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Mesoscale simulation of open cellular convection: roles of model resolutions and physics parameterizations

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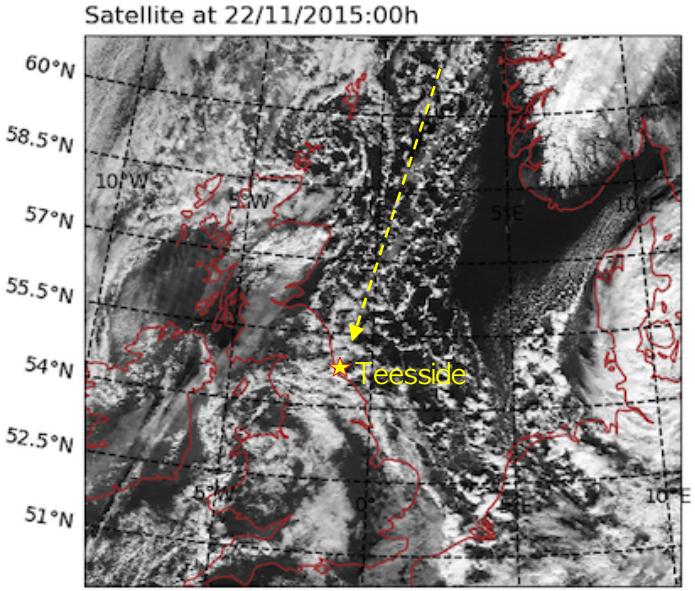
Motivation

The passage of OCC over the Teesside offshore wind farm



Open cellular convection (OCC) is a common phenomenon over the North Sea, where it often associates with the cold air outbreak and appears as honey comb-like pattern in cloud images.

The OCC is accompanied by large fluctuations of wind speed with a short time scale of minutes to hours.

Such fluctuations contribute significantly to the wind speed variability over the wind farms and greatly affect the wind energy operations.

Thus, reliable numerical simulations and forecasts of OCC events have great importance for offshore energy.

Question: can mesoscale model simulate the OCC and how reliable is it?

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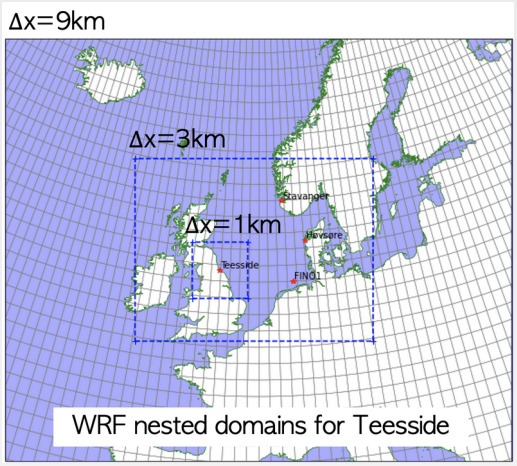
Experiment design

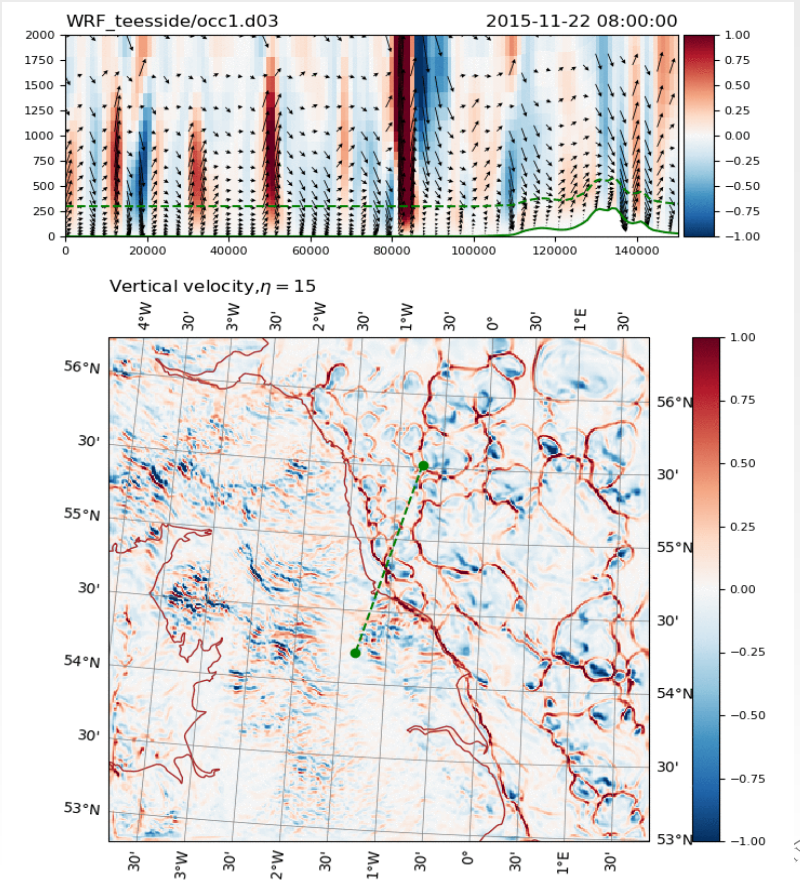
The Weather Research and Forecast (WRF) model, ARW-4.3



Physics sensitivity experiments

	Boundary layer	Microphysics	Radiation
CTRL:	MYNN2	New Thompson	RRTMG
	Bl01: YSU	Mp02: Lin et al.	Ra01: Dudhia
	Bl02: MYJ	Mp04: WSM5	Ra02: Old Goddard
	Bl04: QNSE	Mp06: WSM6	Ra03: CAM
	Bl06: MYNN3	Mp07: Goddard	Ra05: New Goddard
	Bl07: ACM2	Mp10: Morrison	
	Bl08: BouLac	Mp13: YBU-YLin	
	Bl09: UW	Mp14: WDM5	
	Bl10: TEMF	Mp16: WDM6	

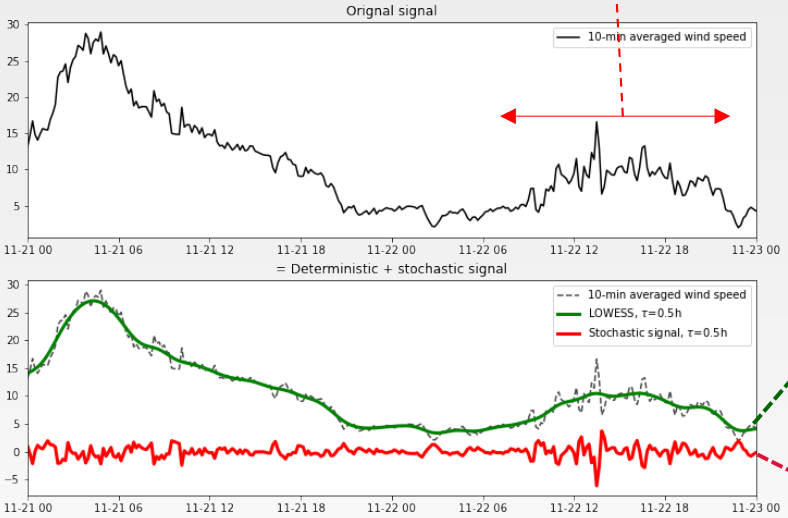
Others: ERA5+Ostia data, Tiedtke cumulus (d01), Noah LSM



An example of OCC simulation (1km domain): vertical (top) horizontal (bottom) cross-sections

Verification method

The passage of OCC



Wind speed at 50m from Teesside's wind mast

Total signal

=

Deterministic (mean) signal*

→ **Correlation**, **RMSE**

+

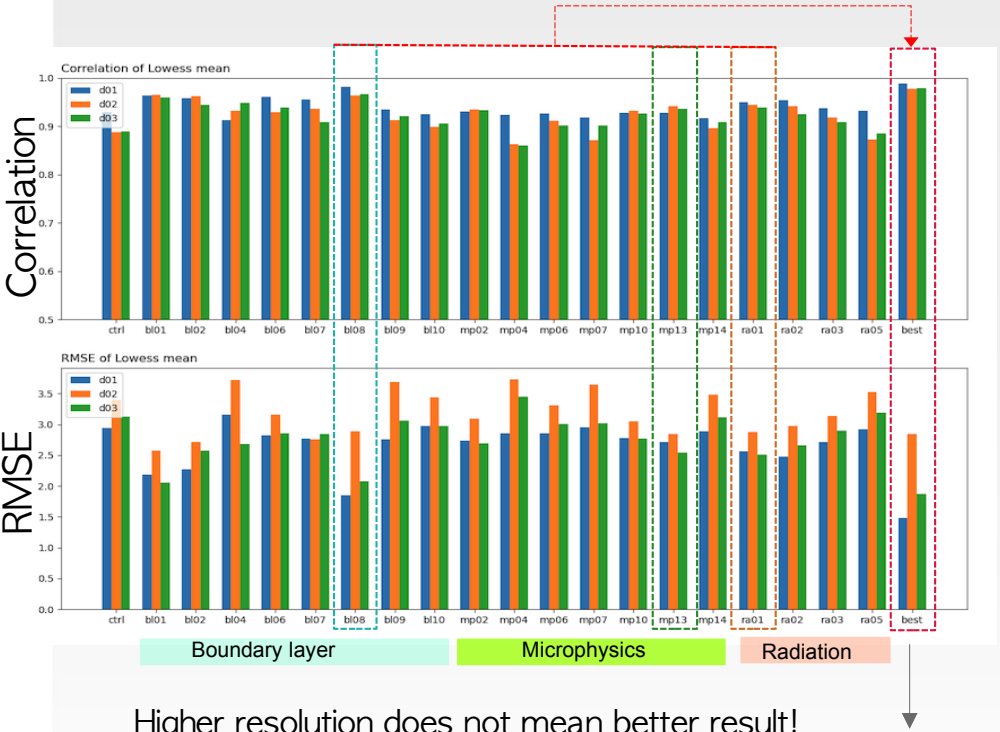
Stochastic (OCC) signal

→ **Standard deviation**

* The deterministic signal is computed use the locally weighted scatterplot smoothing (**LOWESS**) method

Result

Deterministic aspect

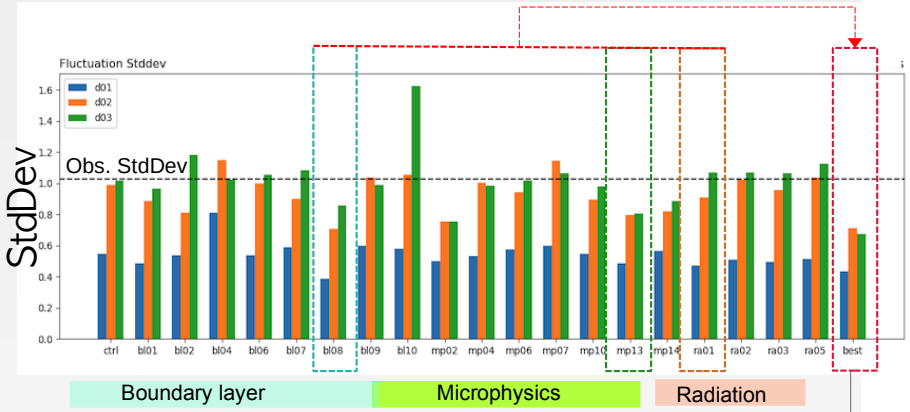


Higher resolution does not mean better result!

Combination of best schemes in each group? → Best overall!

bl: BouLac,
mp: YBU-YLIN
ra: Dudhia

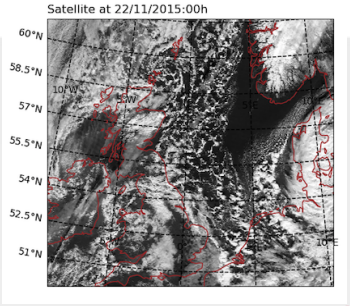
Stochastic aspect



"Best" has the worst variation!

Sensitive to model resolution

Result

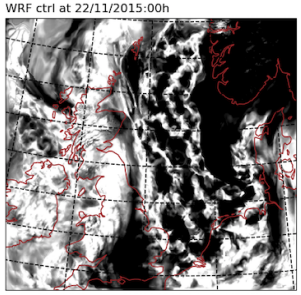


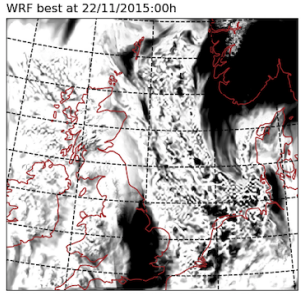
A better compromisation?
(pbl: UW, mp: ACM2; ra: Dudhia)

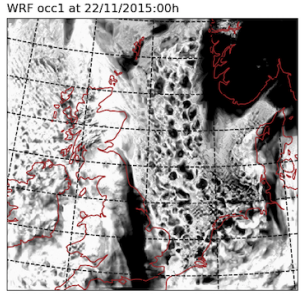
CTRL

"Best"

Low cloud fraction





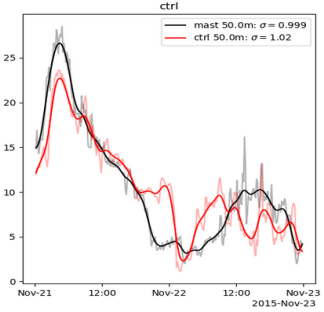


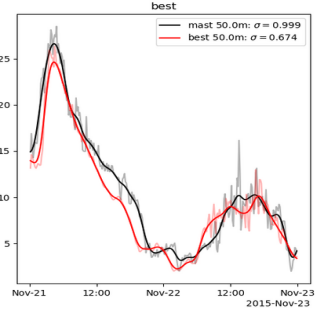
Too coarse!

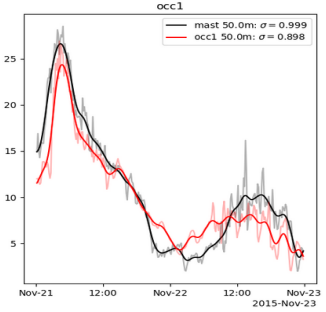
Too fine !

Better representation

Wind speed at 50m







Damped variation

Better variation

Take home message:

- Fine resolution is needed to simulate the OCC fluctuation
- The physics parameterizations play the key role and must be careful selected.
- **Dilemma:** A combination might lead to a better result in the deterministic senses, but worsen the variation. A compromisation may be needed.

Acknowledgement

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