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Highlight results

- New evaluation procedure for remote sensing instruments based on field testing in flat and complex terrain

- Instrument performance classified with stability conditions via the Richardson and Froude numbers

Background :

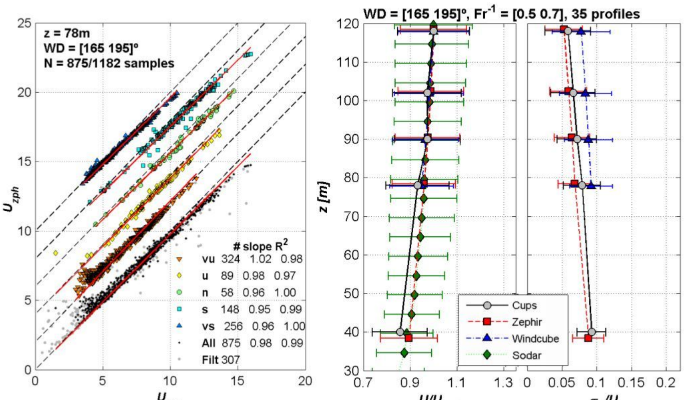
The integration of ground based remote sensing (RS) wind profilers in resource assessment campaigns is booming due to the notable advantages of these devices: long scanning range, high portability, high setup flexibility, non intrusive and competitive costs compare to large met masts. Still, the technology requires extensive evaluation and demonstration before reaching the maturity of cup anemometers, the mutually accepted reference in the wind energy industry.

The calibration of the instrument with a high-quality reference anemometer is also of utmost importance in order to ensure the traceability of the measurements. While cup anemometer calibration procedures are clearly defined, making use of wind tunnels, this is not the case for RS instruments, that require field testing.

As profilers, ground-based remote sensors shall be compared with mast profilers based on cup anemometers. In this context, the evaluation should be extended from point measurements to profile measurements including variables of interest like wind speed and direction shear.

Multi-site Testing

Similar to the calibration of cup anemometers at tilted incidence wind to measure the performance in non-horizontal winds, field testing of remote sensors can be performed in complex terrain in order to determine the sensitivity of the system to non-homogeneous flows. To this end, multi-site field calibration is proposed, wherein the same instrument is tested first in flat terrain and then in complex terrain conditions.



Example ... ensemble-averaged ... (left) and atmospheric stability ...

Case Study

Two lidar systems, a continuous-wave Quinetiq Zephir and a pulsed-wave Leosphere Windcube v1, and a Scintec SFAS sodar, all monostatic, have been tested at the Danish Høvsøre site in flat terrain and then at CENER's Alaiz site in complex terrain.

Evaluation Procedure

The evaluation procedure derived from this multi-site experiment is composed of three steps:

1. Single-point regression analysis
2. Ensemble-averaged profile analysis and
3. Performance matrix.

Before implementing the evaluation, the wind conditions of both sites are characterized based on the reference mast measurements. Flow conditions are classified according to the thermal stratification of the atmosphere using Richardson and Froude dimensionless numbers.

Conclusions

The results [1] show that adding complex terrain testing in instrument evaluation studies is a good complement to flat terrain experiments since it determines the sensitivity to flow inhomogeneity, an important issue for the deployment of RS in complex terrain.

While RS technology evolves from year to year, it is difficult to define standards for testing and calibration beyond the flat terrain domain. Recognizing the position of the cup anemometer as the reference instrument for bankable wind resource assessment campaigns, especially in complex terrain, it is more useful to focus on best practice guidelines for the design of measurement campaigns that make best use of the complementarities of fixed reference masts and portable RS instruments. The design shall be driven by the optimization of the deployment and operational costs of the campaign against the uncertainty reduction in the resource assessment. To this end, it is important to be able to characterize the uncertainties of RS instruments in terms of the wind conditions.

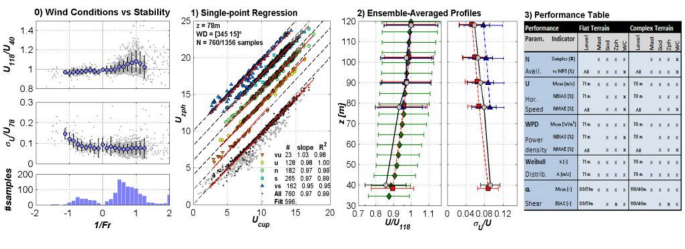


Figure 2 Multi-Site RS Evaluation Process: 0) Wind conditions , 1) Single-point regression, 3) Ensemble-averaged profiles 3) Performance Table

Bibliography

[1] Sanz Rodrigo J, Borbón Guillén F, Gómez Arranz P, Courtney MS, Wagner R, Dupont E. Multi-Site Testing and Evaluation of Remote Sensing Instruments for Wind Energy Applications. Renewable Energy 2012; submitted