Report: Disdrometer Calibration at TU Delft

11.03.2025 – 18.03.2025

This report contains the activities regarding the calibration of two different disdrometers (OTT PARSIVEL and Thies LPM), which I conducted at TU Delft between 11.03.2025 and 18.03.2025, as well as an overview of the first results.

Since the used calibration method was only tested on the Parsivel of the Meteorological Institute of LMU Munich before, the first task was to do the calibration on another Parsivel. For this purpose, I did a calibration of PAR010 of TU Delft. This particular instrument has not been operating at the moment, but was stored in the basement of the university building.

Overall the calibration showed similar results to the calibrations in Munich: The Parsivel overestimates all sizes of steel spheres, with a maximum relative overestimation (+15.5 %) for the smallest spheres used (diameter 0.4 mm), a minimum between 1.0 and 2.0 mm (exactly at 1.3 mm, +2%) and then an increase of the overestimation up to around 7 % for the largest spheres (5.0 mm). The shape of the curve looks very similar to the calibration results of the Munich Parsivel, although overall PAR010 has a bit higher overestimations.

After this, the glass windows in front of the laser and the detector were carefully cleaned and another calibration was carried out. This calibration showed the same shape of the curve again, but with even higher overestimations (see plot). This makes sense because the size of the spheres is calculated from the maximum drop of the laser signal voltage at the detector. If this amplitude is smaller due to dirt on the glasses, also the drop of the amplitude is smaller, which leads to the increase of overestimation after the cleaning.

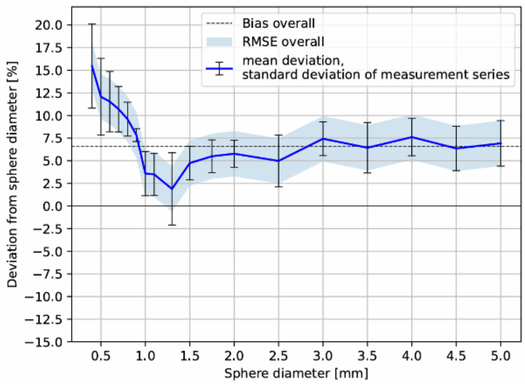

Figure 1: calibration results PAR010 before cleaning

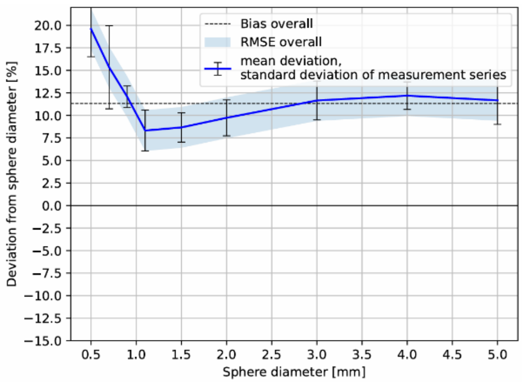

Figure 2: calibration results PAR010 after cleaning

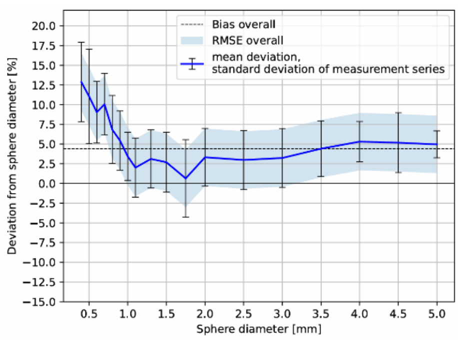

Figure 3: for comparison: Munich Parsivel

During these experiments we noticed that there seems to be a positive correlation between the measured sphere size and the fall velocity of the steel spheres. This correlation also appears if only one and the same sphere is dropped through the laser sheet many times (see plot). This behaviour can be explained as follows: because the Parsivel has only one horizontal laser sheet, it can only measure the time during which the signal of this one sheet is damped. This time refers to the time one particle takes to fall the distance of the height of the laser sheet plus its own diameter. Therefore, the calculation of the fall velocity is not independent of the measured diameter, but depends on it linearly. With t the time of the drop in the signal amplitude, D the sphere diameter and h the height of the laser band, the fall velocity v is calculated as

$$v = \frac{D + h}{t}$$

The linear dependence can also be seen in the following plot for only one sphere:

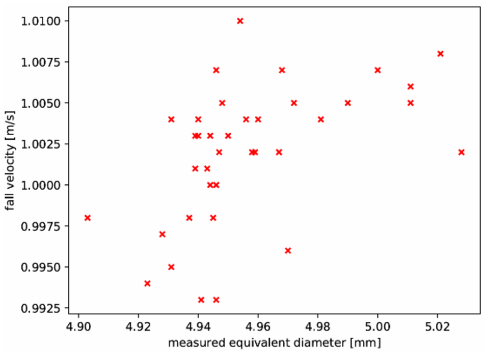

Figure 4: correlation of sphere size and speed for only one sphere, diameter 5.0 mm

The next task during my stay in Delft was to adapt the 3D-printed calibration set for the Thies LPM. With the help of Rob Mackenzie we mounted the set on the U-shaped arms of the Thies using some pipe clamps. After also adapting the Python code for communicating with the Thies via a serial port and thus being able to send commands and set the instrument into the "Event Mode", I carried out a calibration analogue to the Parsivel calibration. It showed the following results:

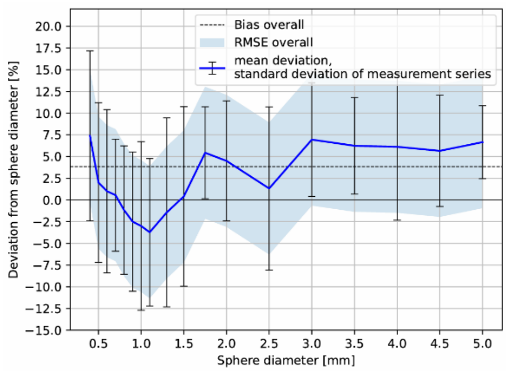

Figure 5: calibration results of Thies012

Surprisingly, again a similar behaviour of the curve can be recognized with the smallest relative deviations at 1.3 mm, a steep increase in the direction of smaller diameters and a less steep increase for larger spheres. This leads to the speculation that this shape of the deviation curve might not be intrinsic with the instruments, but related to the calibration method with the steel spheres. Transparent particles might in fact have different scattering and extinction properties than steel spheres. Maybe the Parsivel and Thies software considers these properties and therefore yields misleading results when used with non-transparent spheres. To further investigate this, theoretical simulations of the scattering and extinction of steel and water spheres will be conducted at TU Delft.

With the Thies also a calibration series with non-transparent polypropylene spheres was carried out, which led to similar results as the calibration with steel spheres (in the overlapping range of sphere diameters).

Another objective was to try a calibration outside. Although setting up the calibration outside at Cabauw measurement site with PAR002 worked well, the experiment was not successful due to two reasons:

1. Small spheres (e.g. 0.6 mm) were blown away by the wind during their fall through the setup and did not even reach the collecting funnel, i.e. were lost.
2. The Event Mode telegram showed many particles that were not steel spheres, but presumably some other particles hovering in the air. These events could probably be filtered out of the raw data, but not without significant effort. However, an opportunity to make use of these events could be to monitor them over time, as they “could contain information about CCNs, vegetation, insects and other aeroplankton” (Marc Schleiss, TU Delft).

After that, a usual calibration of PAR002 in the lab was carried out, which again showed a similar behaviour:

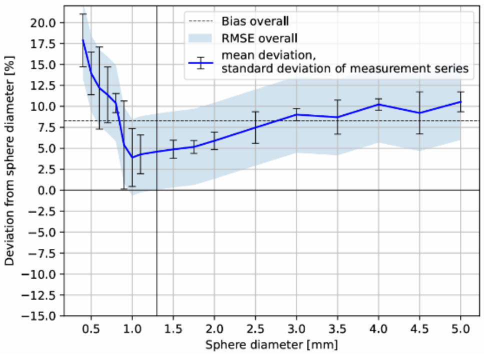

Figure 6: calibration results of PAR002 (Cabauw) in the lab

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