Multi-scale wake modelling

Wind farm and cluster wake interaction

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EERA DTOC
THE EUROPEAN ENERGY RESEARCH ALLIANCE
DESIGN TOOLS FOR OFFSHORE WIND FARM CLUSTER

Support by

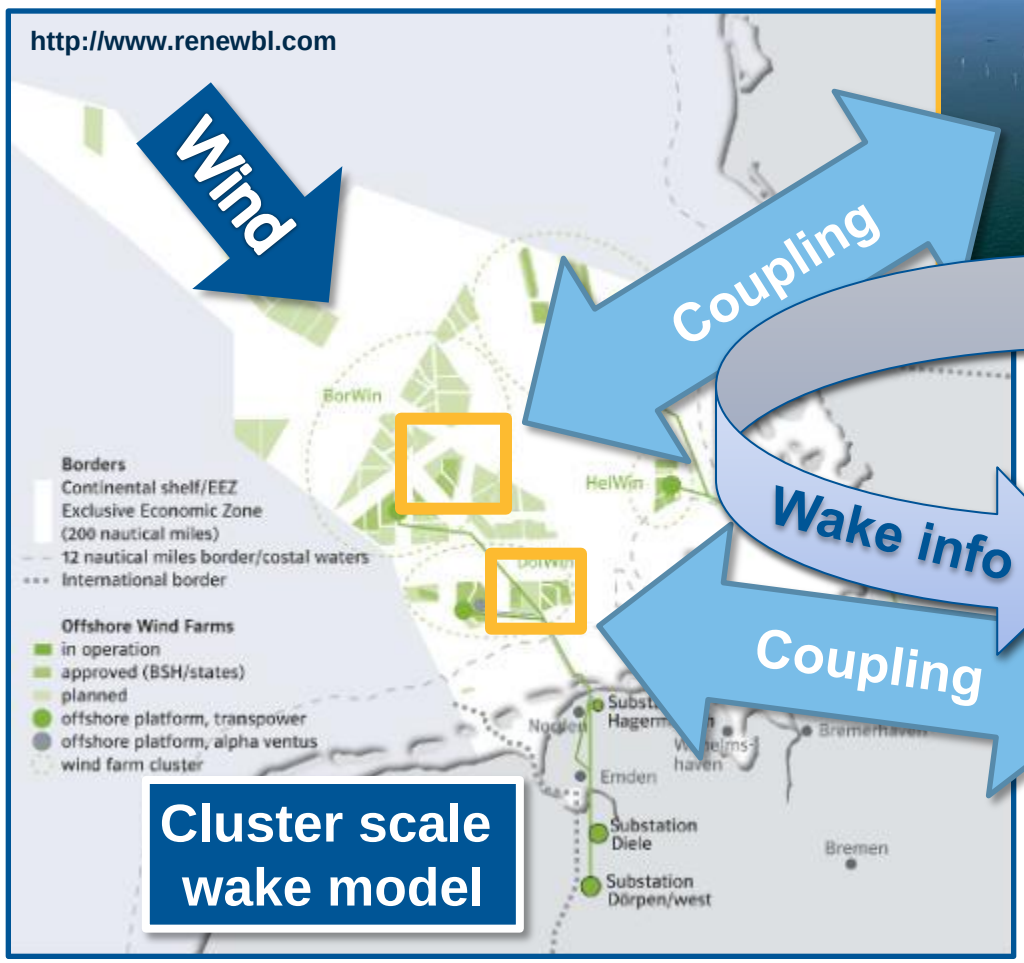
SEVENTH FRAMEWORK PROGRAMME

Outline

- Vision
- Wind Farm Scale Wake Modelling
- Cluster Scale Wake Modelling
- Coupling Wind Farm and Cluster Scale
- Summary

Introduction

The “big wake” picture



Coupling

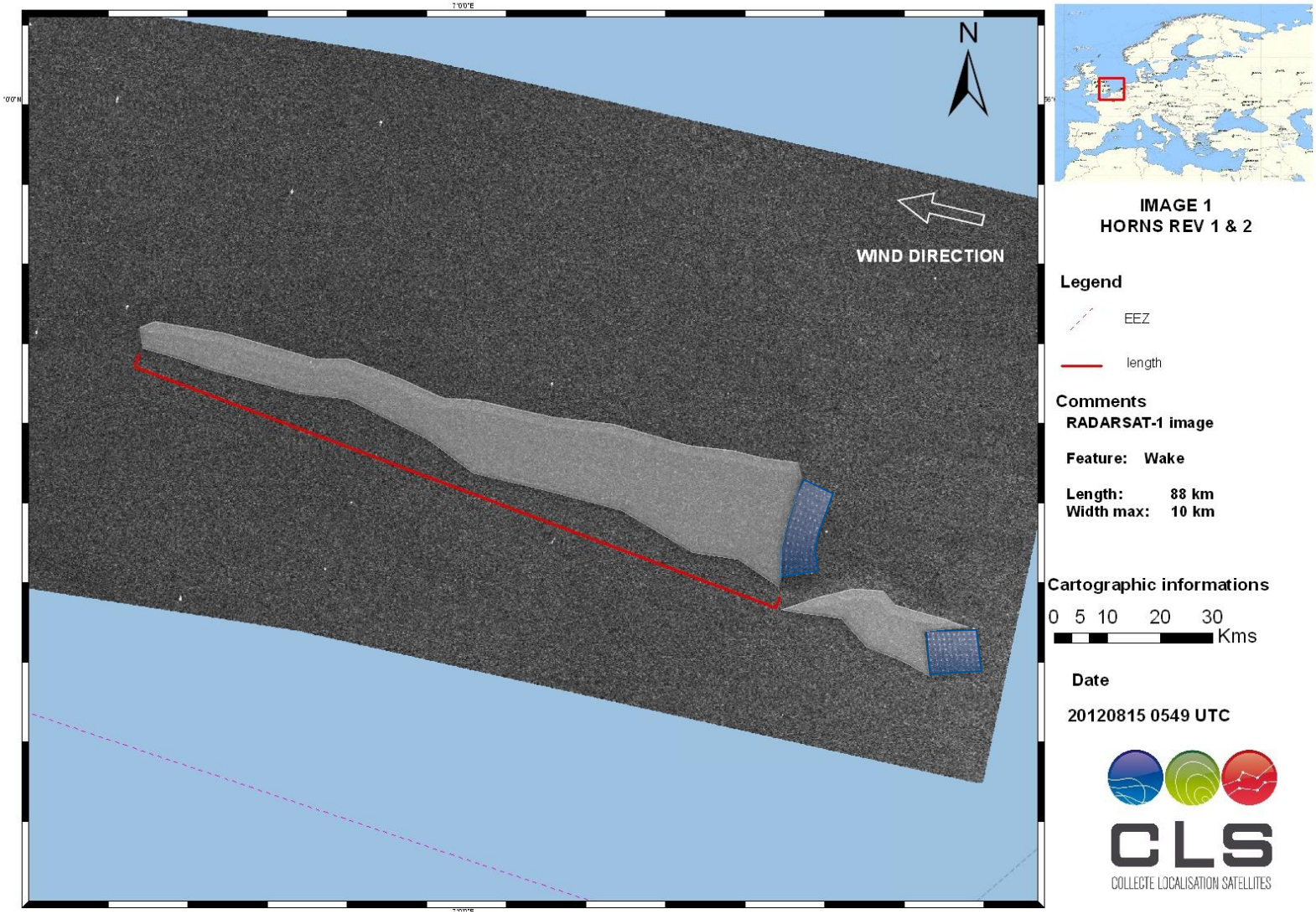
Wake info

Coupling

AEP

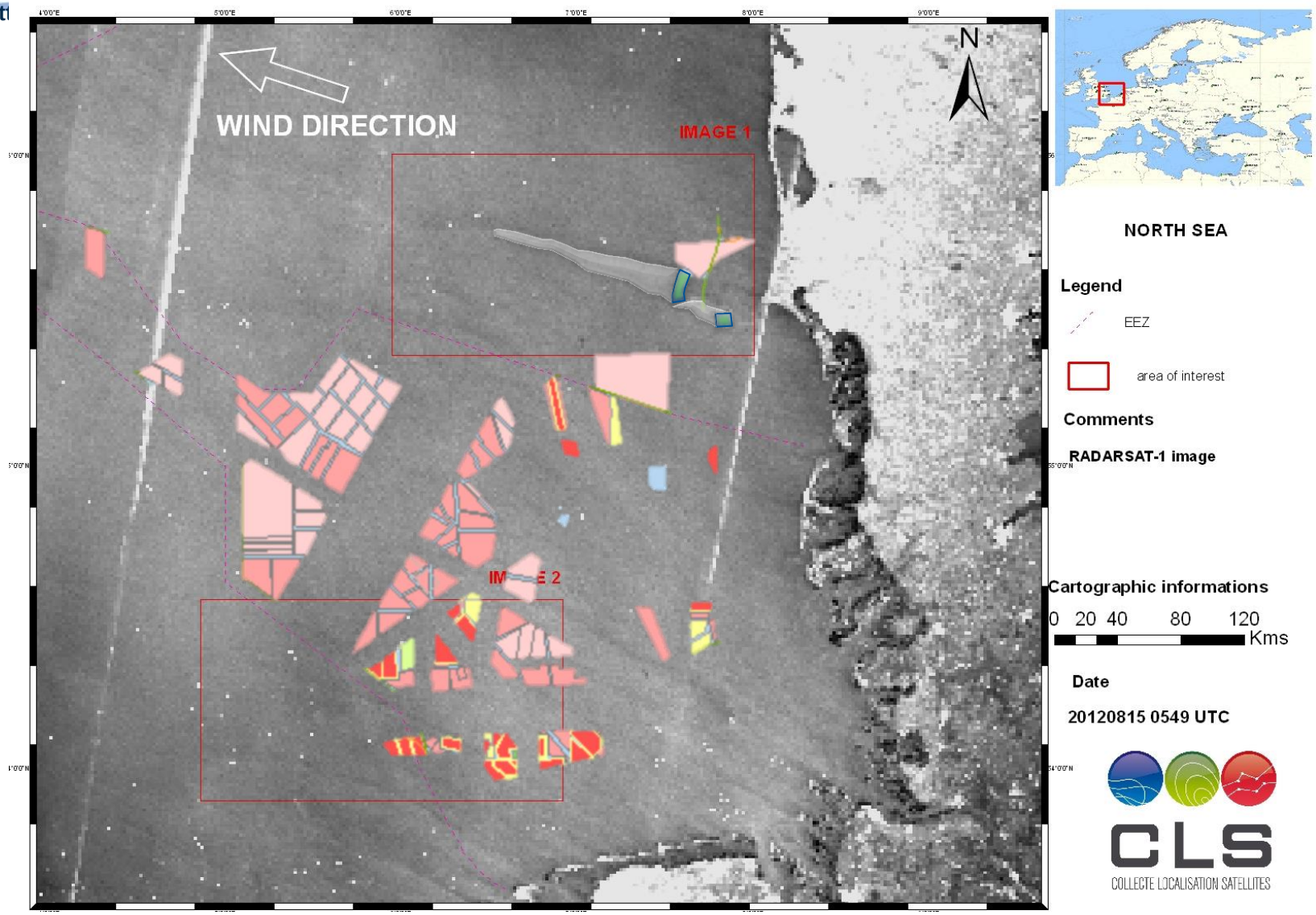
The Challenge

Cluster scale wake satellite pictures



The Challenge

Cluster scale wake satellite pictures



Purpose

*"**Identify, benchmark,** provide **guidelines** for and **couple** the **existing wake models** that can operate over **wind farm scale** and **cluster scale.**"*

Wind farm scale wake models

DTU

INDIANA UNIVERSITY

U.PORTO

res power for good

ECN

DWM

WASP/NOJ

RANS

CRES flowNS

Ainslie

FarmFlow

FUGA

GCL

NOJ

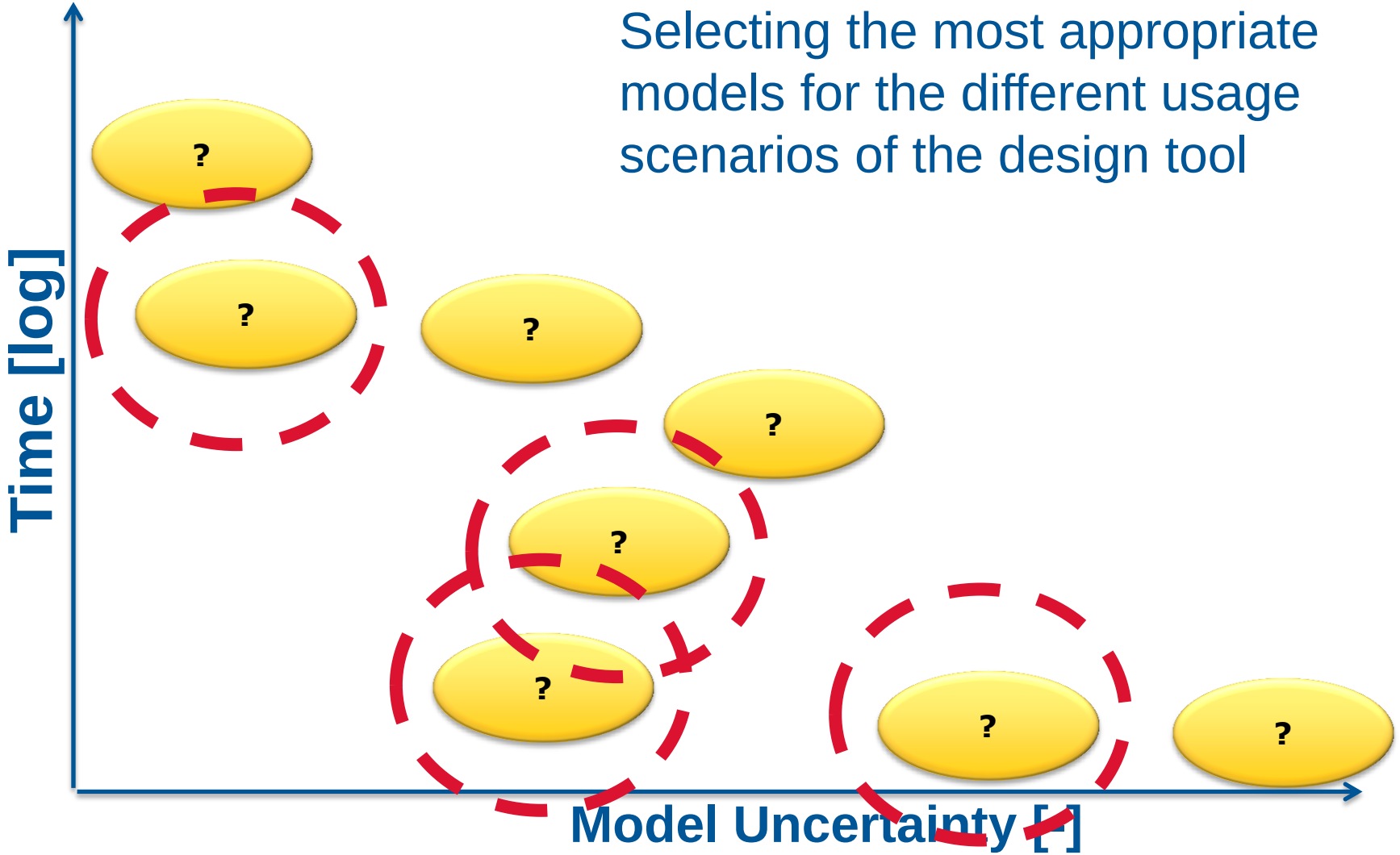
Enginneering

Simplified CFD

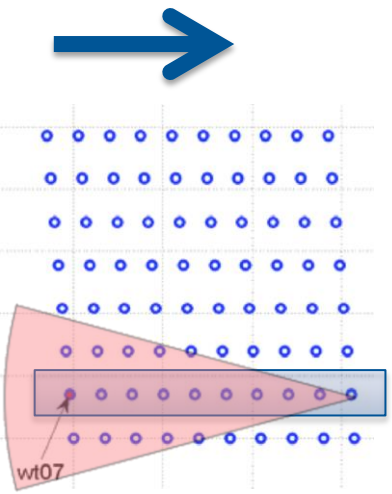
Full CFD

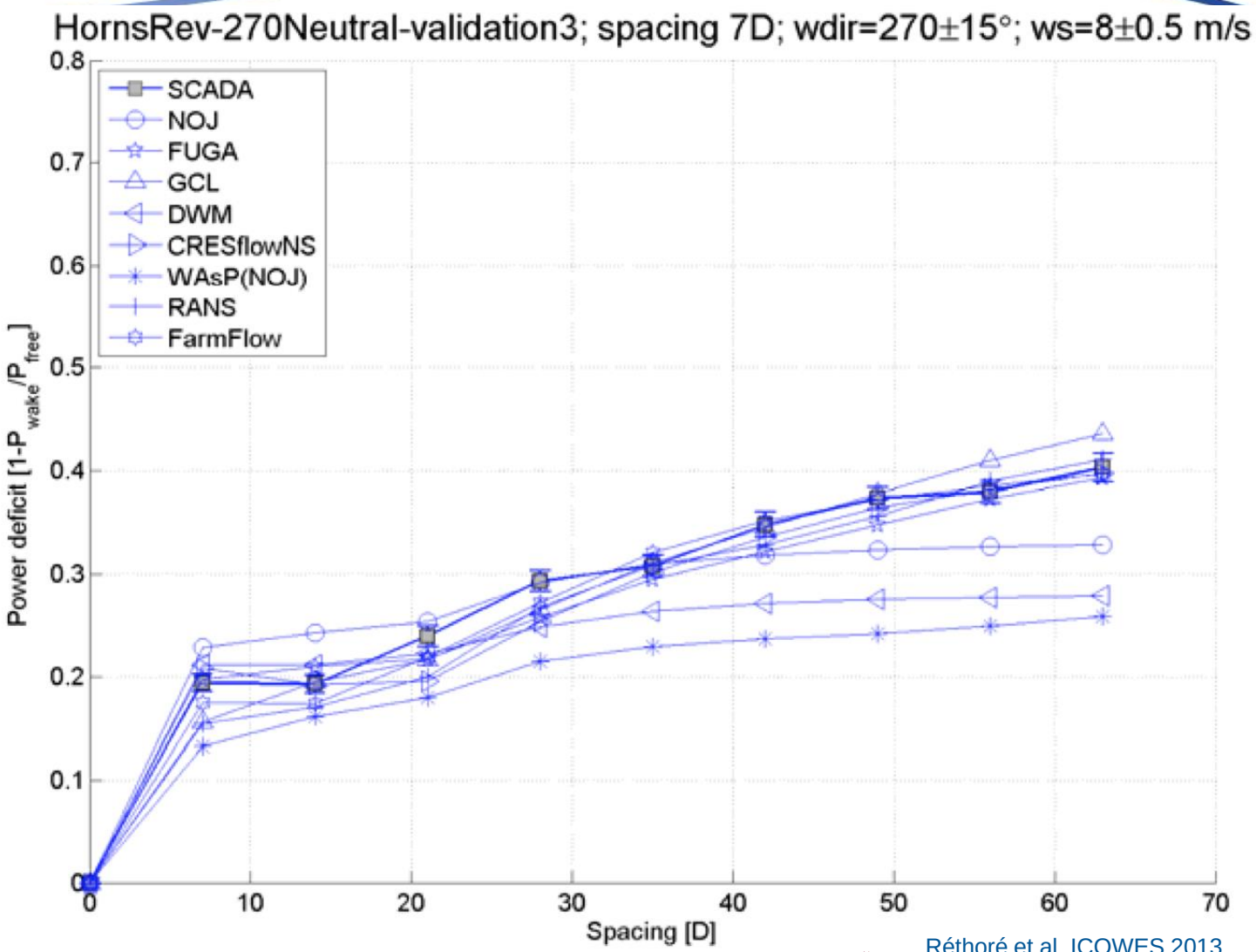
Benchmarking purpose

Selecting the most appropriate models for the different usage scenarios of the design tool



Benchmark preliminary results: Power deficit along a line of turbines





Réthoré et al. ICOWES 2013

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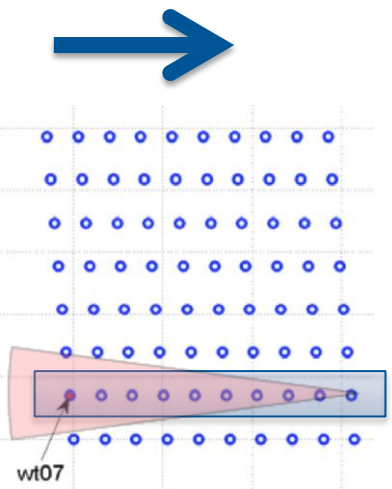

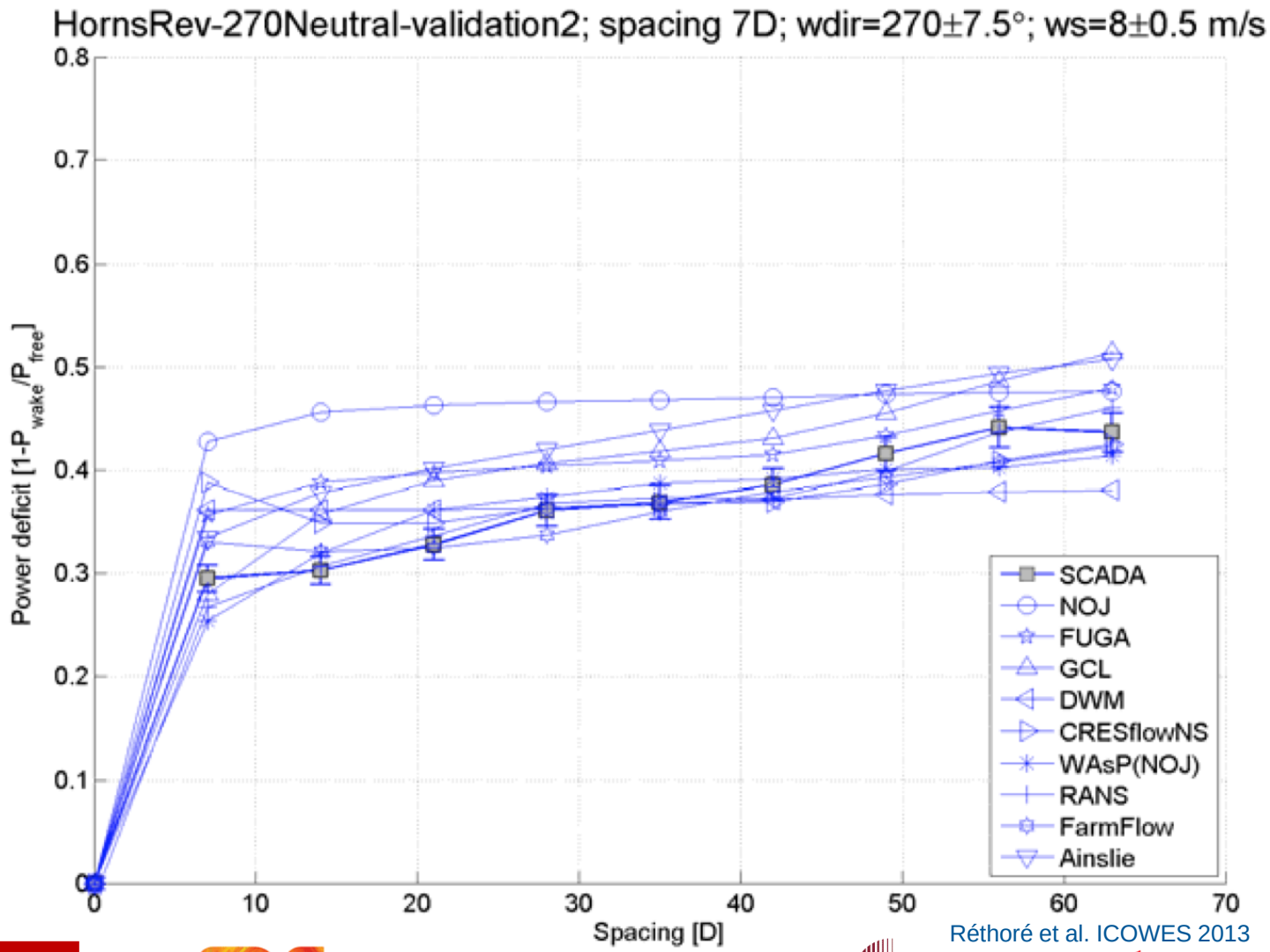

Réthoré et al. ICOWES 2013

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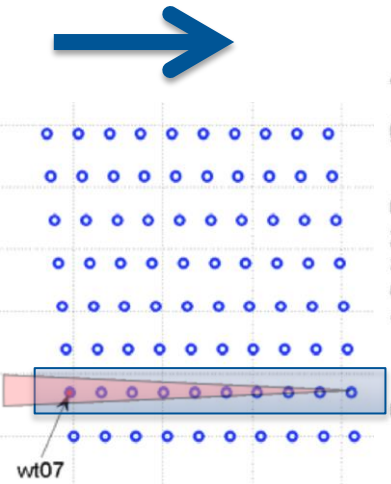

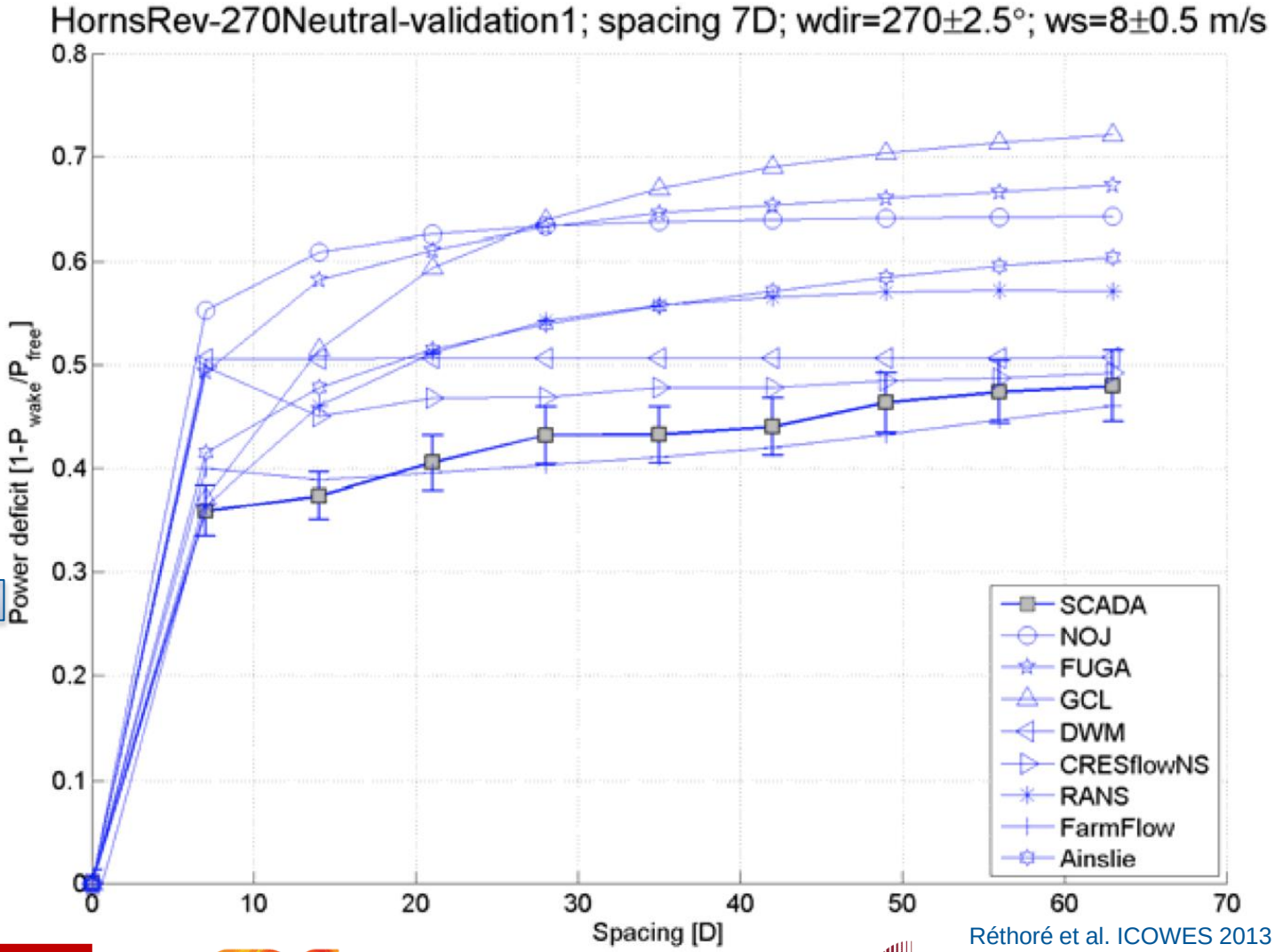

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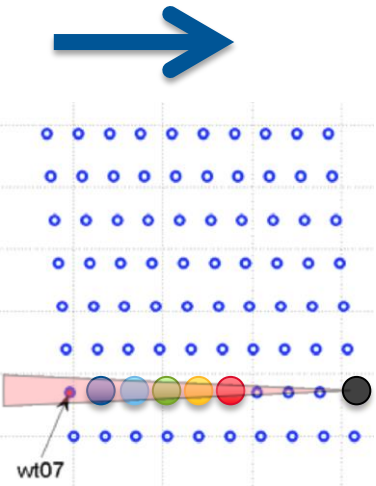
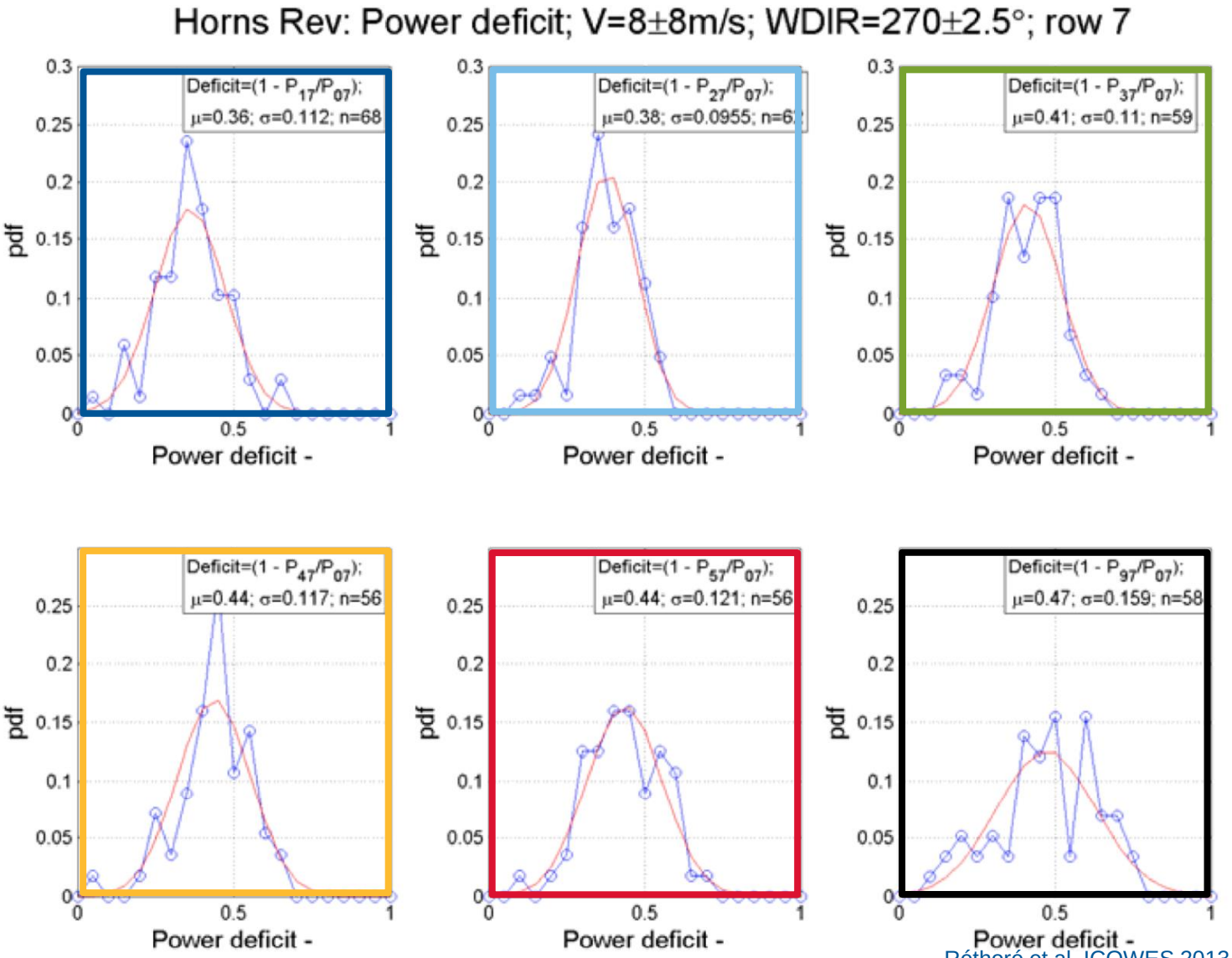
Challenge: Very noisy datasets!





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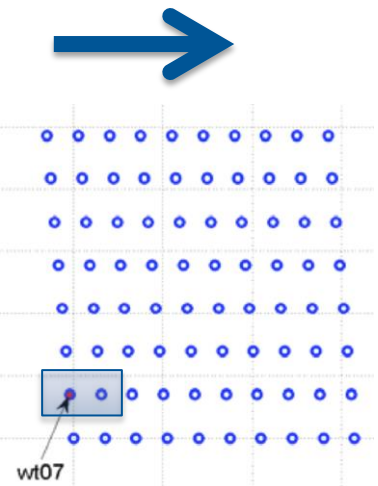
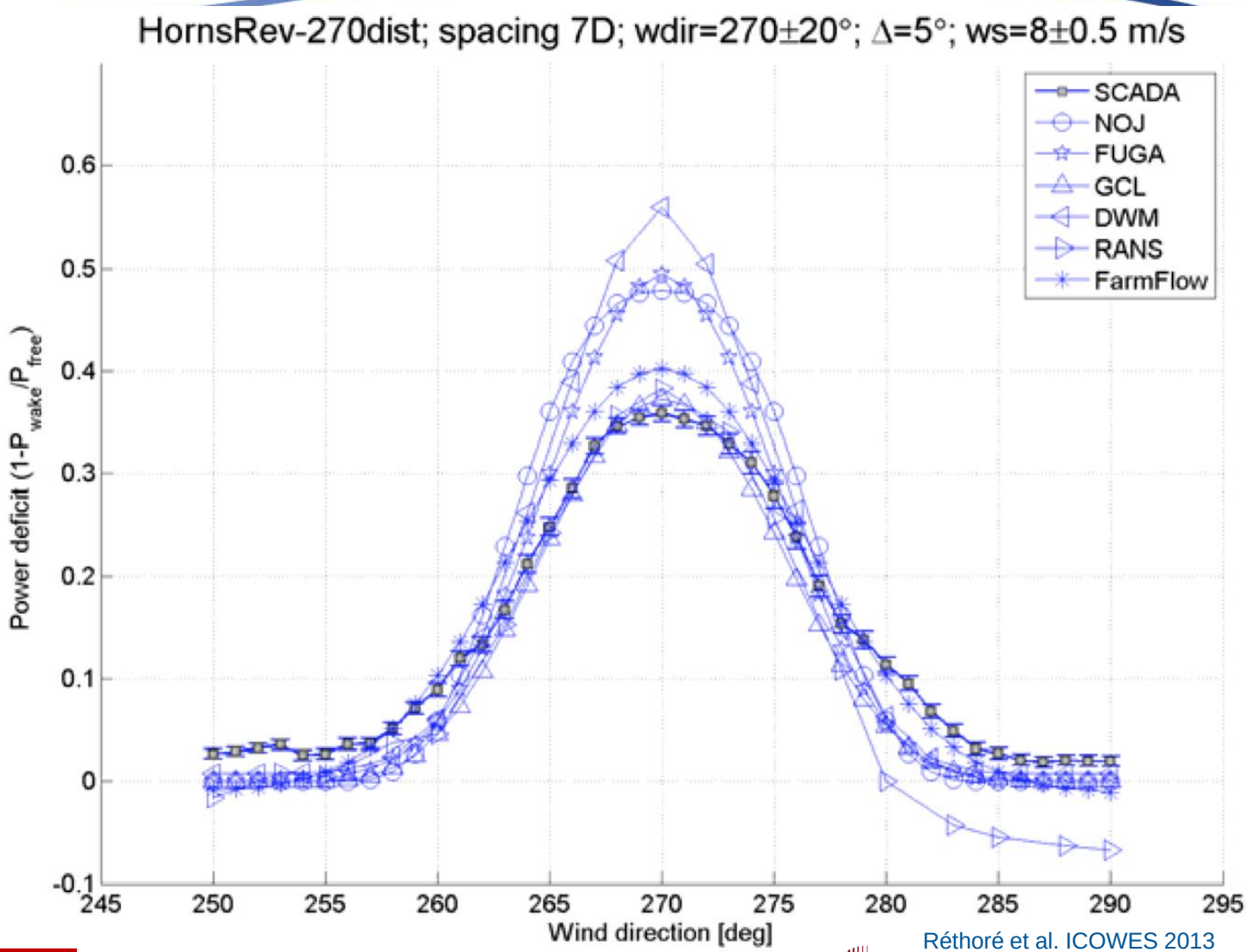
Benchmark preliminary results: Power deficit distribution vs wind direction





Réthoré et al. ICOWES 2013

Cluster Scale Wake Model

Different mesoscale wake modelling strategies

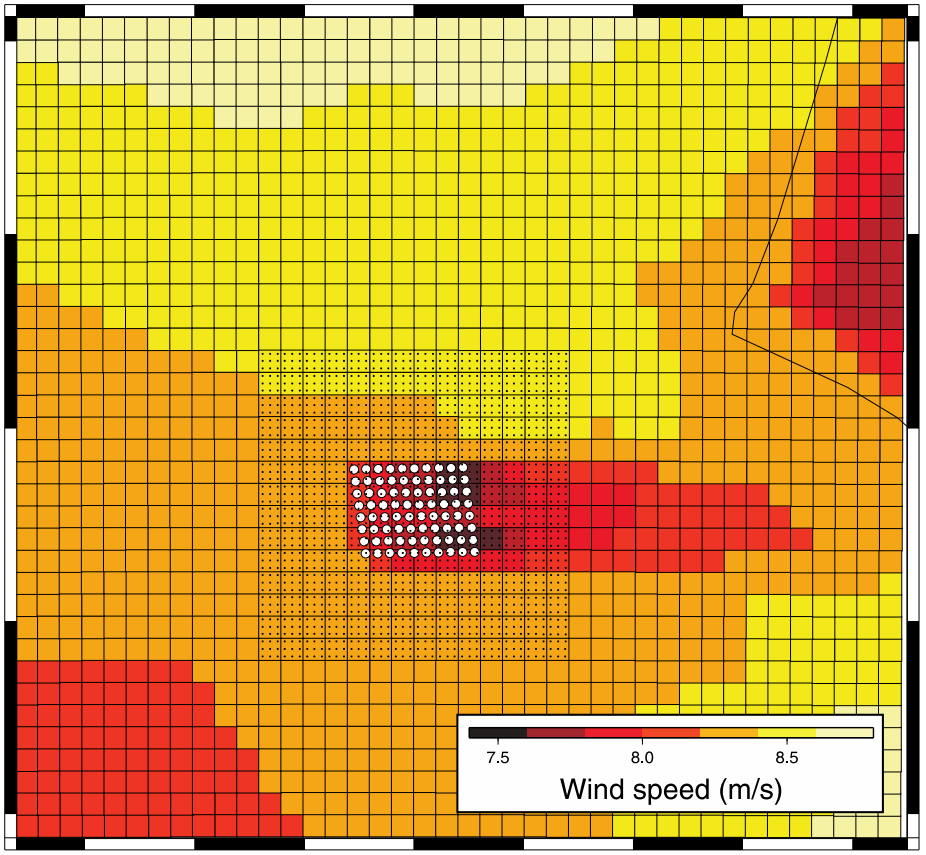
- Should we run the mesoscale model dynamically or in a pseudo-steady state way?

⇒ Compromise between computational expense and physical complexity

- How fine can be the meso-grid cells?

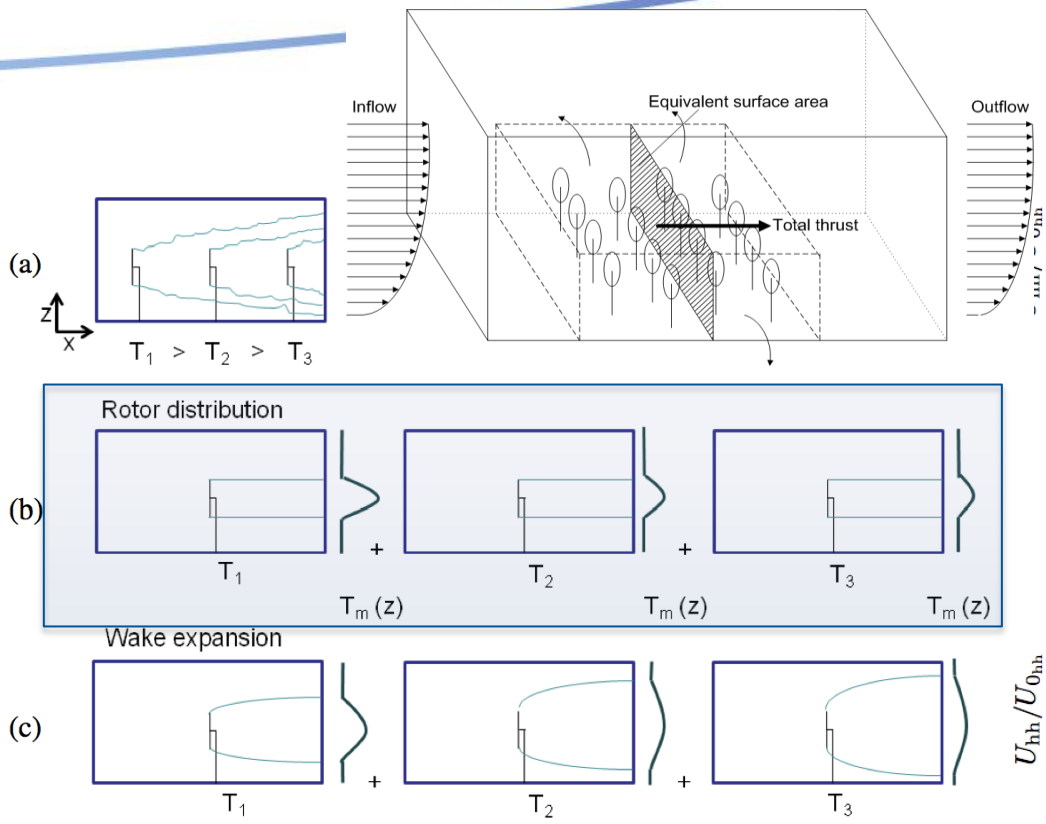
⇒ Finer cells let each wind turbine have its own cell, but approach the limit of model accuracy

- How should the turbine force be applied in the domains?
  - Thrust force
  - Added Roughness

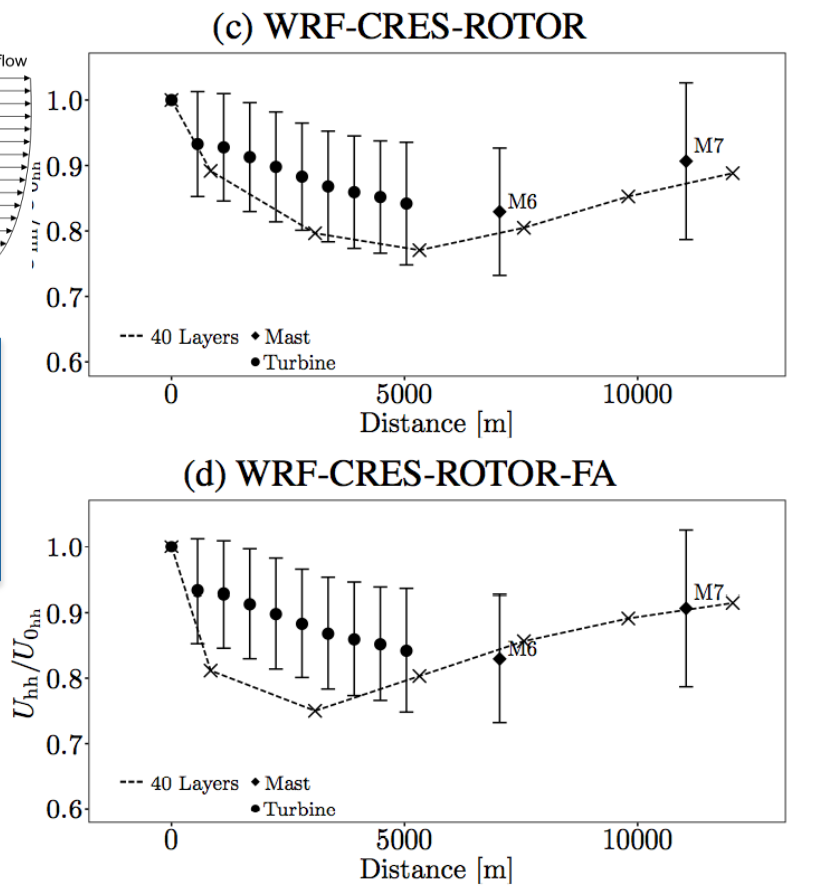


Jimenez et al. Wind Energy (under review)

Windfarm scale => Cluster scale

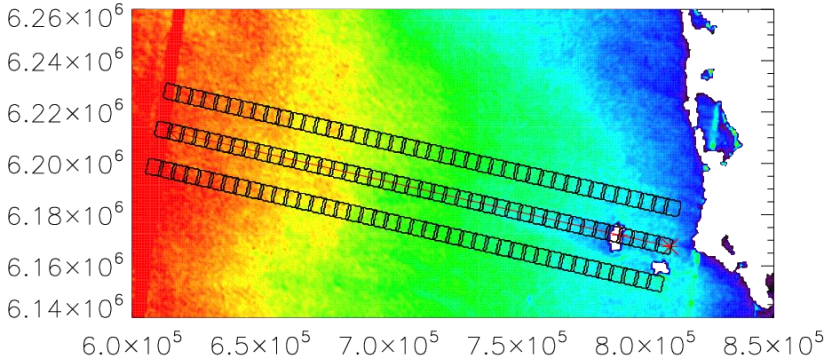


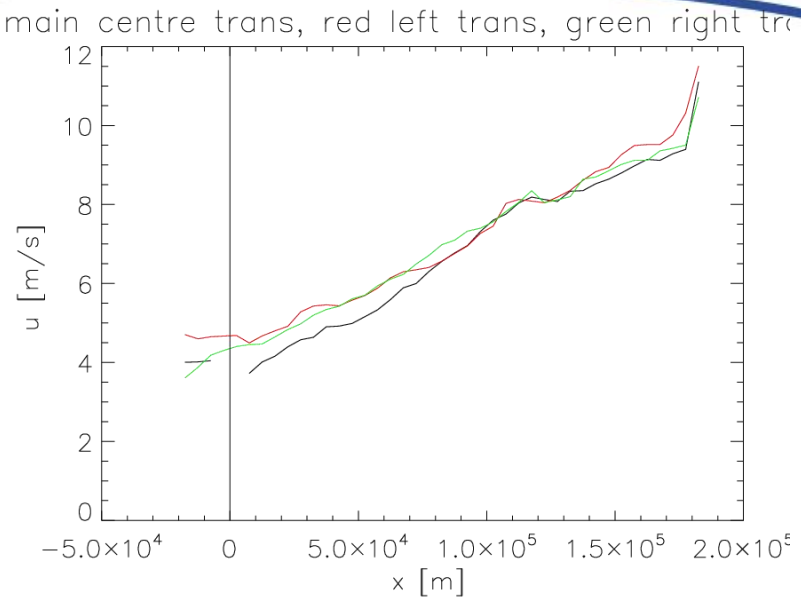
Badger et al. ICOWES 2013



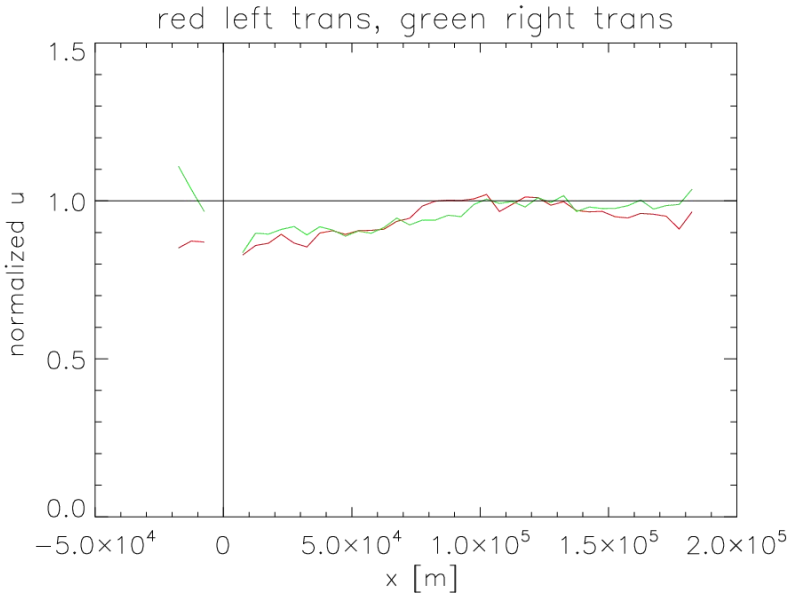
Parameterization	thrust calculation	vertical thrust distribution	aggregation
WRF-EWP	turbine thrust curve	diffusive wake expansion	meso grid aggr.
WRF-CRES-EWP	CRES	diffusive wake expansion	meso grid aggr.
WRF-CRES-ROTOR	CRES	proportional to rotor swept area per level	meso grid aggr.
WRF-CRES-ROTOR-FA	CRES	proportional to rotor swept area per level	wind farm aggr.

SAR scene analysis
Longitudinal transects

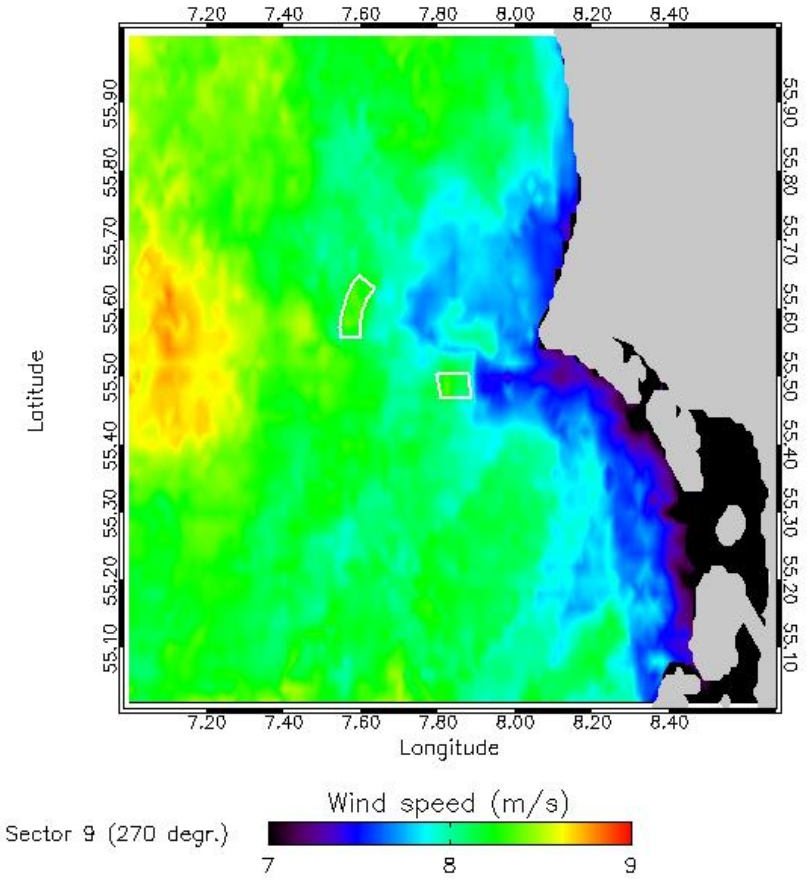


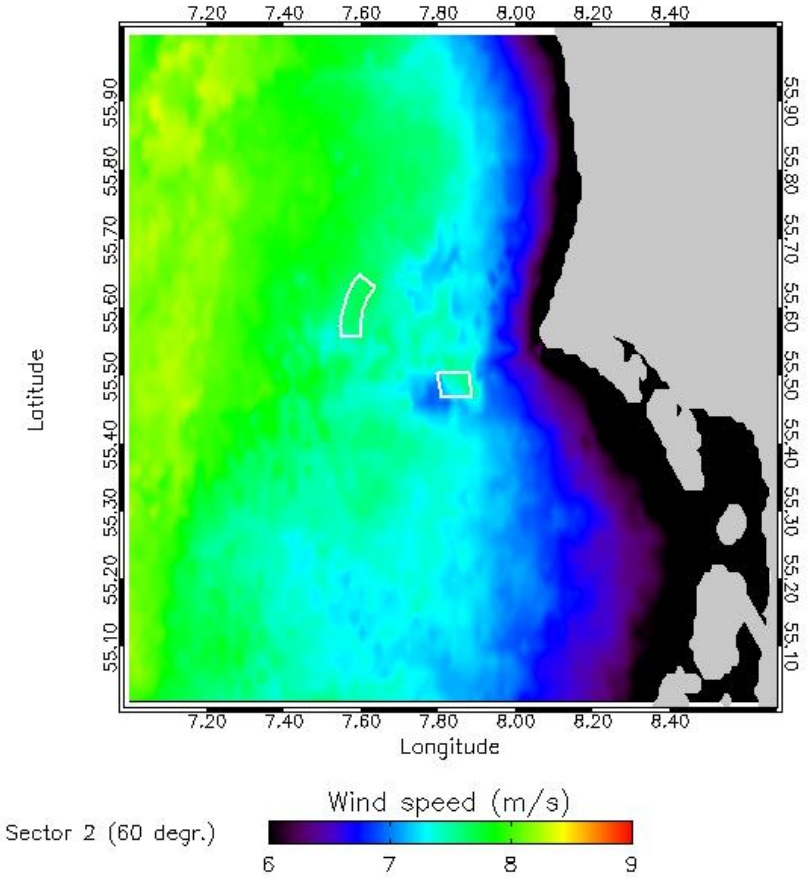


Deficit for ~80 km



SAR derived mean wind climate around wind farms many scenes





Benchmarking Cluster Scale Models

- Different types of data sets:
  - SCADA data
  - Satellite pictures
  - Long range LIDAR + ship mounted LIDAR
- Challenges:
  - Limited amount of datasets
  - No twin wind farm dataset available
  - New area of research

Summary

- Challenging and exciting area of research
- Complex models to setup and expensive to run
- Broad area of expertise focused on solving an important problem:
  - Wake Modelling
  - Mesoscale
  - LIDAR
  - Satellite
  - Wind farm data analysis
  - Industry end users

Thank you very much for your attention

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