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presents

Full Scale Validation of an Updated 3D RANS Model

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WAKEBLASTER

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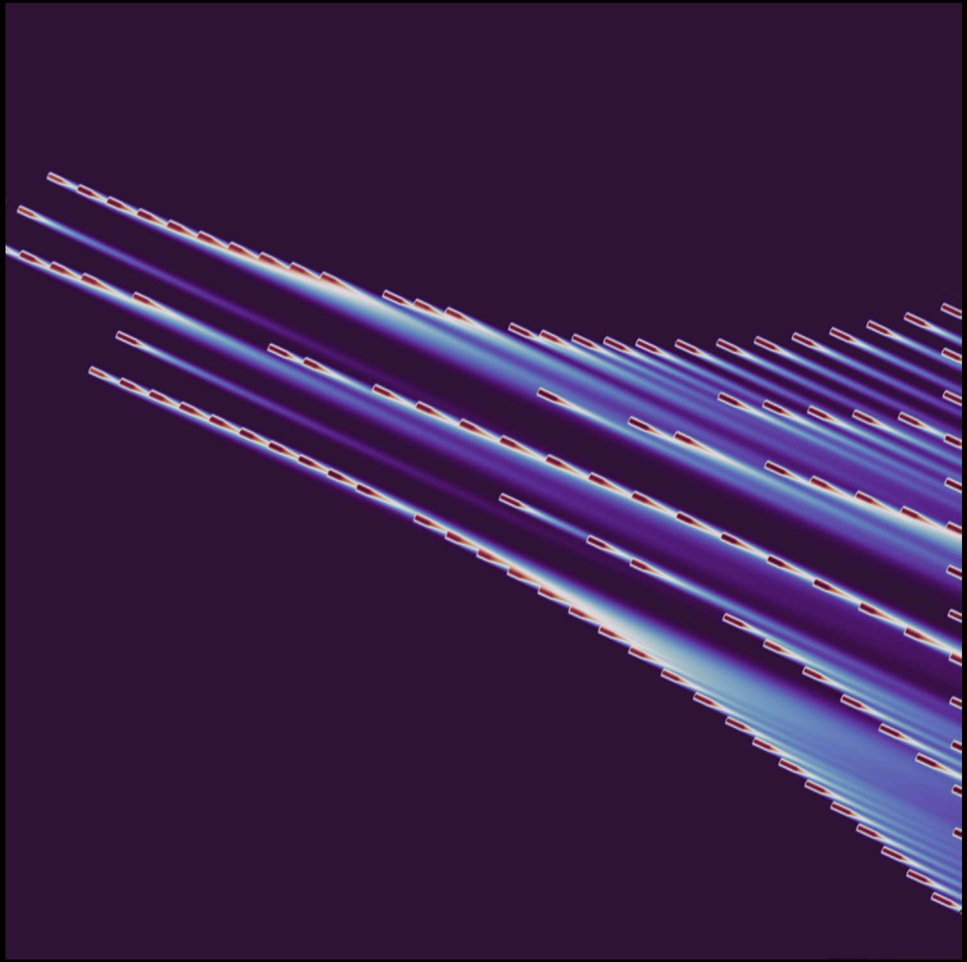
Overview

- Updated Model
  - WakeBlaster
  - Near Wake and Stability
  - Turbulence and Stability
- Validations and Verifications
  - SWIFT
  - Anholt offshore
  - N-6.7 wake correction
  - OWA Dudgeon
- Conclusion



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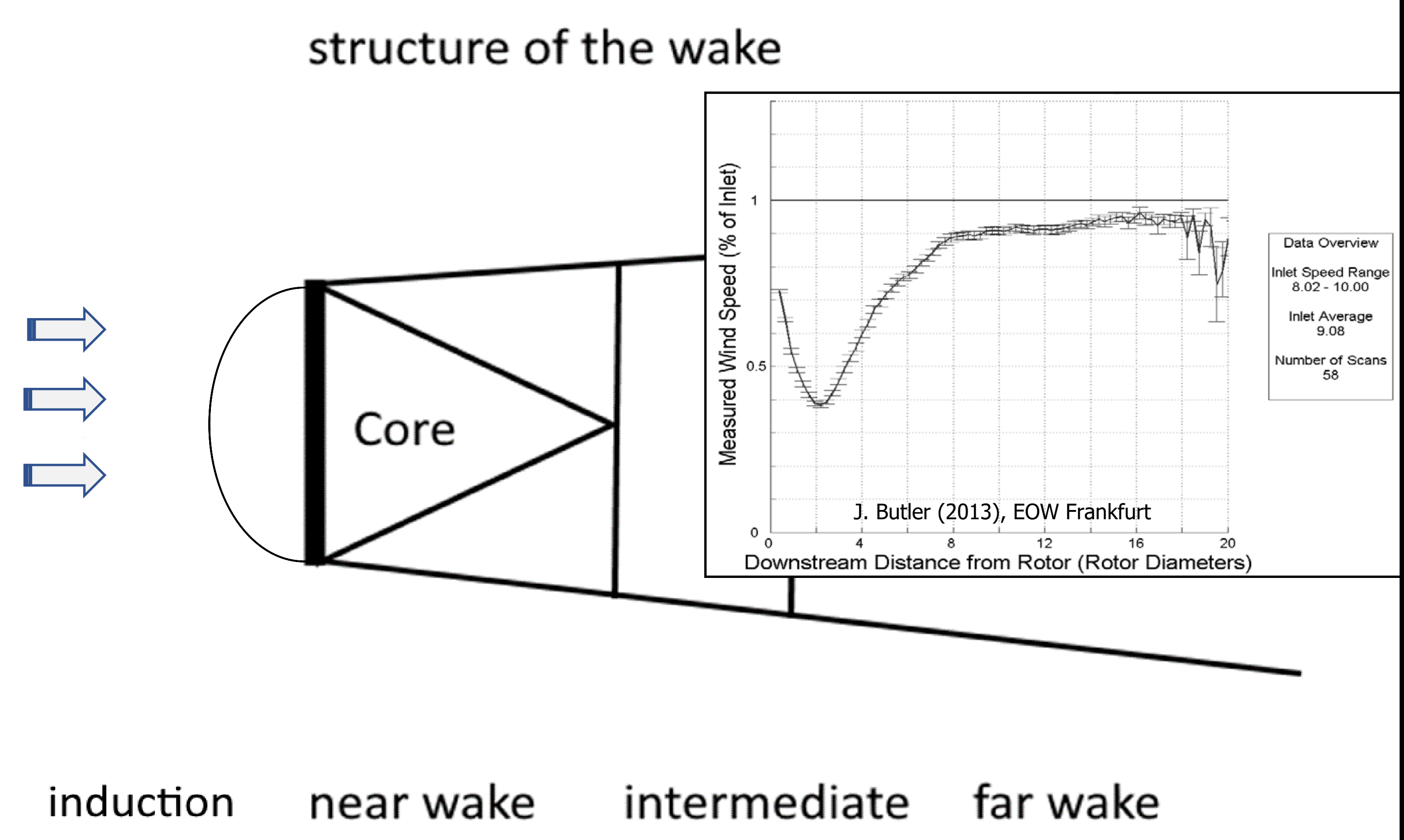
Single Wind Turbine Wake

Near wake
- Core region
- Turbulence generated

Intermediate wake
- Profile forming
- Turbulence decaying

Far wake
- Gaussian profile
- Self generated turbulence

Induction zone
- Upstream impact



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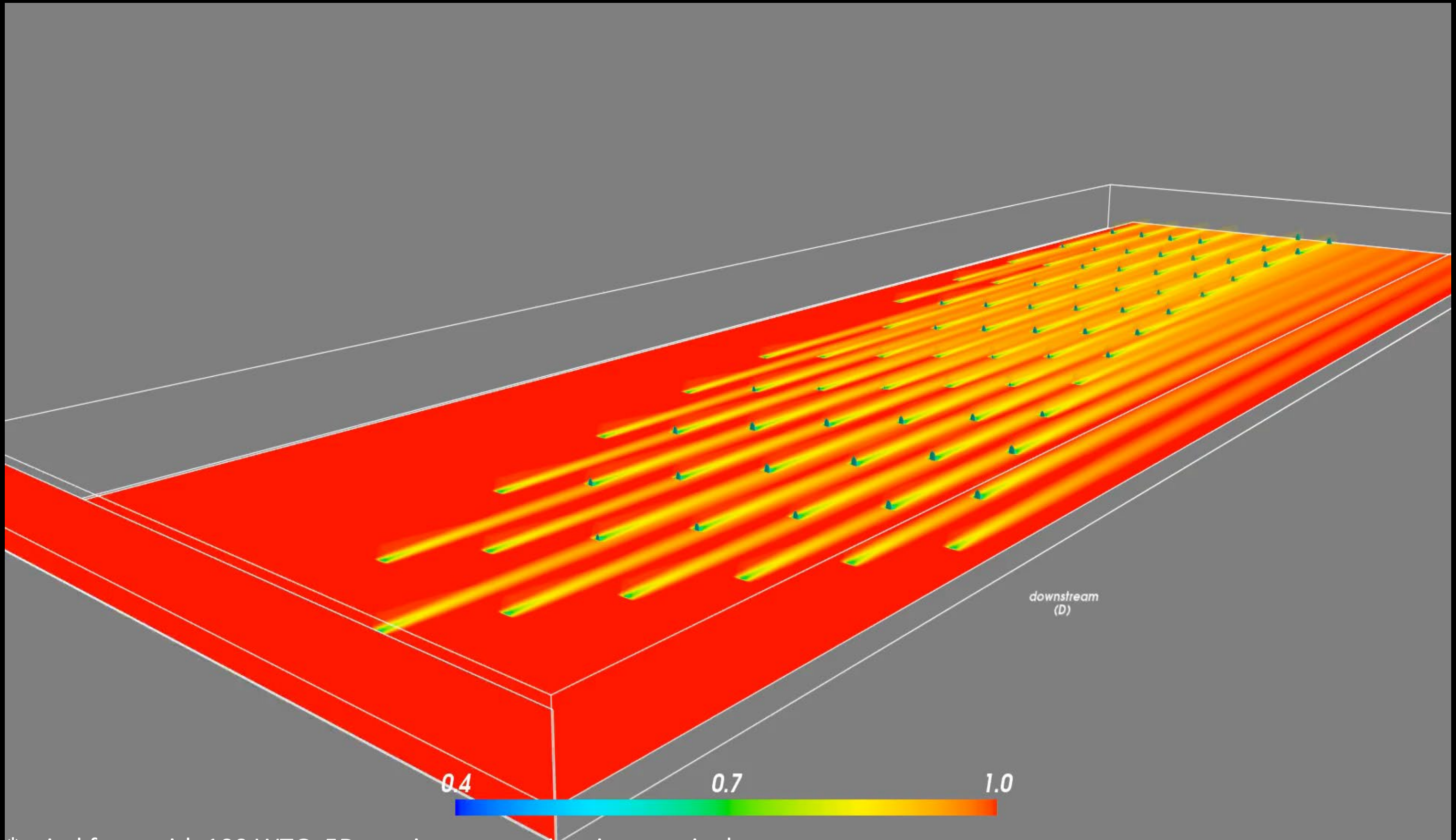
WakeBlaster – Model Description



* wind farm with 100 WTG, 5D spacing, processing time on single core

Validated - with data from many wind farms - onshore and offshore

WakeBlaster Features

- Wind farm model
- 3D model
- Parabolic RANS solver
- 80 nodes over rotor
- Structured grid
- Cloud-based, SaaS
- Highly scalable
- Flow case < 5 sec*

Information:
https://proplanen.info/wakeblaster

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Challenge 1: Near Wake Length

WakeBlaster makes use of Ainslie's (brilliant) approximation to start modelling turbine wakes only from the end of the near wake.
Challenge: The end of the near wake is stability dependent.

Previous Approach → **New Approach**

Fixed Near Wake Length:

- X_n =2 D

Variable Near Wake Length:

- Vary X_n between 1.5 D and 5 D

Model Validation: Updated SWIFT experiment for very stable conditions

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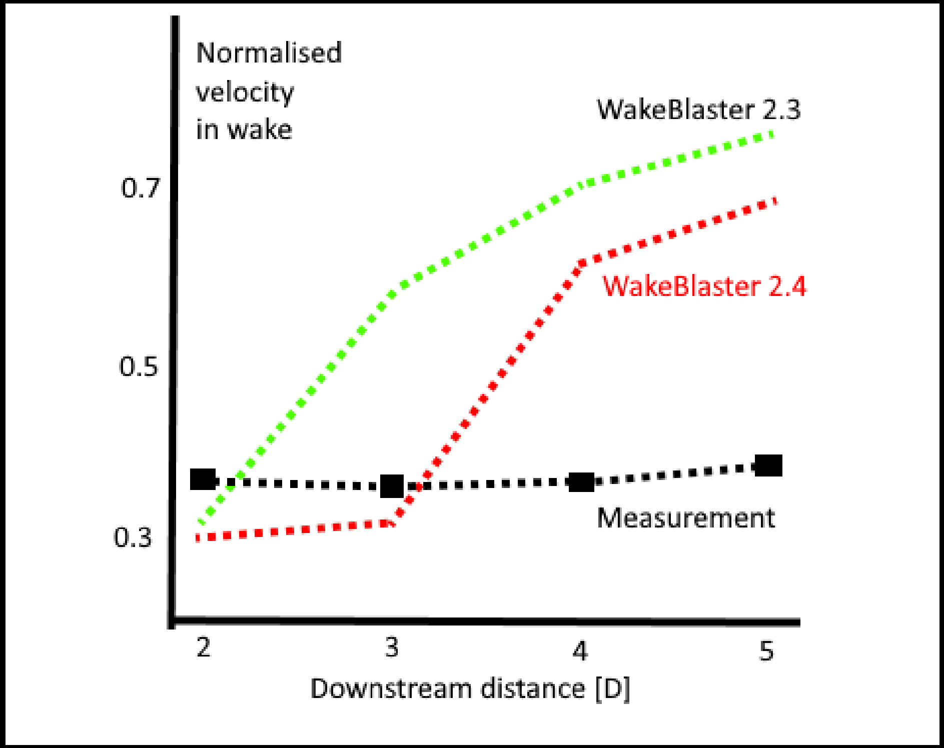
Validation: Variable Near Wake Length



Modified to highlight model update, resampled from: Doubrawa etal., Multimodel validation of single wakes in neutral and stratified atmospheric conditions. https://onlinelibrary.wiley.com/doi/epdf/10.1002/we.2543

WakeBlaster showed good overall performance in SWIFT benchmark.

However for a flow case with

- very stable atmospheric conditions

WakeBlaster 2.4 with the variable near wake length applied shows improved results.

Remaining differences are believed to be specific to the site and data selection leading to very low directional variation

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Challenge 2: Incomplete Input Data I

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Here: turbulence but no stability information available
Note: turbulence and stability are not independent variables

Previous Approach	→	New Approach
Use default values: • Assume neutral stability		Use reasonable assumptions: • Approximate stability

Model Validation: wake correction of measurement (N-6.7)

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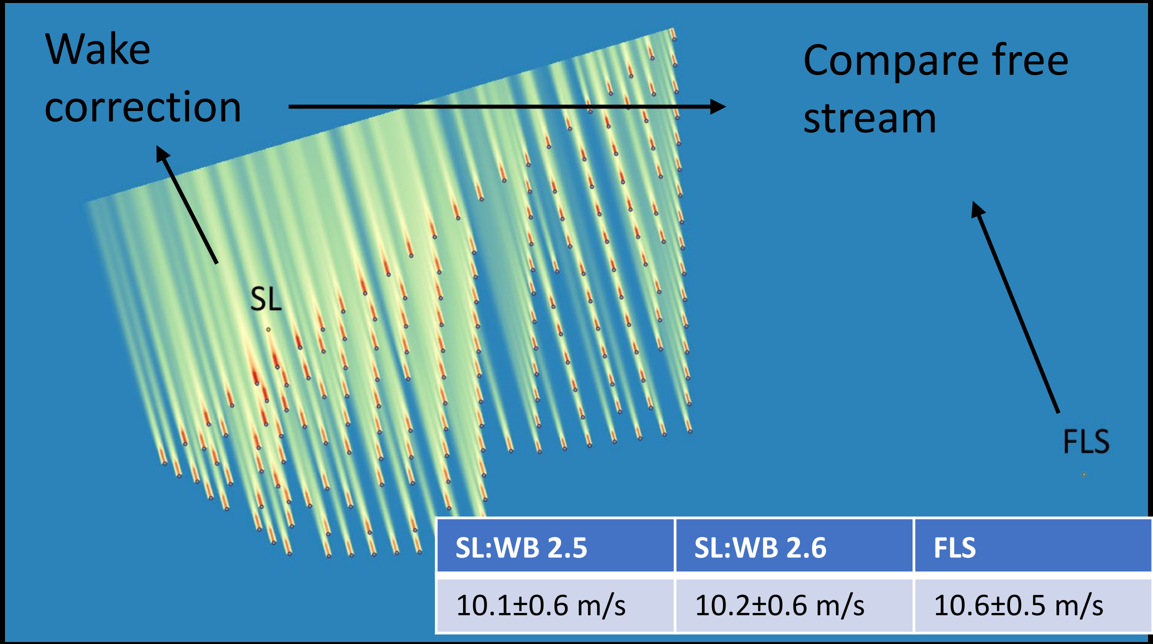
Validation: wake correction of measurement

Experimental setup

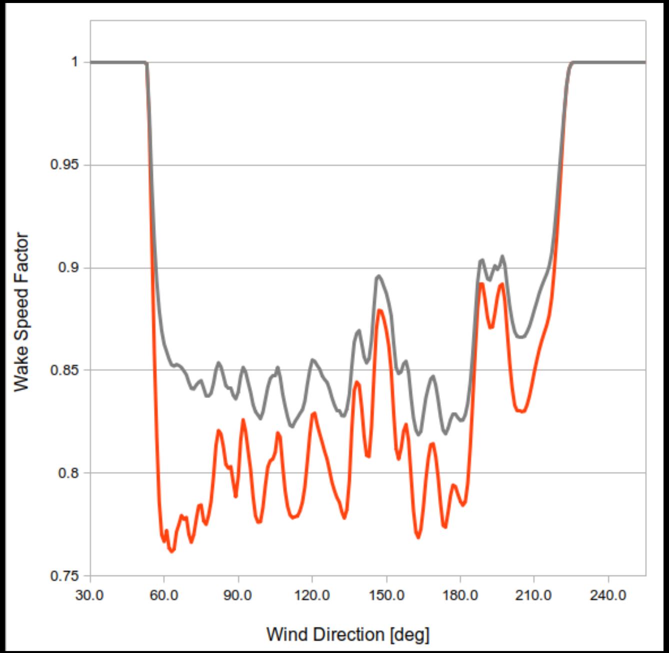


SL:WB 2.5	SL:WB 2.6	FLS
10.1±0.6 m/s	10.2±0.6 m/s	10.6±0.5 m/s

Wake Correction applied to SL

Black: Original wake correction of SL measurement assuming neutral stability.

Red: Updated wake correction of SL measurement using derived stability estimate.



The free wind speed derived from FLS was higher than that derived from SL. Using the updated model significantly increases the wake correction, increases the wind speed derived from SL and so reduces the difference somewhat.

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Challenge 3: Incomplete Input Data II

(Here: stability but no turbulence information available)

Here: Stability but no turbulence information available

Consider relationship between turbulence, stability, shear stress, and roughness

Previous Approach	→	New Approach
Use default value for roughness: Ti=1/(ln(z/zo)+ψ (z/L)); $\sigma = 2.5\, u_*$		Use user defined regional roughness

Model validation: OWA Benchmark Dudgeon offshore wind farm

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Validation: OWAbench Example Dudgeon

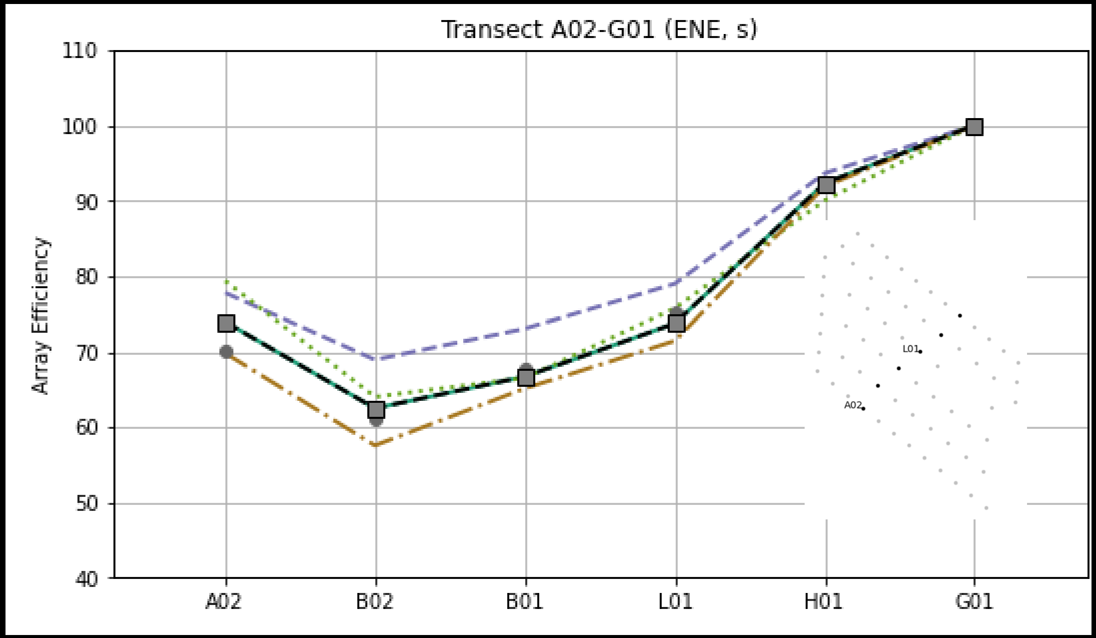

Fig.: Different models plotted against ensemble solution WB 2.4 dashed blue, WB 2.6 grey circles, EMD park brown, TUD park dotted green

WakeBlaster 2.4 was best model in the benchmark, but results showed positive bias (not enough losses).

Weakest OWAbench validation case was a stable case at Dudgeon for which we present the update.

Updated WakeBlaster 2.6 results show improvement.

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Conclusions

Major model updates since WESC 2019:

- Challenge 1) Variable near wake length
- Challenge 2) Missing turbulence information
- Challenge 3) Missing stability information

The success of the changes has been demonstrated on validation cases.

Model development is a continuous process!

Note: Other updates include a model for global blockage that is redistributing power between turbines. The WakeBlaster API was operated via Python for the work presented here, the respective feature implementation in Openwind and WindPRO will be available in due course.

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Full Scale Validation of an Updated 3D RANS Model

See also:

- https://proplanen.info/wakeblaster
- WE Tech Workshop Lyon 2023
  - PO-087 Validation of an updated 3D RANS Wake Model using Floating Lidar
  - PO-088 Wind Farms in Curved Flow and Curved Flow in Wind Farms
  - Ewa Johansson: Benchmarking results from multiple wake models on operational data from offshore wind farms

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