

Imaging the Orientation Dynamics of Snow in Freefall from a Hovering Microscopy Platform

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Session AS1.9

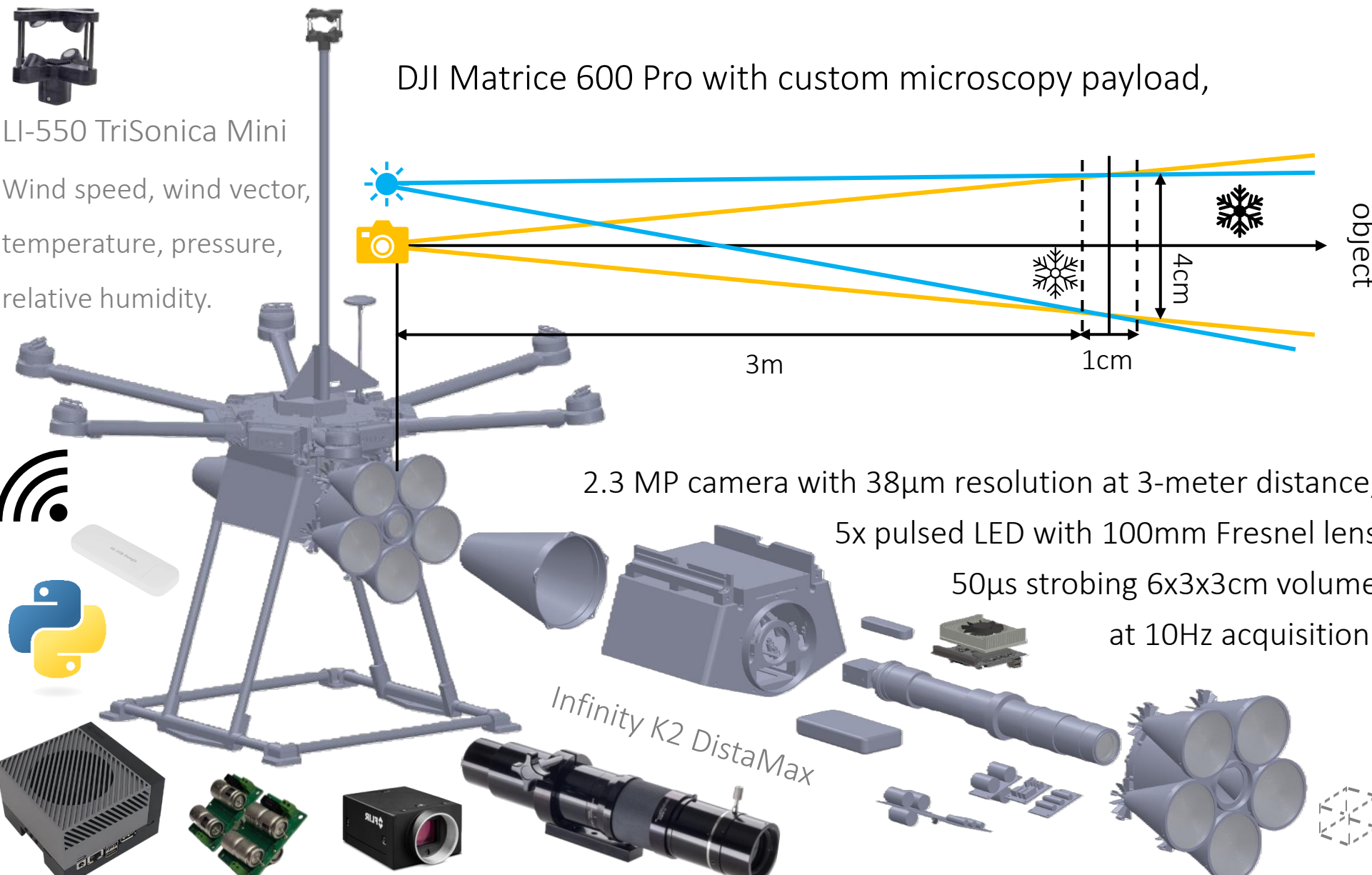
05-05-2026
Vienna



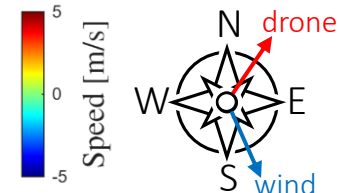
Motivation: Flexibly Deployable Snow Characterization for Fieldwork



Hovering Microscopy Platform



Atmospheric Profiling in near Hover



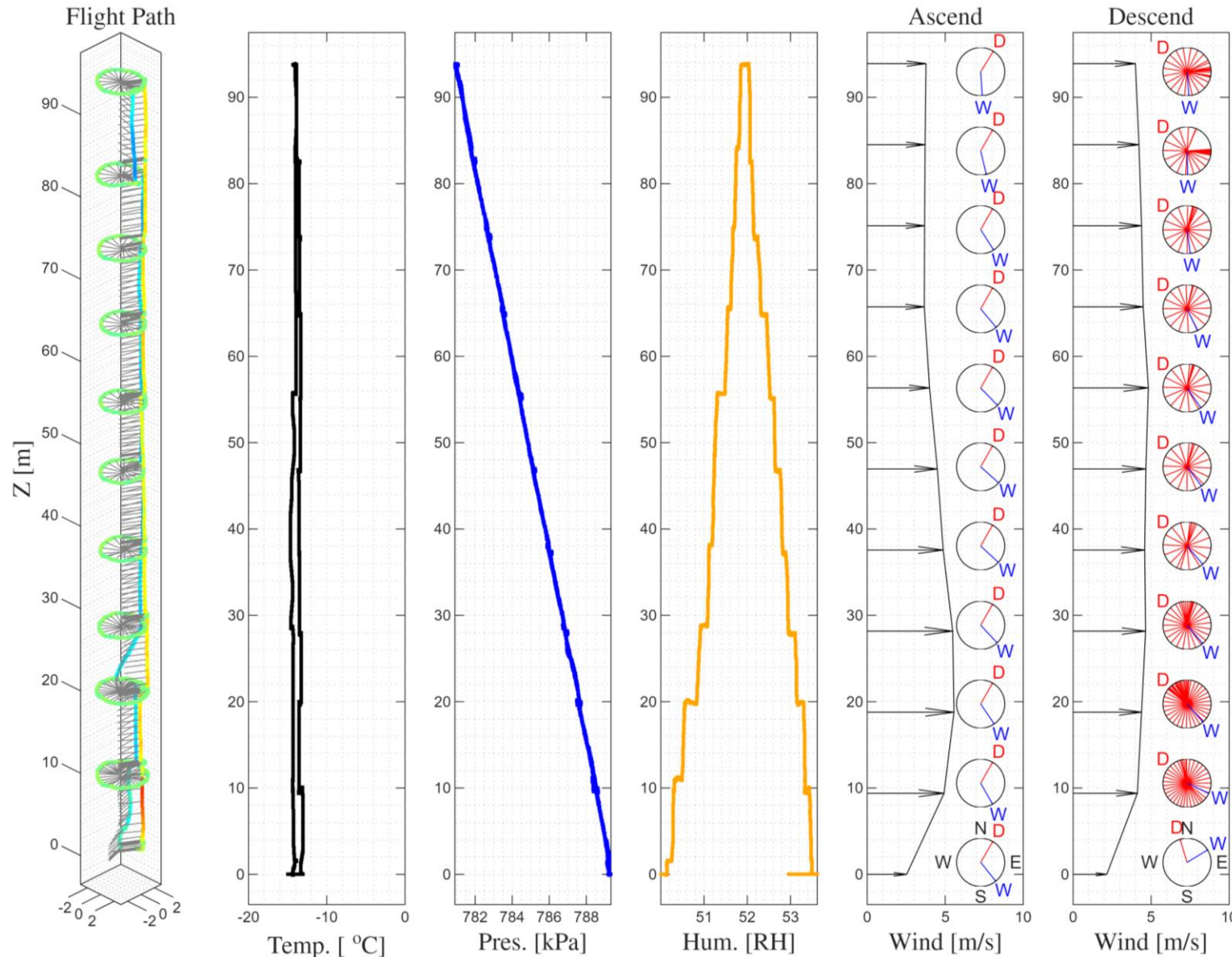
Tschuggen, Davos

Snowscope:

- 10min flights
- 100m AGL
- 10m intervals
- Heading scans

Weather:

- Temp -5 degC
- Wind 4 m/s
- Northern front



Snow Identification and Extraction of Metrics **ETH** zürich

Extract snowflake metrics:

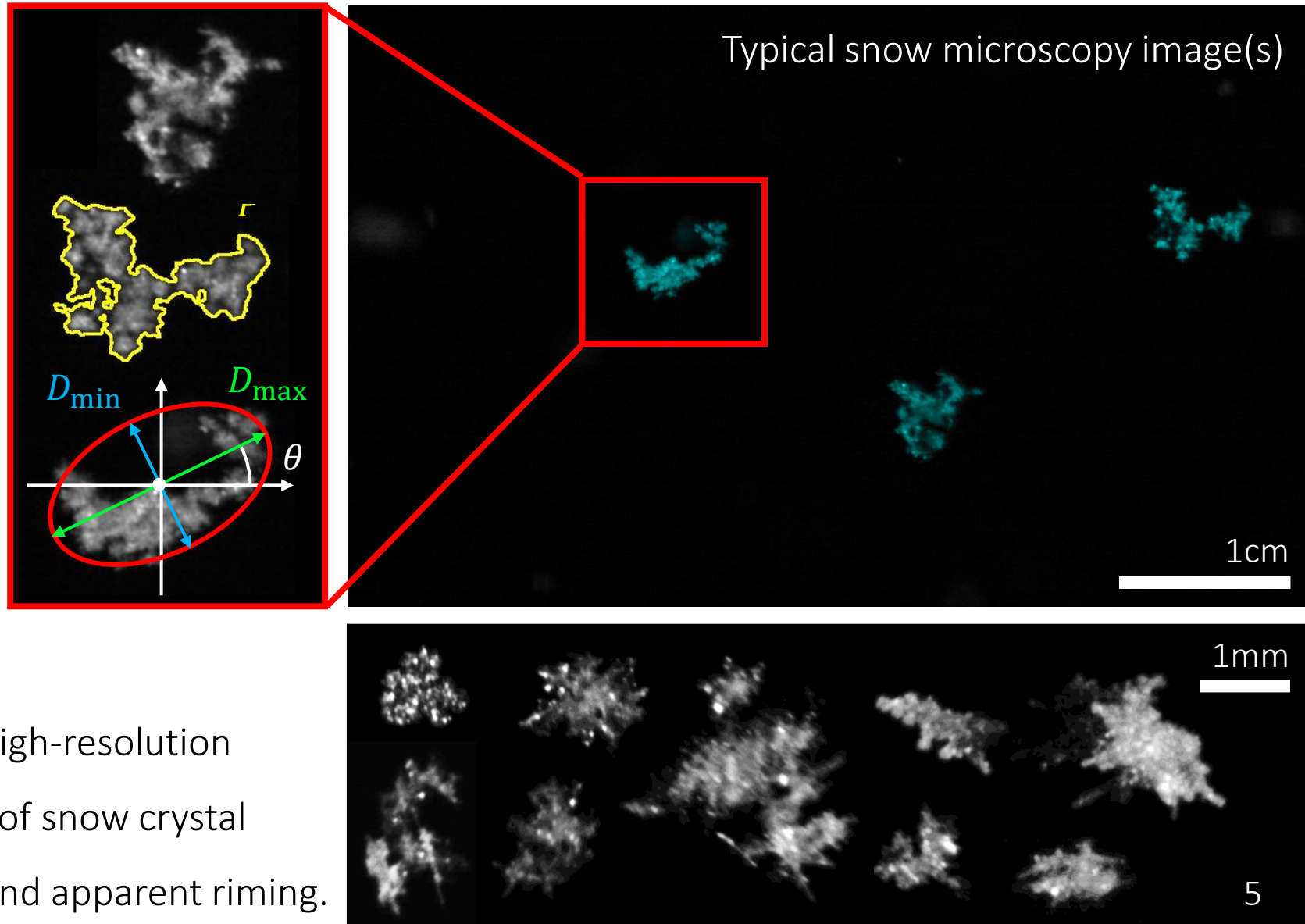
- minimum diameter D_{\min}
- maximum diameter D_{\max}

- aspect ratio $\eta = \frac{D_{\min}}{D_{\max}}$

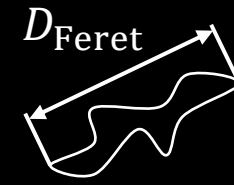
- orientation angle θ

- equivalent diam. $D_{\text{eq}} = \sqrt{\frac{4A_{\text{im}}}{\pi}}$

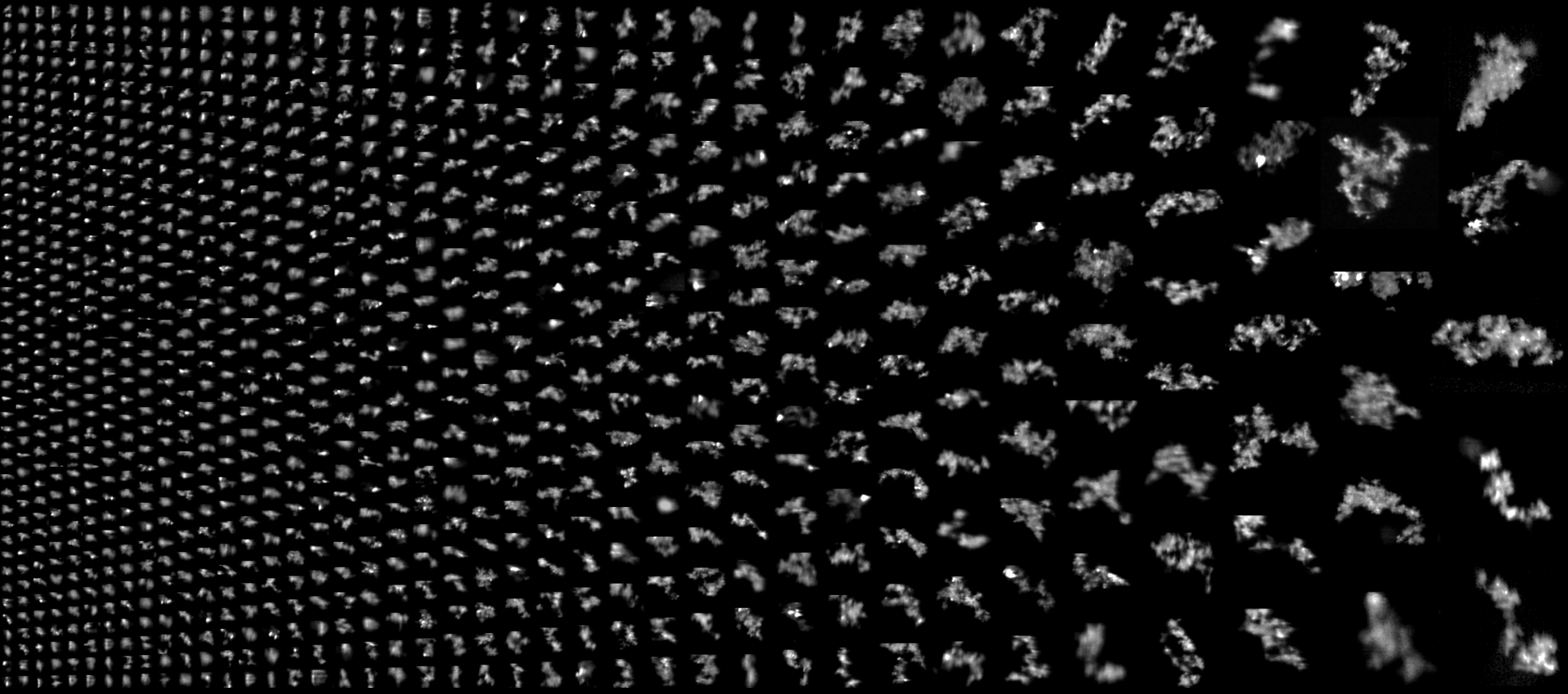
- complexity $X = \frac{P}{\pi D_{\text{eq}}}$
 - etc. { Collect high-resolution
imagery of snow crystal
shapes and apparent riming.



Collecting Large Data Samples $\sim 10^4$



ETH zürich



Feret's diameter

5mm

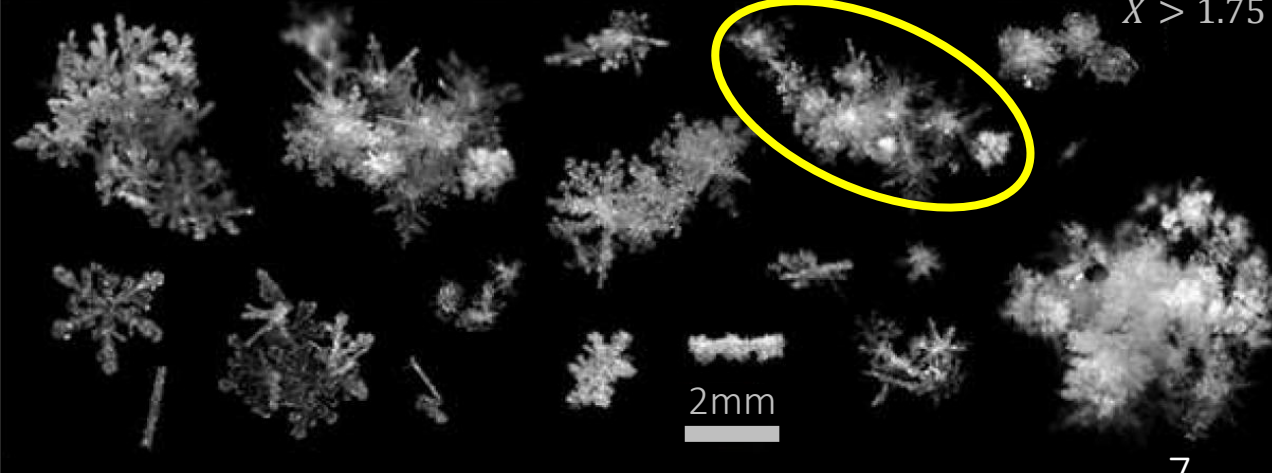
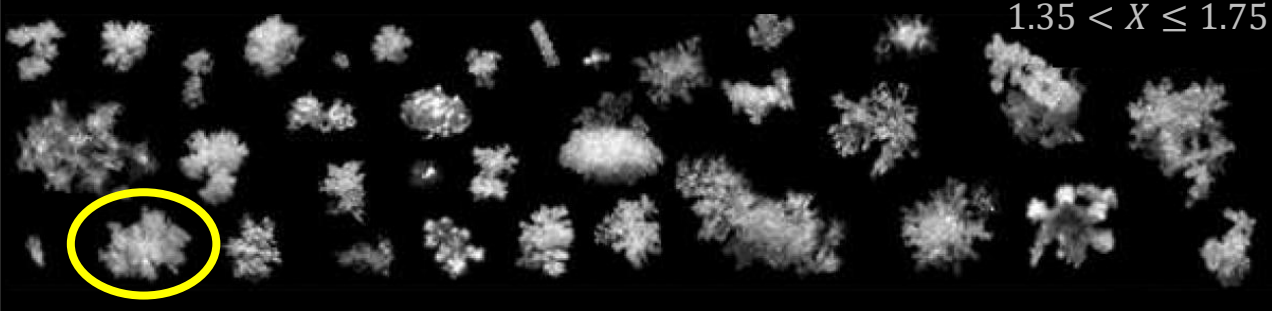
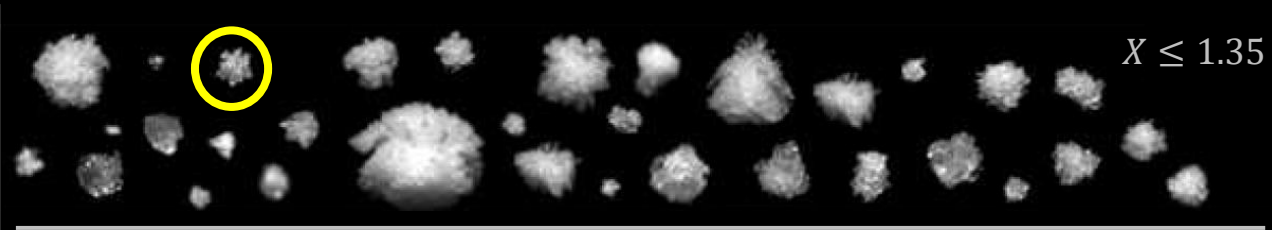
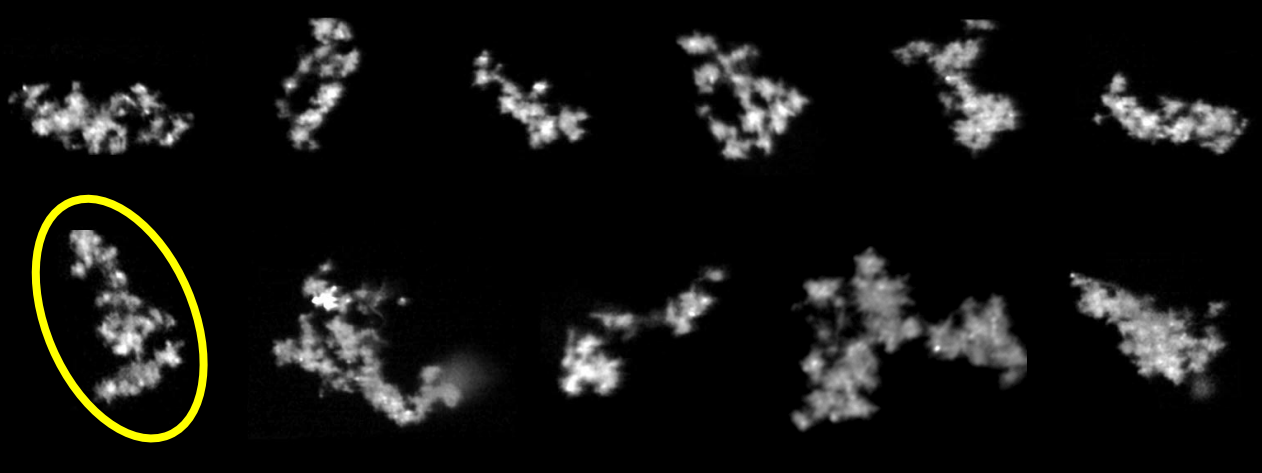
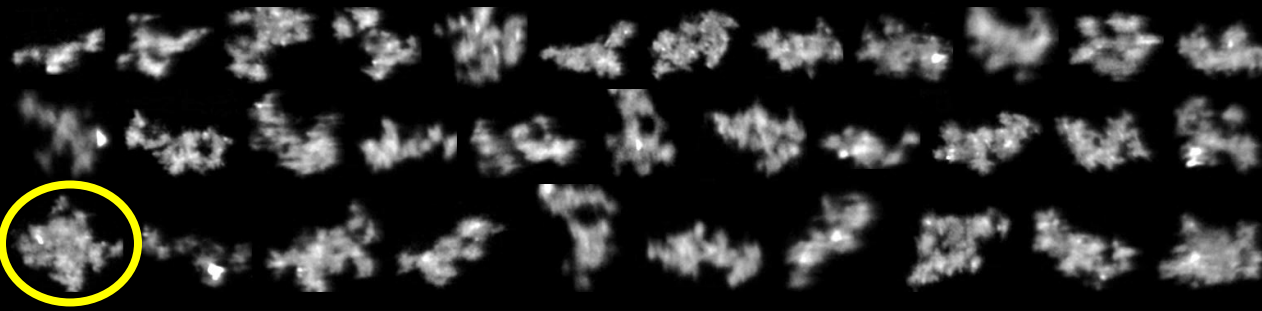
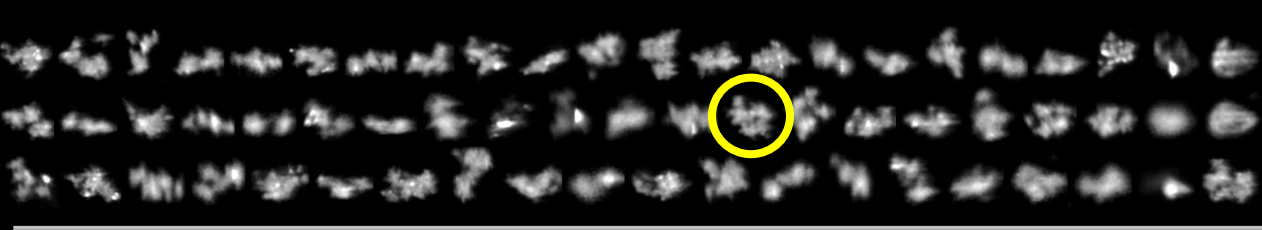
6

Reproducing Snow Complexity Categories

$$X = \frac{P}{\pi D_{eq}}$$

Garrett et al. 2014

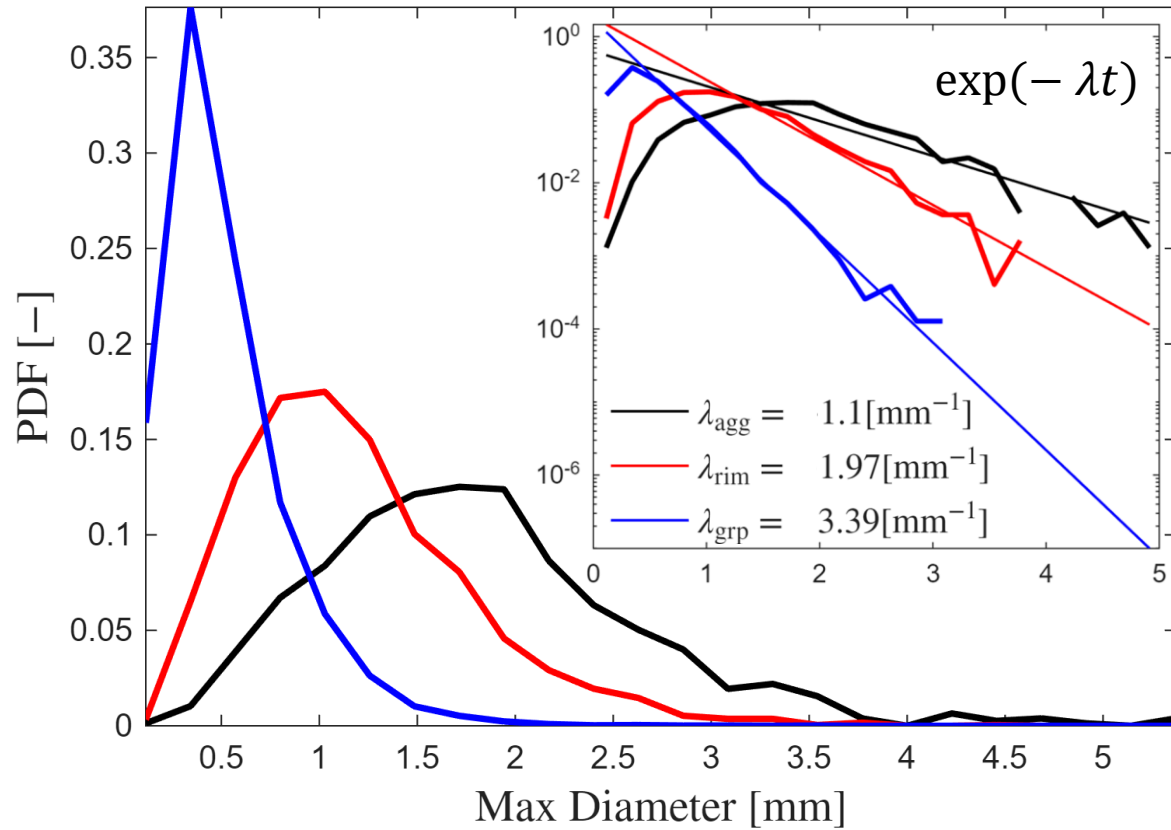
In-flight snow data



Harvesting Snowflake Statistics

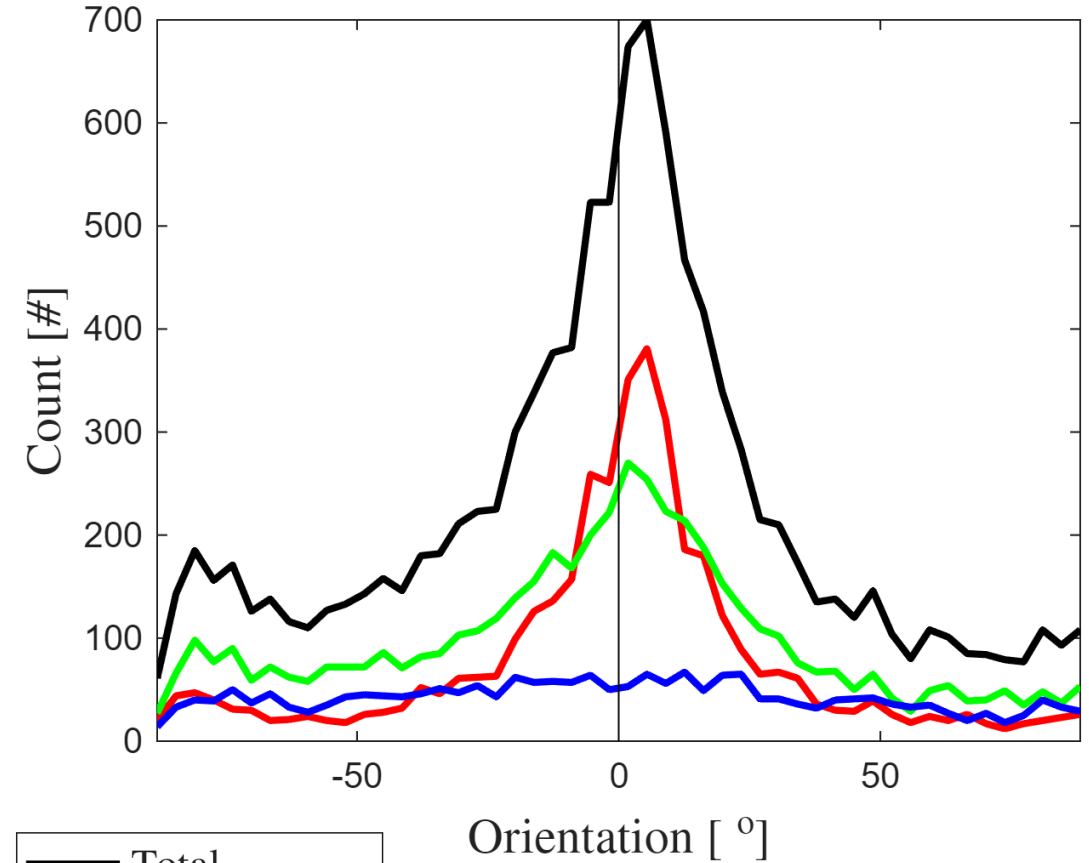


Size resembles the Marshall-Palmer distribution.



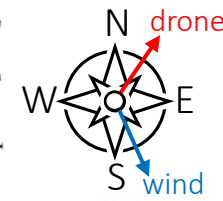
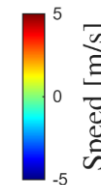
- agg $\chi > 1.75$
- rim $1.35 < \chi \leq 1.75$
- grp $\chi \leq 1.35$

Fall orientation predominantly horizontal.



- Total
- $\eta \leq 0.6$
- $0.6 < \eta \leq 0.8$
- $\eta > 0.8$

Snow Variability over the Air Column



Ascend Flight

Wind Profile

Snowflake

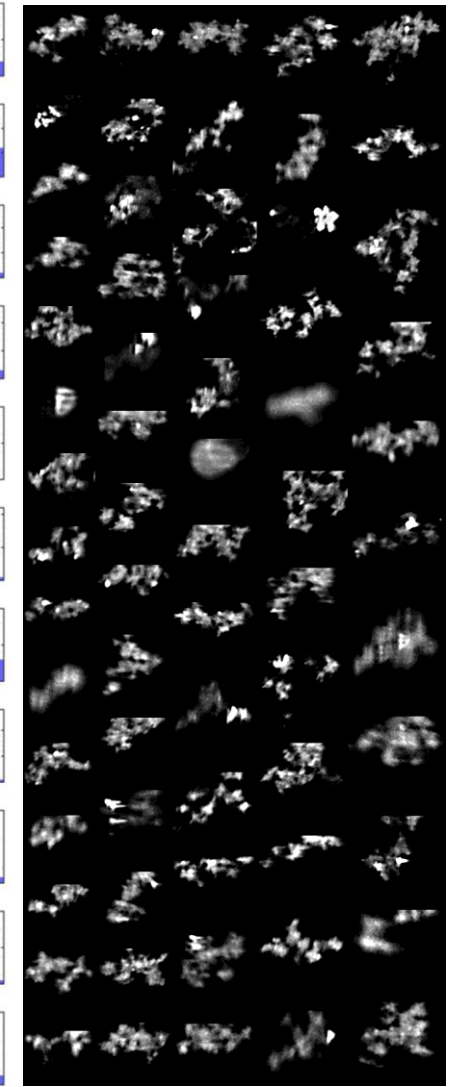
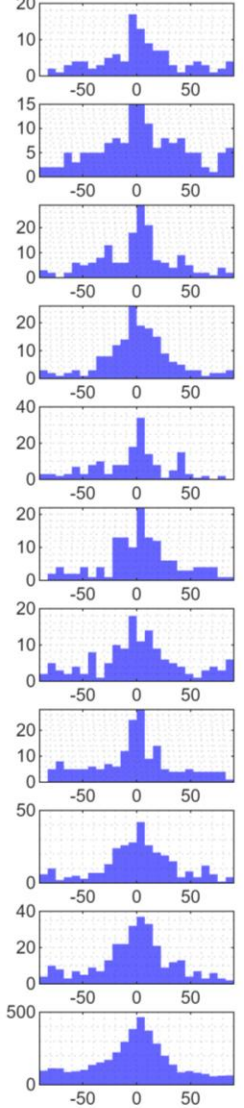
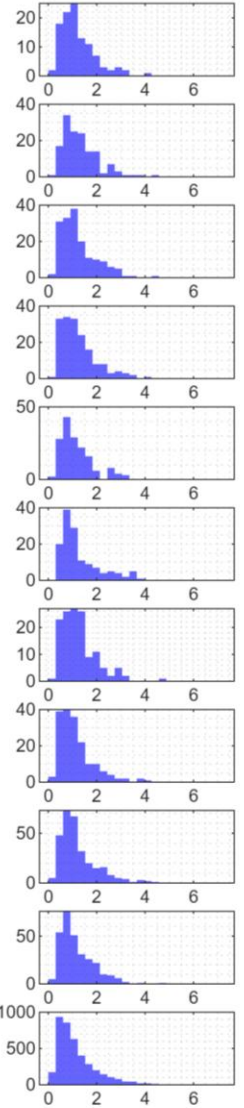
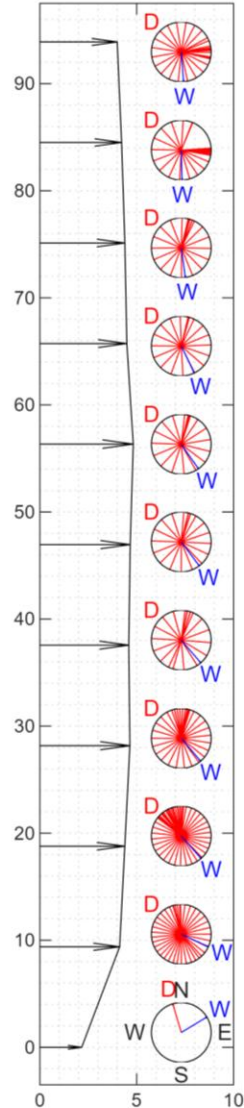
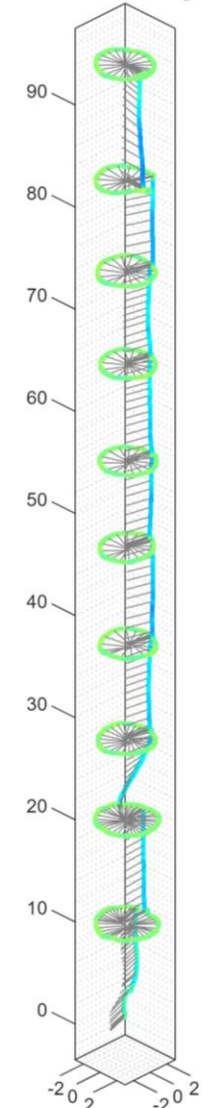
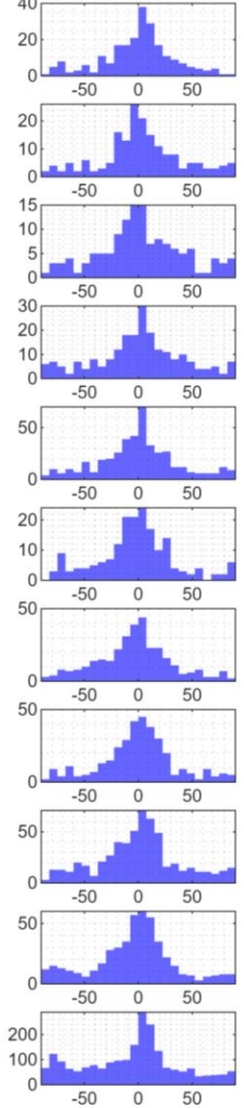
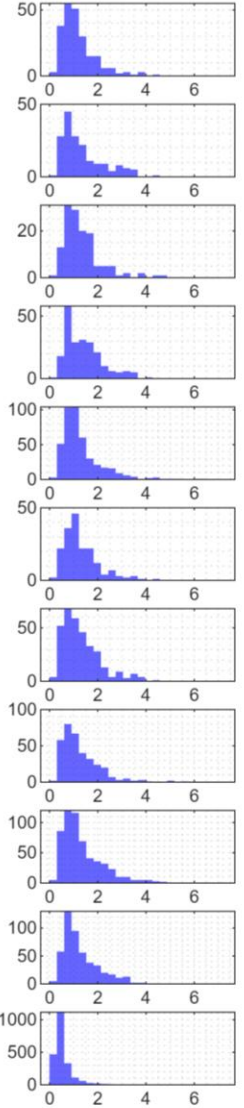
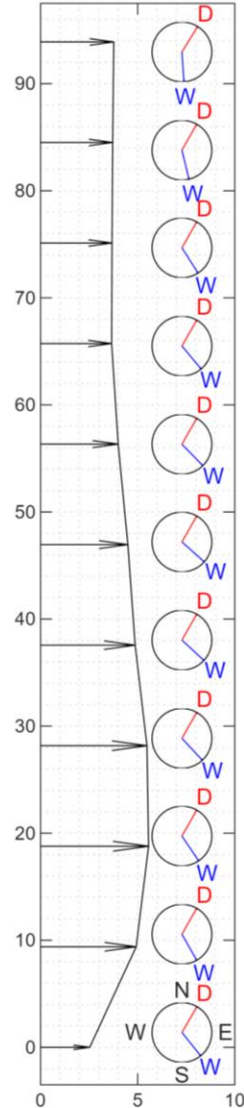
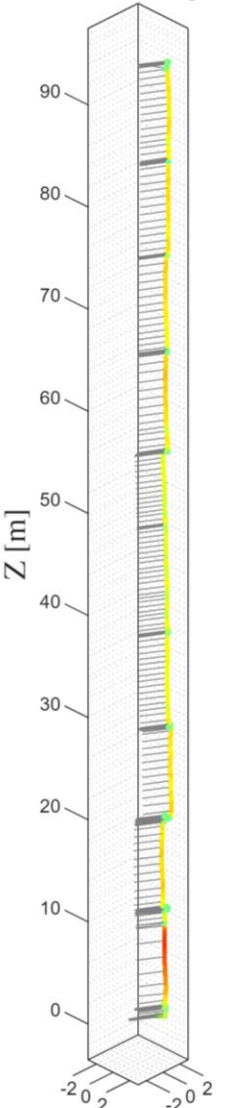
Metrics

Descend Flight

Wind Profile

Snowflake

Metrics



Summary and Conclusions

- We have presented a novel drone-based hovering microscopy platform capable of imaging free-falling snowflakes using a fully automated payload design.
- Performing an atmospheric profiling flight, we collected a large quantity of 10^4 snowflakes at an average acquisition rate of 15 snowflakes per second.
- Inspecting statistical distributions of size and shape, we found a predominance of horizontal flight; especially for elongated snowflakes.
- Notably, these statistics do not significantly vary over the air column or for different drone heading; suggesting uniform statistics and no observed alignment with the wind vector.

In future work, we aim to boost the acquisition rates to harvest in-flight snow tracks and fall speeds.

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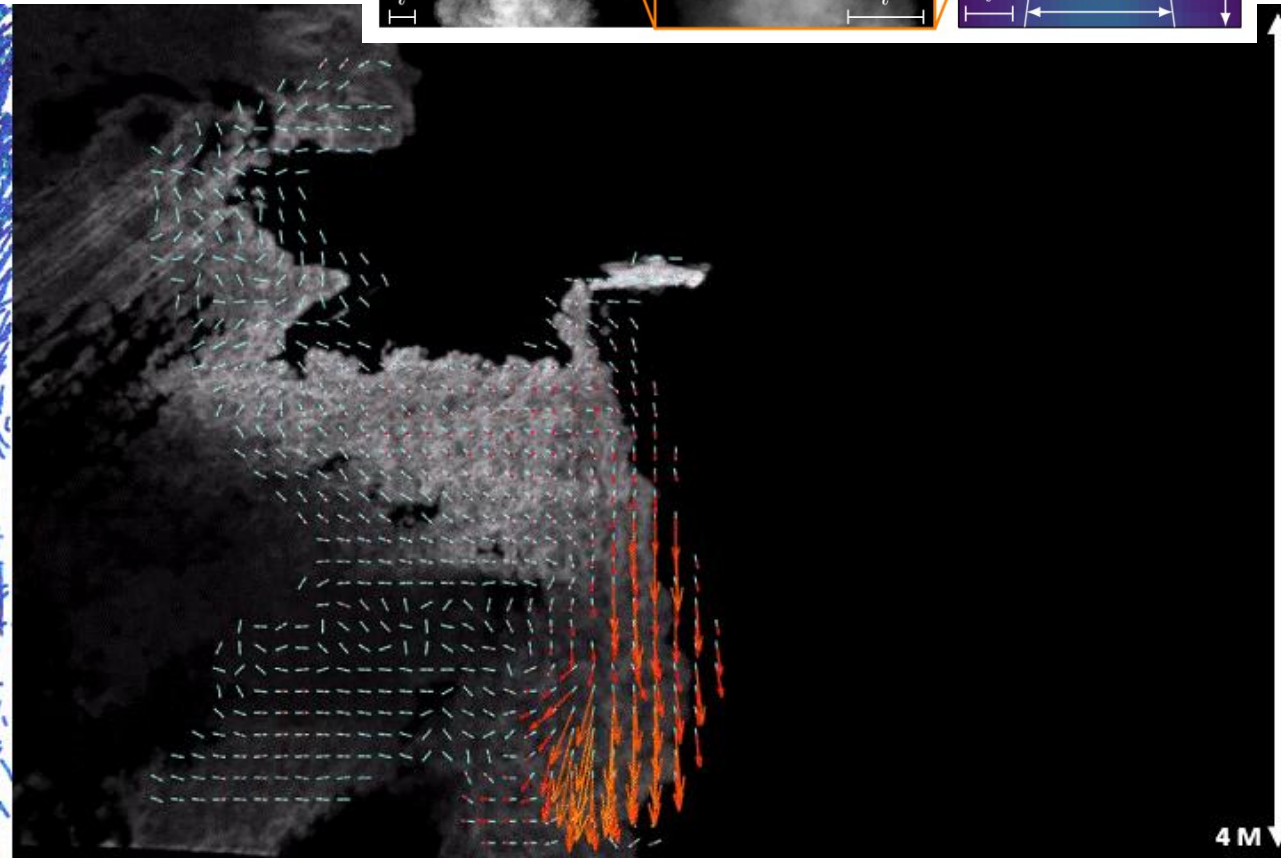
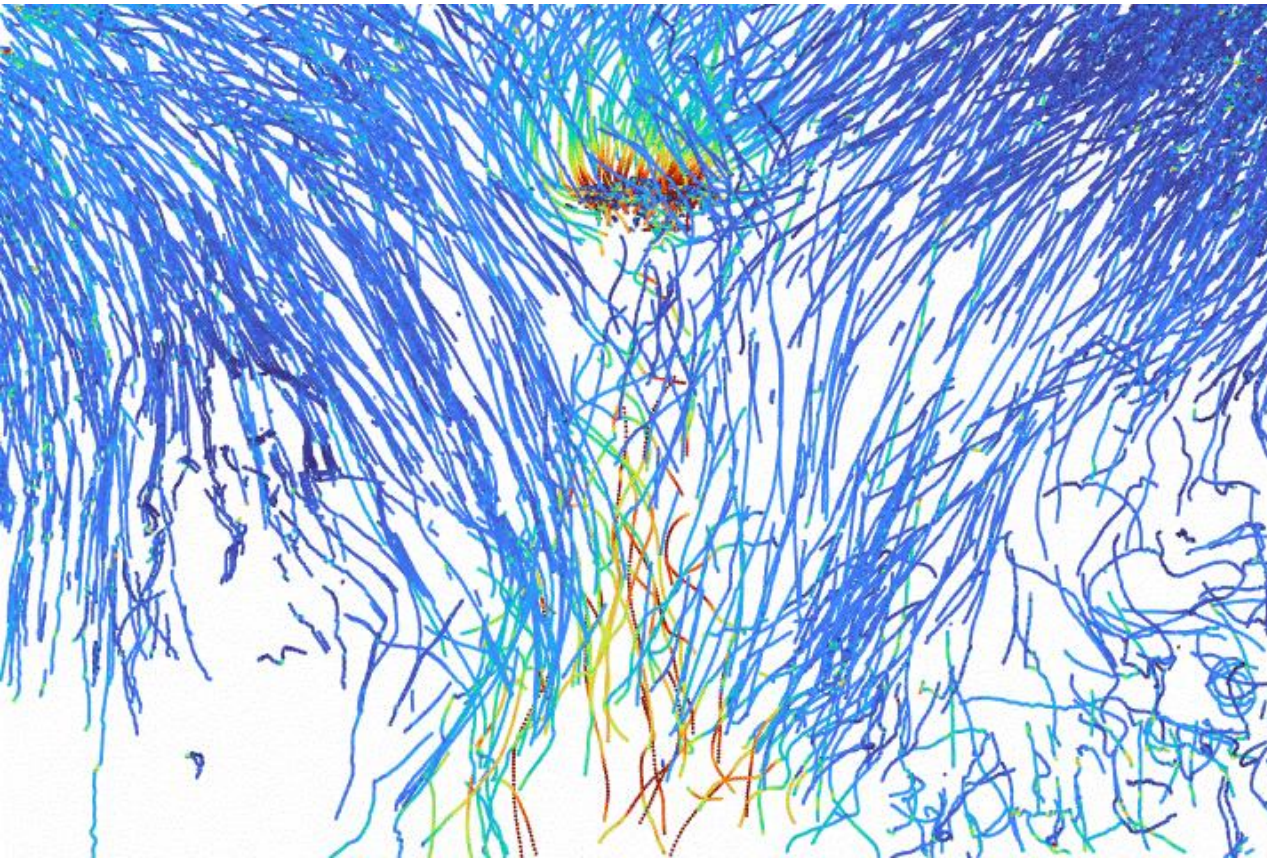
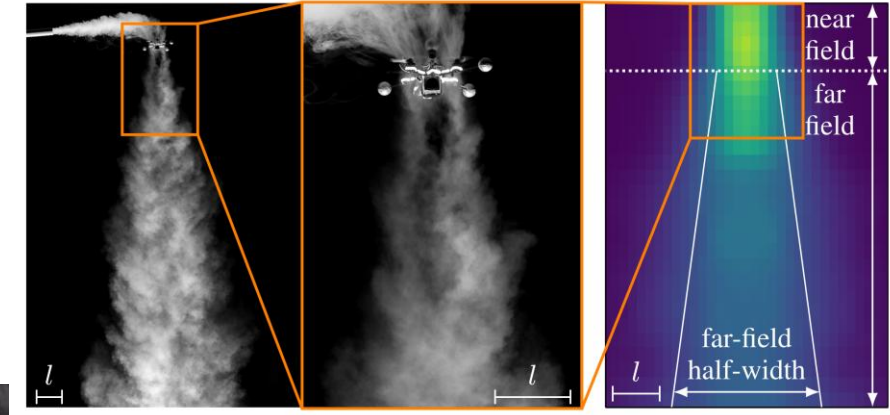


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[Extra] How about the Induced Flow?

L. Bauersfeld, K. Müller, D. Ziegler, F. Coletti and D. Scaramuzza, *Robotics Meets Fluid Dynamics: A Characterization of the Induced Airflow Below a Quadrotor as a Turbulent Jet*, IEEE RAL, vol. 10, no. 2, pp. 1241-1248, 2025

doi: 10.1109/LRA.2024.3518835.



In-Flight Timeseries Atmospheric Profiling

