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The extent of wind-induced undercatch in the UK winter storms of 2015

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The most widely used device for measuring rainfall is the rain gauge, of which the tipping bucket (TBR) is the most prevalent type. Rain gauges are considered by many to be the most accurate method currently available. The data they produce are used in flood-forecasting and flood risk management, water resource management, hydrological modelling and evaluating impacts on climate change; to name but a few. Rain gauges may provide the most accurate measurement of rainfall at a point in space and time, but they are subject to errors – and some gauges are more prone than others. The most significant error is the 'wind-induced undercatch'. This is caused by the gauge itself contributing to an acceleration of the wind speed near the orifice, which disturbs and distorts the airflow. The trajectories of precipitation particles are affected, resulting in an undercatch. Results from Computational Fluid Dynamics (CFD) simulations, presented herein, describe in detail the physical processes contributing to this.

High resolution field measurements of rainfall and wind are collected at four field research stations in the UK. Each site is equipped with juxtaposed rain gauges with different funnel profiles, in addition to a WMO reference pit rain gauge measurement. These data describe the rainfall measurement uncertainty. The sites were selected to represent the prevalent rainfall regimes observed in the UK. Two research stations are on the west coast; which is prone to frontal weather systems and storms swept in from the Atlantic, often enhanced by orography. Two are located in the east. Rural lowland and upland areas are represented, both in the west and the east. Urban sites will also have significant undercatch problems but are outside the scope of this study.

Data from the four research stations are analysed for the 2015 winter storms which caused devastating flooding in the west of the UK, particularly Cumbria and the Scottish Borders, where two of the sites are located. An assessment of the effect of wind on the rainfall catch during these large storm events is presented for each research station. Based on a reference pit rain gauge, the undercatch for these events is calculated. The difference in rainfall catch between several types of rain gauge mounted at variable heights is also investigated. This work aims to demonstrate the importance of improving the accuracy of rainfall measurements, and to emphasise the need to provide an assessment of the measurement uncertainty.

A knowledge gap exists in the understanding of precisely how physical phenomena are contributing to wind-induced undercatch. For instance, a priori, the effect of the wind on the rainfall catch will change depending upon the dimensions of the rain droplets. Rainfall 'type' and rainfall intensity may be able to inform corrections, but rigorous multi-variate statistical analysis of high resolution measurements will be key to the success of these procedures. As the spatio-temporal distribution of rainfall can be highly variable, and each measurement location is different; it is a challenging undertaking to understand and pin down the fundamental processes responsible for the wind-induced undercatch.