Predicting Offshore Wind Farm Cluster Performance Using RaNS-based Actuator Disc Wind Turbine Model

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Portugal

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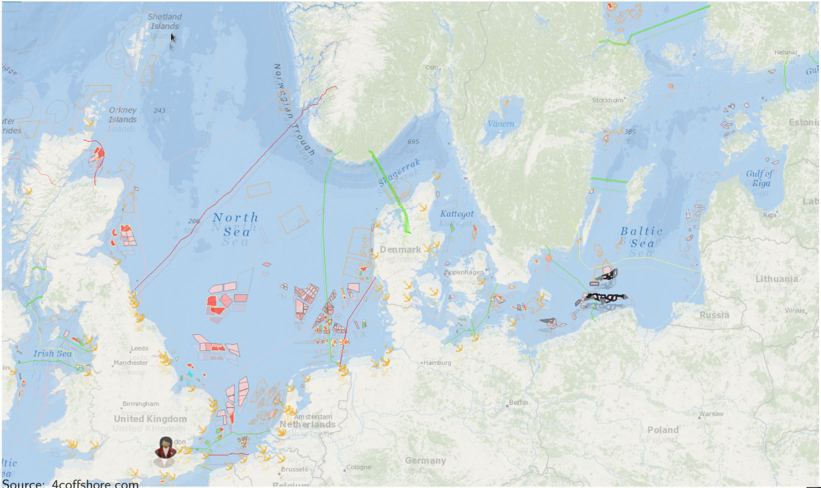
EU Offshore Wind Energy Challenges



Source: 4coffshore.com

EU Offshore Wind Energy Challenges

Wind Farm (WF) positioning conditioned by:

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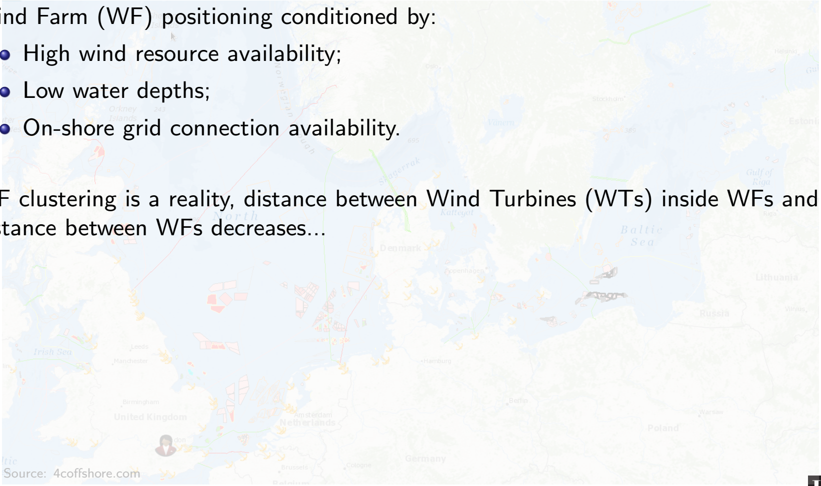
WF clustering is a reality, distance between Wind Turbines (WTs) inside WFs and distance between WFs decreases...



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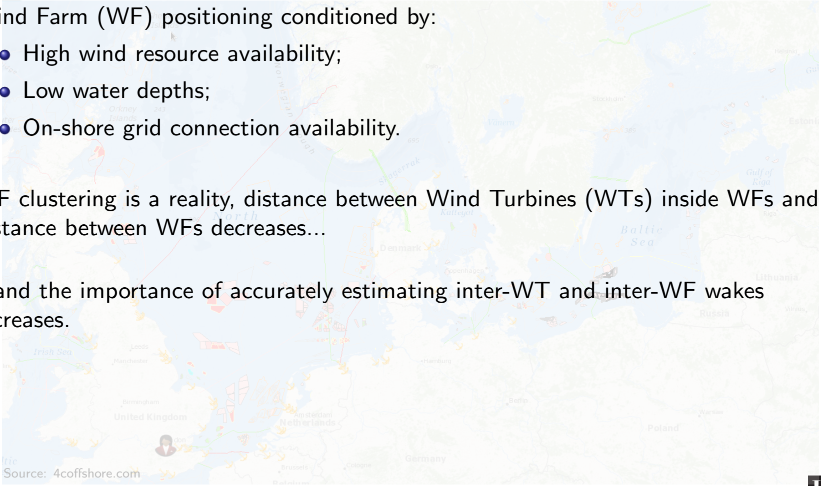

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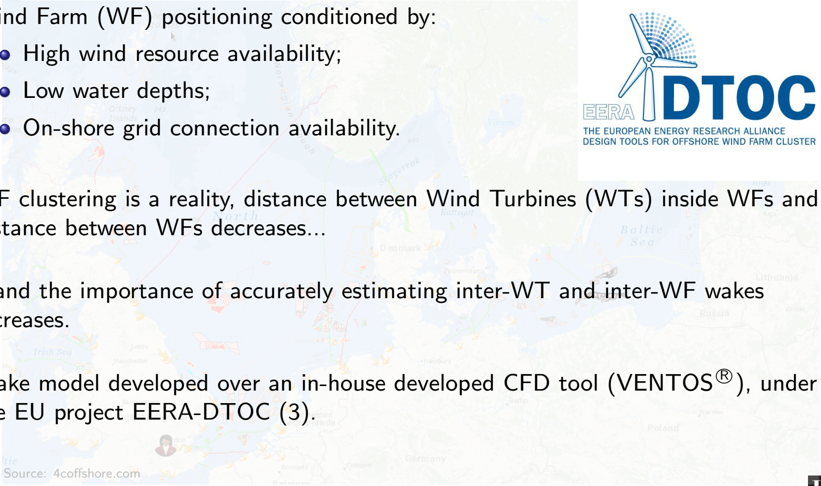
Wake model developed over an in-house developed CFD tool (VENTOS®), under the EU project EERA-DTOC (3).



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Non-linear CFD code geared towards solving wind flow problems over complex terrain (1; 4):

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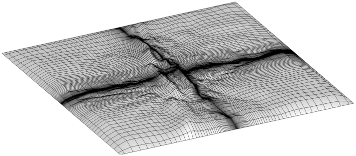

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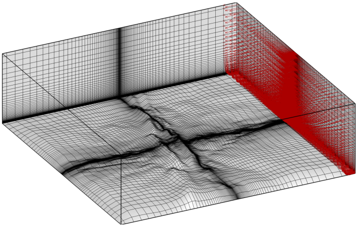
- Structured, horizontally orthogonal, terrain-following mesh to capture topography;
- Channel-like domain, with static boundary conditions.



WT wake modelling in VENTOS®/2...

Wind Turbine (WT) rotor represented by an Actuator Disk (AD) immersed in domain mesh:

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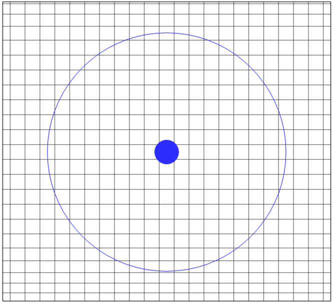
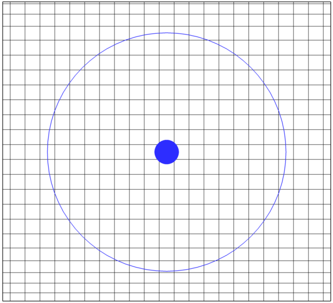
- AD rotates towards inflow;

Smooth discretization of WT drag over course mesh



Smooth discretization of WT drag over course mesh

1. Approximate disk velocity $\mathbf{U}_{\mathbf{disk}}$ as hub position velocity, interpolated from intermediate solution;



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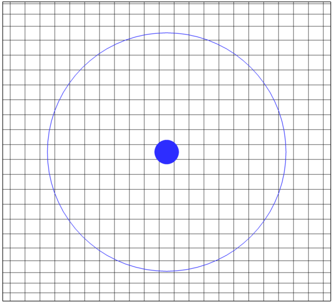

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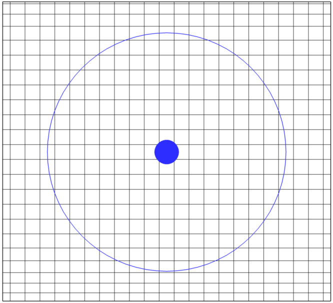

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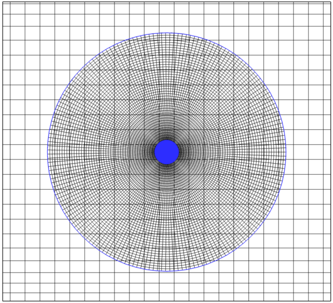

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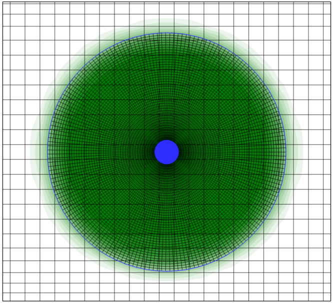
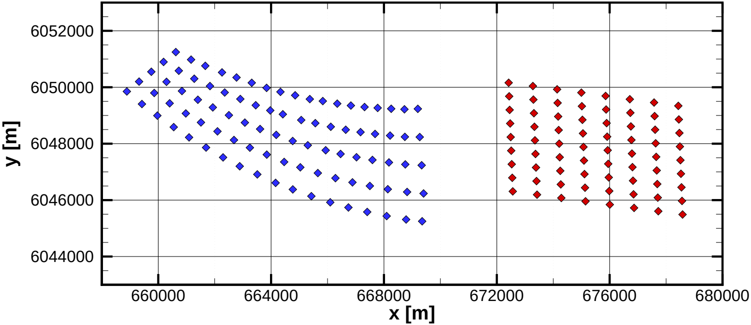
5. Extrapolate F_n distribution from virtual rotor sink terms in momentum equations.



Assess wind farm wakes inside a cluster



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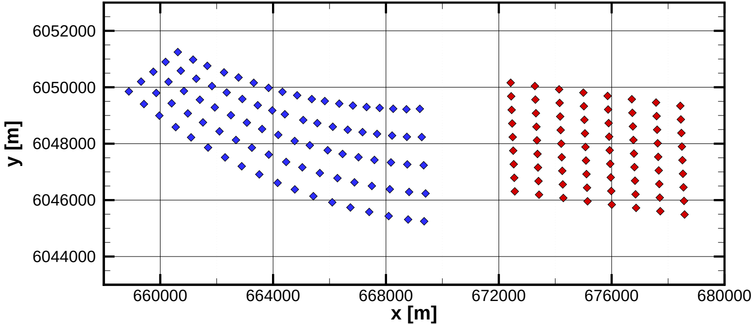

Rødsand 2:

5×18 WTs
Siemens 2.3MW/92.6m machines
Internal spacing: 5-10D

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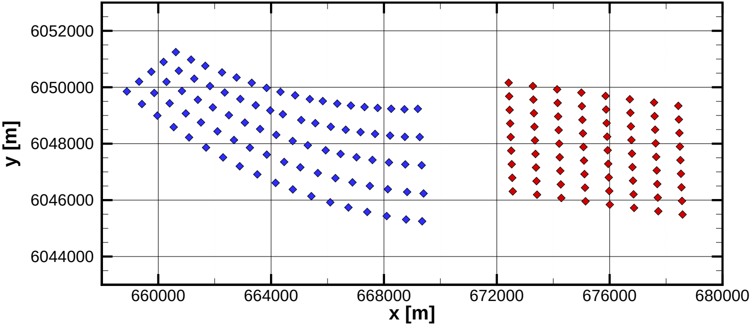

Rødsand 2:

5×18 WTs
Siemens 2.3MW/92.6m machines
Internal spacing: 5-10D

Nysted:

9×8 WTs
Bonus 2.3MW/82.4m machines
Internal spacing: 5.7D, 10.3D

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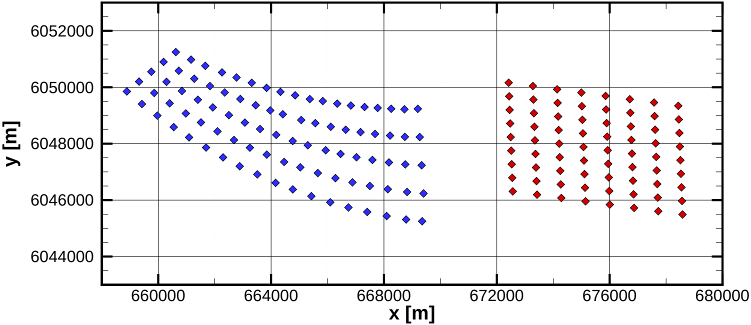

Westerly winds: Rødsand 2

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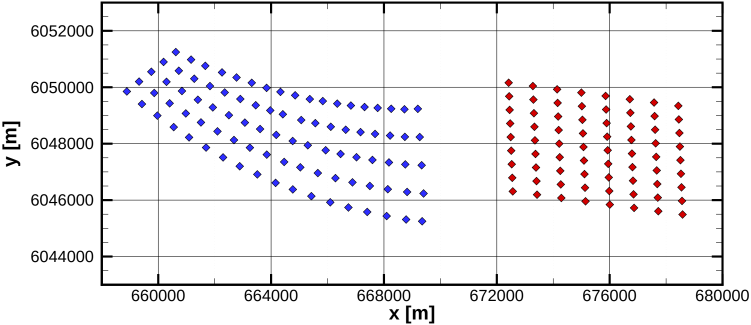

Westerly winds: Rødsand 2

Easterly winds: Nysted + Rødsand 2

20+ km and 152 WTs to model!

Computational costs

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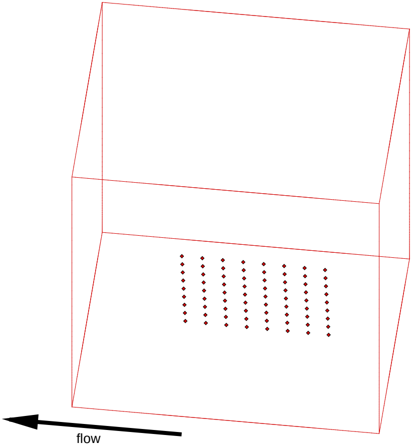
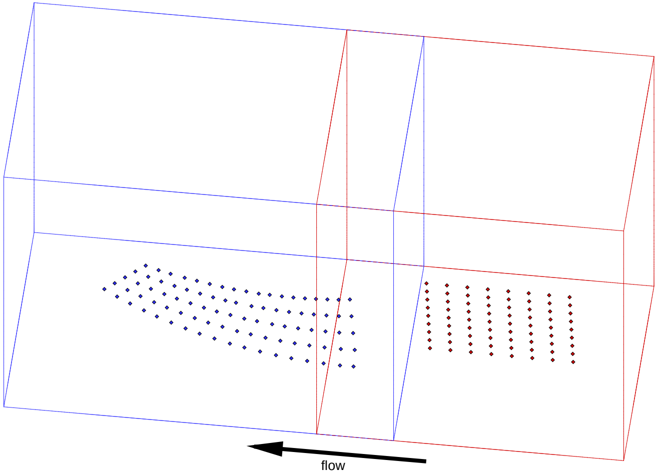
Solution: Break up larger domains into two cases

Precursor solution



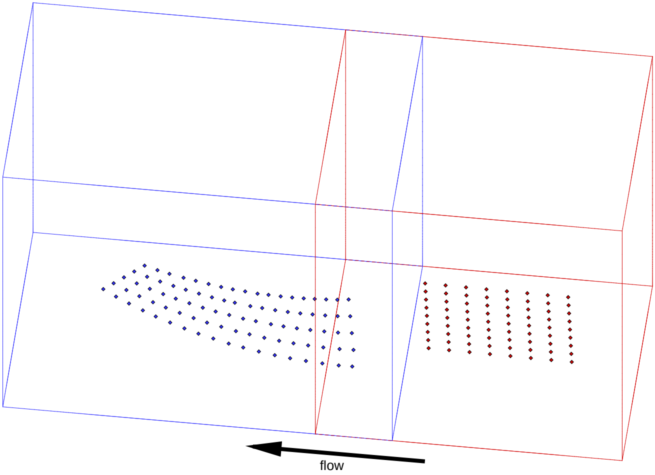
Precursor domain includes upstream wind farm

Precursor solution



Two domains partially super-impose

Precursor solution



Total computational cost: 6M + 7-8M cells,
0.5 + 1-1.5 days wallclock time;

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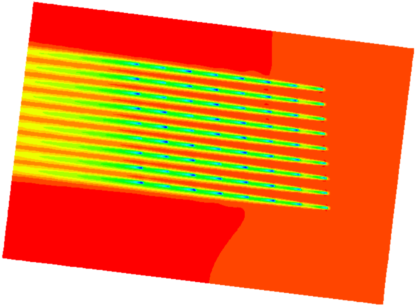
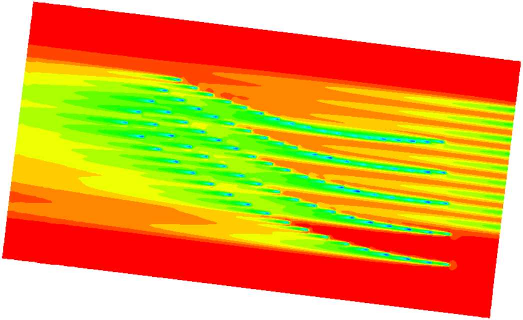


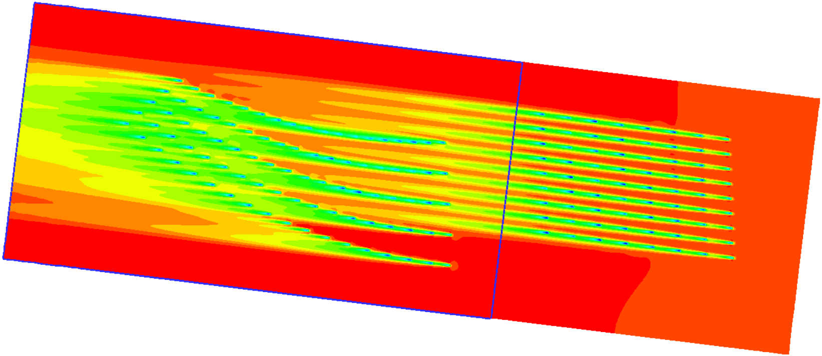
Solution to precursor case

Precursor solution



Use precursor as source for inlet conditions

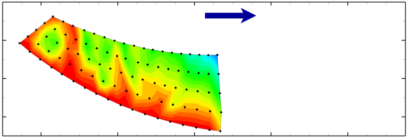
Precursor solution



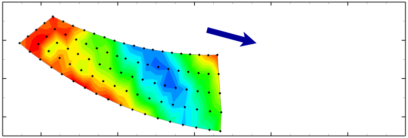
Solution to full case

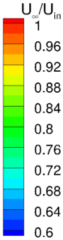
Model results: Westerly winds, "clean" inflow

270°:

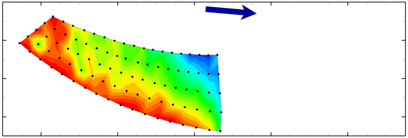


285°:





275°:



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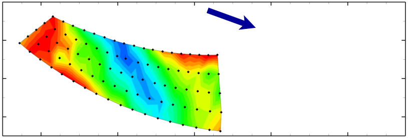

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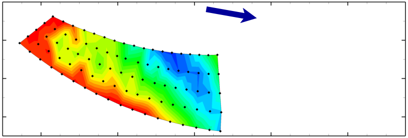

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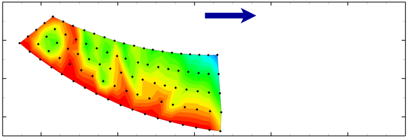

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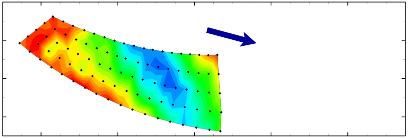

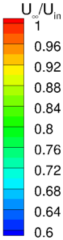

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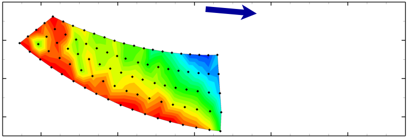

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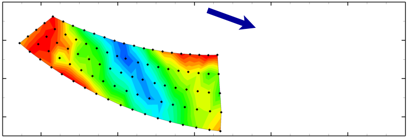

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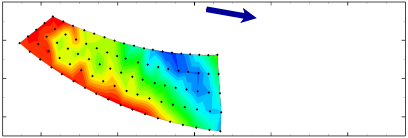
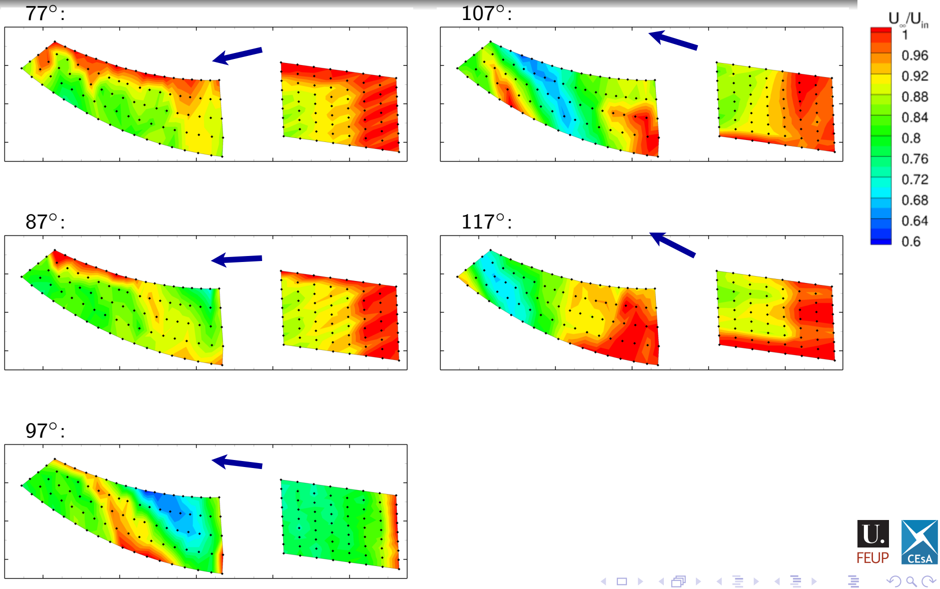


$P_{Avg.}/P_{Ref.WT}$ in Rødsand II

270°	275°	280°	285°	290°
0.80	0.63	0.56	0.56	0.64

Model results: Easterly winds, "waked" inflow



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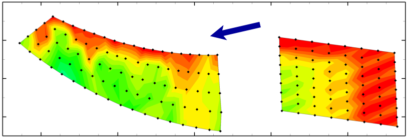
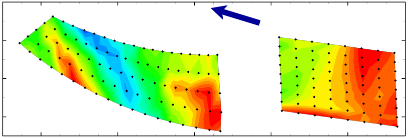
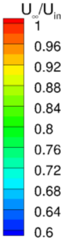
77°:

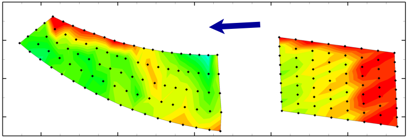


107°:

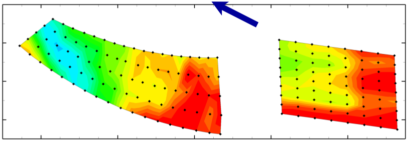




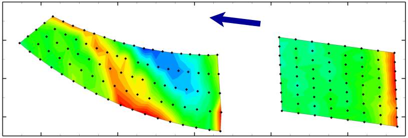
87°:



117°:



97°:



$P_{Avg.}/P_{Ref.WT}$ in Rødsand II

77°	87°	97°	107°	117°
0.65	0.54	0.52	0.55	0.65

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- Easterly sector winds show a strong effect of Nysted WF on Rødsand II's entry WTs, effect extending to the inner WTs.

References

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