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Comparison between three-dimensional wind measurements by wind-lidars and a sonic anemometer

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The flow measured by in-situ wind instruments is always, to some extent, distorted by the instruments themselves. To correct for flow-distortion effects, the instruments are often calibrated in a wind tunnel, where the flow conditions are different from the conditions in the atmosphere. An alternative approach to wind tunnel calibration was explored at a field experiment during November 2013, where three continuous-wave, infrared, coherent Doppler lidars were accurately positioned and aligned to measure the same wind field as a CSAT3 sonic anemometer (Campbell Scientific) mounted on a tower.

For most commercially available wind-lidars, the length of the lidar's probe volume considerably exceeds the path length of a sonic anemometer. However, for this experimental investigation, the three short-range WindScanner lidars (www.windscanner.eu) which allow for measurements with small sampling volume were utilized.

The measurement height was 6m, and the focus distance of the three lidars was 8m giving a full-width half-maximum of the lidar probe volume of 9cm of each of the three lidars, which is comparable to the path length of the sonic anemometer (11.5cm). By use of an infrared camera, it was carefully checked that the lidar beams were focused inside the measurement volume of the sonic anemometer at the start of the experiment. The lidars were equipped with acousto-optical modulators, which allow the determination of the sign of the wind speed. Data from both systems were sampled at 60Hz.

We present the comparison between the data from the three beam-crossing lidars and the sonic anemometer for (1) the situation when the measurement was made inside the sonic anemometer measurement volume and (2) the sonic anemometer was moved 80cm away from the focus point of the three lidars. The comparison includes cross-correlation, time-series and spectra. For the spectra, we focus on the ability of the instruments to measure in the inertial subrange for all velocity components. In this spectral range, the ratio between the vertical and the streamwise velocity component should be 4/3. For sonic anemometers, this ratio is often not realized and one possible cause is flow distortion due to dampening of the vertical velocity component. Although noise impair the capability of accurate lidar measurements below 0.5m/s, optimization of the setup geometry or alternative detection schemes can improve the accuracy as discussed in this contribution.