Merging offshore wind products

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H2020 e-shape: Renewable Energy Showcase

Merging offshore wind products

Ioanna Karagali, Merete Badger, Charlotte Hasager

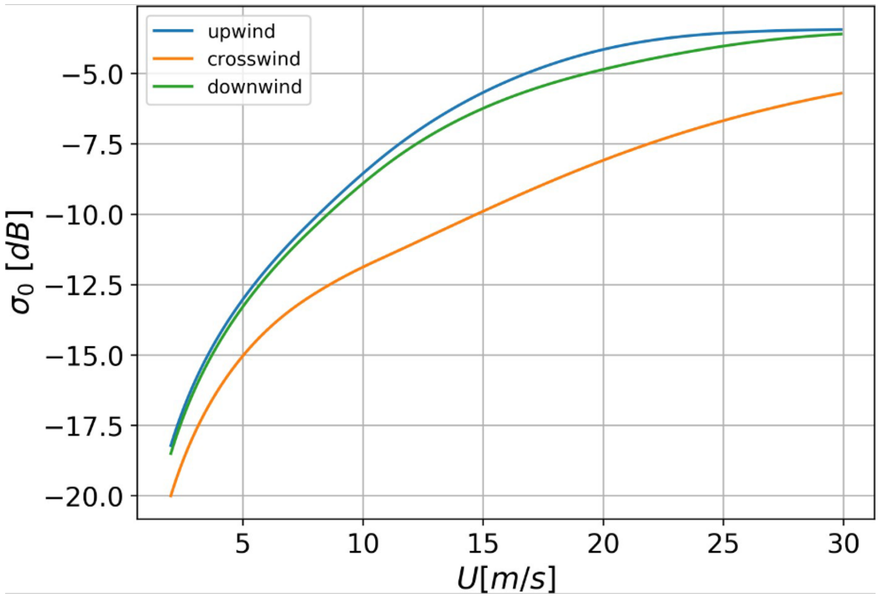
The e-shape project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 820852

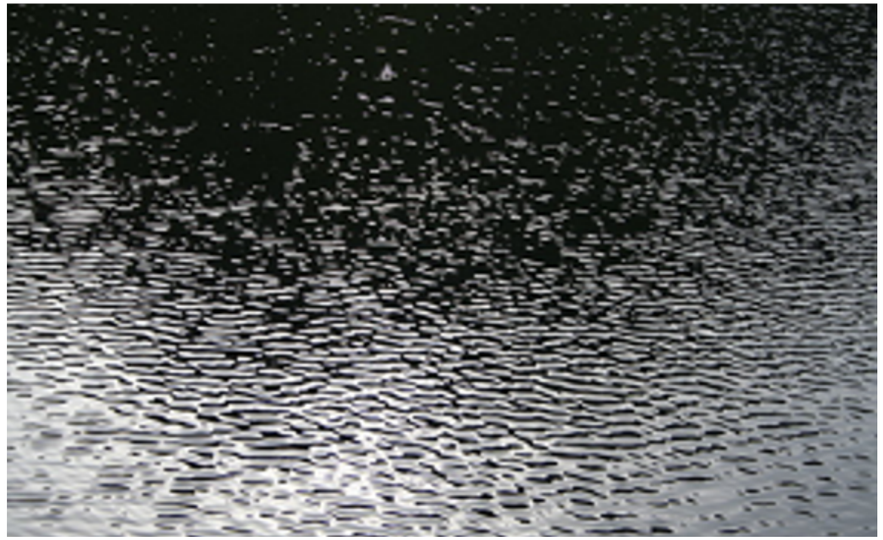
Earth Observation winds at 10 m over the ocean

- Microwave radar technology (~5-13 GHz)
- Backscatter from small scale (~2-5 cm) “ripples”
- Geophysical Model Functions to infer wind speed U from radar backscatter (NRCS)

$$NRCS = U^{\gamma(\theta)}\, A(\theta)\, \left[1 + B(\theta,U)\cos\varphi + C(\theta,U)\cos 2\varphi\right]$$

- Typical wind speed bias ~0.04 m/s, u-/v- σ~1.7 m/s*

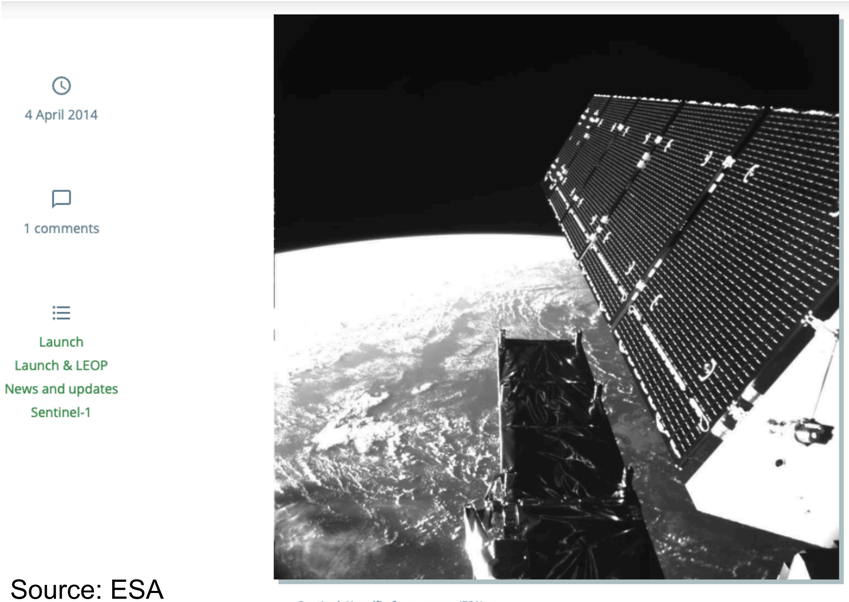




* EUMETSAT O&SI SAF, ASCAT wind validation report 2018 (https://scatterometer.knmi.nl/publications/pdf/ascat_validation.pdf)

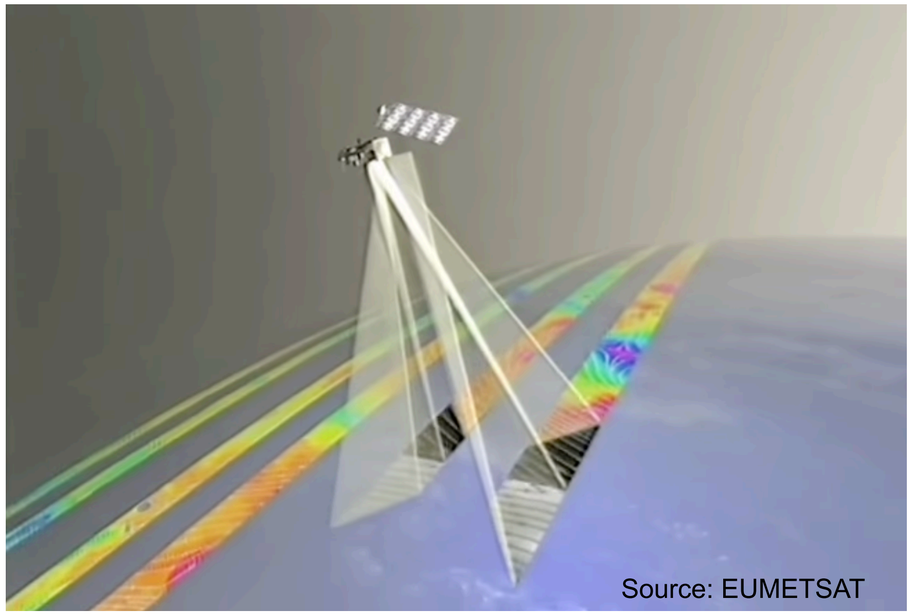
Sensor Advantages

- **S**ynthetic **A**perture **R**adar (**SAR**)
  - Spatial resolution: 500 m
  - 2002 to now (ASAR:2002-2012, S1A/B:2015-now)
  - Global coverage
  - 1 pass every ~2-3 days
  - Only wind speed, requires wind direction input
  - Winds retrieved at DTU Wind Energy



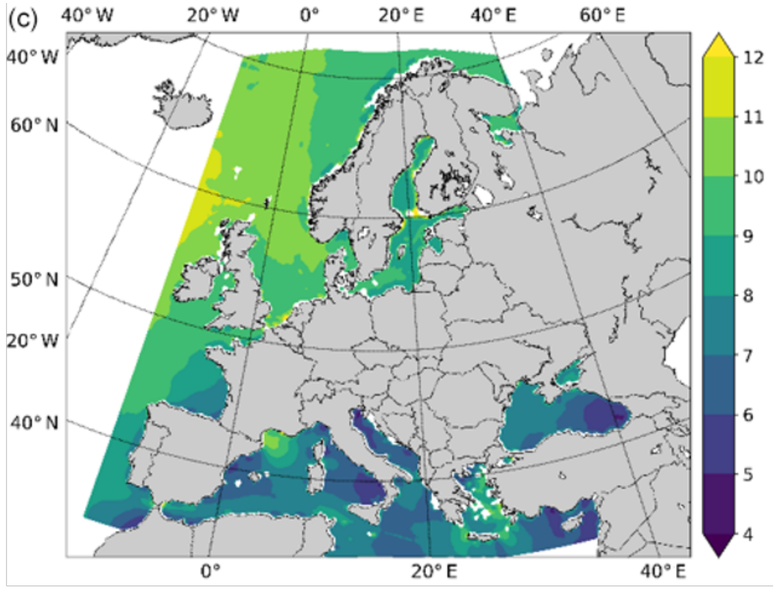
Source: ESA

- Scatterometer (**ASCAT**)
  - Spatial resolution: 12.5 km
  - 2007 to now (MetOp A/B/C)
  - Global coverage
  - 1-6 passes/day (latitude dependent)
  - Wind speed and direction
  - Winds available from CMEMS & the O&SI SAF

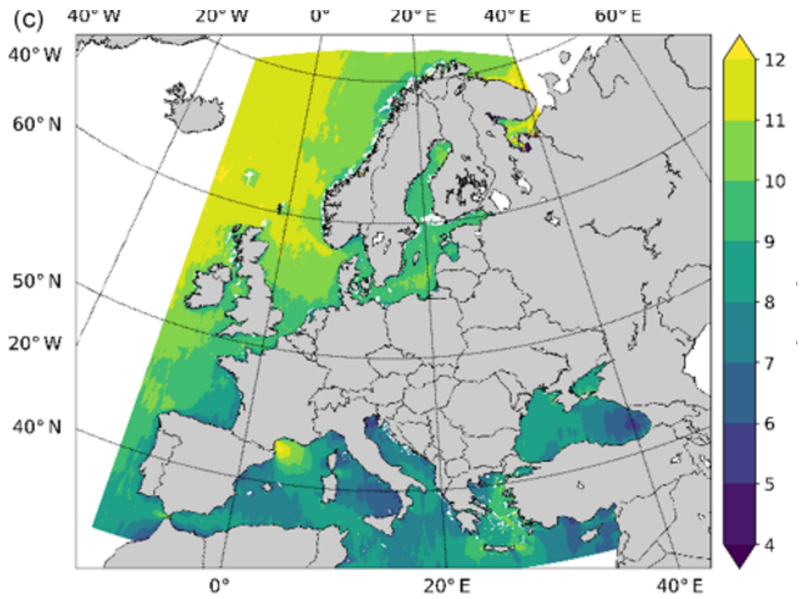


Source: EUMETSAT

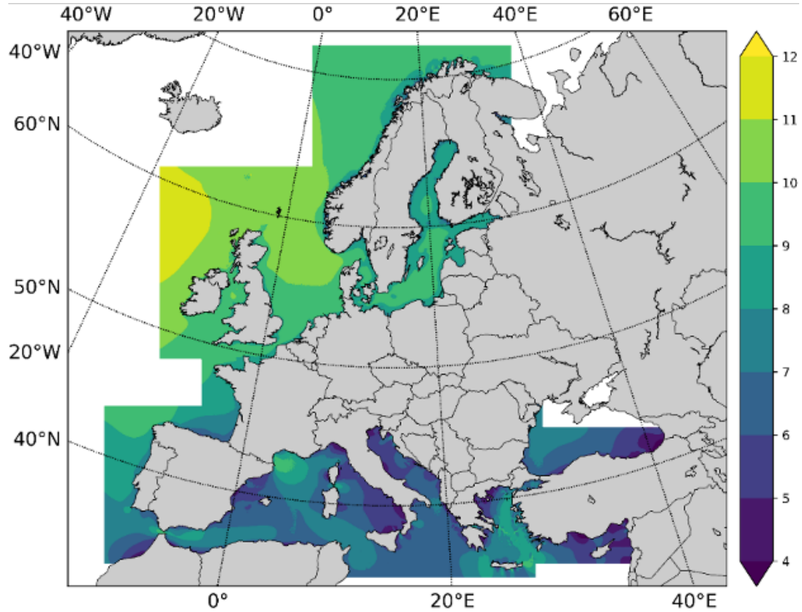
ASCAT 100m winds



SAR 100m winds



Simulated 100m winds

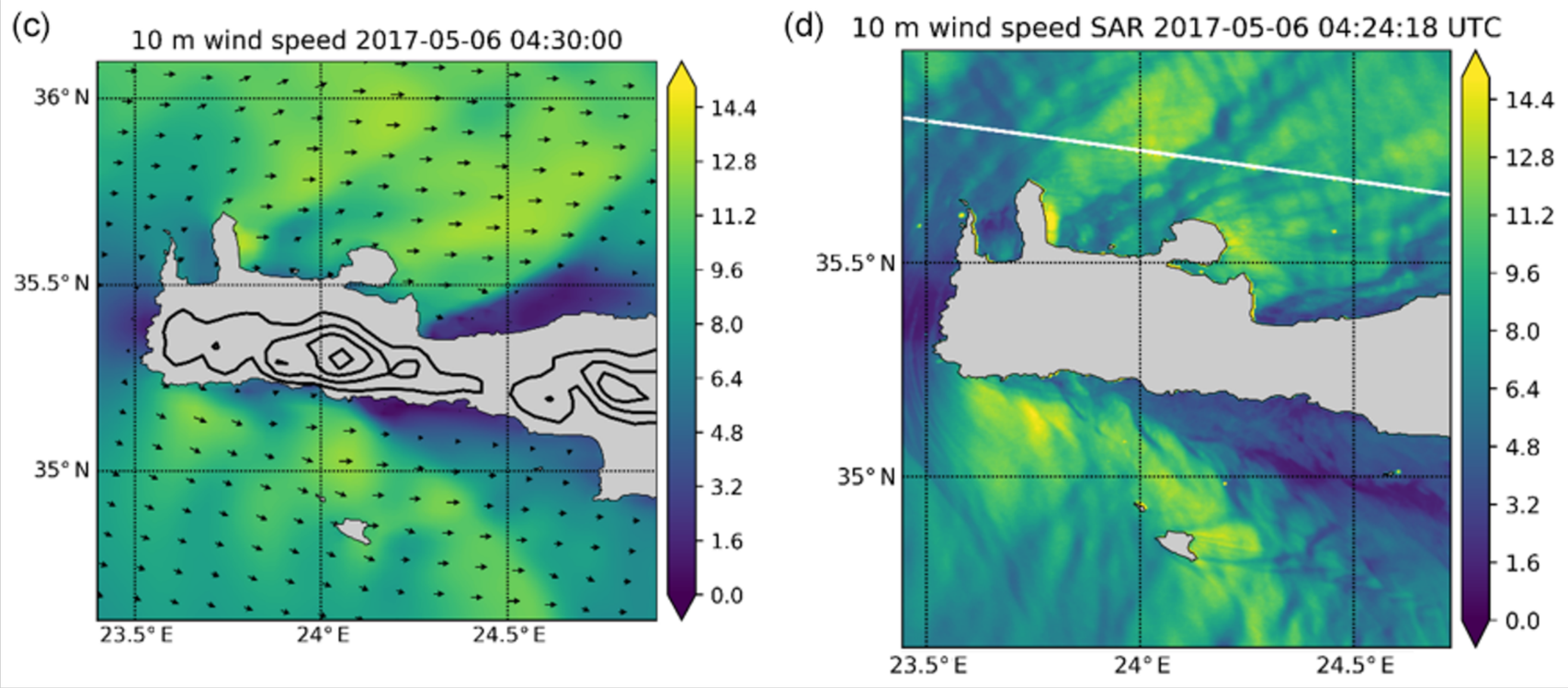


- 10m EO winds lifted using long-term stability correction from the Weather Research & Forecasting (WRF) model following Badger et al. (2016)*
- Comparisons of 100m EO winds with simulations from the New European Wind Atlas **

* Badger, M., Peña, A., Hahmann, A.N, Mouche, A. And Hasager, C.: Extrapolating satellite winds to turbine operating heights, Journal of Applied Meteorology and Climatology, (2016), 55(4), https://journals.ametsoc.org/view/journals/apme/55/4/jamc-d-15-0197.1.xml

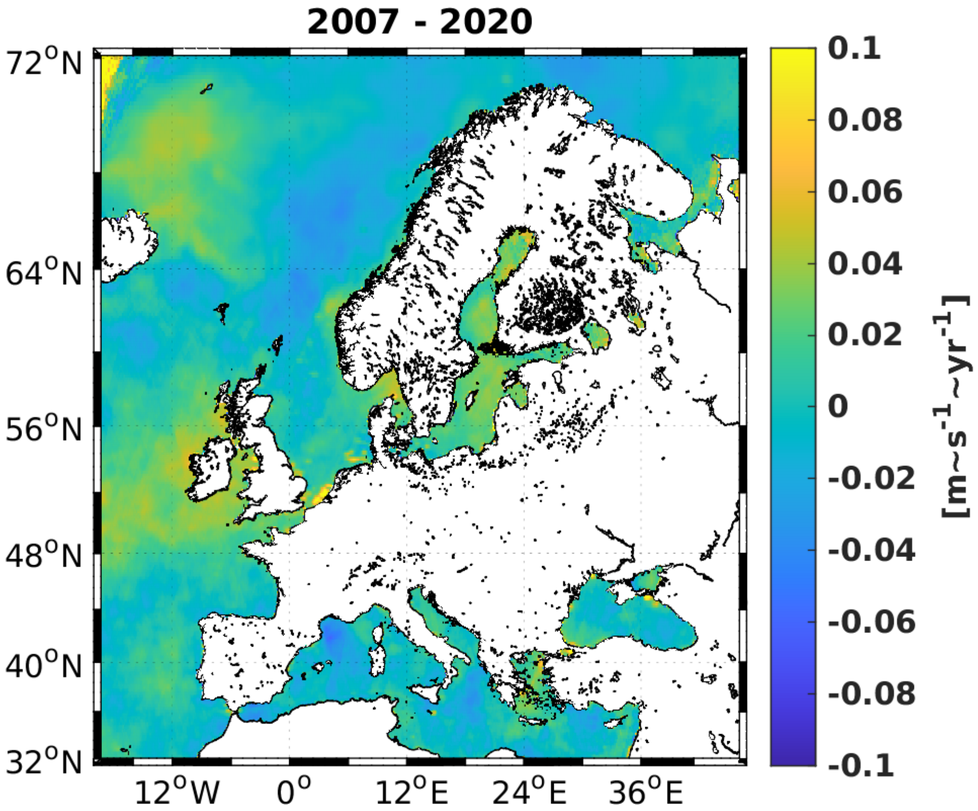
** Hasager, C. B., Hahmann, A. N., Ahsbahs, T., Karagali, I., Sile, T., Badger, M., and Mann, J.: Europe's offshore winds assessed with synthetic aperture radar, ASCAT and WRF, Wind Energ. Sci., 5, 375–390, https://doi.org/10.5194/wes-5-375-2020, 2020.

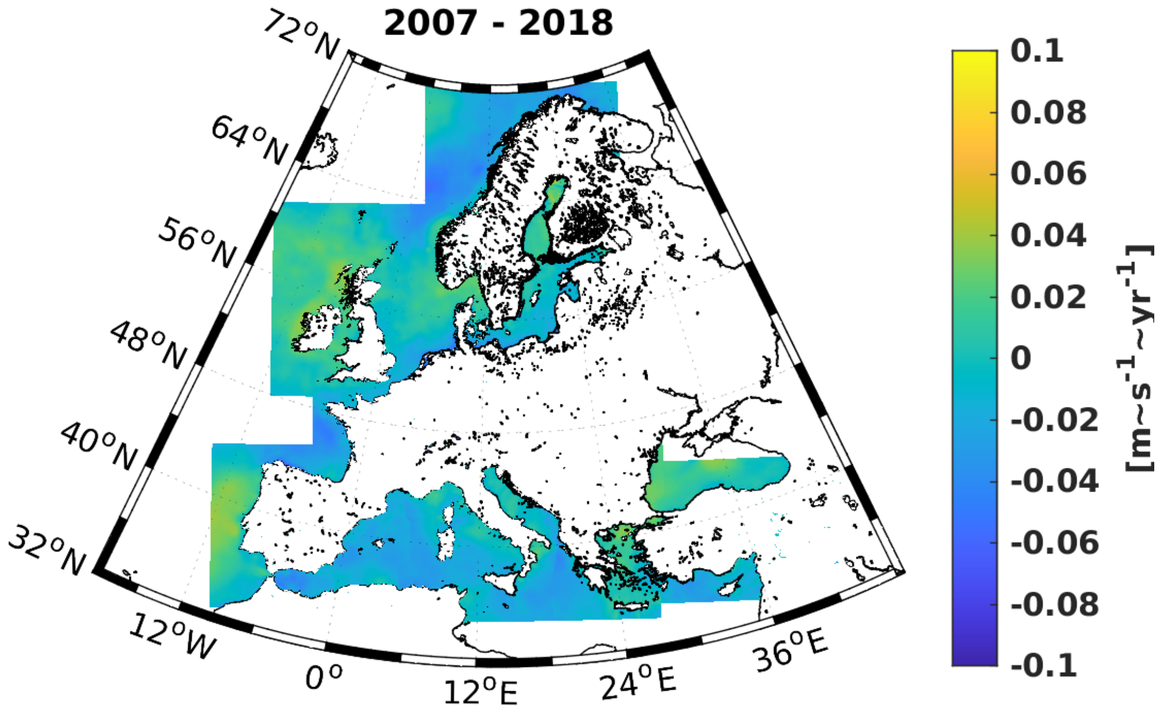
Instantaneous EO vs simulated winds



- Source: Hasager, C. B., Hahmann, A. N., Ahsbahs, T., Karagali, I., Sile, T., Badger, M., and Mann, J.: Europe's offshore winds assessed with synthetic aperture radar, ASCAT and WRF, Wind Energ. Sci., 5, 375–390, https://doi.org/10.5194/wes-5-375-2020, 2020.

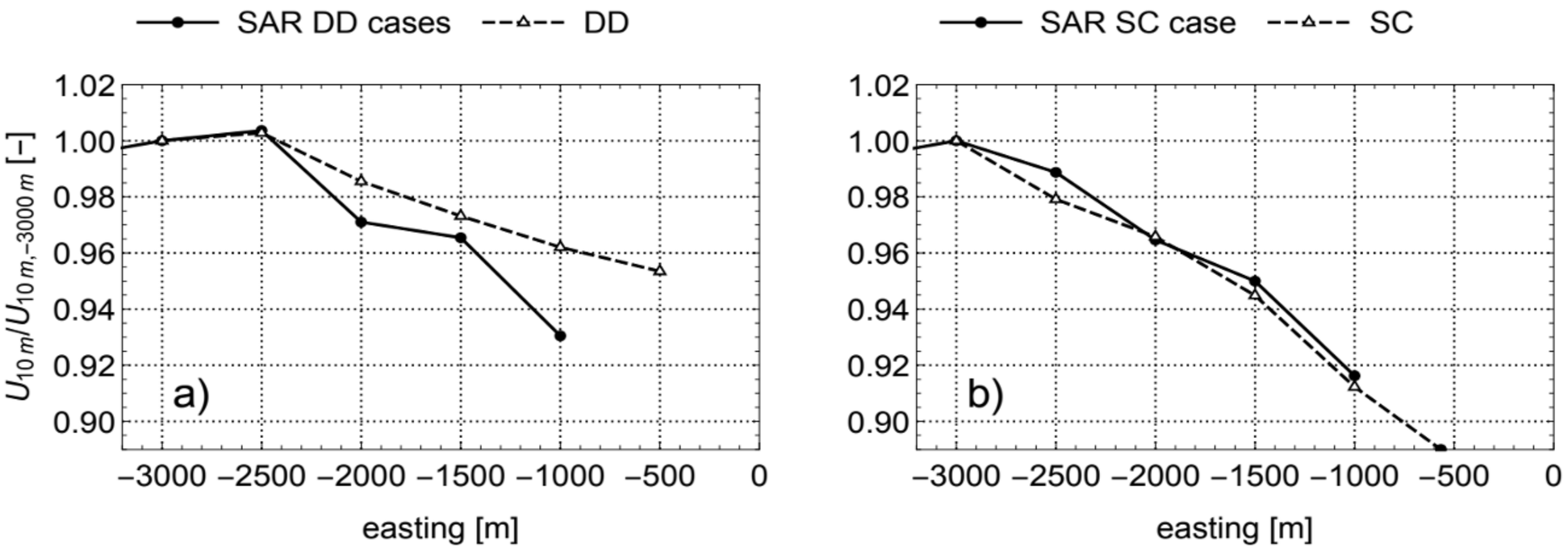
“Long-term” EO vs Simulated Wind Speed Trends





- Linear regression of EO mean monthly wind speeds from ASCAT (left) and NEWA (right).

Coastal gradients from EO winds vs Lidar



- Wind speed change along transect perpendicular to a straight coastline

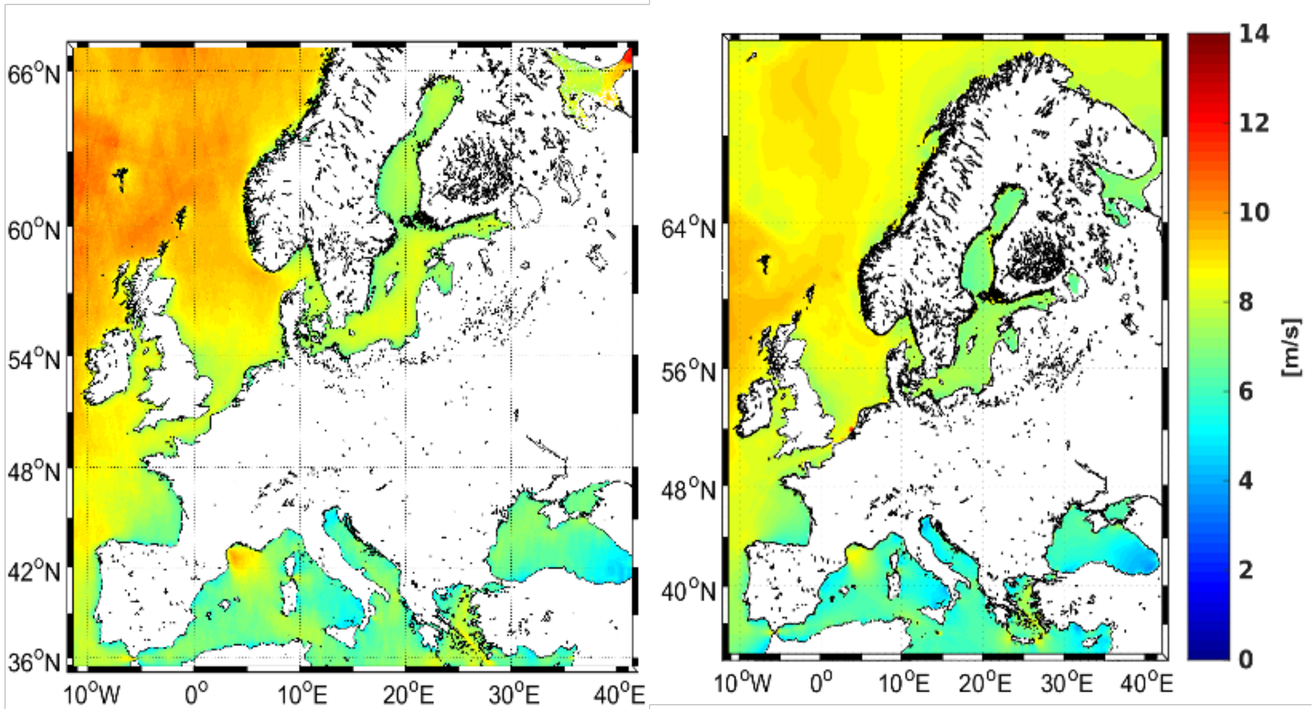
Source: Ahsbahs, T.; Badger, M.; Karagali, I.; Larsén, X.G. Validation of Sentinel-1A SAR Coastal Wind Speeds Against Scanning LiDAR. *Remote Sens.* **2017**, *9*, 552

H2020 project **e-shape** brings together Earth Observation (EO) resources in Europe to establish EuroGEO, Europe's contribution to the Group on Earth Observation (GEO), leveraging Copernicus (Europe's eyes on Earth), using existing European capacities and improving user uptake of data.

Merging Offshore Winds

- **Objective**: EO-based offshore wind resources from Synthetic Aperture Radar (SAR) and Scatterometer winds, for the European Seas.

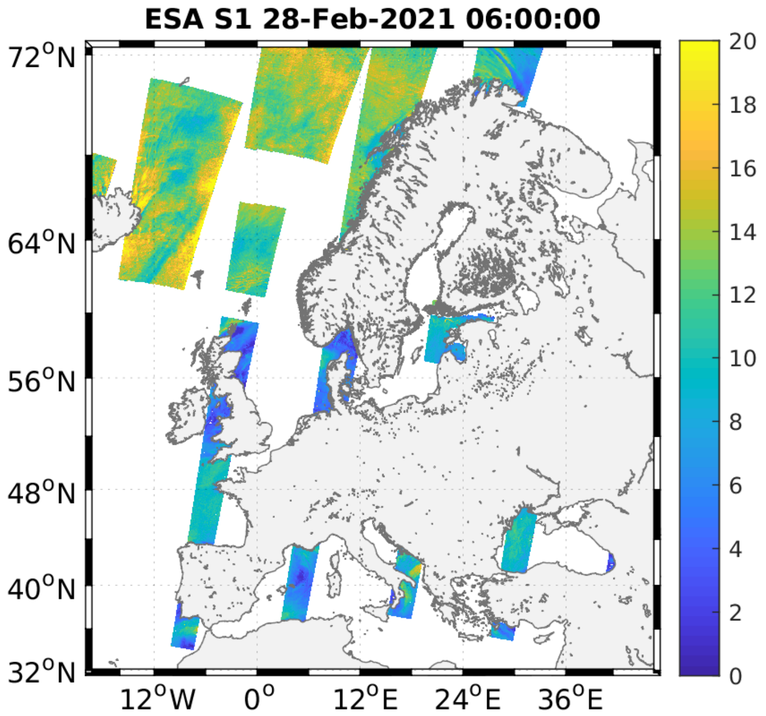
- **Expected user community:** Offshore wind farm developers and operators, consultants for offshore wind farm siting and resource assessment, researchers and policy makers.



Mean wind speed at 10m from SAR (left: 2002-2016) & ASCAT (right: 2007-2016). From Karagali et al. 2018*.

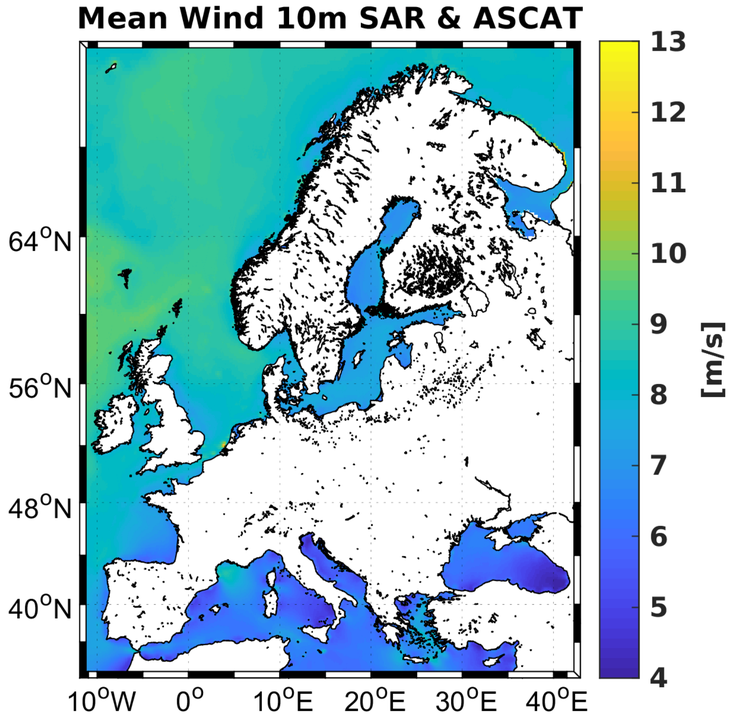
* Karagali, I., Hahmann, A. N., Badger, M., Hasager, C. B., & Mann, J. (2018). New European wind atlas offshore. Journal of Physics: Conference Series, 1037(5), 052007. https://doi.org/10.1088/1742-6596/1037/5/052007

Gridding SAR winds



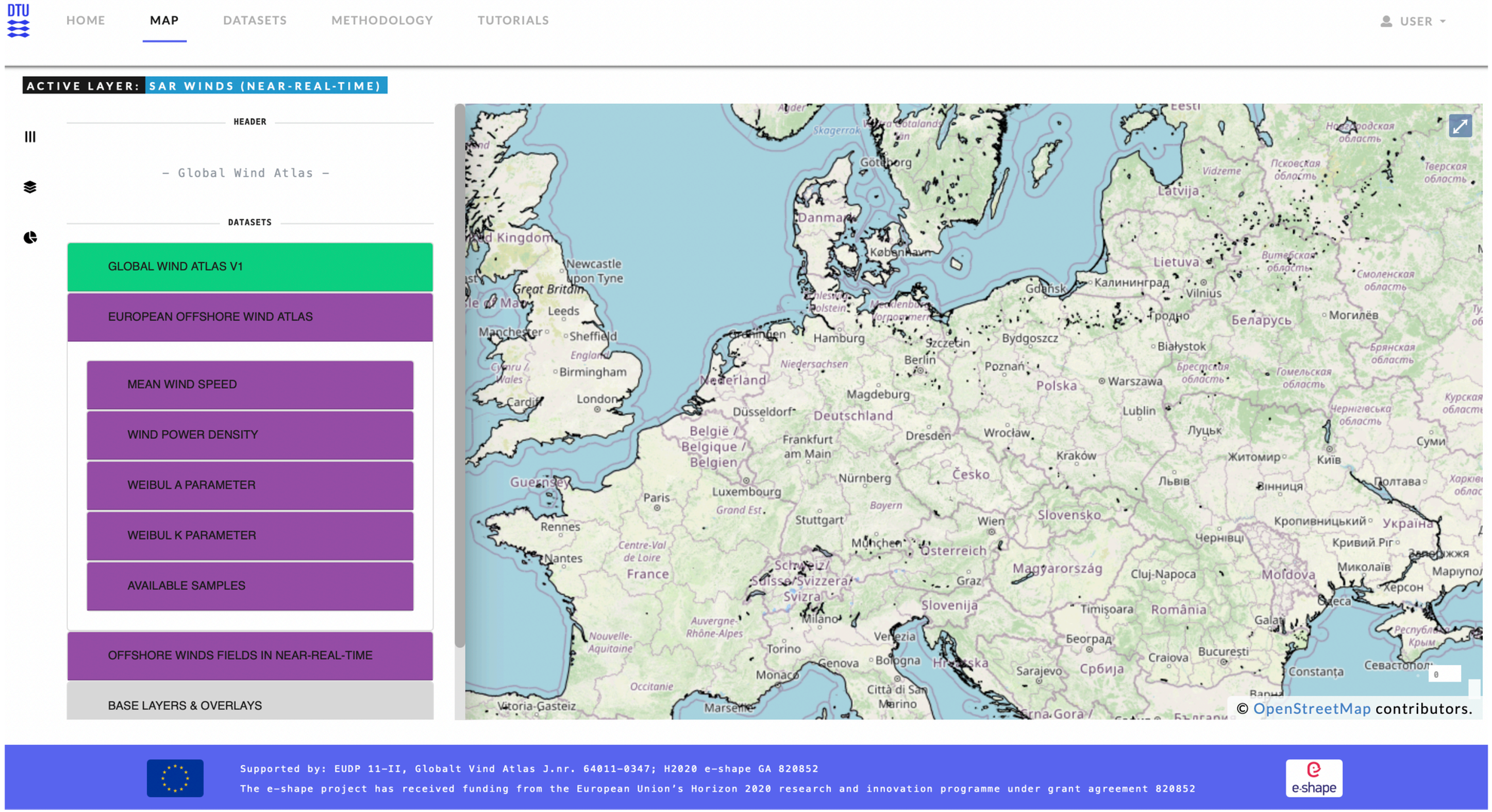
- All individual SAR wind retrievals gridded
  - Regular lat/lon grid
  - 1.5 km resolution

Merging satellite winds



- Combine advantages from SAR & ASCAT
  - long-term and global coverage
  - high spatial resolution near coast lines

DTU Global Wind Atlas Platform



https://science-dev.globalwindatlas.info/#/map

Supported by: EUDP 11-II, Globalt Vind Atlas J.nr. 64011-0347; H2020 e-shape GA 820852
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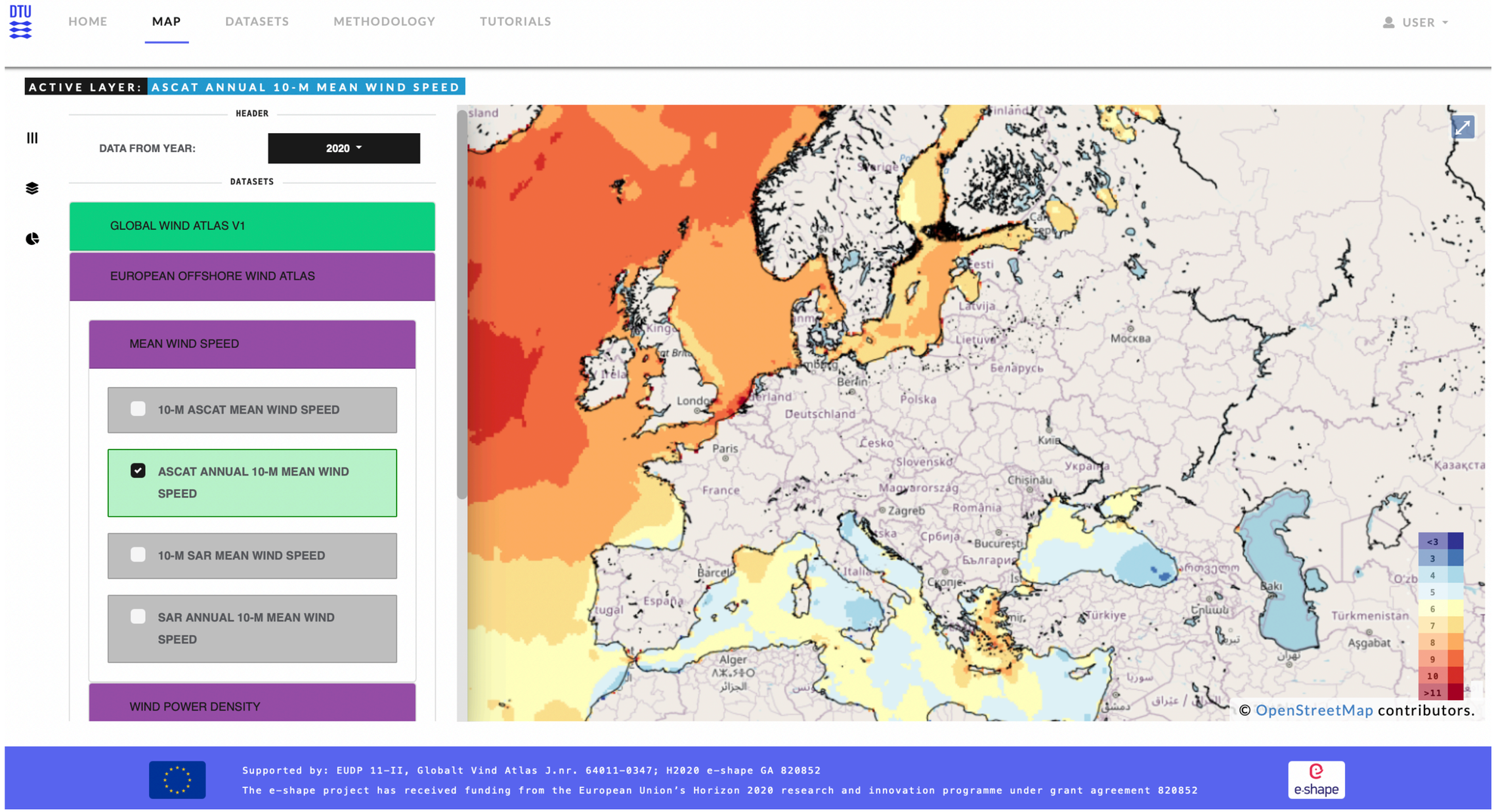
Existing DTU services: wind resources



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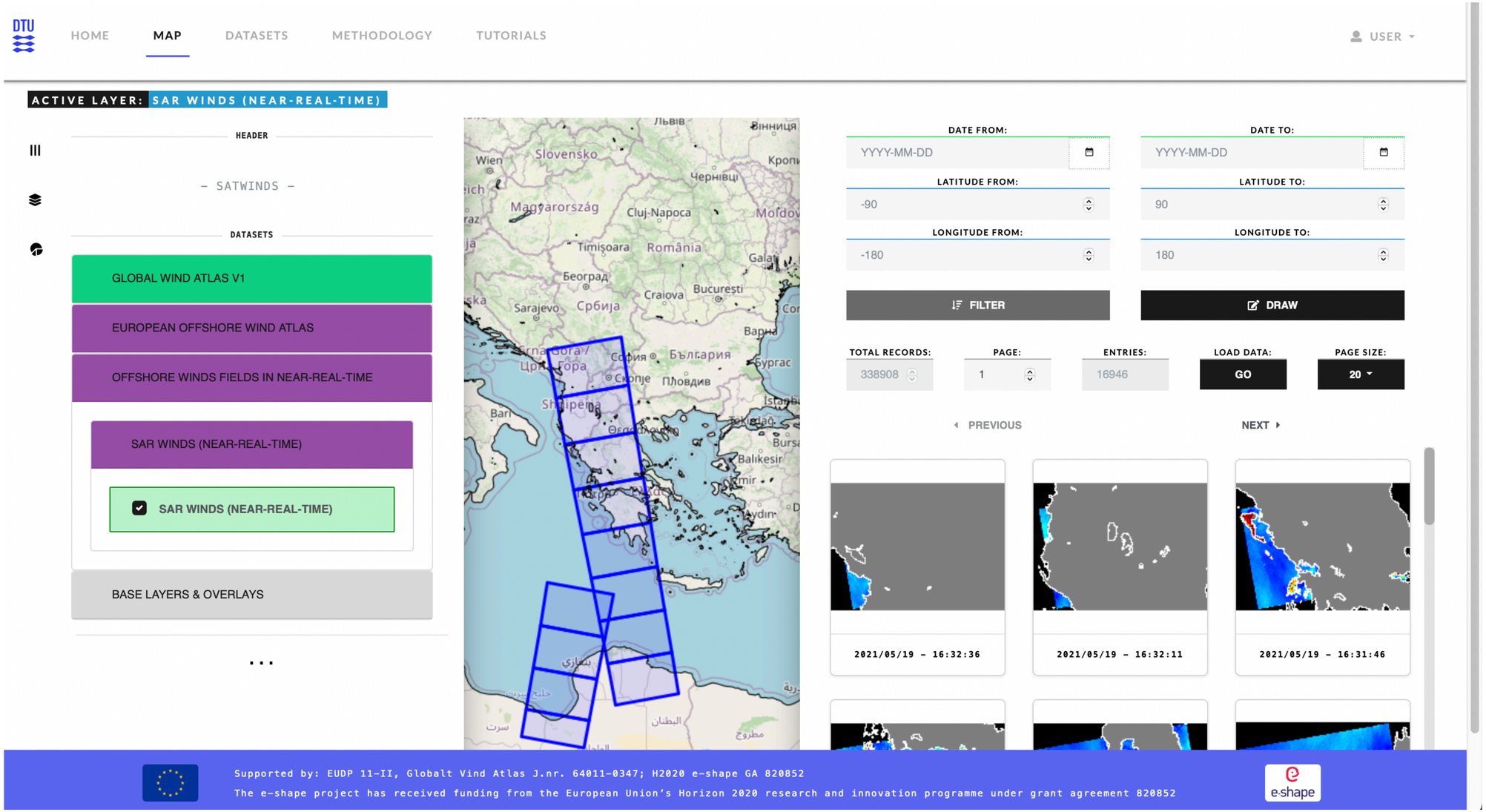
Near-Real-Time Winds



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Thank you for your attention