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Bluff body aerodynamics of the Thies Laser Precipitation Monitor investigated using CFD and wind tunnel measurements

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Optical disdrometers are among the non-catching type instruments used to measure liquid and solid precipitation. The increasing use of such instruments in operational observations is due to their capability to provide additional information than the precipitation rate alone, like e.g. the particle size distribution and the fall velocity of hydrometeors. Furthermore, they are well suited to operate in unattended, automatic weather stations. Having no collector to catch the approaching hydrometeors, their outer shape strongly depends on the measuring principle exploited. The impact of wind on the measurement is therefore different from the typical undercatch that is expected from more traditional catching type precipitation gauges. In general, they are not axisymmetric and base the identification and classification of hydrometeors on the coupling of particle size and fall velocity characteristics, which can be affected by the wind and by the airflow deformation and turbulence produced by their bluff-body aerodynamic response. The focus of this work is the Thies Laser Precipitation Monitor (LPM), which uses an optical sensor to detect the obstruction of an infrared laser beam caused by the crossing hydrometeors. The reduction in the sensor output voltage is proportional to the drop dimension, while the duration of the reduction is proportional to the drop falling speed. This instrument presents a very complex and not axisymmetric outer shape that makes it difficult to qualitatively predict the flow pattern and requires to consider multiple wind directions and wind speeds. The airflow field was obtained with a Computational Fluid Dynamics (CFD) approach, by numerically solving the Reynolds Averaged Navier-Stokes equations with the k-ω SST turbulence closure model. Results are validated through local flow velocity measurements obtained in the DICCA wind tunnel. The Thies LPM® was placed in the measuring chamber of the wind tunnel (1.7 x 1.35 x 8.8 m) on to a rotating plate and the airflow velocity was sampled at multiple positions around the instrument. The measurements were obtained using a traversing system equipped with a "Cobra" multi hole pressure probe, that provides the three velocity components of the local flow. Different orientation angles of the gauge with respect to the incoming flow direction were tested. Based on the simulations and wind tunnel tests performed, the less impacting configuration of the instrument relative to the main wind direction is obtained. The information can be useful to design effective solutions to minimise the impact of wind and turbulence on the measurements (e.g. windshields) and to derive suitable correction curves to improve the measurement accuracy. This work is funded as part of the activities of the EURAMET – Normative project "INCIPIT – Calibration and Accuracy of Non-Catching Instruments to measure liquid/solid atmospheric precipitation".