

## Application of mesoscale models with wind farm parametrisations in EERA-DTOC

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**Copenhagen, 10 March 2015**

**Application of mesoscale models with wind farm  
parametrisations in EERA-DTOC**

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(1) DTU Windenergy (Denmark)

(2) CLS, Plouzane (France)

(3) IFREMER (France)



Support by



# Introduction

Our aim is to understand better wakes of wind farms, especially their:

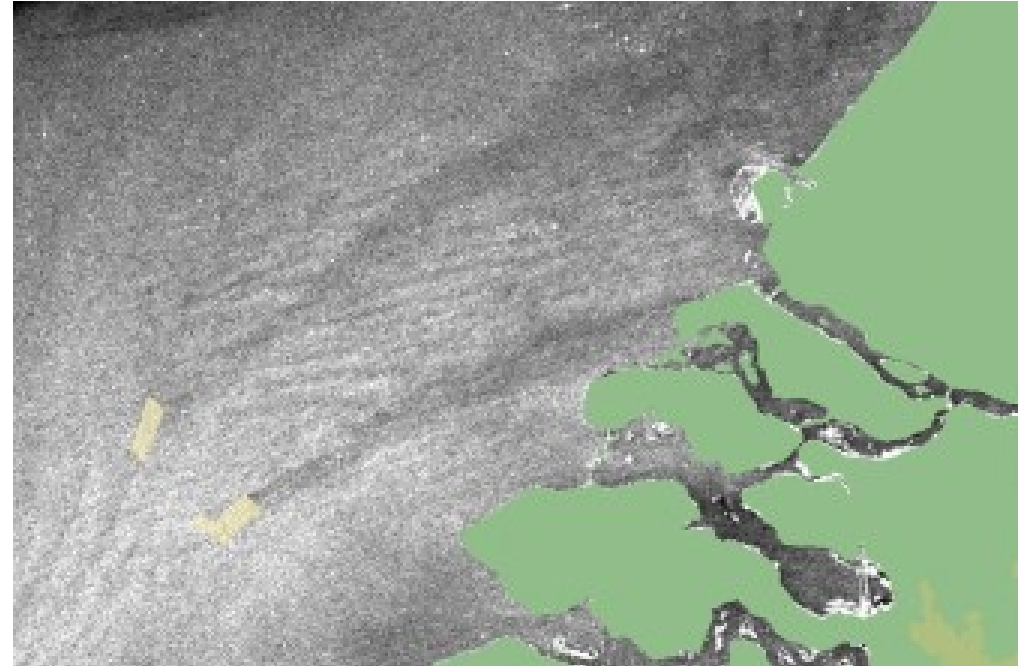
## (1) Properties

- Depth
- Extension
- Dynamics

## (2) Long-term impact on

- Wind resources
- Environment (T, Q)

Wakes behind Belwind/Thornton



## Content:

- 1) Mesoscale models
- 2) EERA-DTOC Project
- 3) Mesoscale models in EERA-DTOC

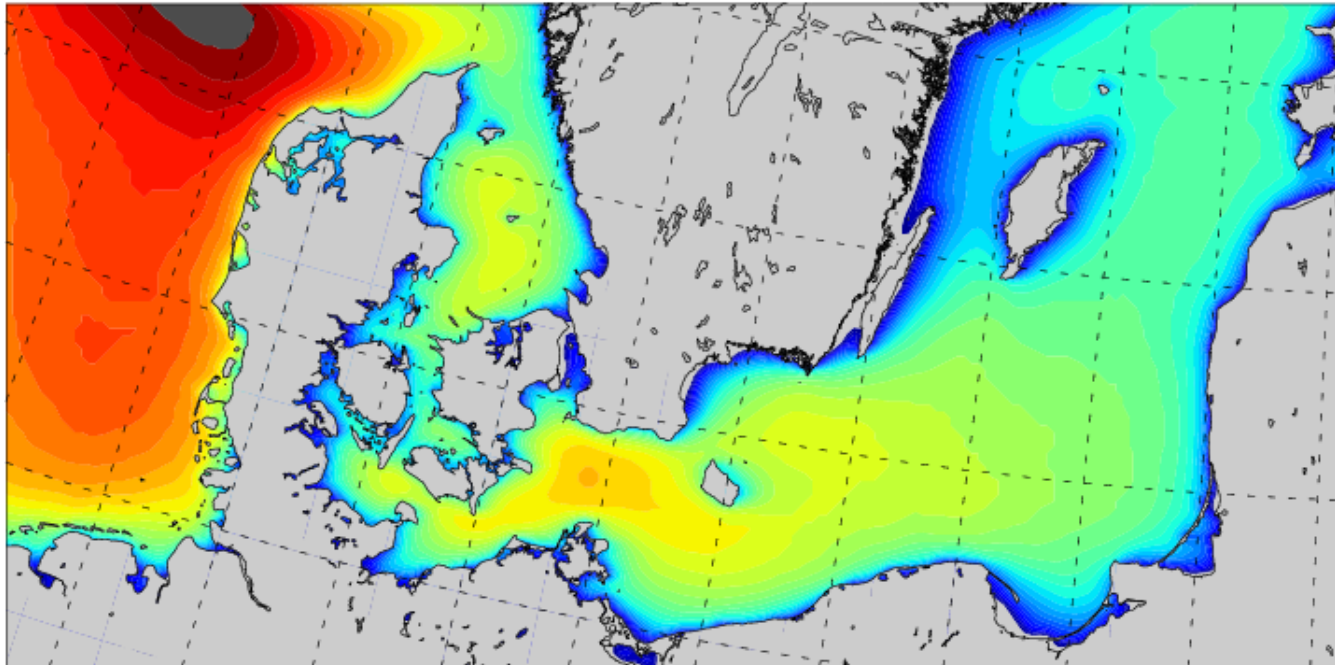
# Mesoscale Model (General)

Mesoscale models are used for:

- Forecasting the weather
- Wind resource assessment

Mean Wind Speed, 2006/05-2007/04

Height: 100 meters



8 8.2 8.4 8.6 8.8 9 9.2 9.4 9.6 9.8 10 10.2 10.4 10.6 10.8 11

wind speed (m/s)

**Weather Research and Forecast model (WRF)**

**2.750.000 Cells for an area  $\approx 180.000 \text{ km}^2$**

**On our cluster: 2/3 Days per year on 70 X 20 processors**

# Wind Farm Parametrisations

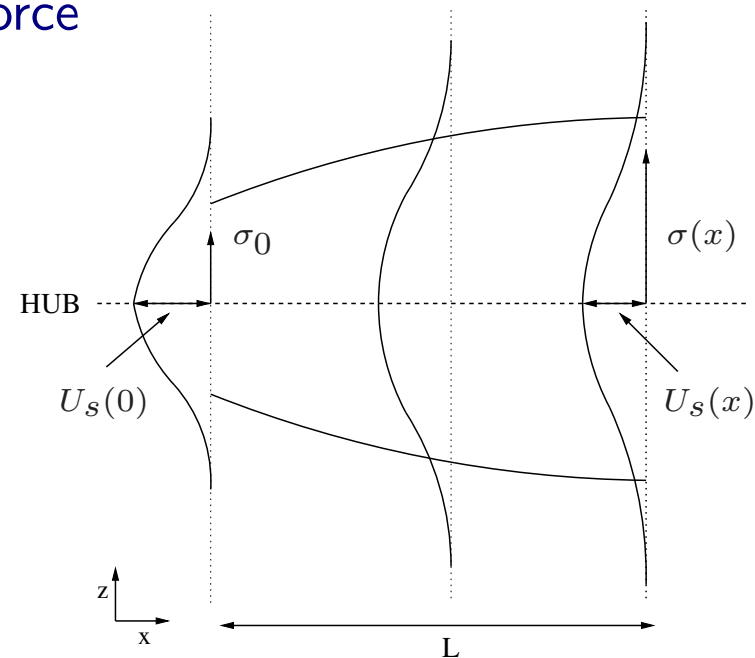
## WRF Wind Farm scheme (Fitch et al. 2012):

- (1) Local drag force (Rotor swept area)
- (2) Additional TKE source term

## Explicit Wake Parametrisation (EWP) approach:

- (1) Accounts for unresolved wake expansion
- (2) Applies Grid-cell averaged drag force

### Concept:



Sketch of the wake development within a grid-cell

**For both schemes the full TKE budget is calculated by PBL-scheme**

# EERA-DTOC Project

EERA-DTOC (Seventh Framework Programme (FP7)):

## European Energy Research Alliance - Design Tool for Offshore Wind Farm Cluster

“Integrated and validated design tool combining state-of-the-art wake, yield and electrical models”

### Universities/Institutes:

- DTU Wind Energy (Denmark)
- ECN (Netherlands)
- Universität Oldenburg (Germany)
- Fraunhofer (Germany)
- CRES (Greece)
- CIEMAT (Spain)
- CENER (Spain)
- CLS (France)

### Industry:

- Carbon Trust (United Kingdom)
- RES (United Kingdom)
- Overspeed (Germany)
- Statoil (Norway)
- Statkraft (Norway)
- Iberdrola (Spain)
- EON (Sweden)

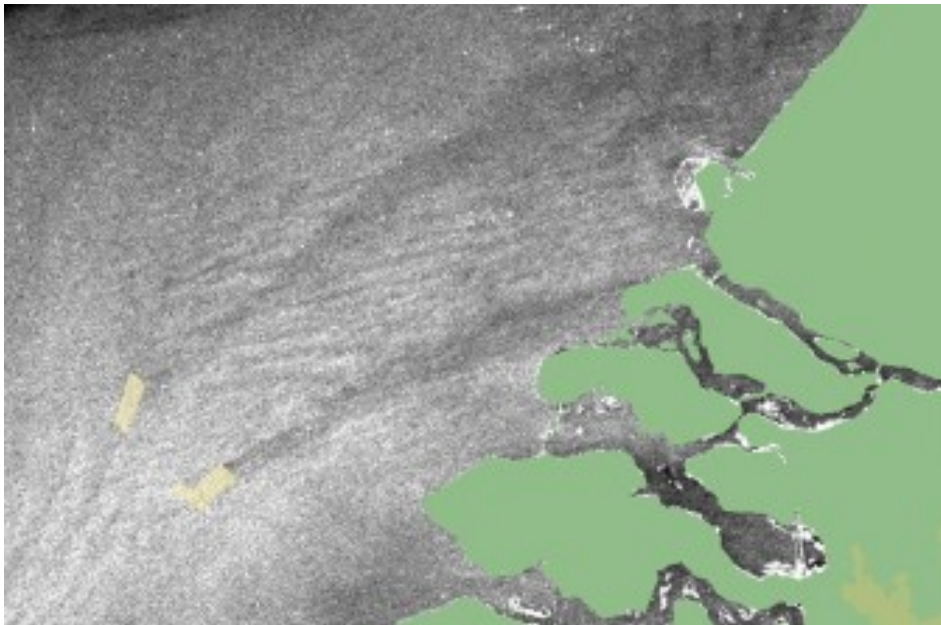


# DTOC - Mesoscale Model Evaluation

Qualitative comparison with Synthetic Aperture Radar (SAR) images. They can retrieve wind speed from back-scatter (higher wind speeds are brighter):

RADARSAT-1/-2 from Data and Products ©MacDonald, Dettewiler and Associates Ltd are acknowledged.

SAR Image (17:34 UTC)



WRF-EWP (17:30 UTC)

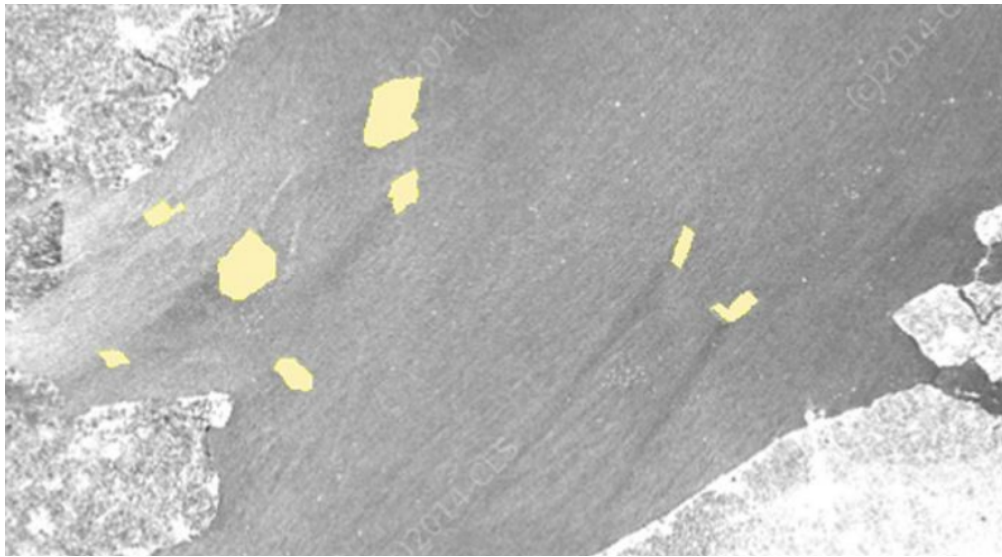


1<sup>st</sup> of July of 2013: Belwind & Thornton

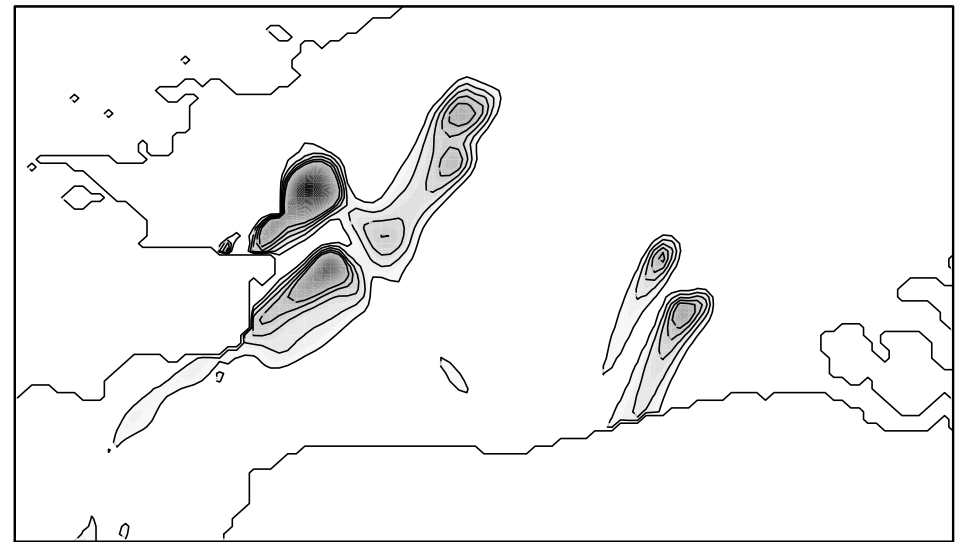
⇒ Comparable extension and divergence

# DTOC - Mesoscale Model Evaluation (cont'd)

SAR Image (17:41 UTC)



WRF-EWP (18:00 UTC)



30<sup>th</sup> of April 2013: UK wind farms and Belwind & Thornton

⇒ Challenge in timing snap-shots



# DTOC - User Interface

Wind climate in the **target area** from WRF with/without **background** wind farms

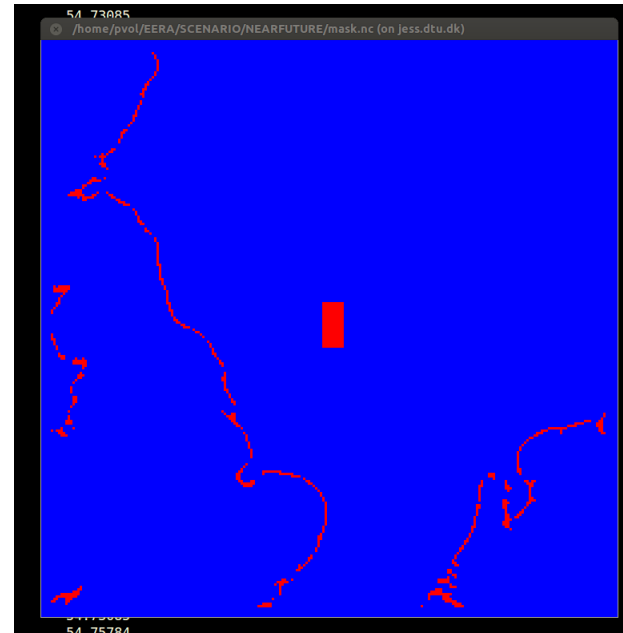
The screenshot displays the DTOC (Department of Wind Energy) user interface. The top navigation bar includes 'DTOC GUI', 'Documentation', and 'About'. The user is logged in as 'overspeed GmbH & Co. KG'. The main interface is divided into several sections:

- Scenario: DTOC WP5 Base Scenario**: A tree view showing the current scenario and other projects like 'DTOC WP5 Near Future Scenario (Dogger Bank)' and 'DTOC Borkum West'.
- Wind Farm Parameters**: A list of parameters for the selected 'Race Bank' wind farm, including location, shape, turbines, substations, cables, and other specific farm details.
- Wind Turbine Type Parameters** and **Model Parameters**: Sections for configuring turbine and model settings.
- Map**: A central map showing the 'North Norfolk Heritage Coast' with several wind farms marked: Triton Knoll A, Triton Knoll B, Race Bank (highlighted as the 'Target area' with a red border), Dudgeon, Sheringham Shoal, Lincs Inner Dowsing, and Lynn. The map includes a Google Maps interface with zoom controls and a 'Map data ©2015 Google' footer.

**Outcome:** Annual Energy Production of the target wind farm accounting for wake losses of neighbouring wind farms

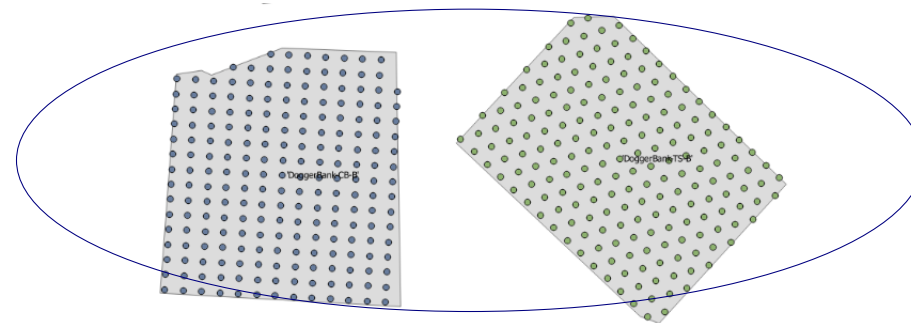
# DTOC - Mesoscale Model Implementation

Three institutes (CENER, CIEMAT and DTU) can calculate a Wind Climate for a **target area**

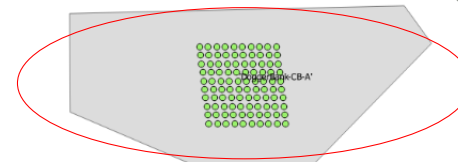


Without and with **background** wind farms

**Background**

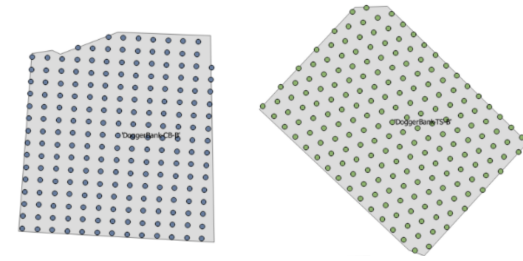


**Target area**



# DTOC - Mesoscale Model Implementation

2 years simulation with WRF-EWP in the North-Sea without/with **background** wind farms

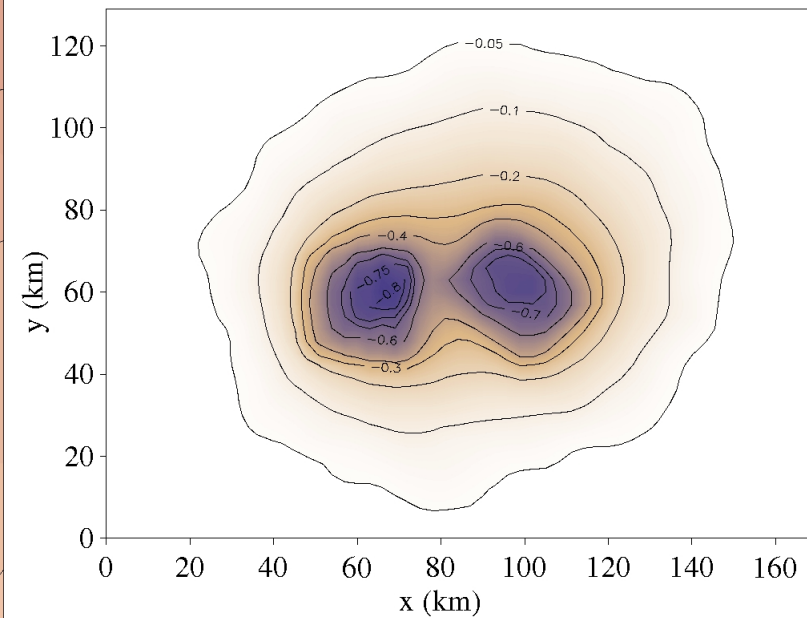
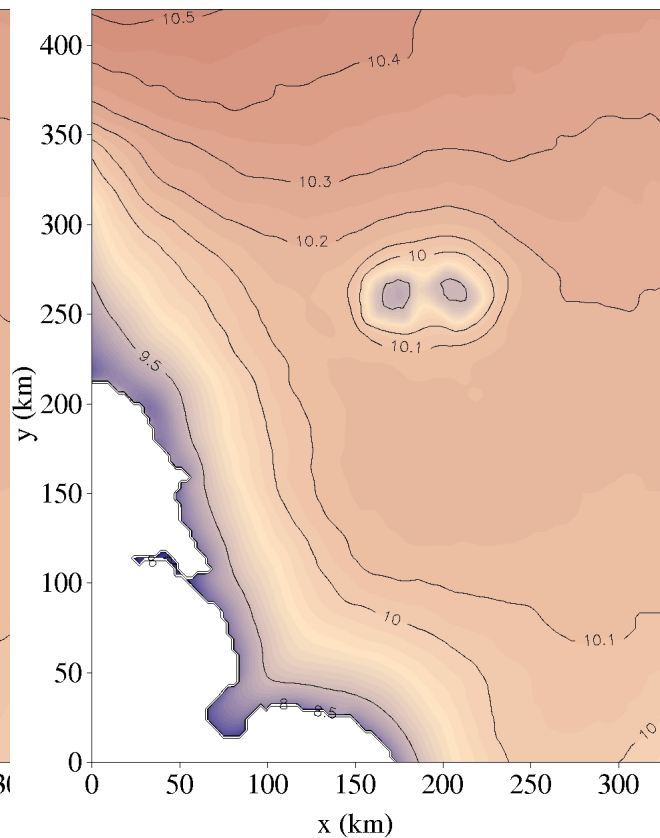
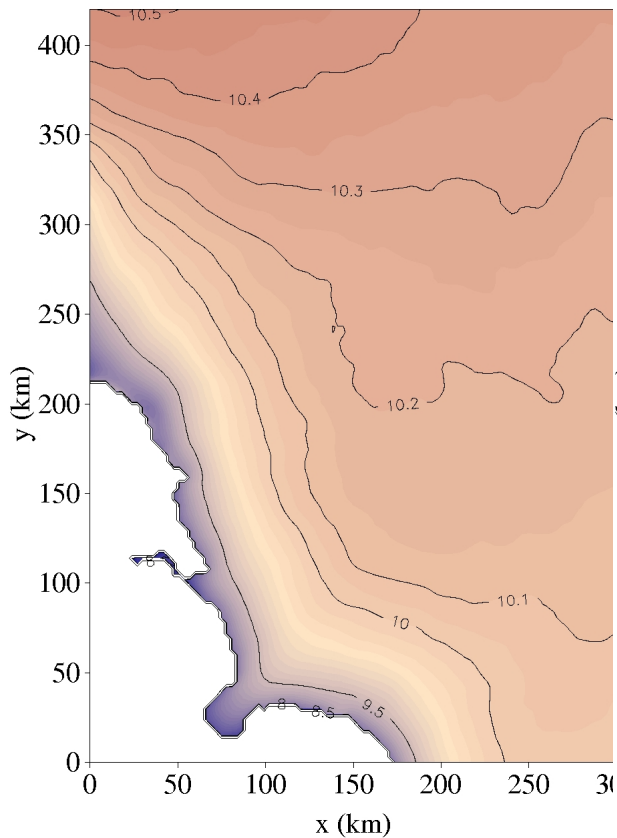


Time averaged wind speed at hub-height (119 m)

Reference

Wind Farm

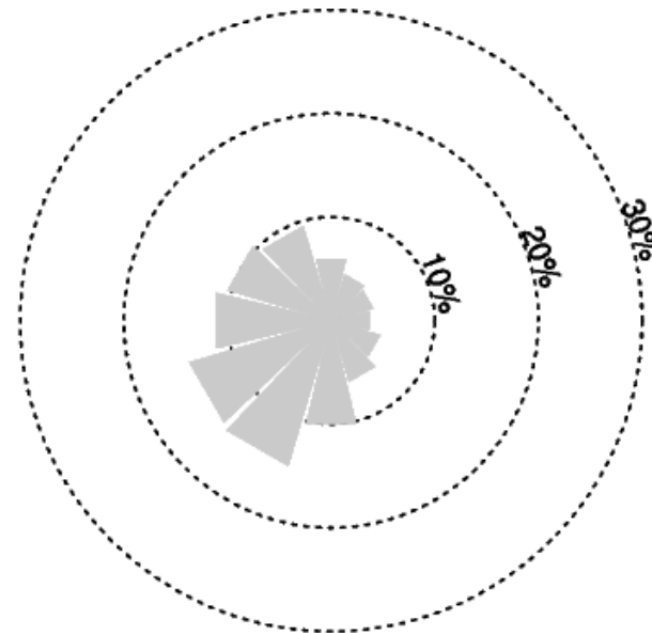
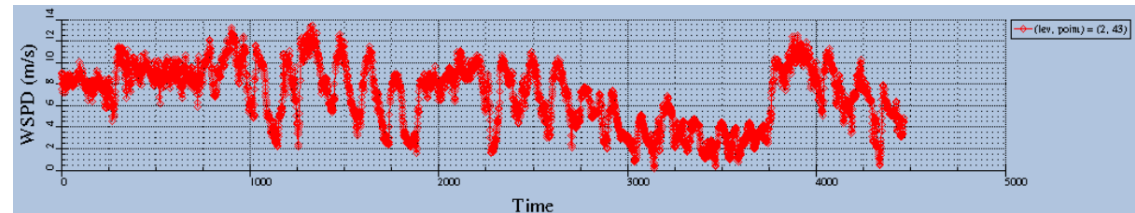
Difference (0.05 – 0.8 m/s)



# DTOC - Mesoscale Model Implementation

The Mesoscale model provides for all point within the **target area** in a given **period**:

- Time-Series
- Modelled Wind Climate
- Generalised Wind Climate (DTU)



# Summary

## Within the EERA-DTOC tool:

- Methodology has been implemented in the DTOC-TOOL
  - Neighbouring wind farms can now be accounted for in time-series and the wind climate
- ⇒ Annual Energy production for a new wind farm for the Wind climate with/without neighbouring wind farms

## Mesoscale models:

- Have the capability to accounts for the dynamics in the wind farm wake
- Further investigation of the long-term velocity reduction is needed

Support by

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