Potential applications of the Fraunhofer IWES Wind Lidar Buoy,

an innovative and flexible wind measurement system

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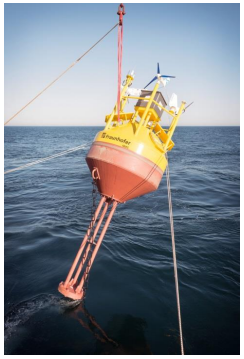

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Outline

- Floating lidar technology (introduction)
- Fraunhofer IWES Wind Lidar Buoy, and Offshore test(s) next to FINO1
- Applications of floating lidar technology

- Conclusions

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Floating lidar technology

… why floating lidar?

- Offshore wind data are relevant for the offshore wind industry but rare
- Offshore met. masts are related to (extremely) high costs

→ Floating lidar systems can provide the needed data at almost any site to significantly less costs

→ Resulting data are of high quality – in terms of accuracy, availability, completeness / level of detail

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Floating lidar technology

… how mature is the technology?

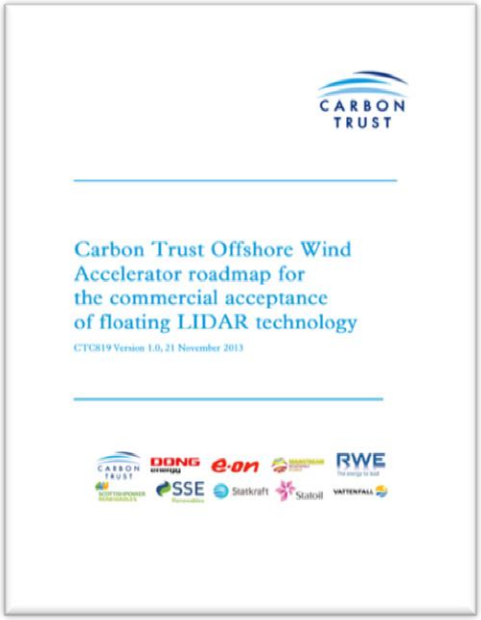
- Besides the technical challenges

  (e.g. compensation of system motions, reliable power supply, offshore suitability of system components, …)

  acceptance of a new technology is critical;

- Three-stage approach by Carbon Trust * → baseline, pre-commercial, commercial;

  for pre-commercial – pilot validation trial completed successfully including independence confirmation of Acceptance Criteria.



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Fraunhofer IWES Wind Lidar Buoy

- Developed within the R&D project ‘Offshore Messboje‘ (funded by BMU/BMWi, 2011-13) –
  prototype #1-W (top) completed in spring 2013,
  updated prototype #1-Z (bottom) in 2014;
  #2-Z in 2015
- Floating lidar system integrating
  a pulsed Windcube v2 or a cw ZephIR 300 lidar device (W / Z) in an adapted marine buoy (LT81 – 7.2 m height, 2.55 m diameter, 4.7 t weight)
  with motion-correction algorithm developed by Fraunhofer IWES, implemented as part of post-processing;
- Offshore trials conducted (in 2013 and 2014 resp.; 2014 ongoing) to validate concept and prepare system for pre-comercial stage according to OWA Roadmap.

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Offshore test(s) next to FINO1 met. mast

- Floating lidar offshore test next to (NW direction / 450 m distance) FINO1 met. mast (German North Sea, 45 km offshore);
- representative offshore conditions:
  30 m water depth, yearly-averaged wind speed of 9.9 ms^{-1} at 100 m height, mean wind direction SW, sea currents governed by tides.

- Duration of trials:

  #1-W – from 2 Aug. to 6 Oct. 2013

  #1-Z – from 5 Aug. to 30 Sept. 2014

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http://www.fino-offshore.de/de/

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Offshore test(s) next to FINO1 met. mast

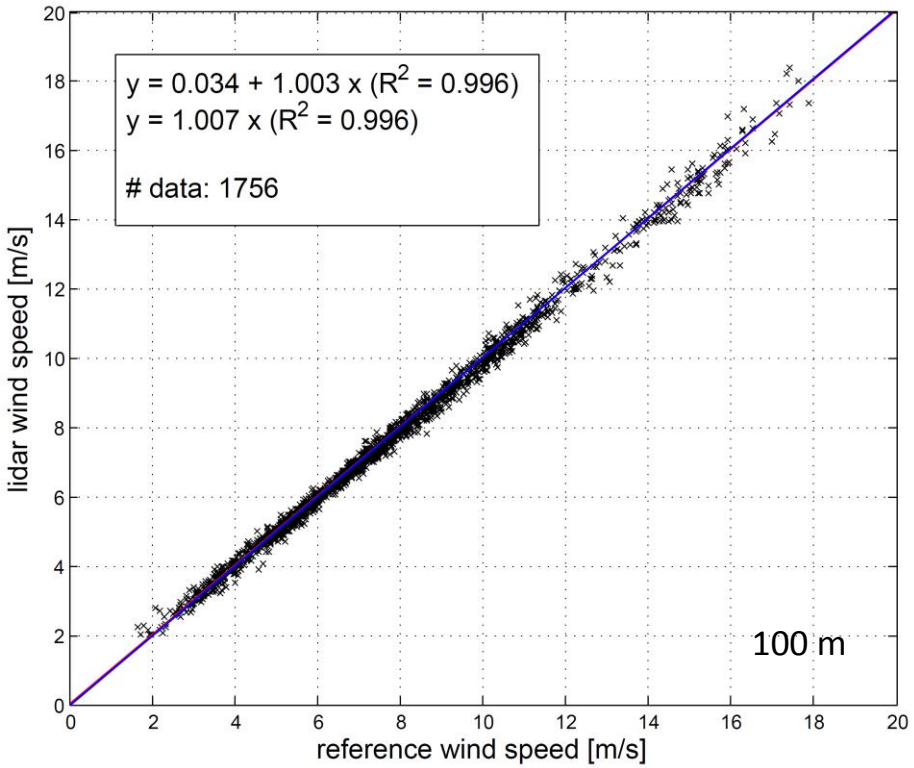
- Results from test #1-W:

  65 complete days of data,

  Overall System Availability = 98%,

  Post-Processed Data Availability less due to missing motion data,

  very good correlation for measured (10-min-mean) wind speeds even without motion correction



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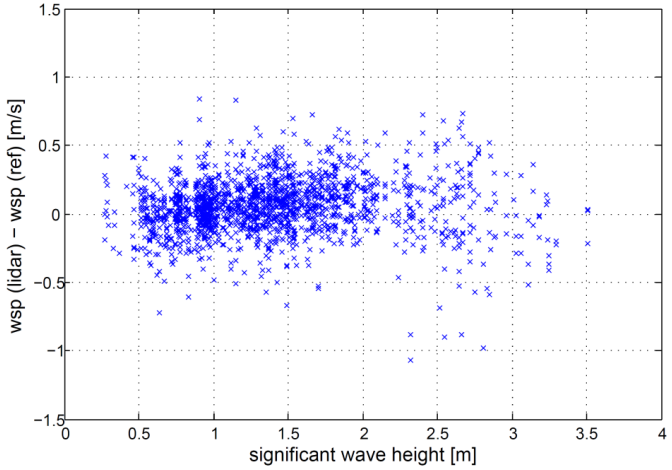

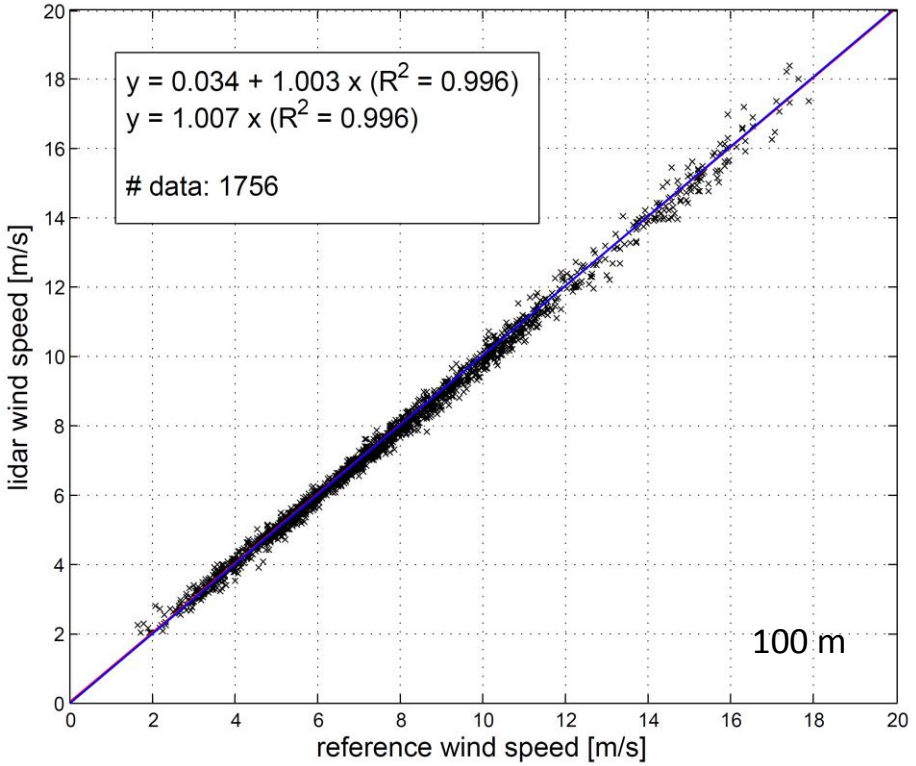

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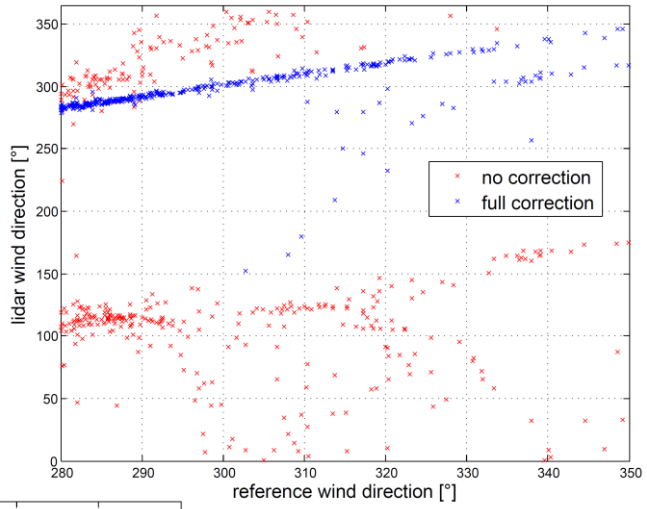
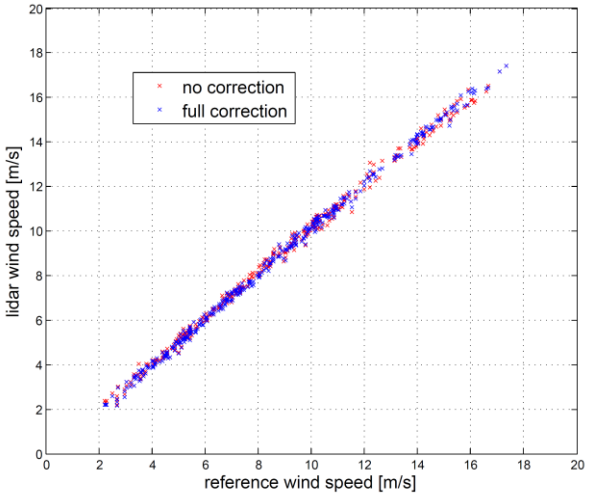
Offshore test(s) next to FINO1 met. mast

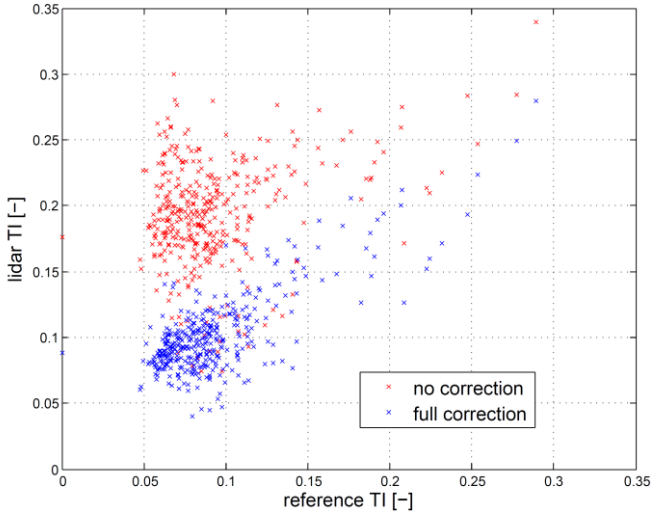
– Results from test #1-W:

application of motion correction

→ necessary for wind direction, helpful for interpretation of TI (Turbulence Intensity) data







100 m

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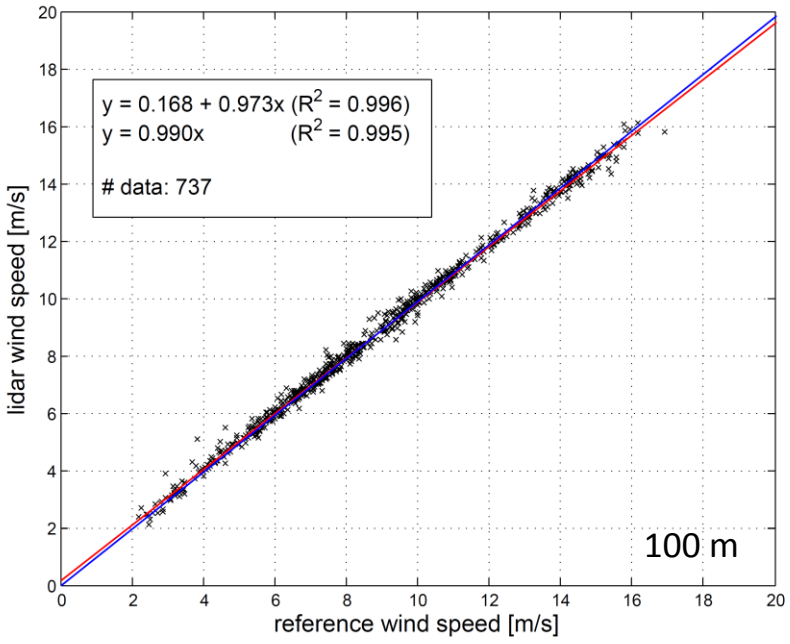
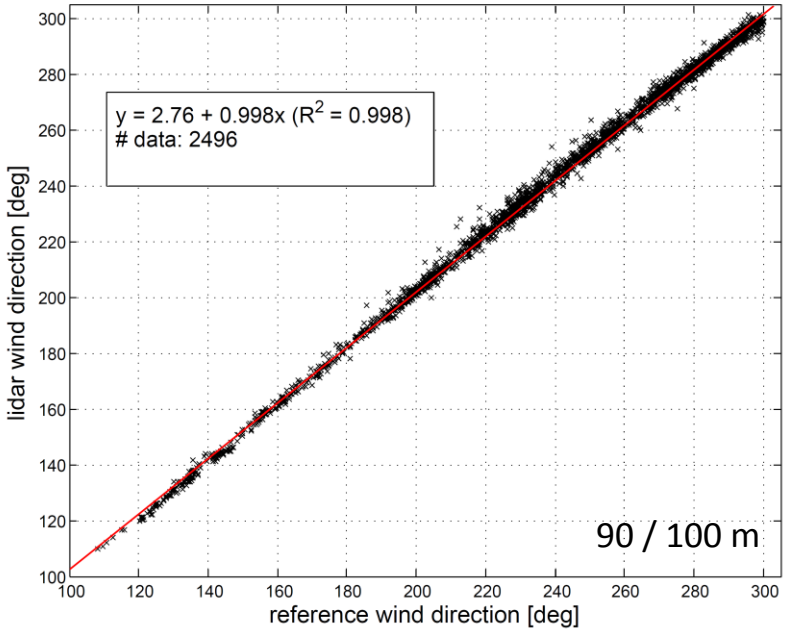
Offshore test(s) next to FINO1 met. mast

– Results from test #1-Z: about 30 days of analysable data, System and Post-Processed Data Availability on same level → motion correction applicable to all recorded lidar data;
again very good correlation for wind speed and wind direction data





Applications of floating lidar technology

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- Floating lidar technology successfully introduced into the offshore wind industry during the last few years

  (first system 2009, first pre-commercial 2013)

  … with particular benefits for application within Wind Resource Assessment (WRA) campaigns

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  Which alternative applications are there?
  (flexibility / costs / accuracy / completeness of data)

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Applications of floating lidar technology

→ power curve tests (e.g. following IEC 61400-12-1)

(flexibility / costs / accuracy / completeness of data)

- Clear cost benefit compared to met. mast
- Alternative (possibly less costly) approaches are available but maybe not always applicable.
- The estimation of a complete uncertainty budget is needed, corresponding guidelines (for floating lidars) are still missing.
- Turbulence data, that may be used in an informative way, are not reliable enough. But profile data – which may not be available from the alternative approaches – are.

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Applications of floating lidar technology

→ design basis / met-ocean database (e.g. according to IEC 61400-1 or -3)

(flexibility / costs / accuracy / completeness of data)

- Floating lidar technology may offer site-specific measurement data with a cost benefit compared to other technologies – alternative or supplementary to model data.
- Floating system may give sea state data as well – wave height and period from motion data.
- Turbulence data are not accurate/reliable enough.

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Conclusions / Outlook

- Floating lidar is a promising technology…
  in terms of saving costs but also for the provision of high-quality data …
  for application in a WRA campaign.
- Validating a system‘s performance and verifying its accuracy in offshore trials is an important prerequisite for gaining acceptance in the industry.
- Alternative applications (to WRA) suggest themselves but are related to critical points that need to be resolved in careful investigations.

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Conclusions / Outlook

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- Alternative applications (to WRA) suggest themselves but are related to critical points that need to be resolved in careful investigations.

- With the **Fraunhofer IWES Wind Lidar Buoy** we have a **robust, flexible, accurate** and validated (!) measurement system…
  which we not only offer to the industry but also use as a basis for further investigation on floating lidar technology and their future fields of applications.

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THANK YOU FOR YOUR ATTENTION

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