Using ATTREX Data to Improve Ice Microphysics in CAM5

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ATTREX/CAST/CONTRAST Science Team Meeting

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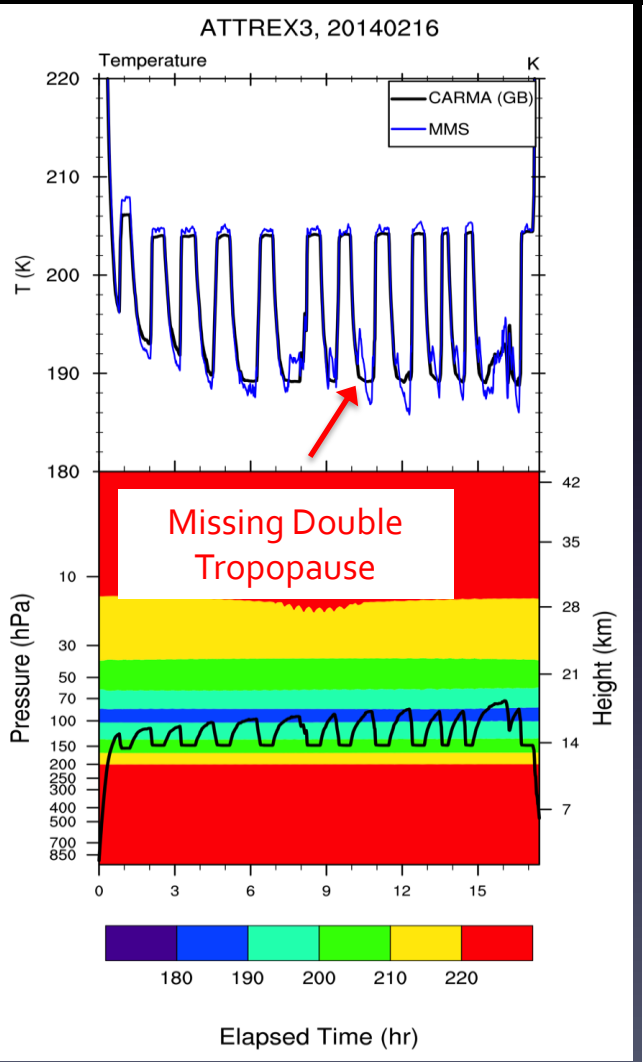
Methodology

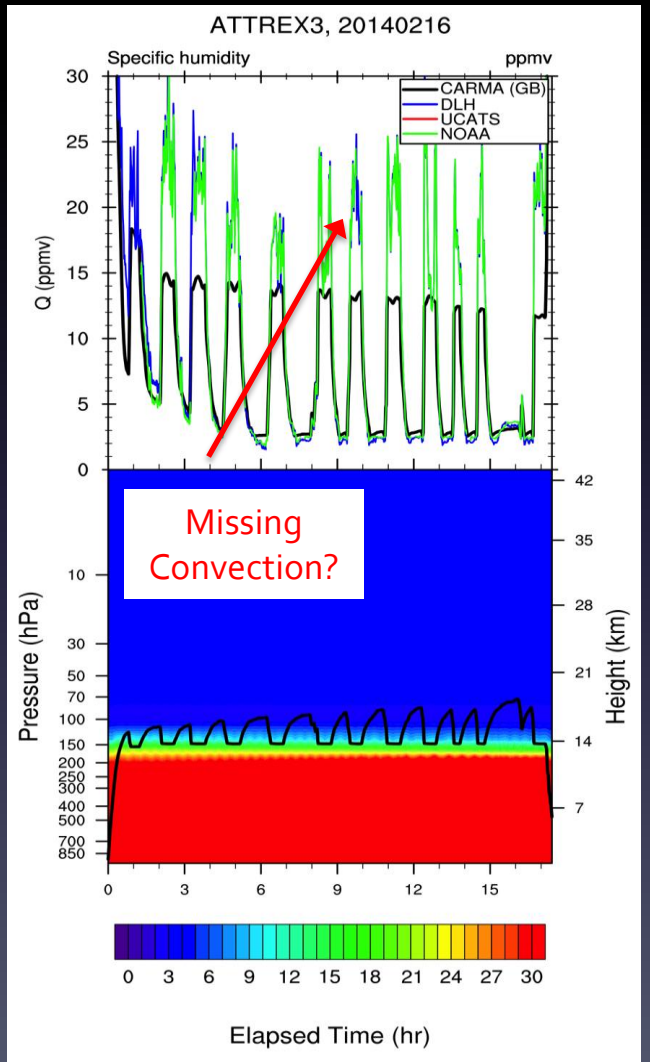
- Used SD-CAM5 (1.9˚ x 2.5˚, 56 levels)
  - Nudge to GEOS-5 Assimilated Meteorology
  - Sample Simulations Along Aircraft Flight Tracks
  - Compare Model to ATTREX3 Observations
- 2 Different Ice Microphysics Schemes
  - MG (Standard; Morrison & Gettelman, 2008)
    - Two Moment (Mass and Number)
    - Ice and Snow
  - CARMA (Bardeen et al., 2013)
    - Sectional (28 Size Bins)
    - In Situ Ice and Detrained Ice

ATTREX3, 20140216

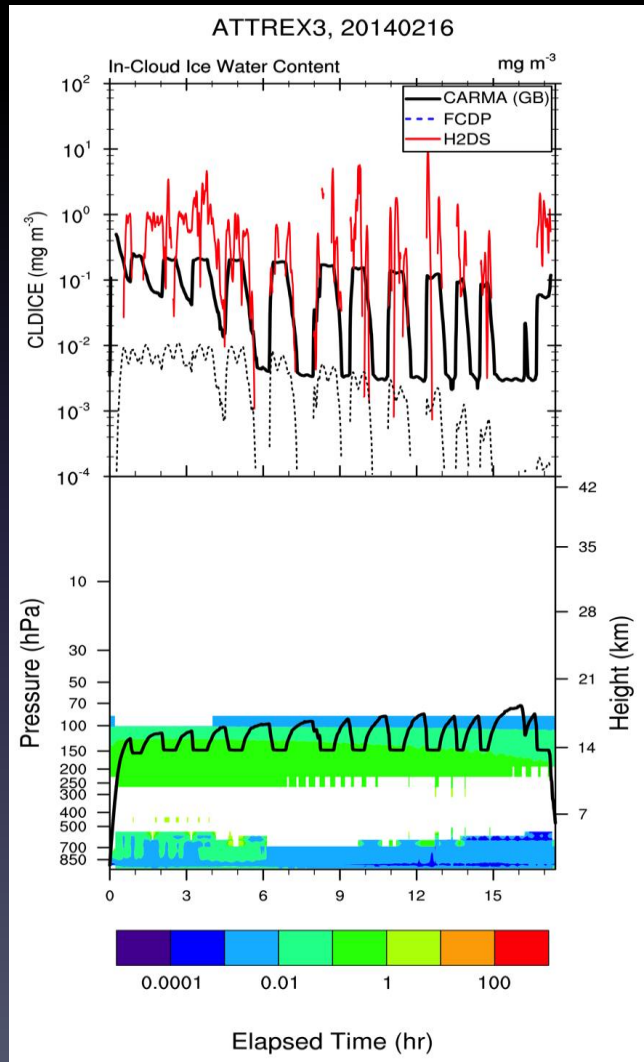
Temperature



Specific Humidity



Ice Water Content

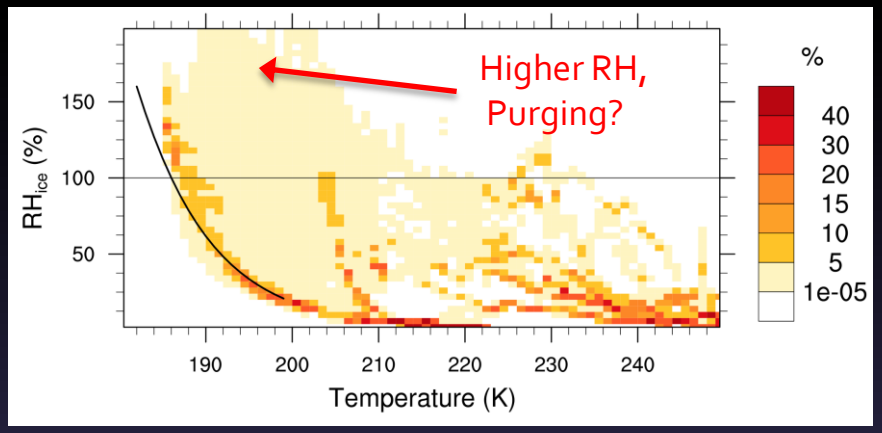


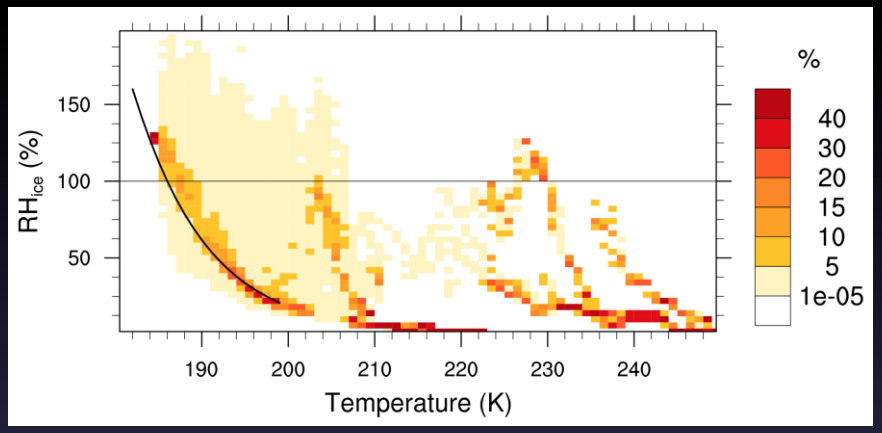
Krämer Plots : RH vs T

DLH

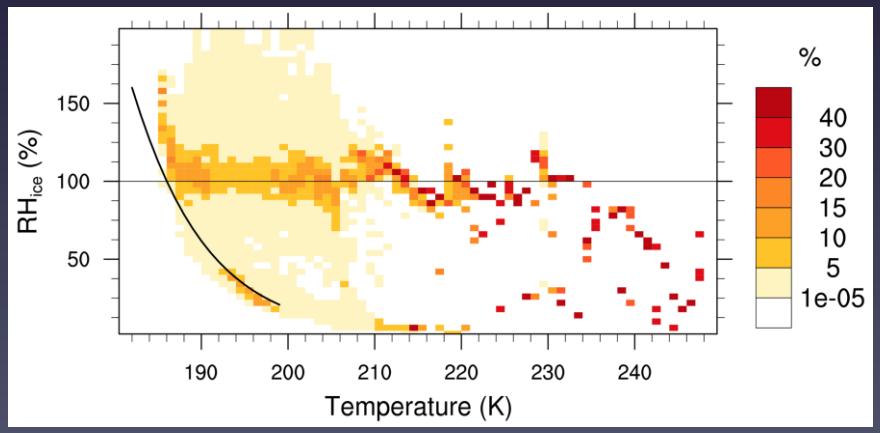
NOAA

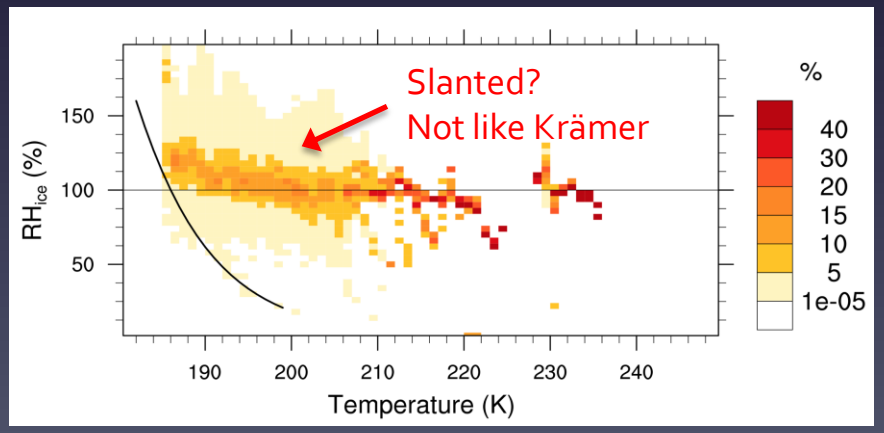
Clear Sky





Cloudy

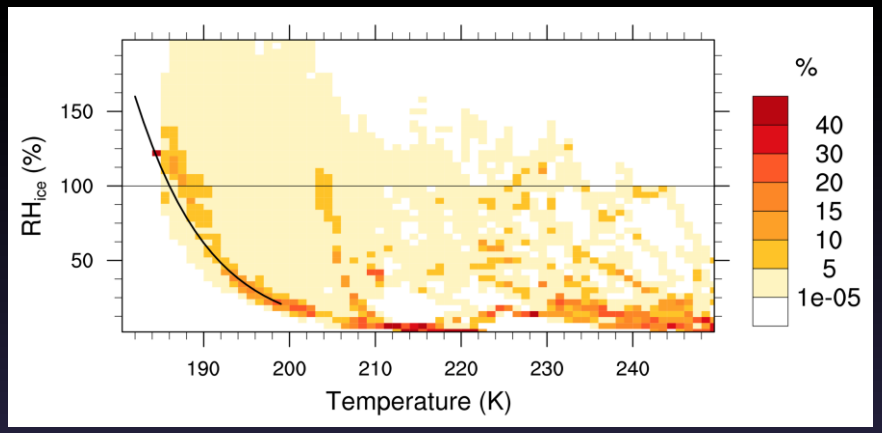




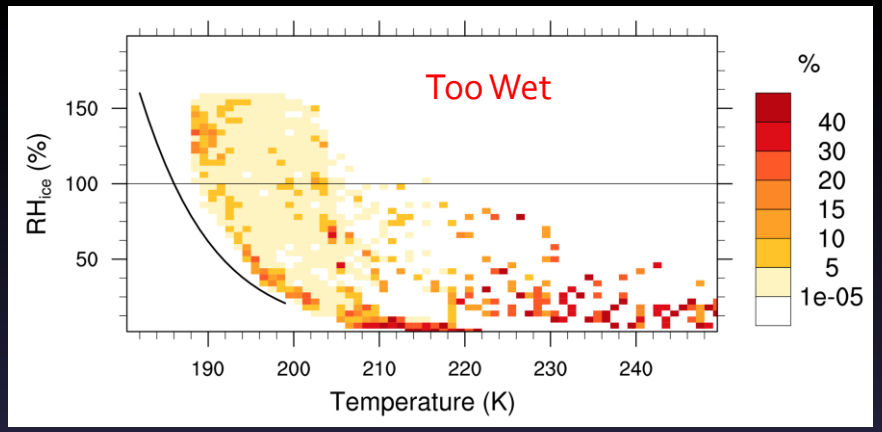
Krämer Plots : RH vs T

All Sky

DLH

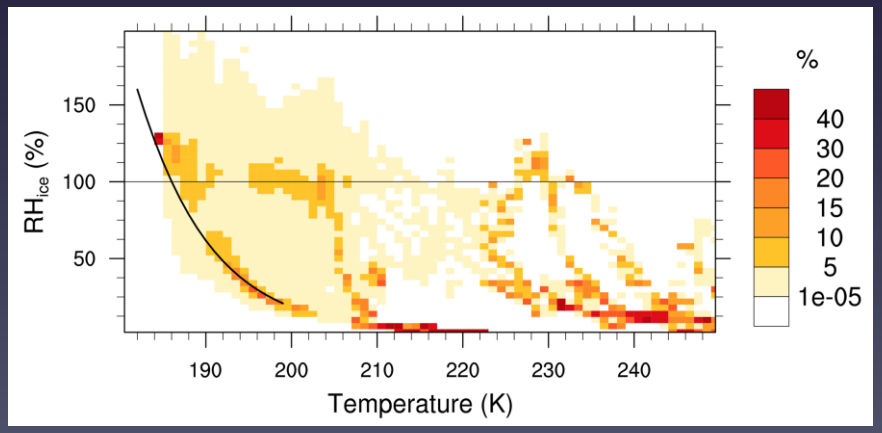


MG

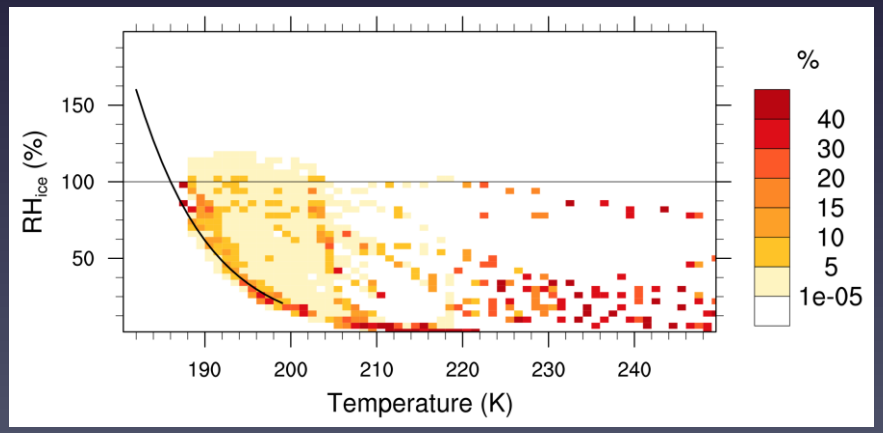


All Sky

NOAA



CARMA



Kramer Plots : M, N, Re vs T

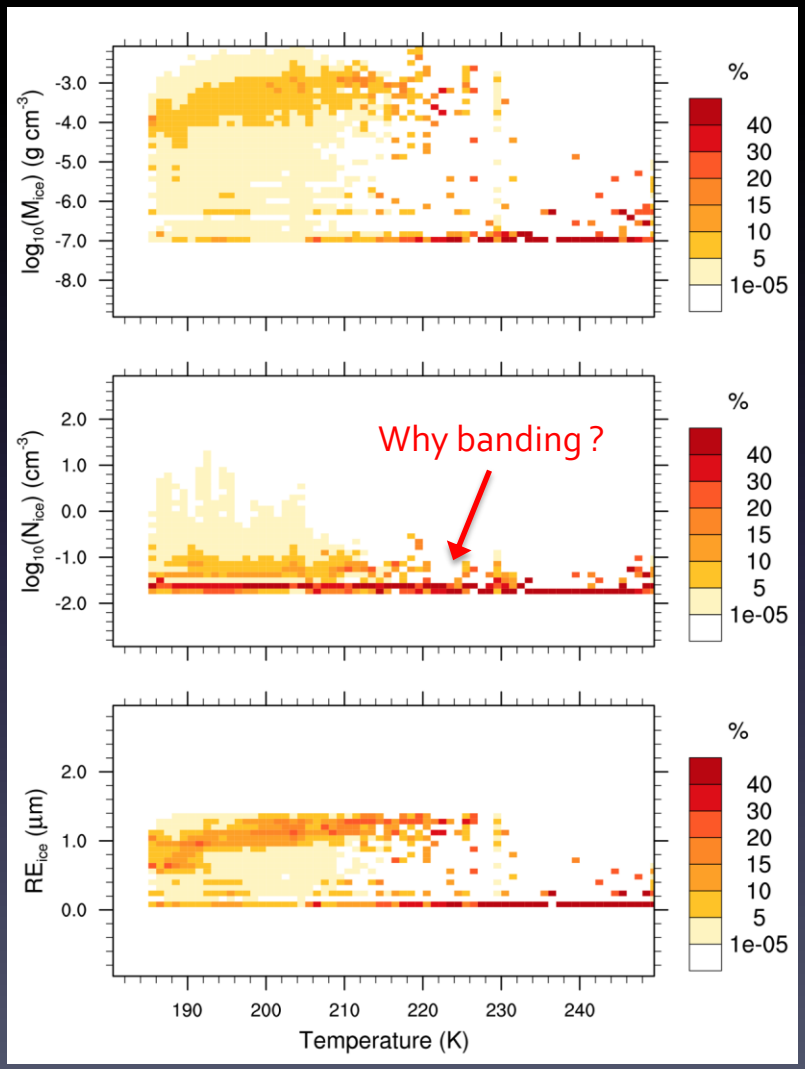
Hawkeye FCDP

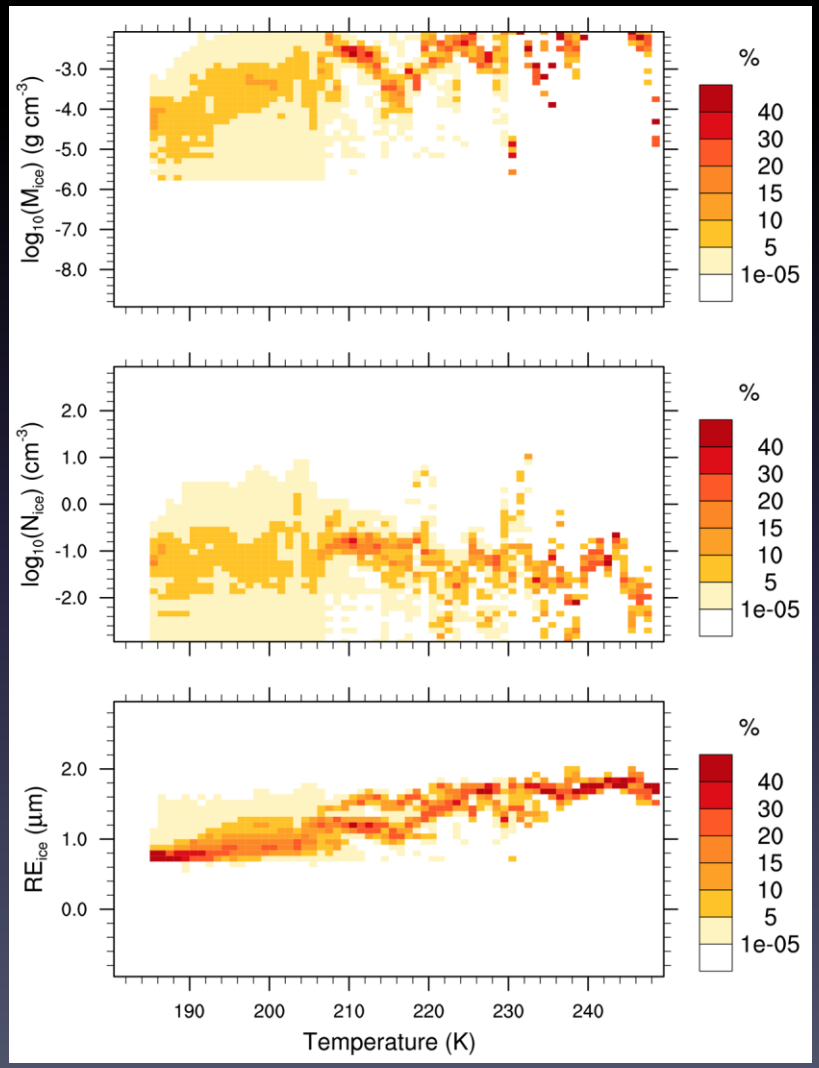
Hawkeye 2DS

Mass

Number

Radius





Kramer Plots : M, N, Re vs T

Hawkeye 2DS

MG

Mass

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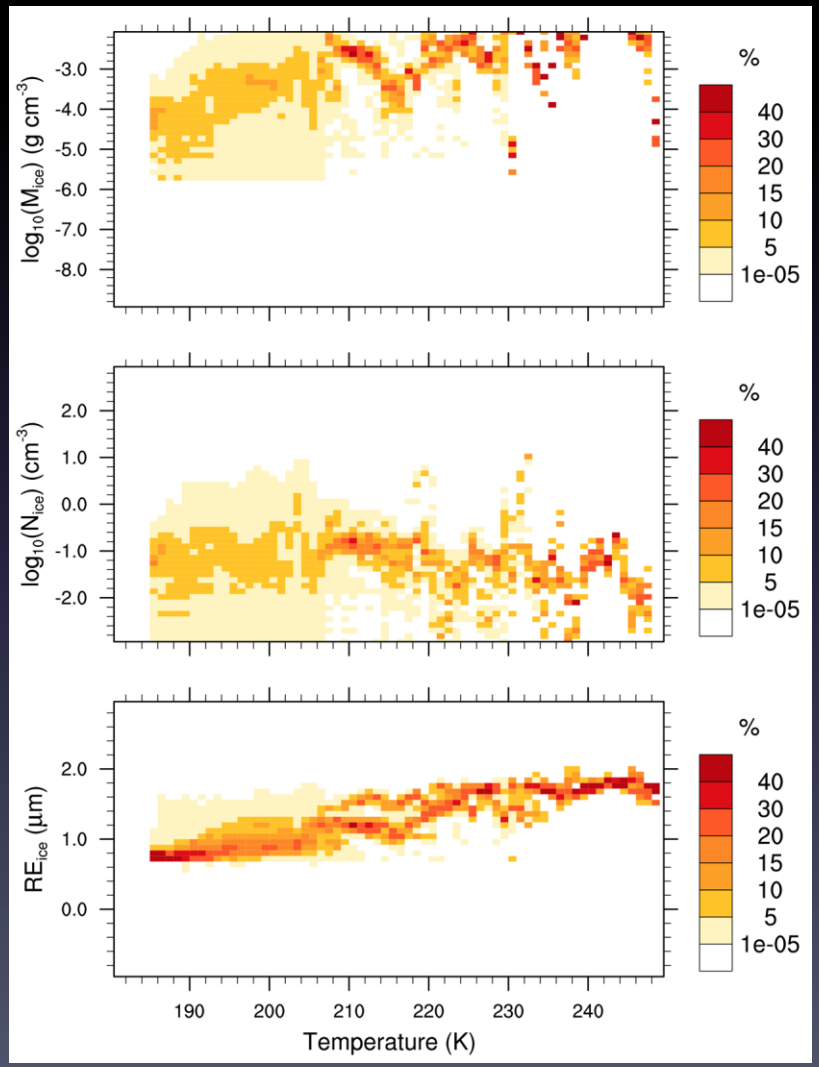
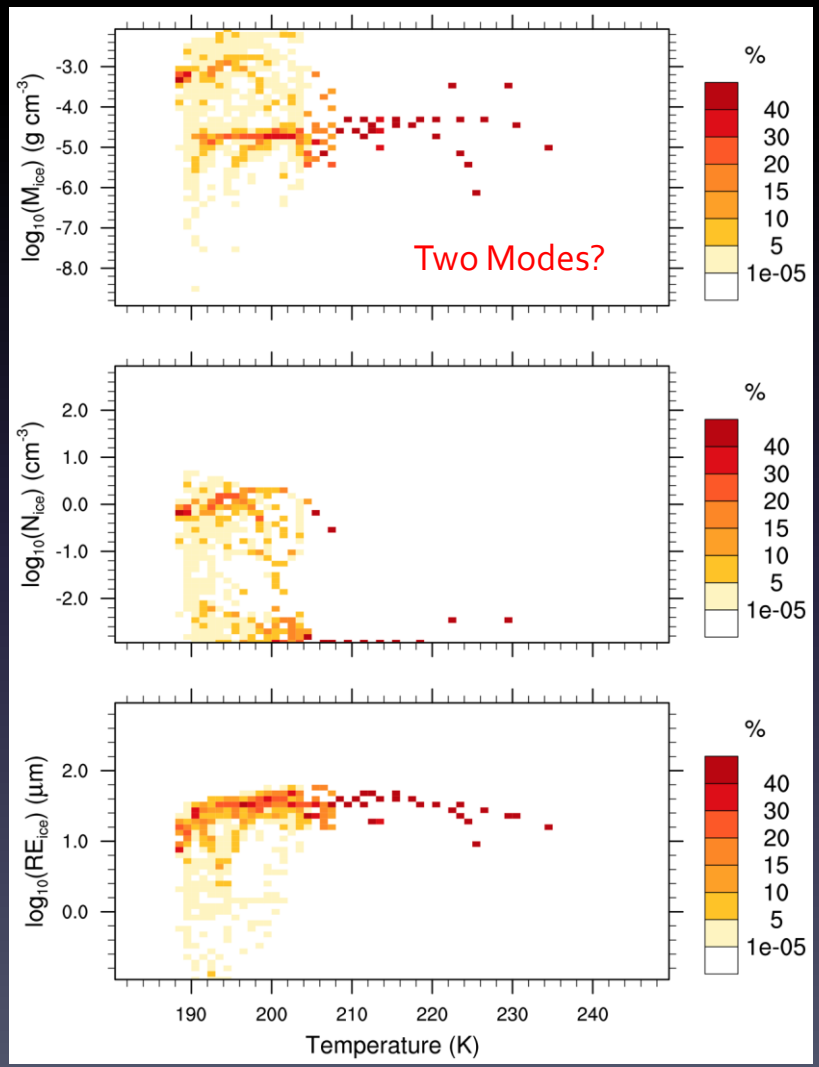
Radius





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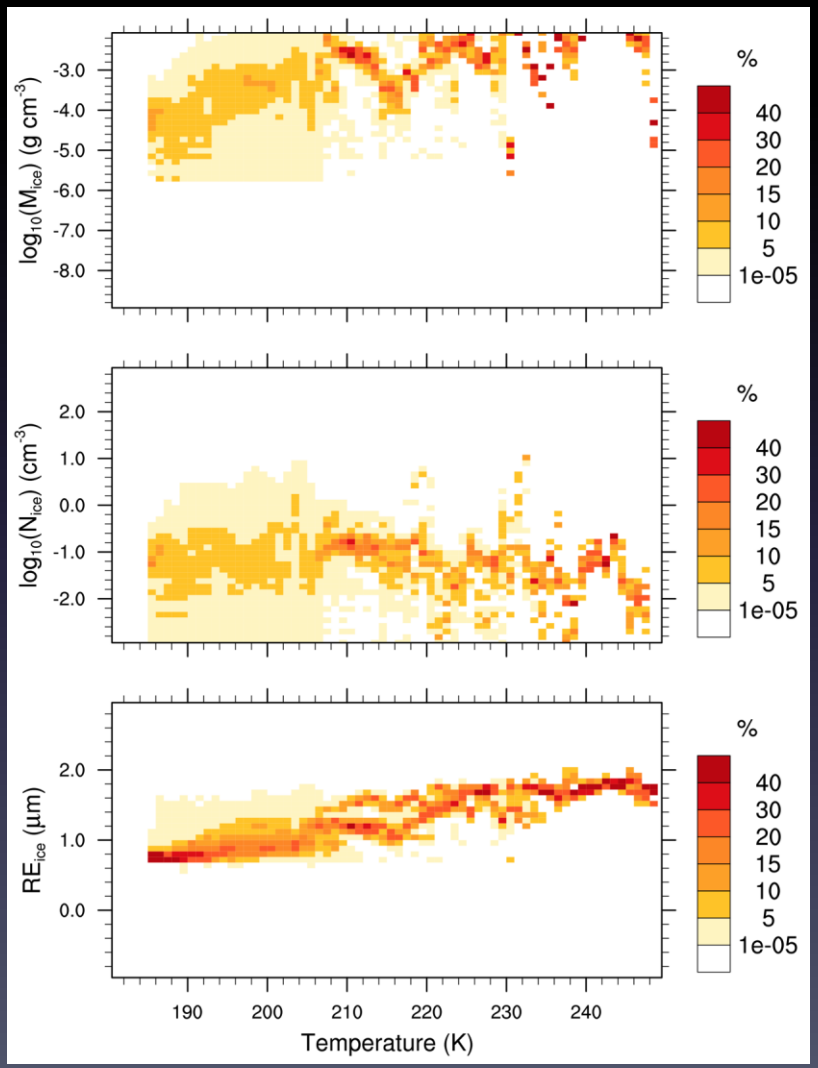
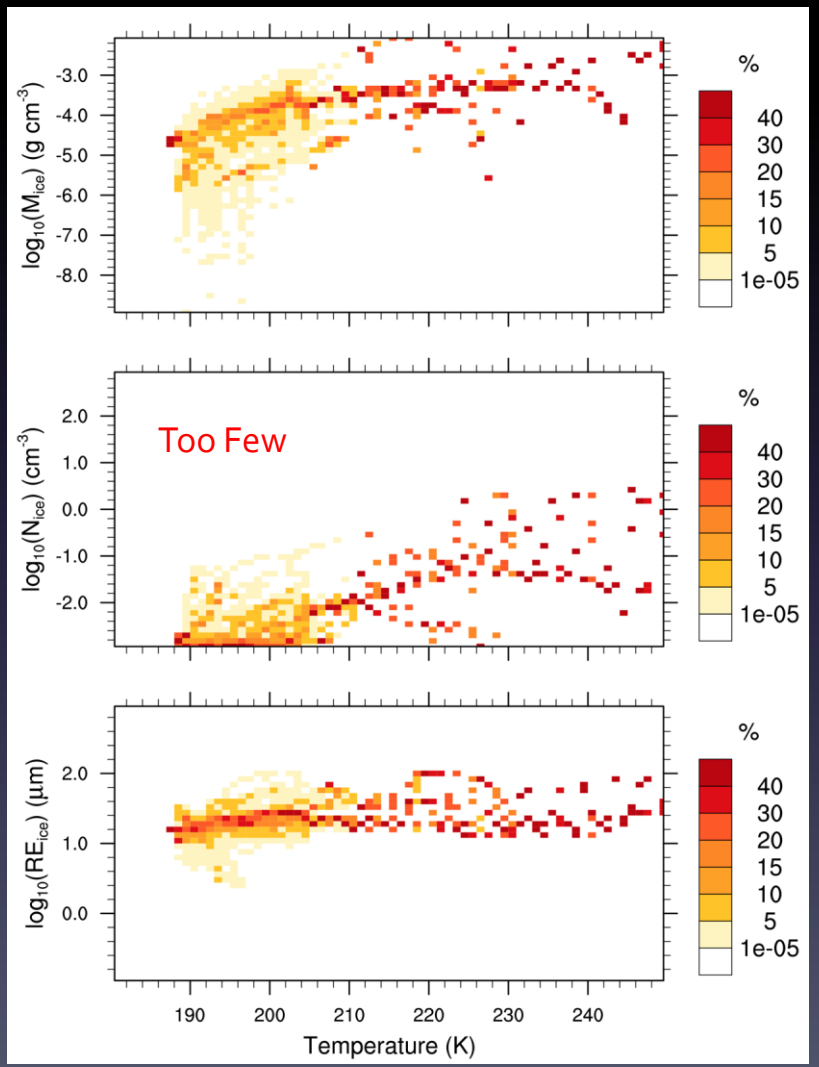
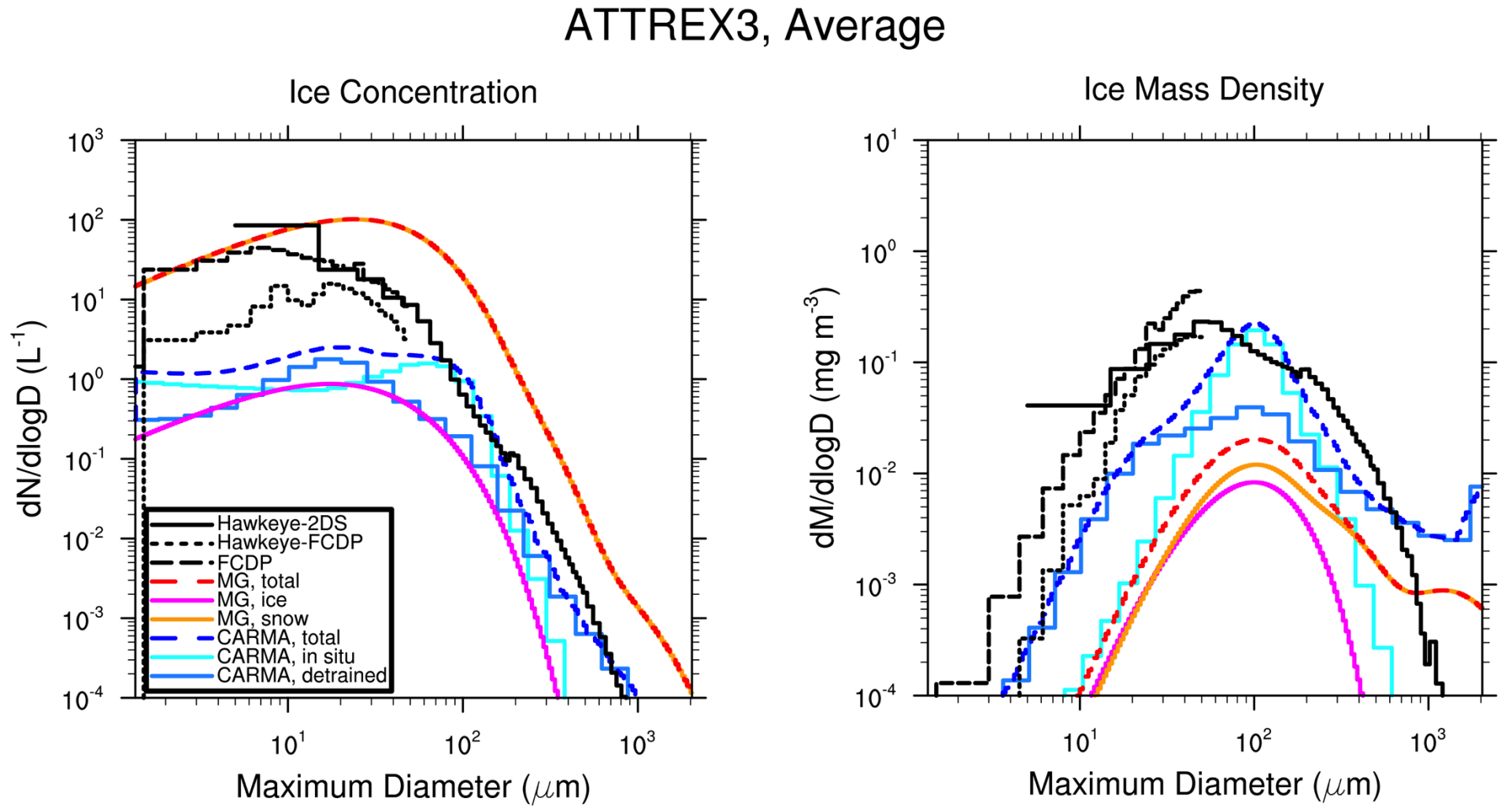
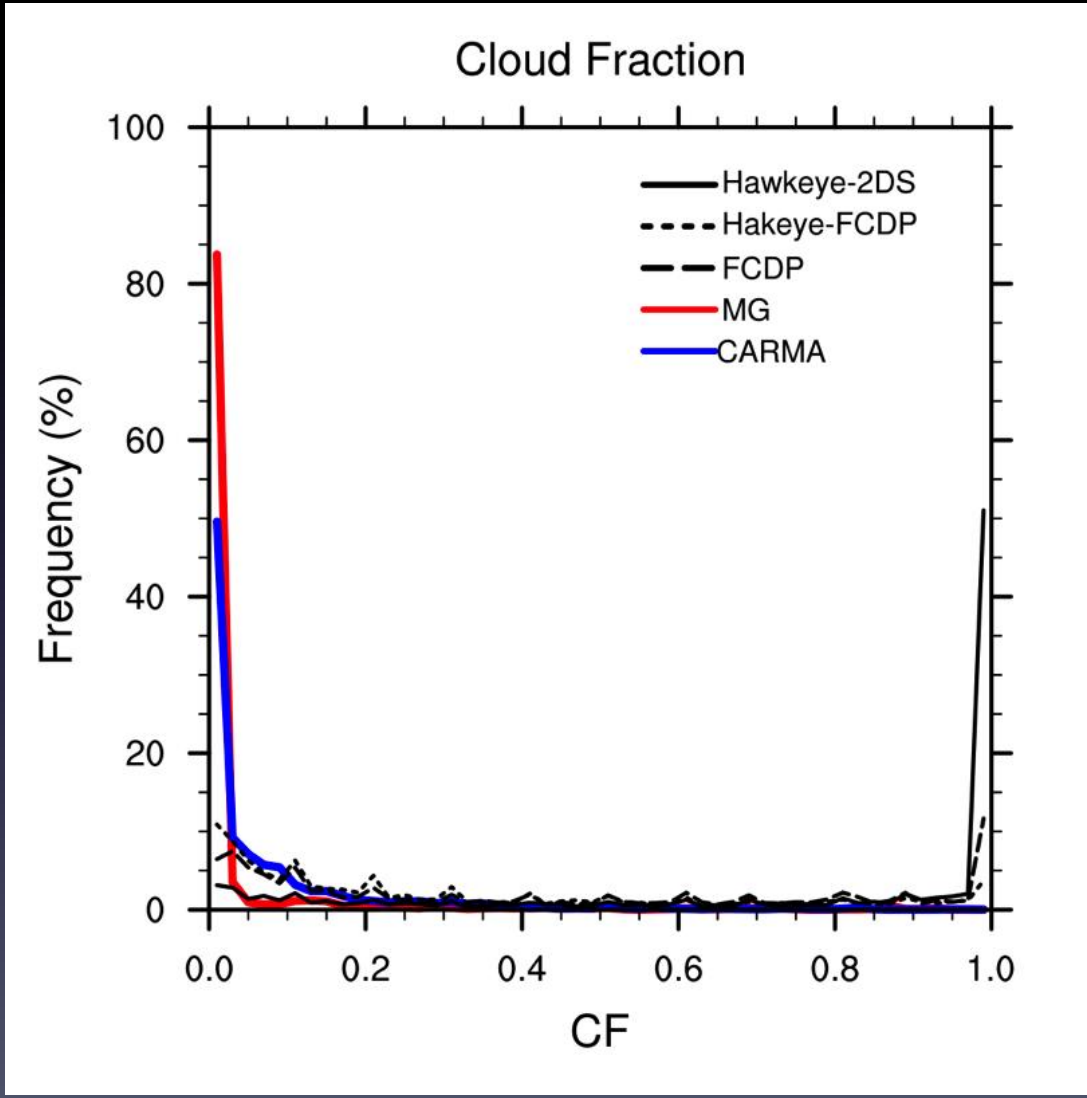




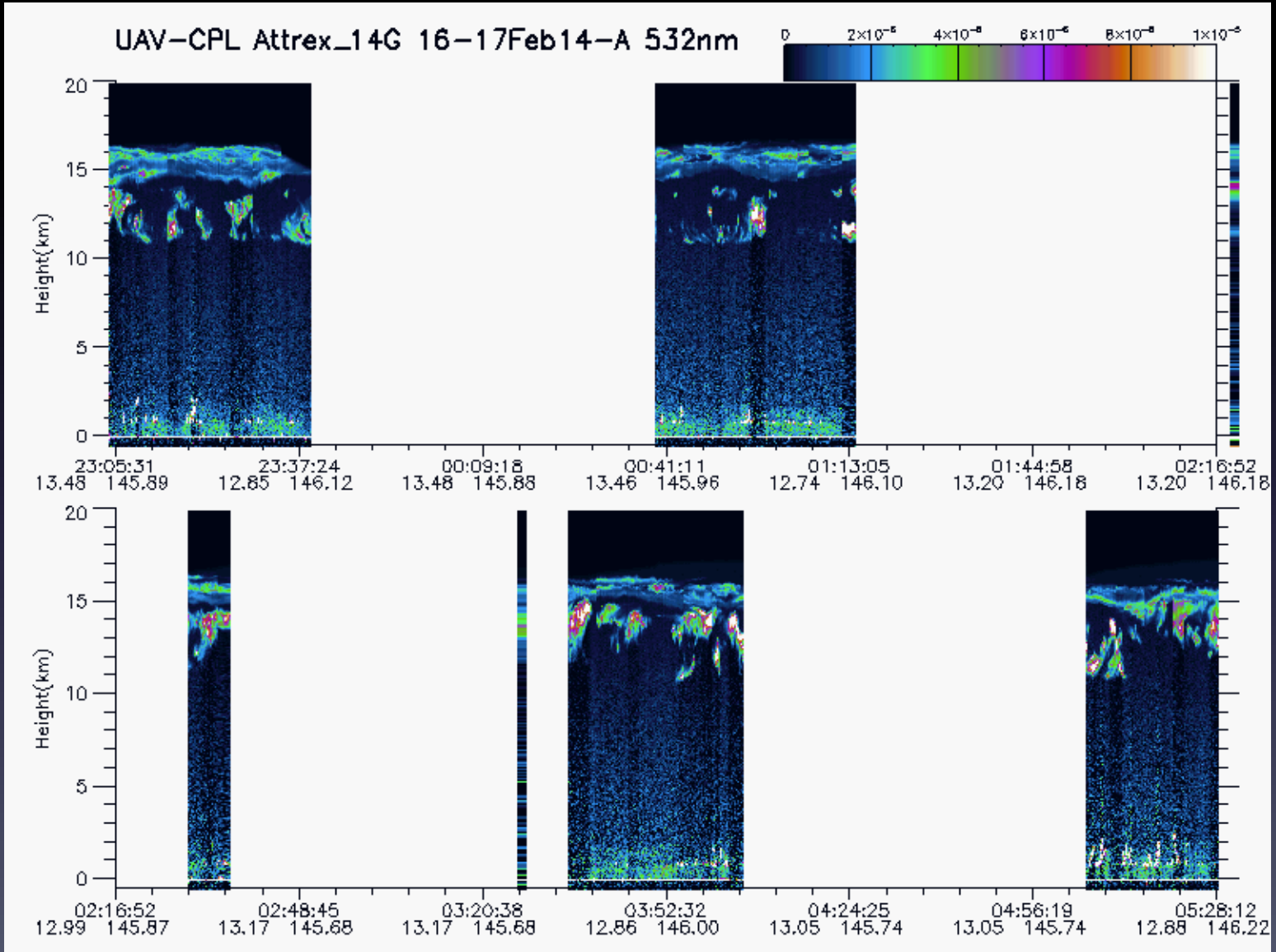
Ice Size Distribution



Ice Cloud Fraction



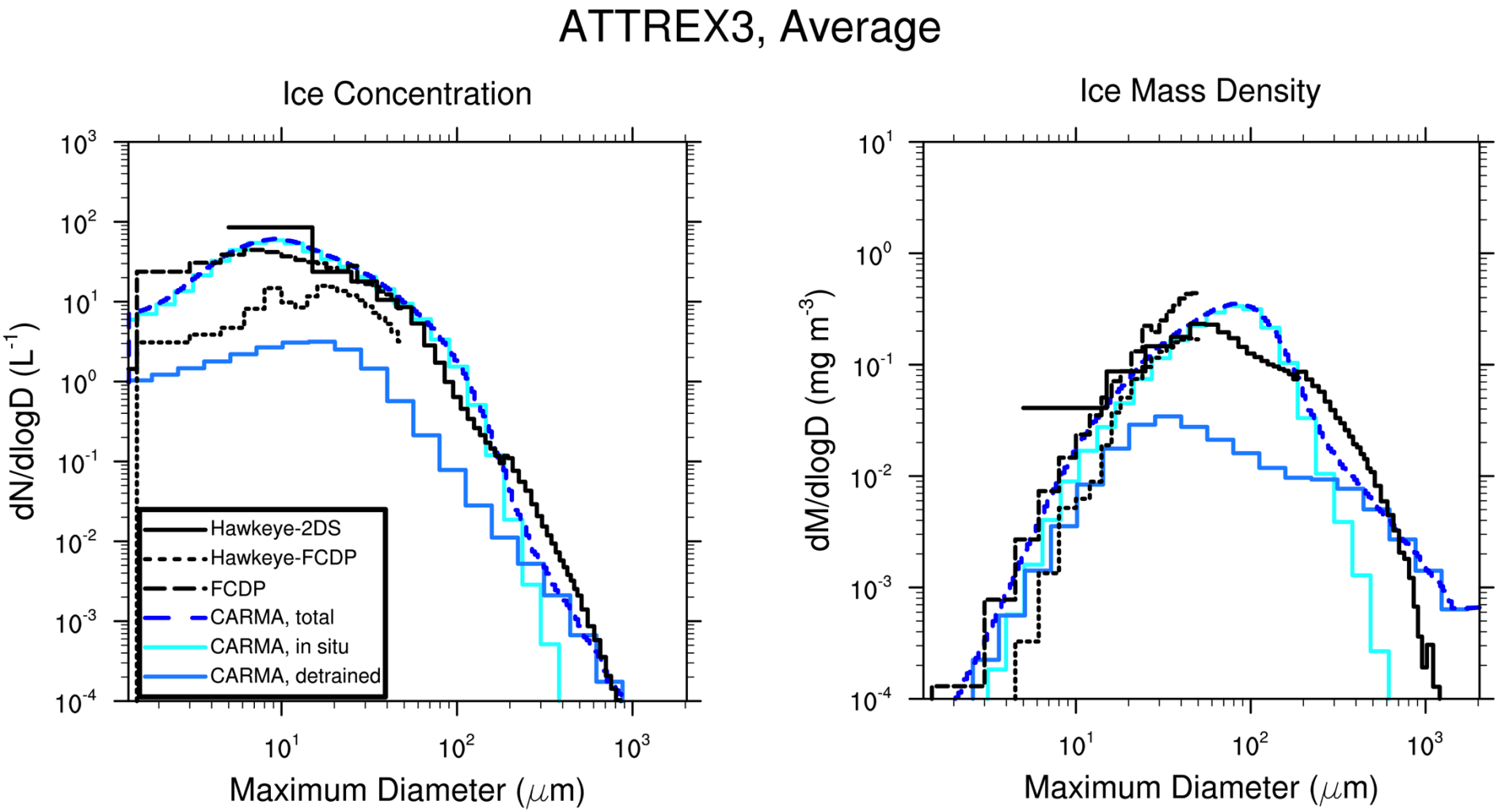
CPL, ATTREX3, 20140216



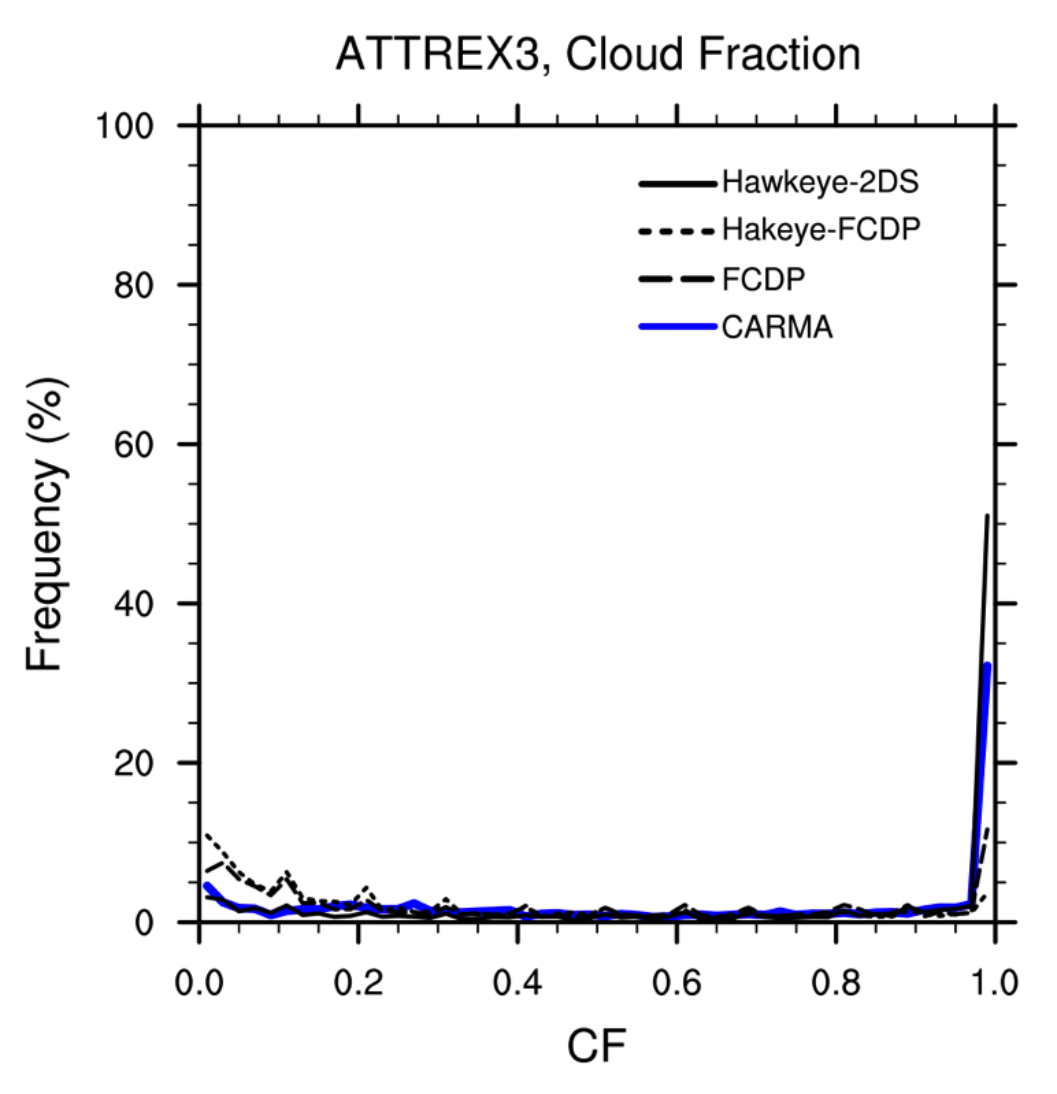
Modified Cloud Macrophysics

- Assume 2 Stratiform Cloud Regimes
  - Tropospheric Region (P > 140 hPa)
    - Subgrid scale
    - Patchy T, H2O, Saturation, Clouds
    - Use subgrid saturation : S α 1/CF
    - Ice Cloud Fraction : CF α IWC
  - TTL Region (P < 120 hPa)
    - Large scale
    - Uniform T, H2O, Saturation, Clouds
    - Gridbox average saturation
    - Ice Cloud Fraction : CF=1, if IWC > IWCmin

Improved Size Distribution



Improved Cloud Fraction



Significant Cloud Heating

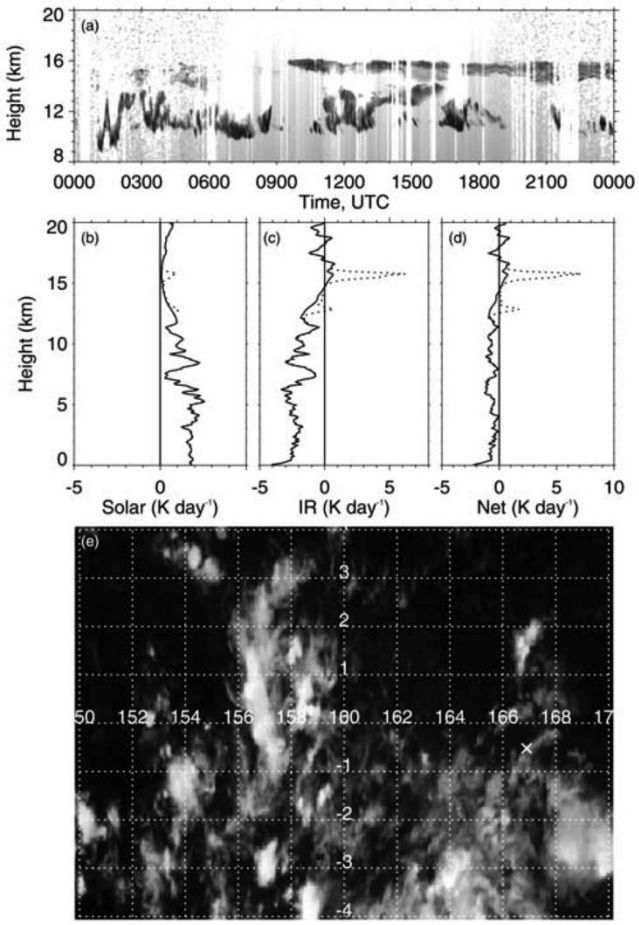
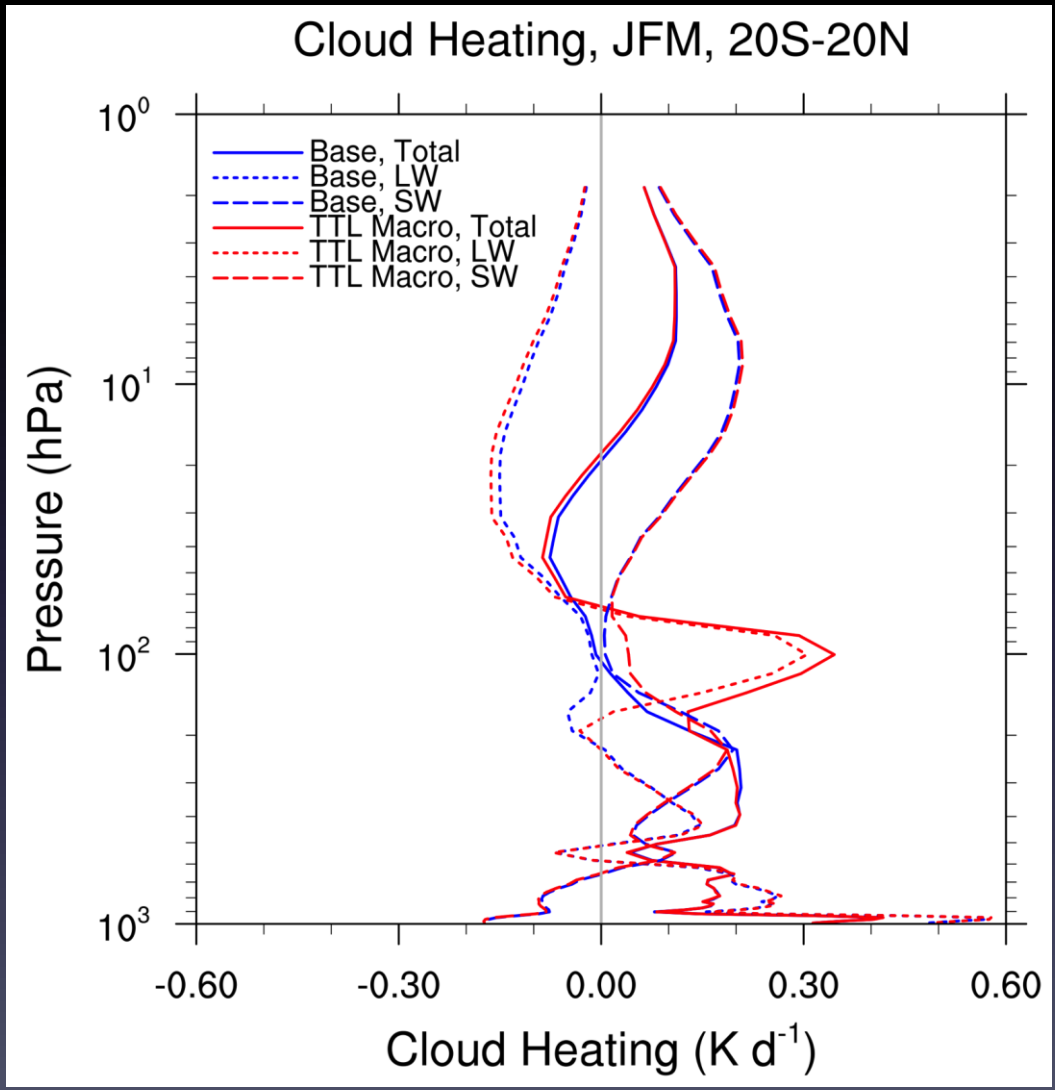


Figure 13. Same as in Figure 12 but for a multiple-layer cirrus observed on 17 June 1999. GMS-5 imagery is for 1432 UTC.



[Comstock et al., 2002]

Conclusions

- ATTREX has been important in understanding and improving the simulation of ice clouds and water vapor in CAM5.
- MG Microphysics
  - RH too high
  - Too much "snow", concentrations too large and mass densities too low.
  - Ice (0.5 g/cm3) and snow (0.1 g/cm3) densities inappropriate for TTL.
  - Cloud fraction too small in the TTL
- CARMA Microphysics
  - Too few small in situ particles
  - Cloud fraction too small in the TTL
  - With changes to the cloud macrophysics consistent with large scale clouds in the TTL, campaign and flight averages from CARMA simulation agree well with Hawkeye data, but RH too high.
- Cloud heating in the TTL may be significantly underestimated in CAM5, which may affect model biases (IWC, LWCF, Tropopause T, …).

Thank You For The Great Data!

Photos Courtesy Dave Fratello

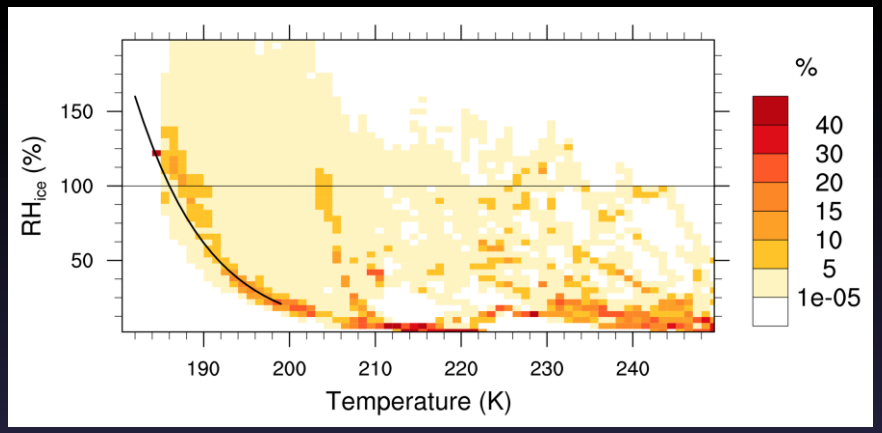
Future Work

- Continue to evaluate and refine this alternate representation for TTL macrophysics, including CAM5/MG and free running CAM5/CARMA.
- Identify a diagnostic field (e.g. stability, eddy diffusivity, …) to define the large scale region rather than arbitrary pressure levels. Might affect regions other than just the TTL and could move with climate change.
- Use SSFR data to validate ice cloud heating rates?
- Evaluate role of TTL cirrus in troposphere-stratosphere exchange (Corti et al., 2006).

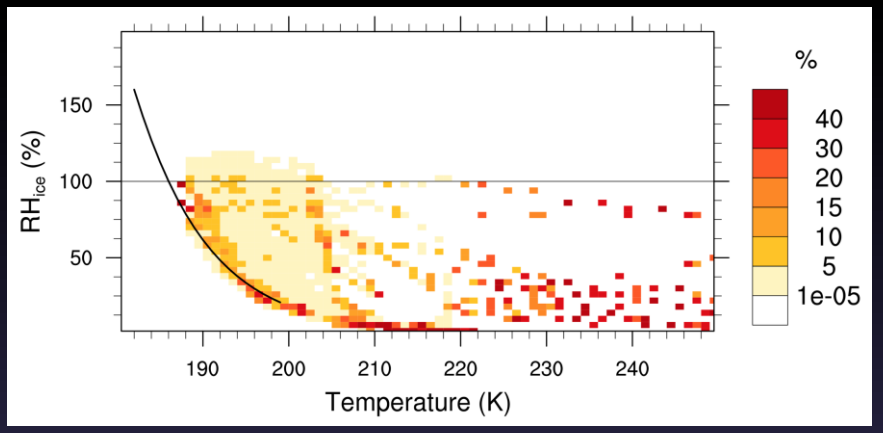
Krämer Plots : RH vs T

All Sky

DLH

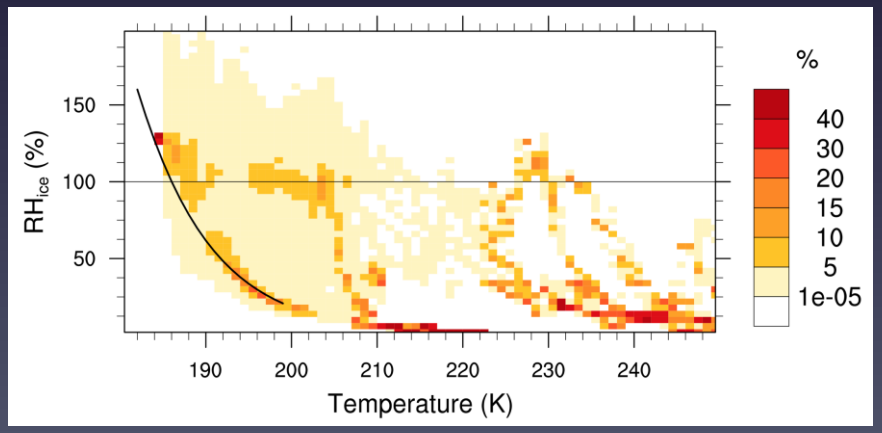


CARMA – Base Macrophysics

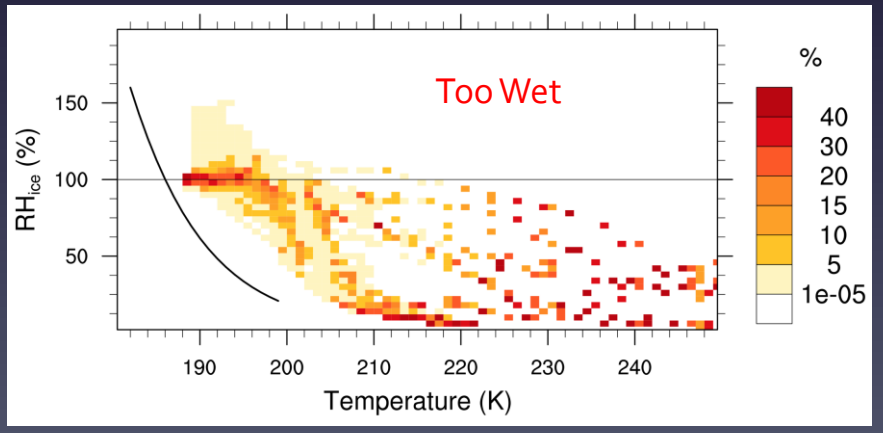


All Sky

NOAA



CARMA – Modified Macrophysics



Kramer Plots : M, N, Re vs T

Hawkeye 2DS

CARMA – Modified Macrophysics

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