# ORCESTRA Parsivel Disdrometer Data

Contacts:

Delián Colón-Burgos
deliancb@colostate.edu

Michael M. Bell
mmbell@colostate.edu

*Please contact us with any questions or comments on the dataset, or about collaboration opportunities.

## I. Dataset Overview

Two optical disdrometers (PARSIVEL, or PARticle SIze and VELocity; Löffler-Mang and Joss 2000) collected drop-size distribution measurements across the Tropical Atlantic during the M203 cruise in the Research Vessel (R/V) METEOR, as part of the ORCESTRA field campaign. The two disdrometers, with station IDs "METEOR1" and "METEOR2", were located on the 6th Superstructure Deck of the R/V Meteor (Fig. 1), at an elevation of 20.66m above sea level. The disdrometers are positioned perpendicular to each other. Both instruments collected data every minute during August 16 through September 23, 2024, for a total of 39 days (Fig. 2).

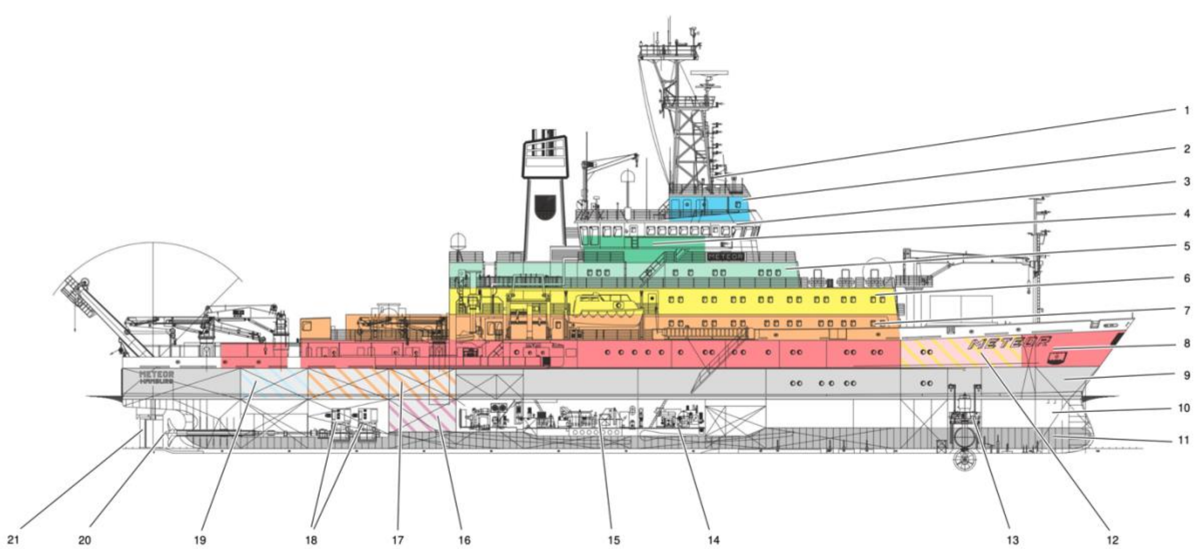


Figure 1. Blueprint of the deck arrangement on the R/V Meteor. The 6th Superstructure Deck is the area labeled 1. (Source: Briese Research On-board Handbook for Expedition participants p. 14).

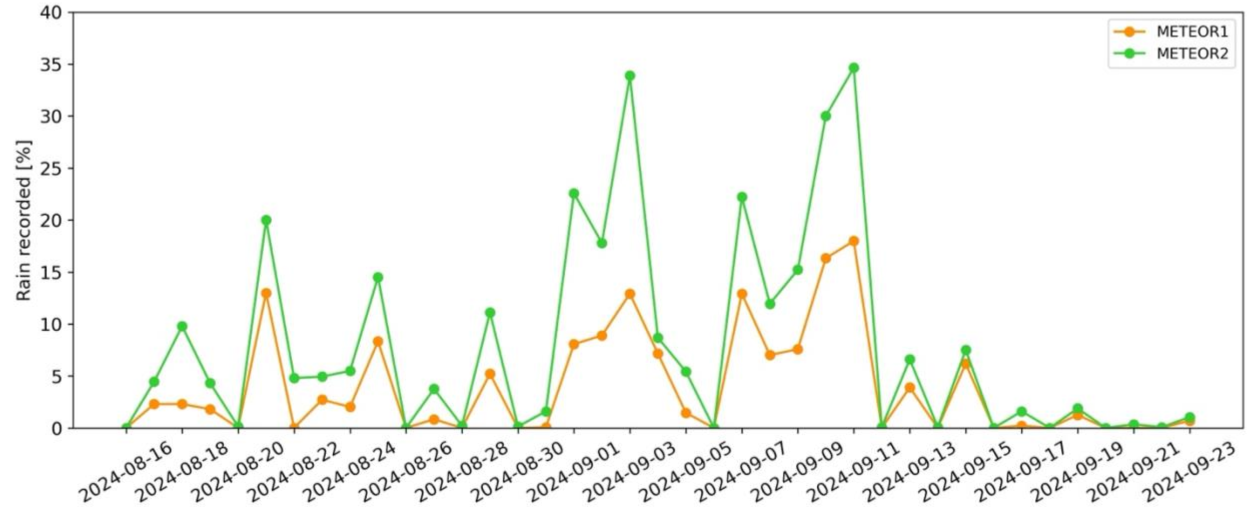


Figure 2. Percentage of time in a day (UTC) when each Parsivel disdrometer recorded rainfall during M203. (Figure by Delián Colón-Burgos)

## II. Data format

### a. Single files

The raw Parsivel data format is a semicolon-delimited text file, where a line corresponds to data collected at each time step. Only the raw files from the METEOR2 include header information. For better user accessibility, the header and data has been converted into netCDF format with a single file for each disdrometer, concatenating all data available in the time dimension. The disdrometers were operating with a 60-second sampling interval (1440-time steps per day). The times of each dataset are in UTC. The individual disdrometer files are named: “DSD_METEOR1_RES.nc” and “DSD_METEOR2_RES.nc”

The primary output of interest from the Parsivel disdrometer is the particle size distribution data. The Parsivel disdrometer outputs particle counts into 32 classes for both particle diameter and fall speed (Table 1). This output creates a 32-by-32 matrix of particle counts sorted by diameter and fall speeds.

### b. Merged file

Given the perpendicular positioning of the disdrometers, there are differences in the data recorded by each. For example, the disdrometer facing the motion of the ship may record greater rainfall than the one perpendicular to the ship’s motion. To ease data usage, a merged file was created, with data from the disdrometer that showed the greatest rain rate (RR) after QC at a given timestep. This file is called

“DSD_METEOR_merged” and contains a flag (“greatest_RR_flag”) of either 1 or 2, indicating which disdrometer recorded the greatest RR at that time. METEOR2 recorded a greater RR than METEOR1 98.4% of the time (Fig. 3). Some of the raw variables, which are not often used for research purposes, were removed in this file (variables with * in Table 2).

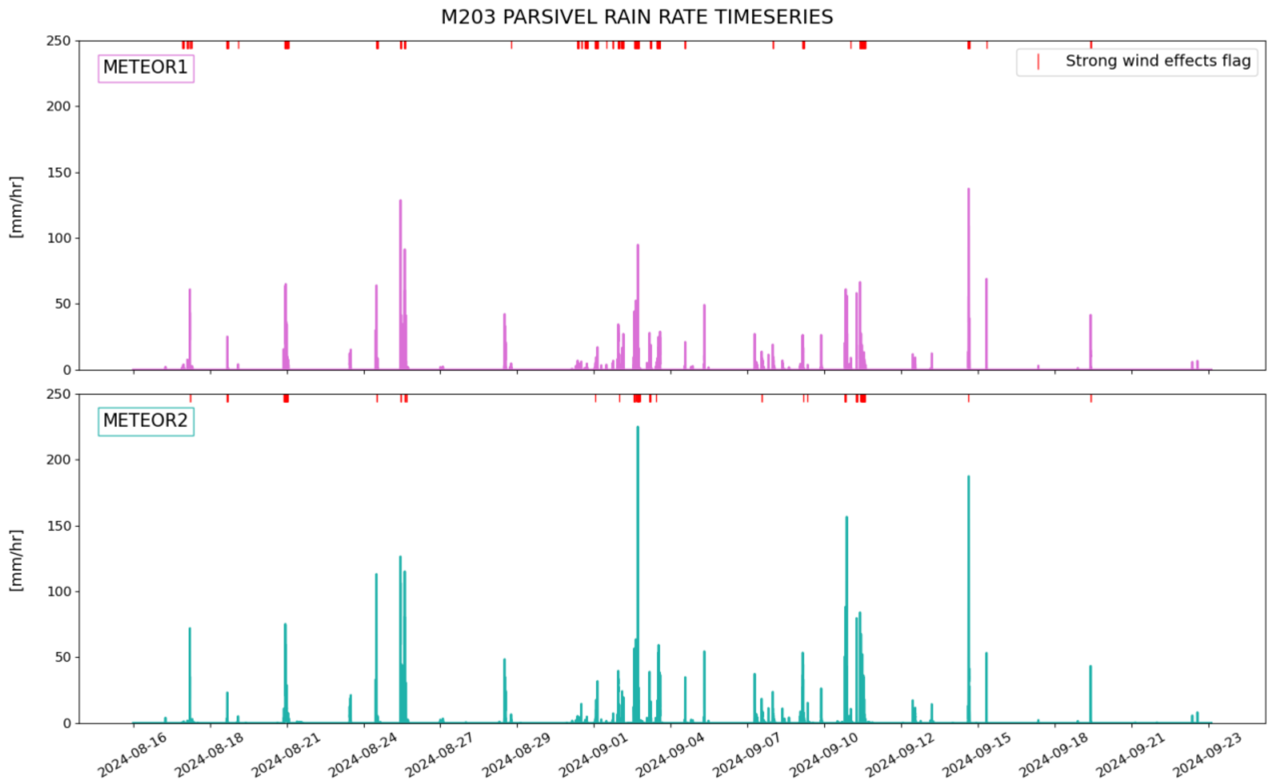


Figure 3. Timeseries of rain rate recorded by the disdrometers and strong wind effects flag (data shown is after QC process).

## III. Quality control workflow

### 1. Raw to NC

First, the raw (semicolon-delimited) disdrometer files were converted into netcdf format. We used the pandas python package to read the text files and extract data from each line. We use the same method to read the data for both disdrometers but for METEOR2 the first 2 lines were skipped, instead of 1 because it contained the list of variable names plus a line full of zeros. For METEOR1 header information is not available, therefore just one line is skipped.

Geographical coordinates were added in this step, as the instrument doesn't record them. Latitude and longitude coordinates corresponding to the data's recording time was extracted from the *dship* data (R/V Meteor's ship data) during M203. One caveat found during data processing was that for a large part of METEOR2 files, the last line of data entry was shorter than expected. It seems that it has to do with the recording time being too close to 23:59:59 and not having time to record the whole data during the last minute on a given day. If the raw spectrum is not available in its entirely for that last time step, data for the whole line was set to nans.

## 2. QC Process

Parsivel disdrometers are susceptible to several sources of error, particularly in high wind conditions. To address such errors, we have implemented the quality control method similar to that used by the Central Weather Administration of Taiwan (Fig. 4) and used in the Prediction of Rainfall Extremes Campaign in the Pacific (PRECIP 2022). The quality control procedure is as follows:

a. 1-minute time steps with rain rates under 0.1 mm or number of particles less than 10 are removed.
b. The minimum particle diameter allowed is 0.2 mm and the maximum particle diameter allowed is 8 mm.
c. The valid velocity-diameter ranges are a function of the velocity – diameter relationship for rain as derived by Brandes et al. (2002):

$$v = -0.1021 + 4.942D - 0.9551D^2 + 0.07934D^3 - 0.002362D^4$$

Here $v$ is the particle fall speed and $D$ as the class particle mean diameter. Bins with velocities ±50% of the Brandes et al. relationship or greater are removed.

Particles with diameters greater than 5 mm and velocities under 1 m/s meet the criteria of a high wind artifact as defined by Friedrich et al. (2013a,b) and a high wind flag is raised (Table 2). Although this criteria is not found within the Central Weather Administration's quality control procedure, it is recommended by Friedrich et al. (2013a,b) that time steps with these artifacts are removed in its entirely.

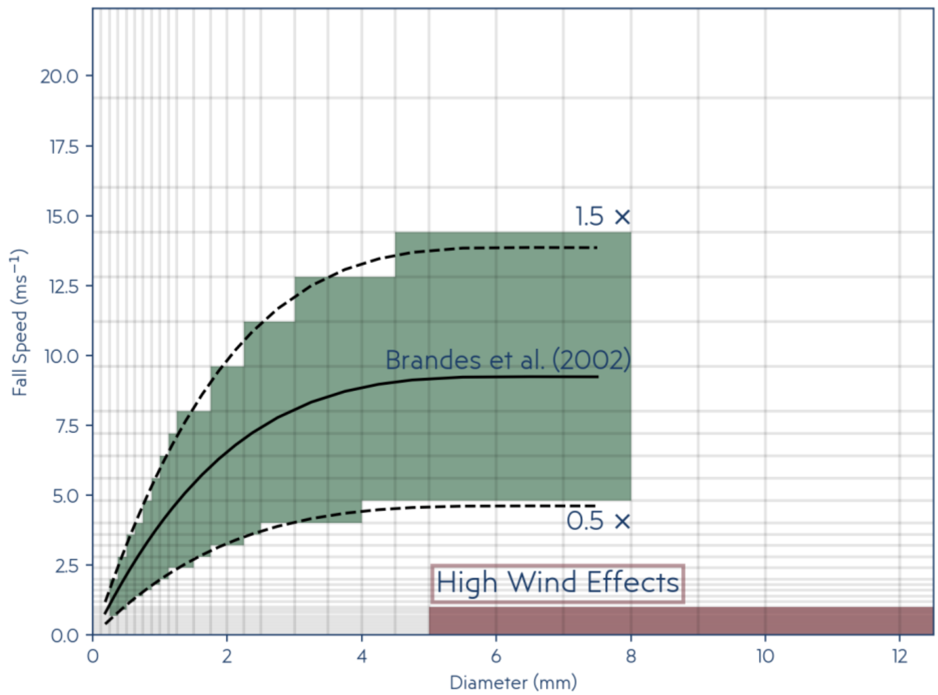


Figure 4. Quality control schematic. The solid black line indicates the fall velocity–diameter relationship derived in Brandes et al. (2002). Dashed black lines indicate the extent of the quality control as a scaling of the Brandes et al. relationship. Valid bins are colored green. Bins indicative of high wind effects as described by Friedrich et al. (2013a,b) are colored red. (Figure courtesy of Ian Cornejo)

### 3. Postprocessed Data Products

Data products were created for microphysical and radar analysis through PyDSD (https://github.com/josephhardinee/PyDSD/n) and PyTMatrix (https://github.com/jleinonen/pytmatrix). These products include drop-size distribution moments and simulated dual-polarization radar quantities at different wavelengths.

## IV. References


Brandes, E. A., Zhang G. , and Vivekanandan J. , 2002: Experiments in rainfall estimation with a polarimetric radar in a subtropical environment. J. Appl. Meteor., 41, 674–685.

Katja Friedrich, Stephanie Higgins, Forrest J. Masters, and Carlos R. Lopez, 2013a: Articulating and Stationary PARSIVEL Disdrometer Measurements in Conditions with Strong Winds and Heavy Rainfall. J. Atmos. Oceanic Technol., 30, 2063–2080.

Katja Friedrich, Evan A. Kalina, Forrest J. Masters, and Carlos R. Lopez, 2013b: Drop-Size Distributions in Thunderstorms Measured by Optical Disdrometers during VORTEX2. Mon. Wea. Rev., 141, 1182–1203.

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## V. Acknowledgements

We would like to thank Pao-Liang Chang of the Central Weather Administration of Taiwan for providing the methodology for quality controlling the Parsivel disdrometer data collected during the PRECIP 2022 field campaign. We also wish to acknowledge Ian Cornejo for software, guidance in running the QC process and providing Figure 4.

**Tables**

**Table 1.** Parsivel disdrometer diameter size classes, class diameter widths, fall speed classes, and fall speed widths.

| Particle Class Number | Mean Class Diameter (mm) | Class Diameter Width (mm) | Mean Fall Speed (m/s) | Class Fall Speed Width (m/s) |
|---|---|---|---|---|
| **1** | 0.062 | 0.125 | 0.05 | 0.1 |
| **2** | 0.187 | 0.125 | 0.15 | 0.1 |
| **3** | 0.312 | 0.125 | 0.25 | 0.1 |
| **4** | 0.437 | 0.125 | 0.35 | 0.1 |
| **5** | 0.562 | 0.125 | 0.45 | 0.1 |
| **6** | 0.687 | 0.125 | 0.55 | 0.1 |
| **7** | 0.812 | 0.125 | 0.65 | 0.1 |
| **8** | 0.937 | 0.125 | 0.75 | 0.1 |
| **9** | 1.062 | 0.125 | 0.85 | 0.1 |
| **10** | 1.187 | 0.125 | 0.95 | 0.1 |
| **11** | 1.375 | 0.25 | 1.1 | 0.2 |
| **12** | 1.625 | 0.25 | 1.3 | 0.2 |
| **13** | 1.875 | 0.25 | 1.5 | 0.2 |
| **14** | 2.125 | 0.25 | 1.7 | 0.2 |
| **15** | 2.375 | 0.25 | 1.9 | 0.2 |
| **16** | 2.75 | 0.5 | 2.2 | 0.4 |
| **17** | 3.25 | 0.5 | 2.6 | 0.4 |
| **18** | 3.75 | 0.5 | 3 | 0.4 |
| **19** | 4.25 | 0.5 | 3.4 | 0.4 |
| **20** | 4.75 | 0.5 | 3.8 | 0.4 |
| **21** | 5.5 | 1 | 4.4 | 0.8 |
| **22** | 6.5 | 1 | 5.2 | 0.8 |
| **23** | 7.5 | 1 | 6 | 0.8 |
| **24** | 8.5 | 1 | 6.8 | 0.8 |
| **25** | 9.5 | 1 | 7.6 | 0.8 |
| **26** | 11 | 2 | 8.8 | 1.6 |
| **27** | 13 | 2 | 10.4 | 1.6 |
| **28** | 15 | 2 | 12 | 1.6 |
| **29** | 17 | 2 | 13.6 | 1.6 |
| **30** | 19 | 2 | 15.2 | 1.6 |
| **31** | 21.5 | 3 | 17.6 | 3.2 |
| **32** | 24.5 | 3 | 20.8 | 3.2 |

**Table 2.** Parsivel variables after QC process. Variables with a star were removed for the merged file. Research variables are not included in this table.

| Variable | Name | Units | Notes |
|---|---|---|---|
| time | Time | UTC | |
| particle_size | Particle class size | mm | See Table 1 |
| raw_fall_velocity | Fall velocity classes | m/s | See Table 1 |
| *particle_size_bin_width | Particle size bin width | mm | See Table 1 |
| *raw_fall_velocity_bin_width | Fall velocity class size width | m/s | See Table 1 |
| *precip_rate | Precipitation intensity from manufacturer's software | mm | - |
| *weather_code | SYNOP WaWa Table 4680 | - | "METEOR 1" or "METEOR2" |
| *equivalent_radar_reflectivity_ott | Radar reflectivity from manufacturer's software | dBZ | - |
| *number_detected_particles | Number of particles detected | count | - |
| *mor_visibility | Meteorological optical range visibility | m | - |
| *laserband_amplitude | Laserband amplitude | - | - |
| *sensor_temperature | Temperature in sensor | °C | - |
| *heating_current | Heating current | A | - |
| *sensor_voltage | Sensor voltage | V | - |
| *raw_spectrum | Raw drop size distribution | count | - |
| missing_data_flag | Missing data flag | - | 1= data missing |
| lon | Longitude | degrees | - |
| lat | Latitude | degrees | - |
| hgt | Elevation | m | - |
| qc_number_detected_particles | Number of particles detected- Post QC | count | See section III (2) |
| qc_spectrum | QC drop size distribution | count | See section III (2) |
| wind_flag | Flag for strong wind effects | - | 1= flag raised |
| vt_rel | Terminal velocity relationship | - | Brandes at al. (2002) |