Task 52 General Meeting 2023

Complex Terrain WG presentation

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Online

2023-06-14

About

- The complex terrain working group functions as part of the IEA wind LiDAR Task 52 and focuses on the application of wind LiDAR in complex terrain and/or complex flow.
- The working group is both concerned with:
  - Ground based (vertical profiling) LiDAR
  - Nacelle based LiDAR

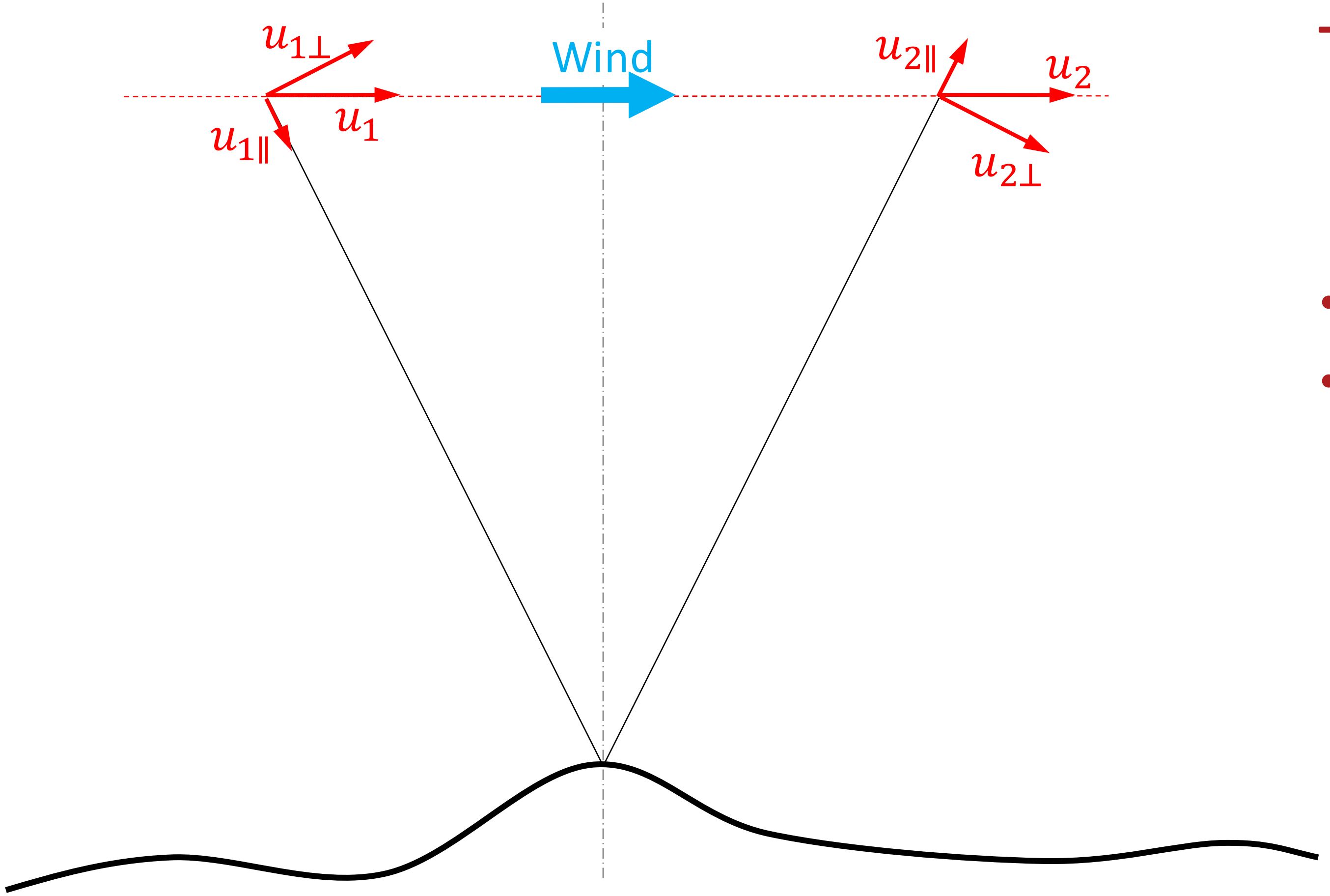
  as distinct, yet connected topics.
- Working group meetings in 6 weeks intervals and shifting focus
- About 15-20 people involved

Motivation

- Complex terrain and complex flow remain major obstacles for the widespread application of wind LiDAR
- Task 52 Theme „replacing met masts“
- Assessing LiDAR measurement uncertainty
- Correction of LiDAR data for complex terrain errors
- Characterization of terrain complexity as a reference for LiDAR errors and uncertainty

Ground based LiDAR

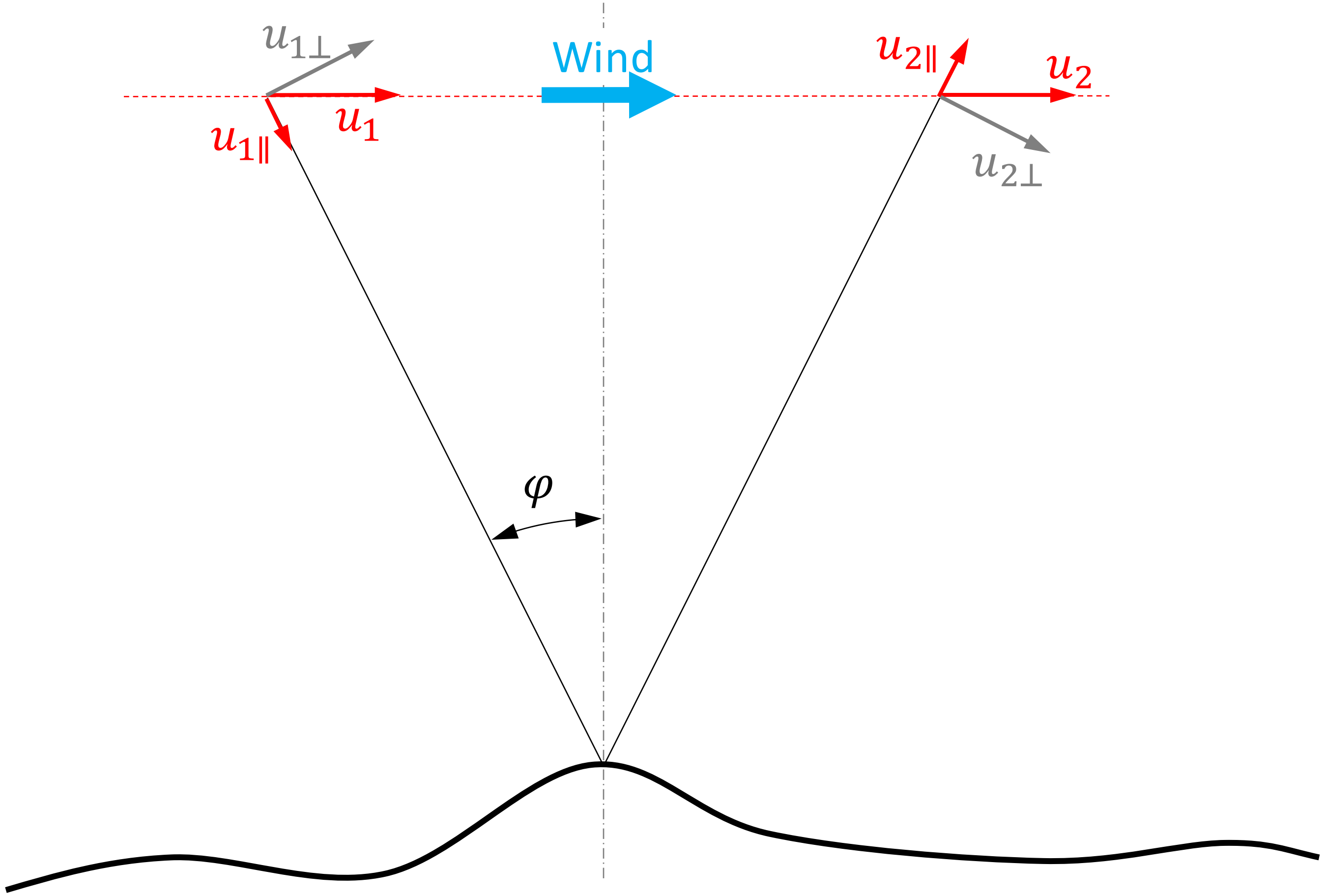
- Follow up to previous Task 32 effort
- Aim:
  - Finding complexity thresholds for ground based LiDAR measurements
  - Finding complexity thresholds for correction methods for LiDAR in complex terrain
- Method:
  - Has to be based on actual data (parallel and co-located LiDAR & met-mast data)
  - No sharing of data but sharing for evaluation tools & collection of results.
- Deliverable:
  - Task 52 recommendation for application of ground based LiDAR in complex terrain.



The problem:

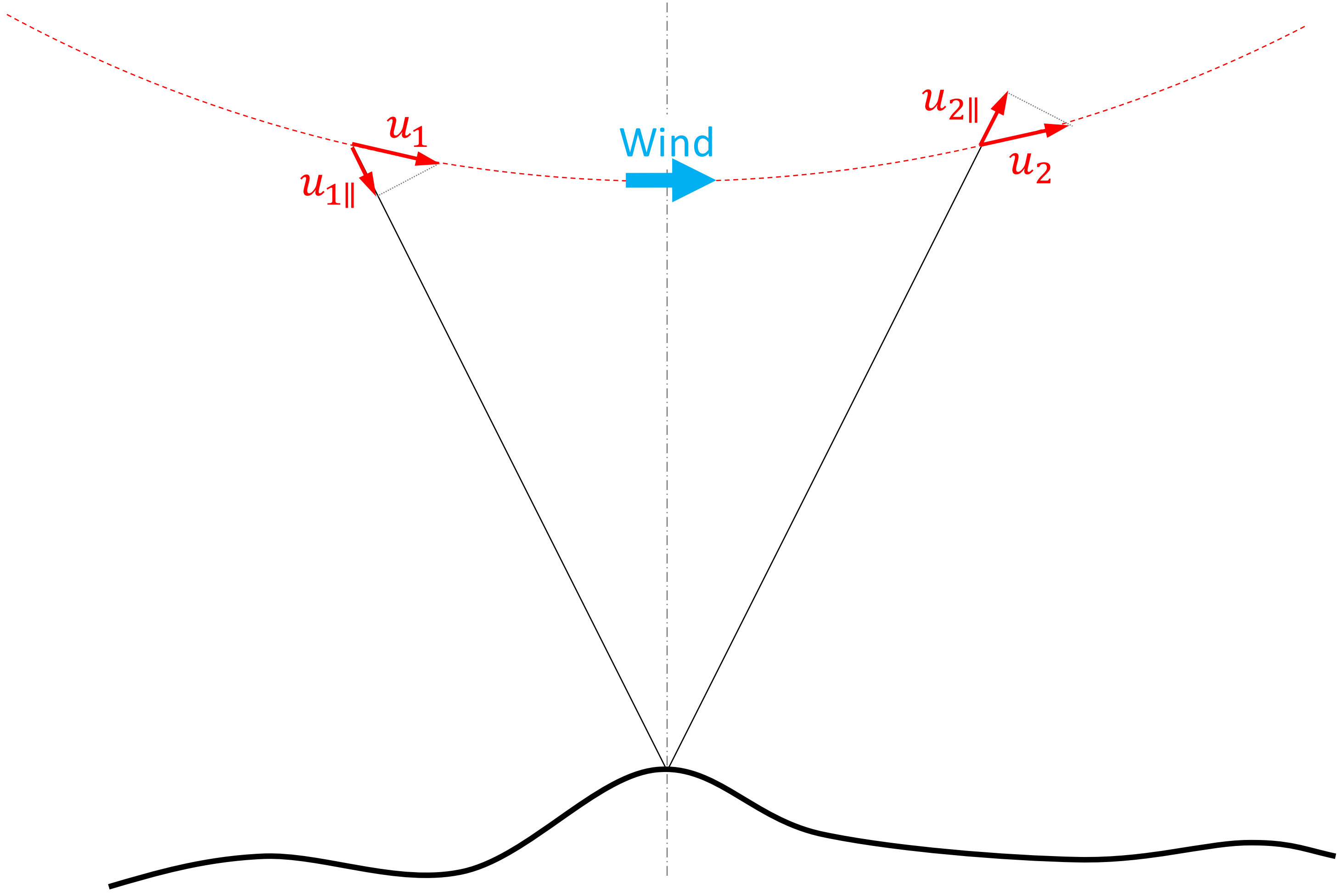
Wind speed has two components:

- Parallel to beam-axis (∥)
- Normal to beam-axis (⊥)



Measurement of the beam-axis component only:

$$u_{\text{measured}} = \frac{u_{1\parallel} - u_{2\parallel}}{2 \cdot \sin \varphi}$$



Different wind speeds with different flow geometries give same measurement result.

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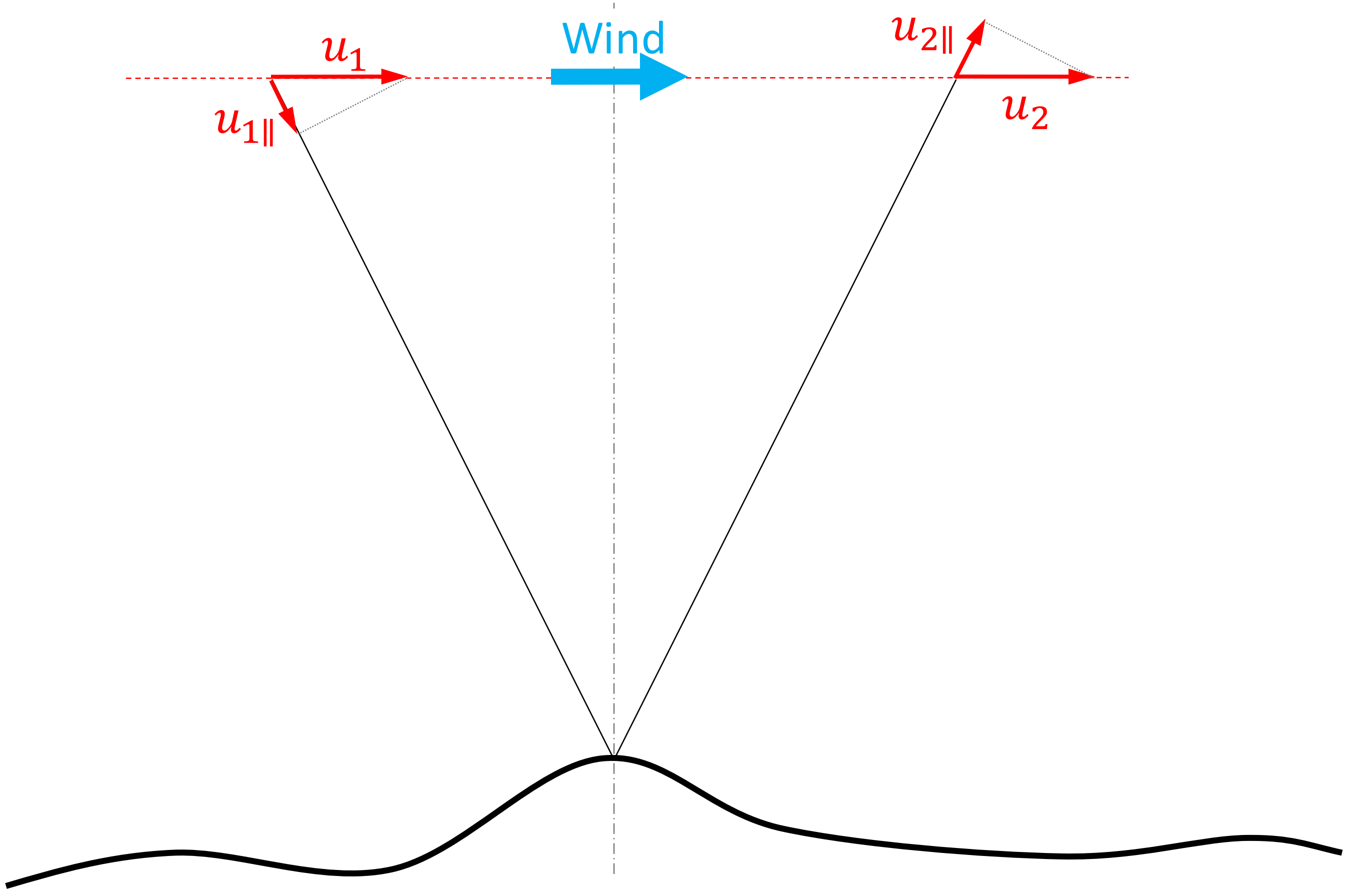

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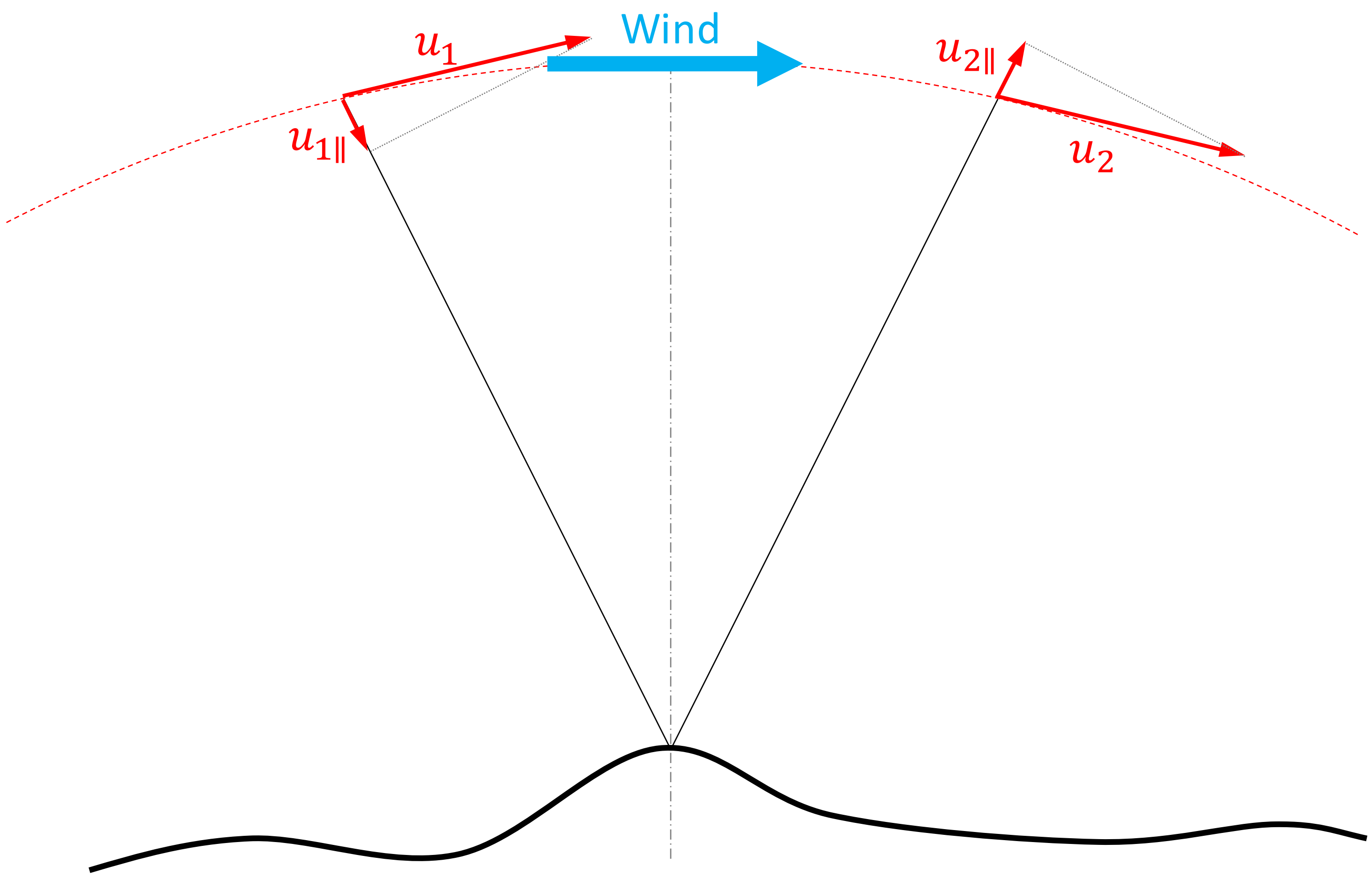

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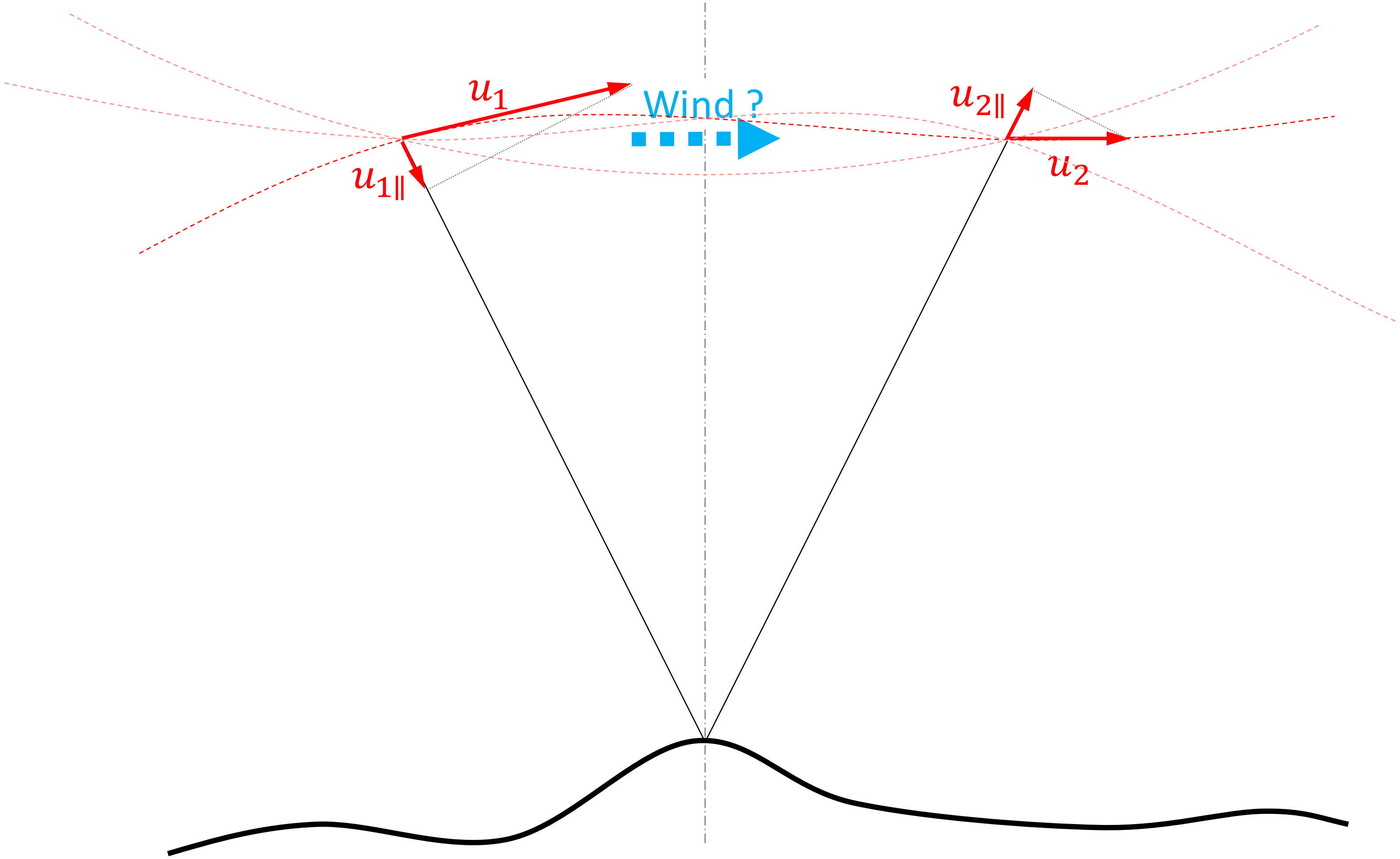


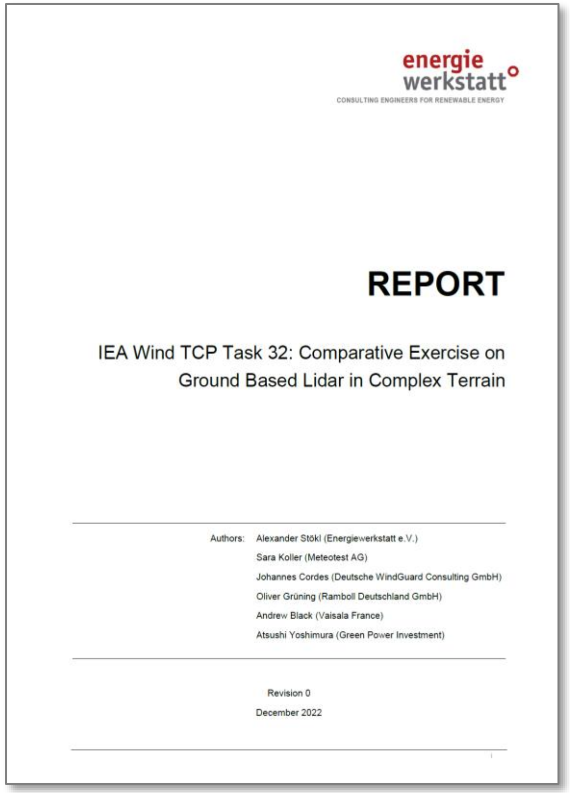
In General:

- Measurement at different locations
- Measurement at different times (scanning pattern, one beam direction after the other)

=> Measurement uncertainty with unknown magnitude

Previous results

- **Report:** IEA Wind TCP Task 32: Comparative Exercise on Ground Based Lidar in Complex Terrain, pub. in December 2022.
- **Setup:** 5 Austrian sites in complex terrain, parallel & co-located LiDAR and met-mast data, 11 different correction methods
- **Results:** All sites, selected for their great complexity, proved to be too complex to allow a reliable correction.
  There are candidates for the characterization of complexity.
- **Conclusions:** For the identification of thresholds, a larger number of datasets, covering a wider range of site complexity and site conditions, is needed.


energie werkstatt
CONSULTING ENGINEERS FOR RENEWABLE ENERGY

REPORT

IEA Wind TCP Task 32: Comparative Exercise on Ground Based Lidar in Complex Terrain

Authors: Alexander Stökl (Energiewerkstatt e.V.)
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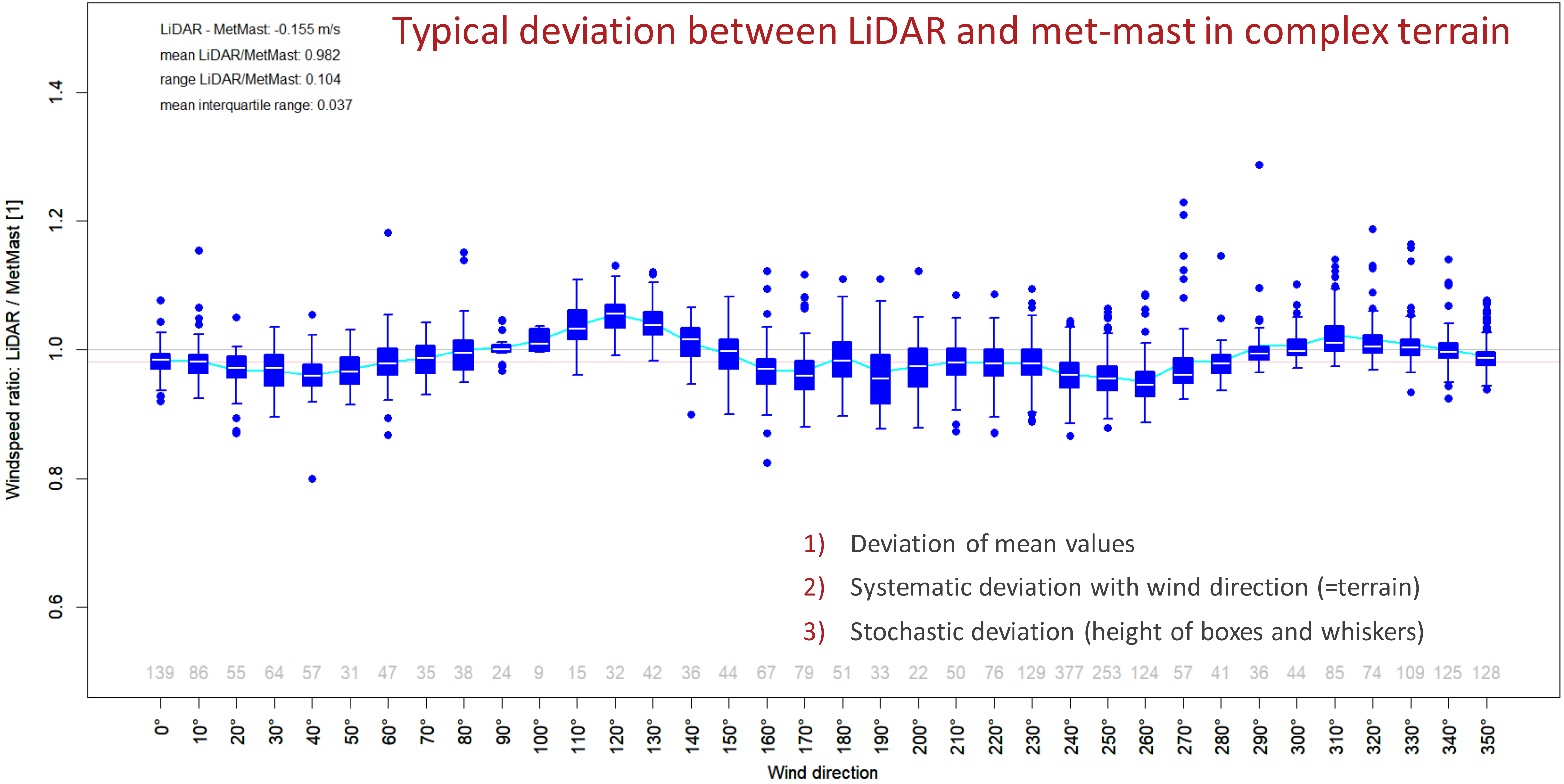
Revision 0
December 2022

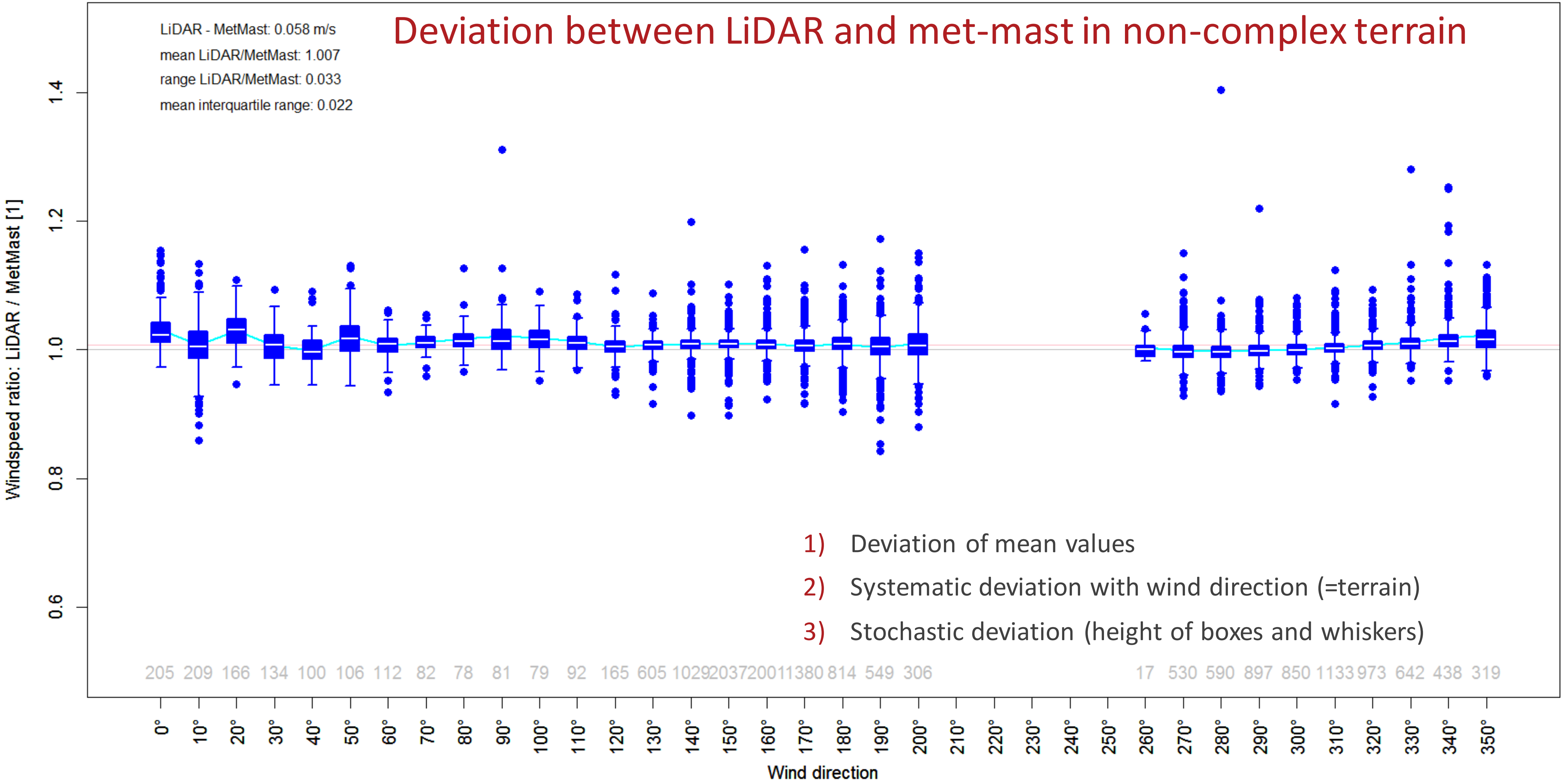
Available at:
https://zenodo.org/record/7598338

Typical deviation between LiDAR and met-mast in complex terrain



1) Deviation of mean values
2) Systematic deviation with wind direction (=terrain)
3) Stochastic deviation (height of boxes and whiskers)

Deviation between LiDAR and met-mast in non-complex terrain



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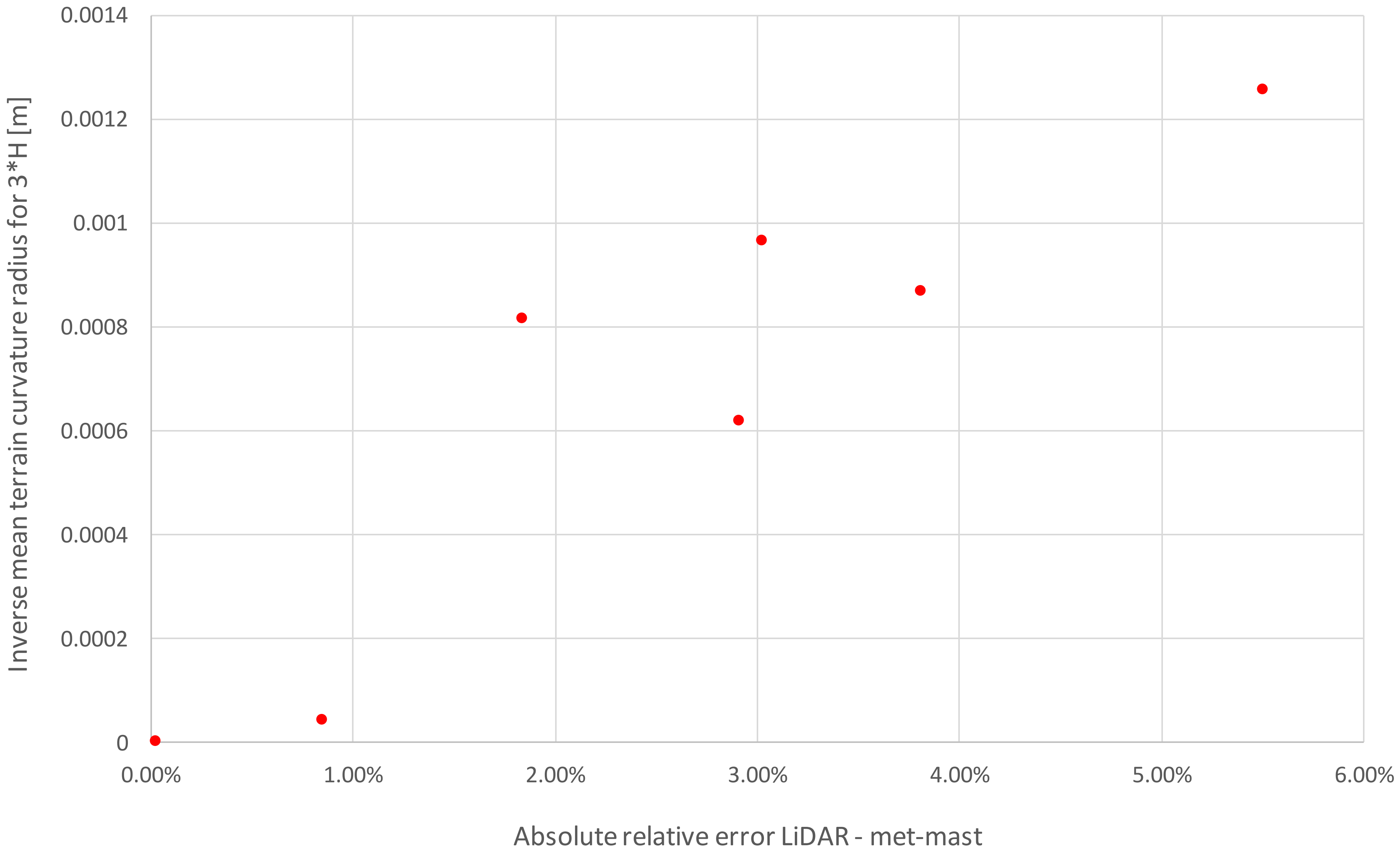
0.0014
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
0.00%
1.00%
2.00%
3.00%
4.00%
5.00%
6.00%
Inverse mean terrain curvature radius for 3*H [m]
Absolute relative error LiDAR - met-mast

Ground based LiDAR

- Aim:
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- Method:
  - Has to be based on actual data (parallel and co-located LiDAR & met-mast data)
  - No sharing of data but sharing for evaluation tools & collection of results.
- Deliverable:
  - Task 52 recommendation for application of ground based LiDAR in complex terrain.
- Time line:
  - Next 12 months: collection of datasets & analysis, write-up in 2nd half of 2024

Nacelle based LiDAR

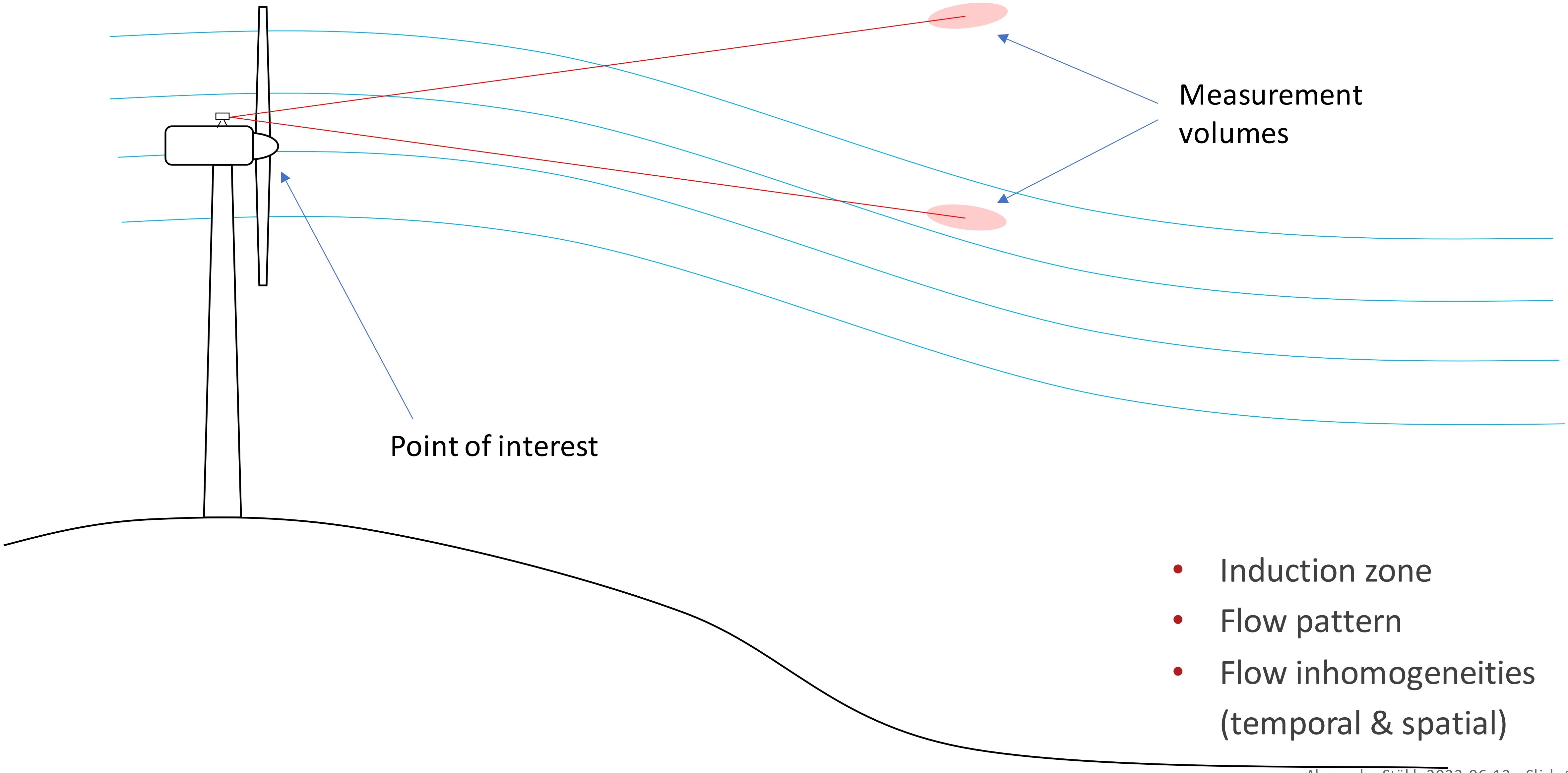
Use cases:

- Power curve verification
- Yaw misalignment
- Turbine control
- Analyzing inflow conditions and terrain effects on site (problem solving)
- Determination of extreme and fatigue loads (WT design & site suitability)

Interpreting of nacelle LiDAR data at turbine position either requires:

- Pre-construction site calibration with 2 met-masts
- Site calibration with stopped WT (limited usefulness)
- Numerical site calibration with flow modelling

Flow modelling would be the preferred method, but involves unknown uncertainties and lacks acceptability.



- Induction zone
- Flow pattern
- Flow inhomogeneities (temporal & spatial)

Nacelle based LiDAR

- Activity currently in a formative phase, not sensible to give a timeline
- Working title: "**Validation of numerical site calibration methods based on flow modeling for nacelle based LiDARs**"
- Method:
  - Contribution of suitable datasets (reference measurements for a site, e.g. from a met mast, and nacelle LiDAR data), covering a range of terrain conditions and complexity.
  - Numerical flow models for the sites with different methodology and parametrization.
  - Analysis of the fidelity of the flow models and their usefulness for interpreting nacelle based LiDAR data.
  - Estimation of the overall uncertainties depending on terrain complexity.

Call for Datasets & Contributors

- Both for ground based and nacelle based LiDARs
- Robust conclusions and guidance depend on a large and diverse number of datasets, covering a range in site complexity, geographical regions & wind conditions.
- Contribution does not necessarily require a clearance for sharing data! (distribution of results rather than distribution of data)
- Happy to welcome new members to the working group!