



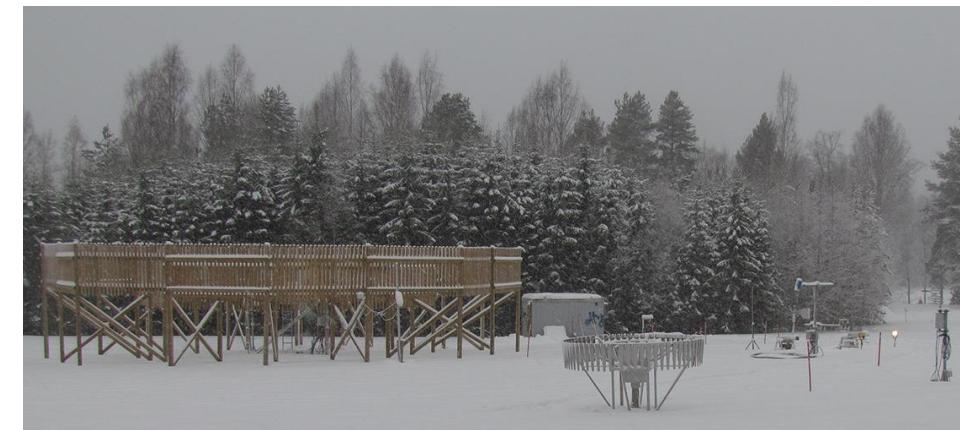
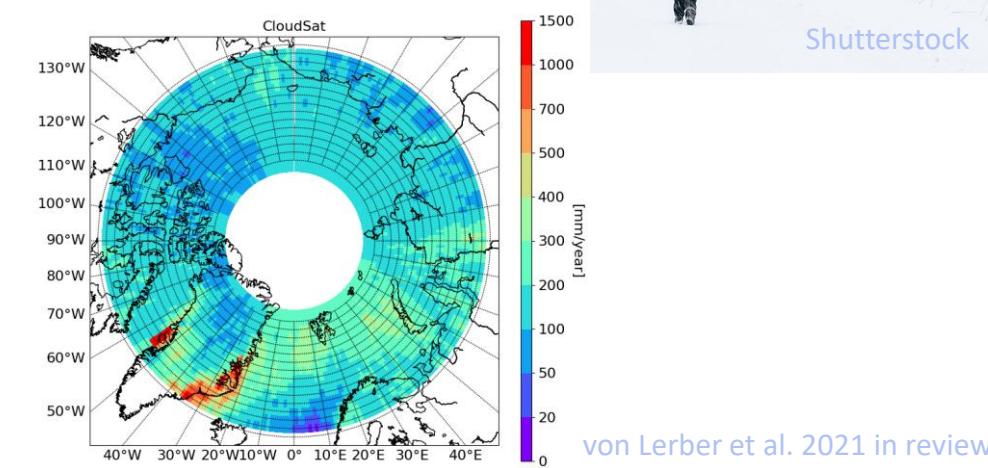
Statistical differences of snowfall microphysics at GPM ground validation sites

Feb, 2 2022. Snow Seminar

von Lerber A., Moisseev D., Pettersen C., Kulie M., Hudak D., and Rodriguez P.

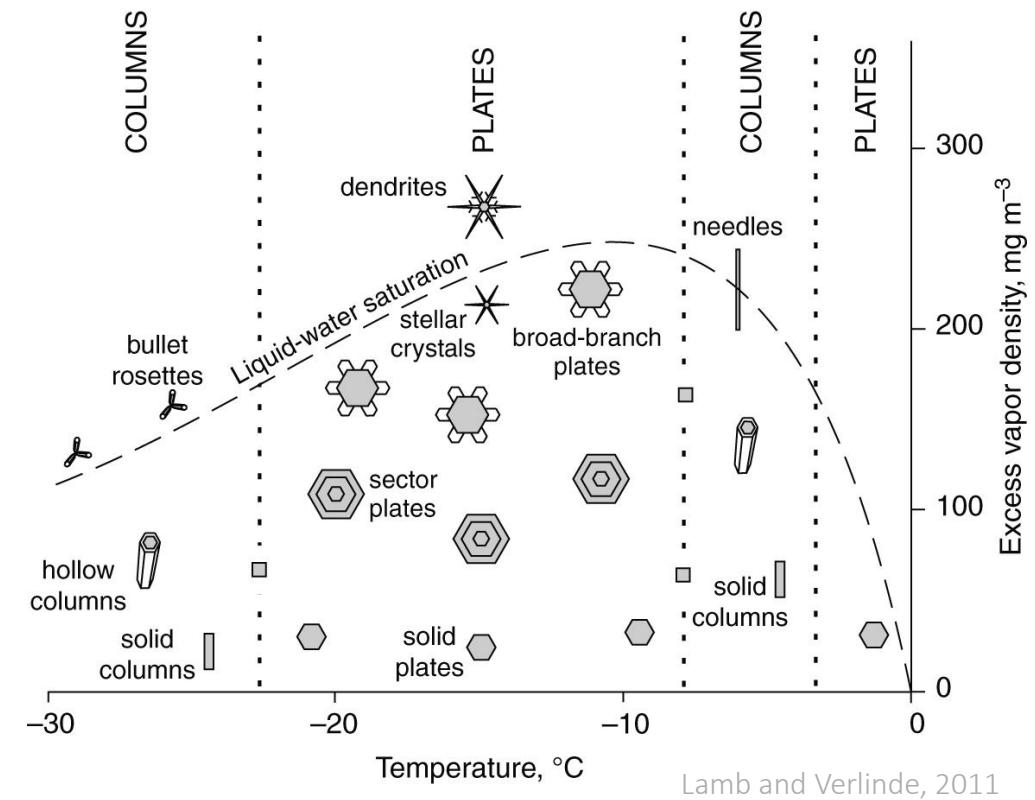
Snowfall observations

- Snowfall affects the societies
- Snowfall is a climate indicator
- Remote sensing instrumentation, radars and radiometers provide a continuous monitoring of precipitation both at local and global scales
- Surface observations:
 - Microphysical parametrization for forward modeling and retrievals
 - Validation of performance and calibration of radar retrievals



Challenges in measuring winter precipitation

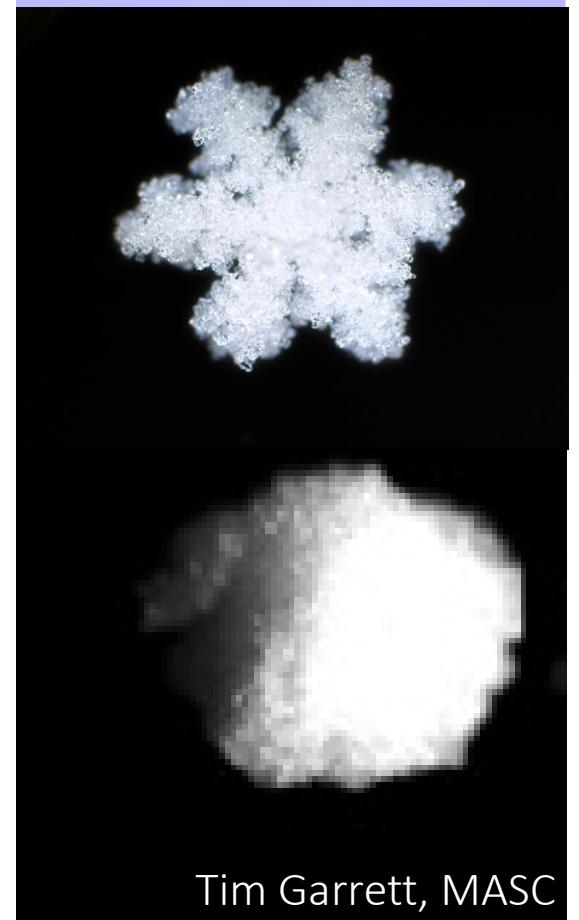
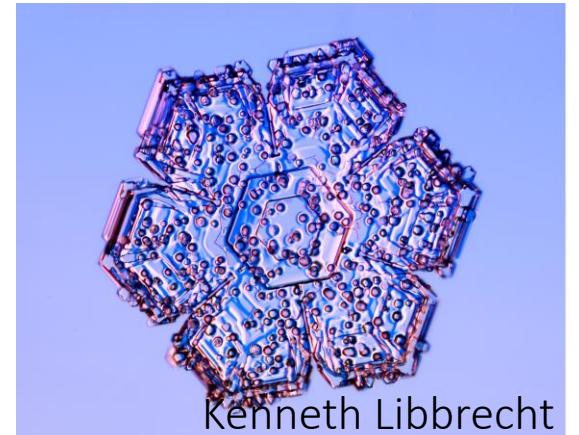
- Irregular structure of snow particles and continuous changes due to microphysical processes
 - Six-fold symmetry (hexagon)
 - Temperature defines the crystal type
 - Humidity conditions influences to the complexity of the snow crystal



Lamb and Verlinde, 2011

Snow growth processes: Riming

- Super-cooled cloud droplets collide with the falling snow particle and rapidly freeze on its surface
- Increases mass and fall velocity of the particle
- Rimming contribute to the snowfall rates and a large percentage of cloud systems contain super-cooled liquid water



Snow growth process: Aggregation

- Grow by colliding and sticking with other crystals
- Aggregation process is dependent on the crystal habit and temperature
- Aggregation is an effective growth mechanism
- Large and fluffy aggregates are typically seen in LES = Lake Effect Snow

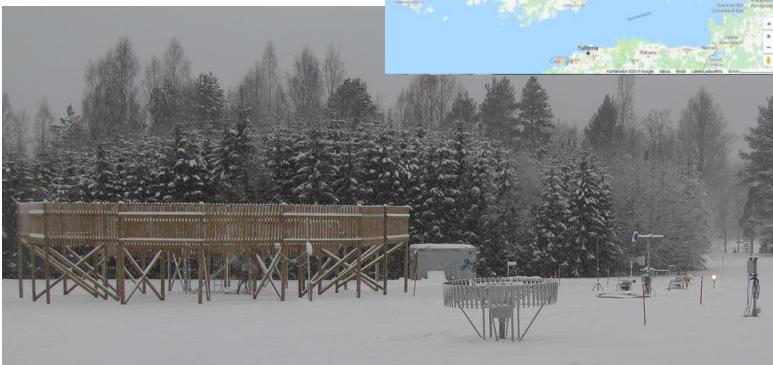


Kenneth Libbrecht



Tim Garrett, MASC

How different is snowfall worldwide?



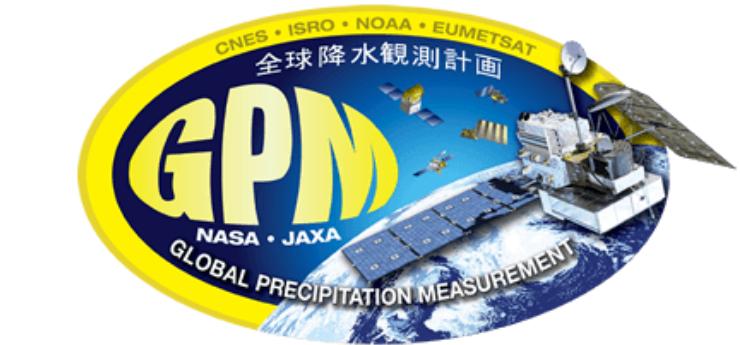
University of Helsinki, SMEAR II-site, Hyytiälä, Finland

Data 2014-2019, 97 events



CARE, Egbert, Canada

Data 2014-2017, 44 events

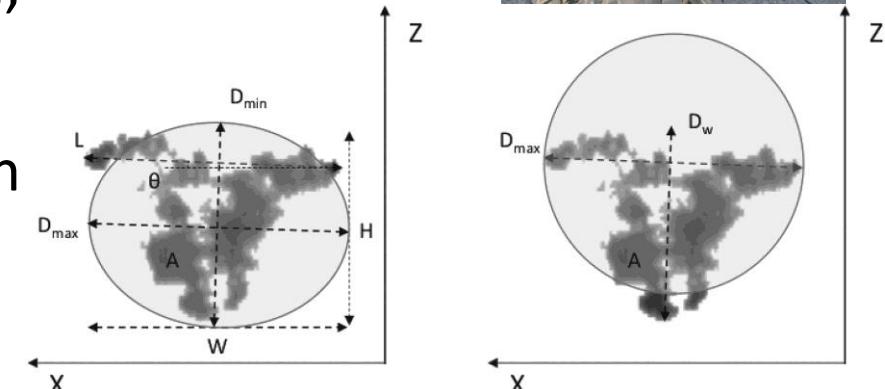
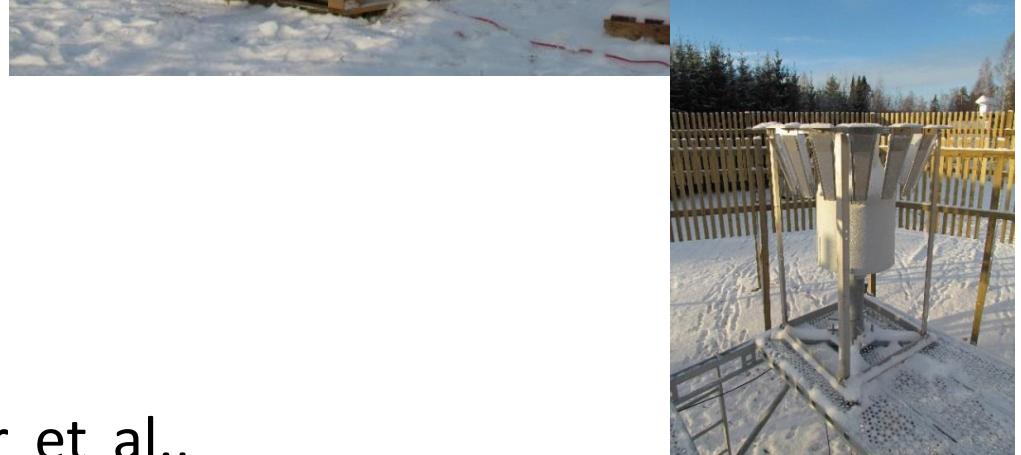


Marquette, Michigan, USA

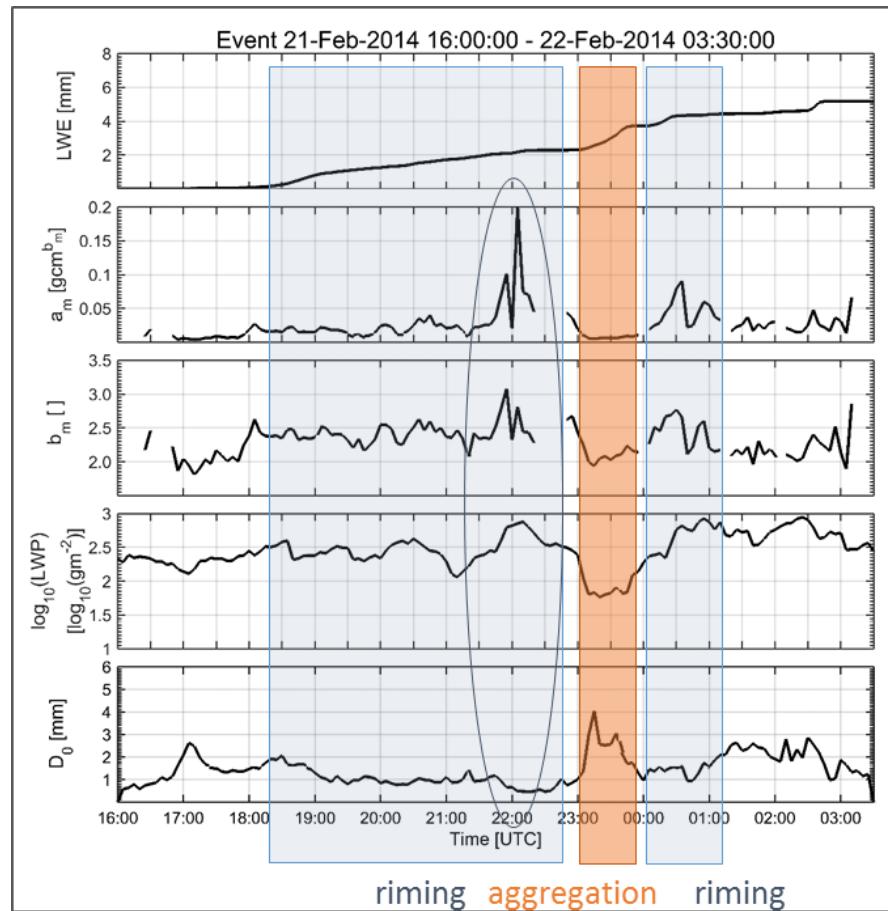
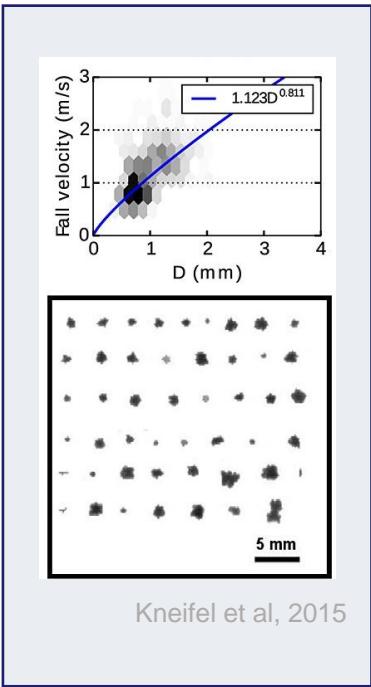
Data 2017-2019, 26 events

Precipitation Imaging Package (PIP) + gauge

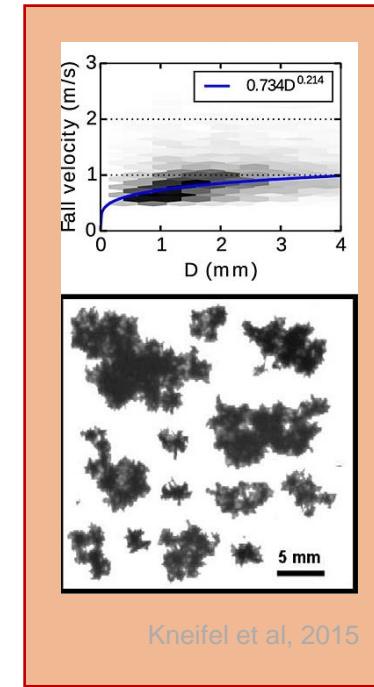
- PIP provides observations
 - particle size distribution (PSD)
 - particle fall velocity
 - particle dimension characteristics
- mass retrieval of the falling particles (von Lerber et al., 2017)
- total retrieved accumulation of PIP is scaled with precipitation gauge observations



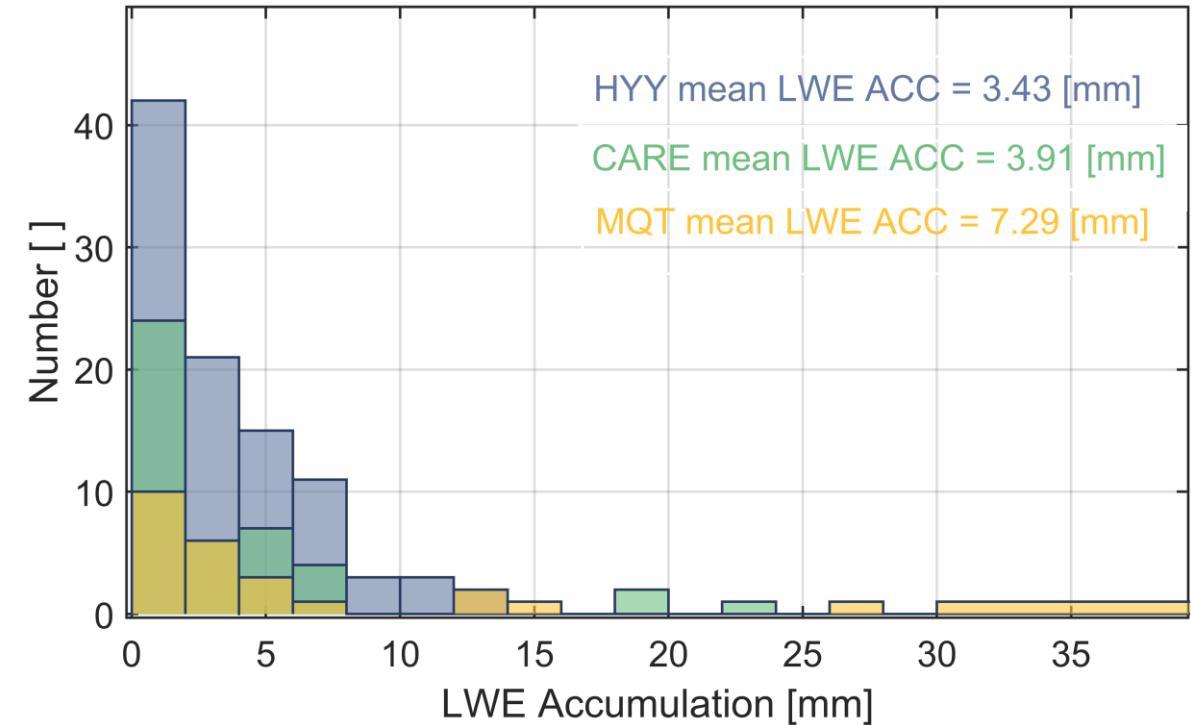
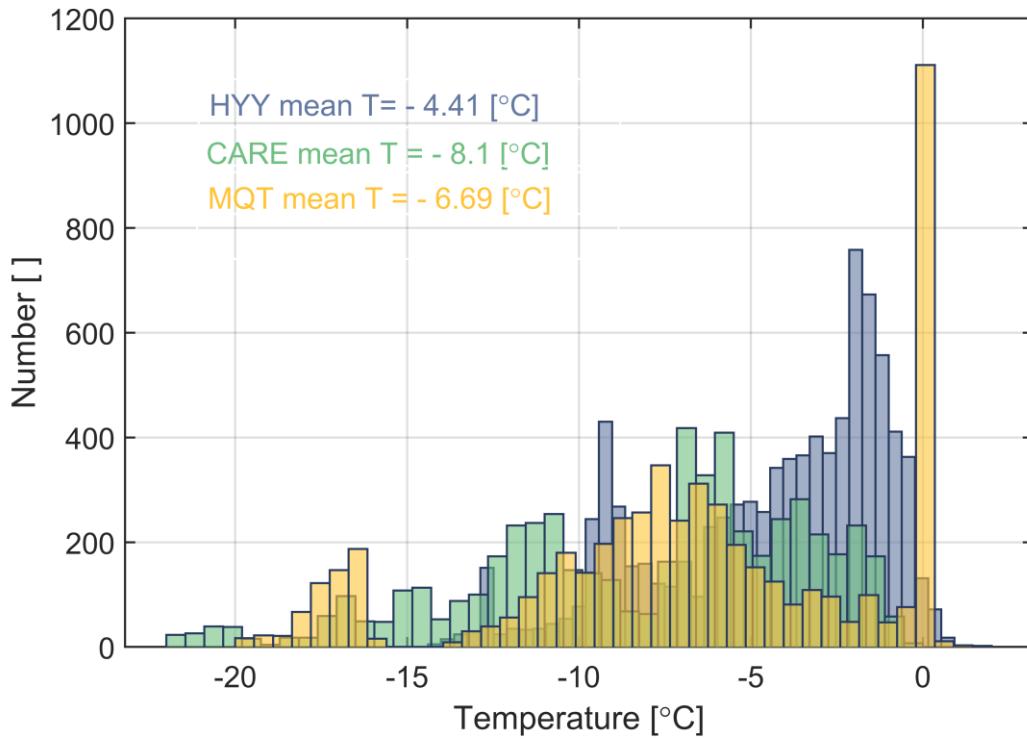
Snowfall retrieval dataset:



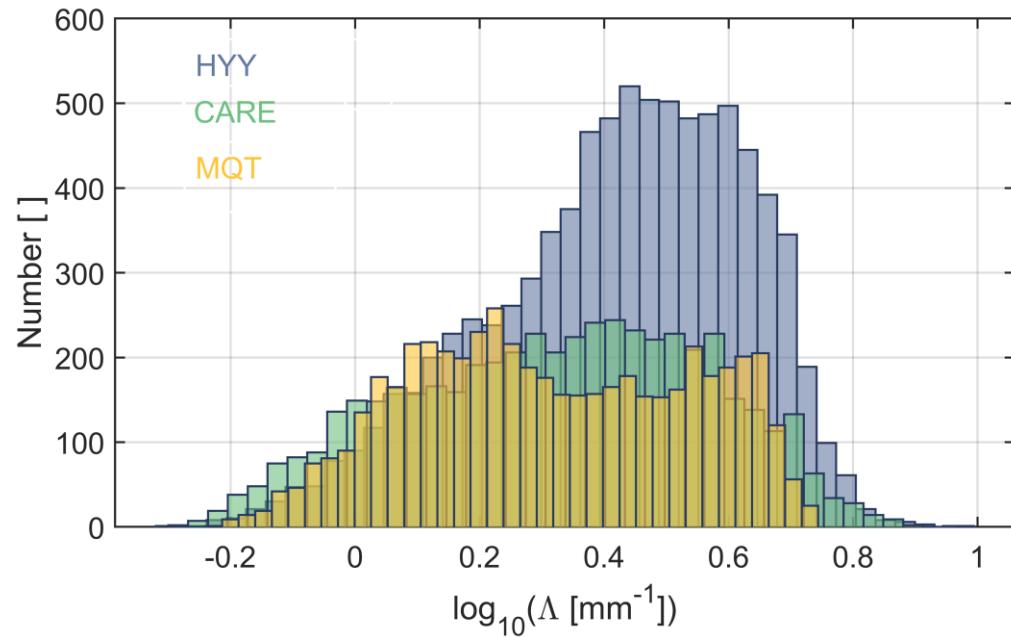
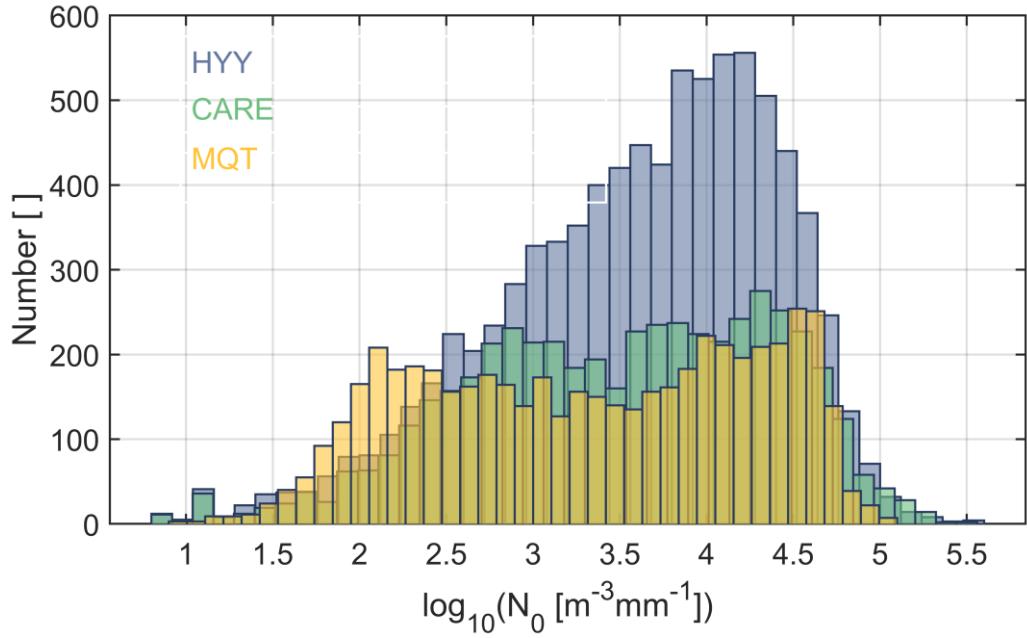
von Lerber et al, 2017



Environmental conditions



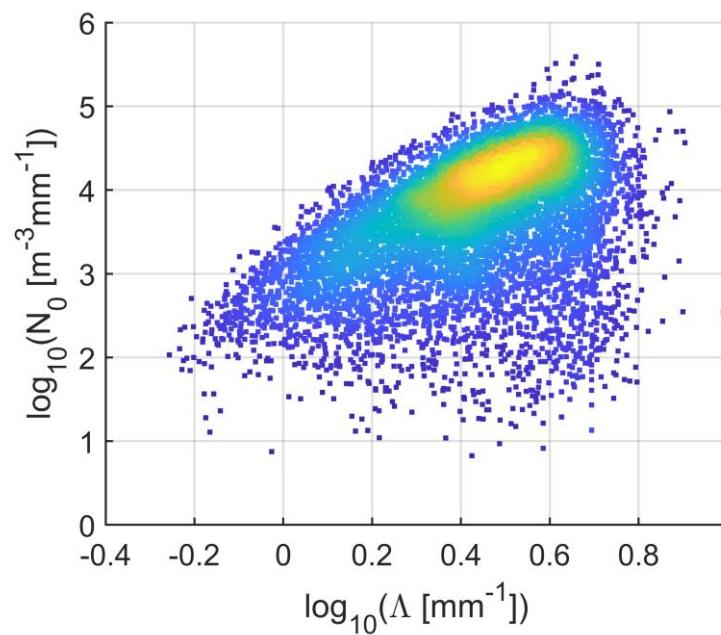
Particle Size Distributions (PSD)



- Bi-modality observed in CARE and MQT PSDs (Pettersen C. et al. 2020)

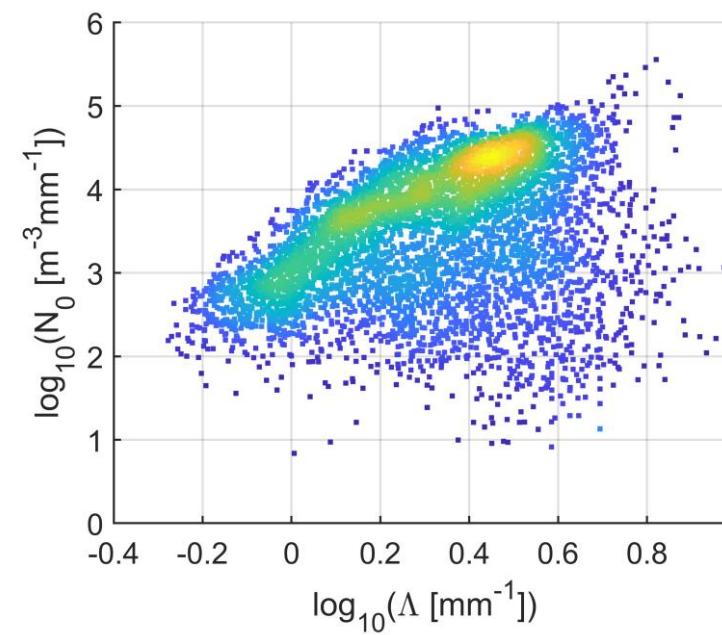
Particle Size Distributions (PSD)

SMEAR II-site, Hyytiälä, Finland



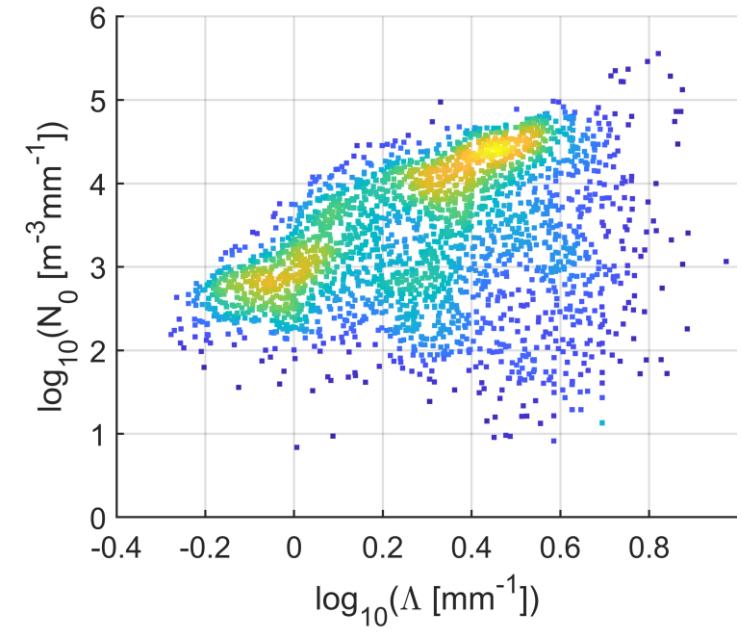
ALL

CARE, Egbert, Canada



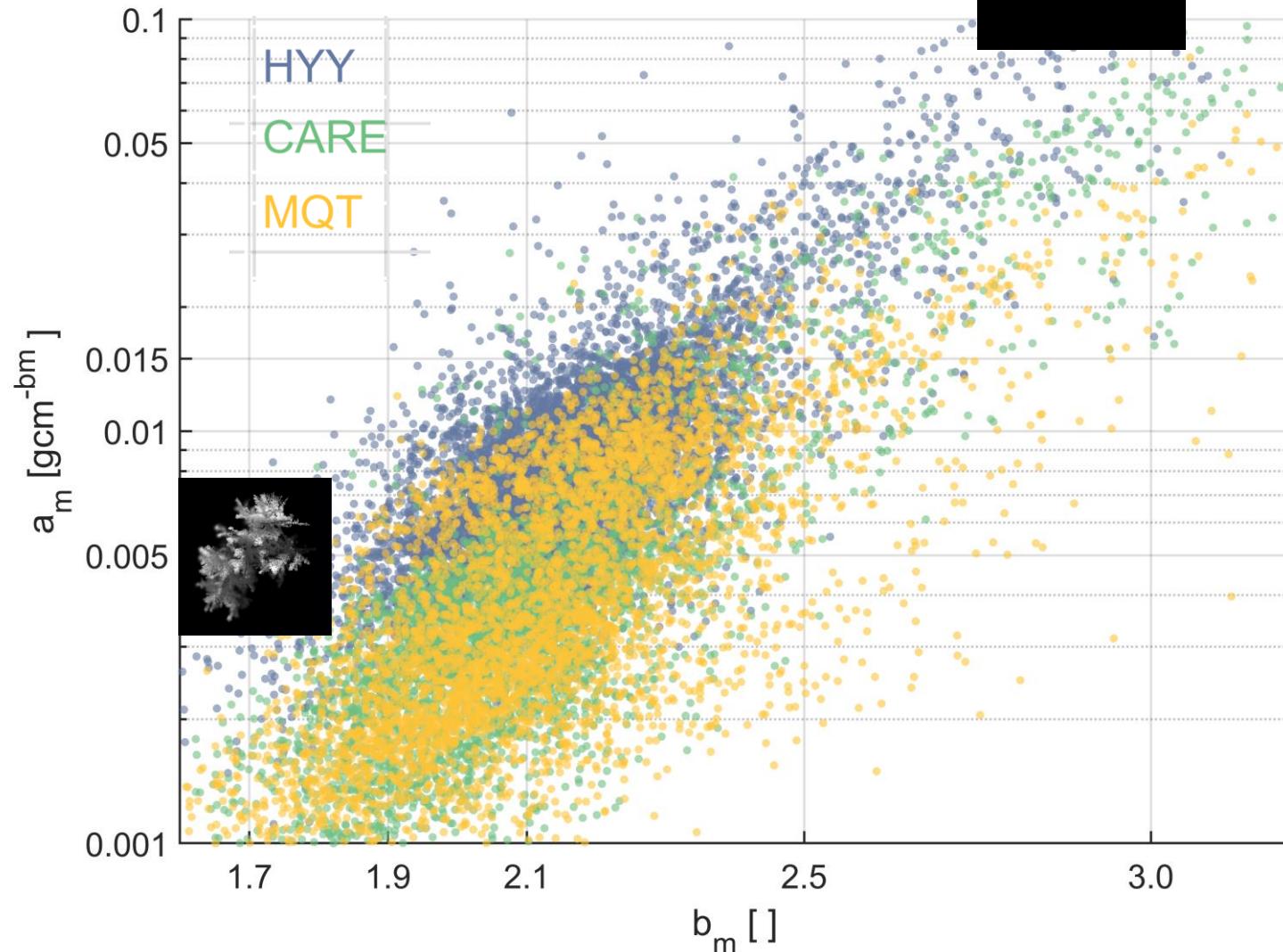
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CARE, Egbert, Canada



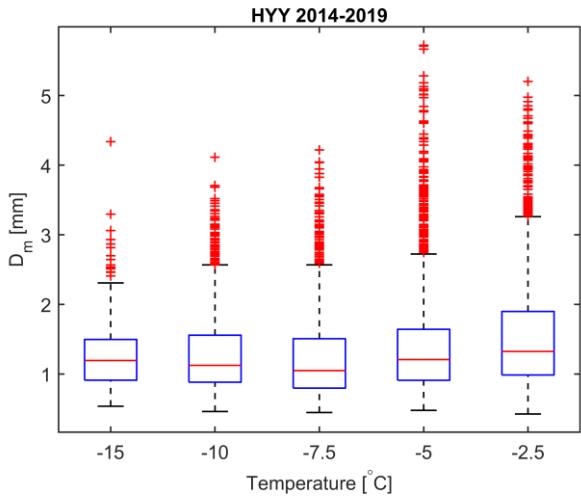
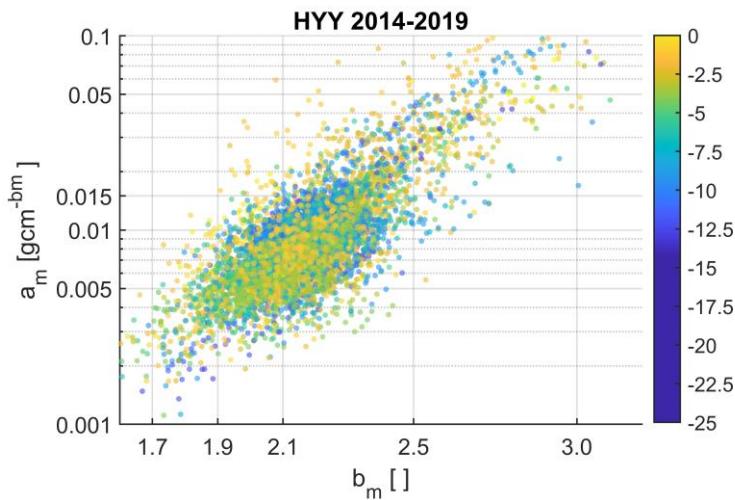
LES

Mass $m = aD^b$

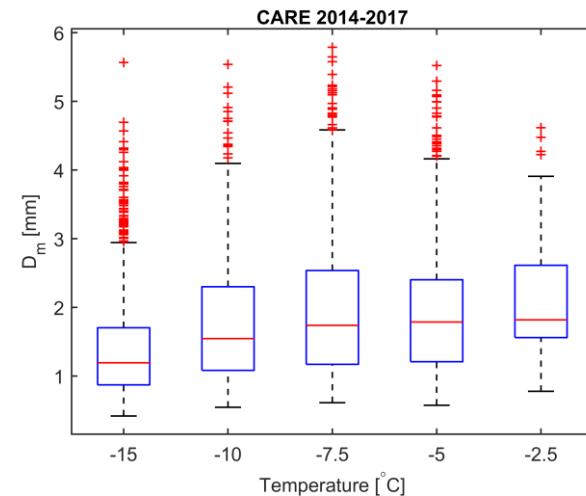
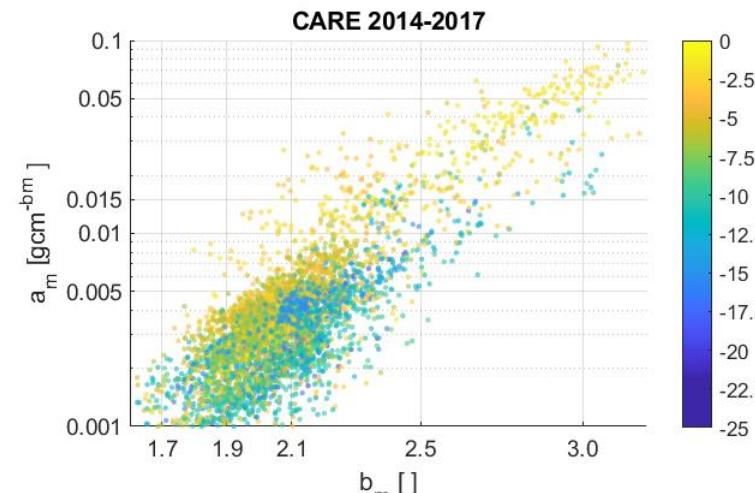


$$\text{Mass } m = aD^b$$

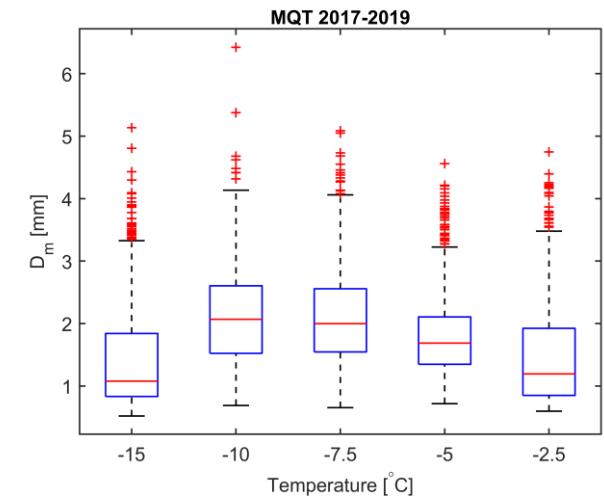
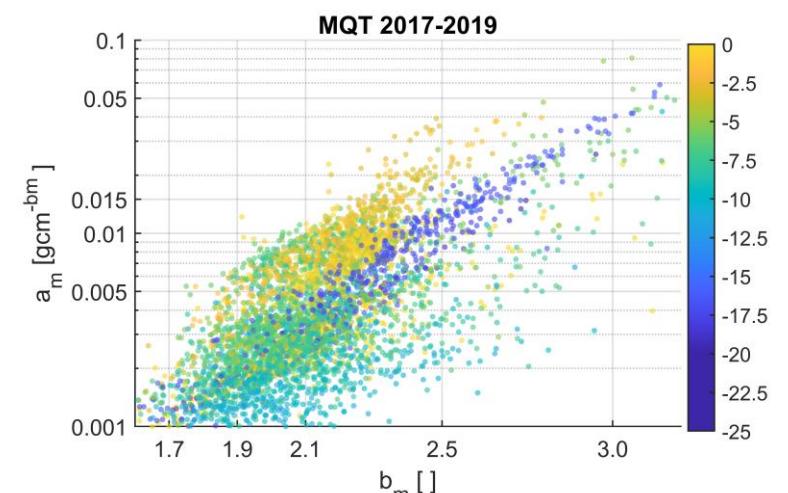
SMEAR II-site, Hyytiälä, Finland



CARE, Egbert, Canada

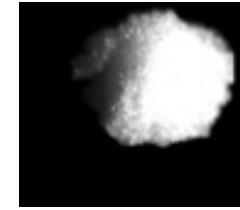


Marquette, Michigan, USA

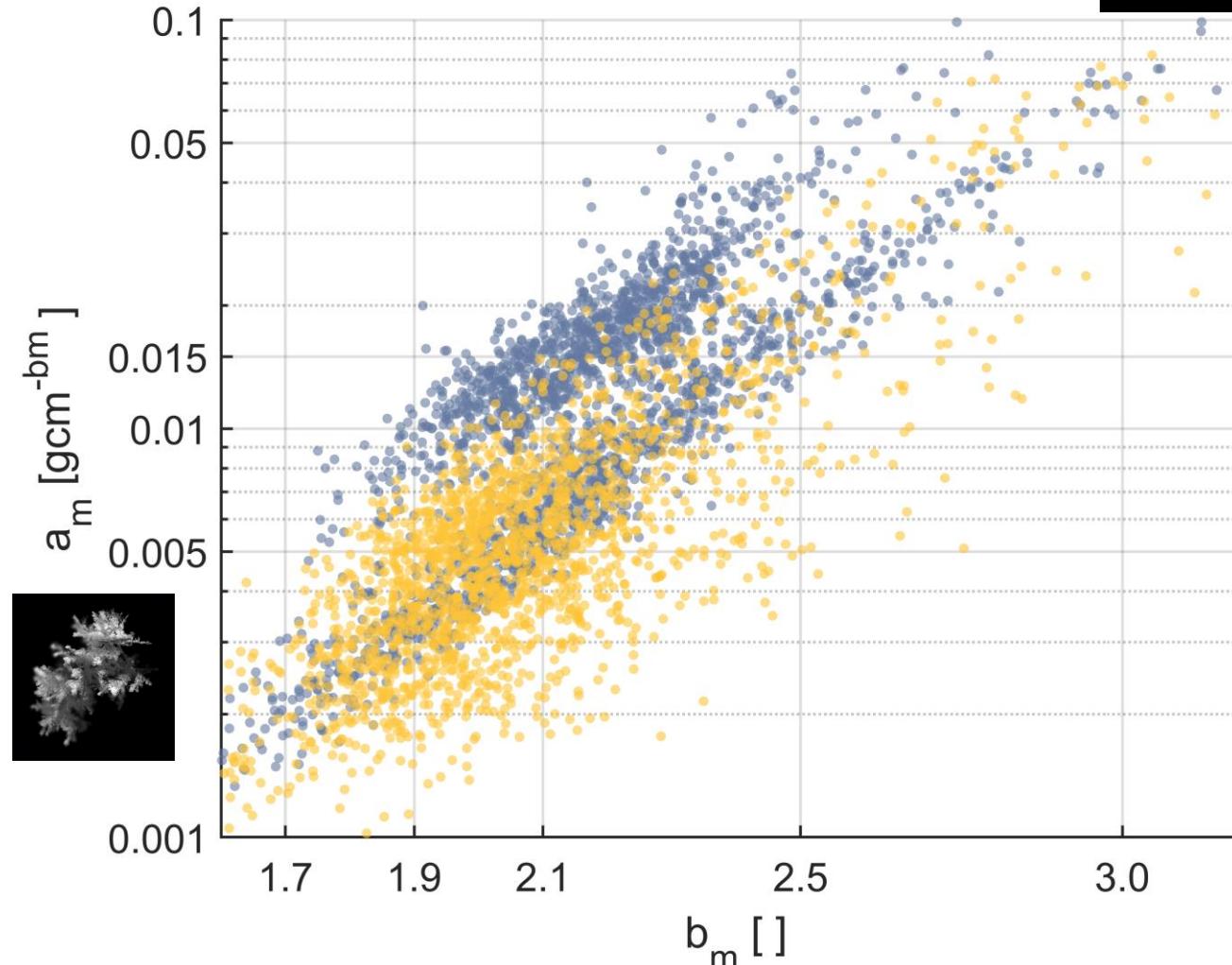


$$\text{Mass } m = aD^b$$

Marquette, Michigan, USA

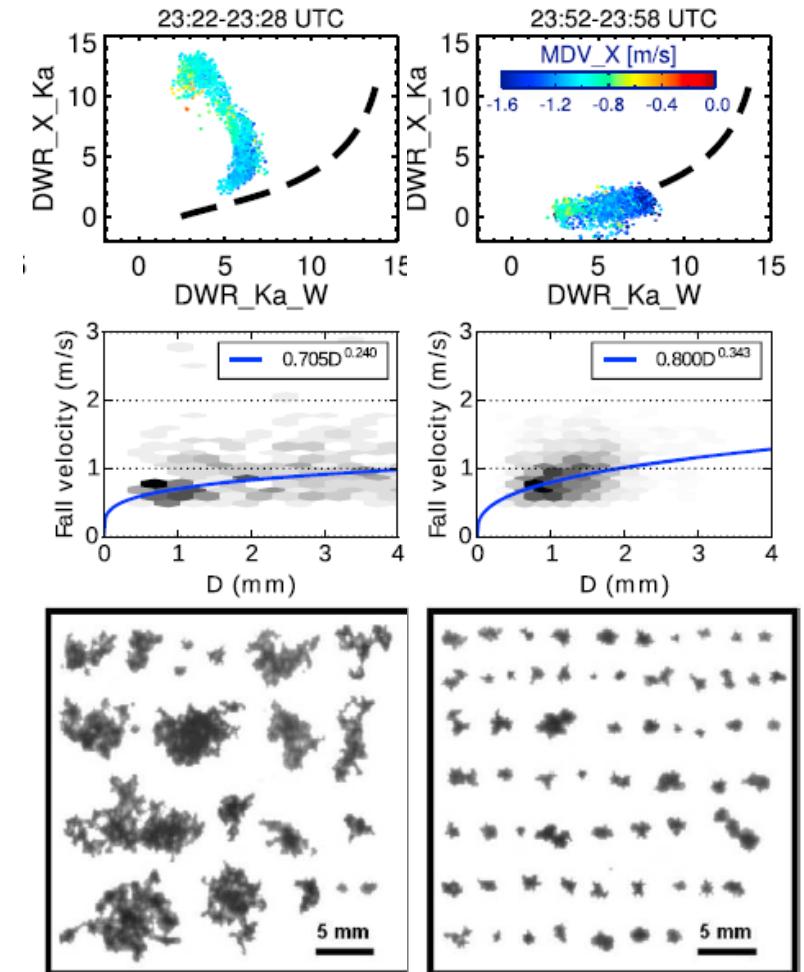


High density
Low density -> LES



Conclusions

- Generally, snow seems to have higher density (prefactor a higher in $m(D)$) in Hyytiälä, than in Marquette or in CARE → riming is more frequent process
- In LES, snow has lower density, and PSD has bi-modality
- Snow particle characteristics in SYNOP cases in Marquette and CARE are closer to snow particles in Hyytiälä
- The radar retrievals can be improved by identifying the snowfall microphysical processes or habits e.g. with triple-frequency observations



Kneifel et al, 2015

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