Mid-latitude and Arctic supersaturations observed during Cirrus-HL

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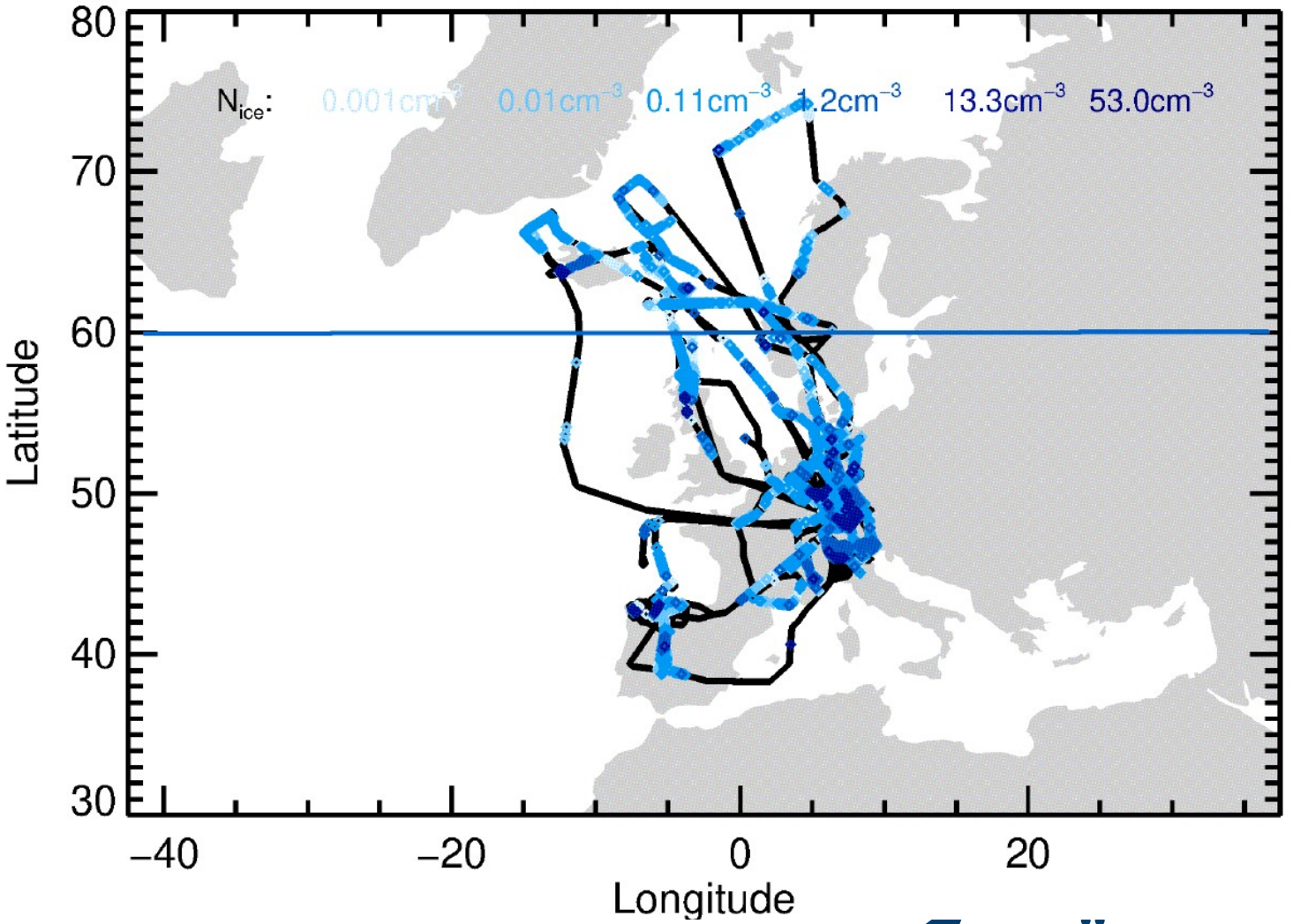
CIRRUS-HL AIRCRAFT MISSION

In-situ cloud and water vapor observations in Mid-latitudes and Arctic upper troposphere

- Latitude coverage: 40-75°N
- Time range: 26.06.-28.07.2021
  with 24 science flights
- In-cloud and out-cloud humidity measured by the Sharc instr. (**RH_{ice}**)
- Ice Particle number concentration (**N_{ice}**) and Ice Water Content (**IWC**) from Nixe-Caps particle spectrometer

28,1 hours inside of clouds

Cloud particle number concentration (3-956 µm, color-coded)



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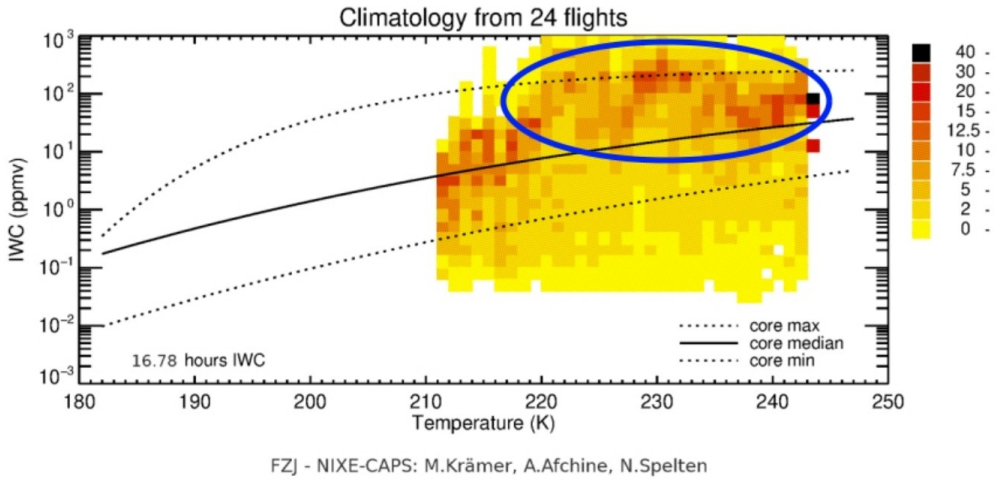
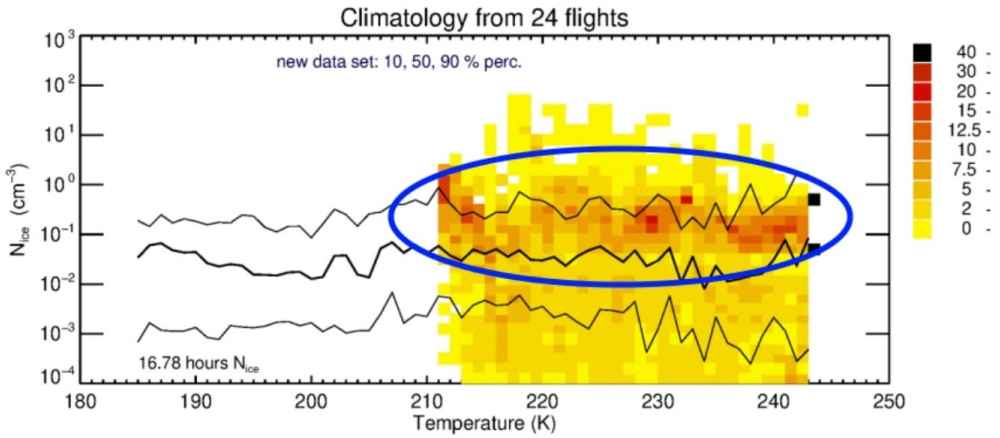
CLOUD OBSERVATIONS DURING CIRRUS-HL

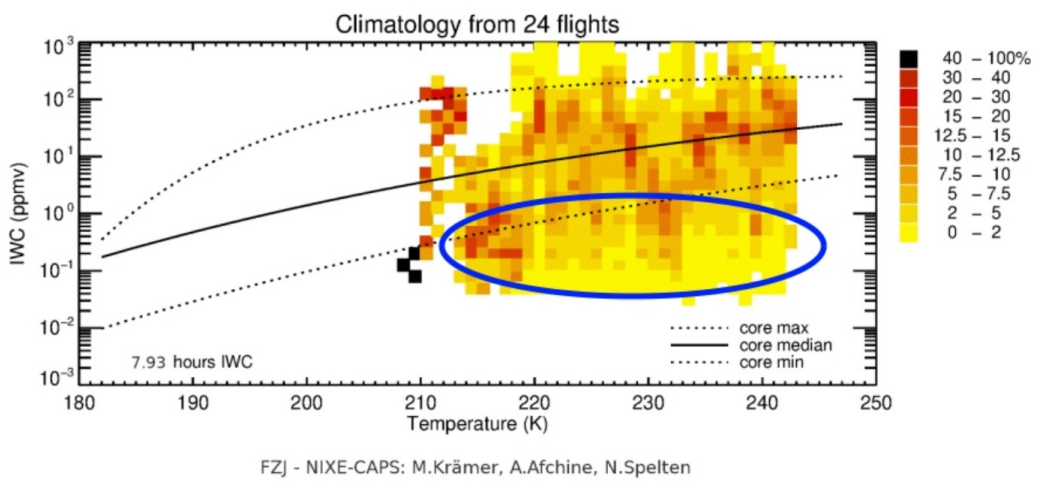
Mid-latitude (40 - 60°N, 18.9 hours)

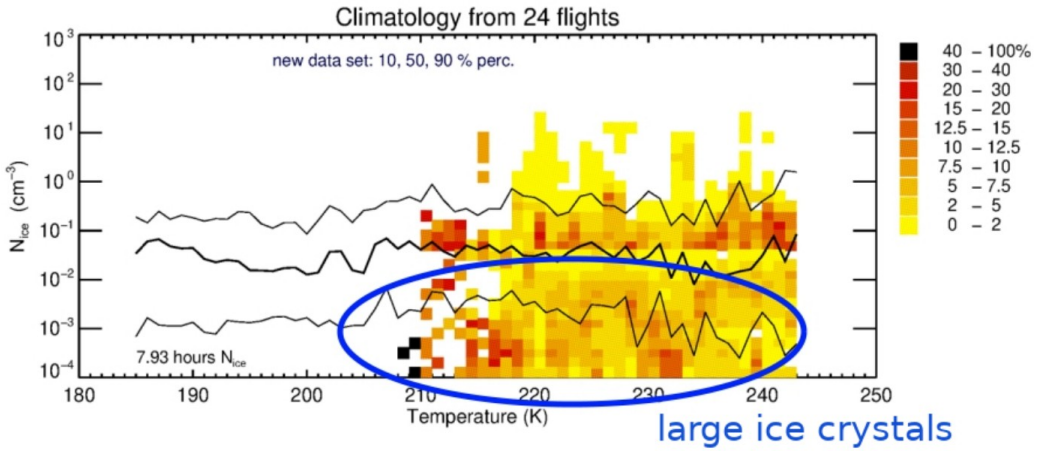




► high IWC and N_{ice}

Arctic (> 60°N, 9.2 hours)





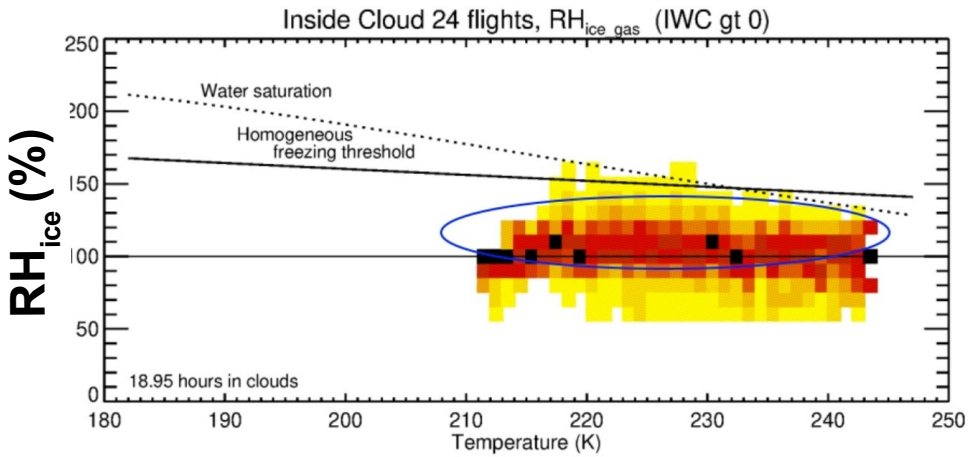
► low IWC and N_{ice}

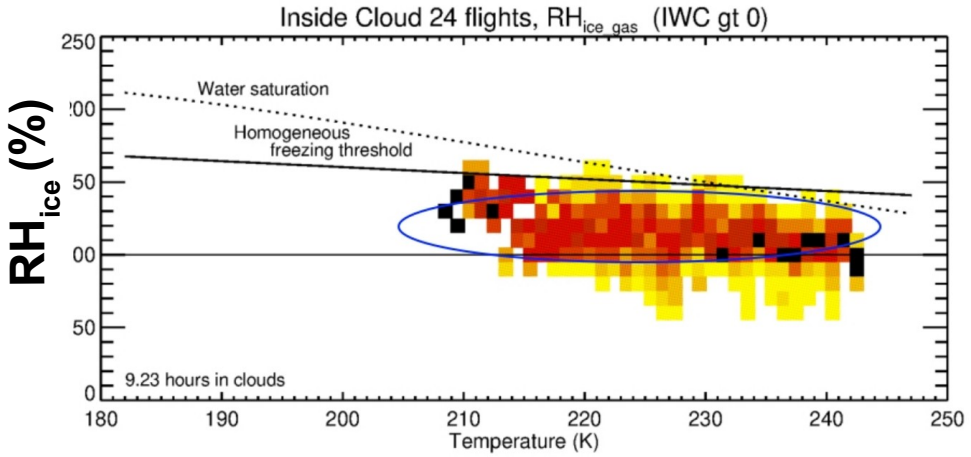
RELATIVE HUMIDITY DURING CIRRUS-HL

Mid-latitude (40 - 60°N)

Arctic (> 60°N)

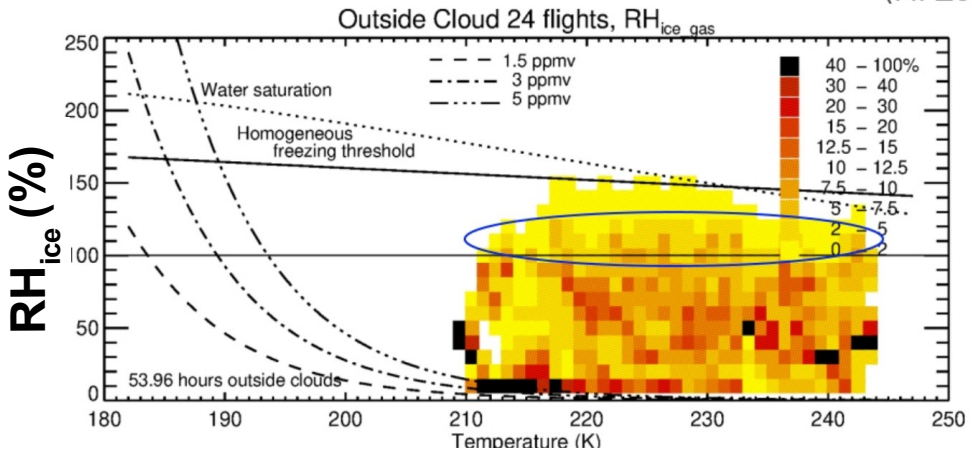
Inside Cirrus clouds

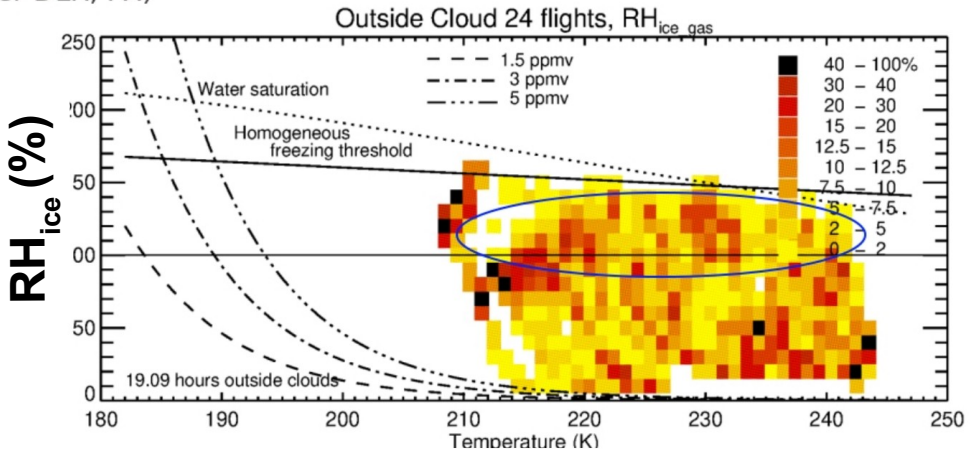




RH_ice from SHARC
(M. Zöger DLR, FX)

Outside Cirrus clouds



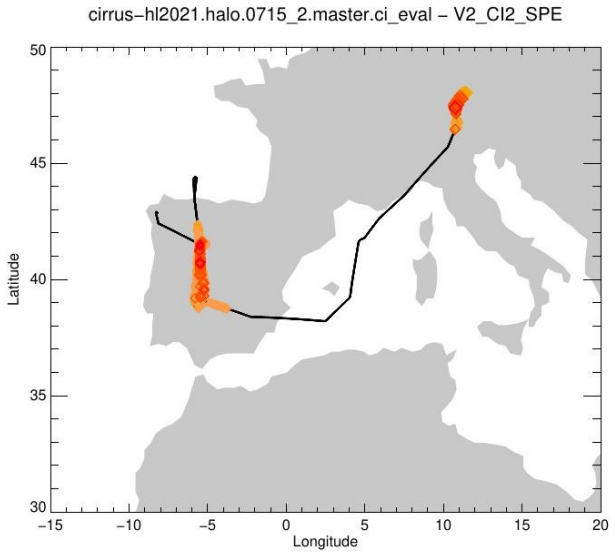


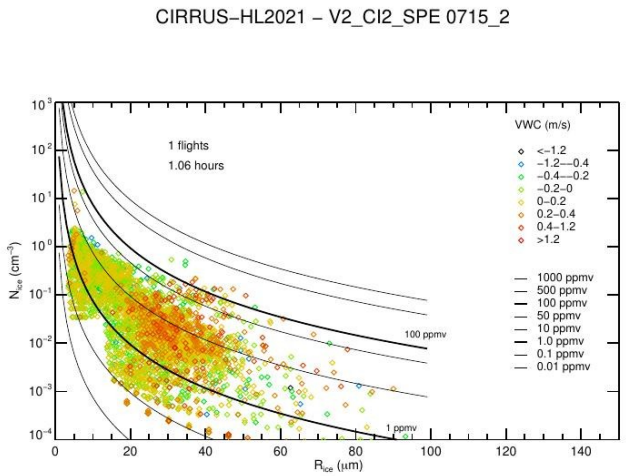
► **frequent in-cloud RH$_{ice}$ ~100% and out-cloud RH$_{ice}$ < 100%**

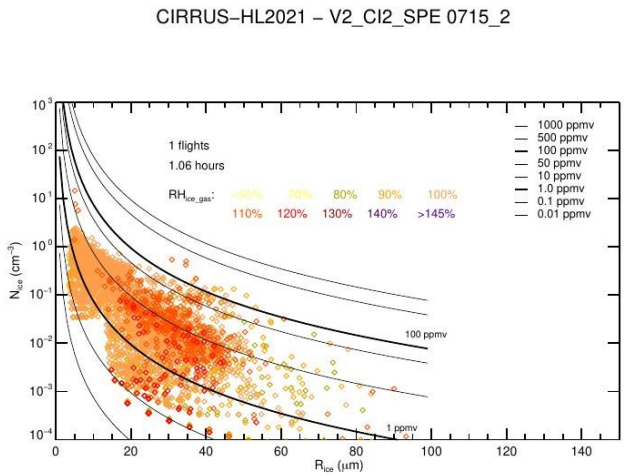
► **more frequent high supersaturation conditions (RH$_{ice}$ > 100%) in both, in- and out-cloud**

TWO TYPICAL CASES

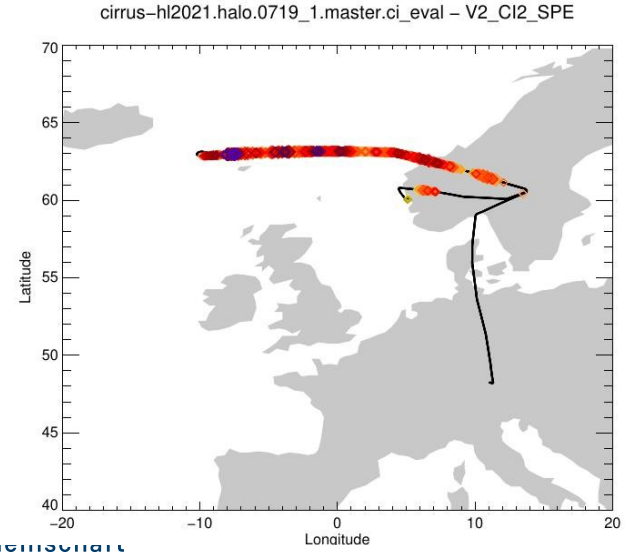
Mid-latitude case

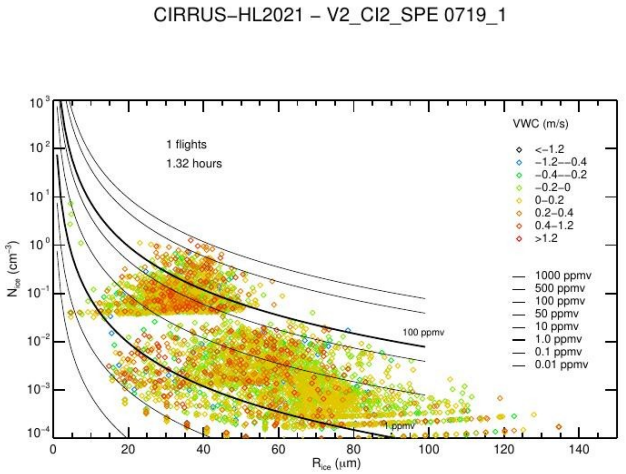


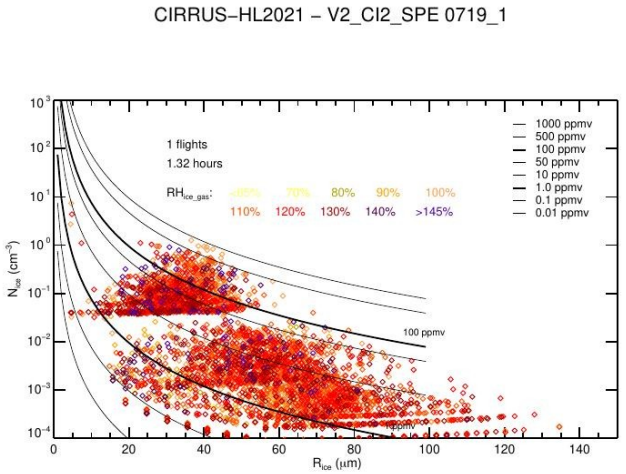




Arctic case

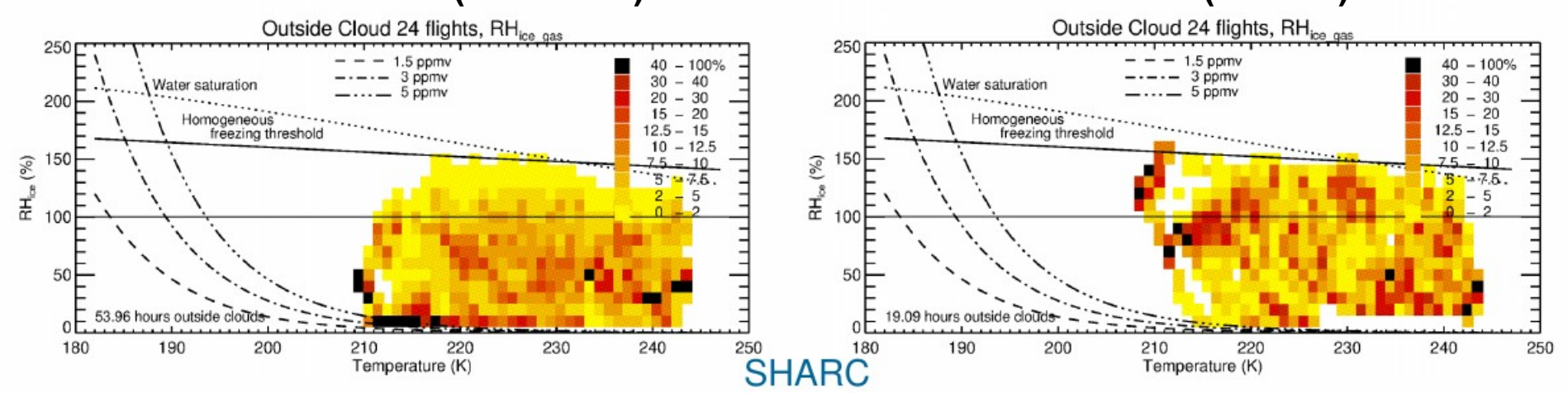






RELATIVE HUMIDITY SIGNATURES

Mid-latitude (40 - 60°N) | **Arctic (> 60°N)**



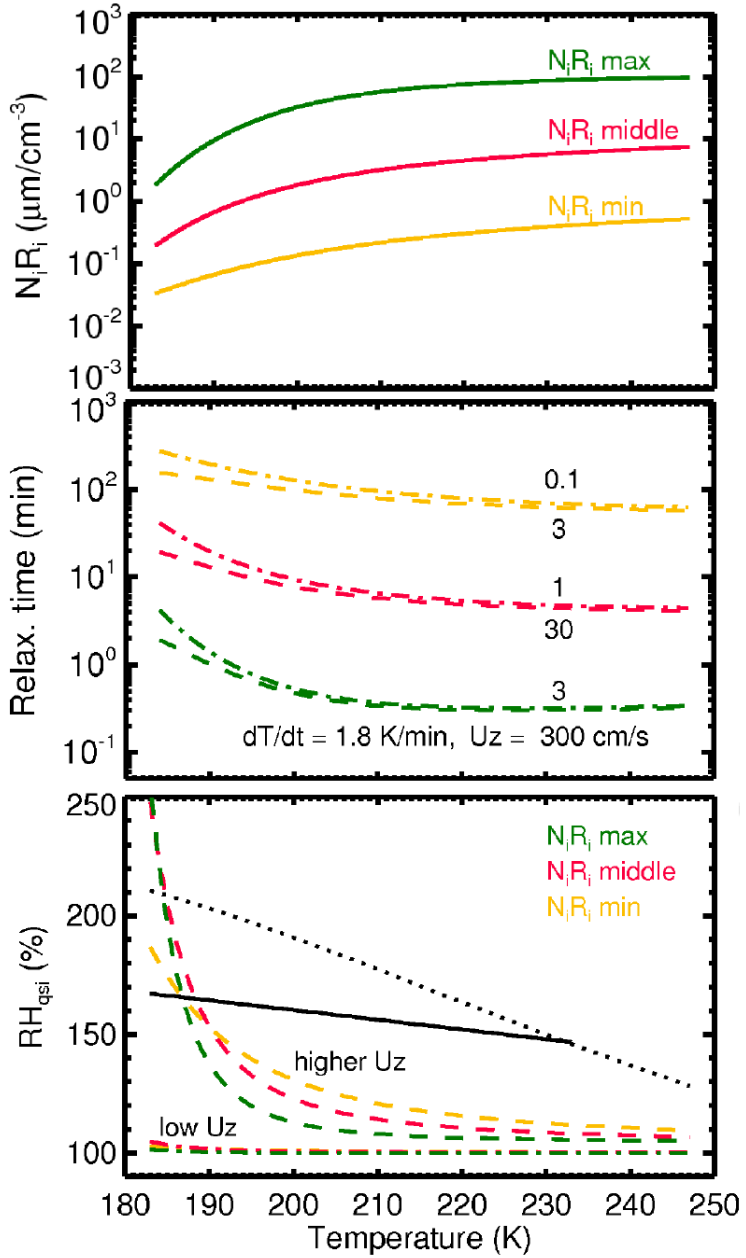
RH_{ice} signatures independet from two different in-situ instruments (FISH / SHARC)

RELATIVE HUMIDITY IN DIFFERENT UPDRAFTS

Integral ice crystal size N_iR_i
($N_iR_i = N_{ice} \cdot R_{ice}$)
from Schiller et al. (2008)

Relaxation times τ

Quasi steady state relative humidity RH_{qsi}



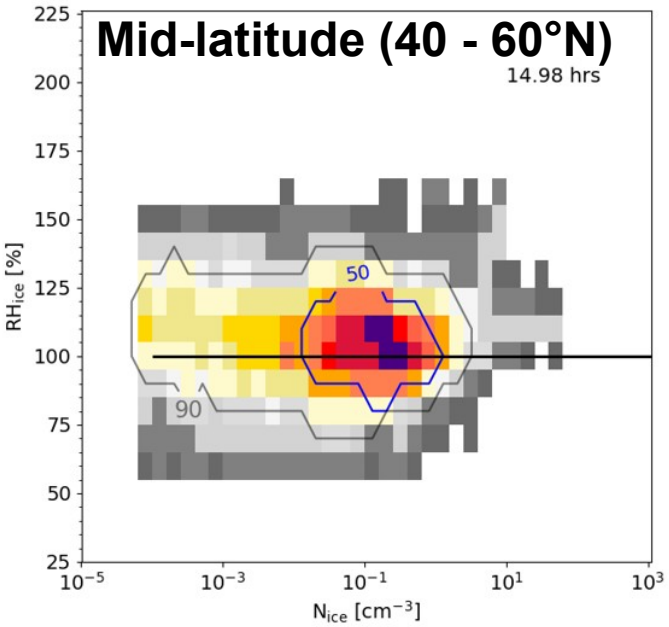
- Vertical velocity (U_z) and intergral ice radius (N_iR_i) control RH_{ice}
- N_iR_i controls relaxation time
- **high U_z or low N_iR_i**
- **► supersaturation**

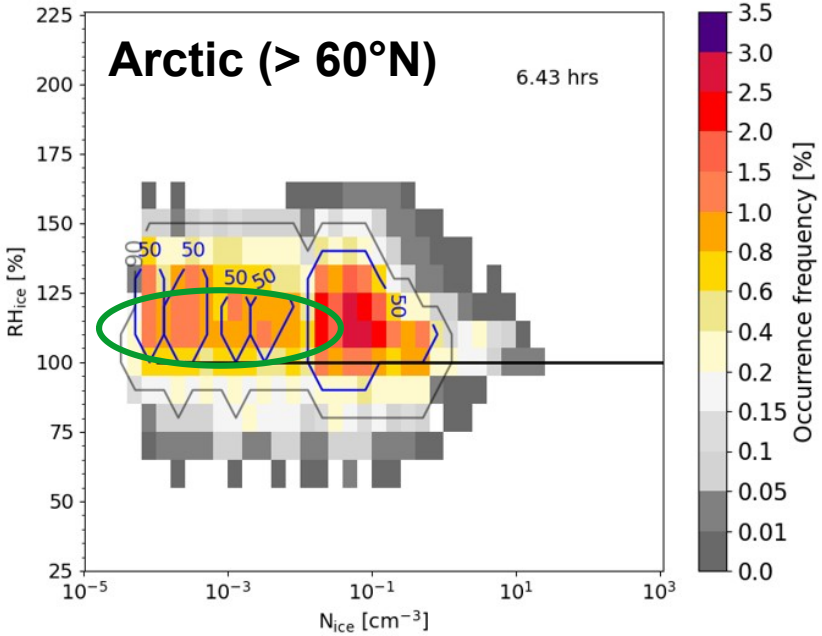
Krämer et al., ACP ,2009

VERTICAL UPDRAFT VS. RELATIVE HUMIDITY

N_{ice}-RH_{ice}

- Expected: RH_{ice} between 90 and 120 %

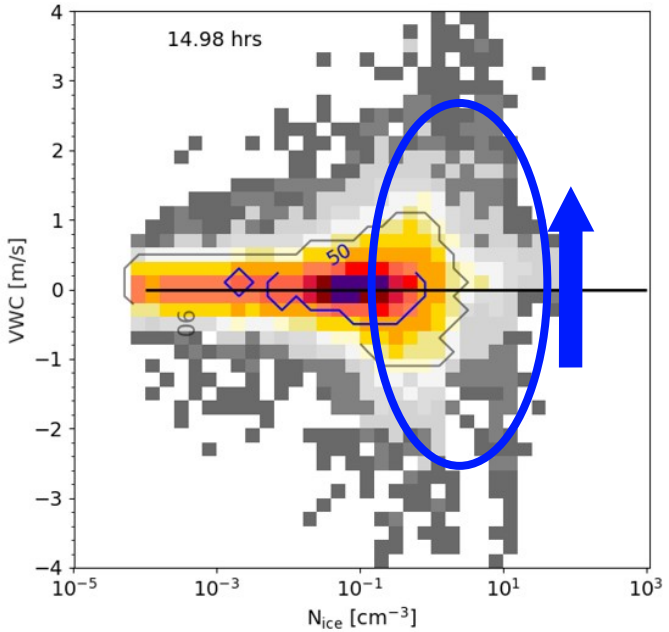


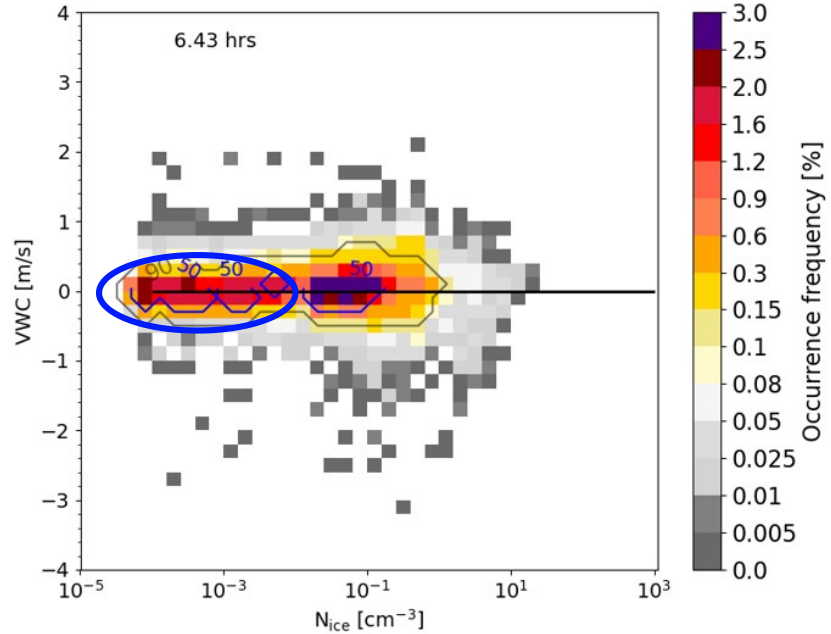


- High RH_{ice} occurs at lower concentrations

N_{ice}-U_Z

- Expected: High updrafts and high N_{ice}





- Medium updraft with lower N_{ice}

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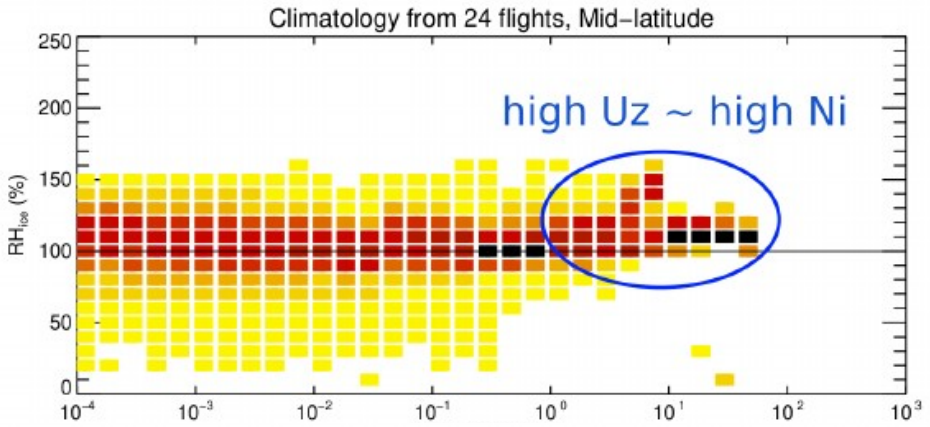
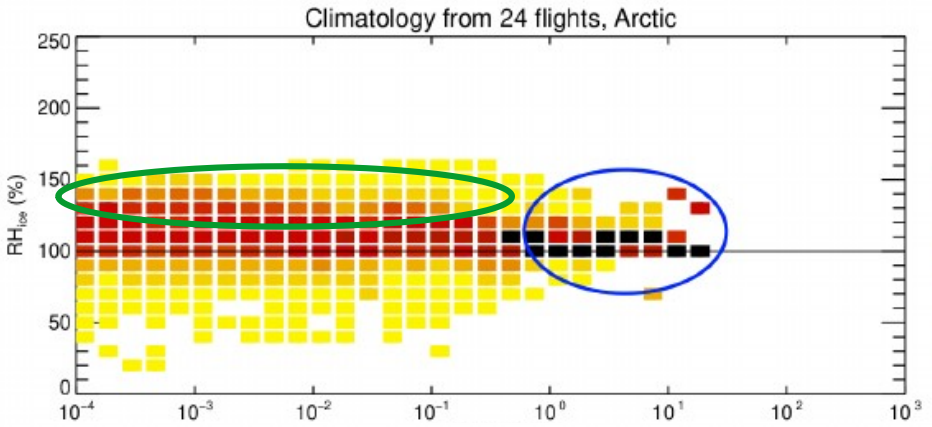
VERTICAL UPDRAFT VS. RELATIVE HUMIDITY

Mid-latitude (40 - 60°N)

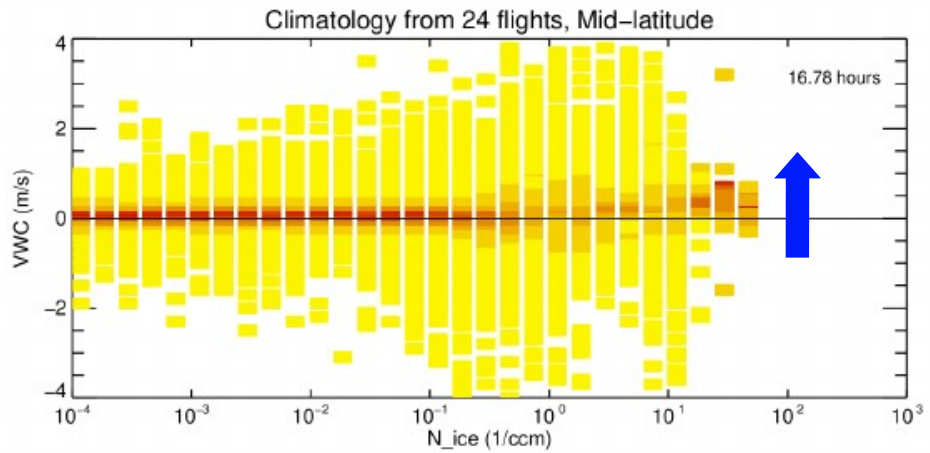
Arctic (> 60°N)

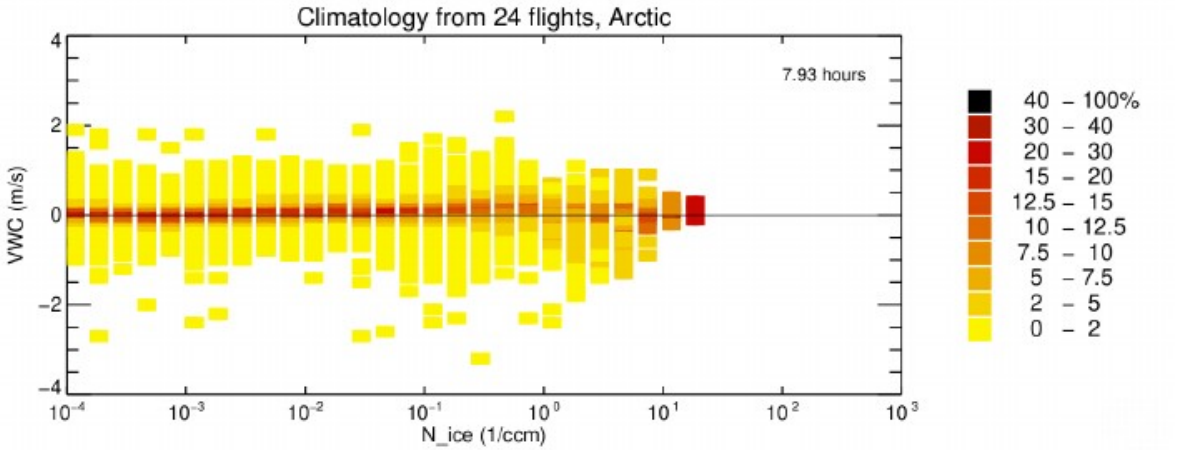
N_{ice}-RH_{ice}





N_{ice}-U_Z



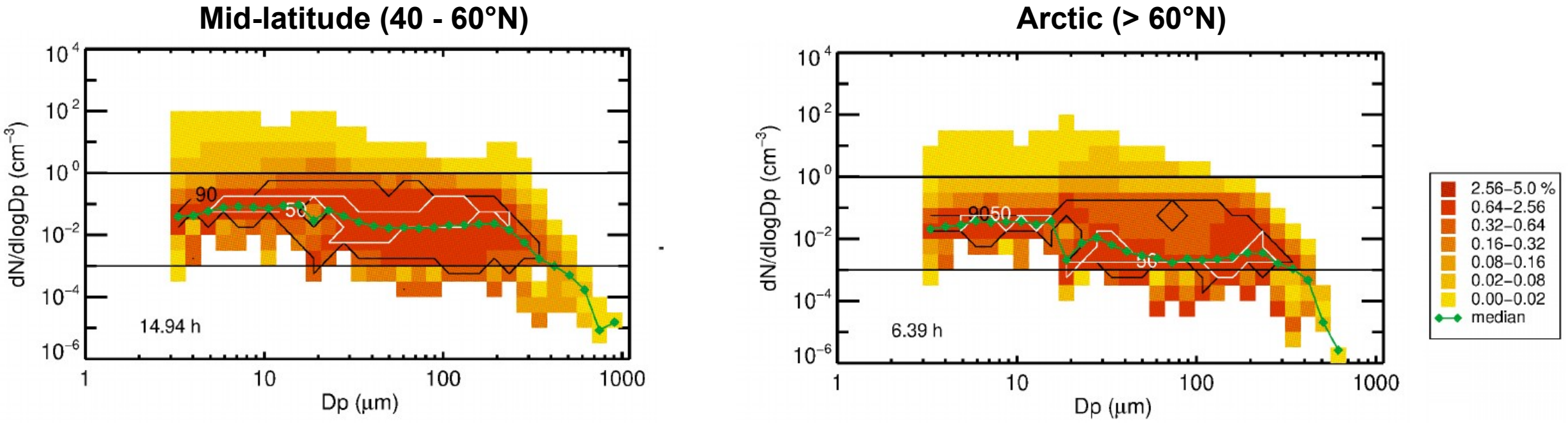


► **Expected high updrafts and high N_{ice}**

► **High updrafts but lower N_{ice}**

► **High relative humidity occurs at lower concentrations**

ICE PARTICLE SIZE DISTRIBUTIONS



- Lower ice particles concentrations in the **Arctic**
- Small ice crystals dominate in the Arctic

- ►low Integral ice crystal size ($N_i R_i$) ►In-cloud supersaturation

CONCLUSIONS

Cloud properties and Updraft conditions

- Mid-latitude: **high IWC and N_{ice}** with high vertical velocities (convection)
- Arctic: **low IWC and N_{ice}** (few, large ice crystals), lower vertical velocities
- Vertical updraft effect only visible in the Mid-latitudes but not in the Arctic

Supersaturations

- Arctic: **higher supersaturations in- and outside of cirrus clouds**
- Hint for low concentration or ineffective INP (heterogeneous freezing)

Acknowledgement:

We would like to thank the two coordinators of the HALO missions Cirrus-HL, Christiane Voigt (DLR) and Tina Jurkat (DLR), for their efforts.

Take home message:

- Aircraft observation indicate **dominant role of homogeneous nucleation** in the **Arctic** under low updraft unpolluted conditions (**low INP** concentration)