

Observations and simulations of wintertime orographic mixed-phase clouds

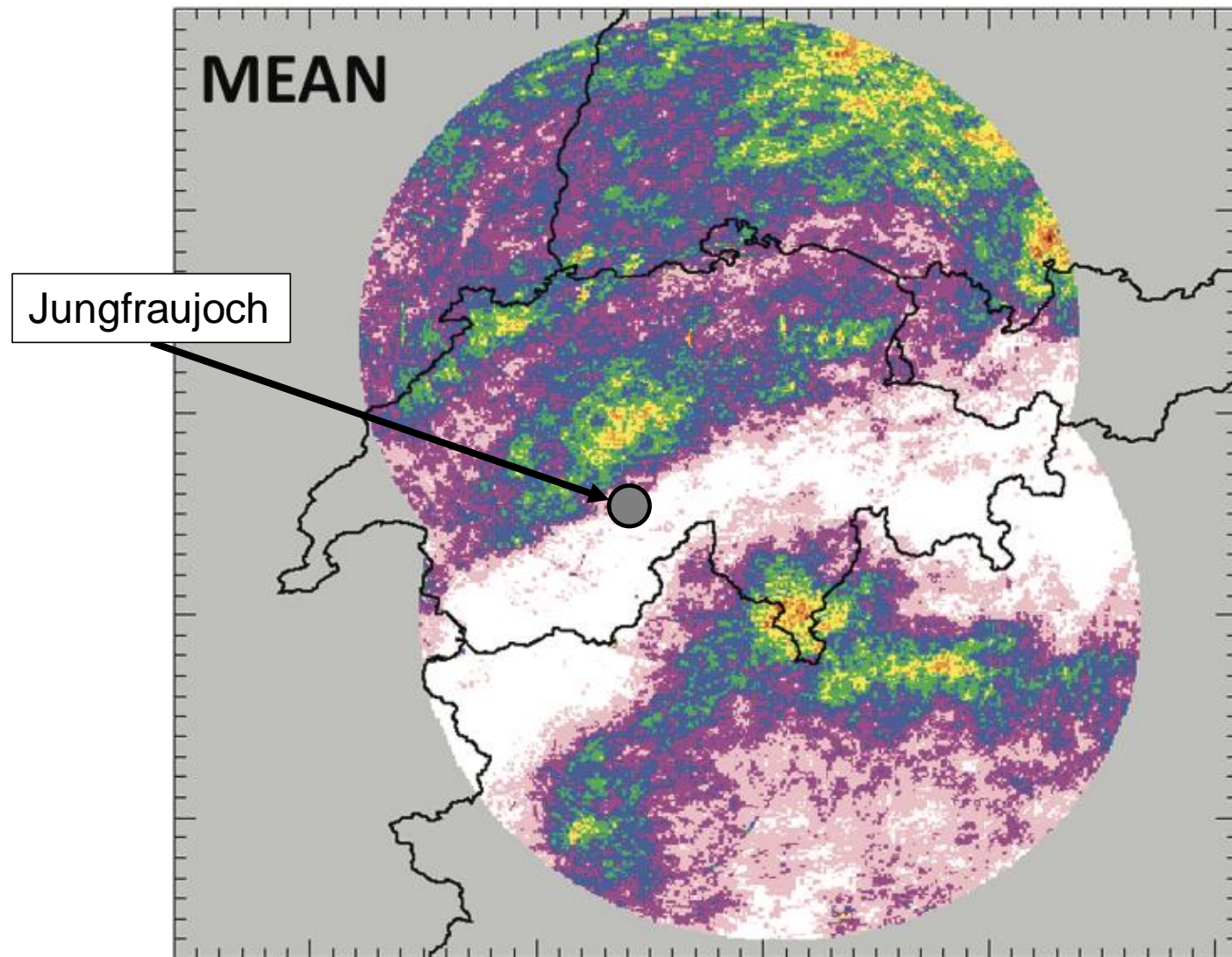
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Henneberg and Jan
Henneberger

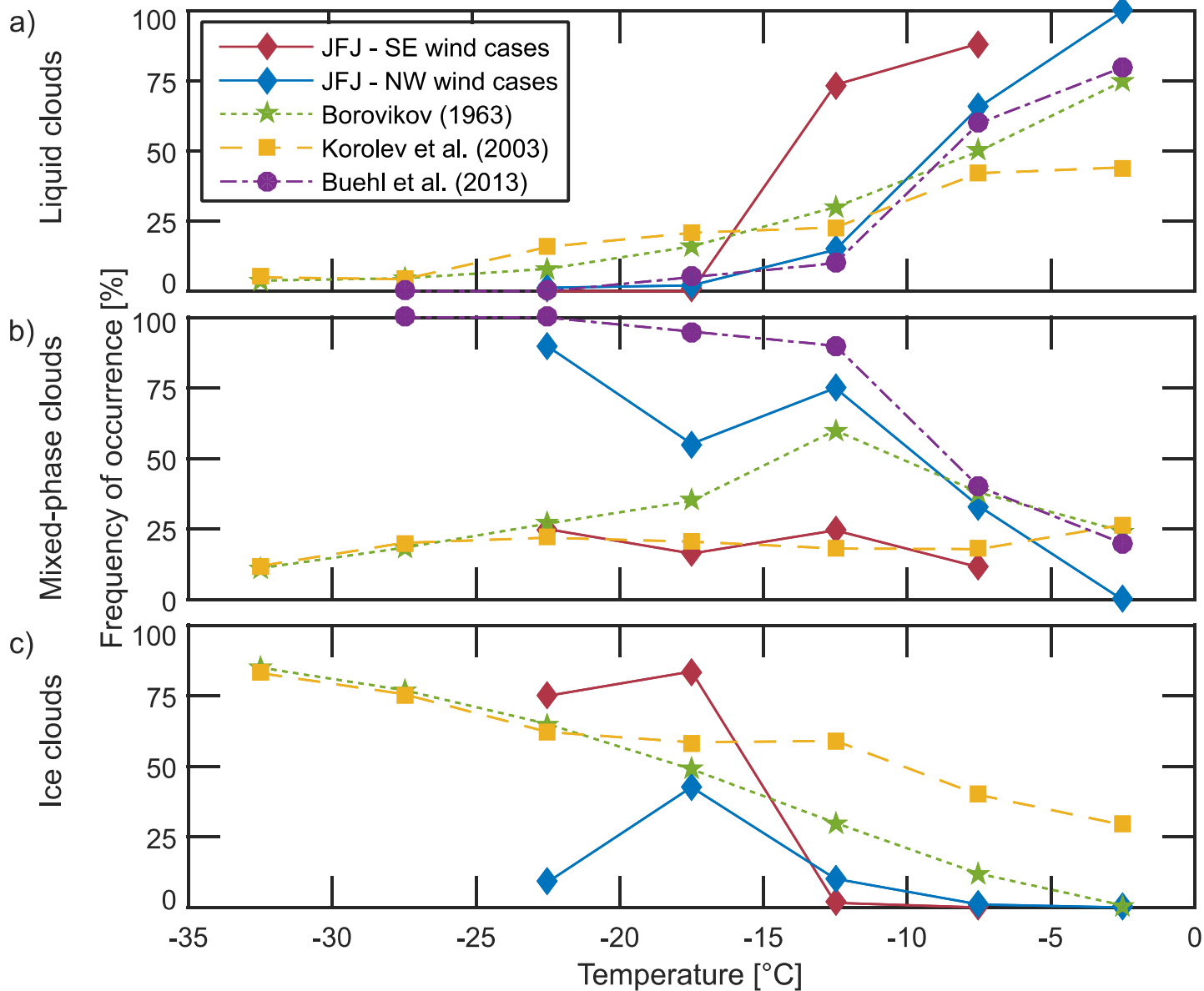
University of Bern, 20.4.2017

Hail frequency in Switzerland



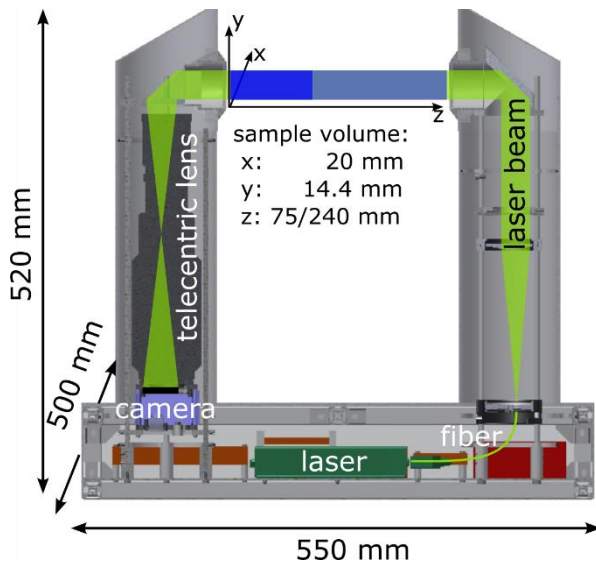
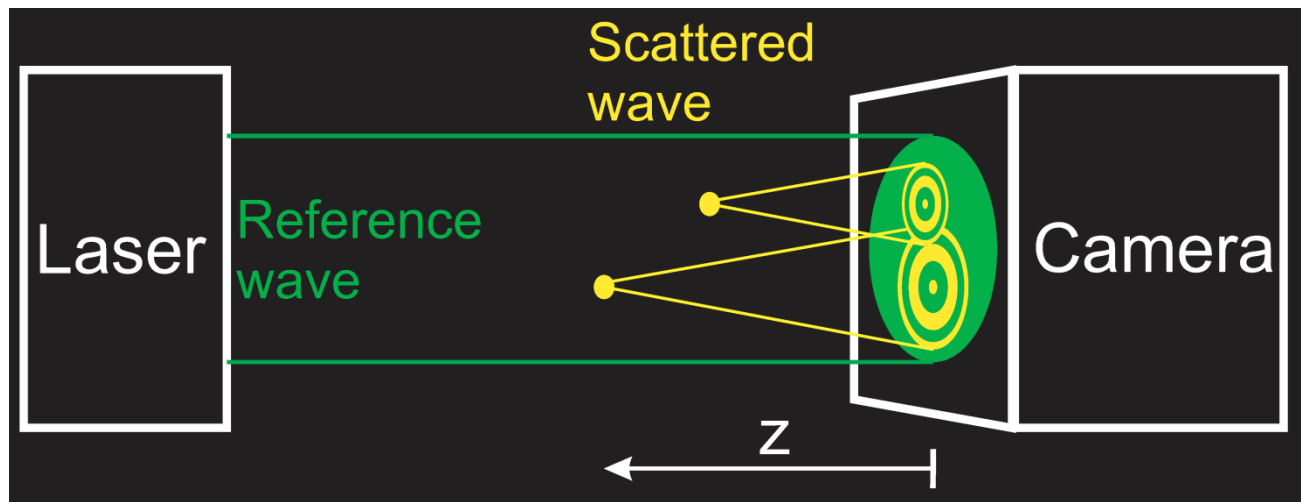
Average number of hail days between April and September (Nisi et al., 2016)

What do we know about mixed-phase clouds?

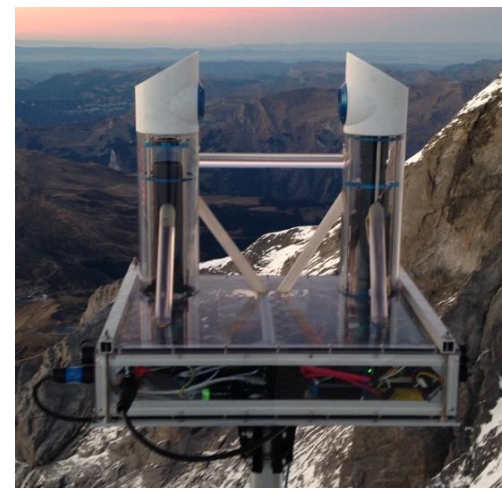


How to observe mixed-phase clouds?

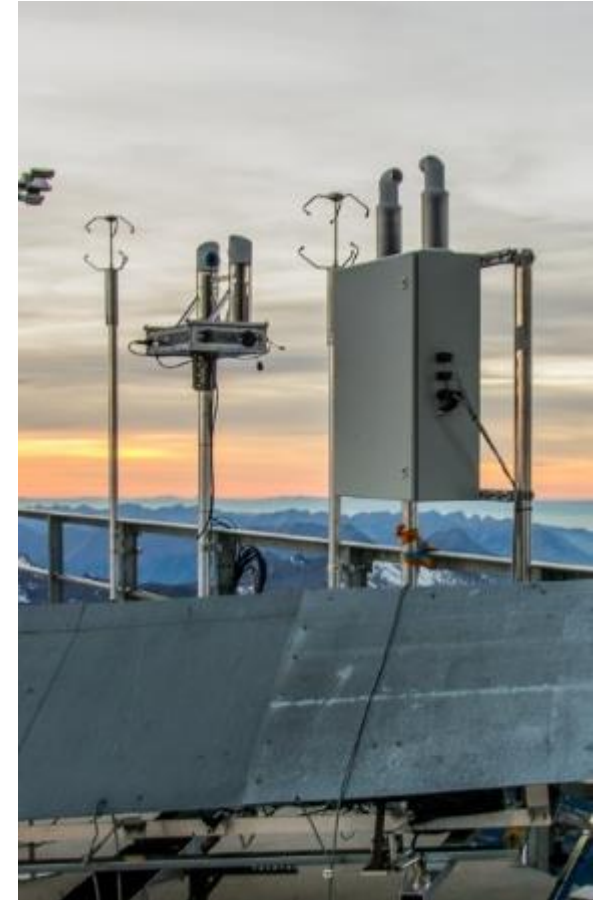
Using the HOLographic Imager for Microscopic Objects (HOLIMO 3G)






Weight	~ 20 kg
Size Range	6 μm - mm
Sample Volume	17 cm^3
Sample Volume Rate	~ 100 cm^3s^{-1}

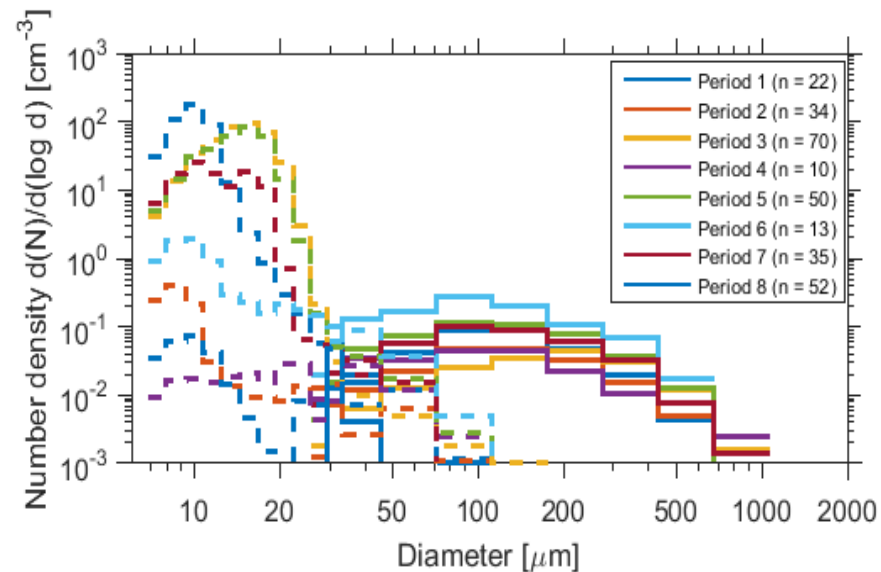


Orographic clouds at the Jungfraujoch






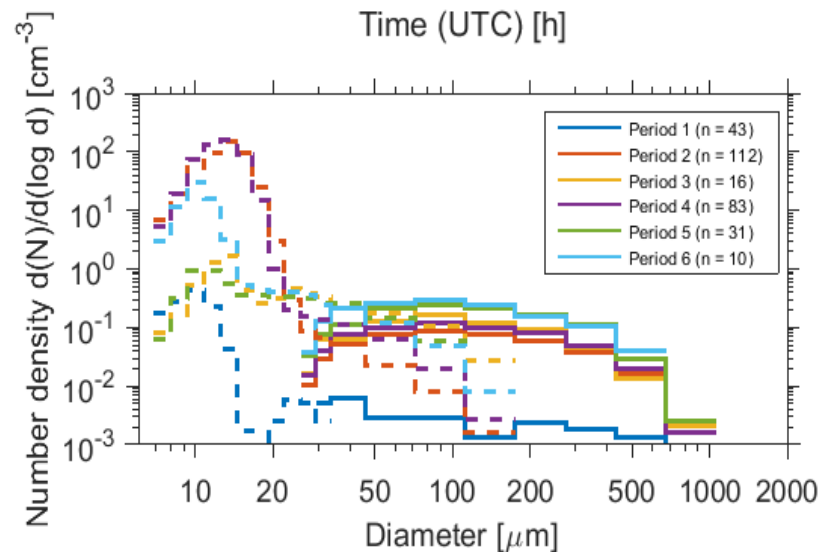
Shapes of ice crystals at Jungfraujoch

Ice Crystal Shape		Case study 16/17.02.2015 (-16.5 to -12 °C, 2-10 m/s, wind from SE to N)
Regular	29 %	
Needle	14 %	
Irregular	57 %	

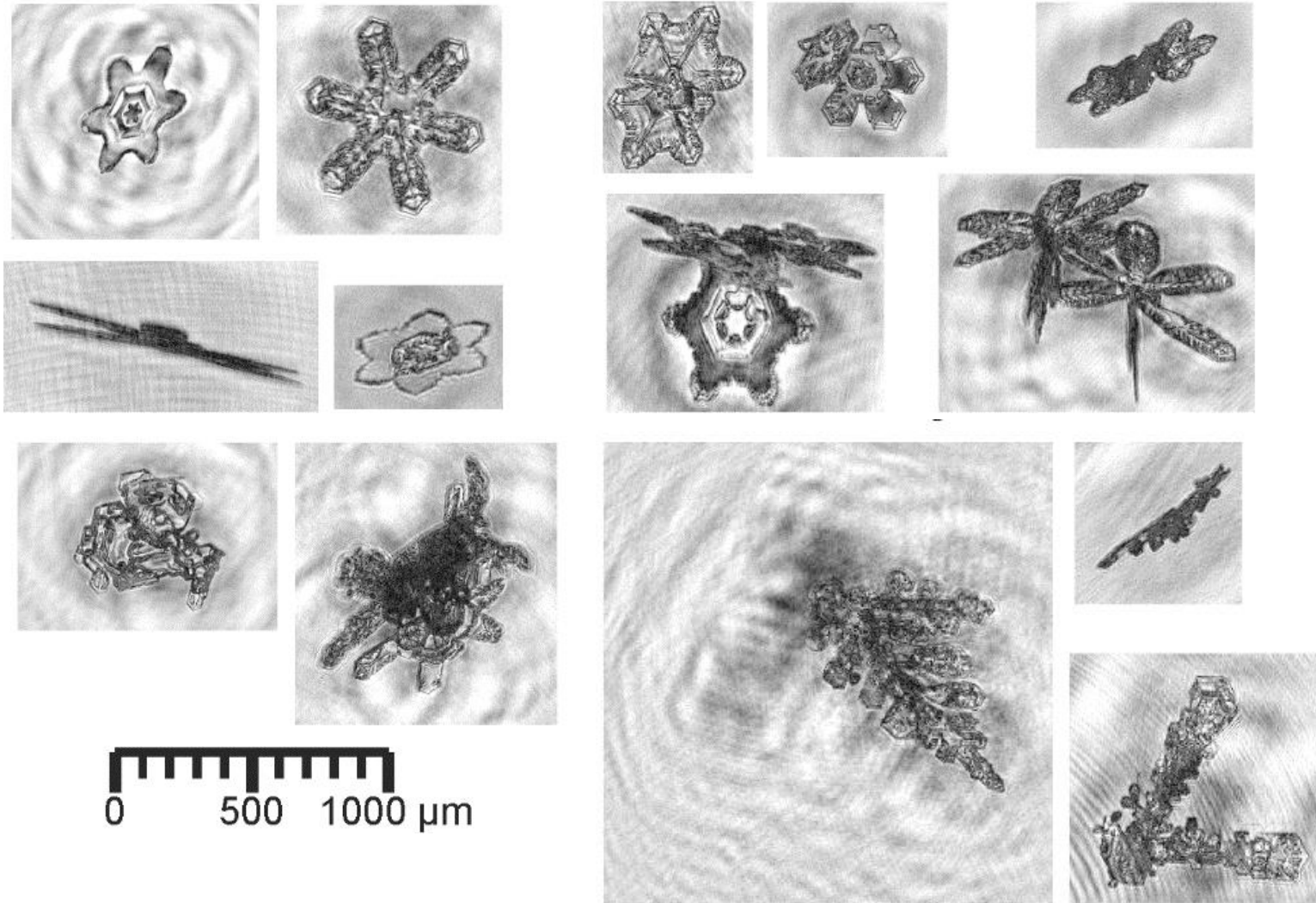


Shapes of ice crystals at Jungfraujoch

Ice Crystal Shape		Case study 13/14.02.2015 (-17 to -13 °C, 4-14 m/s wind from SE)
Regular	6 %	
Needle	20 %	
Irregular	74 %	

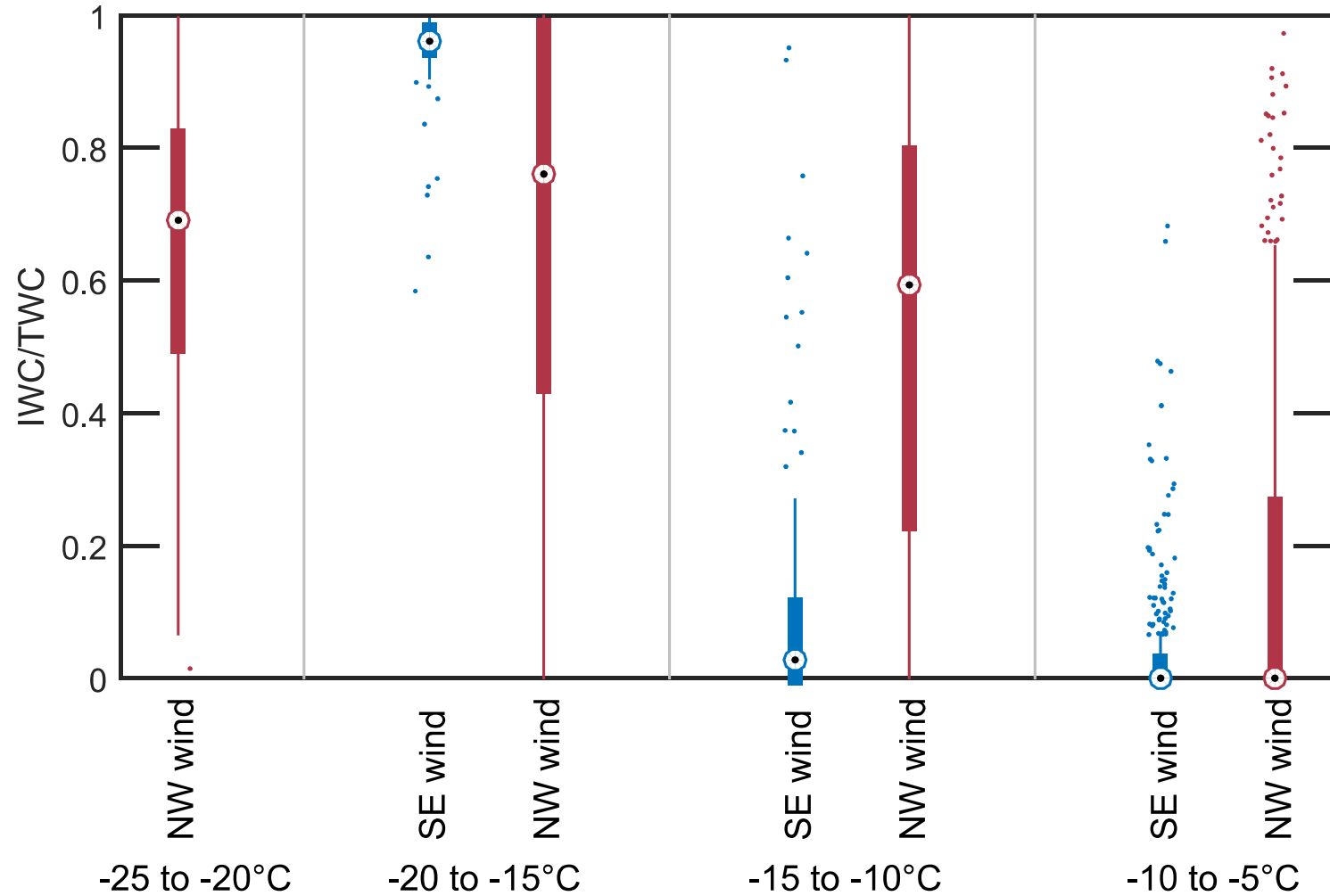


Connection to hail?

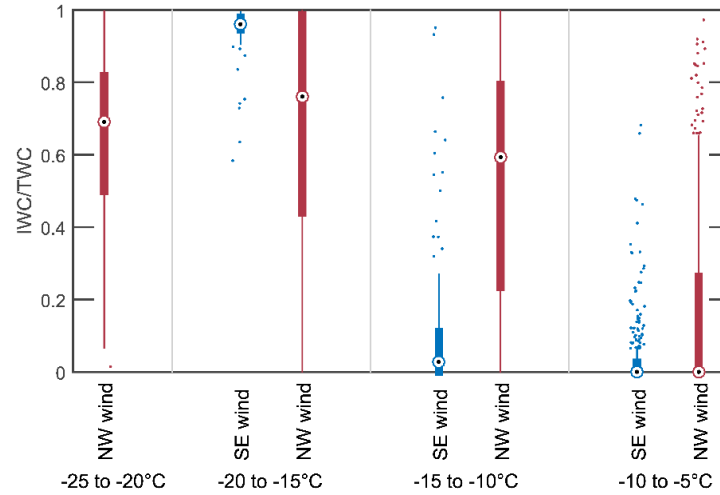


→ While we can detect rimed particles, particles already as large as 1 mm are rare in wintertime orographic clouds.

Ice fraction at Jungfraujoch



Ice fraction: South-East vs. North-West



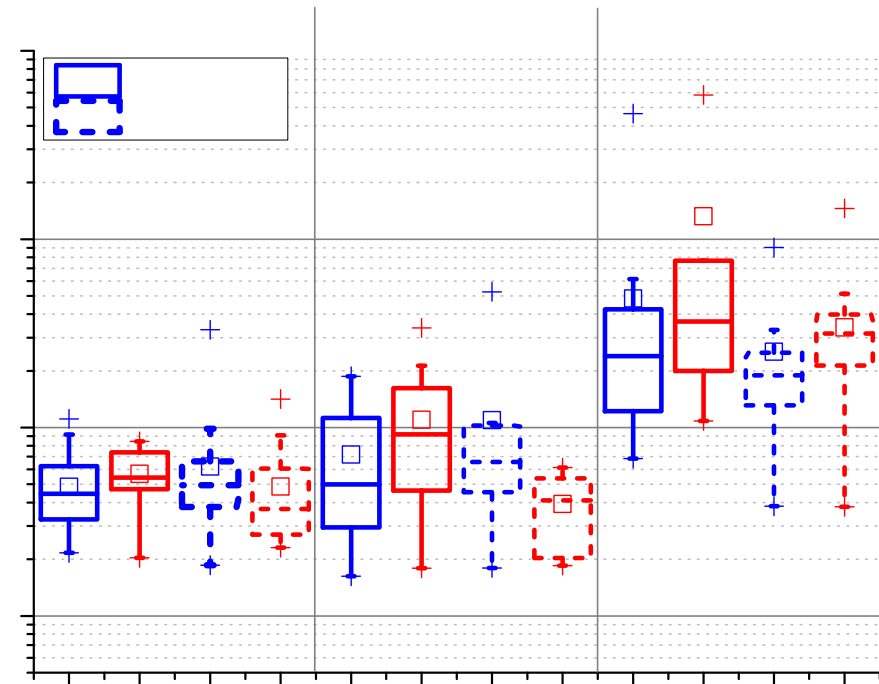
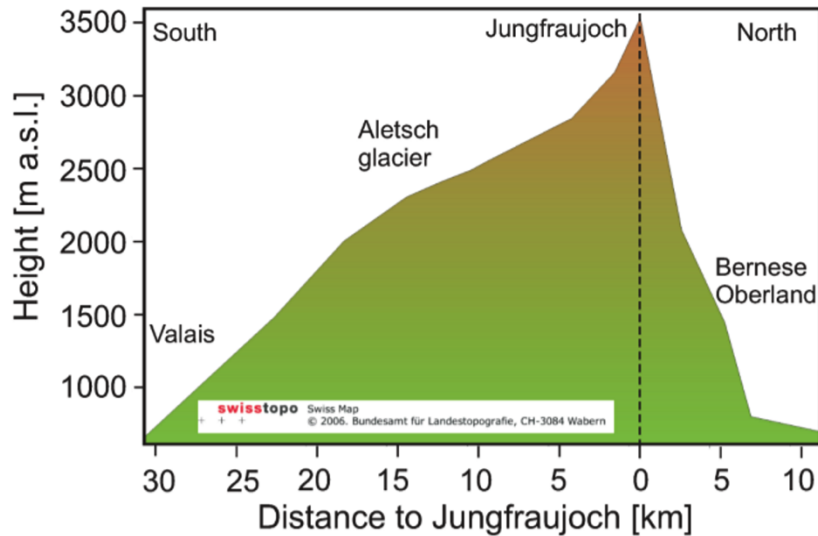
North-West



South-East



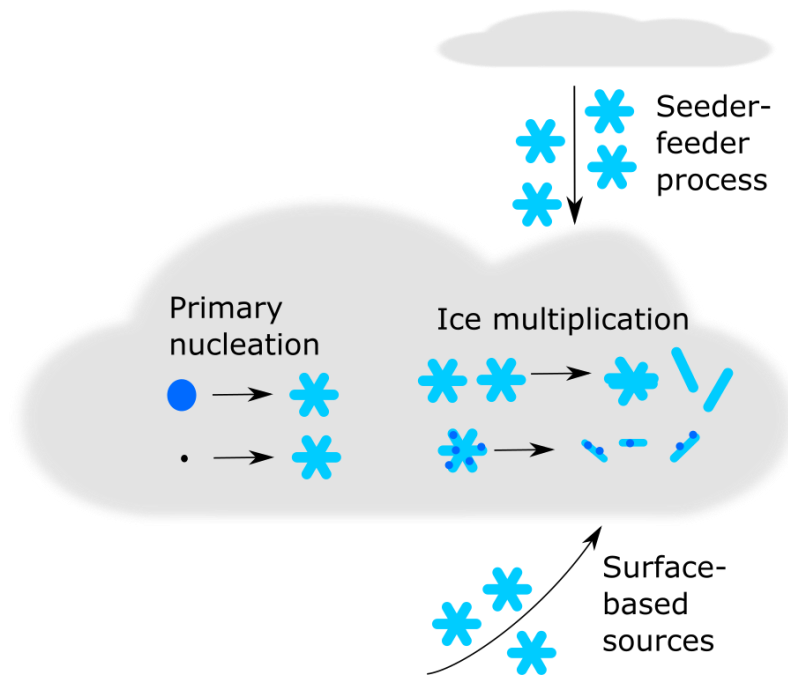
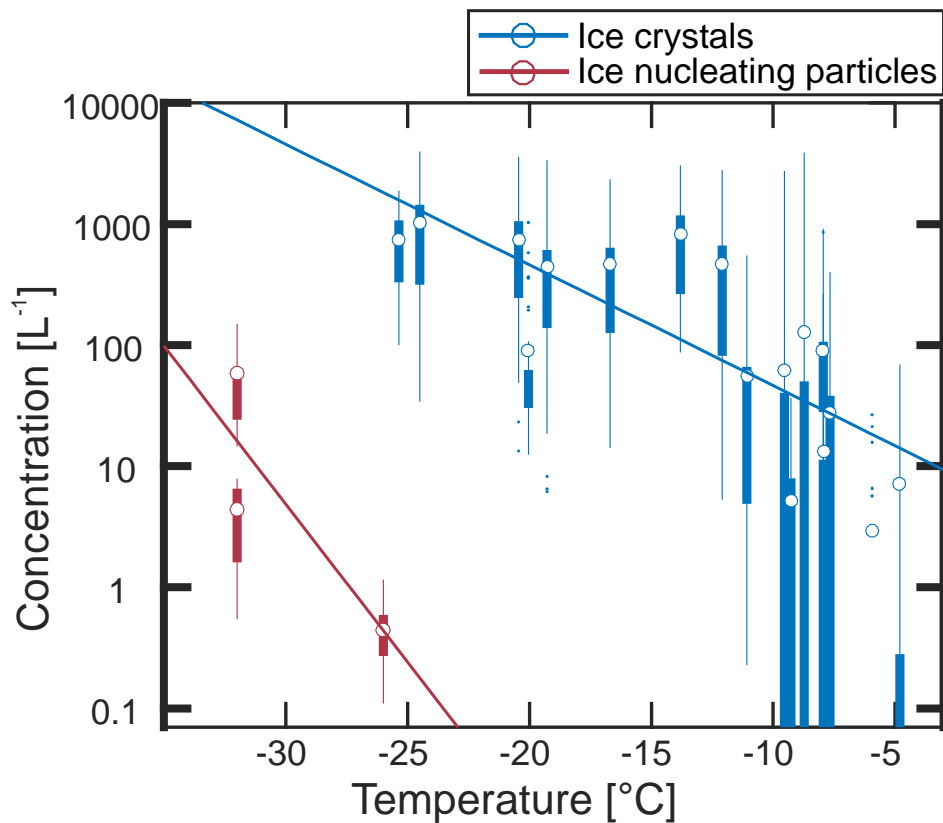
Is the difference due to ice nucleating particles?



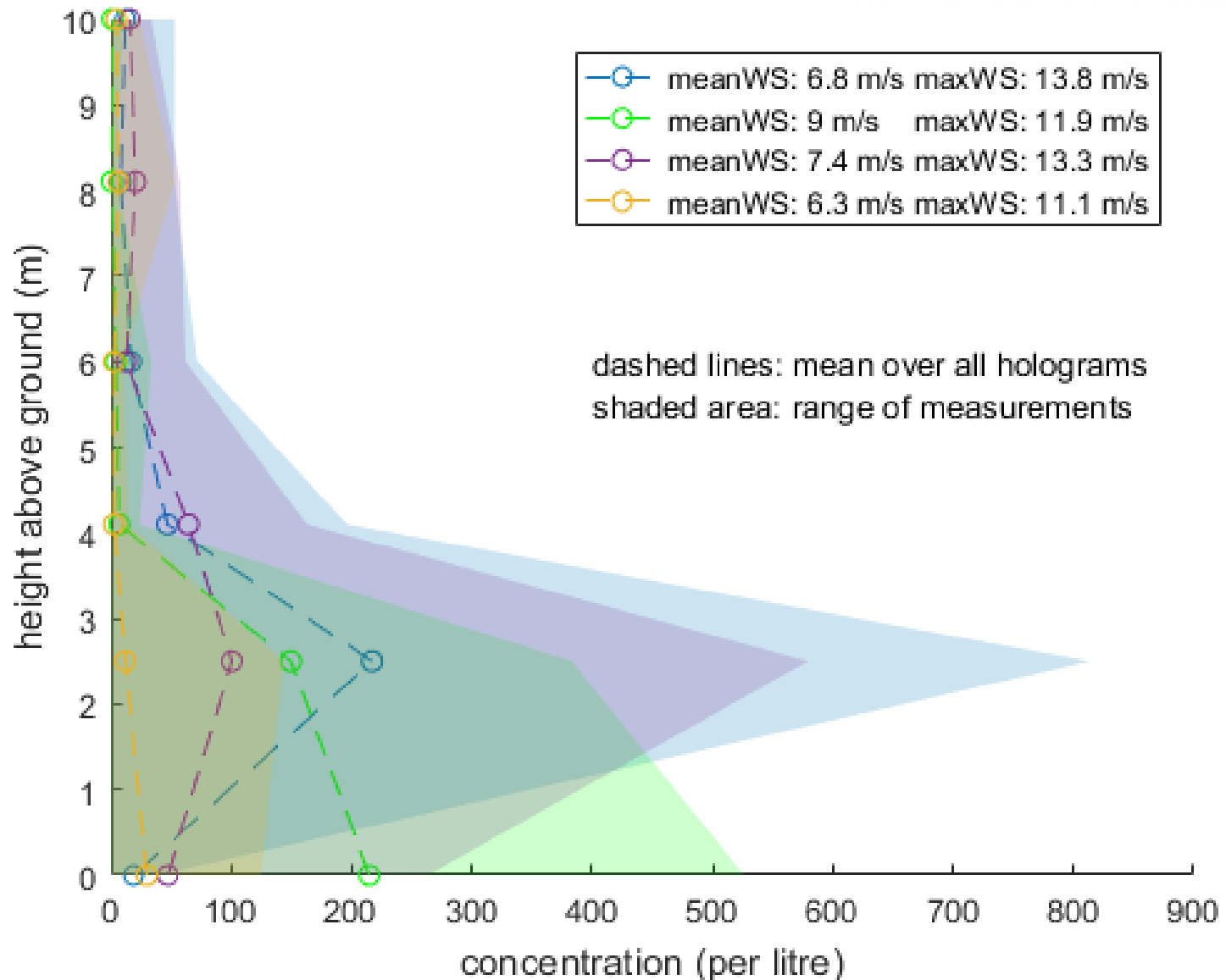
→ Differences in INP concentrations between SE and NW wind cases are small

→ Are there other microphysical reasons or is it due to dynamics?

Ice crystals vs. INP at Jungfrauoch: what causes the discrepancy?

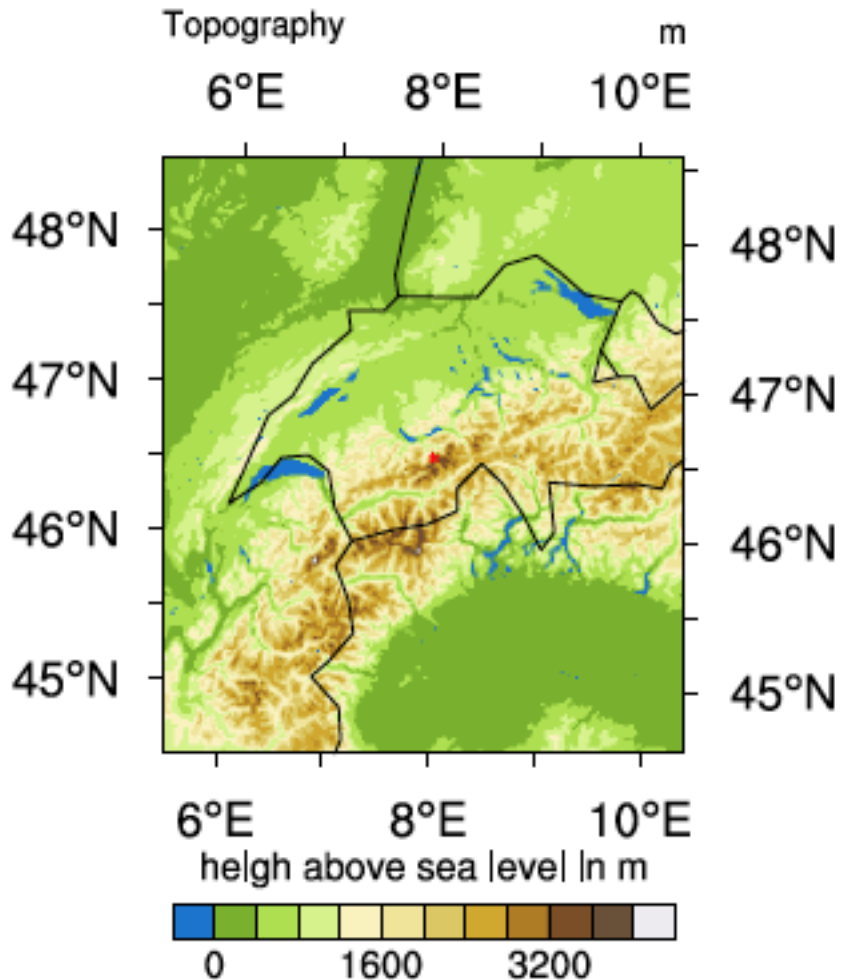


Ice crystal concentration near the surface



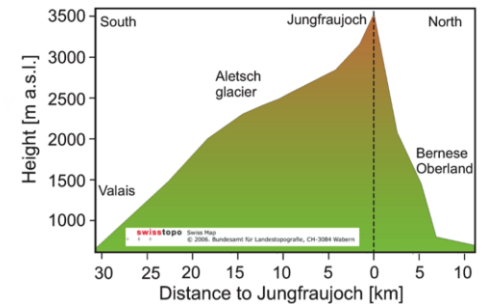
→ Blowing snow could be an important contributor

Can we infer the importance of dynamics from COSMO model simulations?

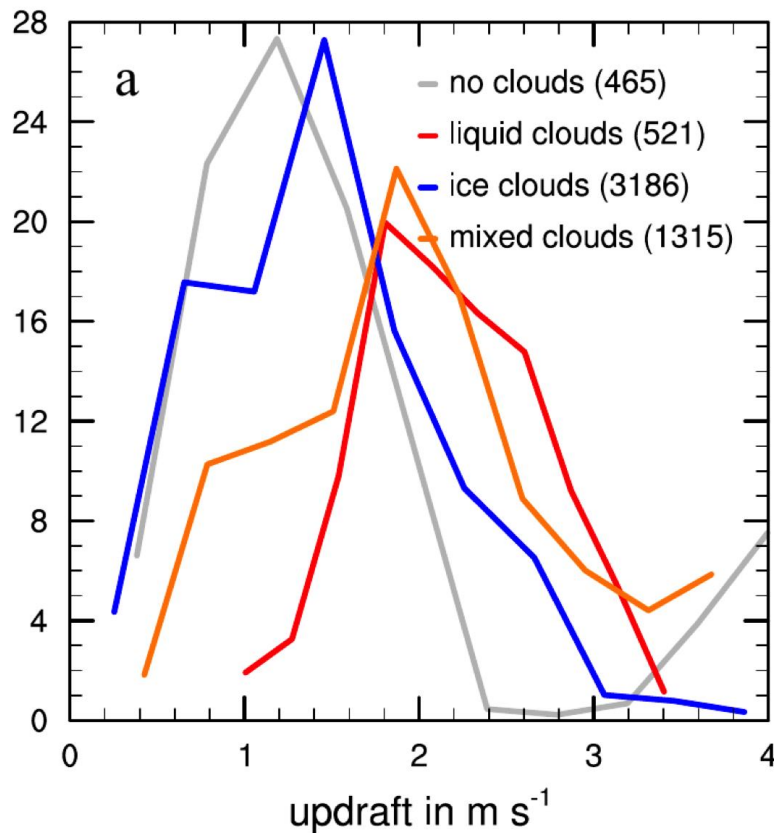


- ▶ 1 km resolution; $\Delta t = 10$ s
- ▶ 350 x 400 grid points
- ▶ Seifert and Beheng (2008) two moment cloud microphysics scheme
- ▶ Phillips et al. (2008) for deposition nucleation and condensation freezing
- ▶ Prescribed CCN and INP concentrations

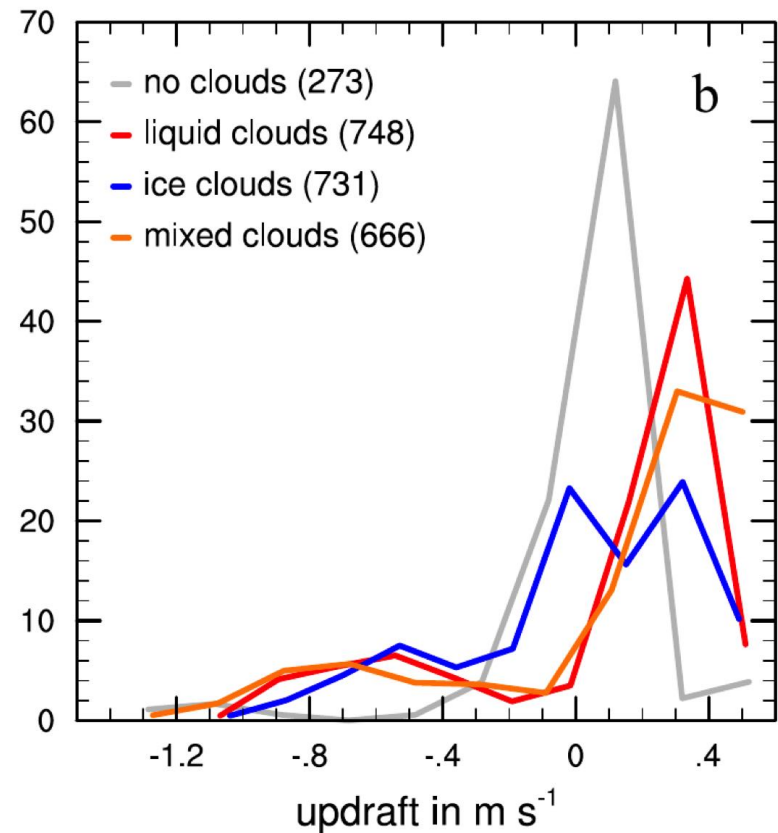
Importance of updraft velocities at Jungfrauoch



NW wind cases

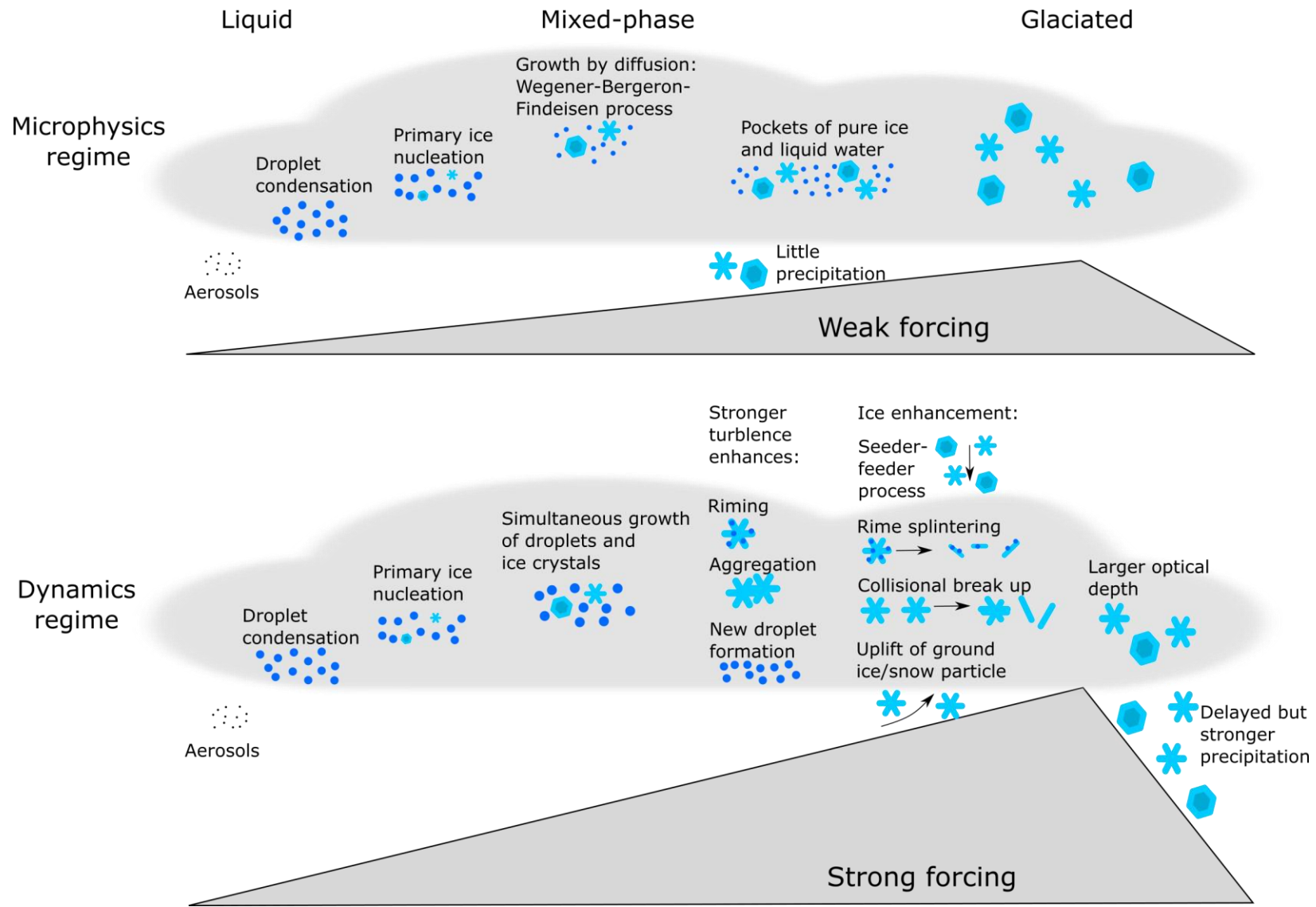


SE wind cases

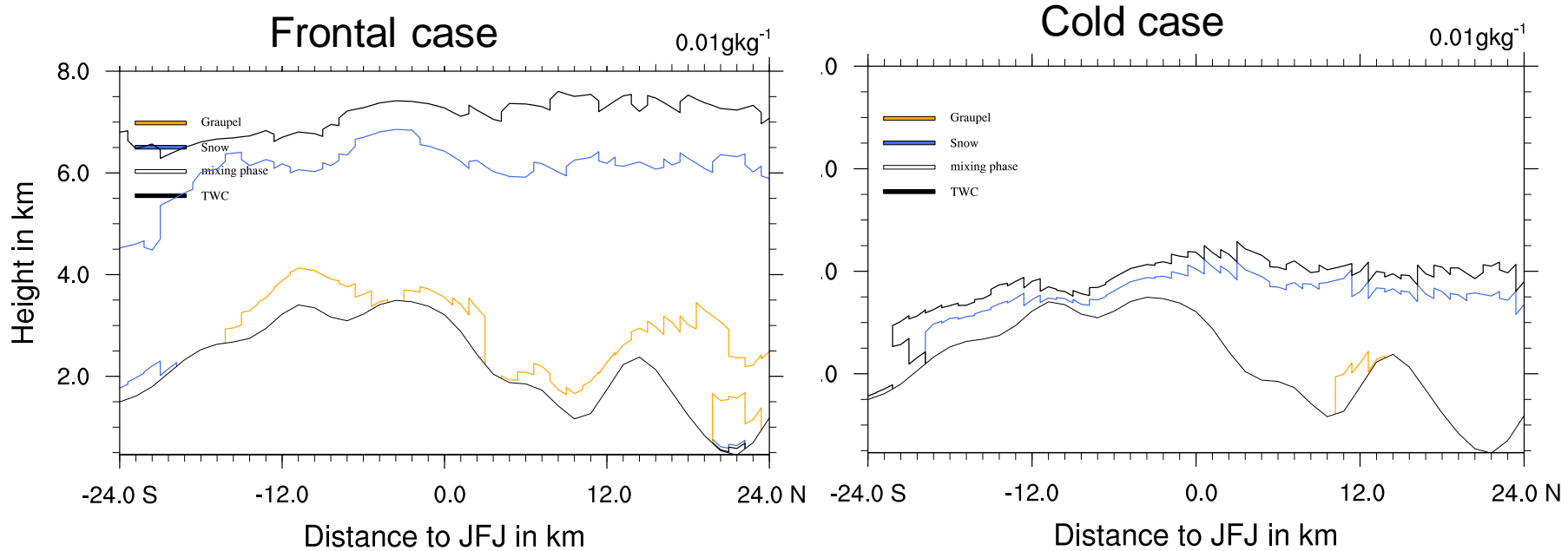


→ Updraft velocities are much higher during NW wind cases

Different cloud regimes at Jungfraujoch

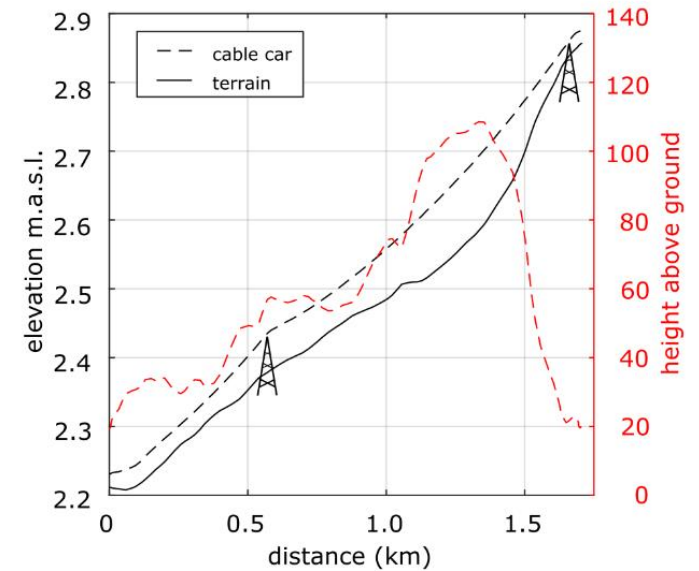
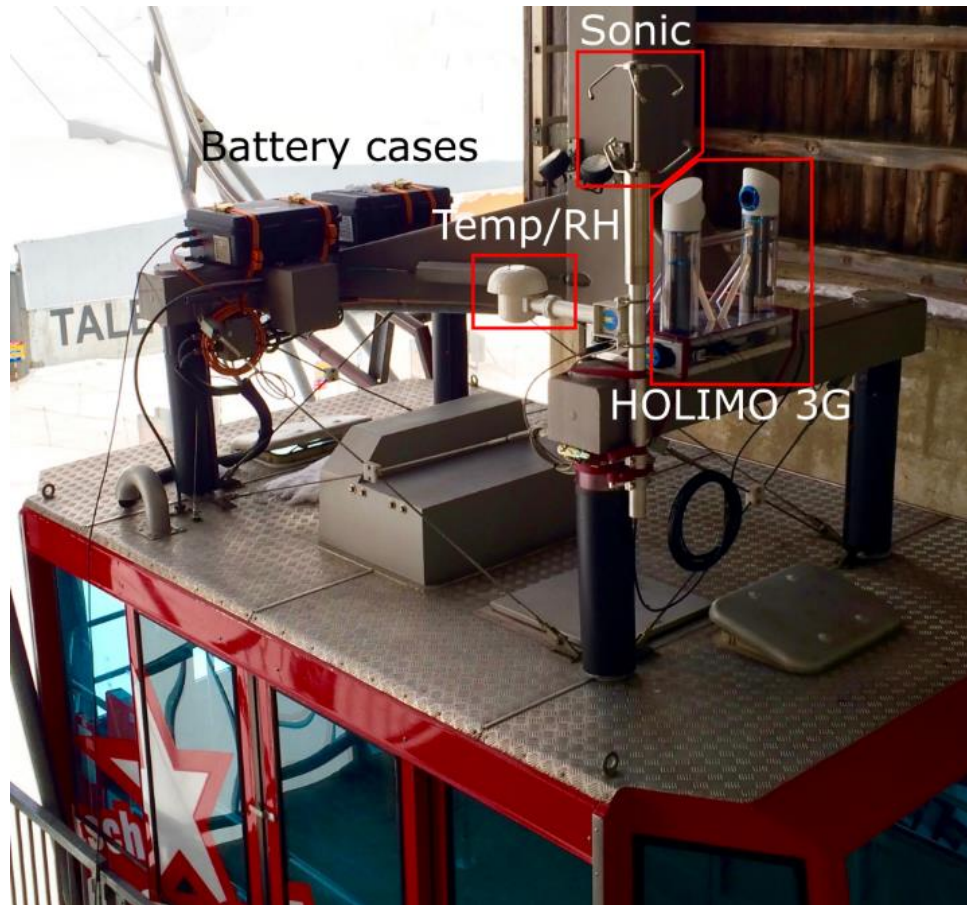


Simulations of orographic MPCs



→ The mixed-phase region is much larger in the frontal case

HoloGondel platform:



How homogeneous are MPCs?

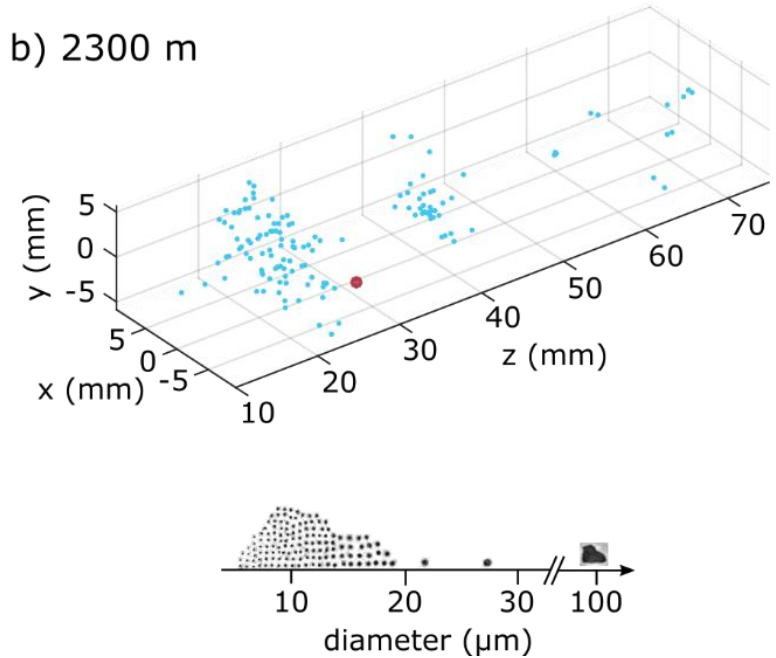
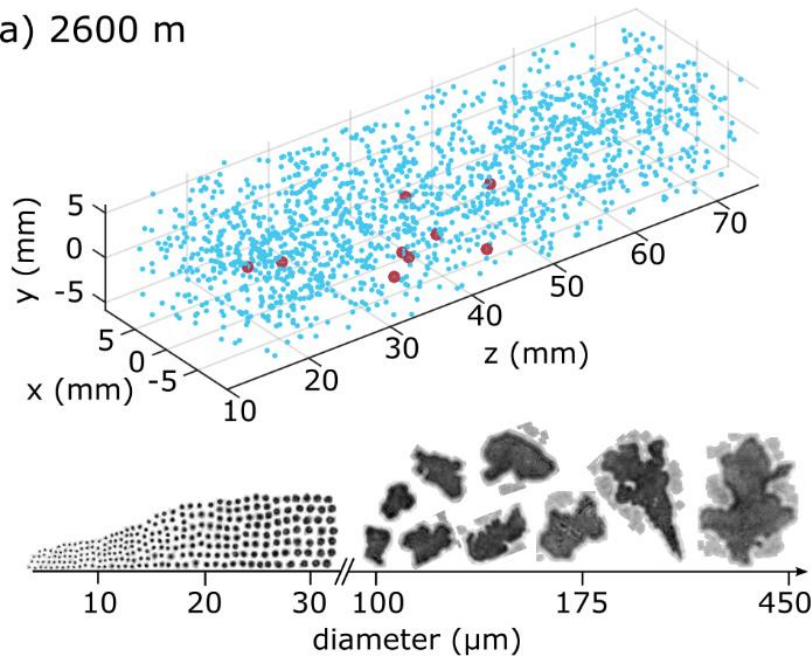
Spatial Distribution:

Undiluted cloud volume

Strongly diluted cloud volume

a) 2600 m

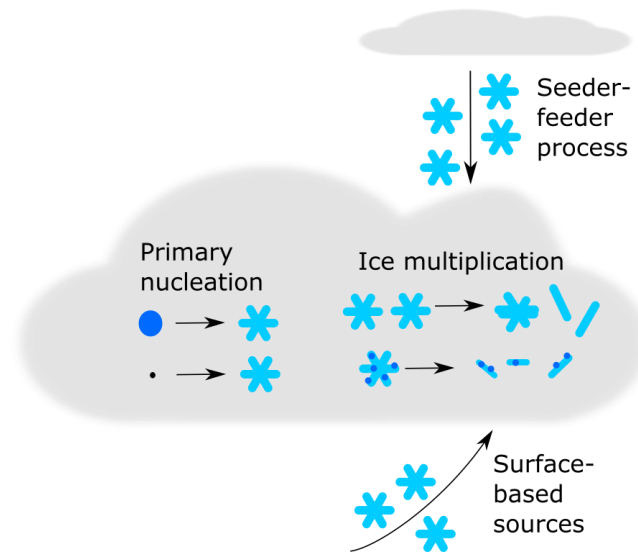
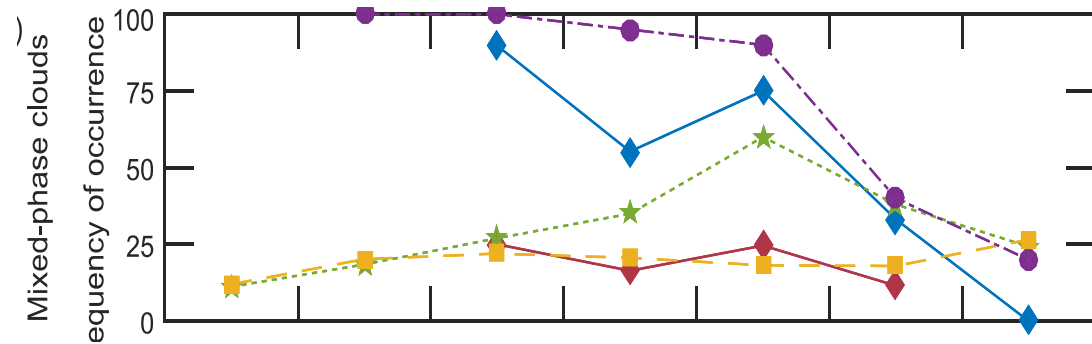
b) 2300 m



Conclusions

- Mixed-phase clouds are persistent in the Alps given a strong dynamic forcing

- The sources of ice crystals in our observed mixed-phase clouds remain uncertain

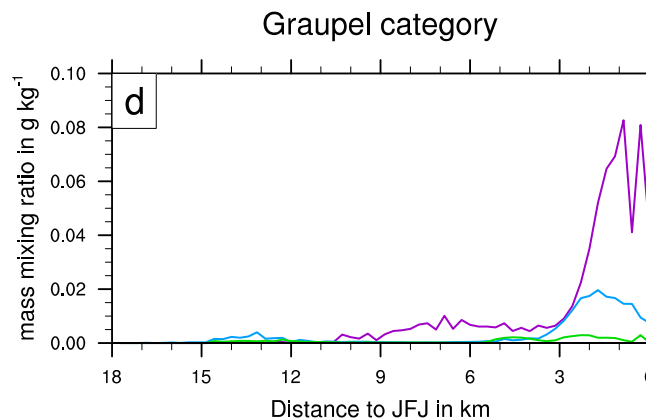
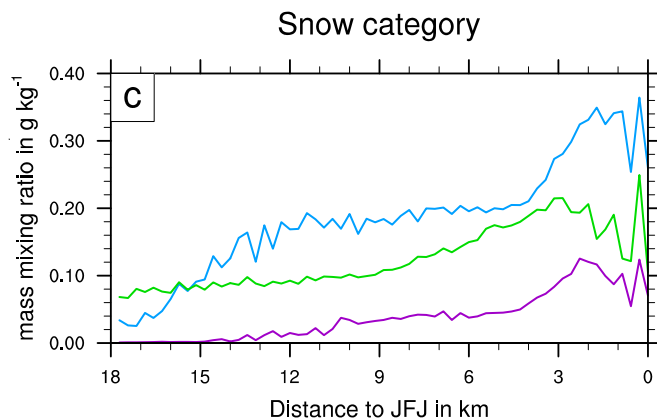
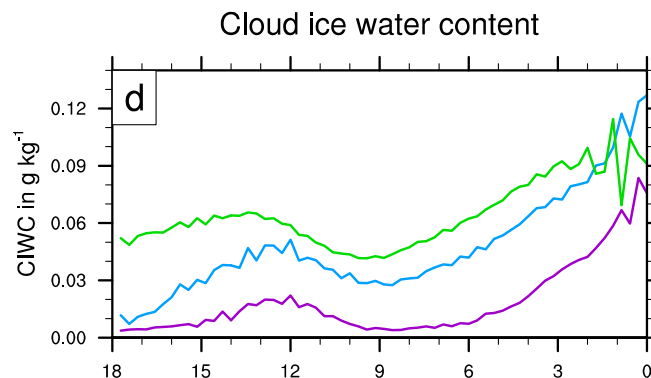
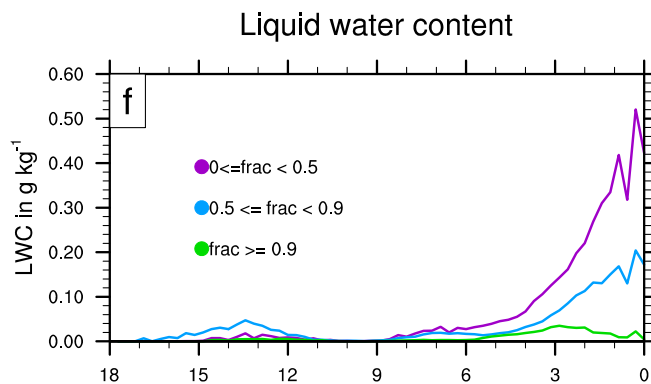
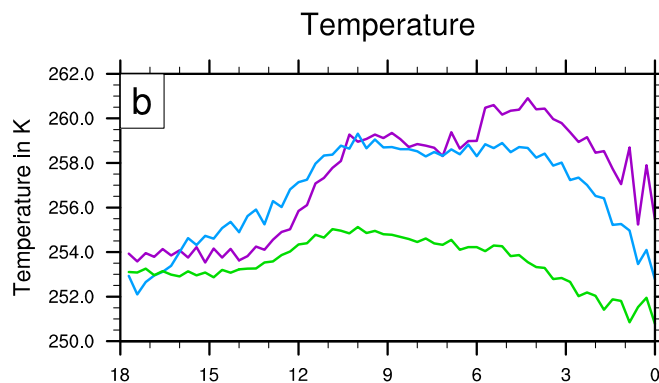
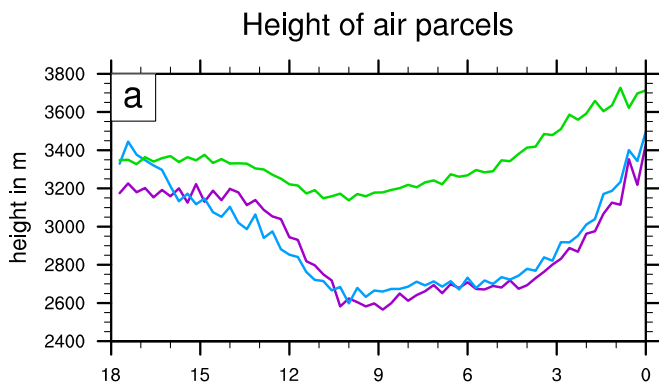


- Our in-situ measurements can help to validate remote sensing algorithms of mixed-phase clouds

Thank you for your attention

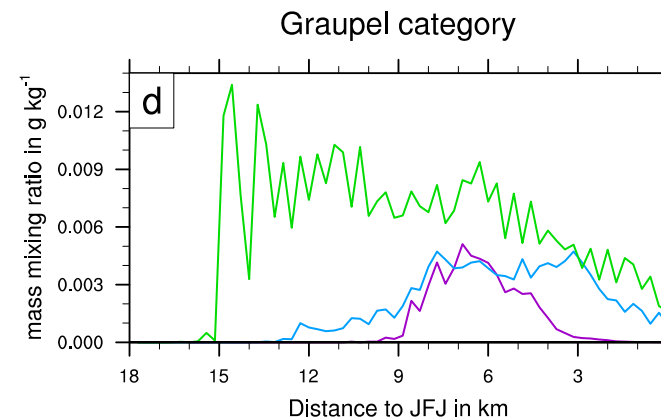
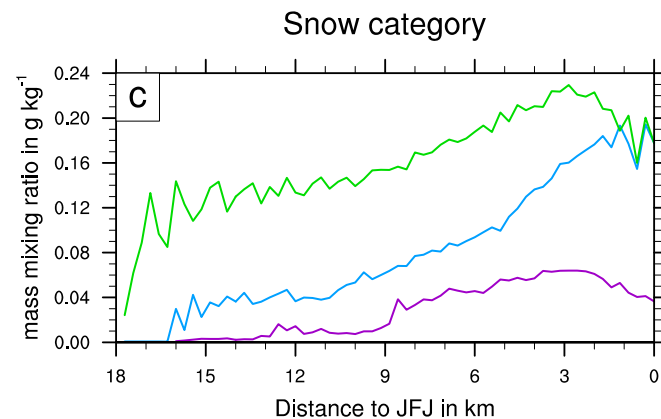
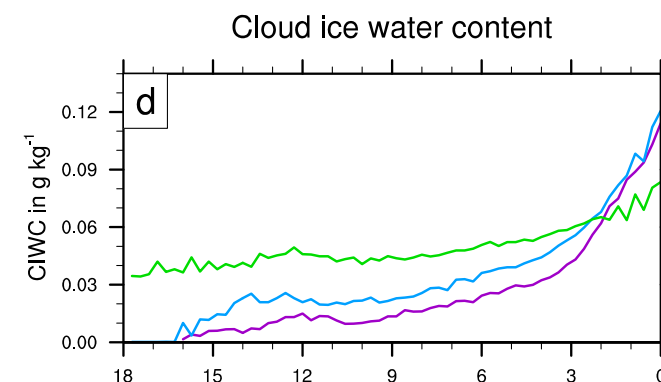
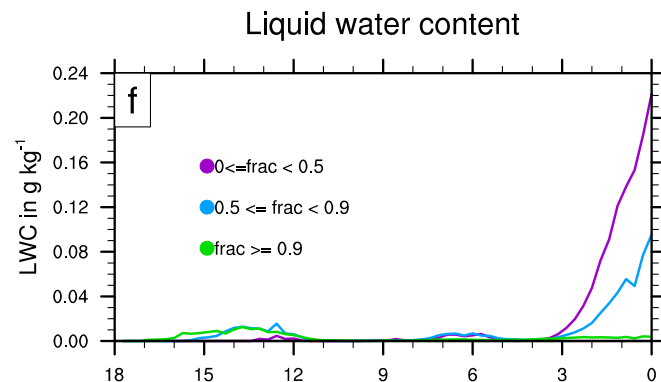
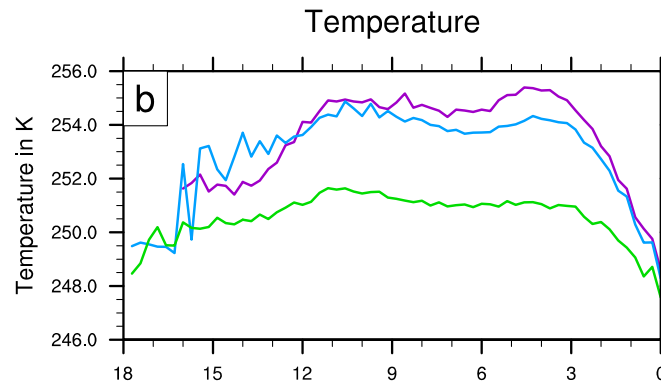
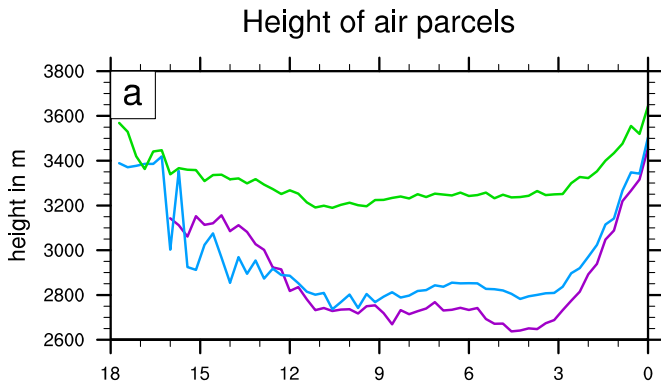


Air parcel trajectories on their way to the JFJ



Frontal case
(Henneberg et al., 2017)

Air parcel trajectories on their way to the JFJ



Cold case
(Henneberg et al., 2017)