An assessment of the CAM5/ CARMA model: TTL cirrus cloud representation through comparisons with ATTREX 3 and CALIPSO observations

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NASA

NCAR

ATOC

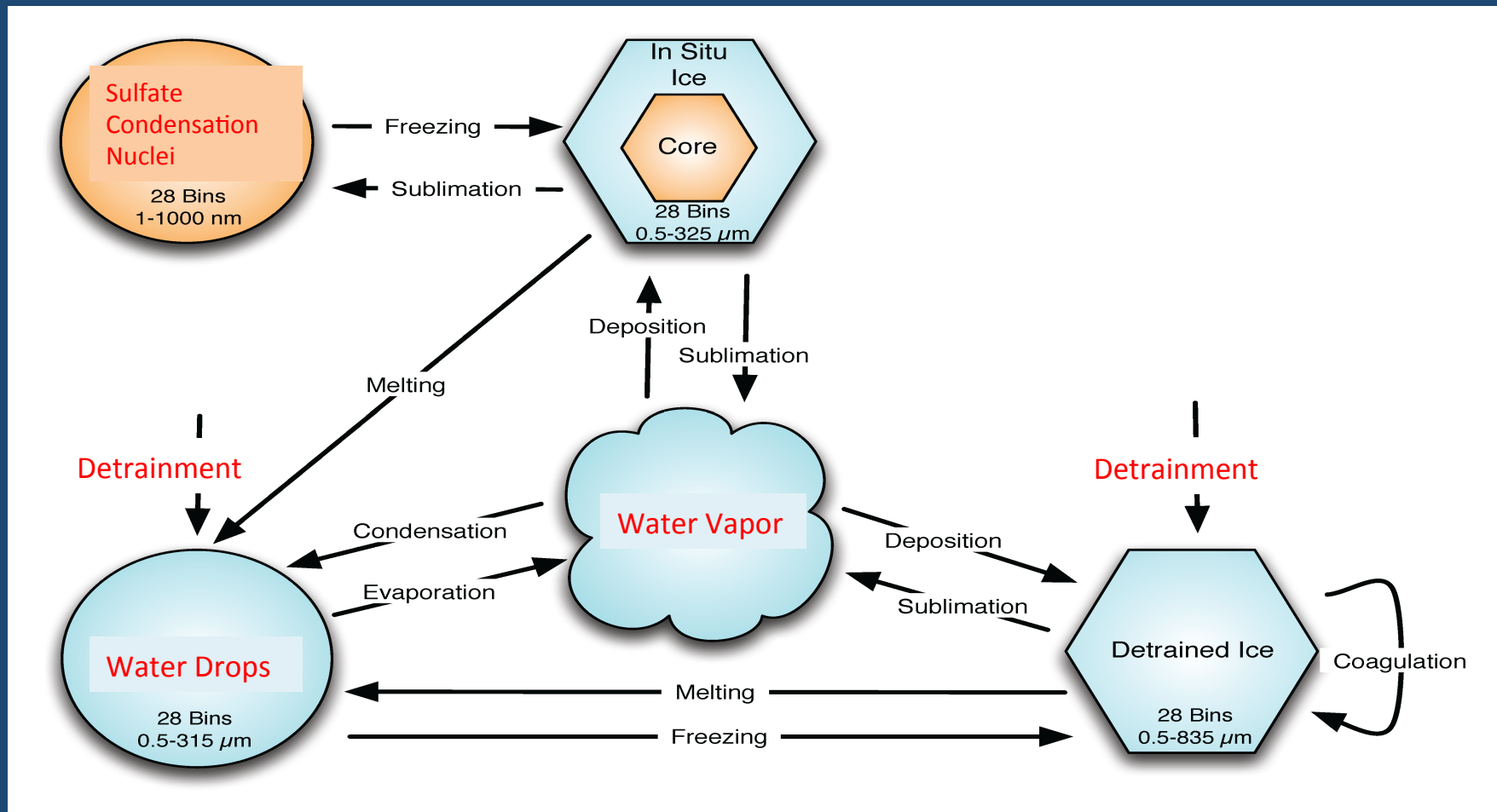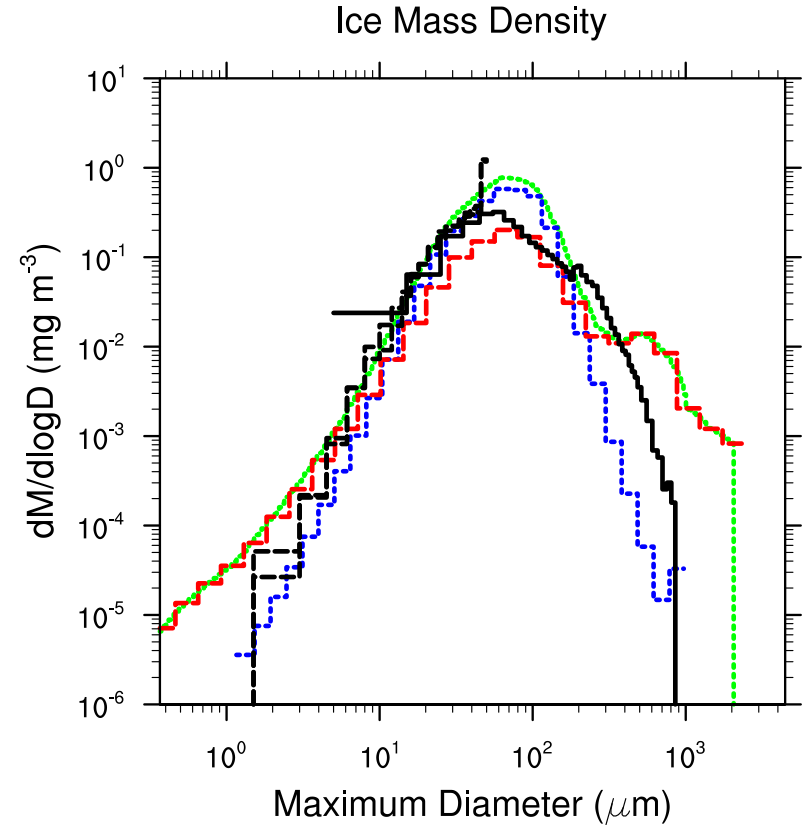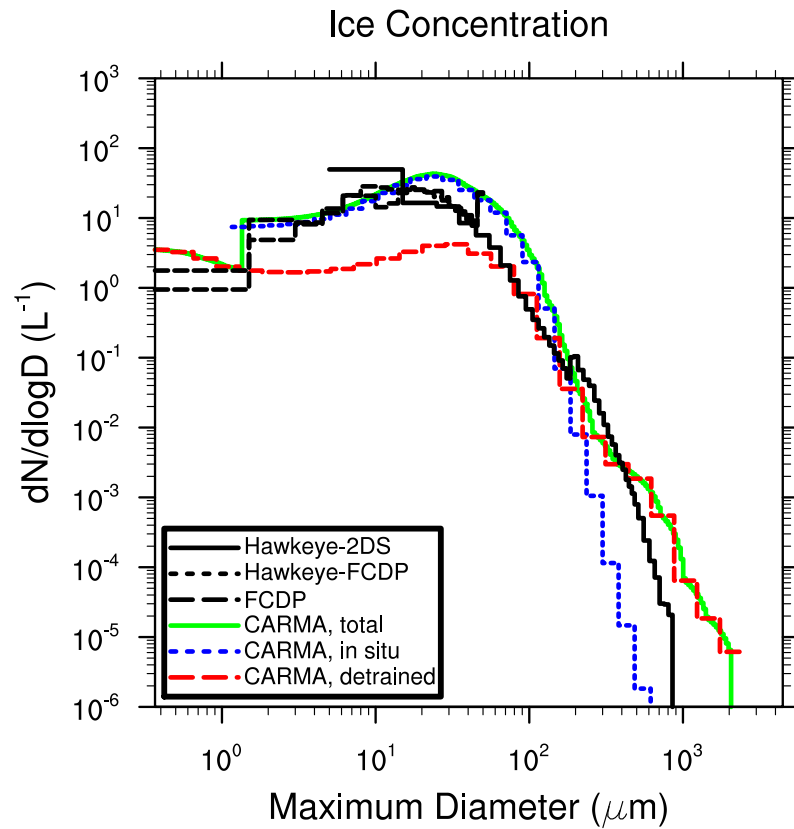# The CAM5/CARMA model resolves ice particle size distribution
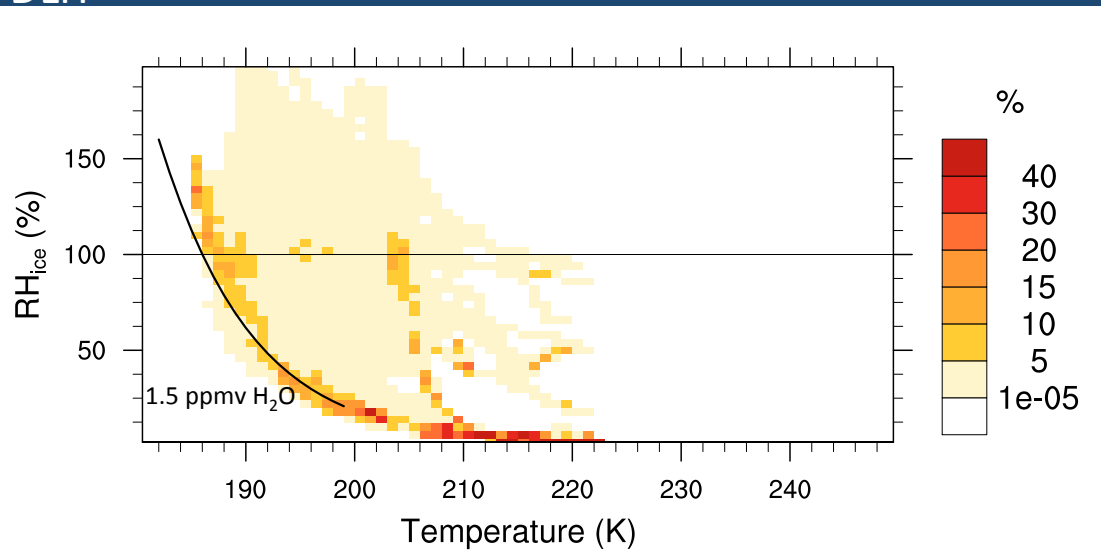

Figure from *Bardeen et al., 2014*

The size distribution compares well between model and observations for the mission

ATTREX3 mission average

Ice Concentration

Ice Mass Density

Legend:
- Hawkeye-2DS
- Hawkeye-FCDP
- FCDP
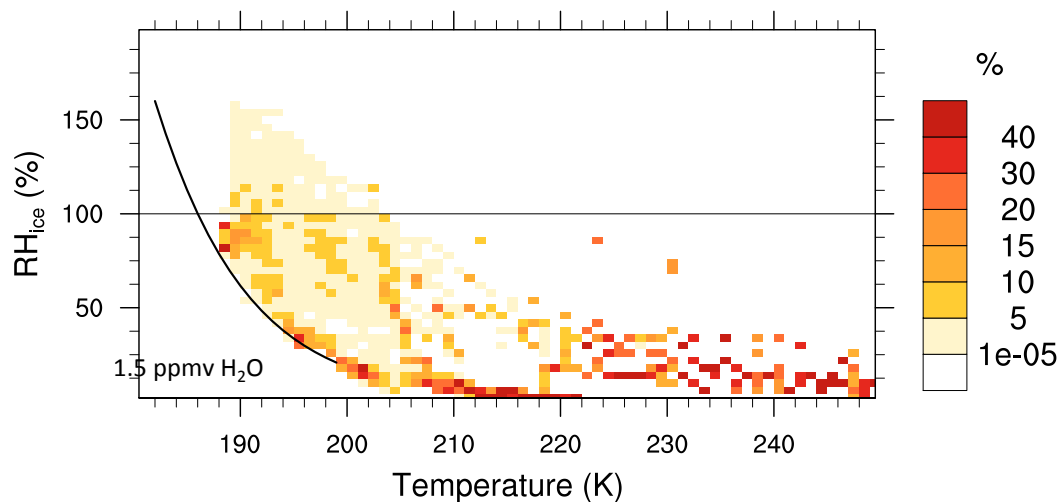- CARMA, total
- CARMA, in situ
- CARMA, detrained

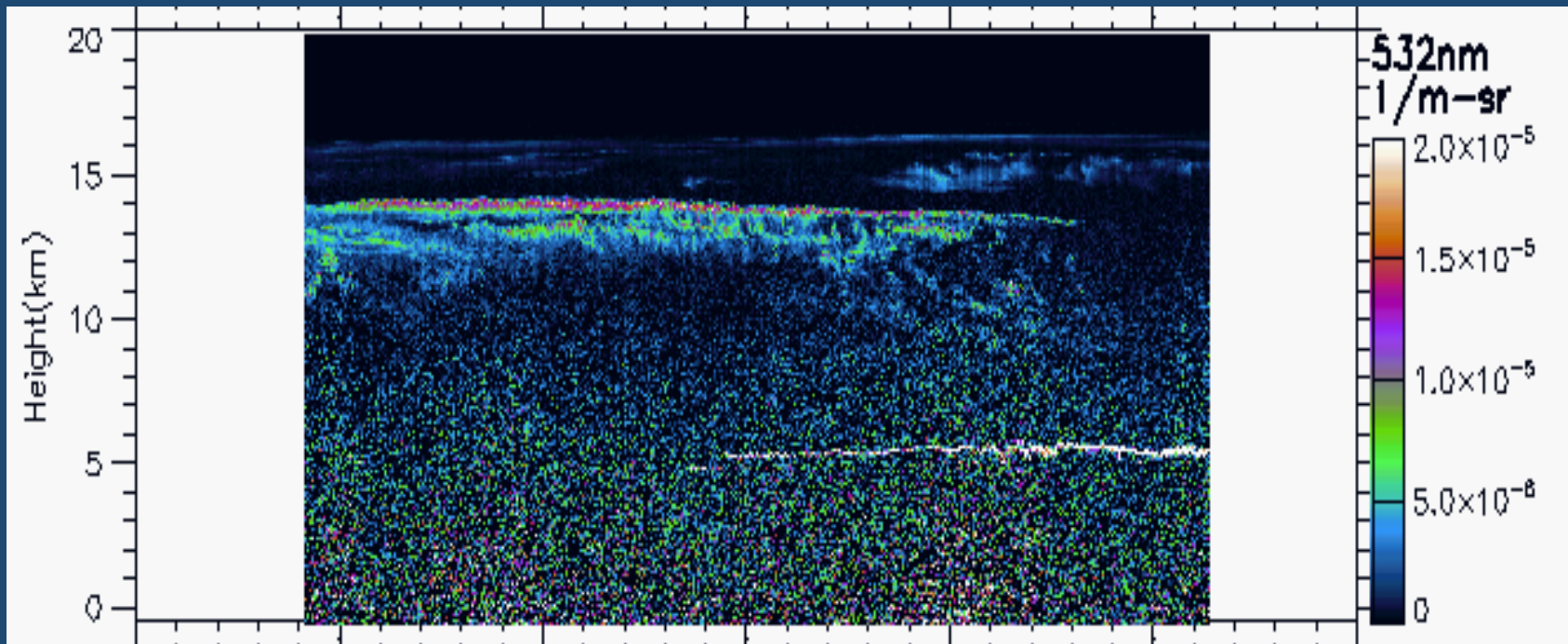# CAM5/CARMA grid box averaged RH$_{ice}$ is generally drier than all sky RH$_{ice}$ seen during ATTREX 3
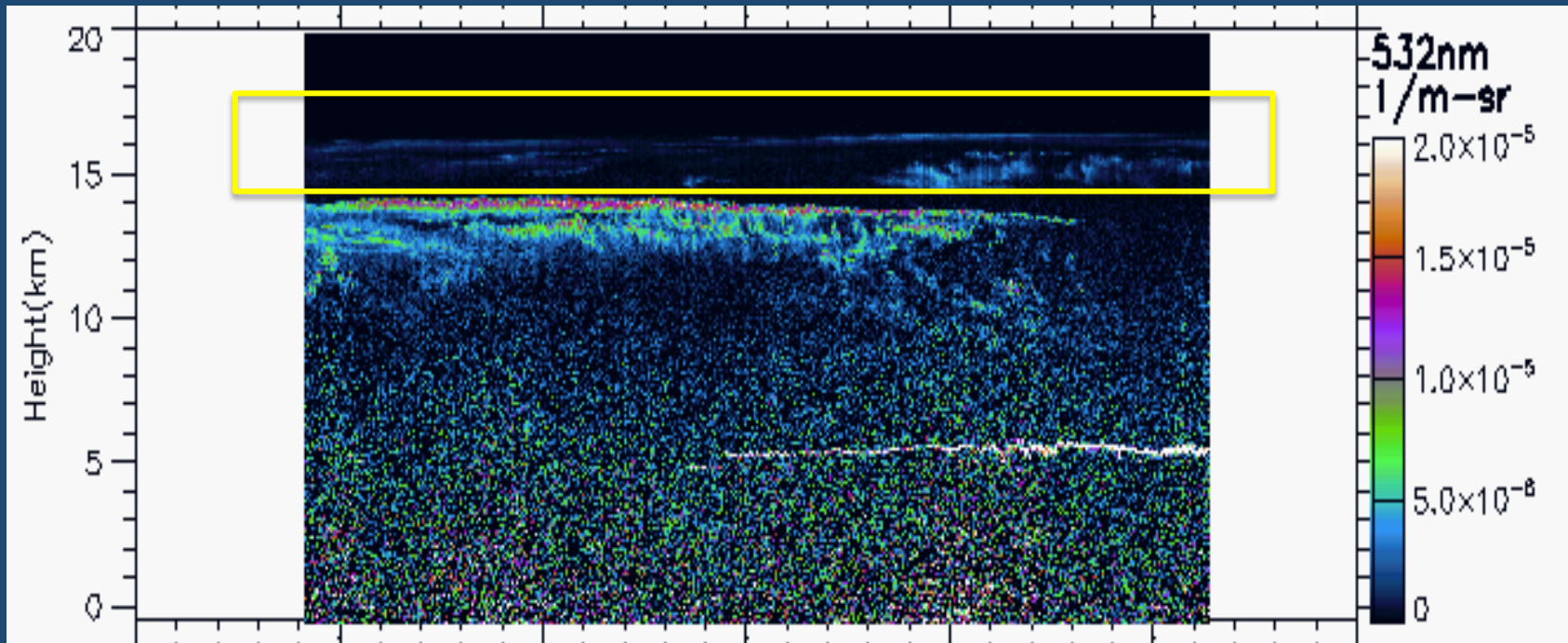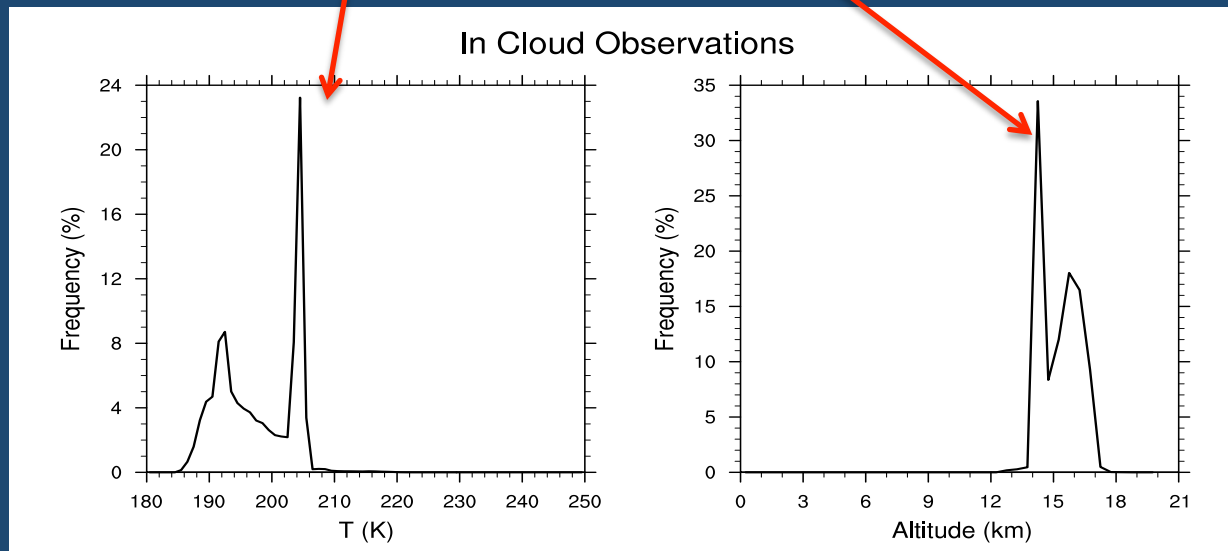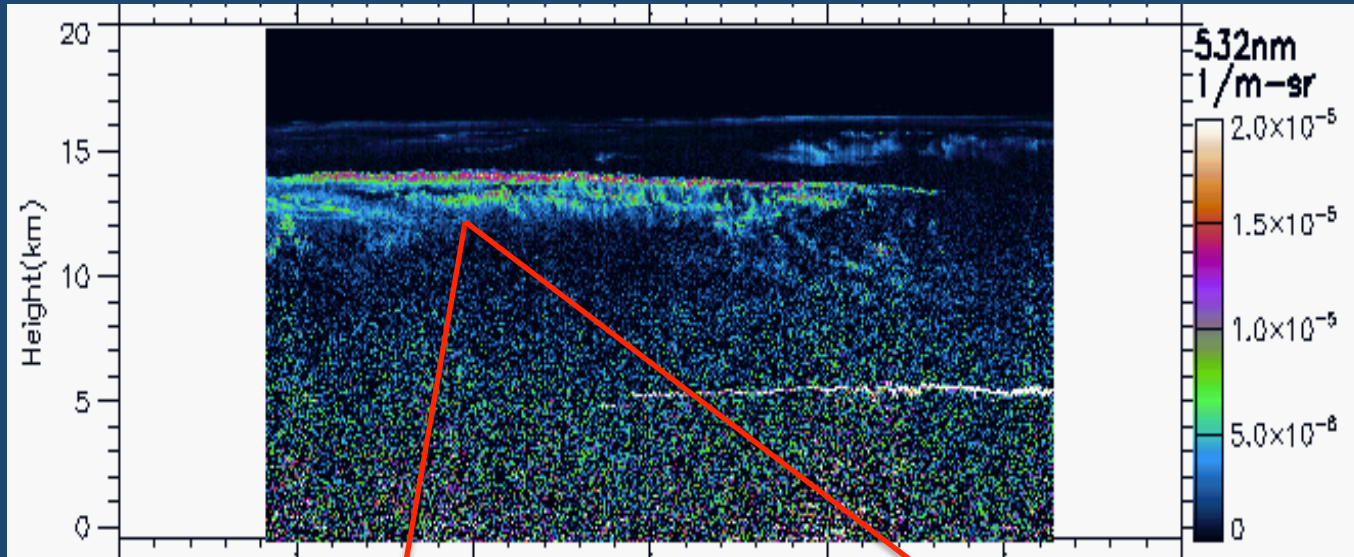
DLH

CAM5/CARMA

CPL reveals two persistent cloud layers throughout ATTREX 3 between 12-14 km 16- 17 km
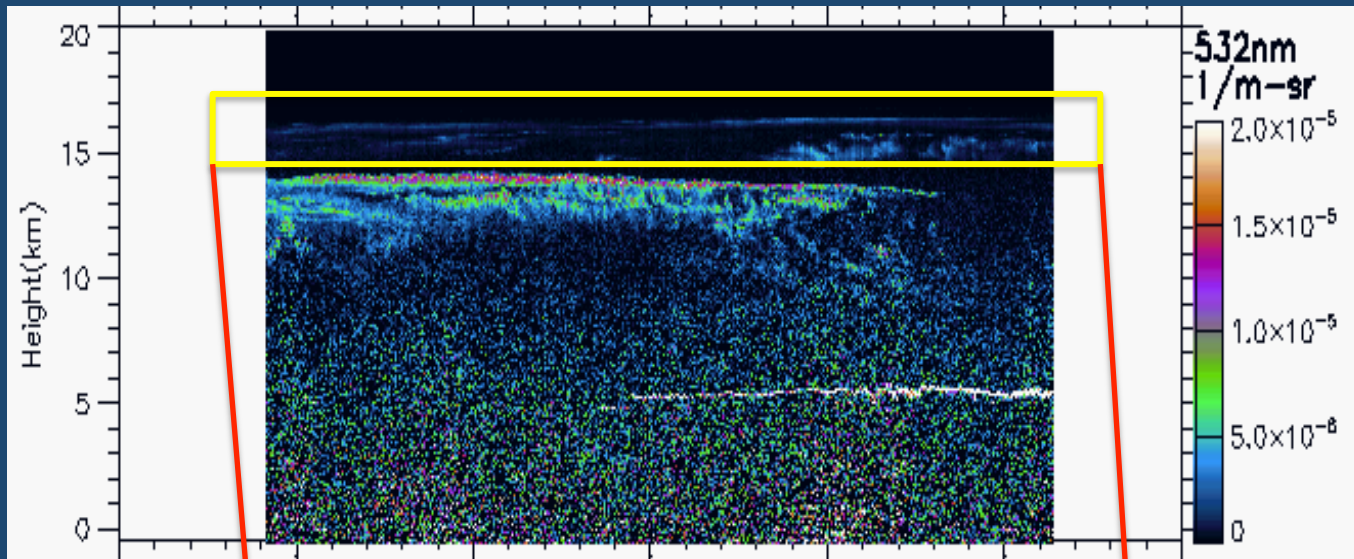
CPL reveals two persistent cloud layers throughout ATTREX 3 between 12-14 km 16- 17 km
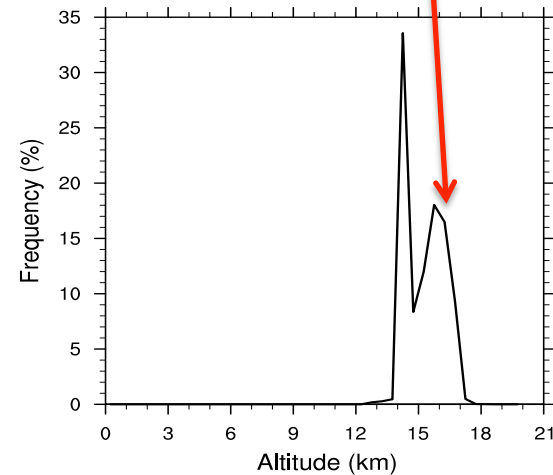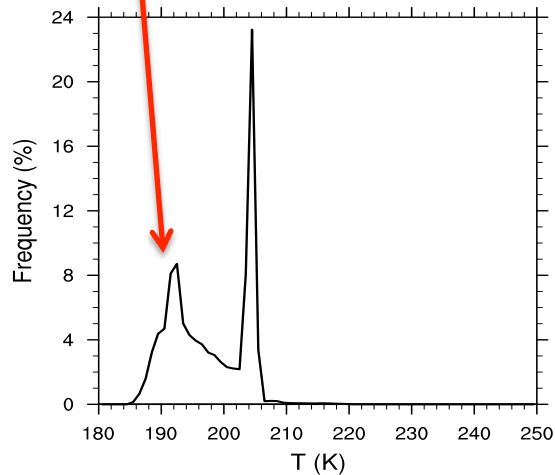
The two observed cloud layers fall into the warm and cold cloud regimes described in Krämer et al., 2009

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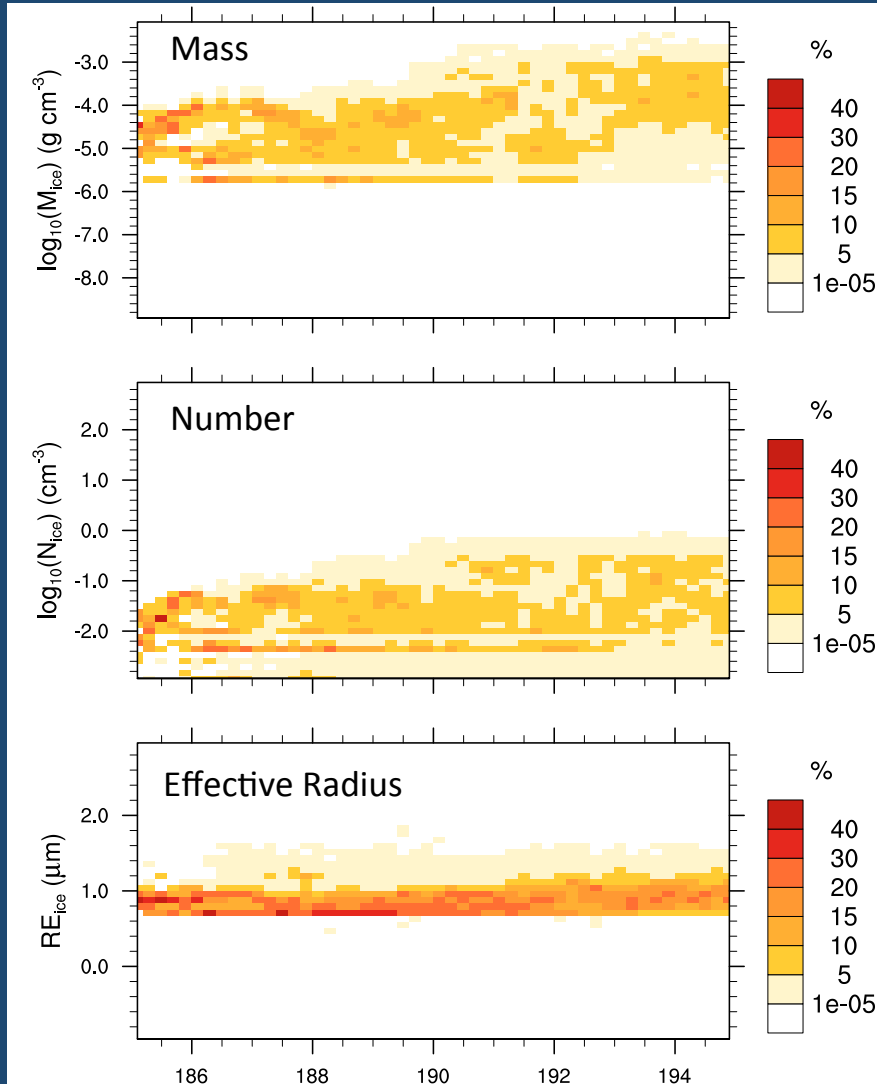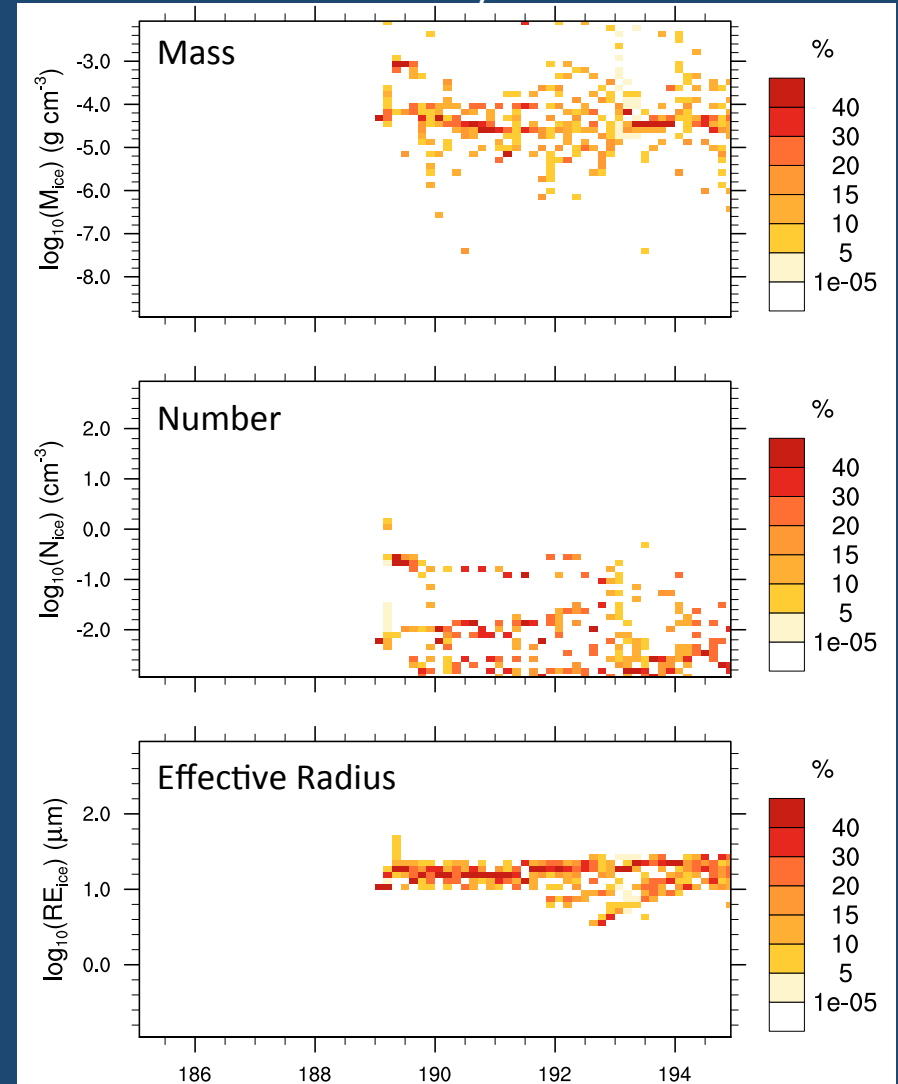
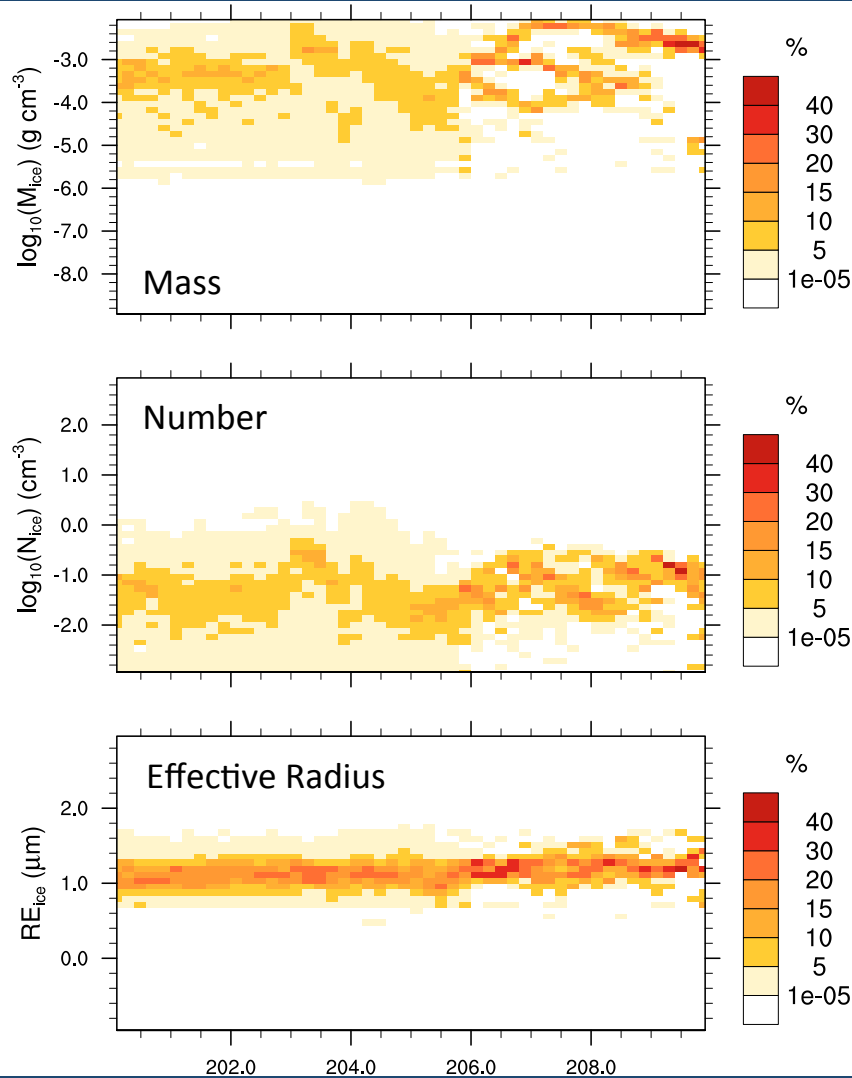# For cold clouds, 0.005 – 0.2 cm^{-3} ice number range and 1 – 10 μm sizes have been previously observed

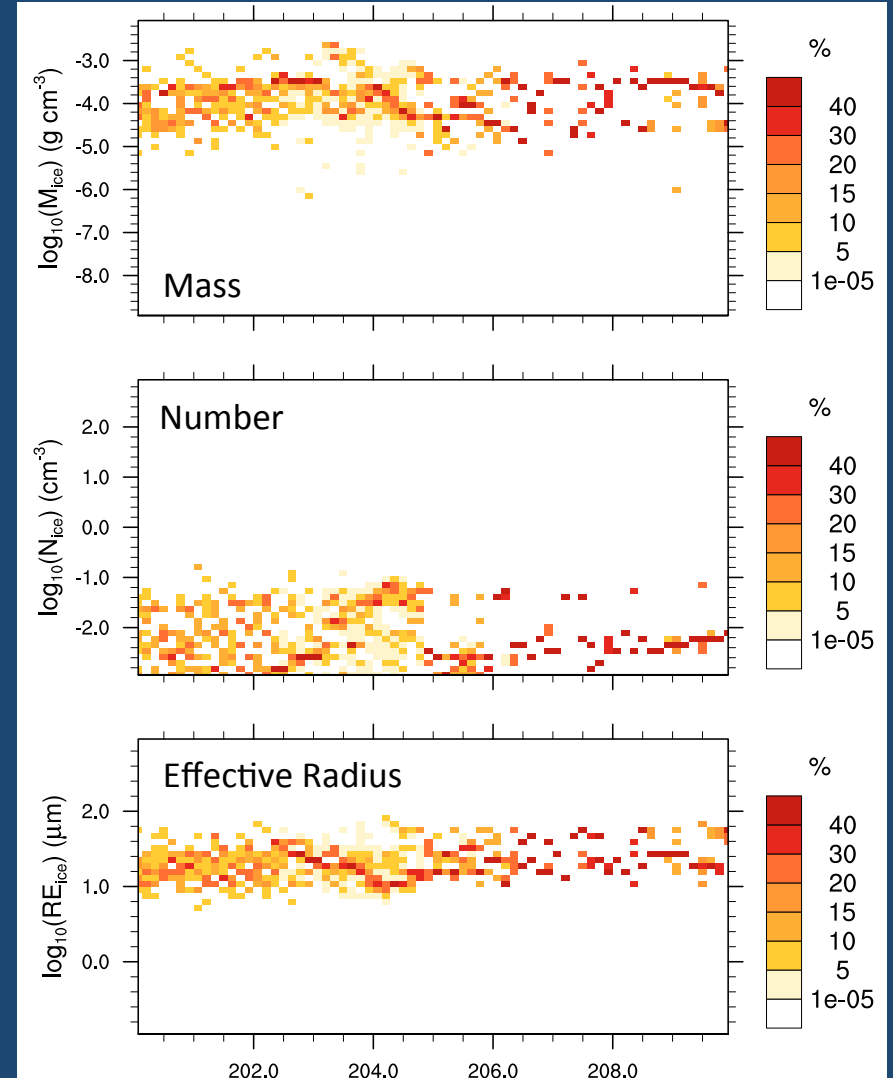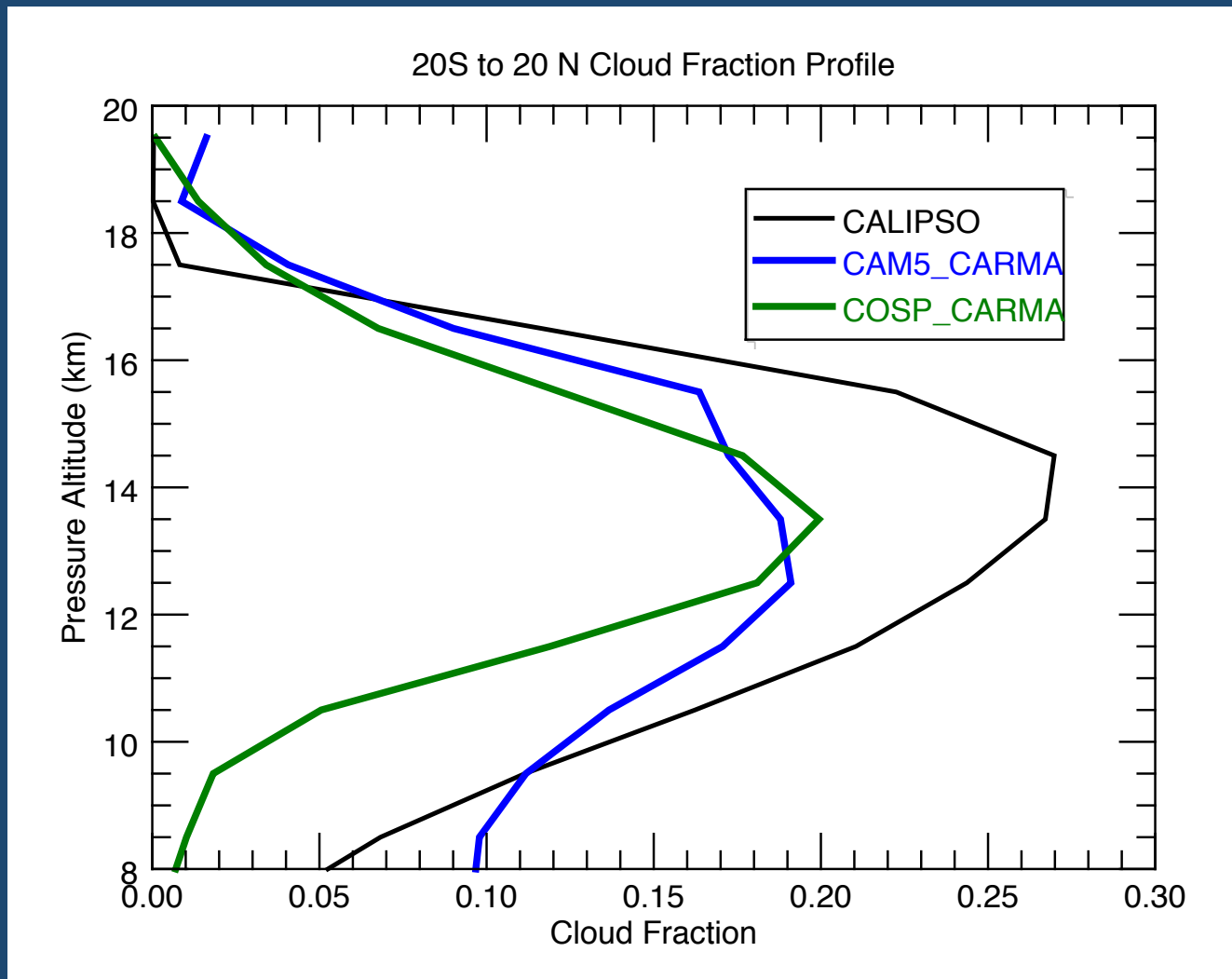# Higher ice concentrations and larger particles expected in warm clouds

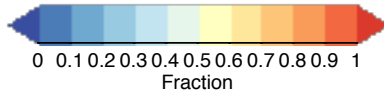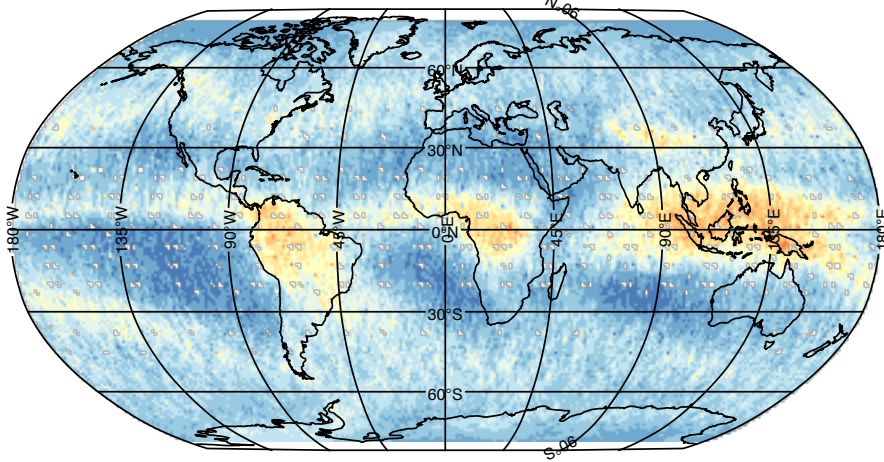# Tropics cloud fraction is too low in CAM5/ CARMA in the ATTREX 3 timeframe
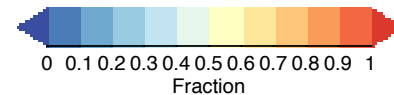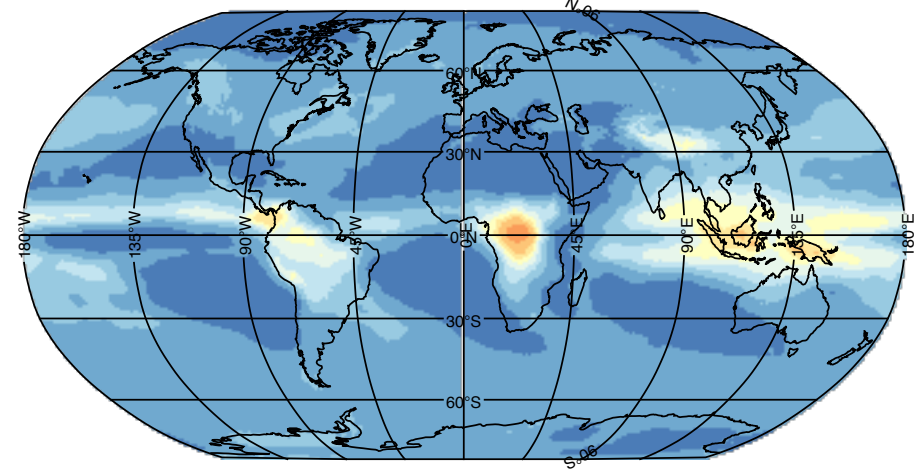
COSP simulator shows CAM5/CARMA under predicts high cloud fraction

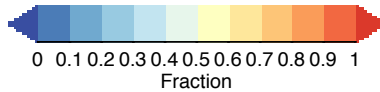GOCCP-CALIPSO 2011 High Cloud Fraction

GOCCP-CALIPSO

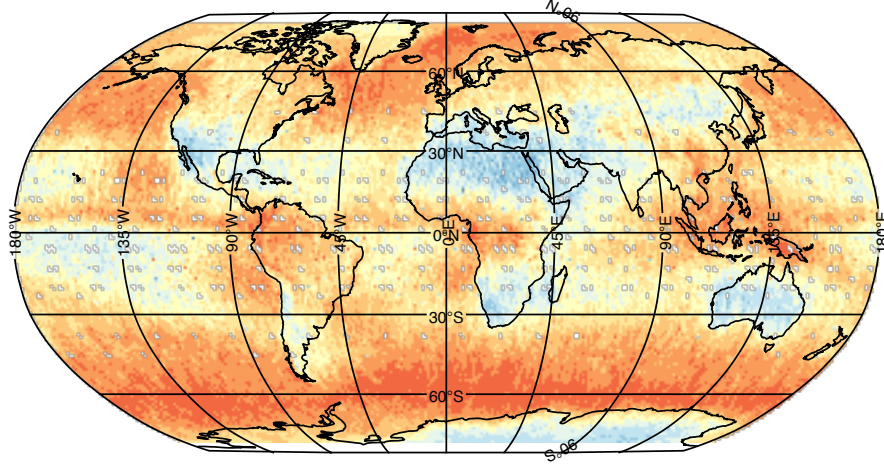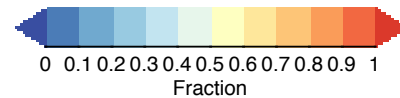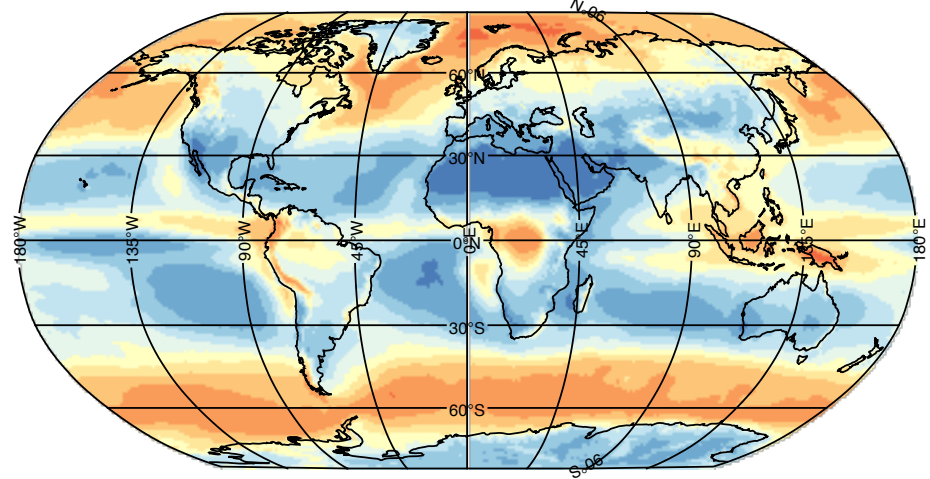CARMA/COSP 2011 High Cloud Fraction

CAM5/CARMA w/ COSP

CAM5/CARMA under predicts total cloud fraction

GOCCP-CALIPSO

CAM5/CARMA w/ COSP

Conclusions

ATTREX 3 Comparison:
- CAM5/CARMA represents clouds along ATTREX 3 flight track, but has too many large particles

- Resolution limitation causes the model to struggle with finer features

CALIPSO Comparison:
- At 1x1 degree resolution, CAM5/CARMA underestimates cloud fraction vertical profile above 8 km for the ATTREX 3 timeframe

- COSP simulator shows the model misses high cloud fraction around the equator

Future Work

- Perform a CAM5/Morrison & Gettleman COSP simulation to determine if CAM5/CARMA is improving on CAM5's cloud representation

- Continue to evaluate the model with COSP simulator against CALIPSO observations

- A combined CARMA aerosol and CARMA cloud model??

Thanks to…

- My advisor, Brian Toon, Charles Bardeen, and Eric Jensen for their guidance on this project
- Melody Avery and the CALIPSO team
- Jen Kay for assistance with COSP
- Sarah Woods, Paul Lawson, and the SPEC science team
- Glenn Diskin and the DLH science team
- NCAR, LASP, the University of Colorado

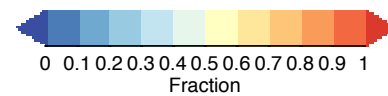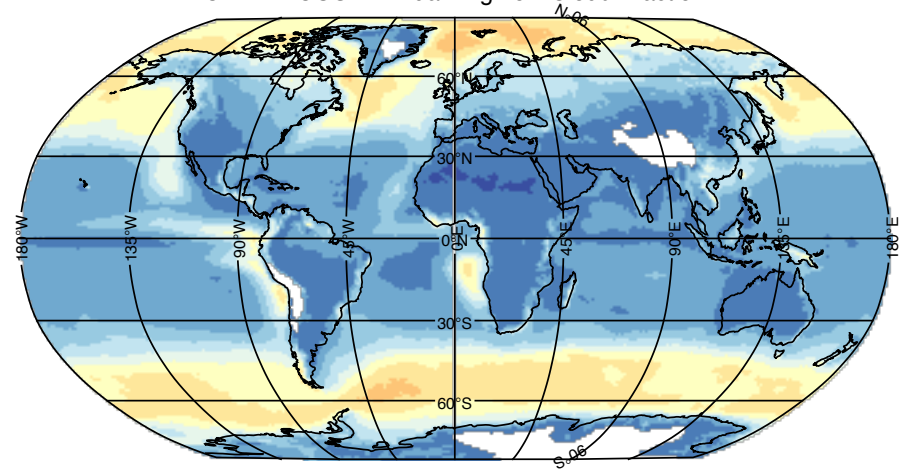….and NASA for allowing me to participate in the awesome ATTREX 3 mission!

Extra Slides

Low Cloud Fraction

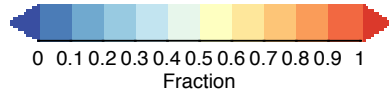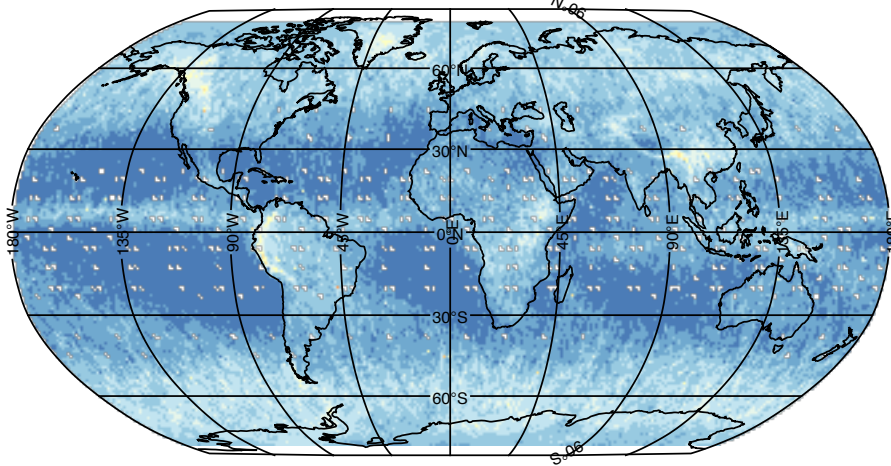GOCCP-CALIPSO Annual Avg Low Cloud Fraction
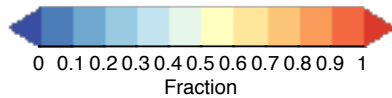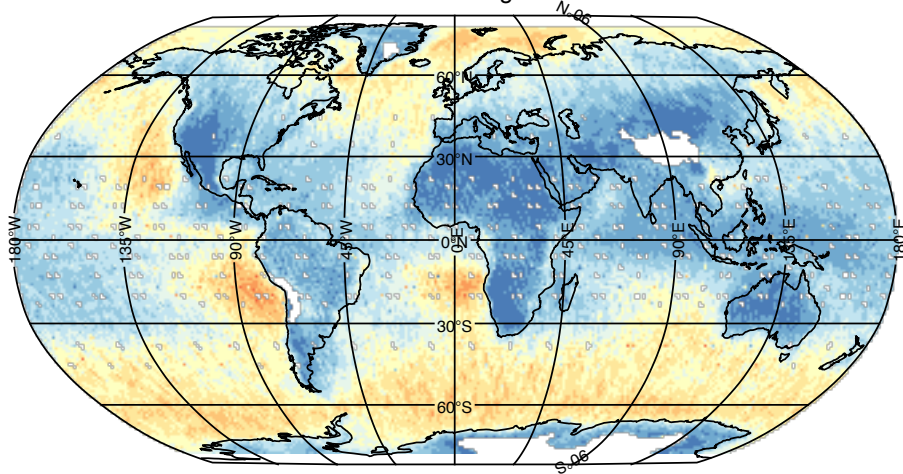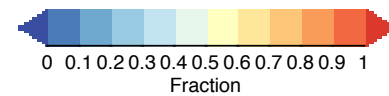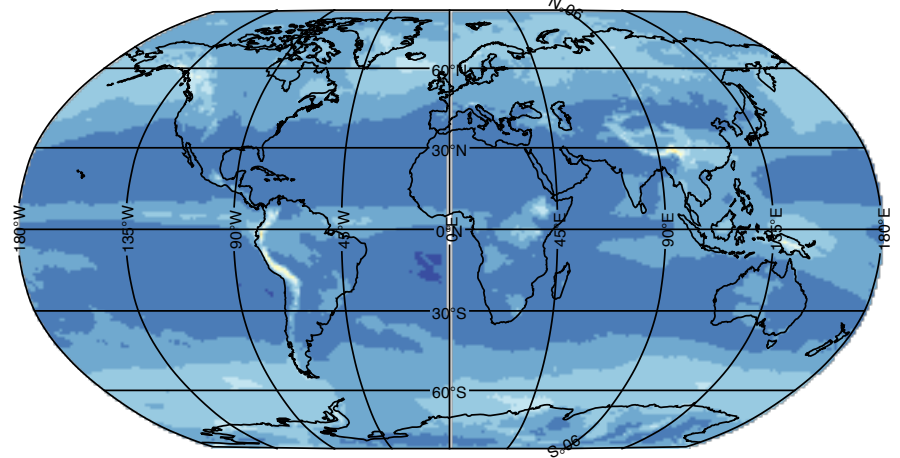
CARMA/COSP Annual Avg Low Cloud Fraction

Mid Cloud Fraction

GOCCP-CALIPSO Annual Avg Mid Cloud Fraction
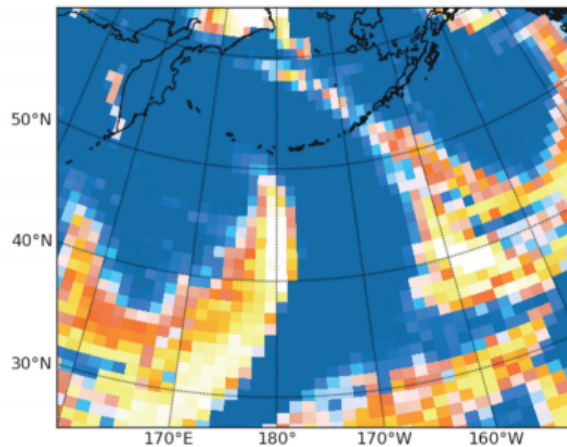
CARMA/COSP Annual Avg Mid Cloud Fraction

COSP Flow Chart
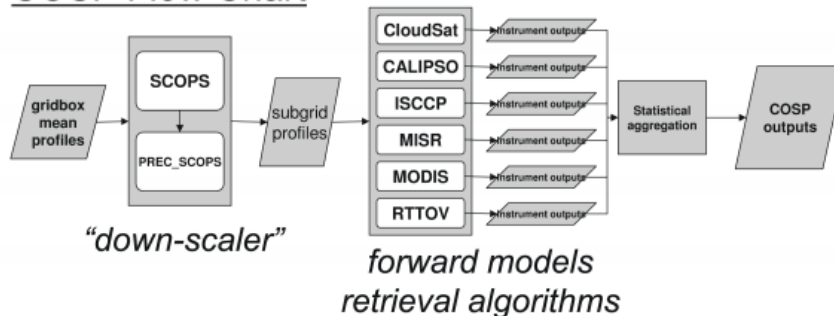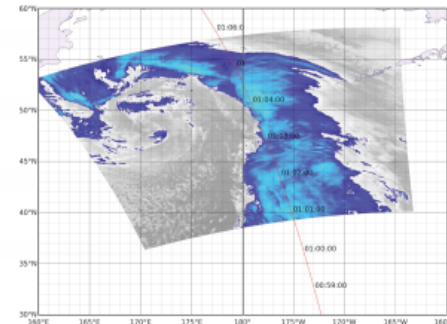
CAM5/CARMA Overlap Scheme
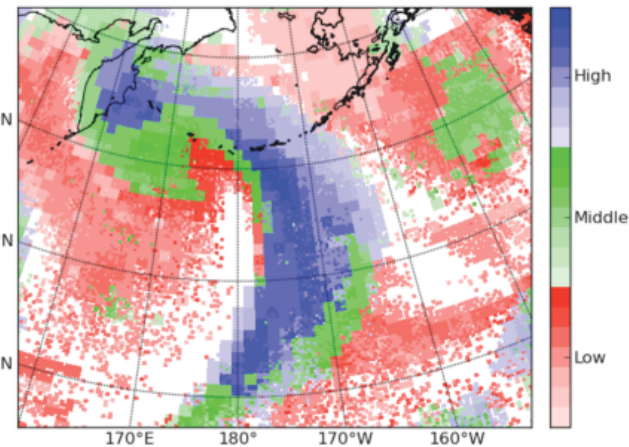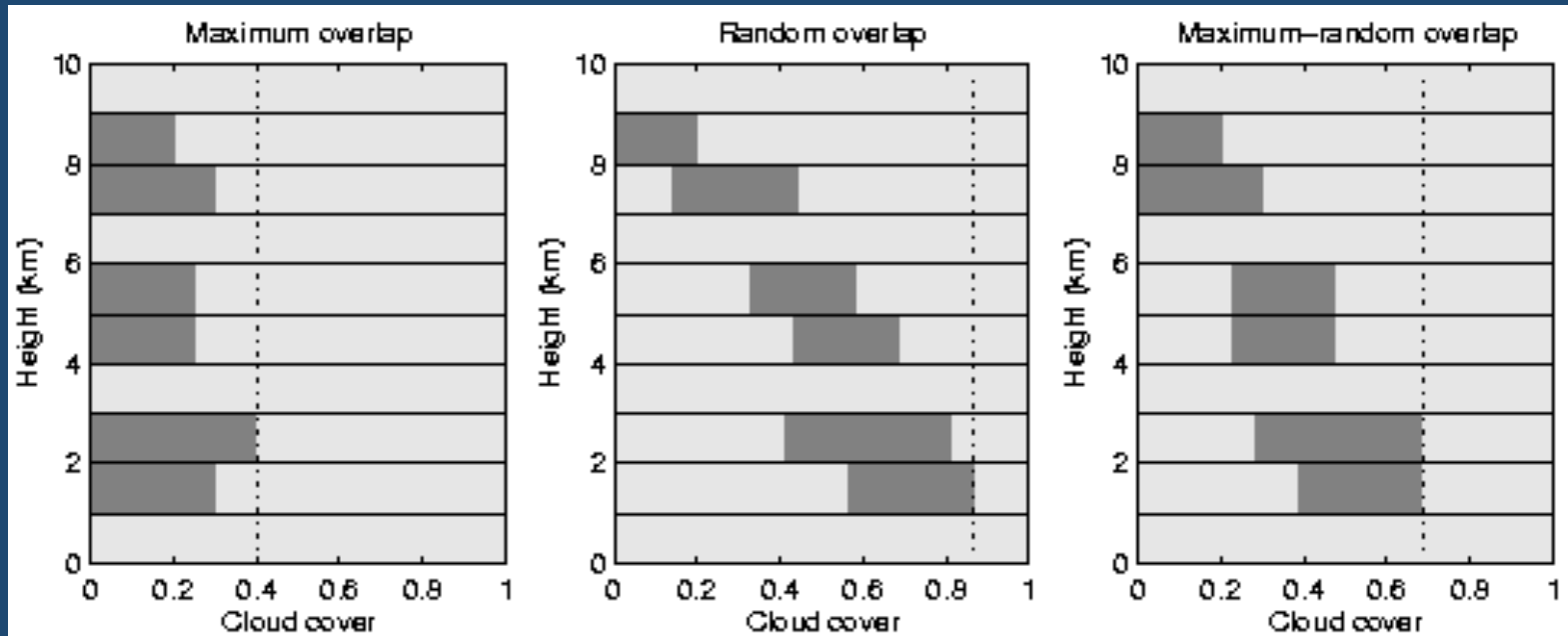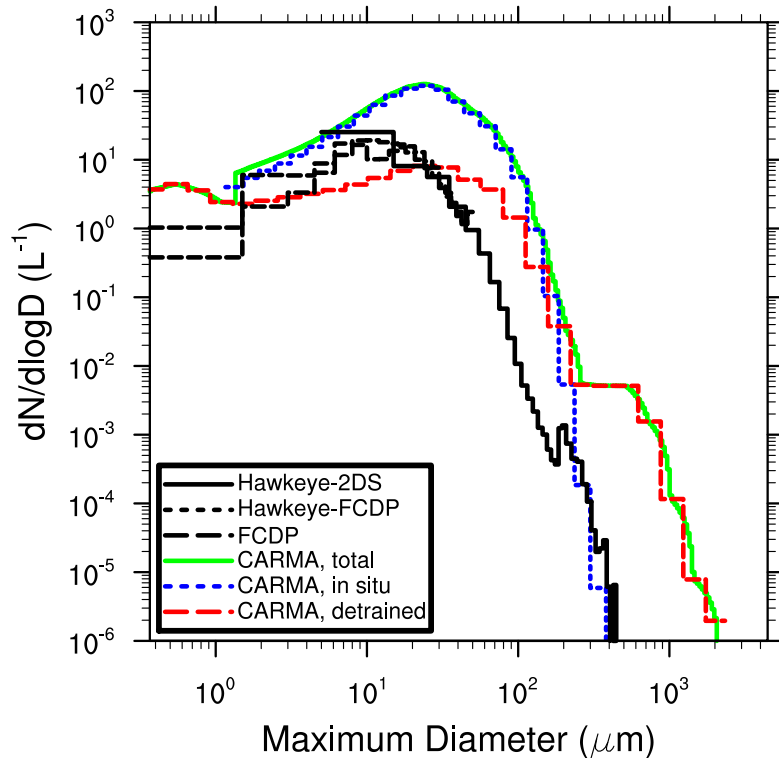

Maximum/random overlap scheme from Hogan
and Illingworth (2000)

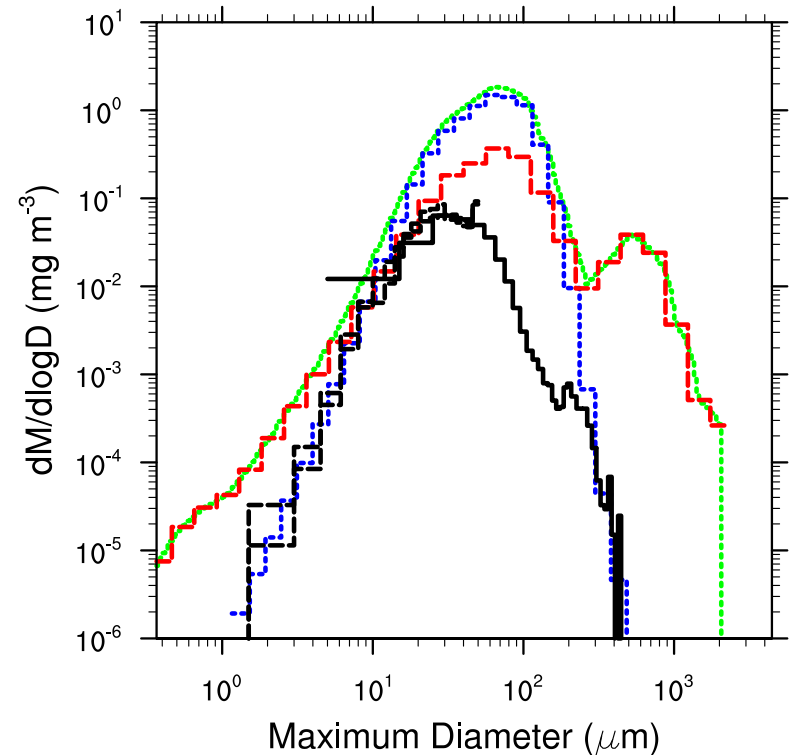# CAM5/CARMA Overestimates Number and Mass For Cold Cirrus Clouds
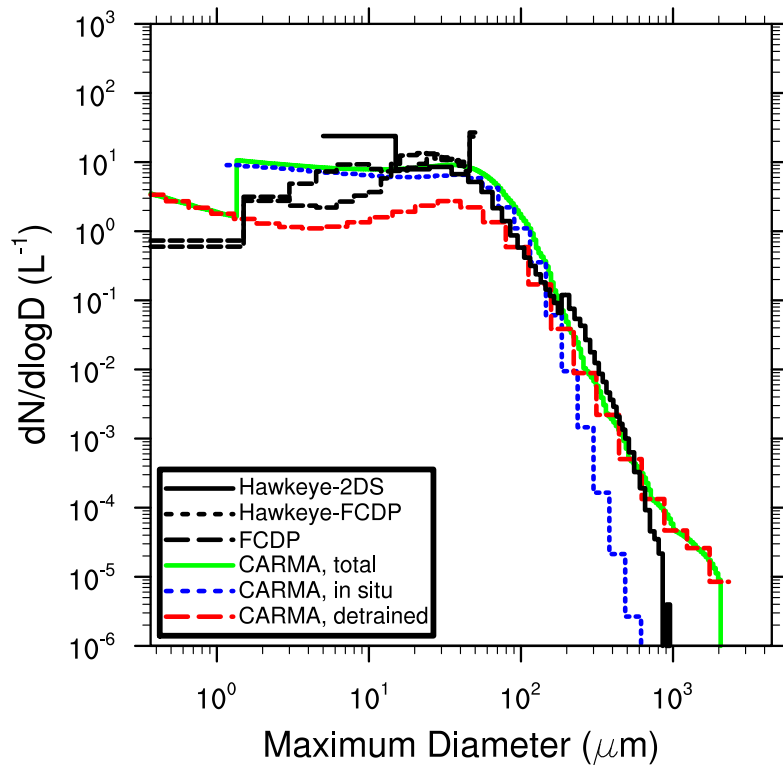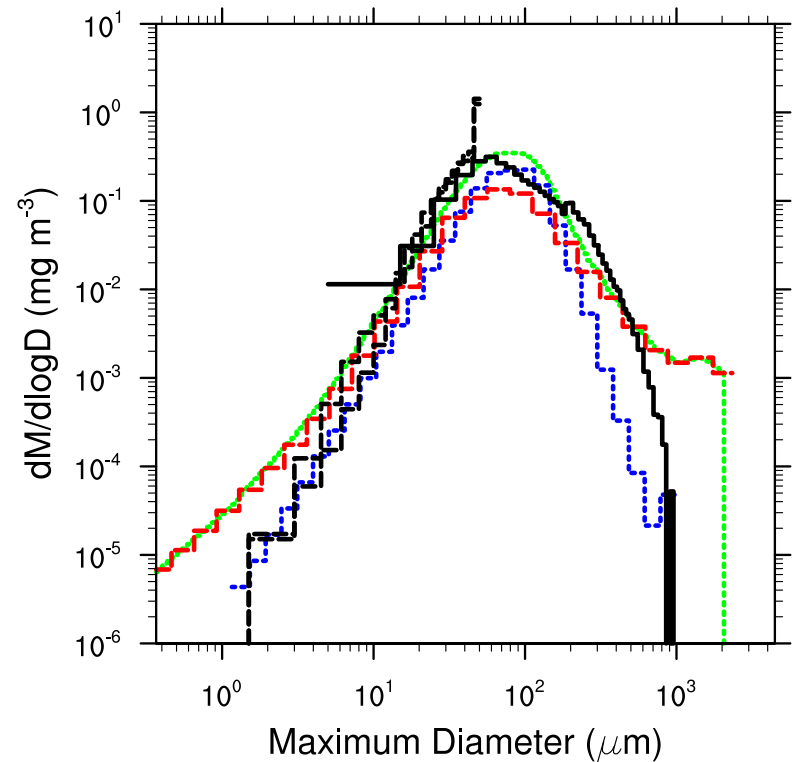

ATTREX3 mission average 190K

CAM5/CARMA Does a Good Job Capturing Warm Cloud Ice Concentration and Mass

ATTREX3 mission average 205K

CALIPSO Provides a Useful Tool to Evaluate GCM cloud representation

- Global coverage since 2006

- CALIOP lidar onboard capable of resolving high thin cirrus
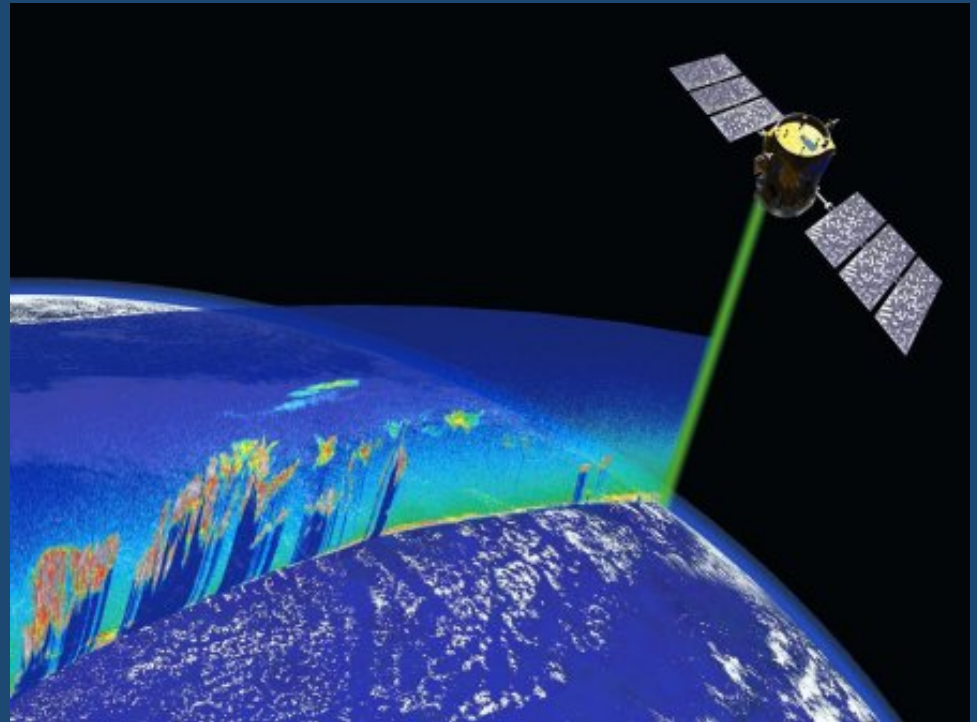
- Few CARMA comparisons with CALIPSO

- COSP has not been used with CARMA

Image from NASA LaRC EPO site