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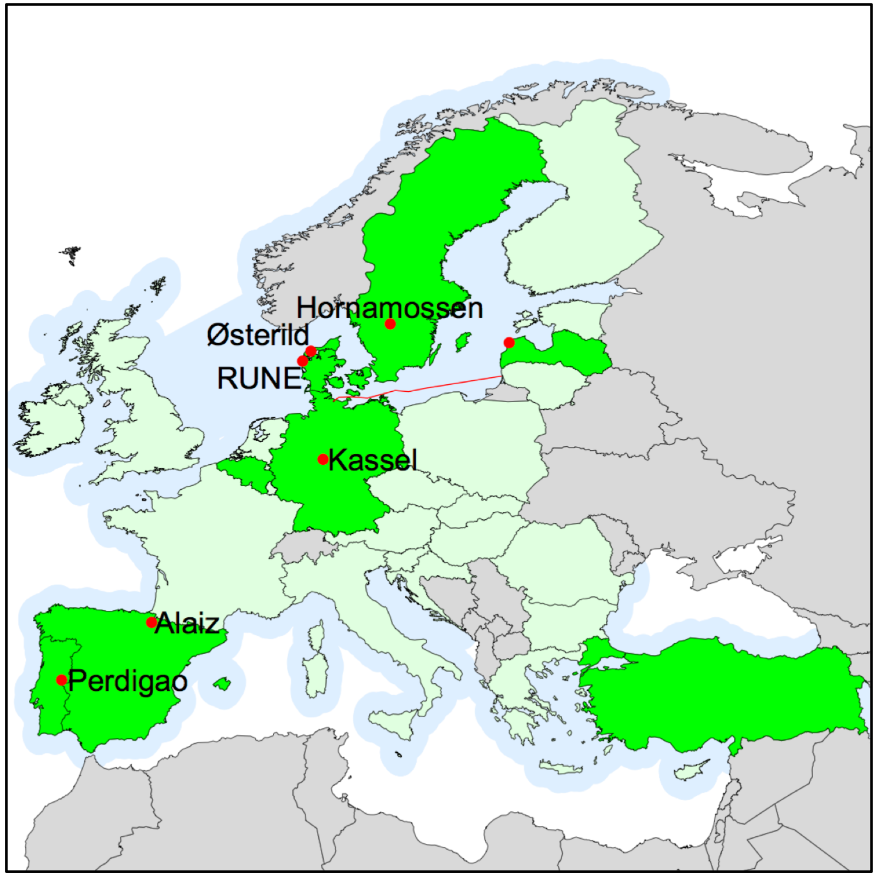
European Geophysical Union annual meeting, Vienna, Austria, 26 April 2018

The New European Wind Atlas (NEWA) project

Objectives:

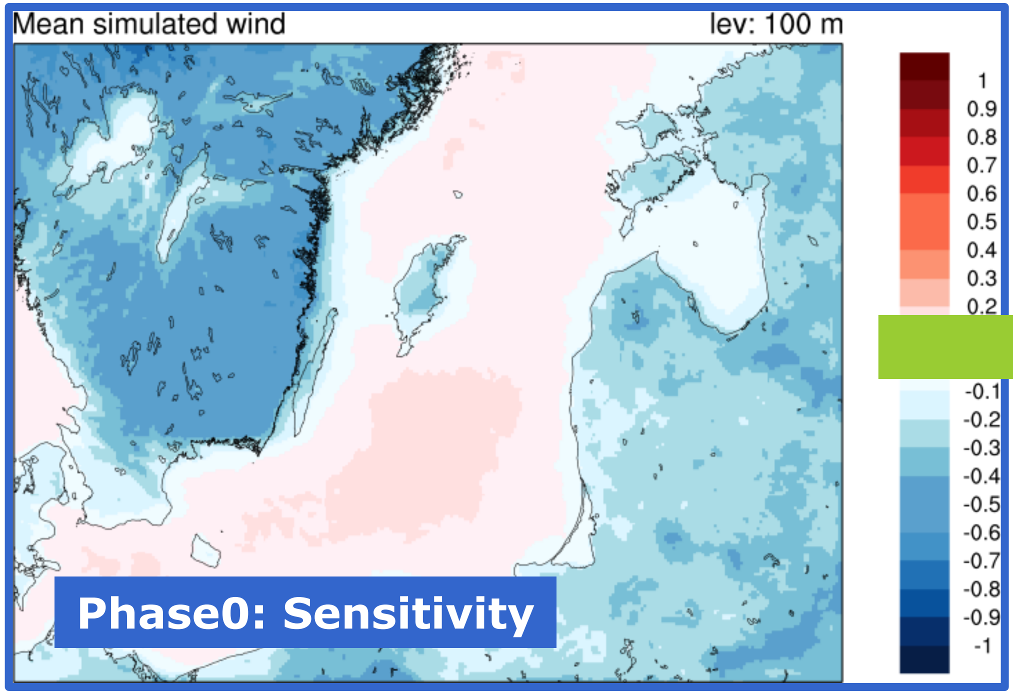
- **Accurate mapping of wind conditions for the estimation of wind resources** and loads
- **Development and testing of the "model-chain"**
- A series of field atmospheric experiments to validate the models and the final atlas

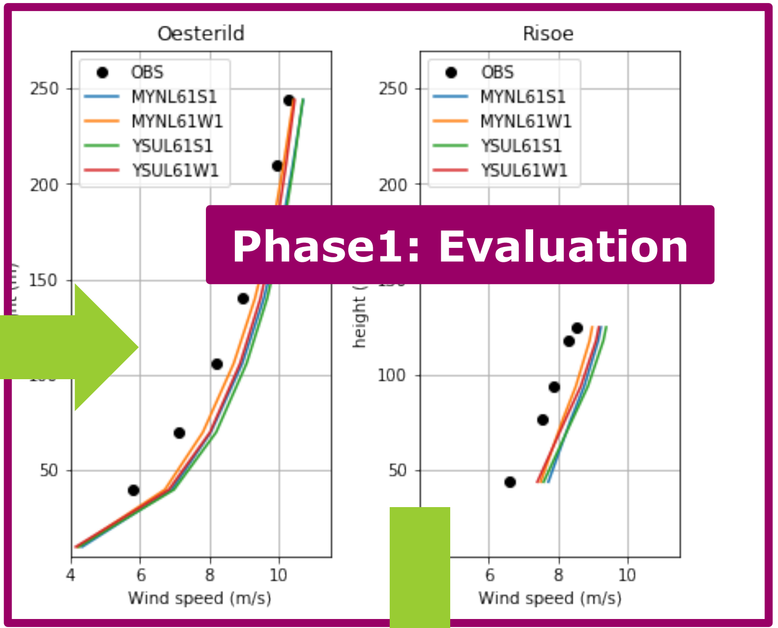


Green – NEWA member countries

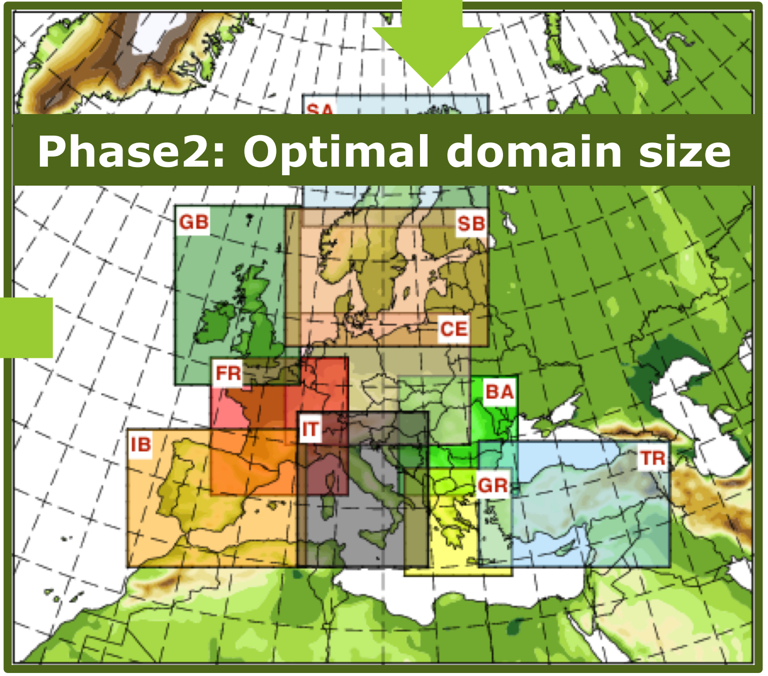
Red – field experiments sites

http://www.neweuropeanwindatlas.eu

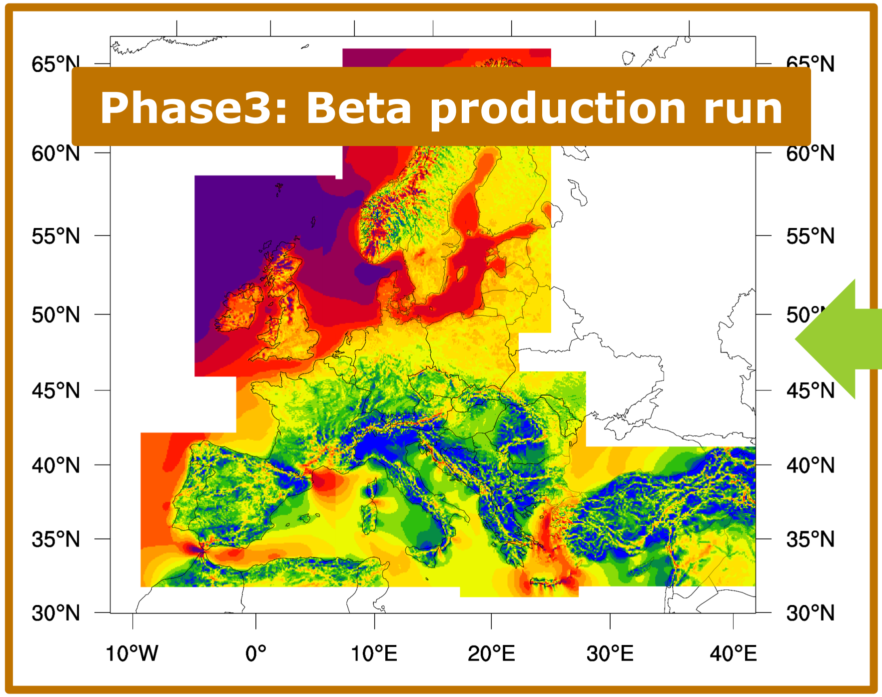




Find the best set of model parameterizations



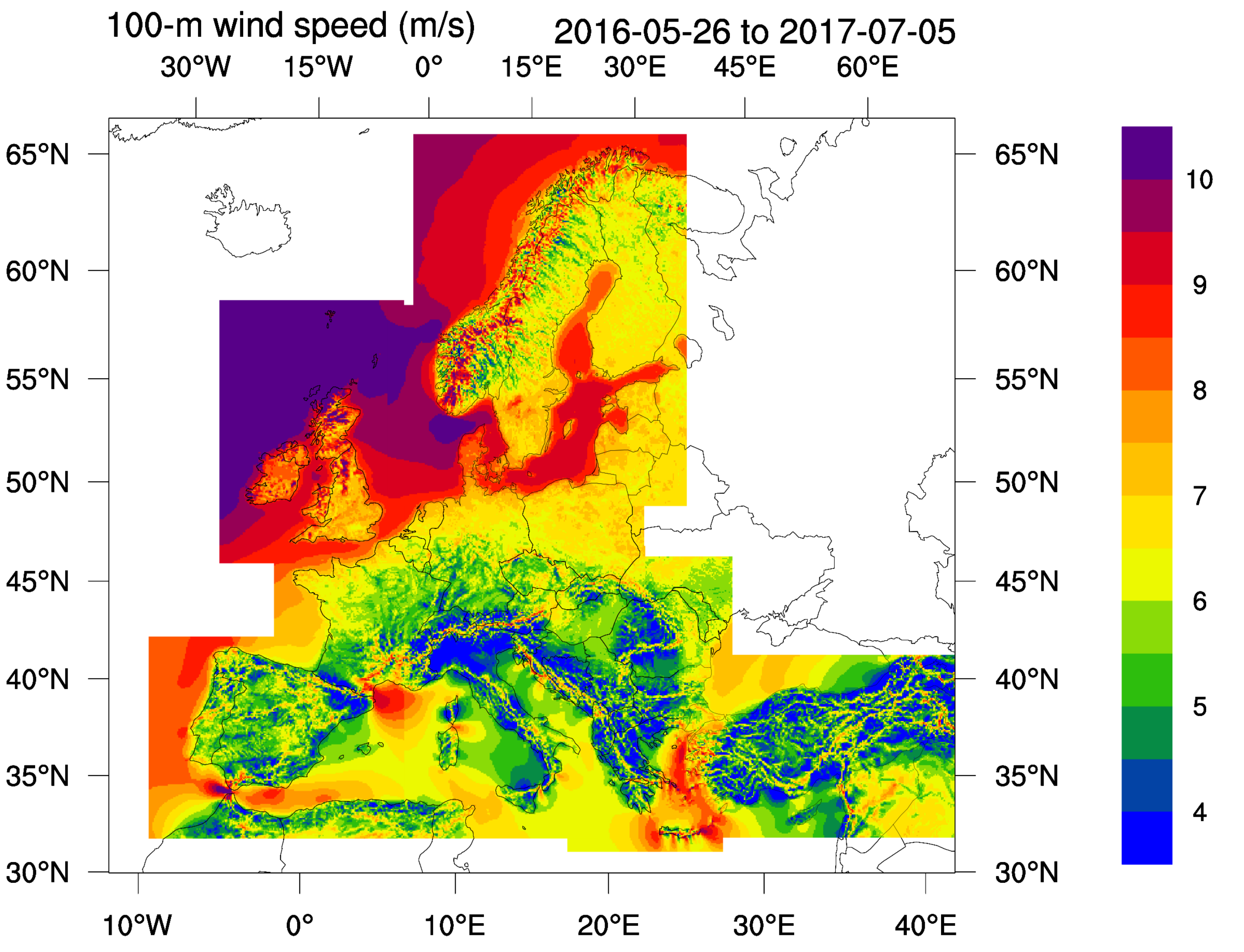
Find the optimal domain size and arrangement



First test of choices

4/26/2018

Mean wind speed at 100 m AGL



Phase0: Sensitivity experiments

Phase0: NEWA WRF sensitivity experiments

Objectives:

- Homogenize the expertise of the various participating groups
- Investigate model sensitivity and whether it is homogeneous across different European wind climates

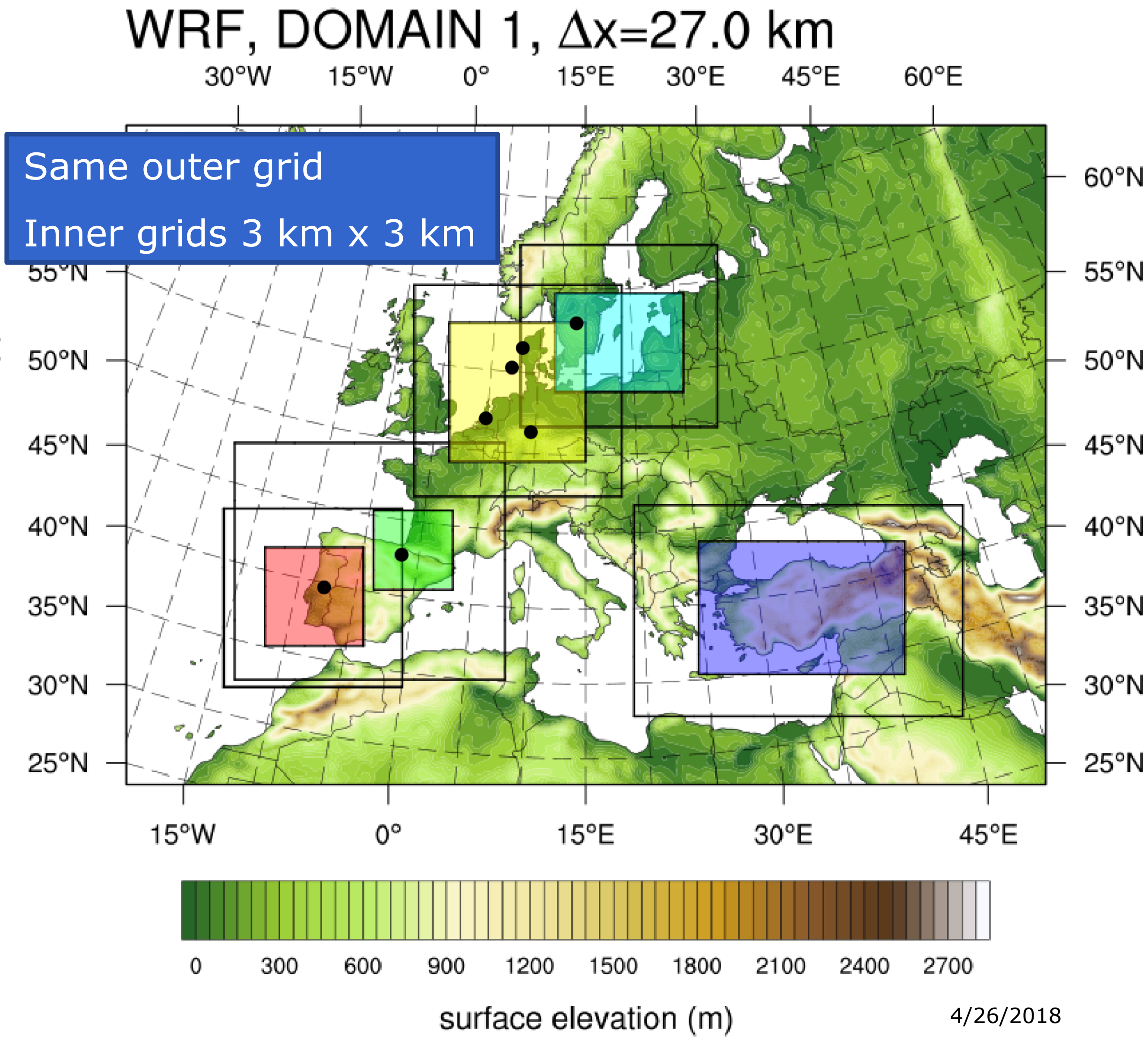
• Year-long (2015) simulations for five different regions in Europe

• Two PBL parameterizations and

• Two integration methods

PBL	Method
MYNN	36 hours simulation, 12 hours spin-up/
YSU	8 days simulation, 1 day spin-up, nudging D1

MYNN - daily	MYNN - weekly
YSU - daily	YSU- weekly

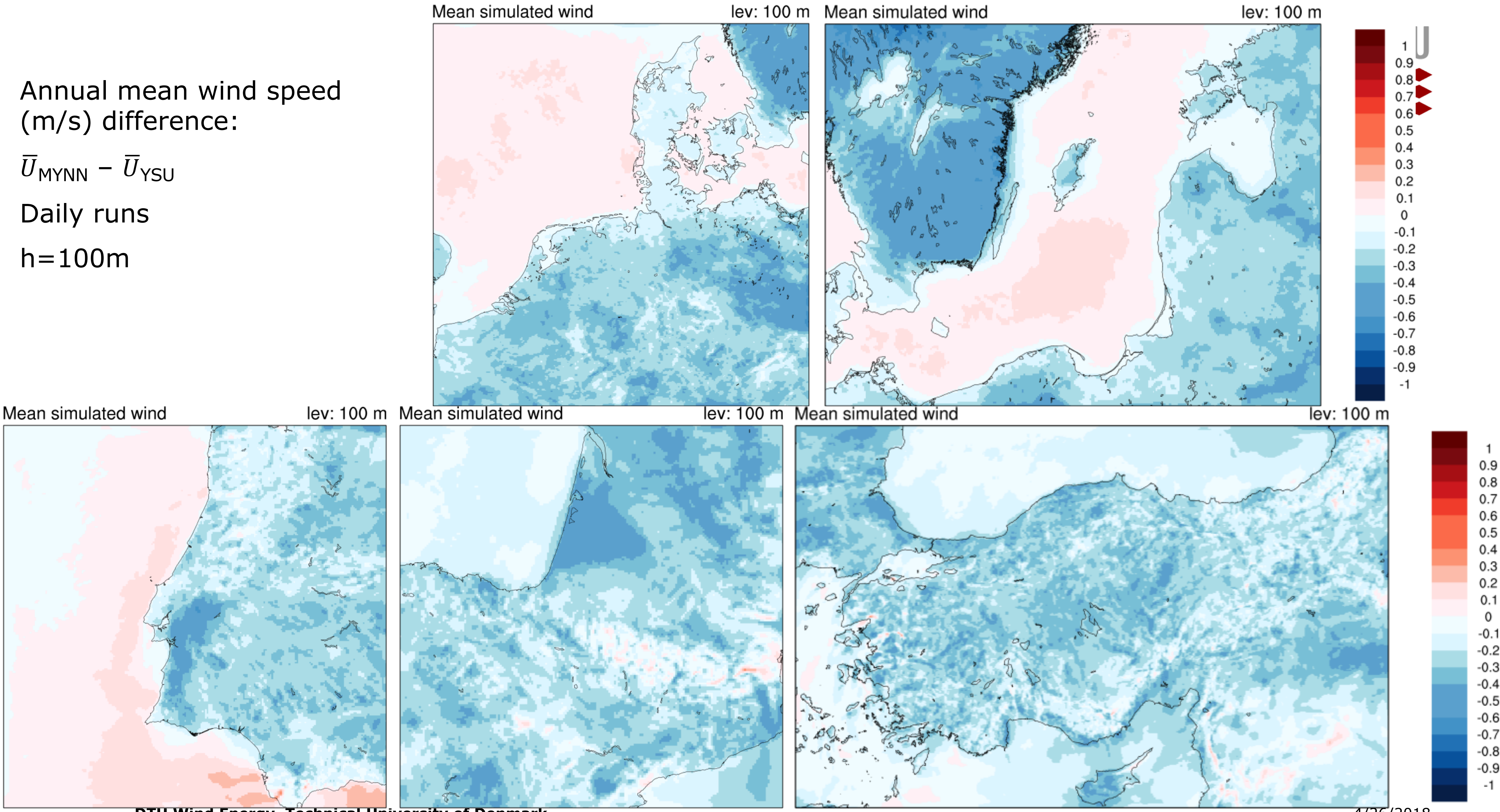


Annual mean wind speed (m/s) difference:

$\bar{U}_{\mathrm{MYNN}} - \bar{U}_{\mathrm{YSU}}$

Daily runs

h=100m



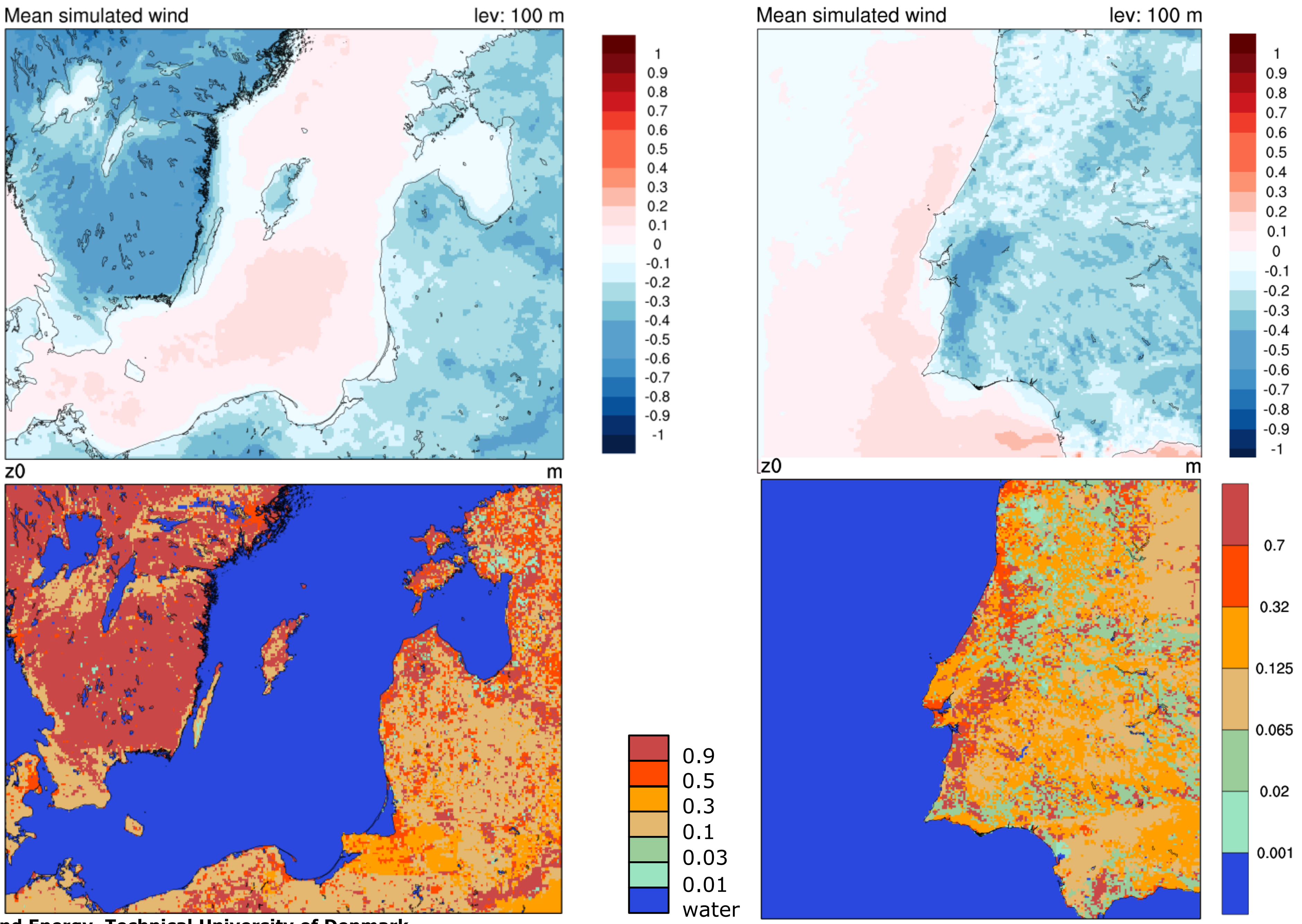
Annual mean wind speed (m/s) difference:

$\overline{U}_{\mathrm{MYNN}} - \overline{U}_{\mathrm{YSU}}$

Daily runs

h=100m

Surface roughness length (m)

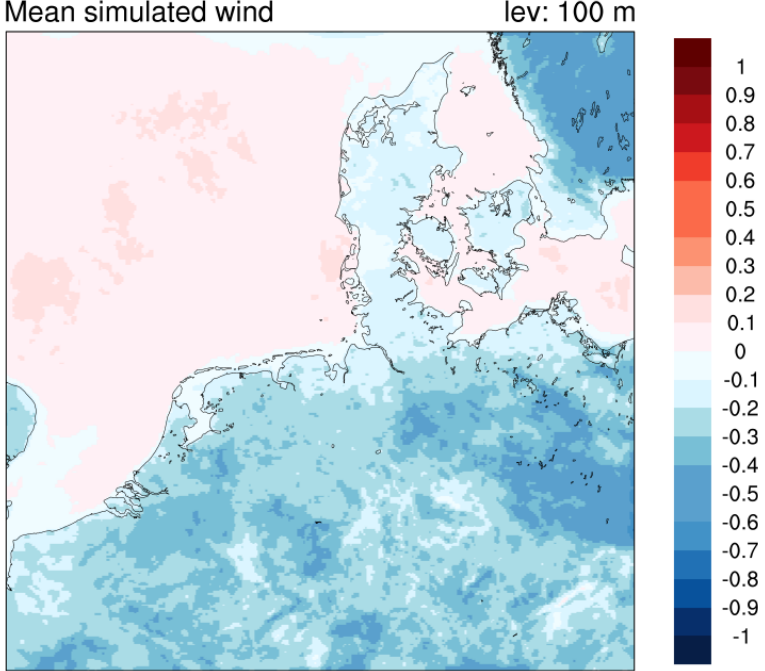


Annual mean wind speed (m/s) difference:

$\overline{U}_{\text{MYNN}} - \overline{U}_{\text{YSU}}$

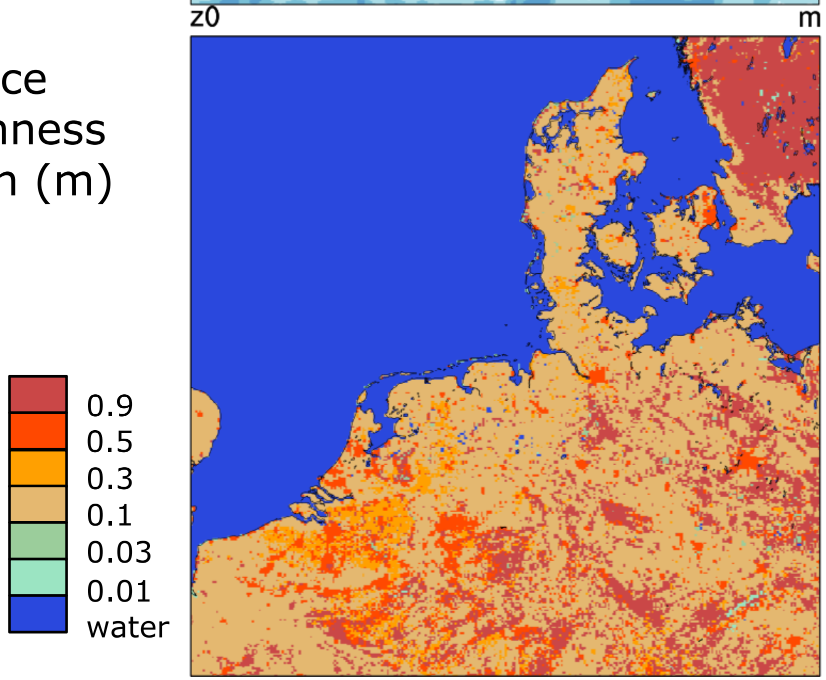
Daily runs

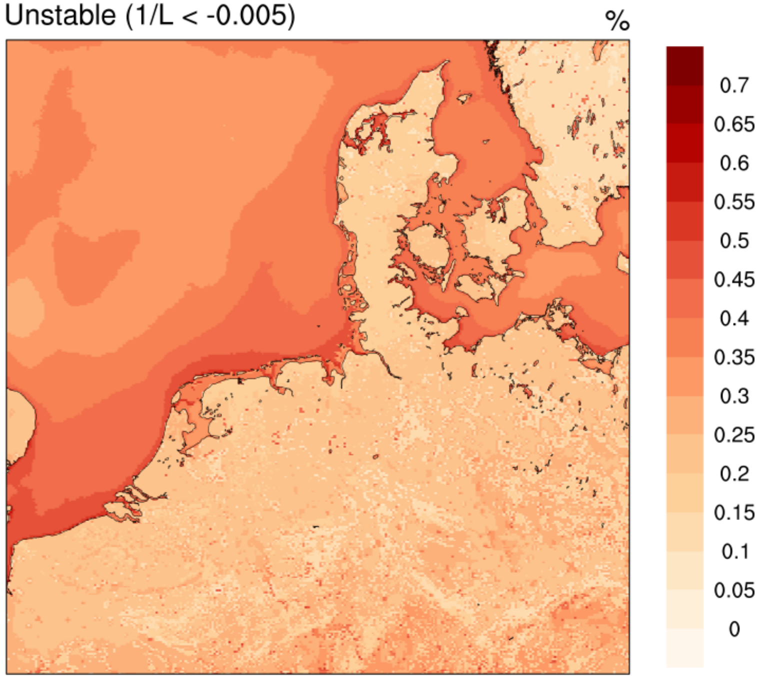
h=100m



Unstable fraction (%)

Surface roughness length (m)



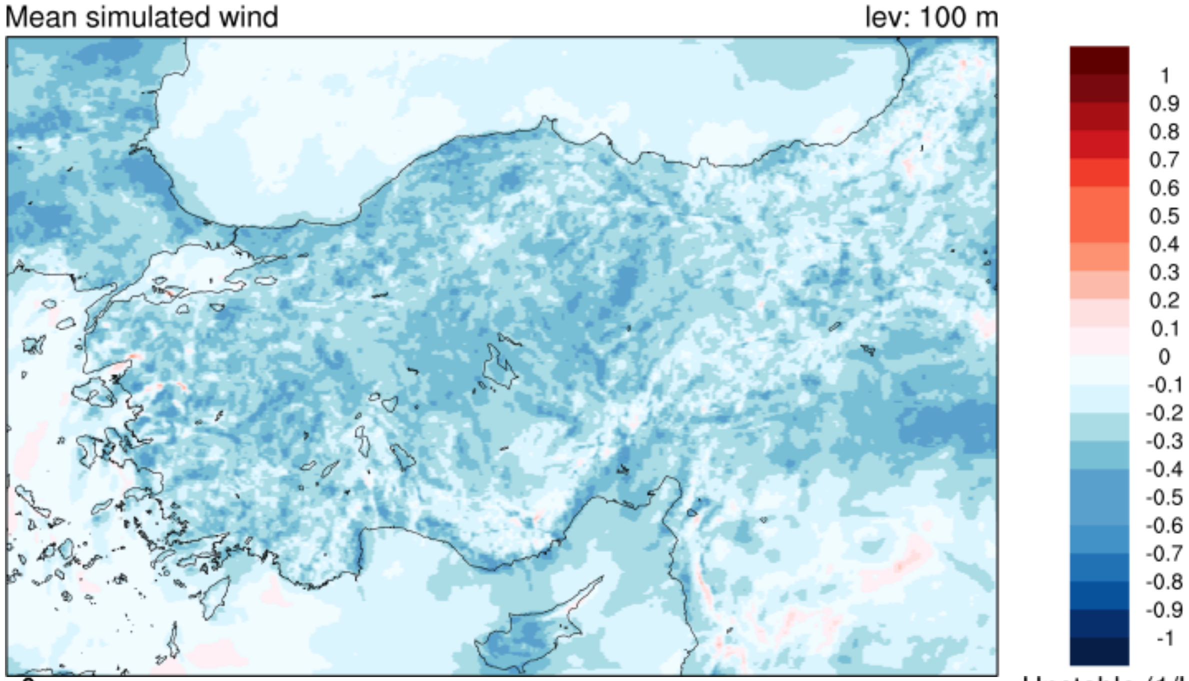


Annual mean wind speed (m/s) difference:

$\overline{U}_{\text{MYNN}} - \overline{U}_{\text{YSU}}$

Daily runs

h=100m



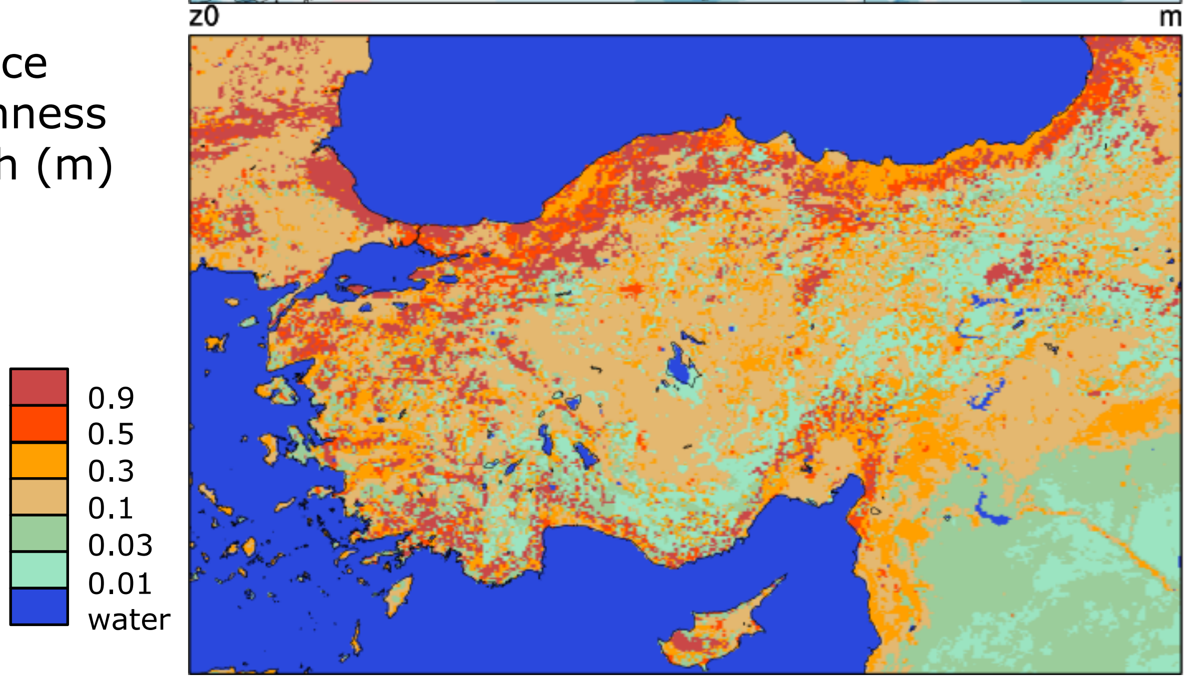
From Monin-Obukhov similarity theory:

$$U(z) = \frac{u_*}{\kappa}[\ln(z/z_0) - \psi(z/L)]$$

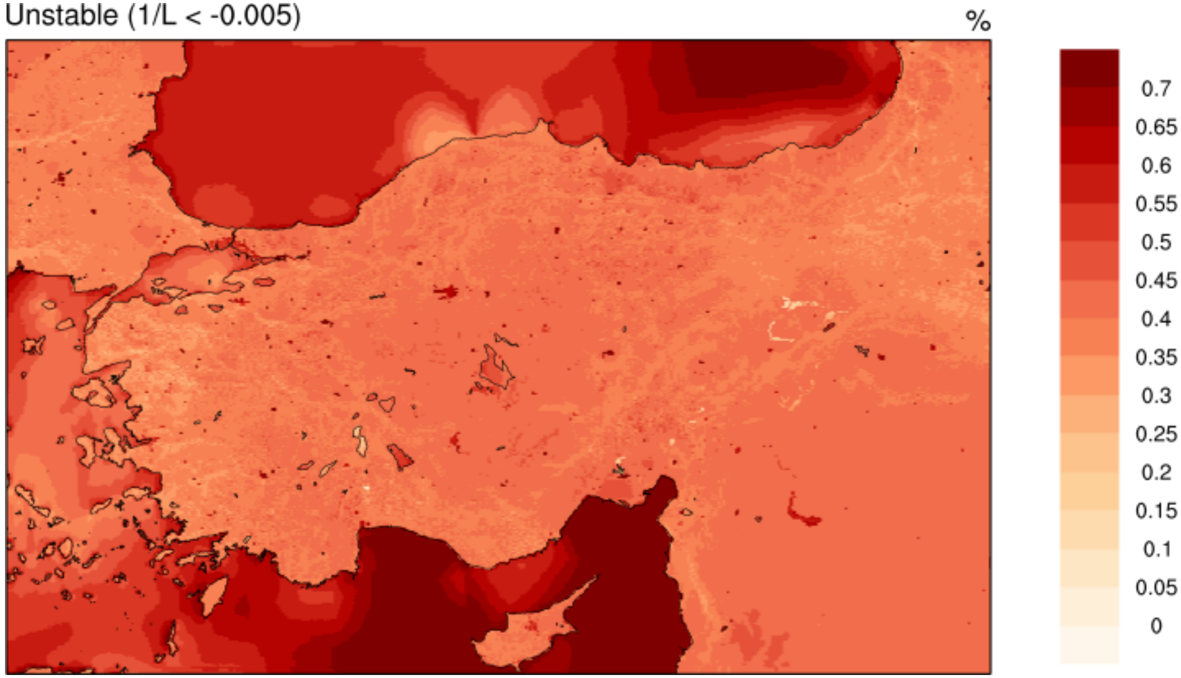
Wind shear is a function of surface roughness and atmospheric stability

Thus, the "first-order" response of the mean wind speed to the PBL scheme depends on z_0 and ${}^1/_L$

Surface roughness length (m)



Unstable fraction (%)



Phase1: Model evaluation

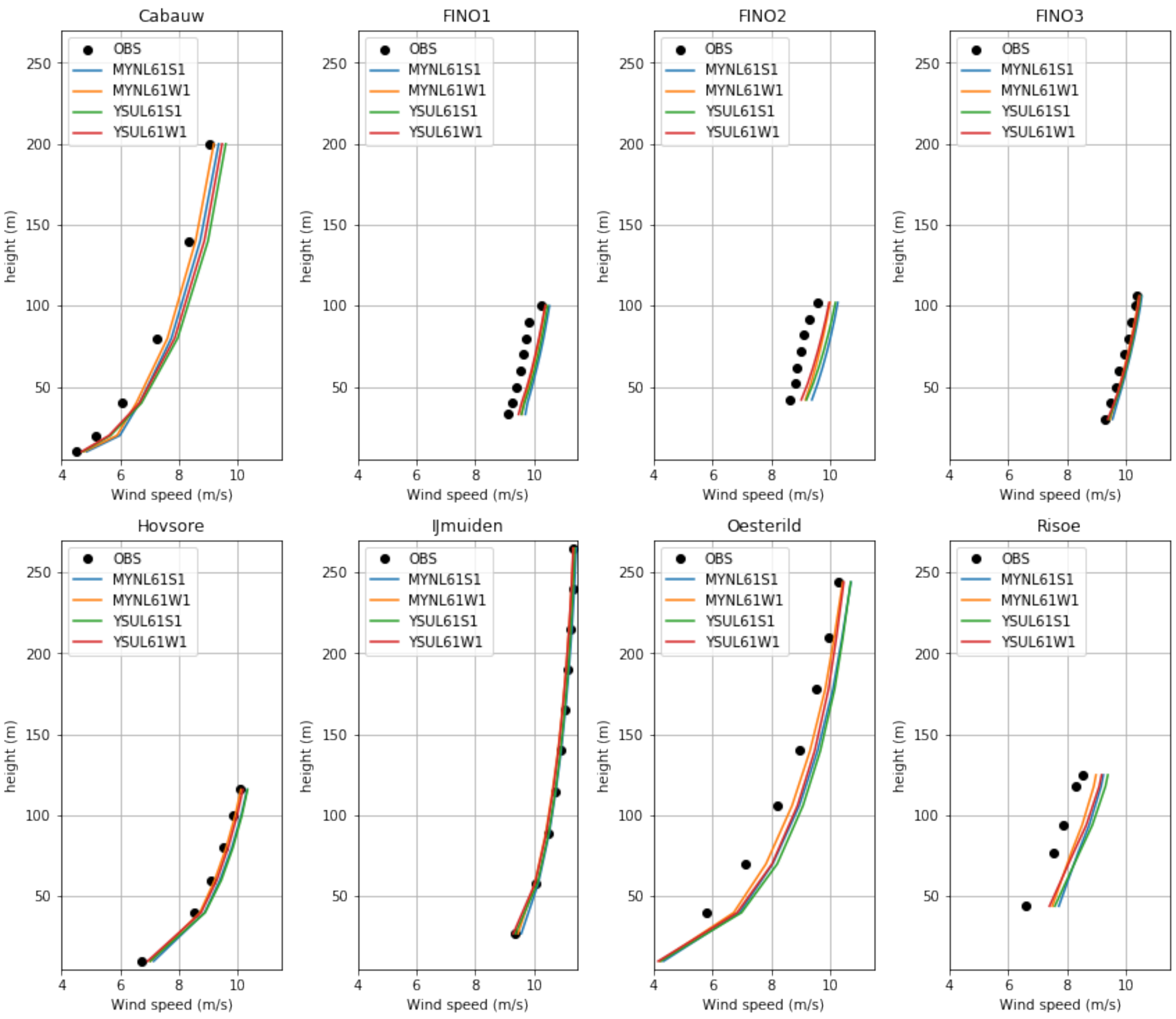
Phase1: Evaluation of sensitivity experiments

Table: Sites used in the wind speed verification

Site	Type	Heights (m AGL)
FINO1	Offshore	100, 90, 80, 70, 60, 50, 40, 33 m
FINO2	Offshore	102, 92, 82, 72, 62, 52, 42 m
FINO3	Offshore	106, 100, 90, 80, 70, 60, 50, 40, 30 m
Høvsøre	Coastal	116.5, 100, 80, 60, 40, 10 m
Risø	Land	125, 118, 94, 77, 44 m
Østerild	Land	244, 210, 178, 140, 106, 70, 40, 10 m
Cabauw	Land	200, 140, 80, 40, 20, 10 m
IJmuiden	Offshore	315, 290, 265, 240, 215, 190, 165, 140, 115, 89, 58, 27 m

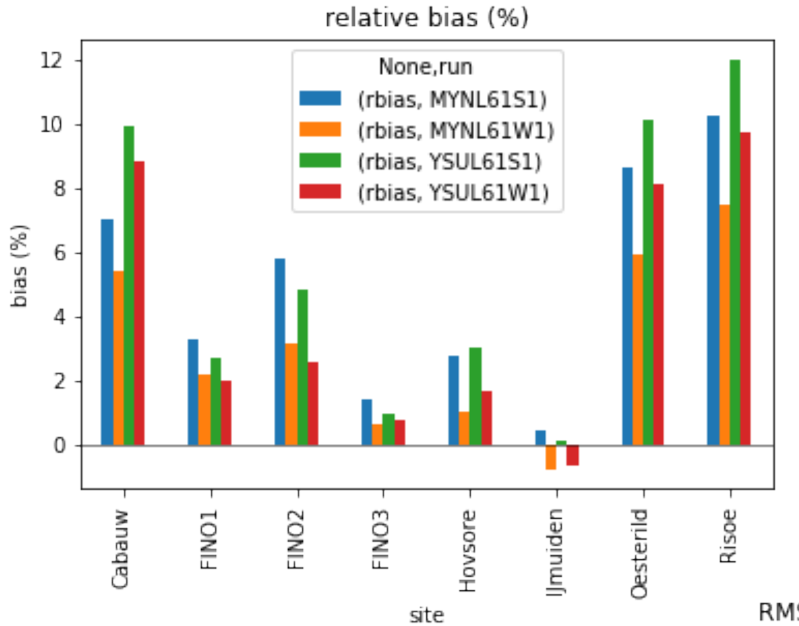
PBL	Method
MYNN	36 hours simulation, 12 hours spin-up/
YSU	8 days simulation, 1 day spin-up, nudging D1

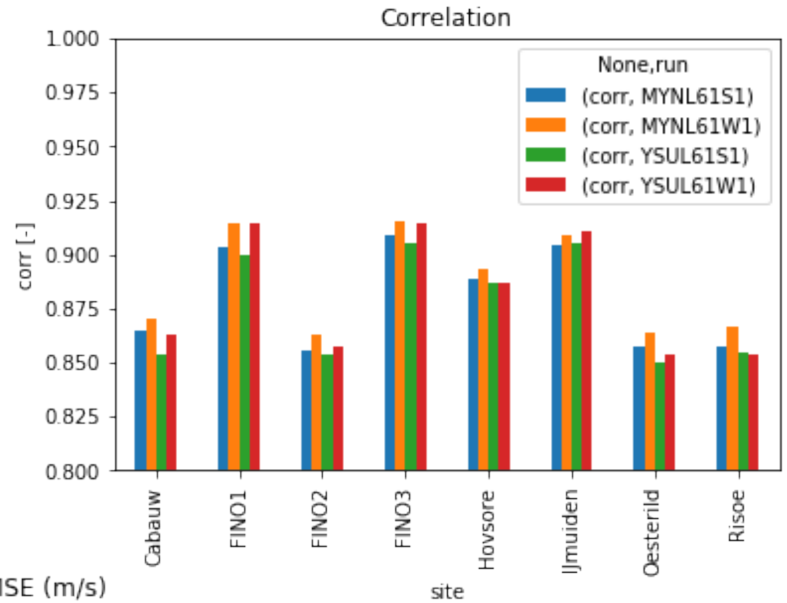
MYNN, daily MYNL61S1	MYNN, weekly MYNL61W1
YSU, daily MYNL61S1	YSU, weekly YSUL61W1



Phase1: NW WRF sensitivity experiments

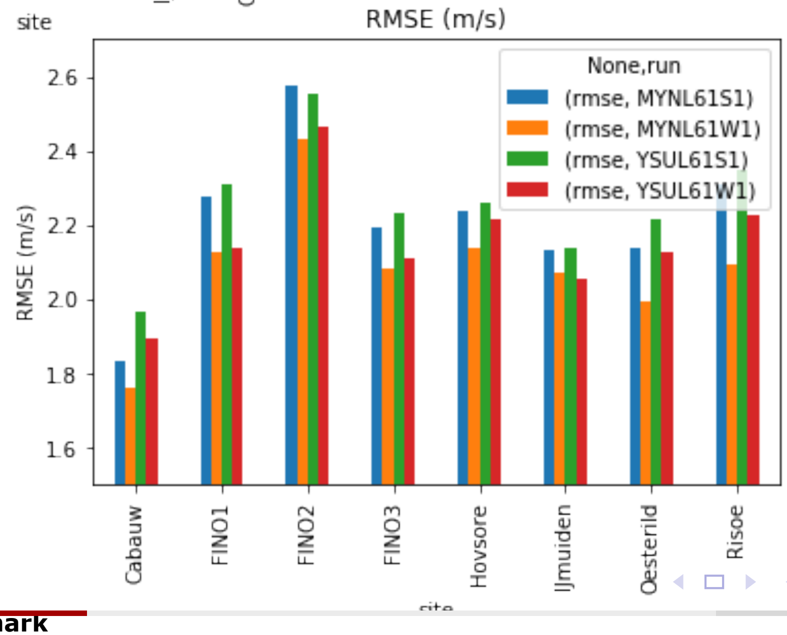
MYNN, daily MYNL61S1	MYNN, weekly MYNL61W1
YSU, daily MYNL61S1	YSU, weekly YSUL61W1





Summary statistics For 8 tall masts in the North Sea

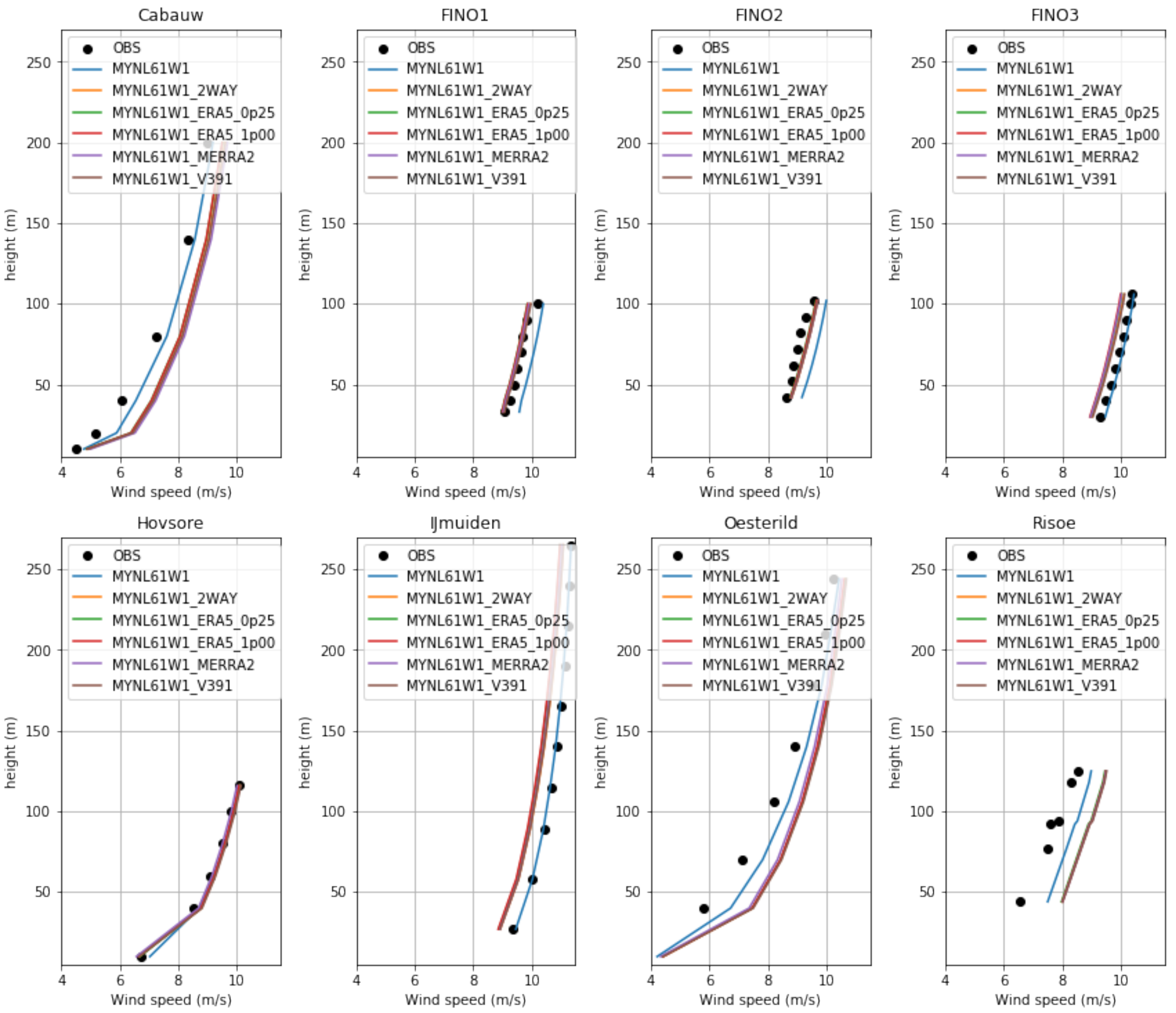
wind speed at ~100m



Best simulation, MYNN weekly runs, in terms of 100m mean wind speed and variability

Table: NW/MYNL61W1 si

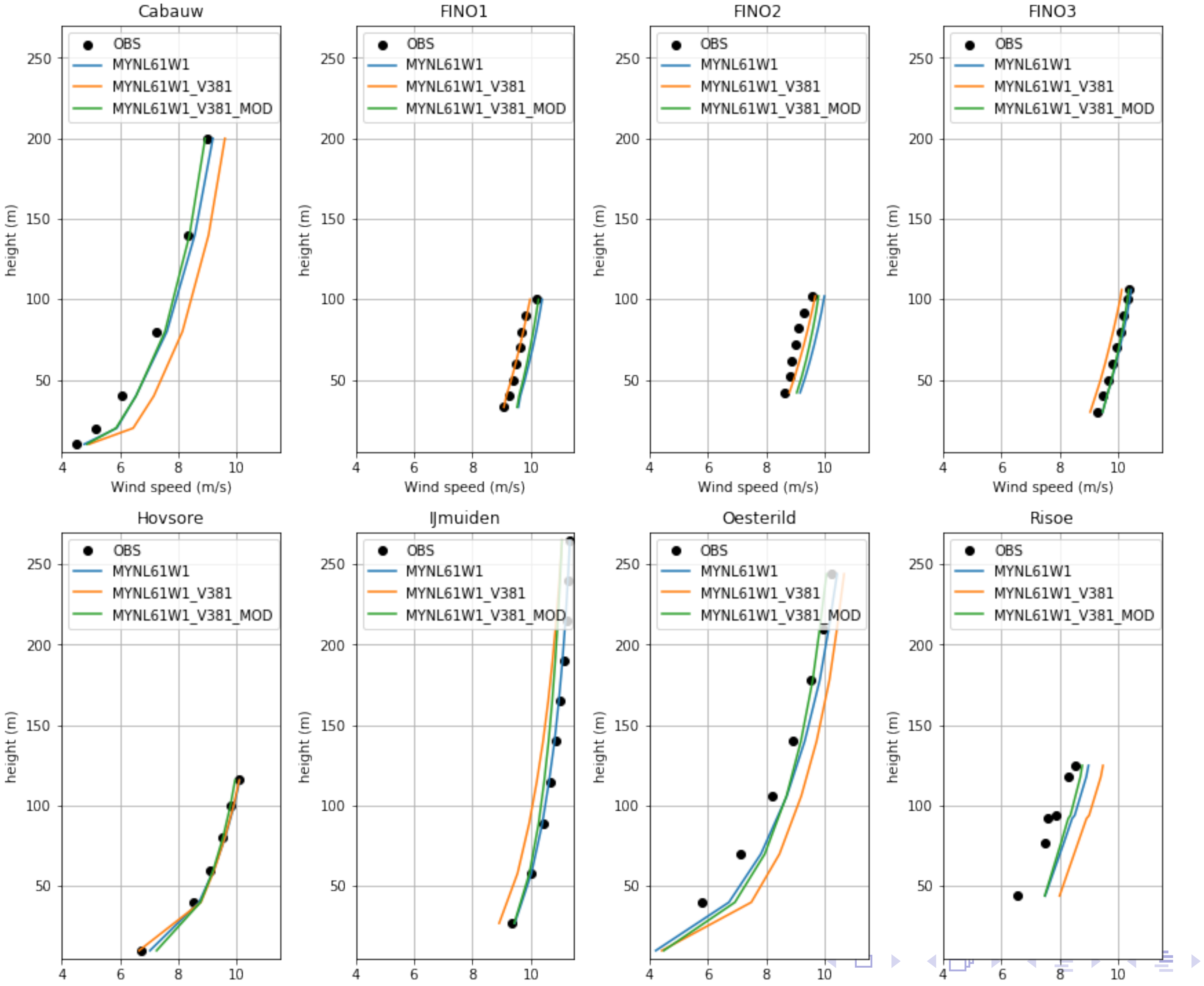
RUN name	version	note
MYNL61W1	3.6.1	cont
MYNL61W1_V381	3.8.1	sam
MYNL61W1_V391	3.9.1	sam
MYNL61W1_2WAY	3.8.1	two-
MYNL61W1_ERA_0p25	3.8.1	ERA
MYNL61W1_ERA_1p00	3.8.1	ERA
MYNL61W1_MERRA2	3.8.1	MEI



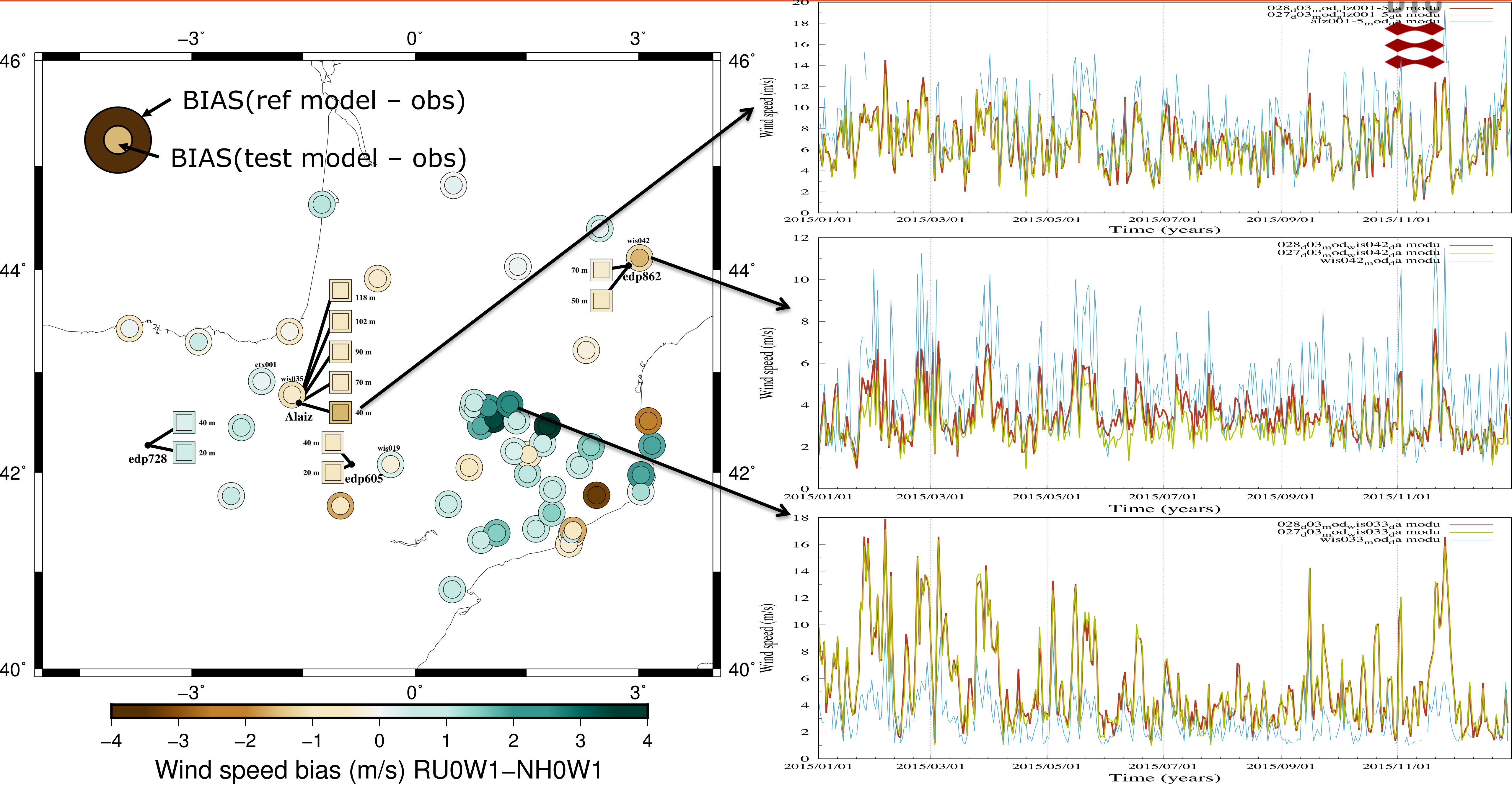
Main differences come from WRF V3.8.1 vs V3.6.1

New simulations

Fixes to WRF V3.8.1, bl_mynn_mixlength=0, COARE OPT=3.0 (sfc layer)

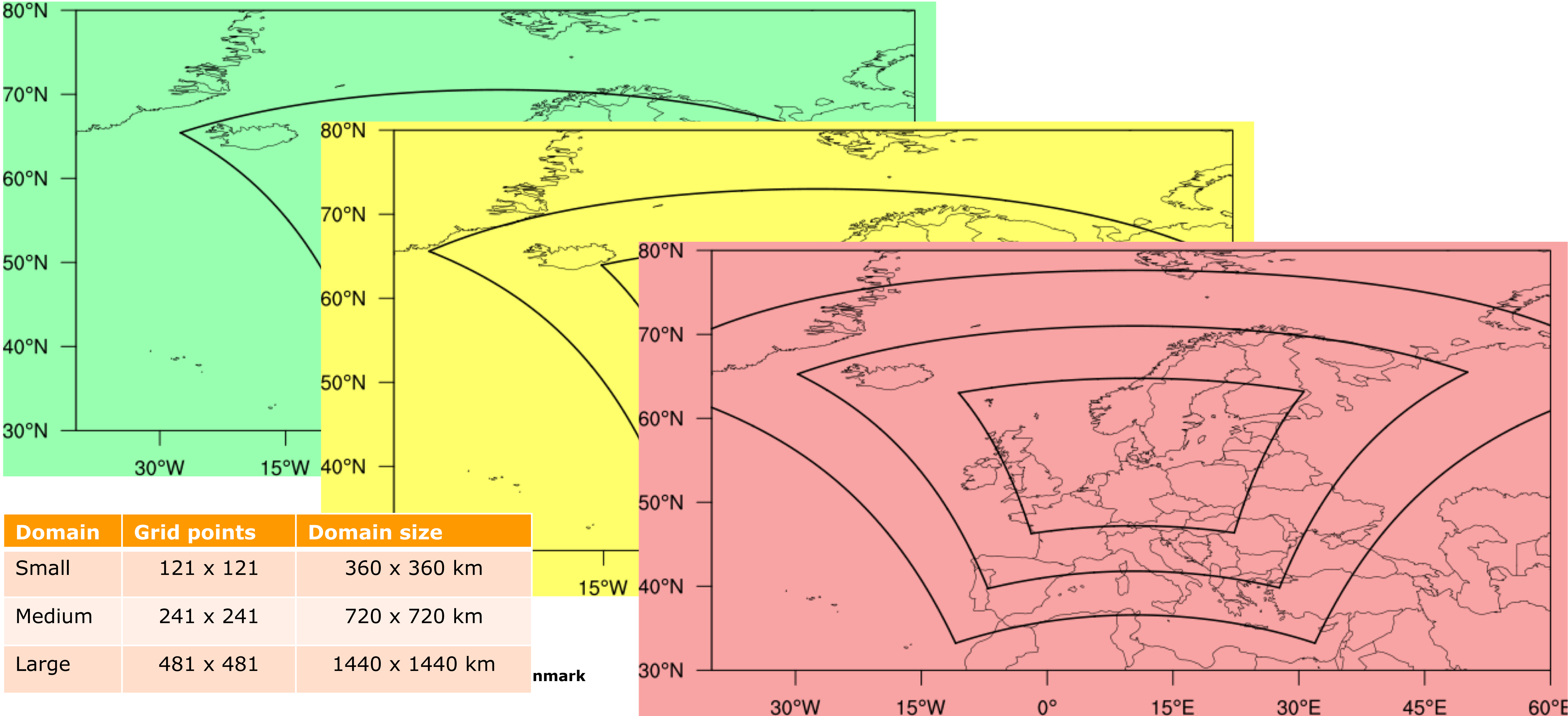


Validation of regional simulations: Temporal Variability



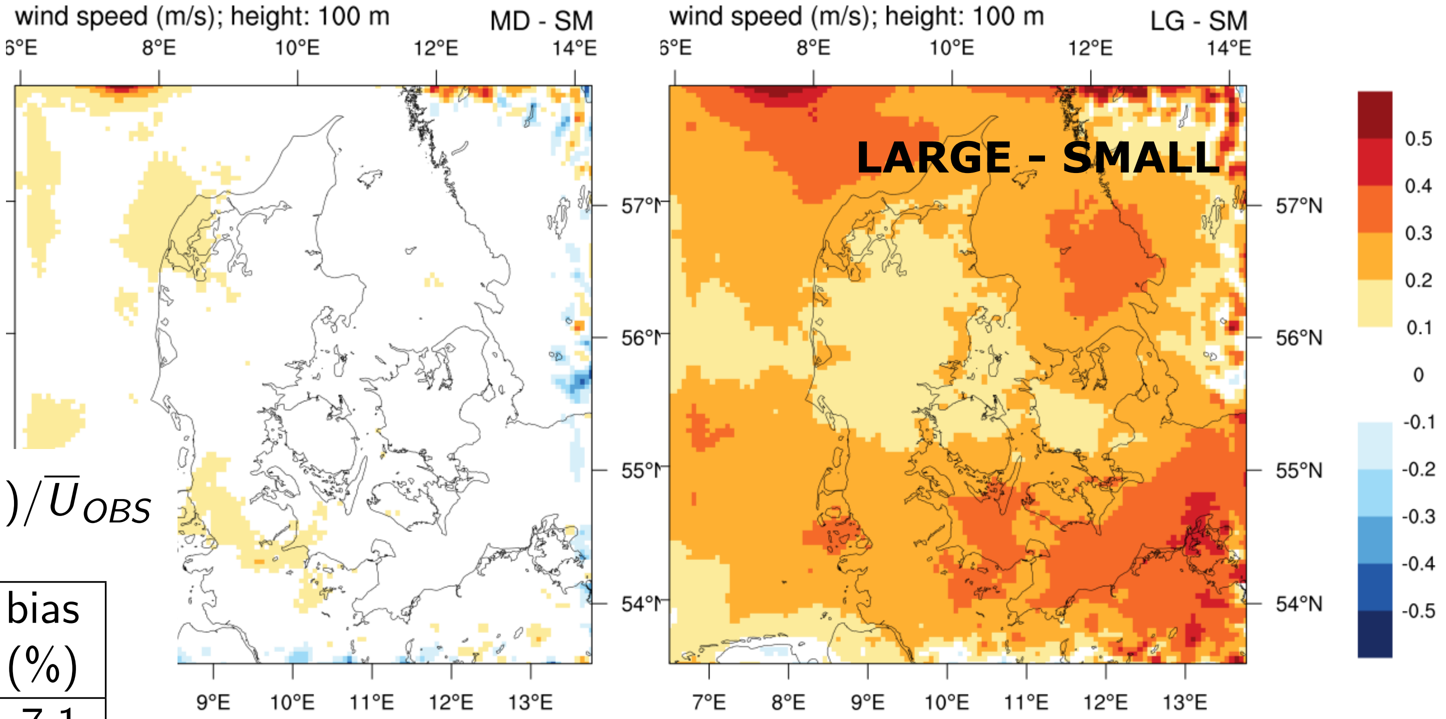
Phase2: Optimal domain size

Phase2: NEWA-Light experiments
What is the optimal size of the domains?



Domain	Grid points	Domain size
Small	121 x 121	360 x 360 km
Medium	241 x 241	720 x 720 km
Large	481 x 481	1440 x 1440 km

Difference from SM long simulations
Annual mean wind speed (m/s), Height: 100 m



Annual mean wind speed bias, $(\overline{U}_{WRF} - \overline{U}_{OBS})/\overline{U}_{OBS}$

site	height (m)	worst sim	bias (%)	best sim	bias (%)
FINO1	100	MD-D1	8.8	SM-L1	7.1
FINO2	102	LG-L1	13.5	SM-L1	9.3
FINO3	100	LG-L1	6.4	SM-L1	2.7
Høvsøre	100	LG-D1	3.2	SM-L1	0.7
Risø	94	LG-L1	10.1	SM-L1	6.8
Østerild	106	LG-L1	16.4	SM-L1	13.0

Smaller domains give better results

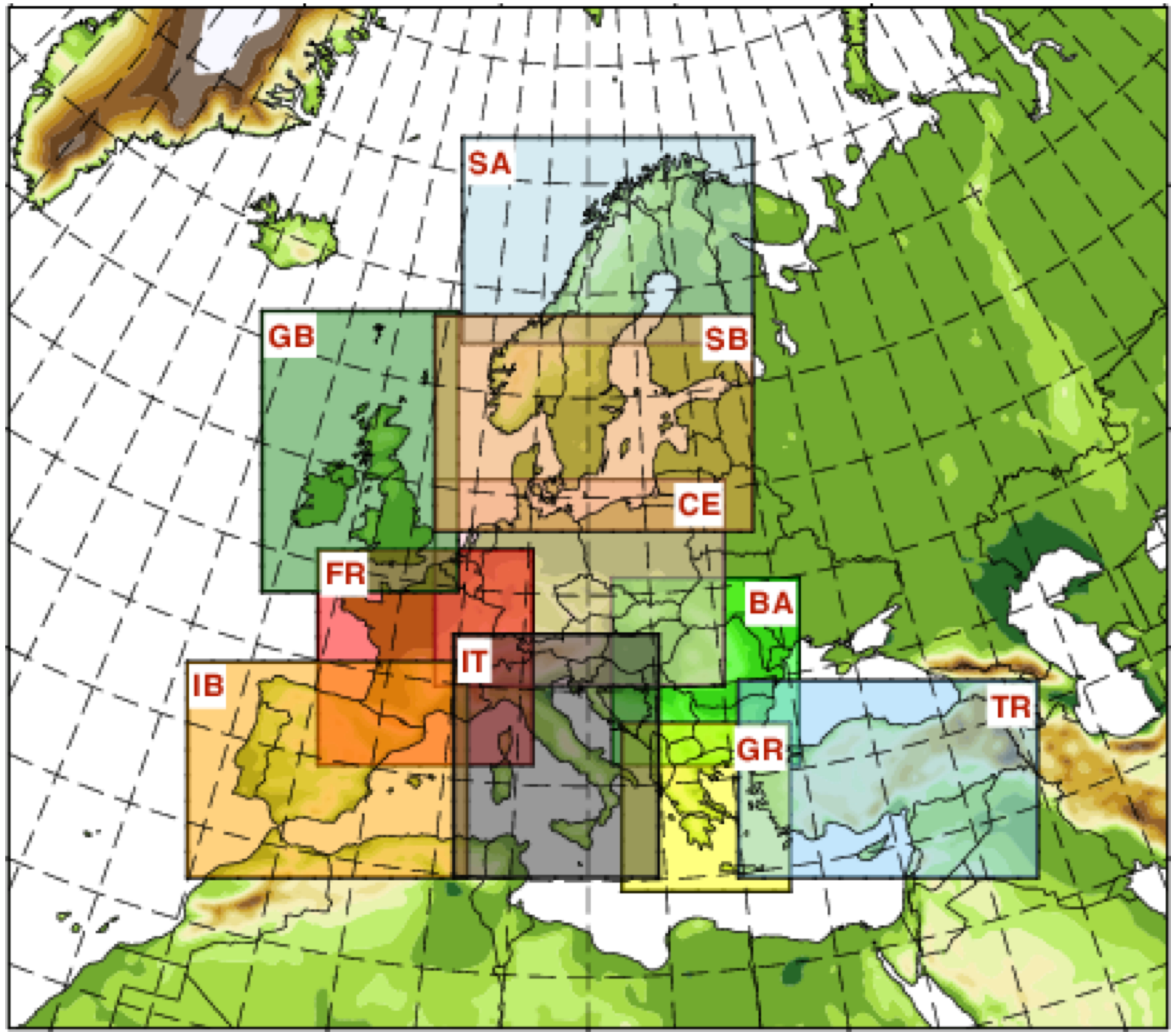
but

Is the location of the inflow conditions that is important?

Phase3: Beta production run

With this in mind…

- Common effort to start simulations waiting for the PRACE application response
- Ten domain NEWA light configuration
  - All domains share the same outer domain, so that the inner grids are coincidental
  - Each European country is contained solely within one domain, except for Sweden, Norway and Finland.
- 13 months (June 2016-June 2017) simulation for BA, FR, GR, IB, IT, SA, and TR at DTU
- 8 years for CE, 8 years for GB at Oldenburg
- 3 years for SB at DTU
- 1 year for IB at CIEMAT



Phase4: Planning for production run

- 56,700,000 CPU hours granted for the next year at BSC MareNostrum4

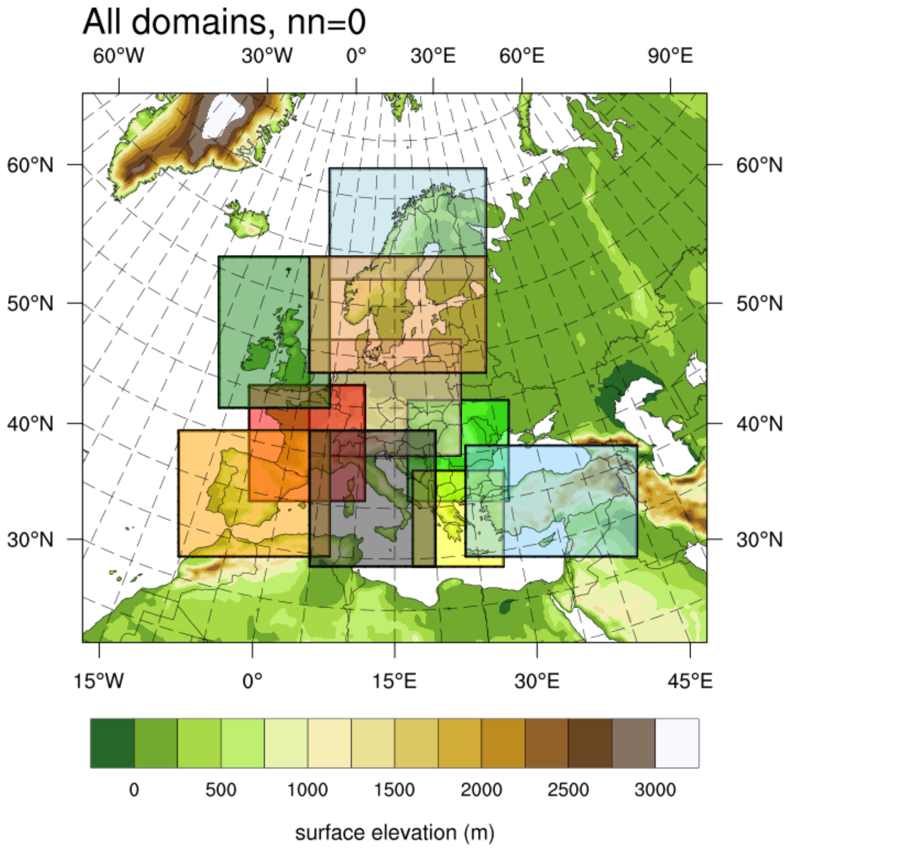


Table 2: Table showing the mesoscale fields and quantities to be served by NEWA.

Field	Quantity	Time interval means	Heights [m]
Power density	(long-term mean)	Static (all sector sum)	(10,50,75,100,150,200,250, 500
	Sectorwise frequency distribution	Static	10,50,75,100,150,200,250, 500
Horizontal winds	Long-term mean wind speed	Static	10,50,75,100,150,200,250, 500
	Sectorwise wind speed frequency distribution	Static	10,50,75,100,150,200,250, 500
	Sector frequency distribution (wind rose)	Static	10,50,75,100,150,200,250, 500
	Wind speed time series	30-min & 1-monthly	10,50,75,100,150,200,250, 500
	Wind direction time series	30-min & 1-monthly	10,50,75,100,150,200,250, 500
Roughness length	Long-term mean value		Surface
Surface elevation	Long-term mean value		Surface
Friction velocity	Time series	30-min & 1-monthly	
Air temperatur e	Long-term mean	Static	2,50,75,100,150,200,250, 500
	Time series	30-min & 1-monthly	2,50,75,100,150,200,250, 500
Air pressure	Long-term mean	Static	Surface
	Time series	30-min & 1-monthly	Surface
Air density	Long-term mean	Static	Surface
	Time series	30-min & 1-monthly	Surface
sTurbulenc e intensity (TKE as proxy)	Long-term mean	Static	50,75,100,150,200,250, 500
	Time series	30-min & 1-monthly	50,75,100,150,200,250, 500
Specific humidity	Long-term mean	Static	
	Time series	30-min & 1-monthly	Surface layer
Inverse M-O length	Long-term mean	Static	
	Time series	30-min & 1-monthly	Surface layer
Boundary layer height	Long-term mean	Static	-
	Time series	30-min & 1-monthly	-