A Rain Gauge in Wind: the Significance of Mounting Height and Gauge Shape

Michael Pollock, Enda O'Connell, Mark Dutton, Matteo Colli, Paul Quinn, Andrew Black, Mark Wilkinson and Chris Kilsby

The accurate measurement of rainfall is vital in, *inter alia*, meteorology, hydrology, climate studies and agriculture. Furthermore, the effective management of flooding and water resources requires quality rainfall measurements. Wind-induced 'undercatching' in rain gauge networks is a longstanding unresolved issue, contributing to the environmental error.

1. Defining 'wind-induced undercatching'

Rainfall measured by a rain gauge should be a true representation of what would have actually hit the ground if the gauge was not present. In windy conditions, the physical presence of a rain gauge distorts the trajectories of precipitation particles. This is caused by the displacement and acceleration of wind flow over the top of the gauge, produced as a result of the aerodynamic blockage by the gauge body.[a] The extent of reduction (undercatching) due to the wind effect is a function of the wind speed at gauge orifice, precipitation type and particle falling velocities (drop size and distribution), rainfall intensity and the aerodynamic properties of the gauge.

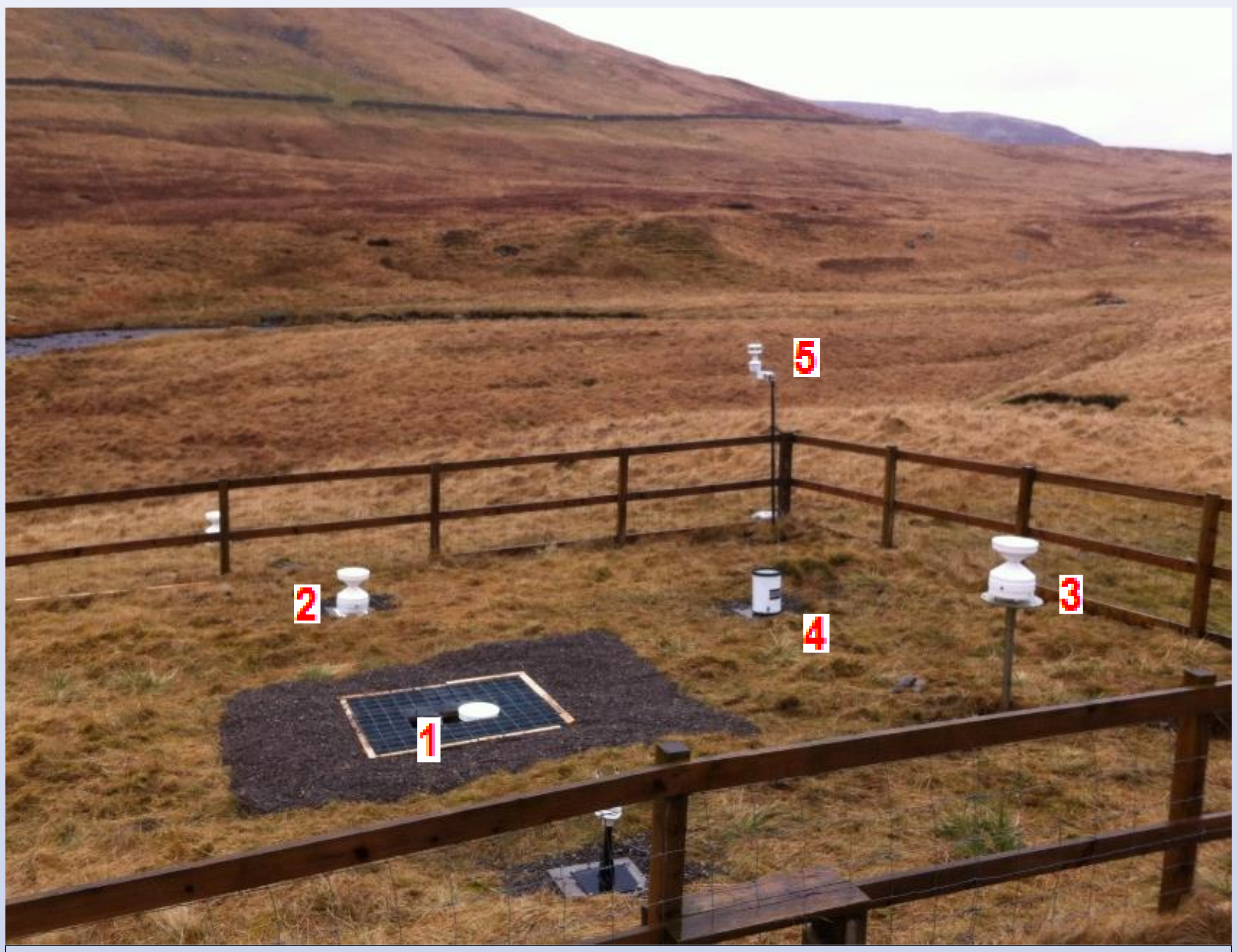

Figure 1. Talla Water research station, Scottish Borders. Elevation: 430m. Identical aerodynamic rain gauges (ARG100s) are mounted at different heights: reference pit gauge (1), ground-mounted gauge (2), 1-metre mounted gauge (3). There is also a ground mounted straight-sided gauge (4) and wind speed measurement at two metres (5) This upland site is situated at the top of a valley running east-west, with strong winds observed. (Picture by M.Pollock, April 2015. With thanks to University of Dundee/British Geological Survey/Borders Forest Trust for site provision).

2. Methodology

An exposed site at Talla Water in the Scottish Borders, Scotland, was selected for the study. To minimise instrument error, identical rain gauges and calibration procedures where used, where practicable. The research station was instrumented with a variety of meteorological equipment, shown in Figure 1. The caption describes five rain gauges and their positions within the research station enclosure. To capture the nature and evolution of rainfall events, high resolution (1 minute) data is recorded. Other meteorological variables such as temperature and wind are also measured.

3. Results

The plots presented in Figure 2 show rainfall totals from the four rain gauges during a spring and a summer period. If the pit gauge measurement (1) is assumed to be the "truth", the 1-metre mounted aerodynamic gauge (3) is comparable to the ground mounted straight-sided gauge (4). Both gauges (3) and (4) underestimate by between 17 – 20% across the time intervals selected. During the summer period, gauge (2) underestimates by 5%, whereas in the spring period the equivalent figure is around 12%.

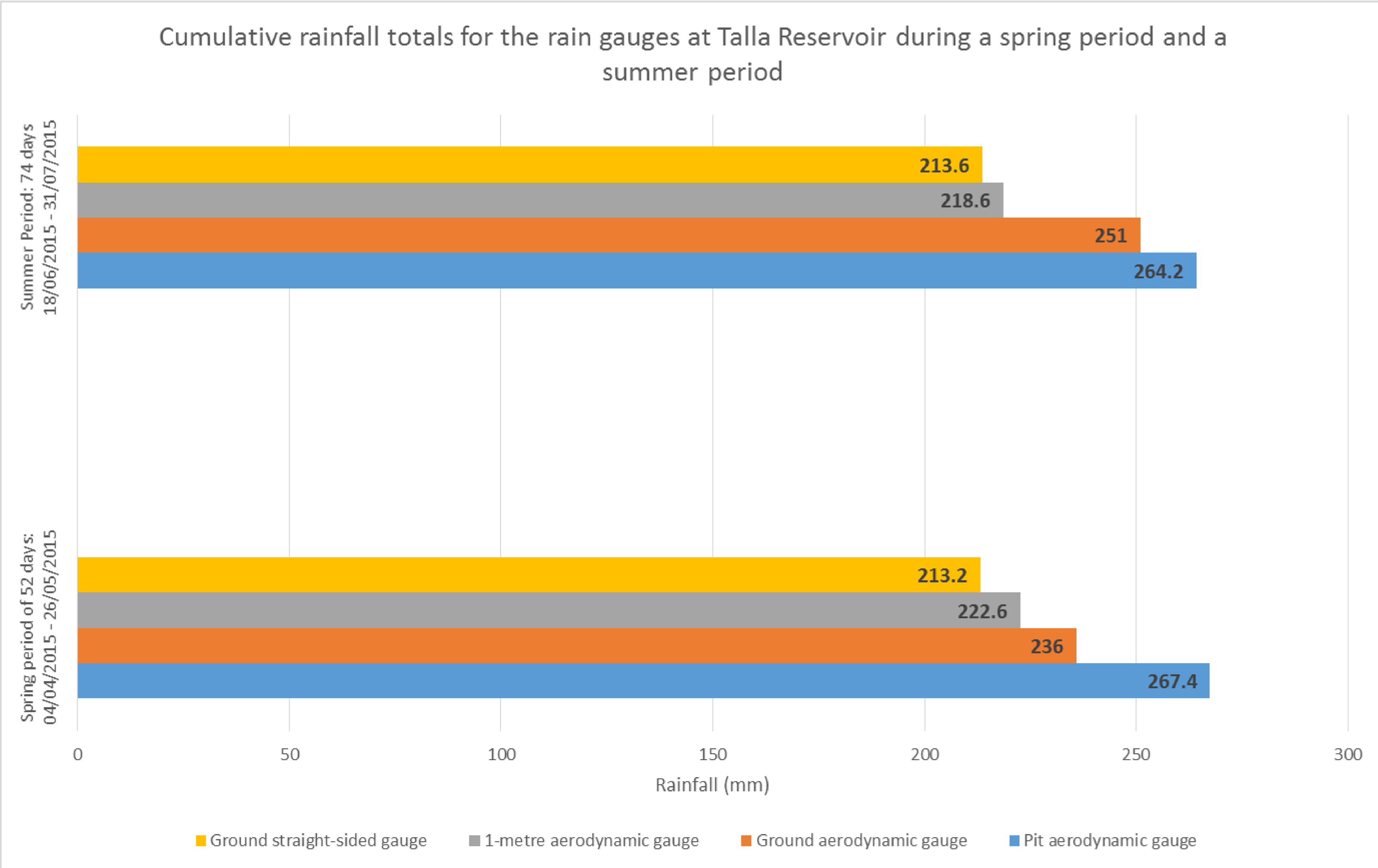

Figure 2. Cumulative rainfall totals for the four chosen rain gauges, covering a spring period lasting 52 days and a summer period lasting 74 days, at Talla Water.

4. Results and interpretation

Table 1 shows the gauge catch ratios for two events, (A) and (B). (A) is characterised as a low wind event and (B) is classified as a high wind event. Data plotted in Figure 3 show cumulative rainfall for (A) and (B). Cumulative rainfall totals are provided for gauges (1), (2), (3) and (4), as described in the caption to Figure 2. In both events the pit gauge records consistently the highest amount of rainfall. The results provide an indication that the shape of gauge and mounting height affect the catch ratio, especially in windy conditions.

Table 1: Comparison of catch ratios for two events, A and B, for gauges mounted at different heights.

% of Pit Catch	Ground (2)	Pedestal (3)	Ground (4)
Event A	91%	84%	82%
Event B	93%	83%	78%

Figure 3. Two events from Talla Water research station. (A) is a rainfall event where wind speeds ranging from 0-3 m/s. (B) is a rainfall events where wind speeds range from 1-11 m/s. The cumulative totals (mm) of rain gauges mounted at different heights are plotted.

References

a. Goodison, B. E., Louie, P. Y. T. and Yang, D. (1998) WMO Solid Precipitation Measurement Intercomparison: Final Report. World Meteorological Organisation

Civil Engineering and Geosciences • Cassie Building • Newcastle University • Newcastle upon Tyne • NE1 7RU • UK • www.ceg.ncl.ac.uk
further information: michael.pollock@newcastle.ac.uk