

A world map with a color-coded overlay, likely representing cloud cover or precipitation. The colors range from dark blue (low values) to yellow and red (high values). The map shows higher values in the tropical regions, particularly in the Amazon basin, the Congo basin, and parts of the tropical Pacific and Indian Oceans. The text is overlaid on the map.

# Cirrus Simulations Using Sectional Microphysics (CAM/CARMA)

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February 1, 2012

# CAM/CARMA Cirrus Model

## Particle Types

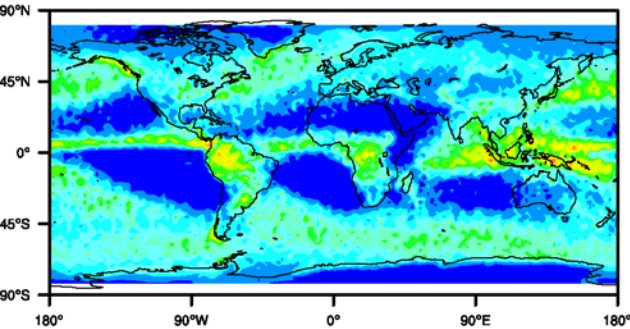
- Ice : CARMA sectional (bin) microphysics for ice
  - In Situ : hexagonal plates, AR=3, bulk density
  - Detrained : sphere, variable density & projected area (Heymsfield et al., 2010; Schmitt & Heymsfield, 2010)
- Liquid : Morrison-Gettelman two-moment microphysics
- Sulfates : Prescribed from CARMA sulfate model (English et al. 2011)

## Processes

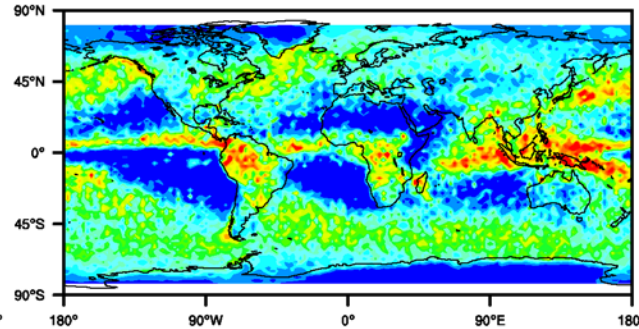
- Prognostic snow (No ice to snow autoconversion)
- Subgrid ice cloud fraction and water saturation (Wilson & Ballard, 1999)
- Ice Detrainment : T sensitive size distribution (Heymsfield et al., 2010)
- Ice Fall Velocity : Heymsfield & Westbrook, 2010
- Ice Nucleation : homogeneous freezing (Koop et al., 2000)
- Reduced Eddy Diffusion : maximum dissipation length = 100 m

# Ice Water Path

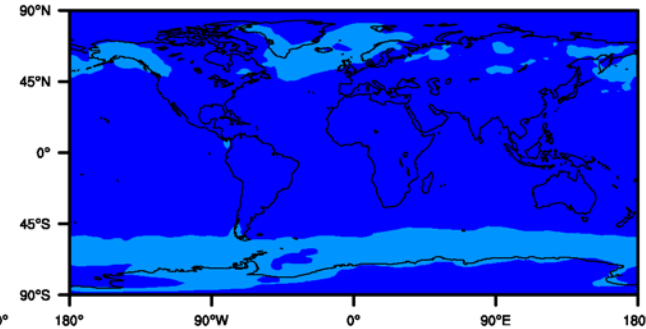
**DARDAR, (85.7, 82.2, 0.959)**



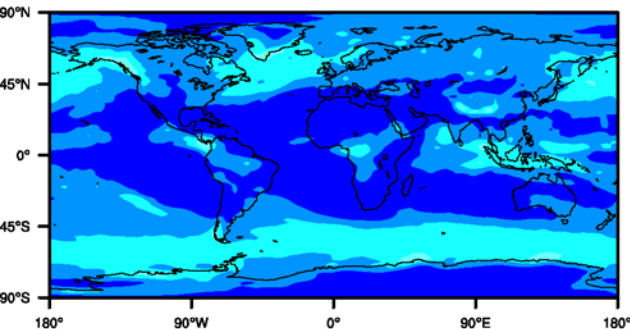
**2C-ICE, (124.9, 126.6, 1.014)**



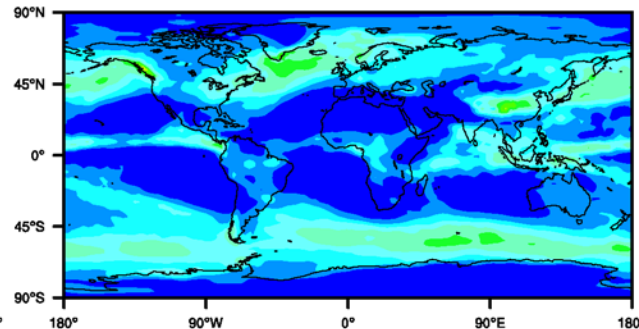
**CAM4, No Snow (16.2, 9.2, 0.566)**



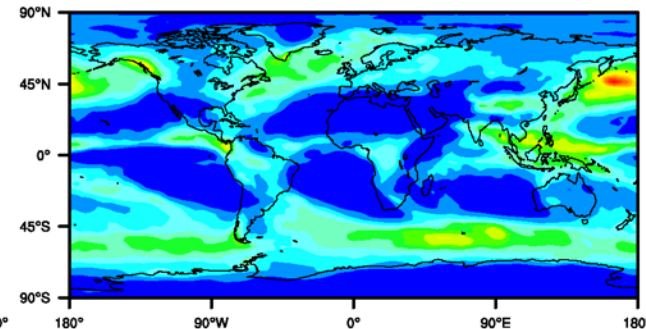
**CAM4 (37.0, 25.9, 0.698)**



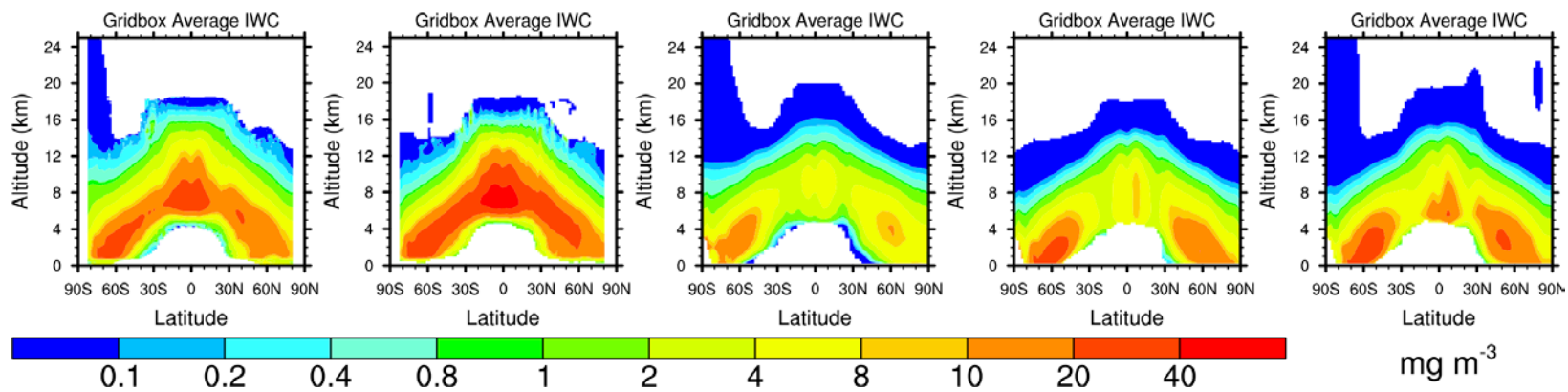
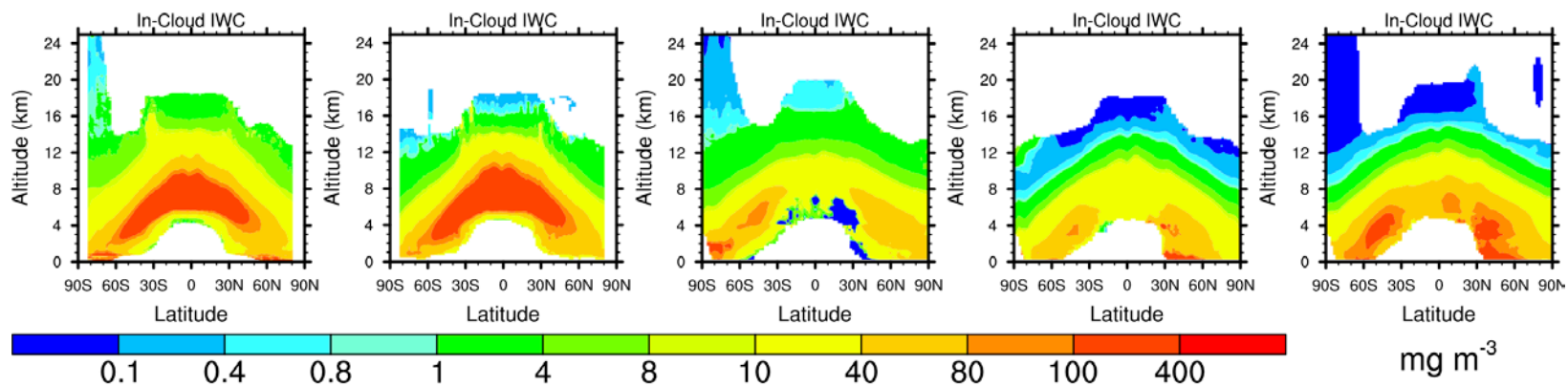
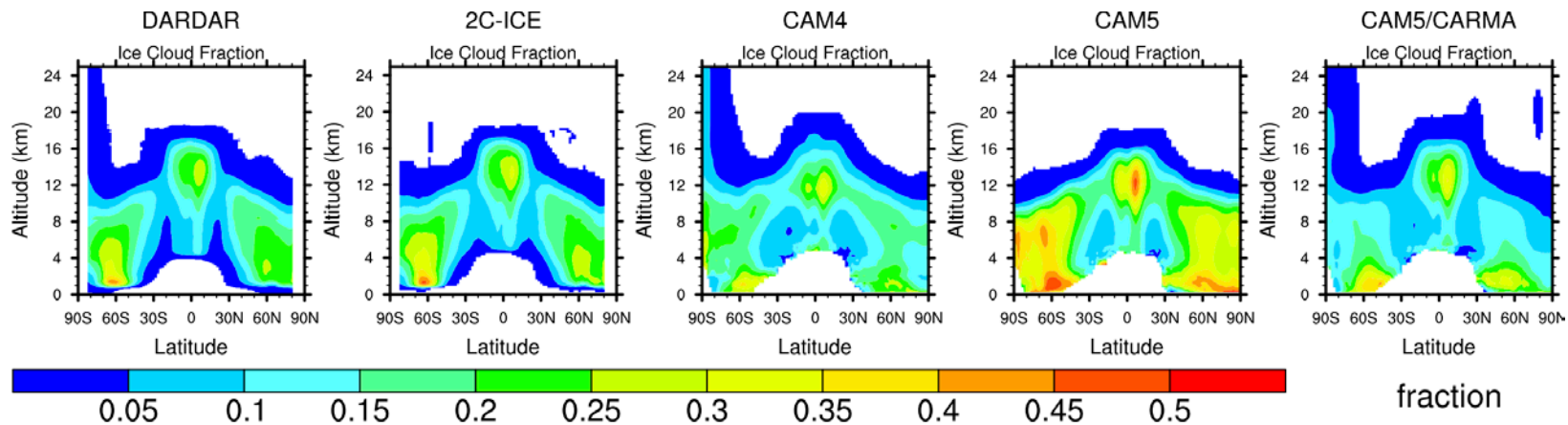
**CAM5 (55.6, 37.6, 0.676)**



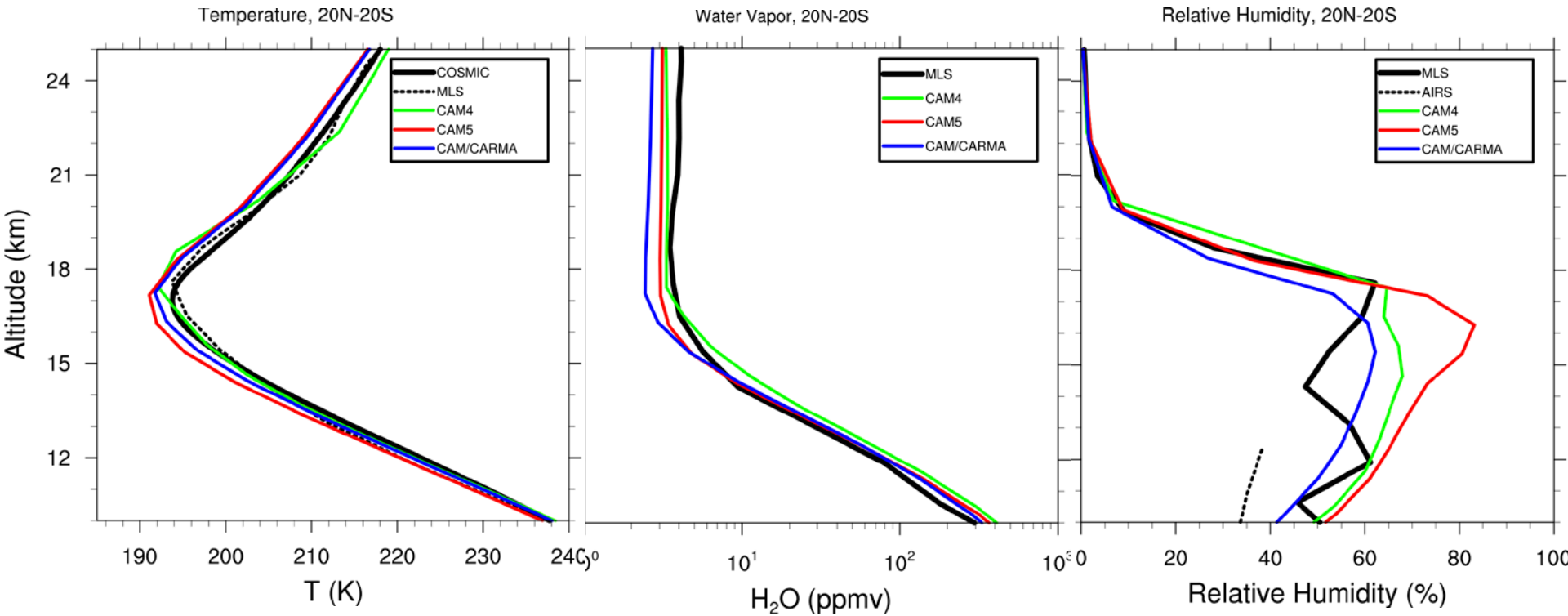
**CAM5/CARMA (71.2, 54.2, 0.761)**



$\text{g m}^{-2}$



# Tropical Averages, 20N-20S

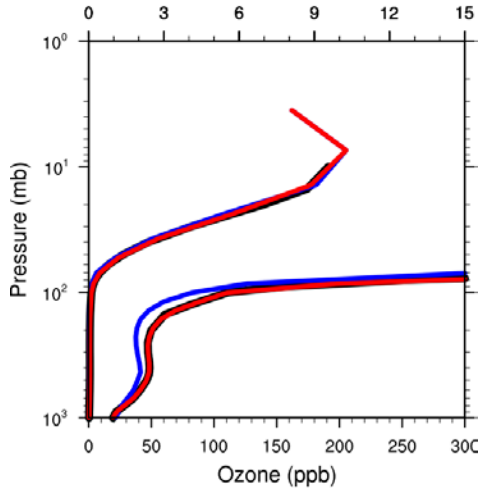


# Prescribed Ozone

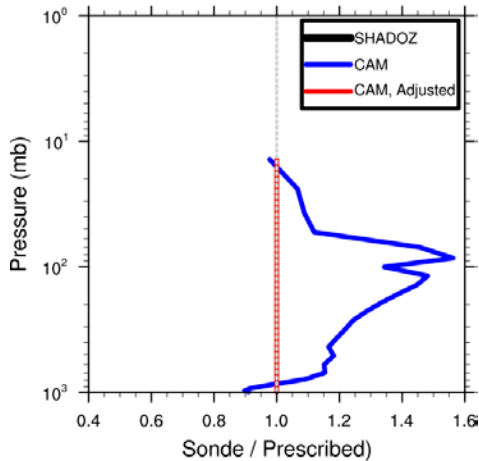
## SHADOZ Ozone

Average : -21.06 - 19.4

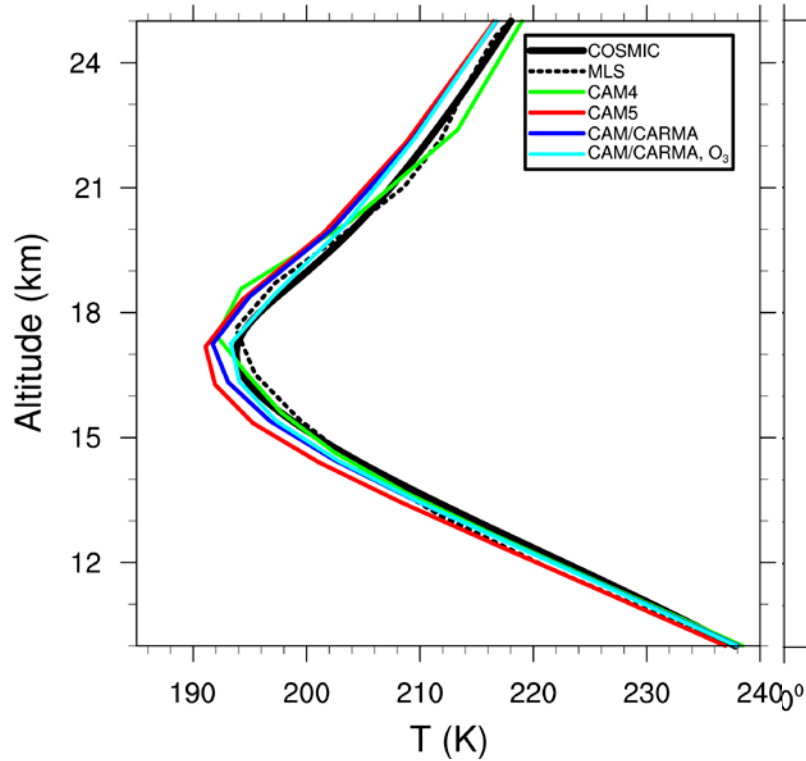
Ozone (ppm)



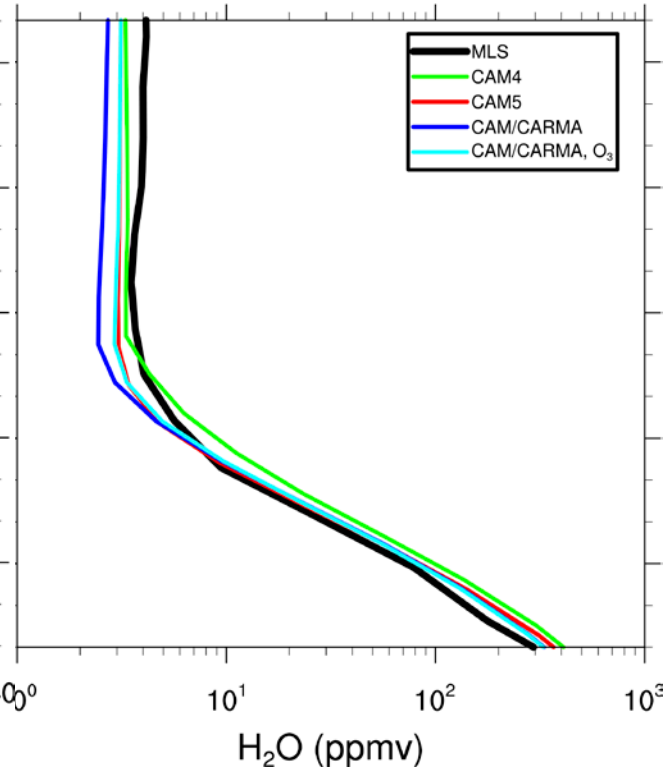
Sonde / Prescribed



Temperature, 20N-20S

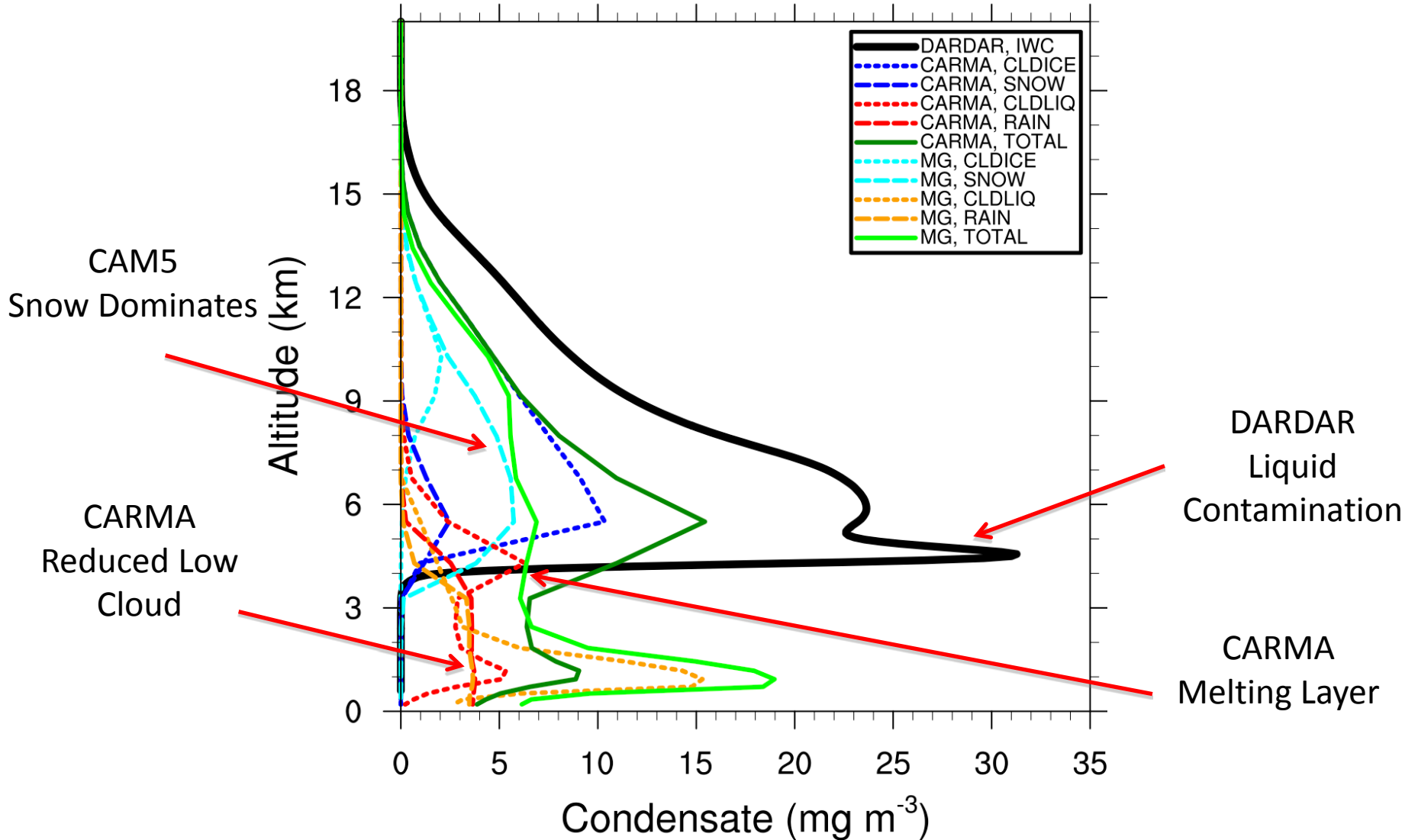


Water Vapor, 20N-20S



# Melting Layer

Gridbox Average Condensate, 20N-20S

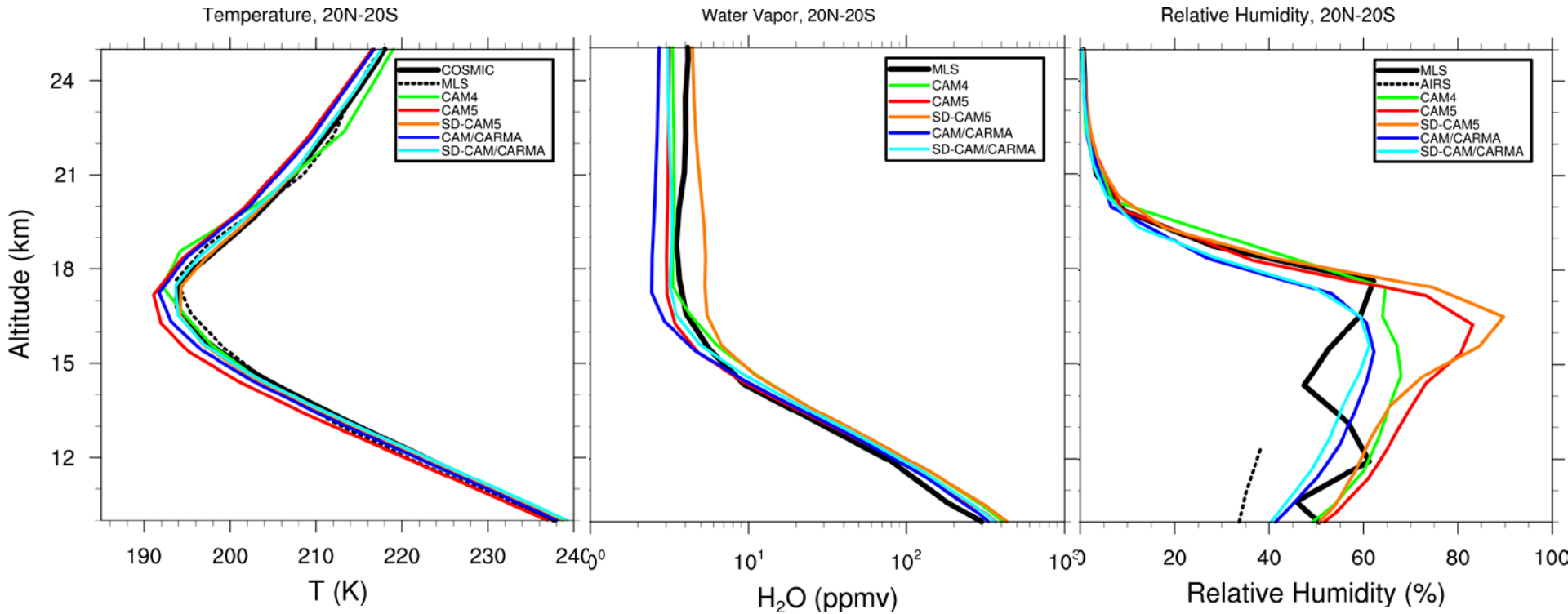


# Specified Dynamics : SD-CAM

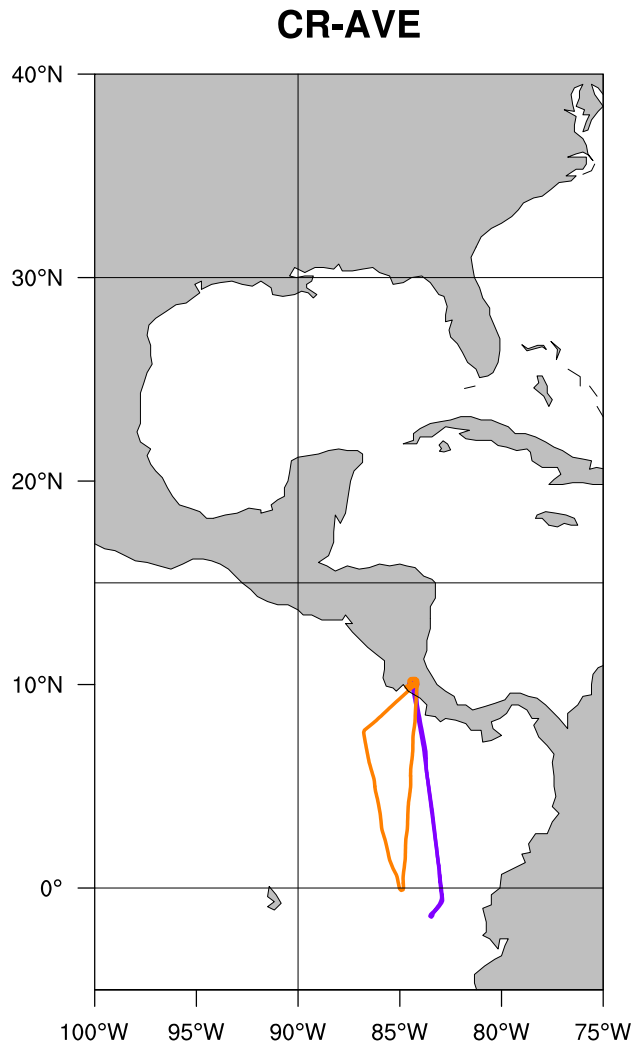
- Similar to SD-WACCM (Vitt, Kinnison, ...)
  - 1.9°x2.5° Horizontal Resolution
  - GEOS-5 Meteorological Data
  - Fields : T, U, V, PS, QFLX, SHFLX, TAUX, TAUY
  - 1% Nudging
- 56 Levels (GEOS-5 levels to CAM model top)
  - Nudge all fields, unlike SD-WACCM which forces QFLX, SHFLX, TAUX and TAUY
- Simulations from 2004 – 2007



# Tropical Averages



# Costa Rica – Aura Validation Experiment



- January – February 2006

- 16 WB-57 Flights

- February 01

- February 02



- Simulations

- SD-CAM5, SD-CAM5/CARMA

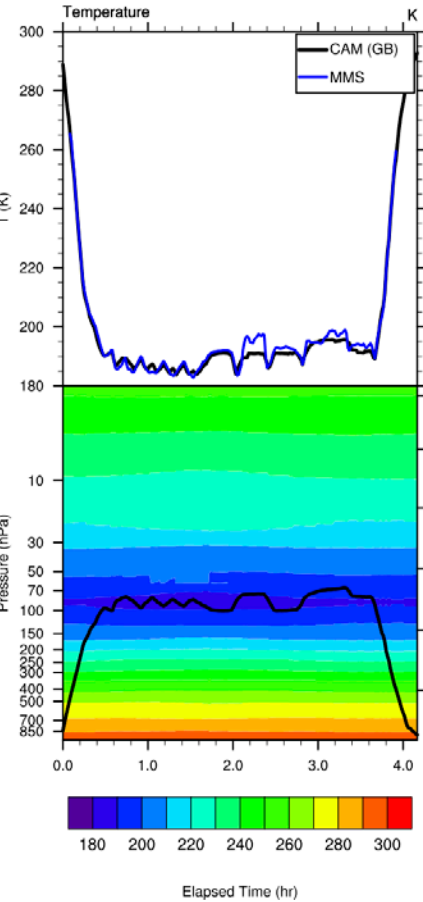
- GEOS-5 Meteorology

- Satellite History

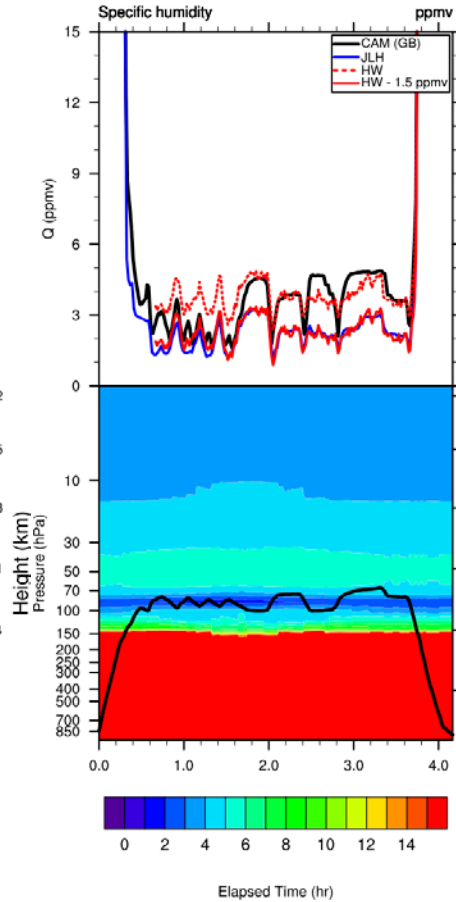
- 4 Nearest Columns

# CAM5, 02 Feb 2006

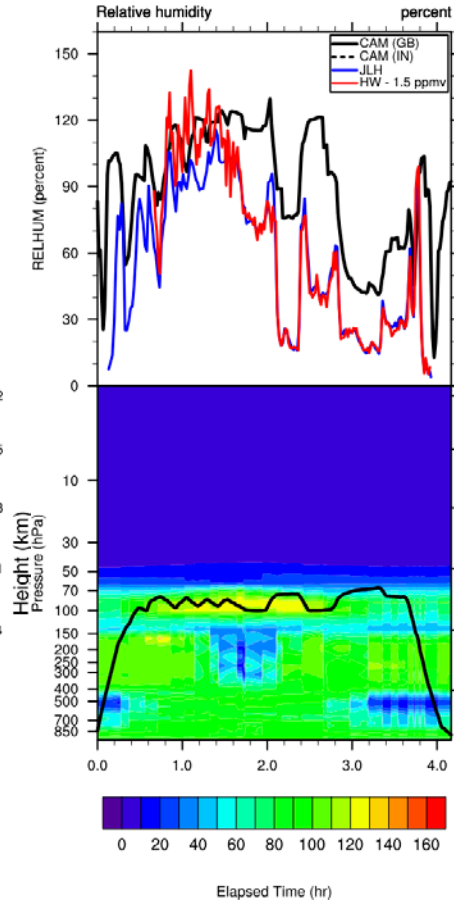
## Temperature



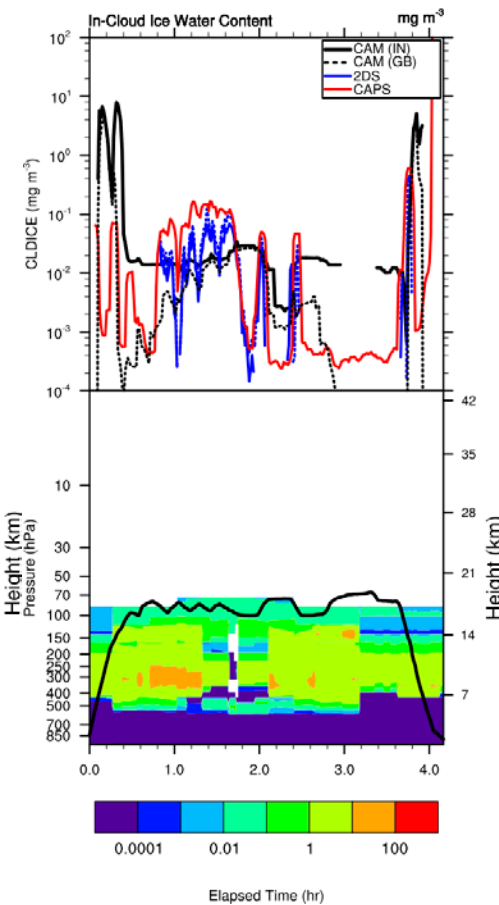
## Specific Humidity



## Relative Humidity

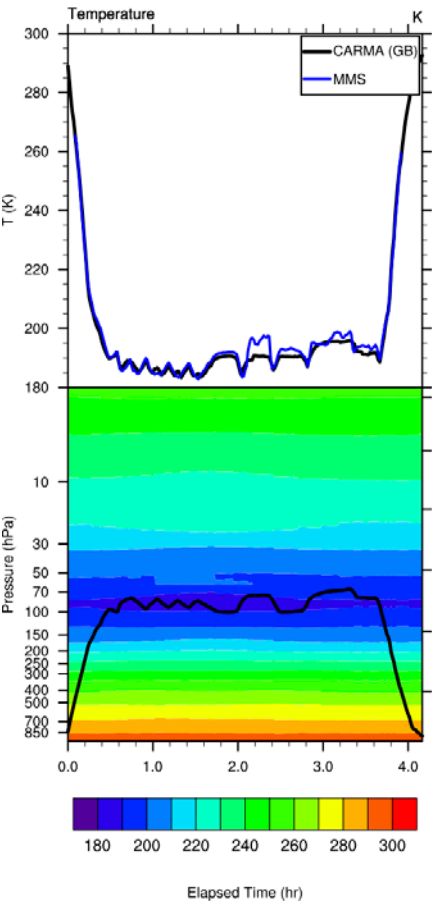


## Ice Water Content

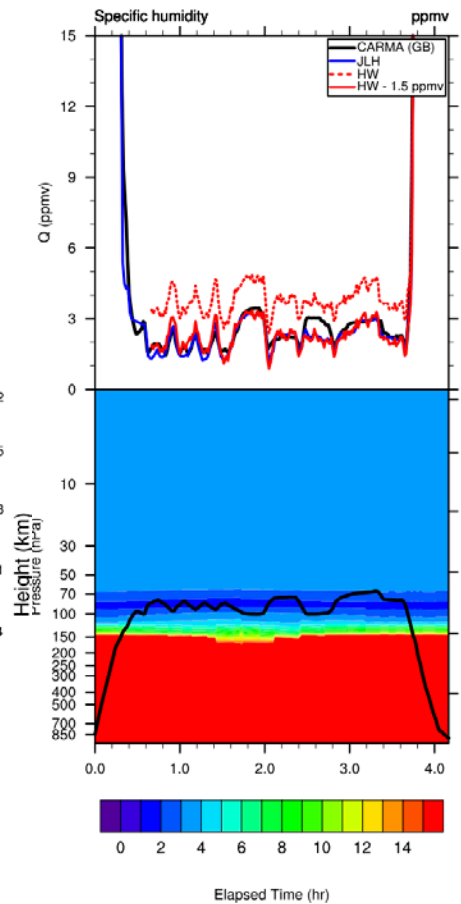


# CAM5/CARMA, 02 Feb 2006

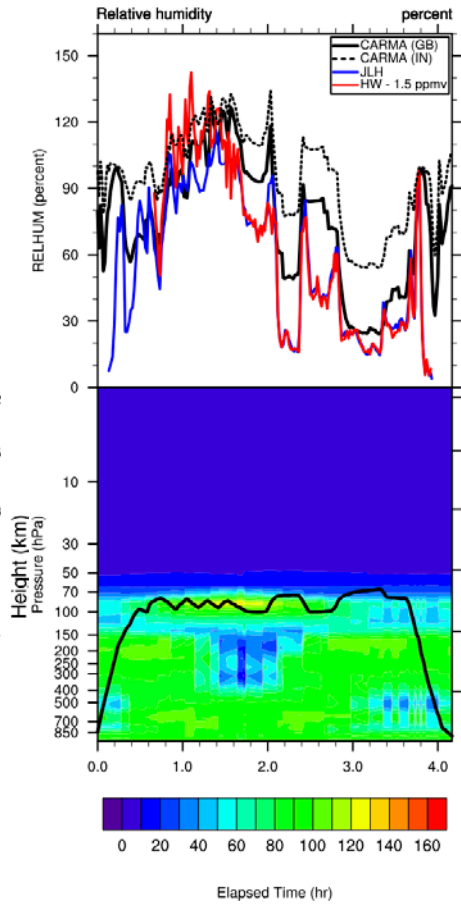
## Temperature



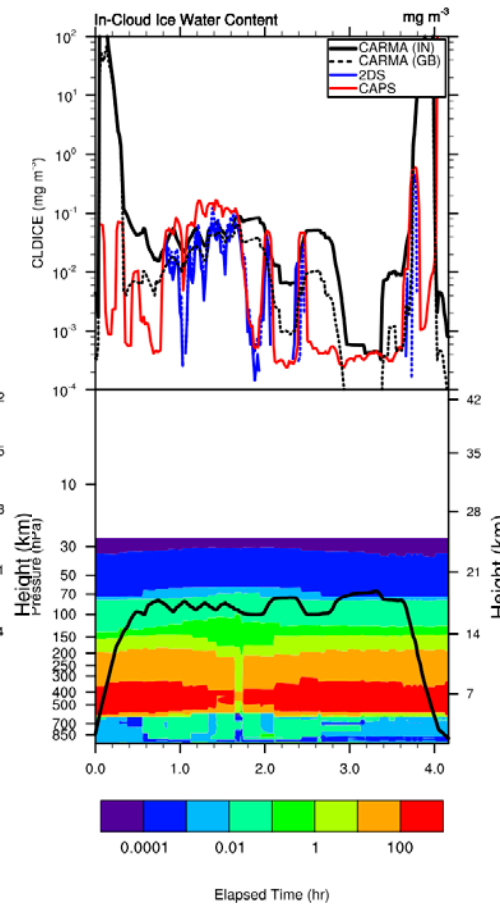
## Specific Humidity



## Relative Humidity



## Ice Water Content



# Cloud Fraction

01 Feb 2006

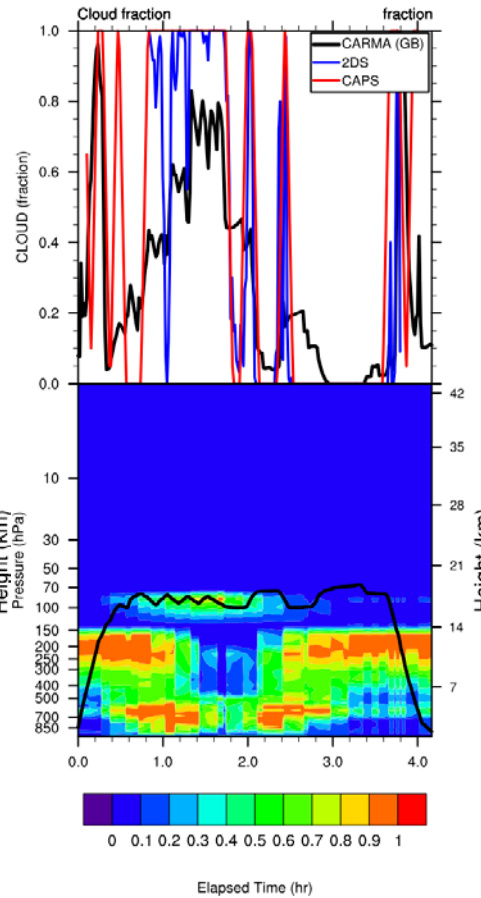
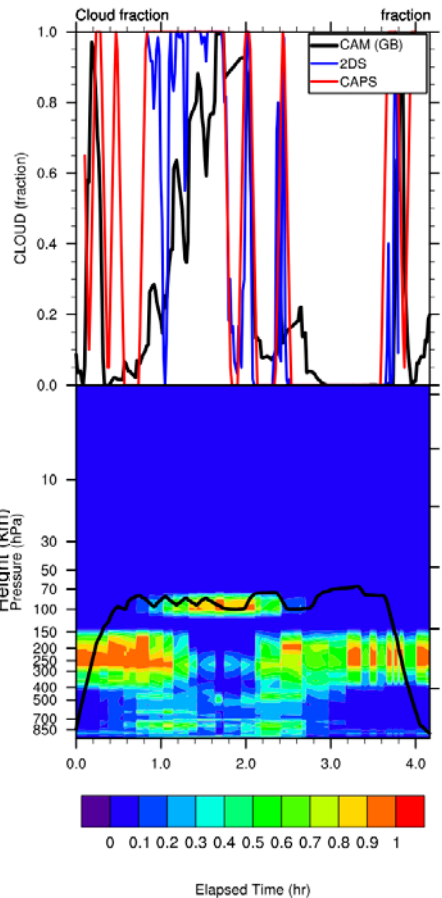
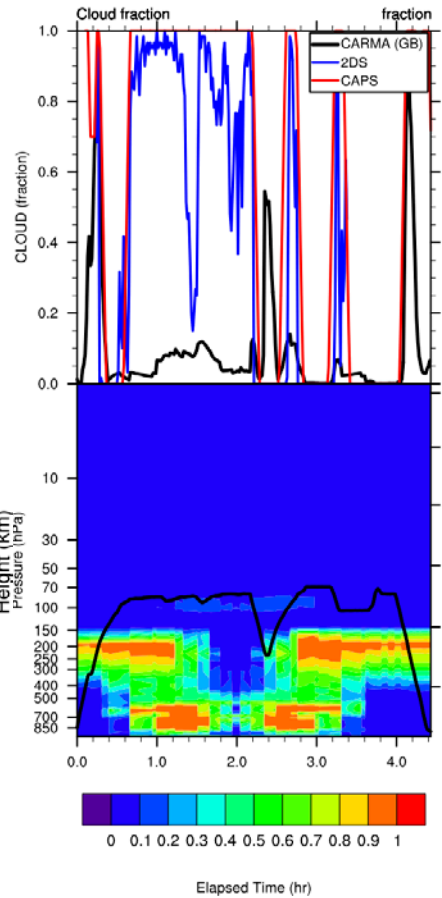
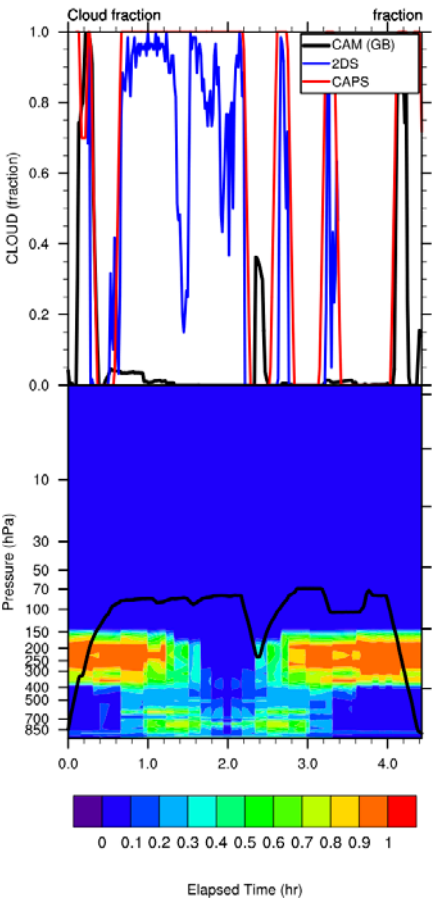
02 Feb 2006

CAM

CAM/CARMA

CAM

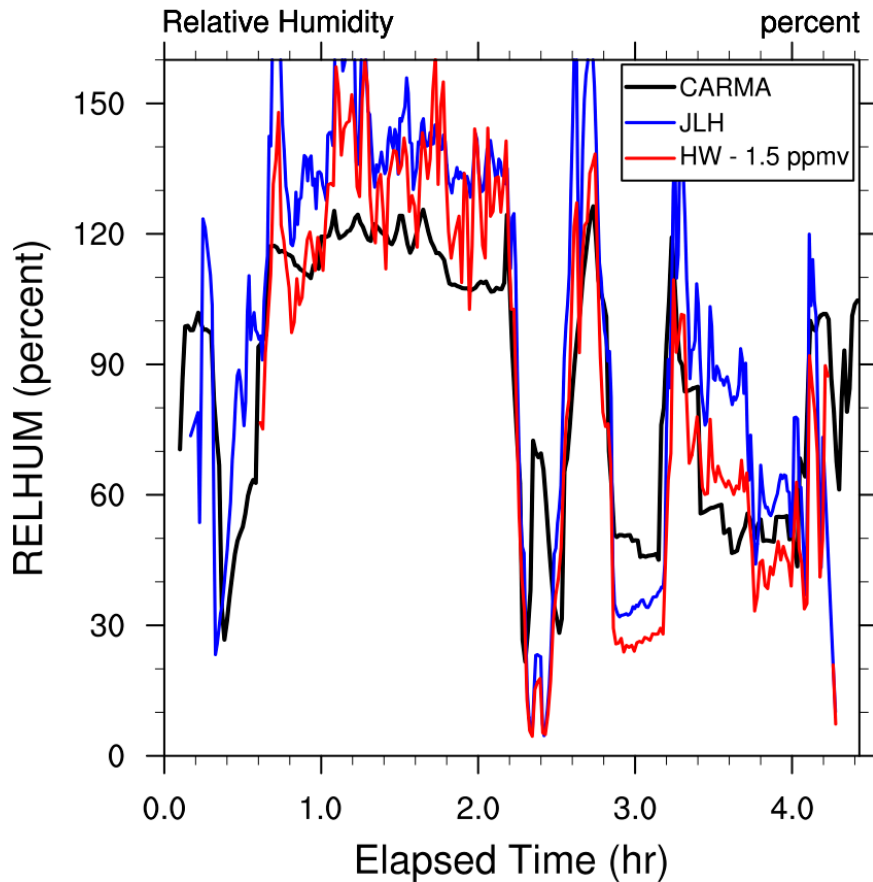
CAM/CARMA



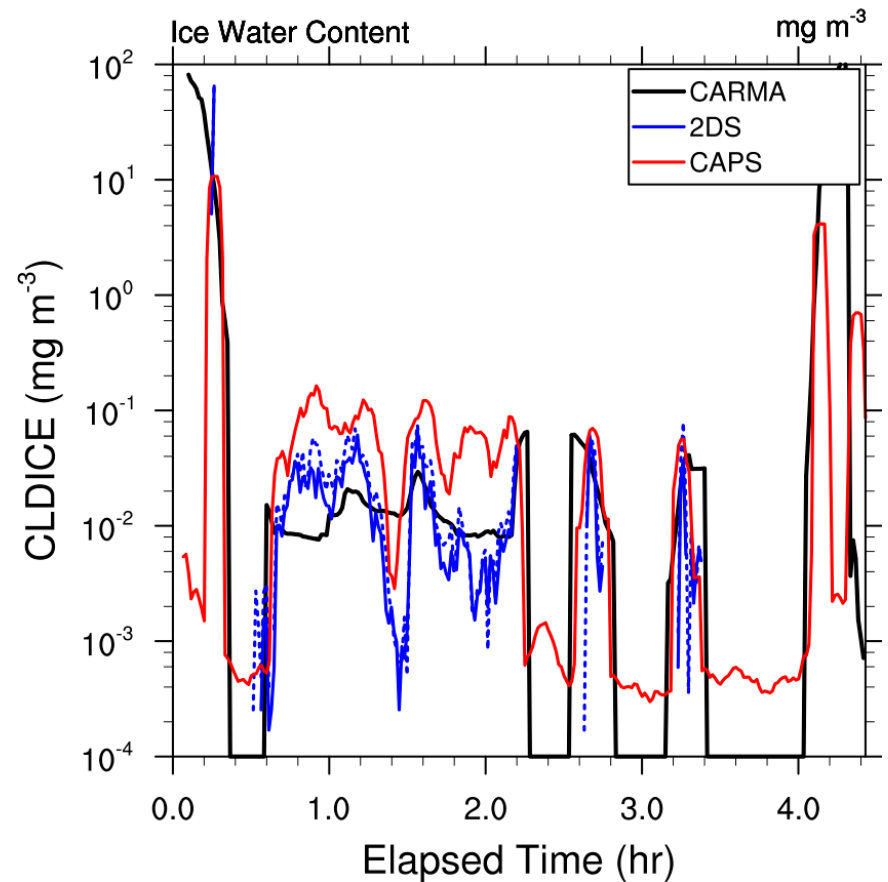
# Sampled By CAPS Cloud Fraction

## CARMA, 01 Feb 2006

CR-AVE, 20060201



CR-AVE, 20060201



# Summary : CAM/CARMA Cirrus

- Prognostic snow
  - Increases ice mass (less removal)
  - Generates melting layer
- Subgrid scale saturation
  - increases ice mass (nucleation and growth)
  - reduces relative humidity
- Prescribed ozone too low near 100 mb?
  - Increases UTLS temperature and water vapor
- CAM5 UT relative humidity too large?
- IWC & IWP improved with CARMA, but still below observations, particularly in tropics
- CARMA requires reduced low clouds for TOA energy balance
- CARMA requires reduced eddy diffusivity

# Summary : Specified Dynamics

- SD-CAM does a good job of recreating CR-AVE aircraft observations
- Subvisible cirrus cloud fraction too small
  - Incorrect radiative transfer
  - Incorrect microphysics
- CAM5 UTLS relative humidity too large





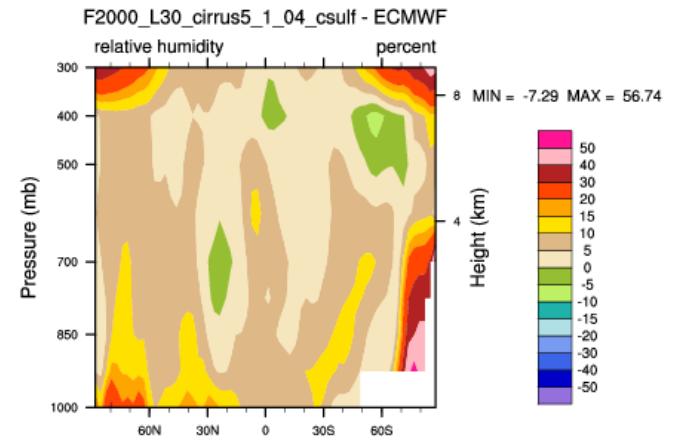
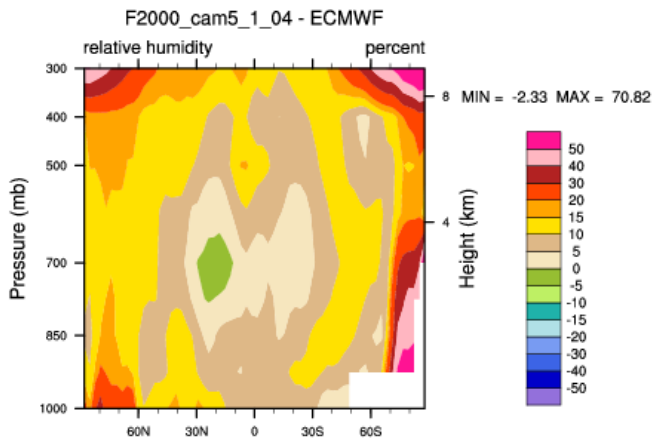
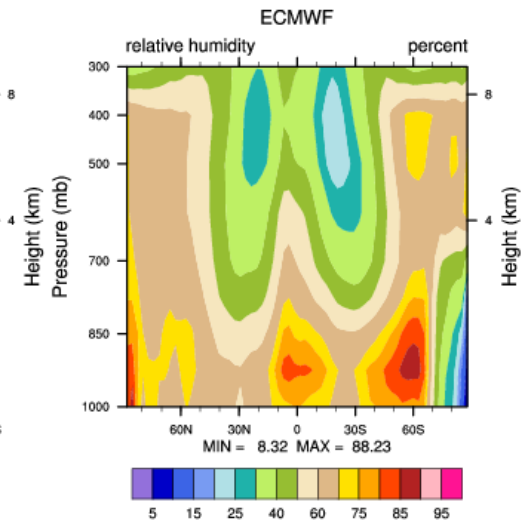
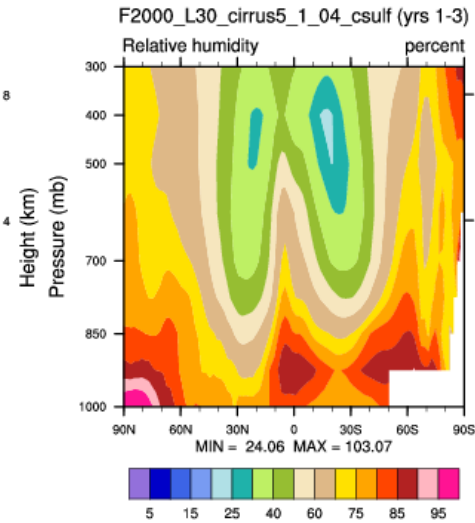
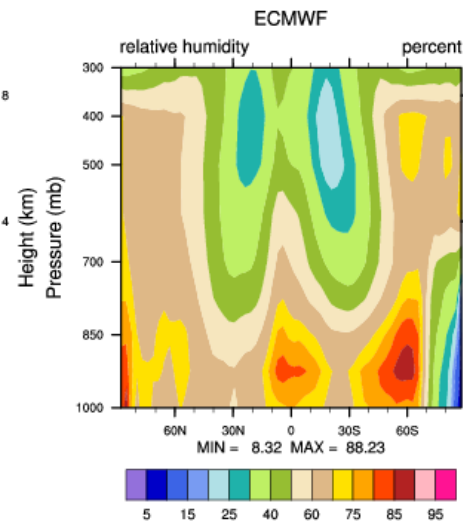
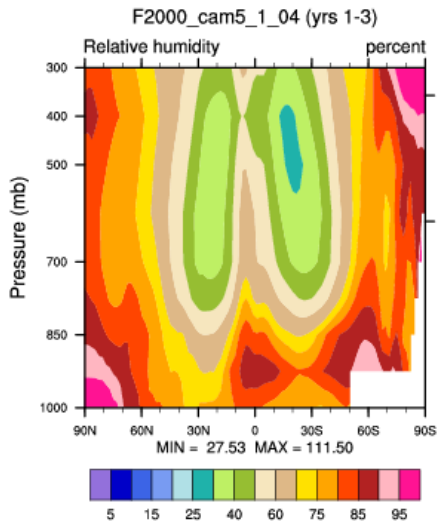
# Relative Humidity

CAM5

CAM5/CARMA

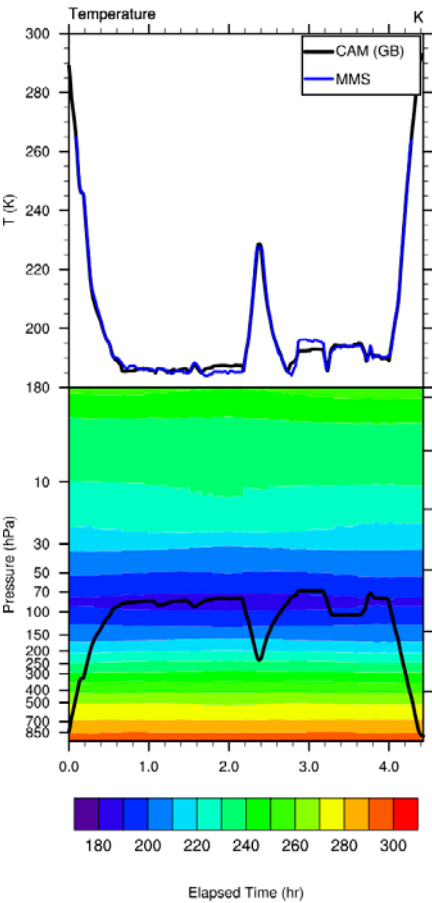
ANN

ANN

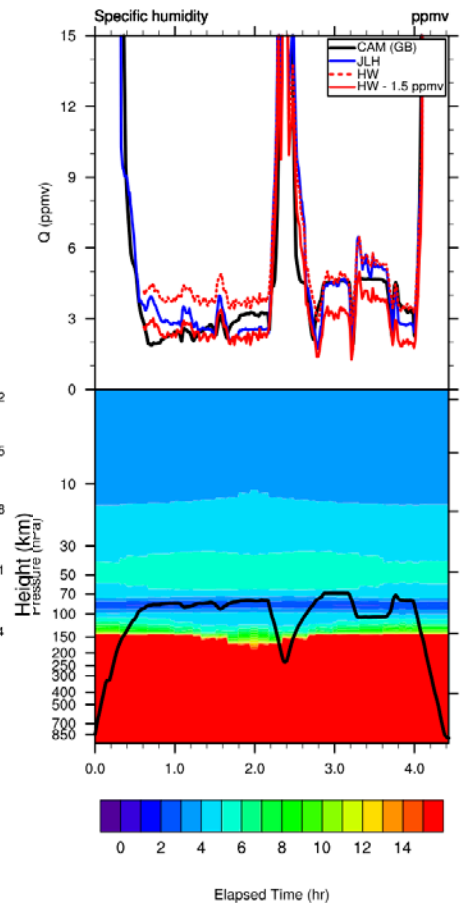


# CAM5, 01 Feb 2006

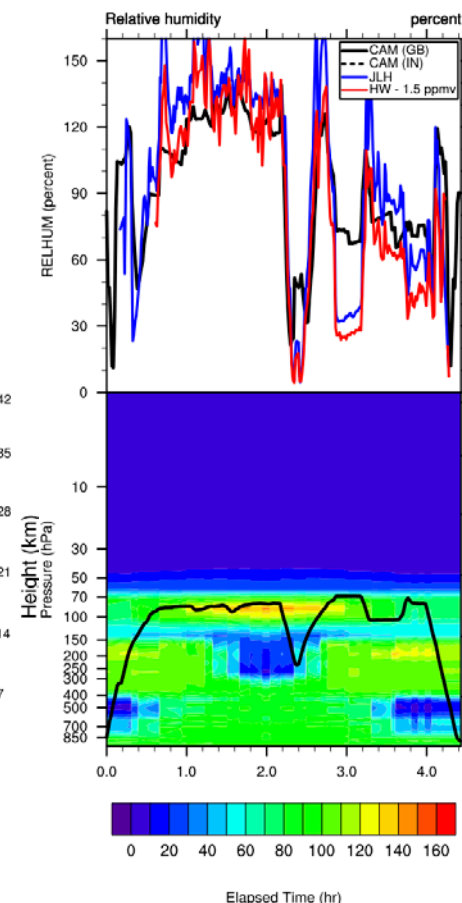
## Temperature



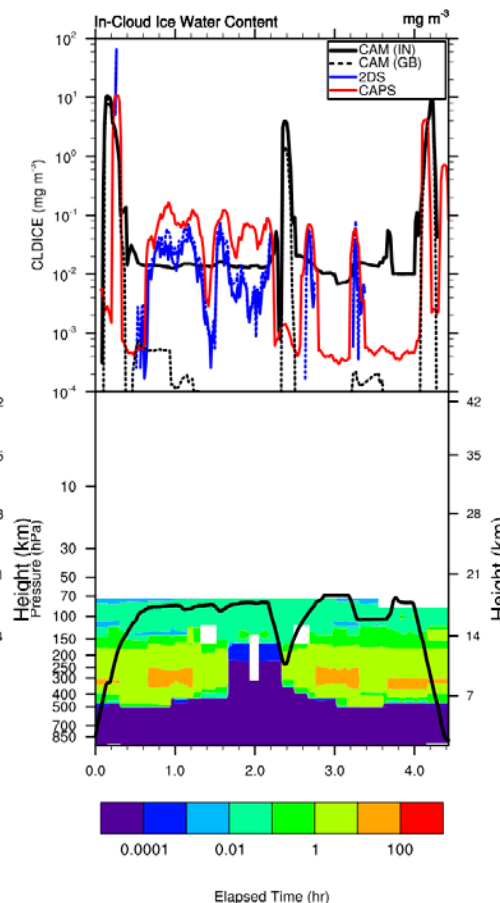
## Specific Humidity



## Relative Humidity

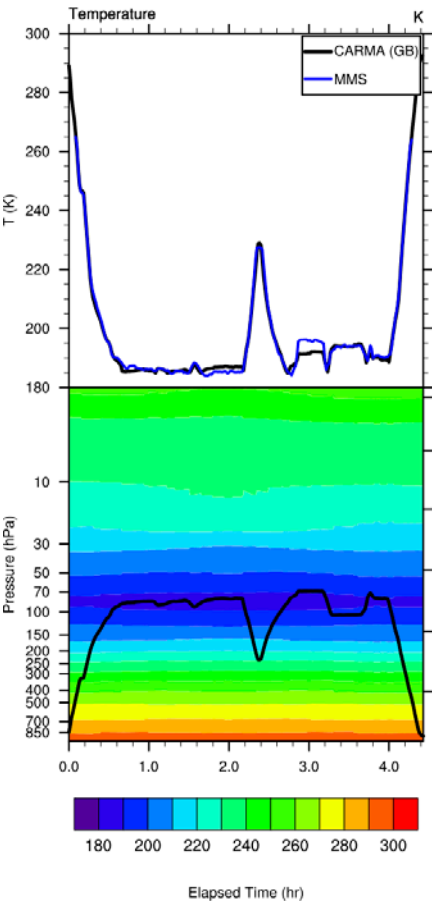


## Ice Water Content

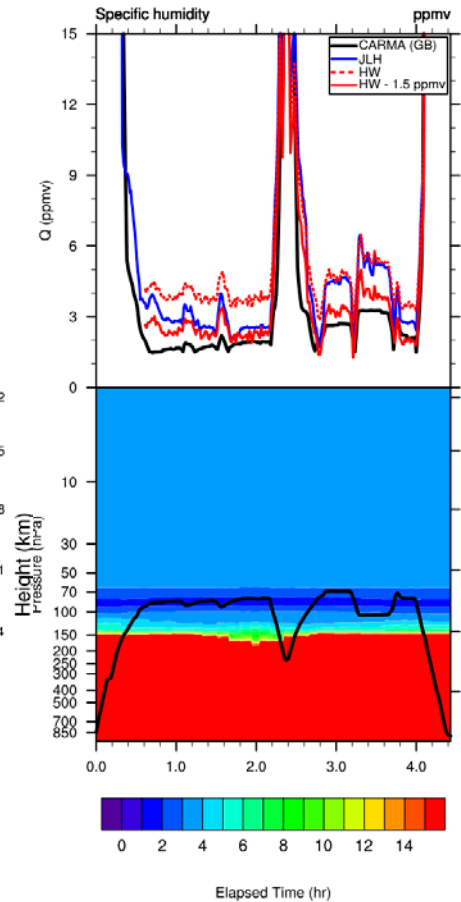


# CAM5/CARMA, 01 Feb 2006

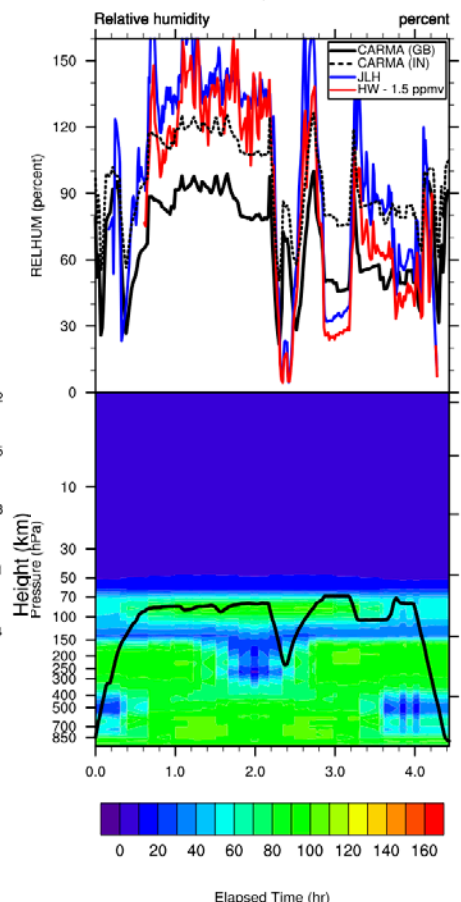
## Temperature



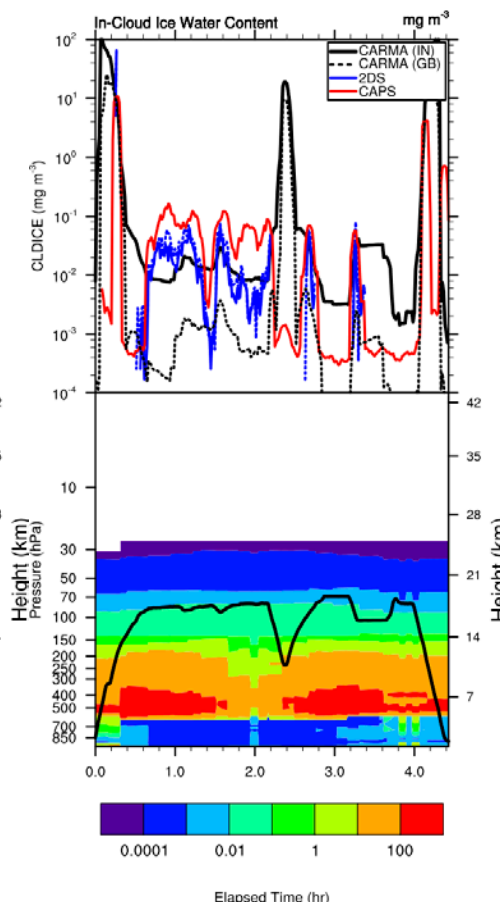
## Specific Humidity



## Relative Humidity



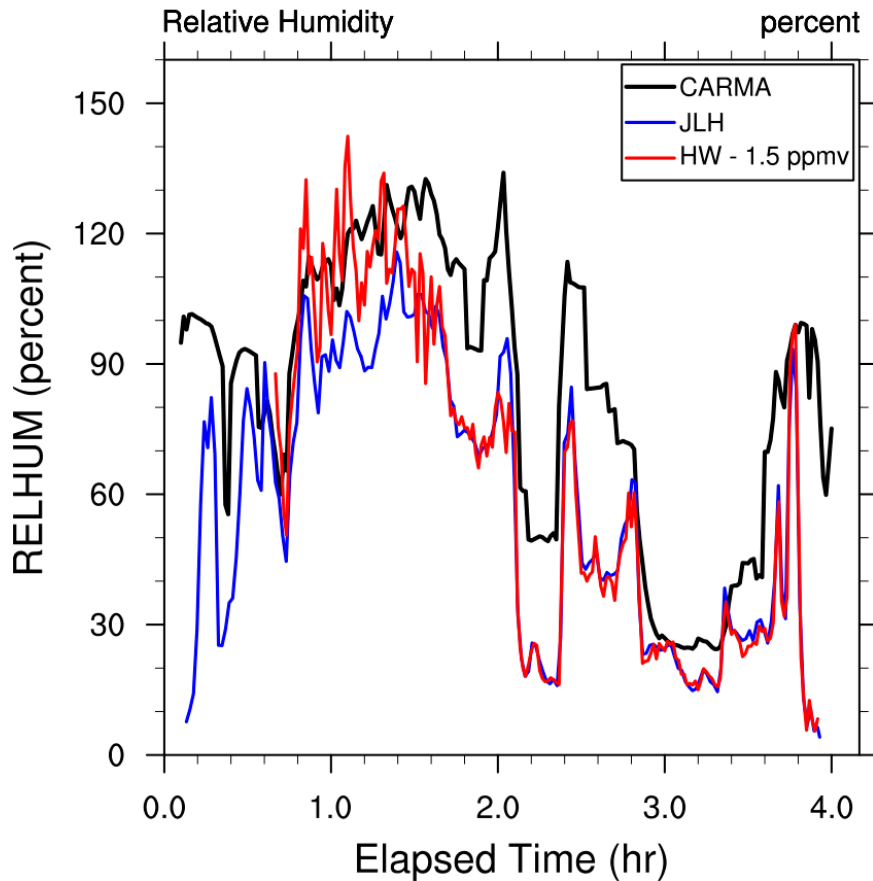
## Ice Water Content



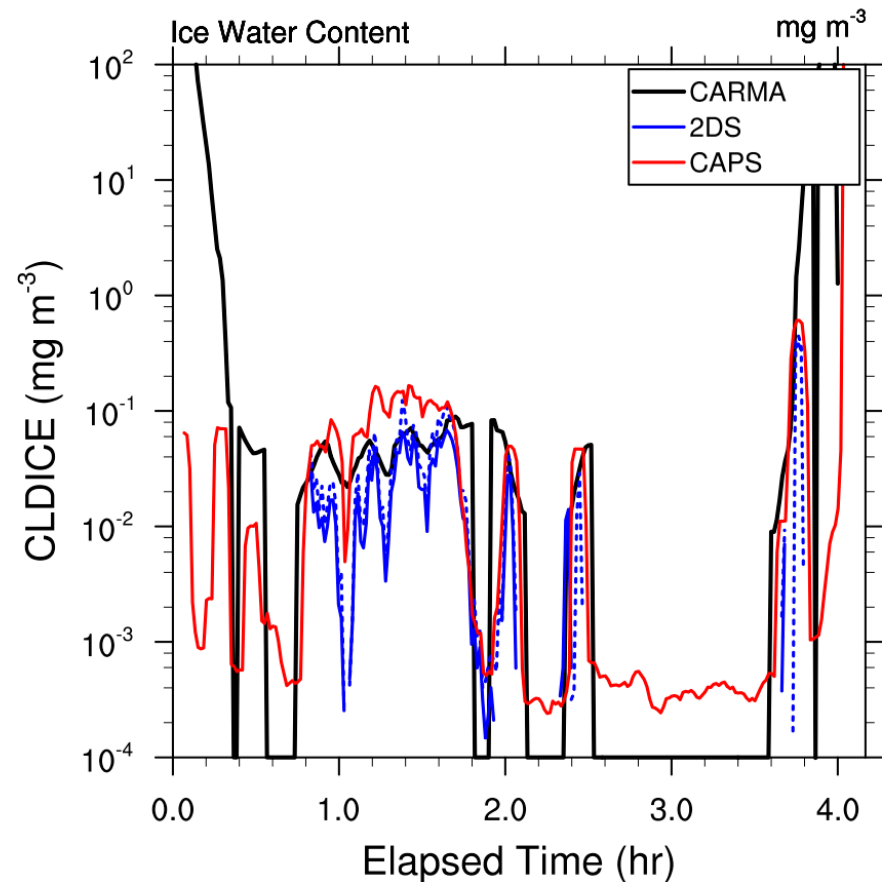
# Sampled By CAPS Cloud Fraction

## CARMA, 02 Feb 2006

CR-AVE, 20060202



CR-AVE, 20060202



# Eddy Diffusivity

