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

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

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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)

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

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:

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)
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\textsuperscript{st} of July of 2013: Belwind & Thornton

⇒ Comparable extension and divergence
30\textsuperscript{th} 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

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