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FORECASTING OFFSHORE WIND POWER IN PORTUGAL

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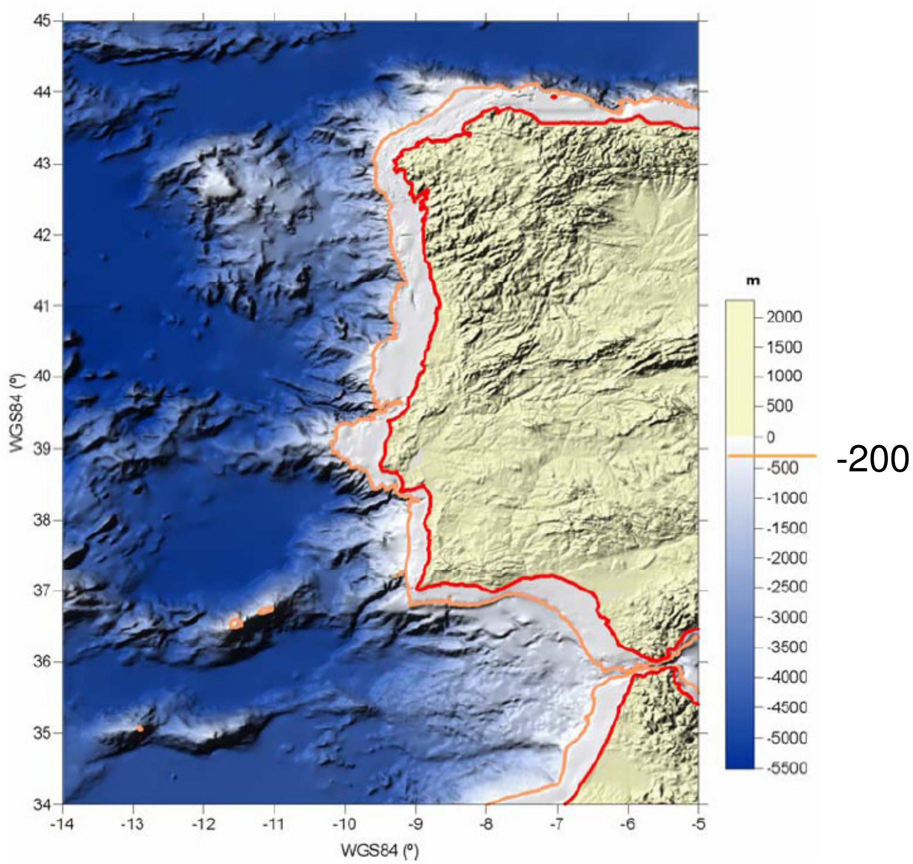
Outline

- 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.

Offshore Forecasting: State of the art

- 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?

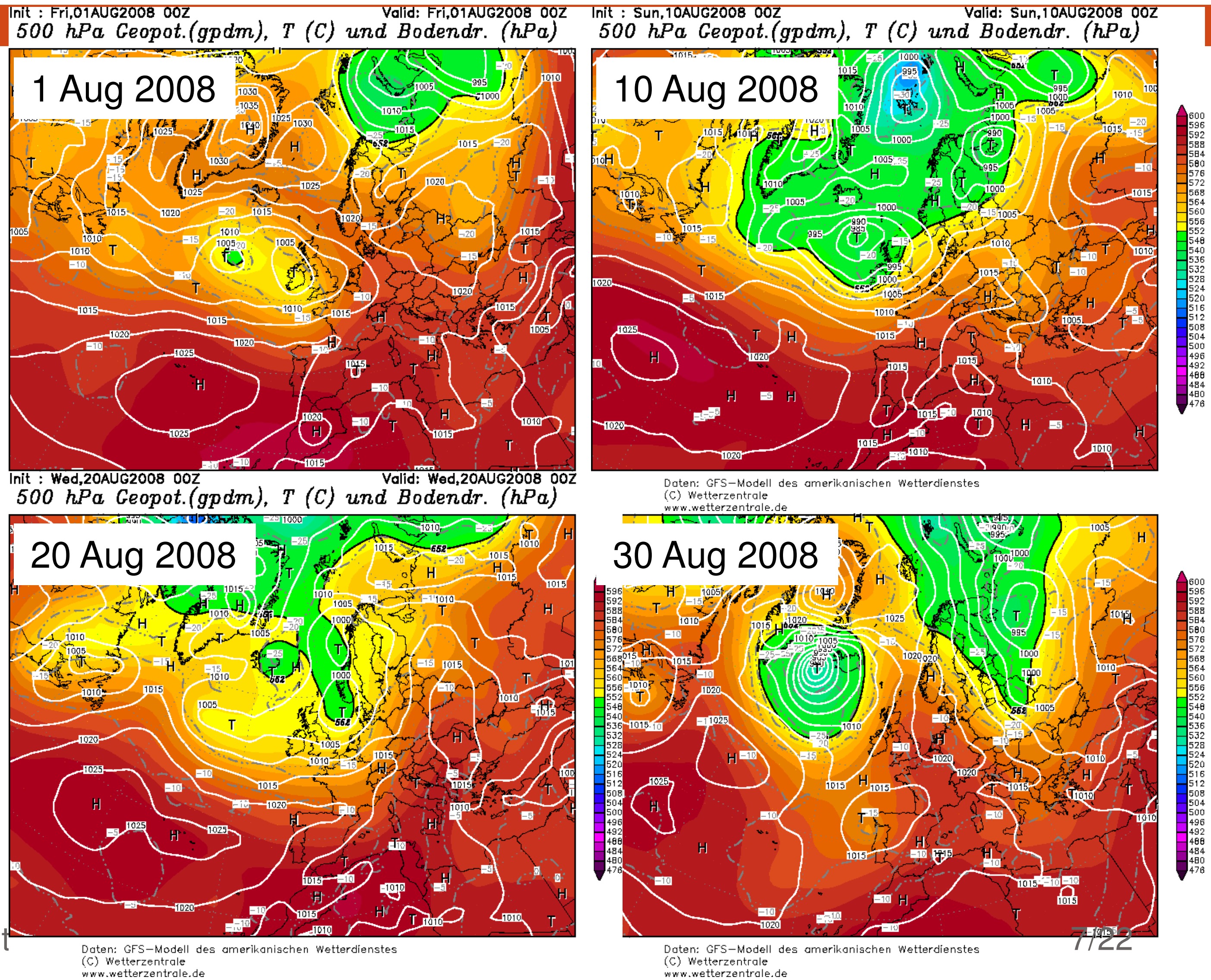
Case Study: August 2008

Synoptic Situation by GFS Reanalysis

Colour:
500 hPa geopotential (gpdm)

White contours:
Pressure at surface (hPa)

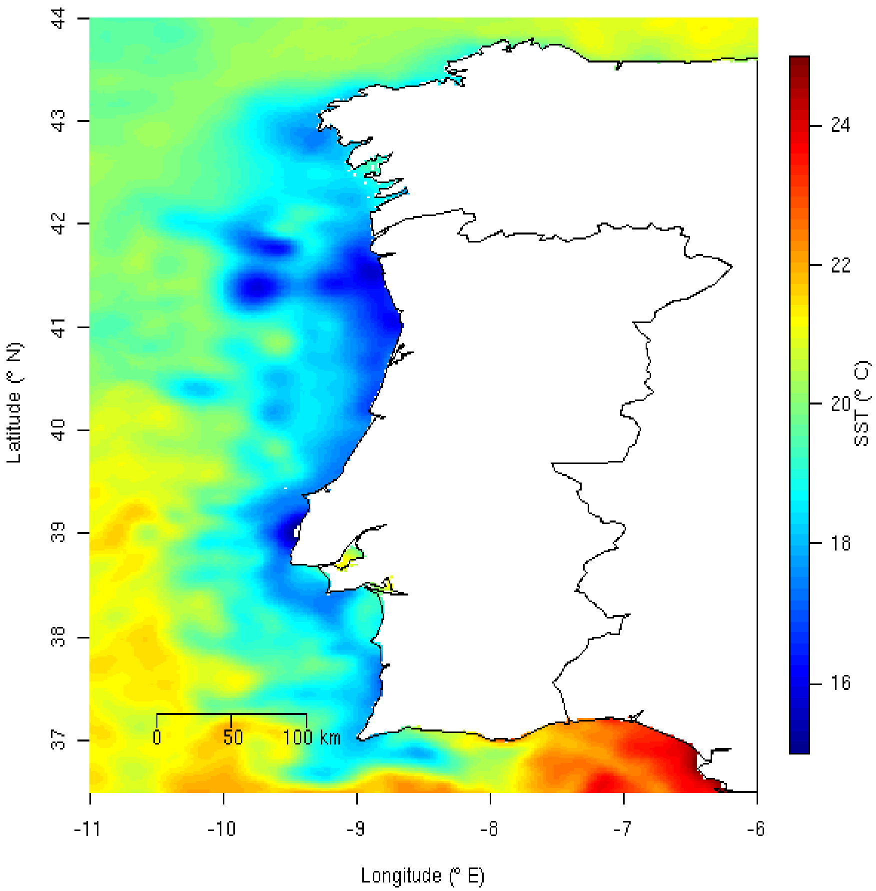
Source:
http://www.wetterzentrale.de



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!**

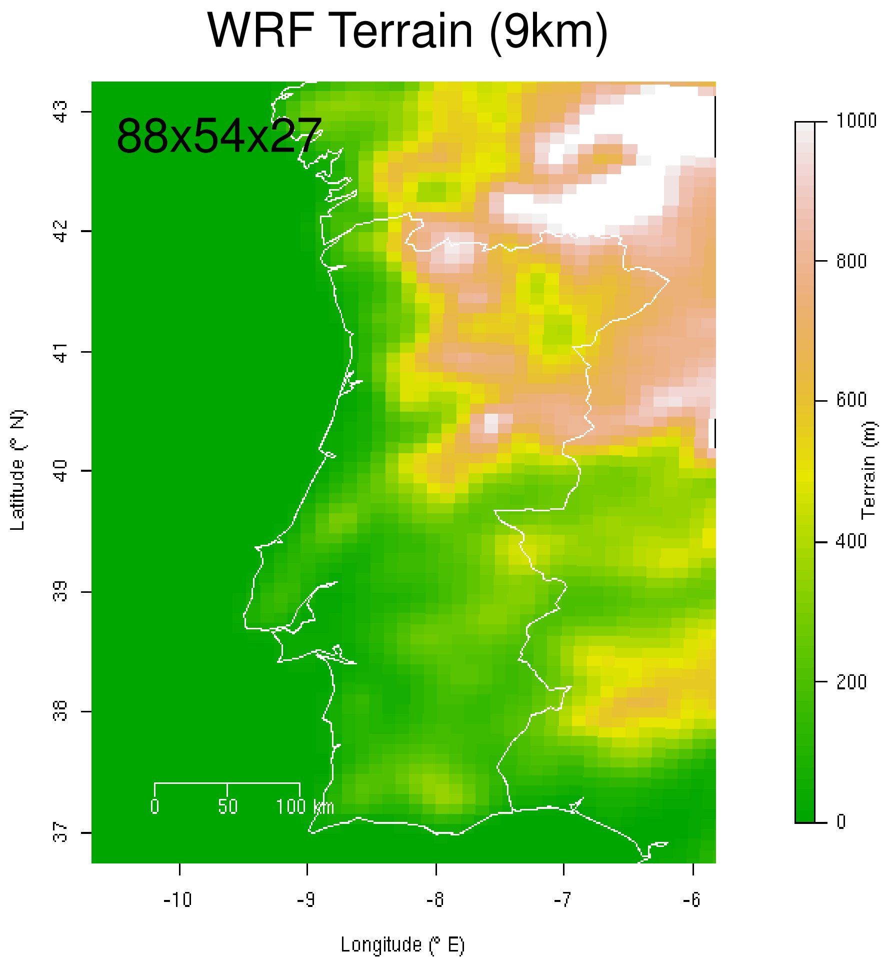
26 Aug 2008 12:00



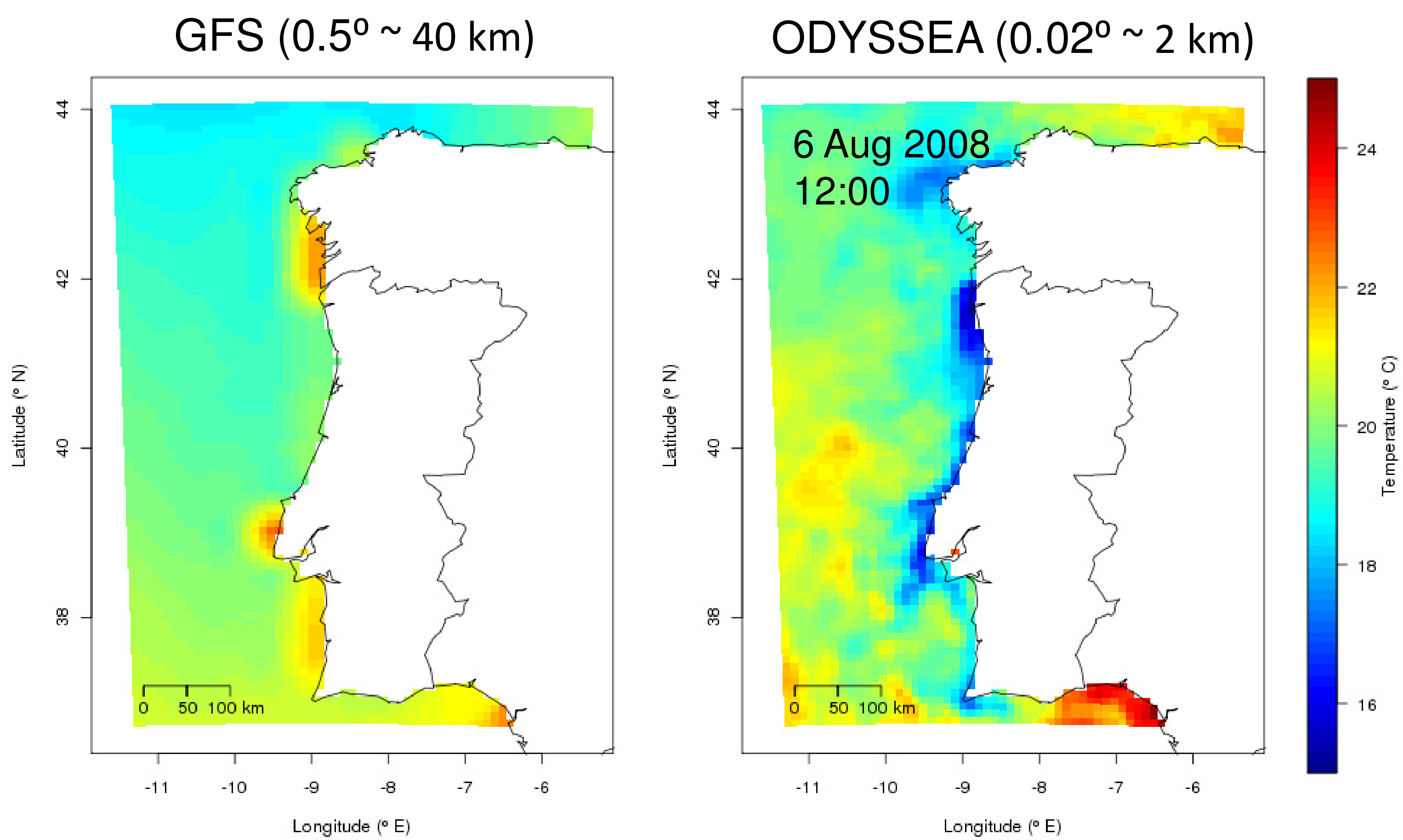
Methodology: WRF

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^o)

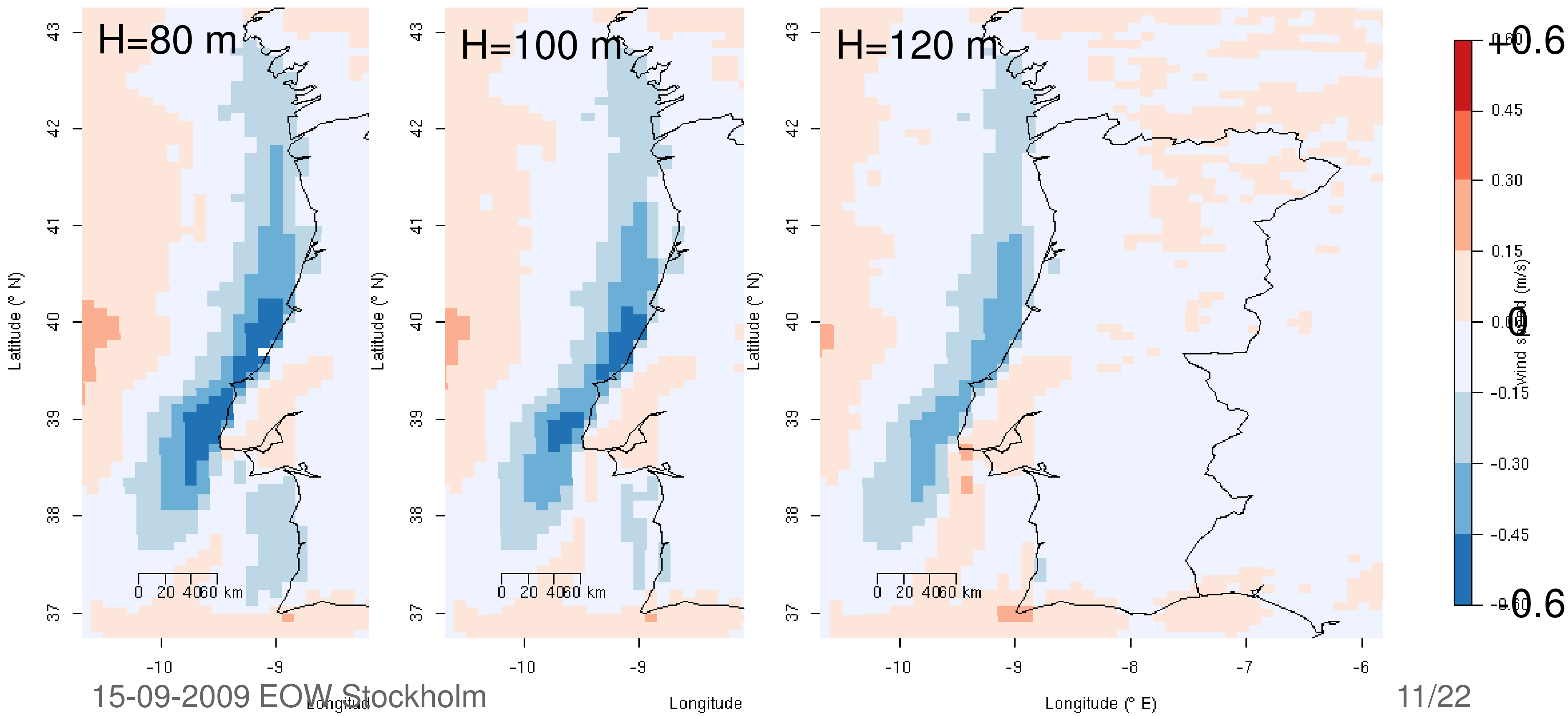


Methodology: Twin Experiment

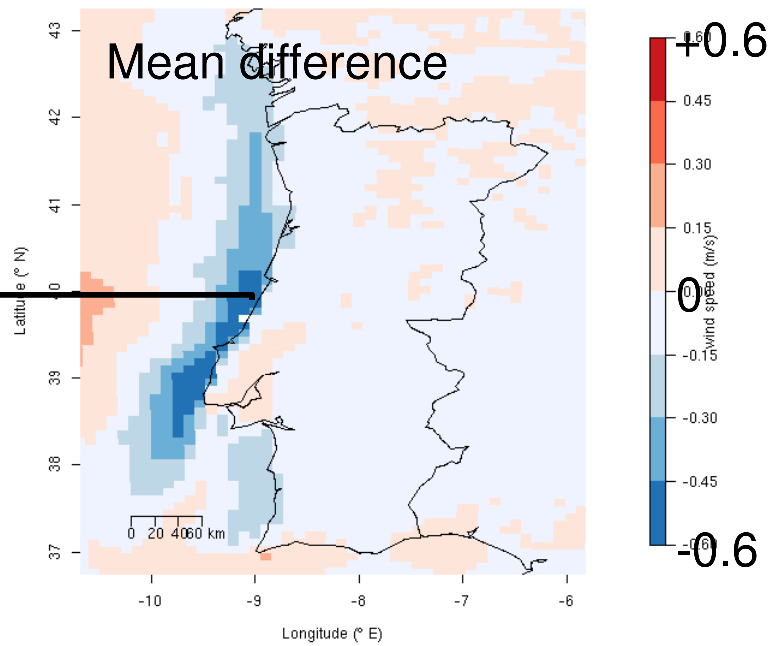


Results: Mean Wind Speed

August 2008 Mean Wind Speed = $\overline{V^{H}_{ODYSSEA} - V^{H}_{GFS}}$



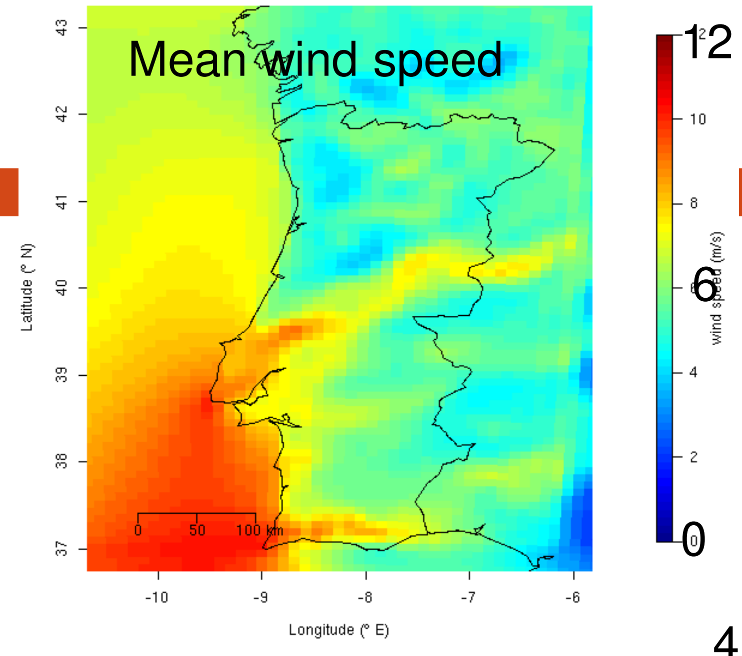
Wind Speed @80m

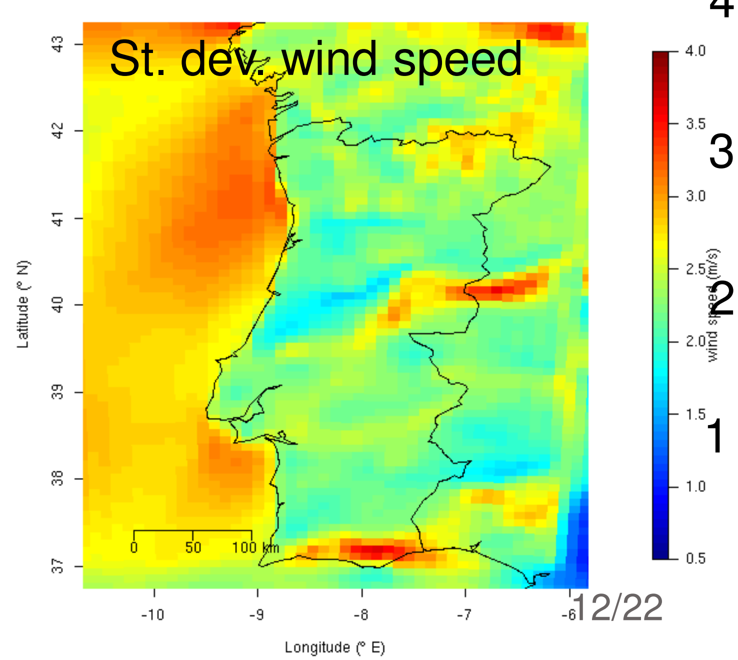


$$\overline{V_{ODYSSEA} - V_{GFS}} \approx -0.6\ m/s$$

$$\overline{V_{GFS}} \approx 6\ m/s$$

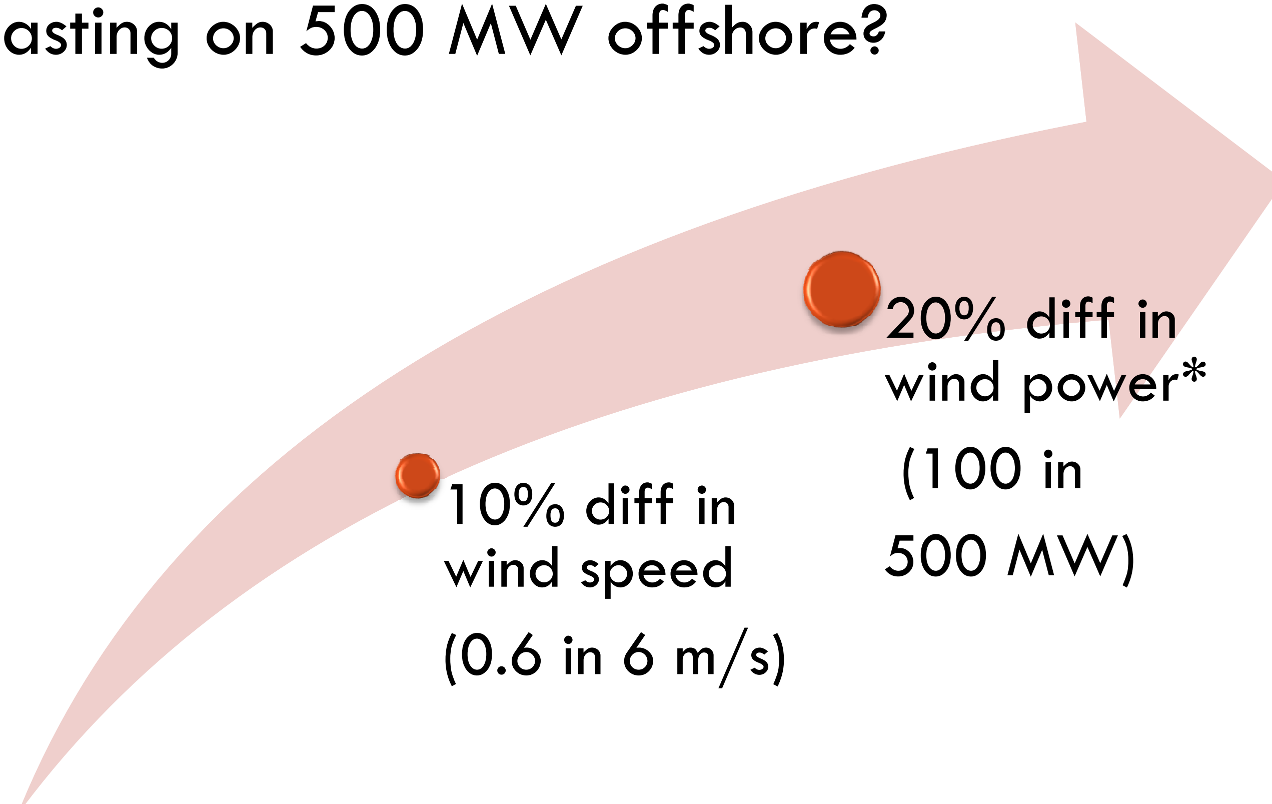
$$\sigma_{GFS} \approx 3\ m/s$$





Converting to Power

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

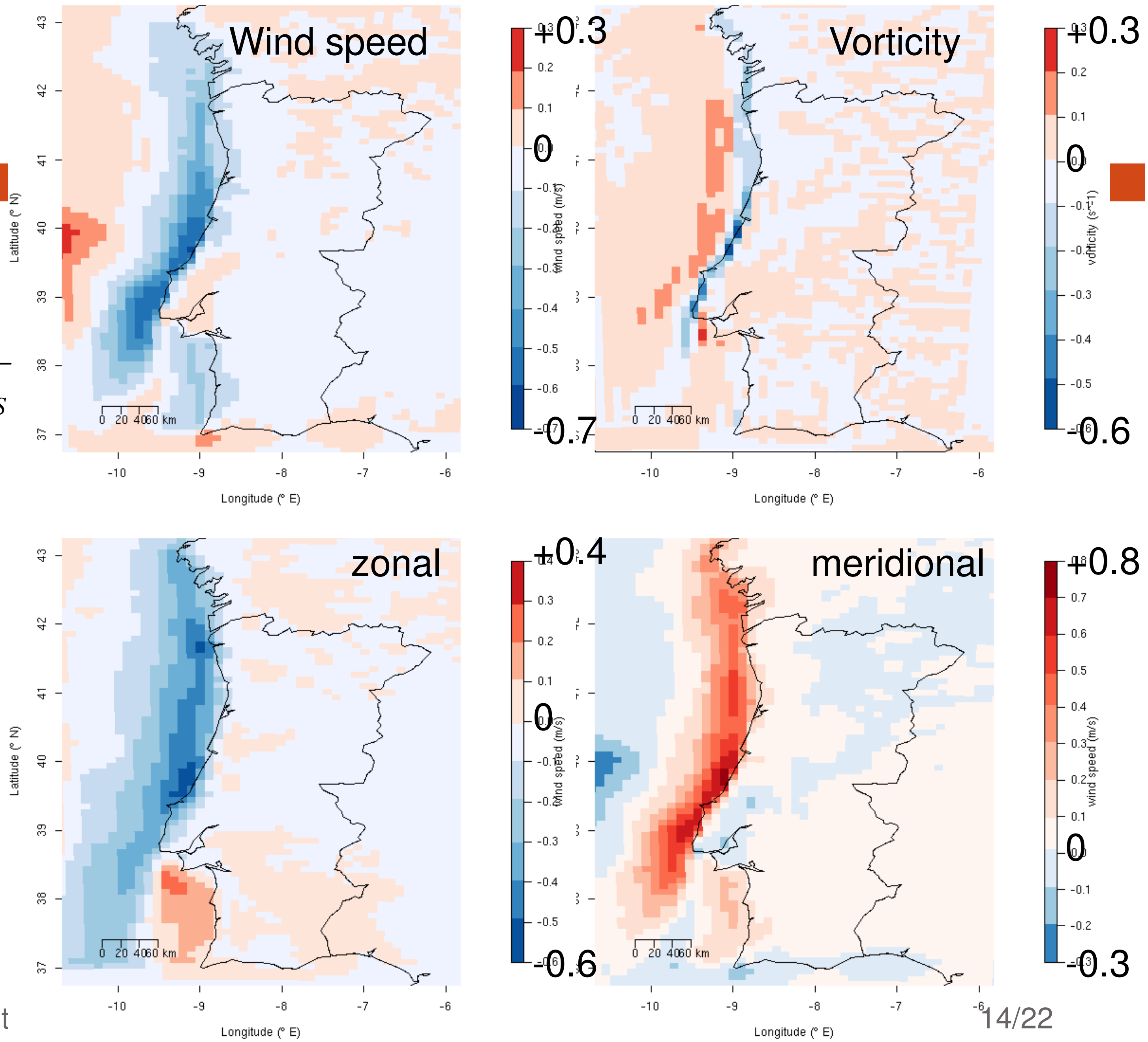


*Lange, 2005

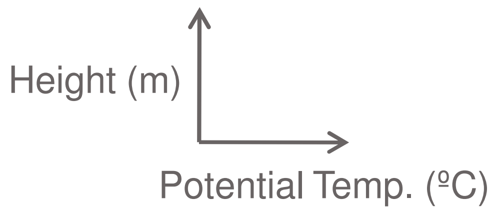
Mean Differences

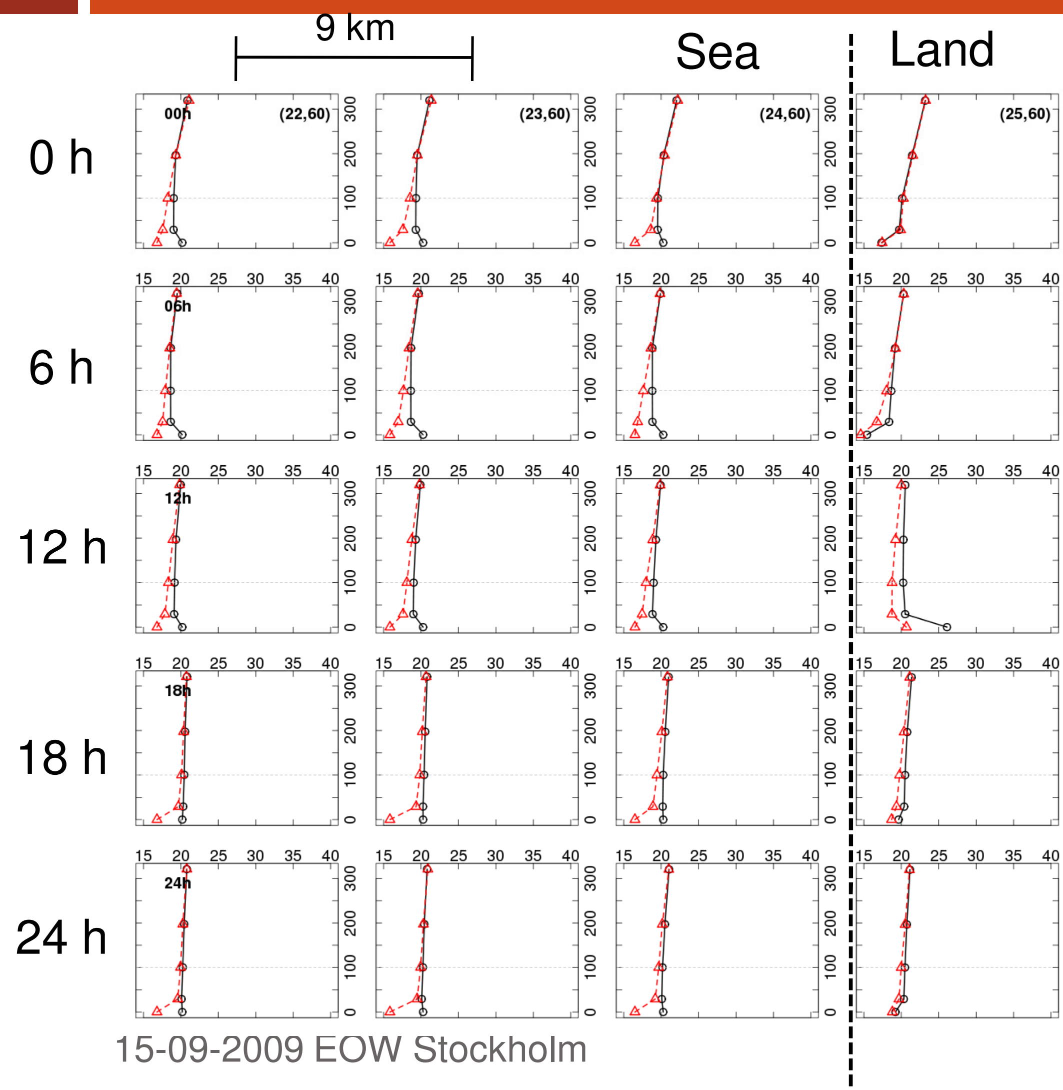
August 2008 @ 80m

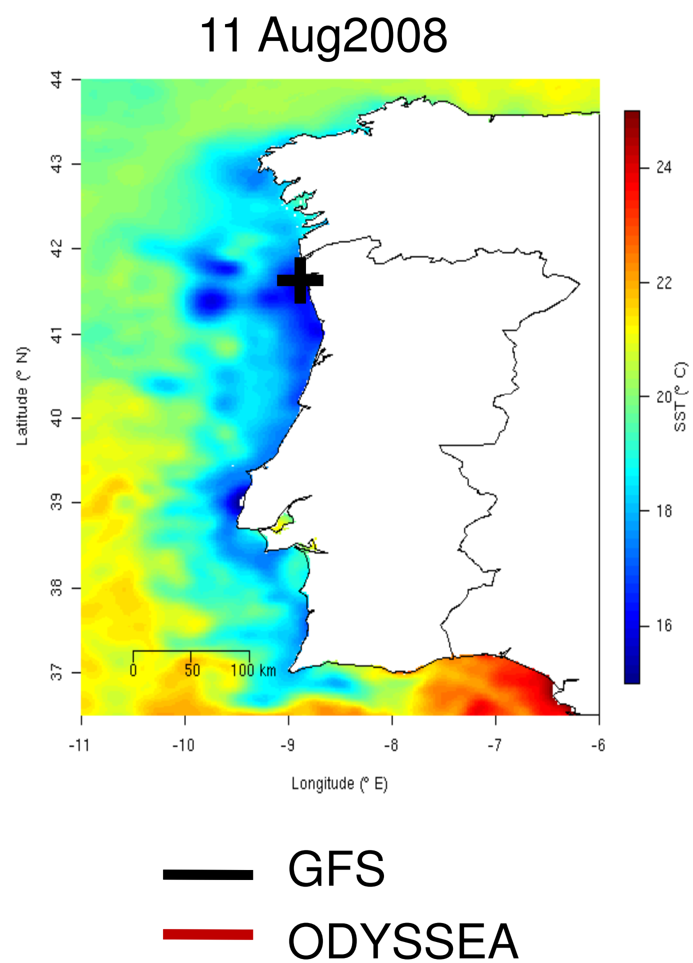
$$Diff = \overline{x_{ODYSSEA} - x_{GFS}}$$



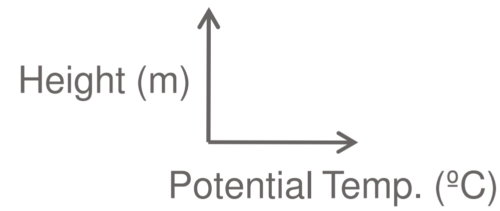
Stability: Viana Castelo

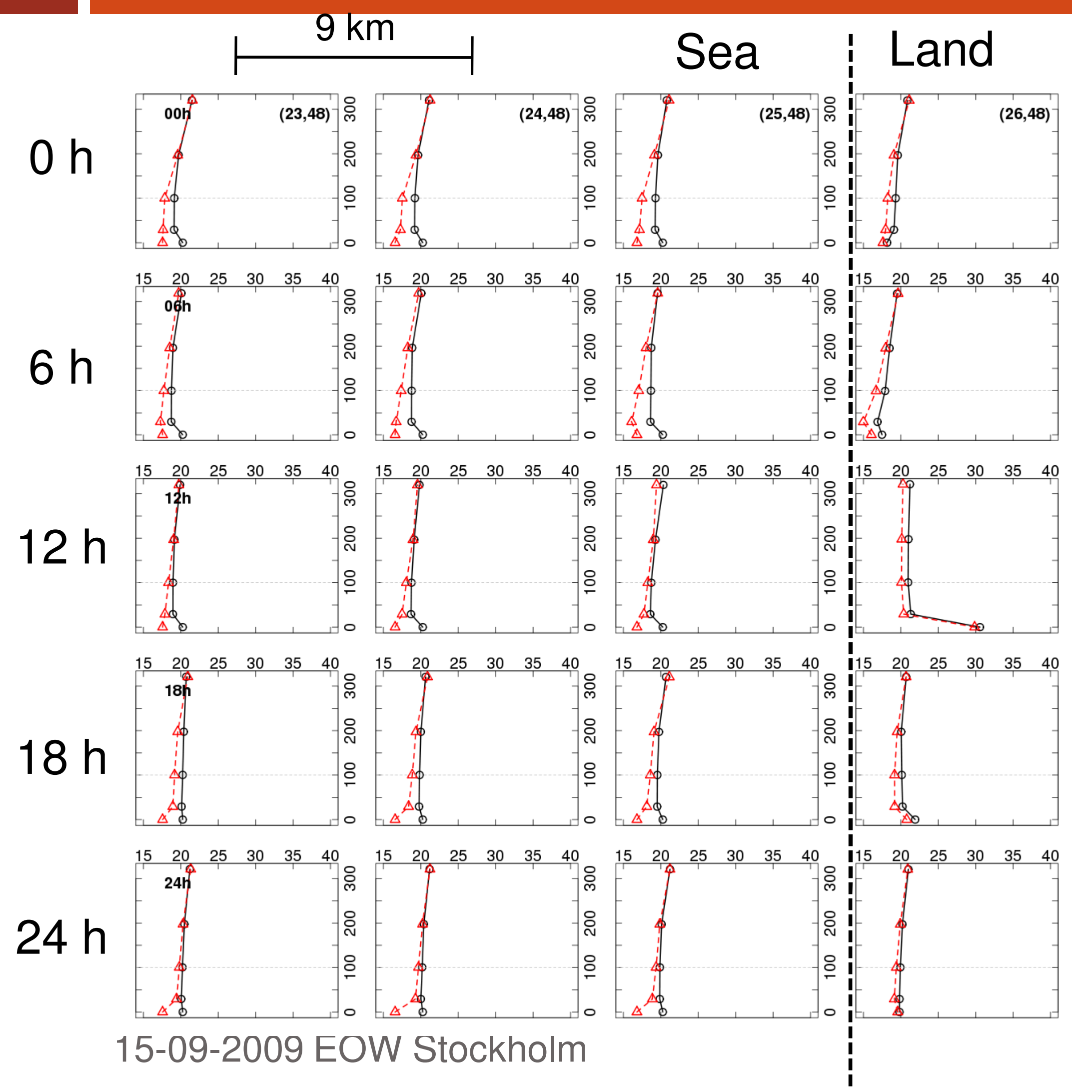


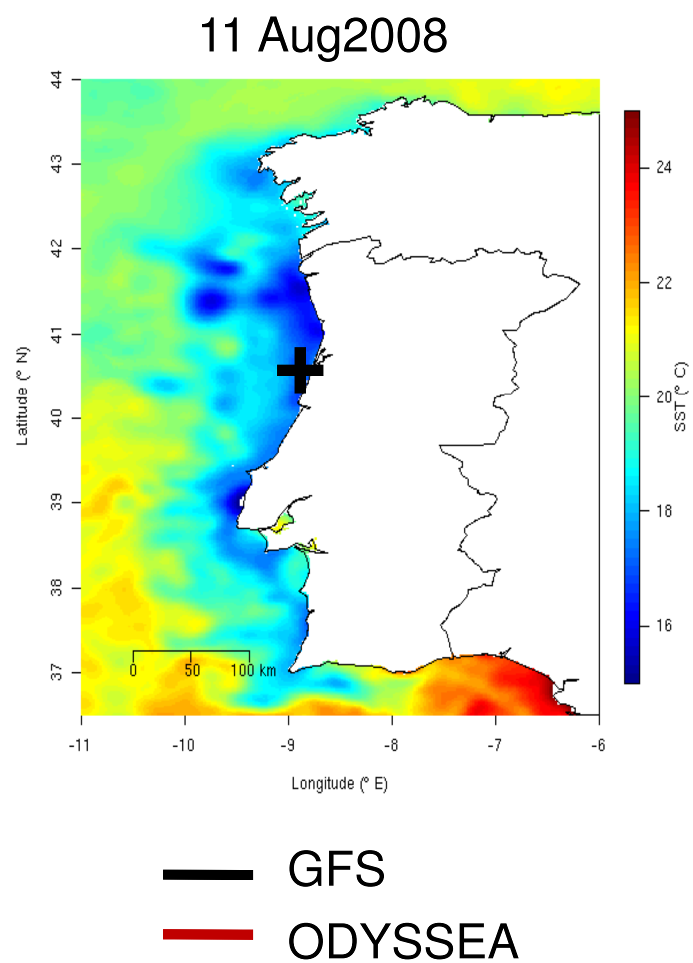




Stability: Aveiro

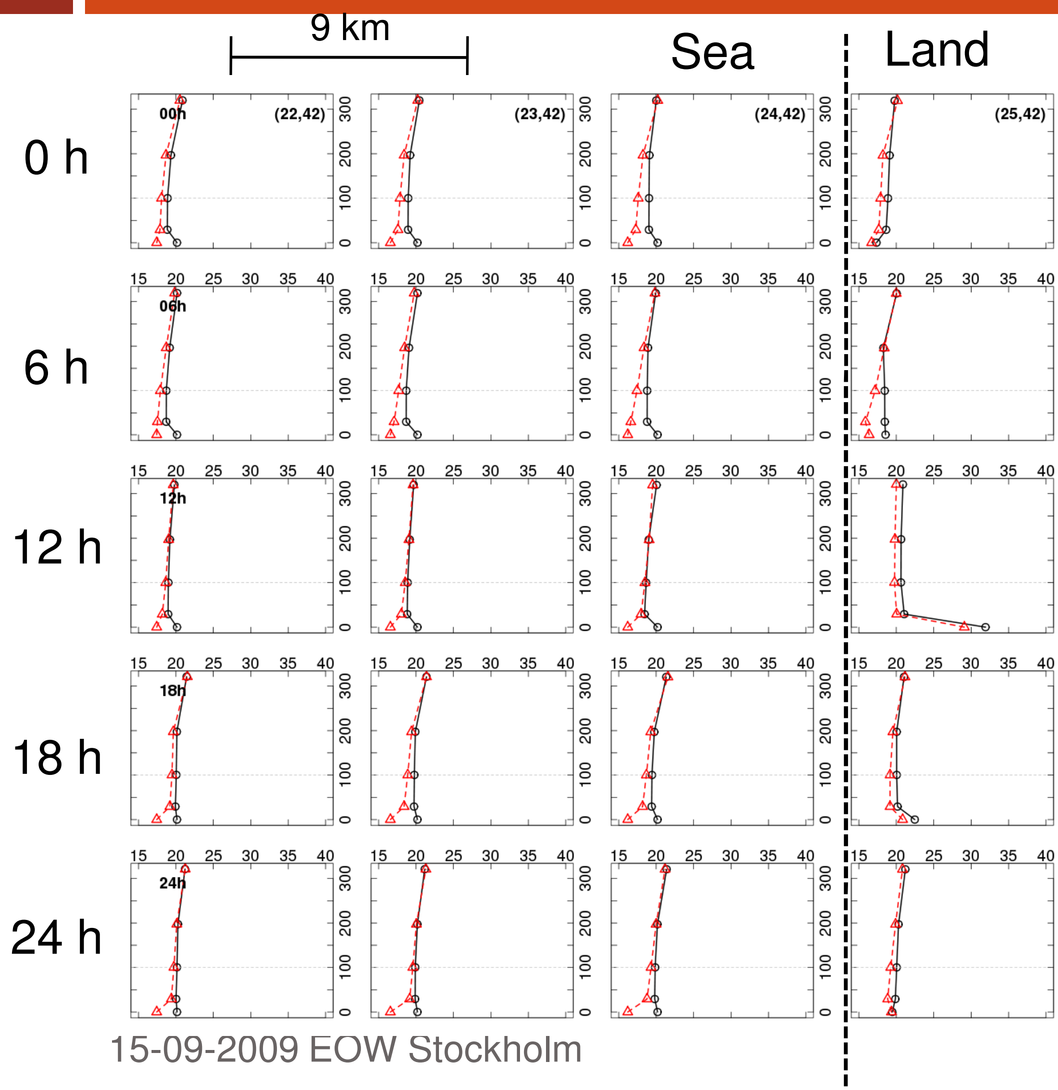


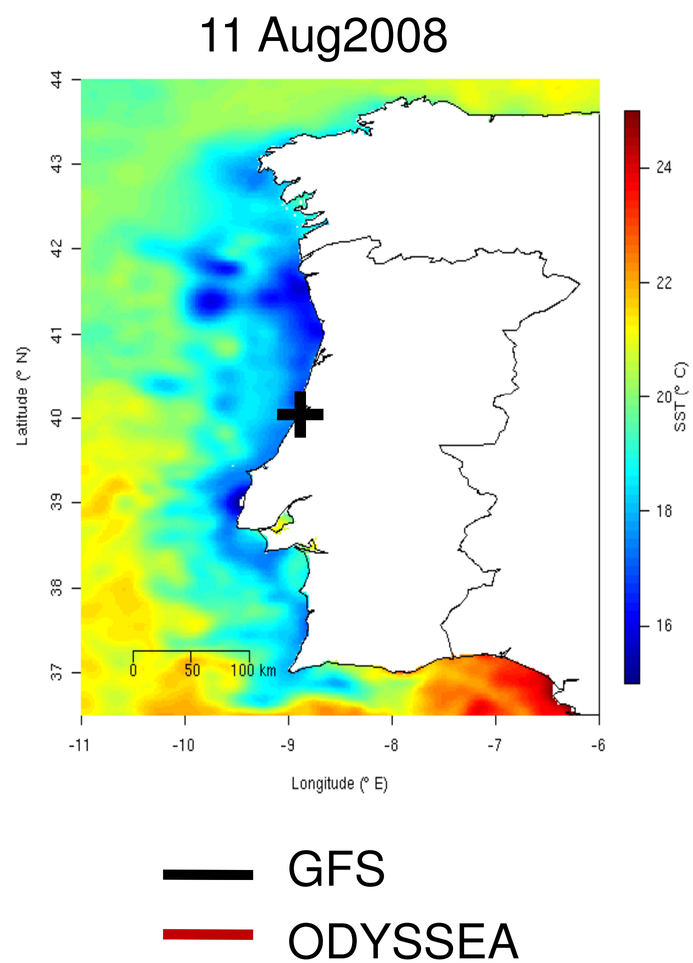




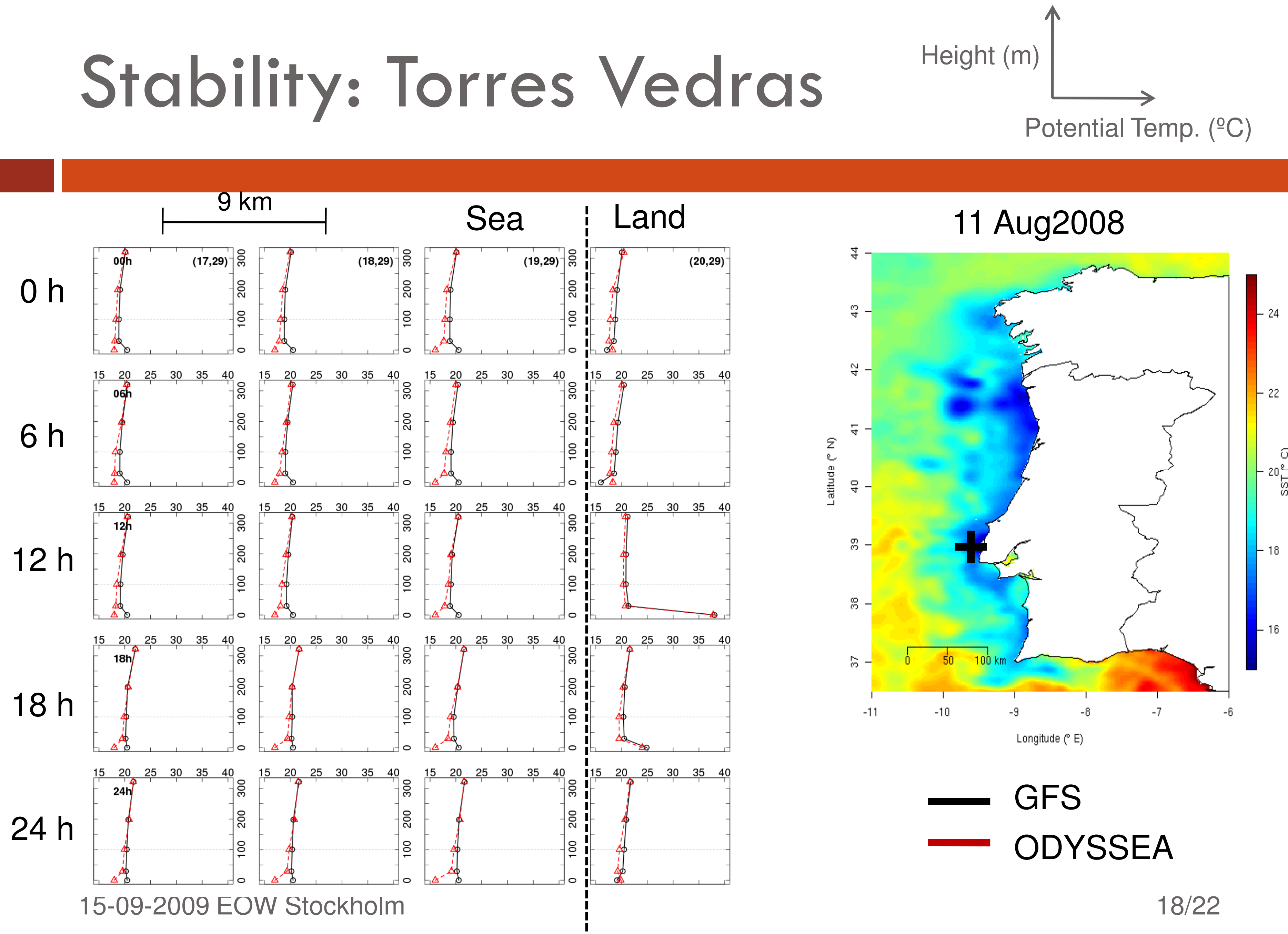
Stability: Figueira da Foz

Height (m)
Potential Temp. (ºC)





Stability: Torres Vedras



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

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Thank you!

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