Technische Universität Braunschweig

Institut für Flugführung

Coastal influence on wind speed in the North Sea based on wind lidar, airborne measurements and ERA5 data

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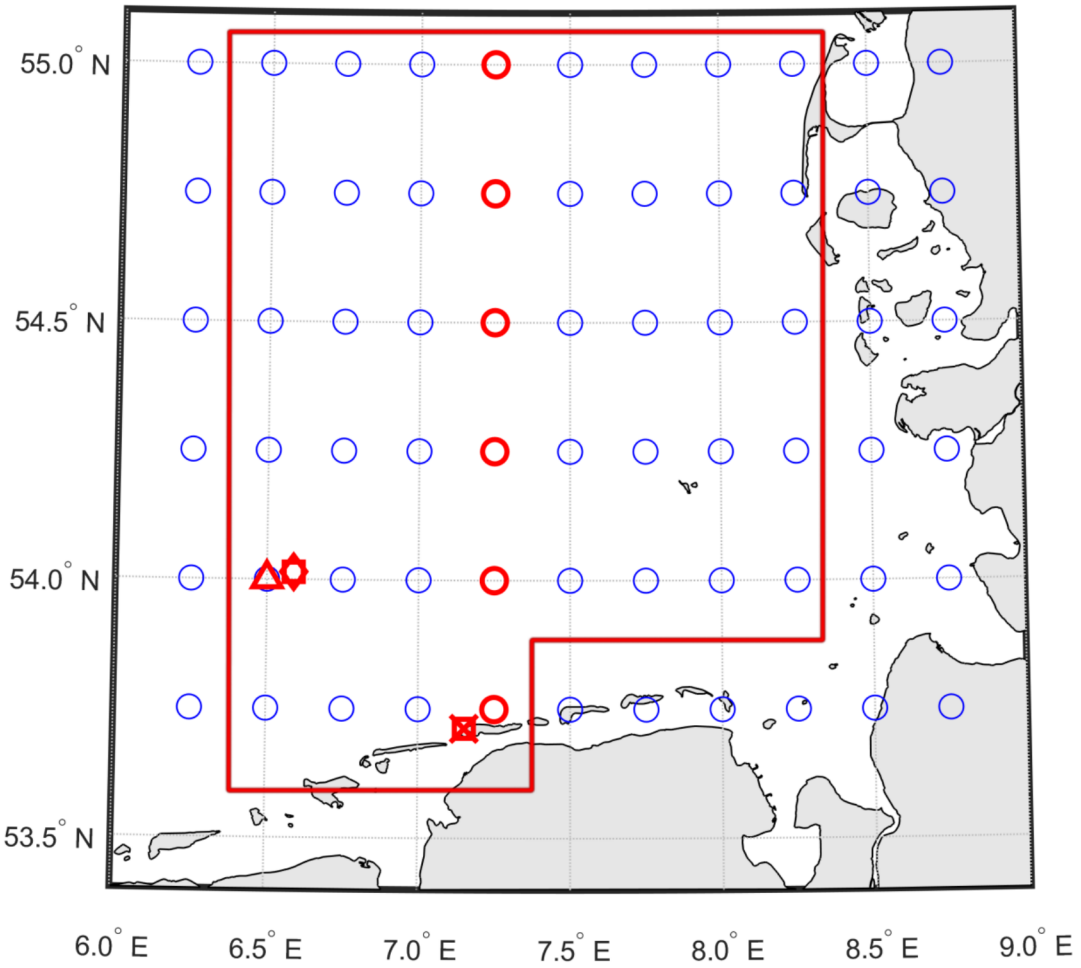
Coastal influence on wind speed

- Methods:
  - Wind lidar, ERA5 grid point locations
  - Comparison wind lidar/ERA5/WRF
  - Airborne measurements
- Two case studies: decreasing/increasing wind speed with distance
- Influence of stability
- Statistics based on ERA5

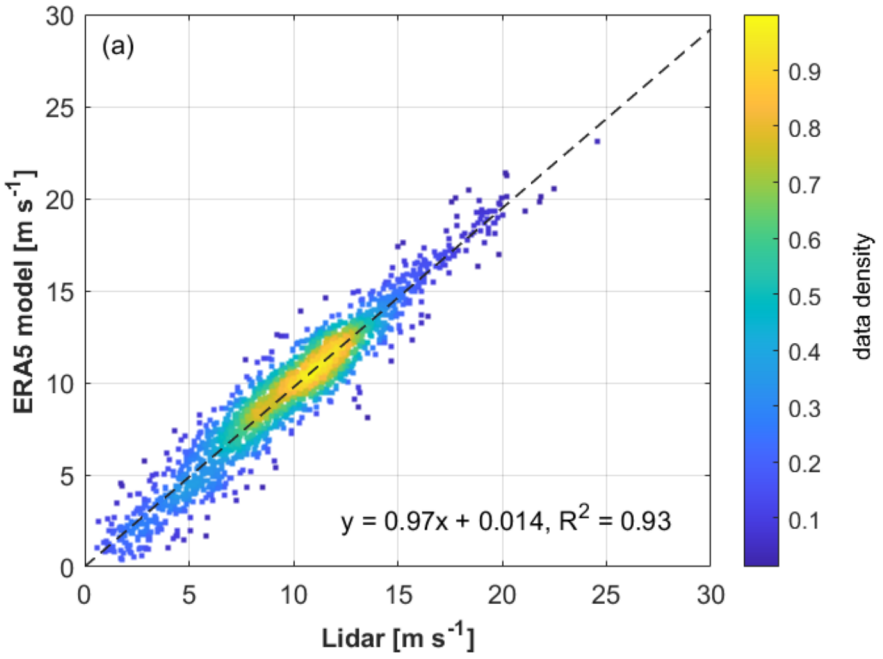
Cañadillas, B., Wang, S., Ahlert, Y., Djath, B., Barekzai, M., Foreman, R., and Lampert, A.: Coastal horizontal wind speed gradients in the North Sea based on observations and ERA5 reanalysis data. Meteorologische Zeitschrift, Accepted for publication on 22 November 2022.

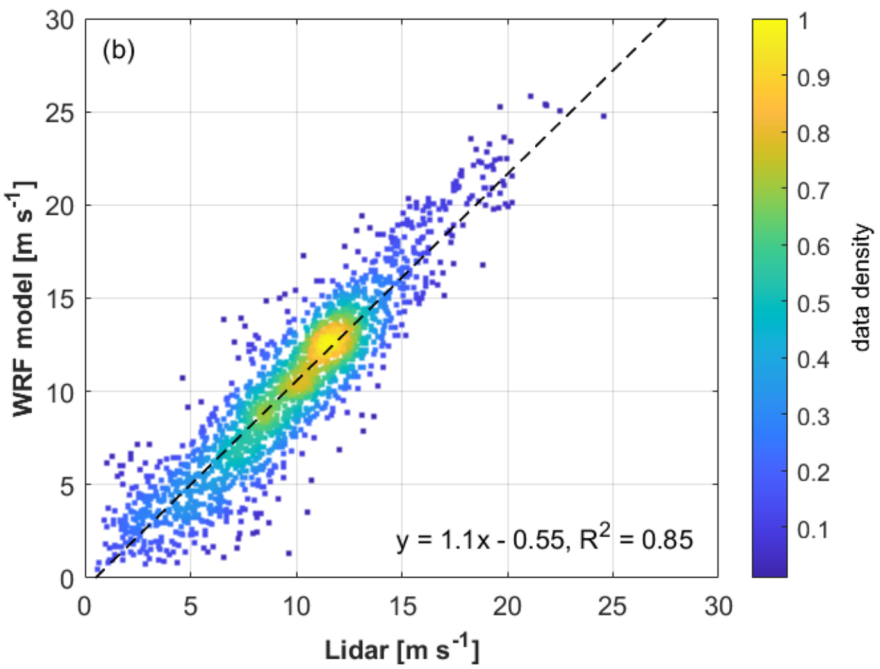
Methods: ERA5 & wind lidar

- Grid ERA5 (red – selected for analysis
- Location wind lidar (40-500 m) at the island of Norderney (red cross)
- Location of FINO1 (red star)
- Location of closest WRF/ERA5 point (red triangle)



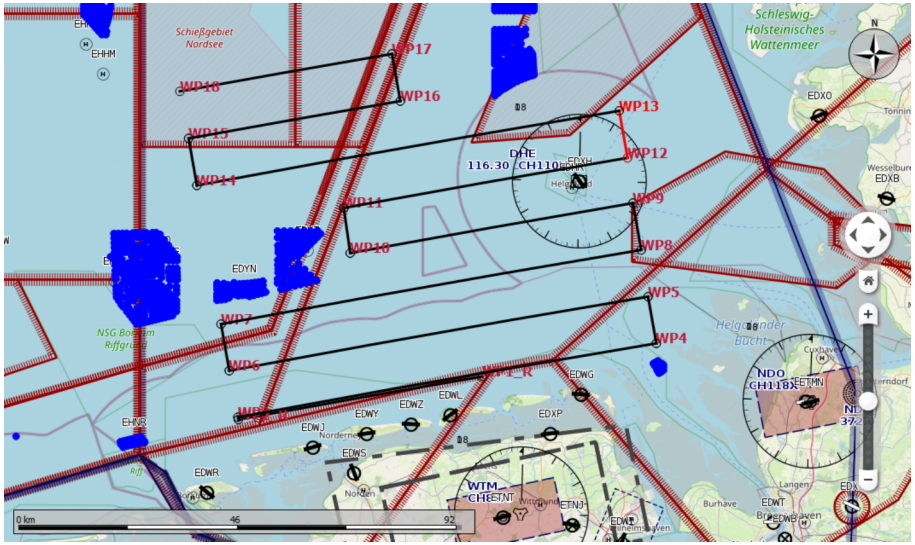
Comparison: wind lidar/ERA5/WRF

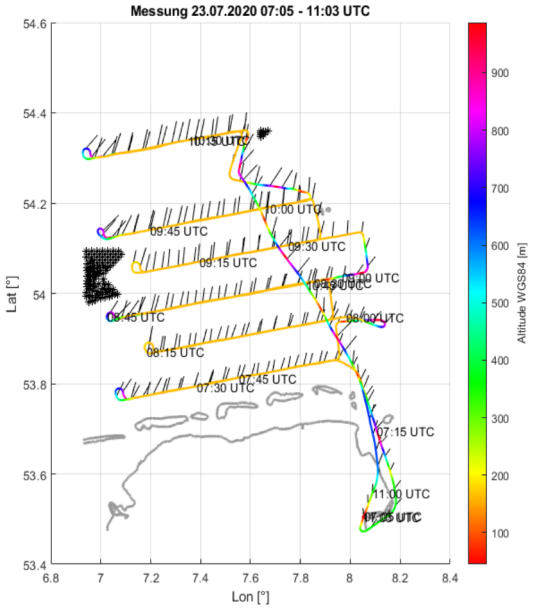




Hourly comparison, flow from South (150°-210°) only, 100 m altitude, time period 1 April 2020-31 March 2021

Methods: airborne measurements

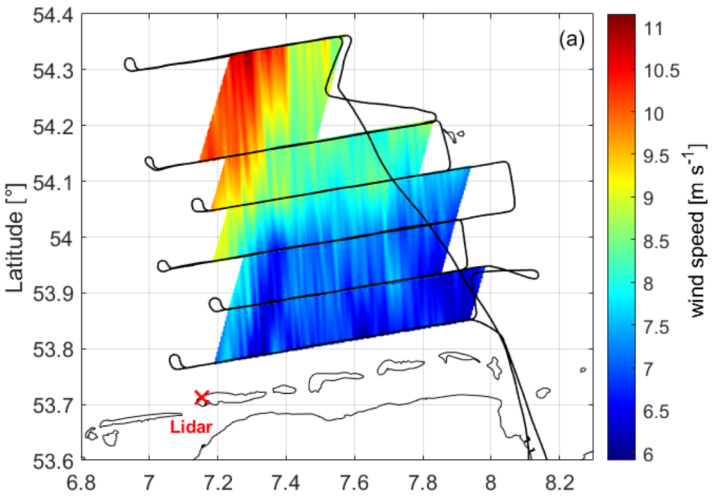


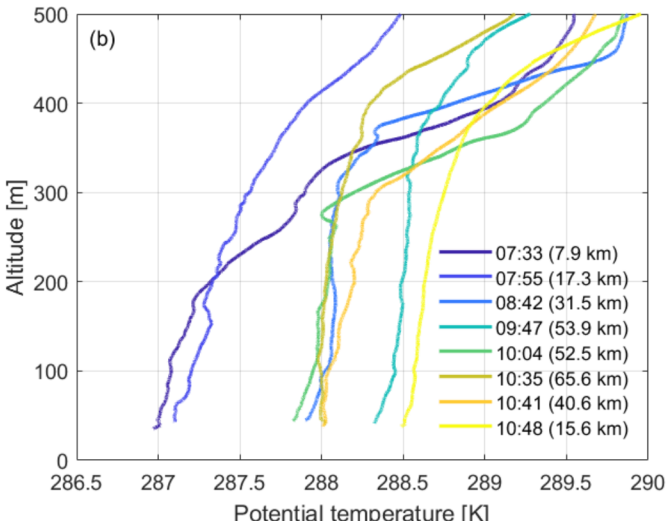


Dornier 128, former „Polar 1“
at TU Braunschweig 1985-2021

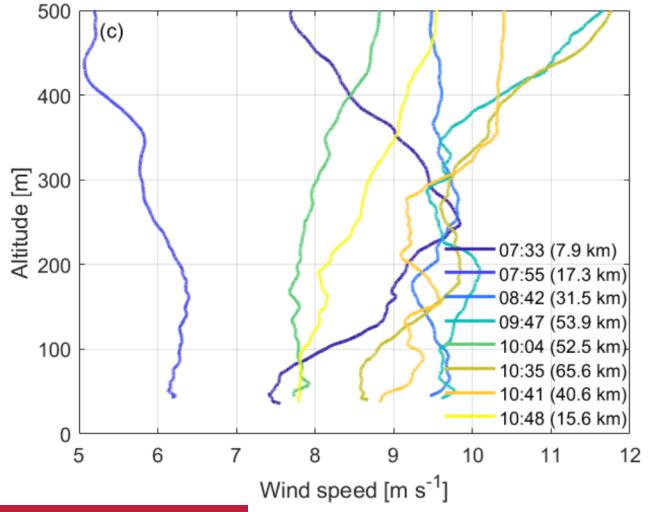
- 2 pilots, 1 engineer, 1-2 scientists
- 4 h flight duration
- air speed 65 m/s (measurement and ferry)
- nose boom for meteorological measurements
- surface temperature, sea state, cameras

Increasing wind speed (23 July 2020)

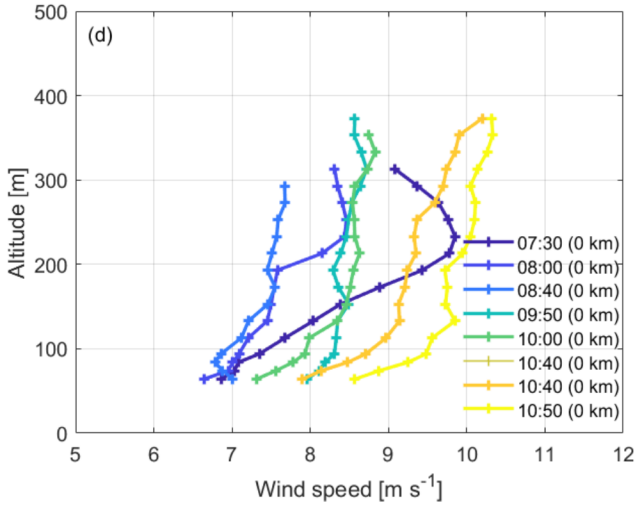




Stability aircraft

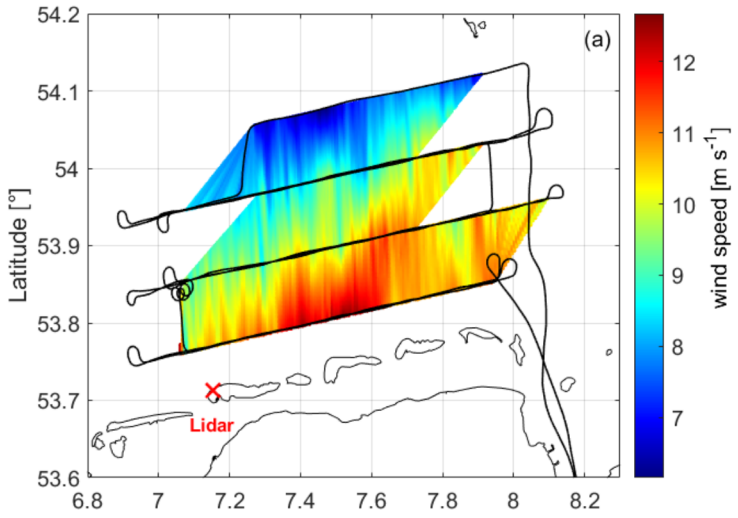


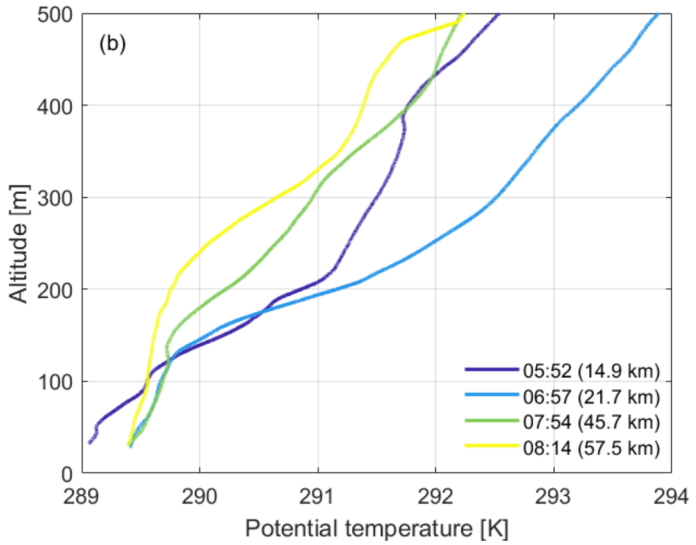
Wind profiles aircraft



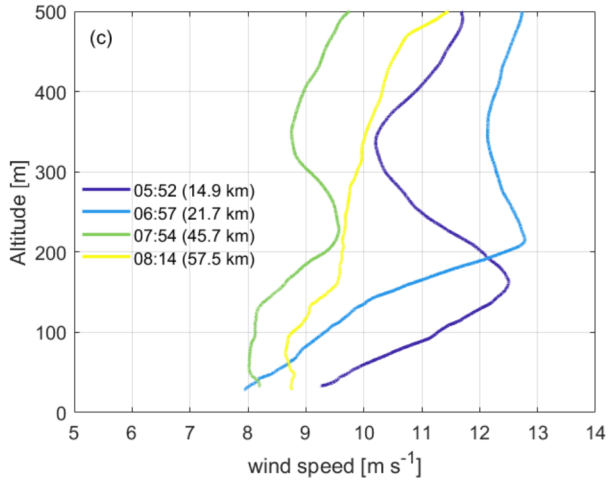
Lidar Norderney

Decreasing wind speed (23 September 2020)

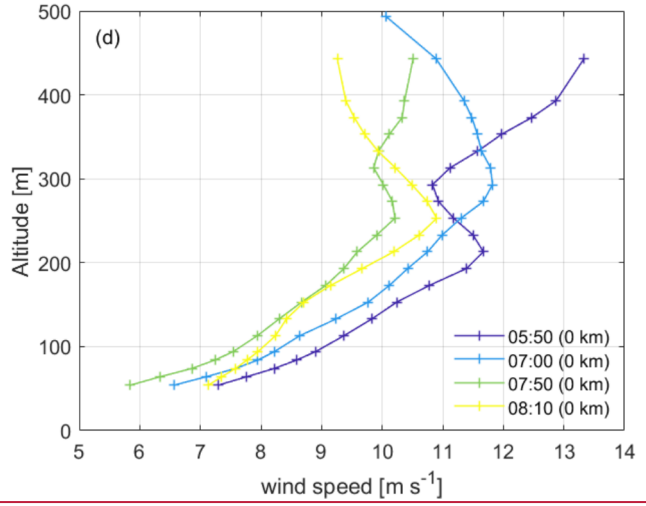




Stability aircraft



Wind profiles aircraft



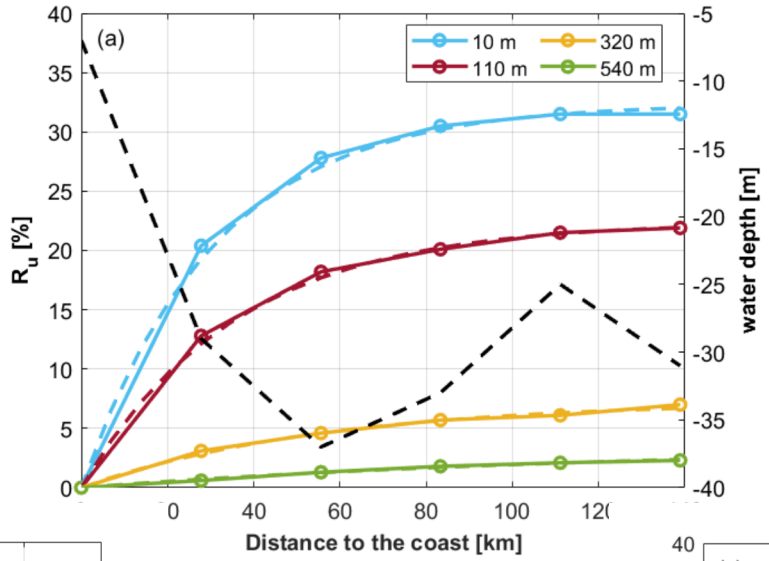
Lidar Norderney

Influence of stability

First case:
•General increase of wind speed with distance
•Slightly stable conditions: lapse rate 2 K/km
•Surface temperature: 13°C above land, 17°C at FINO1
•Similar stability with time, spatial and temporal variability of wind speed

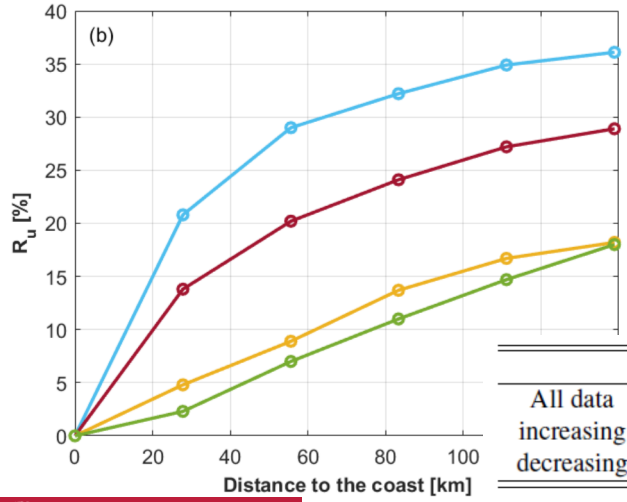
Second case:
•General decrease of wind speed with distance
•High stability above land, weakening with distance: Highly stable conditions: lapse rate 8 K/km
•Surface temperature: 12°C above land, 18°C at FINO1
•Low-level jet weakens, breaks up
•Nonlinear height-dependent wind speed gradient

Wind speed development for ERA5



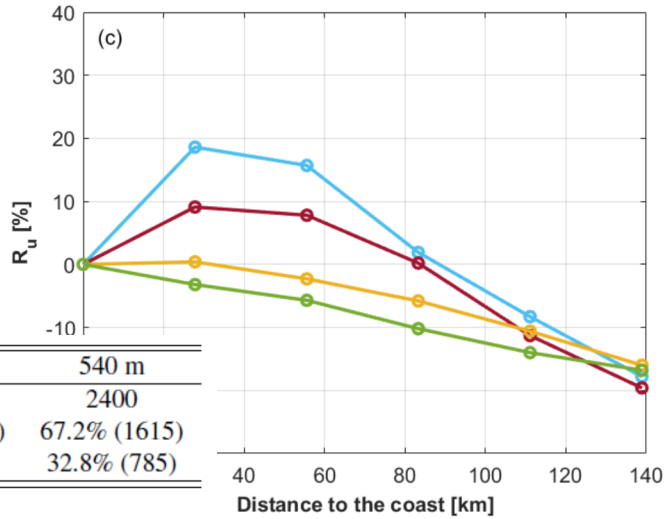
Horizontal wind speed gradient relative to grid point closest to coast

Increasing wind speed



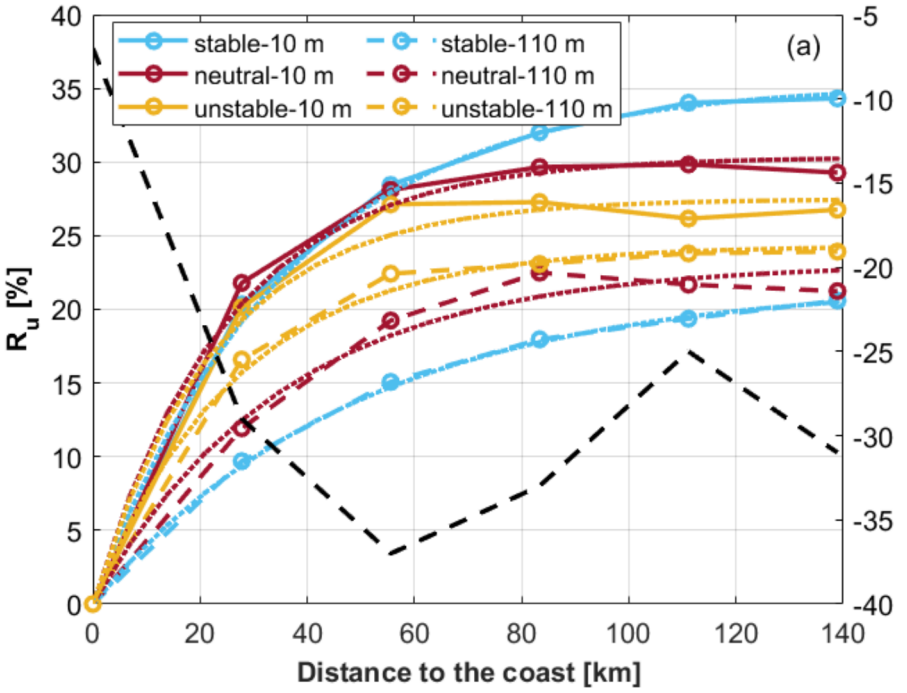
All data for wind from South

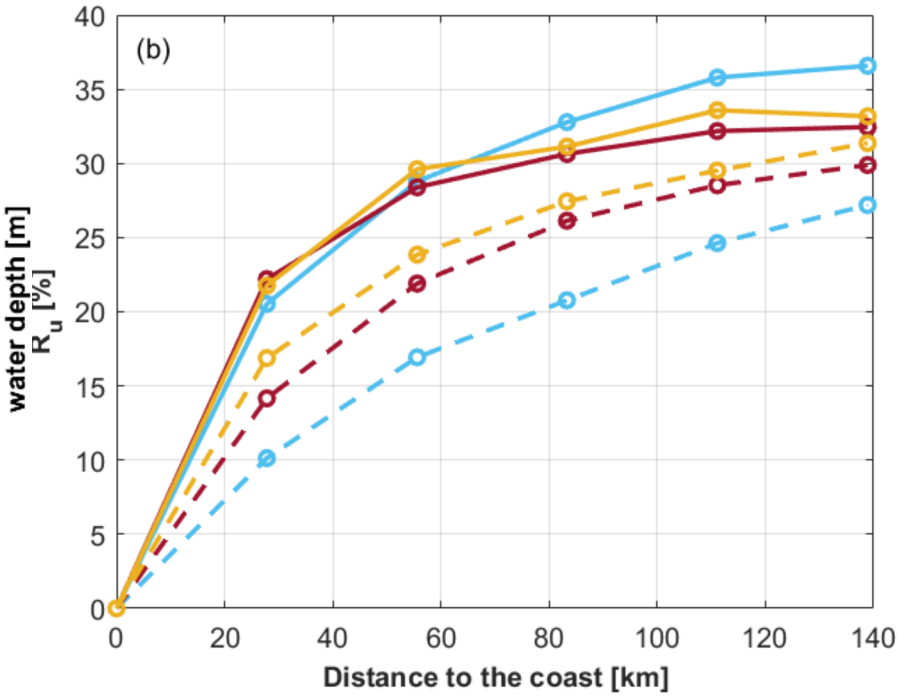
Decreasing wind speed



	10 m	110 m	320 m	540 m
All data	3254	3162	2749	2400
increasing	89.9% (2924)	85% (2688)	73.8% (2029)	67.2% (1615)
decreasing	10.1% (330)	15% (474)	26.2% (720)	32.8% (785)

Influence of stability





All data for wind from South

Increasing wind speed

Questions? ☺

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Airborne data:

Rausch, T., Bärfuss, K., Hankers, R., Bitter, M., Feuerle, T., Cremer, M., Angermann, M., Füllgraf, J., and Lampert, A.: In-situ airborne measurements of atmospheric and sea surface parameters related to offshore wind parks in the German Bight, PANGAEA, https://doi.pangaea.de/10.1594/PANGAEA.955382 (DOI registration in progress), 2023.

Bärfuss, K., Hankers, R., Bitter, M., Feuerle, T., Schulz, H., Rausch, T., Platis, A., Bange, J., and Lampert, A.: In-situ airborne measurements of atmospheric and sea surface parameters related to offshore wind parks in the German Bight, PANGAEA, https://doi.pangaea.de/10.1594/PANGAEA.902845, 2019.

Windlidar data:

Rausch, T., Cañadillas, B., and Lampert, A.: Coastal vertical wind lidar measurements of horizontal wind speed and wind direction from 40 to 500 m at Norderney island, German Bight, North Sea, Germany. PANGAEA, https://doi.org/10.1594/PANGAEA.953770, 2023.

Rausch, T., Schuchard, M., Cañadillas, B., and Lampert, A.: One year measurements of vertical profiles of wind speed and wind direction from 40 to 500 m at Heligoland, German Bight, North Sea, Germany. Technische Universität Braunschweig, PANGAEA, https://doi.org/10.1594/PANGAEA.924184, 2020.