Where Are We and Where Do We Need To Go? Focus on data

Hasager, Charlotte Bay

Publication date:
2020

Document Version
Publisher's PDF, also known as Version of record

Where Are We and Where Do We Need To Go?
Focus on data

Charlotte Hasager
Prof.
DTU Wind Energy

MMC-Sponsored Industry Workshop: Atmospheric Science Challenges for the Wind Energy Industry, October 19-20, 2020, online

DTU Wind Energy

- A department in the Technical University of Denmark
- Founded in 1979 in Denmark
- 250 employees
- Largest wind energy research institute in the world
- Research, Education, Scientific Advice
- Organized in 3 divisions:
  - Wind Energy System
  - Wind Turbine Technology
  - Structures, Material and Components

- https://www.vindenergi.dtu.dk/english

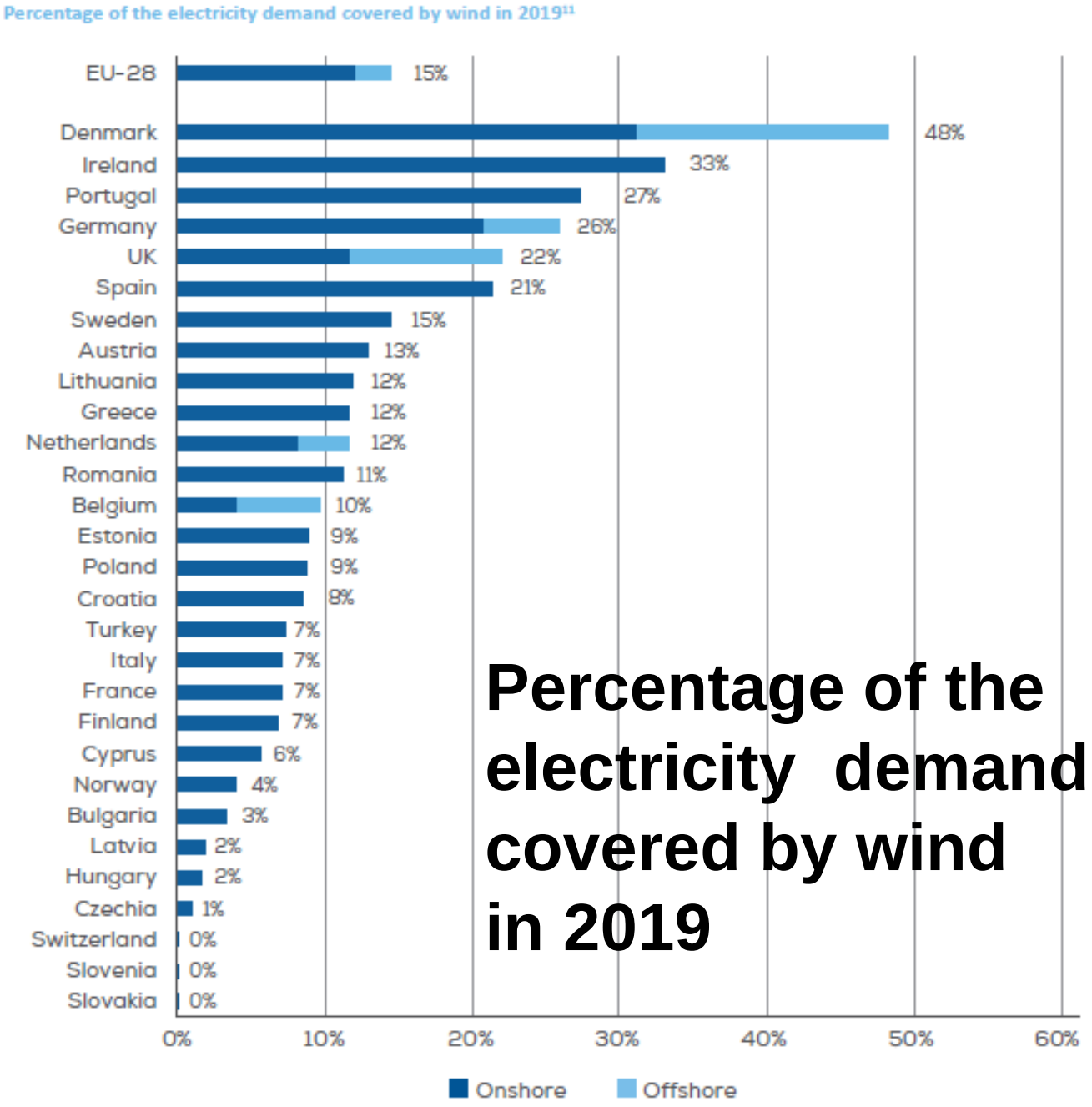
Photo of Reception of DTU Wind Energy, Roskilde, Denmark

Where are we?

Europe has a total installed wind capacity of 209 GW hereof 22 GW offshore.

Source: Wind Europe 2029

https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Statistics-2019.pdf



Percentage of the electricity demand covered by wind in 2019

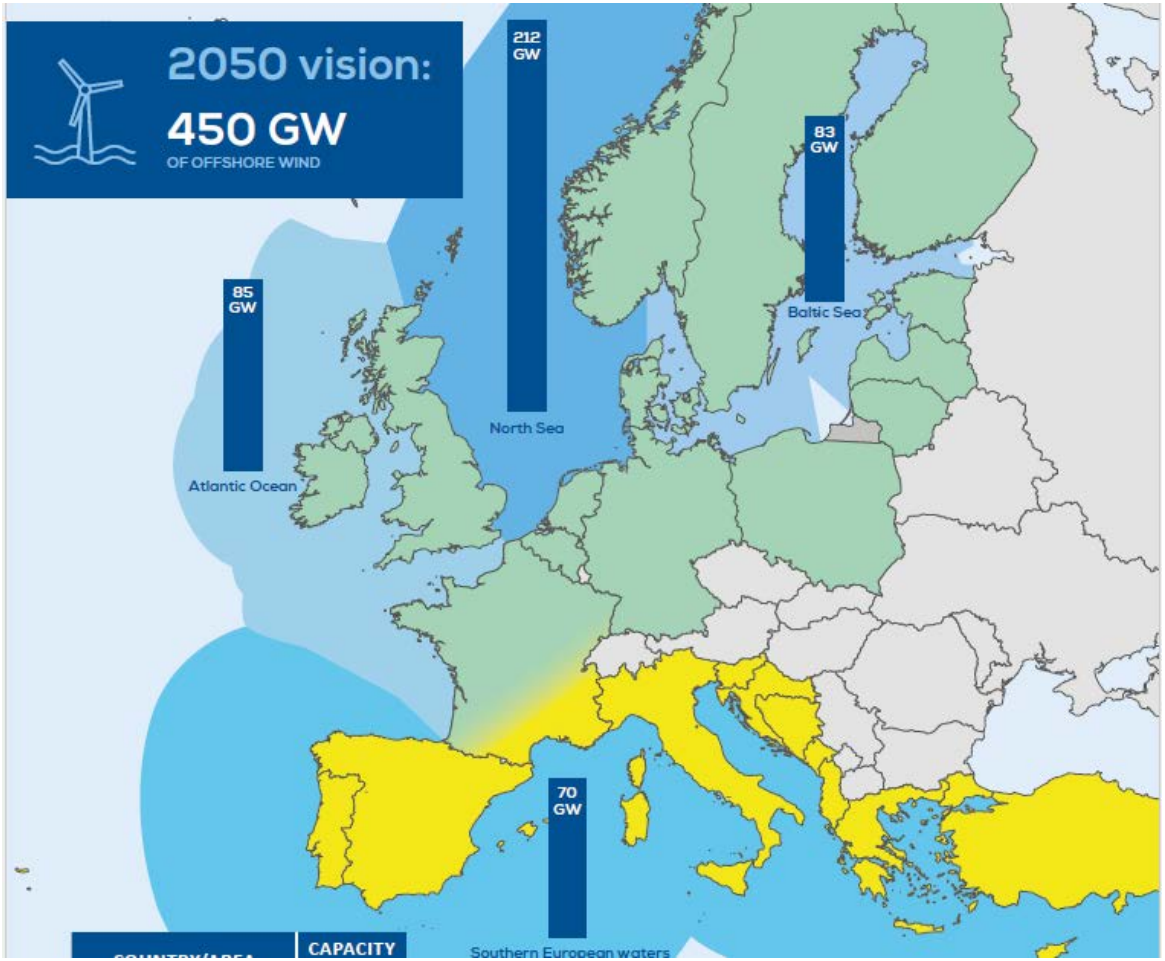
Where do we need to go?

Install 14 GW per year next 30 years

Planning is needed

Our energy, our future

How offshore wind will help Europe go carbon-neutral



Source:

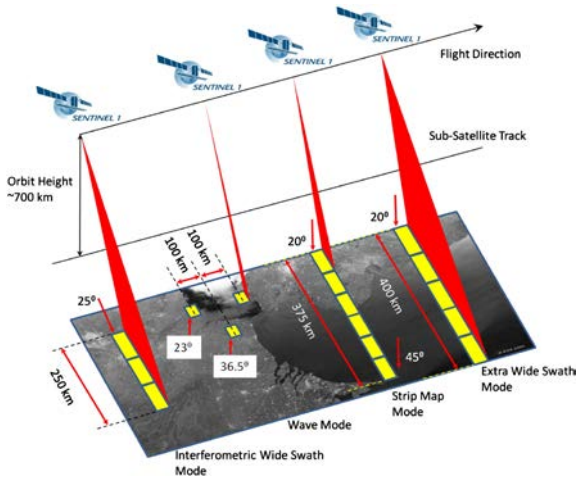
Wind Europe 2019
https://windeurope.org/wp-content/uploads/files/about-wind/reports/WindEurope-Our-Energy-Our-Future.pdf

Satellite wind maps

- We add Synthetic Aperture Radar satellite wind maps to the analysis

Envisat

Sentinel-1



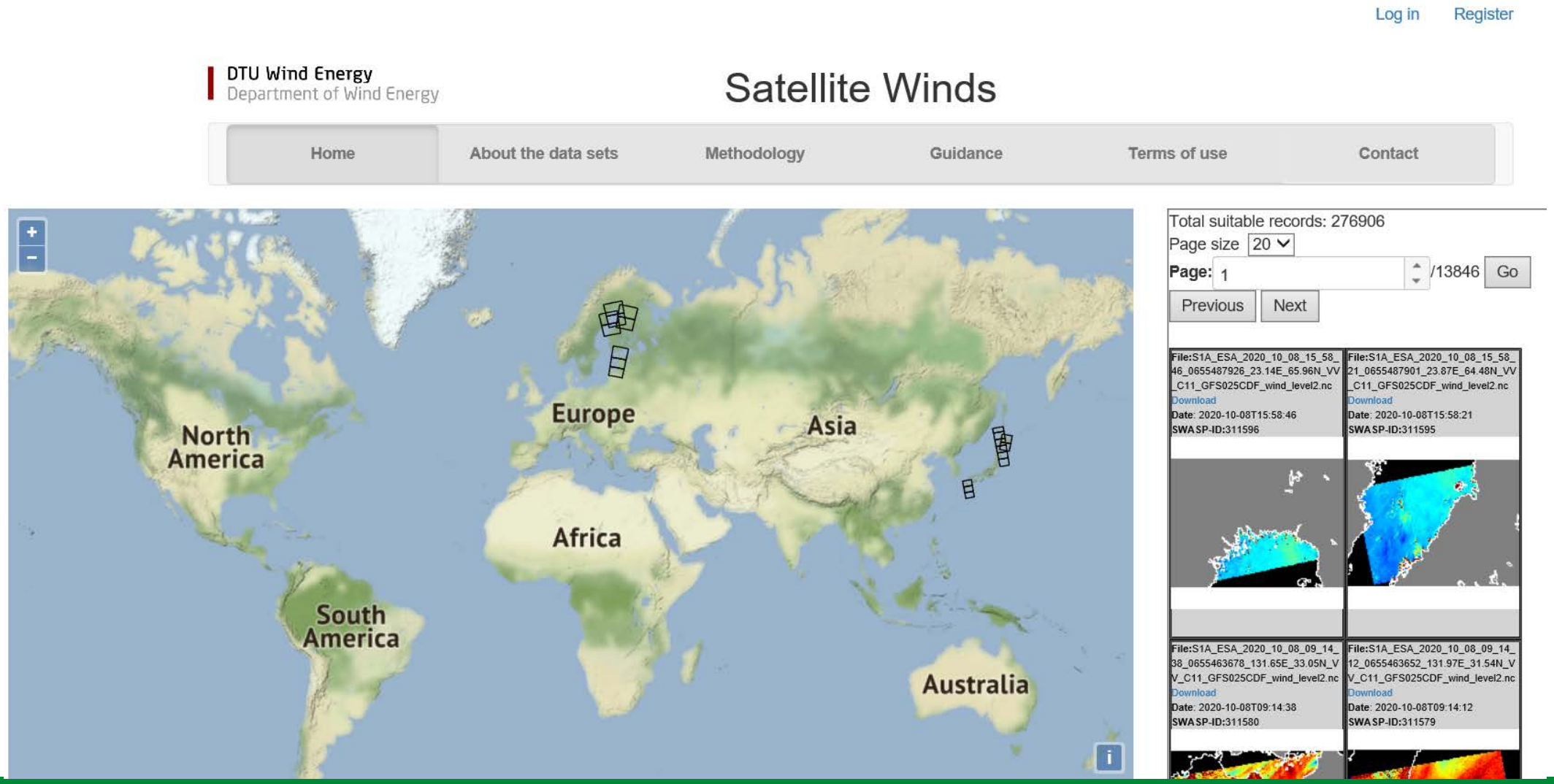
Sentinel-1 swath

Source: ESA

https://satwinds.windenergy.dtu.dk/

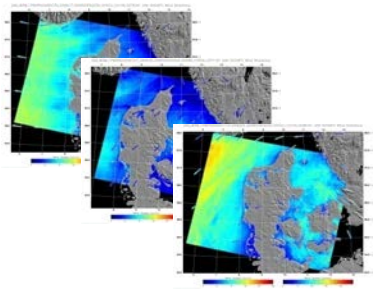
Satellite SAR wind data archive at DTU

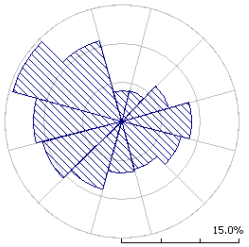
Contact: Merete Badger, mebc@dtu.dk

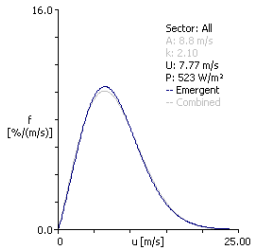


Applications for offshore wind energy

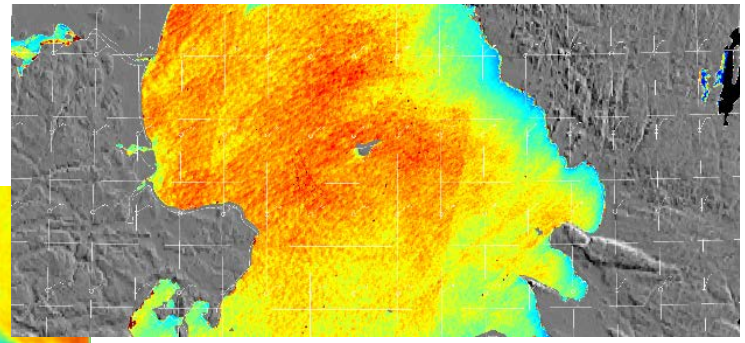
- Mean wind conditions



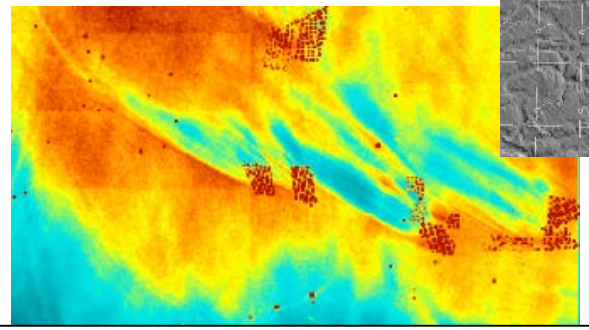




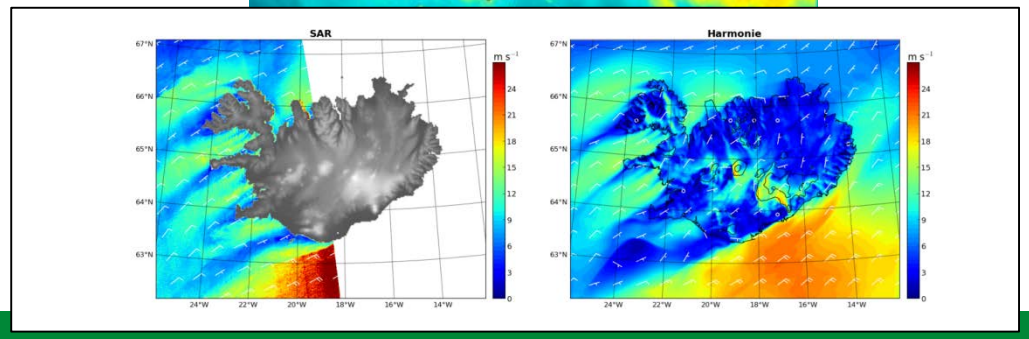
- Horizontal coastal wind speed gradients



- Wind farm wake effects

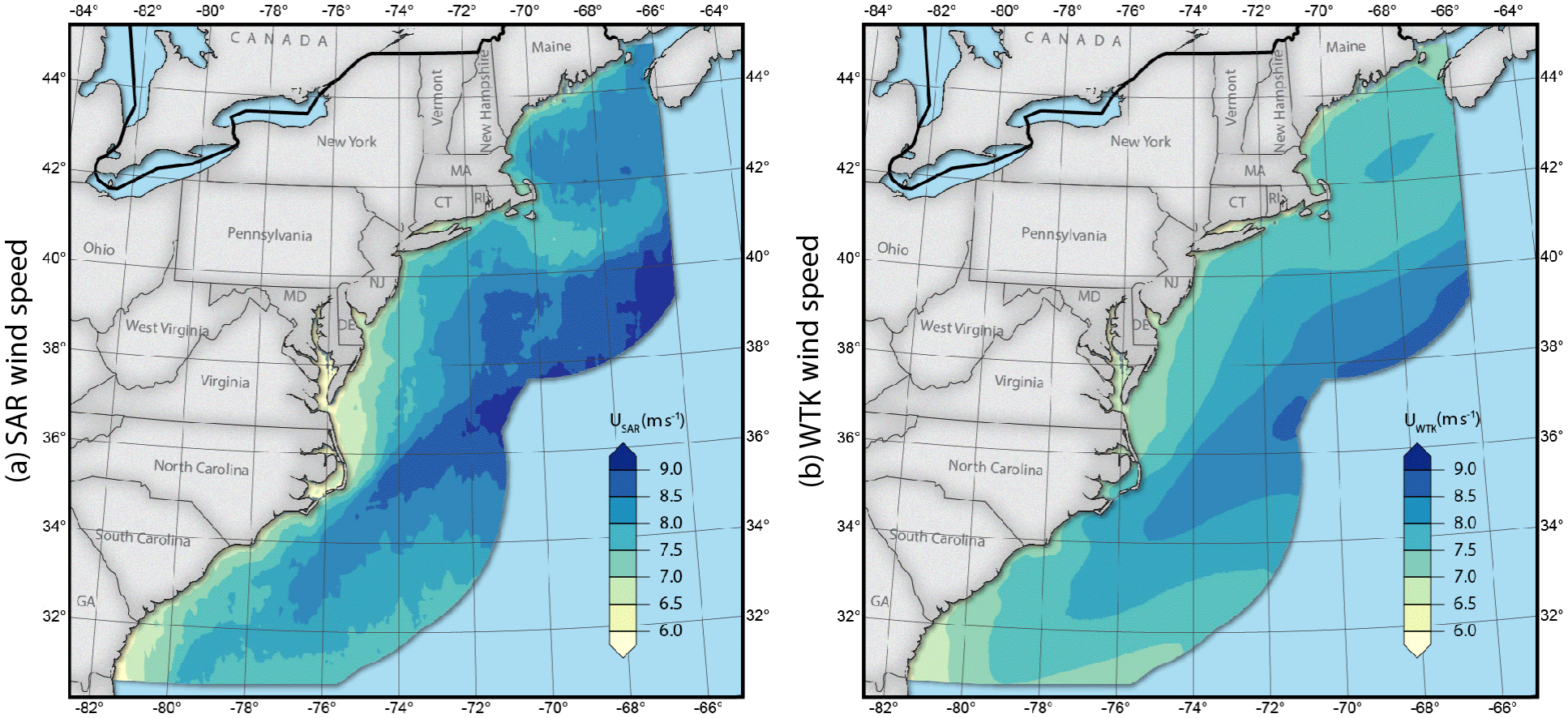


- Model validation



US East Coast: SAR vs. WRF

Ahsbahs, T., Maclaurin, G., Draxl, C., Jackson, C. R., Monaldo, F., and Badger, M. 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



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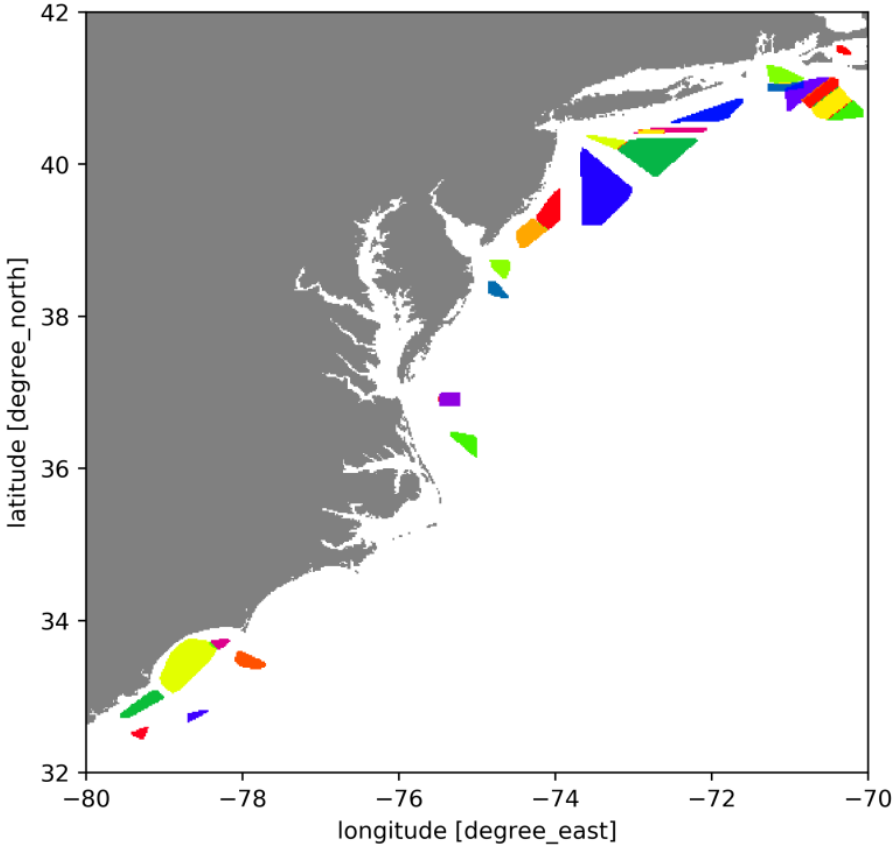
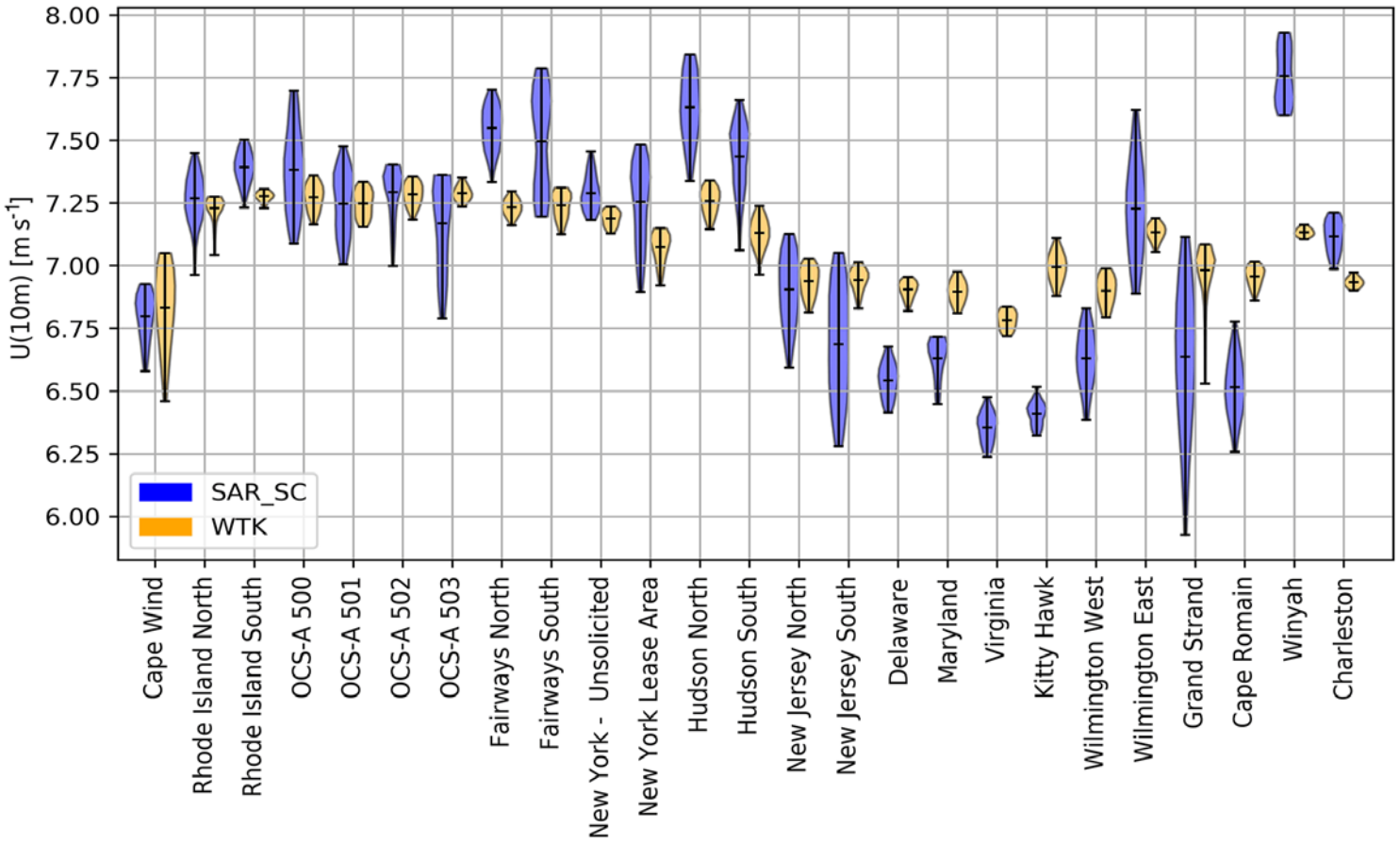
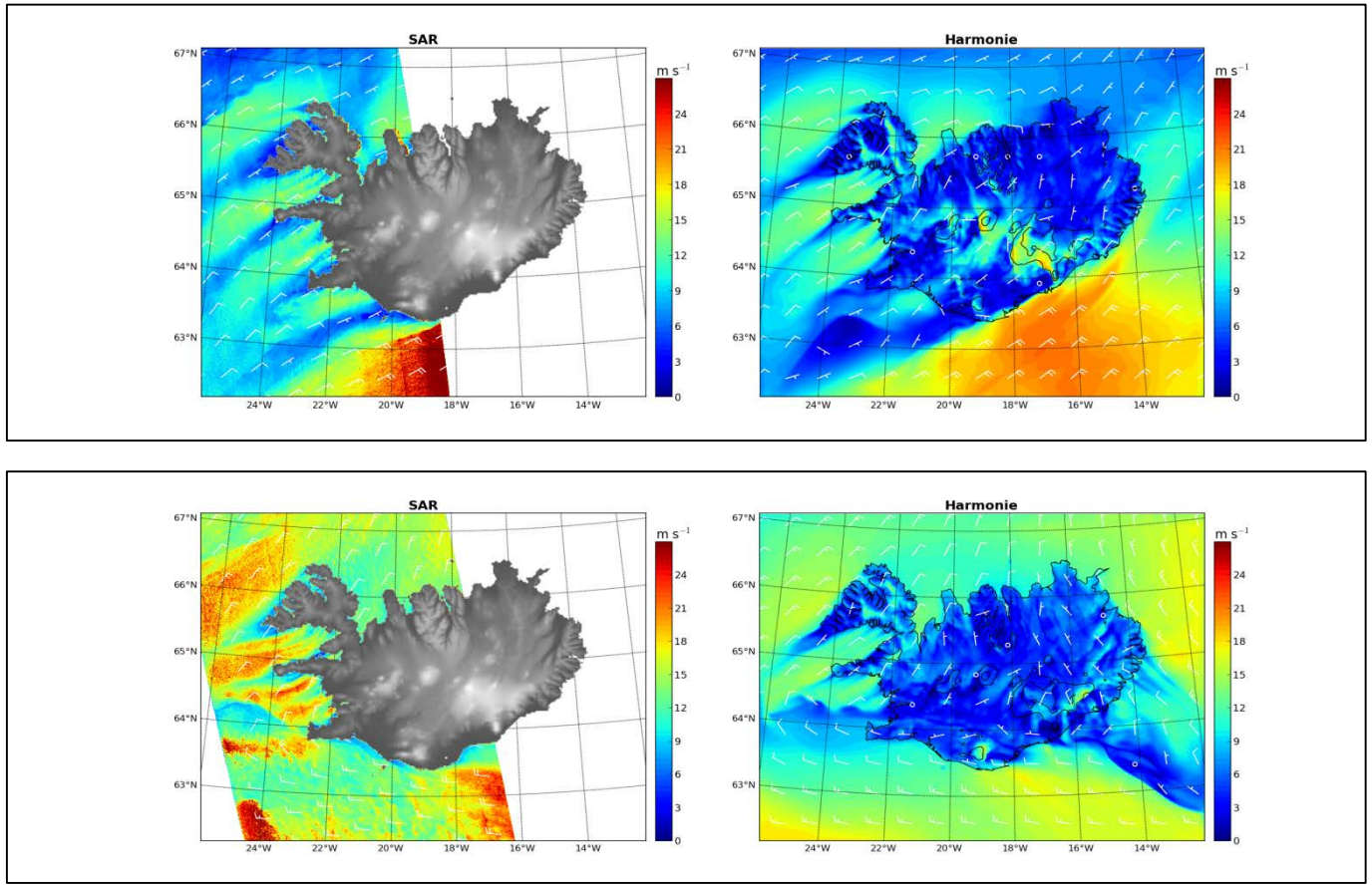


25 designated areas

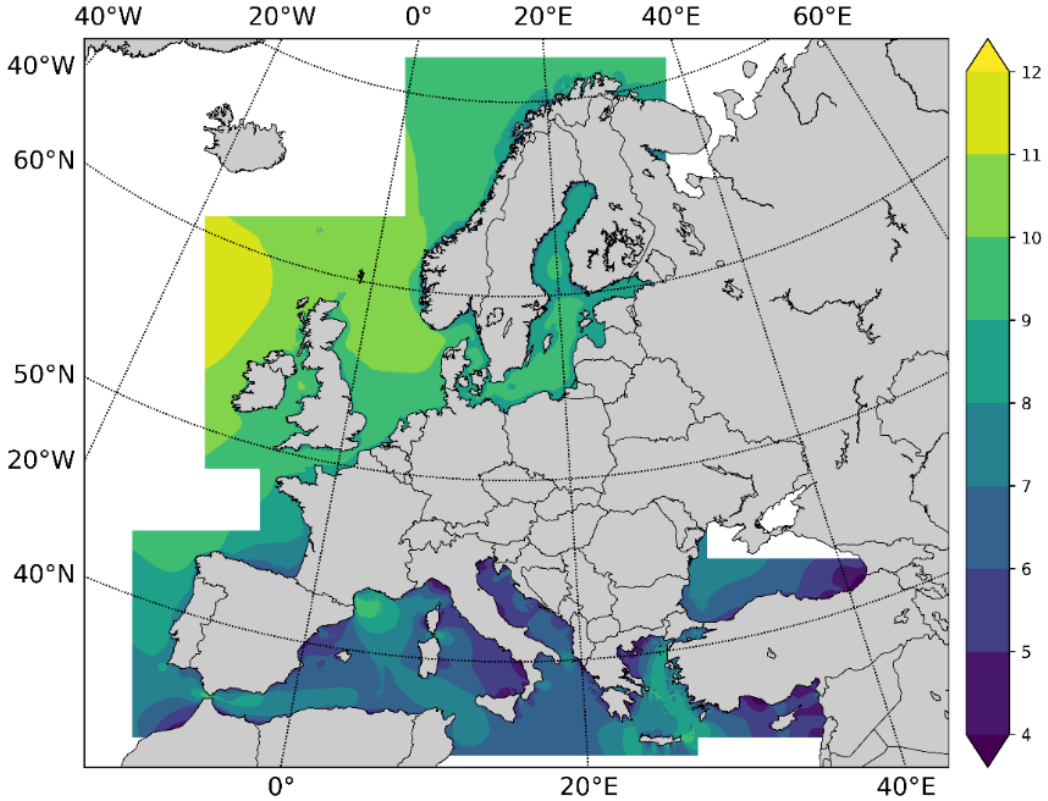


Model validation – compex flows around islands



Hasager, C.B., Badger, M. Nawri, N., Furevik, B.R., Petersen, G. N., Björnsson, H., Clausen, N.-E. (2015): Mapping offshore winds around Iceland using satellite Synthetic Aperture Radar and mesoscale model simulations. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 10.1109/JSTARS.2015.2443981.

WRF New European Wind Atlas



Mean wind speed at 100 m height for 1989 to 2018 with 3 km resolution

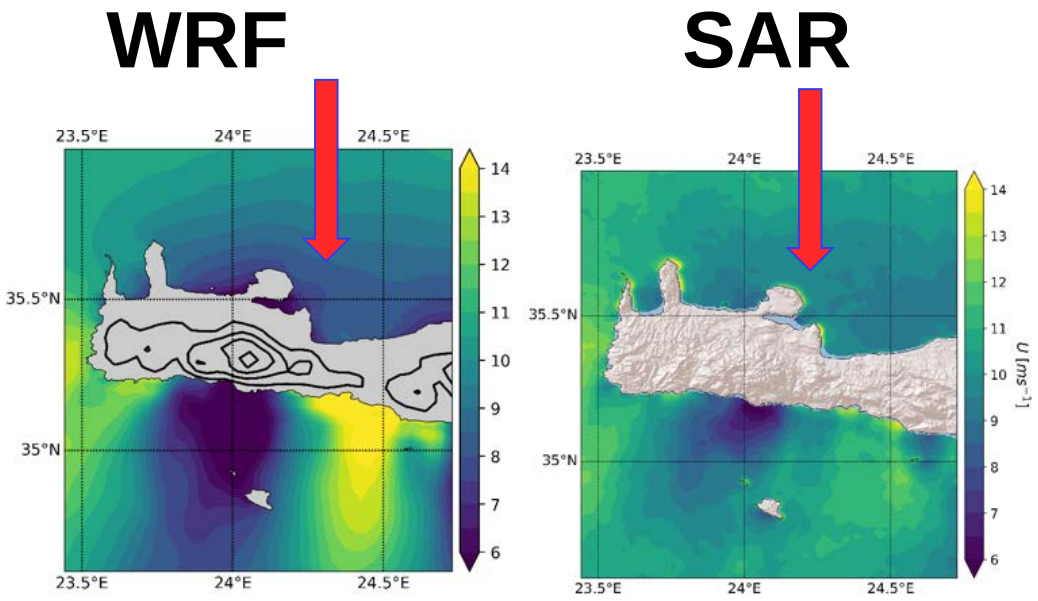
Data are available at:

http://www.neweuropeanwindatlas.eu/

Hasager et al. 2020 Europe's offshore wind resource assessed with synthetic aperture radar, ASCAT and WRF, Wind Energ. Sci., 5, 375–390, https://doi.org/10.5194/wes-5-375-2020

Northerly wind

Mean wind speed of 59 cases



Stagnation is flow similar.

Lee effect is similar.

But gap flow is not.

We conclude orography is not resolved fully in WRF.

Hasager et al. 2020 Europe's offshore wind resource assessed with synthetic aperture radar, ASCAT and WRF, Wind Energ. Sci., 5, 375–390, https://doi.org/10.5194/wes-5-375-2020

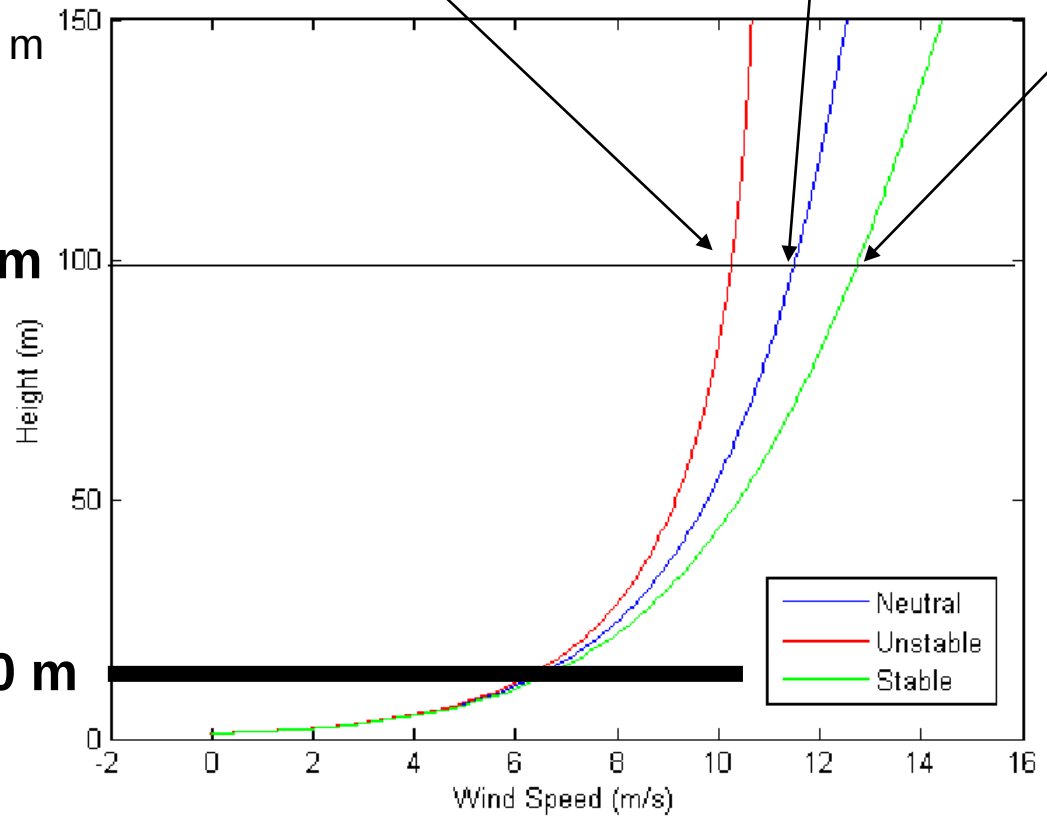
Wind speed with height

Height in m

??? 100 m

Satellites observe wind at 10 m height

10 m



Wind speed in m/s

Neutral

Same air and sea temperature

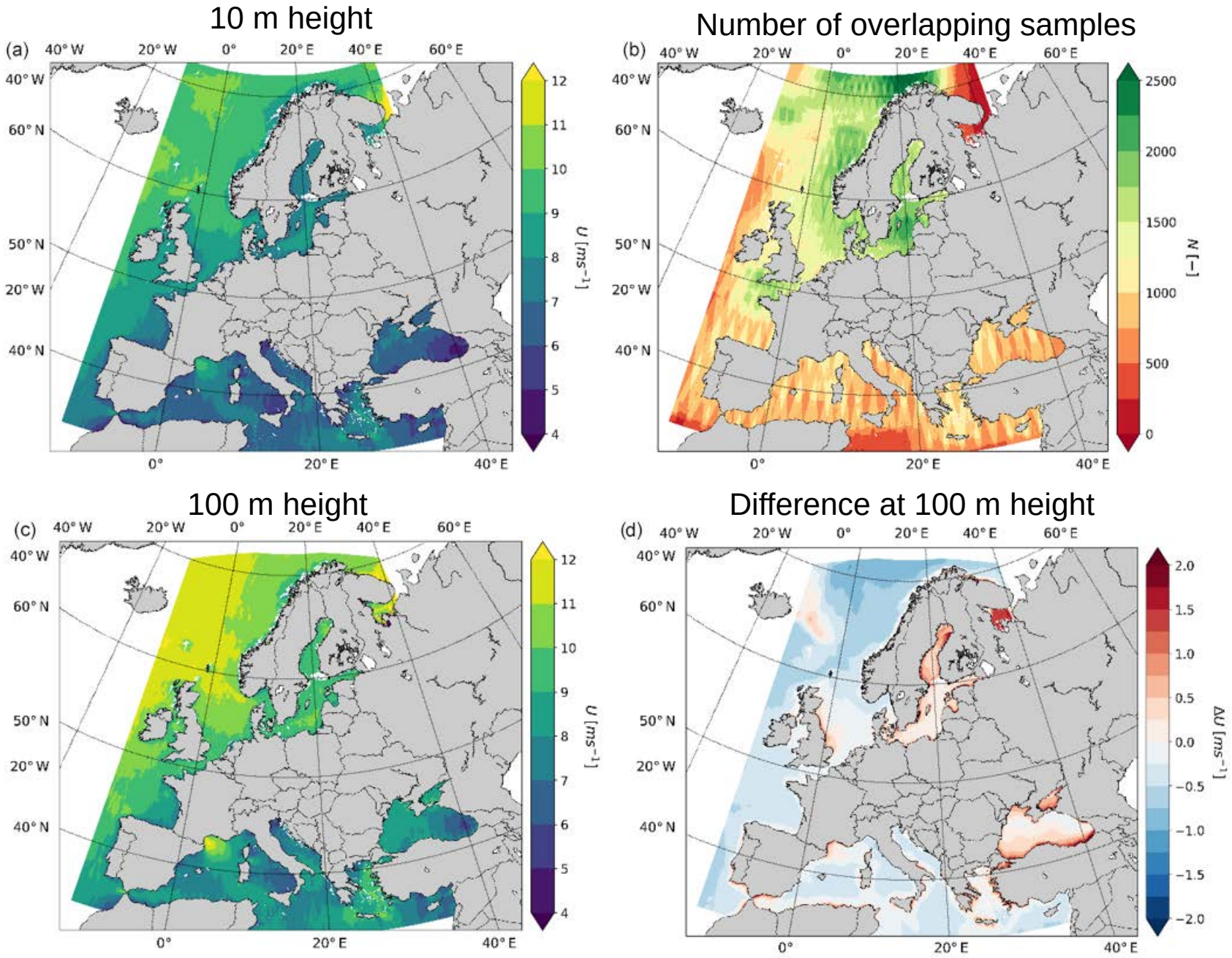
Unstable

Warmer sea than air

Stable

Colder sea than air

https://www.researchgate.net/figure/Stability-variation-curves-of-the-logarithmic-wind-profiles_fig1_277995087



a) Envisat ASAR and Sentinel-1 combined mean wind speed ($m\,s^{-1}$) at 10 m height

b) number of samples

c) mean wind speed at 100 m a.m.s.l. including long-term stability correction for extrapolation

d) and difference on wind speed at 100 m height based on long-term stability correction minus neutral wind profile assumption

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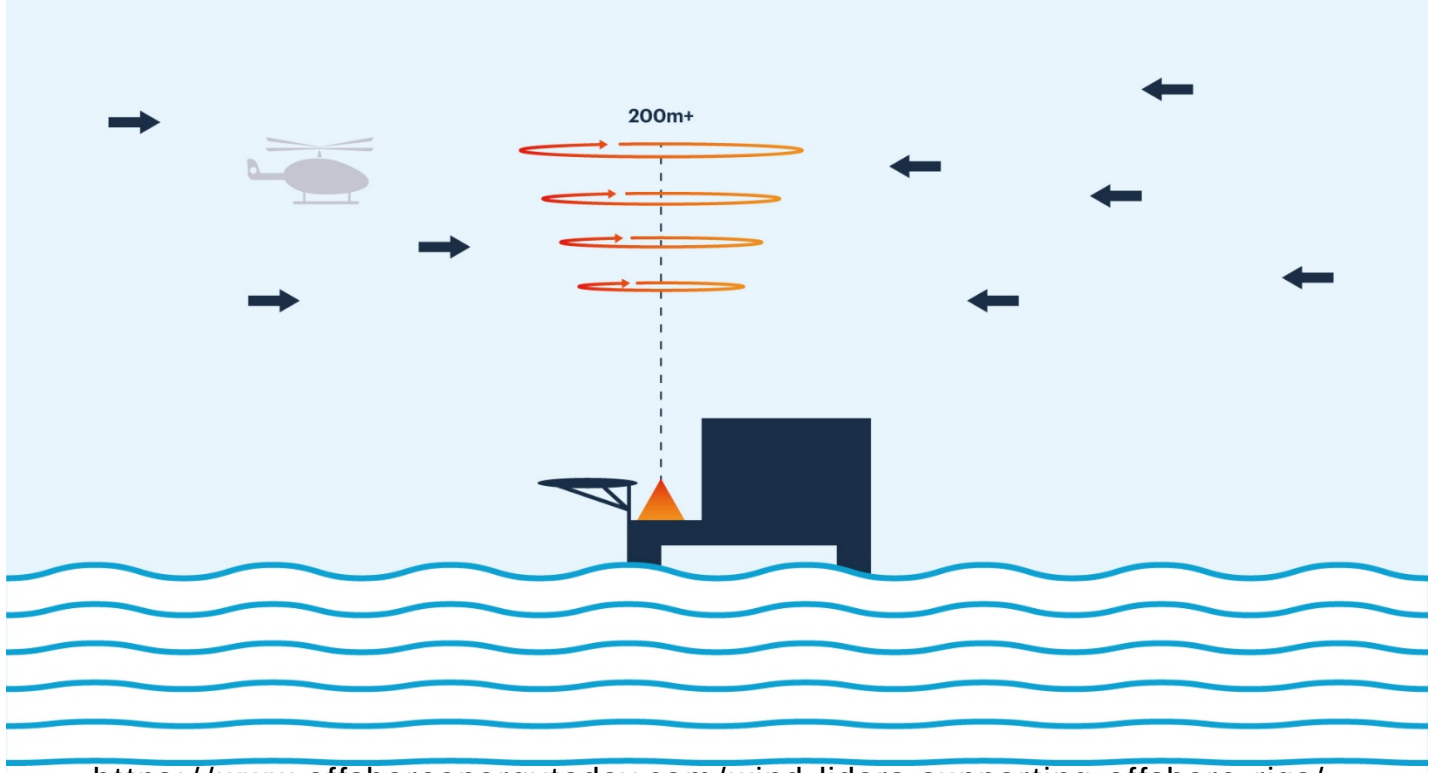
Vertical profile

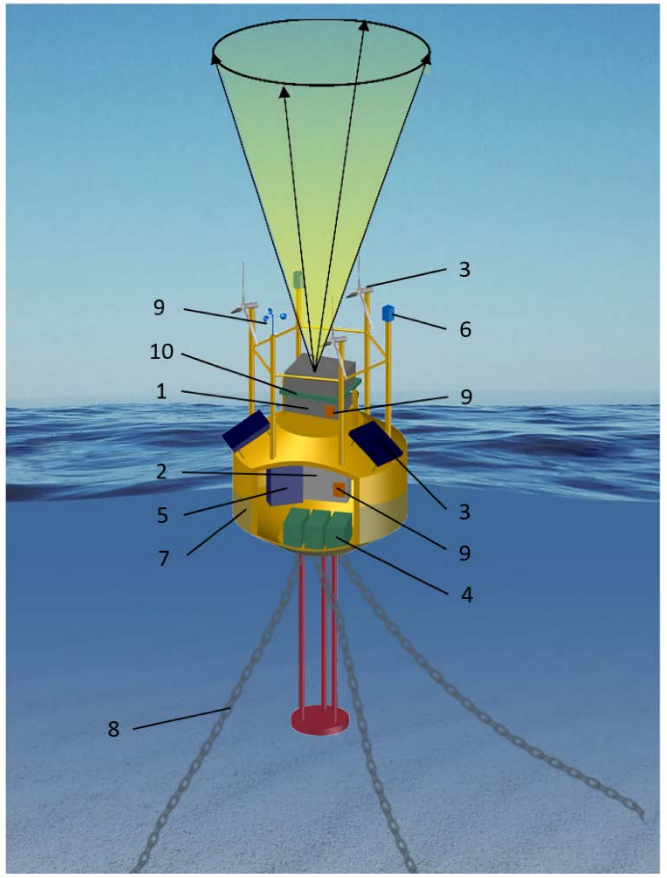
Wind lidar

Measure winds at several heights including hub-height



https://www.offshoreenergytoday.com/wind-lidars-supporting-offshore-rigs/

Floating lidar systems



1 Lidar

2 FLS operating system

3 Energy generation system

4 Energy storage system

5 Data logging system

6 Communication system

7 Floating platform

8 Station-keeping system

9 Sensors

10 Motion compensation

IEA Wind TCP RP Floating lidars systems, 2017

https://community.ieawind.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=99ec44ff-4493-4bad-6510-d42d152ae963&forceDialog=0

Source: Clifton *et al.*, IEA Wind Task 32: Wind Lidar Identifying and Mitigating Barriers to the Adoption of Wind Lidar, *Remote Sens.* 2018, *10*(3), 406; https://doi.org/10.3390/rs10030406

Conclusions

- *Offshore wind farm planning is relevant for green transition*
- *Assessment of the wind resource*

***Data** recommendation*

- *Satellite SAR for spatial details in the flow*
- *LIDAR for wind profile at height*