DTU

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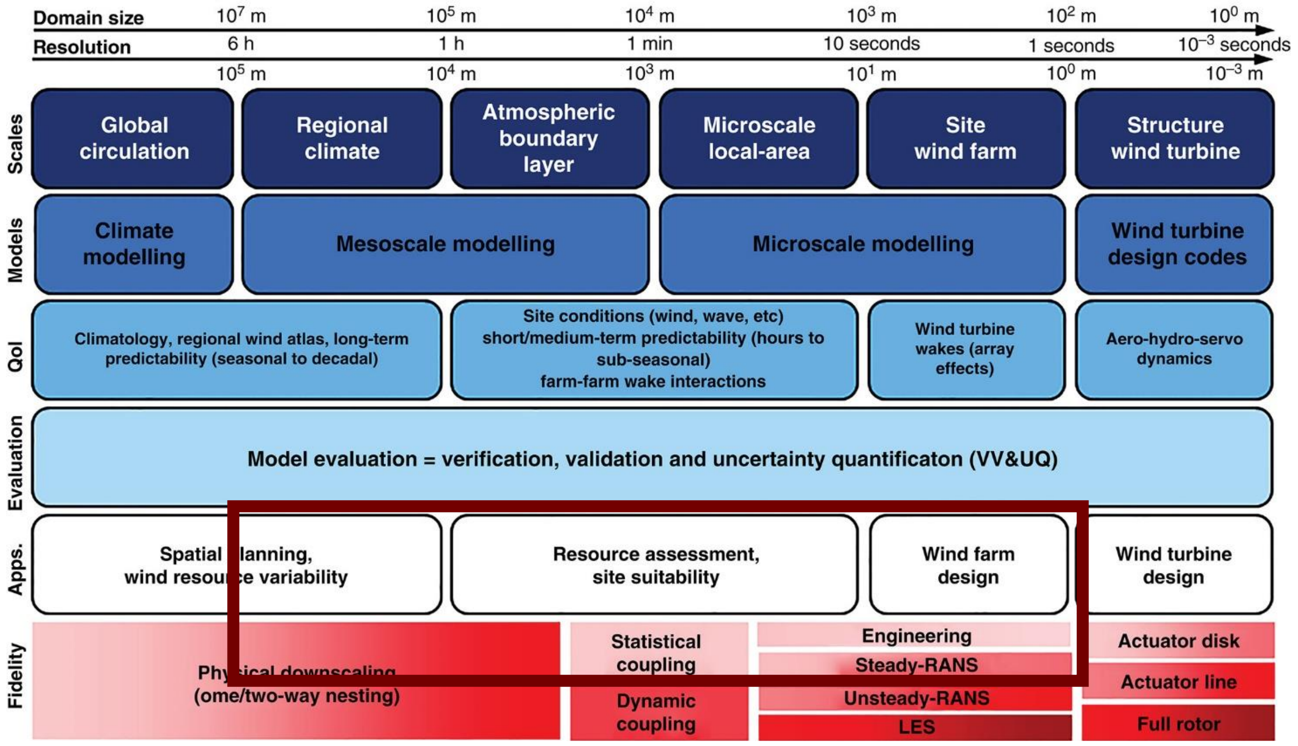
Using mesoscale and microscale models for wind resource assessment

Introduction

- For wind resource assessment the wind distribution has to be known
- Mesoscale models are frequently used for assessing wind resources
- Typical resolutions are 1-3 km, higher resolution very expensive for multiyear runs.
- This is typically not enough to resolve microscale flow features, particularly over land
- Here we show:
  - Illustrations of microscale effects on the flow near a coastal site
  - A tool chain that couples these models and a validation



Sanz Rodrigo, J., Chávez Arroyo, R.A., Moriarty, P., Churchfield, M., Kosović, B., Réthoré, P.-E., Hansen, K.S., Hahmann, A., Mirocha, J.D. and Rife, D. (2017), Mesoscale to microscale wind farm flow modeling and evaluation. WIREs Energy Environ, 6: e214. https://doi.org/10.1002/wene.214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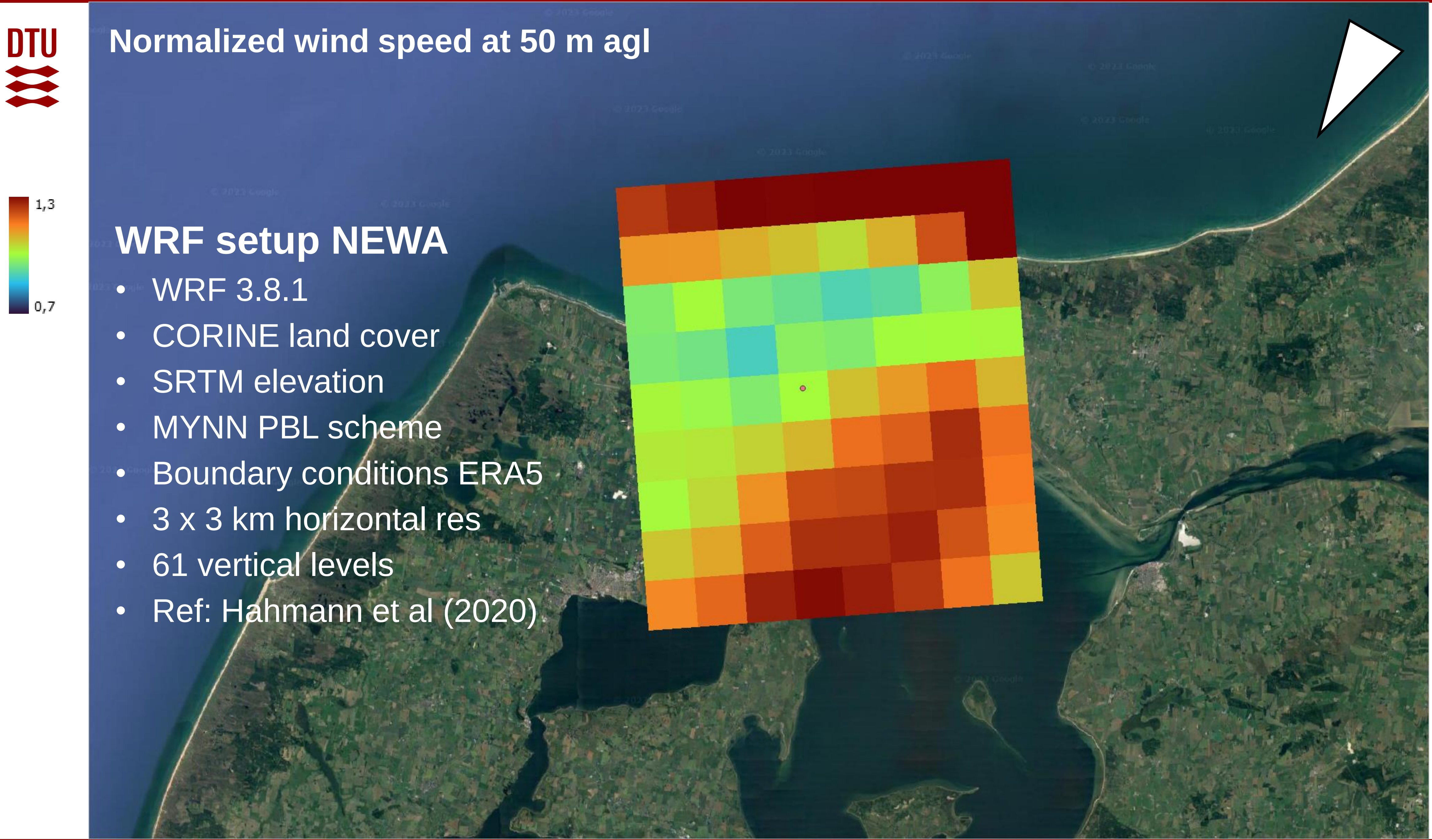
Normalized wind speed at 50 m agl

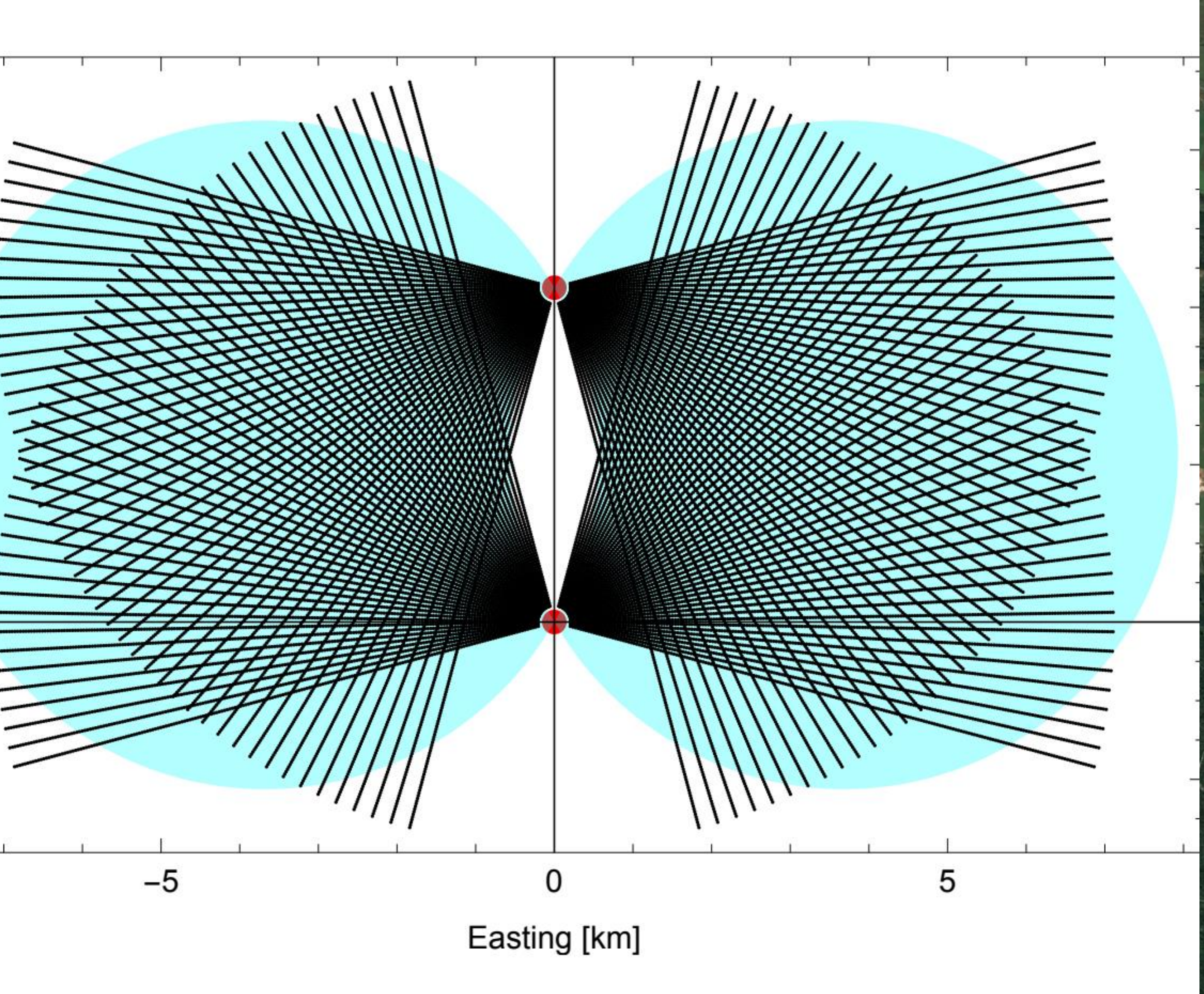


WRF setup NEWA

- WRF 3.8.1
- CORINE land cover
- SRTM elevation
- MYNN PBL scheme
- Boundary conditions ERA5
- 3 x 3 km horizontal res
- 61 vertical levels
- Ref: Hahmann et al (2020)

Two meteorological masts

- One mast 241 m north of row and one 241 m mast in the southerly end
- Equipped with cup and sonic anemometers



Balcony experiment NEWA

- 2 Scanning lidars installed at 50 m above the ground
- Scanning using 45 line-of-sight in 90 degree plain
- Range gates varying from 105 to 7000 m
- 1 scan of full plain in 45 sec
- 2016-04-12 to 2016-06-17, 66 days (1584 hours)
- Wind speed and direction reconstructed on a ~7x7 km area with 100 m resolution
- Ref: Karagali et al. (2018)

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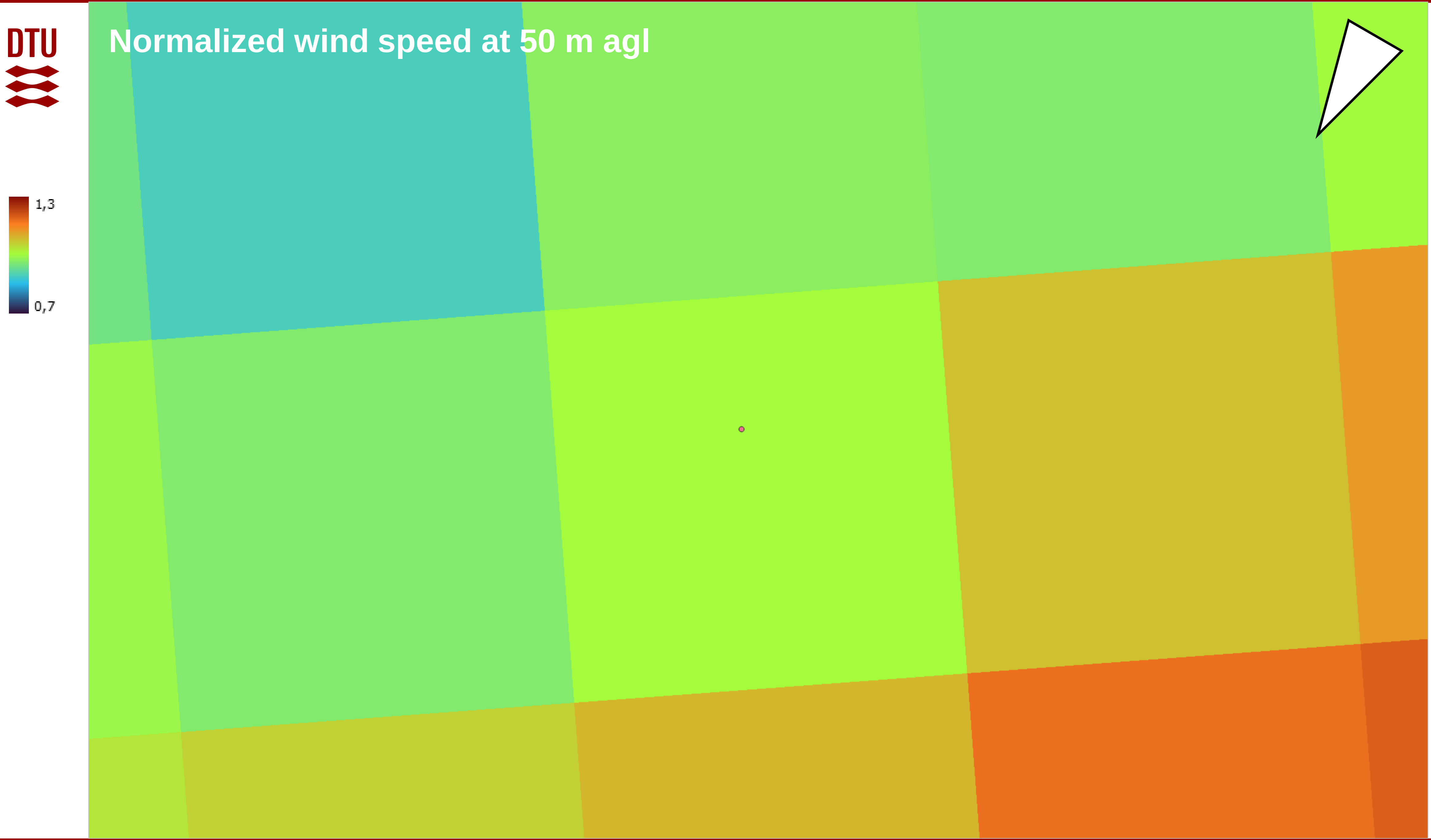
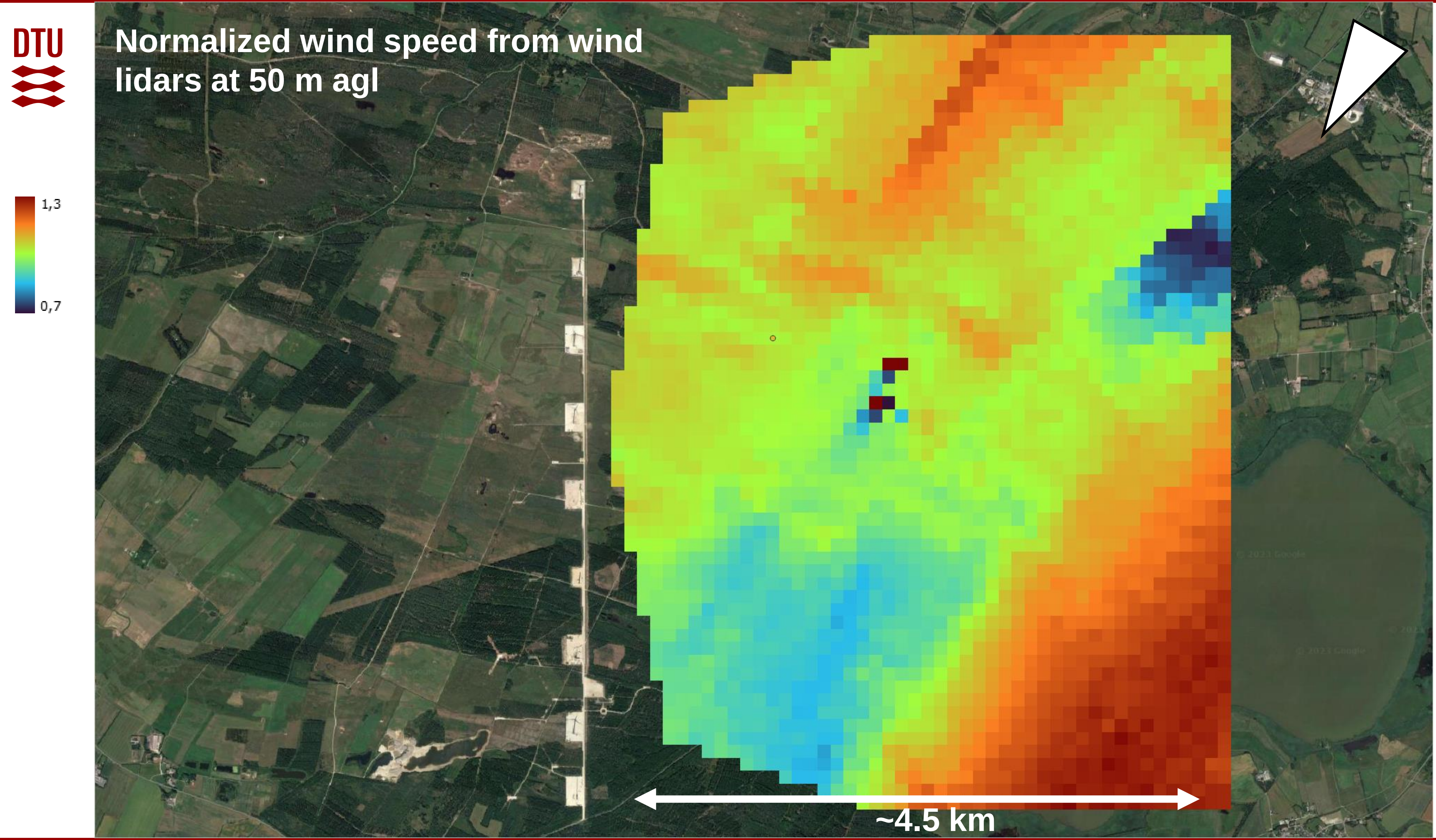
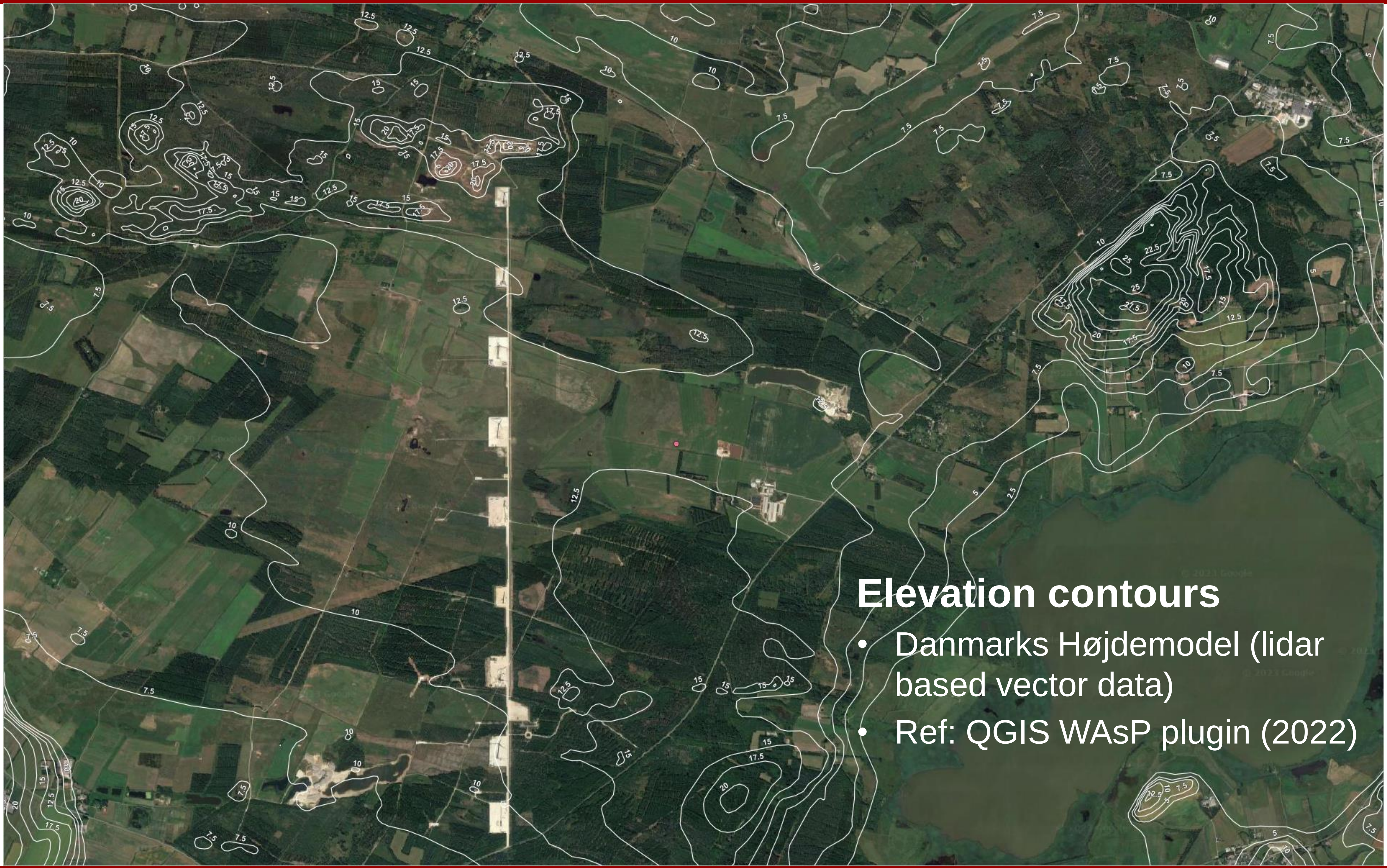


Normalized wind speed from wind lidars at 50 m agl





Elevation contours

- Danmarks Højdemodel (lidar based vector data)
- Ref: QGIS WAsP plugin (2022)

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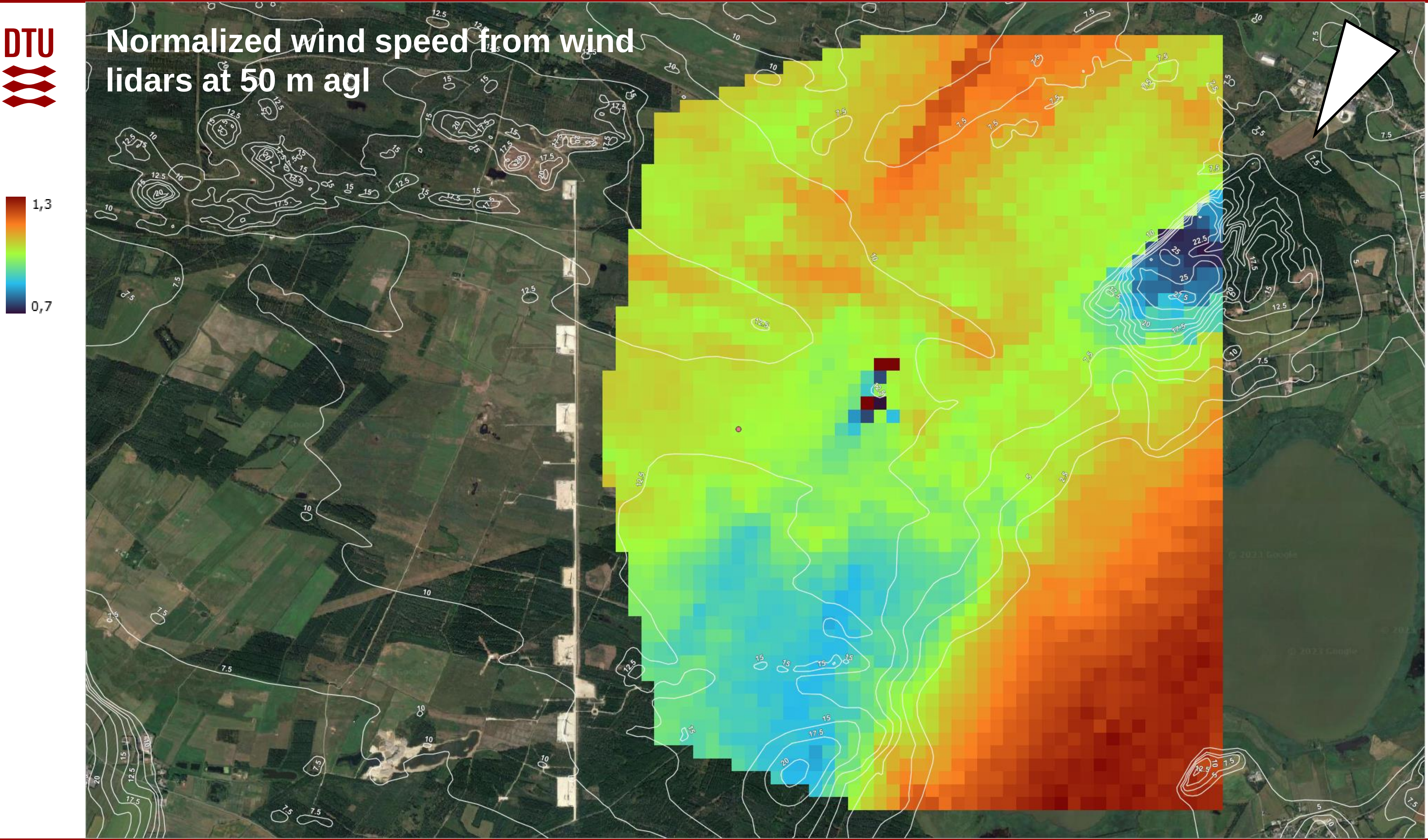

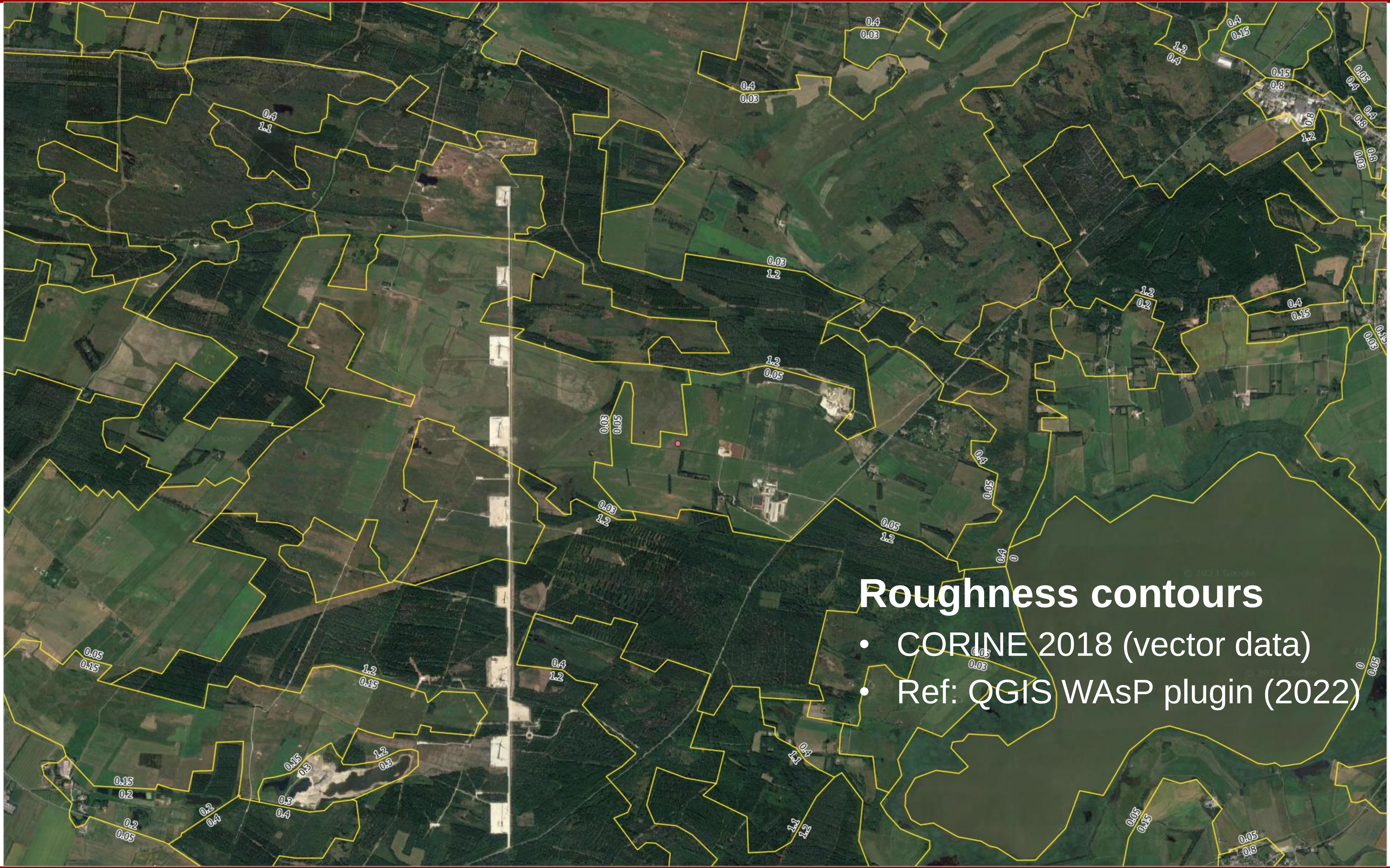

Roughness contours

- CORINE 2018 (vector data)
- Ref: QGIS WAsP plugin (2022)

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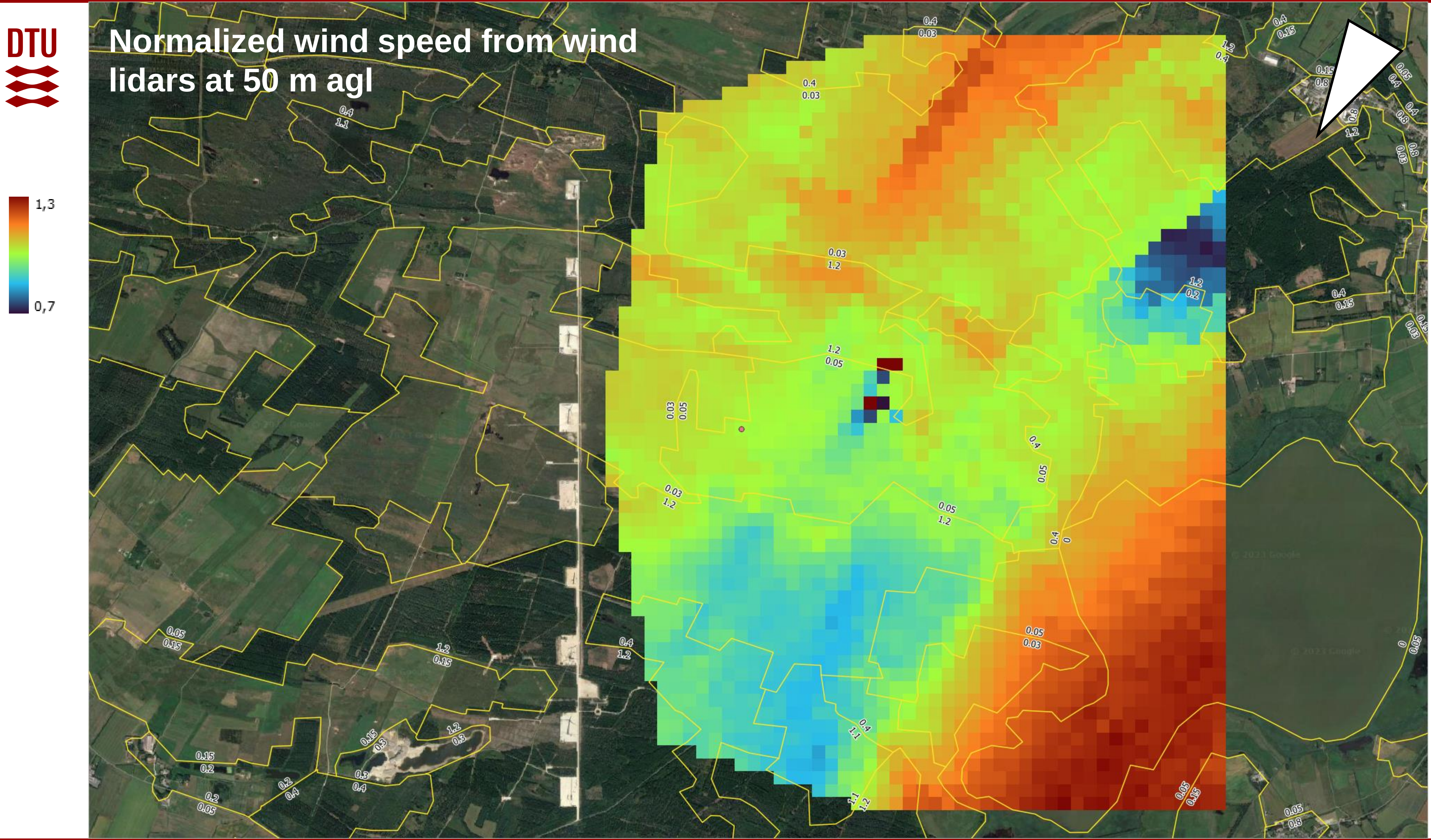
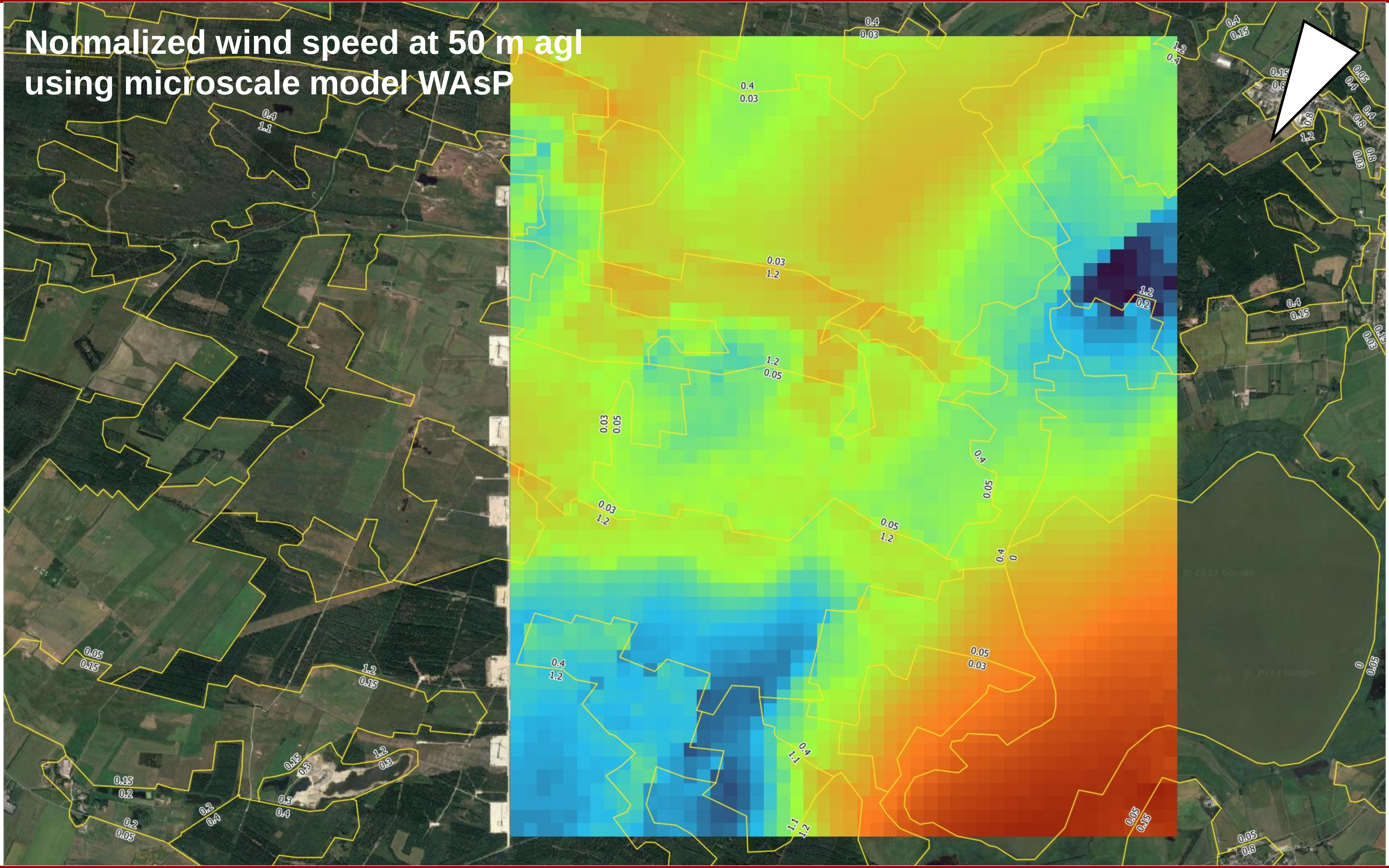
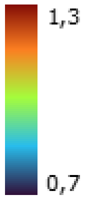


Normalized wind speed at 50 m agl using microscale model WAsP





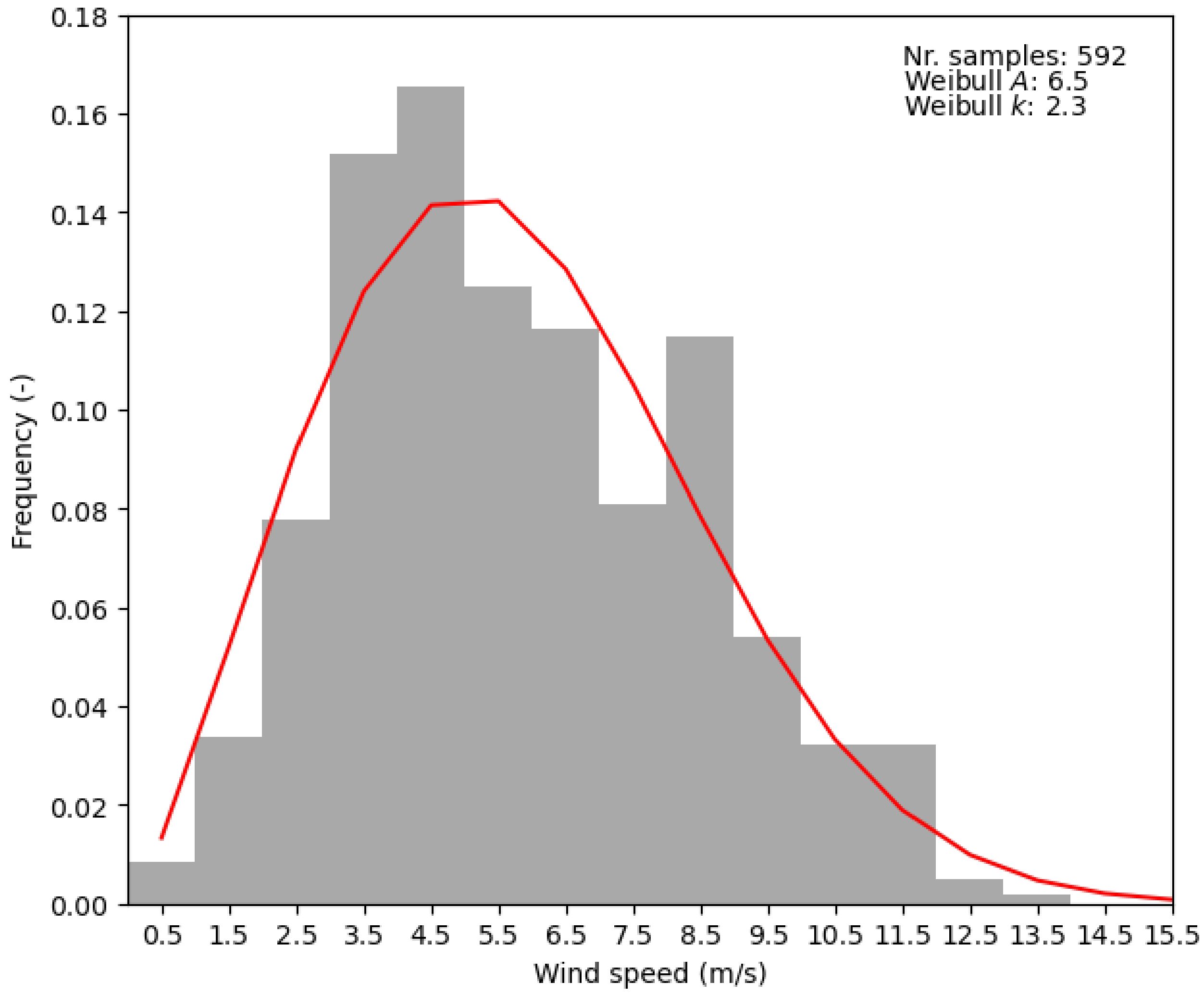
Climatological behaviour of the wind

- Averaged over a sufficiently long time, for a particular wind direction sector near always resembles a Weibull distribution

$$f_u(u) = \frac{k}{A}\left(\frac{u}{A}\right)^{k-1} \exp\left(-\left(\frac{u}{A}\right)^{k}\right)$$

- A is the scale parameter
- K is the shape parameter

The higher the k, the more narrow the distribution is.



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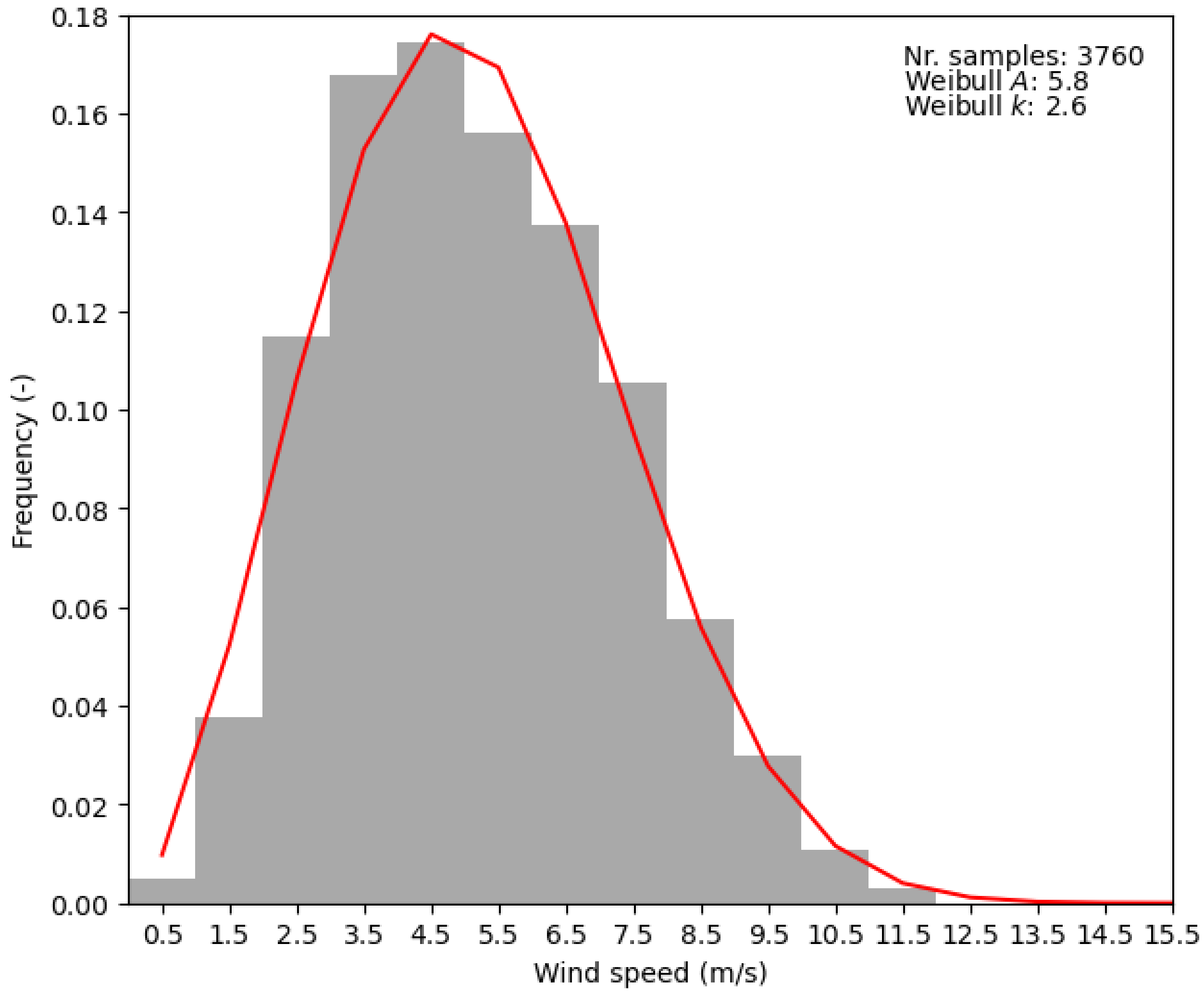
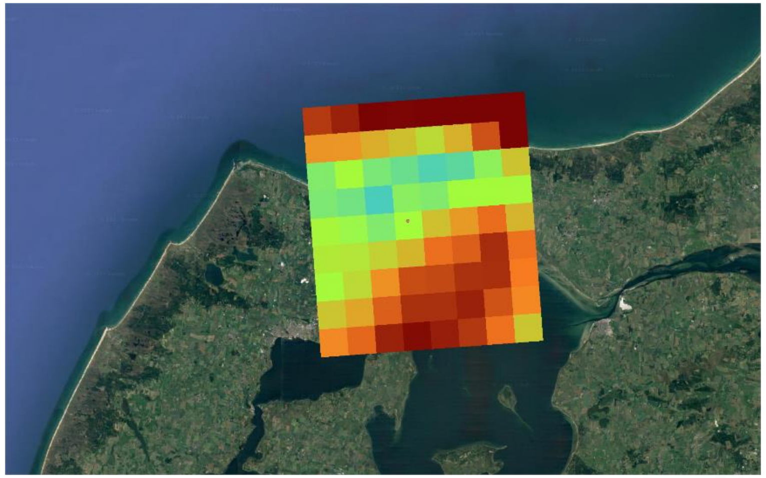
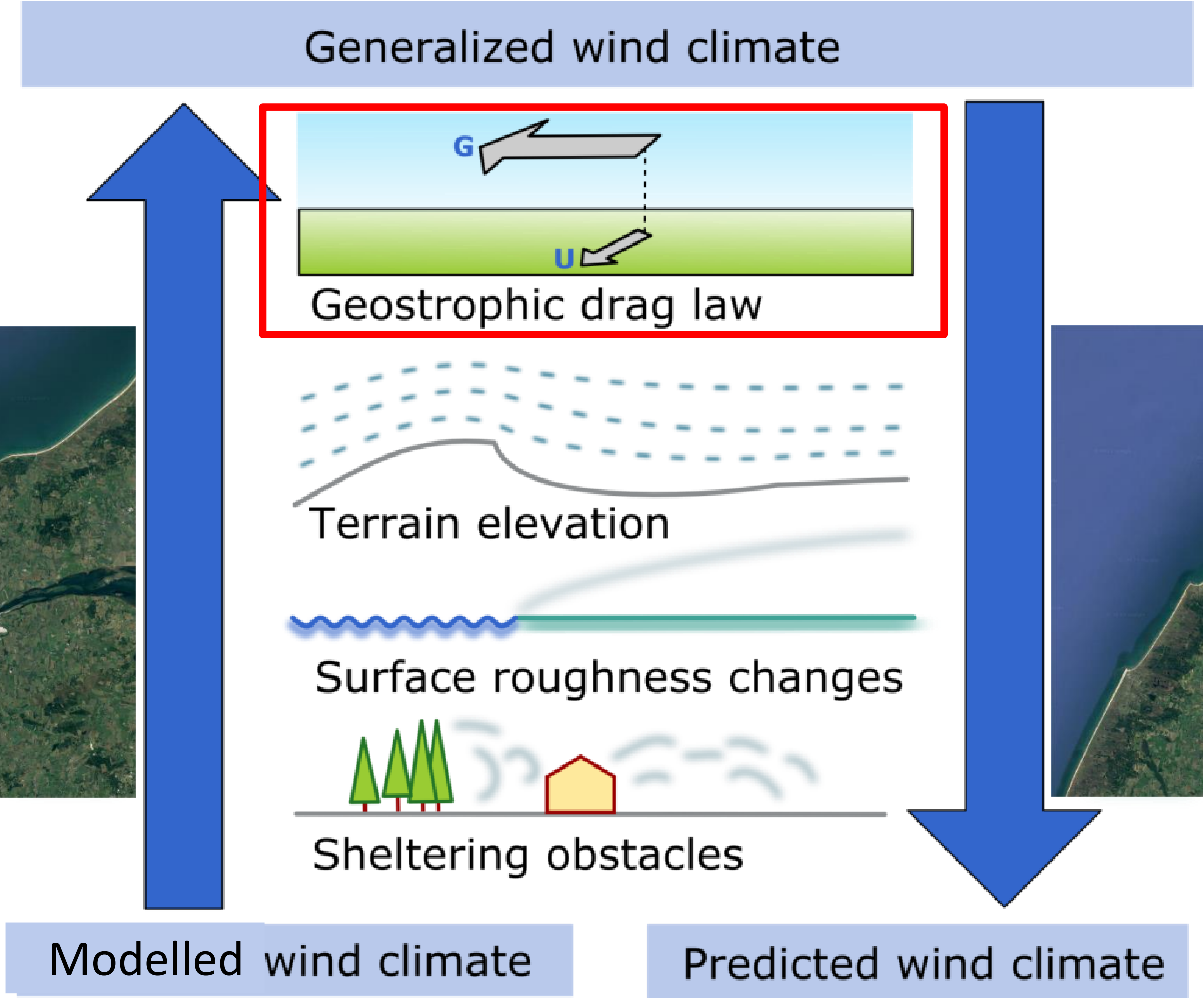


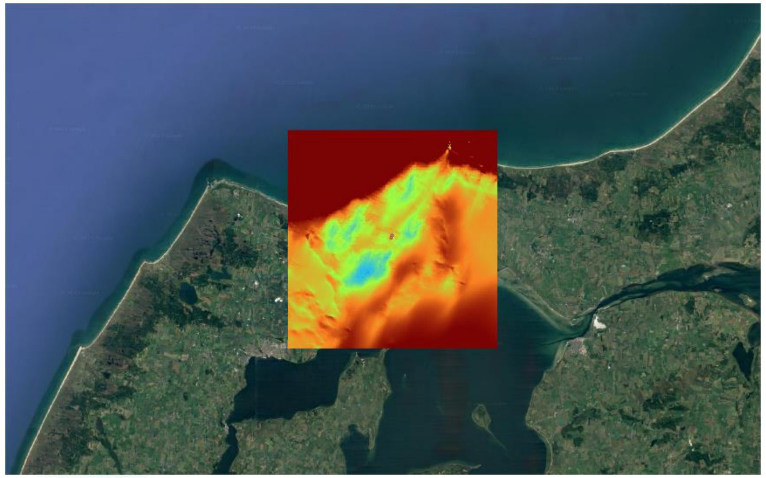
Transforming wind distribution with height and roughness

NEWA WRF

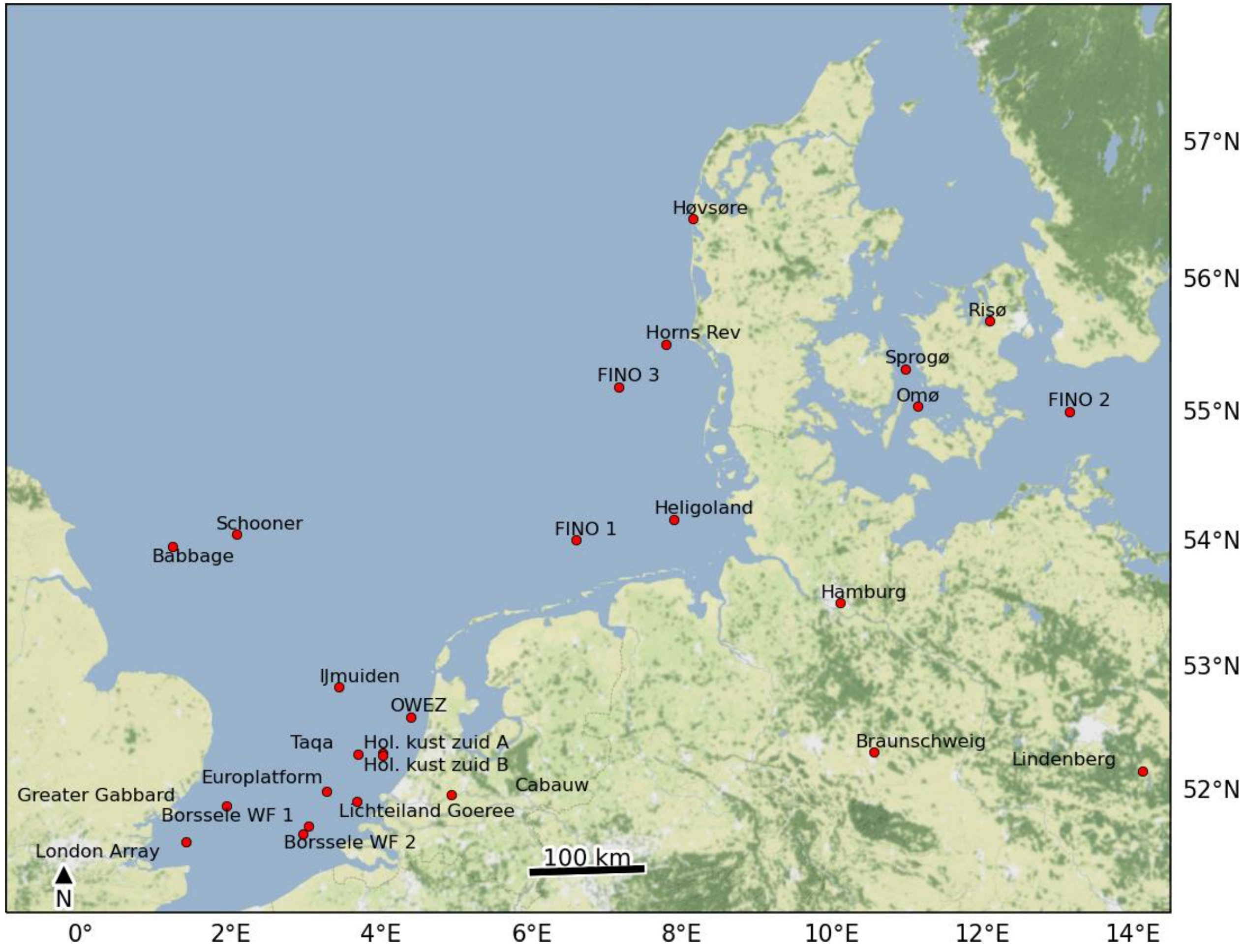




Microscale



Validating the NEWA downscaling method



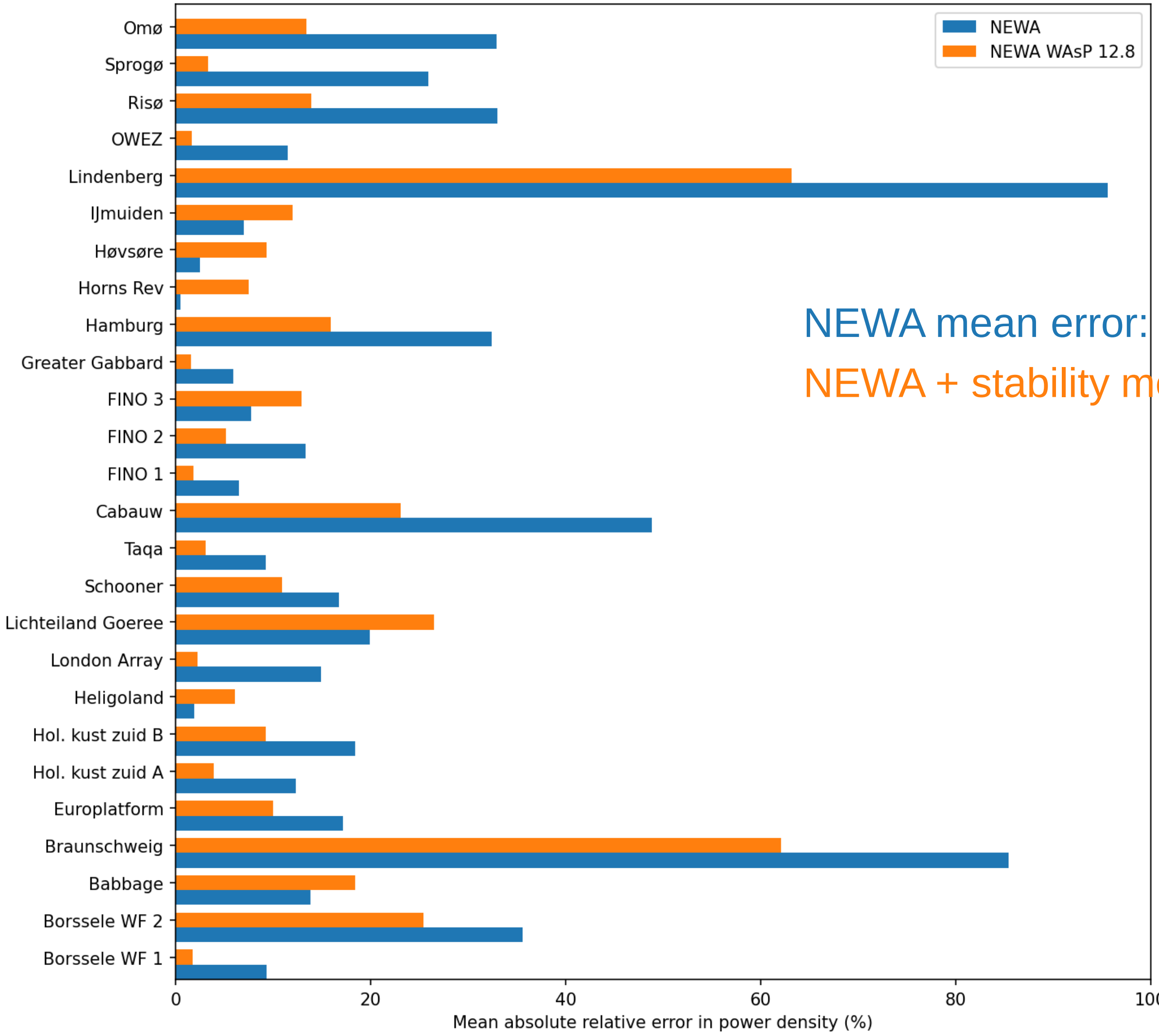
Comparison of:

1. NEWA microscale model chain (Hahmann, 2020)
2. New model chain developed based on PyWAsP and using stability data from mesoscale model (Floors, 2023)

- 26 masts with time series were selected within the NEWA Central Europe domain
- Elevation data NASADEM 30 m resolution
- CORINE vector data for roughness maps

Power density downscaled WRF vs. obs.

- Plain comparison between measurement campaigns (typically 1-5 yrs)
- The WRF simulations are based on 30 yrs, so year-to-year variability might contribute to errors.

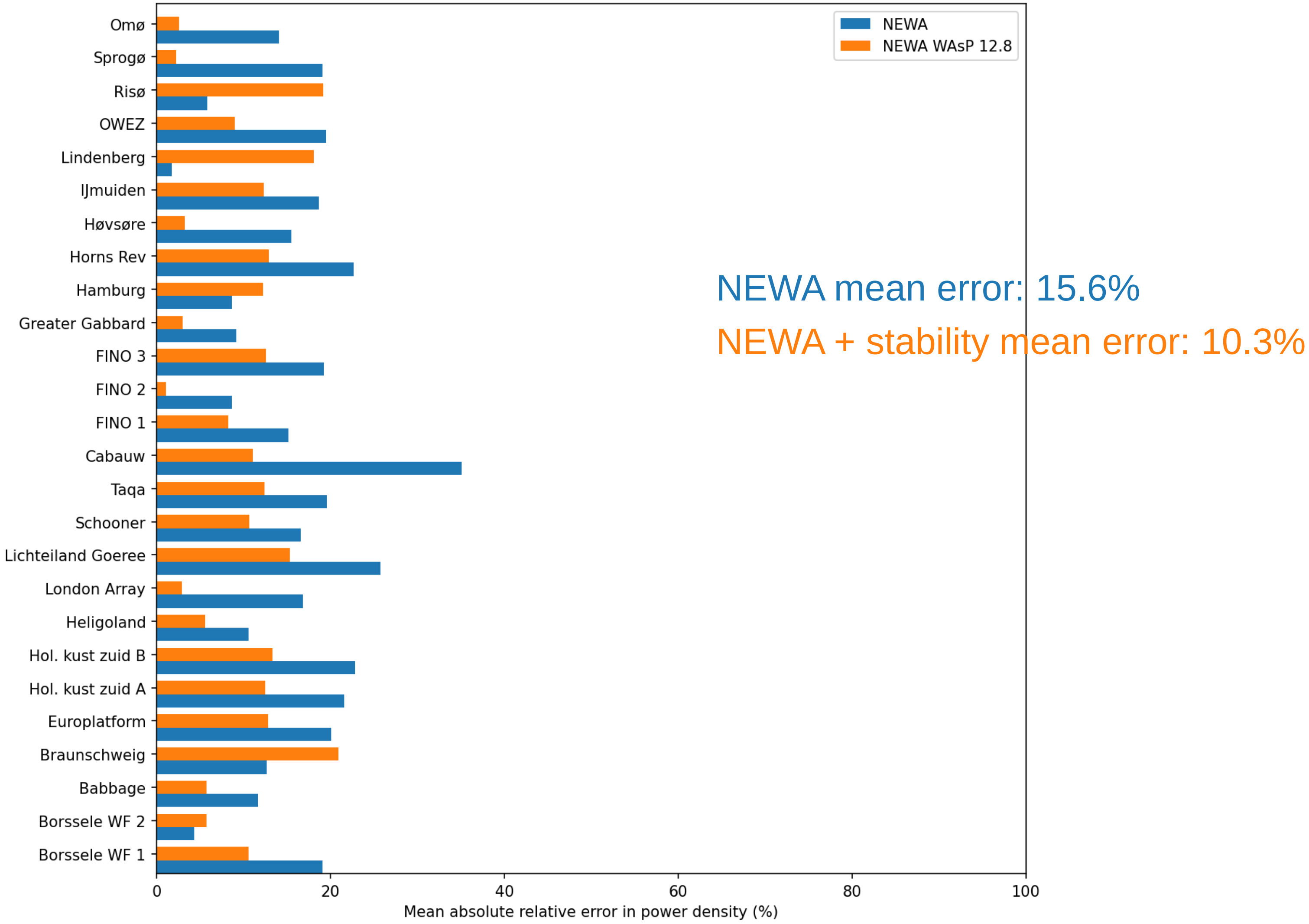


NEWA mean error: 21.2%

NEWA + stability mean error: 14.7%

Power density downscaled WRF + LTC vs. obs.

- Measurements corrected to same 30 yr period using variance ratio method



Conclusions

- Microscale effects contribute to +- 30% of variation in mean wind speed at 50 m over a relatively flat forested coastal site
- Microscale model was able to capture areas of most speed-up and speed-down
- Incoorporating a newly developed stability model improved the power density predictions of a model chain involving WRF and WAsP.
- Year-to-year variations explained part of the mismatch between model results and measurements.

Next steps:

- Checking model chain for ‘correct’ periods without LCT
- Look at more micrometeorological ‘complex’ sites

References

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