



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

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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>

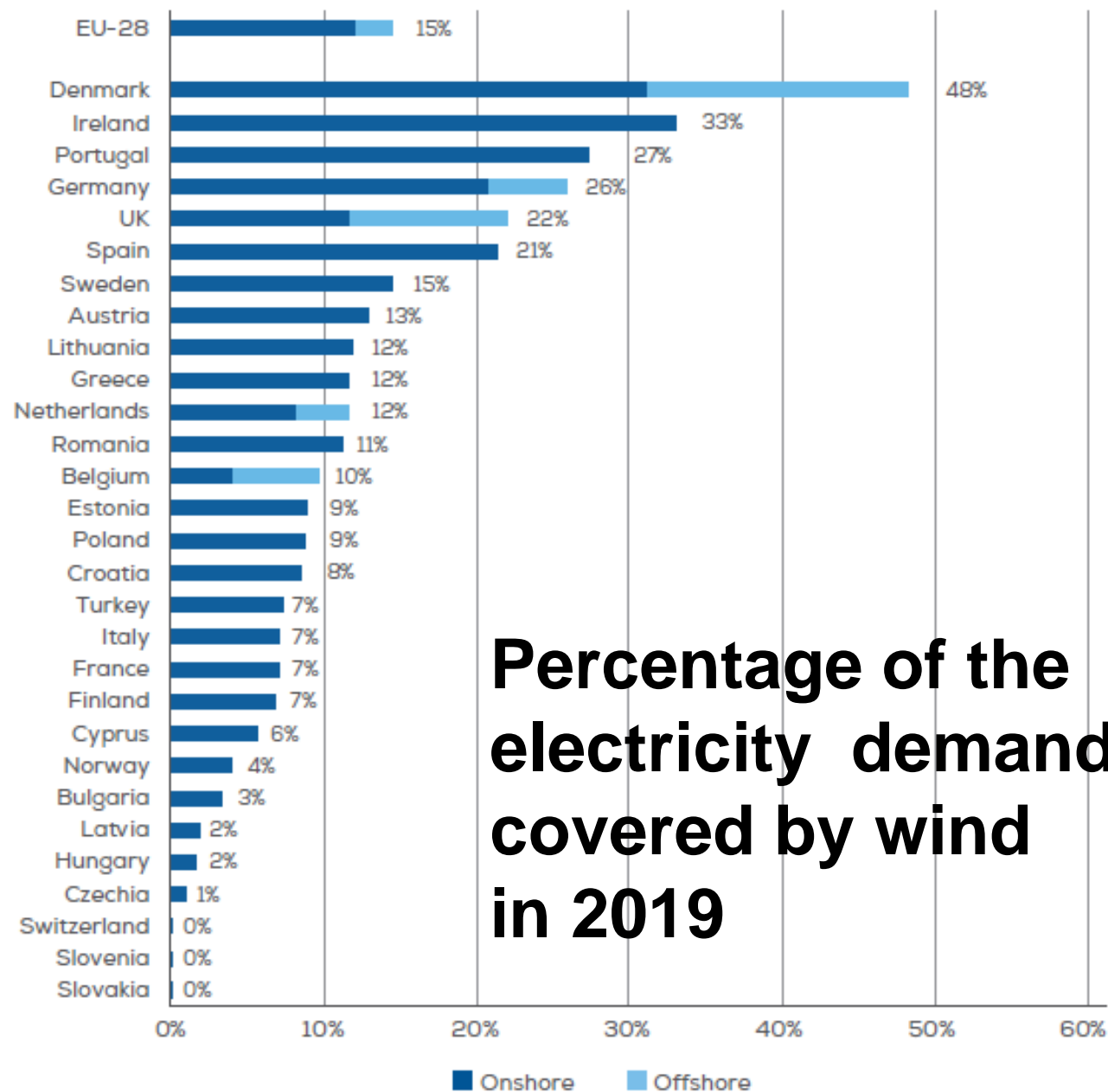


Photo of Reception of DTU Wind Energy, Roskilde, Denmark

Where are we?

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

Percentage of the electricity demand covered by wind in 2019¹¹



Percentage of the electricity demand covered by wind in 2019

Source: Wind Europe 2029

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

Where do we need to go?

Install 14 GW per year
next 30 years

Planning is needed

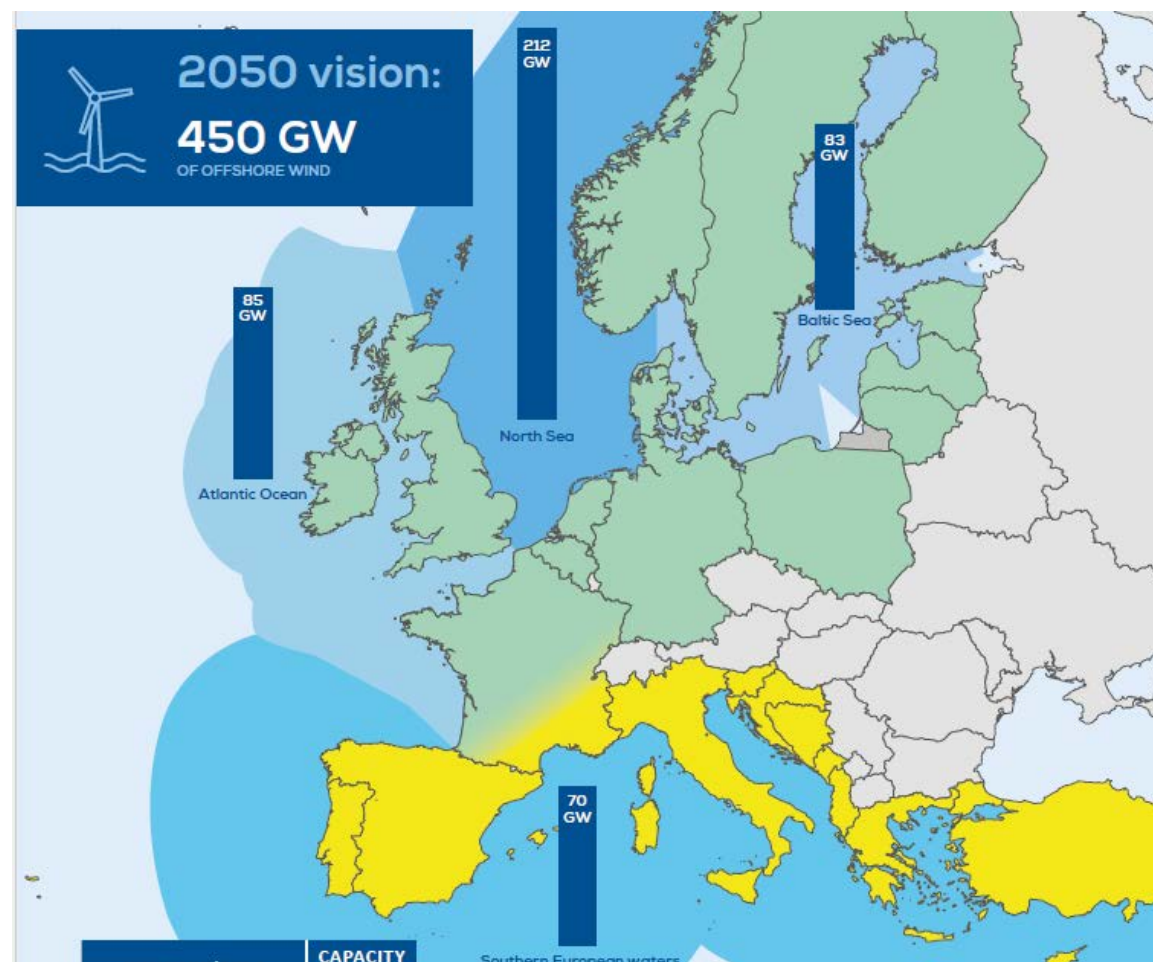
Our energy, our future

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

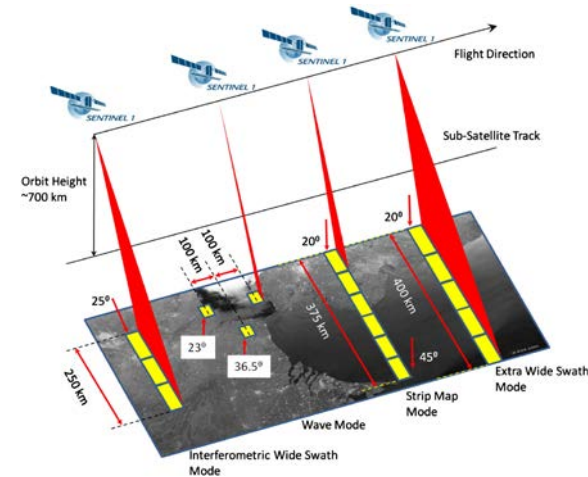
- We add Synthetic Aperture Radar satellite wind maps to the analysis



Envisat



Sentinel-1



Sentinel-1 swath

Source: ESA

Satellite SAR wind data archive at DTU

Contact: Merete Badger, mebc@dtu.dk

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Satellite Winds

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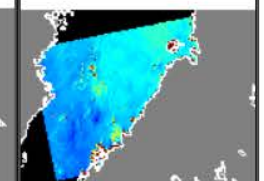
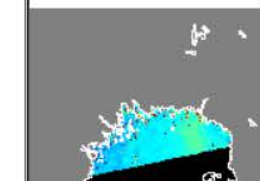
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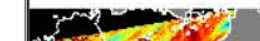


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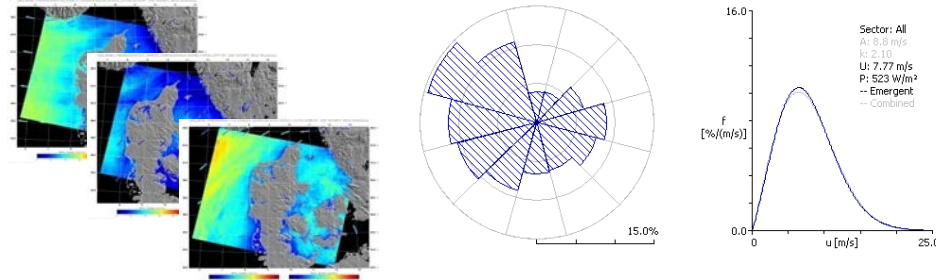
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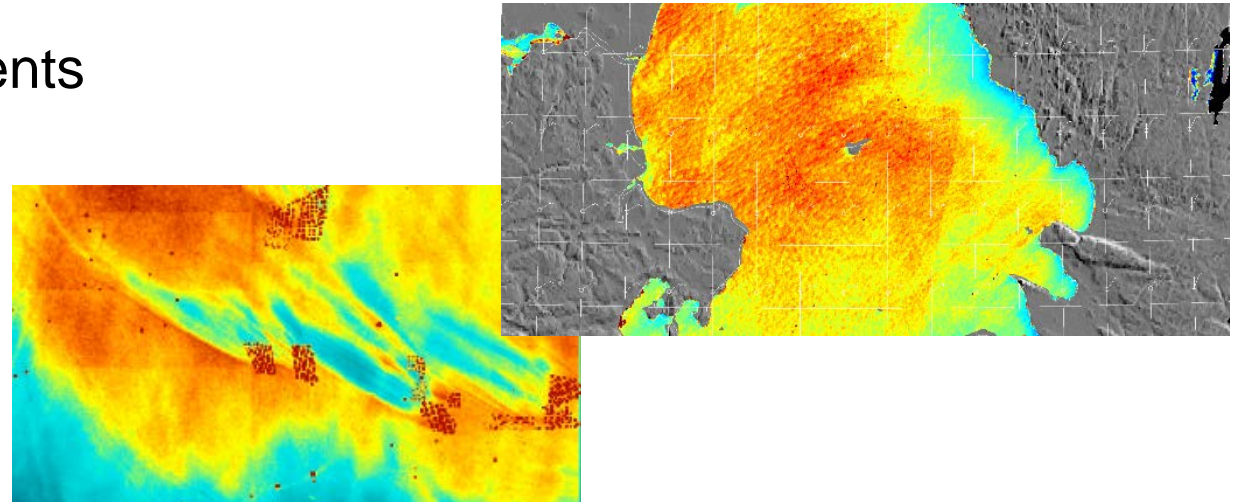


Applications for offshore wind energy

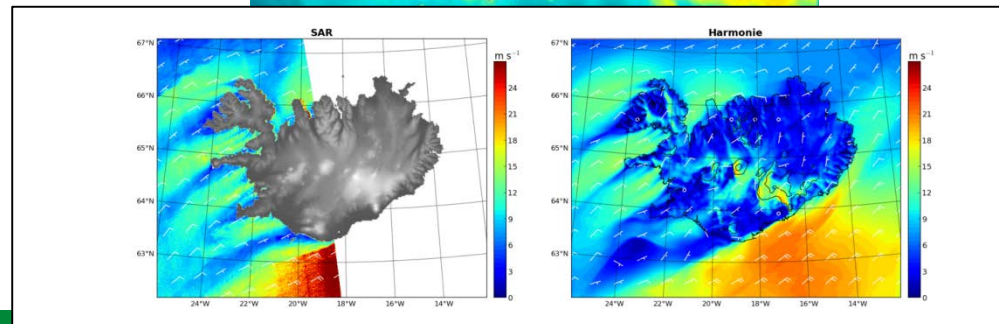
- Mean wind conditions



- Horizontal coastal wind speed gradients



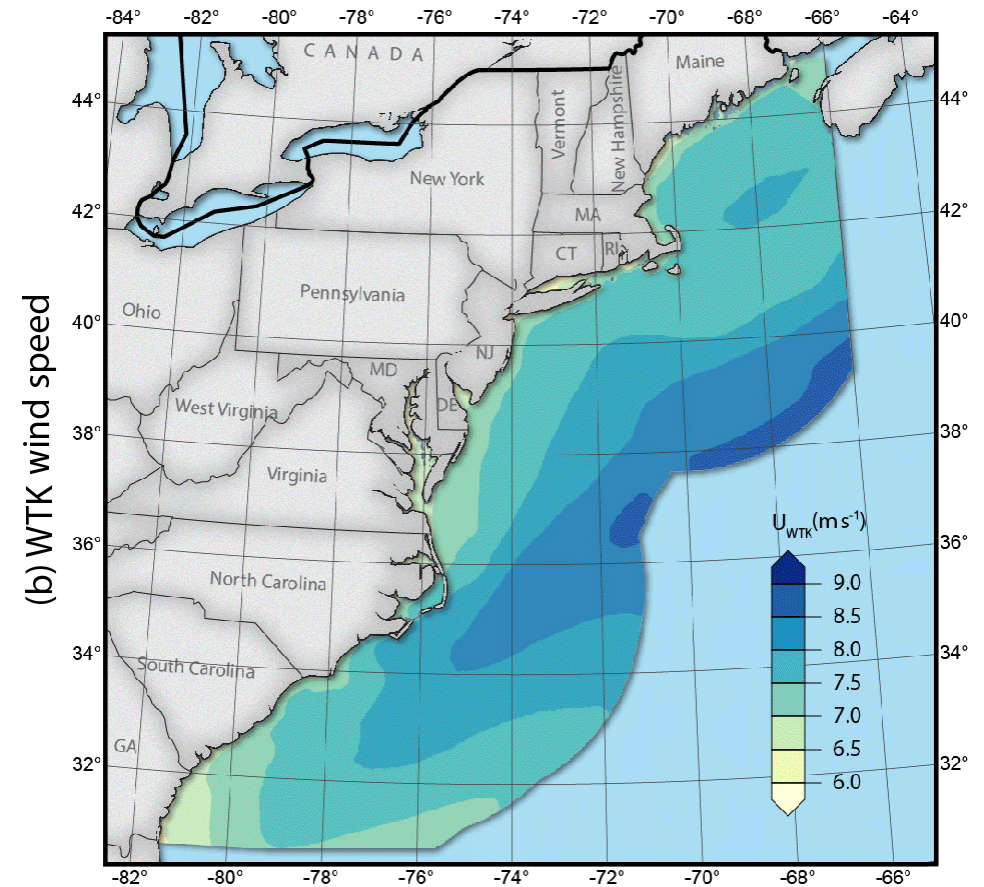
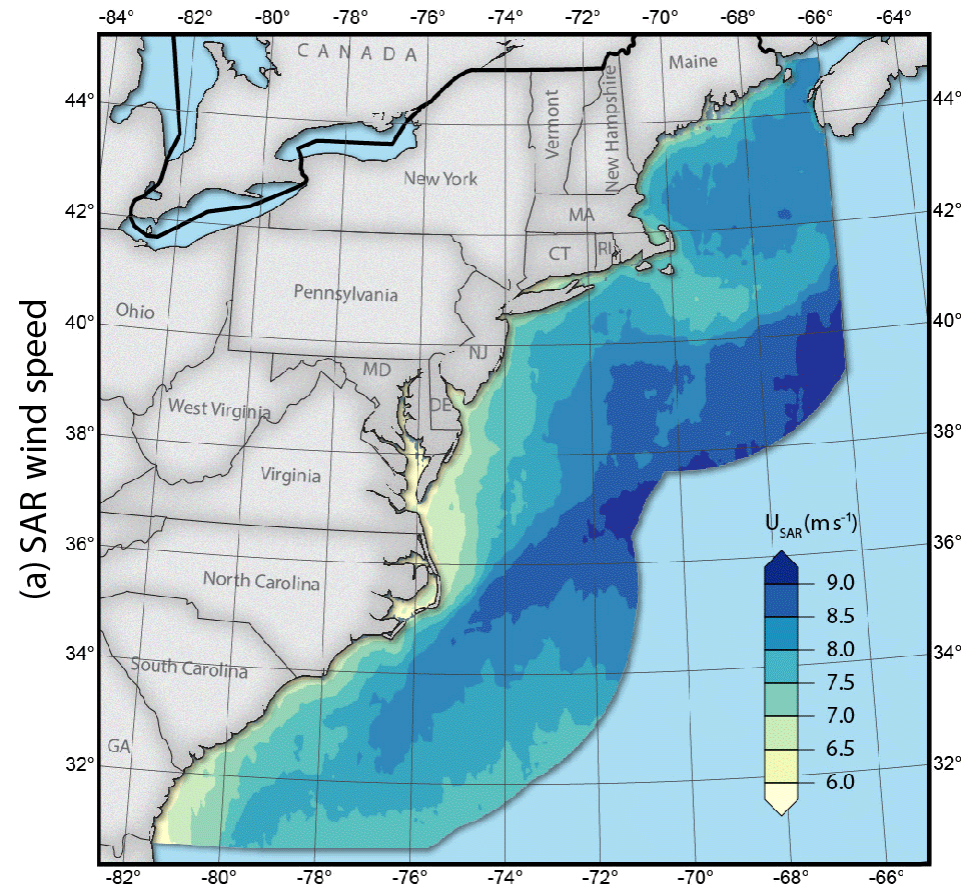
- Wind farm wake effects



- Model validation

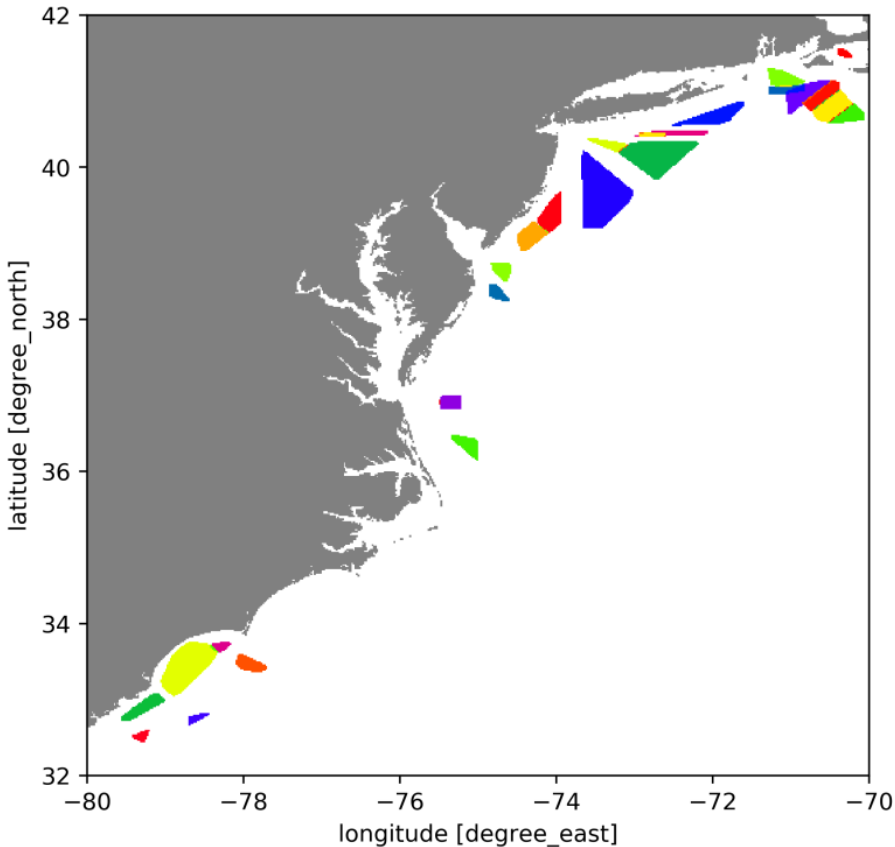
US East Coast: SAR vs. WRF

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 Energy. Sci., 5, 1191–1210, <https://doi.org/10.5194/wes-5-1191-2020>

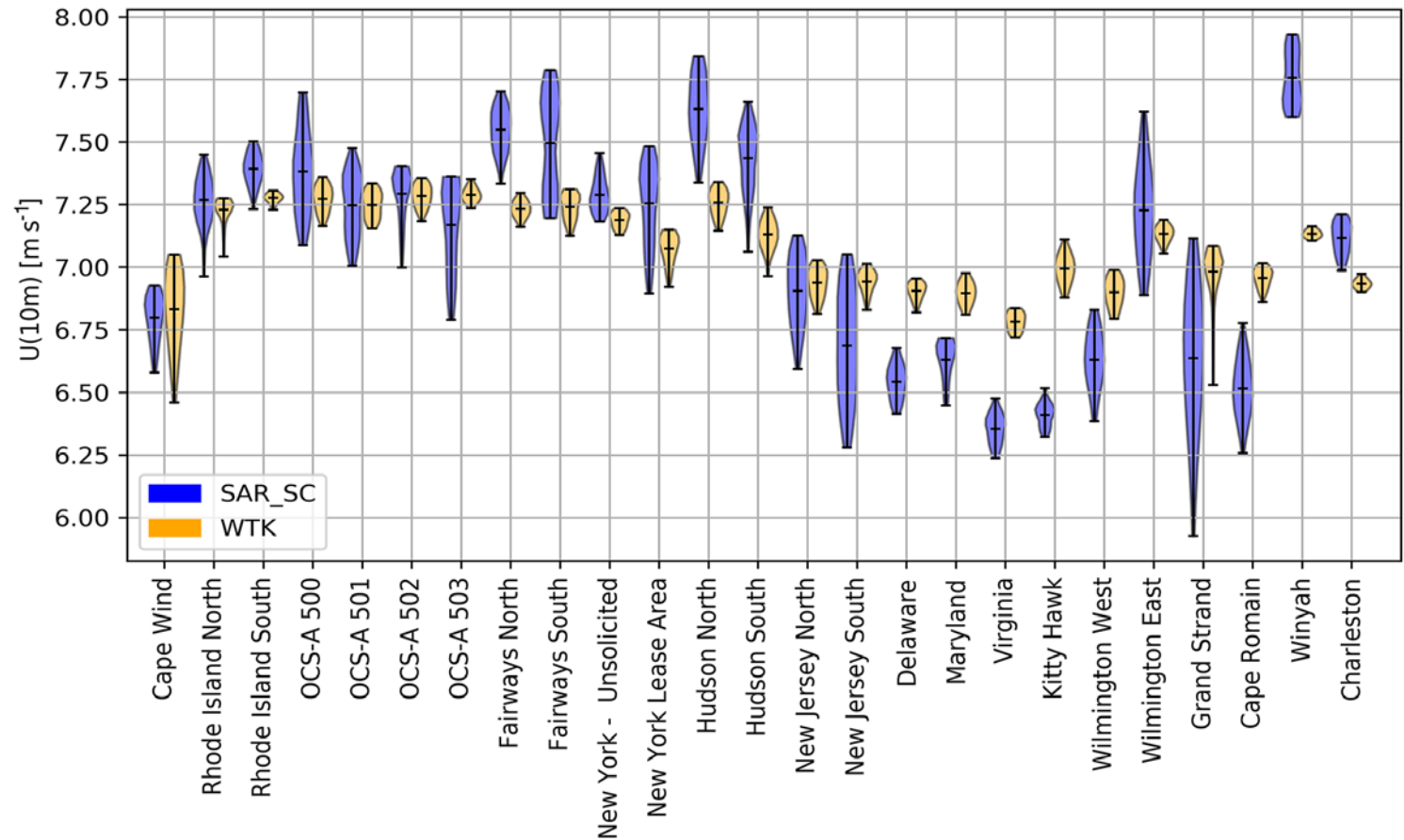


US East Coast: SAR vs. WRF

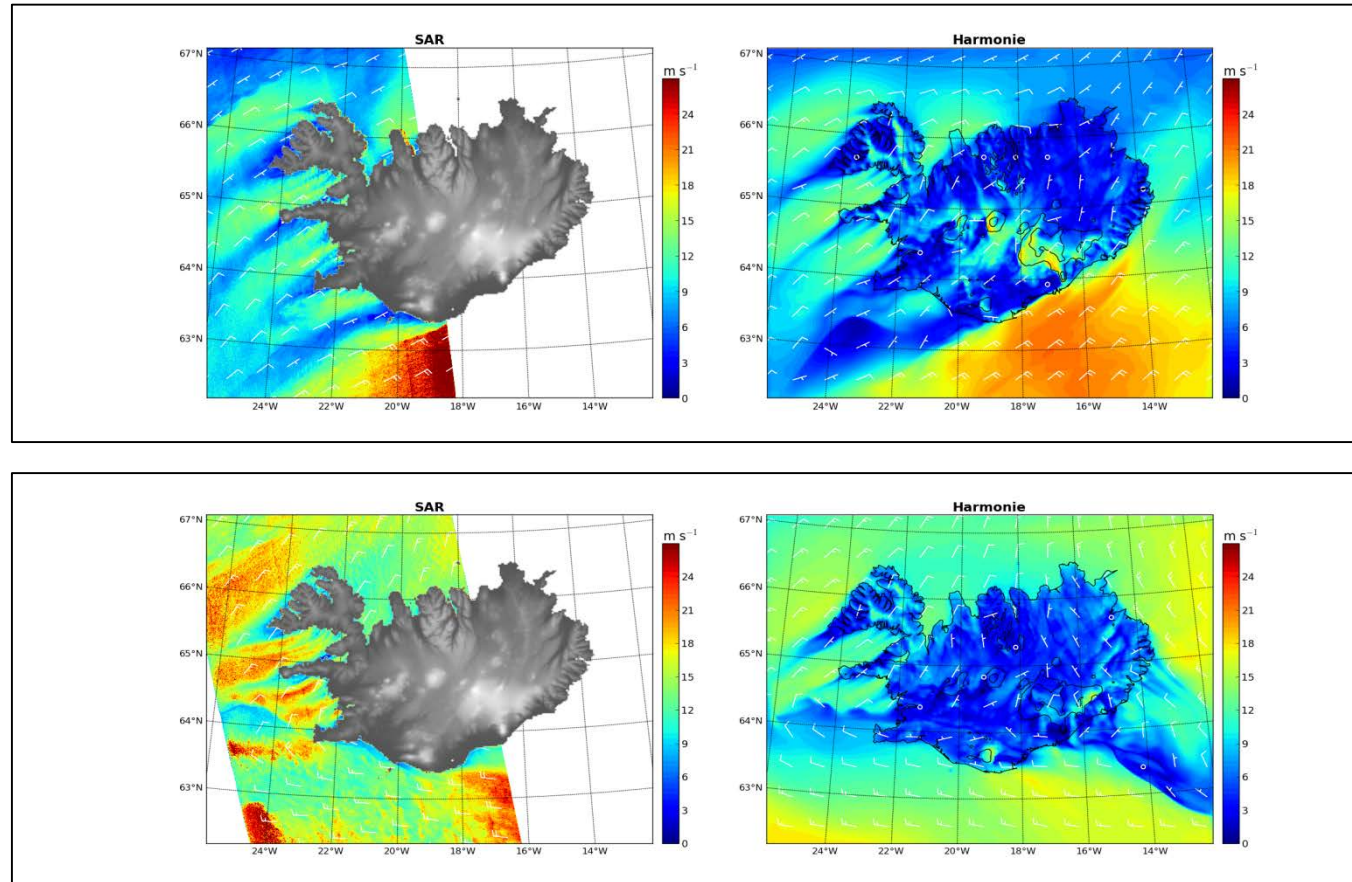
Ahsbabs, T., Maclaurin, G., Draxl, C., Jackson, C. R.,
 Monaldo, F., and Badger, M. 2020 US East Coast
 synthetic aperture radar wind atlas for offshore wind
 energy, Wind Energy. Sci., 5, 1191–1210,
<https://doi.org/10.5194/wes-5-1191-2020>



25 designated areas

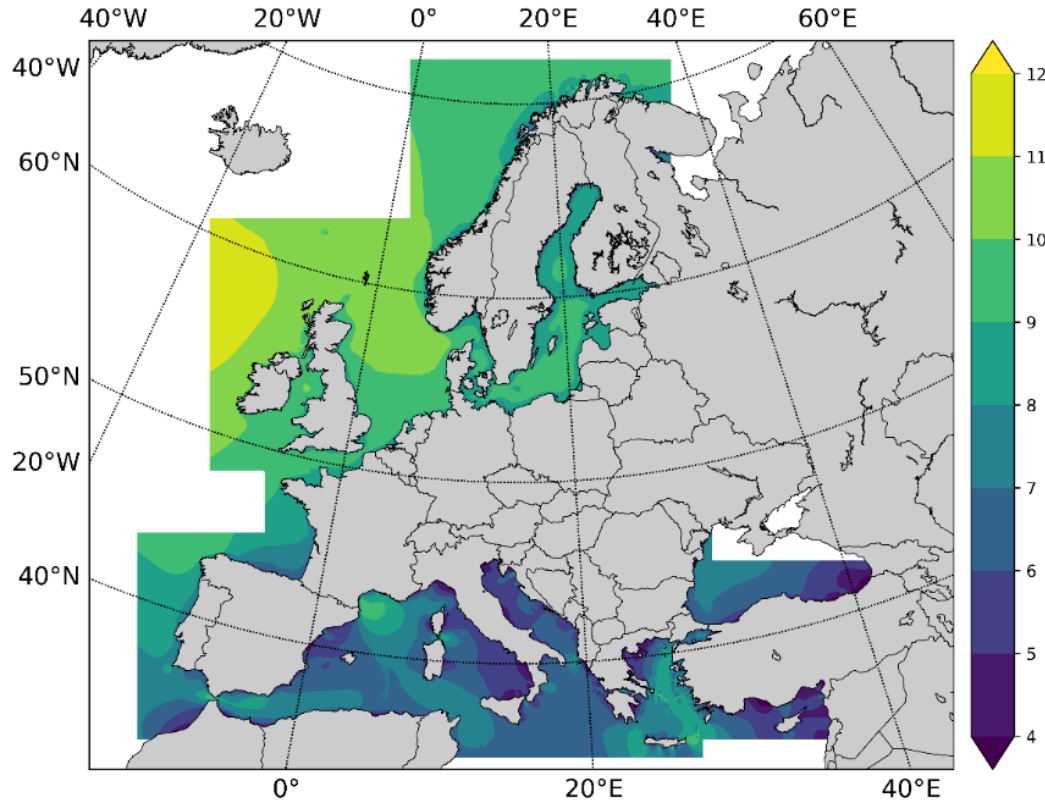


Model validation – complex flows around islands



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](https://doi.org/10.1109/JSTARS.2015.2443981).

WRF New European Wind Atlas



Data are available at:

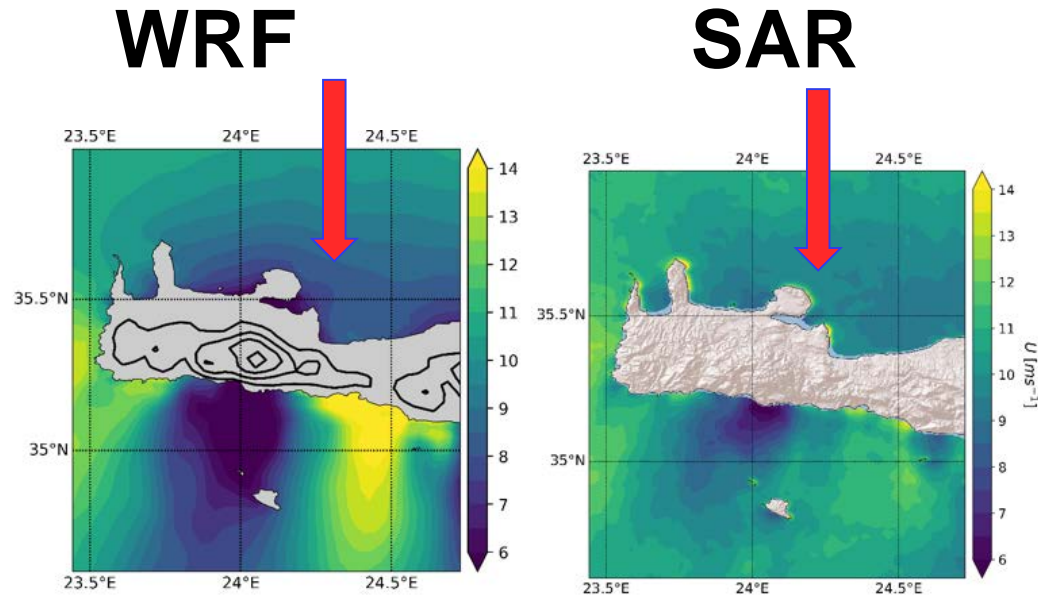
<http://www.neweuropeanwindatlas.eu/>

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

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

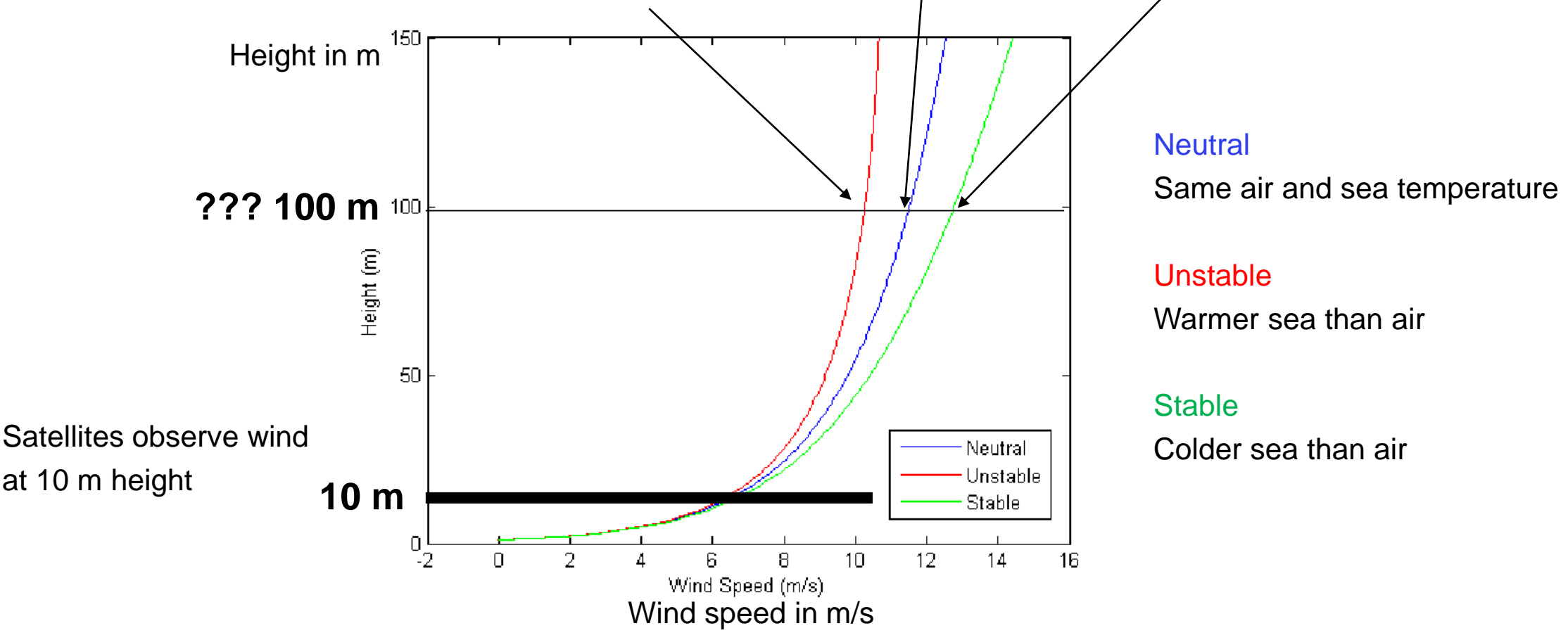


Stagnation is flow similar.
Lee effect is similar.
But gap flow is not.

We conclude orography is not
resolved fully in WRF.

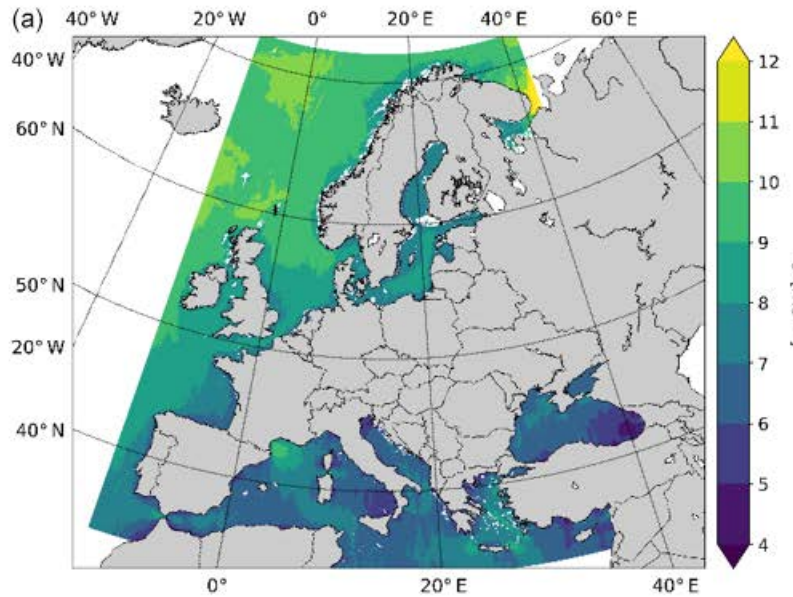
Hasager et al. 2020 Europe's offshore wind resource assessed with synthetic aperture radar, ASCAT and WRF, Wind Energ. Sci., 5, 375–390,
<https://doi.org/10.5194/wes-5-375-2020>

Wind speed with height

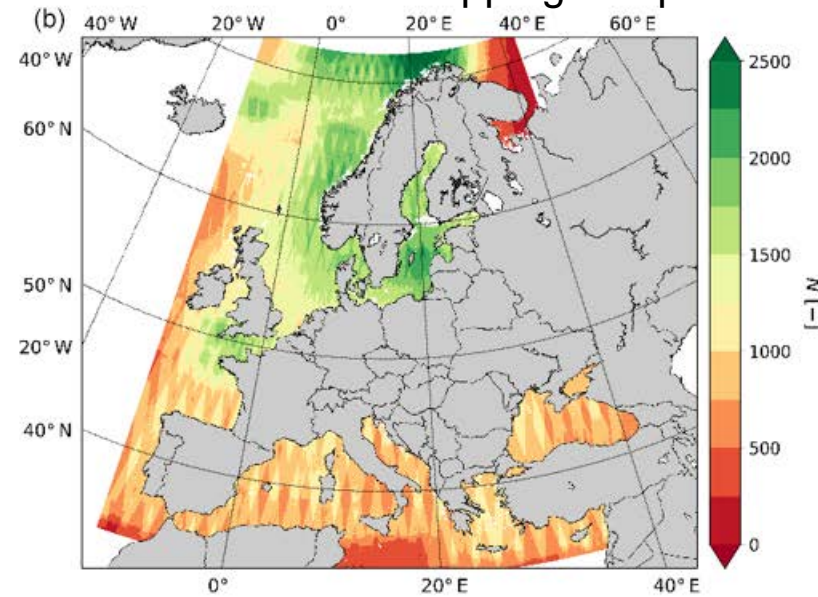


https://www.researchgate.net/figure/Stability-variation-curves-of-the-logarithmic-wind-profiles_fig1_277995087

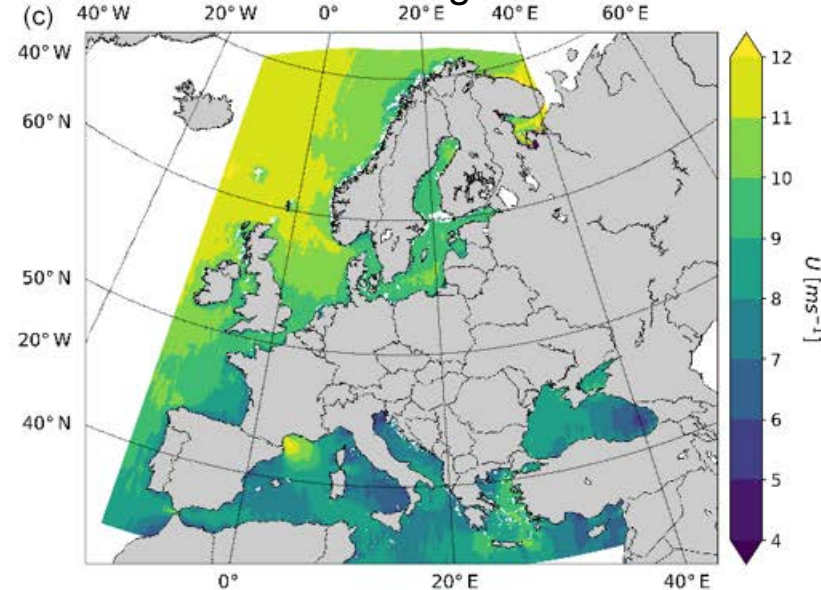
10 m height



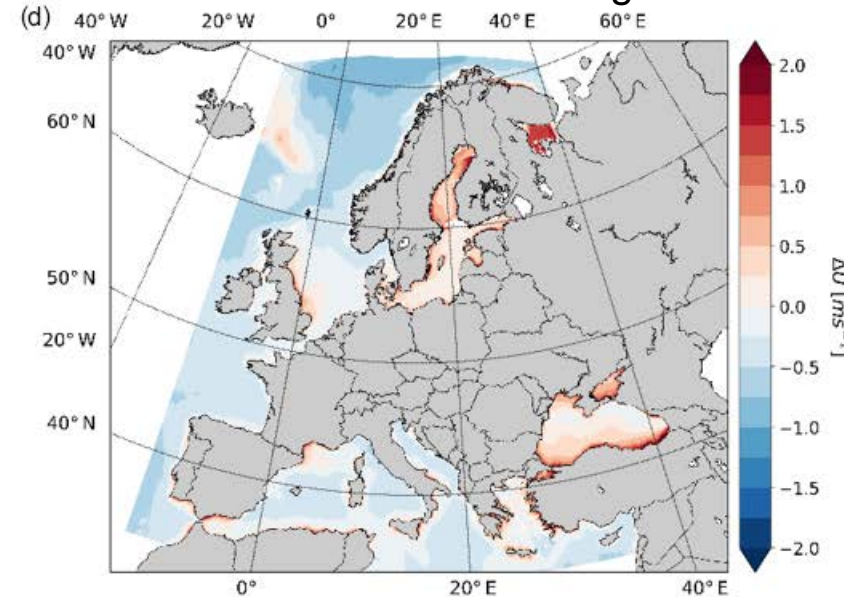
Number of overlapping samples



100 m height



Difference at 100 m height



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

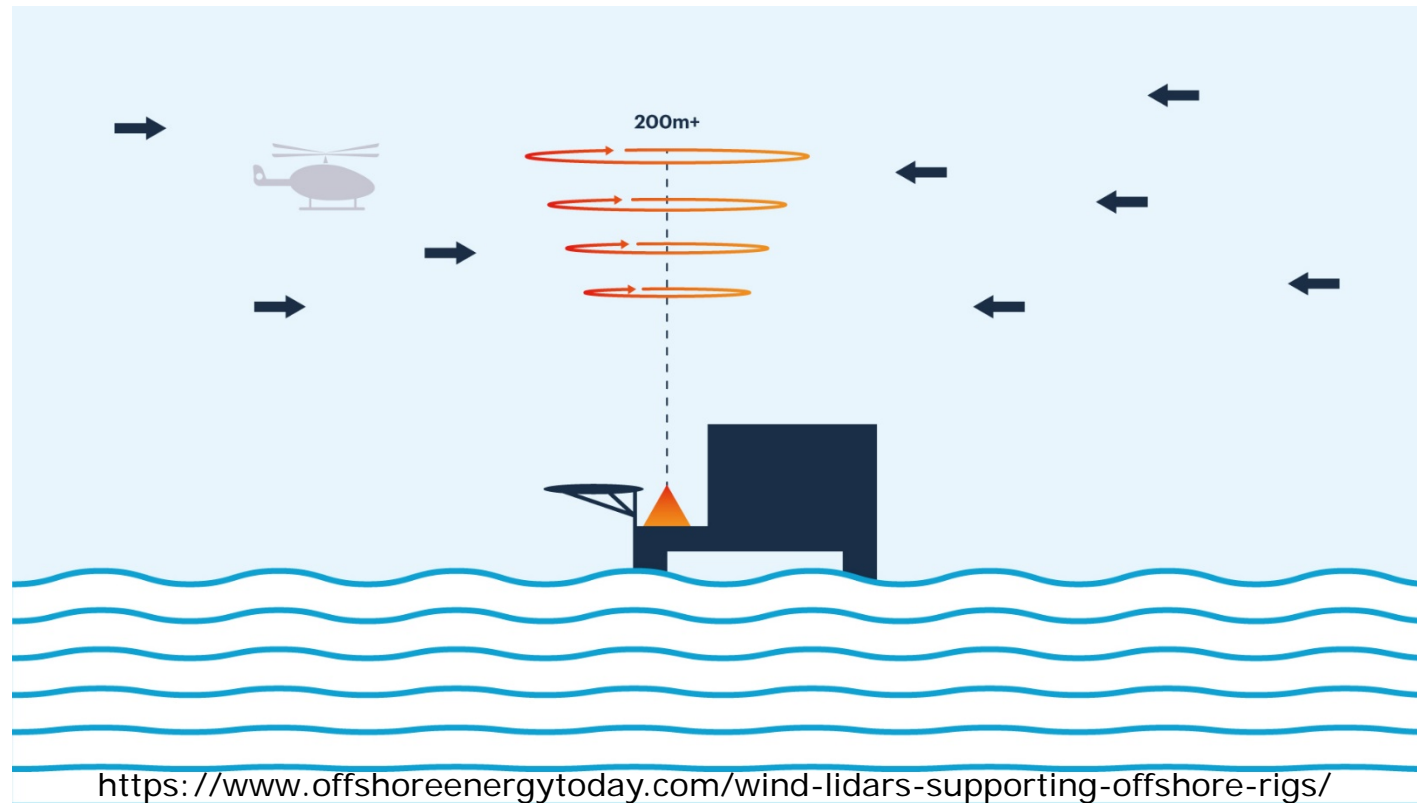
d) and difference on wind speed at 100 m height based on long-term stability correction minus neutral wind profile assumption

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>

Vertical profile

Wind lidar

Measure winds at several heights
including hub-height

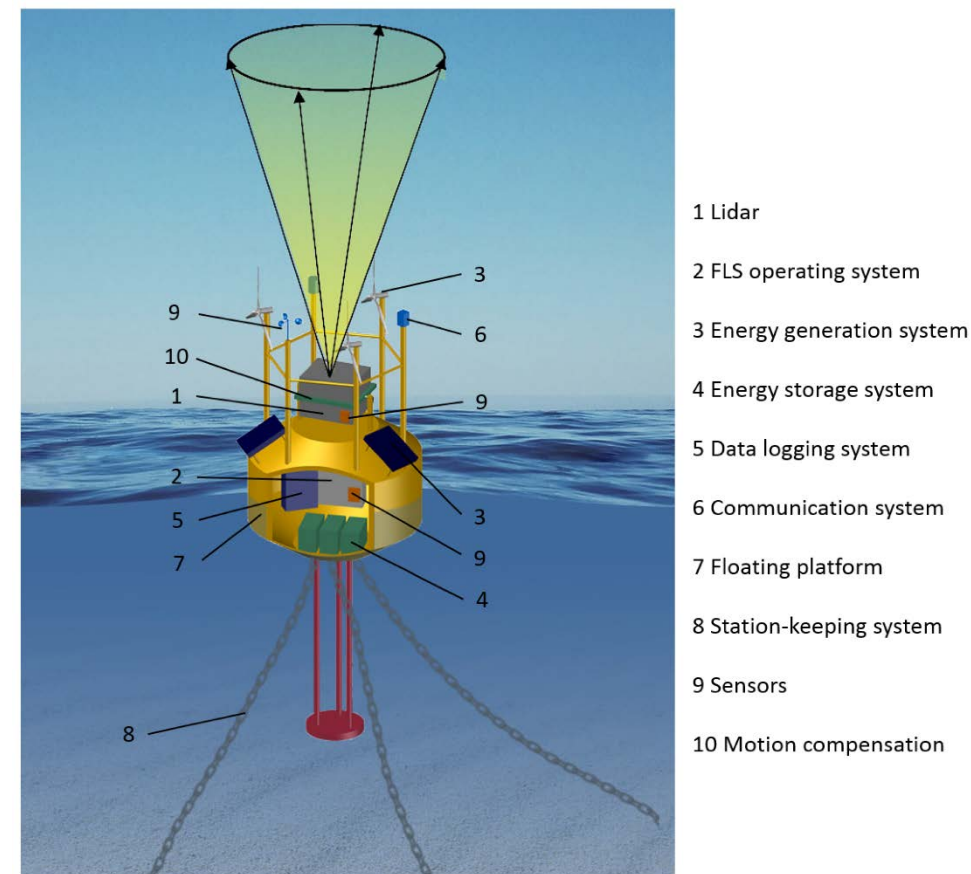


Floating lidar systems



IEA Wind TCP RP Floating lidars systems, 2017

<https://community.ieawind.org/HigherLogic/System/DownloadDocumentFile.aspx?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*