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Wind-induced bias of catching-type precipitation gauges and their overall collection efficiency

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In windy conditions, the measurement of liquid and solid atmospheric precipitation is still a challenge even using the most advanced automatic instrumentation (Cauteruccio et al., 2021). The measurement accuracy is affected by various environmental sources of bias, including siting issues and exposure. These add to the instrumental bias, which can be minimized in case of accurate instrument calibration. Wind is however recognised as the most impactful source of environmental bias, outperforming by 3 to 50 times the total impact of all other environmental factors.

Computational Fluid Dynamics simulation with embedded liquid (raindrops) and solid (snowflakes) particle tracking is here used to quantify the wind-induced bias of catching-type precipitation gauges. Starting from the numerically calculated catch ratios, six common commercial gauges having different outer geometry are compared in terms of their expected performance under various precipitation intensity and wind speed conditions. Preliminary wind tunnel experiments allowed full validation of the simulated aerodynamic behaviour and its effect on water drop trajectories.

The overall collection efficiency is shown to depend on the precipitation intensity and its functional dependence is quantitatively derived as a measure of the instrument performance under a wind climatology characterised by a uniform probability density function. A less pronounced diversion of hydrometeor trajectories is shown – at any given size – by instruments with aerodynamic design than in case of more traditional geometry.

Chimney-shaped instruments rank low in case of liquid precipitation measurements, while a high performance is shown by inverted conical and Nipher shielded instruments and the investigated quasi-cylindrical gauges have intermediate behaviour, which depends on their specific aerodynamic features. All instruments rank low at light to moderate precipitation intensity for the measurement of solid precipitation, except the Nipher shielded gauge.

This work provides the basic information needed to apply adjustments to the measured data and supports manufacturers in upgrading instruments with an existing design by introducing on-board adjustments of the measured precipitation. These would only require contemporary measurement of the wind velocity (often included in typical meteorological stations). The full work

and the numerically derived adjustments for the six investigated commercial gauges are published in Cauteruccio et al. (2024).

References

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