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Comparison of three-dimensional wind measurements by wind-lidars and a sonic anemomete

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Sonic anemometer turbulence and flux measurements are often used for validation of atmospheric models. However, the flow measured by sonic anemometers is always, to some extent, distorted by the instruments themselves, which leads to a systematic error. To correct for the flow-distortion effects, the instruments are often calibrated in a wind tunnel, which has the drawback that the flow conditions are different from the conditions in the atmosphere. Here an alternative calibration approach, which was successfully explored at a field experiment in November 2013, is presented.
The three continuous-wave short-range WindScanner lidars (www.windscanner.eu) were accurately positioned and aligned to measure the same wind field as a CSAT3 sonic anemometer (Campbell Scientific) mounted on a meteorological mast. These unique wind-lidars allow for measurements with small sampling volumes. The measurement height was 6 m and the focus distance of the three lidars was 8 m giving a full-width at half-maximum of the lidar probe volume of 9 cm for each of the three wind-lidars, which is comparable to the path length of the sonic anemometer. 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.
We present the comparison between the high-frequency data (60 Hz) from the three wind- lidars and the sonic anemometer for the cases when (1) the lidars were focussed inside the sonic anemometer measurement volume and (2) the sonic anemometer was moved 80 cm away from the focus point of the wind-lidars. For (1) the comparison of time-series showed excellent agreement for the horizontal wind components, while the vertical wind measured by the wind-lidars was a few per cent larger, whereas for (2) the vertical velocity was significantly larger. The difference between the two measurement techniques are described and analysed as a function of atmospheric stratification and the effects of flow distortion are discussed. The presented results are especially relevant for the measurement and interpretation of surface fluxes.