Simulations of Thin Cirrus Clouds in the Tropical Tropopause Layer Using CAM5/CARMA

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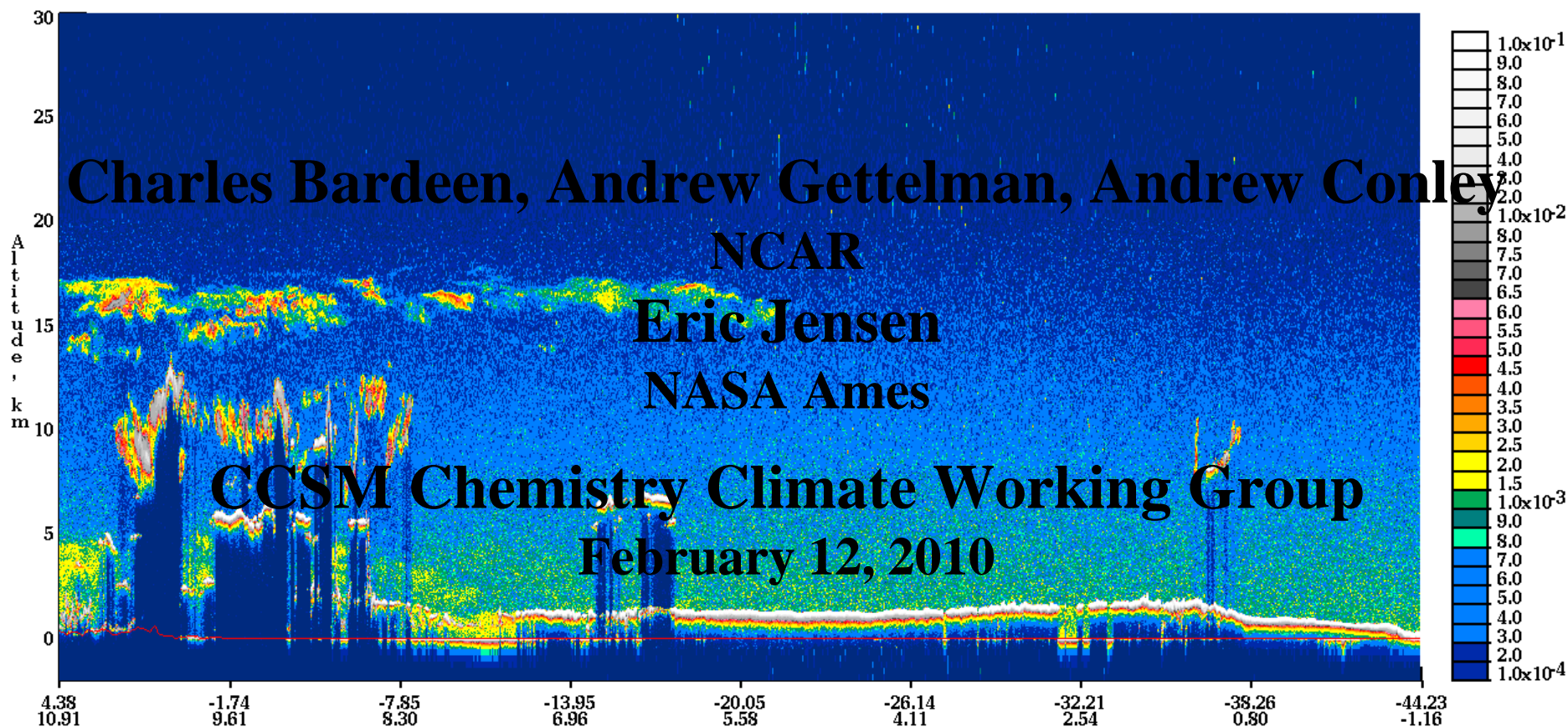
Tropical Tropopause Layer
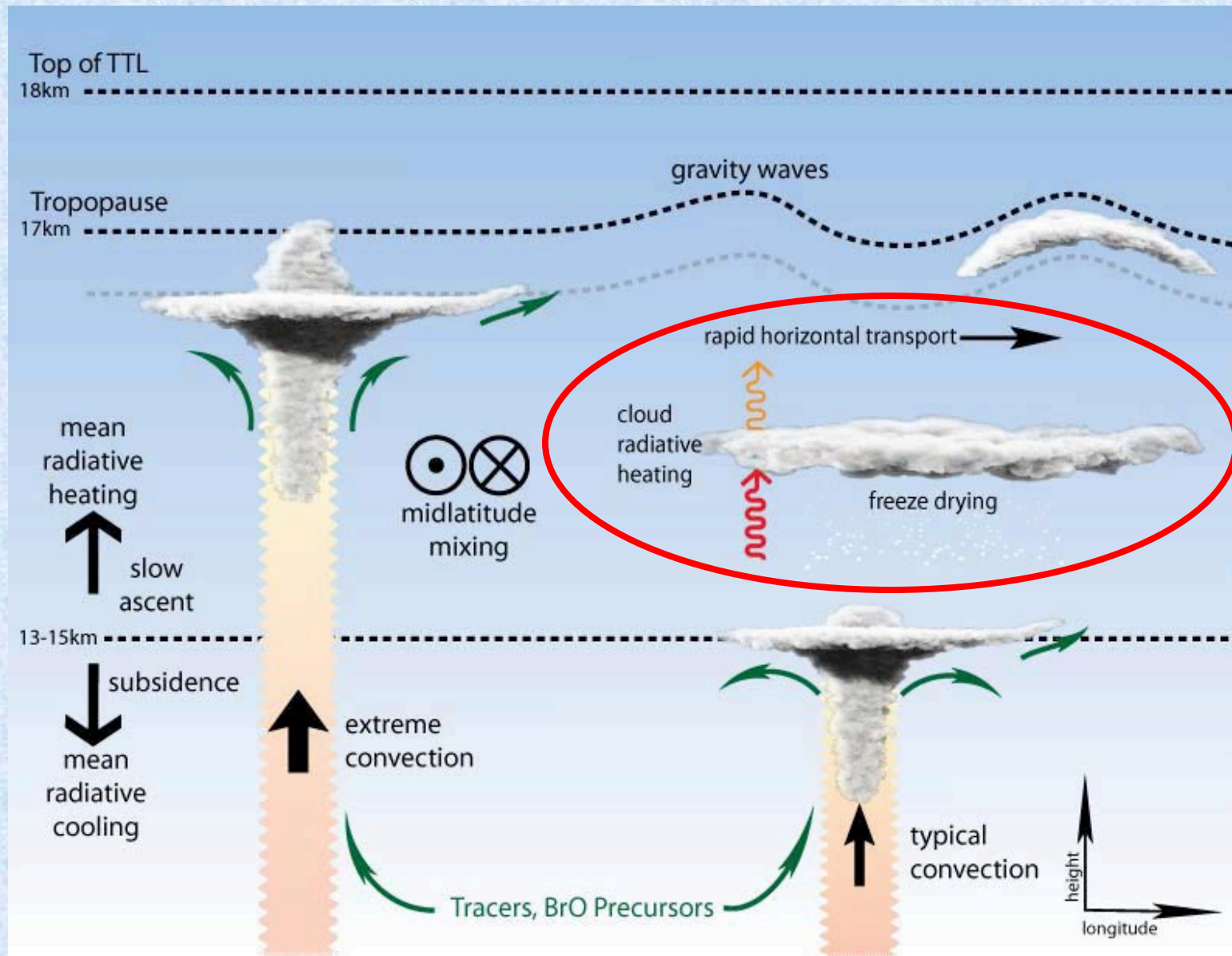
CARMA
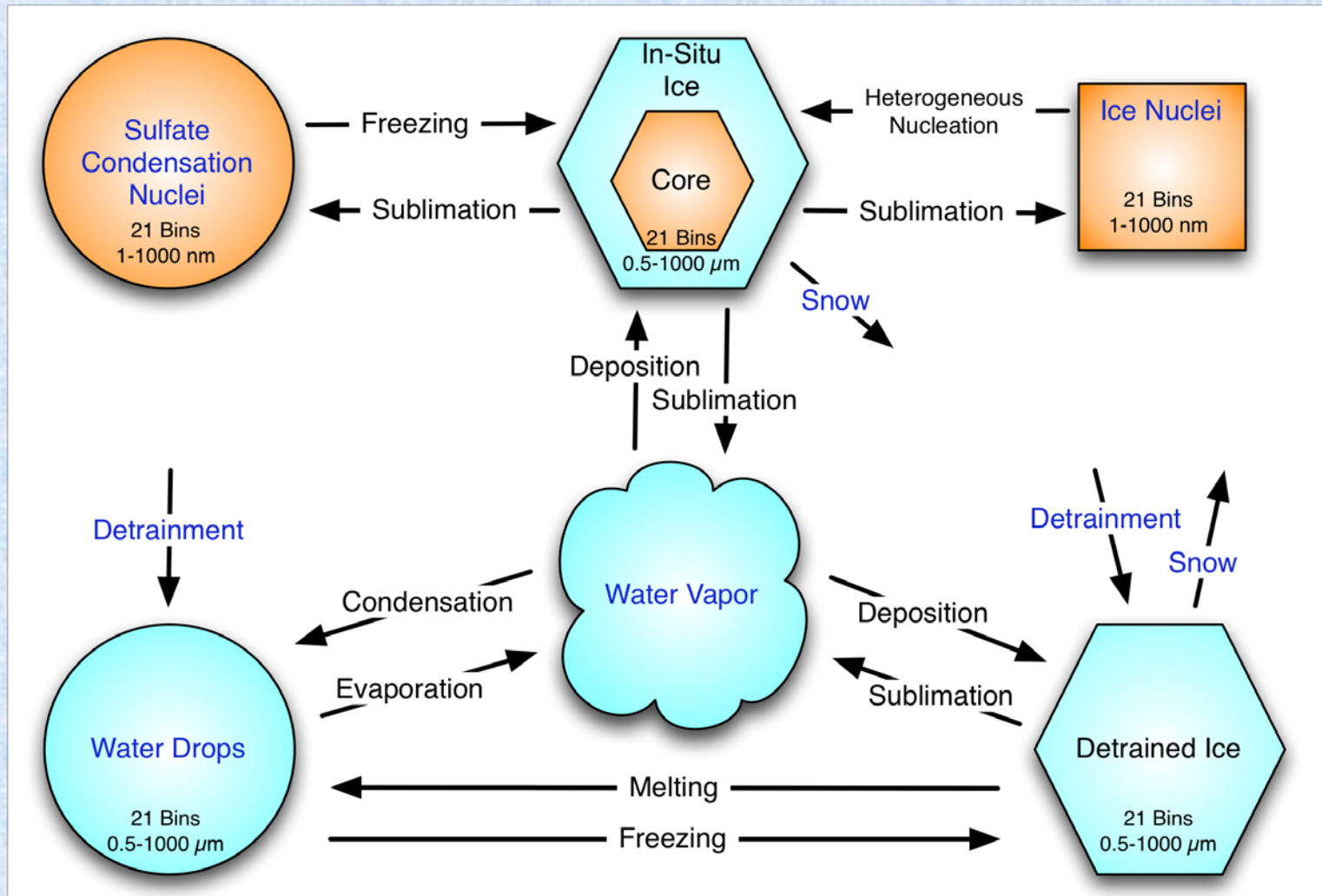
Community Aerosol and Radiation Model for Atmospheres

- *Turco et al.* [1979], *Toon et al.* [1988], Jacobson et al. [1994], …
- Sectional (Bin) Microphysics
- Flexible and Extensible
  – Sedimentation
  – Coagulation
  – Nucleation
  – Growth & Evaporation
  – Brownian Diffusion
  – Wet & Dry Deposition
  – Particle Swelling
  – Optical Properties (Mie)

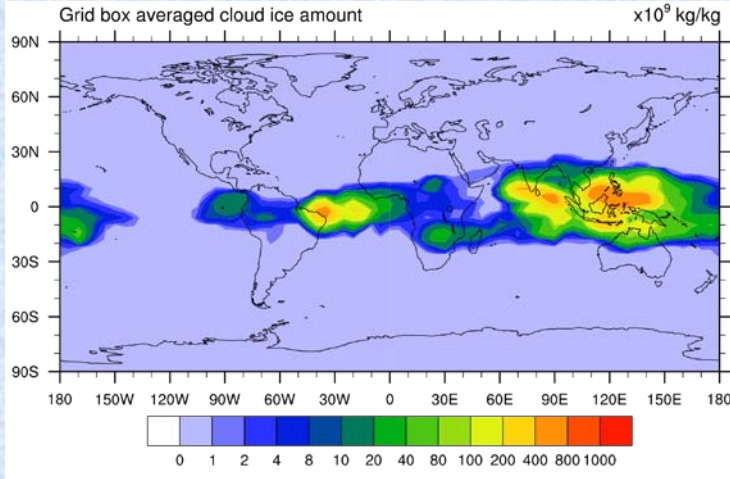# CAM5/CARMA
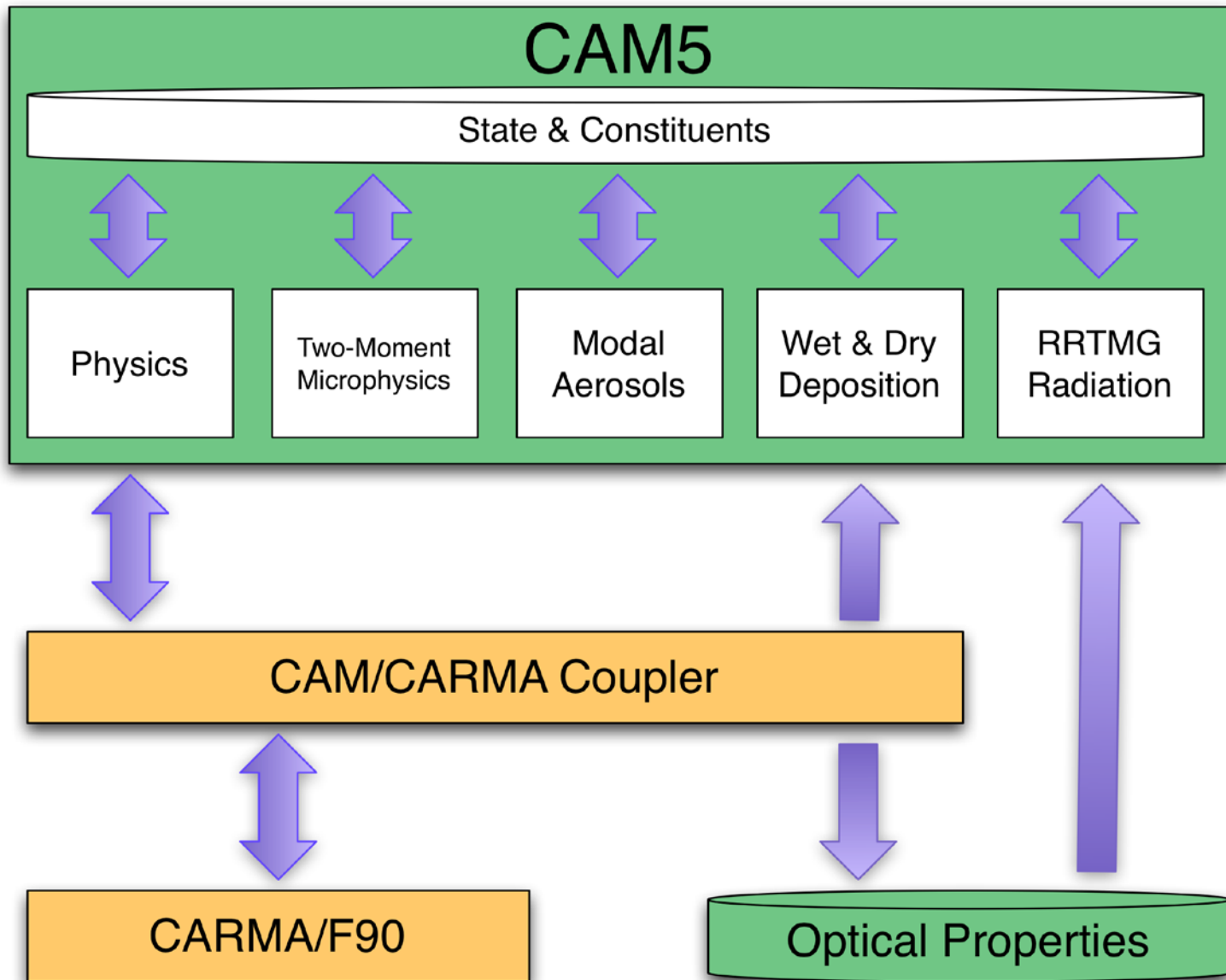
CAM5/CARMA
Cirrus Microphysical Model

Model Setup

- **CAM (3_6_56)**
  - Morrison-Gettelman (MG) Microphysics
  - RRTMG Radiation Code
  - Prognostic Aerosols (trop-bam)
  - Not Using UW Boundary Layer Scheme
  - Use Murphy & Koop [2005] for Vapor Pressures
  - 49 Vertical Levels, ~350m Near Tropopause

- **CARMA/F90**
  - Based Upon CARMA 2.3
  - Rewritten in Fortran 90
  - Thread Safe
  - Improved Substepping
  - Prescribed Sulfates
  - No Heterogeneous Nucleation
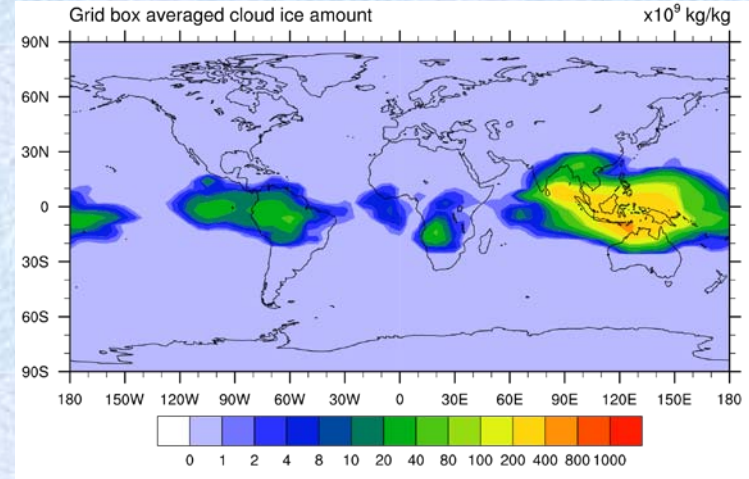 - Detrain Ice Using Aged Anvil Size Distribution (TC[4])

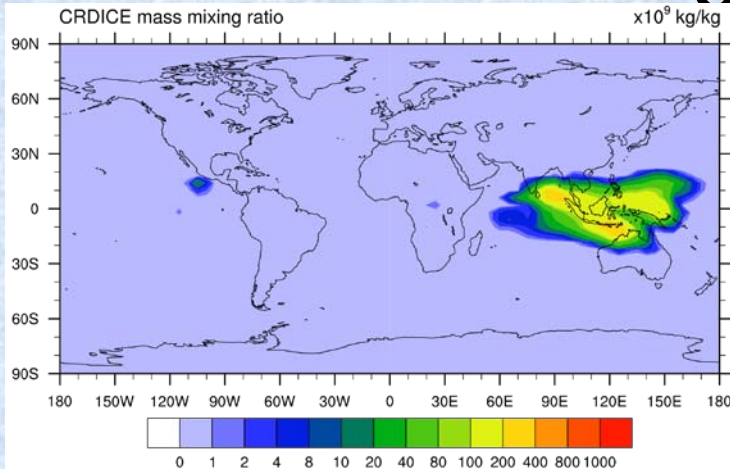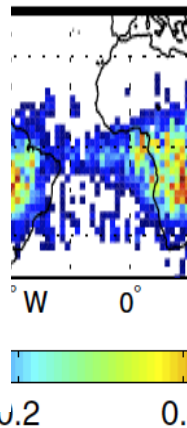# Results, 4˚x5˚, DJF
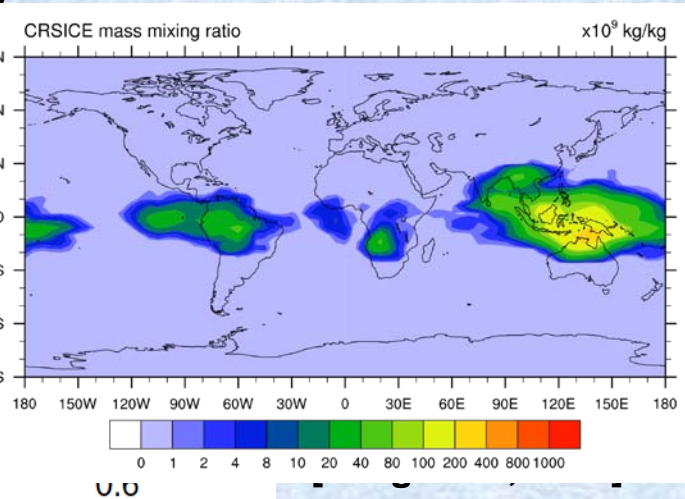## Cloud Ice/Frequency, ~100 mb
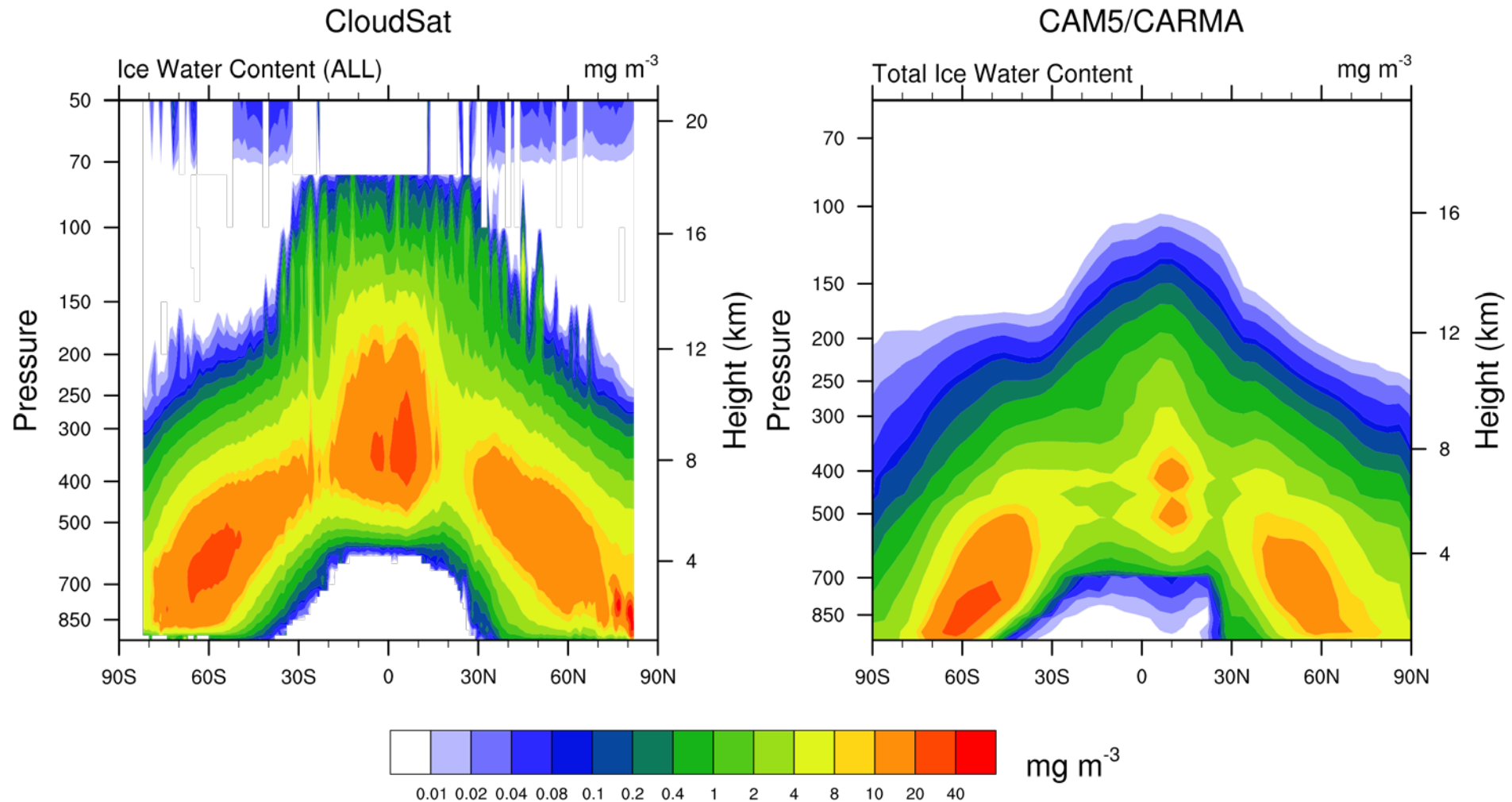
CAM5

CAM5/CARMA

Detrained Ice

<u>CALIPSO</u>

In-Situ Ice

Results, 4˚x5˚, Annual Average
Ice Water Content

Results, 4˚x5˚, DJF
Temperature

COSMIC
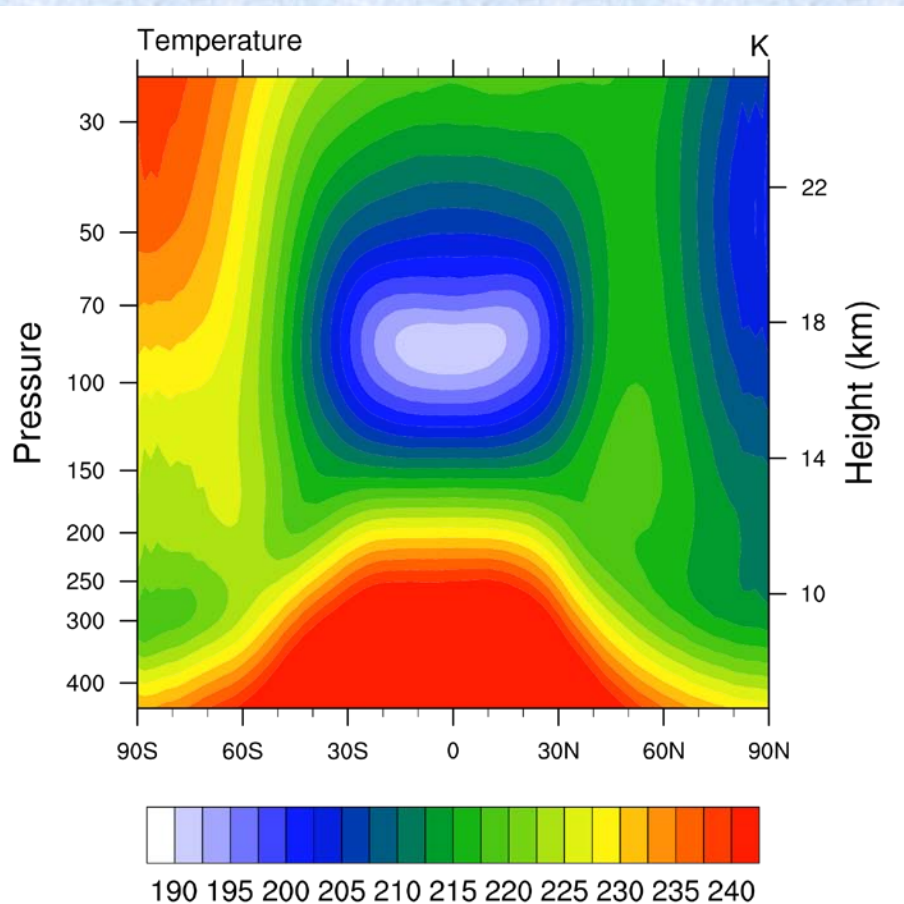
CAM5/CARMA
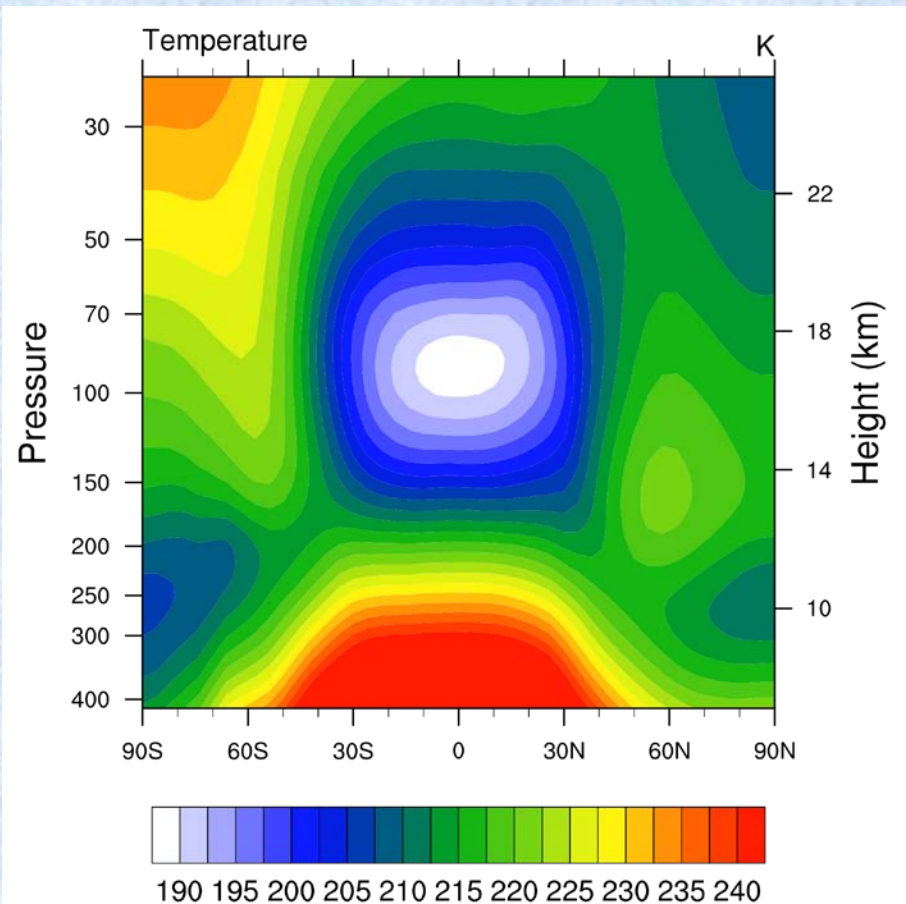
Sensitivity Tests, 10˚x15˚, Jan
Convection (Hack & ZM)
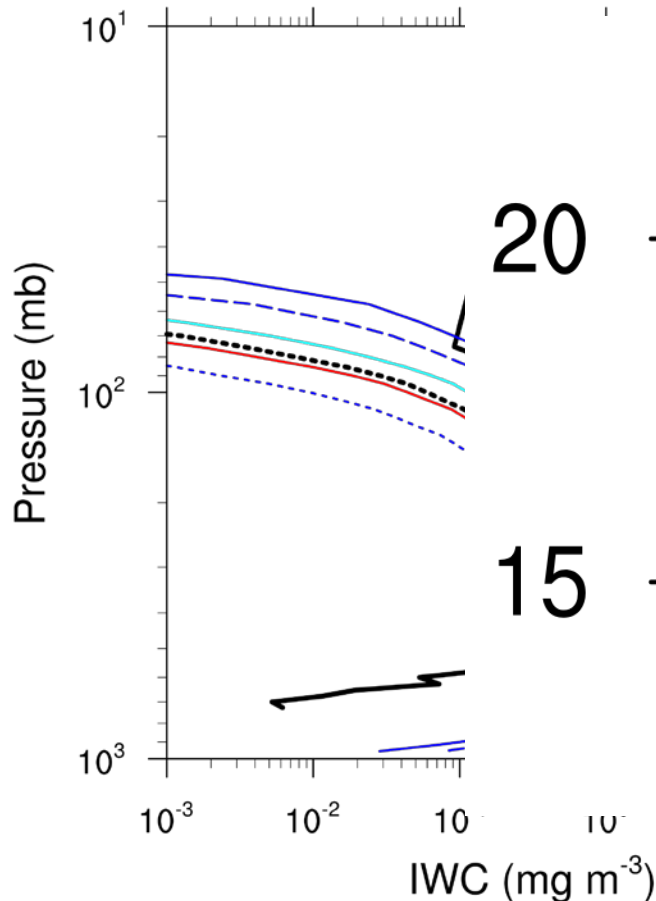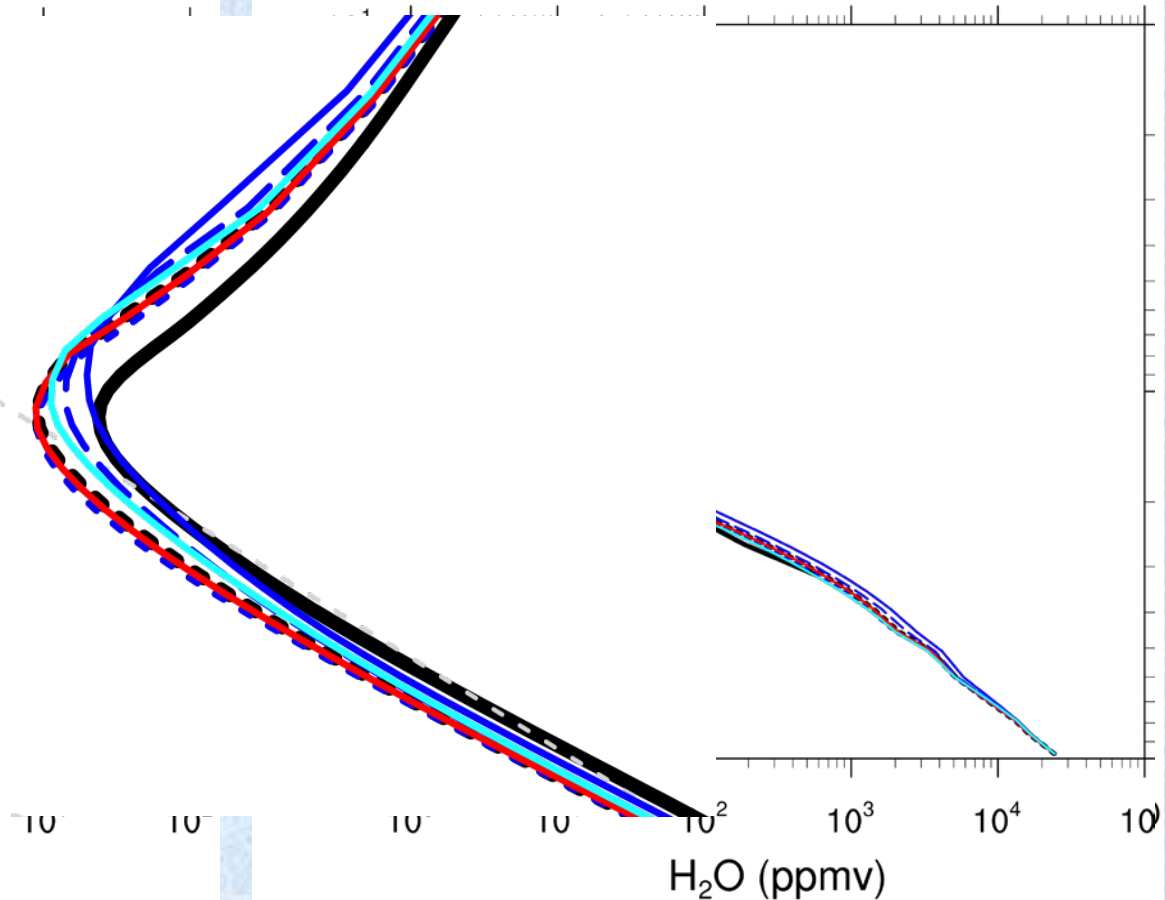
Sensitivity Tests, 10˚x15˚, Jan
Microphysics

CloudSat, Ice Water Content, 20N-20S
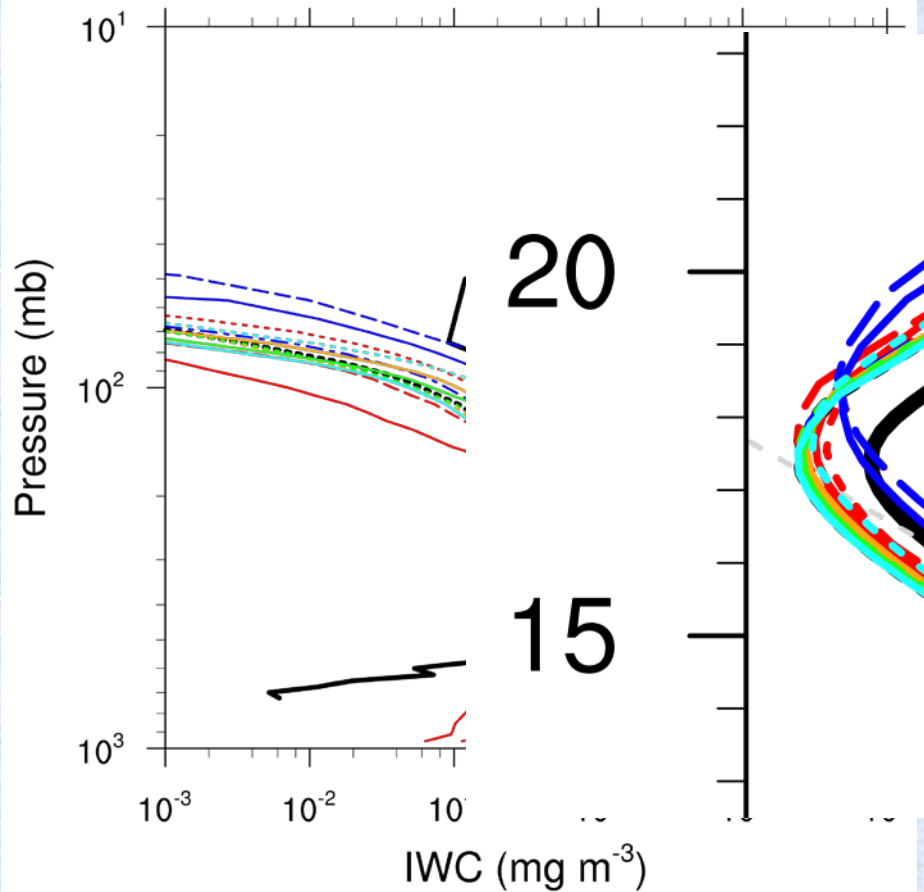
MLS, WaterVapor, 20N-20S

Sensitivity Tests, 10˚x15˚, Jan
Ozone
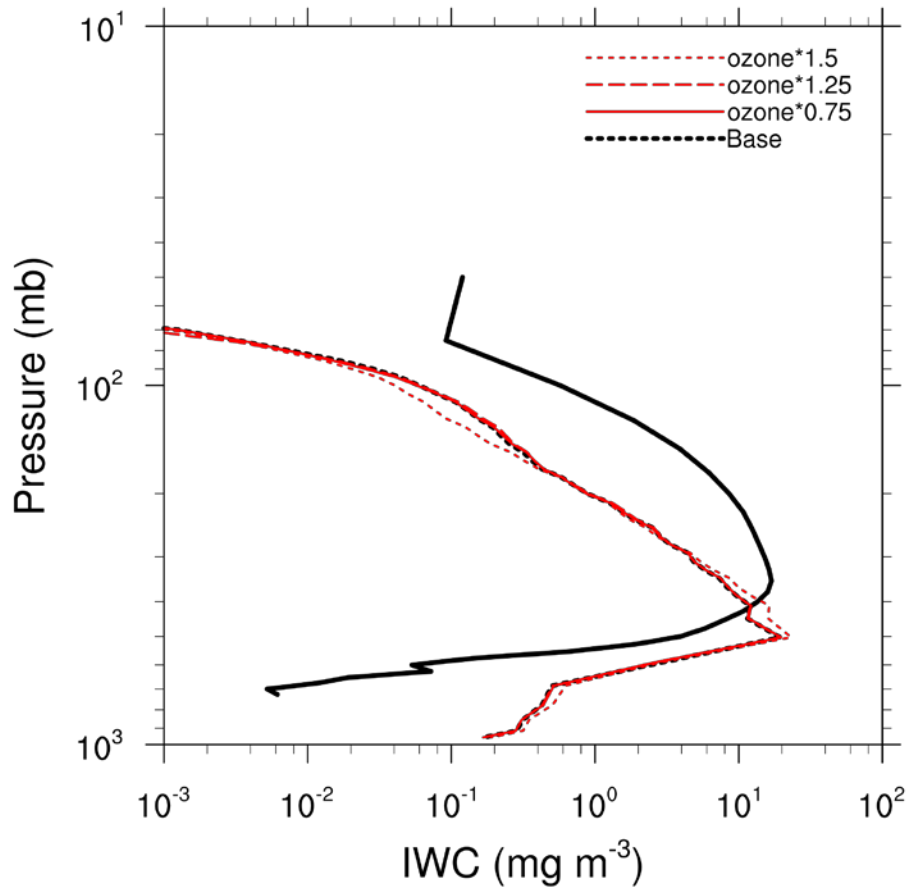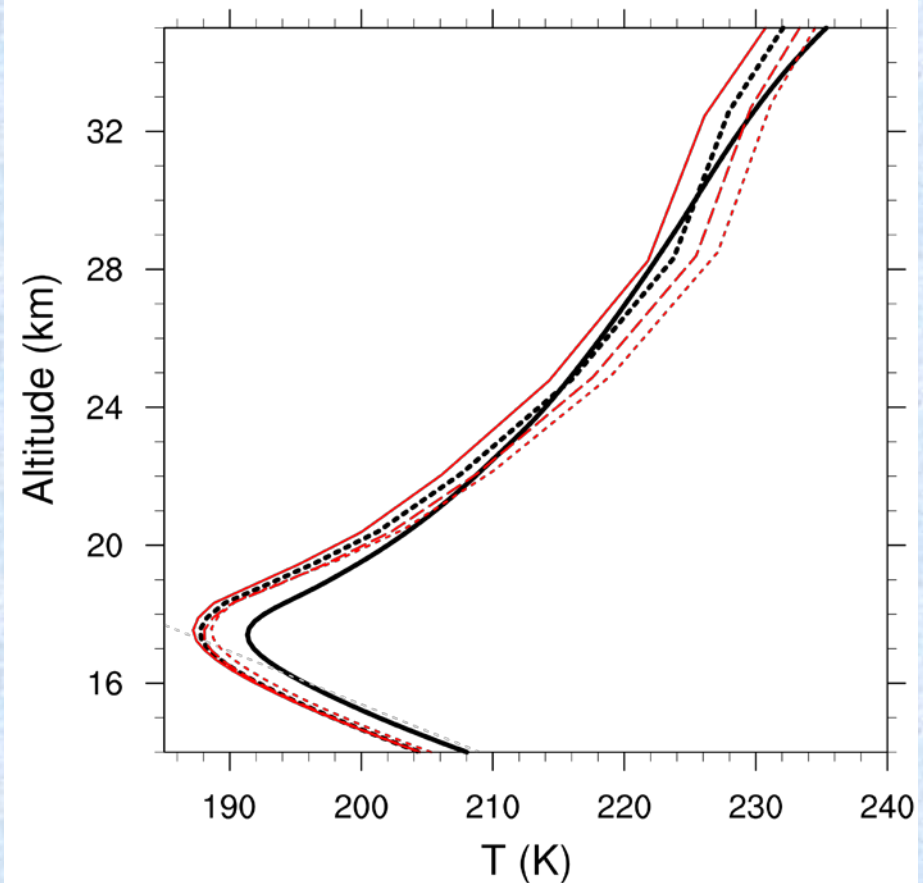
Summary

- **CAM5/CARMA**
  - Improved Fortran 90 version of CARMA
  - Integrated With Radiation Code (RRTMG)
  - Planned to be Future CAM (WACCM) Optional Component
- **TTL Cirrus Simulations**
  - Replaced MG with CARMA for Ice Microphysics
  - Improved Ice Spatial Pattern
  - Low Ice Mass? (Similar to MG)
  - Tropopause Too Cold and Broad
- **Sensitivities**
  - Detrainment Radius?
  - Stratiform Ice & Cloud Drop Fall Velocities?
  - Convective Rain Autoconversion Rate (c0)?
  - Convective Rain Evaporation Efficiency (ke)?
  - Prescribed Ozone?

CARMA Projects

- **CAM/CARMA**
  - TTL Cirrus (Bardeen)
  - Dust (Su)
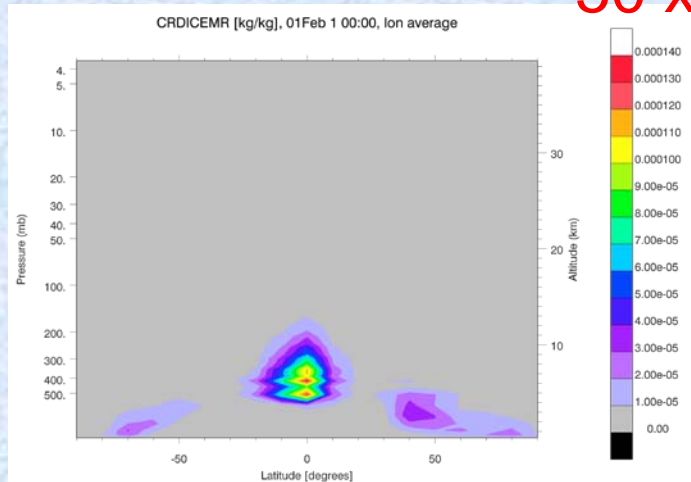 - Sea Salt (Fan)
  - Smoke (Smith)

- **WACCM/CARMA**
  - Meteoric Smoke Particles (Bardeen)
  - Stratospheric Soot Particles (Mills)
  - Polar Mesospheric Clouds (Bardeen, Mills, Benze)
  - Sulfate Aerosols (Mills, English)
  - Early Earth Haze (Wolf)
  - Polar Stratospheric Clouds (Zhu)
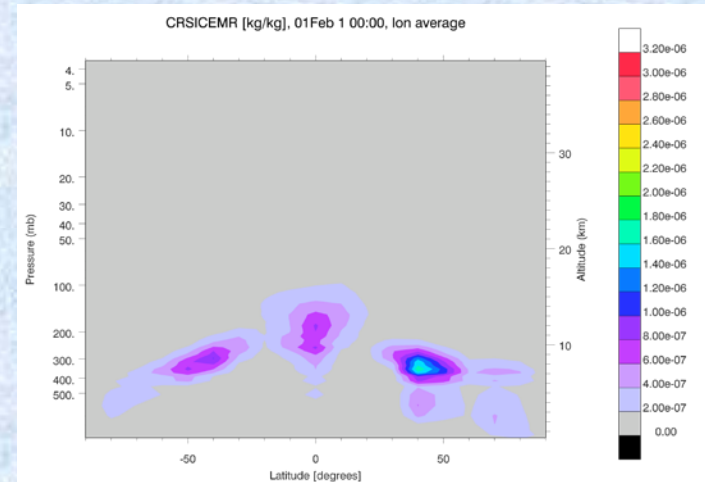 - Meteor Impact (Bardeen, Mills)

Sensitivity Tests, 10˚x15˚, Jan
Detrainment Radius

Detrained Ice 50 x

In-Situ Ice

r=25 um

r=100 um