ENERGY

Improving confidence in wake predictions through operational validations

Wind Europe Offshore 2017

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6 JUNE 2017

Outline

What have we learn so far when trying to validate wakes

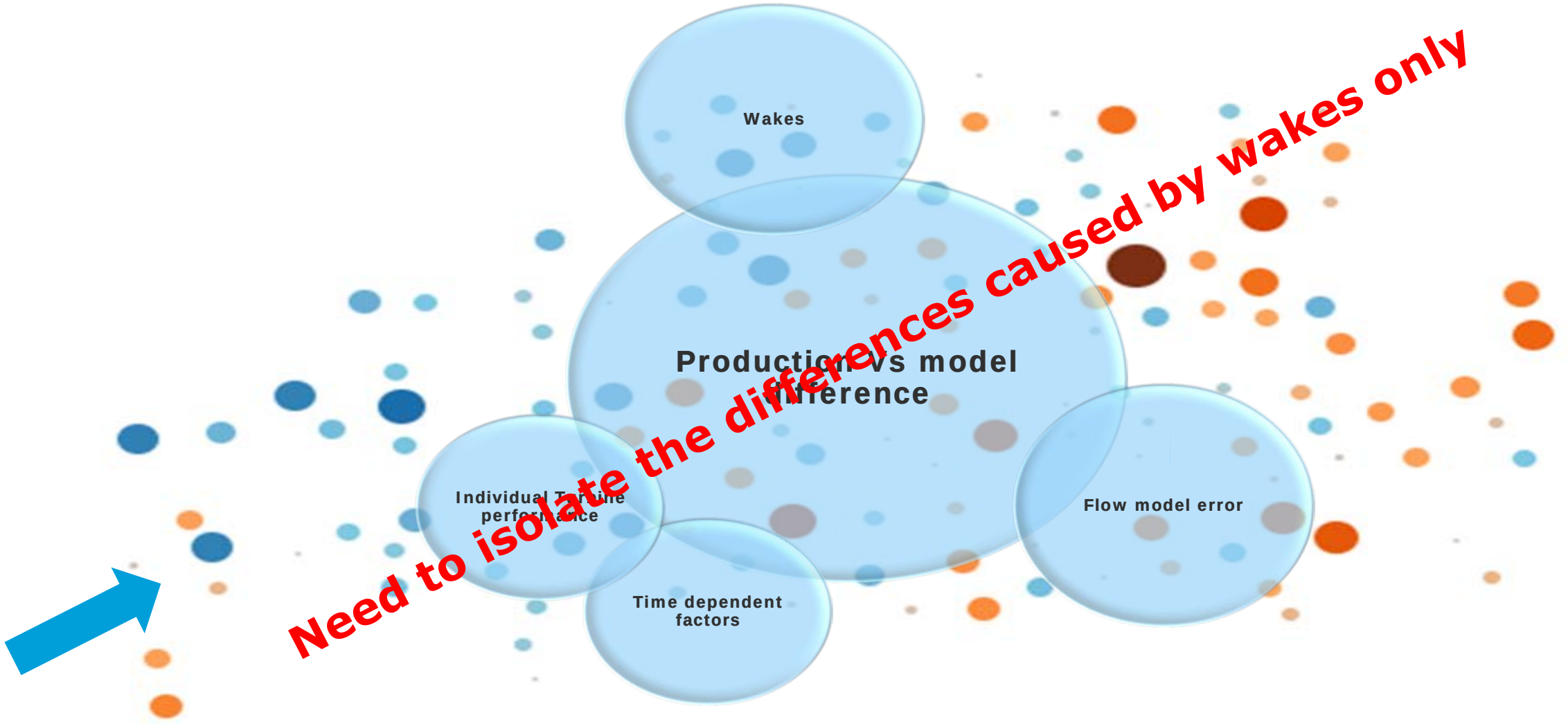
How can we relate this to offshore?

What is next for wake modelling

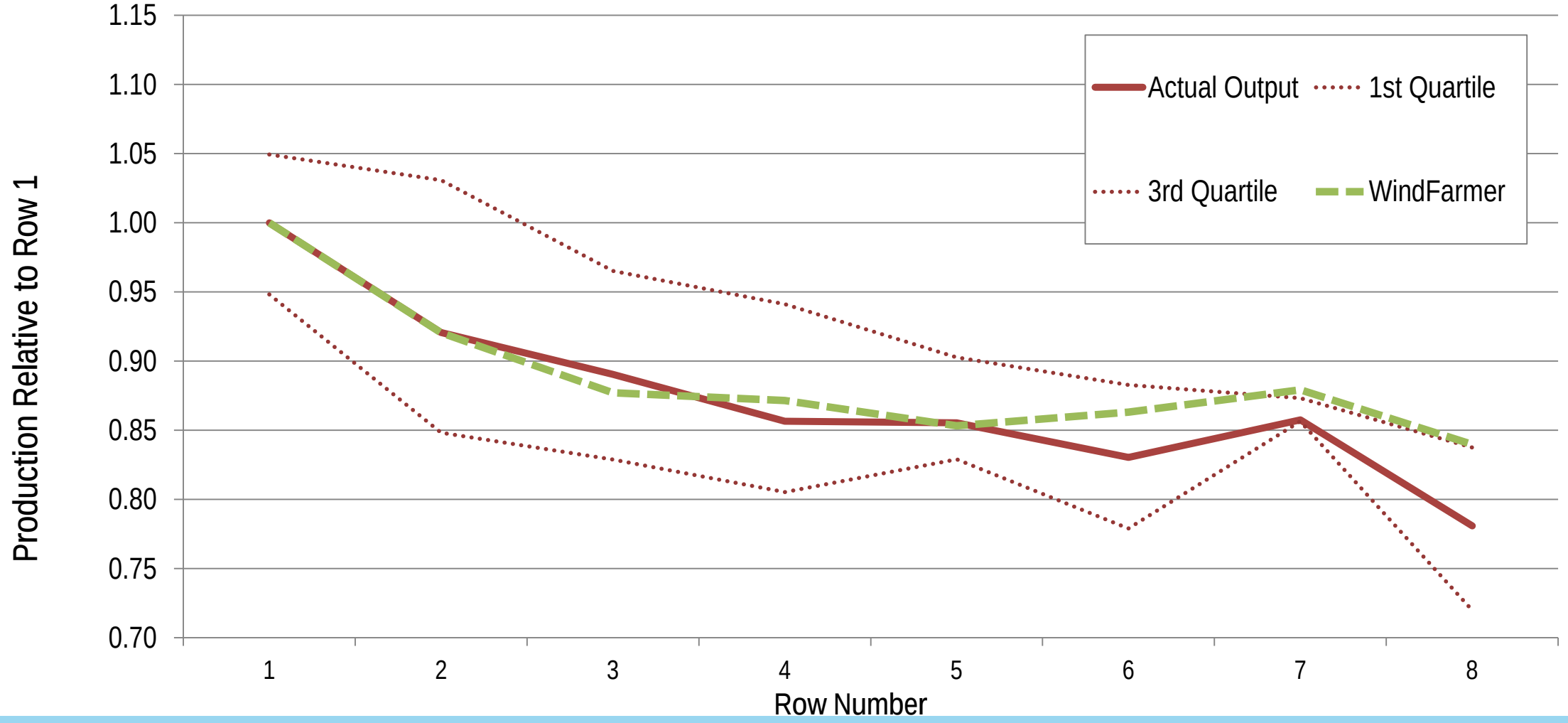
What have we learn so far when trying to validate wakes

- Challenges
- The validations undertaken so far and lessons learnt
- What we currently use onshore

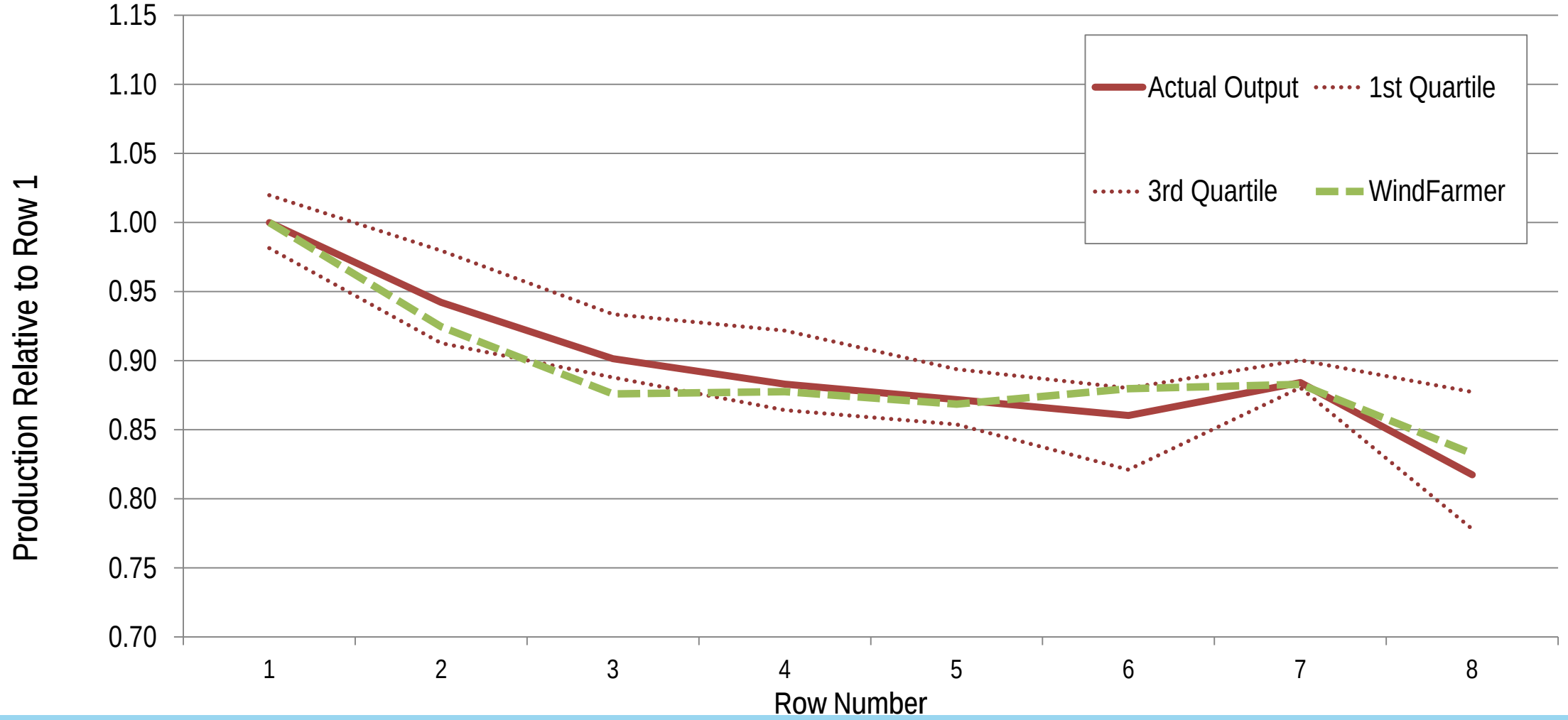
Challenges


Wakes
Production vs model difference
Individual Turbine performance
Time dependent factors
Flow model error
Need to isolate the differences caused by wakes only

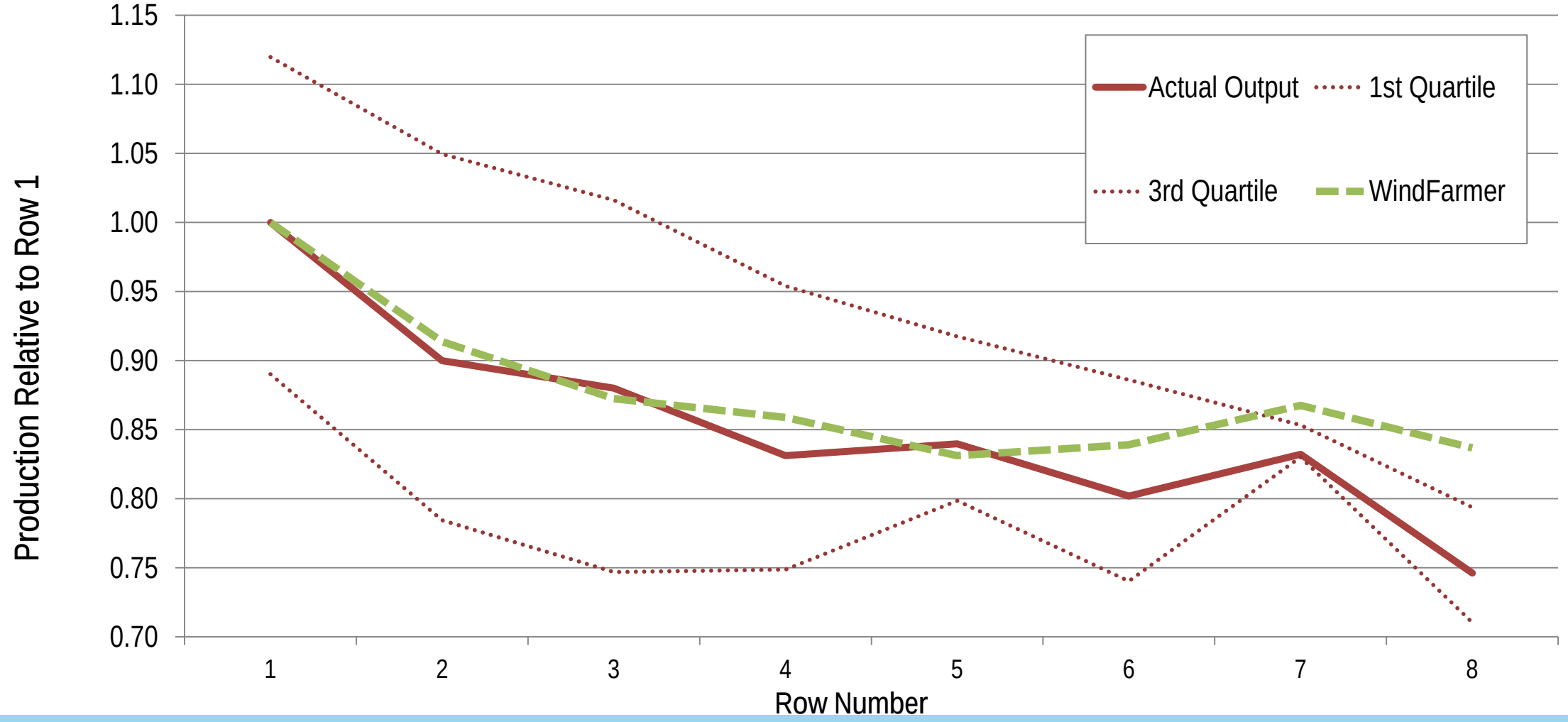
Validations: Onshore project with stability – All atmospheric conditions



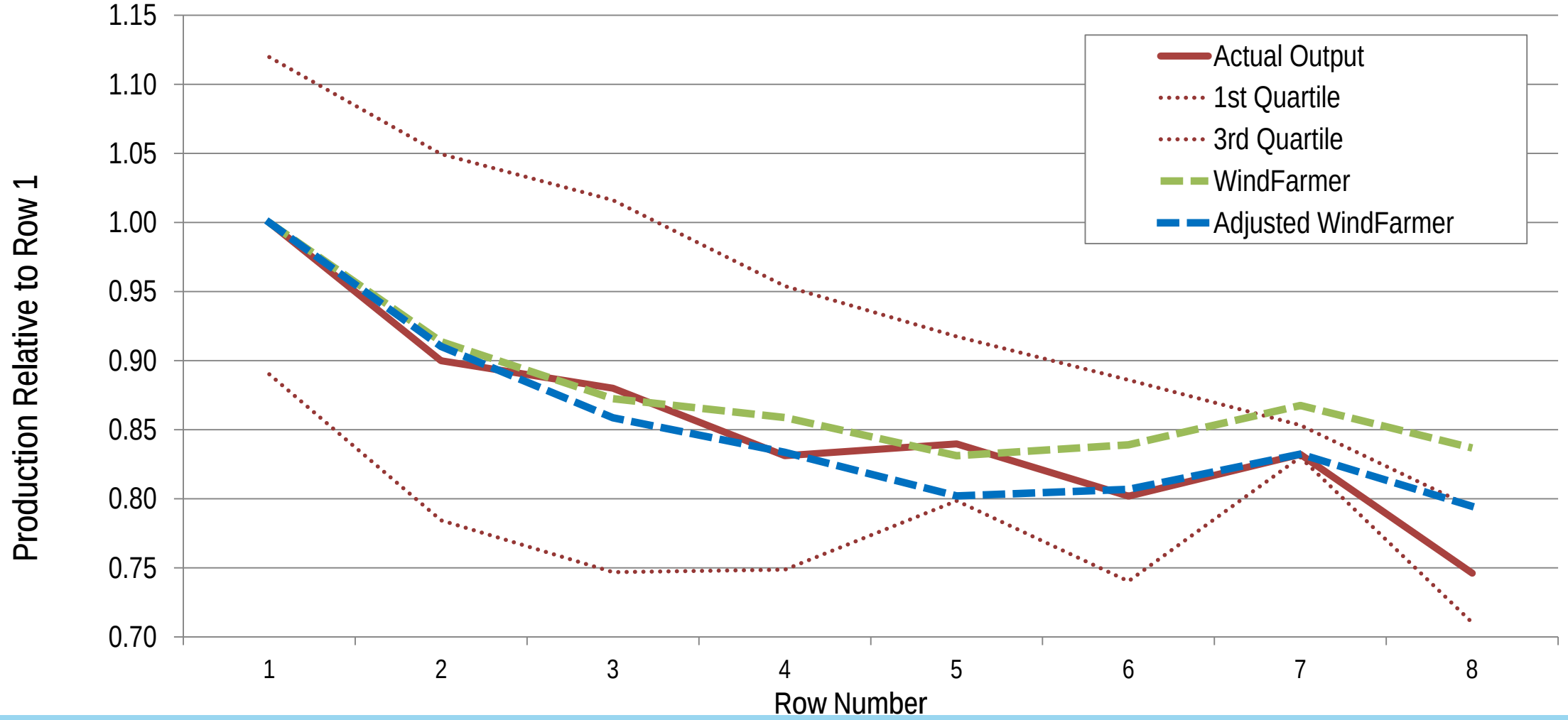
Validations: Onshore project with stability – Neutral conditions



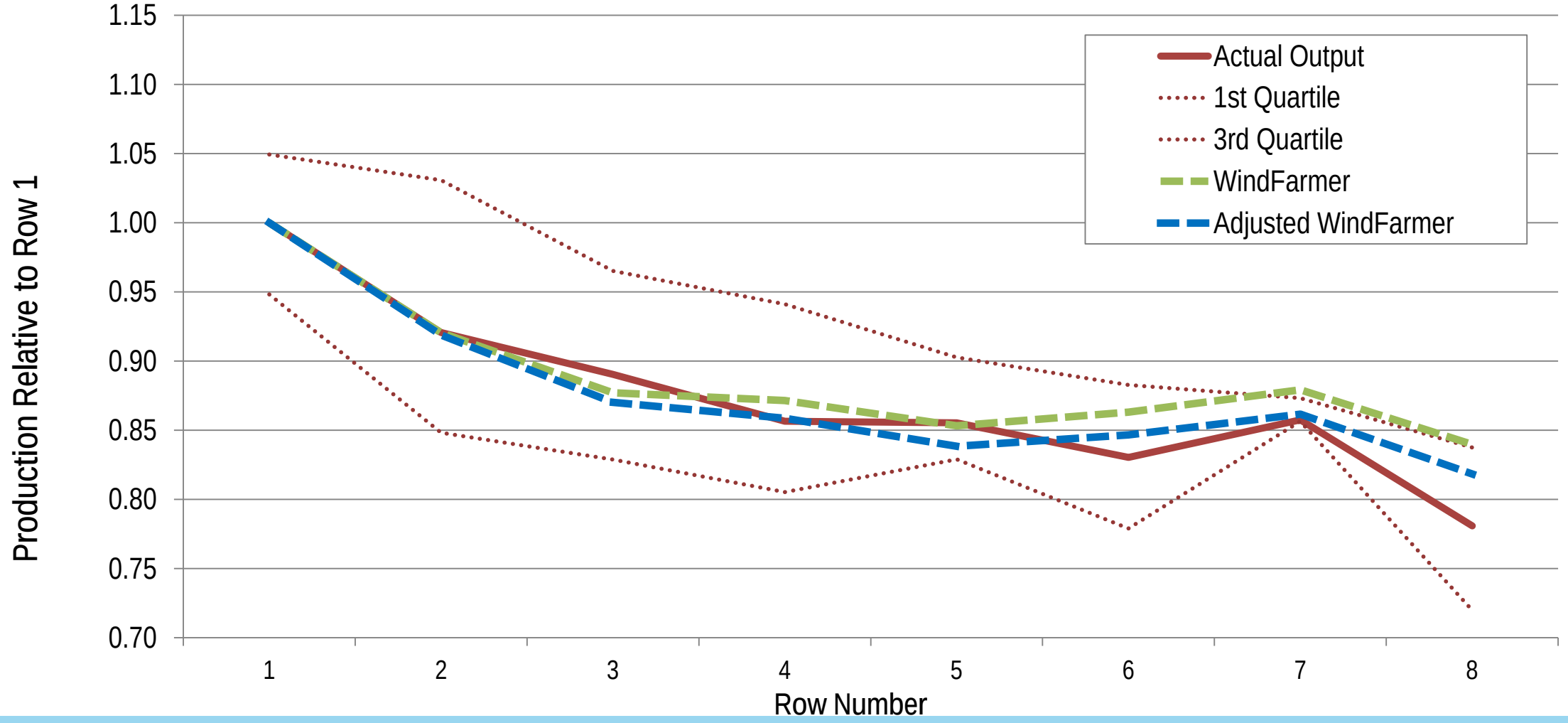
Validations: Onshore project with stability – Stable conditions



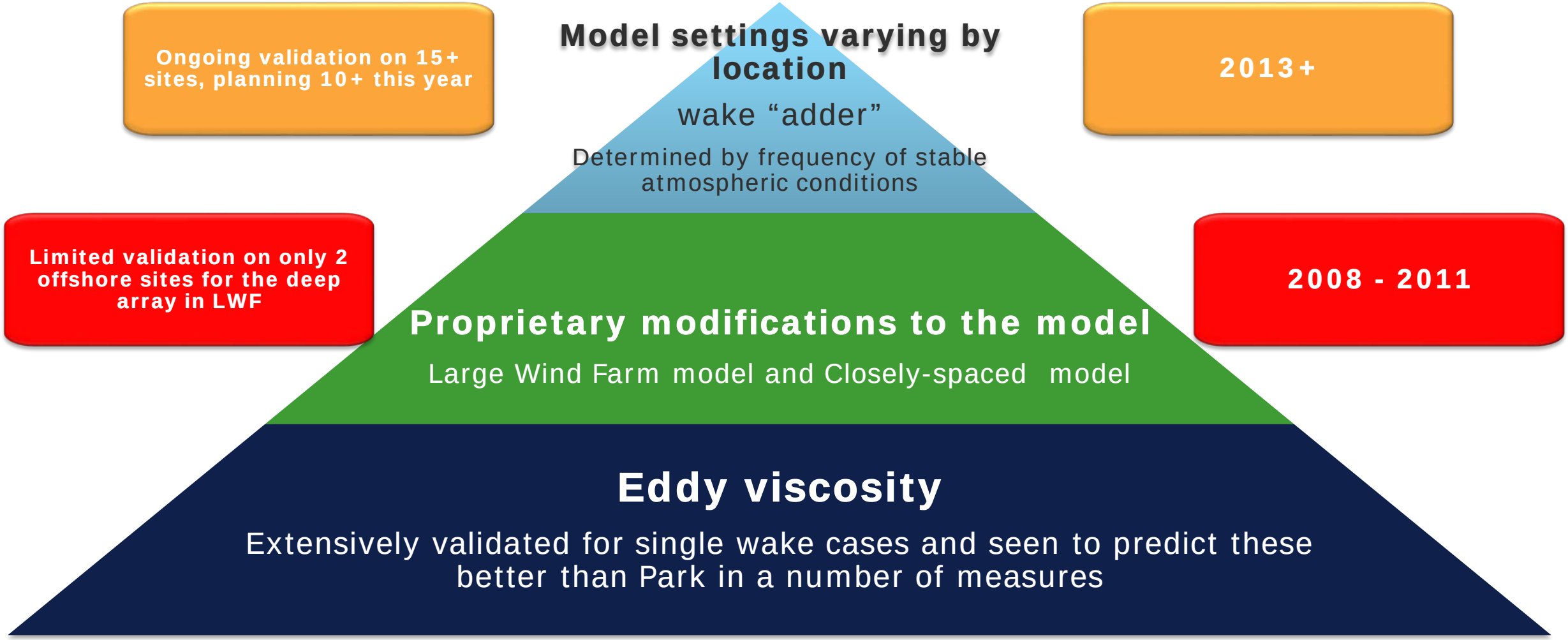
Validations: Onshore project with stability – Stable conditions



Validations: Onshore project with stability – All atmospheric conditions



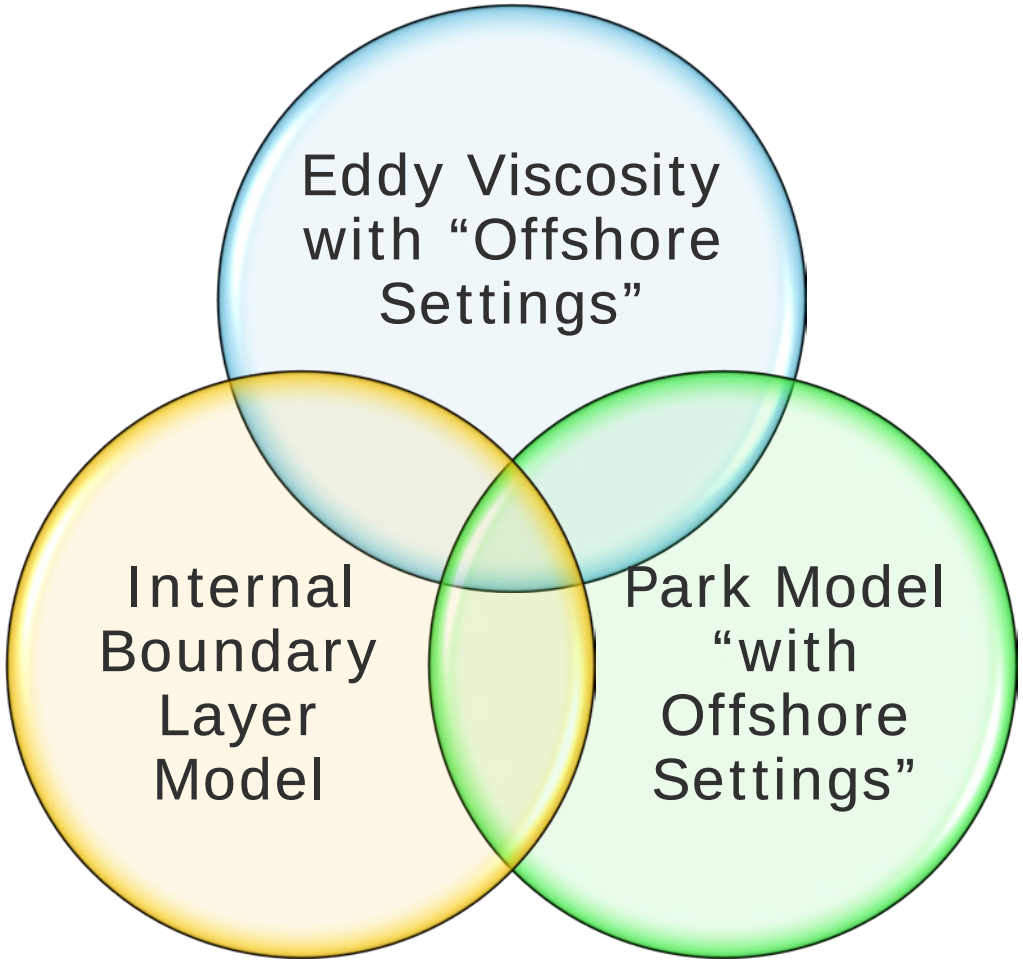
What we currently use *onshore*– DNV GL



How are we doing offshore?

- What is the current practice
- What are we doing this year
- The future…

What is the current practice



limited validation has been conducted.

- Each method was initially calibrated using the Horn Rev data

Why use an ensemble method?

- With limited validation, minimizes potential for bias.

What will we do this year

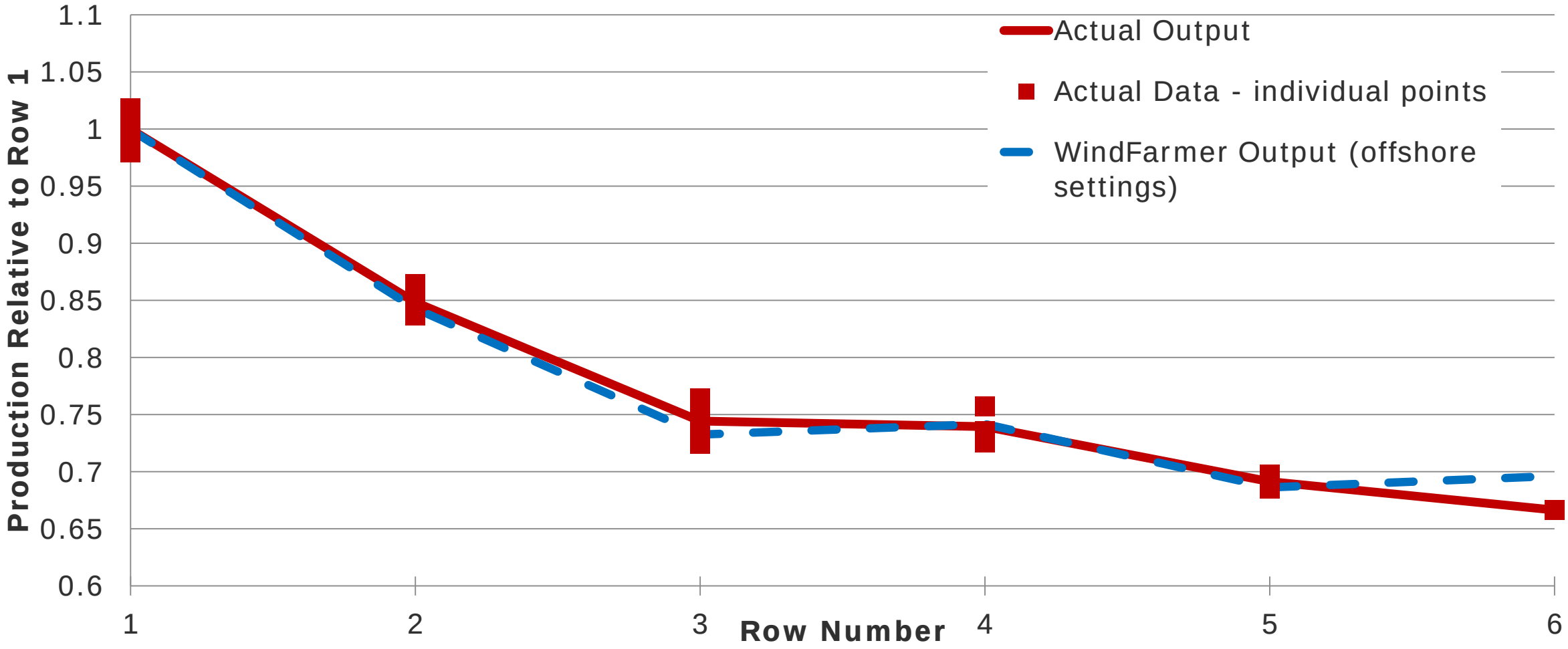
- Fine-tuning parameters – improvement by validation
  - **Validate / improve offshore wake approach**
  - Improved characterization of site roughness
  - **Quantify frequency of stable flow**
  - Adjust Large Wind Farm roughness parameter to reflect site-specific atmospheric conditions

- Validating time-series modelling
  - Wind shear & turbine performance
  - **Stable & neutral wind flow (DNV GL CFD / VMD)**
  - **Stable & neutral wakes (WindFarmer)**
  - Assess time-value of production, hedge risk, integration considerations

What are we doing this year? Extending offshore validation cases!

New project!	• Has not been used to calibrate the wake model
Wind Direction	• Limited validation to direction band to maximize waked rows (6 rows)
Wind speeds	• From 6 m/s to 10 m/s considered • Wind speeds determined from average of nacelle anemometers in first row of turbines.
Running WindFarmer in "**Time series**"	• Each 10 minute time stamp has a unique wind speed, TI, air density, and wind direction

Offshore validation case – default WindFarmer “Offshore Settings”

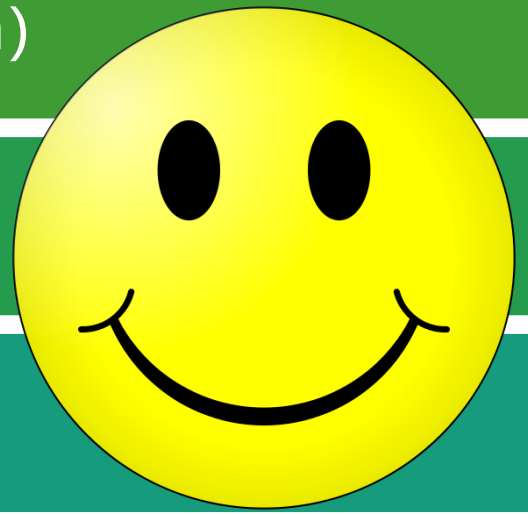


Offshore validation case – initial conclusions

Overall wake validation looks very good! (<0.3% deviation)

No obvious trend by row

Only one validation, and only a medium sized project



Time series energy modelling shows promise (next test will be onshore with large stability swings)

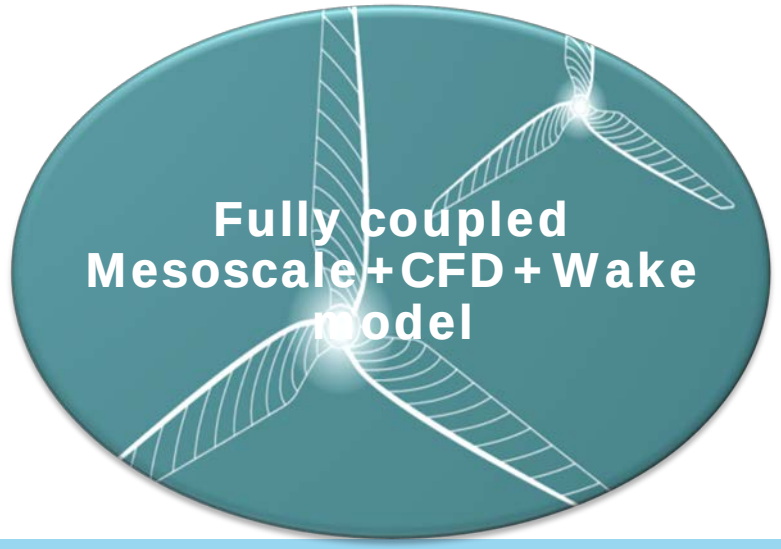
Very promising first results indicating ensemble approach may not be necessary

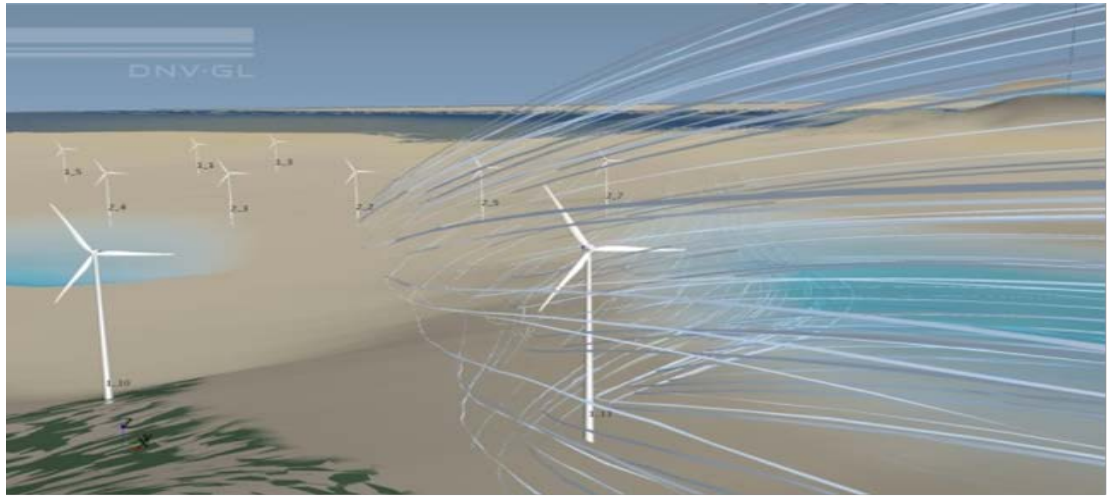
What is next for wake modelling

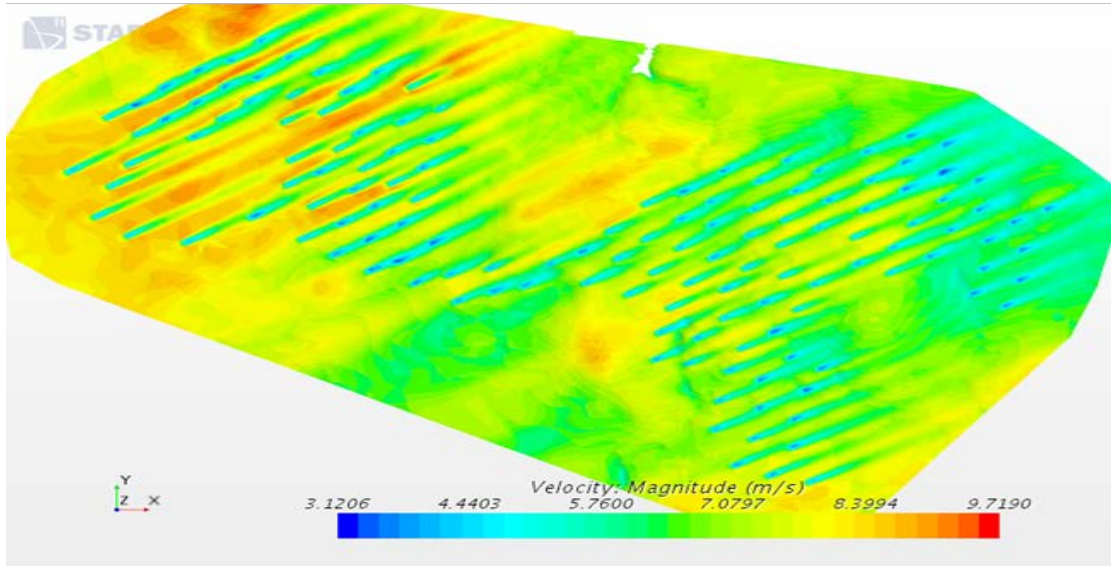
Next Generation: 3D Wake Modeling

- Consider asymmetric solutions
  - Vertical shear profile
  - Boundary layer interactions

- Explicitly model wake superposition







Conclusions

What have we learn so far when trying to validate wakes

- Need to use good CFD to decrease wind flow model error
- Need to account different atmospheric conditions
- Need to look at time series validation

What is our proposed methodology to validate wakes

- SCADA based time series validation
- CFD wind flow modelling considering different atmospheric conditions

What is next for wake modelling

- 3D CFD wake modelling
- Consider asymmetric solutions
- Explicitly model wake superposition
- Fully coupled Mesoscale+CFD+Wake

Thank you

With thanks to: Anja Neubert, Marie-Anne Cowan, Tom Levick, Melissa Elkinton, Carl Ostridge, Carla Ribeiro, Christian Peake, Jim Bleeg, *et al*

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