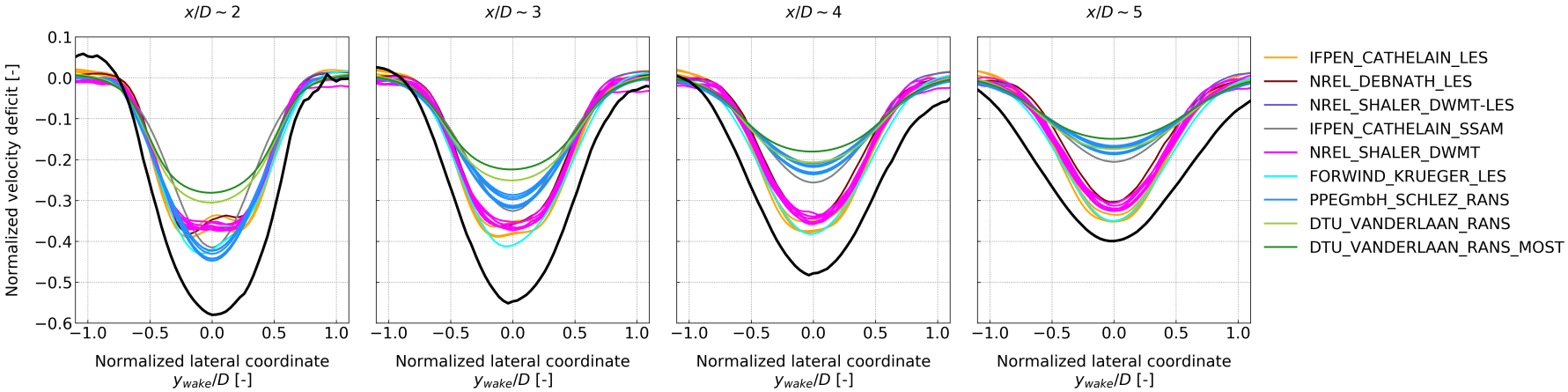
Mean Wake



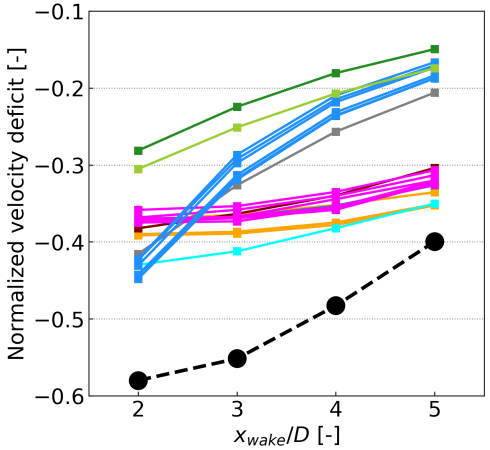
Neutral Benchmark

[analysis in meandering frame of reference]

> Horizontal profiles of normalized velocity deficit at hub height

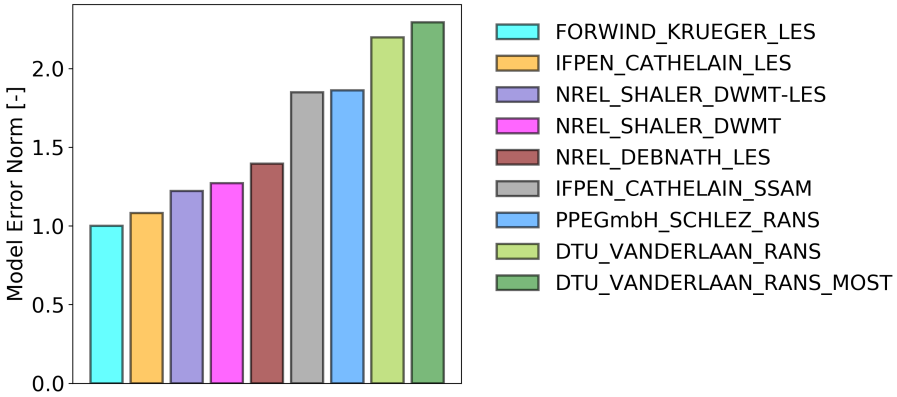


> Downstream evolution of maximum magnitude of mean normalized velocity deficit



> Ranking of model performance in terms of the mean wake deficit at the hub, computed via:

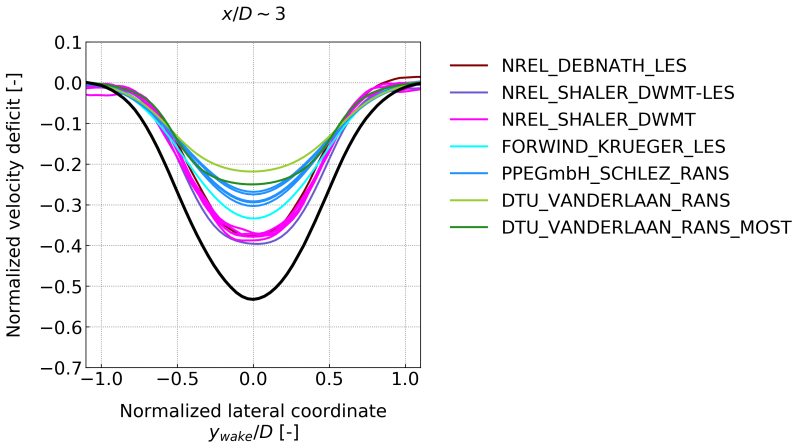
$$\sum_{x/D\sim 2}^{x/D\sim 5} \frac{||vd_{obs}(y, z_{hub}) - vd_{sim}(y, z_{hub}||}{||vd_{obs}(y, z_{hub})||}$$



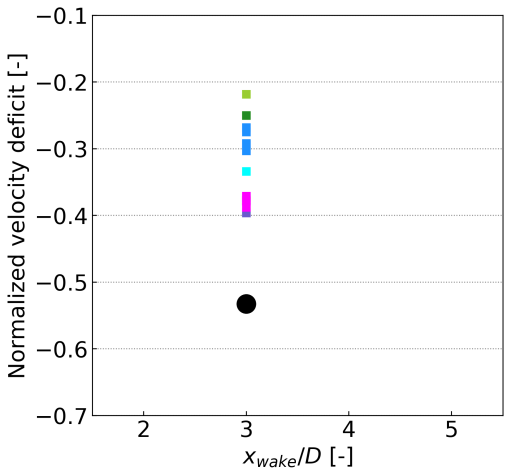
Unstable Benchmark

[analysis in meandering frame of reference]

> Horizontal profiles of normalized velocity deficit at hub height



> Downstream evolution of maximum magnitude of mean normalized velocity deficit



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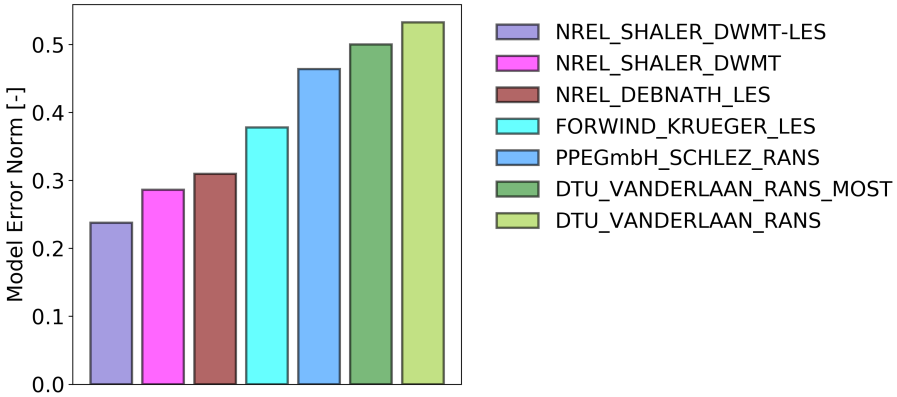
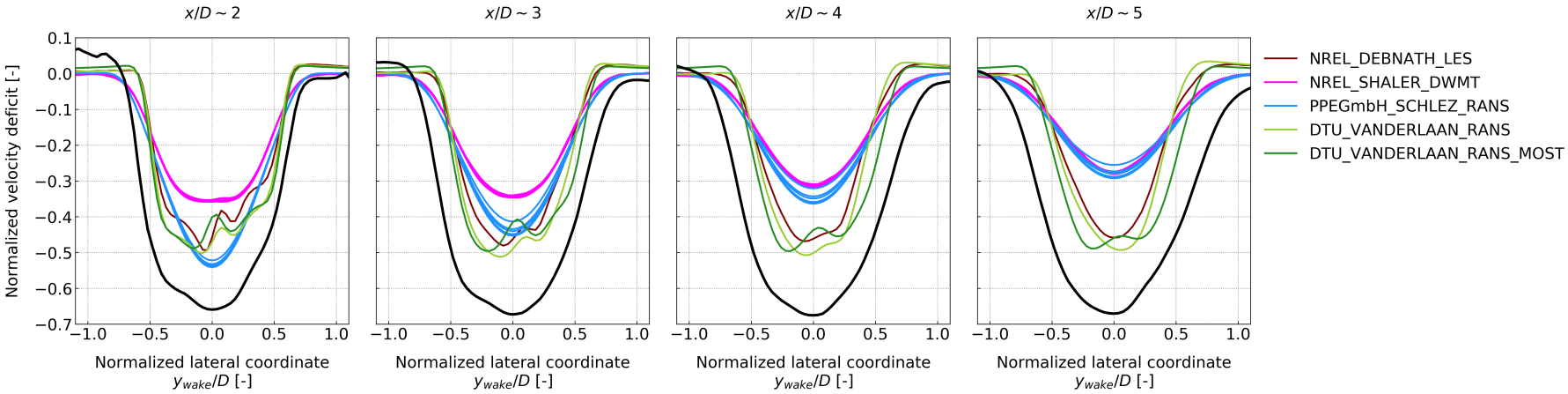


Stable Benchmark

[analysis in meandering frame of reference]

> Horizontal profiles of normalized velocity deficit at hub height



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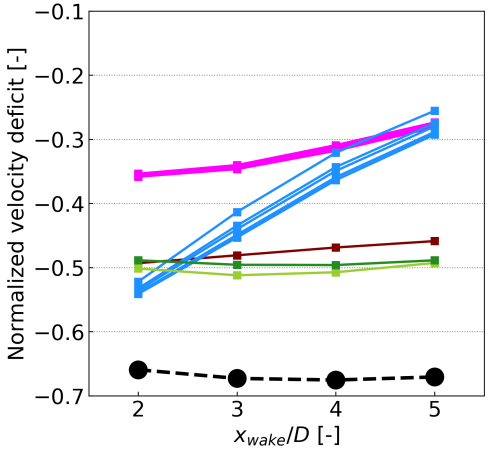

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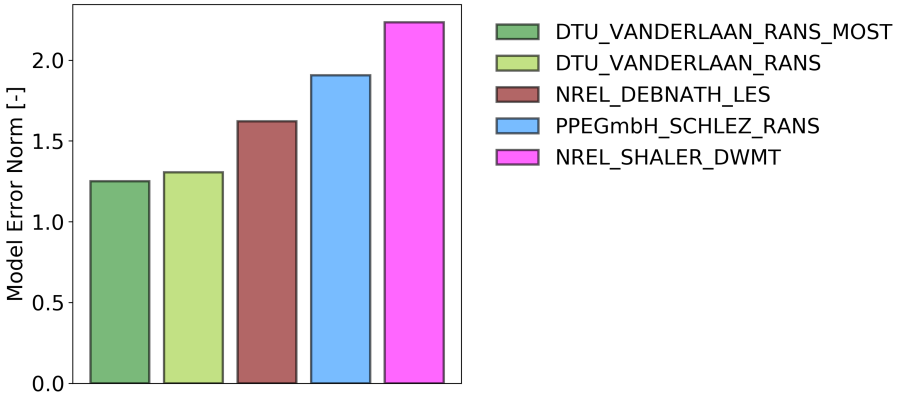
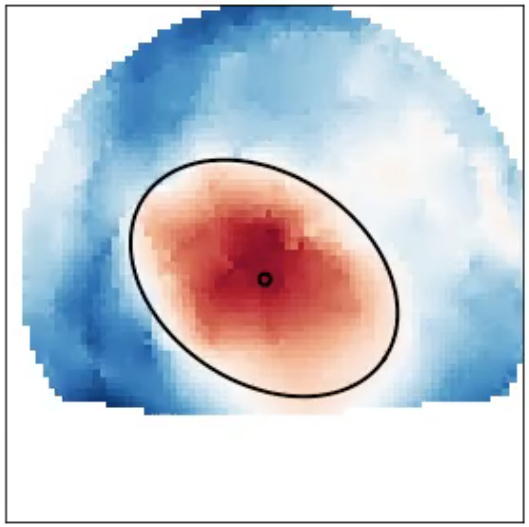
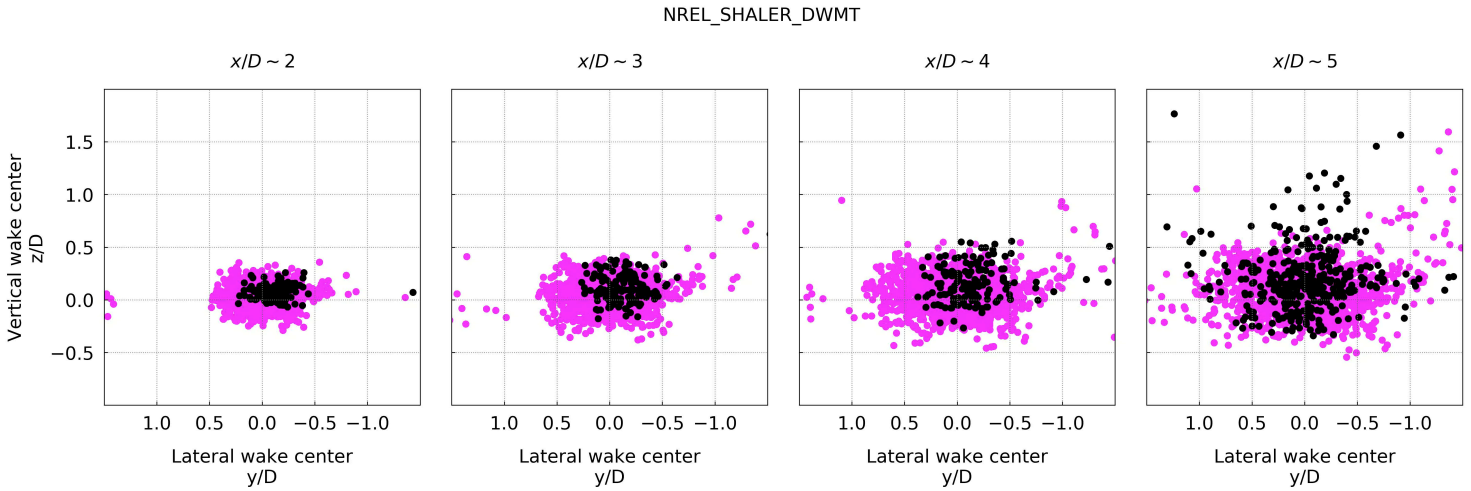
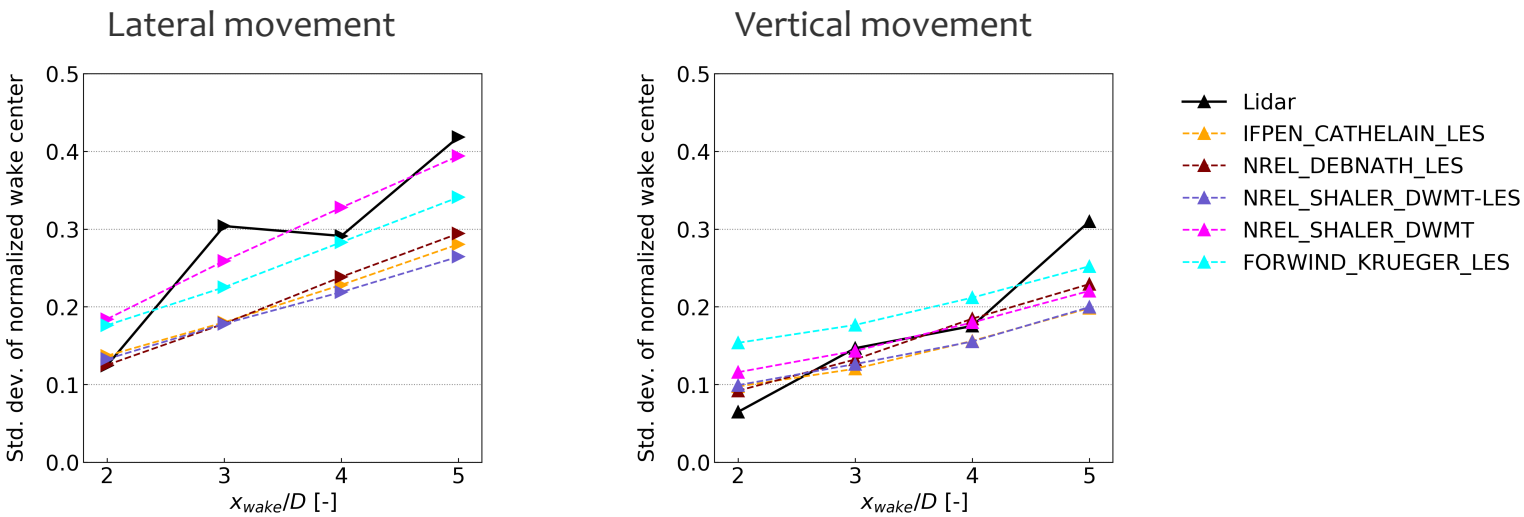


Dynamic Wake

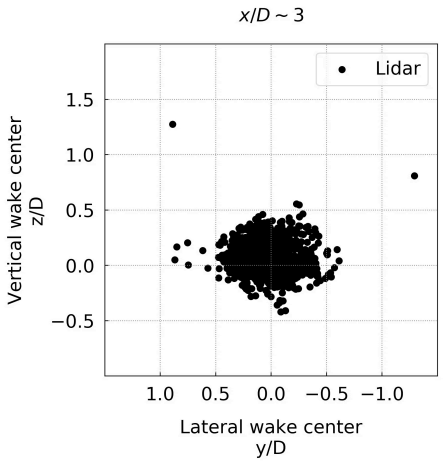


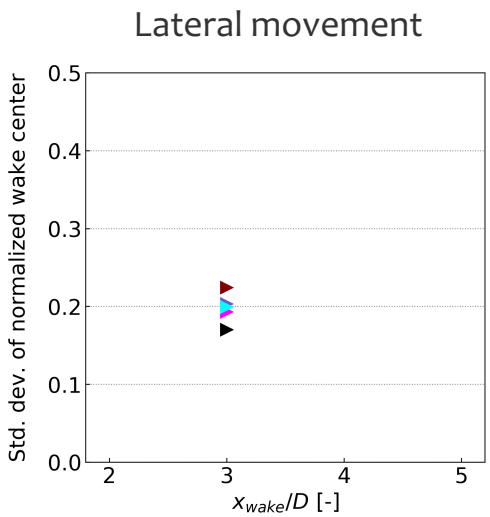
Neutral Benchmark

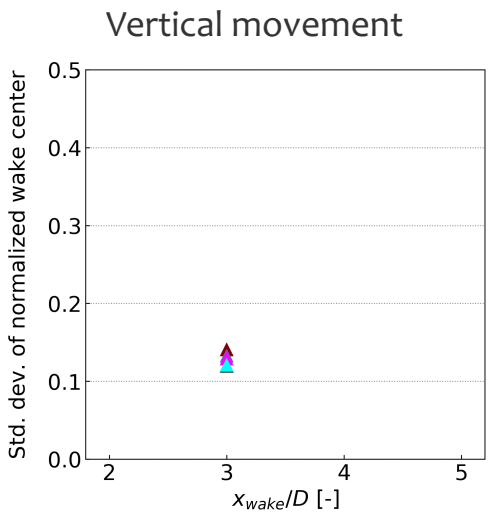


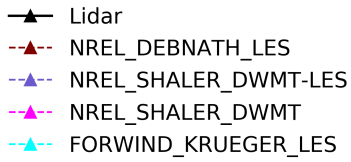


Unstable Benchmark

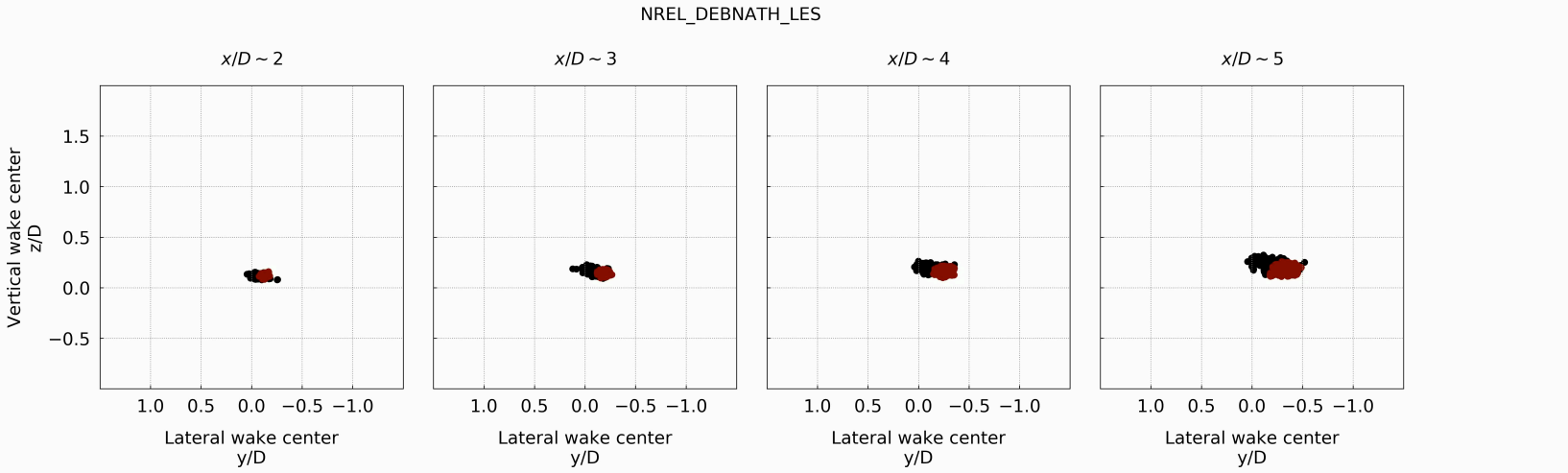


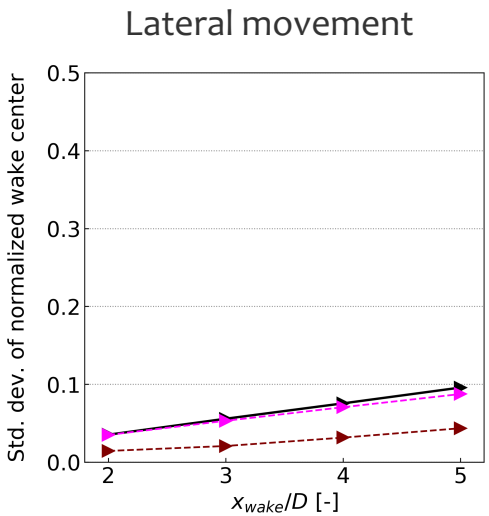


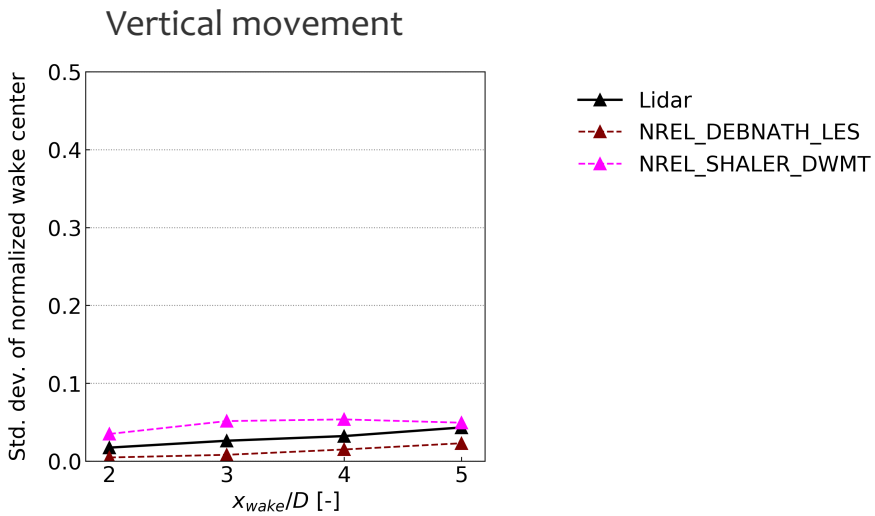




Stable Benchmark







Summary

Phase 3: "Iteration" is open until July 1

- Next steps **by organizers**
  - Release of all measurements (freestream, turbine, wake)
  - Release of python code used in analysis
  - Mean wake analysis along other directions (vertically or radially, not just laterally)

- Next steps **by participants**
  - Download the released data
  - Perform your own analysis
  - Iterate on the simulation results until July 1

- Next steps **by organizers and participants**
  - Assessment of uncertainty in model validation methodology
    - Use virtual lidar data (obtained from LES)
    - Test different wake identification methods (e.g. Gaussian 2D)
    - Test methods of normalizing the wake velocity deficit

Thank you

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