EarthCARE 2026 Science and Validation workshop

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Isolating aerosol impacts on high clouds

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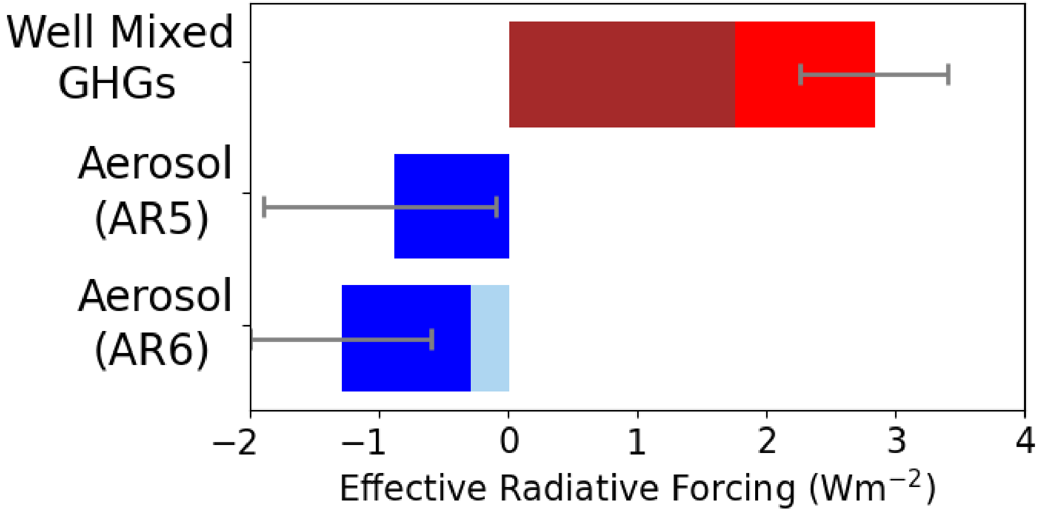
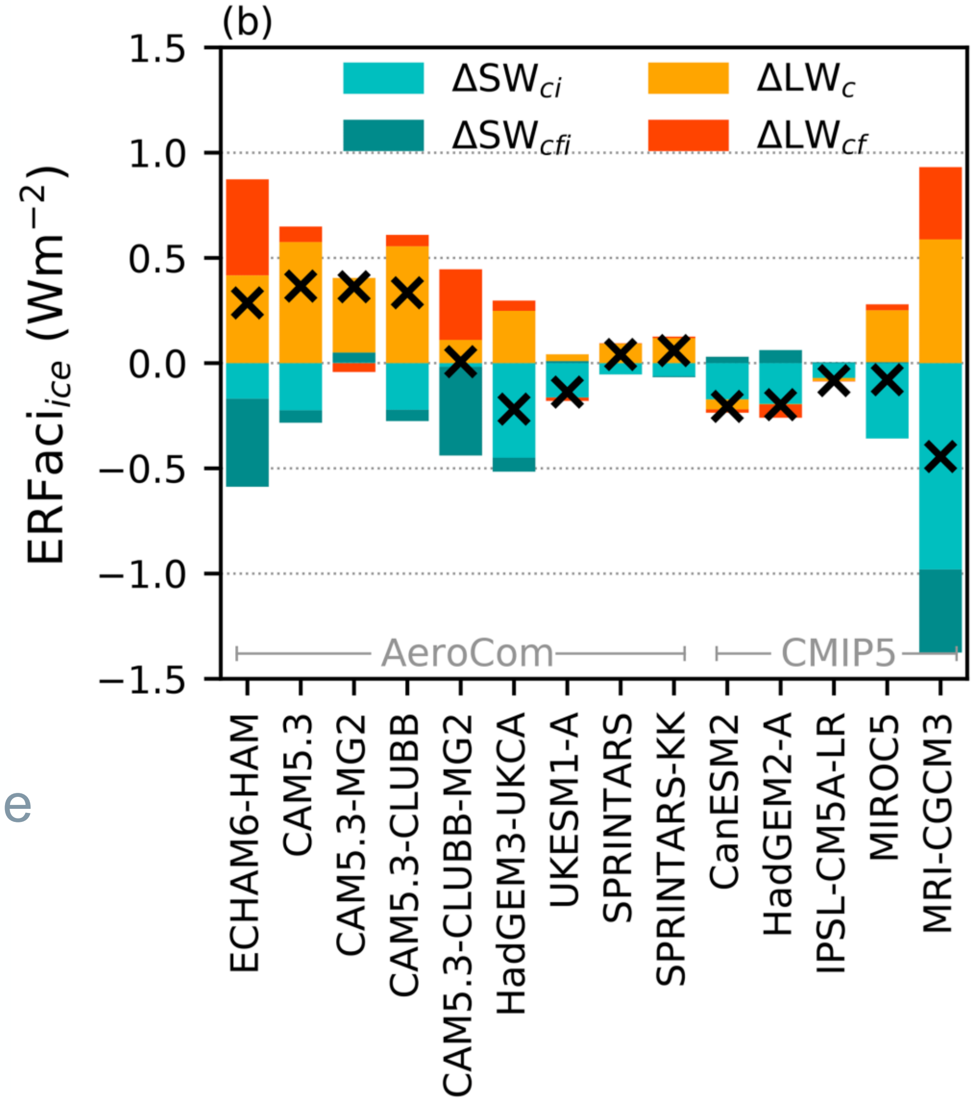
Ice cloud ACI





Aerosol impacts on clouds remain uncertain

Aerosol impacts on ice clouds remain uncertain

These AeroCom and CMIP5 models show a variation in the forcing of -0.6 Wm-2

- Even though the SW and LW terms almost balance
- Similar to the variation in the ERFaci from liquid clouds

Gryspeerdt et al, 2020

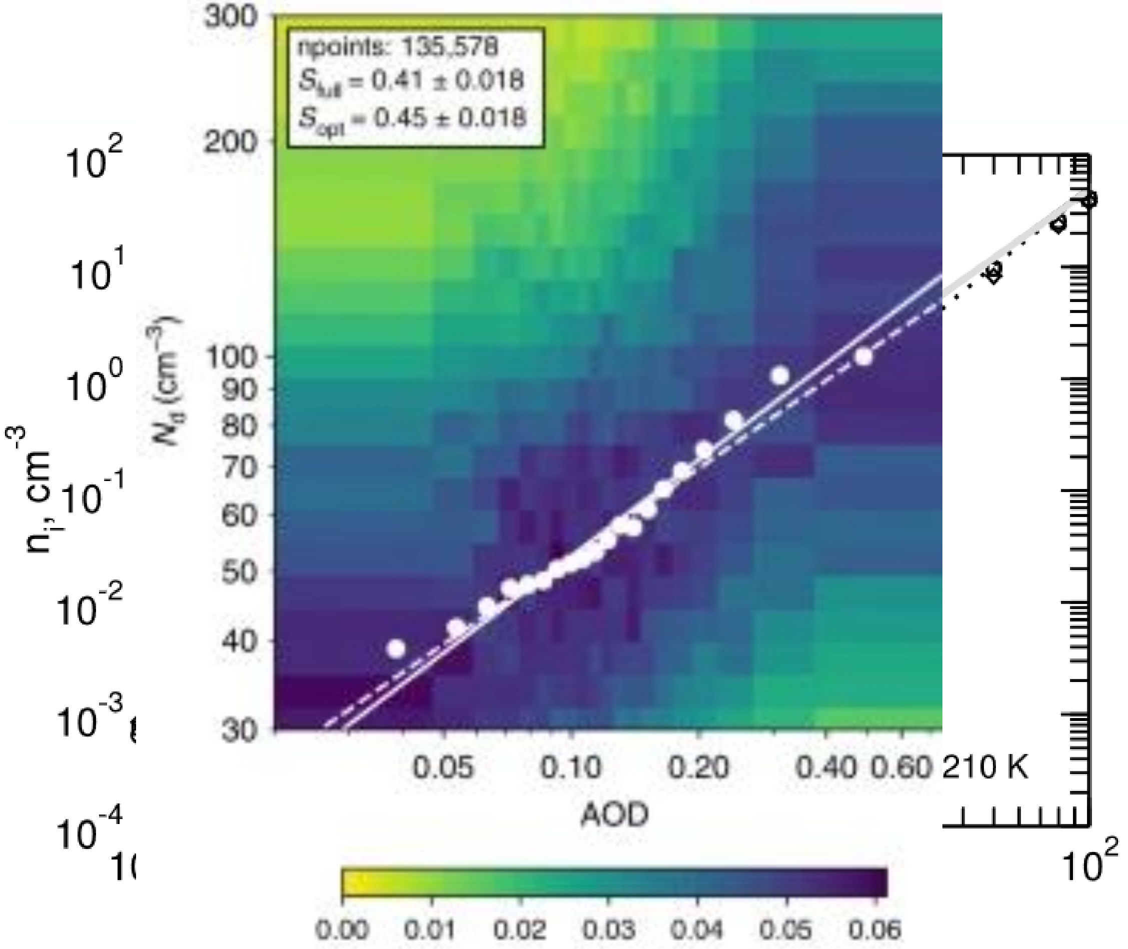
Why are ice clouds difficult?

Liquid clouds are *comparatively* simple:

- Increases in aerosol *usually* bring increases in droplet number
- Droplet number is more sensitive to CCN than cloud updraught
- Cloud droplets are spherical

For ice clouds:

- Adding aerosol might increase crystal number
- It might decrease crystal number
- Changes in updraught can modify these effects.



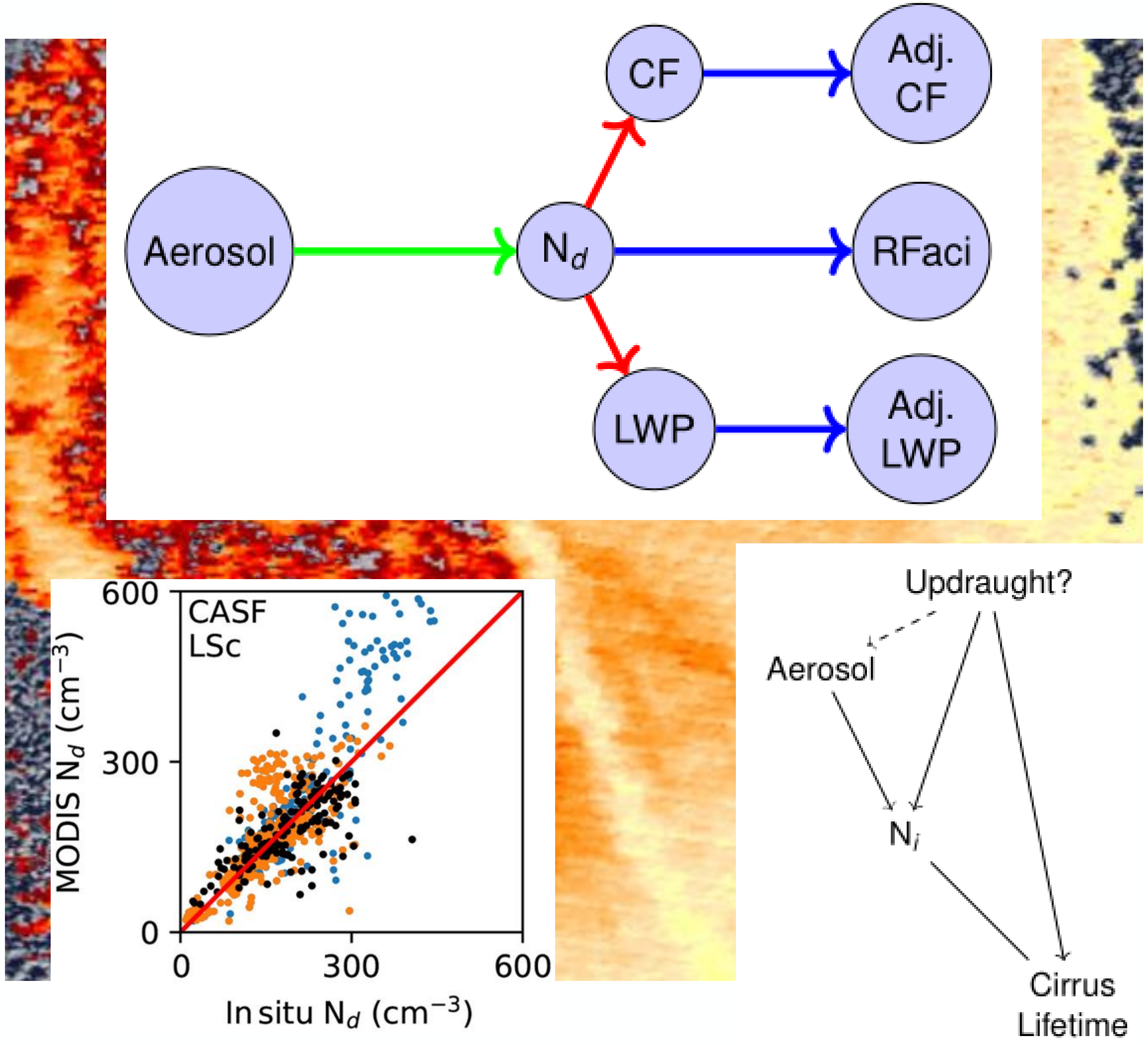
Hasekamp et al, 2019; Kärcher et al, 2006

Number concentrations

Retrievals of droplet number concentration are very important for liquid cloud studies:

- Droplet number is often the clearest change in cloud
- It mediates other changes (CF, LWP)
- The retrieval is surprisingly good!

Can we do the same with crystal number for ice clouds?



Gryspeerdt et al, 2022

Measuring ice crystal number

Ice number is difficult to measure

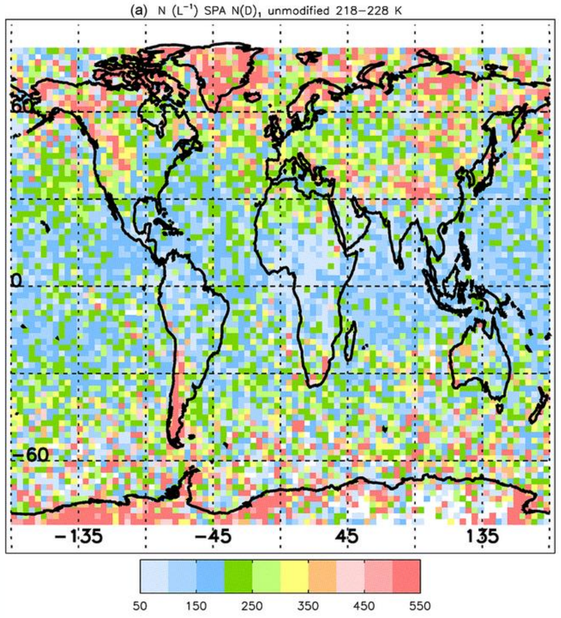
- Crystal shattering can affect older measurements
- Newer measurements are limited by aircraft availability

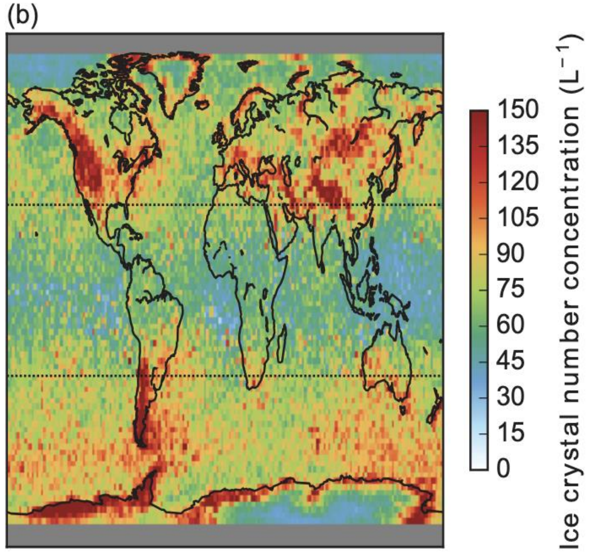
Satellite retrievals give a wider coverage

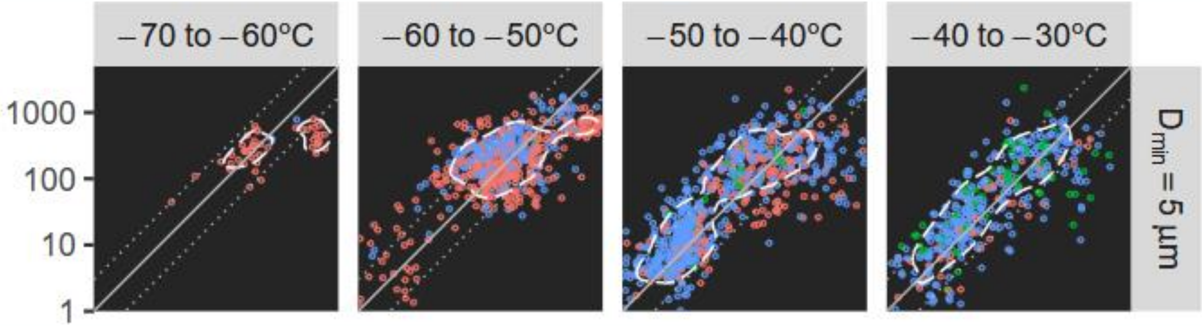
- CALIPSO-only (lidar+IR) show regional differences
- Combined radar-lidar retrievals (DARDAR/DARDAR-Nice) compare well to (newer) aircraft measurements

Increases around mountains

- The impact of dynamics(?)







Korolev et al., 2013; Kramer et al. 2012;
Mitchell et al, 2018; Sourdeval et al., 2018; Gryspeerdt et al, 2018

Ni from EarthCare

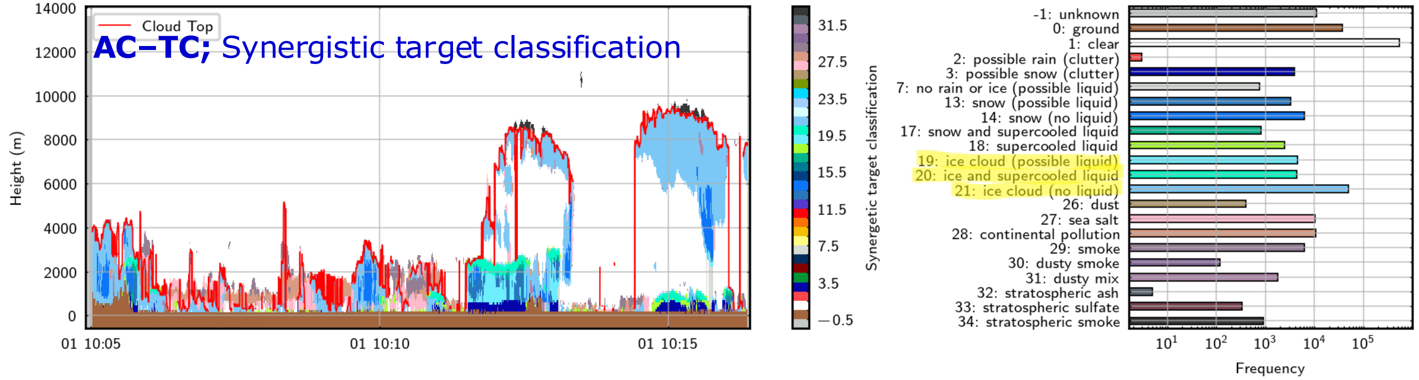
Focus on behaviour near cloud top

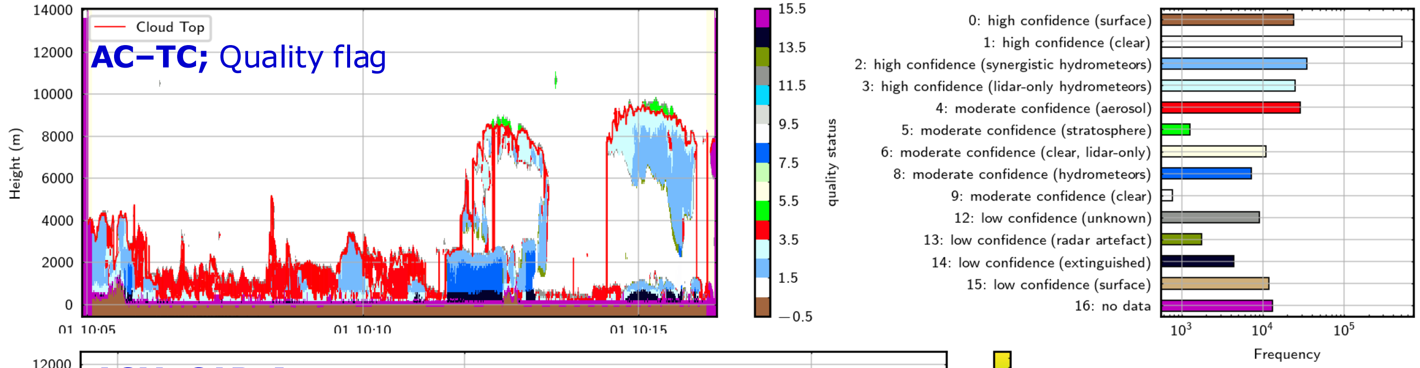
- The coldest part of the cloud
- Expect the clearest temperature dependence

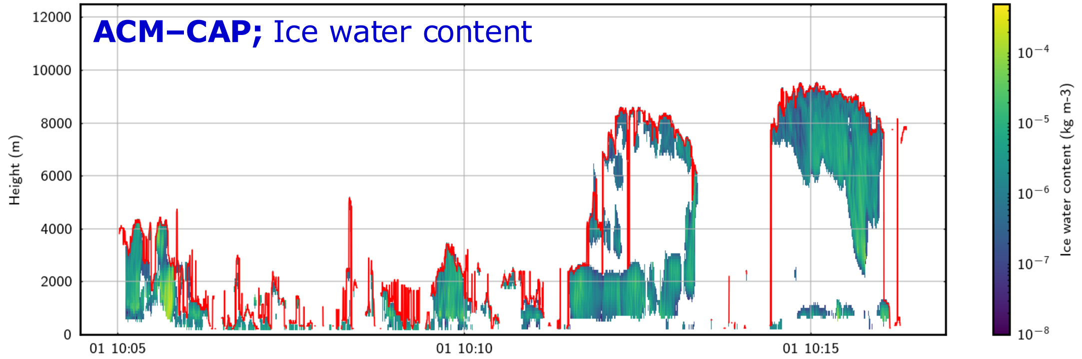
Use the target classification to select the top ~100m of the cloud

- Note: This is often lidar-only

Convert normalised number concentration to Ni (Field et al, 2005)



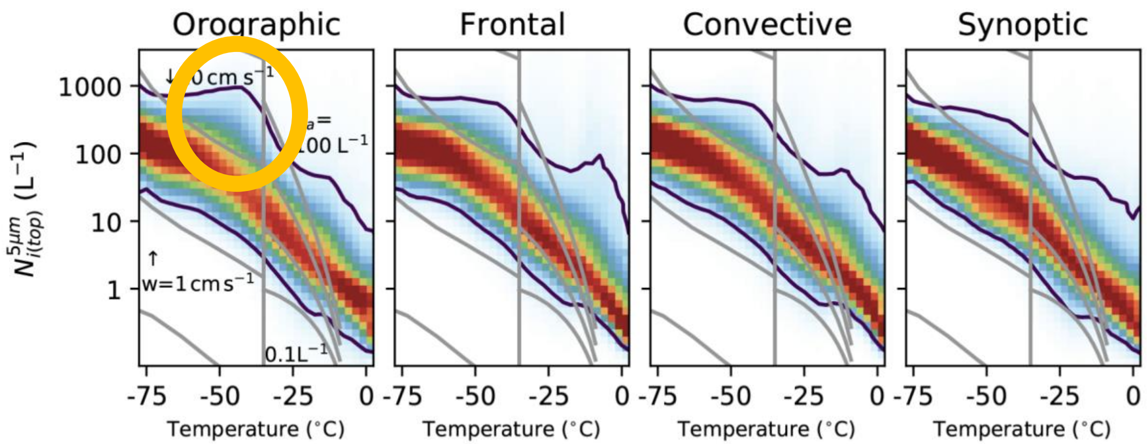




Temperature dependence

DARDAR showed a clear temperature dependence for Ni at cloud top

- ACM-CAP is similar, but weaker for coldest clouds
- There is a temperature dependent prior…

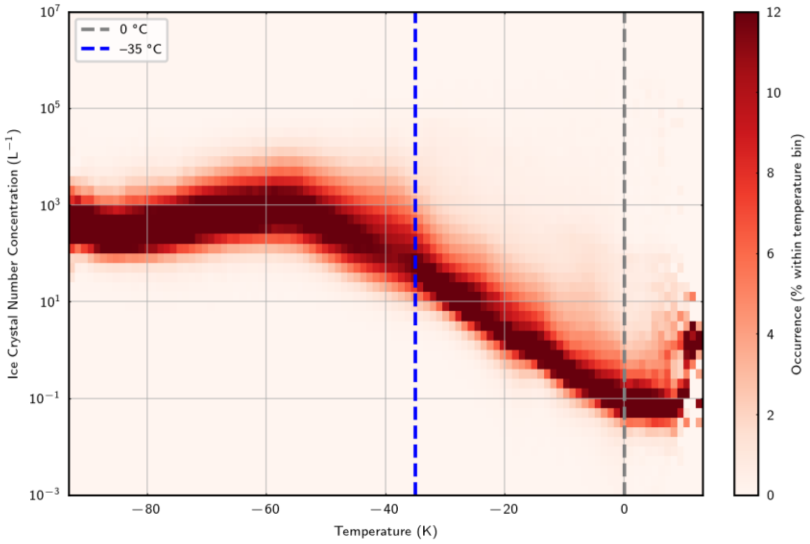


EarthCare Ni values are much higher than DARDAR

- Partly from size distribution used for Ni conversion
- Absolute values not a good comparison

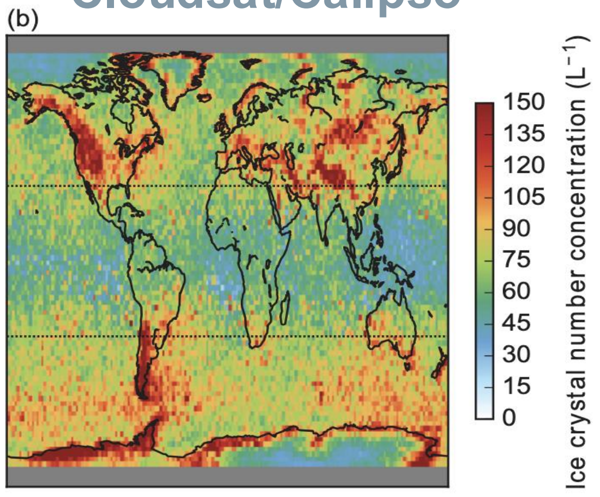
The peak at approx. -40C is less clear

- Possibly due to sampling

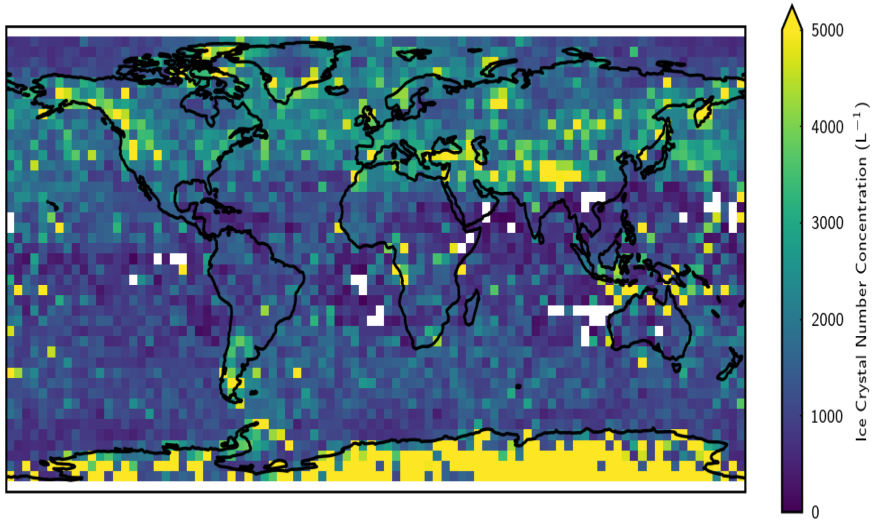


Locations of high Ni

Cloudsat/Calipso



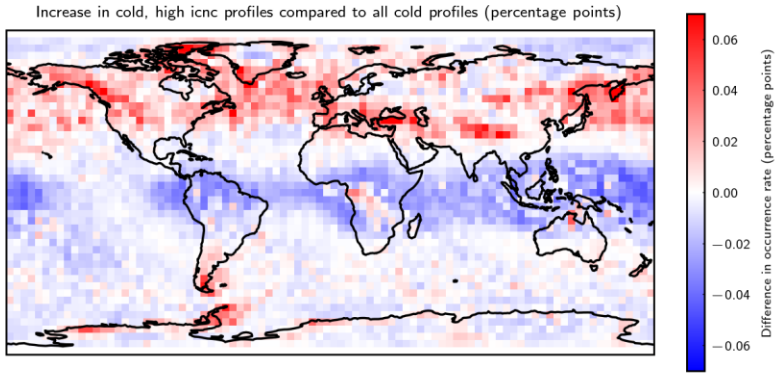
EarthCare



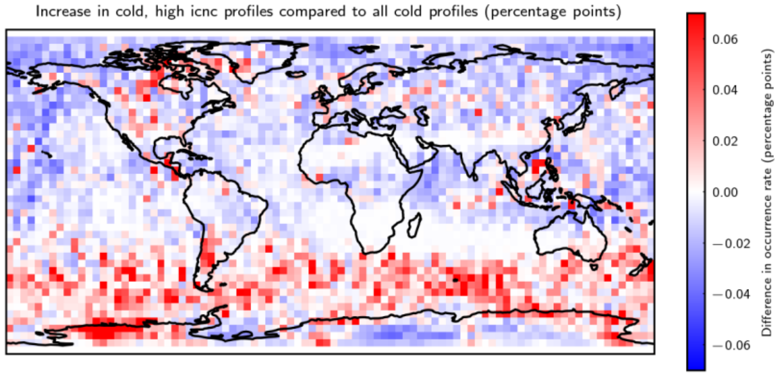
freq((CLTT ≤ −35°C)&(Ni ≥ 5*Ni_T)) freq(CLTT ≤ −35°C)

(where Ni_T is median observed Ni in each temperature bin)

Jan/Feb only



June only



Some similar features appear in the Ni distribution (around -40C)

- Higher Ni over mountains, lower in the tropics

A strong seasonal cycle in the ‘higher than expected Ni’ cases

- Particularly in the winter hemisphere

Impact of updraught

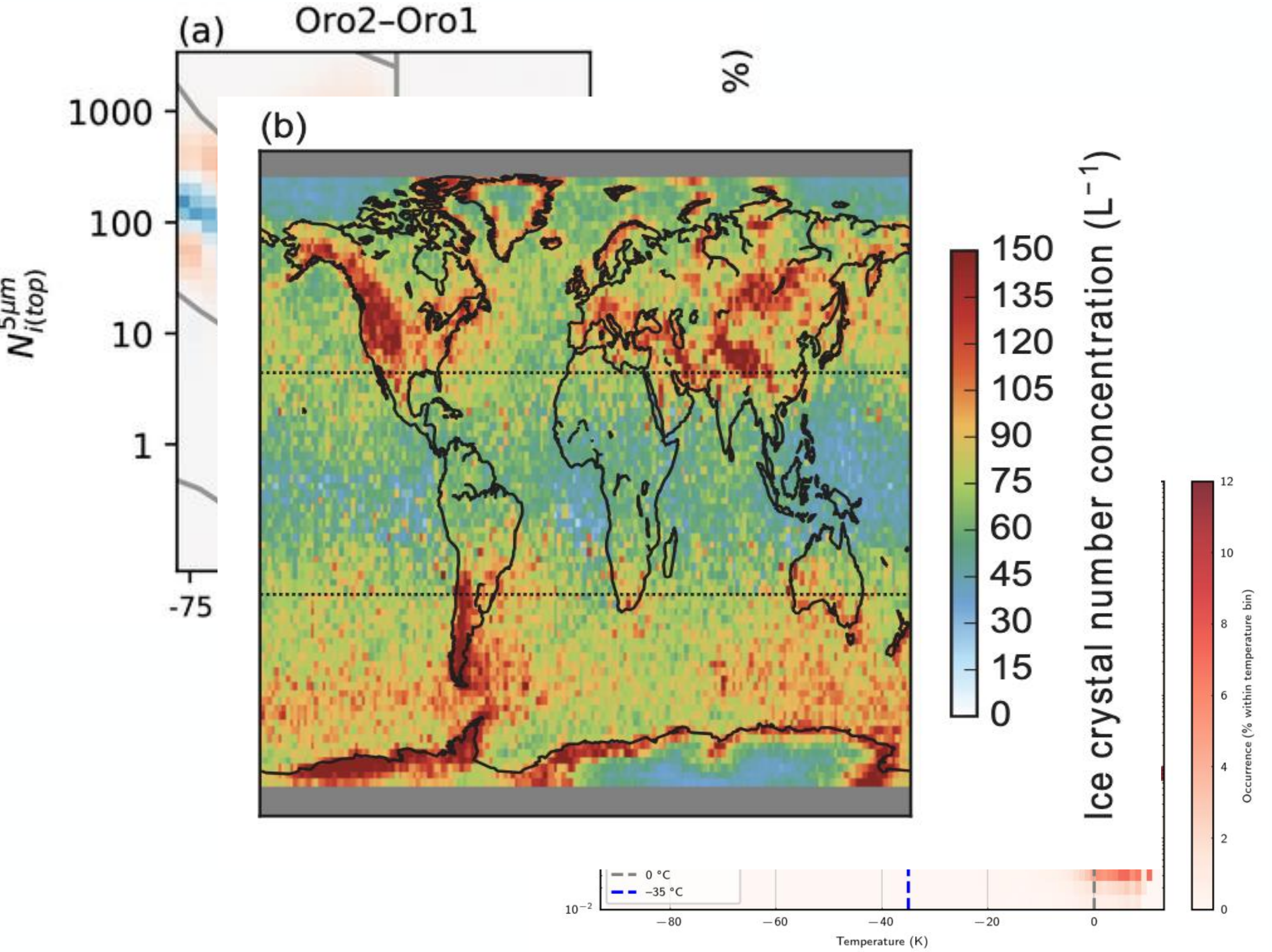
The mountain signatures hint at a role for dynamics

With DARDAR we estimated this using an orographic updraught parametrisation

- Biggest changes in Ni in the coldest clouds

For EarthCare, use doppler velocity within 500m of cloud top

- Some impact on median Ni around -40C
- Very little effect for the coldest clouds
- Sampling effects at play here?



Summary

Ice cloud processes are complex

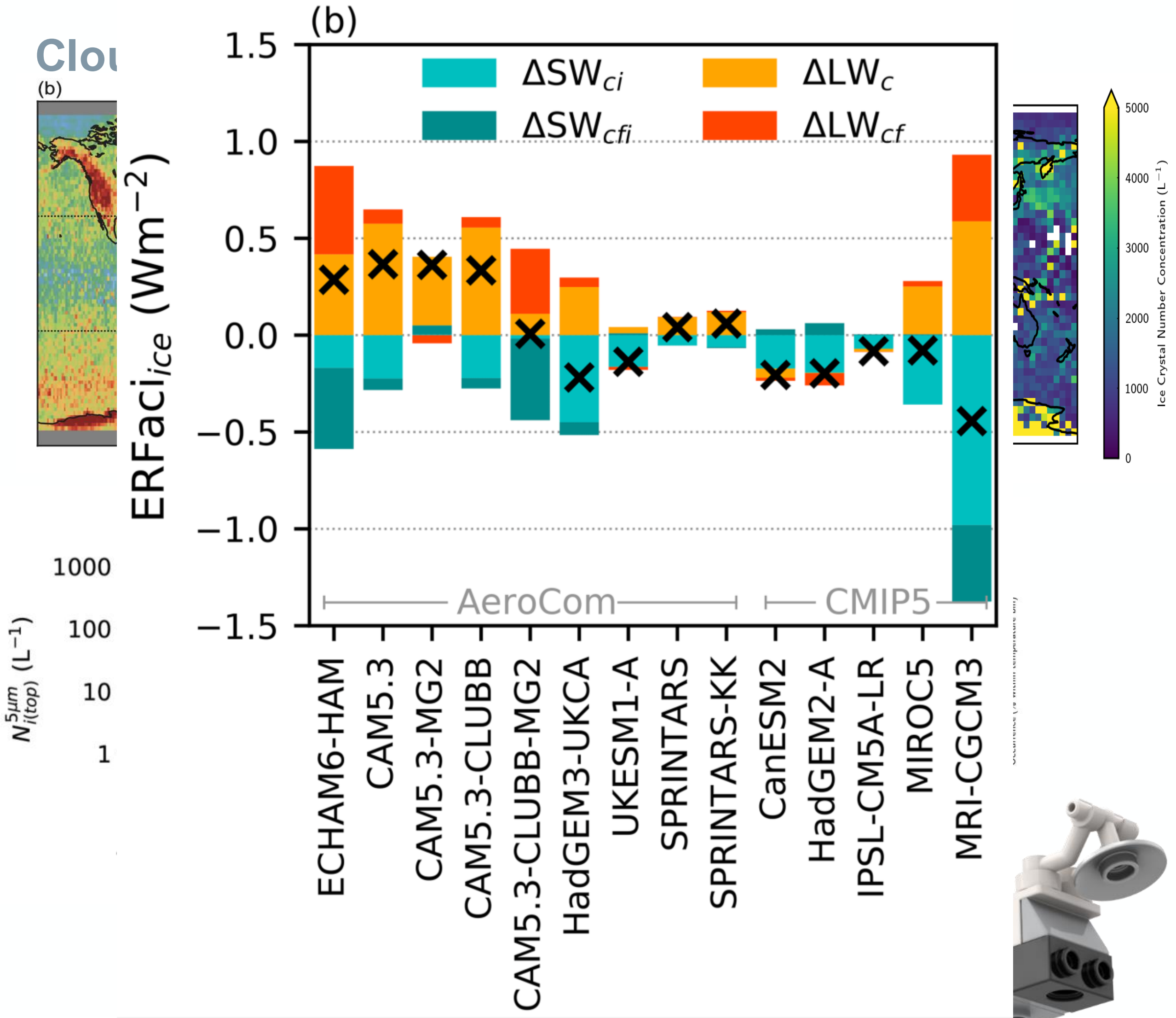
- A significant variation in model forcing estimates
- Number concentration would be a very useful property to measure

EarthCare/ACM-CAP has similar features to CloudSat-CALIPSO retrievals

- Ni peaks near mountains
- Strong temperature and latitudinal variations

The dynamics impact is not as strong as expected

- Possibly a cloud top/sampling effect?



Can you name all the lEgO satellites?