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

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(3) IFREMER (France)



Support by

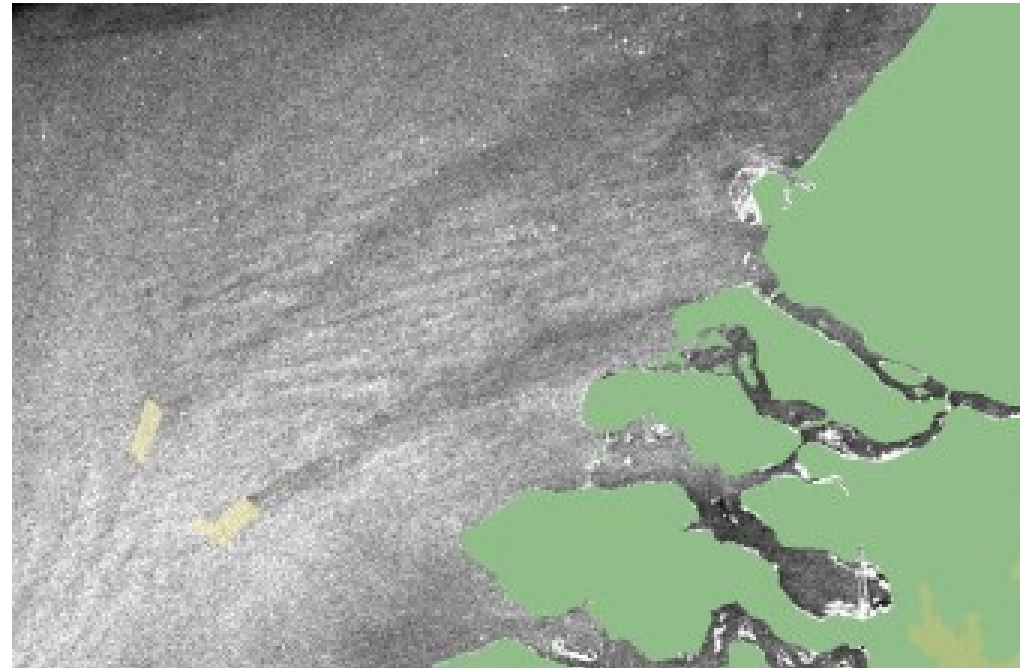


# Introduction

It becomes increasingly important to better understand wakes of wind farms, especially their:

- (1) Properties (Extension, Dynamics)
- (2) Long-term impact

Wakes behind Belwind/Thornton



## Content:

- **EERA-DTOC Project**
- **Mesoscale models**
- **Mesoscale models in EERA-DTOC**

# EERA-DTOC

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:

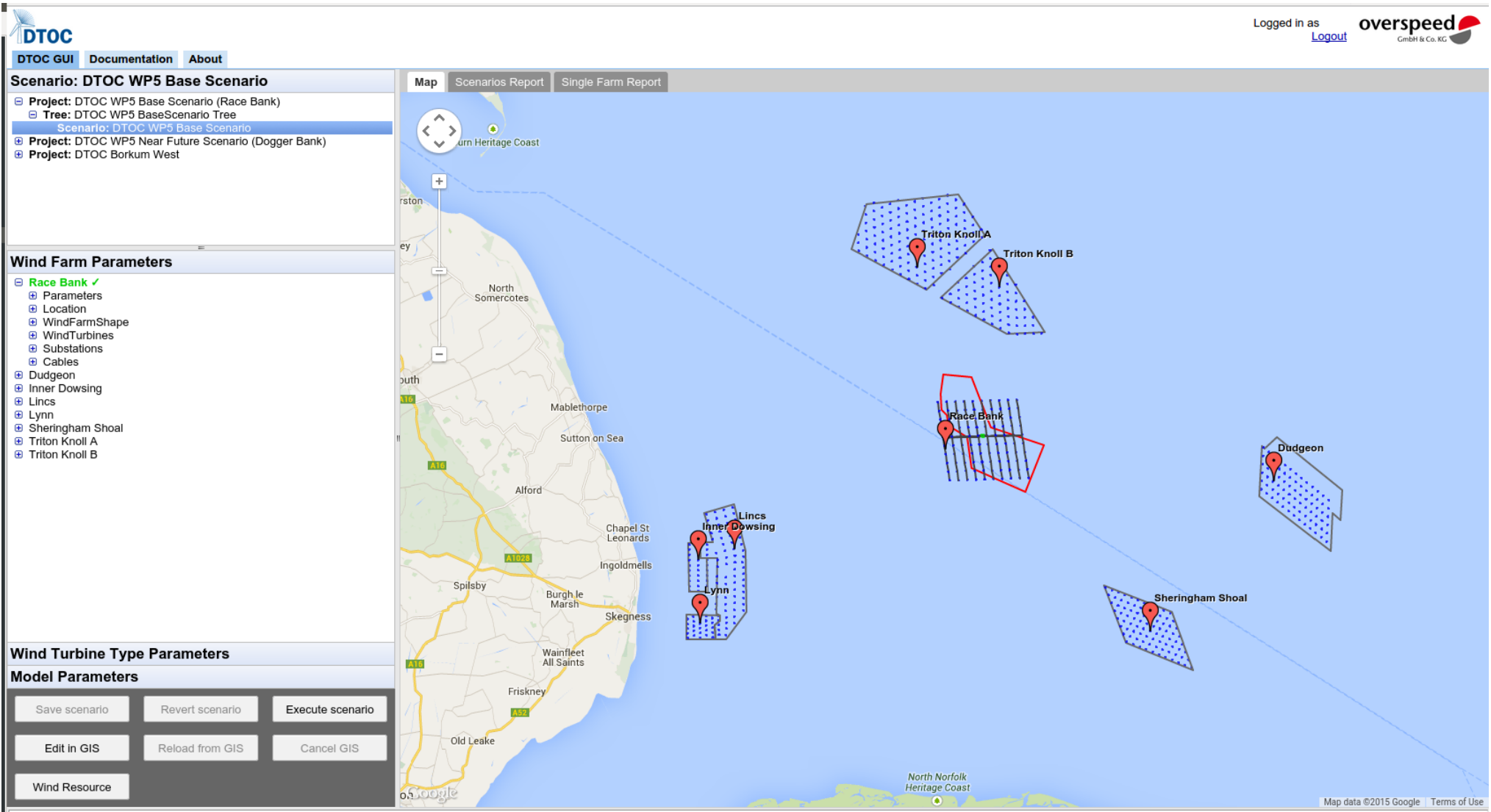
- DTU Wind Energy (Denmark)
- ECN (Netherlands)
- Universität Oldenburg (Germany)
- Fraunhofer (Germany)
- CRES (Greece)
- CIEMAT (Spain)
- CENER (Spain)
- CLS (France)

### Industry:

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

# DTOC User Interface

Interface in which wake models can be run with **wind climate from WRF**



**Outcome:** for example Annual Energy Production and net yield

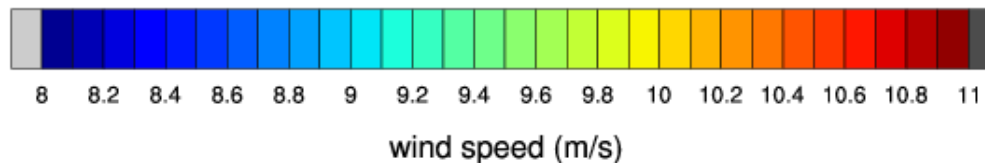
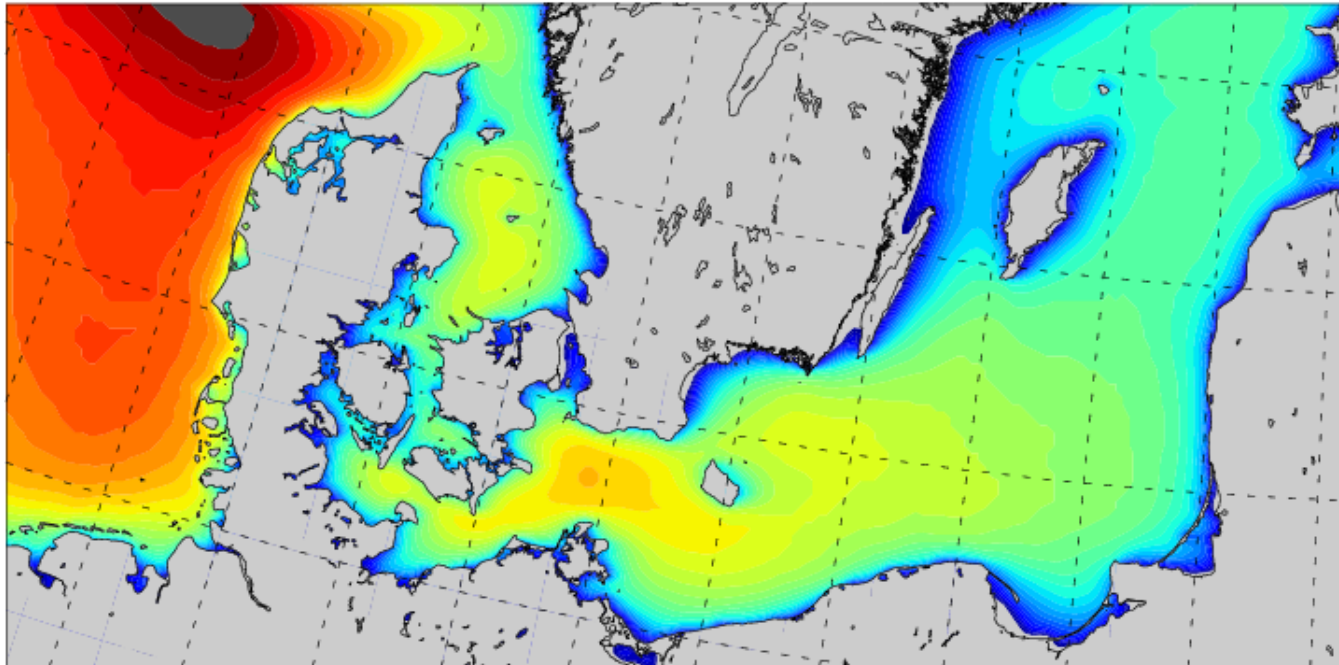
# Mesoscale Model (General)

Mesoscale models are used for:

- Forecasting the weather
- Wind resource assessment

Mean Wind Speed, 2006/05-2007/04

Height: 100 meters



**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

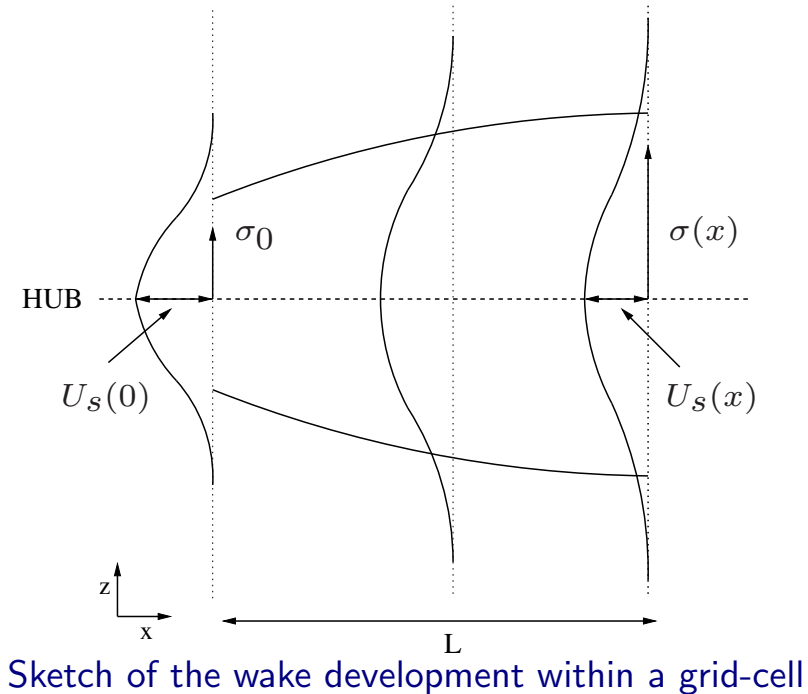
## WRF Wind Farm scheme (Fitch et al.2012):

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

## EWP approach accounts for unresolved expansion and applies:

- (1) Grid-cell averaged drag force

Concept:



For both schemes turbulence shear is regulated by the PBL-Scheme

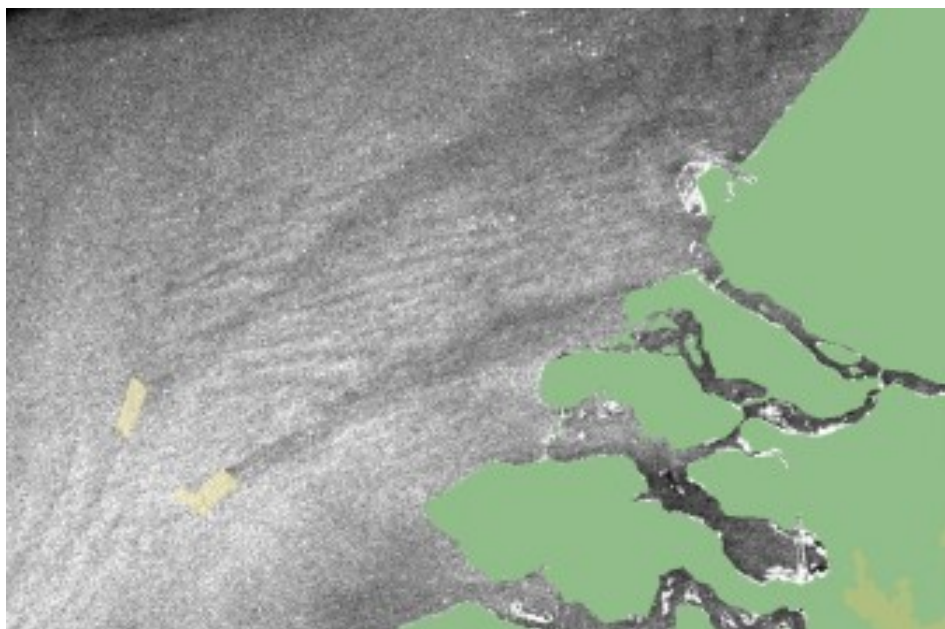


# Mesoscale Model (Evaluation)

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)

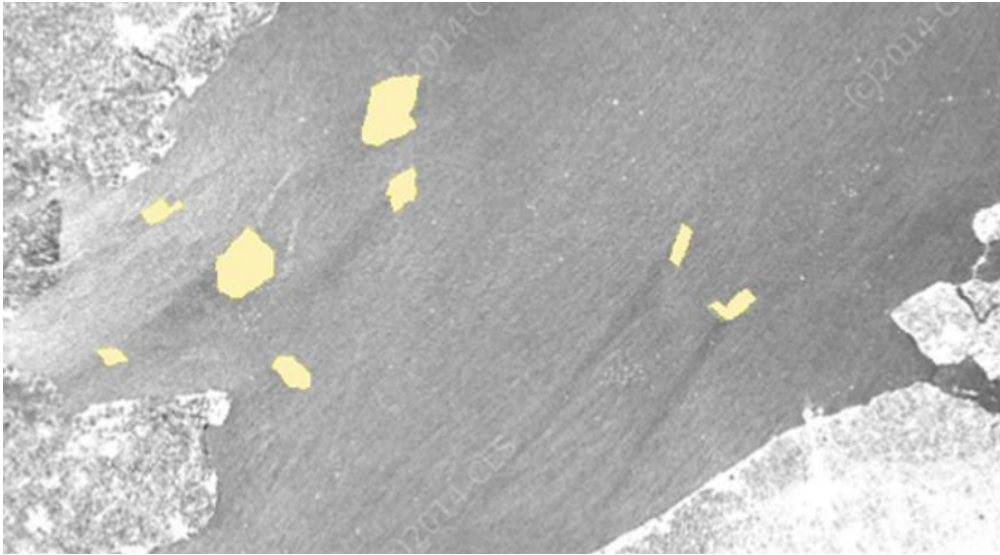


1<sup>st</sup> of July of 2013: Belwind & Thornton

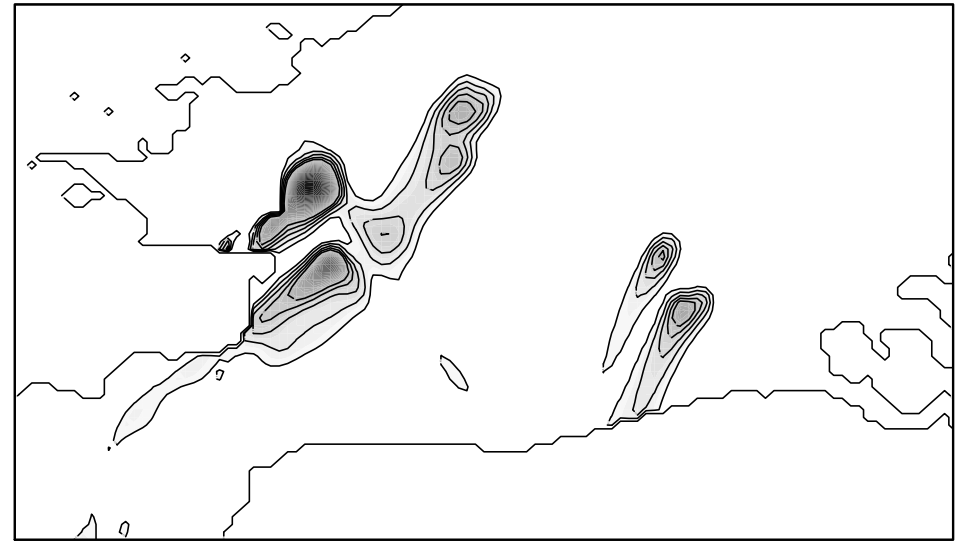
⇒ Comparable extension and divergence

# Mesoscale Model (Evaluation cont'd)

SAR Image (17:41 UTC)



WRF-EWP (18:00 UTC)



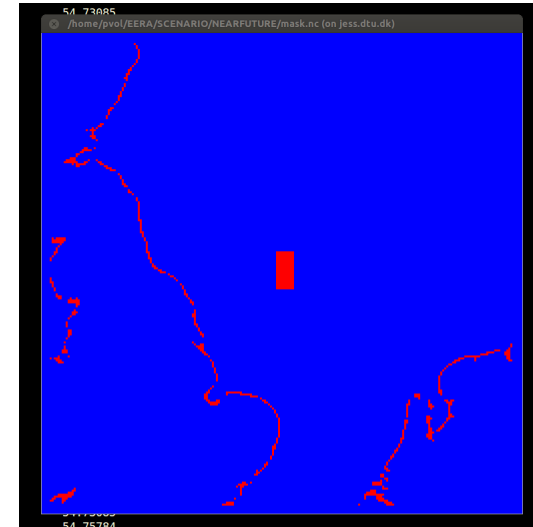
30<sup>th</sup> of April 2013: UK wind farms and Belwind & Thornton

⇒ Challenge in timing snap-shots



# Mesoscale Model in EERA-DTOC

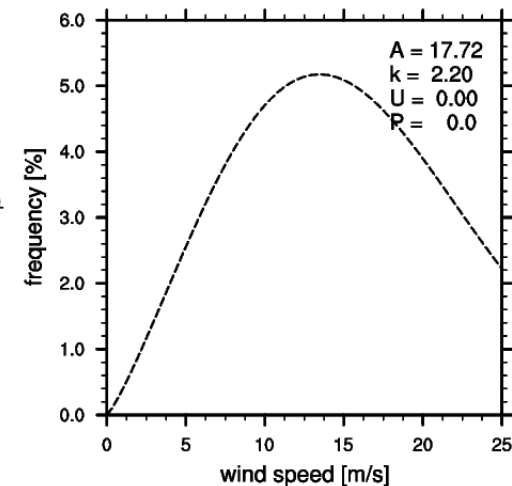
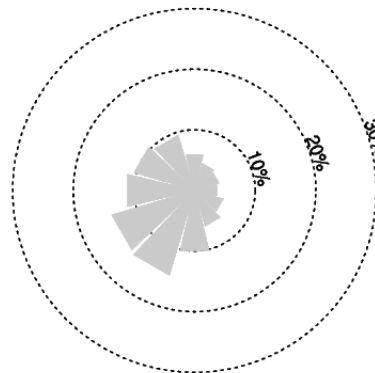
Three institutes (CENER, CIEMAT and DTU) can calculate a Wind Climate for a target area



**Without and with background wind farms**

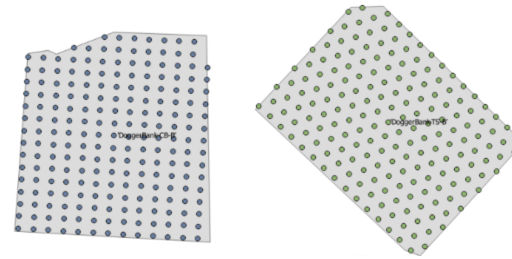
The Mesoscale model provides at the **target area** for a given **period**:

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



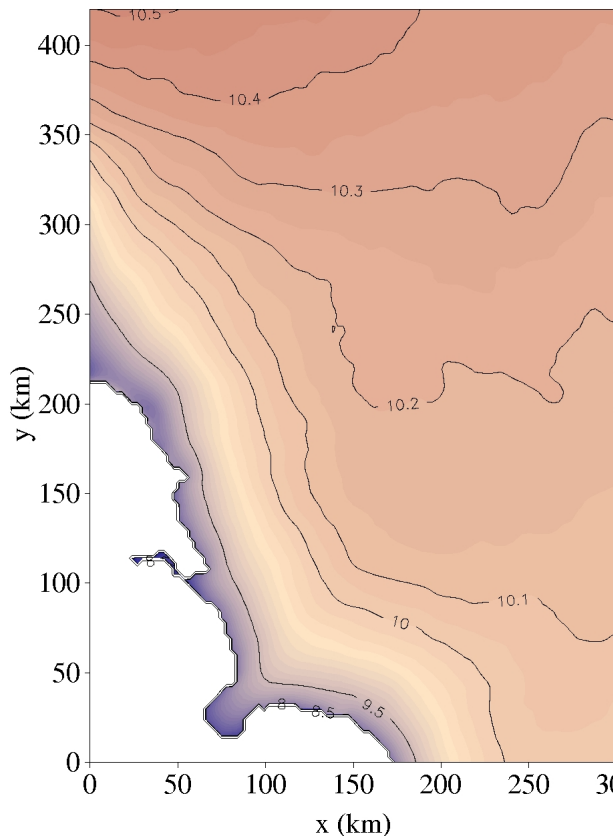
# Wind Climate with background Wind Farms

Example: 2 years simulation in the North-Sea with 2 background wind farms

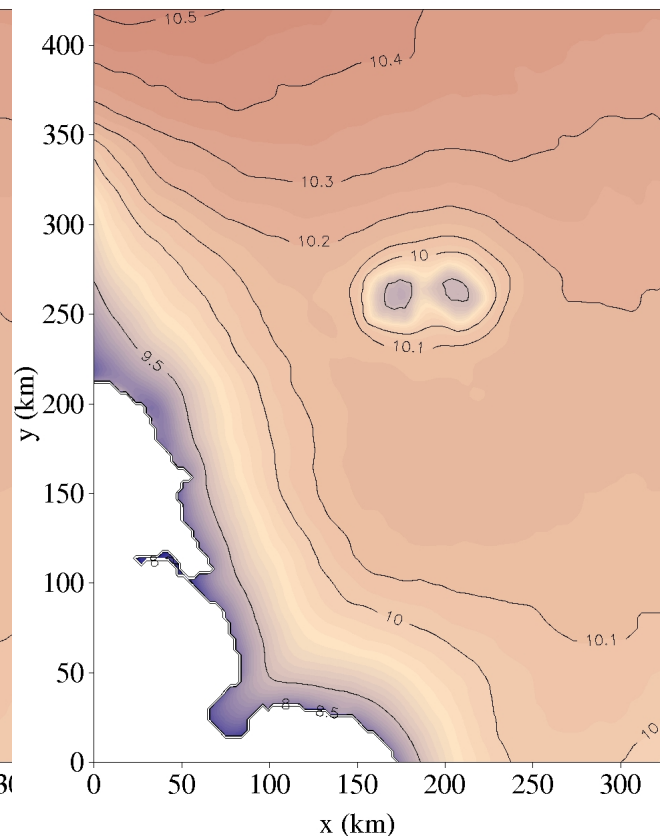


Time averaged wind speed at hub-height

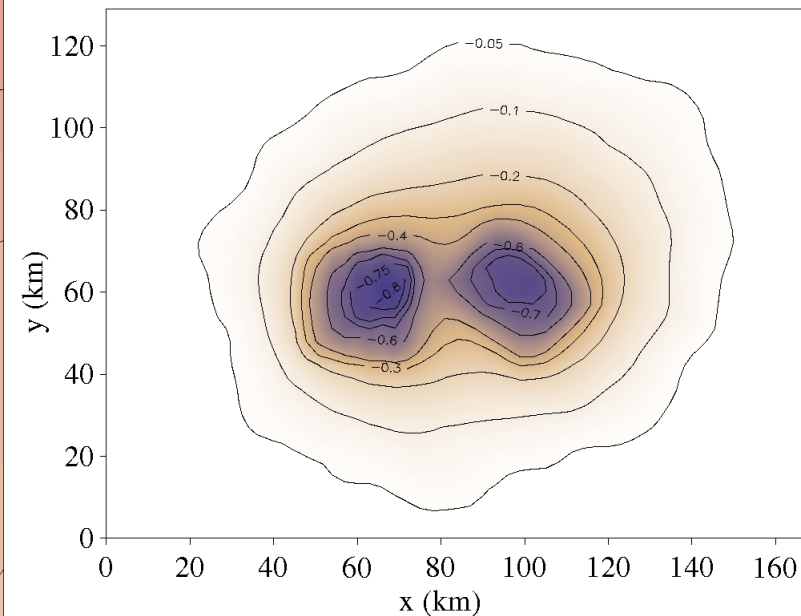
Reference



Wind Farm



Difference



# Conclusions

## Mesoscale models:

- Accounts for the dynamics in the wind farm wake
- The wind farm parametrisations do not resolve the local flow around turbines
- How well are they able to estimate the long-term velocity reduction of neighbouring wind farms?

## Within the EERA-DTOC tool:

- Neighbouring wind farms can 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

Support by

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