Measuring snowfall properties with the Video In Situ Snowfall Sensor during MOSAiC

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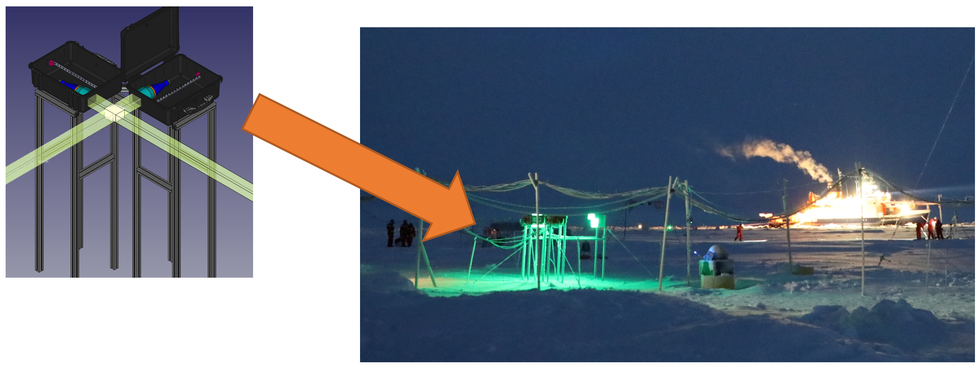
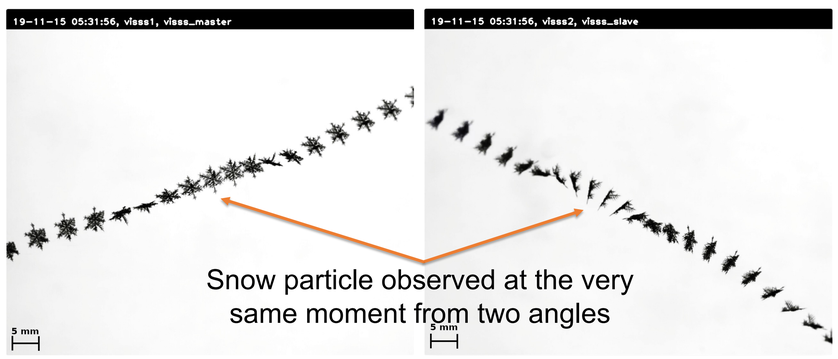
Motivation

- Snowfall formation is an essential process of the climate system impacting surface albedo, glaciers, sea ice, freshwater storage, and cloud lifetime.
- The processes involved in snowfall formation can be identified by their fingerprints on snow particles:
  - Water vapor deposition determines the general shape
  - Aggregation causes snowflakes consisting of multiple particles
  - Riming describes the freezing of cloud droplets onto the snow particle and can eventually form graupel
- In order to exploit these unique fingerprints of cloud microphysical processes, high quality optical observations are required
- Also, retrievals of remote sensing observations can be better constrained when knowing snow particle shapes and sizes
- Crucial observational gap during the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) experiment where the research icebreaker Polarstern was drifting with the sea ice for a full year.



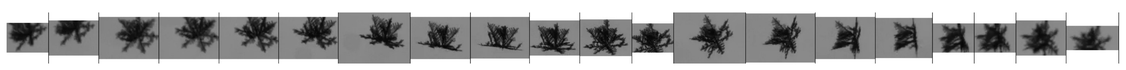
The Video In-Situ Snowfall Sensor (VISSS)

- Developed specifically for the MOSAiC campaign, funded by CIRES
- Observes shadows of snow particles in front of green backlight
- Two synchronized cameras allow for observing snow particles from different perspectives
- Reliable particle size estimation due to telecentric optics
- Measurement volume approx. 8 x 8 x 6 cm
- Optical resolution approx. 60 µm
- 140 frames per second
- Open source design (hard & software!)



Data processing

1. Identify moving particles ✓
2. Characterize particles (size, aspect ratio, complexity,…) ✓
3. Use probabilistic retrieval to match particles in time and combine cameras (in progress)
4. Estimate fall velocity and “3D” properties (max. Dimension) (planned)
5. Apply degree of riming retrieval (proposal pending)
6. Integrated into snowfall rate retrieval and process all MOSAiC Data (proposal pending)



MOSAiC Data set

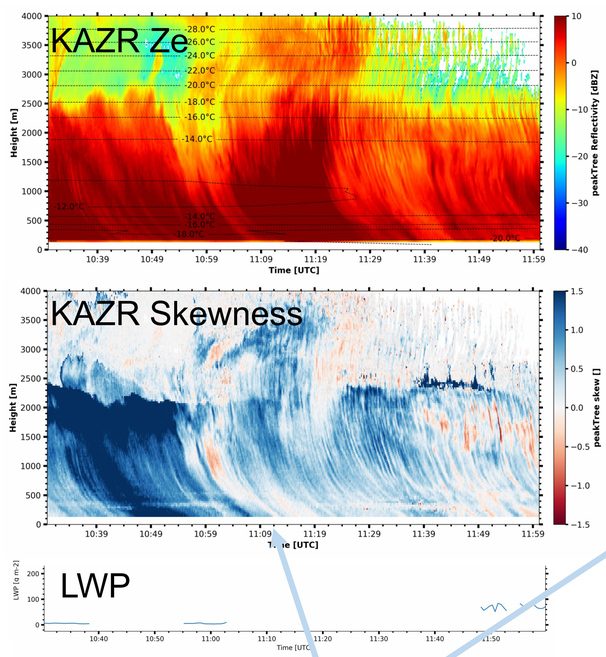
- high instrument availability & good data quality if wind velocity < 10 m/s
- quality control: blowing snow
- 10 TB data needs to be processed

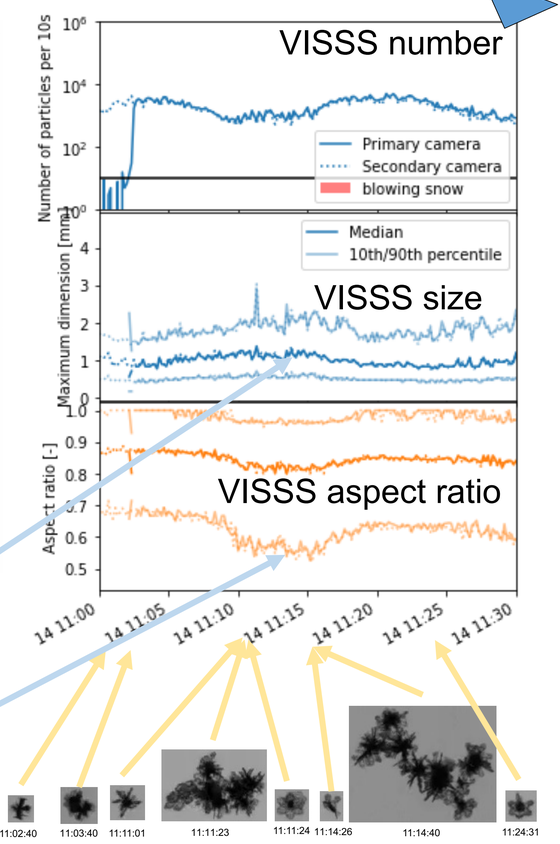
Future plans

- Proposal for MOSAiC data analysis pending
- Install VISSS at Hyytiälä, Finland in fall 2021
- 2nd gen VISSS with increased distance between camera and measurement volume, higher frame rate and better resolution is built right now and will be installed in Ny-Ålesund in fall 2021
- Proposal to deploy 2nd gen at DOE ARM SAIL campaign in Colorado 2022 will be submitted in May

Case study 14th Feb 2020

- VISSS helps to understand radar observations
- Radar skewness increased in fall streak around 11:10
- Positive skewness – few faster falling particles
- VISSS shows that these are aggregates that are mixed with the regular plates
- Aggregation decreases number concentration
- Aggregates are composed of the same particle type
- Why is aggregation only active during in this fall streak 11:11 to 11:17 UTC?
- No riming visible – consistent with low LWP values

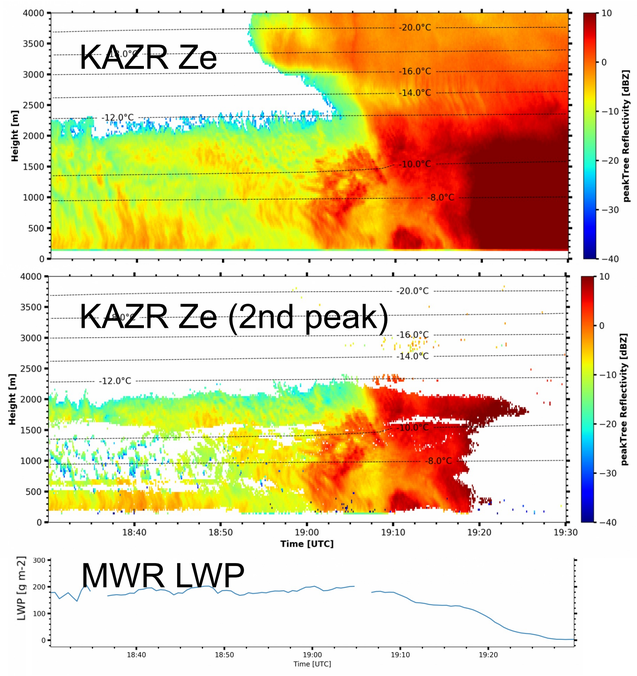


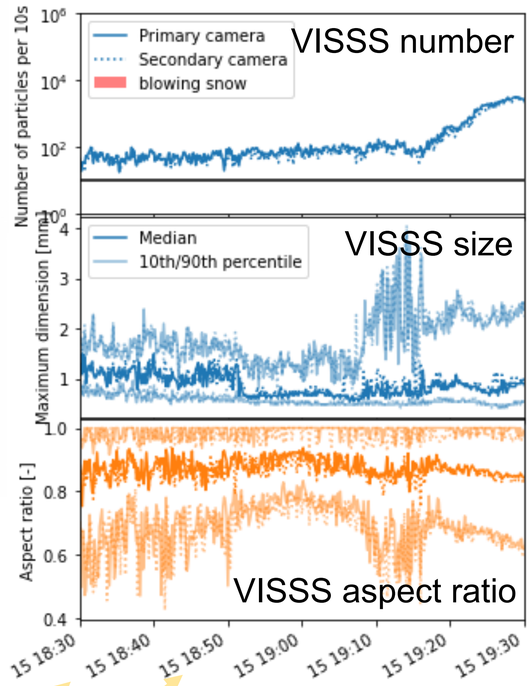


additional aggregates:
- enhanced skewness
- increased size
- decreased aspect ratio

Case 15th Apr 2020

- VISSS can observe large sample sizes!
- Use PeakTree (Radenz et al 2019, AMT) to separate contributions of individual hydrometeor types to the radar signal
- Radar shows at least two particle types until 19:20
- LWP drops o almost 0 g/m2 at the same time
- VISSS shows particle types are rimed dendrites (low aspect ratio)
- Particle size drop at 18:50 consistent with radar reflectivity drop





- 18:30 – 18:50 irregular rimed particles
- 18:50 – 19:10 very small particles
- 19:10 – 19:20 very small particles and rimed dendrites
- 19:20 – 19:30 very small particles and occasional aggregates (not resolved by radar)