First steps towards evaluating the PARSIVEL disdrometer calibration

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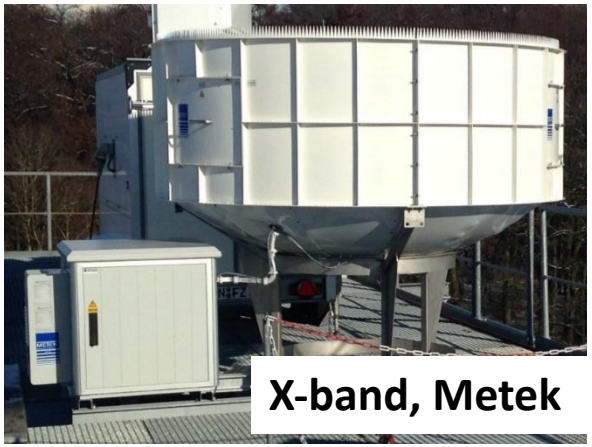
Motivation: „Radar-Zoo“ needs calibration…



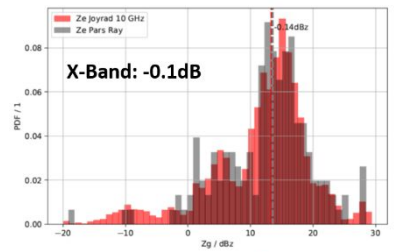
X-band, Metek

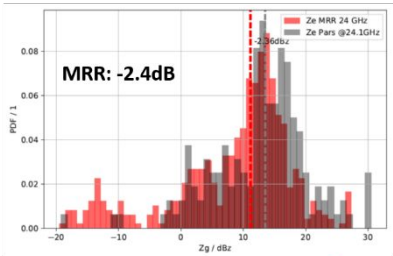
Ka-band, Metek

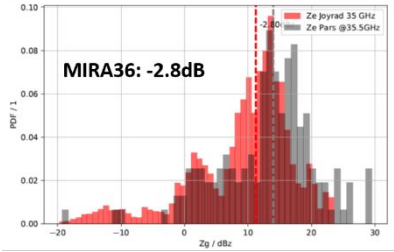
Rain calibration approach presented at cloud radar calibration workshop, Paris, 2018

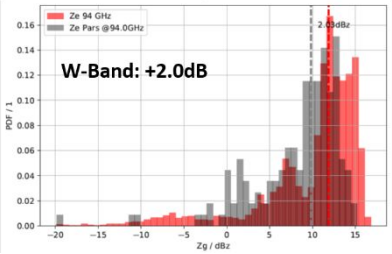
W-band, RPG

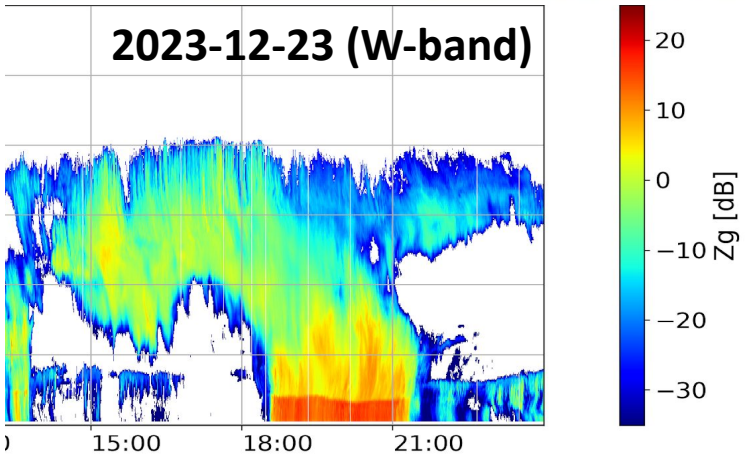
MRR-pro, Metek







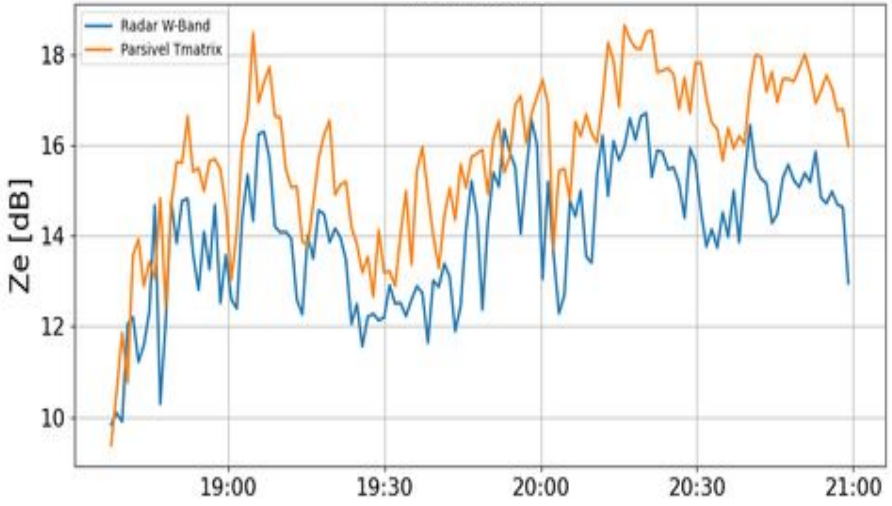




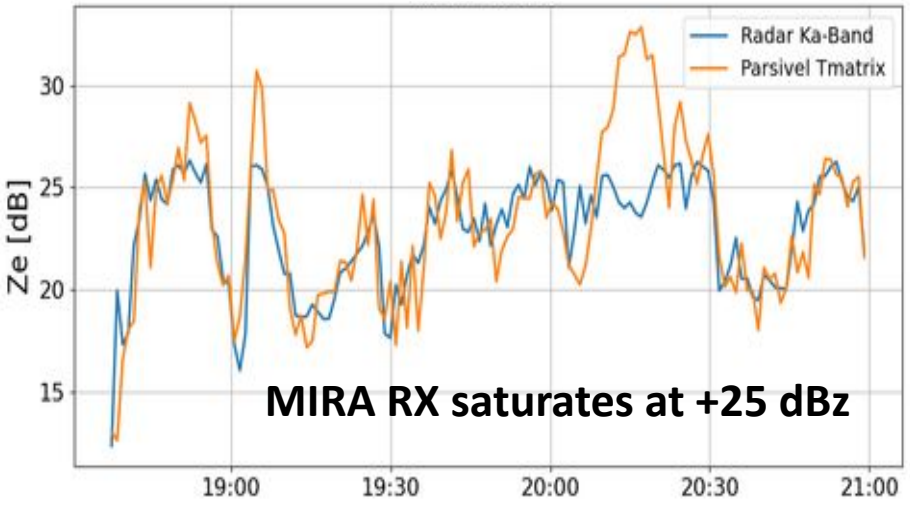
Light rain event 13th Dec. 2023

- Rainrates 1-5 mm/h
- ML at ca. 1km
- Both radars in zenith-only mode
- Using Parsivel N(D) and Raincoat software python tool

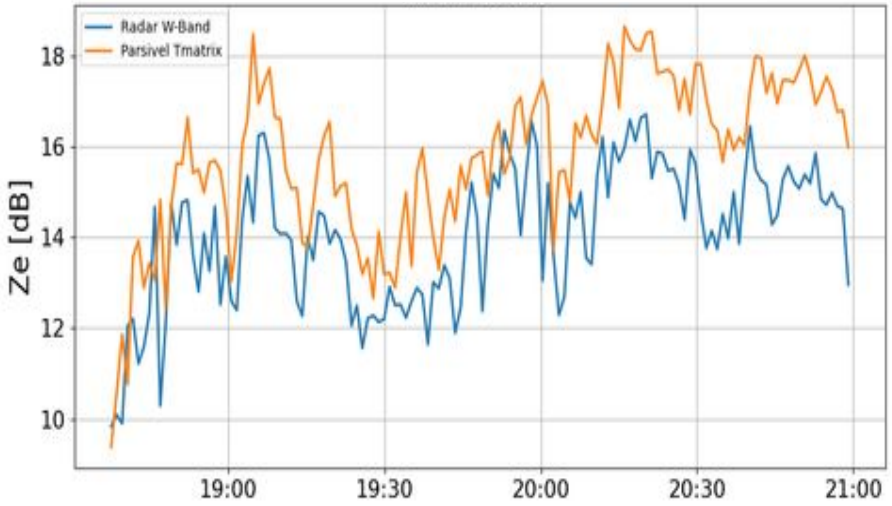
W-band, Offset: ca. -1.7 dB

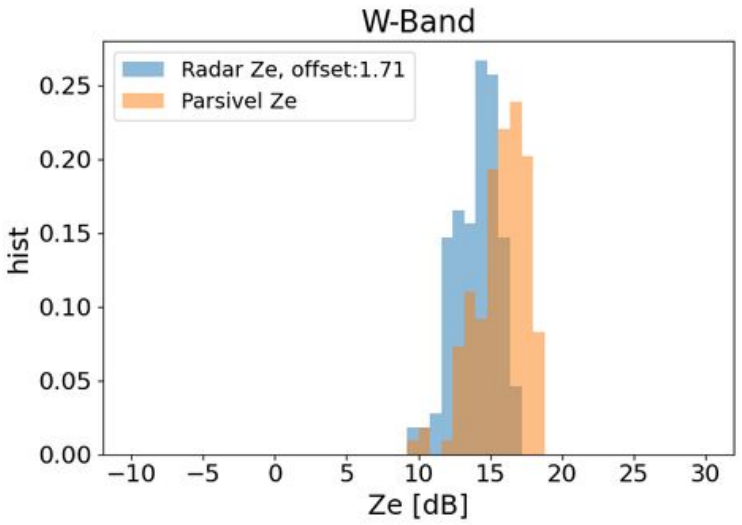


Ka-band, Offset: ca. +0.4 dB

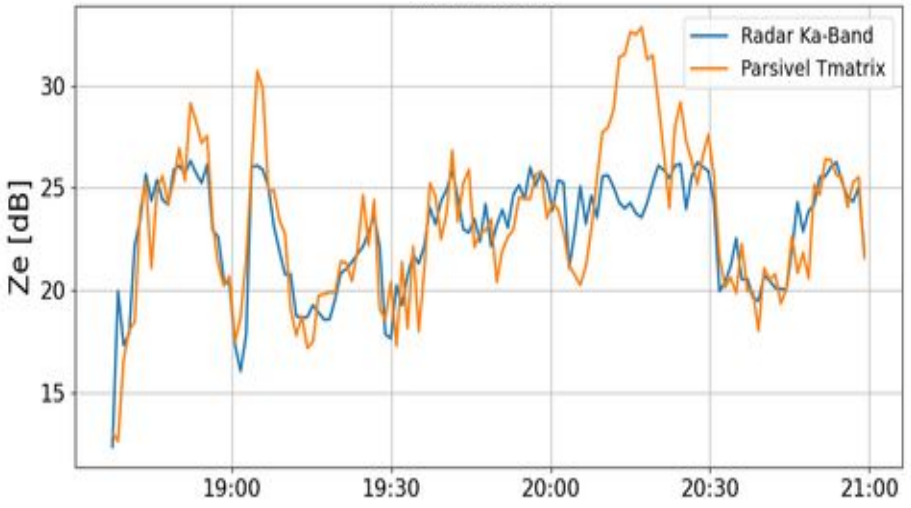


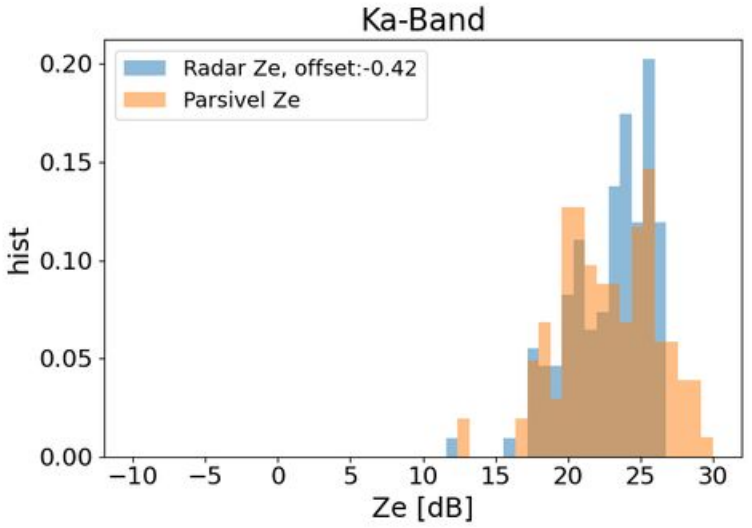
W-band, Offset: ca. -1.7 dB





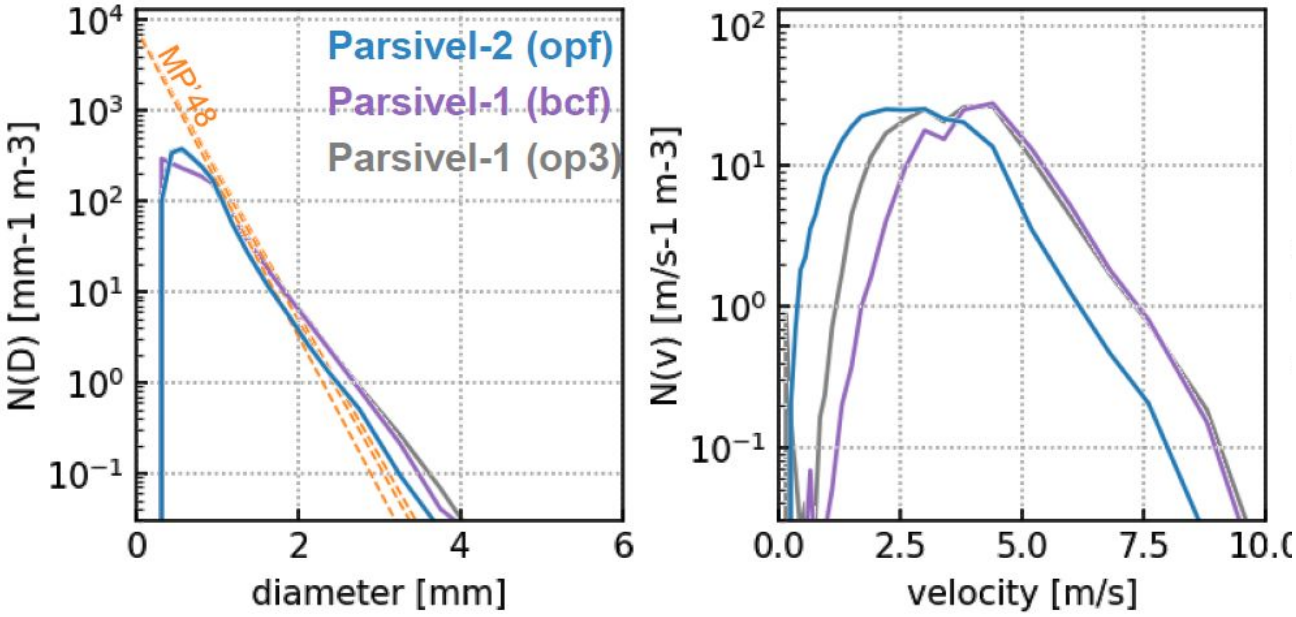
Ka-band, Offset: ca. +0.4 dB





Comparison of different Parsivel disdrometers

Parsivel-1 and Parsivel-2
22 September 2023 03:00 – 12:00 (9:00 hour



Parsivel-2 (opf)

	OTT	matrix
Ntot	205	205
RR	1.27	1.27
Z	26.15	25.64

Parsivel-1 (bcf)

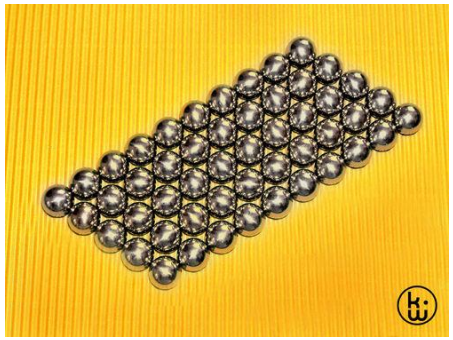
	OTT	matrix
Ntot	184	196
RR	1.68	1.63
Z	28.15	27.98

Parsivel-1 (op3)

	OTT	matrix
Ntot	218	224
RR	1.90	1.82
Z	28.93	28.67

Courtesy Martin Hagen, DLR

Evaluation of Parsivel calibration in the Lab using reference spheres



- Stainless steel spheres available online
- e.g., www.kugel-winnie.de
- Diameter 0.3 - 5.0 mm
- Acc. 10 µm
- Costs: ca. 5-6€ for 50 spheres

- Also PP and Polyacetal spheres
- Density closer to ice
- smaller diameter range, less accurate

- 3D printed mobile dropping device (LMU developmenet)
- Utilizes Parsivel mounting
- Allows testing of various configurations
- Still optimizing design, work in progress…

Evaluation of Parsivel calibration in the Lab using reference spheres

Dropping device also provides a tool to make sure that laser band is well aligned.

Important: Parsivel has to be set into „event mode“

Description Parsivel² output - field 61

The output of field 61 is possible with Parsivel² devices and firmware version V2.10.0 or higher. You can download the firmware on our home page www.ott.com (register and log in to myOTT). The firmware update can be done easily with the software ASDO. Please check the manual for details.

61	List of all particles detected (including size and particle speed)	13	00.000;00.000	0.200 ... 25.000; 0.20 ... 20.000	mm;m/s

- Set telegram parameter for parameter 61: **CS/M/S/%61/r/n**

⇒ 1. Value: Size (0.2…25mm)

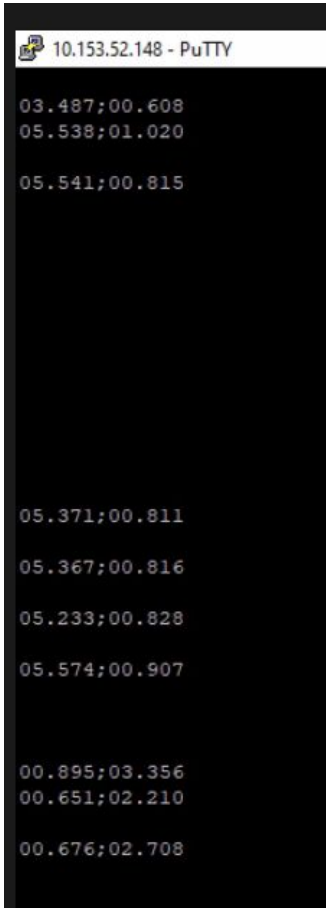
⇒ 2. Wert: Fall speed (0.2…20 m/s)

- Set custom build telegram: **CS/M/M/1**
- Set push interval (in seconds): **CS/I/10**

Output is not automatically logged!

Evaluation of Parsivel calibration in the Lab using reference spheres

Example output (D;v)



Important Note:

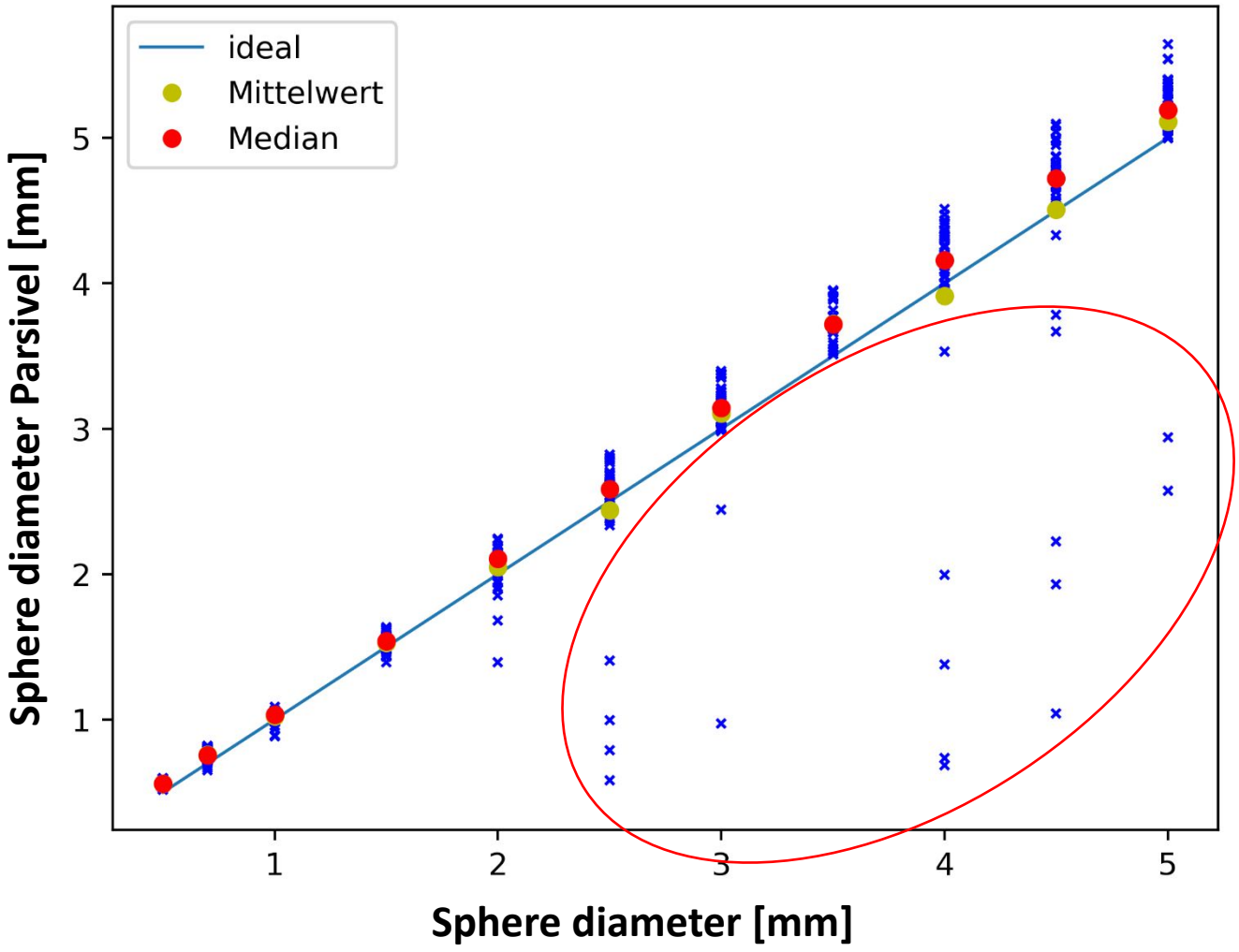
- Parsivel assumes internally, that it measures ellipsoidal rain drops with size dependent aspect ratio
- Those are converted into **equivolume sphere diameters D_{eq}**
- This conversion needs to be re-done before comparison
- Need to ask OTT if this relation has been changed over time

$$a_r^{\mathrm{PAR}} \equiv \begin{cases} 1 & D_{\mathrm{eq}}^{\mathrm{PAR}} \le 1\,\mathrm{mm} \\ 1.075 - 0.075 D_{\mathrm{eq}}^{\mathrm{PAR}} & 1\,\mathrm{mm} < D_{\mathrm{eq}}^{\mathrm{PAR}} < 5\,\mathrm{mm}\,, \\ 0.7 & D_{\mathrm{eq}}^{\mathrm{PAR}} \ge 5\,\mathrm{mm} \end{cases} \quad (1)$$

$$\mathrm{WHD}_{\mathrm{retr}}^{\mathrm{PAR}} \equiv \frac{D_{\mathrm{eq}}^{\mathrm{PAR}}}{(a_r^{\mathrm{PAR}})^{1/3}}\,, \quad (4)$$

from Battaglia et al., JTECH, 2010 (https://doi.org/10.1175/2009JTECHA1332.1.)

First results: Size calibration

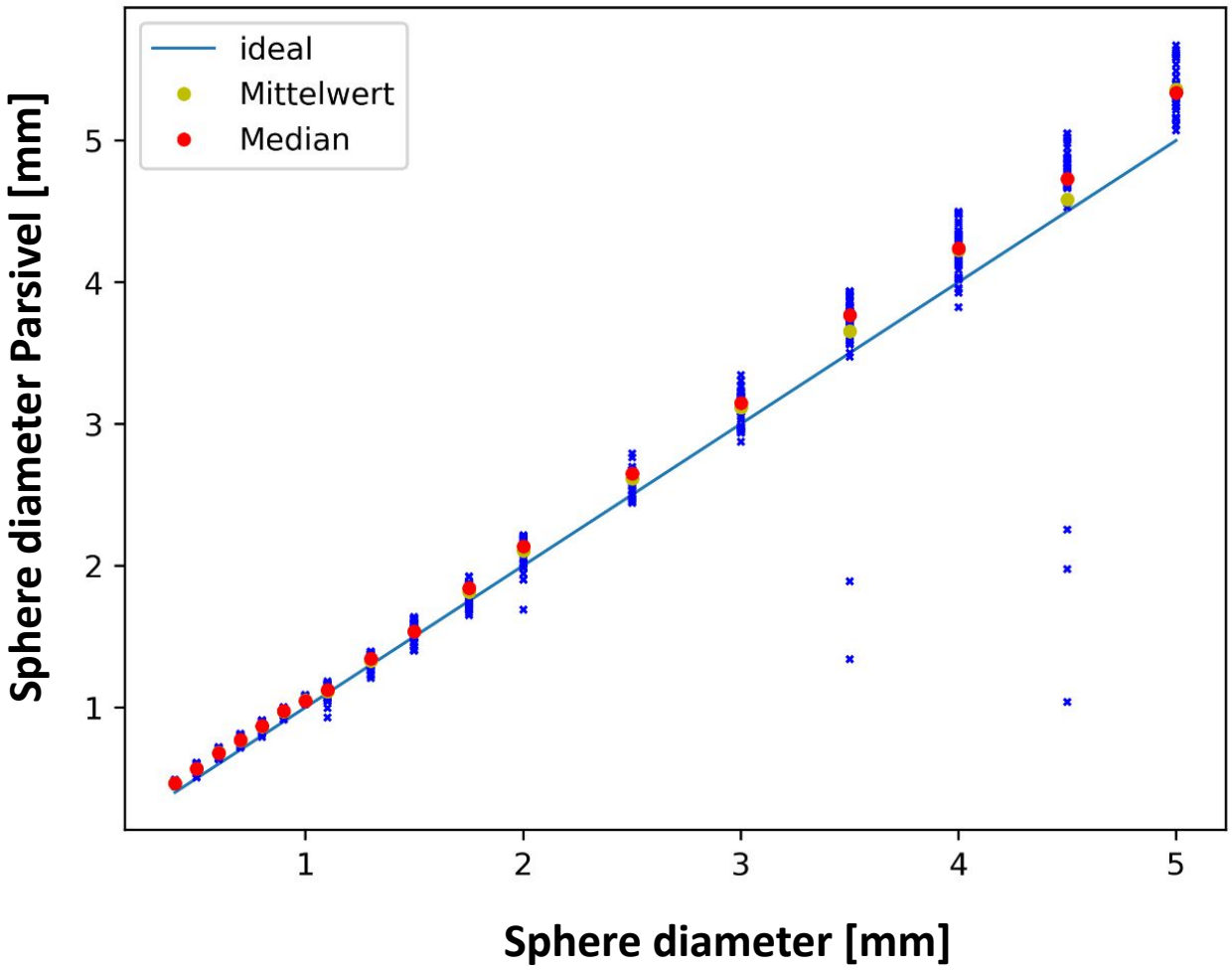


Avoiding Outliers

The diameter of the funnel has to closely match the sphere diameter

If not, spheres don‘t fall centric through laser band!

First results: Size calibration

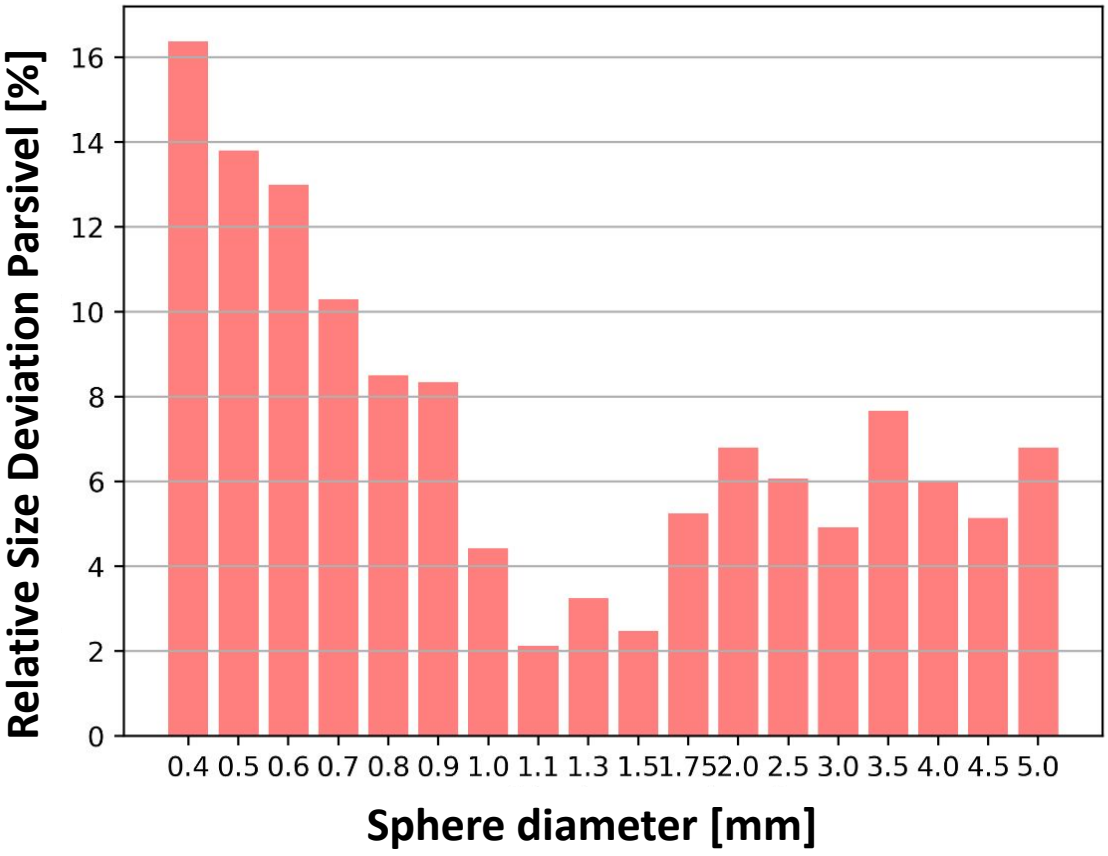


With appropriate funnels (3D printed), the outliers are strongly reduced!

ca. 50 spheres for each sphere diameter (0.3…5mm)

Needs ca. 10 minutes per diameter to receive all measurements via the serial interface!

Size calibration results and their potential impact

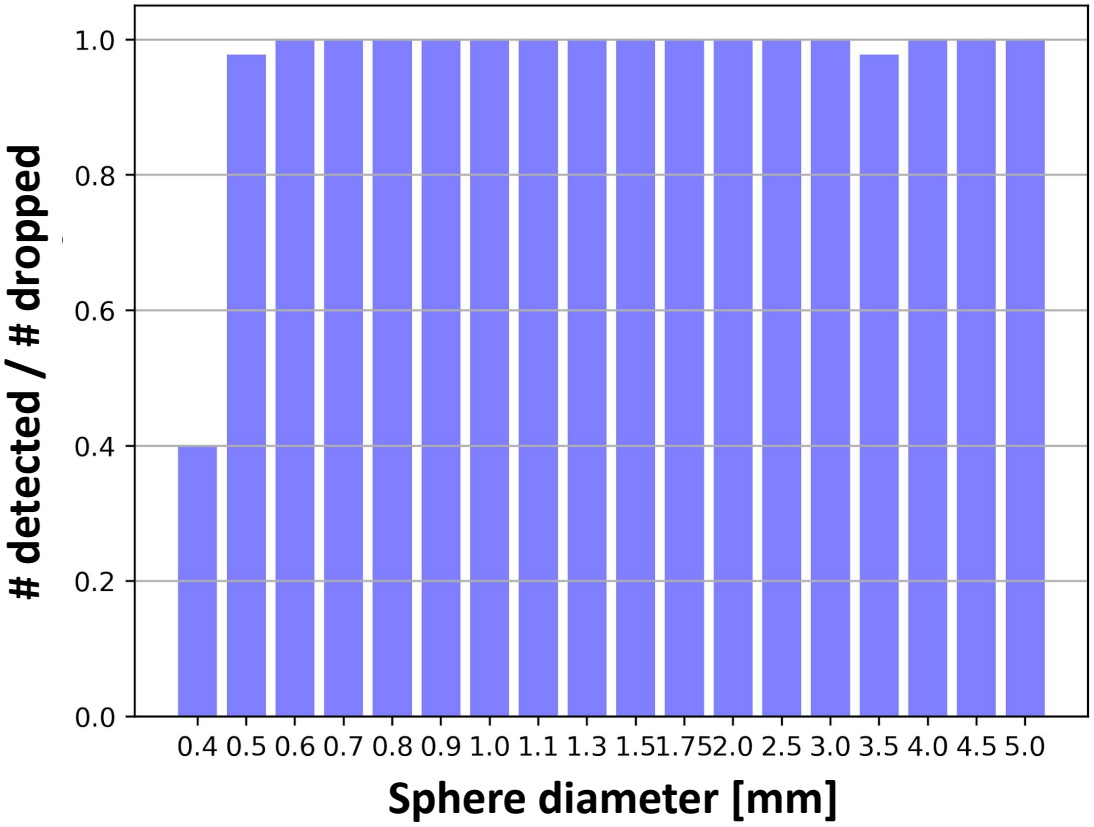


- **Systematic overestimation** of size by our new Parsivel-2
- The **5-6% overestimation** tranlates into biases of
- **ca. 1.6 dB in Z (Rayleigh)**
- **ca. 22% in RR**

Note

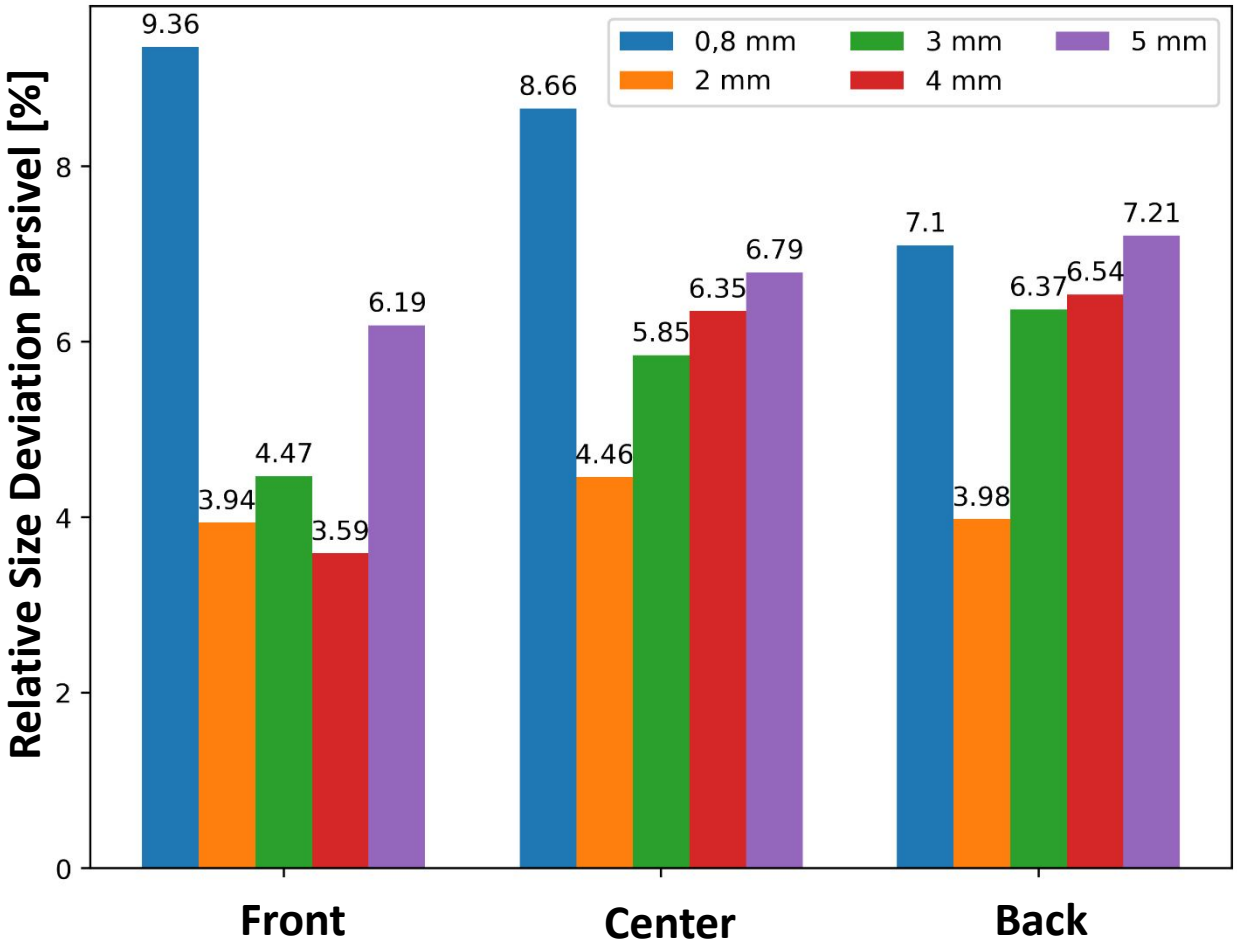
- 0.3mm spheres were NOT detected at all!
- Manual states: 0.2…5mm

Detection rate



- Smallest detected diameters (0.4mm) **are strongly undercatched**
- Almost 100% detection rate for larger diameters

Size bias dependent on dropping position?



Conclusions, Outlook, and Discussion

- Every Parsivel (similar Thies, etc.) used in ACTRIS should be calibrated with precision spheres at least once per year
- Even our brand-new Parsivel-2 shows systematic size bias of 5-6% which can easily introduce a systematic 1-2 dB Ze bias
- Parsivel-1 and old Parsivels can be expected to be much worse (e.g. degrading laser, older software, etc.)
- Mobile dropping device might also be used for a Parsivel mounted outside (still to be tested, only during good weather conditions)

Ongoing activities at LMU:

- Evaluating velocity calibration (more tricky, terminal velocity not reached in short dropping distance)
- Checking whether same bias if using standard mode (M-Matrix, N(D))

Conclusions, Outlook, and Discussion

Open questions:

- Why does Parsivel detection start at 0.4mm rather than at 0.2mm?
- Can OTT tell us more how they do the sphere calibration? How to best contact/reach them?
- How to best derive and apply correction function to M-Matrix or N(D)

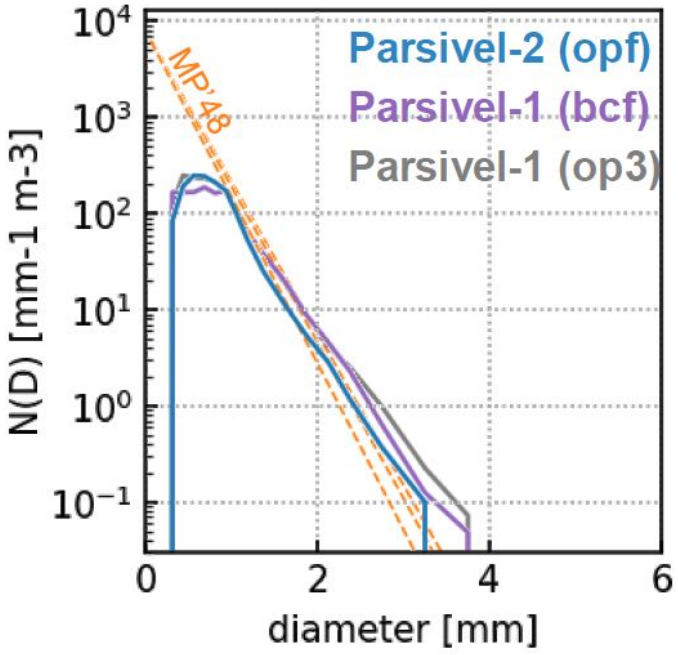
Discussion:

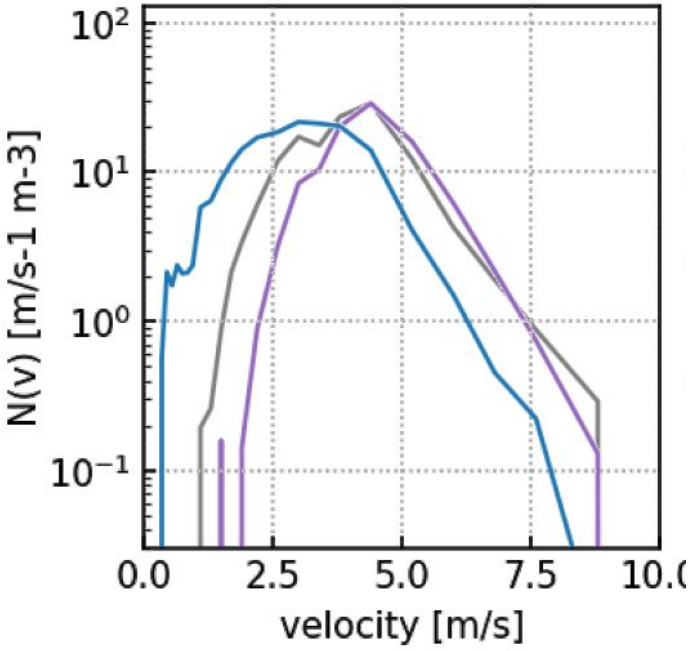
- Joint effort of CCRES to collect hardware, software, comparison in real rain with other disdrometers for maybe a joint publication?
- How to best perform similar calibration with Thies? Has anybody done this already?

Backup Slides

Comparison of different Parsivel disdrometers

24 May 2023 09:40 – 10:10 (0:30 hours)





Parsivel-2 (opf)

	OTT	matrix
Ntot	171	171
RR	1.15	1.15
Z	27.14	26.74

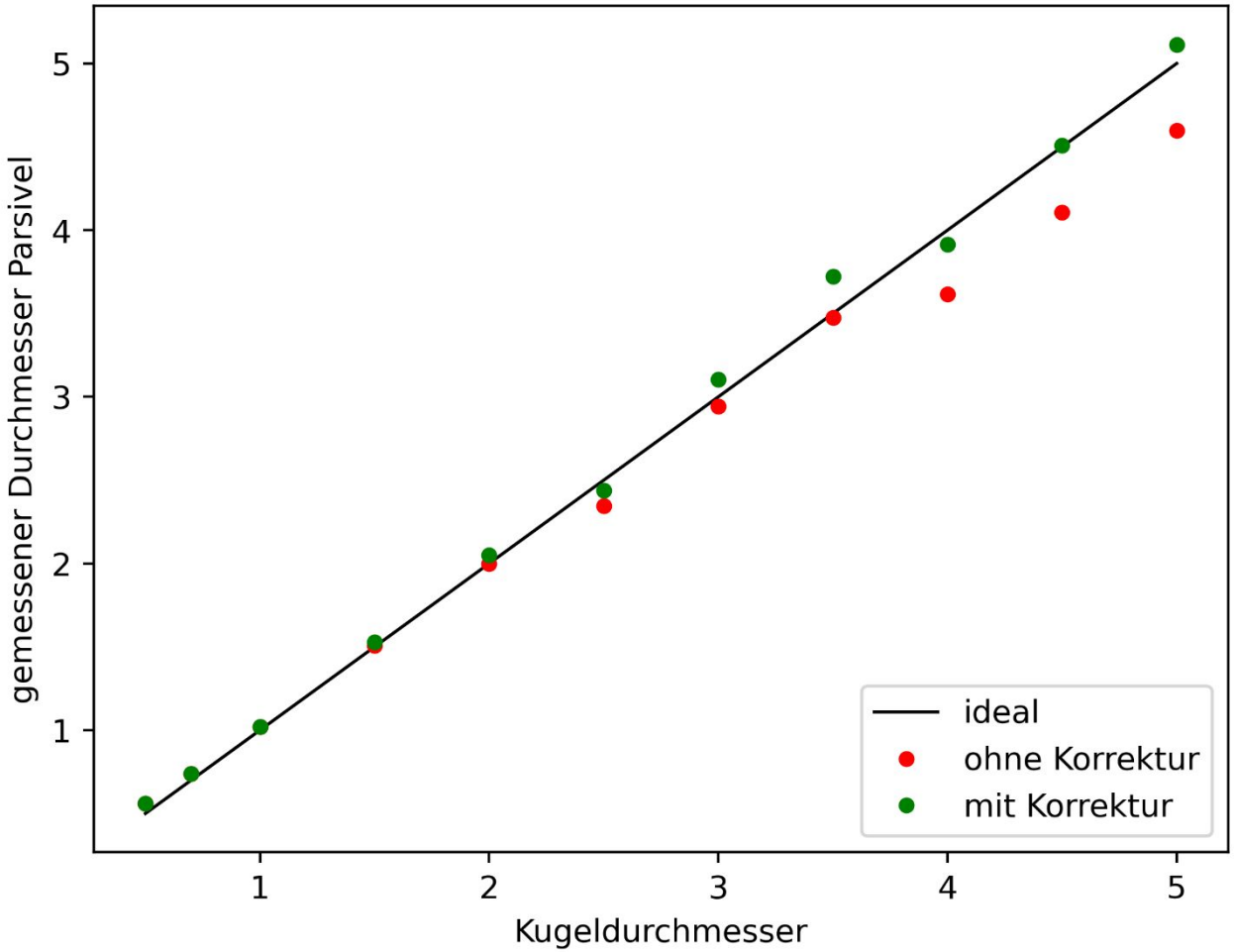
Parsivel-1 (bcf)

	OTT	matrix
Ntot	150	169
RR	1.60	1.56
Z	29.18	29.04

Parsivel-1 (op3)

	OTT	matrix
Ntot	180	191
RR	1.77	1.79
Z	30.73	35.00

Courtesy Martin Hagen, DLR



Red: No correction for ellipsoid assumption

Green: Inlcuding correction