FORECASTING OFFSHORE WIND POWER IN PORTUGAL

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Outline

- Portugal Offshore Wind Power
- Offshore Forecasting
- Objective
- Case Study
- Methodology
- Results
- Conclusions
- Future Developments
Portugal Offshore Wind Power

Current Situation

- Large continental platform (~25 to 200m depth)
- Low slopes (~3%)
- Potential 3.5 GW up to 40m depth*
- 500 MW already being planned by TSO up to 2014.

* Source: Ana Estanqueiro, Director of Wind and Oceans Energy Unit, INETI.
Offshore Forecasting: The Problem

(vs Onshore)

**Higher Wind Power**
- Larger turbines (5 MW) to compensate higher investment

**Higher Energy Availability**
- Lower surface roughness
- Higher turbine hub heights

**However!**
- Lack of spatial smoothing (statistical compensation) increases fluctuations magnitude
- Dominant physical processes are different.
Extrapolation based on Monin-Obukhov similarity theory is not adequate above 50 m over sea.

Sea surface roughness has minor impact.

Thermal effects (air-sea temperature gradients and thermal winds such as sea breeze) are being recognized as non negligible.

(Lange, 2002, Sempreviva et al., 2007)
Objective

- **Upwelling** is a phenomena where cold deep waters rise to the surface and decrease Sea Surface Temperature (SST)
- It’s frequent and intense in Portugal, from April to September, stronger in August.

*What is the influence of this phenomena in offshore wind power forecasts?*
Case Study: August 2008

Synoptic Situation by GFS Reanalysis

Colour: 500 hPa geopotential (gpdm)

White contours: Pressure at surface (hPa)

Source: http://www.wetterzentrale.de
Case Study: Sea Surface Temperature

- **ODYSSEA** (Ocean Data Analysis System)
- L4 product (multi-sensor merged high-resolution)
- 0.02° (~2km)
- Daily images
- Since Oct 2007
- Online!
Methodology: WRF

Simulation Conditions

- WRF-ARW v3.011:
  - Microphysics: 3-class WRF
  - Radiation: RRTM
  - Land Surface Model: Noah
  - PBL: Yonsé Univ.
  - Cumulus: Kain-Fritsch

- Boundary: Analysis from GFS grib2 (0.5°)

WRF Terrain (9km)
Methodology: Twin Experiment

GFS (0.5° ~ 40 km)

ODYSSEA (0.02° ~ 2 km)

6 Aug 2008 12:00
Results: Mean Wind Speed

August 2008 Mean Wind Speed = \( \overline{V^H_{ODYSSEA} - V^H_{GFS}} \)

15-09-2009 EOW Stockholm

11/22
Wind Speed @80m

\[ \bar{V}_{ODYSSEA} - \bar{V}_{GFS} \approx -0.6 \text{ m/s} \]
\[ \bar{V}_{GFS} \approx 6 \text{ m/s} \]
\[ \sigma_{GFS} \approx 3 \text{ m/s} \]
Converting to Power

What is the importance of this difference for forecasting on 500 MW offshore?

- 10% diff in wind speed
  (0.6 in 6 m/s)

- 20% diff in wind power*
  (100 in 500 MW)

*Lange, 2005
Mean Differences

August 2008 @ 80m

$$\text{Diff} = x_{\text{ODYSSEA}} - x_{\text{GFS}}$$
Stability: Viana Castelo

11 Aug 2008

9 km

0 h

6 h

12 h

18 h

24 h

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Stability: Aveiro

11 Aug 2008

0 h

6 h

12 h

18 h

24 h

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Stability: Figueira da Foz

11 Aug 2008

0 h

6 h

12 h

18 h

24 h

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GFS

ODYSSEA
Stability: Torres Vedras

11 Aug 2008

Height (m)
Potential Temp. (°C)

9 km

Sea

Land

0 h

6 h

12 h

18 h

24 h

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Conclusions

- Offshore wind forecasting presents different challenges than onshore.

- Twin experiment indicates:
  - positive feedback in winds, e.g., decrease in SST causes a decrease nearshore northerly wind speed.
  - Increase stability on and offshore, up to 200m.
  - Seems to decrease transversal sea breeze.

- Offshore wind resource assessment and forecasts should take into account sea interaction, otherwise optimistic.
Future Developments

- 2-way coupling with ocean to identify positive & negative feedbacks in air-sea interaction.
- Validation with buoys and satellites.
- Best resolution compromise.
References


Thank you!
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http://meteo.ist.utl.pt/new
http://rosatrancoso.googlepages.com