Introducing the maximum diameter as a new 2DVD variable for the investigation of aerosol-cloud-interaction

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Introducing d_{max} as a new 2DVD variable

The 2-dimensional video disdrometer (2DVD)

The 2DVD is a ground-based in-situ precipitation sensor which provides information about particle size and shape, particle number concentration (PNC), and precipitation rates [1].

The maximum diameter (d_{max})

- newly introduced variable
- d_{max} represents true particle size better than the previously used volume-equivalent diameter (d_{eq})
- defined as the larger of the two feret diameters from both camera perspectives

➢ *feret diameter = longest distance between two points of a geometrical two-dimensional shape*

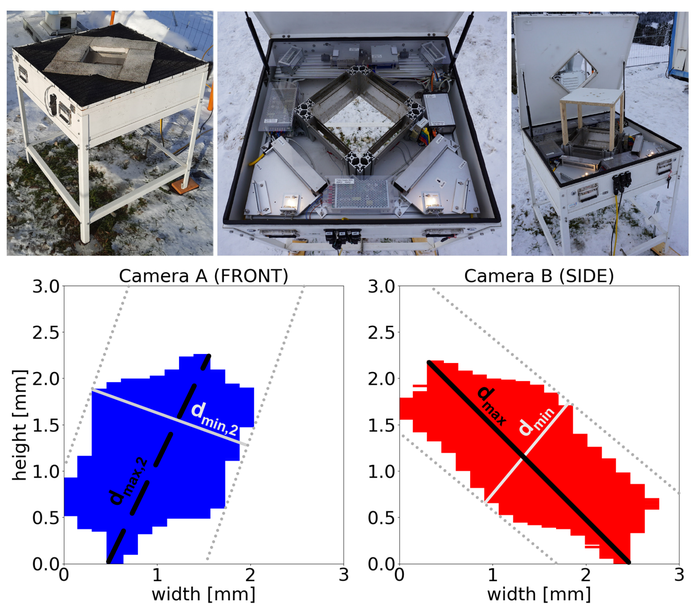

Fig. 1: The 2DVD in operation mode, with open lid, and with calibration pattern (top) as well as new variables sketched on an exemplary dendrite from both camera perspectives (bottom)

First evaluation of d_{max} with calibration spheres

Comparison with d_{eq}

d_{max} vs. d_{eq} for a set of steel spheres with different diameters reveals that d_{max} is slightly larger than d_{eq}

- as pixel edges are considered as boundaries
- if spheres are not recognized spherically (especially accounting for „outliers“)

Outlook:

d_{max} should be evaluated against other precipitation in-situ sensors such as the Video In Situ Snowfall Sensor [5].

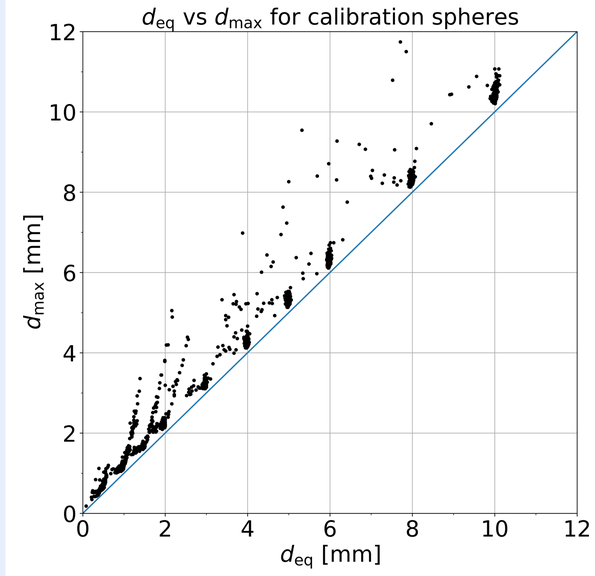

Fig. 3: d_{eq} versus d_{max} for the set of calibration spheres on 12 December 2022.

Particle shape comparison with HOLIMO

HOLIMO (HOLographic Imager for Microscopic Objects) [6] is an in-situ sonde developed by ETH Zürich. Both instruments detected columns and aggregates. Further crystal shapes could be identified by HOLIMO and 2DVD, respectively.

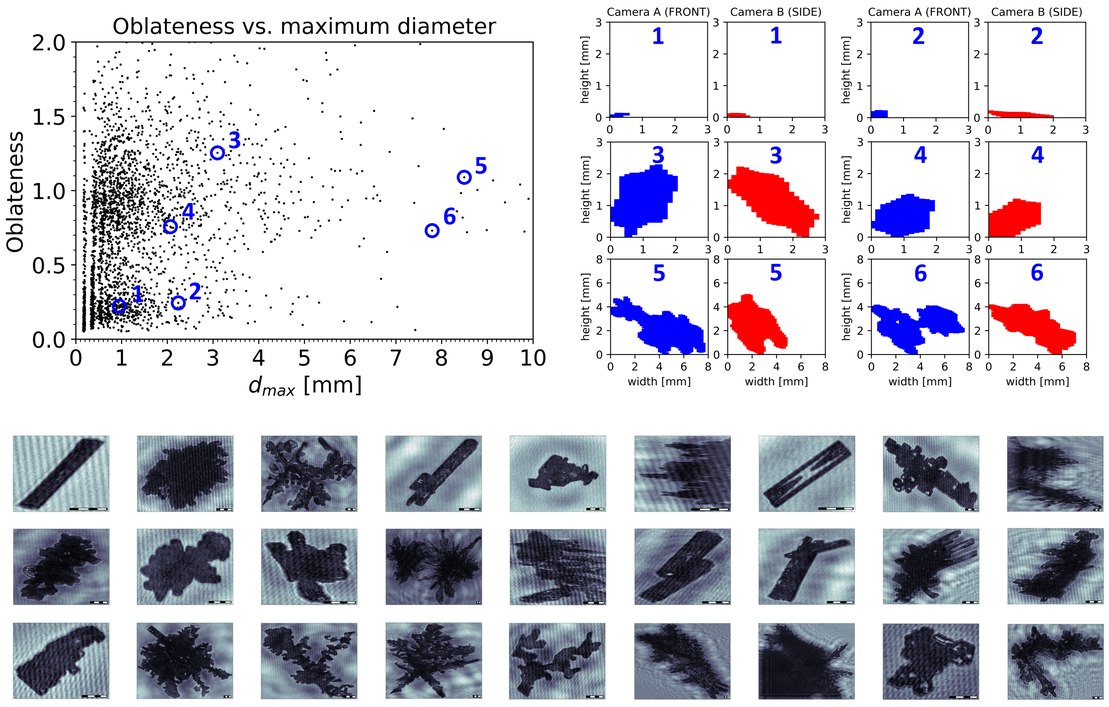

Fig. 4: 2DVD (top) and HOLIMO (bottom) measurements during PolarCAP/Cloudlab in Eriswil, Switzerland, on 17 January 2023 from 14:07 UTC to 14:11 UTC. Different clusters in the 2DVD oblateness vs. d_{max} diagram indicate different particle species. The scale in the lower right corner of each HOLIMO picture corresponds to 100 µm with 25 µm subdivision.

Measurement campaigns

PolarCAP / Cloudlab

- winter campaign 2022/23 within the collaborating projects PolarCAP (TROPOS) and Cloudlab (ETH Zürich) [2]
- location: Rapier-Platz near Eriswil, Switzerland
- operation of the mobile research platform LACROS [3] and further instrumentation of ETH Zürich and METEK GmbH

MOSAiC

(Multidisciplinary drifting Observatory for the Study of Arctic Climate)

- one-year Arctic Ocean expedition of the research vessel Polarstern, including a nine-month drift with the sea ice
- operation of the research platform OCEANET [4] including Raman lidar and 2DVD measurements

Fig. 2: The mobile platform LACROS in Eriswil, Switzerland, in winter 2022/23 (top) and the mobile platform OCEANET onboard of Polarstern during MOSAiC in winter 2019/20 (bottom, picture was taken by Michael Gutsche (CC-BY 4.0), AWI).

Comparison with remote sensing retrieval LIRAS-ice

LIRAS-ice and its comparison with d_{max} and PNC from 2DVD

LIRAS-ice [7]

- retrieves ice crystal number concentration (ICNC), ice water content, and mean particle maximum diameter from combined LIDAR and cloud Doppler radar
- assumes a dominating particle shape

2DVD

- can deliver dominating particle shape
- mean d_{max} calculated by averaging all d_{max} over Δt (30 s)
- $PNC = \frac{1}{\Delta t}\sum_{j=1}^{M}\frac{1}{A_{eff,j}\cdot 10^{-6}\cdot v_j}$ [m^{-3}] with the effective measuring area A_{eff} and fall velocity v for each particle j

Case study: 2DVD vs. LIRAS-ice (different shape assumptions) during MOSAiC (Arctic Ocean) on 10 November 2019

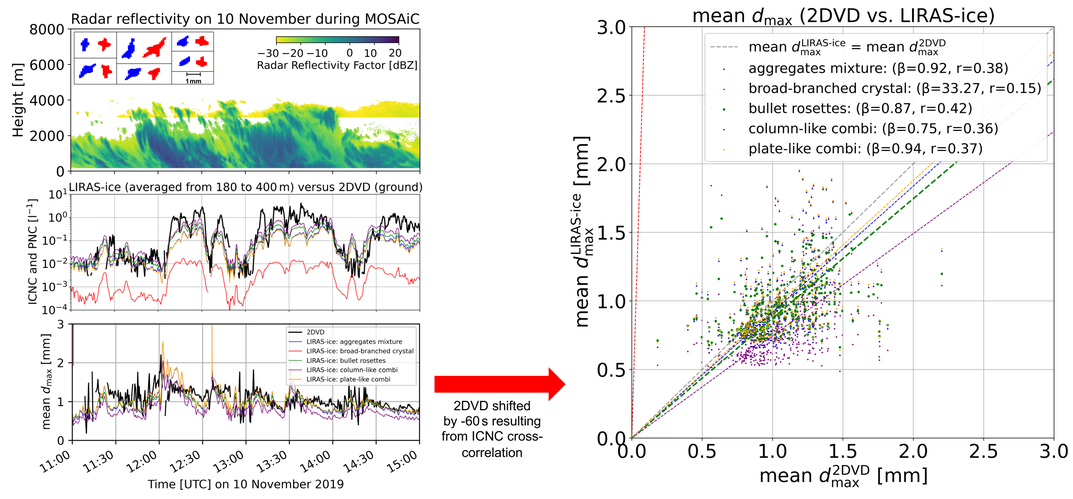

Fig. 5: LIRAS-ice versus 2DVD results of measurements during MOSAiC in the Arctic Ocean on 10 November 2019 including different shape assumptions for LIRAS ice. The 2DVD mainly detected bullet rosettes. Left: Radar reflectivity and exemplary 2DVD, LIRAS-ice ICNC and 2DVD PNC timeseries, and d_{max} timeseries. Right: Scatter plot with 2DVD data shifted by -60 seconds (cross-correlation); the plot includes regression slope β and Pearson correlation coefficient r.

Conclusions

- LIRAS-ice and 2DVD ICNC / PNC and mean d_{max} agree well in this period
- bullett rosettes detected by the 2DVD as shape assumption for LIRAS-ice: amongst the highest correlations of the testet particle shapes

References

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