



Numerical evaluation of the wind-induced bias for the 2D Video Disdrometer

Enrico Chinchella^{1,2}, Arianna Cauteruccio^{1,2}, Pak-Wai Chan³, and Luca G. Lanza^{1,2}

¹University of Genova, Dep. of Civil, Chemical and Environmental Engineering (DICCA), Genoa, Italy

²WMO Measurement Lead Centre “B. Castelli” on Precipitation Intensity, Genoa, Italy

³Hong Kong Observatory, Hong Kong, Hong Kong SAR, China

Reconciling rainfall records from different sources, even from co-located instruments, is often difficult unless proper adjustment for instrumental and environmental sources of bias is applied. Comparisons between disdrometer and rain gauge measurements may show deviations that are usually attributed to their very different measurement principles. In this work, we show that rainfall intensity measurements from the 2D Video Disdrometer (2DVD) and a co-located tipping-bucket rain gauge can be largely reconciled once the relevant sources of bias are quantified and raw measurements are consequently adjusted.

The instrumental bias of the co-located tipping-bucket rain gauge is obtained from laboratory calibration performed at the Hong Kong Observatory (HKO). Meanwhile we rely on factory calibration for the instrumental bias of the 2DVD. Wind is assumed as the primary source of environmental bias for both instruments. Adjustment curves for the wind-induced bias of cylindrical rain gauges are here derived from existing literature (see Cauteruccio et al. 2024).

For the 2DVD, the wind-induced bias is obtained by means of numerical simulation. Using the OpenFOAM software, Computational Fluid Dynamics (CFD) and Lagrangian particle tracking simulations have been performed. CFD simulations provide the wind velocity field around the instrument body for different combinations of wind speed and direction. A $k-\omega$ SST turbulence model and a local time-stepping approach are used. Hydrometeor trajectories are modelled by numerically releasing drops ranging from 0.25 mm to 8 mm in diameter into the computational domain. The wind-induced bias is then expressed in terms of the Catch Ratio (CR), representing the ratio between the number of drops crossing both the 2DVD's light beams in the presence of wind and their number considering undisturbed conditions.

The simulations shows that wind direction is a relevant factor since the instrument is not radially symmetric. A significant geometric shielding effect is also present and CRs may reach zero for medium to high wind speeds and small raindrop size, meaning that no drops are sensed by the 2DVD in certain conditions.

After adjustment, measurements from the 2DVD installed at the HKO's field test site at the Hong Kong International Airport are compared against co-located rain gauge measurements. Results

show an average reduction of the deviation between measurements to less than about 1 mm/h. Adjusted measurements from both instruments also report about 10% higher RI values, indicating that the raw data significantly underestimate precipitation. The adjustment procedure presented in this work is quite general and can be applied to raw measurements obtained from any 2DVD sensor if measurements from a co-located anemometer are available at the site.

Measurements obtained from the 2DVD in windy conditions should be therefore treated with caution, especially when the measured DSD is used to inform research studies on the microphysical properties of the rain process or for any comparison with other disdrometers or precipitation gauges.

References:

Cauteruccio, A., Chinchella, E., & Lanza, L. G. (2024). The overall collection efficiency of catching-type precipitation gauges in windy conditions. *Water Resources Research*, 60(1), e2023WR035098. <https://doi.org/10.1029/2023WR035098>