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Evaluating the catching performance of aerodynamic rain gauges by means of field comparisons and CFD modelling

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Accurate precipitation measurement is a fundamental requirement in a broad range of applications including flood risk management and hydrological studies. At present, the most widely used method of measuring precipitation is the 'rain gauge', which is often also considered to be the most accurate. In the context of hydrological modelling, measurements from rain gauges are interpolated to produce an areal representation, which forms an important input to drive hydrological models. The results of these models may be applied in a variety of contexts, such as evaluating the hydrological impacts of climate change. In each stage of such a process another layer of uncertainty is introduced. The initial measurement errors are propagated through this chain, compounding the overall uncertainty. This study looks at the fundamental source of error, the precipitation measurement itself, and specifically addresses the systematic 'wind-induced' error.

The shape of a precipitation gauge significantly affects its collection efficiency (CE), with respect to a reference measurement. This is due to the airflow around the gauge, which causes a deflection in the trajectories of the raindrops or snowflakes near the gauge orifice.

Computational Fluid-Dynamic (CFD) simulations are used to evaluate the time averaged airflows realized around the EML ARG100, EML SBS500 and EML Kalyx-RG rain gauges, when impacted by wind. Terms of comparison are provided by the results obtained for standard precipitation gauge shapes manufactured by Casella and OTT which, respectively, have a uniform and a tapered cylindrical shape. The simulations were executed for five different wind speeds; 2, 5, 7, 10 and 18 ms-1.

This study demonstrates how aerodynamic gauges manufactured by EML have a different impact on the time averaged airflow patterns observed in the vicinity of the collector, compared to the standard gauge shapes. Both the air velocity and the turbulent kinetic energy fields present structures that may improve the interception of particles by the aerodynamic gauge collector. The positive indications provided by this study could be confirmed by tracking the hydrometeor trajectories with a Lagrangian method basing on the available set of airflows and investigating time-dependent aerodynamic features by means of dedicated CFD simulations. Furthermore, wind-tunnel tests could be carried out as a means of providing physical validation to the CFD model.

To provide empirical validation of these results, a field-based experimental campaign was undertaken at four UK research stations to compare the results of aerodynamic and conventional gauges, mounted in juxtaposition. The reference measurement is recorded using a rain gauge pit, as specified by the WMO. The focus of this study is therefore rainfall; snowfall is disregarded in the present analysis. The results appear to demonstrate how the effect of the wind on rainfall measurements is influenced by the gauge shape and the mounting height. Significant undercatch is observed compared to the reference measurement. Aerodynamic gauges mounted on the ground catch more rainfall than juxtaposed straight sided gauges, in most instances. This appears to provide some preliminary validation of the CFD model.