WP1: Wake Modelling

Wind farm and cluster wake interaction

Alfredo Peña on behalf of Pierre-Elouan Réthoré

Senior Researcher

DTU Wind Energy

EERA DTOC

THE EUROPEAN ENERGY RESEARCH ALLIANCE

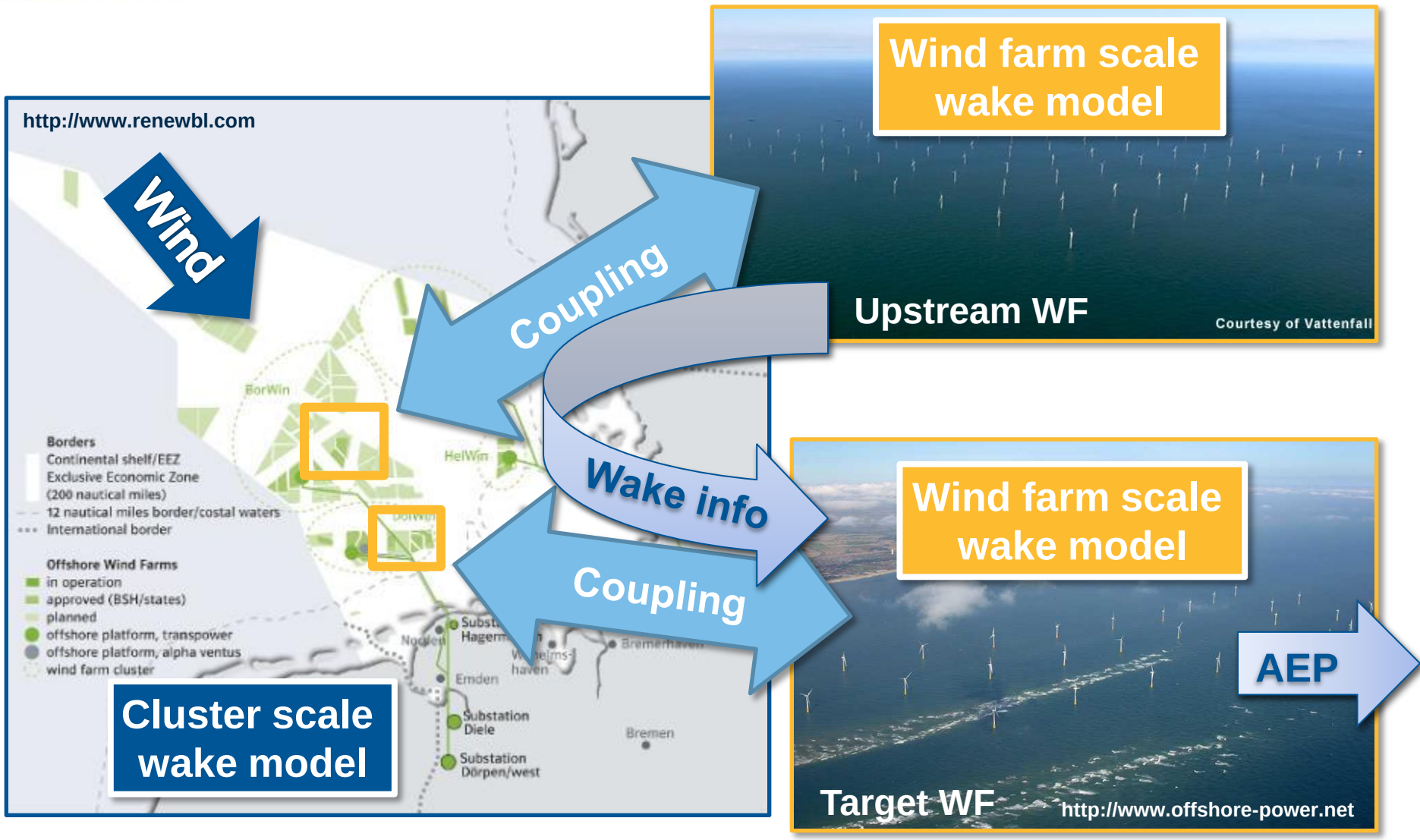
DESIGN TOOLS FOR OFFSHORE WIND FARM CLUSTER

Support by

SEVENTH FRAMEWORK PROGRAMME

Introduction

The “big wake” picture



Outline

- T1.1 Wind Farm Scale Wake Modelling
- T1.2 Cluster Scale Wake Modelling
- T1.3 Coupling Wind Farm and Cluster Scale
- T1.4 Other Offshore Cluster Challenges
- Summary

Wind farm scale wake models

DTU

- DWM
- FUGA
- GCL
- NOJ

INDIANA UNIVERSITY

- WASP/NOJ

U.PORTO

- RANS

CRES

- CRES flowNS

res power for good

- Ainslie

ECN

- FarmFlow

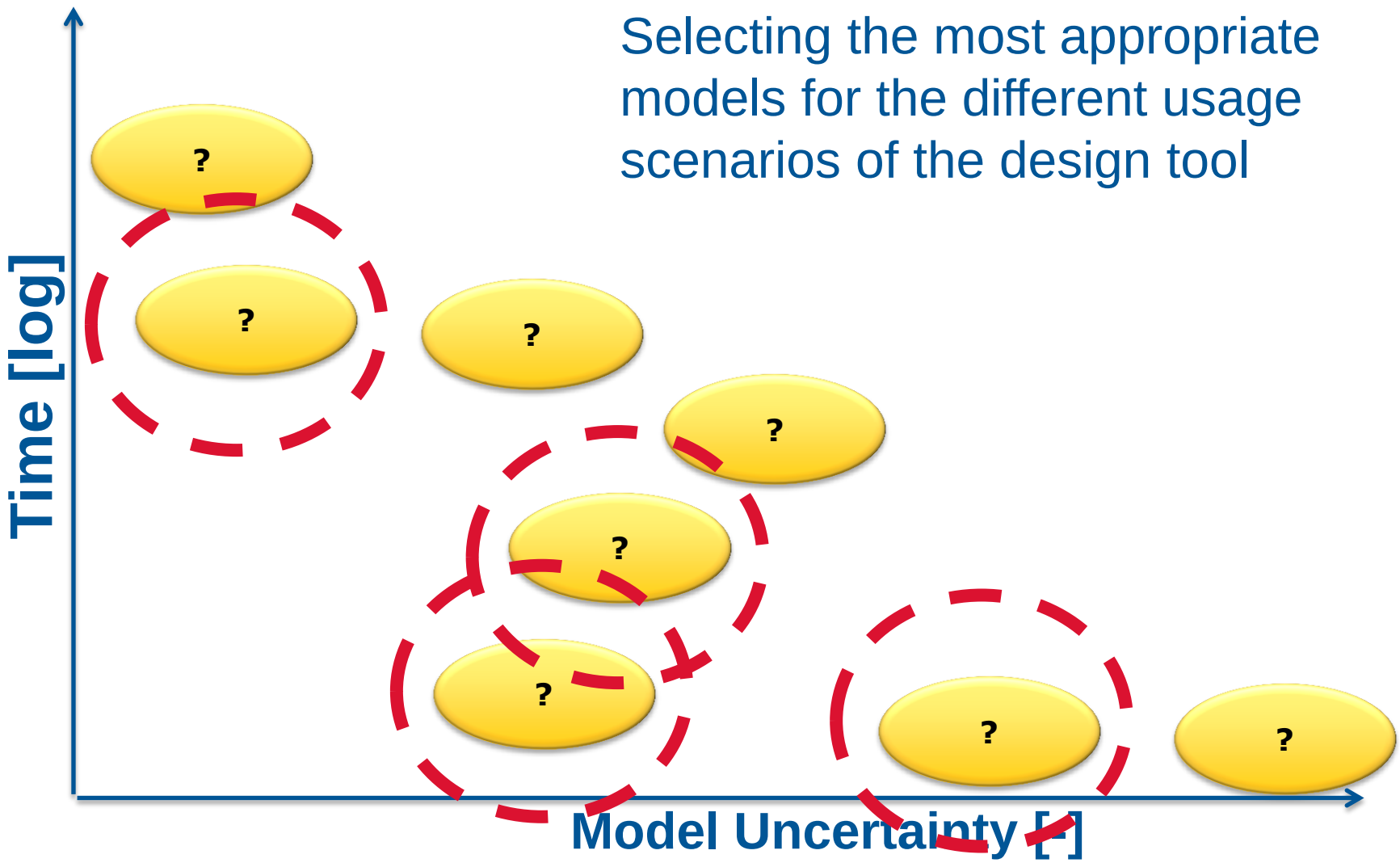
Enginneering

Simplified CFD

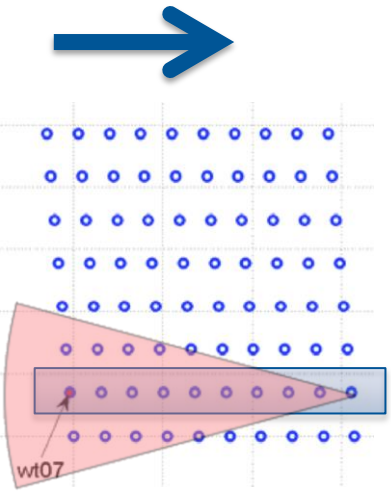
Full CFD

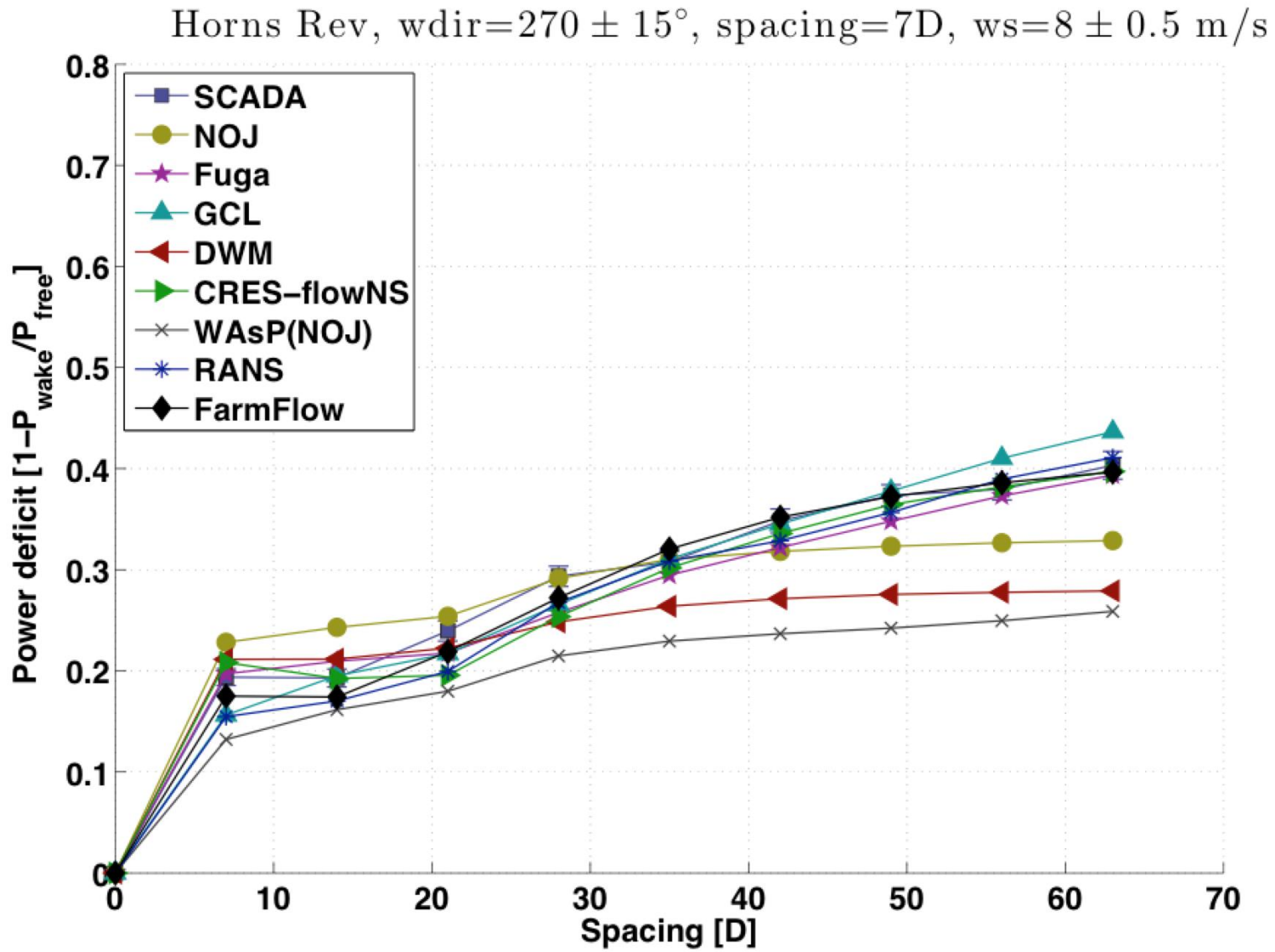
Benchmarking purpose

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



Horns Rev Benchmark:
Power deficit along a line of turbines





Summary of T1.1

- Two benchmarking campaigns carried out
- Existing datasets too noisy to be able to benchmark in detail the wake models
- A new benchmarking methodology was developed within EERA-DTOC and is now under review by the scientific community
- The ultimate decision of which model(s) to use in the tool will be taken by WP4 using the inputs from the T1.1 benchmarks
- D1.1 “Datasets for benchmarking couple use”
- D1.3 “Benchmark report on wake models at the wind farm scale”

Outline

- T1.1 Wind Farm Scale Wake Modelling
- T1.2 Cluster Scale Wake Modelling
- T1.3 Coupling Wind Farm and Cluster Scale
- T1.4 Other Offshore Cluster Challenges
- Summary

Cluster Scale Wake Model

DTU

WRF

GOBIERNO DE ESPAÑA | MINISTERIO DE CIENCIA E INNOVACIÓN | Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

WRF

CENER

SKIRON

Different mesoscale wake modelling strategies

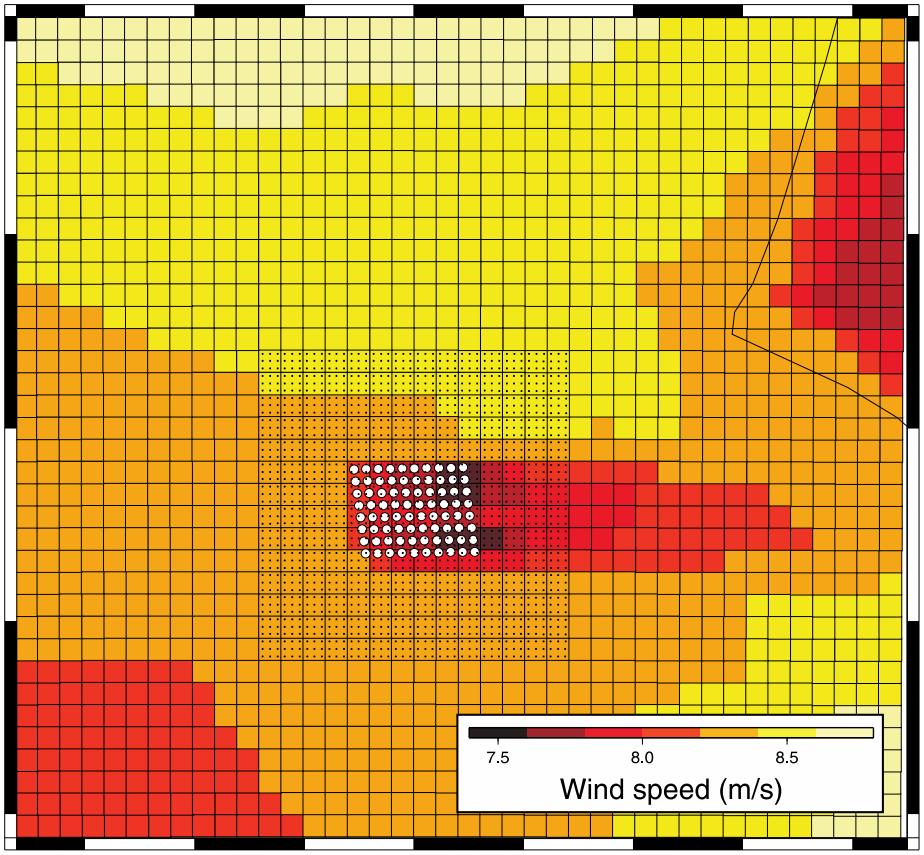
- Should we run the mesoscale model dynamically or in a pseudo-steady state way?

⇒ Compromise between computational expense and physical complexity

- How fine can be the meso-grid cells?

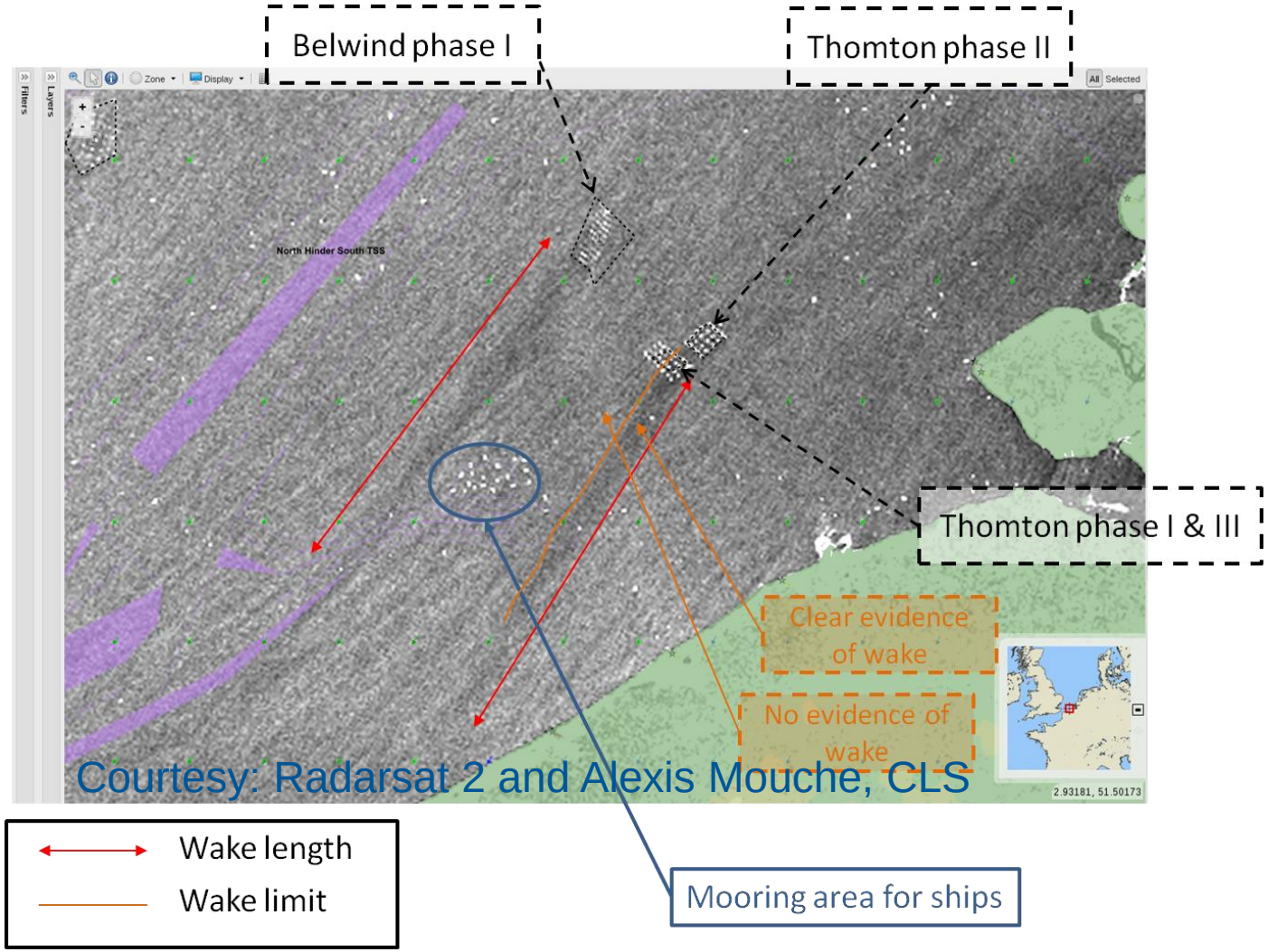
⇒ Finer cells let each wind turbine have its own cell, but approach the limit of model accuracy

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



Jimenez et al. Wind Energy (under review)

SAR images


Belwind phase I
Thomton phase II
Thomton phase I & III
North Hinder South TSS
Clear evidence of wake
No evidence of wake
Courtesy: Radarsat 2 and Alexis Mouche, CLS
Wake length
Wake limit
Mooring area for ships

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

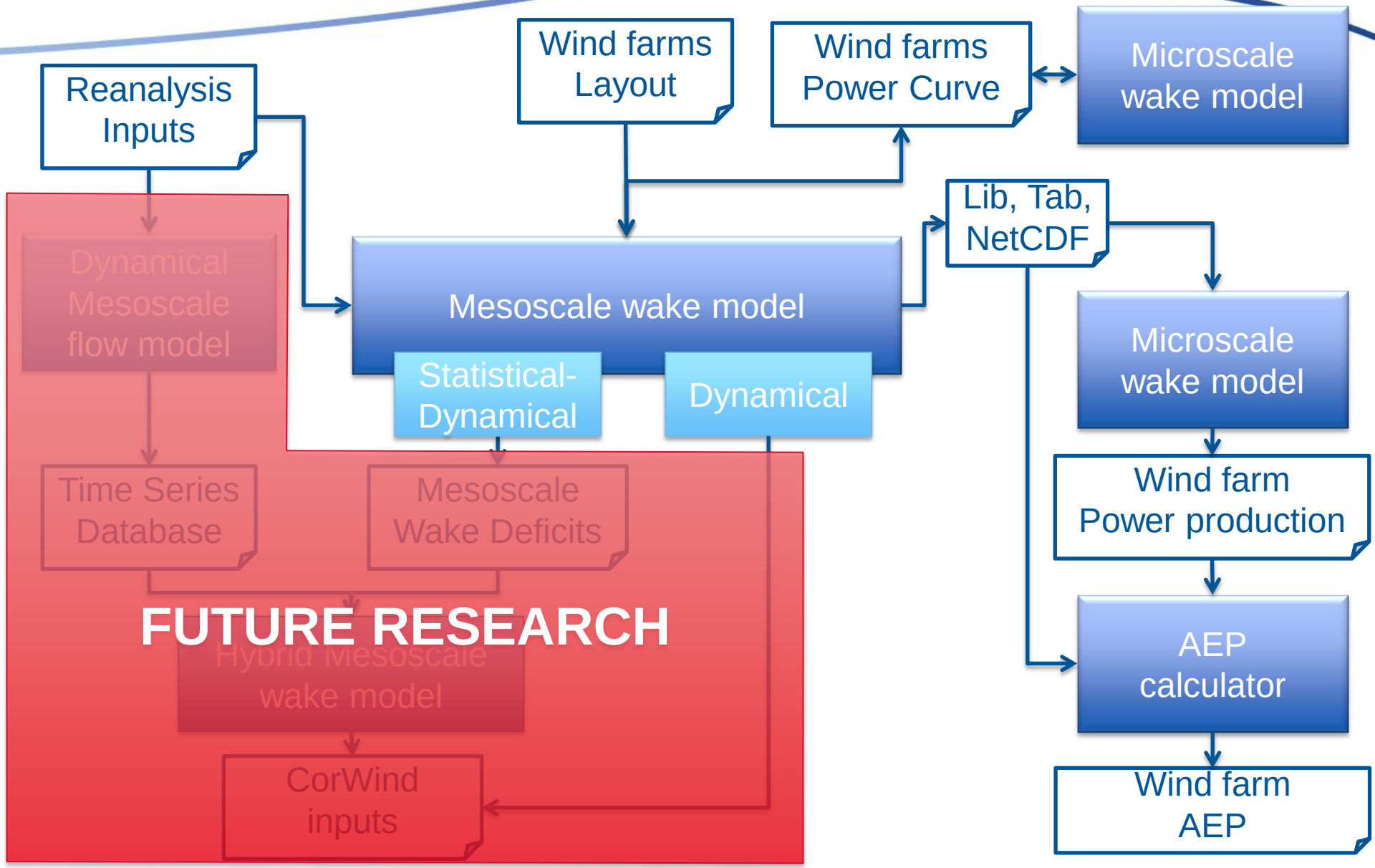
Summary of T1.2

- Creation of the Horns Rev cluster scale benchmark
- Investigating different wind farm parameterizations
- SAR images selection and processing
- D1.4 “Benchmark report on wake models at the cluster scale”

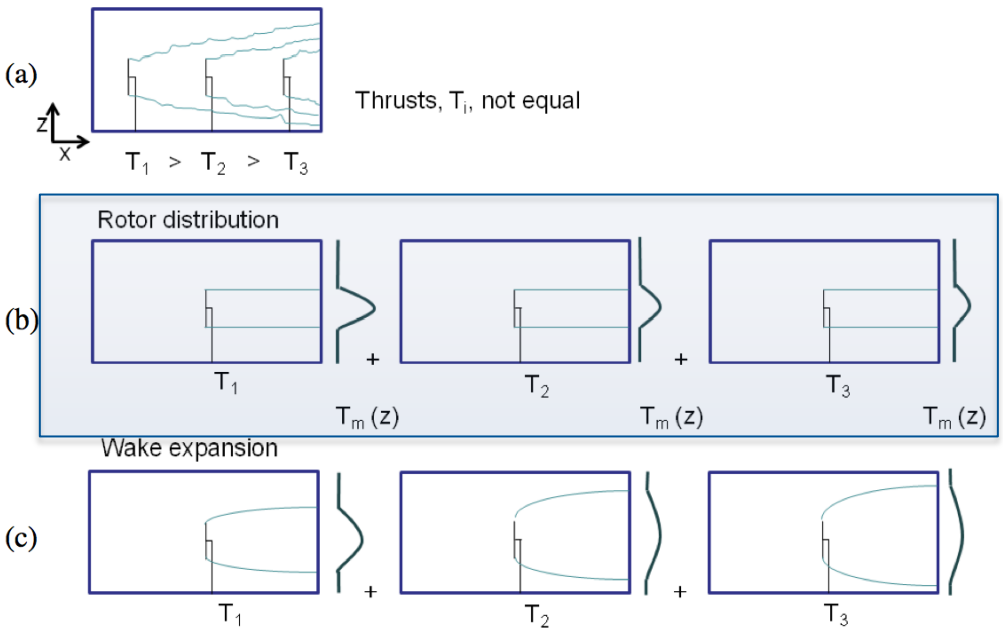
Outline

- T1.1 Wind Farm Scale Wake Modelling
- T1.2 Cluster Scale Wake Modelling
- T1.3 Coupling Wind Farm and Cluster Scale
- T1.4 Other Offshore Cluster Challenges
- Summary

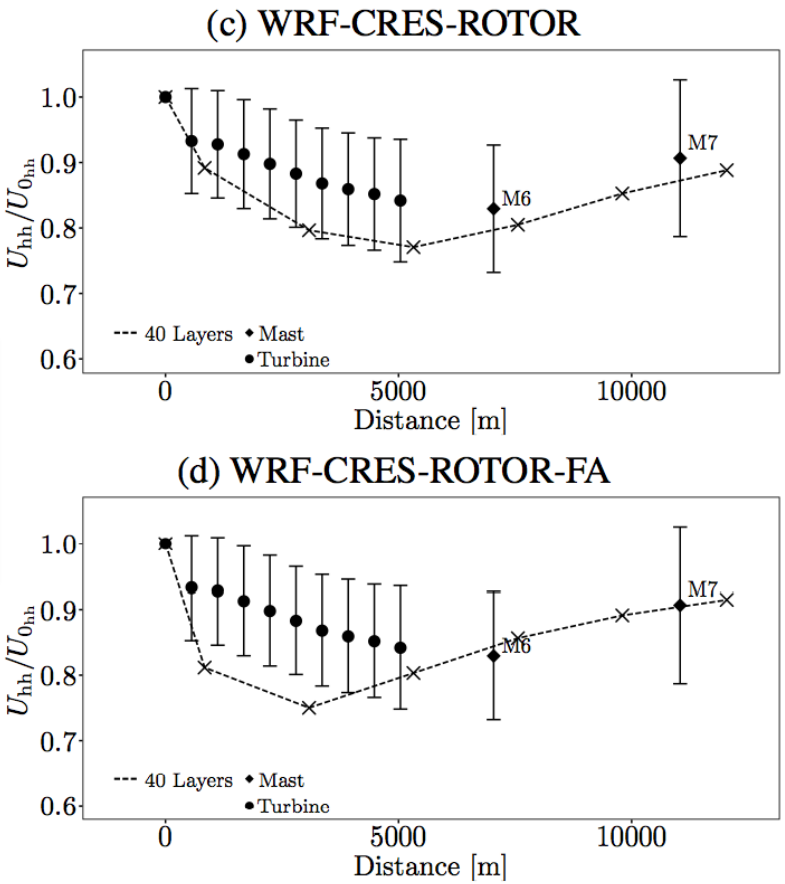
Coupled use: Model Workflow



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.

Summary of T1.3: Coupling micro-meso scales

- Design of possible model workflows
- Investigation of different coupling strategies
- Selection of a promising methodology and model workflow
- D1.2 “Report on physical scale integration and coupled use”

Outline

- T1.1 Wind Farm Scale Wake Modelling
- T1.2 Cluster Scale Wake Modelling
- T1.3 Coupling Wind Farm and Cluster Scale
- T1.4 Other Offshore Cluster Challenges
- Summary

T1.4 Other offshore wind cluster challenges

- Marine operation (Access, Operation)
- Wind turbine life cycle
  - wind/wave resource
  - Water depth
  - Sea bottom condition
  - Electrical grid connection
  - Foundation
  - Installation
  - Operation & Maintenance
  - Decommission
- Risk assessment

Summary of T1.4

- 3 presentations on different offshore challenges during the project workshops
- Summary report under preparation about the experience learned by Statoil, Carbon Trust and Hexicon while developing offshore wind farms.
- -> Task moved to WP5.4

Thank you very much for your attention

EERA DTOC

Support by

SEVENTH FRAMEWORK PROGRAMME