Evaluation of the New Version of the Laser-Optical Disdrometer, OTT Parsivel2

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Introduction

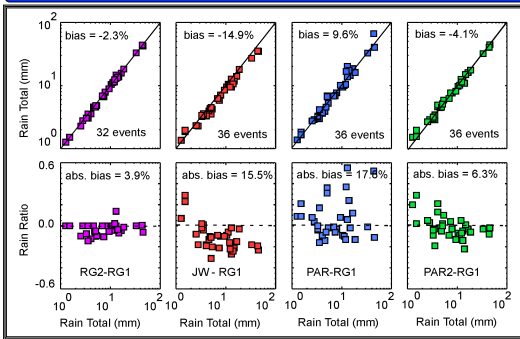
The cost-effectiveness, low maintenance, and robust performance of the laser-optical disdrometer, Parsivel (Particle-size-velocity) resulted in the production of over 1000 units since 2005 OTT received the right of the instrument in 2005. While many operational agencies mainly use Parsivel for present weather sensors, research institutes are interested in the microphysical properties of rain and snow and their small-scale variability. Parsivels measure the size and fall velocity of the hydrometeors and the accuracy of these measurements is vital in determining the microphysical properties of rain and snow. A Parsivel consists of a laser-beam of 180 mm length x 30 mm (27 mm old version) width x 1 mm thickness. The sensor's transmitter unit generates a horizontal beam of visible red laser light, which is converted into an electric signal by the receiver unit. The absolute amplitude of the signal changes when a particle falls through the beam. The resulted dimming is related to the particle size, while the particle's fall speed is derived from the duration of extinction. Parsivel's raw output is a 32 x 32 size versus velocity matrix which covers 0.2 to 20 m s^{-1} velocity and 0.2 to 25 mm size range.

Since Löffler-Mang and Joss introduced PM Tech Parsivel in 2000, the instrument passed two major milestones. OTT Parsivel was able to improve the Parsivel's calibration such that the raindrop fall velocity measurements showed better agreement with the terminal fall speed (Beard 1976). OTT Parsivel used a less expensive laser device for cost cutting, which resulted in non-homogeneous beam at approximately 20% rate. An overestimation of the drops larger than 2.0 mm in diameter is attributed to the non-homogeneous laser beam. Recently, OTT produced a beta model of Parsivel2, which uses homogeneous laser device.

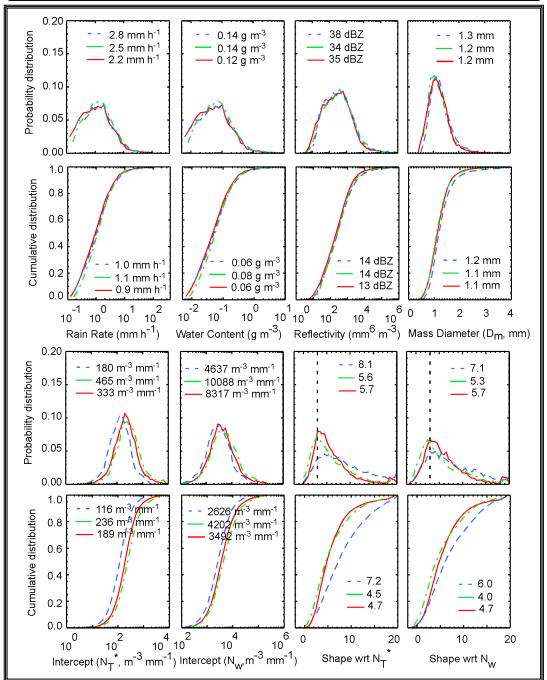
Measurement Site and Data

This study evaluates the Parsivel2 (PAR2) through comparisons with Parsivel (PAR), impact type Joss-Waldvogel (JW) disdrometers, and tipping bucket rain gauges (RG). All instruments were collocated at the roof of Building 33 at NASA Goddard Space Flight Center (39.0˚N, 76.8˚W). The time of the tip (0.254 mm) was recorded for the gauges, while the 10-sec disdrometer records were integrated to 1-minure. The gauges were considered as a reference for rain totals and collected 394 mm of rainfall during the experiment period (Feb. 28 to Aug. 2, 2011). Parsivel2 recorded 361 mm of rainfall in 165 rainy hours while Parsivel and JW had 414 mm and 333 mm of rainfall, respectively both in 150 rainy hours.

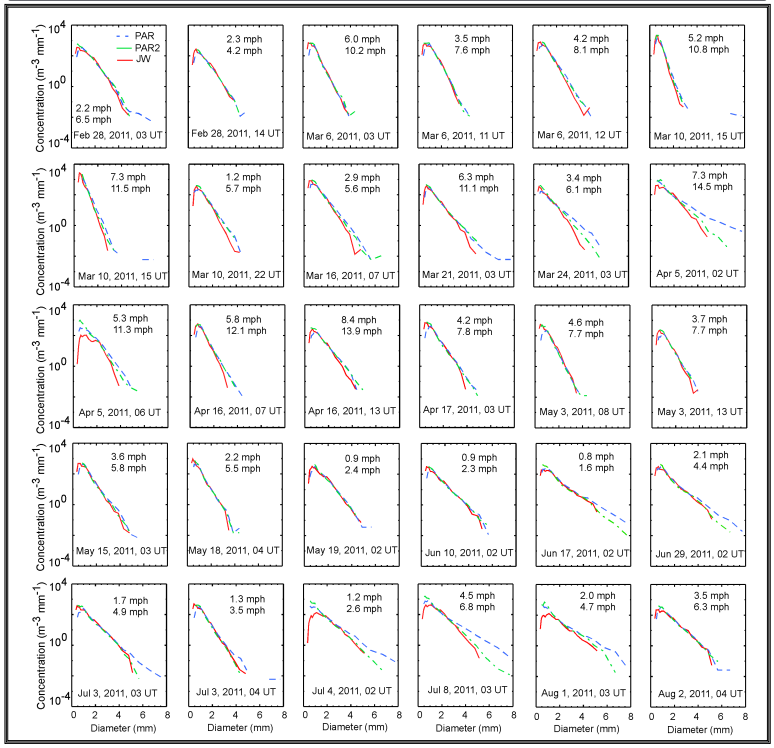
Event Rain Totals



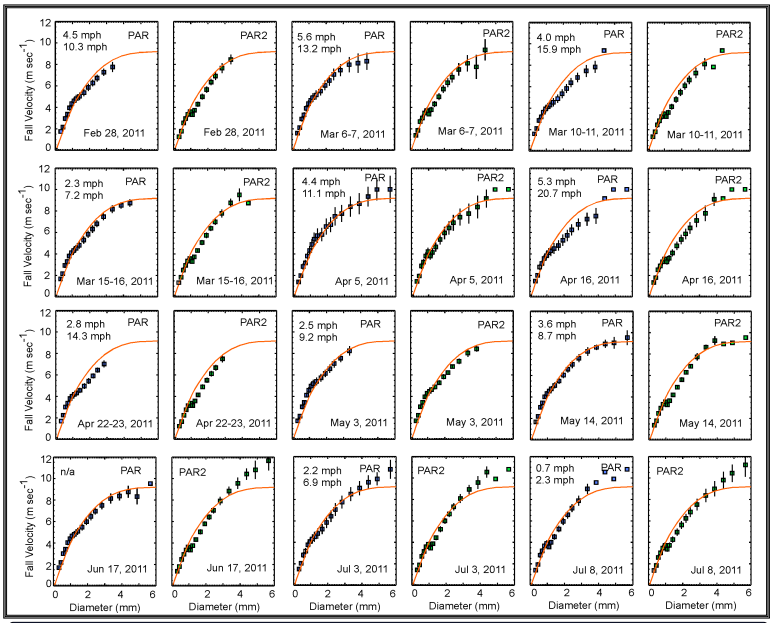
Probability and Cumulative Distributions



Raindrop Size Distribution – Hourly Composites



Event Fall Velocity



Conclusions

- PAR2 had the best agreement with the rain gauges in event rain totals.
- PAR2 had peak concentrations between 0.2 mm to 0.6 mm in diameter demonstrating its ability to capture the small drops. The underestimation of small drops is an issue for PAR, JW, and two-dimensional video disdrometers.
- PAR2 recorded very large drops (>5.0 mm in diameter), which is a well-known shortcoming of the JW, and did not overestimate the drops larger than 2.0 mm in diameter which is a shortcoming of the PAR.
- PAR2 showed the underestimation of fall speeds between 1.0 mm and 4.0 mm in diameter in number of events and overestimation of fall speed for the drops larger than 3.0 mm in diameter in a few events.
- PAR2 provided the most accurate intercept parameters of gamma distribution and the shape parameter had a mode at 3.0, median at 4.0 and 4.5 and mean at 5.4 and 5.6, depending on the choice of size distribution parameterization.
- No direct correlations were found between the instrument shortcomings and local wind observations.