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Influence of the number of lidar sounding heights on Adaptive Unscented Kalman Filtering for Floating Doppler wind-lidar motion correction

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A study on the floating Doppler wind lidar (FDWL) motion-correction performance by means of the Unscented Kalman Filter (UKF) method as a function of the lidar measurement heights is presented. The study is carried out by simulating one, three, and five lidar measurement heights by means of time-series down-sampling techniques. The performance is tested over experimental data measured by a fixed and a FDWL sited 50 m appart in the context of Pont del Petroli measurement campaign.

The motion-correction UKF [1] relies on FDWL dynamics as formulated by Kelberlau et al. [2] as well as on the lidar internal wind-vector estimation algorithm to recursively estimate the clean (i.e., motion-free) wind vector. To carry out the correction, the filter uses the FDWL-measured wind vector and 6 Degrees of Freedom buoy motion measurements by the Inertial Measurement Units installed on the FDWL buoy.

Continuous-wave focusing DWLs measure the wind at multiple heights sequentially and, therefore, they sound a particular height every n scans (≈1 scan/s), with n the number of measurement heights. When a lidar is configured to measure at multiple heights, this is equivalent to down-sampling the wind-vector time-series by a factor n.

To study the UKF motion-correction performance, the turbulence intensity (TI) measured by the FDWL, with and without correction, were compared (at 10-minute resolution) against the TI measured by the reference fixed DWL considering three measurement-height configurations (emulated as downsampled time-series): single-height sounding, and 3, and 5 sounding heights.

The experimental results showed that the filter successfully takes the sea motion out of the wind speed measurements, hence it virtually removes the apparent turbulence induced by wave motion for all three measurement-height configurations. However, the poorer one-to-one-point correspondence found when increasing measurement height numbers (equivalently, lower sampling rates in the simulation) stated that less wind information was retained in the 10-min time-series. Thus, the coefficient of determination reduced from R^2=0.94 (1 height) to 0.81 (5

heights), and the RMSE increased from 0.74 % (1 height) to 1.34 % (5 heights).

Future work plans to validate the quantitative statistical indicators retrieved by the UKF simulator with reference to experimental wind-speed data measured under real conditions.

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