Compiled by Mike Courtney

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Lidars – the latest news

Three main topics

- What are lidars being used for? Status within:
  - Resource assessment
  - Power performance verification
  - Loads verification/prototype testing
  - Control

- Where are lidars going?

- Some random/relevant lidar research (slightly biased)

Resource assessment

- <u>On-shore flat</u>
  - Ground-based lidar is fine (but not formaly accepted without a mast)

- <u>On-shore complex</u>
  - Ground-based lidar gives errors but are still used. Errors on cups are probably just as big though.
  - Scanning lidars are being investigated – http://www.recastproject.dk/

- <u>Offshore</u>
  - Use a floating lidar – more manufacturers now available
  - CT roadmap 2.0 last year - https://www.carbontrust.com/media/676857/owa-w-uflr-updated-fl-roadmap_18102018.pdf
  - Uncertainties from 61400-12-1 are even sillier here – https://www.carbontrust.com/media/676998/owa-w-lusr_nov-2018.pdf
  - Scanning lidars from coast/neighbouring windfarms have some niche applications

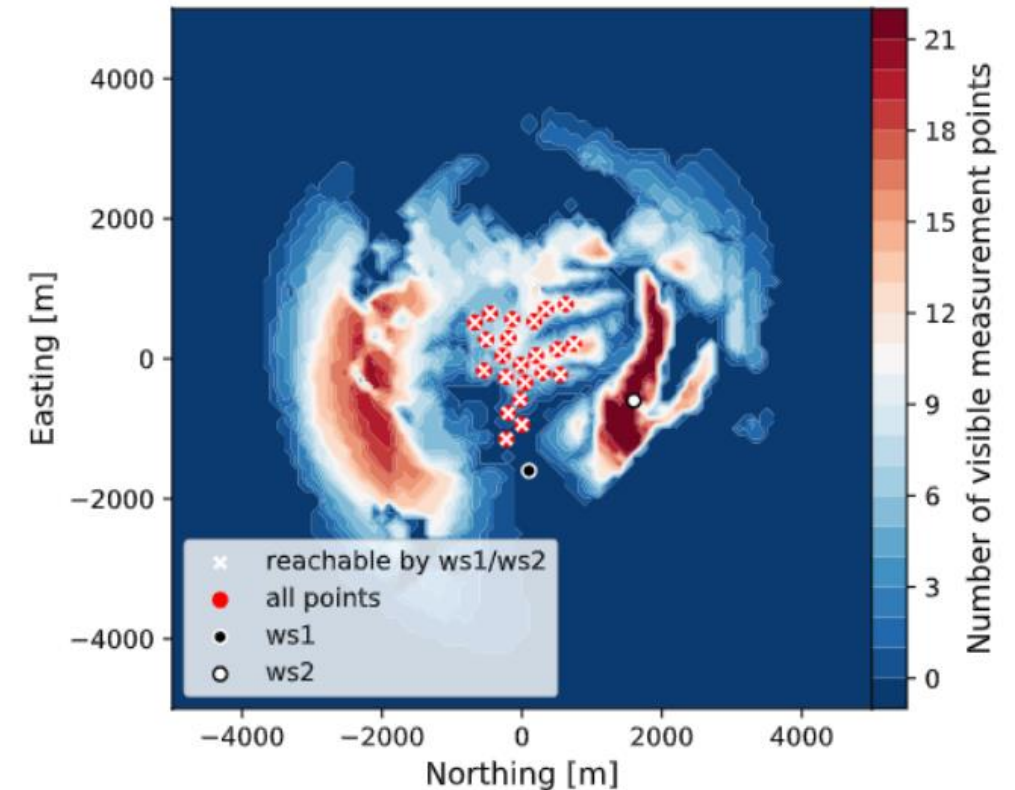# ReCast - campaign planning tool for scanning lidar campaigns

Vasiljevic   https://www.wind-energ-sci-discuss.net/wes-2019-13/wes-2019-13.pdf

Where to put the lidars based on:
- Turbine positions to measure at
- Orography and obstructions
- Measuring angular constraints

Trajectory is optimised and sent directly to the windScanners

Demonstration campaign next Spring

Campaign Planning Tool

Power curves –ground-based lidar

- Flat
  - Can use a ground-based lidar + mast (61400-12-1 Ed2)
  - Need to get rid of the mast in the next version
  - Possibly/probably better to use a nacelle-lidar

- On-shore complex
  - Nothing formally permitted. Not really done.
  - Site calibration in slightly complex terrain?
  - Probably better to use a nacelle lidar

Power curves – nacelle lidar

- <u>On-shore flat and offshore (fixed bottom)</u>
  - Use of nacelle-mounted lidar is now common
  - 61400-50-3 has reached CD (300 comments) – CDV by spring 2020 – finished by early 2021 (Rozenn Wagner is the convener)
  - Experimental use of induction method (measuring closer than 2.5D) – still not yet established – but getting there (IEA Task 32 Round Robin)
  - Work in progress: Effects of global blockage (new RR)

- <u>Floating WTG</u>
  - Nacelle-mounted will probably still work quite well but we need to try!
  - Will need a 61400-50-3 version 2 (or 3).

- <u>Complex</u> – see next slide

# Power curves – (moderate) complex terrain using nacelle lidar

Upcoming exercise in IEA task 32 trying:

- Site calibration with turbine stopped
- UniTTe approach (no terrain correction)
- Please contact Rozenn
- Input for version 2 of 61400-50-3

https://www.ieawindtask32.org/workshop-14-comparative-exercise/

IEA Wind Task 32 Comparative Exercise:

Power curve verification in complex terrain using nacelle mounted lidar
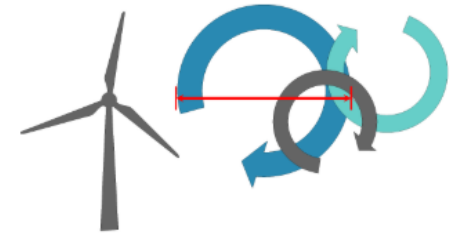
November 2019 - November 2020

Exercise leader: Rozenn Wagner (DTU Wind Energy)

Organization team: Luke Simmons (DNV GL), Ioannis Antoniou (Siemens Gamesa Renewable Energy), Andy Clifton (U. Stuttgart).

Background to the exercise

IEA Wind Task 32 Workshop 14 will focus on the use of nacelle mounted lidars for wind turbine power curve verification (PCV) in complex terrain.

Control (WT and park)

- Several new big commercial wind farm projects where nacelle lidars are included as original equipment. These will be used for
  - Wind speed measurement (performance verification and/or control)
  - Yaw error
  - Wake detection
  - Feed-forward load alleviation??
  - Power enhancement???
  - Park control??

- Examples:
  - https://www.evwind.es/2019/04/01/fred-olsen-deploys-zx-lidars-at-hogaliden-wind-farm/66599
  - https://www.greentechmedia.com/articles/read/china-plans-6-gigawatts-of-subsidy-free-wind-in-mongolia#gs.4yydsq

Loads verification/Prototype test using nacelle-mounted lidars – your input needed!

- Some good experiences using commercial nacelle lidars from the UniTTe project at a flat and homogeneous site (see Dimitrov: https://onlinelibrary.wiley.com/doi/abs/10.1002/we.2385)

- Is this good enough or do we need more specialized lidars for loads and prototype testing?

- DTU spinner lidar can measure all the 3+3 turbulence components (Reynolds stress tensor) (see Mann: https://zenodo.org/record/3403943#.XYyCpSgzZPY).

- Is the turbulence profile also important?

- What level of turbulence detail necessary?

- Do we need to combine load verification and power performance verification in one lidar?

Turbulence from lidars

- JIP headed by DNV/GL: https://www.dnvgl.com/news/dnv-gl-launches-new-joint-industry-project-to-cut-wind-energy-costs-through-lidar-measurements-154393 Aims "*to develop a new Recommended Practice to support wider acceptance and adoption in industry standards of TI measurement by LIDAR*"

- CFARS Site suitability group (http://www.cfars.org/working-groups/) have similar aims

- Is lidar measured turbulence somehow more representative of the turbulence seen by the wind turbine?

- How can lidar turbulence estimates be improved?

- Is academia sufficiently involved?

Where are lidars going?

- More lidar manufacturers appearing (e.g. China, Germany)

- Prices are falling (50k€ for a wind lidar)

- Lidar modules appearing https://abacus-laser.com/

- Will lidars become just another (cheap) component?

HB100 Doppler Speed Sensor - Arduino Compatible
★★★★☆ (25 Reviews)
Speed and pseudo-distance sensor using the Doppler effect
Designed by limpkin in Switzerland

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(170,70 kr DKK)

Ask a Question

Shipping to Denmark starts at $6.00 (40,97 kr DKK)
Ships from Switzerland

Quantity*
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RADAR!

The drones are coming…

https://www.atmos-meas-tech-discuss.net/amt-2019-102/

Applications within:

- Resource assessment
- Power performance
- Loads validation
- Wake detection
- ....

# LiDAR to reduce/prevent erosion of leading edges

- By reducing the tip speed during severe precipitation events, the erosion on the leading edges can be reduced and the lifetime of the blade extended (Bech et al., 2018)
- But how to measure precipitation offshore?
  - Weather radar: Provides a good overview but measures above the wind turbines
  - LiDAR: Use of already available data to monitor precipitation at turbine position
- Comparison of drop numbers from LiDAR and disdrometer in relation to EROSION project
  - 3 short-range Windscanner vs. Parsivel^2 at Risø
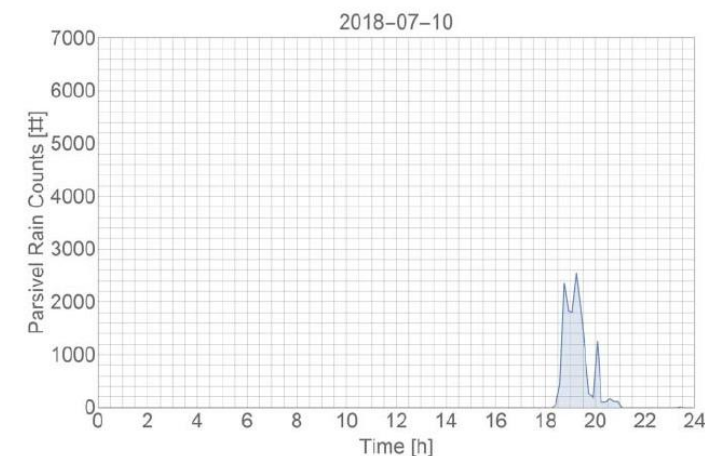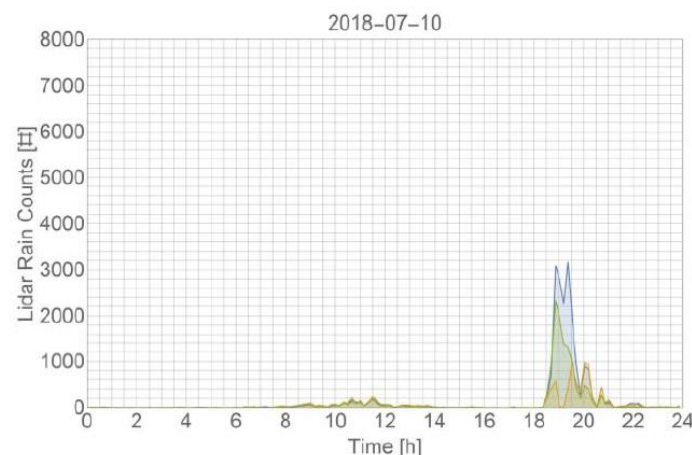
Two recently finished (DTU) PhDs

- Dominique Held *Inflow Measurements with Nacelle Mounted Lidars for Turbine and Wind Farm Control*
  - Highlight: Using nacelle lidars to identify wake conditions
  - https://orbit.dtu.dk/en/projects/lidar-detection-of-wakes-for-wind-turbine-and-farm-control(56966c7d-5455-4176-bec0-219e7ba404d9).html

- Elliot Simon *Minute-scale forecasting using Lidar Inflow Measurements*
  - Highlight: How to predict the wind speed arriving at your wind farm in 5 mins
  - YouTube https://www.youtube.com/watch?v=jTeYLlcouHU
  - https://orbit.dtu.dk/en/publications/minutescale-wind-forecasting-using-lidar-inow-measurements(e1bff2d8-4ecb-433e-a077-89f445968c00).html
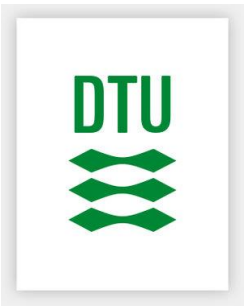
LIKE

Lidar Knowledge Europe

Innovative Training Network

H2020-MSCA-ITN-2019

1 October 2019 to 30 September 2023 (4 years)

Contract 858358

DTU Wind Energy is Coordinator

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msca-like.eu

15 PhD students to be employed early 2020
Job announcements to open during October 2019

The five PhD positions at DTU Wind Energy

1. Lidars in wind tunnels
2. New lidar concept for wind energy application
3. Lidar data from satellite for wind mapping
4. Lidar for power performance assessment
5. Lidar for turbulence measurement

All PhDs relate to wind energy and wind engineering

The other 10 positions are at Beneficiaries
All PhDs will include secondment with Partners

Beneficiaries	Shortname
Technical University of Denmark	DTU
University of Oldenburg	UOL
University in Bergen	UiB
University of Stuttgart	USTUTT
PolitTNOico di Milano	POLIMI
University of Porto	UPORTO
University of Stavanger	UiS
Flensburg University of Applied Science	FUAS
Fraunhofer IWES	IWES
UL International GmbH	UL

Partners	Country
DNV-GL	DE
FORCE	DK
Kitemill	NO
KVT	NO
KNMI	NL
Leosphere	FR
METEK	DE
NMI	NO
NOAA	US
NP	UK
NREL	US
NTNU	NO
RES	UK
SGRE	DE
Sowento	DE
TNO	NL
Wood	UK

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So much more to tell, already 3 mins over…

Lillgrund wake measurements

What WindScanners are actually good for.

The new Section Leader finally doing something useful.

Thanks to Rozenn, Jakob, Charlotte, Mikael, Anna-Maria and the other Mike for your help and comments