Simulation of wake effects between two wind farms

EERA DTOC
THE EUROPEAN ENERGY RESEARCH ALLIANCE
DESIGN TOOLS FOR OFFSHORE WIND FARM CLUSTER

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Support by

SEVENTH FRAMEWORK PROGRAMME

Outline

- Introduction to EERA-DTOC;
- Offshore wind farm cluster layout;
- SCADA data analysis;
- Participants & models;
- Model results from Rødsand II;
- Cluster model results;
- Park efficiencies;
- Conclusion & acknowledgement;

Introduction to EERA-DTOC

EERA:
European Energy Research Alliance

EERA-DTOC.EU

DTOC:
Design Tool for Offshore Wind Farm Cluster.

A multidisciplinary integrated software tool for creating an optimized design of offshore wind farms or clusters of wind farms.

The wake models results are compared to the measurements of wake effects:
1) Interaction between wind turbines;
2) Interaction between wind farms;

Offshore wind farm cluster

Rødsand II wind farm

- Owner: E•ON
- SWP: 2.3-92.6m, VS & VP
- Spacing: variable 5 – 6 – 7 - 10D
- Operational status: good
- 1 month data 5-10 m/s representing East & West

Problems

- Lack of inflow reference & time stamps

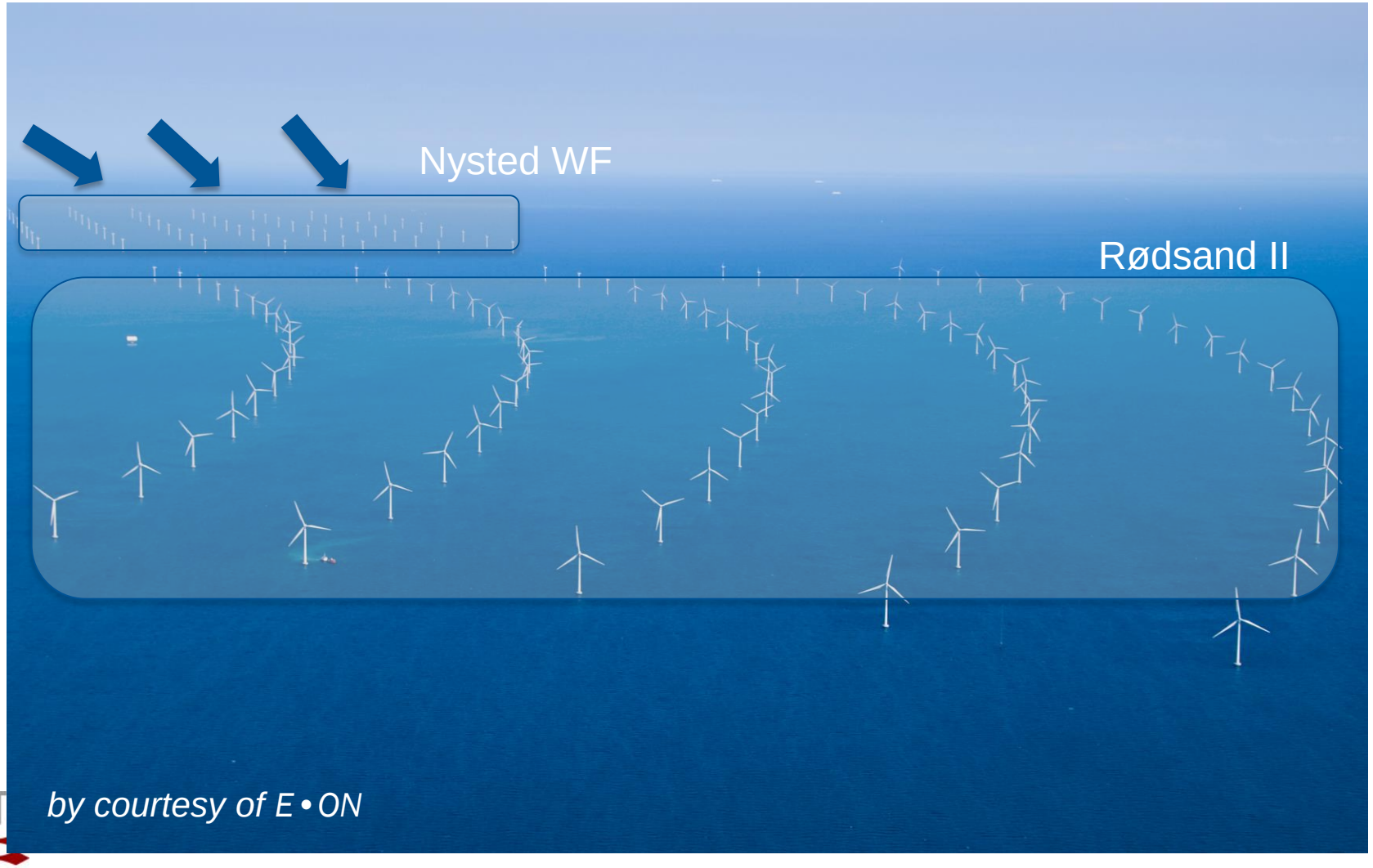
Nysted wind farm

- Owner: DONG Energy A/S
- Bonus 2.3-82.4 m, 2-speed, active stall
- Principal spacing: 10.1 & 5.6 D
- Annual eq. full load hours≈3300

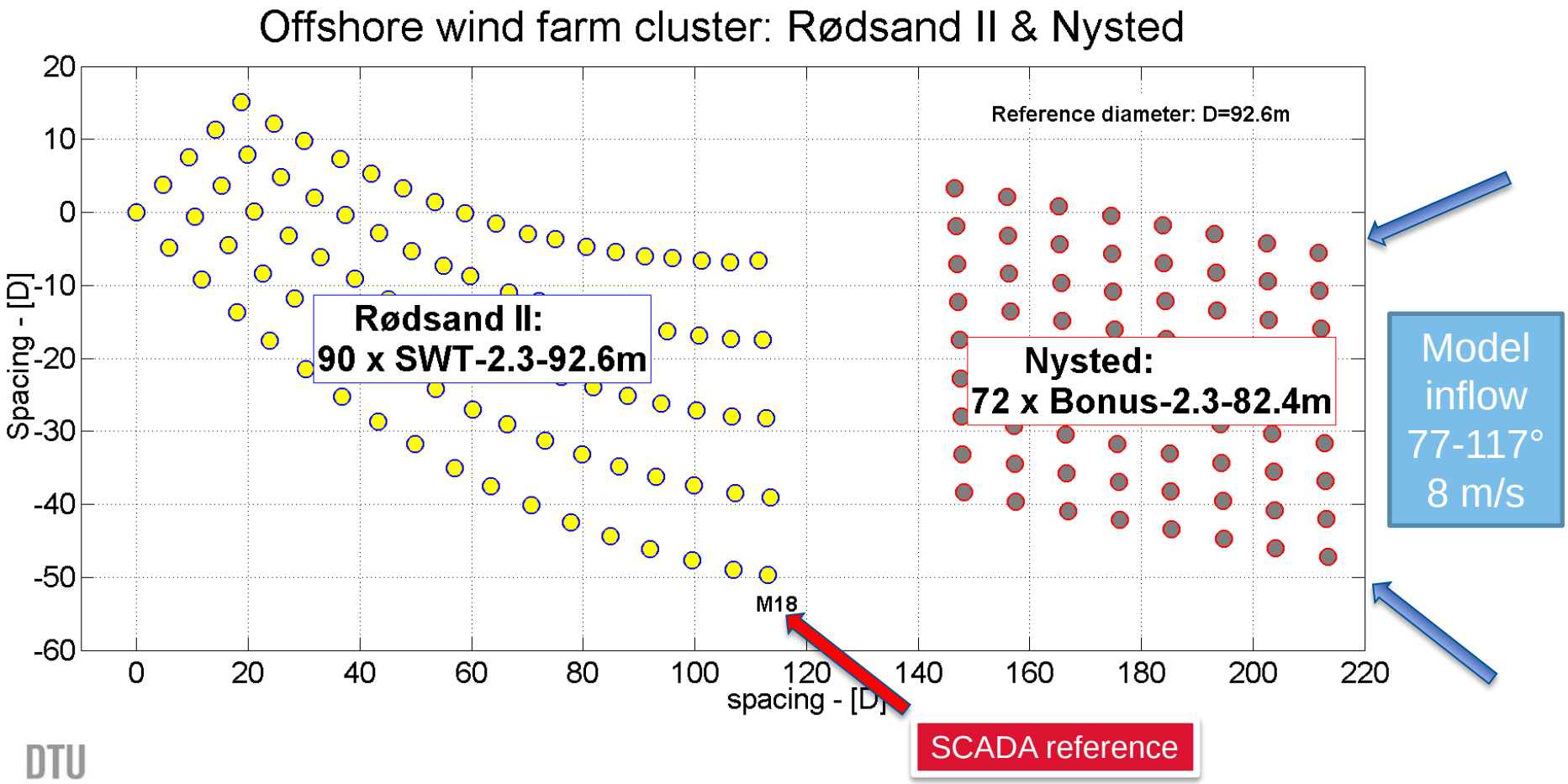
Problems

- Different owner
- Lack of synchronization ←

Cluster layout



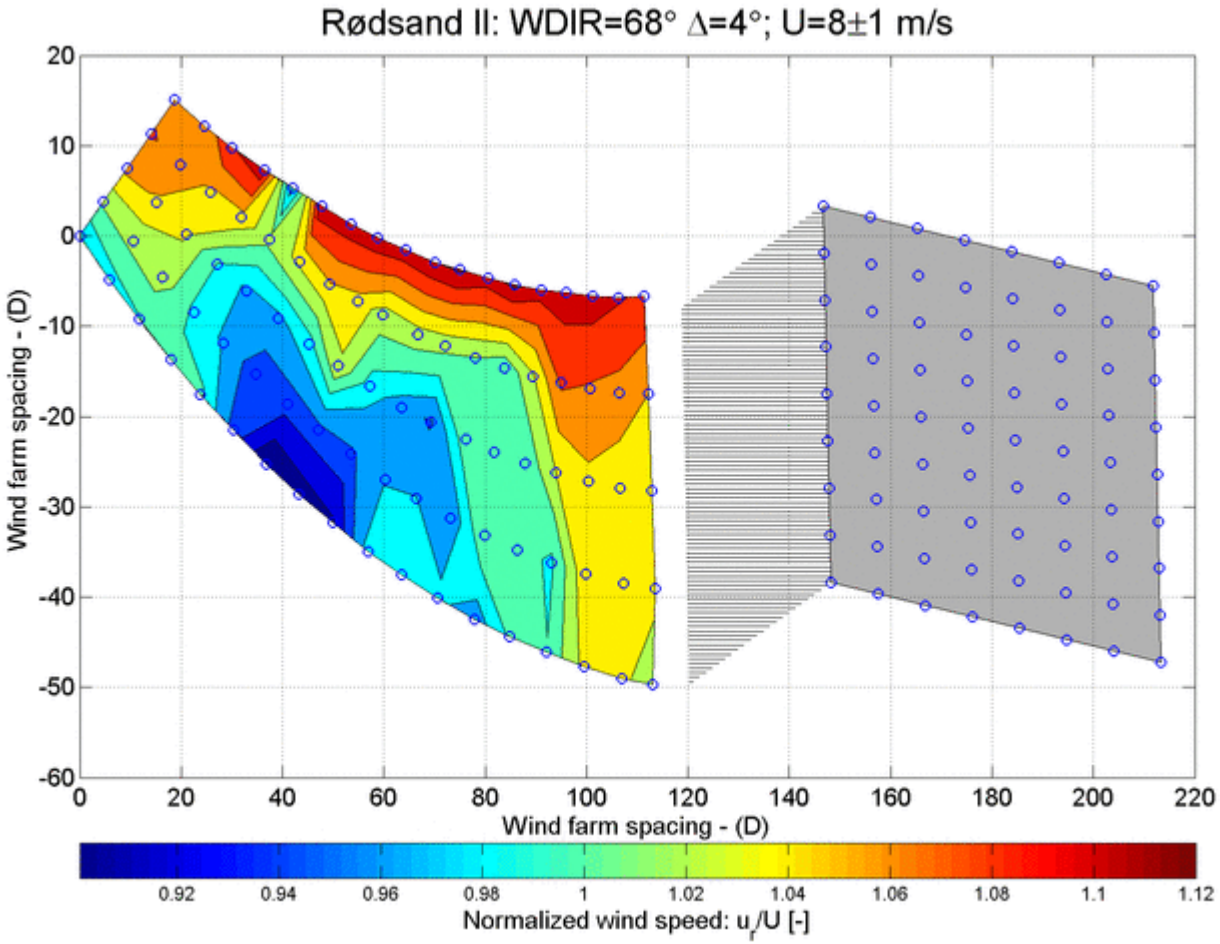
Wind farm clustering



Presentation of results - definitions

- The power references are the official power curves;
- Inflow conditions are characterized with
  - U=8 ±0.5 m/s;
  - WD=77, 87, 97, 107 & 117 ±5°
- Measured or simulated power values are transformed to inflow rotor speeds u_r;
- All results are presented as normalized wind speeds u_r/U;

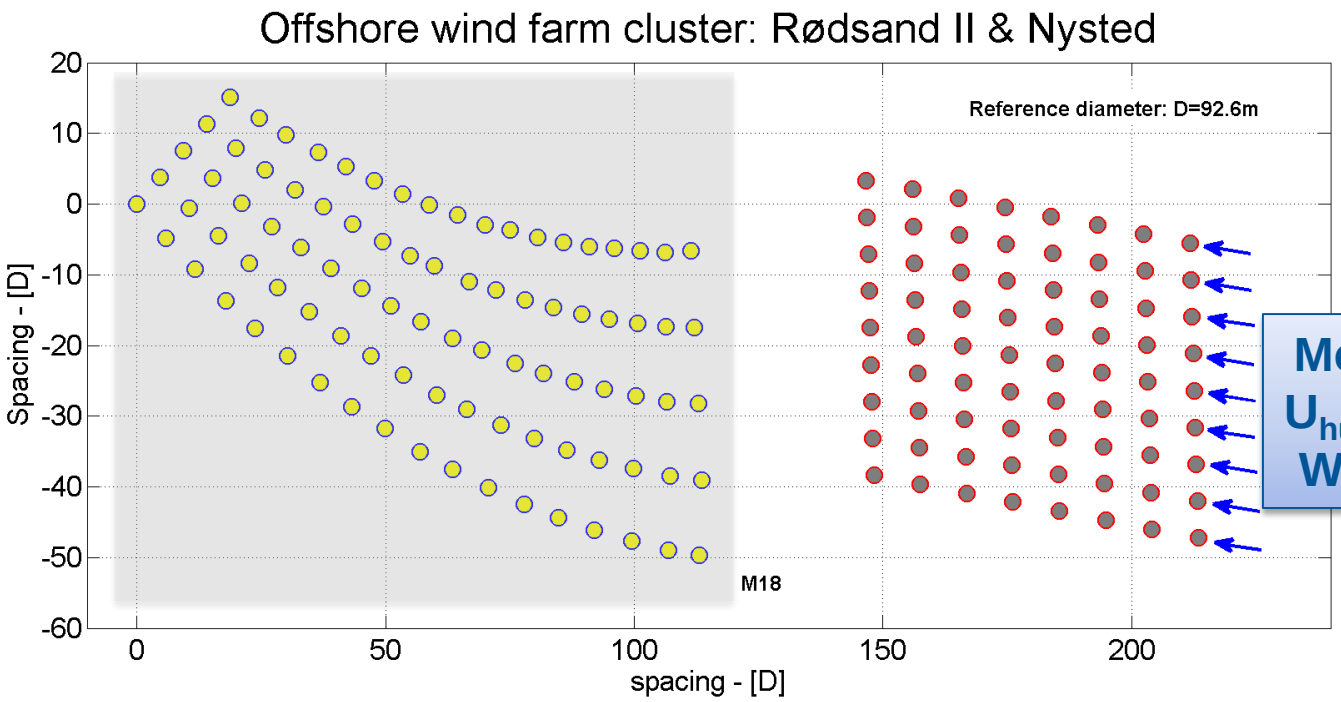
Visualisation of SCADA analysis



Participants & models

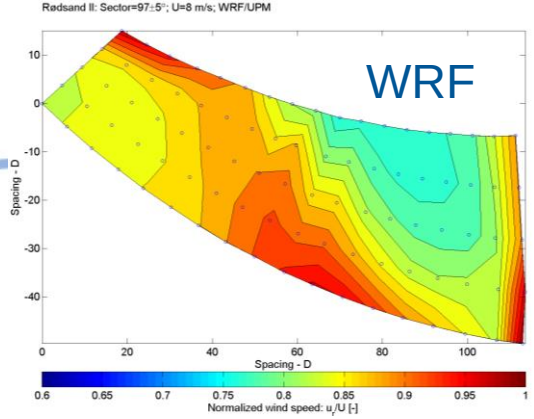
	Models	Affiliation
	SCADA(BA)	DTU Wind Energy/K.S.Hansen
1	FUGA/SO	DTU Wind Energy/S. Ott
2	NOJ(GU)	DTU Wind Energy/A. Pena
3	NOJ/Penã	DTU Wind Energy/A. Pena
4	WRF/UPM	Ciemat/A.Palomares
5	Meso/PV	DTU Wind Energy/P.Volker
6	AD/RANS	UPORTO/J.L. Palma
7	CFDWake	CENER/B.G. Hevia
8	CRESflowNS	CRES/ J. Prospathopoulos
9	FarmFlow	ECN Wind Energy/J.G Scheepers
10	RANS/f_PC	DTU Wind Energy/P.vd Laan

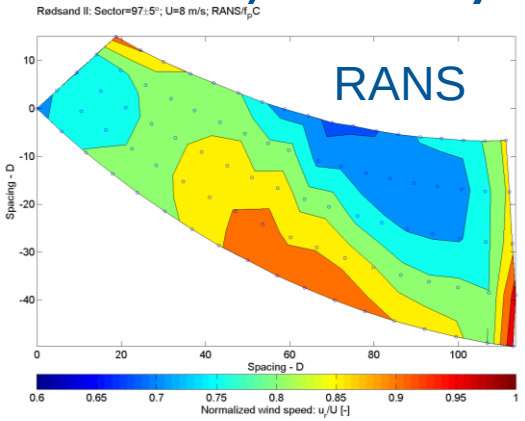
Model results for Rødsand II, U=8 m/s; WD=97

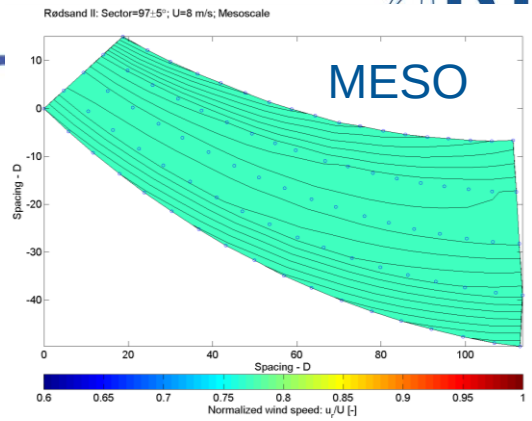


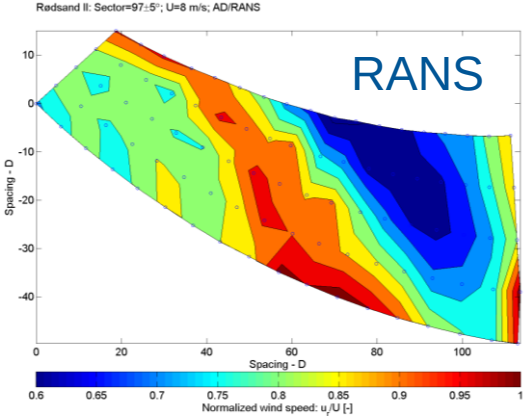
Model inflow
U_{hub}=8±.5 m/s
WDIR=97±5°

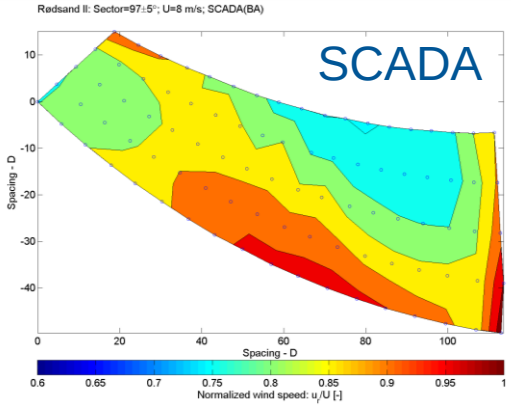
Model results for Rødsand II, U=8 m/s; WD=97 °

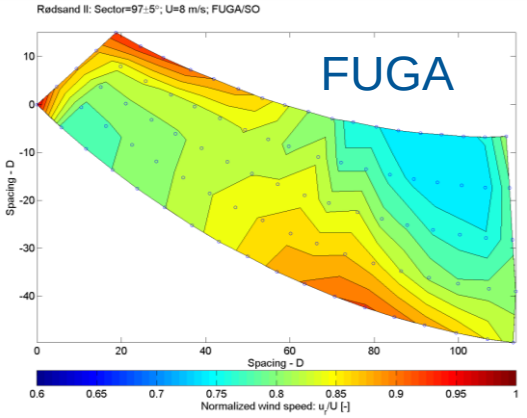


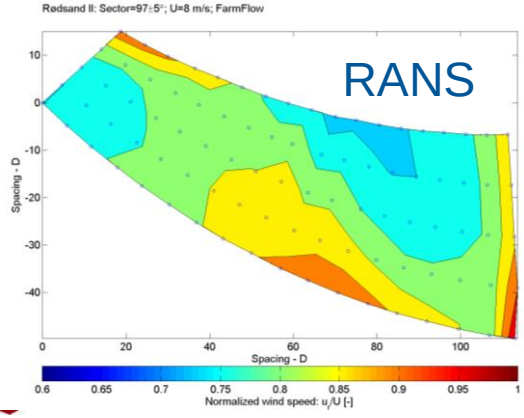


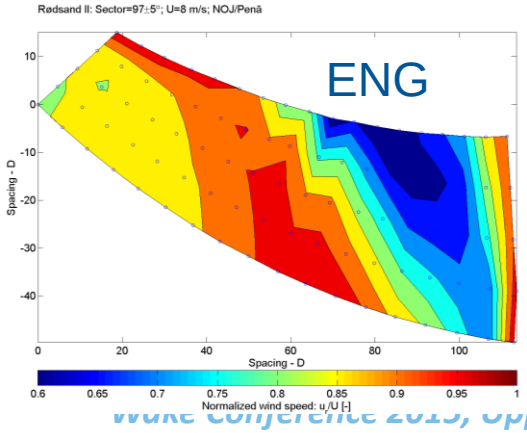


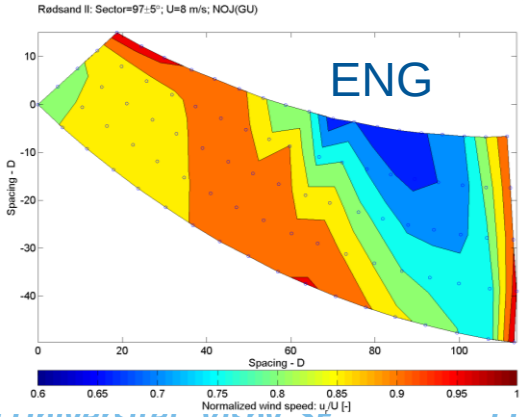




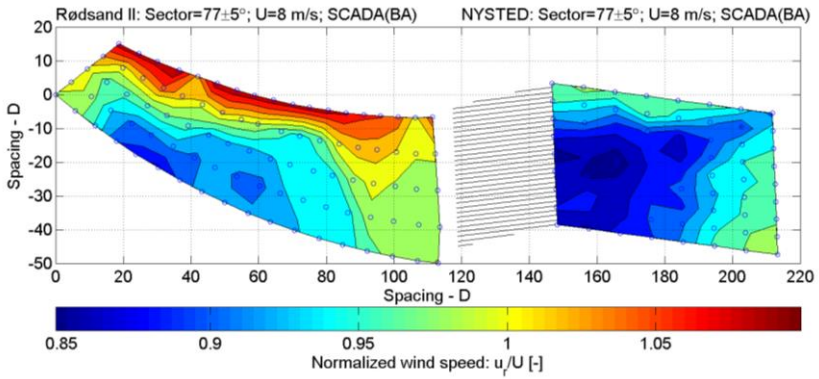


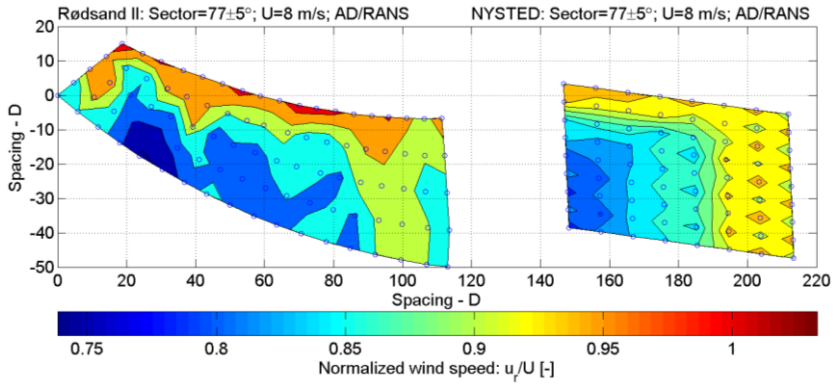


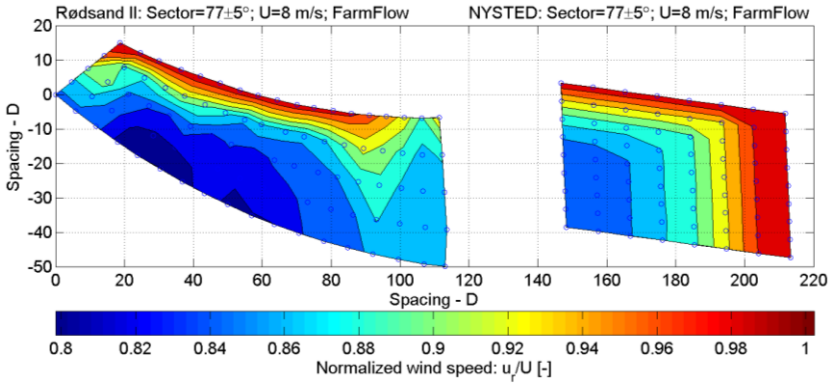


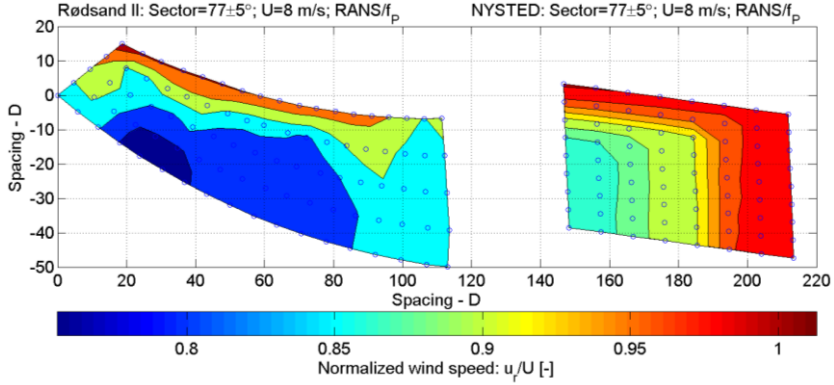


Cluster modeling results, U=8 m/s; WD=77°

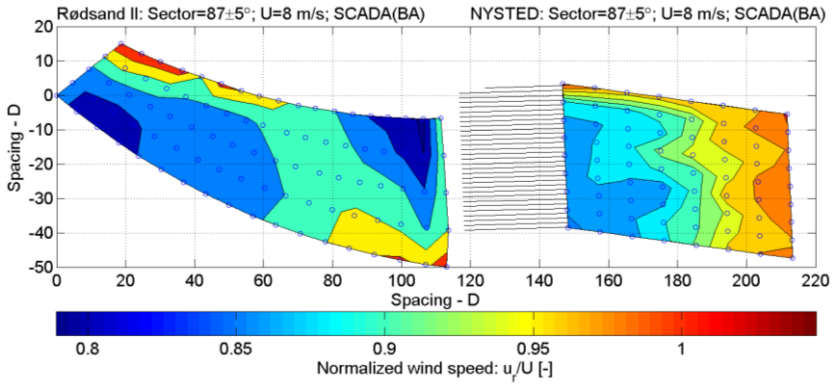


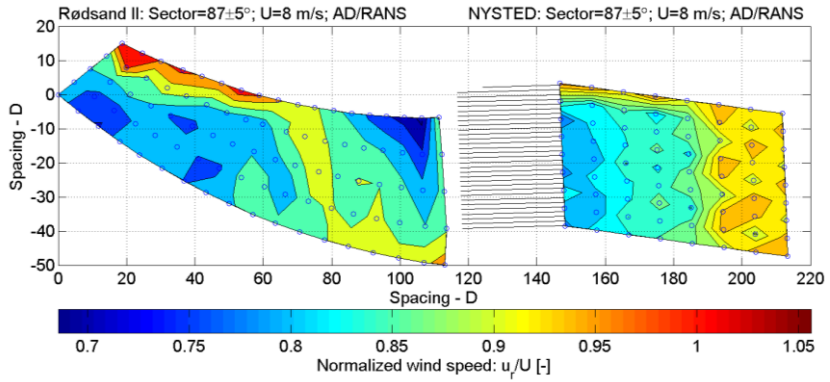


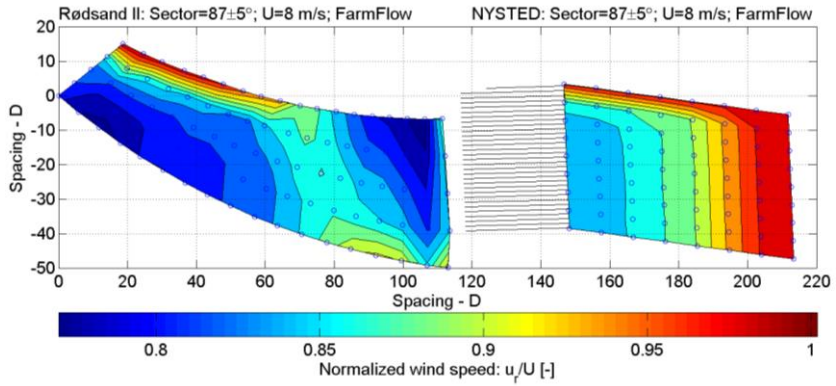


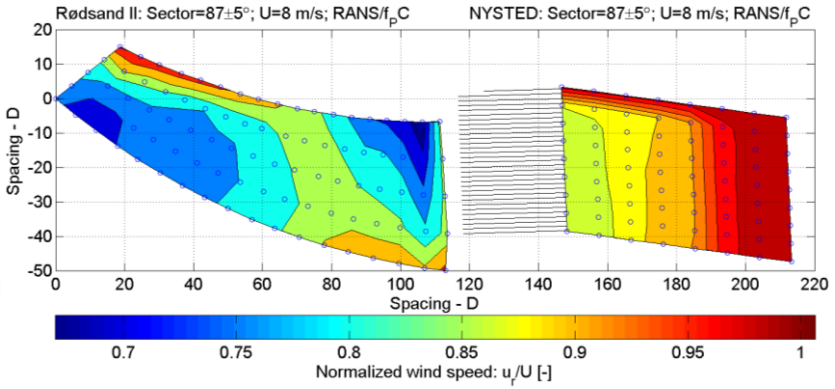


Cluster modeling results, U=8 m/s; WD=87 °

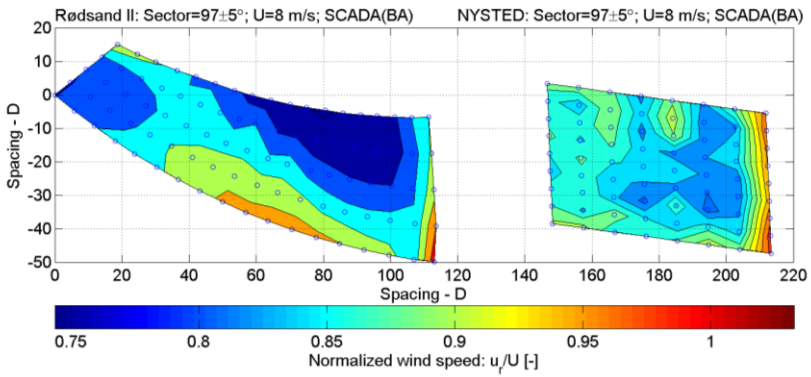


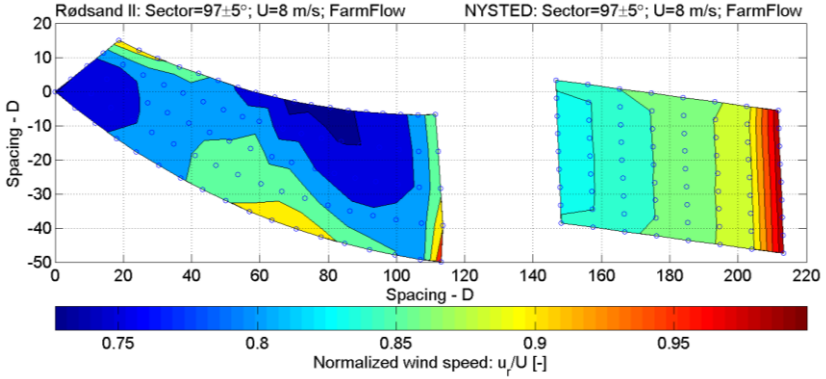


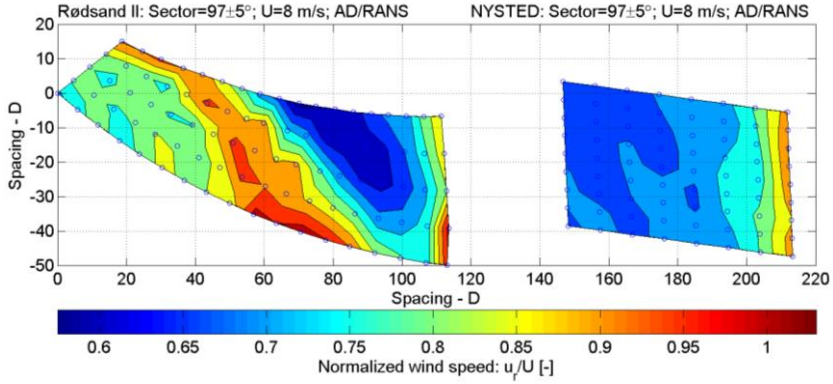


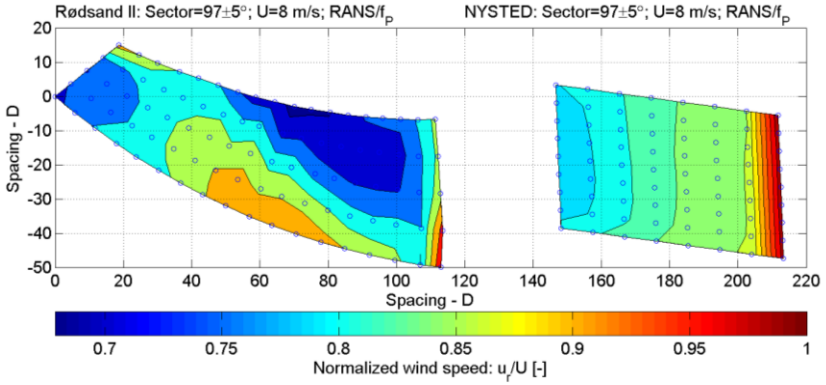


Cluster modeling results, U=8 m/s; WD=97°

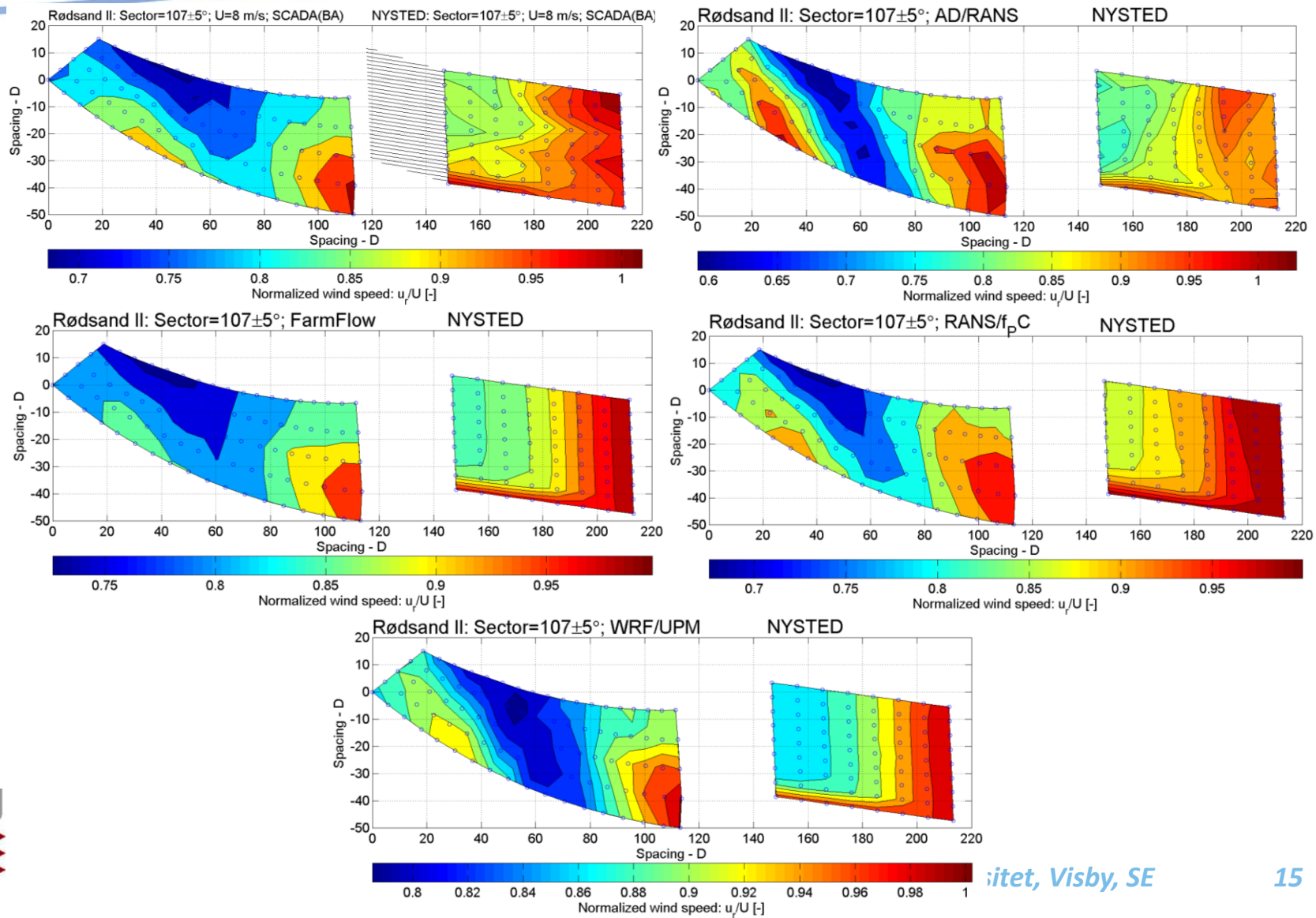




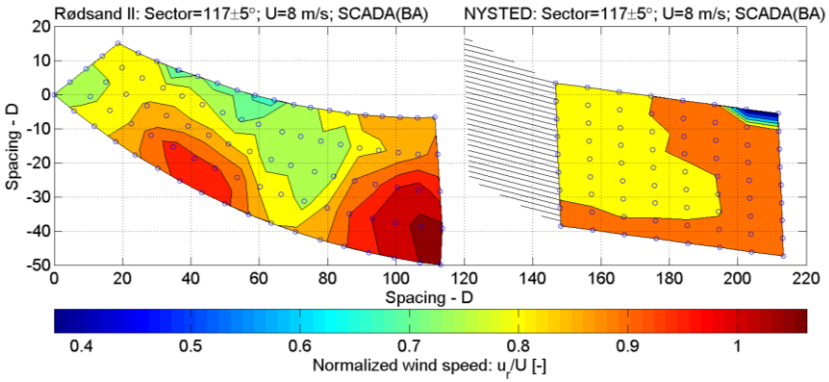


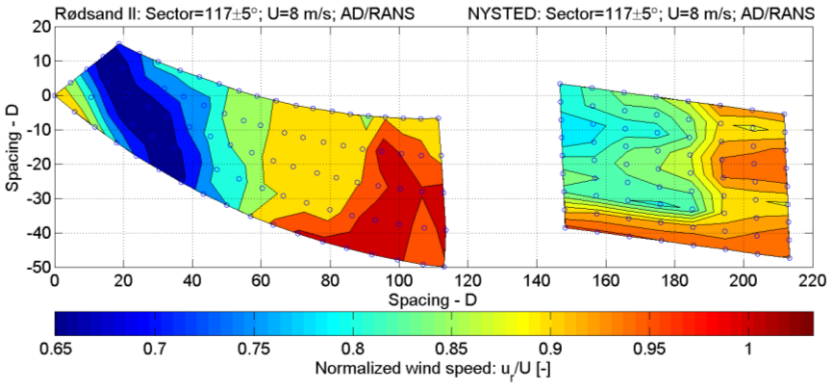


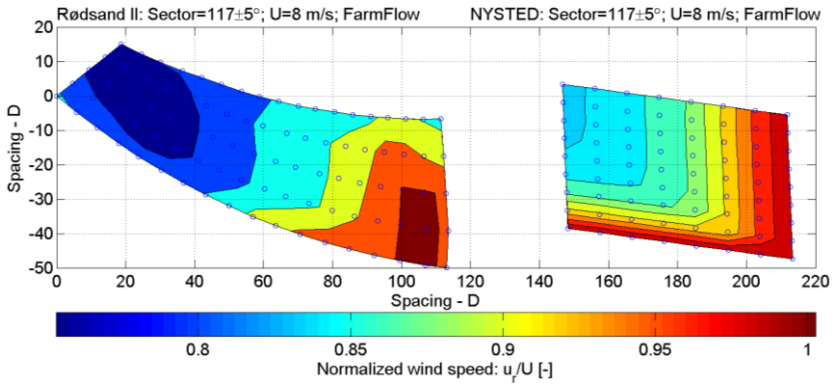
Cluster modeling results, U=8 m/s; WD=107 °

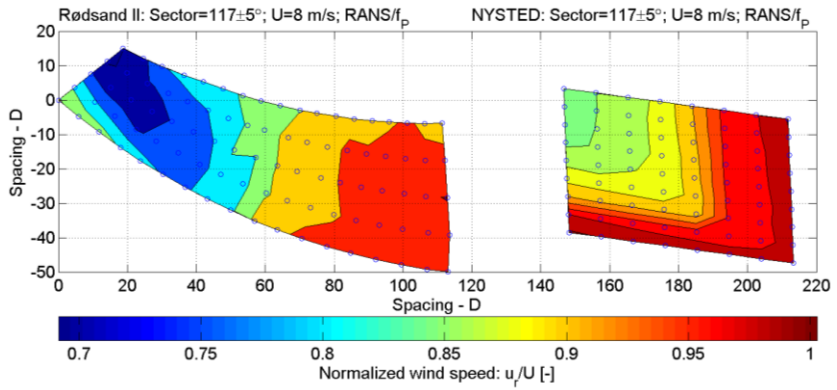


Cluster modeling results, U=8 m/s; WD=117°

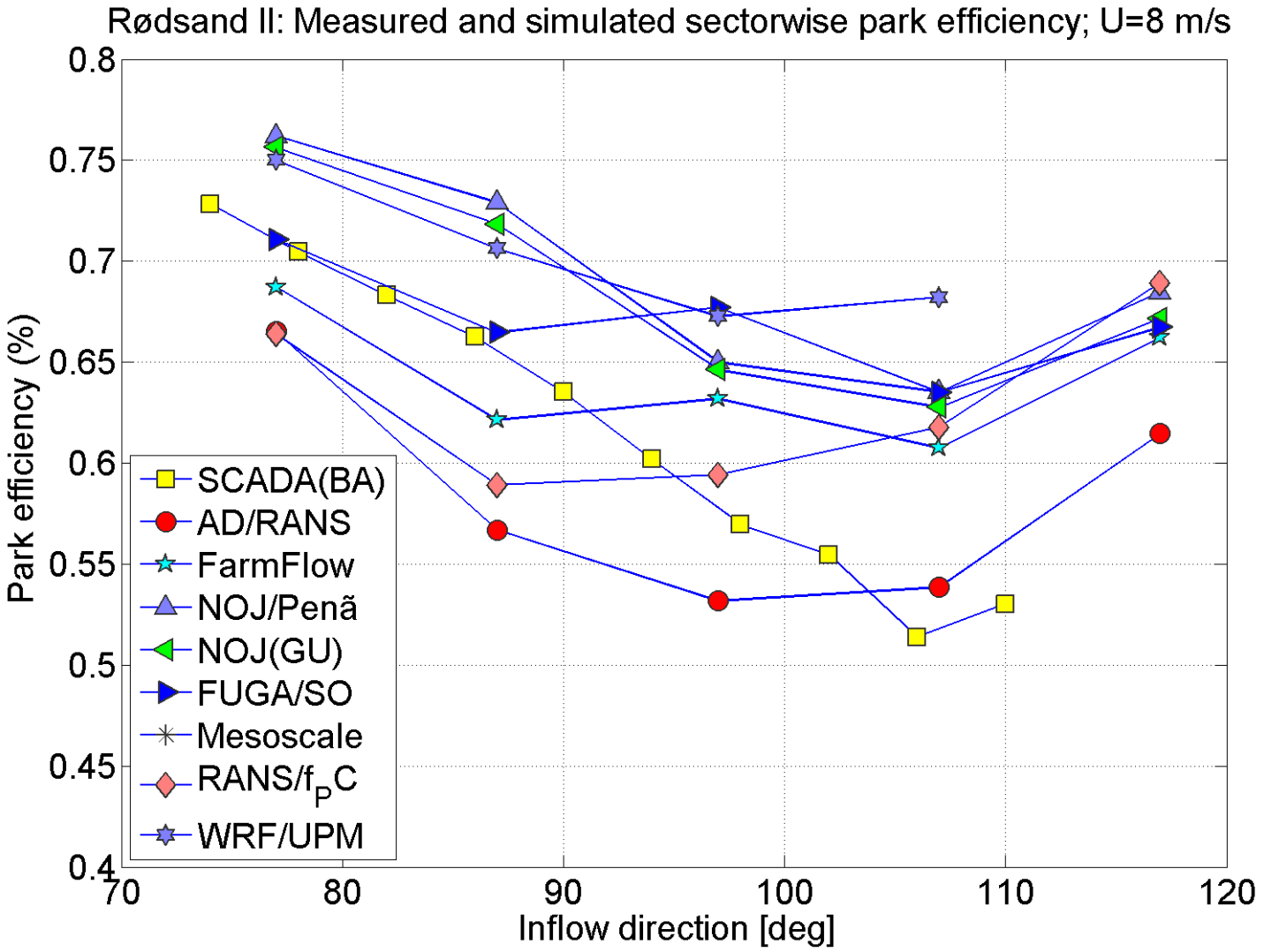








Park efficiency comparison



Conclusion

- This is the first investigation that include two wind farms, and the apparent conclusion is that the models give a significantly large spread, which illustrate our current predictive capability.

- The benchmark have demonstrated that both size and location of the distinct deficit zones - caused by the Nysted wind farm have been predicted by the models.

- The benchmark concludes that most of the park models are able to handle the clustering of wind farms and can be integrated in the software, developed as part of “Design Tool for Offshore Wind Farm Cluster” (EERA-DTOC).

Acknowledgement

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