ARE ICE CLOUDS MELTING THE ARCTIC?

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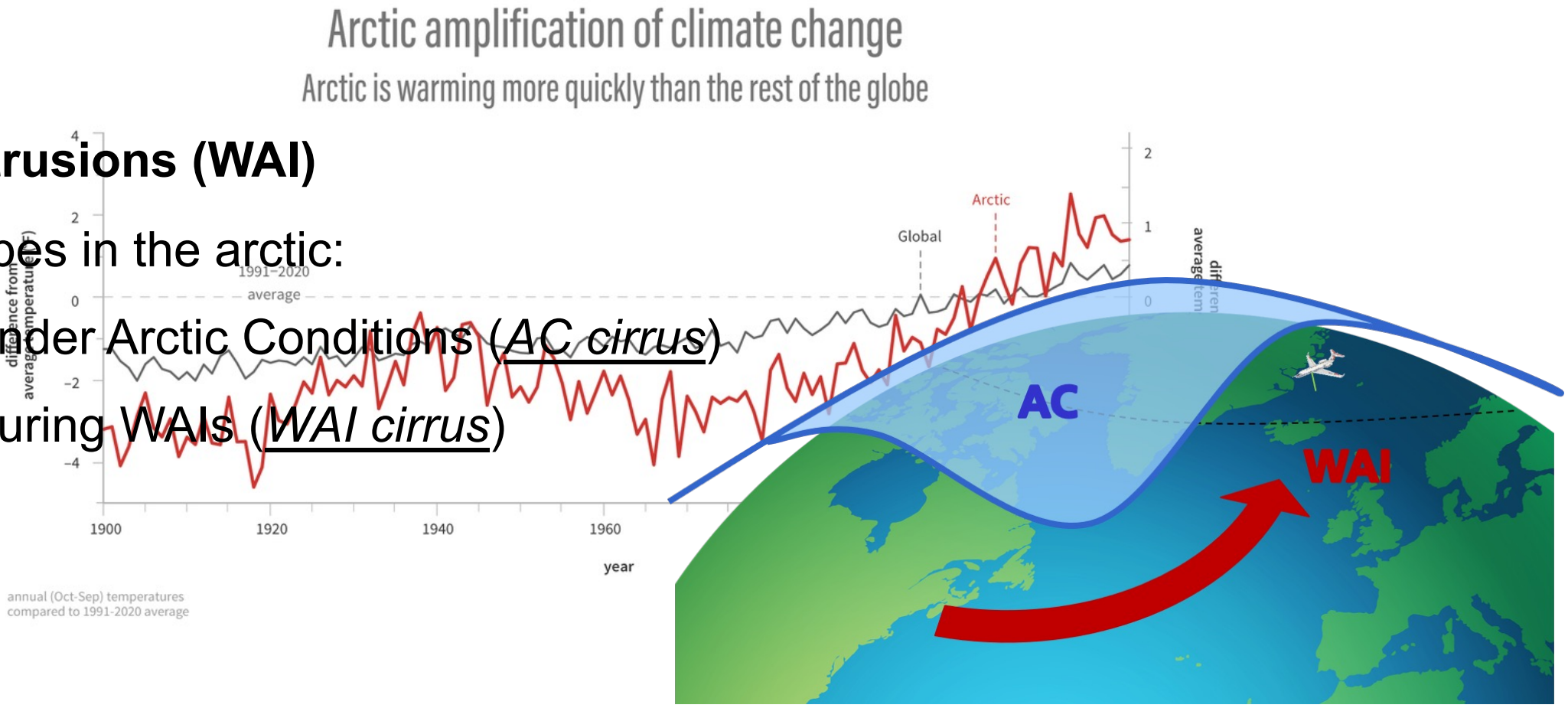
Ice Clouds in the Arctic

- contribute to Arctic Amplification of climate change
- partake in Arctic-specific processes and feedbacks



Warm Air Intrusions (WAI)

Two cirrus types in the arctic:

Formed under Arctic Conditions (*AC cirrus*)

Formed during WAIs (*WAI cirrus*)

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Ice Clouds in the Arctic

Radiative Effects

Ambient Conditions (AC v WAI)

Groß et al. (2026), to be submitted

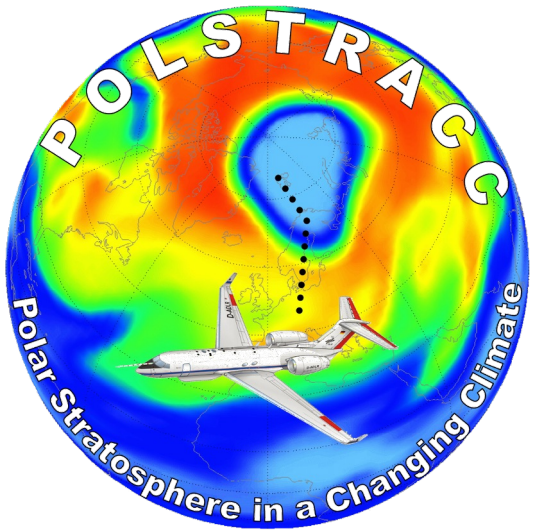
Dekoutsidis et al. (2026), submitted

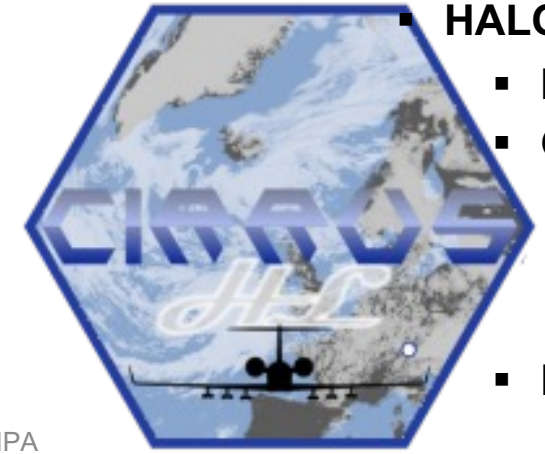
Dekoutsidis et al. (2024)

Measurements of ice cloud properties under varying conditions are required

Arctic Aircraft Campaigns

… with measurements form the **WALES** lidar system onboard the **HALO** research aircraft

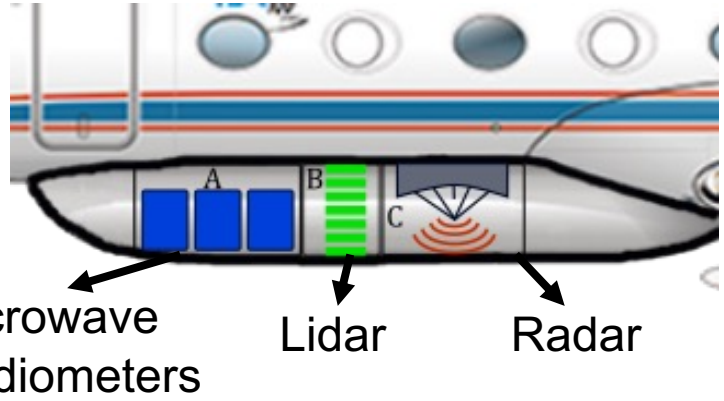




- **HALO-(*AC*)³** field campaign
  - March & April 2022
  - German research aircraft HALO
    - Flight ceiling: ~15 km
    - Flight range: ~ 12.500 km
    - Flight time: > 10 hours
  - Remote sensing instrumentation

ORCESTRA

Data - Instruments



HAMP (HALO Microwave Package)

Microwave Radiometers + **MIRA-36**

- Three modules
- 26 frequencies
- Cloud radar at 36 GHz
- Doppler radar

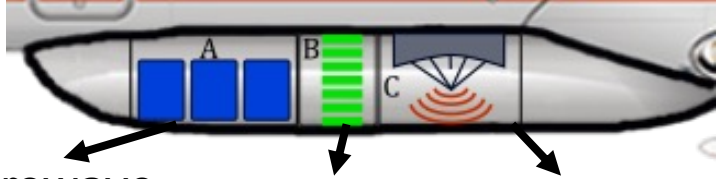
- *Radar reflectivity*
- *Doppler velocities*
- *Linear depolarization ratio*
- Cloud and precipitation properties

WALES (WAter vapor Lidar Experiment in Space)

- **Water Vapor**
  - **Differential Absorption Lidar (DIAL)**
    - H2O absorption band ~**935 nm**
    - *Water vapor mixing ratio*
- **Aerosol properties**
  - **High Spectral Resolution Lidar (HSRL)**
    - Aerosol extinction (**532 nm**)
    - *Backscatter coefficient* (**532 nm**,1064 nm)
  - *Aerosol depolarization* (532 nm,1064 nm)

VarCloud: optimal estimate retrieval
Microphysics

Data - Instruments



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VarCloud: optimal estimate retrieval
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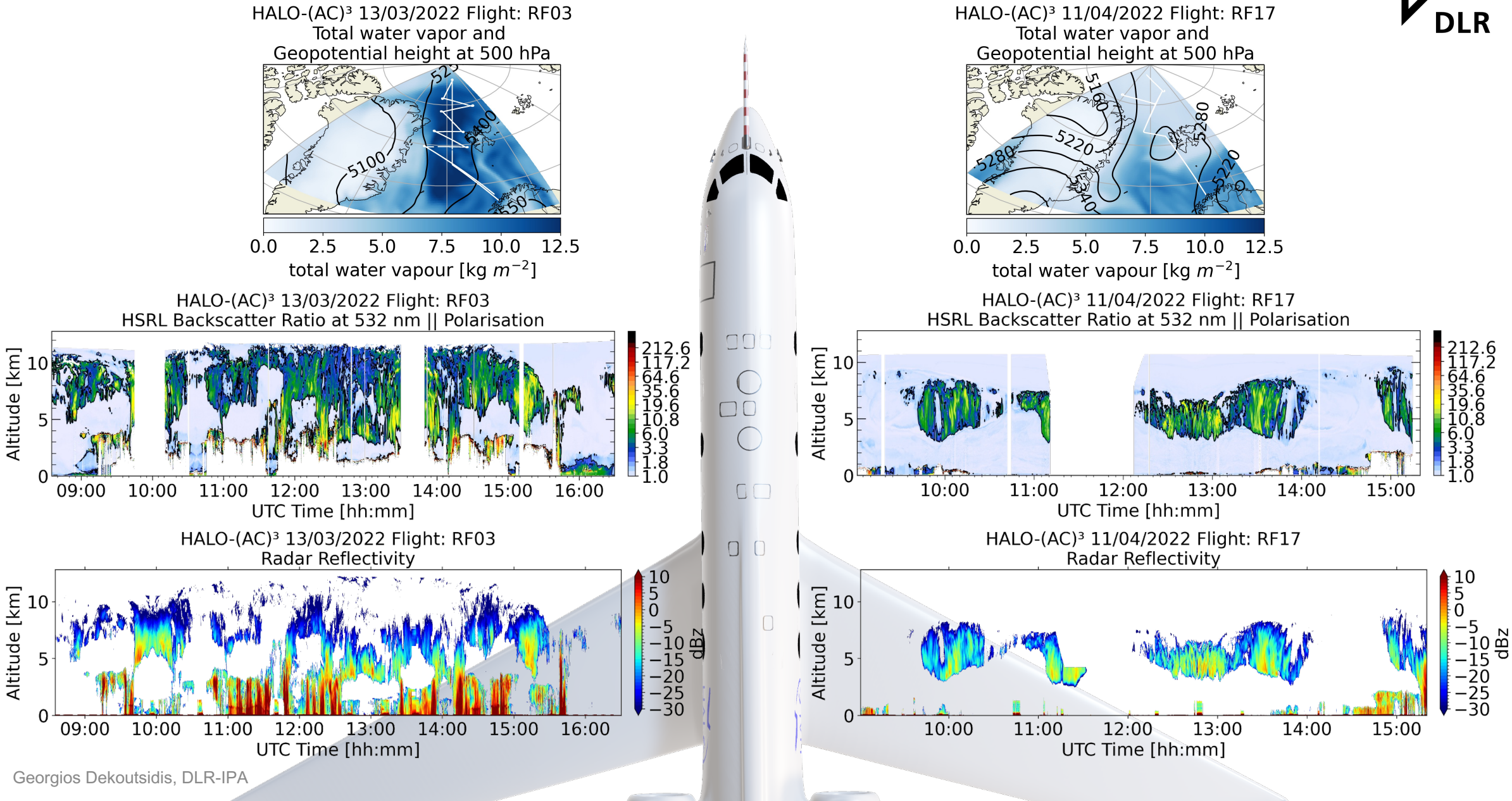
libRadtran: Radiative transfer calculations
Radiative Effect

Case Study



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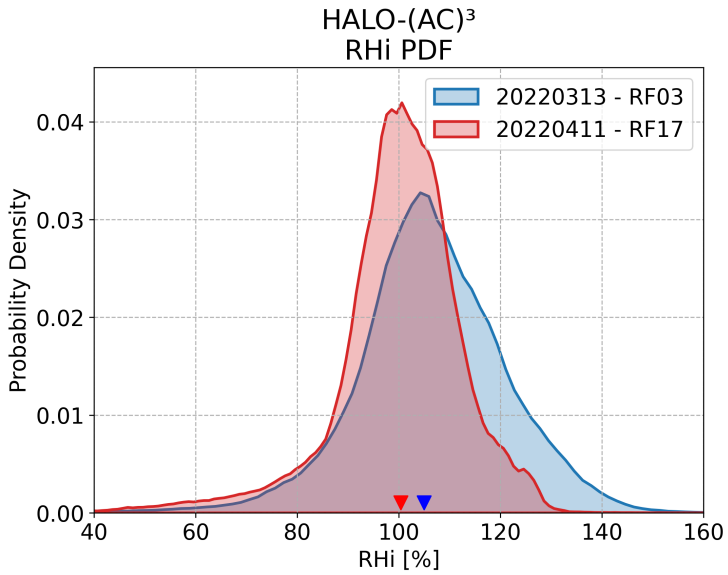
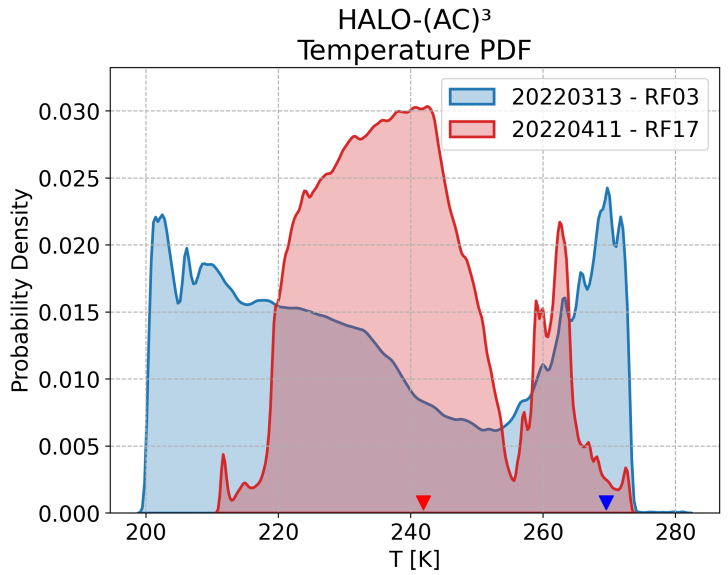
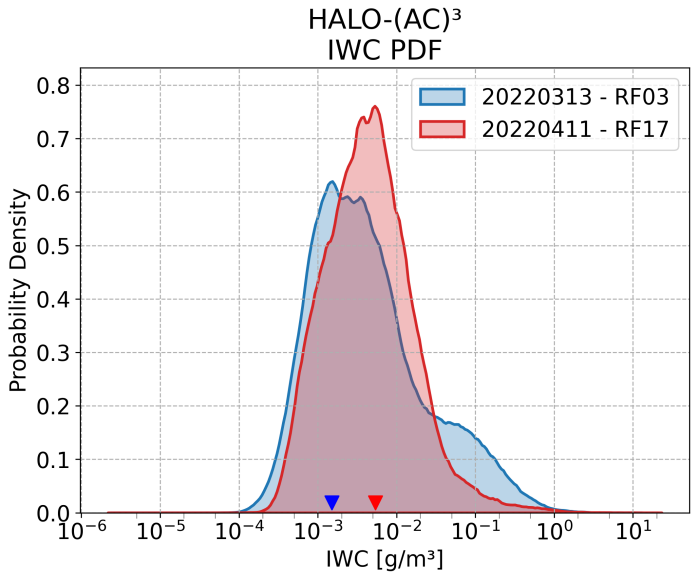
Results - Properties

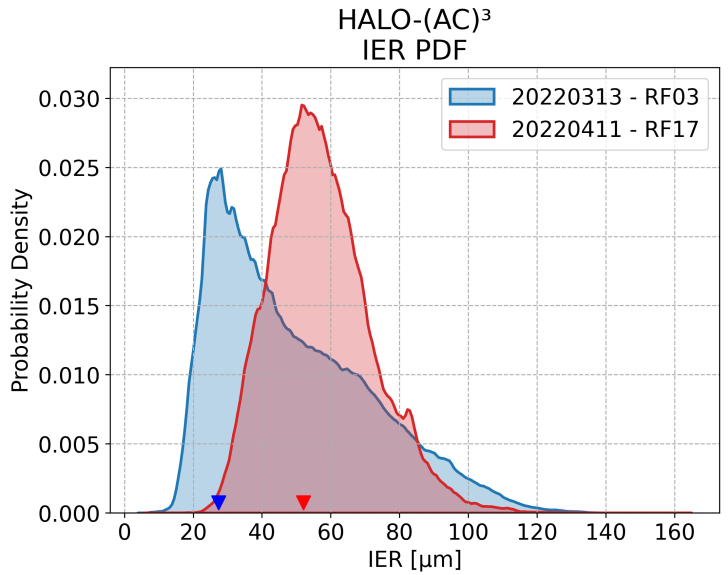
WAI Cirrus

- Higher RHi supersaturation
- Wider Temperature Range
- On average smaller IWC and IER with higher extremes

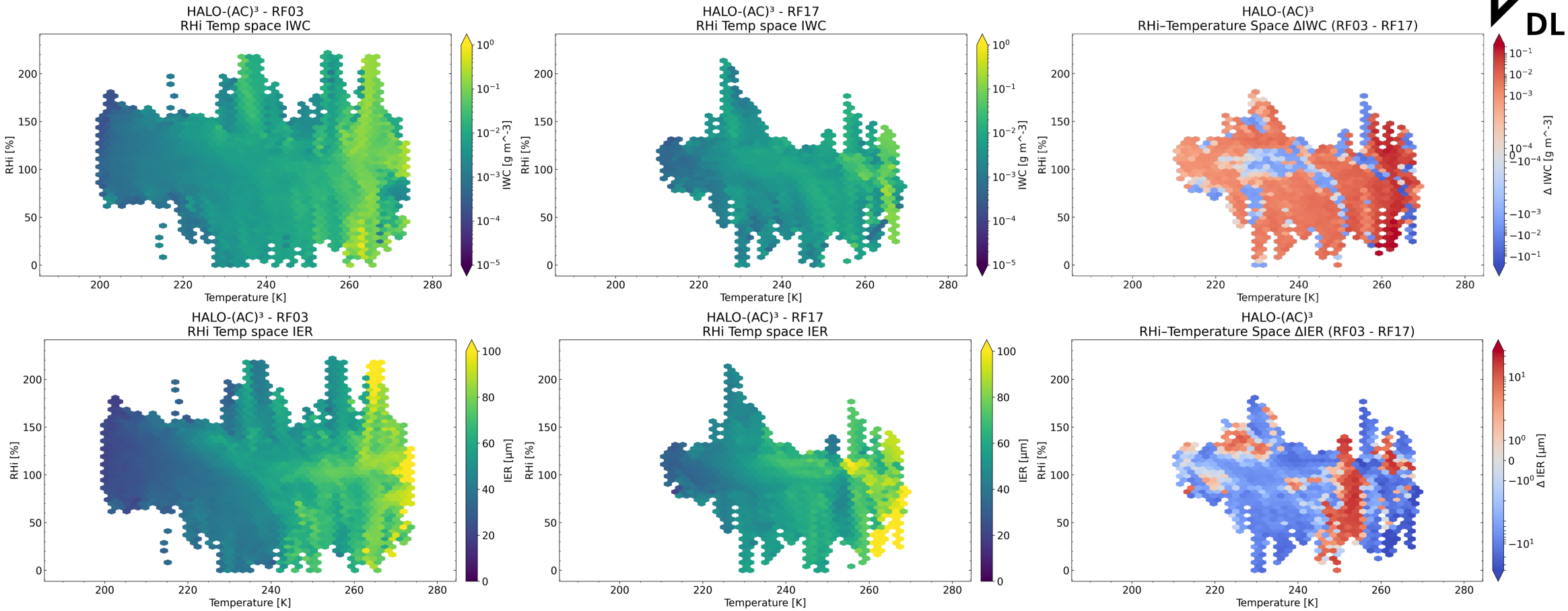








Results - Properties



- Strong dependence of IWC and the IER on the temperature with largest values in the warmer parts
- WAI cirrus mostly with higher IWC. Difference smaller in the colder parts
- Smaller IER for the WAI cirrus, almost throughout the temperature range. Difference slightly smaller in the colder parts
- Larger IER for the AC only between ~250 and ~255 K.

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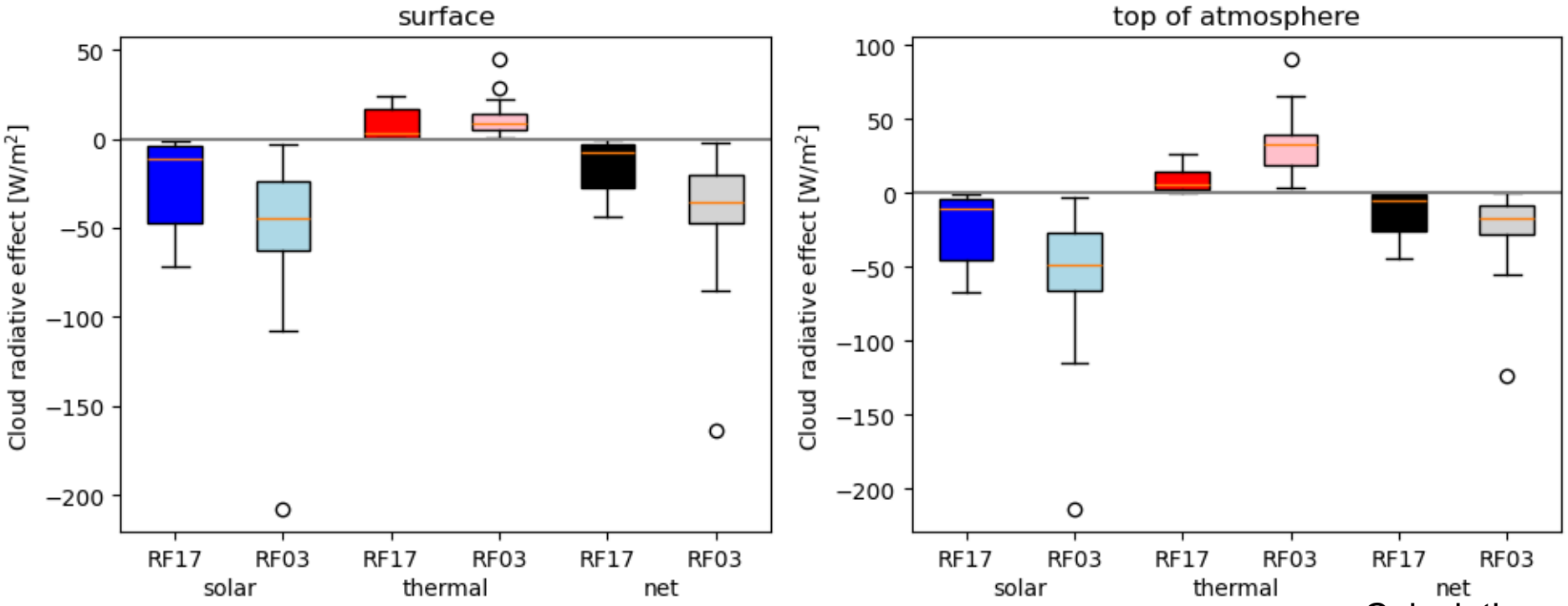
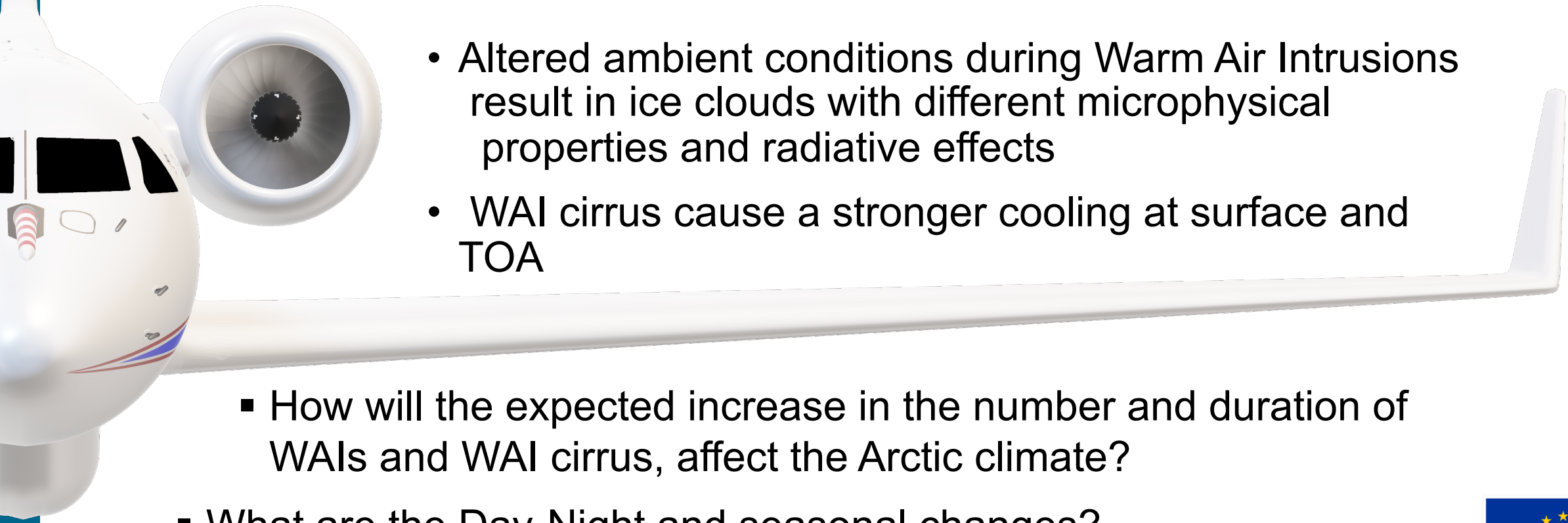
Results – Radiative Effect



Calculations by Anna Weber

- Solar wavelength range
  - Both clouds have a cooling effect, stronger for WAI cirrus
- Thermal wavelength range
  - Both clouds have a warming effect, stronger for WAI cirrus especially at TOA
- Net cloud radiative effect
  - Negative at the surface and the TOA, stronger for WAI cirrus

Conclusions - Outlook



- Altered ambient conditions during Warm Air Intrusions result in ice clouds with different microphysical properties and radiative effects
- WAI cirrus cause a stronger cooling at surface and TOA

  - How will the expected increase in the number and duration of WAIs and WAI cirrus, affect the Arctic climate?
  - What are the Day-Night and seasonal changes?
- What is the connection to other parameters (sea ice, circulation, aerosol load etc.)?

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