Added value of LiDAR correction methods from a user’s perspective

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Abstract

The application of LiDAR measurements in complex terrain is influenced by volume effects caused by non homogeneous wind flow. This effect on derived wind speeds can be assessed and corrected by different methods:

- **Online methods** like the FCR (Flow Complexity Recognition) implemented in the WindCube v2 software can directly calculate corrected speed values. This method works completely automatic.

- **Offline methods** get correction factors from flow field variables of a CFD model like WindSim and apply them to the data later on. This method is dependent on the quality and parameter settings of the CFD.

Objectives

The German “Technical Guideline TR6” requires the application of correction methods in complex terrain and the introduction of an additional uncertainty of half of the correction value in an energy yield expertise.

The aim of this study is to test the performance of the standard tools to estimate the magnitude of possible differences, corrections and uncertainties and to understand the mechanisms behind these effects.

Methods and Results

From a wide range of sites we present examples of four sites with different complexity and direction offset in LiDAR mounting.

Mast-LIDAR Differences

- **Site 1**: Small mean differences, overestimation from E
- **Site 2**: Small mean differences, underestimations SE, overestimation NW
- **Site 3**: General overestimation strongest SE and NW
- **Site 4**: Big underestimation from LiDAR, main sectors W and E

Comparisons indicate the wide range of possible results, including total over- or underestimation from LiDAR as well as strong sectorwise differences. Influence of both correction methods also differ considerably from site to site.

Conclusions

- Although doing a good job at some sites, corrections do not improve Mast-LIDAR difference in every case and results differ for the same site and different methods
- For both methods it is not recommended to use them without carefully cross checking the results with mast measurement on their reliability.
- Further studies can help to understand these effects better and improve the correct application.

- Correction of lidar remote sensing measurements by CFD simulations.
  Dr. C. Meissner, WindSim AS, M. Boquet, LEOSPHERE SAS, EWEA 2011 poster presentation.
  - Cartography of WINDCUBE v2 performances with FCR – A case study in Europe
  - R. Krishnamurthy, M. Boquet, LEOSPHERE SAS, France, EWEA 2015 Poster Presentation

LiDAR vertical speed (solid), standard deviation (dashed) and Mast-Lidar Differences (pink)

Vertical Speed Component w

The horizontal gradient of vertical wind represents the flow inhomogeneity over the LiDAR cone but is not easy to retrieve from single point measurements. Standard deviation of vertical speed can give an impression of the actual state and flow modification through orography.

For Site 2 (slope) and Site 4 (ridge top) the connection between orography, LiDAR derivations and stddev w can be understood from the pictures.

The general overestimation of the LiDAR at Site 1 and the failure of both methods here can’t be explained from this data.

Sensitivity study of necessary correction parameters (exemplary sectors) and influence of model parameters

Model Resolution and Parameters

Good horizontal resolution (normal vs. fine) has more impact on output quality than the increase of modelling sectors. Forest parametrization and stability parameters that reduce vertical motion and were often helpful in improving the models in terms of profile fitting on the other hand seem to decline the quality of CFD corrections.

Comparison of Mast-LIDAR difference and standard deviation of w

Diurnal Cycle of Mast-LIDAR difference and standard deviation of w

LiDAR differences are not automatically minimized by the correction methods. Also sites with small absolute differences (Site 2) can have large sectorwise maxima which are only averaged out. This effect can be misleading. The mean magnitude of corrections of ~1% would lead to uncertainties of ~0.5% according to TR6, but in case of poorer correction (Site 4 CFD) uncertainty also gets smaller, although correction results don’t get better, which is also misleading. These effects have to be checked carefully when applying a correction.