Effect of Offshore Wind farm Design on the Oceanic Motion

POLYTEC

SEEING THINGS DIFFERENTLY

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OBECTIVES

Study the effect of wind farm design on the ocean

Part I: Method

- Use a wake model to calculate the wind velocity
- Perform ocean model simulations with anomaly wind forcing

Part II: Case study

- Havsul area
- 2 different wind farm designs

WHY STUDY THE OCEAN RESPONSE?

Large scale: **Transport of nutrients (ecosystem)**

Modify regional ocean circulation (heat/salt transport)

Small scale: **Local ecosystem**

Fish farms (waste transport, lice spread)

SOME HISTORY

Brostrøm (2008):

The idea of wind farm induced upwelling/downwelling is introduced

Paskyabi and Fer (2013)

Wave effects included

This study:

sensitivity to wind farm design

WAKE MODEL (GONZÁLEZ-LONGATT ET AL, 2011)

Jensen model – linear wake expansion

Shaddow effects included to account for multiple turbines

Include a layer downwind the wind farm where free slip wind speed is retained

WIND FARM DESIGN

Diameter: 120 m

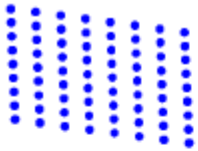
Hub heigth: 90 m

Number of turbines: 70

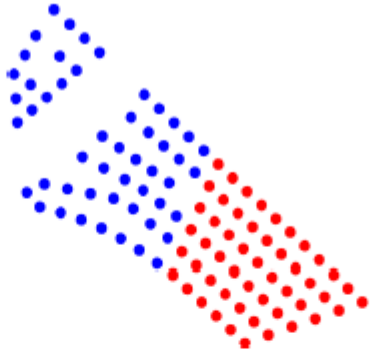
Wake expansion coefficient: 0.05

Thrust coefficient: 0.4

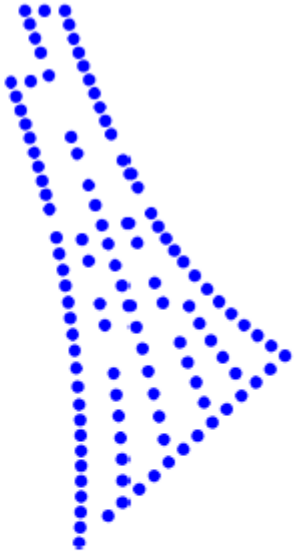
POTENTIAL WIND FARM DESIGNS (JENSEN, 2013)



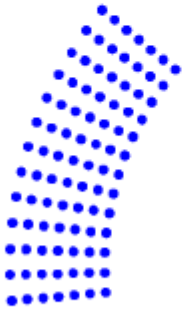
Nysted (NHP)
72x2.3 MW
Hub height: 68 m
Rotor diameter: 82 m



Walney 1&2 (WOW)
2x51x3.6 MW
Hub height: xx&yy m
Rotor diameter:
107&120 m



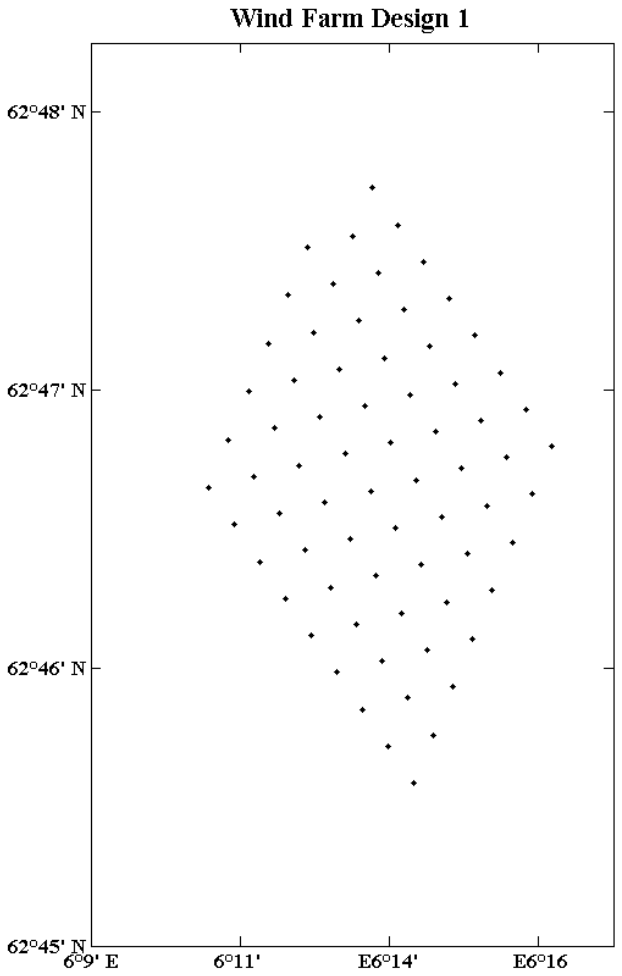
Anholt (ANH)
111x3.6 MW
Hub height: YY m
Rotor diameter: 120 m

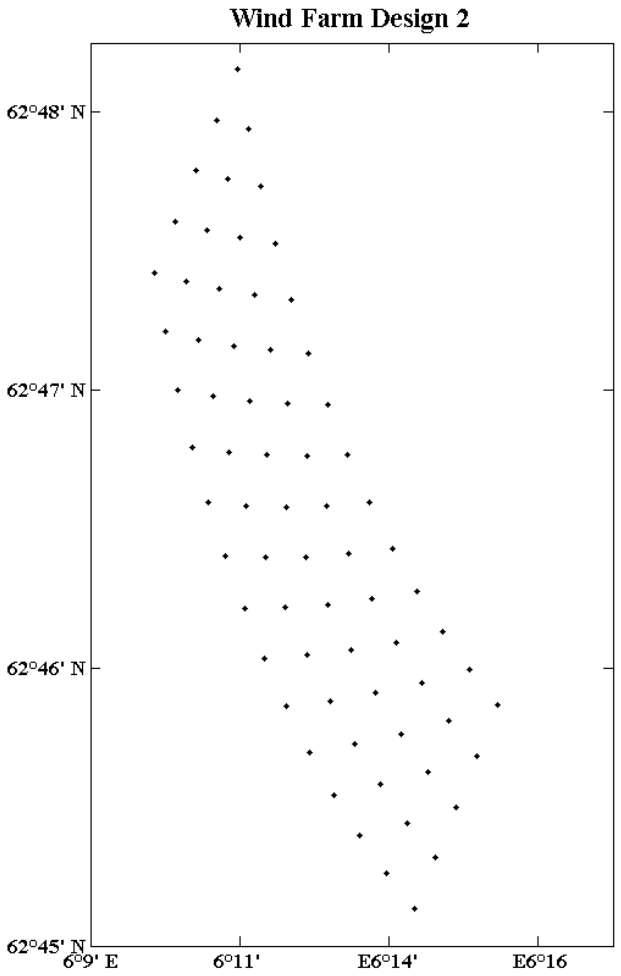


Horns Rev 2 (HR2)
91x2.3 MW
Hub height: 68 m
Rotor diameter: 93 m

DONG energy

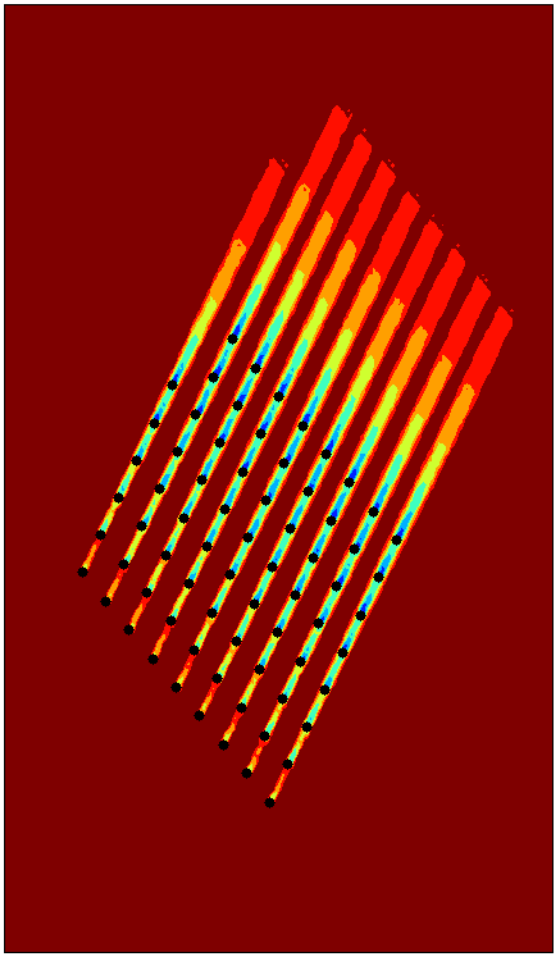
CHOSEN WIND FARM DESIGN



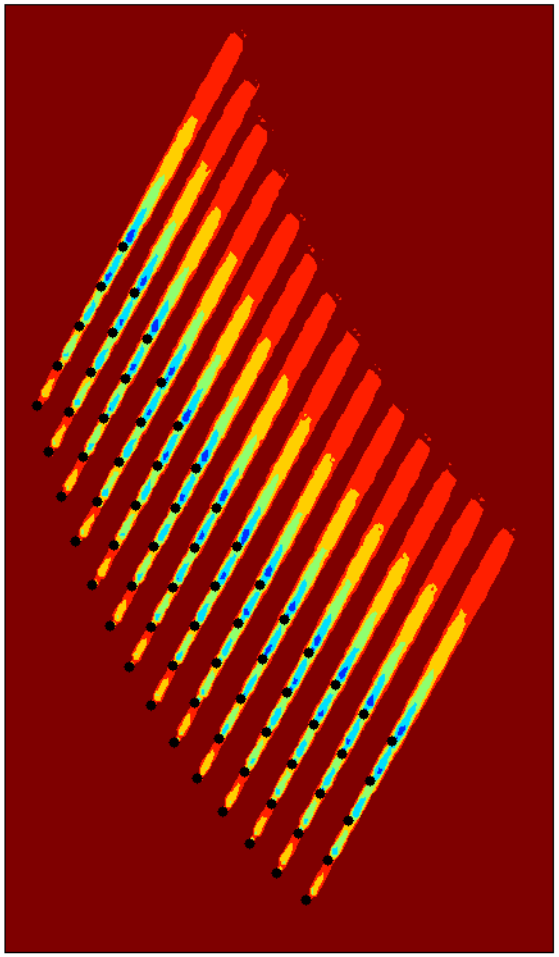


WAKES (NORMAL WIND)

Wind Farm Design 1



Wind Farm Design 2



OCEAN MODEL - ROMS

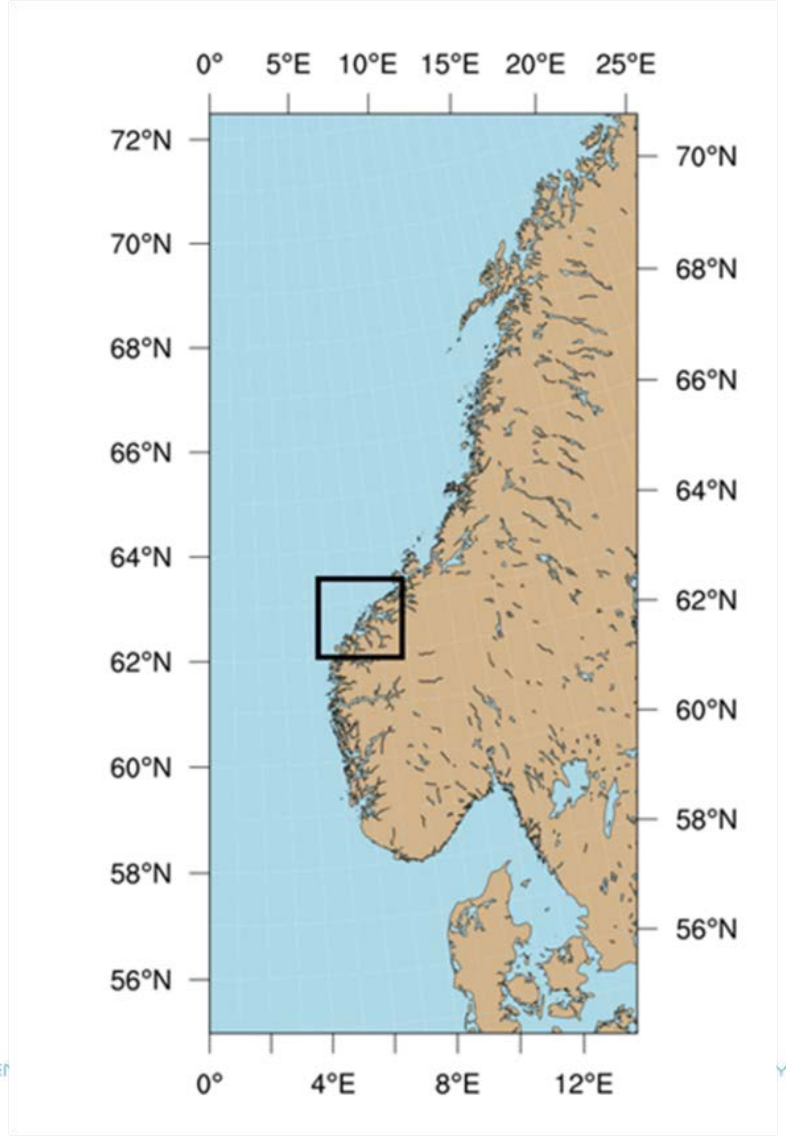
Terrain following (20 vertical sigma layers)

500 m grid resolution

Surface forcing: HIRLAM 12 km (met.no)

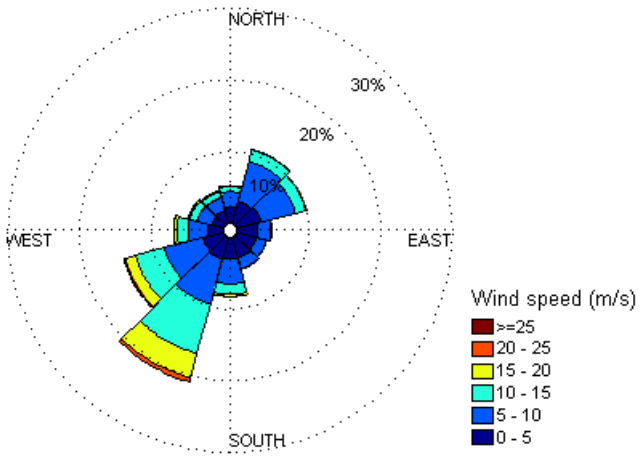
Boundary forcing: Norkyst-800 + TPXO tidal model

CASE STUDY – HAVSUL AREA

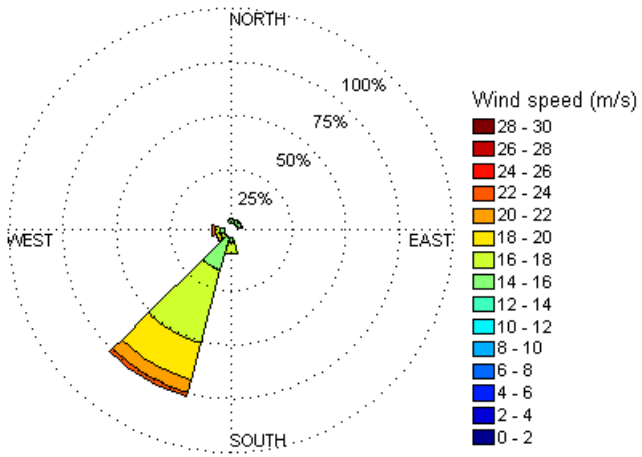


WIND FIELD - HAVSUL

Havsul: 1958-2011



Havsul: 11-13 March 2014



EXPERIMENTS

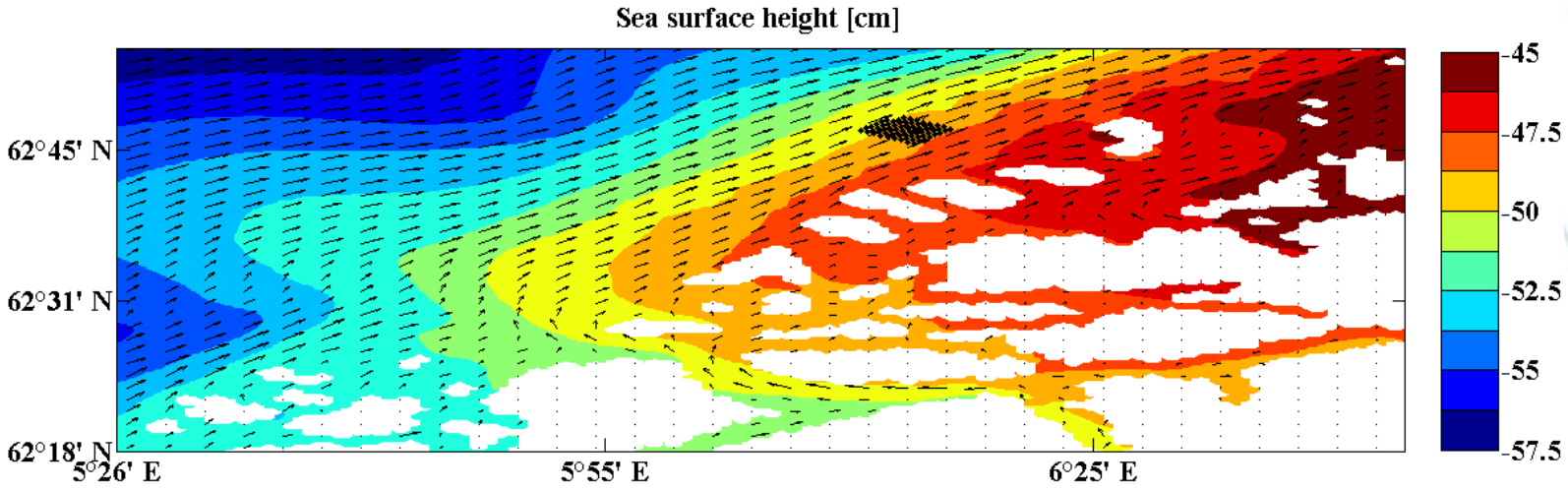
Simulation period: March 11, 2014 – March 13, 2014

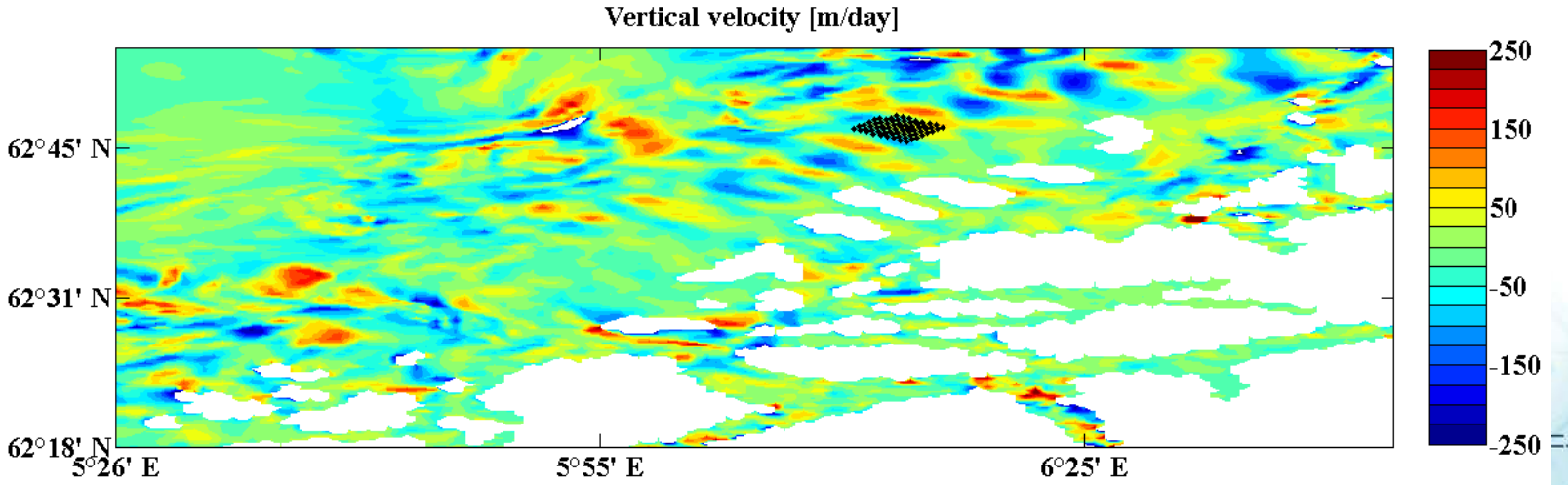
Control run: Unperturbed wind field

Model Run 1: Wake generated by Wind Farm Design 1

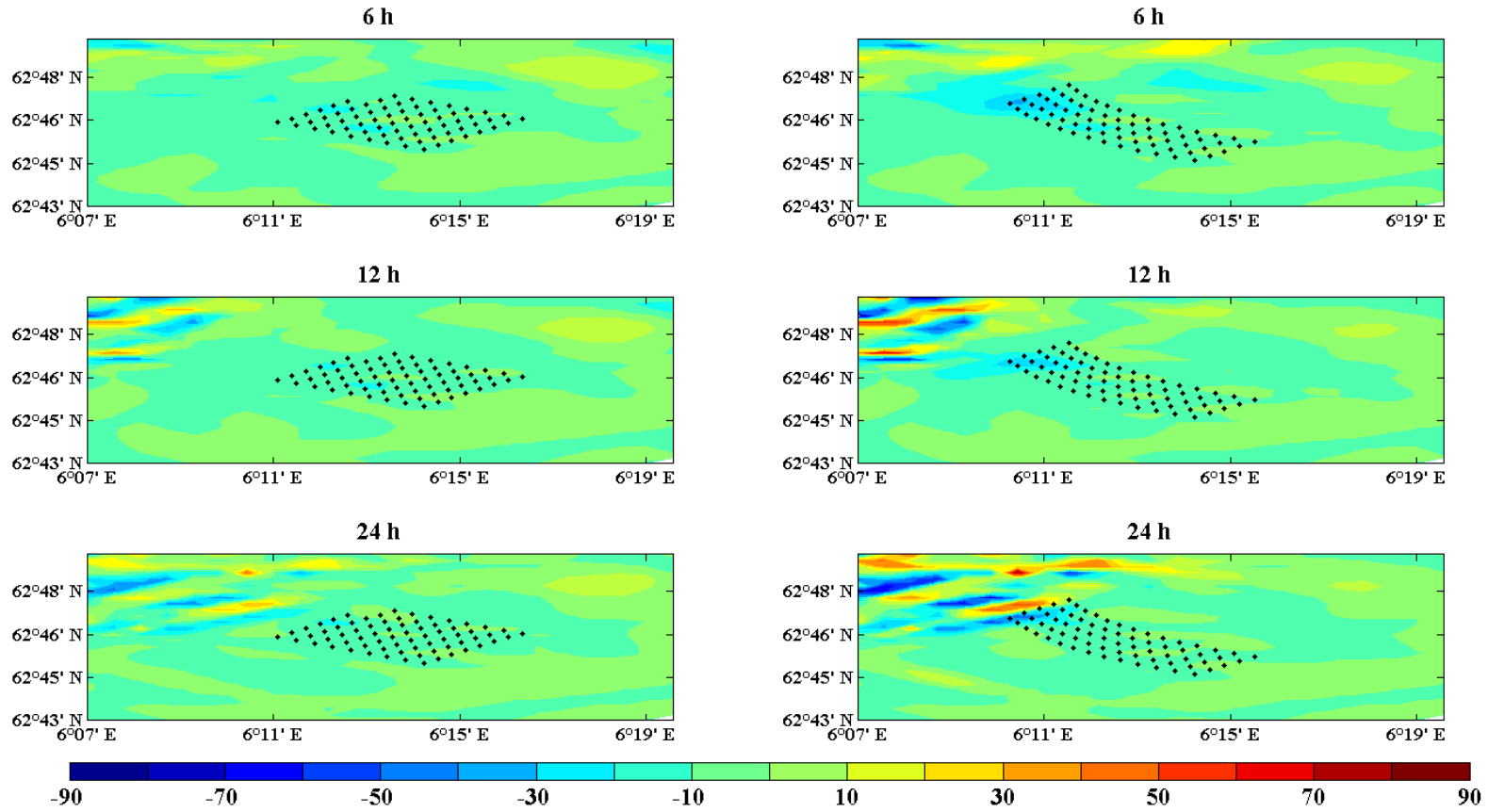
Model Run 2: Wake generated by Wind Farm Design 2

MEAN FIELDS – SSH & W

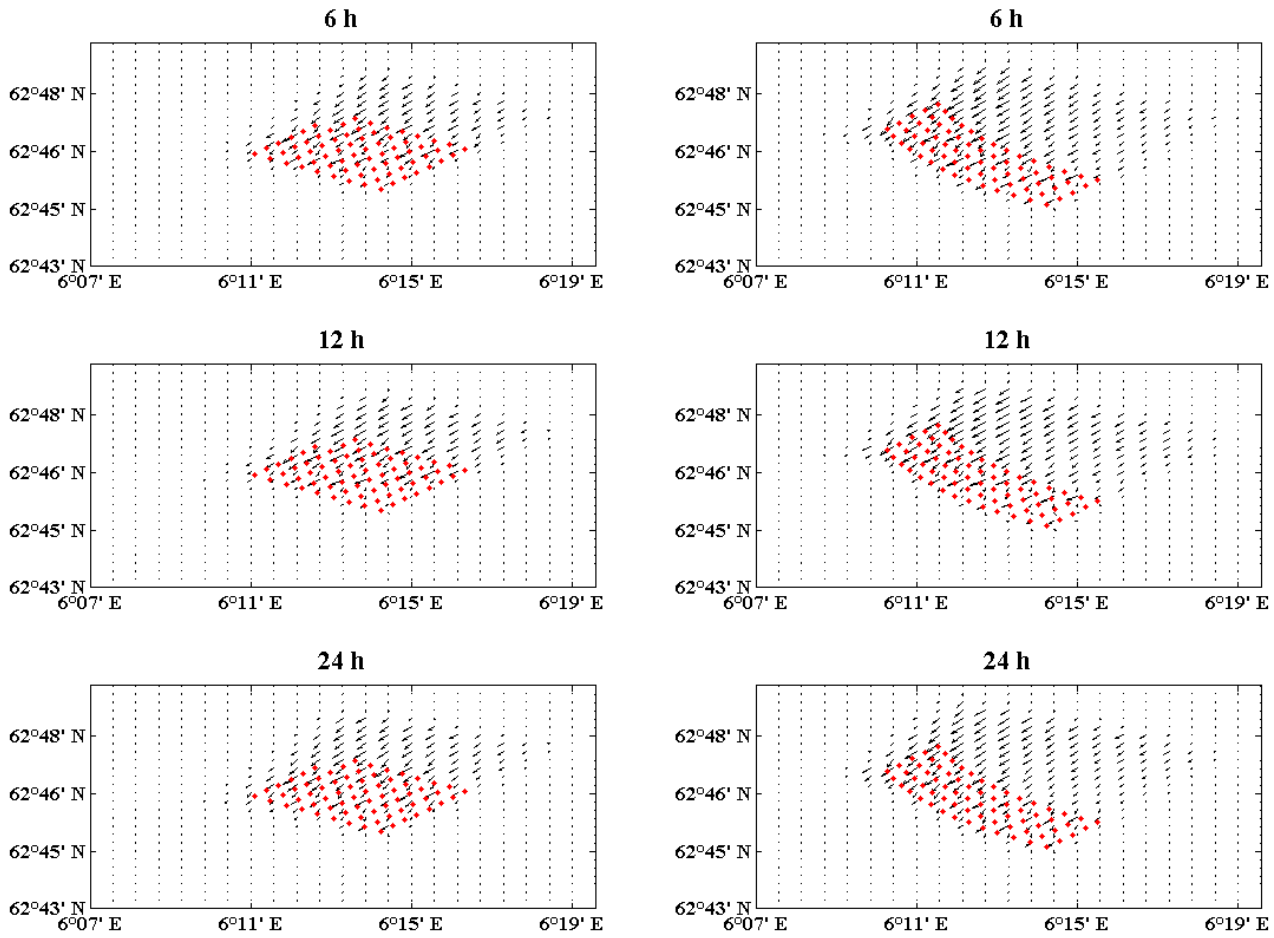




ANOMALY VERTICAL VELOCITY (M/DAY)

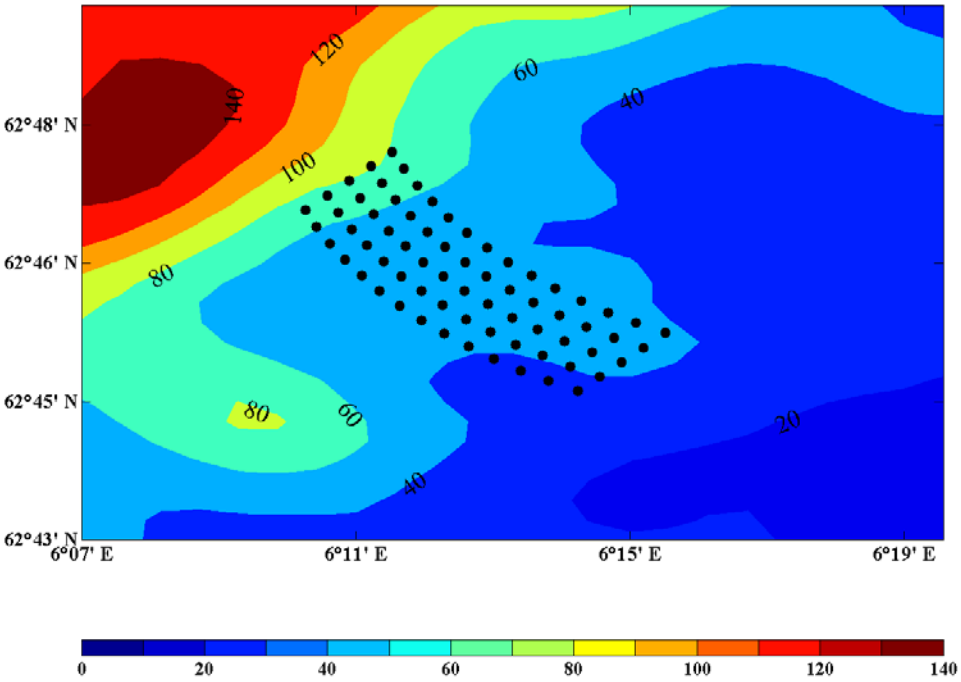


ANOMALY WIND STRESS (N/M²)

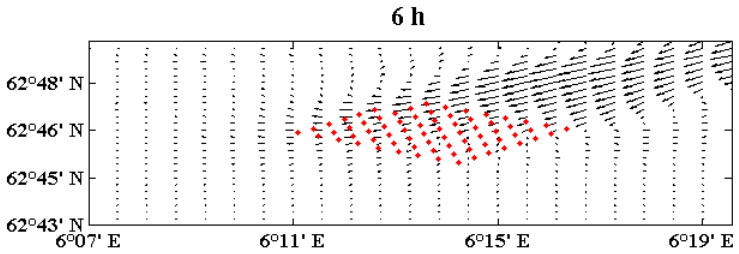


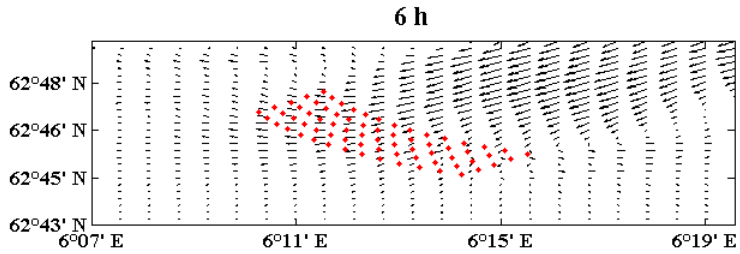
TOPOGRAPHIC EFFECTS

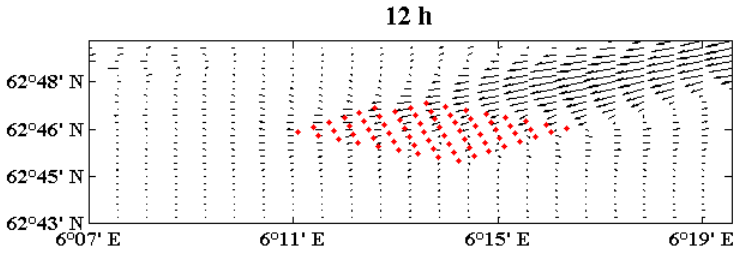
Horizontal flow over varying topography →vertical velocities

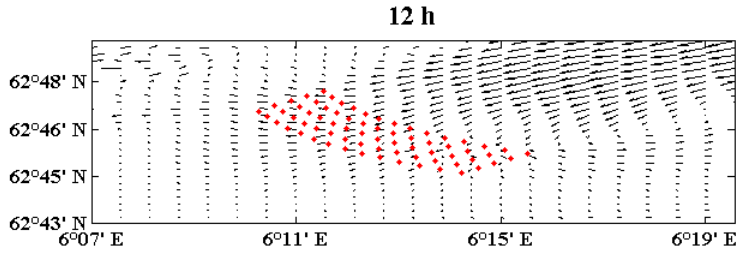


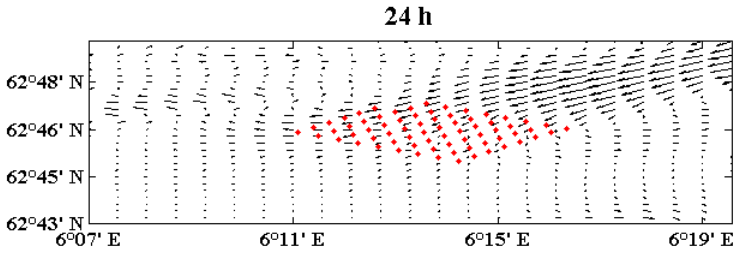
ANOMALY CURRENTS (M/S)

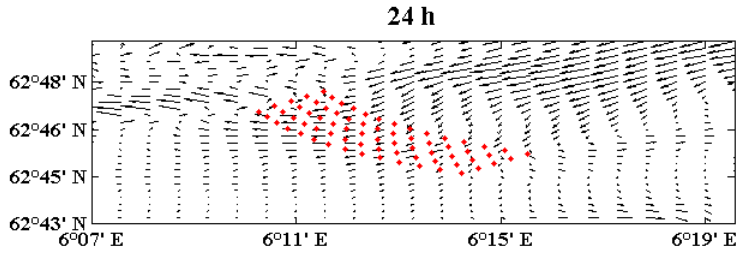












SUMMARY

Outlined a method to relate ocean respons to wind farm design

For case study (Havsul):

- Anomaly upwelling/downwelling in both experiments
- Topographic effects of greatest importance
- Ocean response **IS** dependent on wind farm design

Thanks for your attention