ICE PARTICLE PROPERTIES IN ARCTIC CIRRUS

In situ balloon measurements

Thomas Kuhn, LTU

SRS Meeting Lund, March 16, 2021

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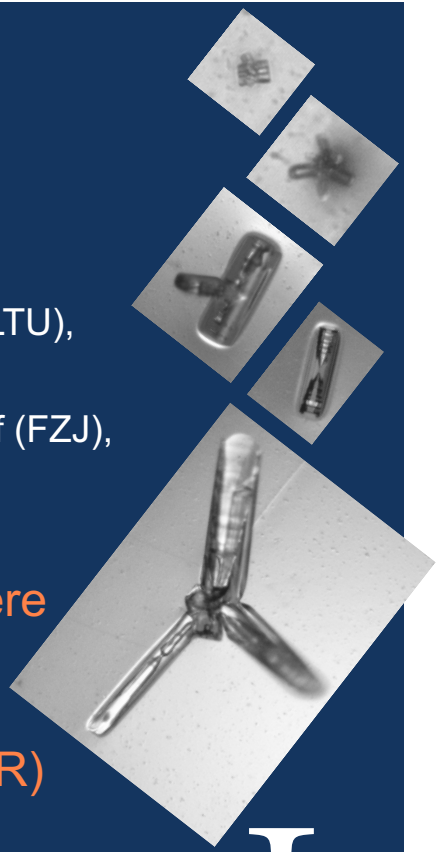
Ice particle properties in Arctic cirrus
In situ balloon measurements

Balloon launch from Esrange Space Center

- Thomas Kuhn, LTU
- Veronika Wolf, Mathias Milz (LTU),
- Peter Völger (IRF),
- Martina Krämer, Christian Rolf (FZJ),
- Andrew Heymsfield (NCAR)



Cirrus: ice clouds in upper troposphere
- ~4 – 11 km; ~-40 – -70ºC
- Often; large areas
- Thin, translucent (vis), absorbing (IR)

Observation:
- In-situ; remotely
- Few in situ in Arctic

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Balloon-borne in-situ measurements

- Series of balloon launches (2012 - 2018)
- Esrange Space Center, Kiruna
- Funded by SNSA

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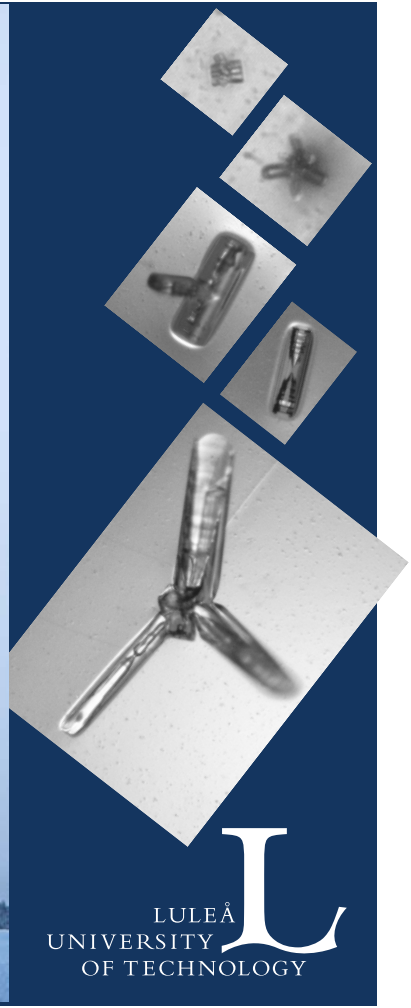

Balloon launches from Esrange Space Center

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inlet


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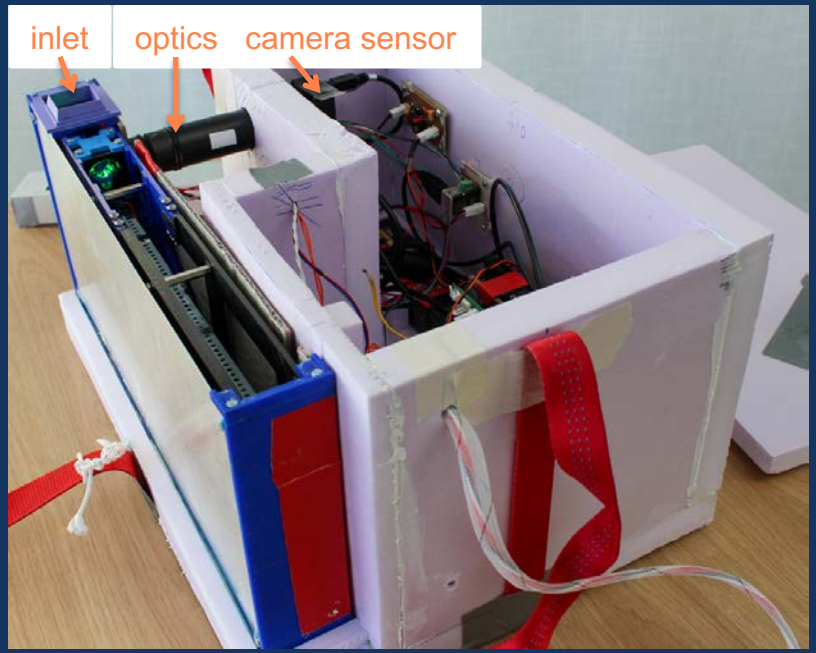
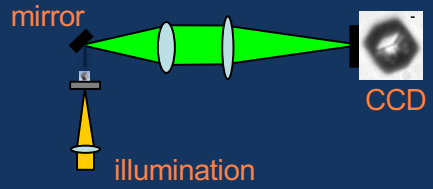
Ice particle in-situ imaging:
Balloon-borne Ice Cloud particle Imager **B-ICI**

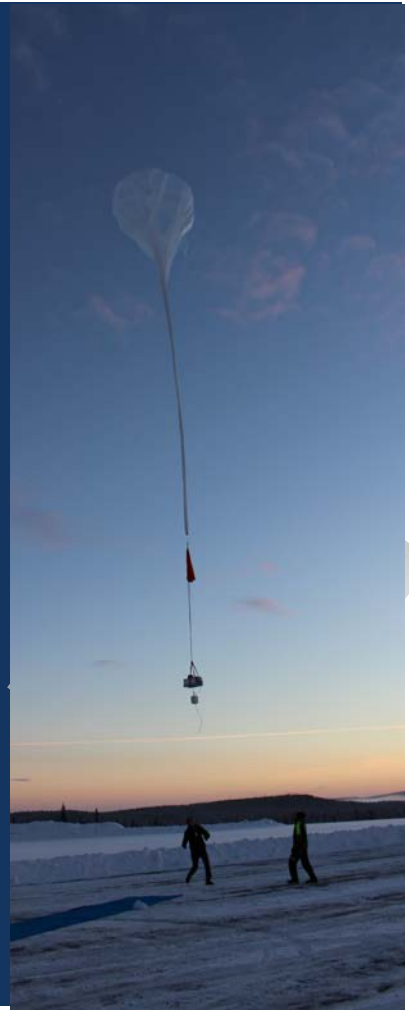


B-ICI
Kuhn, T., and A. J. Heymsfield (2016), Pure Appl. Geophys., 173 (9), doi: 10.1007/s00024-016-1324-x.

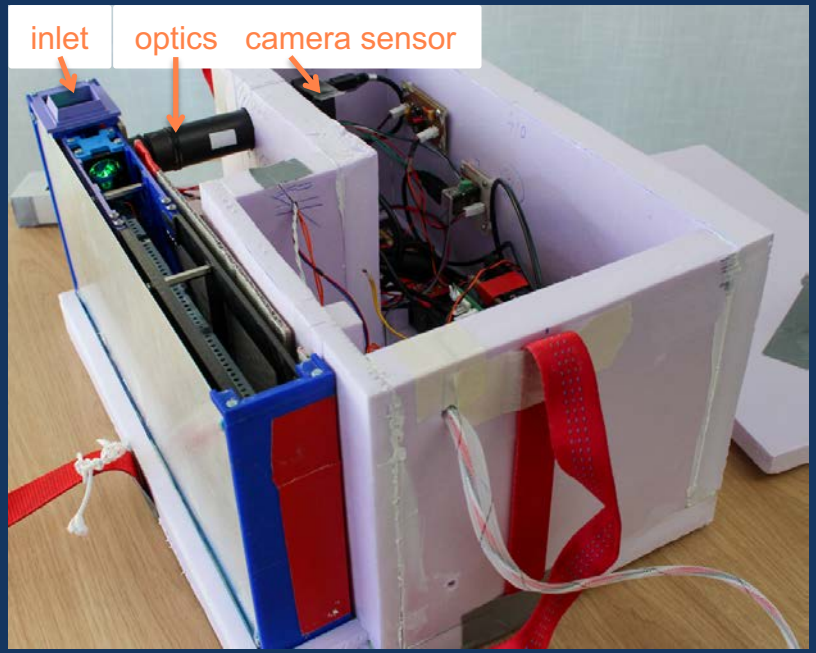
instrument uncovered Particles…

- "fall" through the inlet
- collide with a film tape
- imaged on the film
- high resolution images





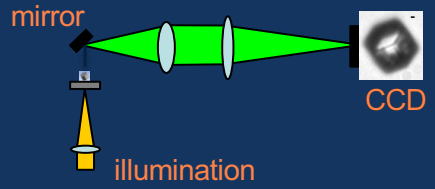
Ice particle in-situ imaging: B-ICI



B-ICI
Kuhn, T., and A. J. Heymsfield (2016), Pure Appl. Geophys., 173 (9), doi: 10.1007/s00024-016-1324-x.

instrument uncovered

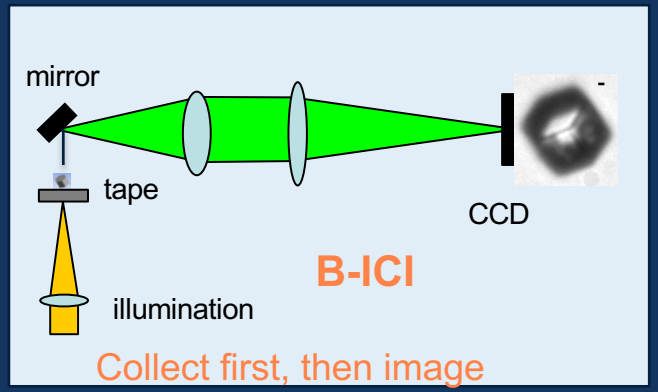
- 4 m long film
  - oil coated
  - 1 mm s^{-1}
- 30 mm long inlet
- well defined sampling volume

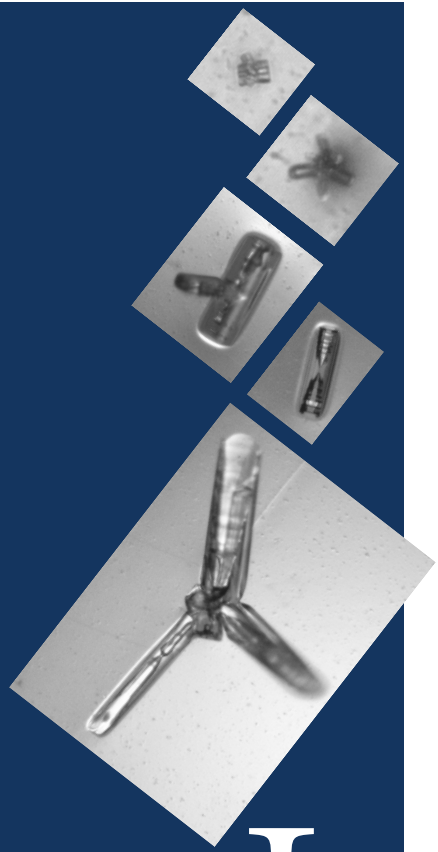


Ice particle in-situ imaging: B-ICI

Determine properties

- Single ice cloud particles
  - Size
  - Area
  - Shape
  - Volume, mass
- Ice clouds
  - Particle concentration
  - Particle size distribution (PSD)
  - Extinction coefficient





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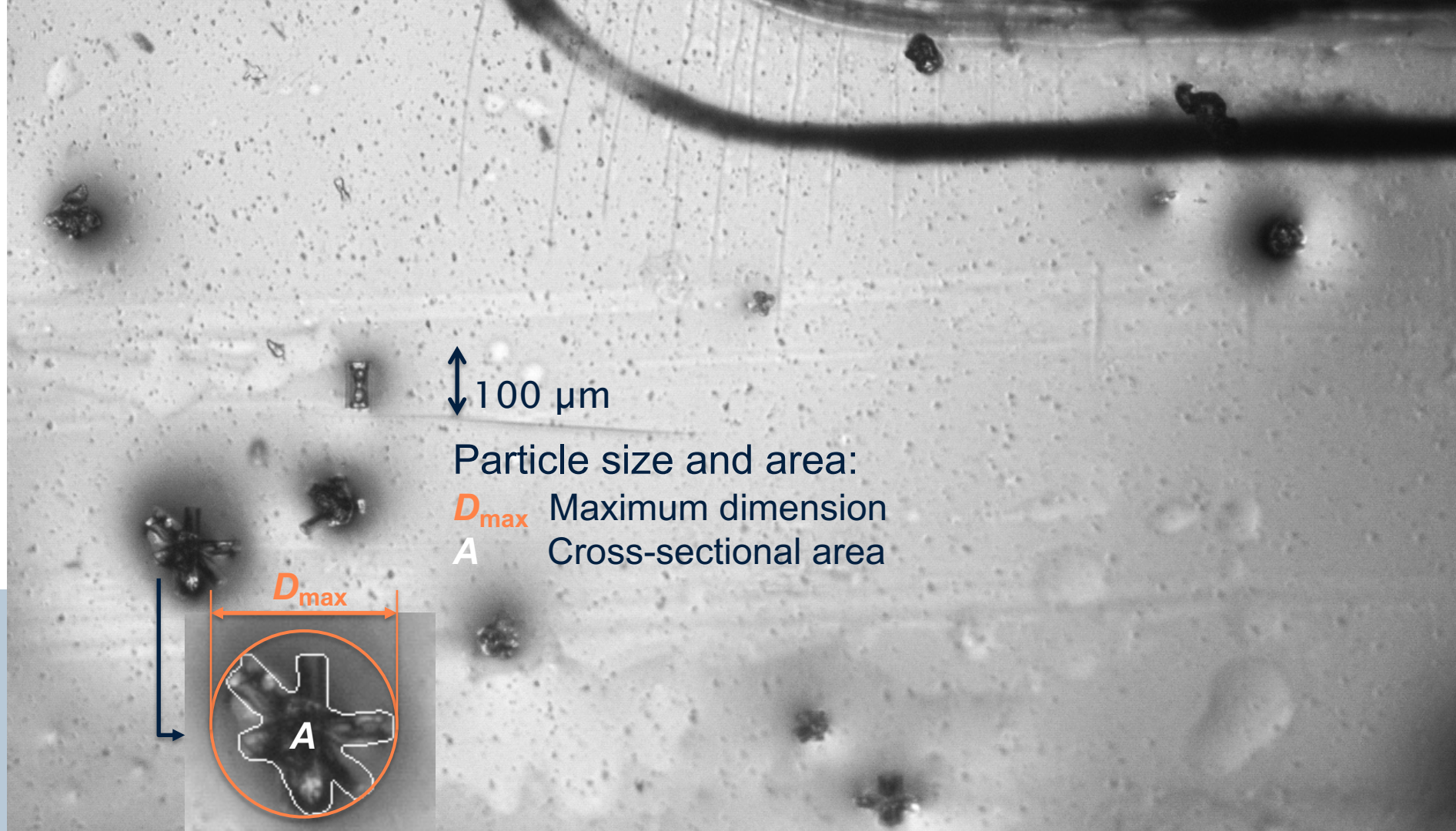
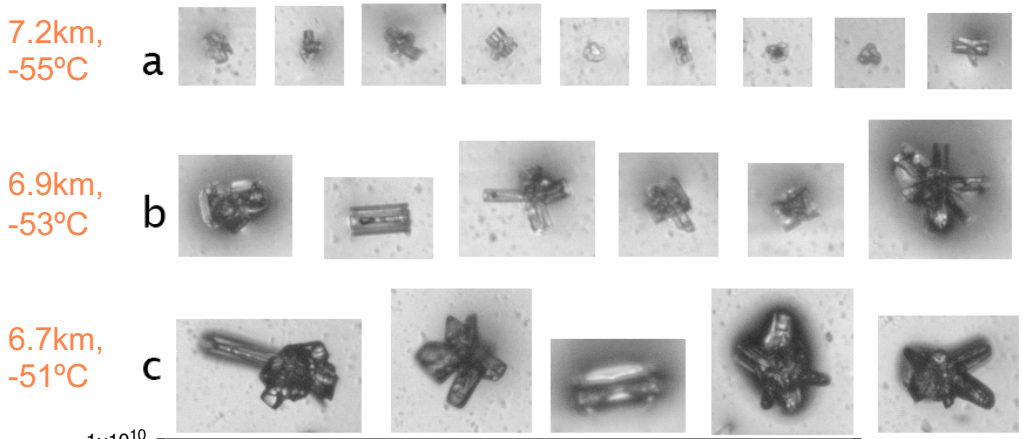
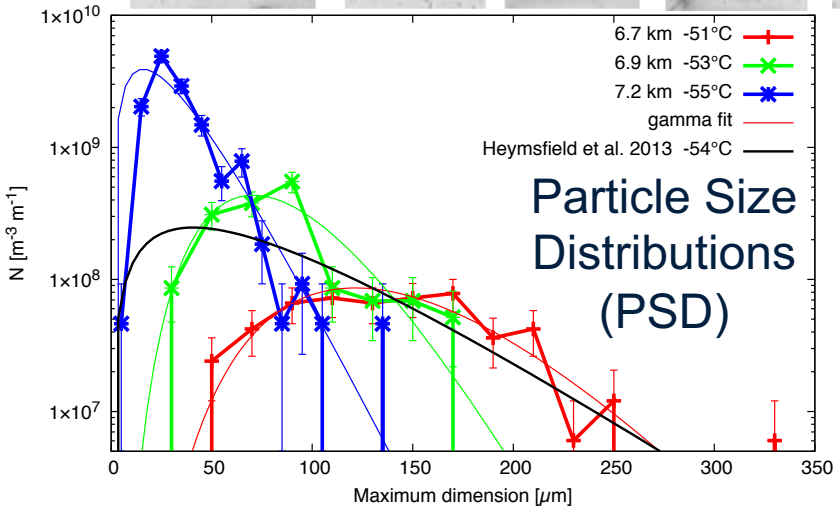
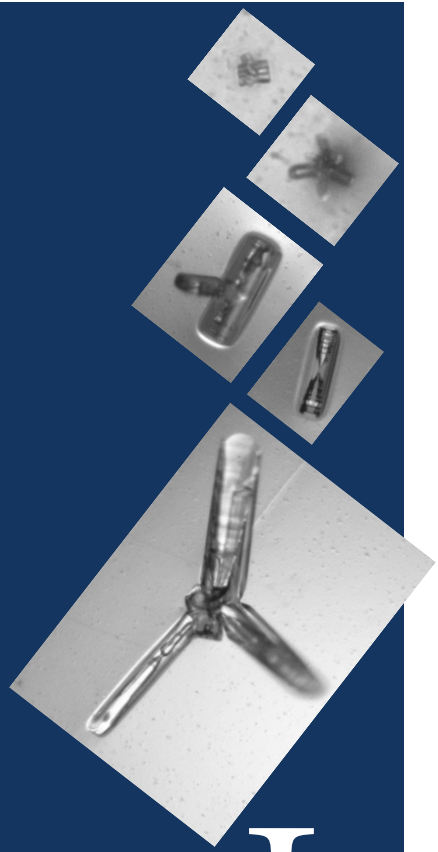

100 µm
Particle size and area:
D_{max} Maximum dimension
A Cross-sectional area
D_{max}
A

Images 2012-04-04





100 μm



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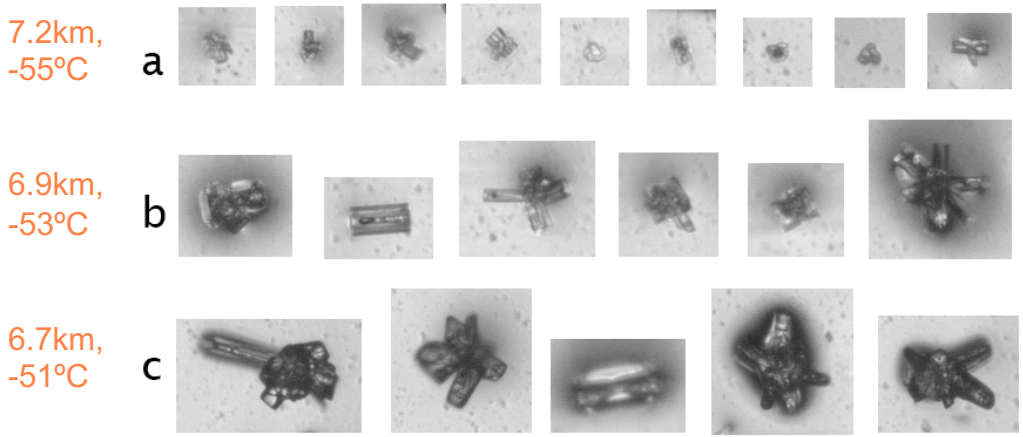
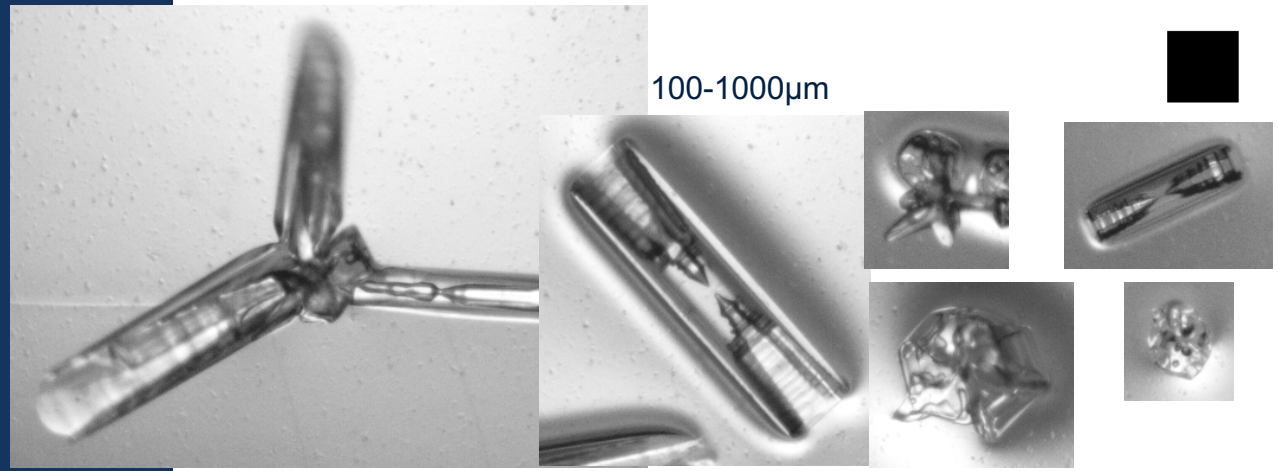
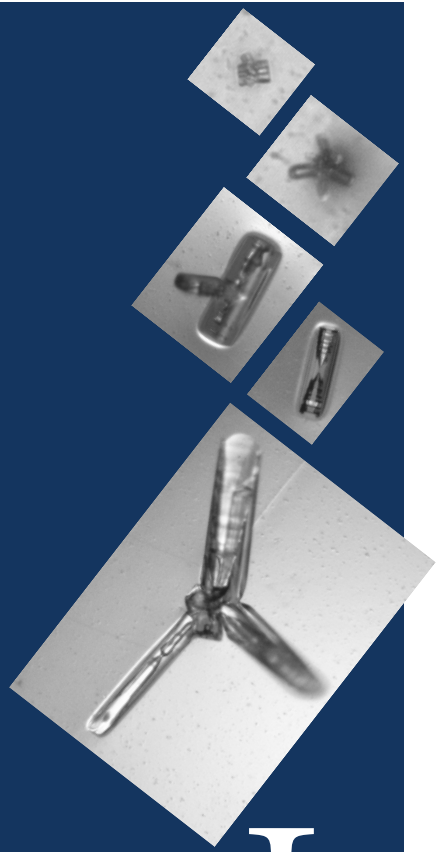
Images 2012-04-04

Images 2016-02-12







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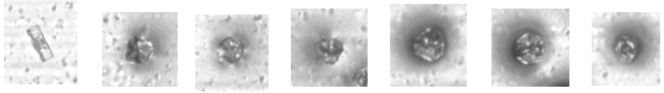
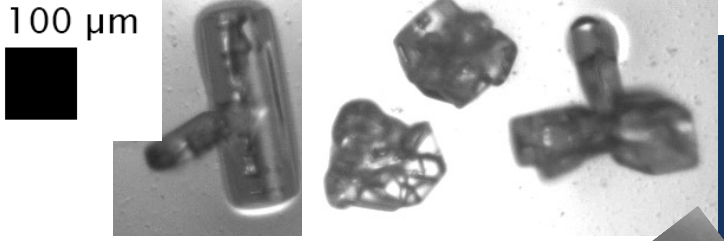
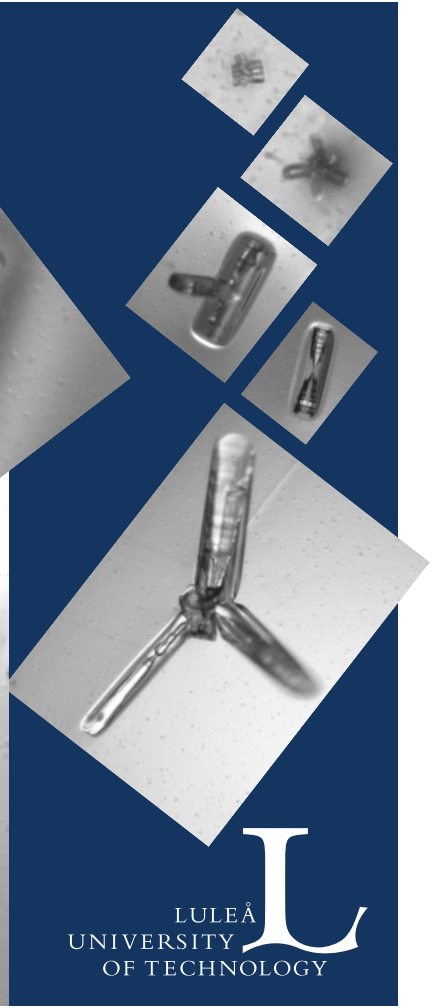


2013-02-20

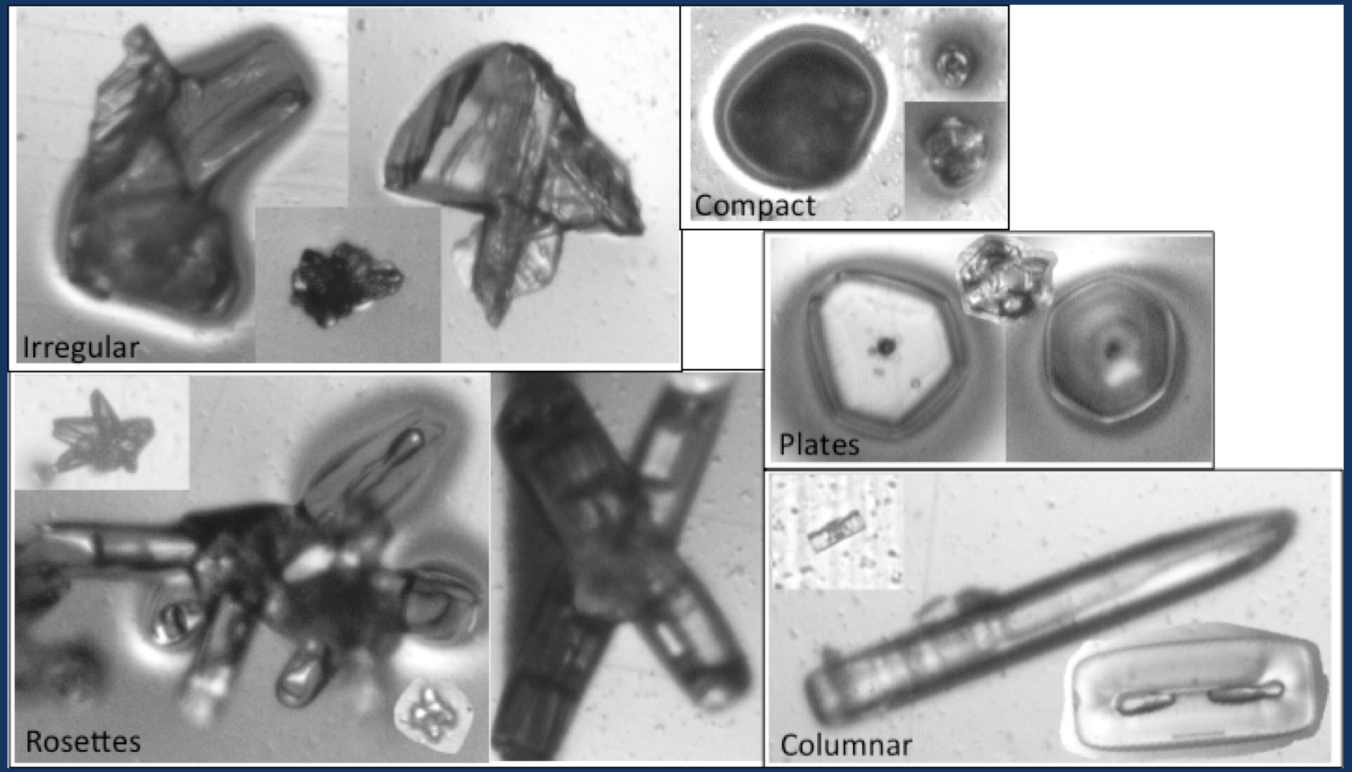


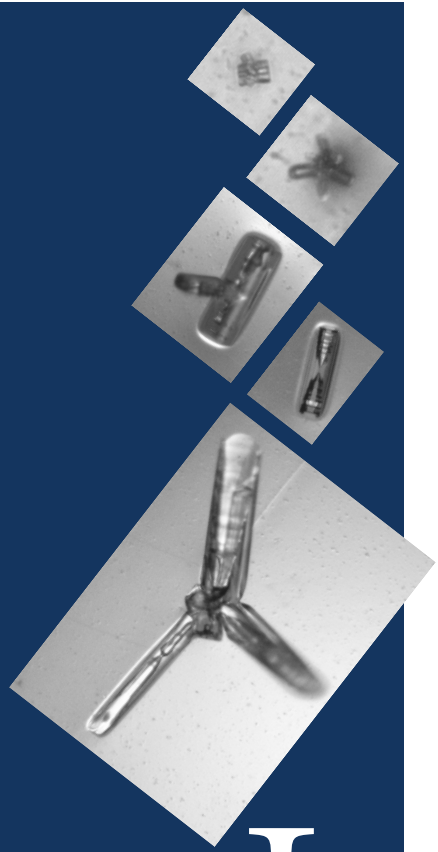
2016-02-12



- Temperature seems related to cloud particle properties, but not always…
- Local conditions can be misleading
- Look at conditions at formation!
  - look at conditions along back trajectory (history)
  - cloud formation at:
    - warmer (**liquid origin**)
    - colder temperatures (**in situ origin**)
    - Different origin leads to different properties
- Classify clouds according to origin!
  - Liquid origin or
  - In situ origin

Shape Classification





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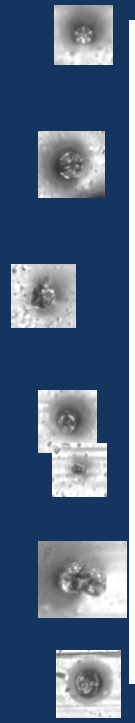
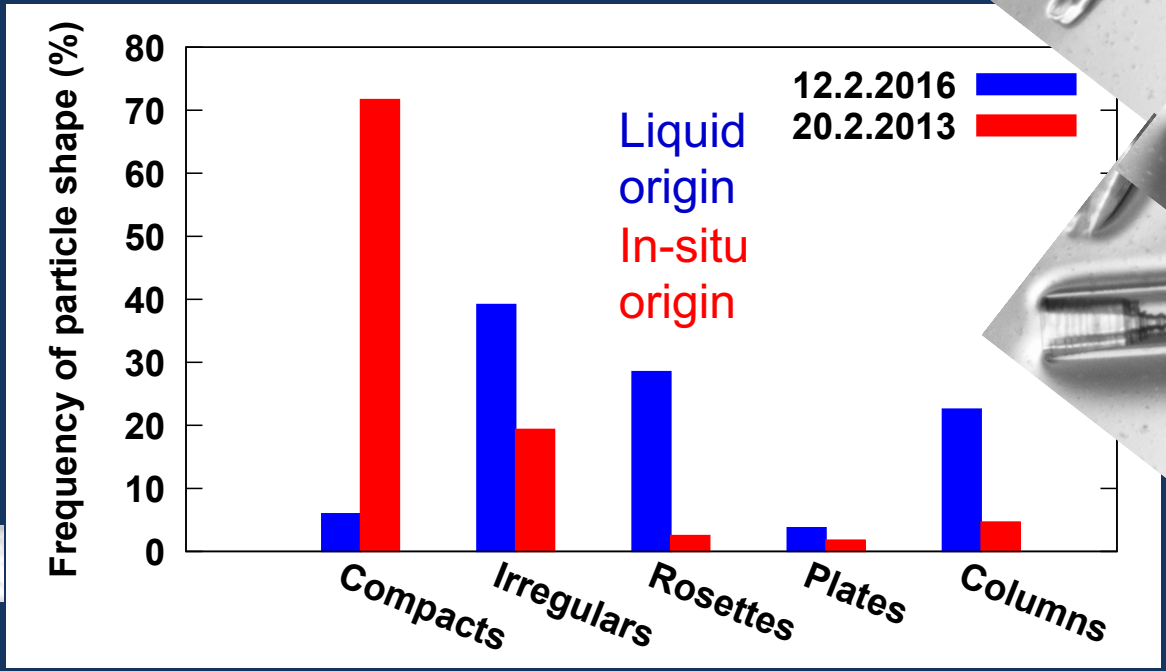
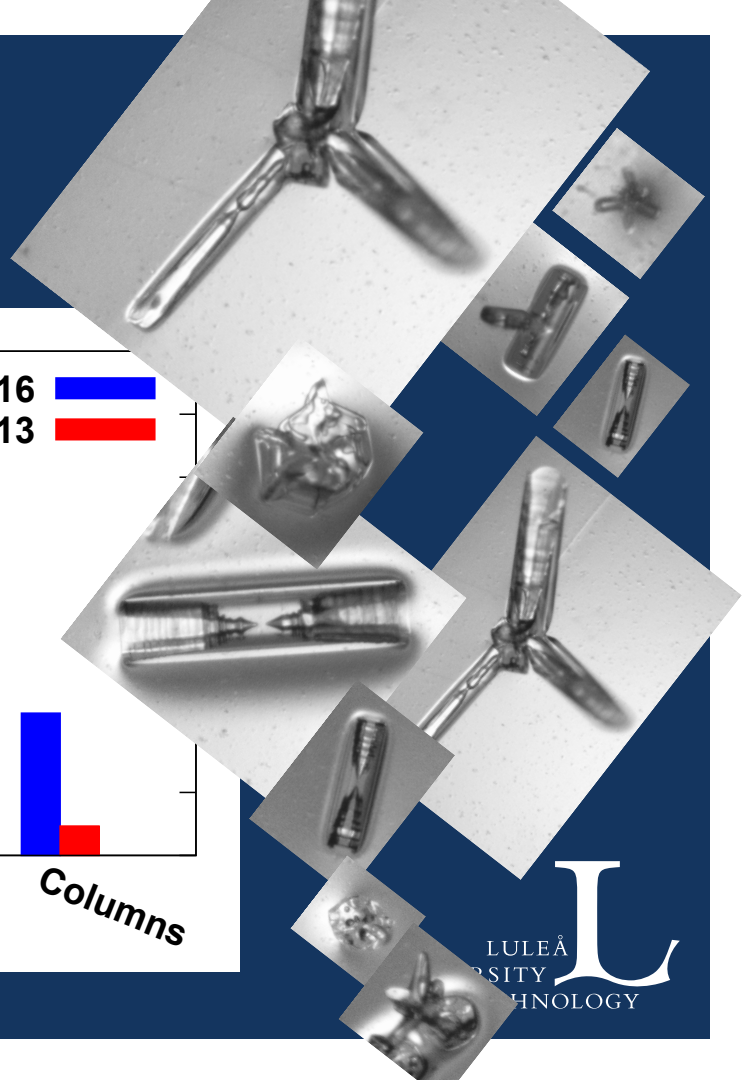
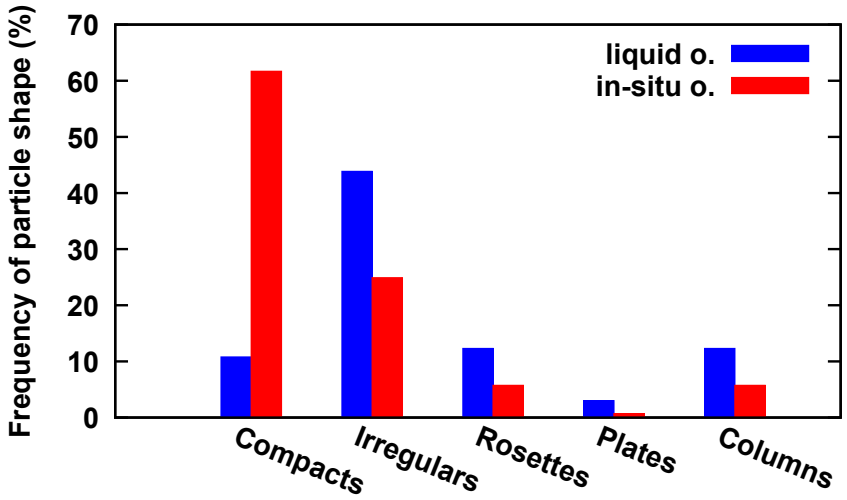
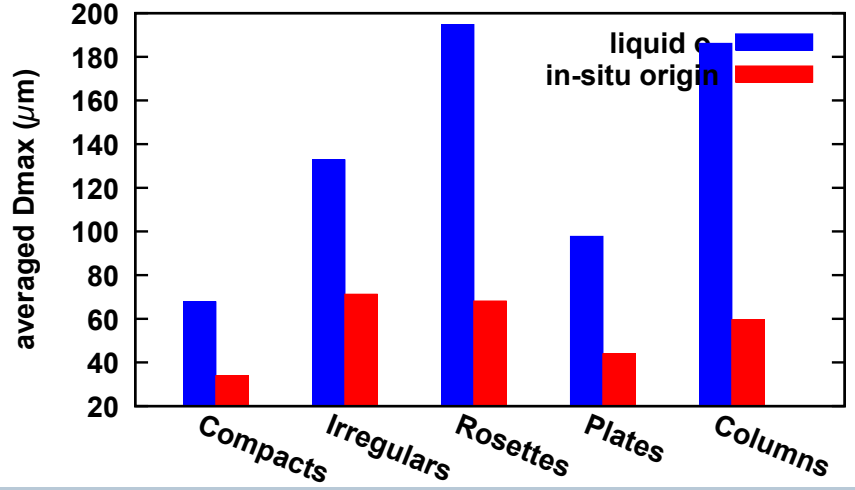
Shape distribution











Shape distribution and average size

Wolf, V., T. Kuhn, M. Milz, P. Voelger, M. Krämer, and C. Rolf (2018), Atmos. Chem. Phys., 18(23), doi: 10.5194/acp-18-17371-2018.

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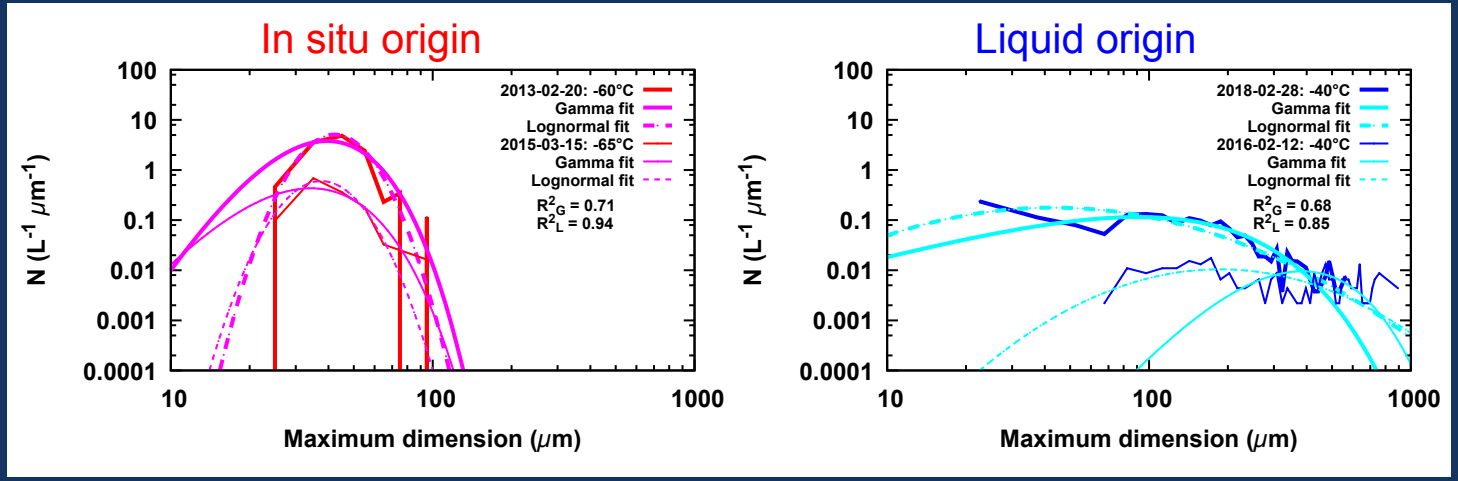
Particle size distribution



10 measurement days:
4x in situ origin (21 PSDs)
6x liquid origin (24 PSDs)
Particle size: 10 µm - 1000 µm
Number concentration: 1 L^{-1} - 500 L^{-1}

Wolf, V., T. Kuhn, and M. Krämer (2019), Geophys. Res. Lett., 46(21), doi: 10.1029/2019GL083841.

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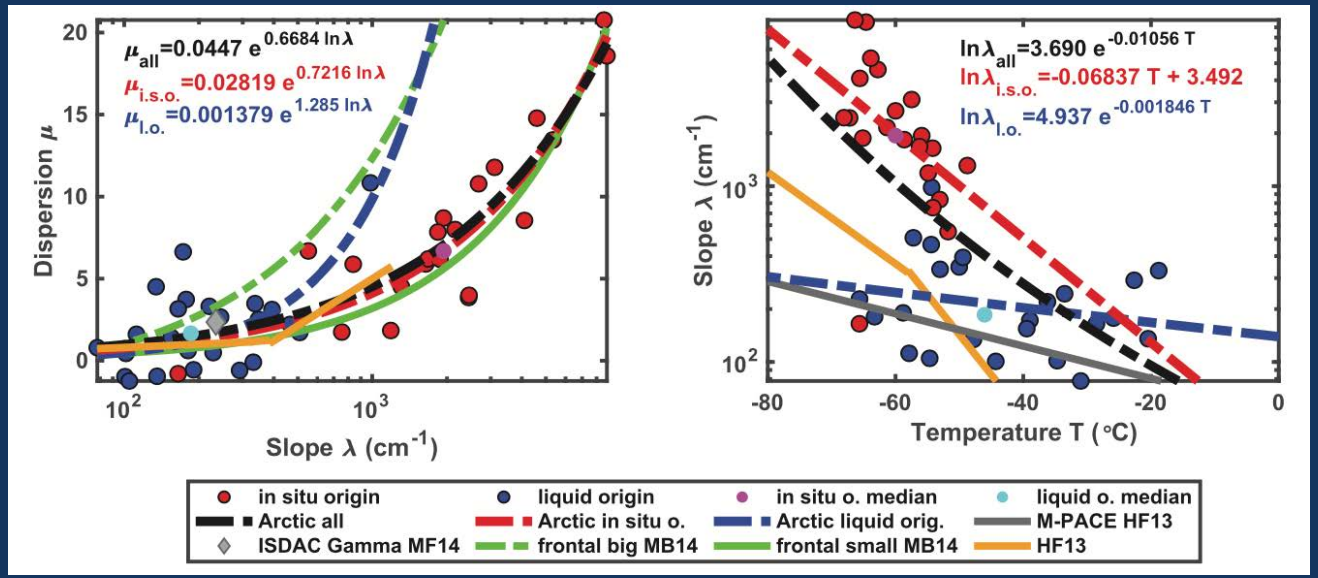
Particle size distribution



Gamma function: $N = N_0 \times D^{\mu} \times e^{-\lambda D}$

N_0 = intercept

μ = dispersion

λ = slope

D = maximum dimension

Wolf, V., T. Kuhn, and M. Krämer (2019), Geophys. Res. Lett., 46(21), doi: 10.1029/2019GL083841.

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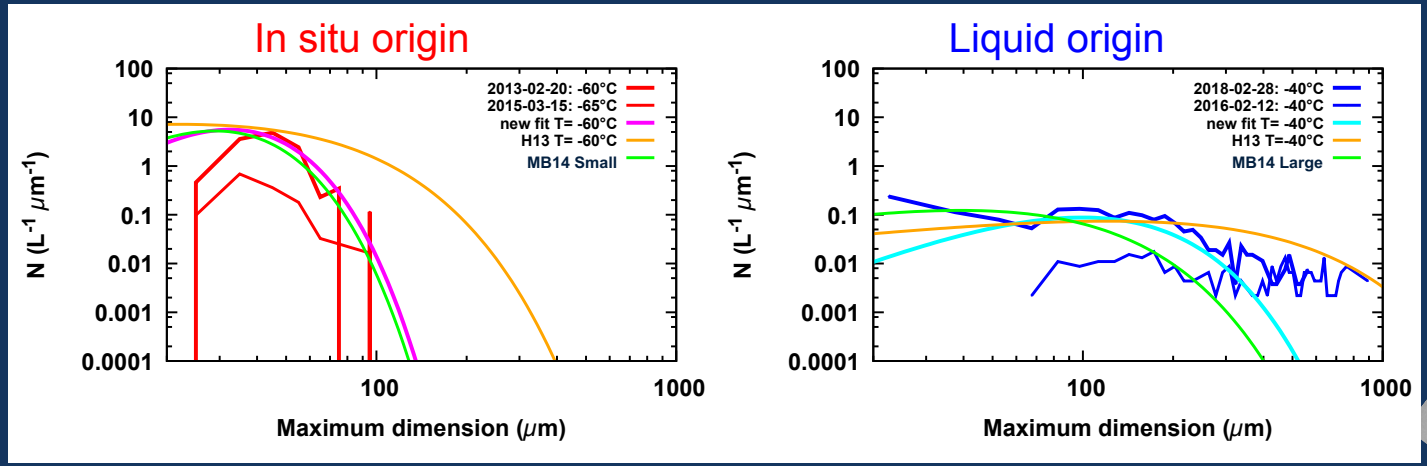
Particle size distribution



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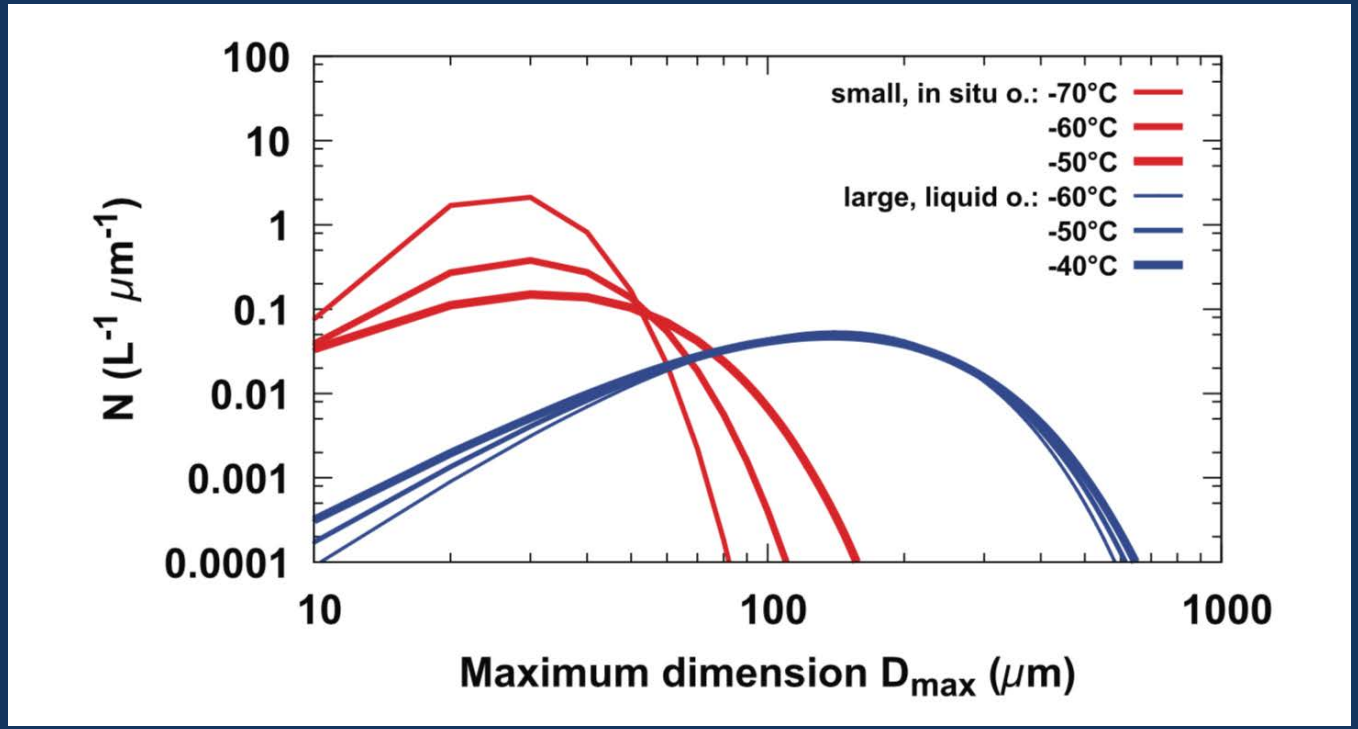

Wolf, V., T. Kuhn, and M. Krämer (2019), Geophys. Res. Lett., 46(21), doi: 10.1029/2019GL083841.

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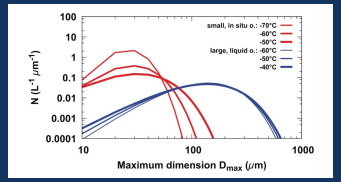
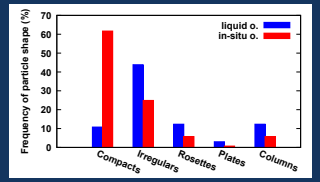
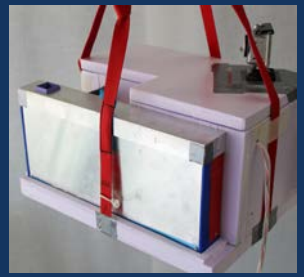
Conclusions and outlook







- Growing dataset: high-resolution images of cirrus ice particles
- Useful to classify cirrus by origin
  - Liquid origin: large and complex particles
  - In situ origin: small and *compact* particles
- Cirrus PSD in Arctic similar to midlatitudes
- Shape distribution

- Improve B-ICI
- More B-ICI data
- More concurrent lidar and B-ICI
- Lidar validation (EarthCARE)
- New PhD position soon!

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Thomas Kuhn thomas.kuhn@ltu.se