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Fog gauge measurements of cloud liquid water content: proposing a new standard

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Quantifying fog is a major challenge in tropical montane cloud forest (TMCF) research. Fog gauges are popular for their low maintenance and operational simplicity, qualities particularly valuable at remote TMCF sites. The use of fog gauges raises questions when making comparisons between studies and between gauge catch and cloud water interception by vegetation (CWI). Comparing results of different fog gauge studies is hindered by the uncertainty in gauge-specific collection efficiency. In addition, CWI in continuous, complex natural vegetation canopies is clearly not represented by the water catch of an isolated, artificial fog gauge. To facilitate inter-study comparisons and to estimate CWI based on fog gauge measurements, the raw fog gauge catch should be calibrated to an independent measure of fog water such as cloud liquid water content (LWC). While the effects of varying wind direction and wind-driven rain can be corrected, few have examined the performance of different gauge types and information on their efficiency is sparse. One reason for this knowledge gap is that most LWC sensors are designed for in-flight cloud physics observations. These instruments are expensive and often include bulky, power-consuming and non-waterproof electronics, making them difficult to use at TMCF sites.

In this study, we propose the use of LWC as the standard variable to report when using fog gauges and present a method to calibrate fog gauge observations using cloud droplet measurements. We obtained assistance to make cloud droplet measurements through collaboration with two research groups across the university campus. To enable in situ observations, we designed a mobile station that can be easily transported and assembled on a pickup truck, provides an elevated sensor-mounting platform, and protects the weather-sensitive instruments. We tested the mobile station at the summit of Mt. Ka'ala (1,200 m) on O'ahu Island within a TMCF equipped with a long-term climate station. We deployed 10 instruments including two types of cloud droplet sensors, a Juvik-type fog gauge, wind monitor, rain gauge, visibility sensor, digital camera, water isotope sampler, UAV atmospheric sensor, and aerosol spectrometer. Almost 18 hours of observations were recorded on three days from April to July 2018. We analyzed the cloud droplet measurements for LWC and compared it with the fog gauge observations to calculate the fog gauge collection efficiency. The results showed that the Juvik gauge efficiency was 13%, much lower than previously thought. However, the fog gauge-derived estimates were well correlated with the droplet-based LWC and this relationship seems to be consistent under the range of wind speed and LWC conditions tested. Although these results are preliminary due to the small sample size at the time of writing, it is promising that after calibration, fog gauges are capable of estimating fog LWC with reasonable accuracy.