Showcase B: Merging Offshore Wind Products

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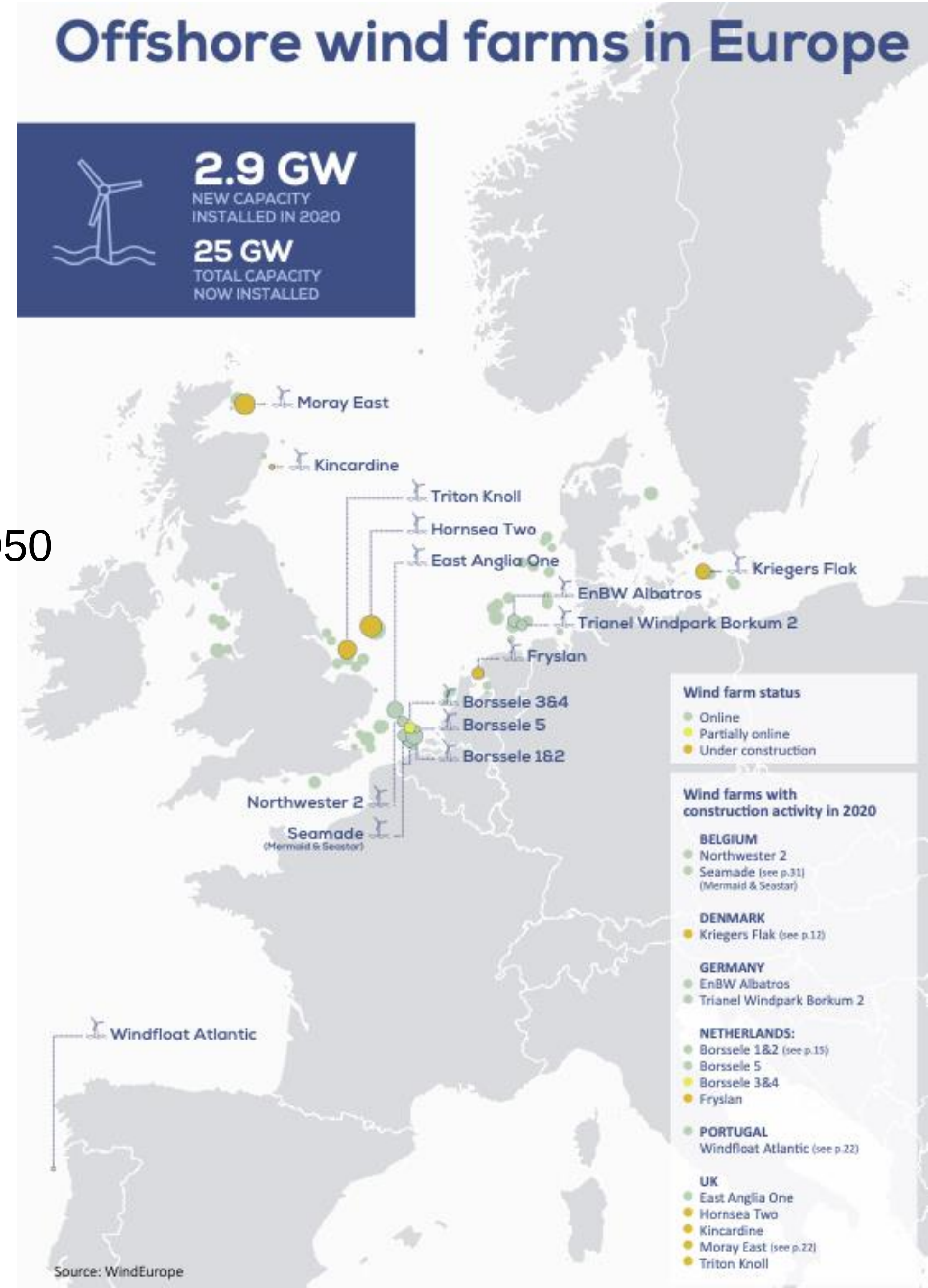
Offshore Wind Energy

- EU carbon-neutral by 2050*
- EC Offshore Renewable Energy strategy
  - Need for 230-450 GW by 2050
  - European Floating Offshore Alliance: 100 GW by 2050

- Currently 25 GW installed
- 116 wind farms
- 12 countries
- Expected by 2030: 111 GW offshore wind capacity
- 1 of 5 major barriers: Finding enough space at sea

*WindEurope, The EU Offshore Renewable Energy Strategy, June 2020



DTU Wind Energy

renewable energy

e-shape

How can EO help?

Assessing resources offshore:

Meteorological masts, Lidars

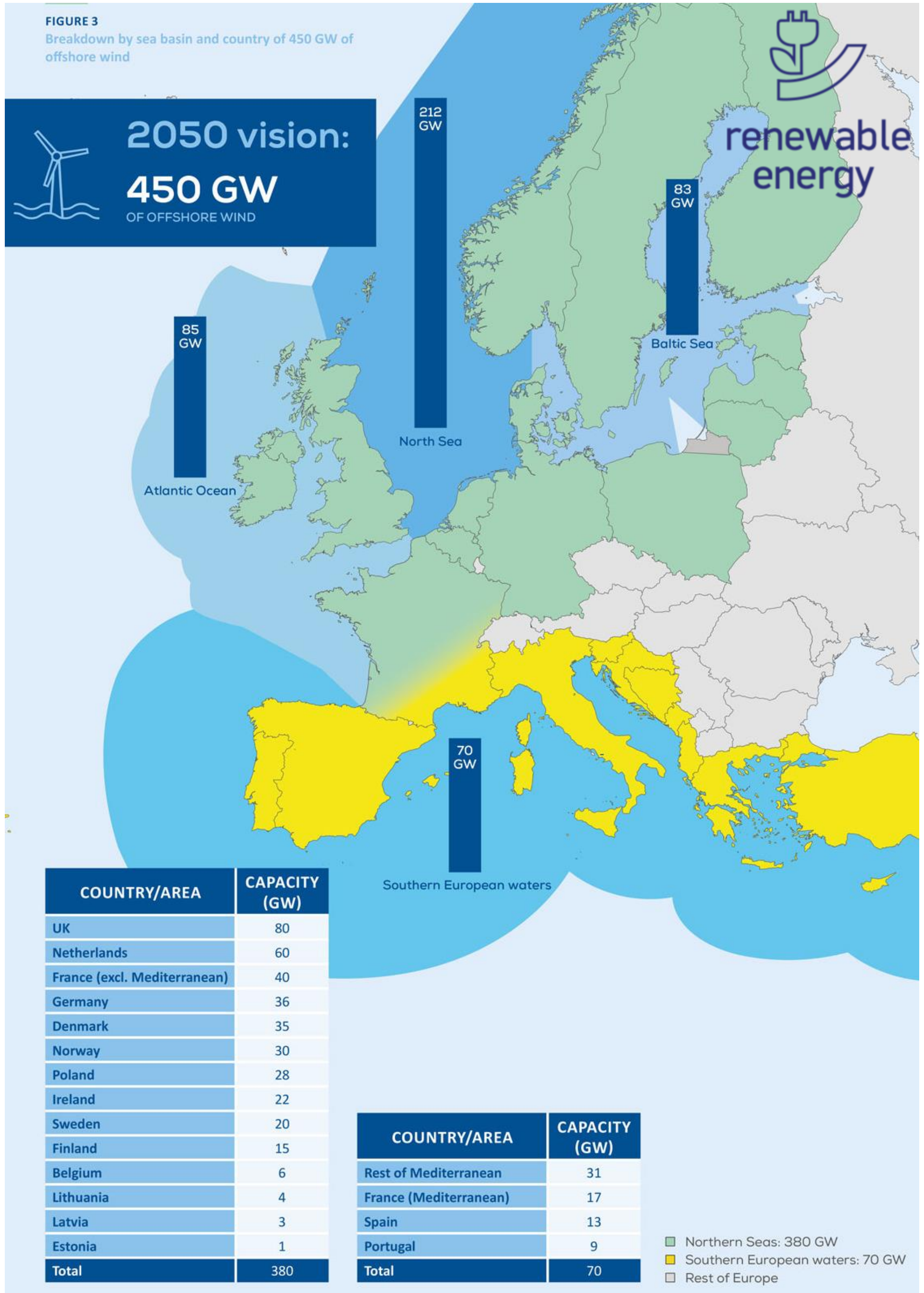
- Expensive
- Difficult to maintain
- Challenging for depths more > 60 m

Numerical Weather Prediction models

- Reanalyses readily available, low spatial resolution
- Dedicated simulations, not readily available

EO winds readily available

- Higher spatial resolution
- Lower temporal resolution
- At 10 m, extrapolation to turbine heights needed

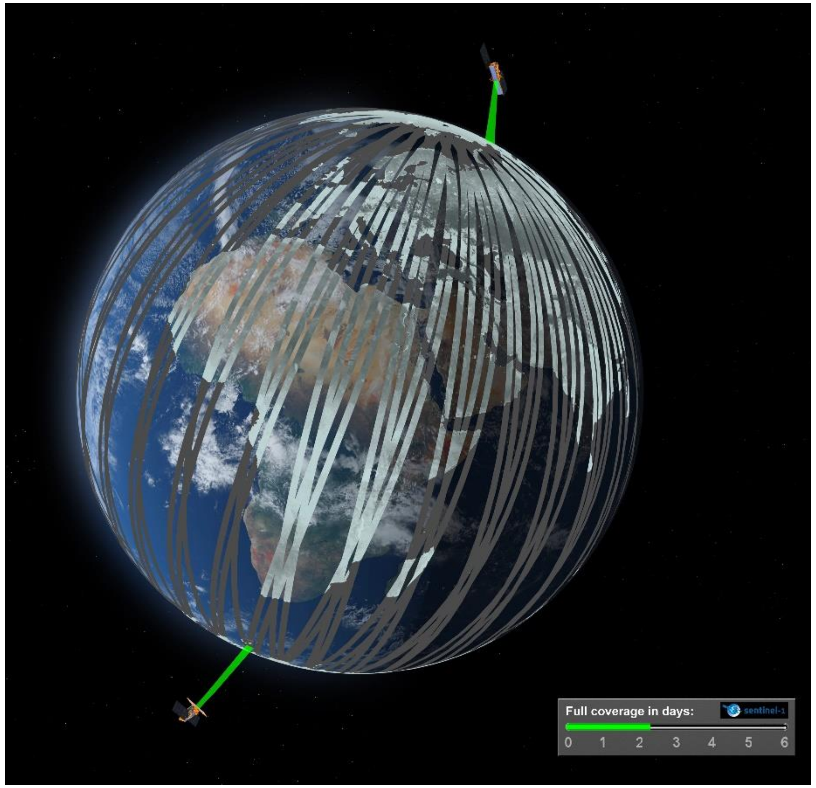


COUNTRY/AREA	CAPACITY (GW)
UK	80
Netherlands	60
France (excl. Mediterranean)	40
Germany	36
Denmark	35
Norway	30
Poland	28
Ireland	22
Sweden	20
Finland	15
Belgium	6
Lithuania	4
Latvia	3
Estonia	1
Total	380

COUNTRY/AREA	CAPACITY (GW)
Rest of Mediterranean	31
France (Mediterranean)	17
Spain	13
Portugal	9
Total	70

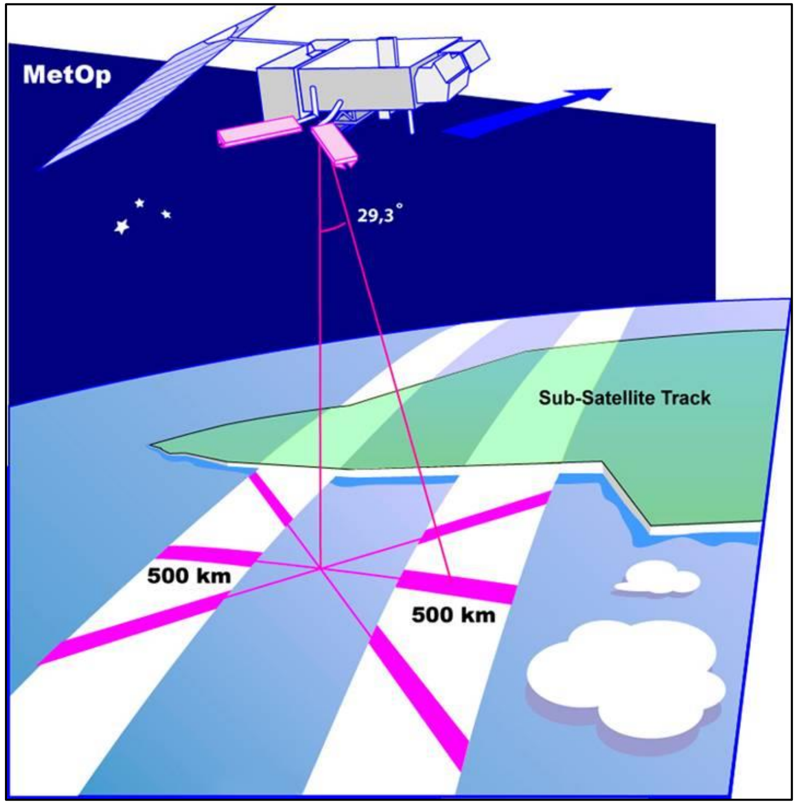
Ocean wind fields from space

sentinel-1



Sentinel-1A and 1B constellation

ASCAT

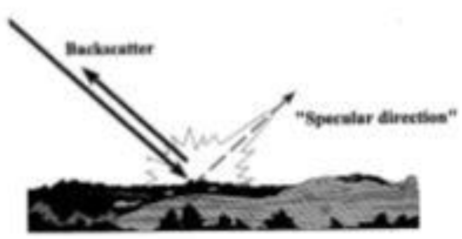


MetOp satellites A, B, C

Wind speed vs. radar backscatter

Specular reflection

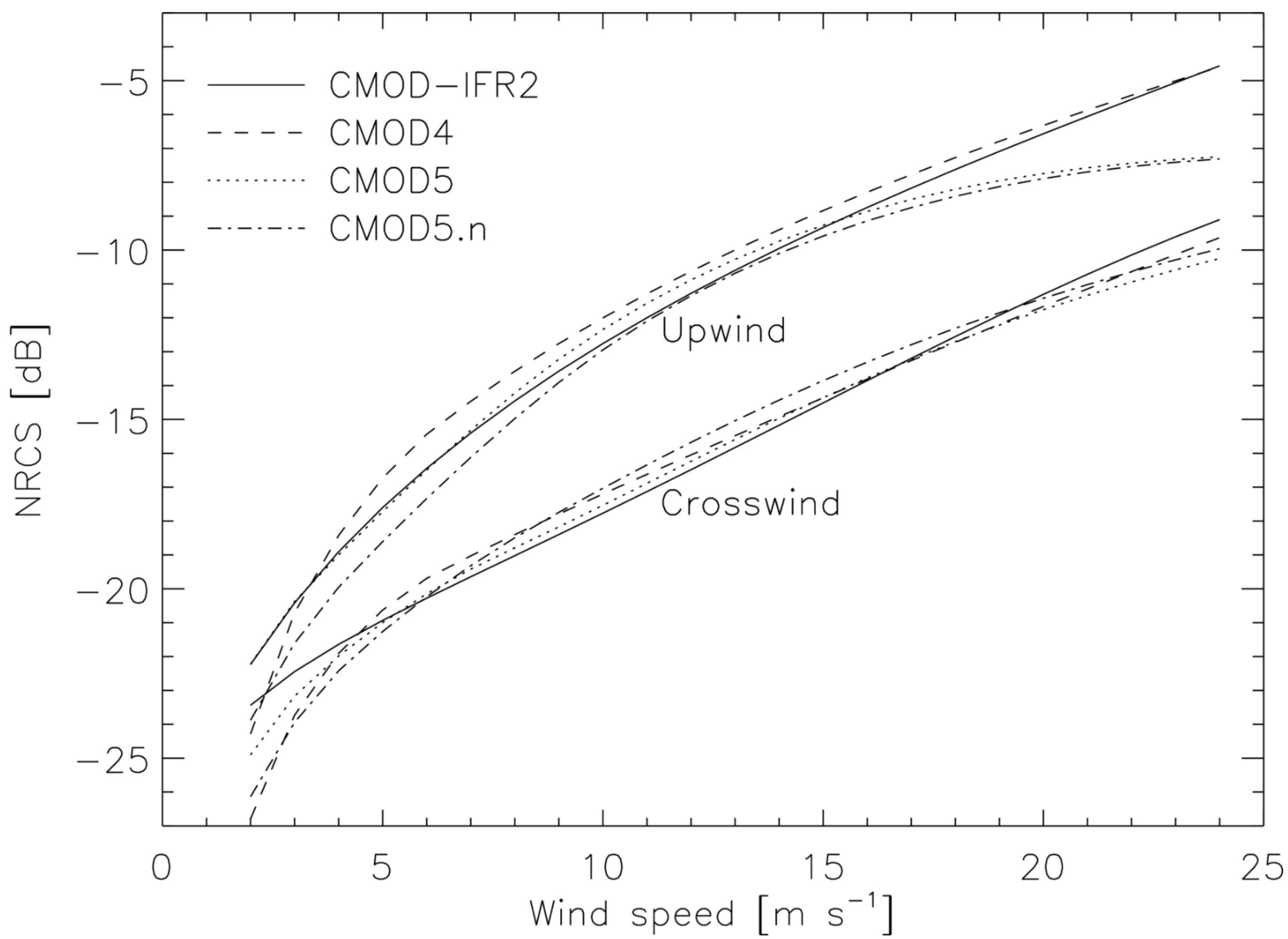
Rough surface scattering



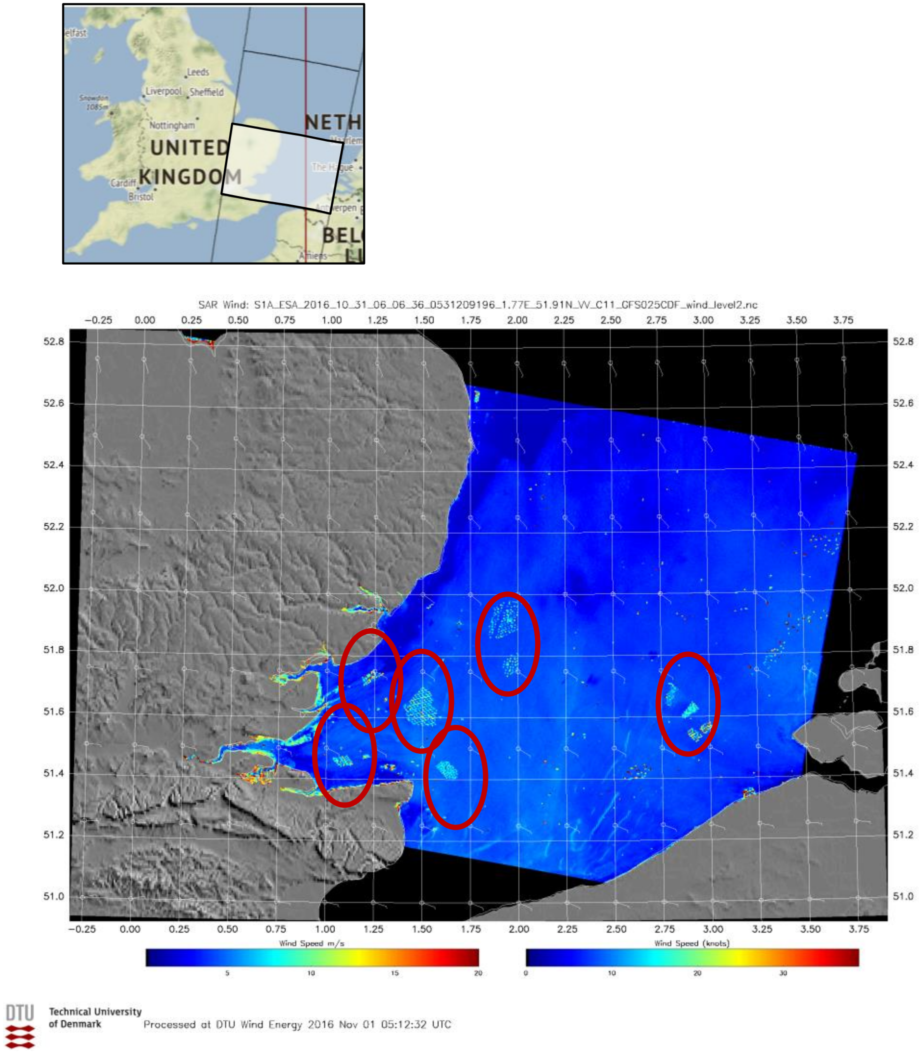
Low wind speed

High wind speed

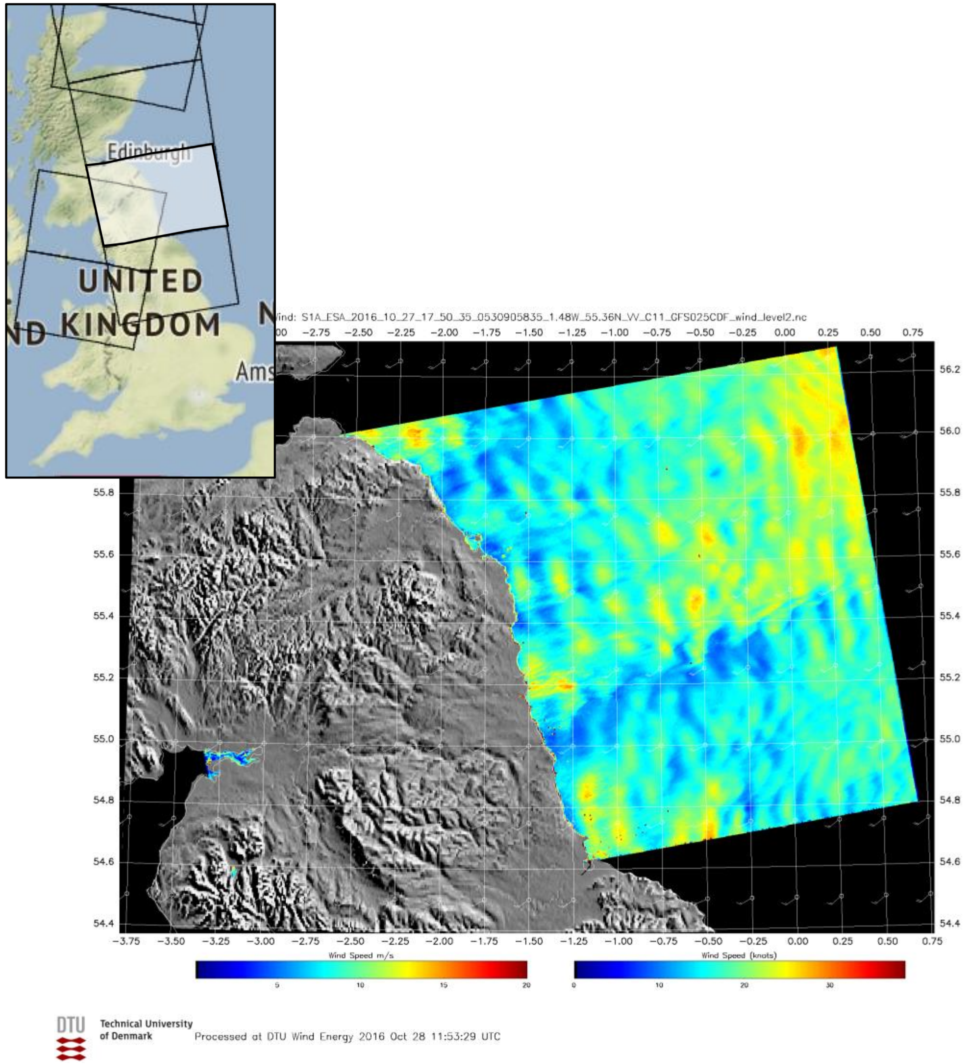
Geophysical Model Functions (GMF)



Sentinel-1A wind retrievals over the UK

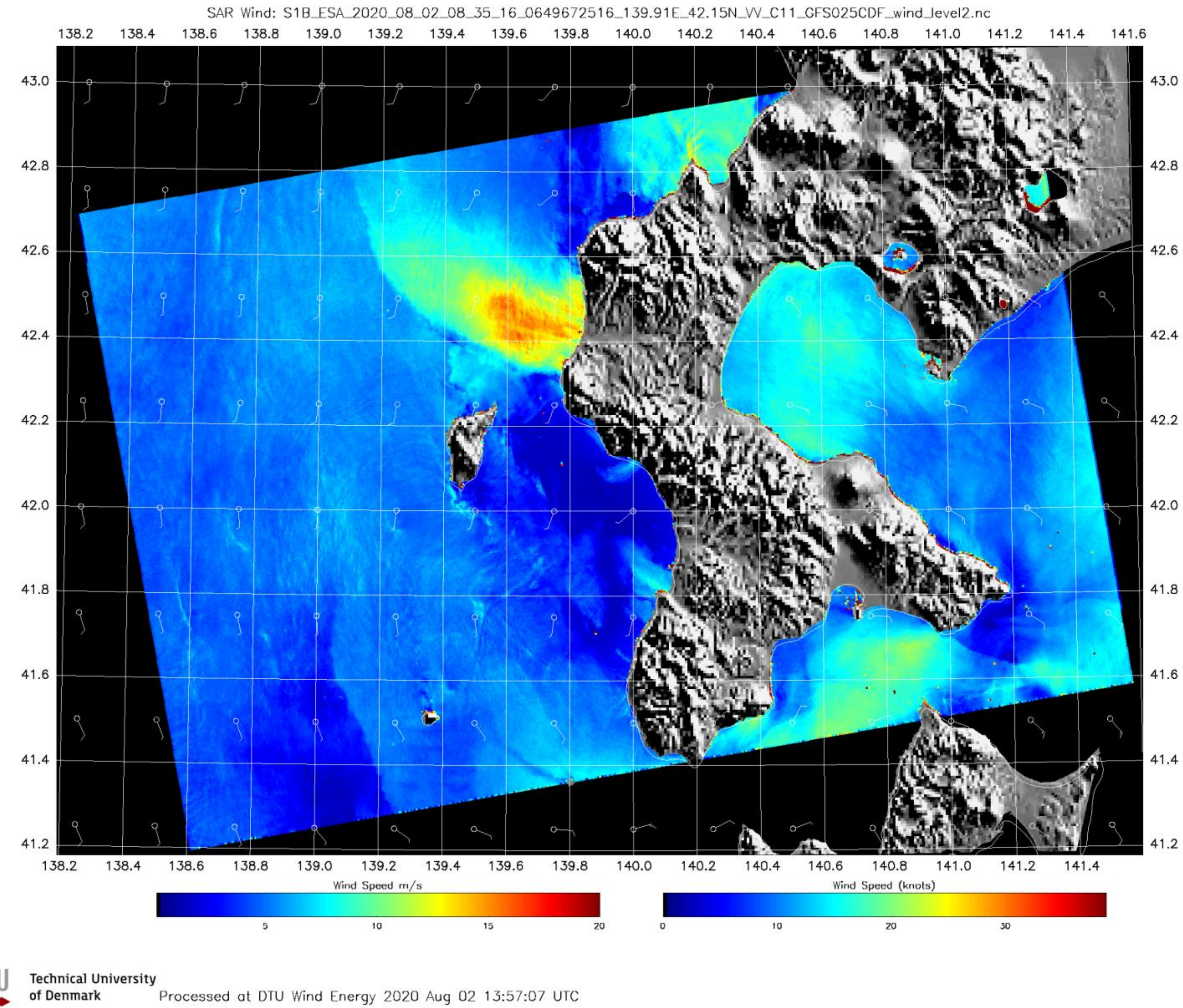


October 31, 2016 at 06:06 UTC



October 27, 2016 at 17:50 UTC

Sentinel-1B wind retrieval over Japan



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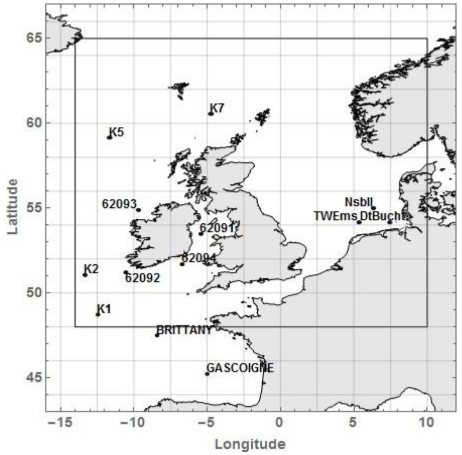
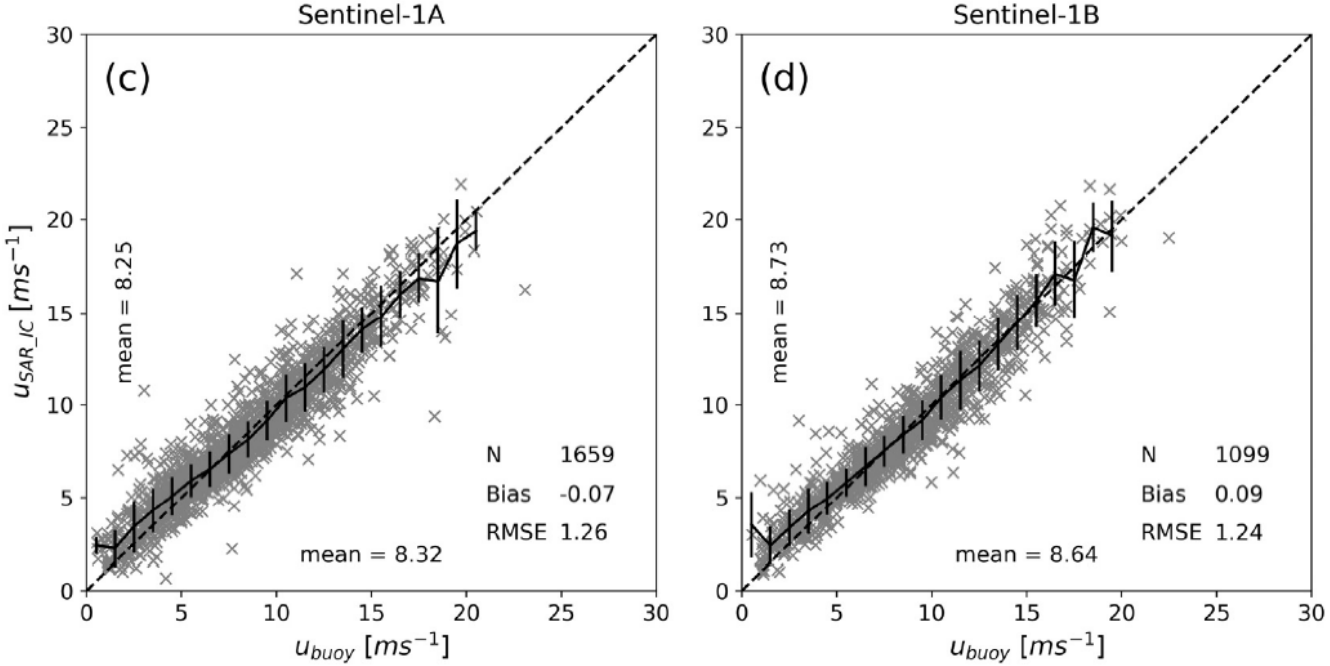
Wind speed comparisons – SAR vs. ocean buoys



In situ measurements from Met Eirinn, MetOffice, BSH

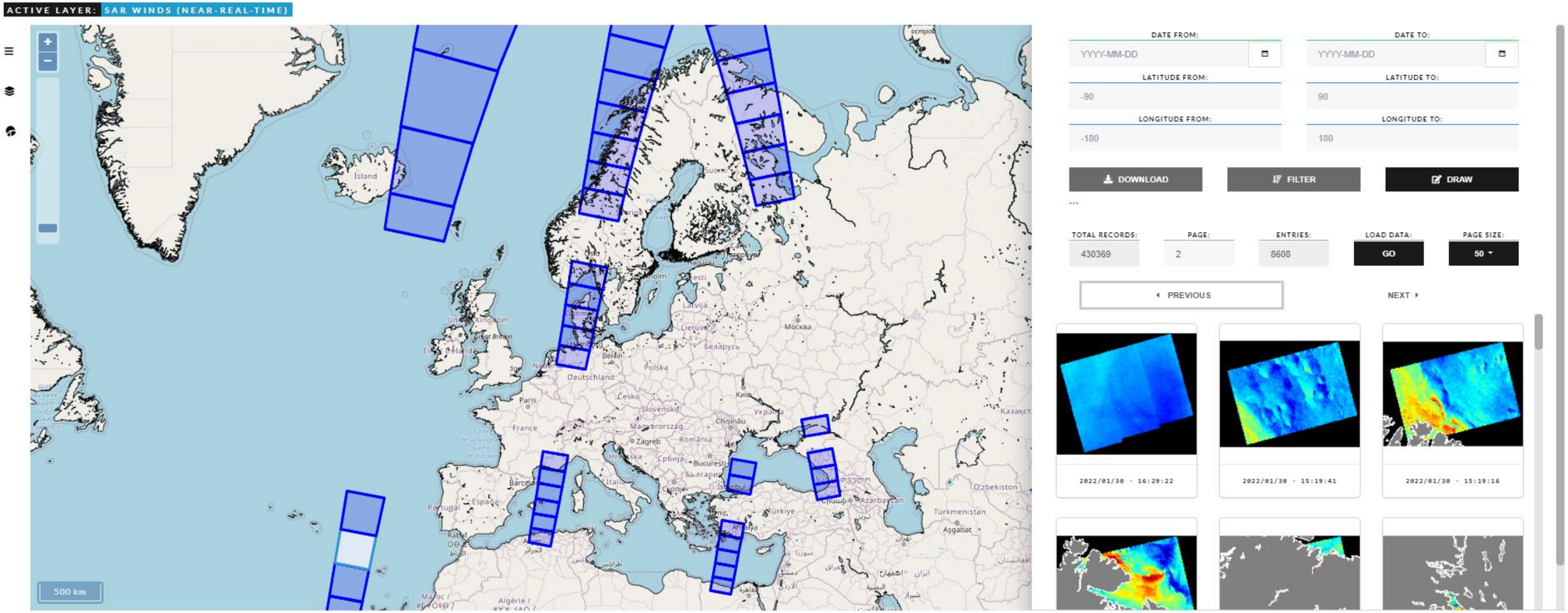


Wind retrieval processing with inter-calibration of NRCS

Source: Badger, M., Ahsbahs, T. T., Maule, P., & Karagali, I. (2019). Inter-calibration of SAR data series for offshore wind resource assessment. Remote Sensing of Environment, 232, 111316. https://doi.org/10.1016/j.rse.2019.111316

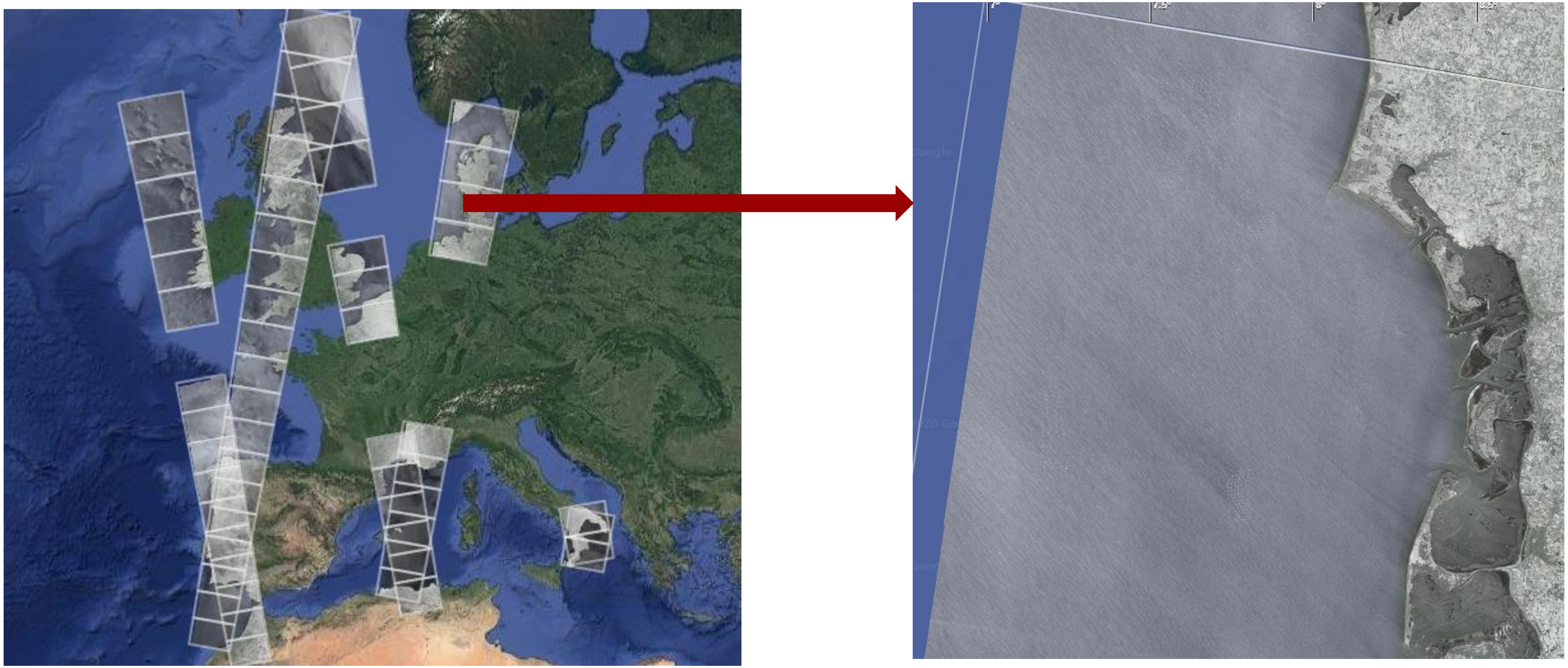
Near-real-time winds from SAR

https://science.globalwindatlas.info



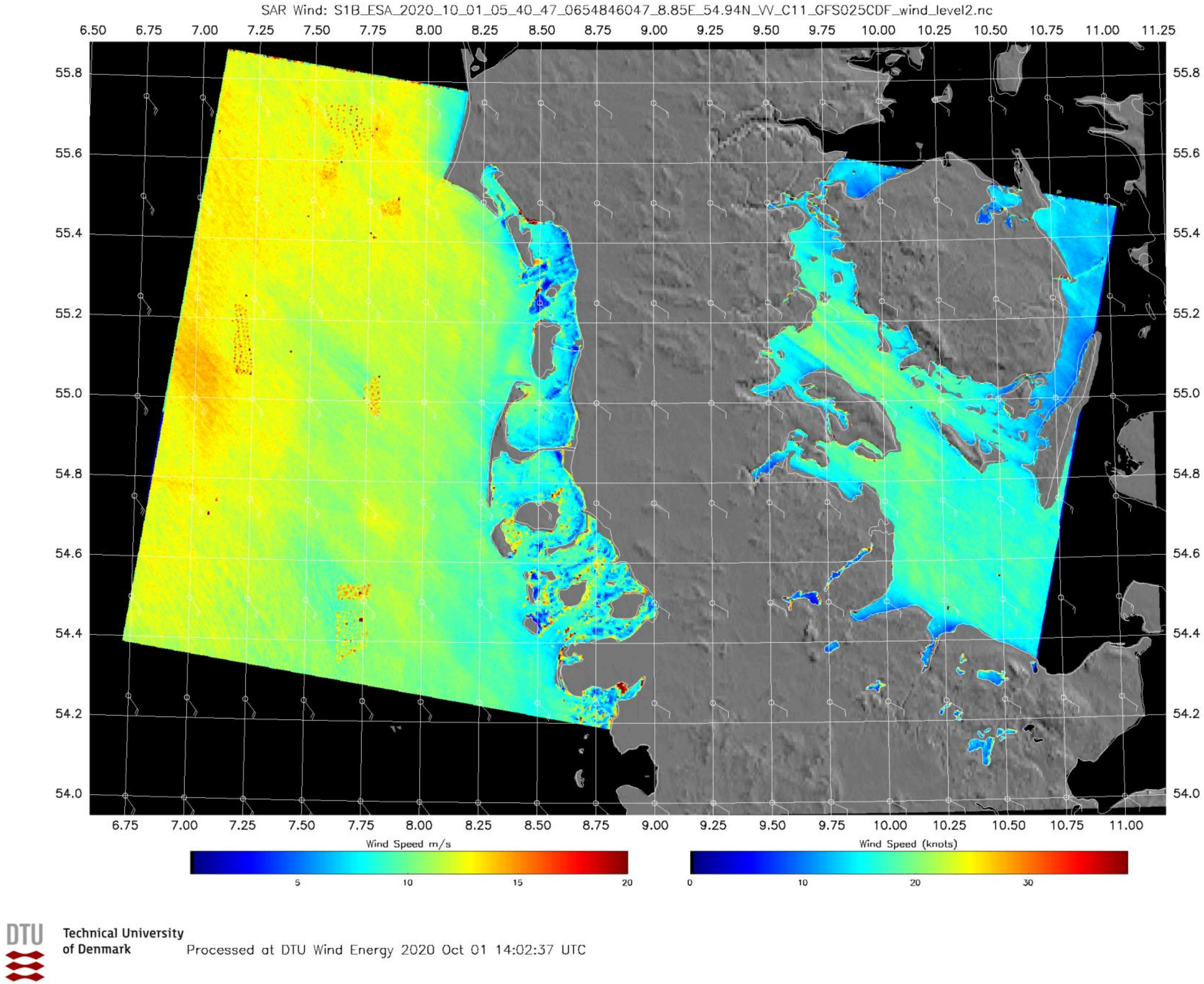
Supported by: EUDP 11-II, Globalt Vind Atlas J.nr. 64011-0347; H2020 e-shape GA 820852 & Global Atlas of Siting Parameters, J. nr. 64018-0095;
The e-shape project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 820852

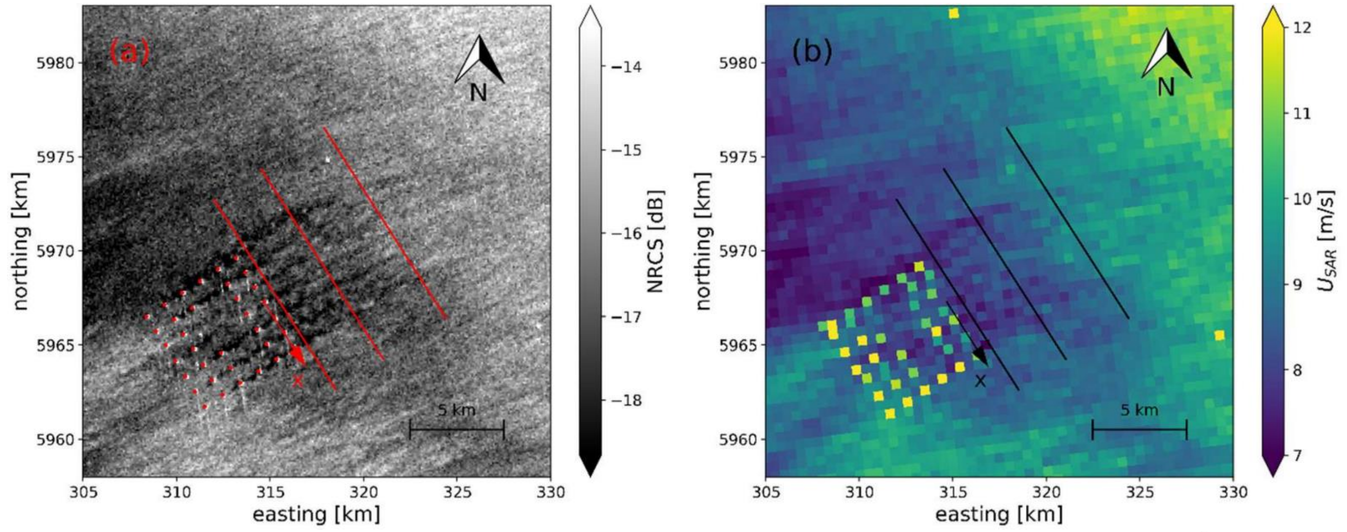
Wind farm wakes



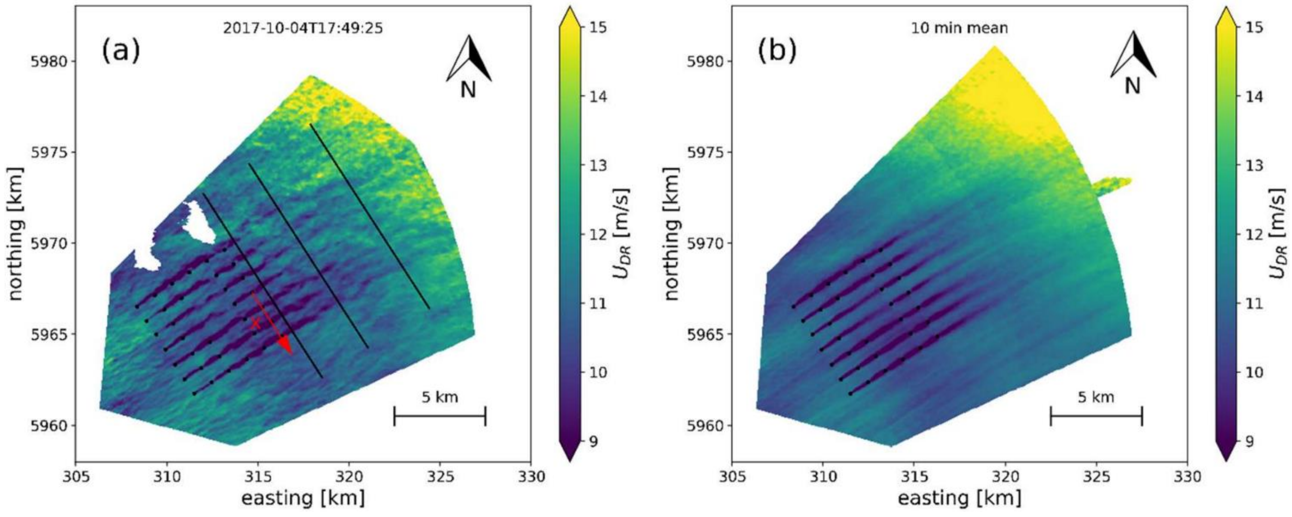
October 1st 2020. Source: ESA Ocean Virtual Laboratory

Explore at https://odl.bzh/Fod_4JQ-


SAR Wind: S1B_ESA_2020_10_01_05_40_47_0654846047_8.85E_54.94N_VV_C11_GFS025CDF_wind_level2.nc
Wind Speed m/s
Wind Speed (knots)
Technical University of Denmark
Processed at DTU Wind Energy 2020 Oct 01 14:02:37 UTC



SAR image (left) and 10-m wind speed (right)

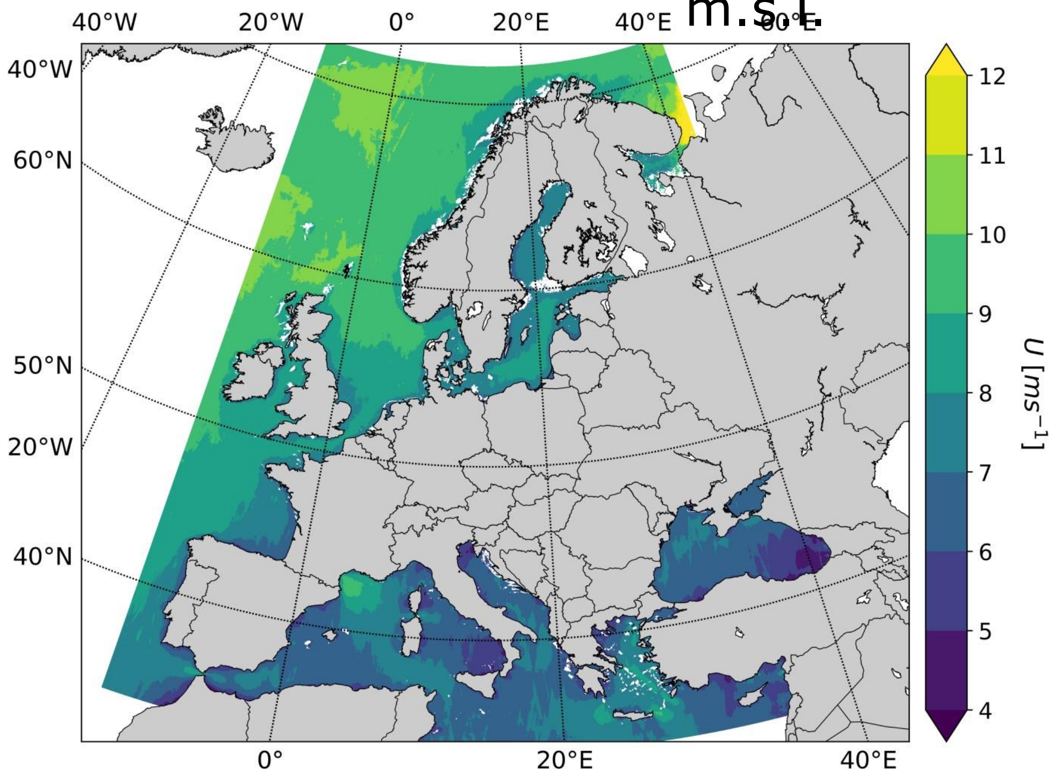


Source: Ahsbahs, T.; Nygaard, N.G.; Newcombe, A.; Badger, M. Wind Farm Wakes from SAR and Doppler Radar. Remote Sens. 2020, 12, 462.

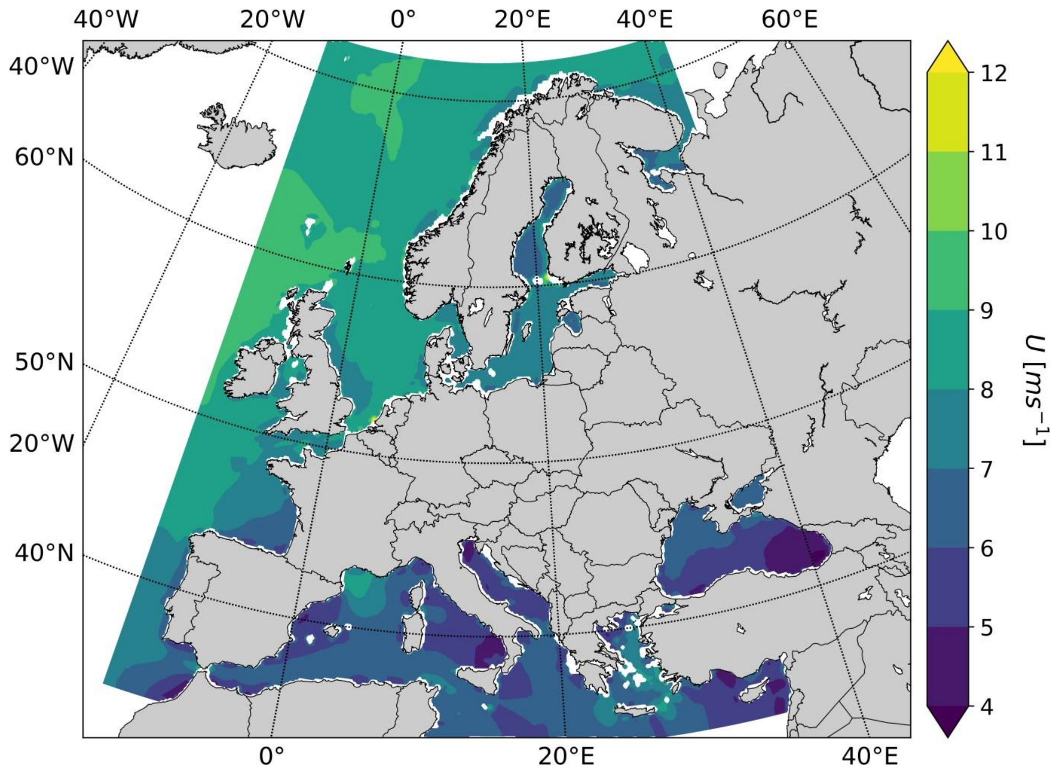
Ground-based Doppler Radar 10-m wind speed

Wind atlas for Europe

Mean wind speed at **10 m** above m.s.l.



Envisat and Sentinel-1 A/B SAR

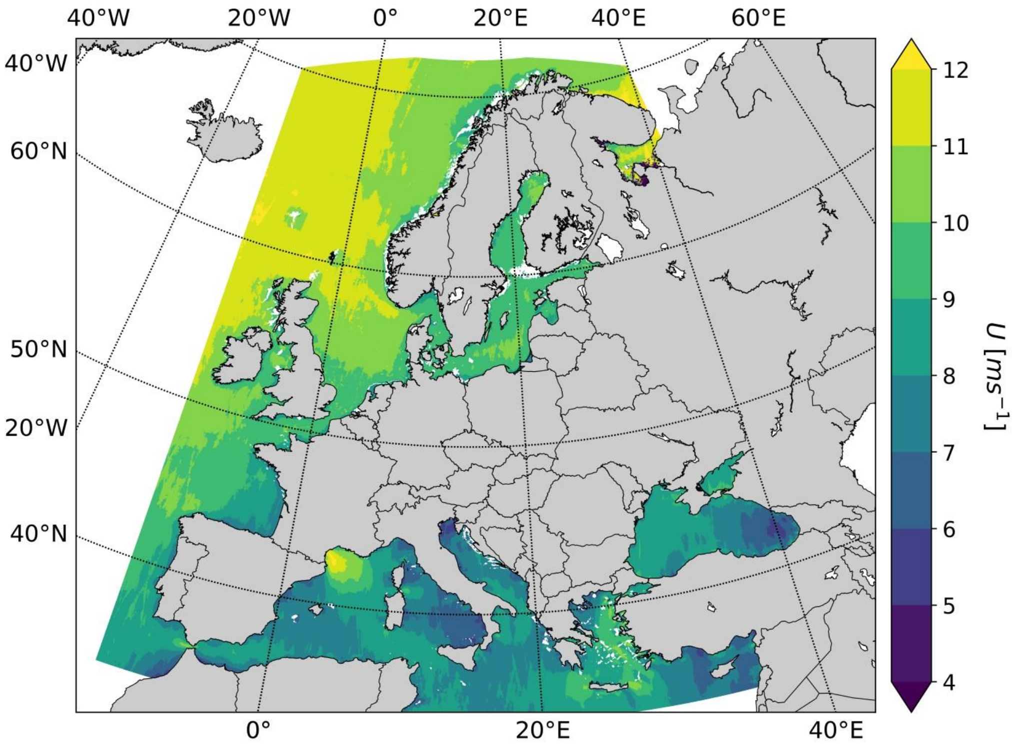


ASCAT

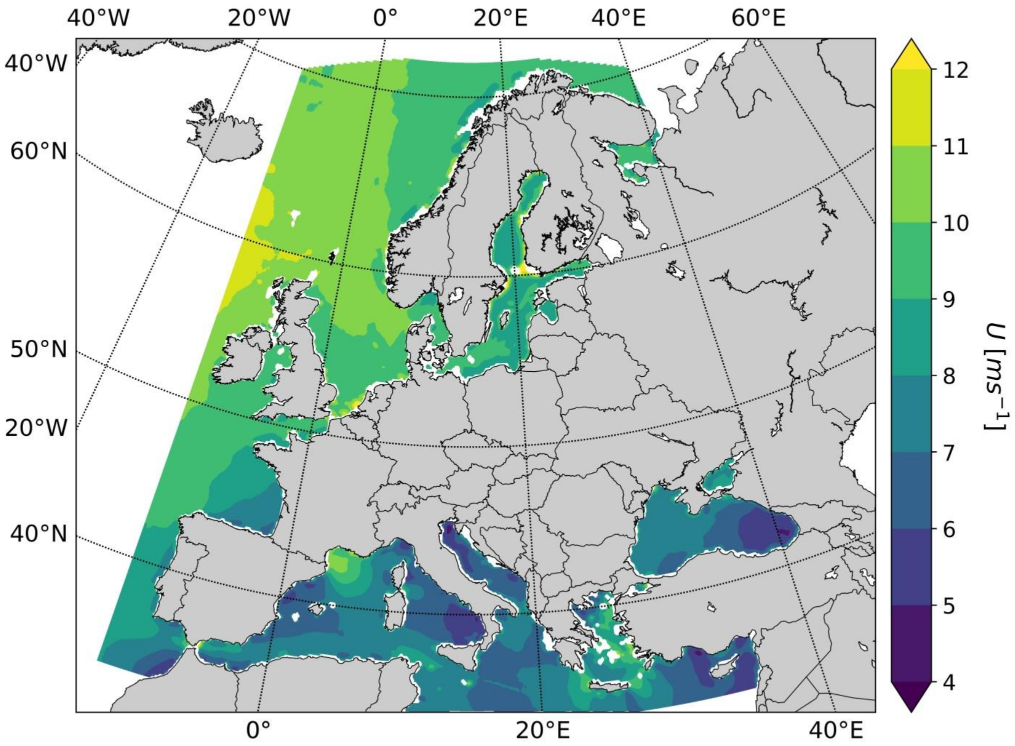
Source: Hasager et al. (2020). Europe's offshore winds assessed with synthetic aperture radar, ASCAT and WRF. Wind Energy Science, 5(1), 375–390. https://doi.org/10.5194/wes-5-375-2020.

Wind atlas for Europe

Mean wind speed at **100 m** above m.s.l.



Envisat and Sentinel-1 A/B SAR

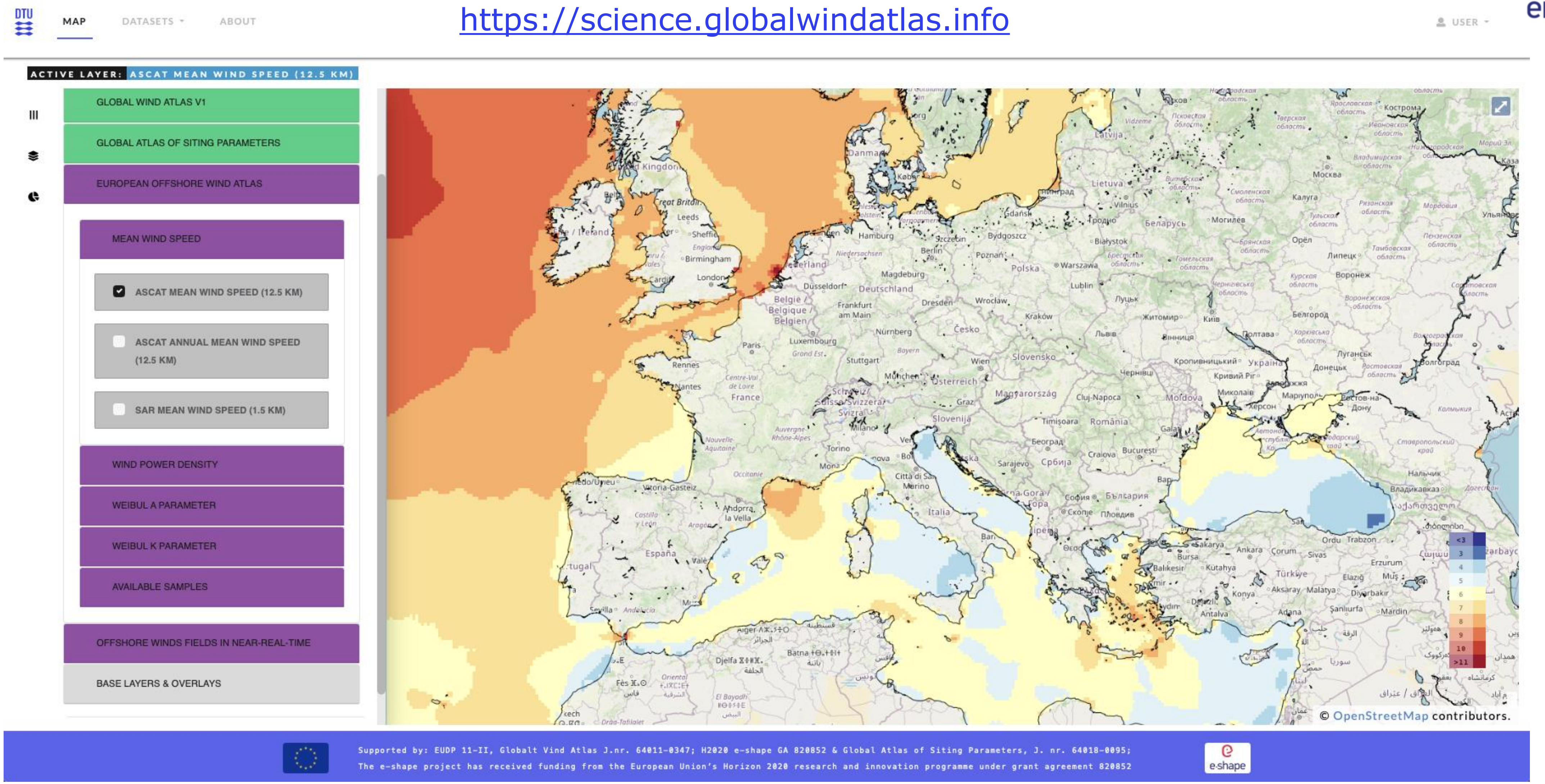


ASCAT

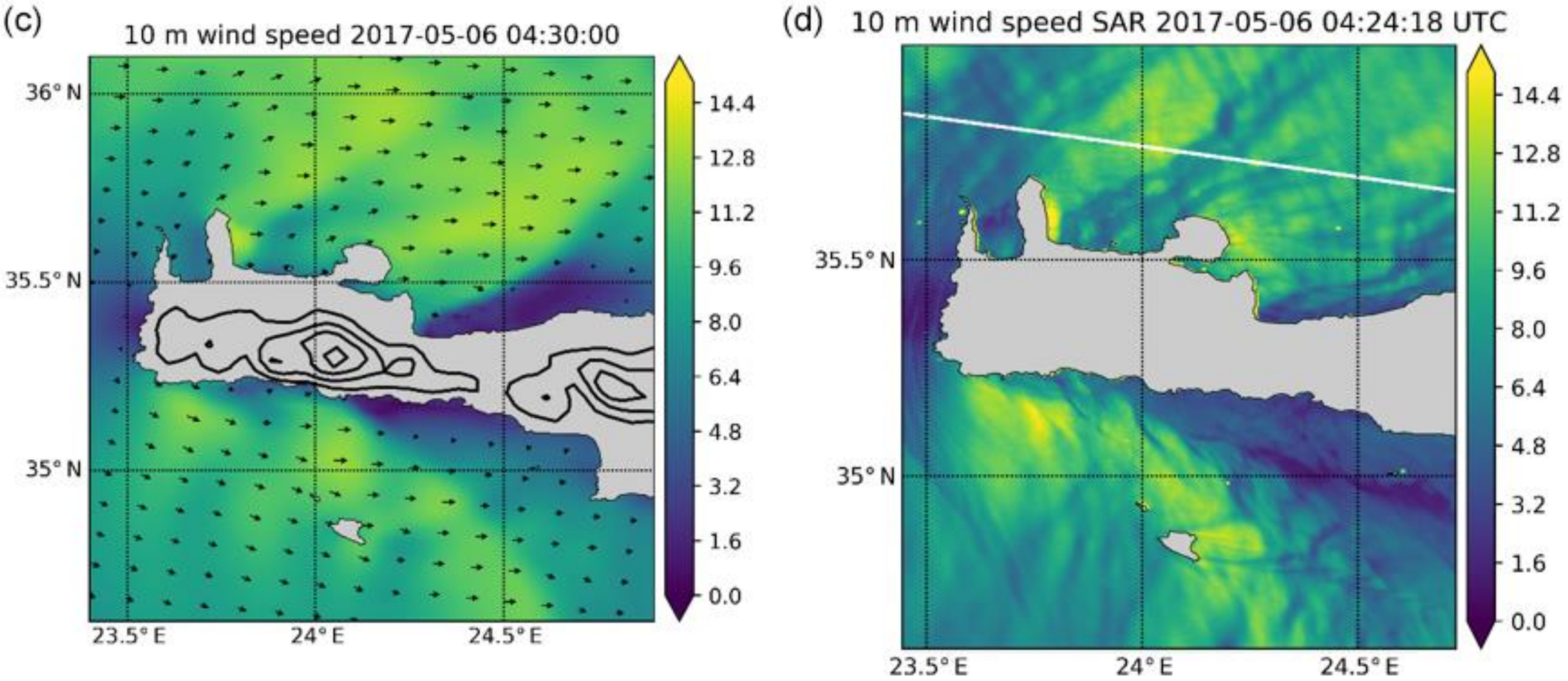
Source: Hasager et al. (2020). Europe's offshore winds assessed with synthetic aperture radar, ASCAT and WRF. Wind Energy Science, 5(1), 375–390. https://doi.org/10.5194/wes-5-375-2020.

Wind atlases from SAR and scatterometer

https://science.globalwindatlas.info



Model validation - instantaneous wind conditions

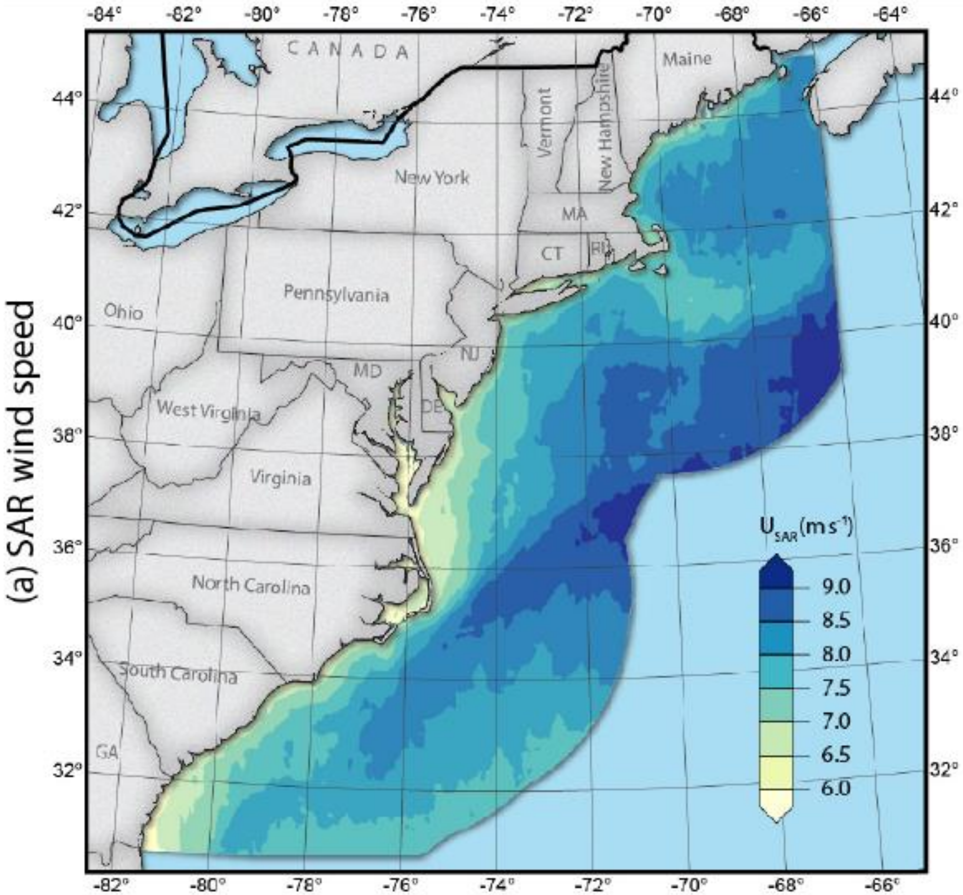


Modelled 10-m wind speed (WRF)

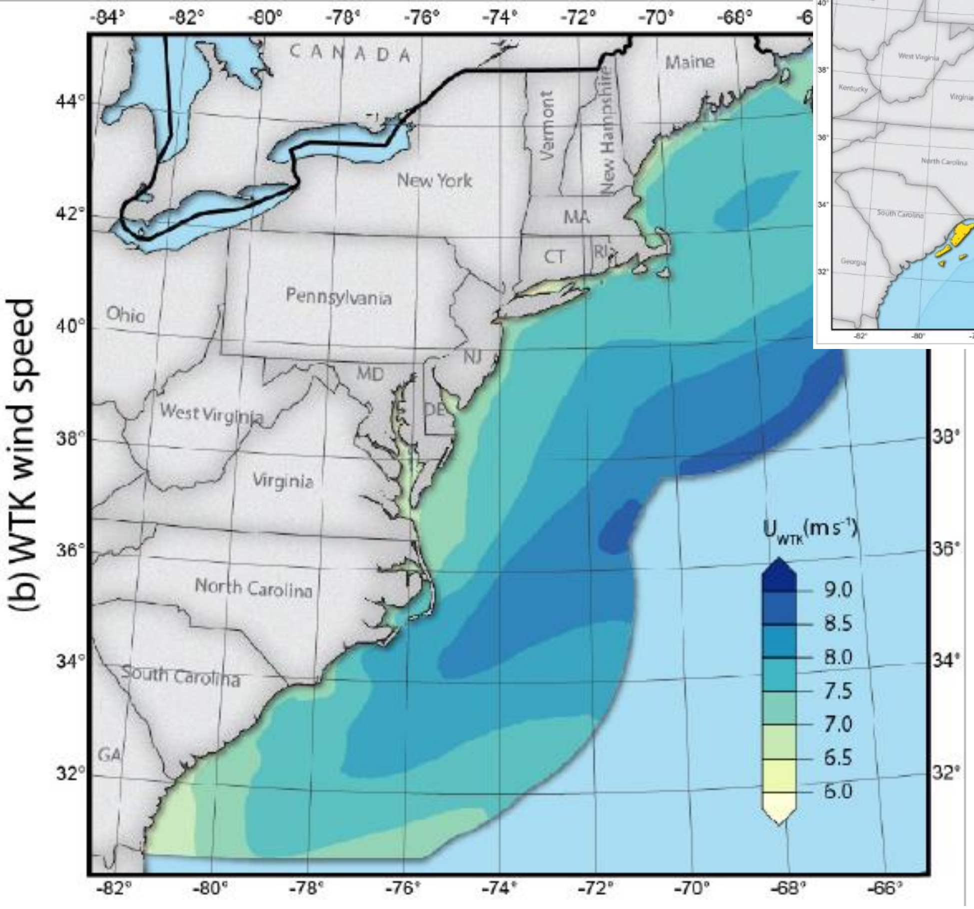
Satellite-based 10-m wind speed

Hasager et al. (2020). Europe's offshore winds assessed with synthetic aperture radar, ASCAT and WRF. Wind Energy Science, 5(1), 375–390. https://doi.org/10.5194/wes-5-375-2020

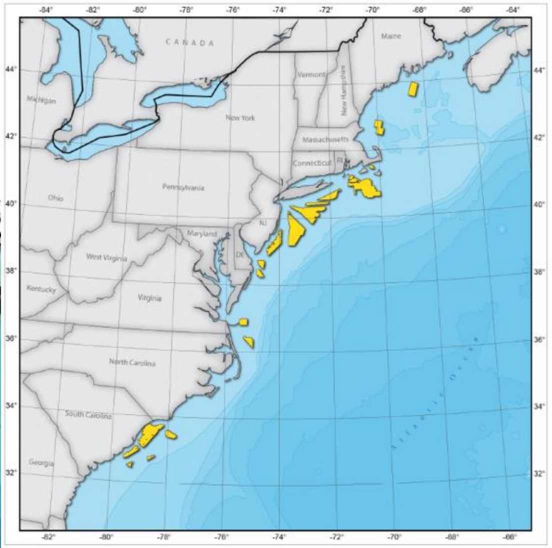
Model validation - wind resources



Satellite-based 10-m mean wind speed



Modelled 10-m mean wind speed



Ahsbahs et al. (2020): US East Coast synthetic aperture radar wind atlas for offshore wind energy, Wind Energ. Sci., 5, 1191–1210, https://doi.org/10.5194/wes-5-1191-2020.

Workshops with end users – using tools from e-shape

Rémi Gandoin
Senior Specialist, C2Wind

Gil Lizcano,

R&D Director, VORTEX

Wei He
Principal Engineer, Equinor

Outcome: Improved documentation pages

DTU MAP DATASETS ABOUT

- Global Wind Atlas v1
- Global Atlas of Siting Parameters
- European offshore wind atlas
- **Offshore wind fields in near-real-time**

OFFSHORE WIND FIELDS IN NEAR-REAL-TIME

INSTRUCTIONS

This site contains an archive of wind maps retrieved from satellite Synthetic Aperture Radar (SAR) observations over the ocean by DTU Wind Energy. The wind maps can be considered as instantaneous snap-shots of the ocean wind conditions, which the user can browse and download using different search functions on the right hand side of the screen (Fig. 1).

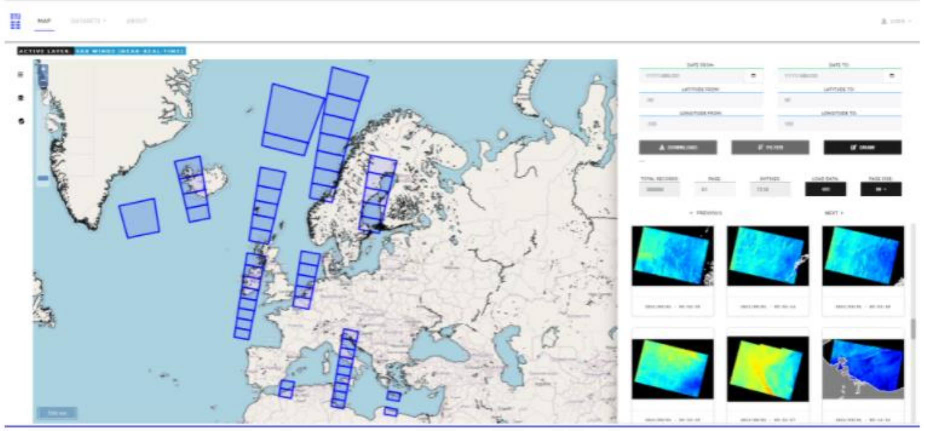


Figure 1. Interface for browsing and downloading satellite SAR wind maps

For each SAR wind field, two types of outputs are available for download (Fig. 2): A netCDF* (.nc) file holds the wind speed data together with various ancillary data used for the wind processing and metadata describing the product. An image file in .png format shows the wind field with a standard color scaling.

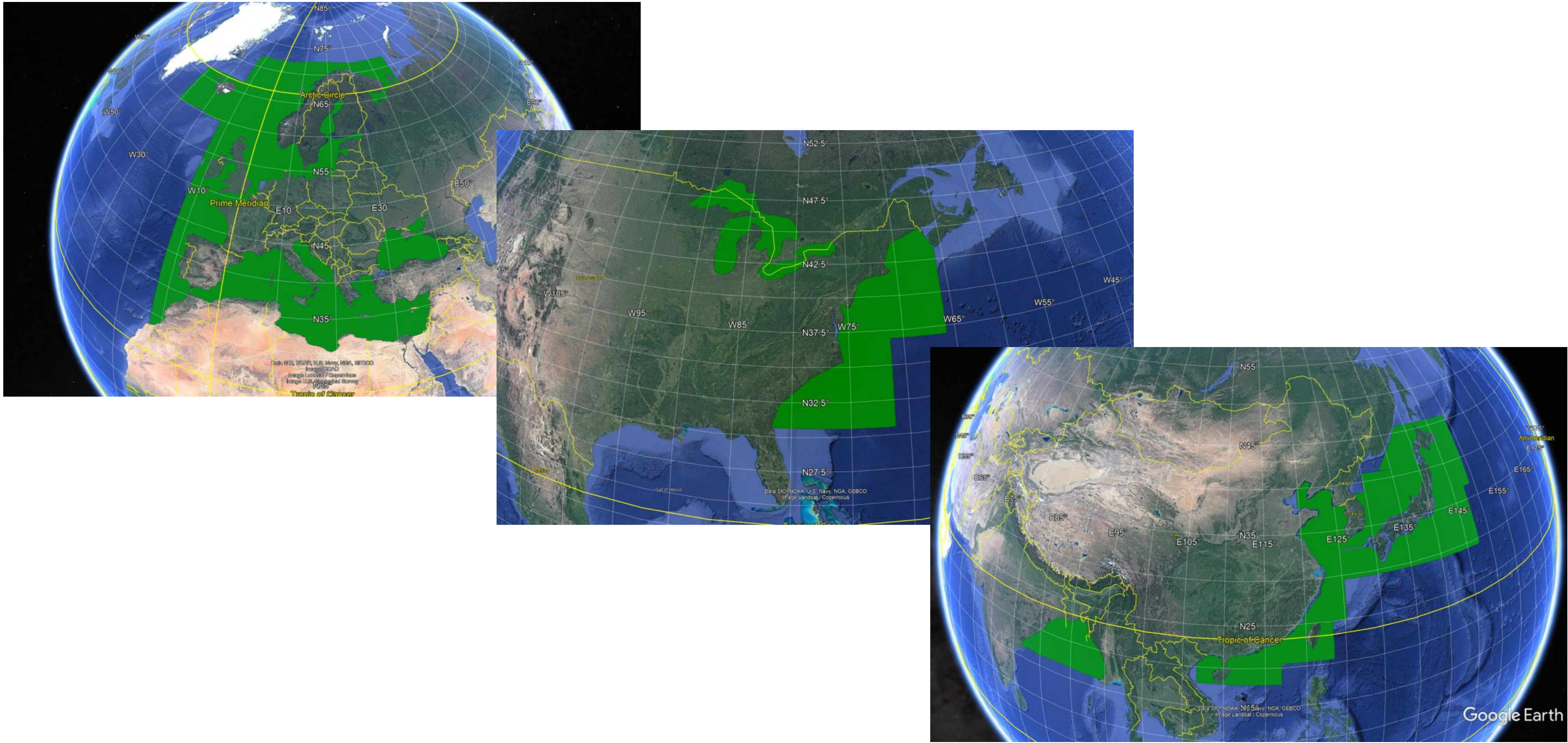
*In order to be able to download any netCDF files, you first have to be authenticated by either being logged in or register for an account.

SATELLITE DATA DETAILS ×

FILE: S1B_ESA_2021_08_17_17_21_48_0682536108_8.46E_41.42N_VV_C11_GFS025CDF ...
CREATED: 2021/08/17 - 17:21:48

Supported by: EUDP 11-II, Globalt Vind Atlas J.nr. 64011-0347; H2020 e-shape GA 820852 & Global Atlas of Siting Parameters, J. nr. 64018-0095;
The e-shape project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 820852

Outcome: Extended coverage of SAR wind retrievals



Summary and Conclusions

- EO winds available for more than 20 years
- EO winds have higher spatial resolution compared to standard mesoscale models
- EO winds offer a large spatial coverage
- Temporal sampling is reduced compared to in situ stations and numerical simulations
- 10-m reference height requires extrapolation to wind turbine hub heights (~100 m)
- Readily available for basic wind resource assessment to guide further analysis steps:
  - Installation of in situ measuring stations
  - High resolution numerical simulations
  - Wake analysis
  - Decision-making

Acknowledgements

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The Johns Hopkins University, Applied Physics Lab (JHU/APL) and the US National Oceanographic and Atmospheric Administration (NOAA) are acknowledged for the SAROPS tool, which we use for wind retrieval processing.

DTU's archive of SAR wind maps has been developed with financial support from the following sources:

- EuroGEO Showcases: Applications Powered by Europe (e-shape), H2020 (GA 820852).
- ESA Atlantic Regional Initiative Topic A2 (ARIA2), European Space Agency.
- Copernicus Evolution and Applications with Sentinel Enhancements and Land Effluents for Shores and Seas (CEASELESS), H2020 (GA 730030).
- New European wind Atlas (NEWA), FP7-ENERGY.2013.10.1.2.

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