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Flow tilt angle measurements using lidar anemometry,

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A new way of estimating near-surface mean flow tilt angles from ground based Doppler lidar measurements is presented. The results are compared with traditional mast based in-situ sonic anemometry. The tilt angle assessed with the lidar is based on 10 or 30 minute mean values of the velocity field from a conically scanning lidar. In this mode of measurement, the lidar beam is rotated in a circle by a prism with a fixed angle to the vertical at varying focus distances. By fitting a trigonometric function to the scans, the mean vertical velocity can be estimated.

Lidar measurements from (1) a fetch-limited beech forest site taken at 48-175m above ground level, (2) a reference site in flat agricultural terrain and (3) a second reference site in very complex terrain are presented.

The method to derive flow tilt angles and mean vertical velocities from lidar has several advantages compared to sonic anemometry; there is no flow distortion caused by the instrument itself, there are no temperature effects and the instrument misalignment can be corrected for by comparing tilt estimates at various heights. Contrary to mast-based instruments, the lidar measures the wind field with the exact same alignment error at a multitude of heights.

Disadvantages with estimating vertical velocities from a lidar compared to mast-based measurements are slightly increased levels of statistical errors due to limited sampling time, because the sampling is disjunct and a requirement for homogeneous flow. The estimated mean vertical velocity is biased if the flow over the scanned circle is not homogeneous. However, the error on the mean vertical velocity due to flow inhomogeneity can be approximated by a function of the angle of the lidar beam to the vertical, the measurement height and the vertical gradient of the mean vertical velocity, whereas the error due to flow inhomogeneity on the horizontal mean wind speed is independent of the lidar beam angle. For the presented measurements over forest, it is evaluated that the systematic error due to the inhomogeneity of the flow is less than 0.2 degrees.

Other possibilities for utilizing lidars for flow tilt angle and mean vertical velocities are discussed.