Evaluation of a dynamical downscaling of ERA5 with COSMO-CLM for the North Sea at kilometer-scale resolution

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Nicole Van Lipzig
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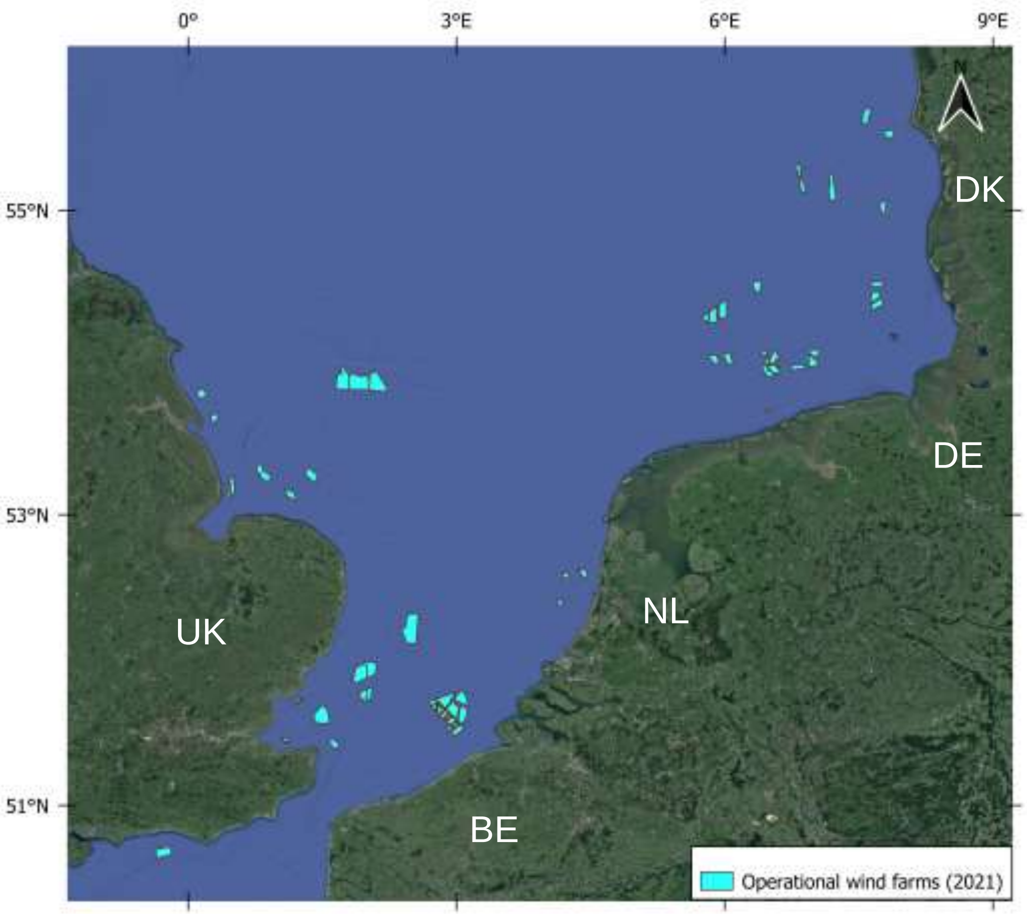
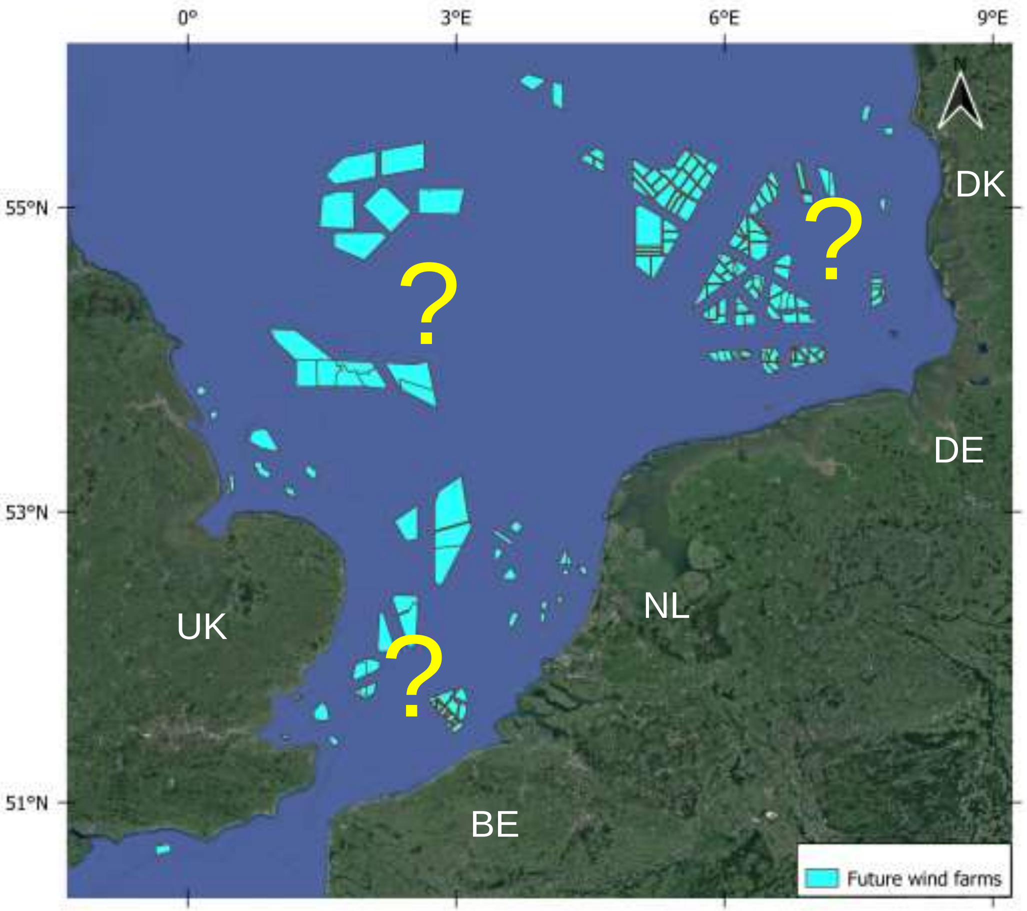
Research context





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Research context

- Long-term characteristics and uncertainty of the wind climate are crucial and most valuable at a high spatio-temporal resolution.

- Farm density increases, so array- and cluster-scale wake deficits influence neighbouring wind farm arrays and clusters.

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- Long-term characteristics and uncertainty of the wind climate are crucial and most valuable at a high spatio-temporal resolution.

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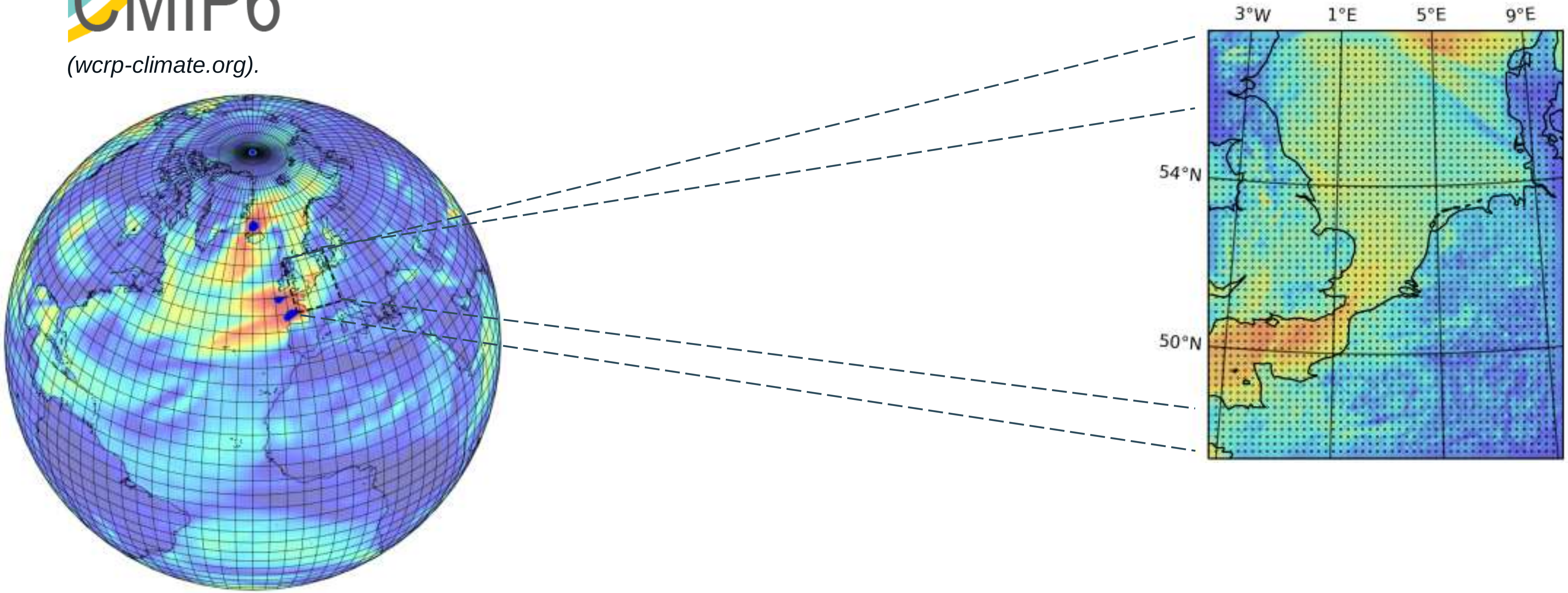
The approach

CMIP6

(wcrp-climate.org).

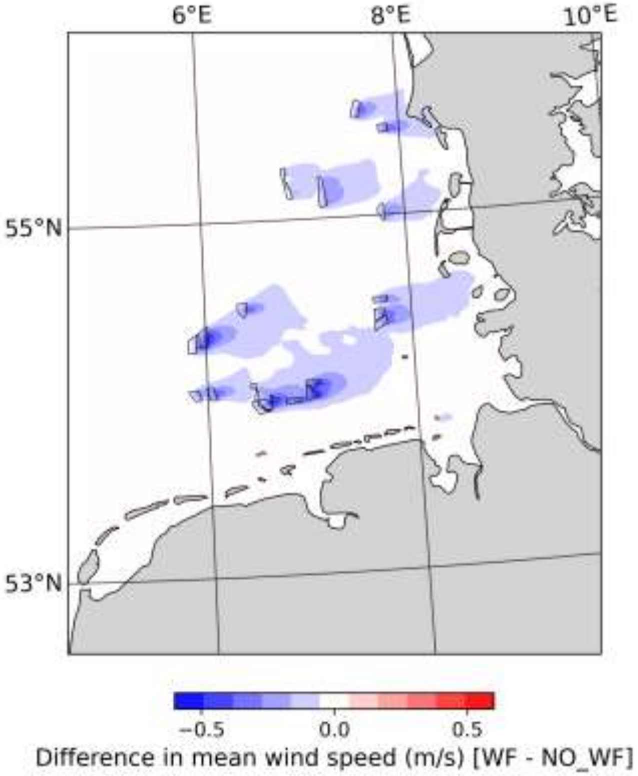
COSMO-CLM



But why such a high spatial resolution?

The land-sea transition: better representation of the coastal regions in the domain, and by extension also the coastal gradients.

The windfarm parametrization: Take into account the subgrid-scale interactions between wind turbines and the atmosphere (CCLM_wf).



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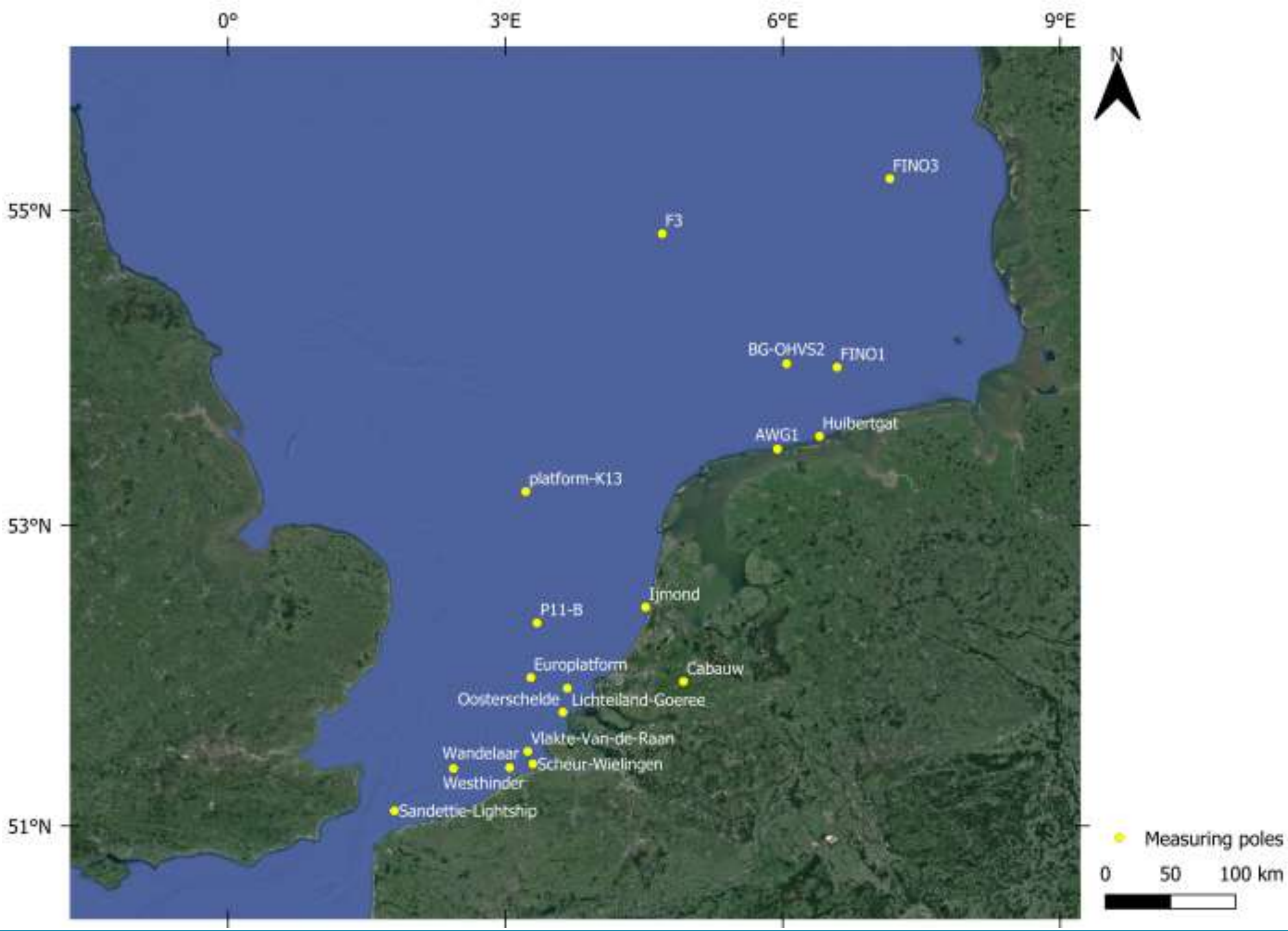
Model validation

In-situ data

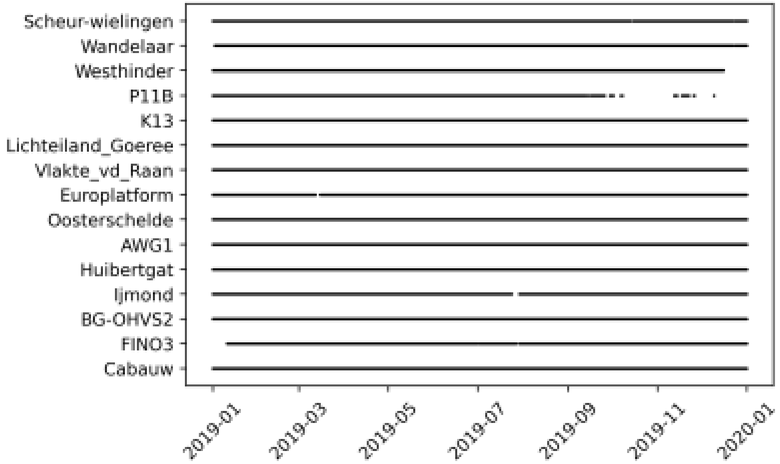


Scatterometer data

(ESA).

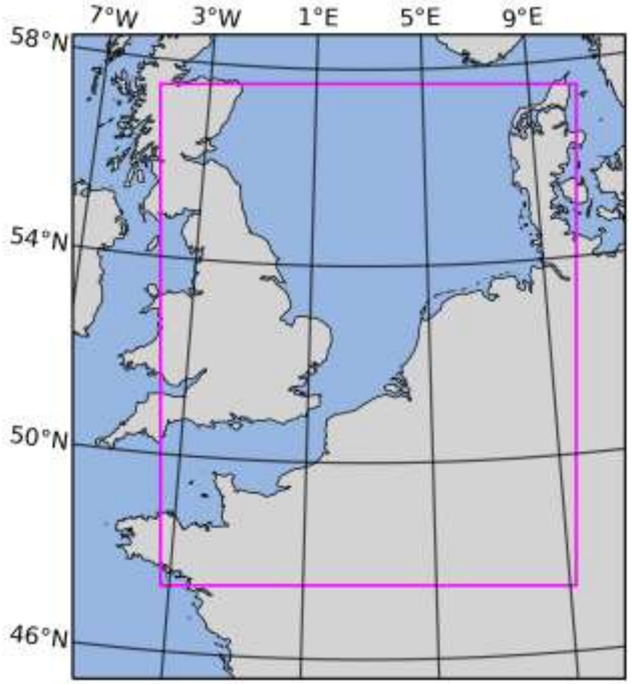
- ASCAT sensor on MetOp-satellites
- 12.5 or 25km spatial resolution
- (sub-)daily instantaneous 10m wind speed values
- Uncertainty on climatological mean: around 0.1 m/s

CCLM simulation for 2019



General model setup:

- Horizontal resolution: 2.8km (0.025°)
- Vertical resolution: 61 levels
- Hourly boundary updates from ERA5
- No spectral nudging



Parametrizations:

- Shallow convection scheme (reduced Tiedtke)
- 1D TKE-based diagnostic turbulence scheme (itype_turb = 3)
- No wind farm parametrization

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CCLM simulation for 2019

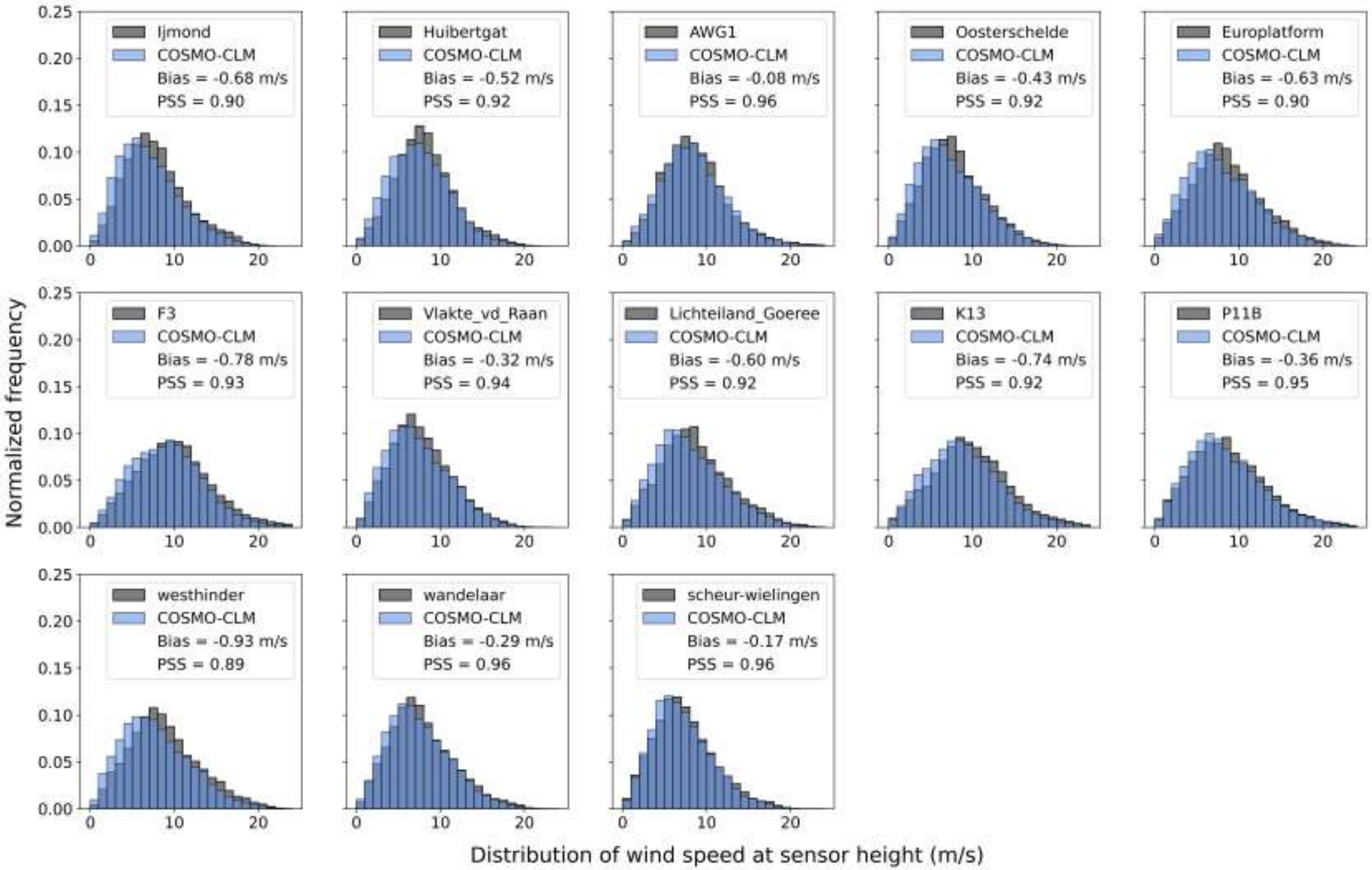
Comparison of output with in-situ data:

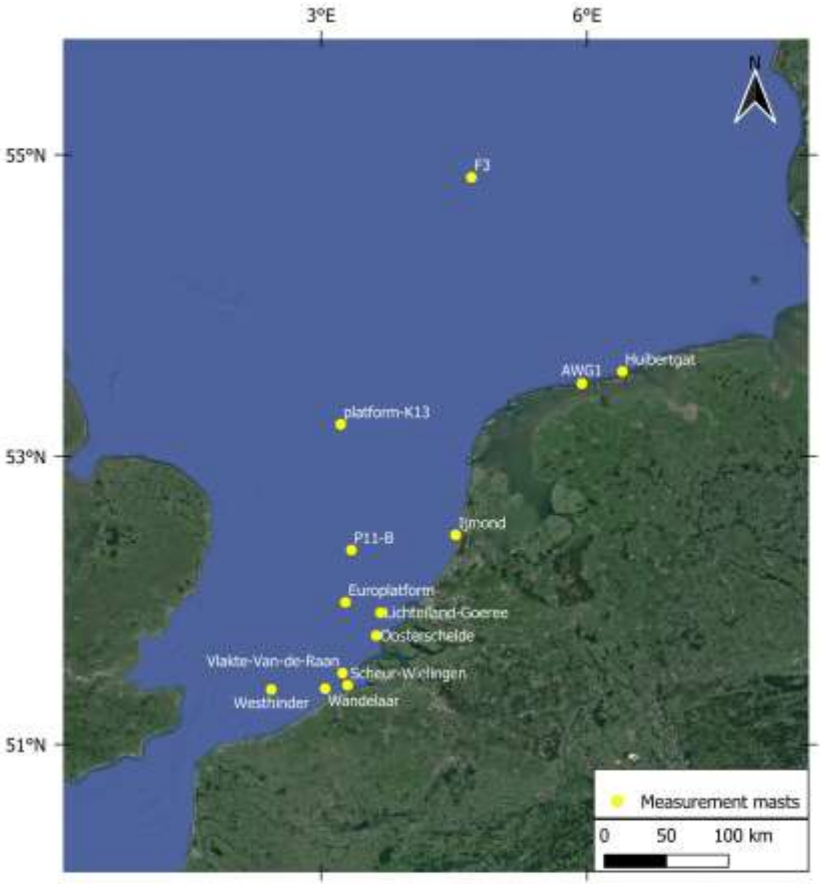
- U,V every 10 min at [10m, 30m, 50m, 70m, 90m, 110m, 130m] above the surface (MSL above water)
- Shear-informed extrapolation of model output to sensor height using the power law relationship (HL = height level):

$$\boldsymbol{V}_{h_{sensor}} = \boldsymbol{V}_{h_{HL}} * \left(\frac{h_{sensor}}{h_{HL}}\right)^{\alpha}, \; with\ \alpha = \frac{\ln\left(\frac{\boldsymbol{V}_{h_{HL+1}}}{\boldsymbol{V}_{h_{HL}}}\right)}{\ln\left(\frac{h_{HL+1}}{h_{HL}}\right)}$$

- 10min nearest-gridbox values are compared to 10min averages from the measurement mast

CCLM simulation for 2019





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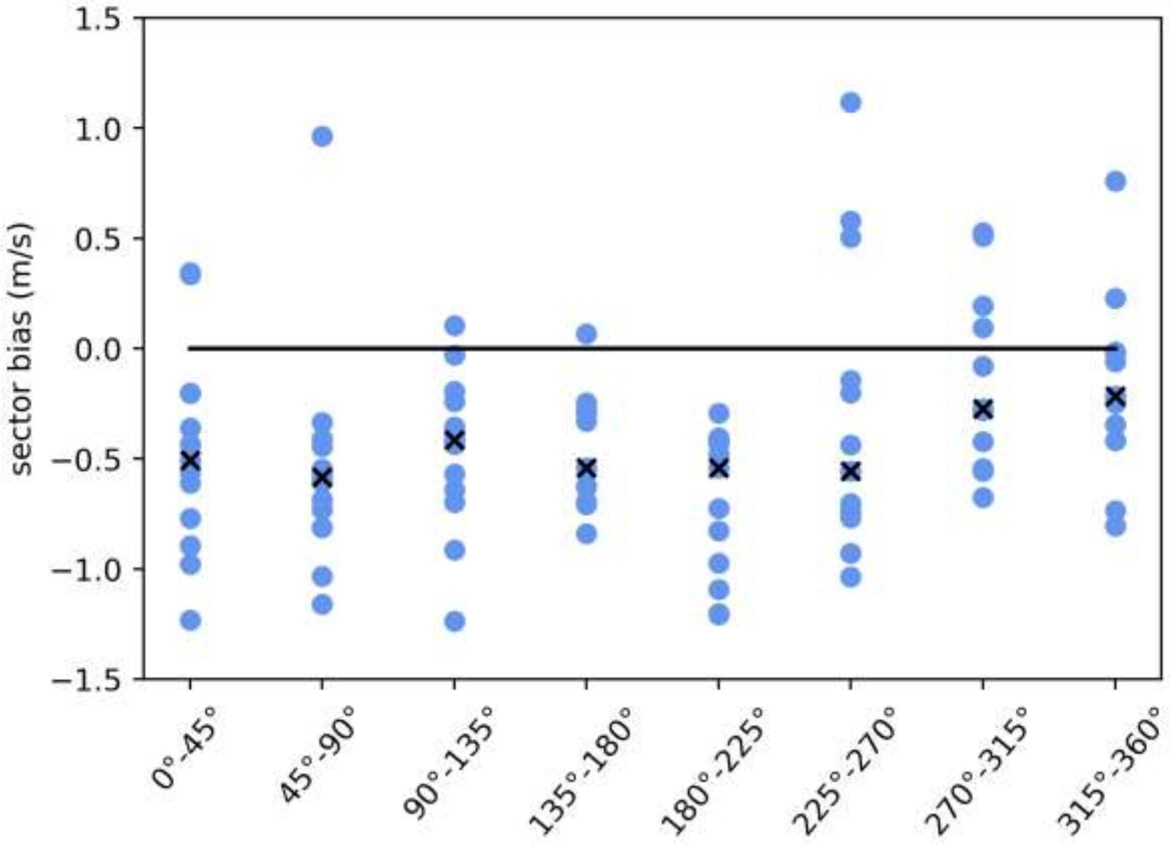
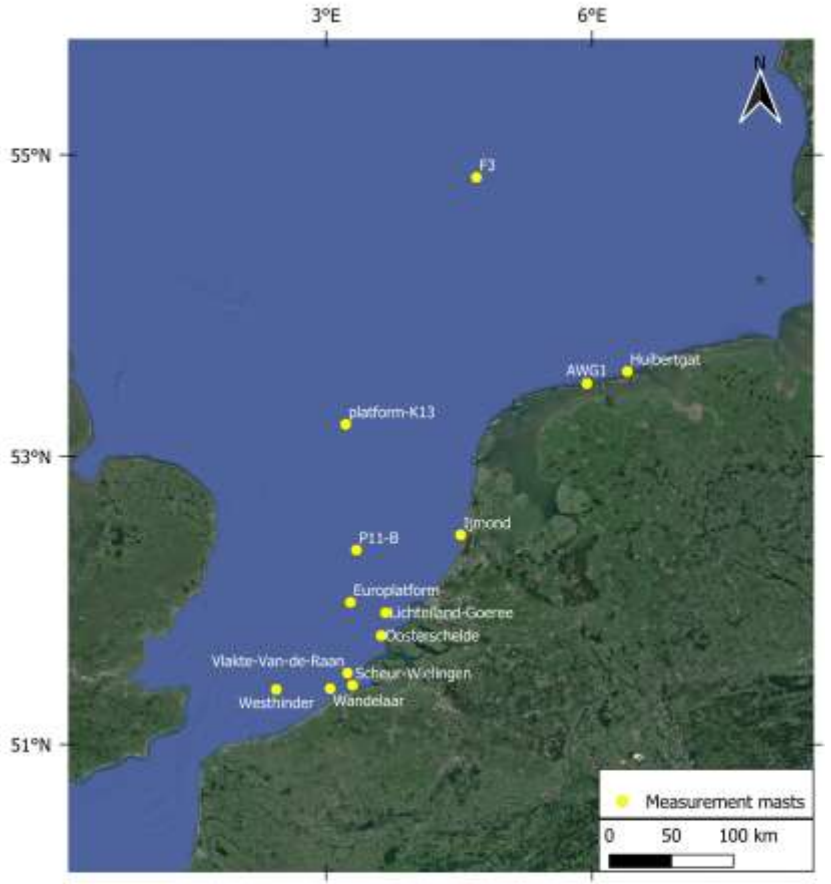
CCLM simulation for 2019





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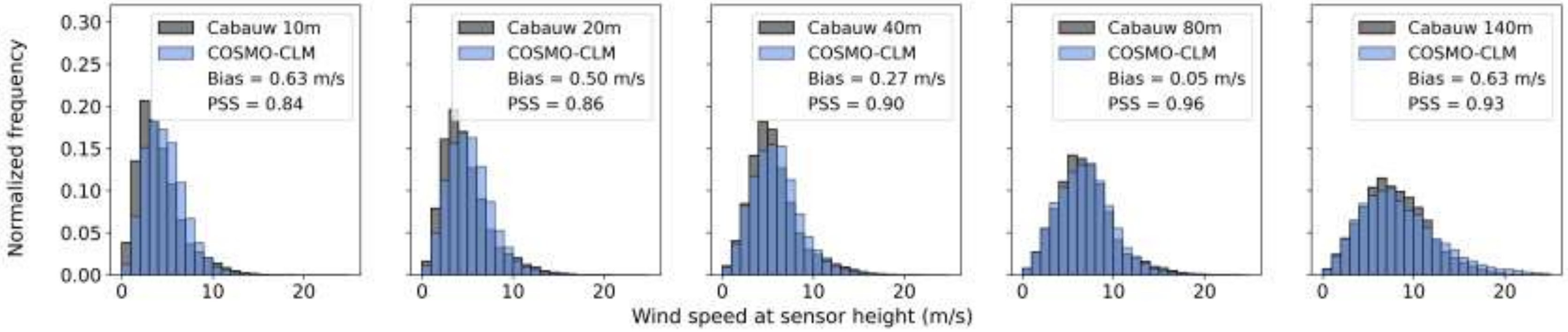
CCLM simulation for 2019

Cabauw:



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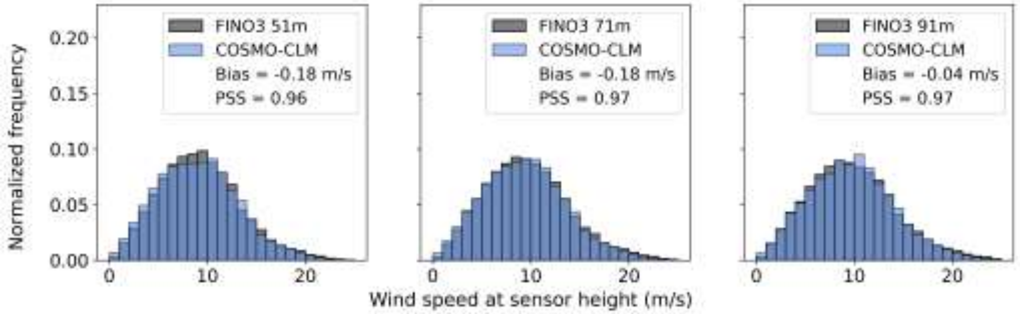

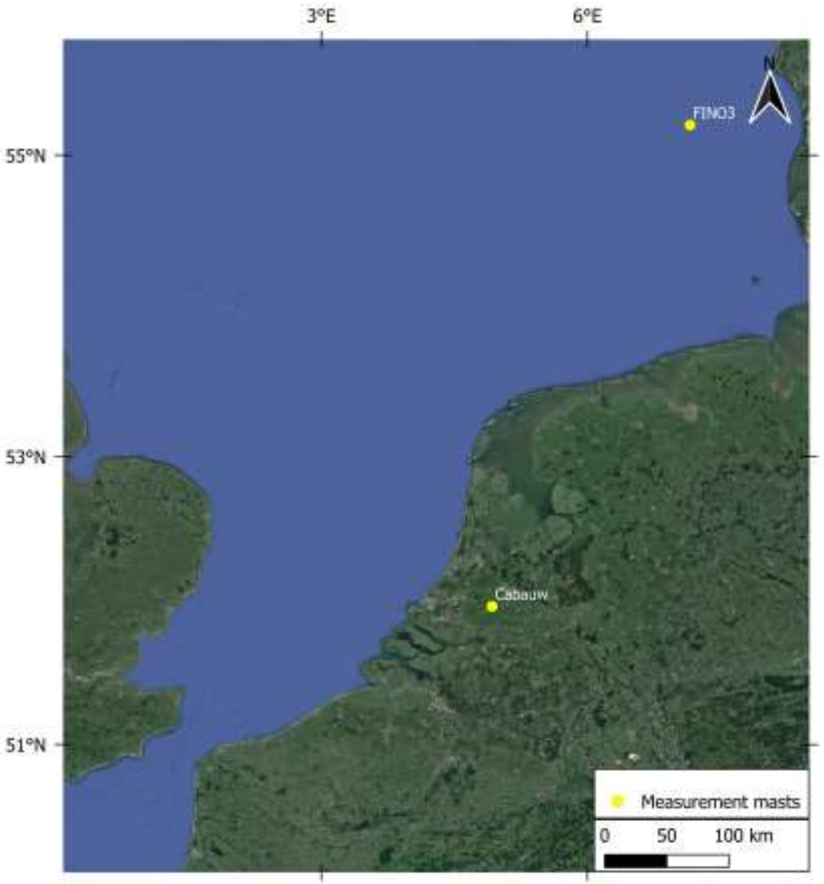

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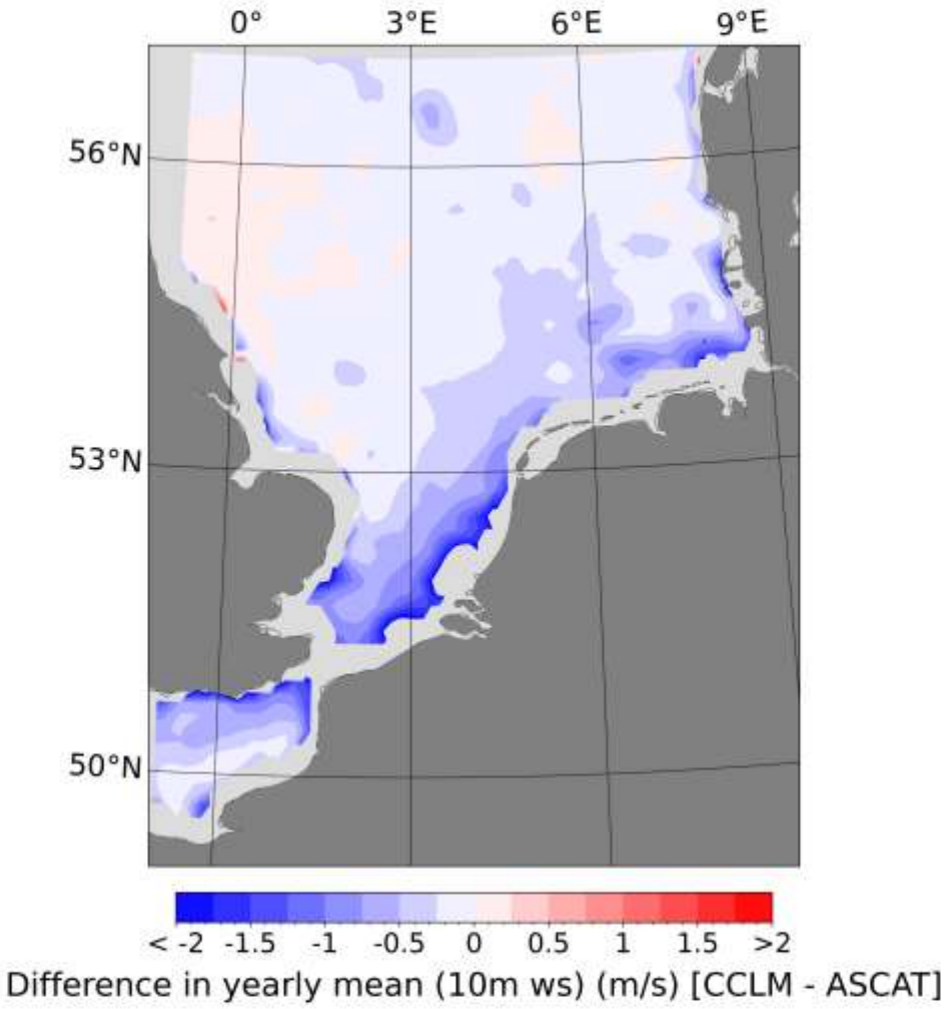
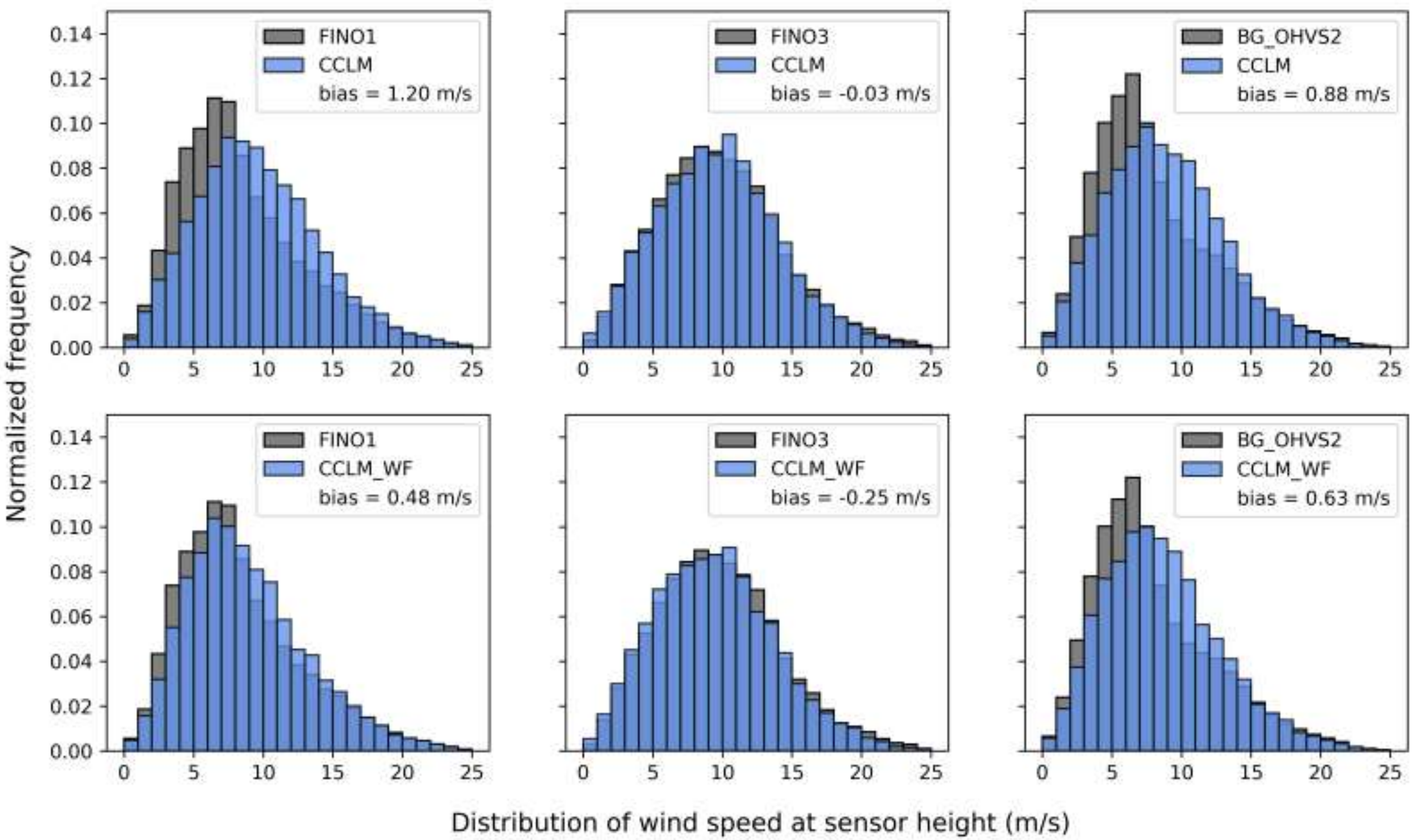
CCLM simulation for 2019



Comparison with ASCAT

- 35% of grid boxes ➔ element of [-0.1 m/s, +0.1 m/s]
- 72% of grid boxes ➔ element of [-0.3 m/s, +0.3 m/s]

CCLM_wf simulation for 2019



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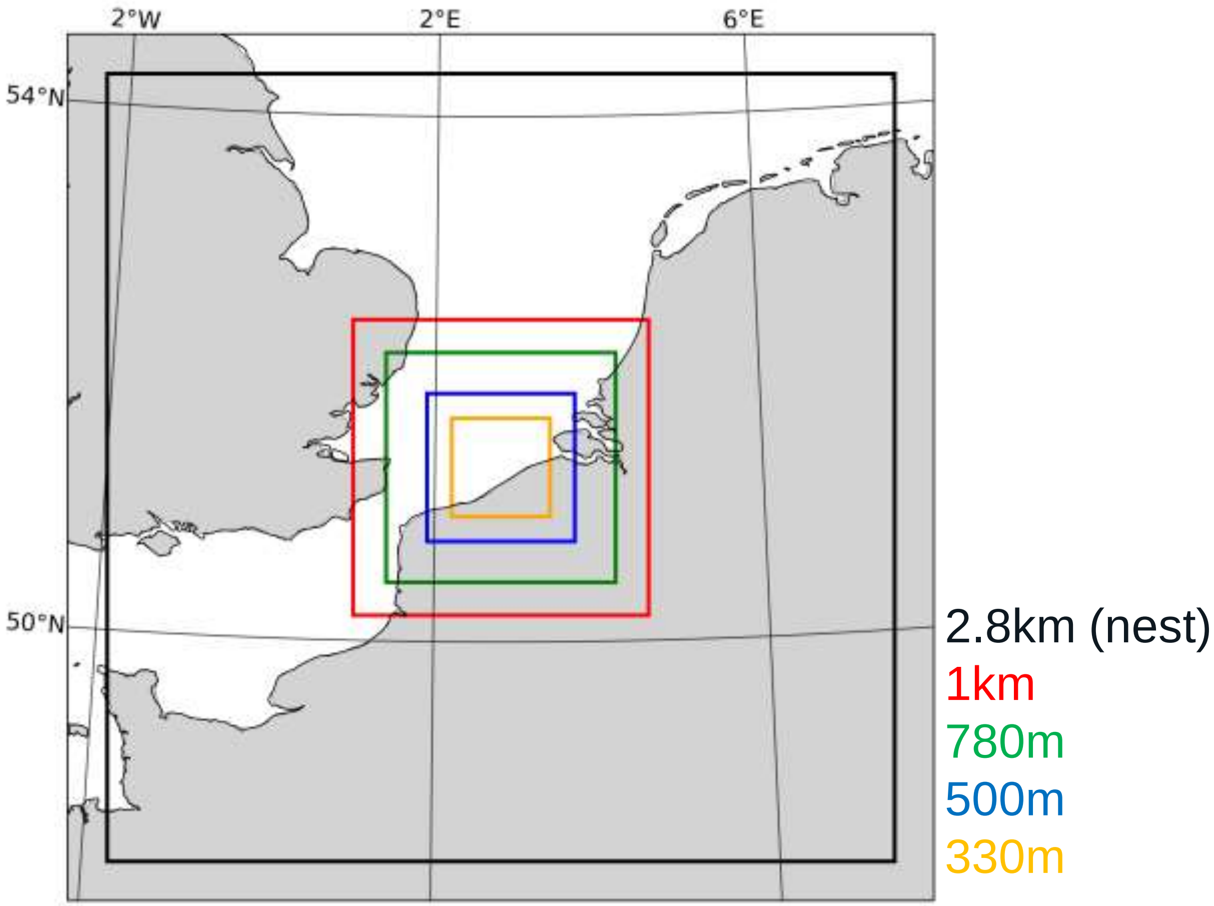
(Sub-)km scale use of CCLM_wf



Approach

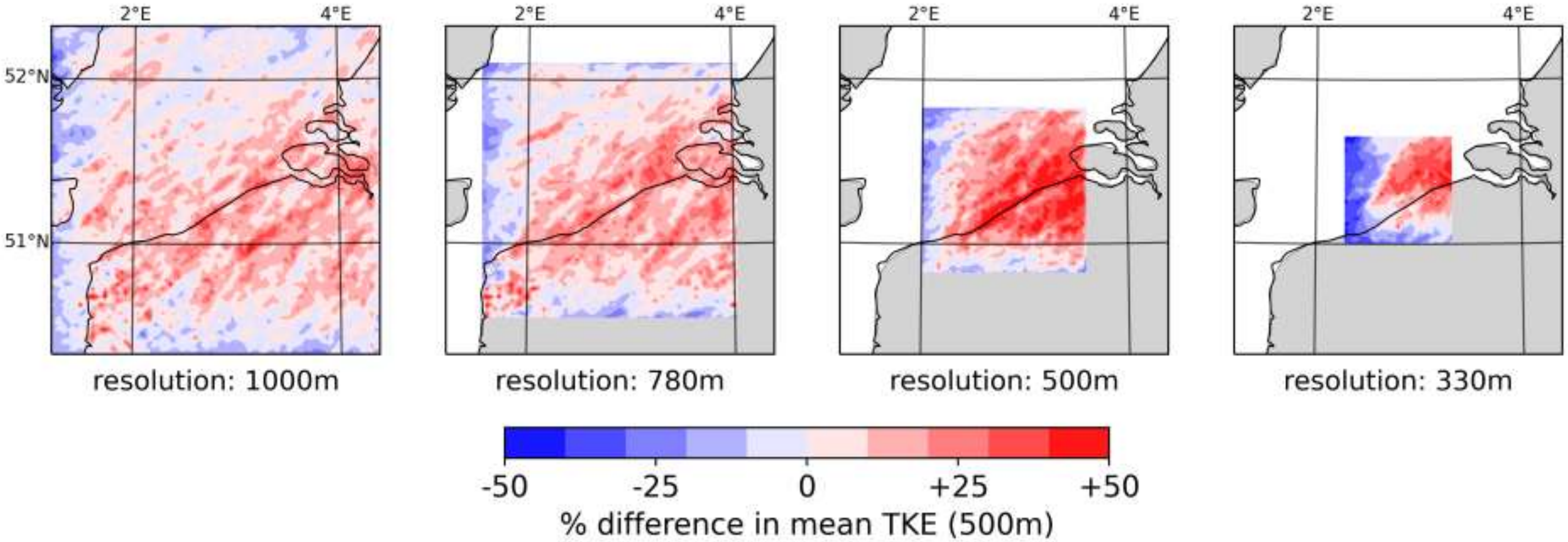
- **01/01/2019 => 08/03/2019 CCLM2.8 intermediate run**
  - Hourly BC update from ERA5
  - 2 months spin-up of soil state.

- **4 Nested simulations for 01/03 > 08/03 [250x250 cells]**
  - Belgian coastal zone
  - Hourly BC update from CCLM2.8
  - Mainly westerly, south-westerly and southerly winds.

(Sub-)km scale use of CCLM(_wf)

First analysis

- Comparison of the nested simulations and the 2.8km nest run: TURBULENT KINETIC ENERGY



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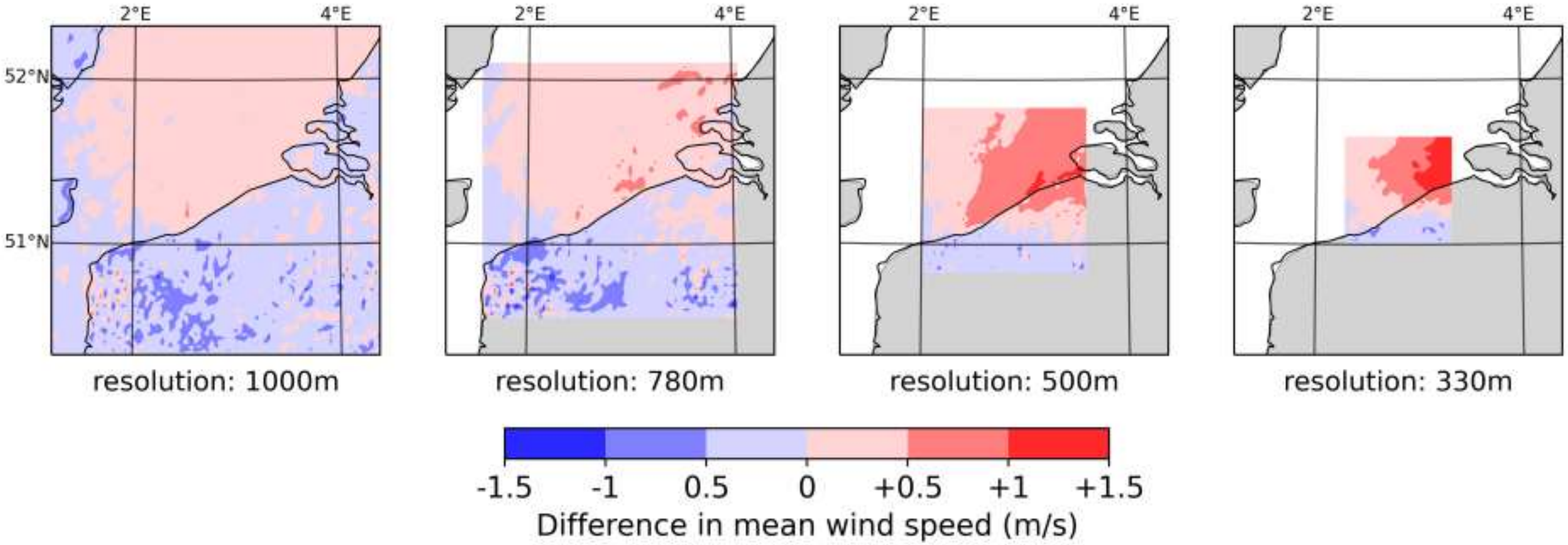
(Sub-)km scale use of CCLM(_wf)

First analysis

- Comparison of the nested simulations and the 2.8km nest run: WIND SPEED



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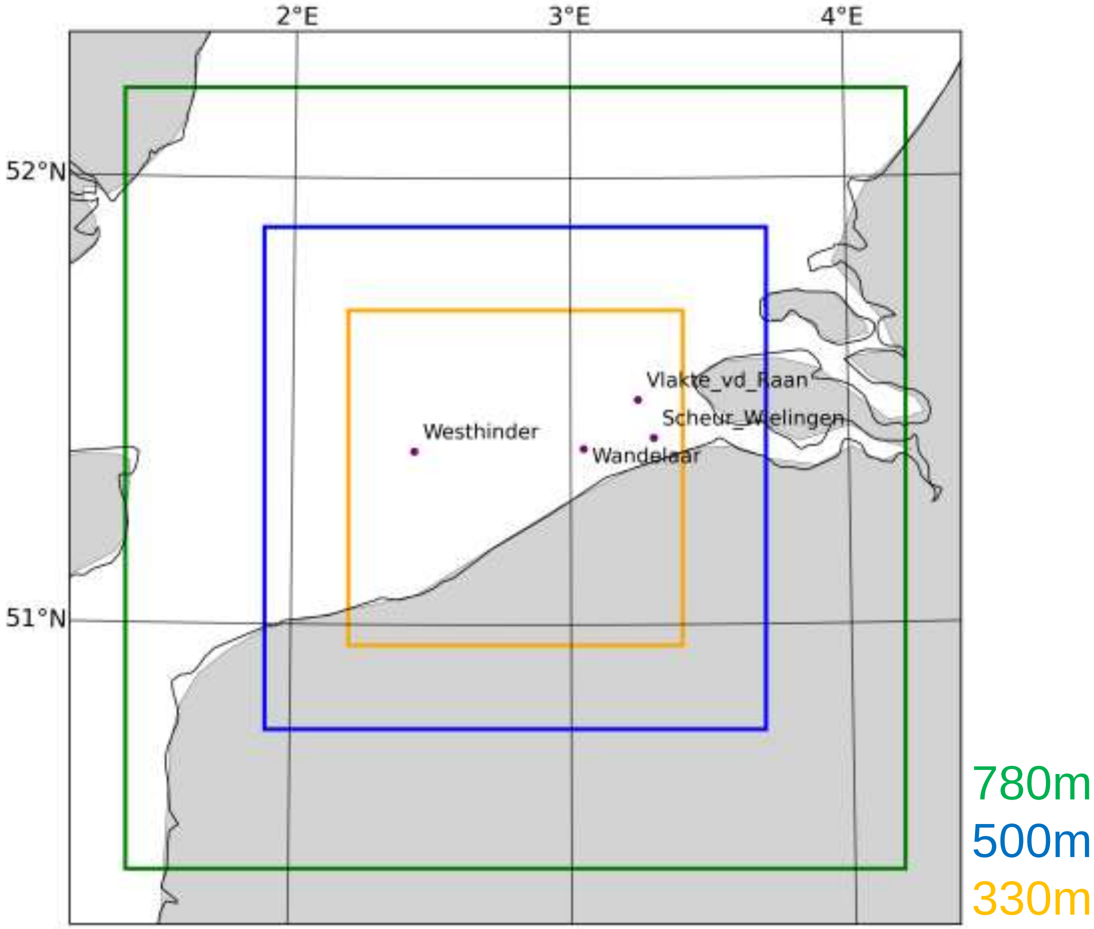
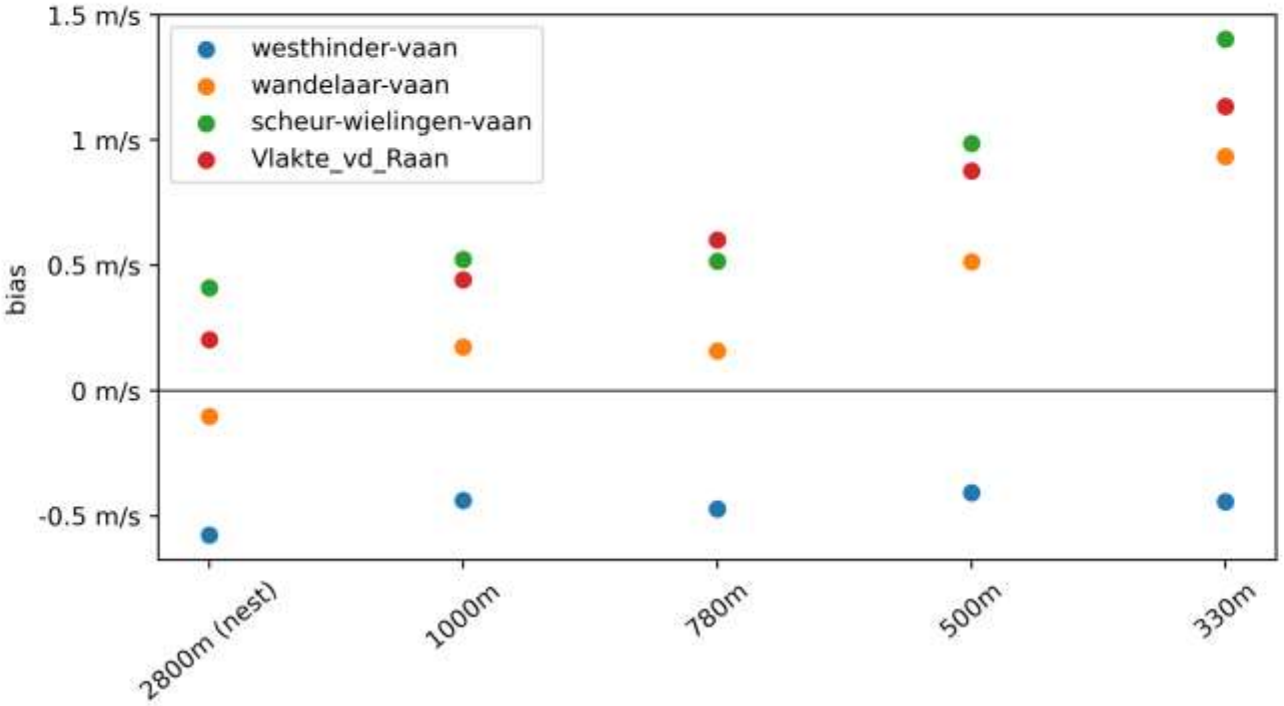
(Sub-)km scale use of CCLM(_wf)





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Thank you! Questions?