Evaluation of climate model parameterizations using ATTREX in situ observations

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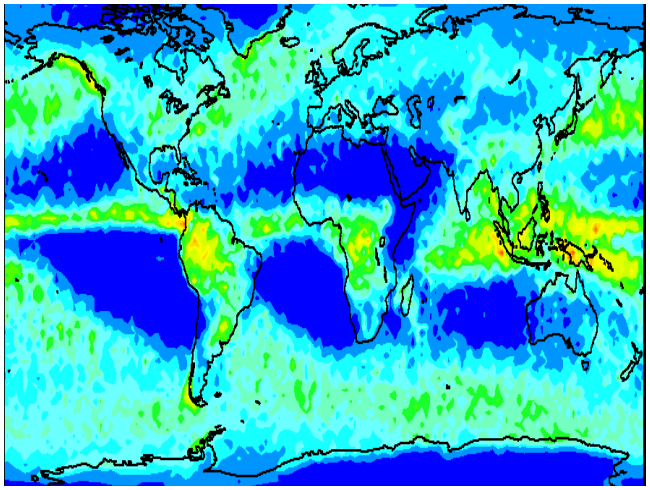


ATTREX Science Team Meeting

June 12, 2012

NCAR Earth System Laboratory

NCAR Climate Models

- **Community Atmosphere Model (CAM5)**
  - Atmospheric component of CESM (Community Earth System Model)
  - Morrison-Gettelman Two-Moment Microphysics
  - UW Macrophysics

- **Community Aerosol and Radiation Model for Atmospheres (CARMA)**
  - Sectional microphysics framework integrated into CAM and WACCM

- **Whole-Atmosphere Community Climate Model (WACCM)**
  - ~150 km model top version of CAM
  - Interactive chemistry

CAM/CARMA Cirrus Model

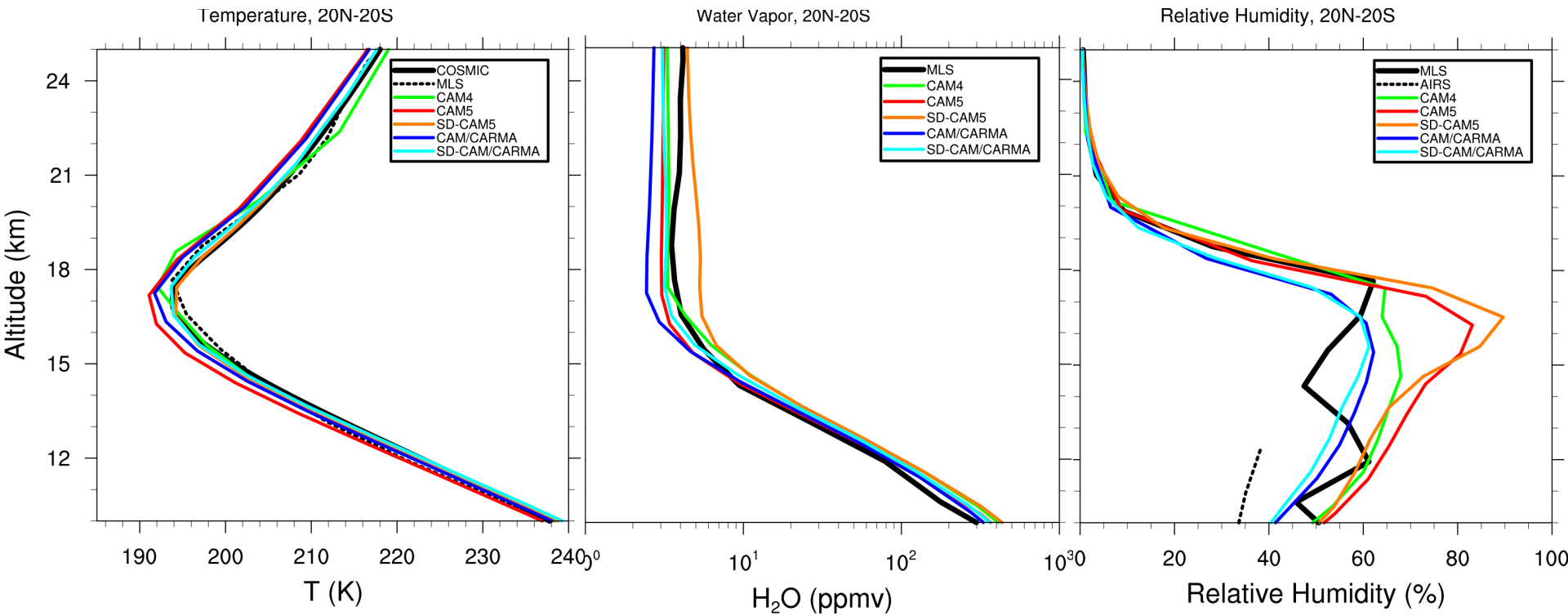
Particle Types

- 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)

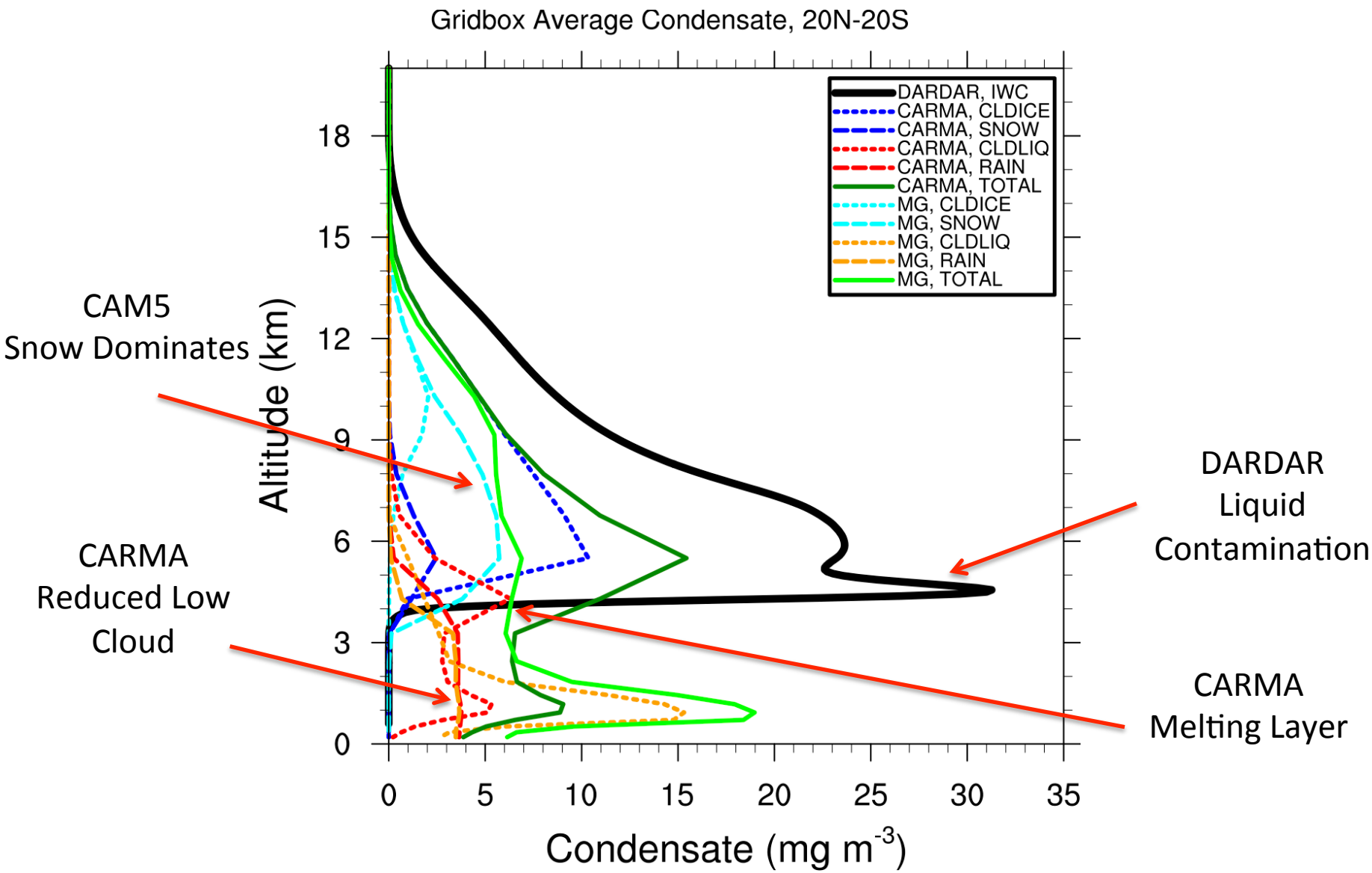
Processes

- 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

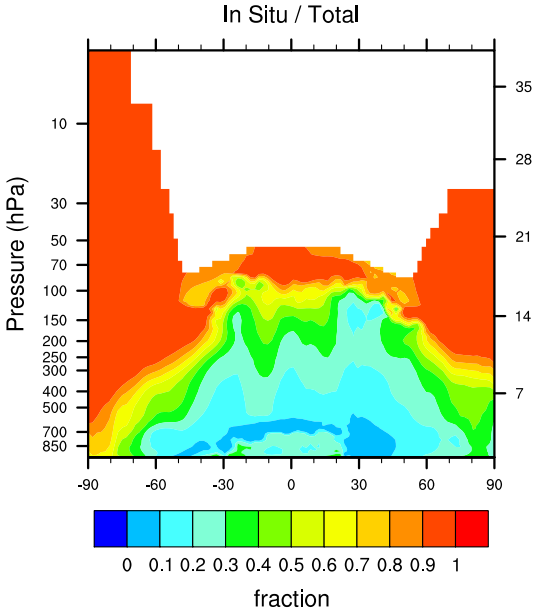
Tropical Averages: T, Q, RH

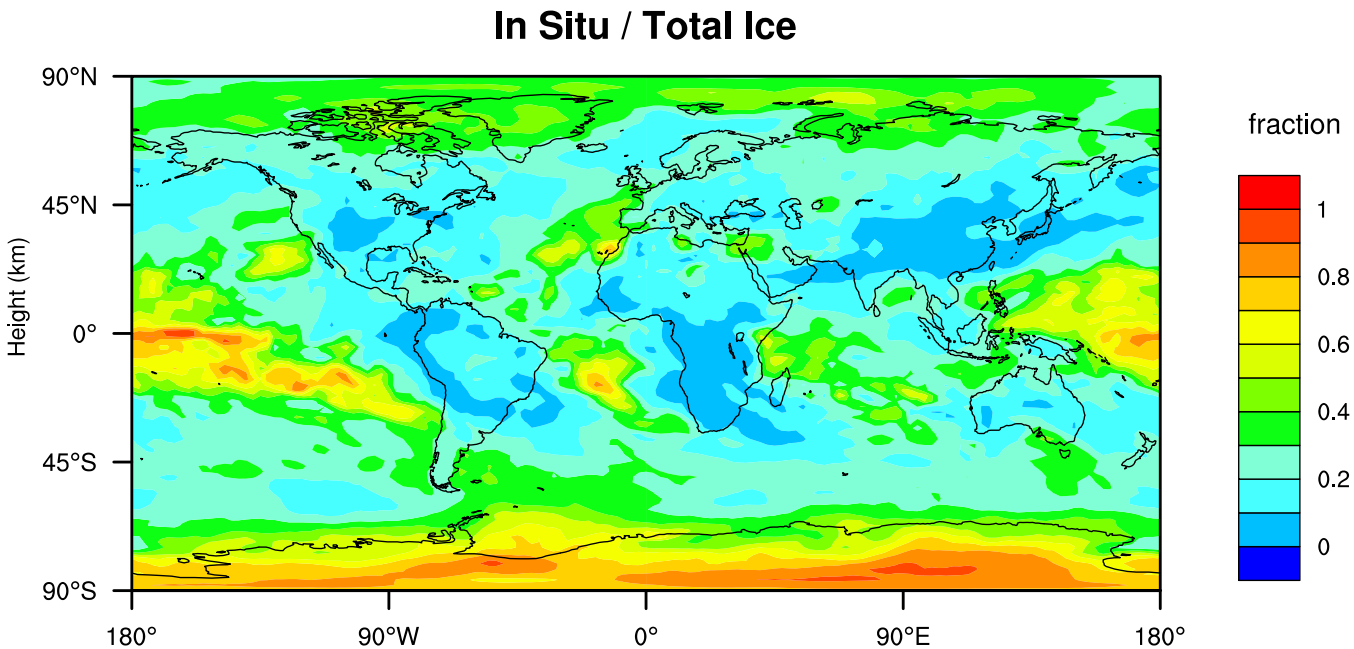


Tropical Averages: Condensate



CAM/CARMA: In Situ Ice / Total Ice

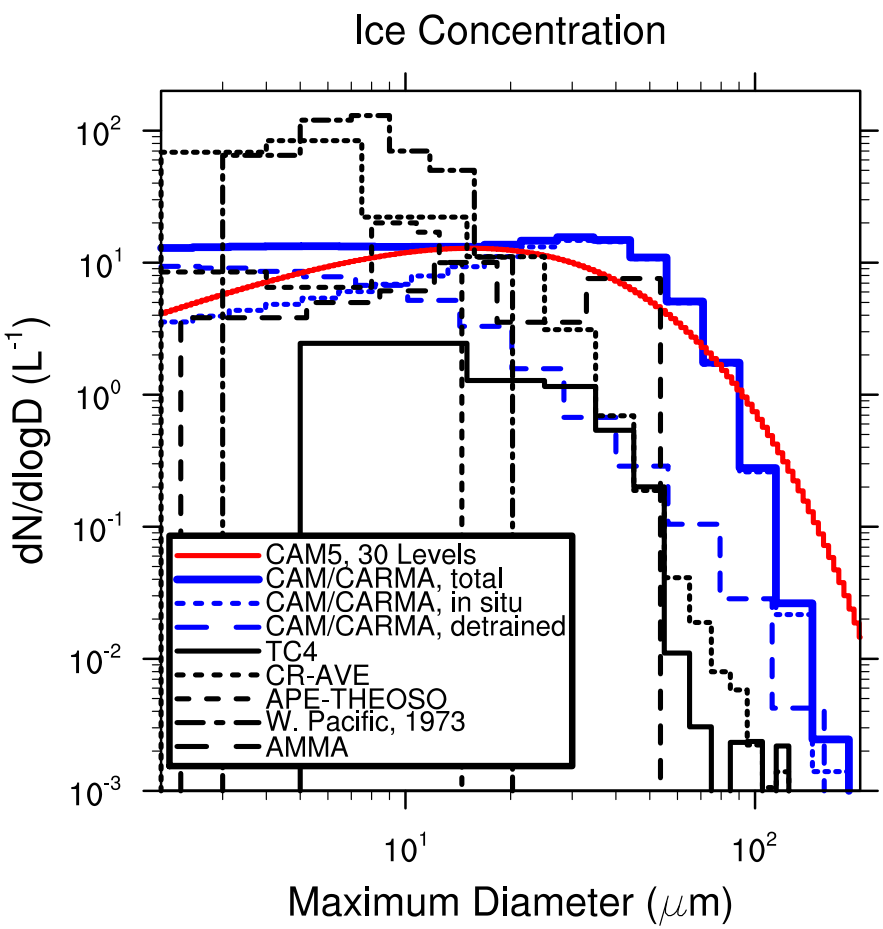


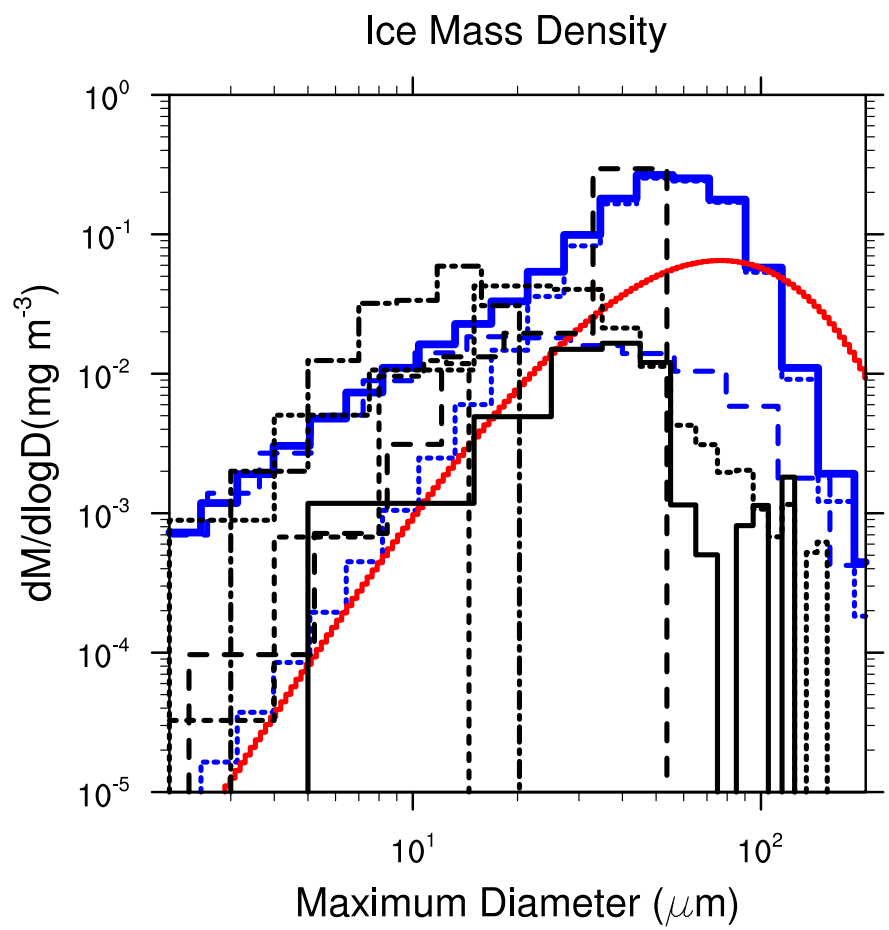


In Situ : Nucleation in Stratiform Microphysics
Detrained : Detrained from Convection

Total = In Situ + Detrained

Ice Size Distribution, TTL, Subvisible



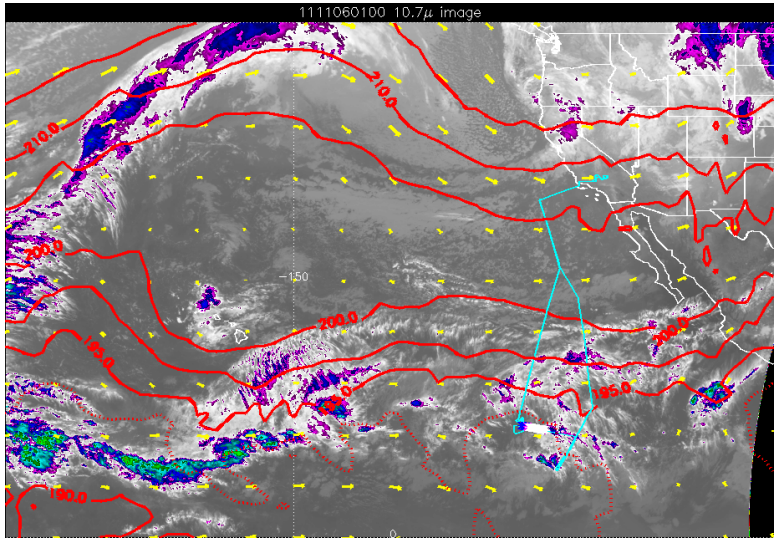


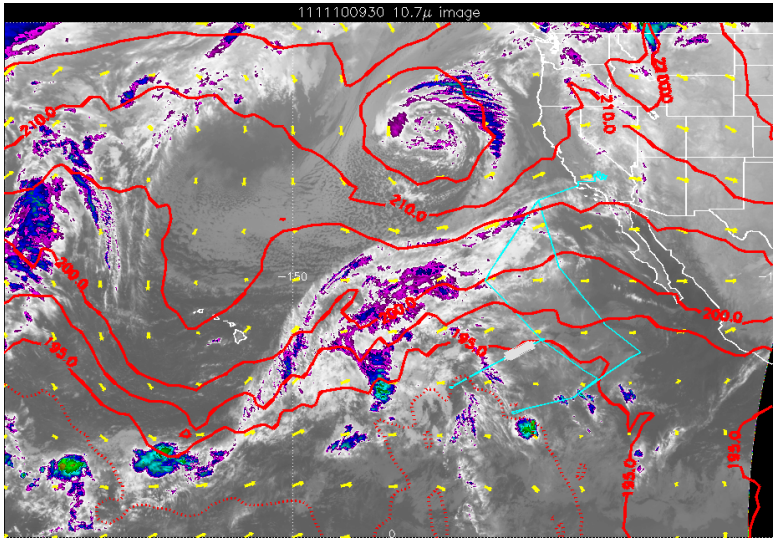
[adapted from Davis et al. 2010]

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

ATTREX: 05 Nov & 09 Nov



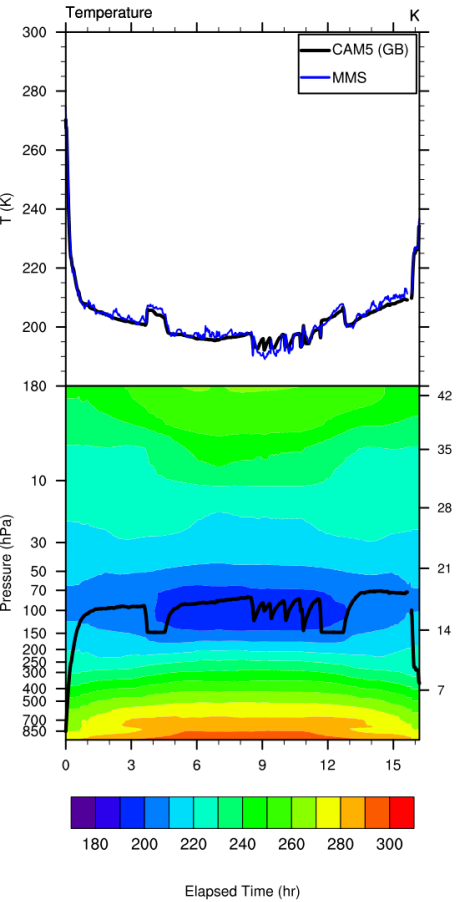


- October – November, 2011
- 2 Flights
  - November 05, 2011
  - November 09, 2011

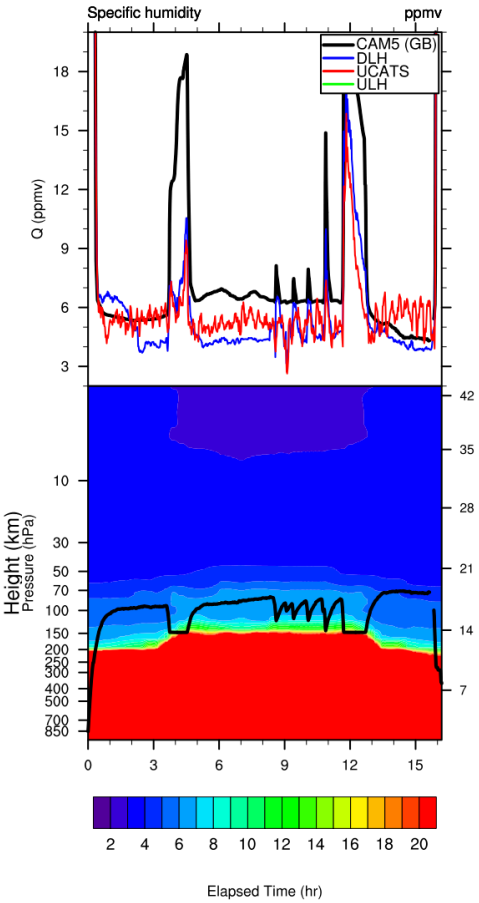
- Simulations
  - SD-CAM5, SD-CAM5/CARMA
  - GEOS-5 Meteorology
  - Satellite History
    - Follow Flight Path
    - 4 Nearest Columns
    - 2 Closest Times

CAM5, 05 Nov 2011

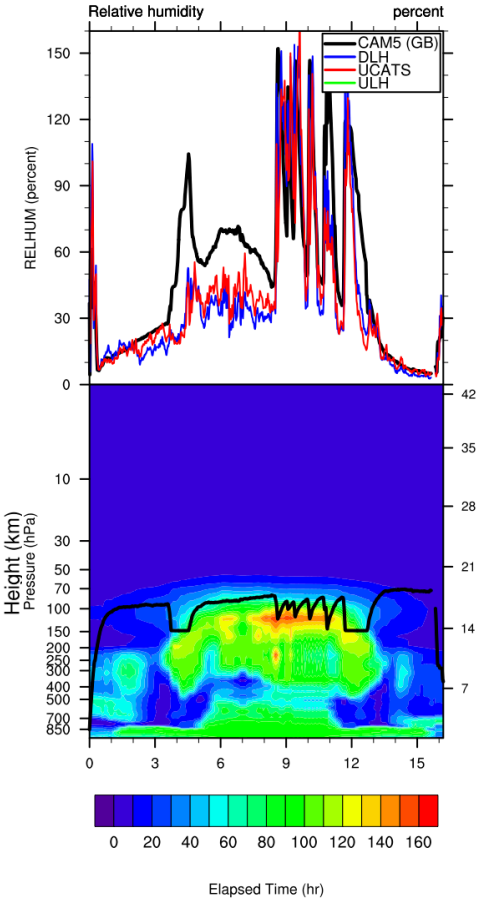
Temperature



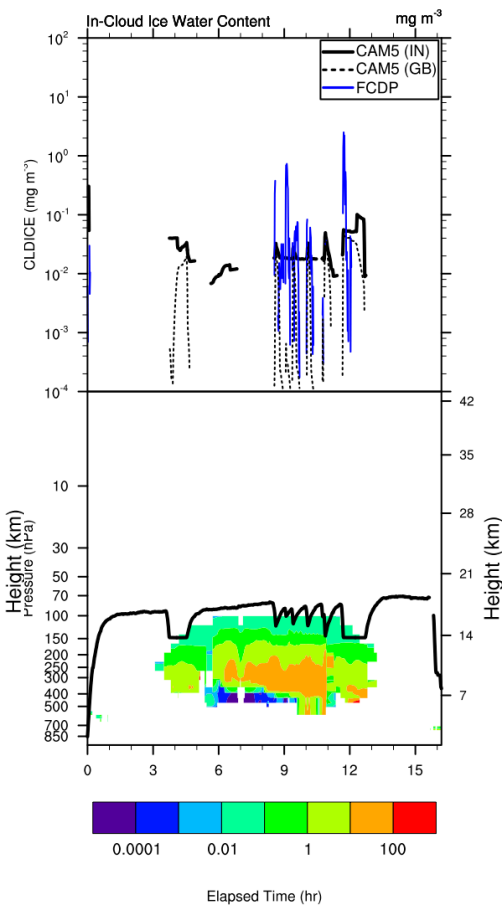
Specific Humidity



Relative Humidity

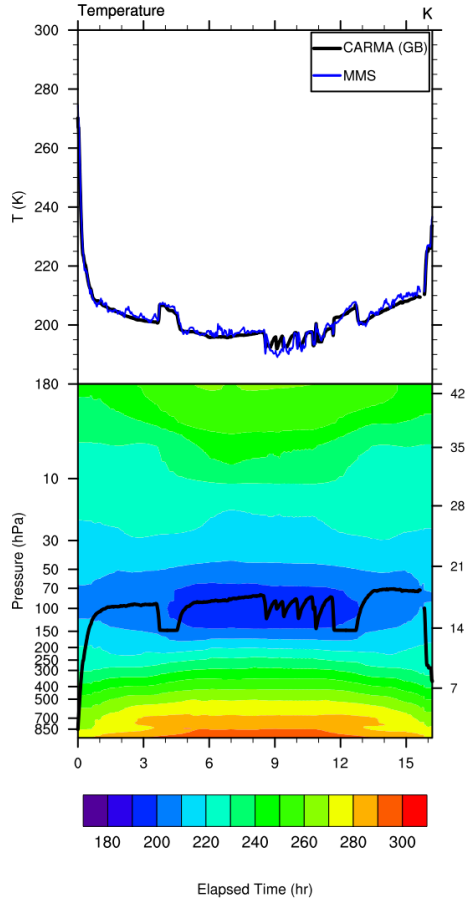


Ice Water Content

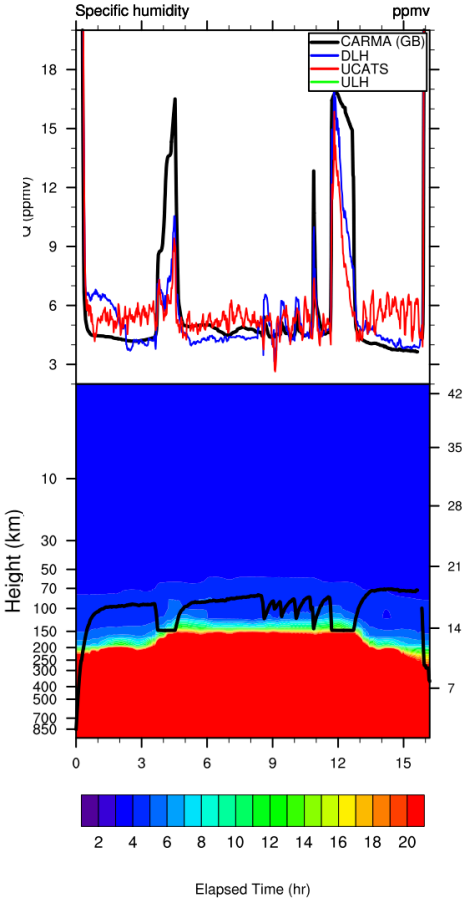


CAM/CARMA, 05 Nov 2011

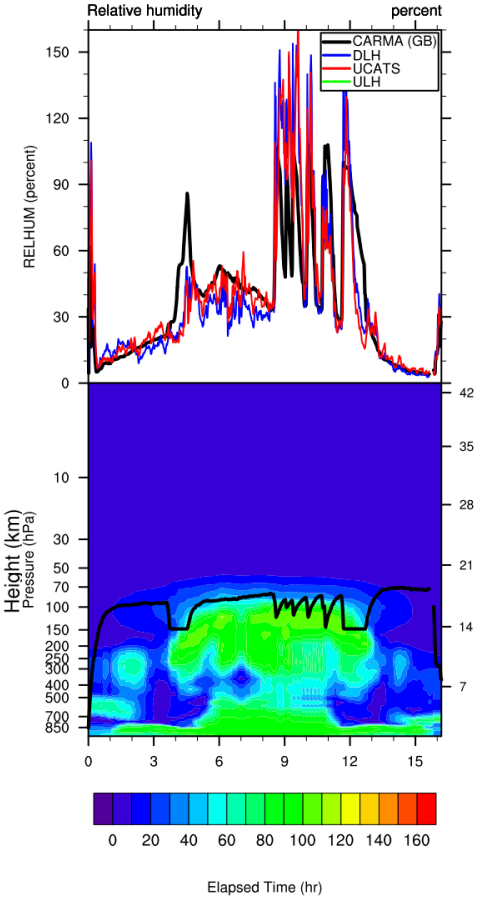
Temperature



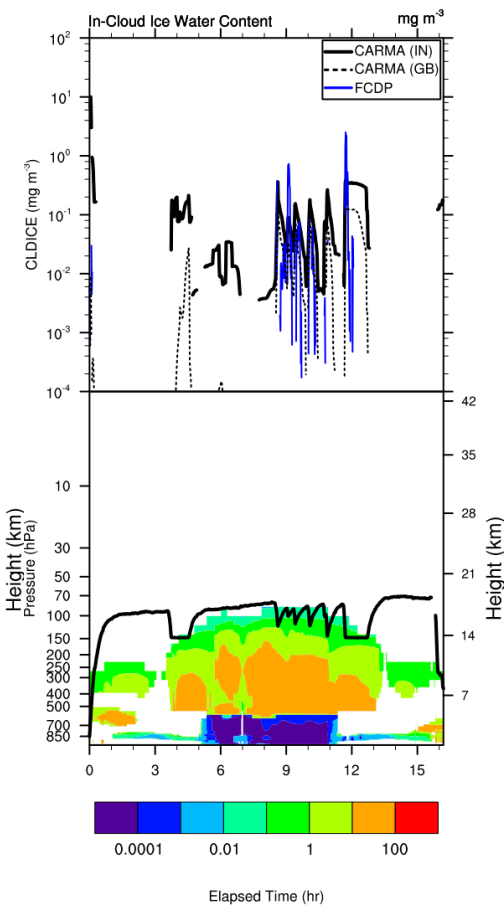
Specific Humidity



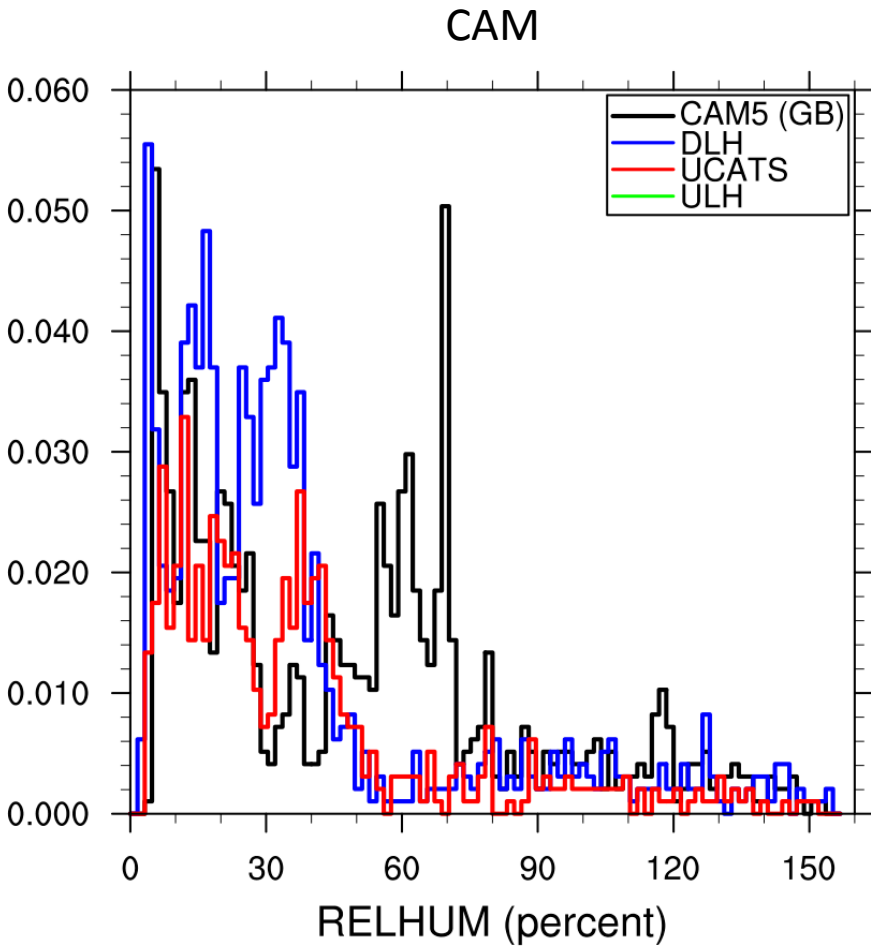
Relative Humidity

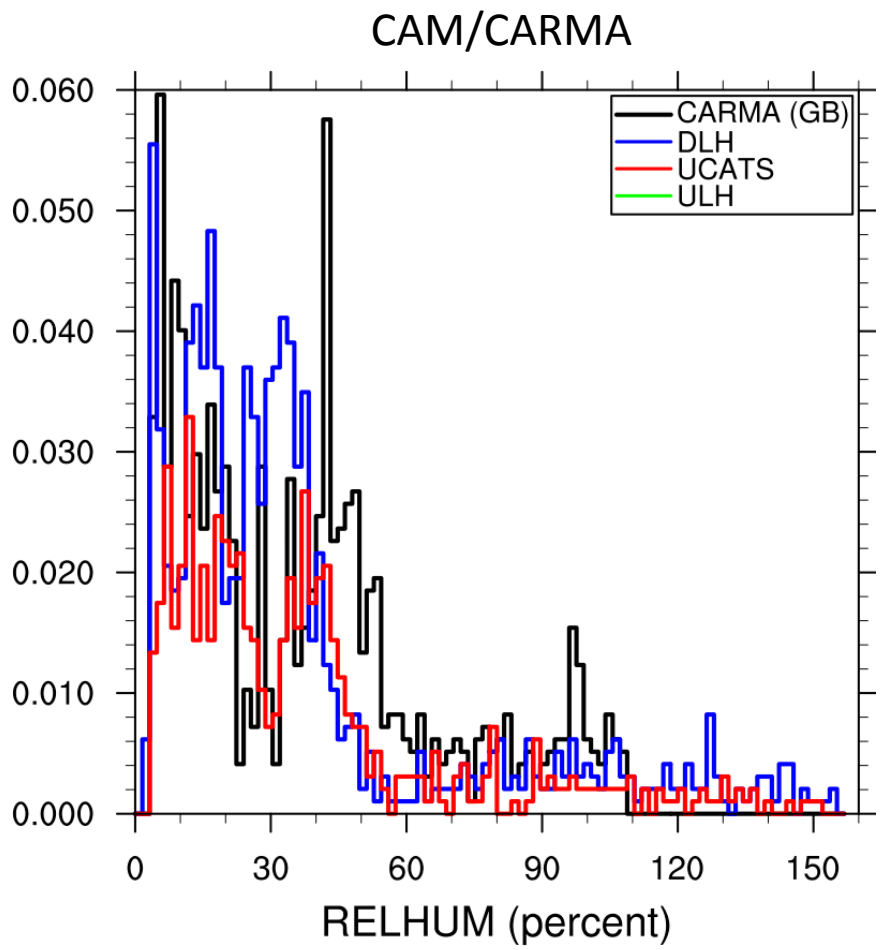


Ice Water Content

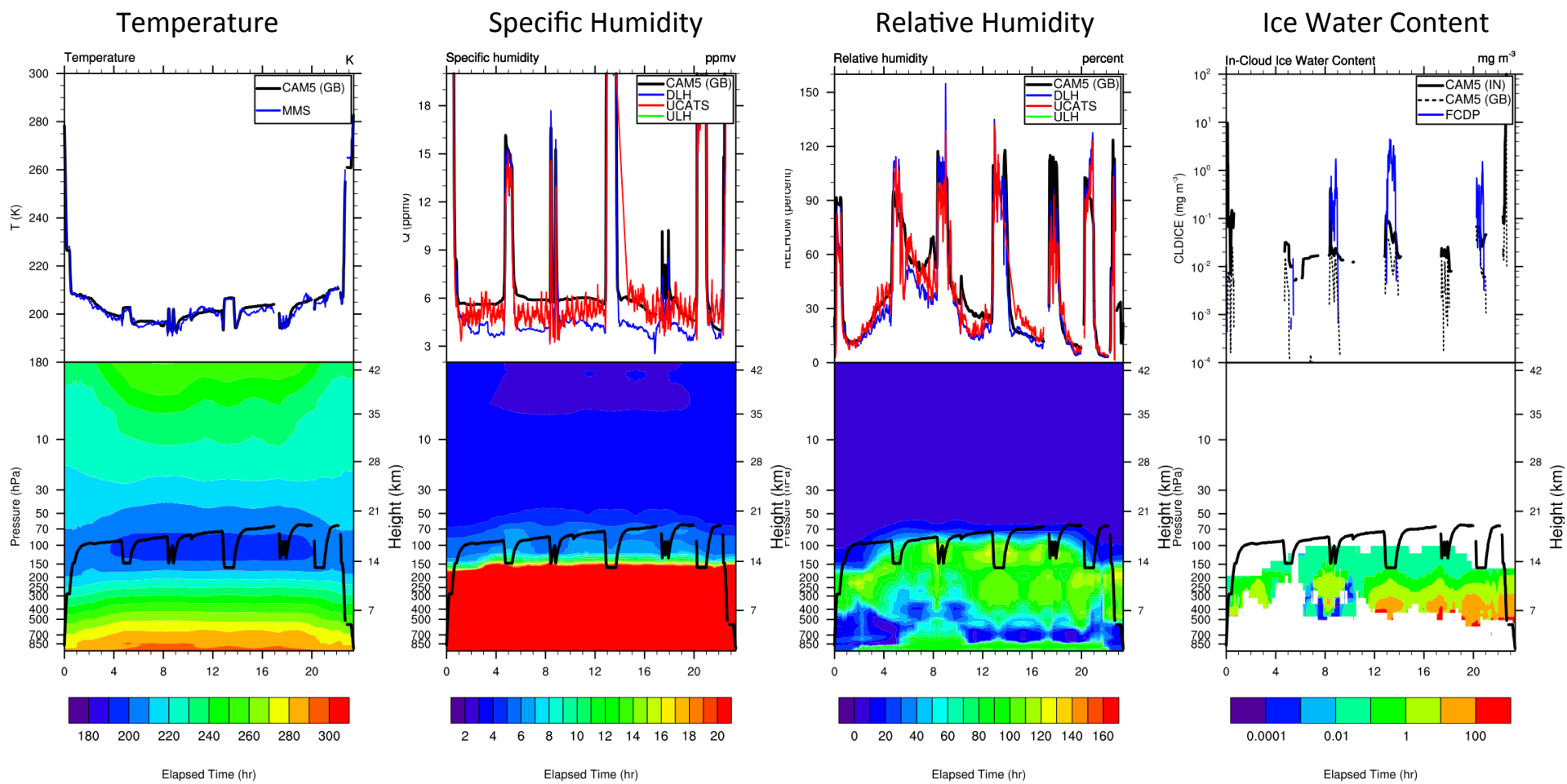


RH PDF, 05 Nov 2011

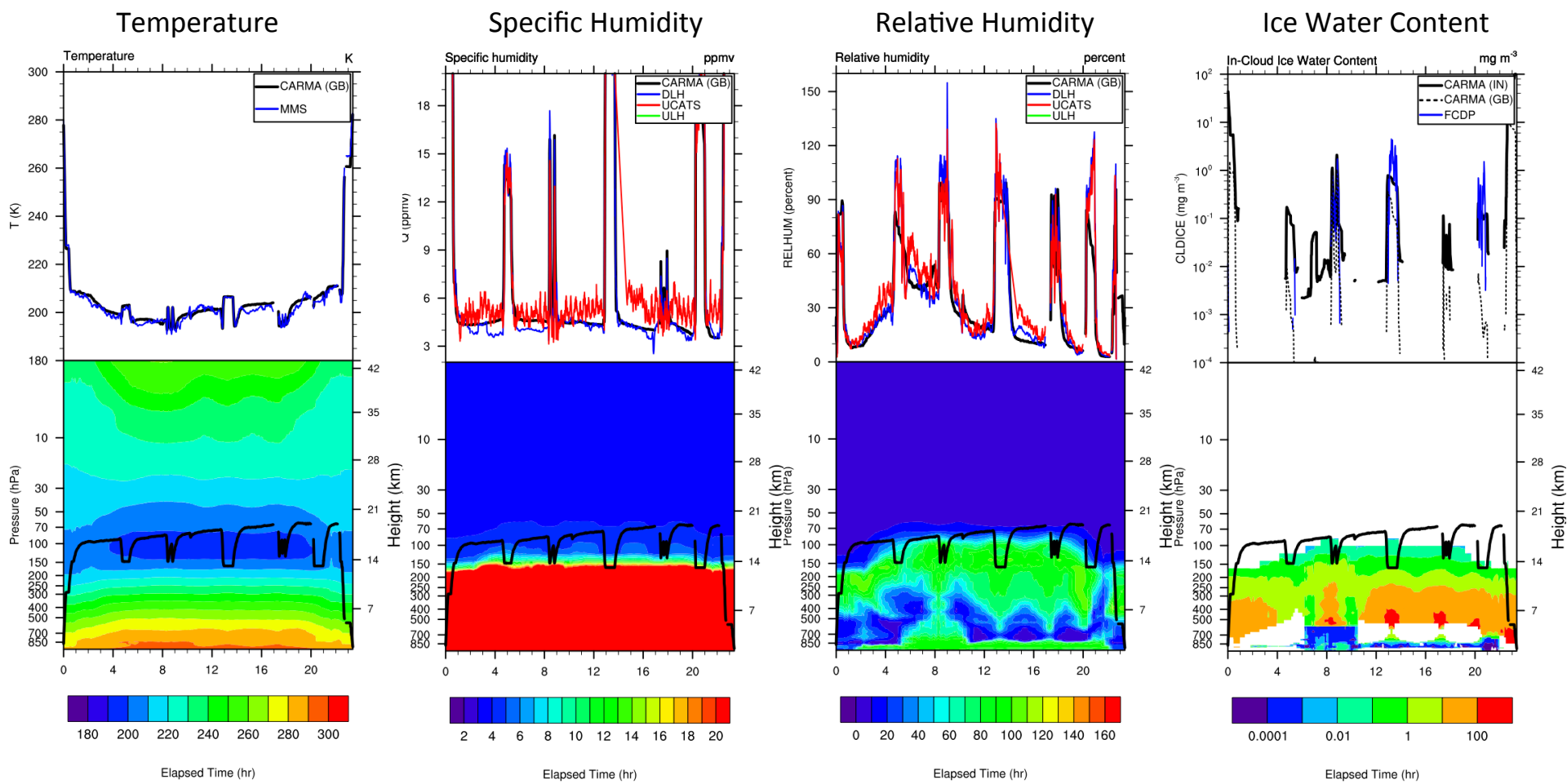




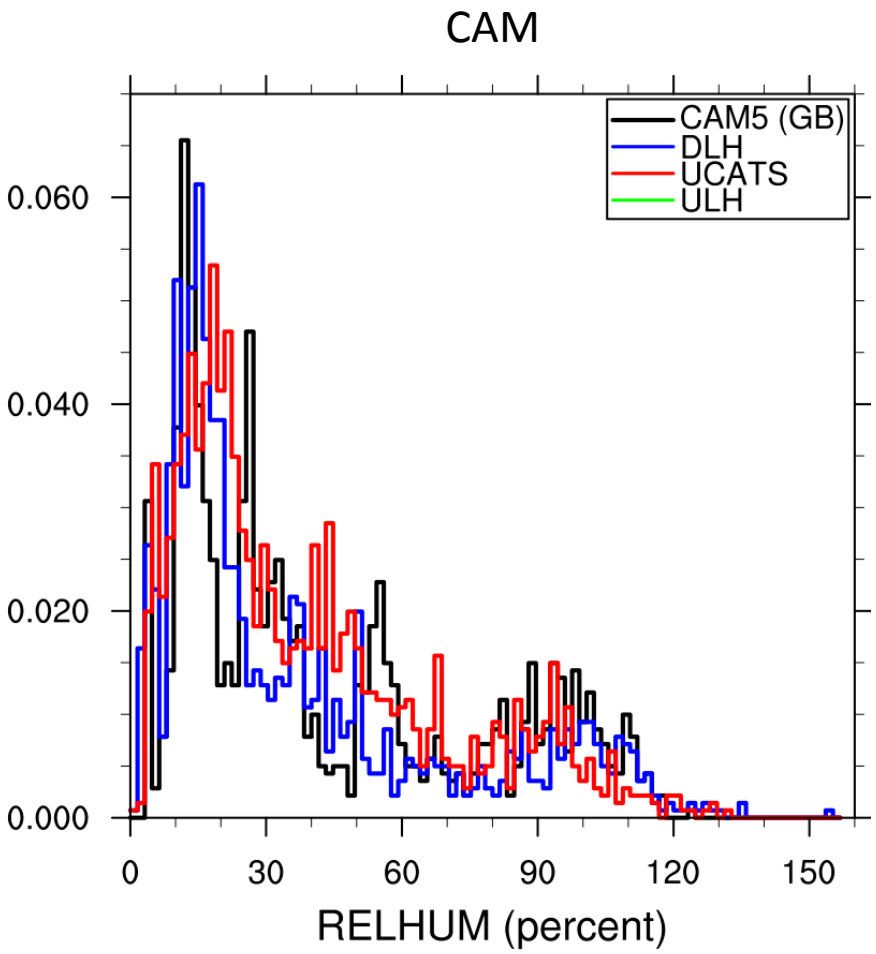
CAM5, 09 Nov 2011

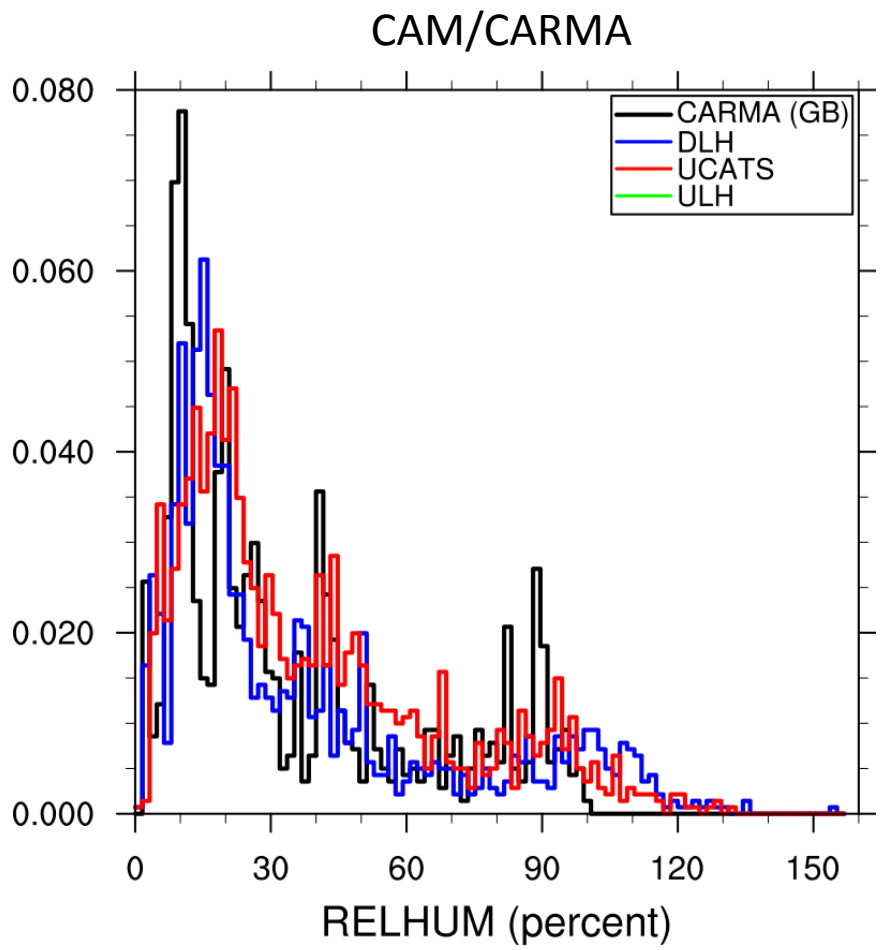


CAM/CARMA, 09 Nov 2011



RH PDF, 09 Nov 2011





Cloud Fraction

05 Nov 2011

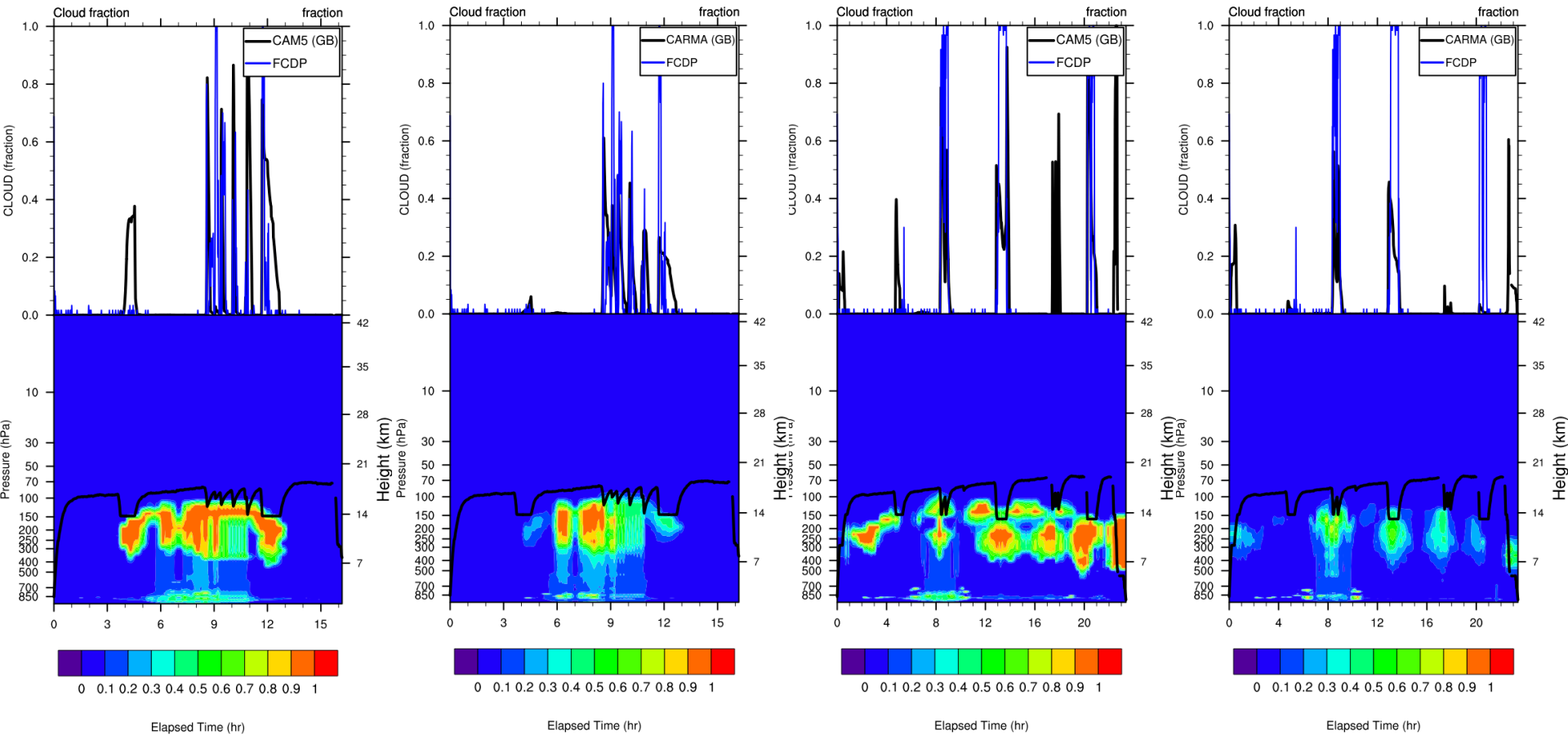
09 Nov 2011

CAM

CAM/CARMA

CAM

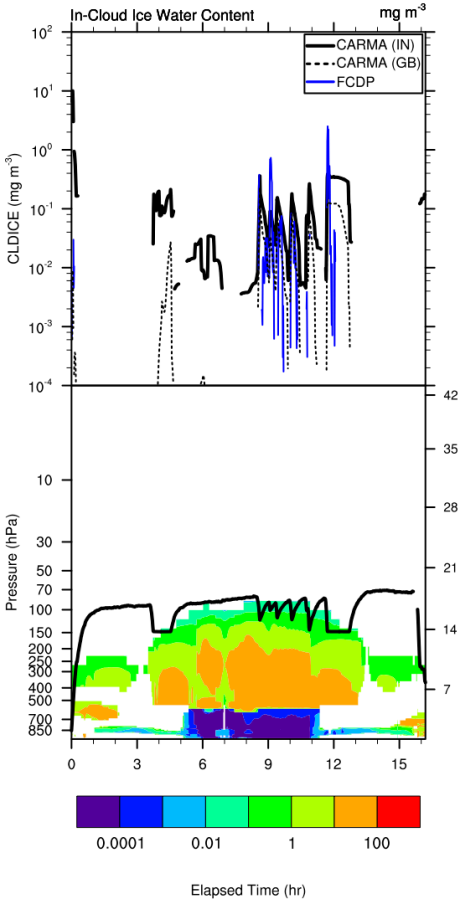
CAM/CARMA



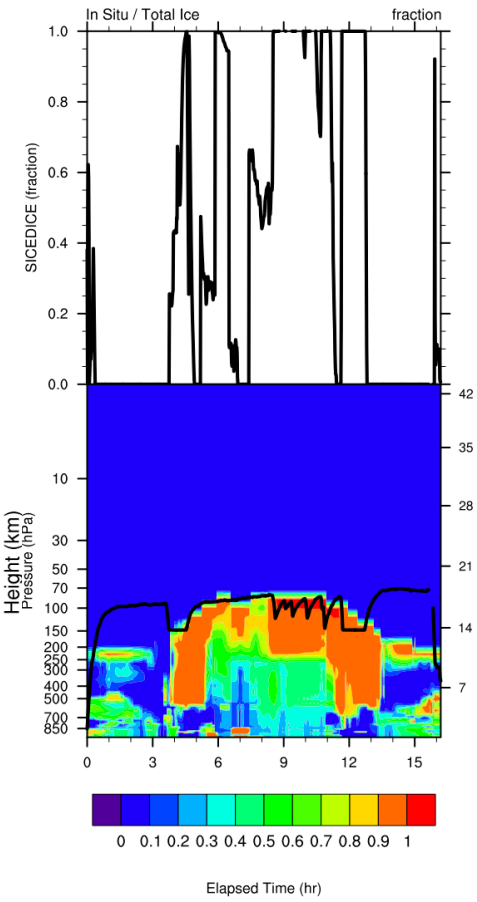
Ice, In Situ / Total

05 Nov 2011

IWC

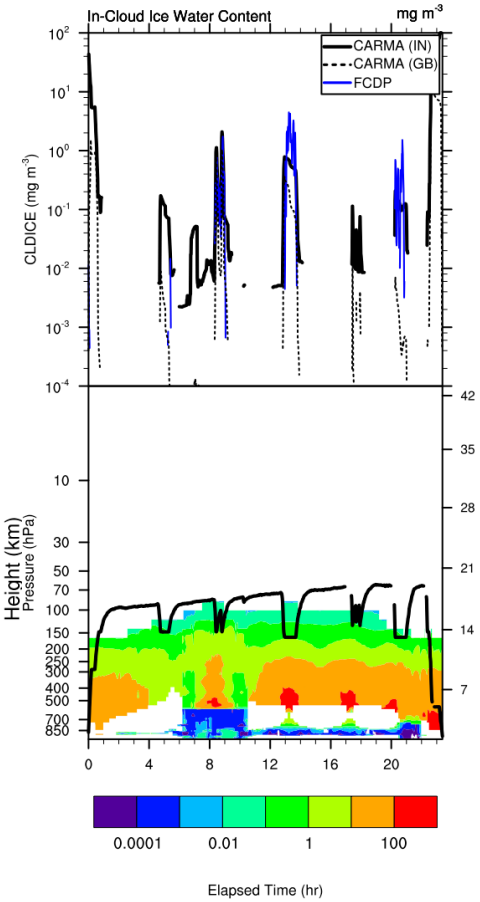


In Situ / Total

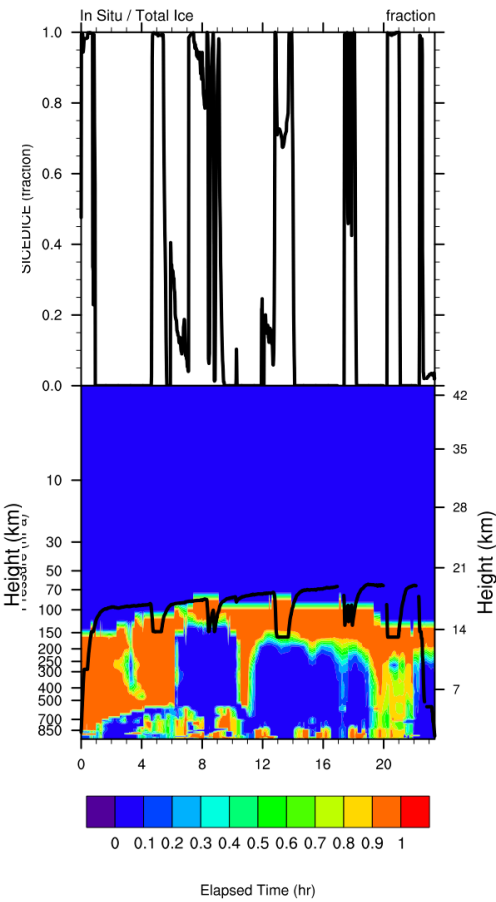


09 Nov 2011

IWC

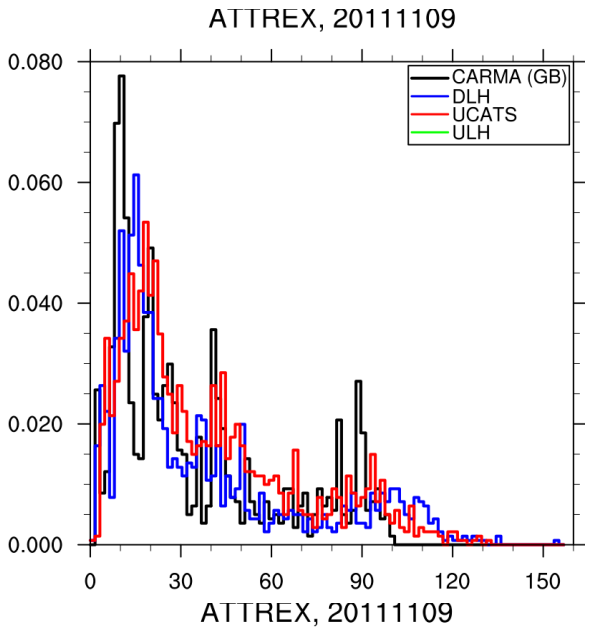


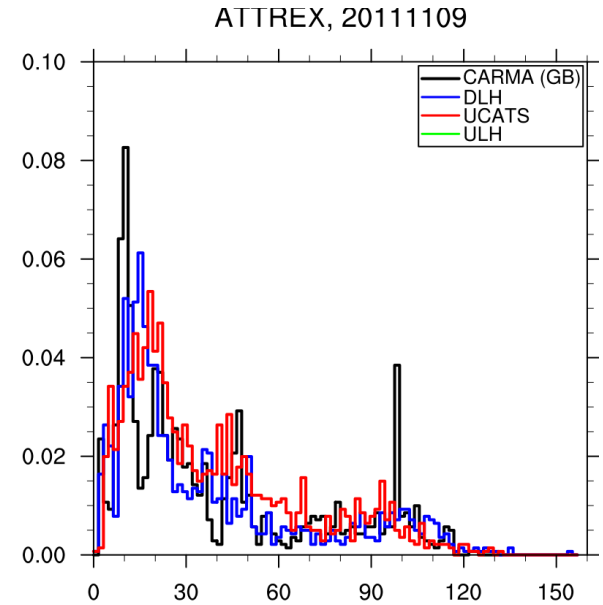
In Situ / Total



RH PDF, 09 Nov 2011

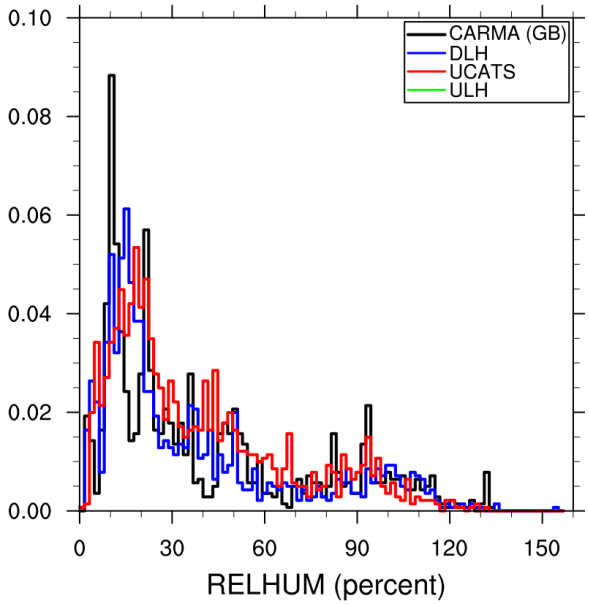
CAM/CARMA

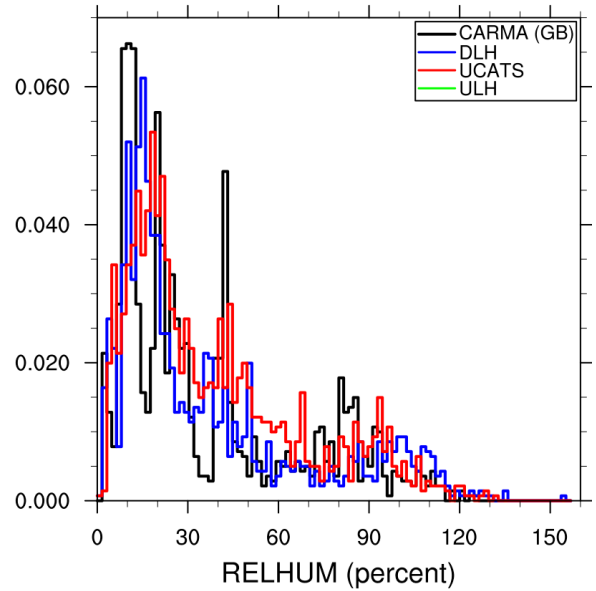




CF = 1.0

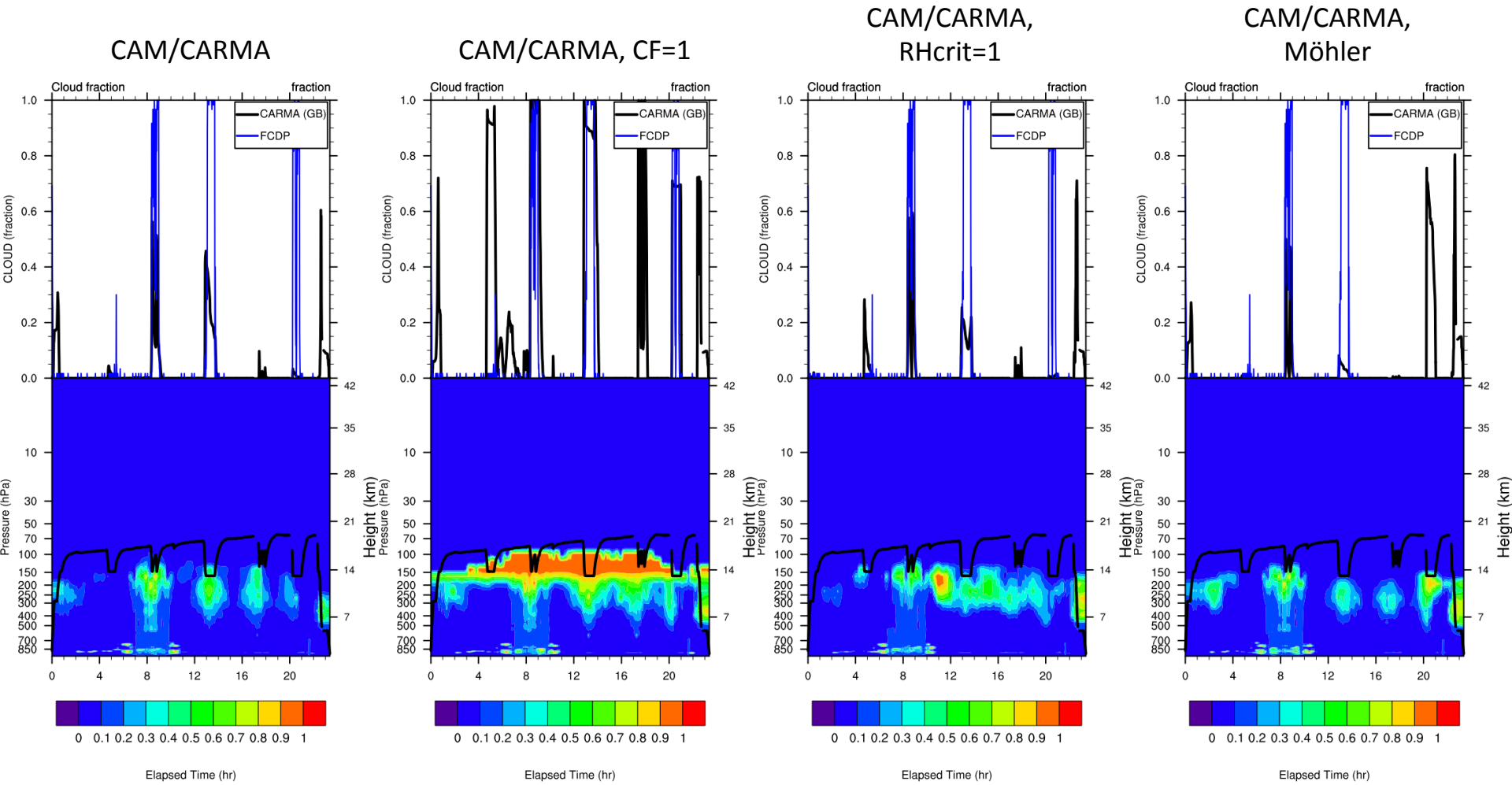
RHcrit = 1.0





Möhler

Cloud Fraction, 09 Nov 2011



Summary

Summary

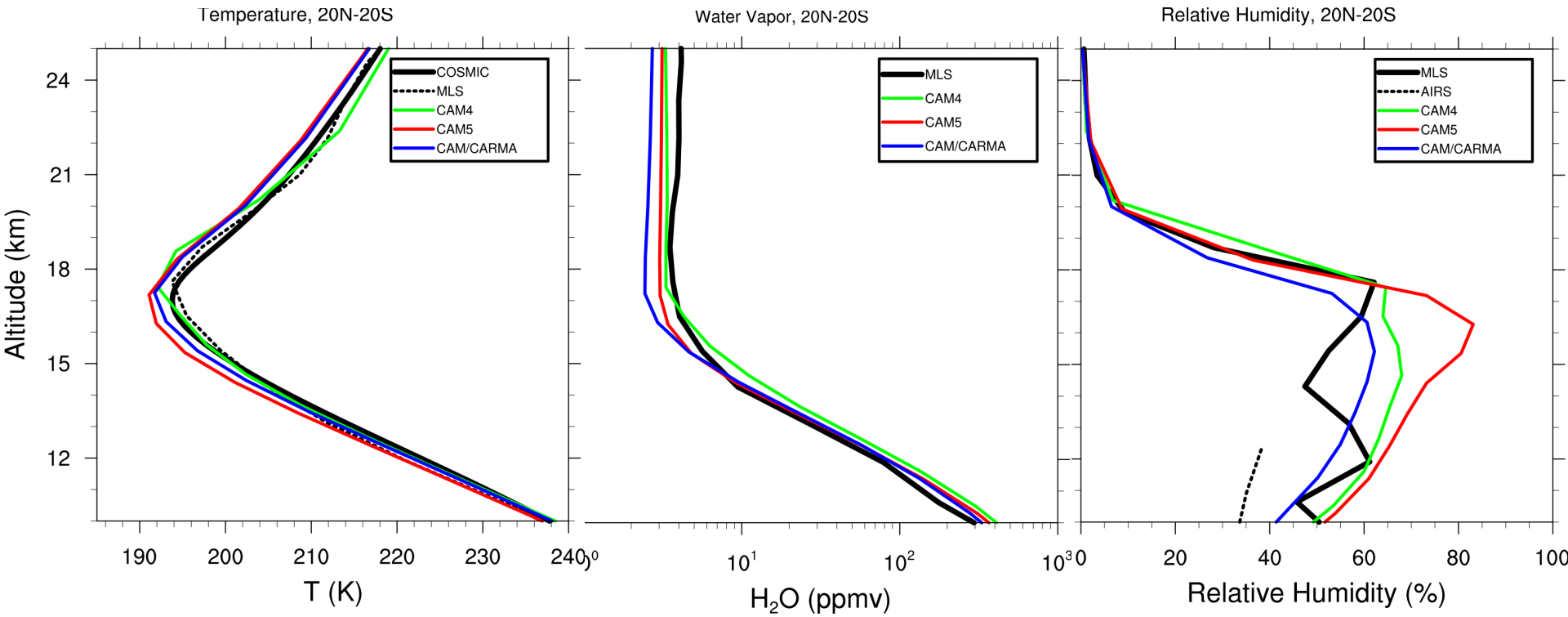
- Despite scale mismatch, SD-CAM does a good job of recreating aircraft observations in the UTLS and ATTREX data appears to be useful in evaluating model parameterizations.
- Need to understand differences between DLH and UCATS water vapor. ULH appears to be more like DLH, but is only available for fractions of some flights.
- CAM5 has RH too high and IWC to low; however, it has frequencies of supersaturation similar to the observations.
- CAM/CARMA has RH and IWC similar to observations; however, its doesn't have enough supersaturation.
- Both CAM and CAM/CARMA appear to have lower cloud frequencies for thin and subvisibile cirrus than observations.
- Alternate versions of CAM/CARMA show better agreement with PDFs of relative humidity.

Futures

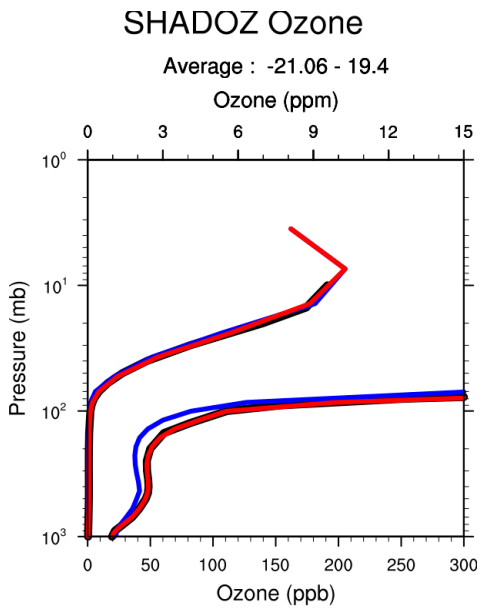
- Looking forward to more cloud data (Hawkeye).
- Since not spending most of our time in the clouds, need to use CPL, SSFR and MTP to look vertically in the column.
- Need to further evaluate cloud macrophysics, cloud nucleation and connection between convection and large scale clouds.
- Will also look at other campaigns (e.g. CR-AVE, TC4, MACPEX, …).
- When WACCM5 is available or perhaps with CAM5-Chem, will run with chemistry and look at trace gases.

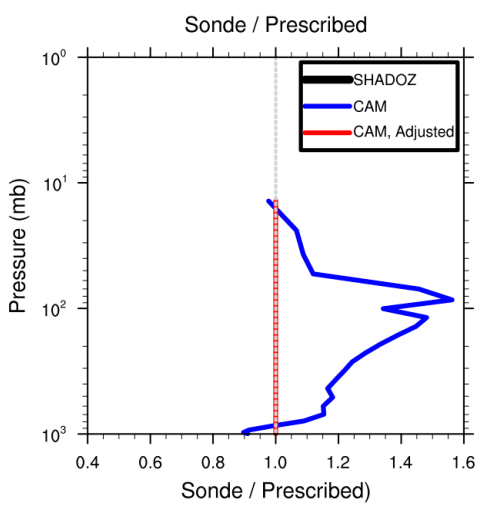
Tropical Averages: T, Q, RH

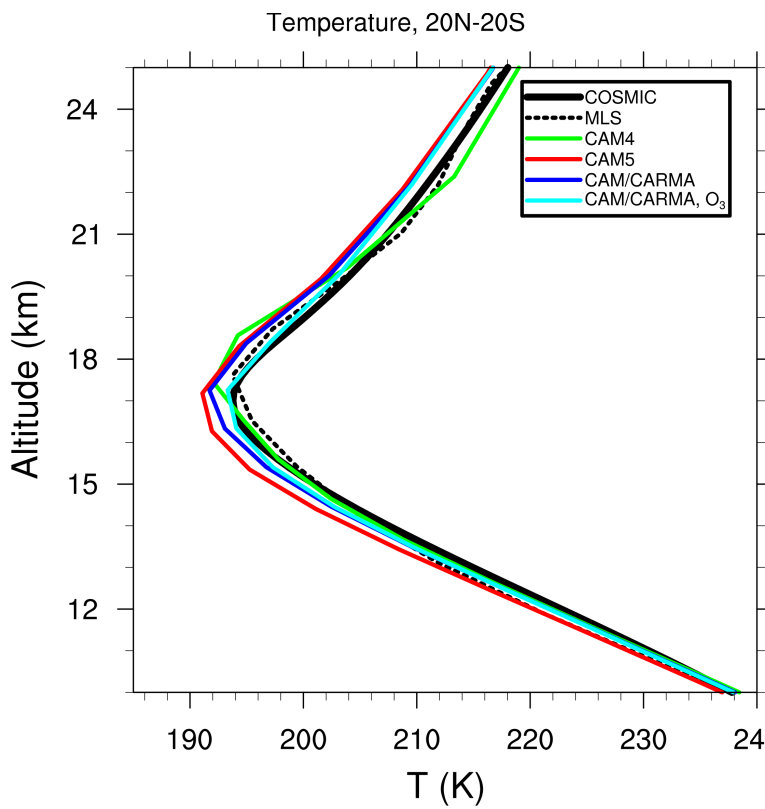
Free Running

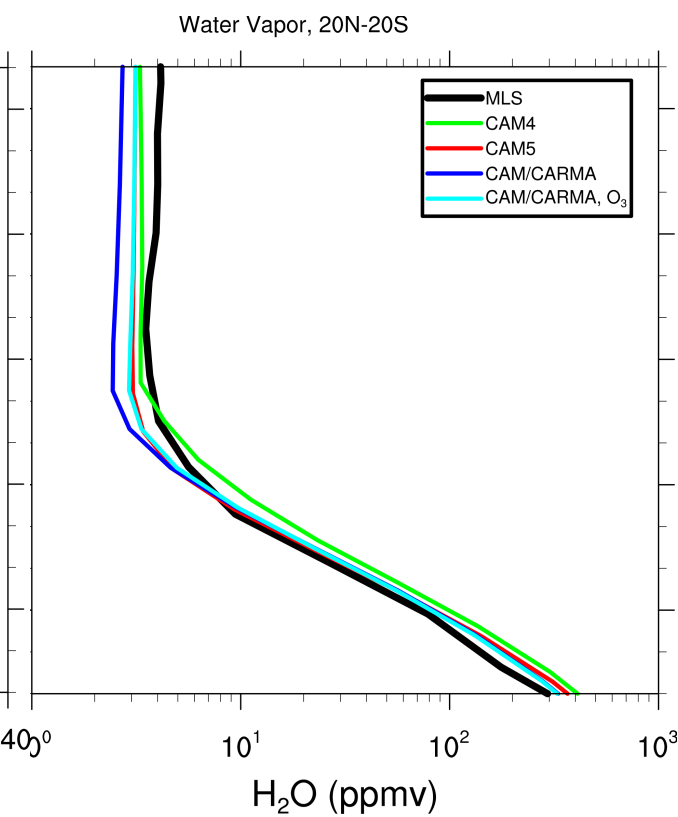


Prescribed Ozone









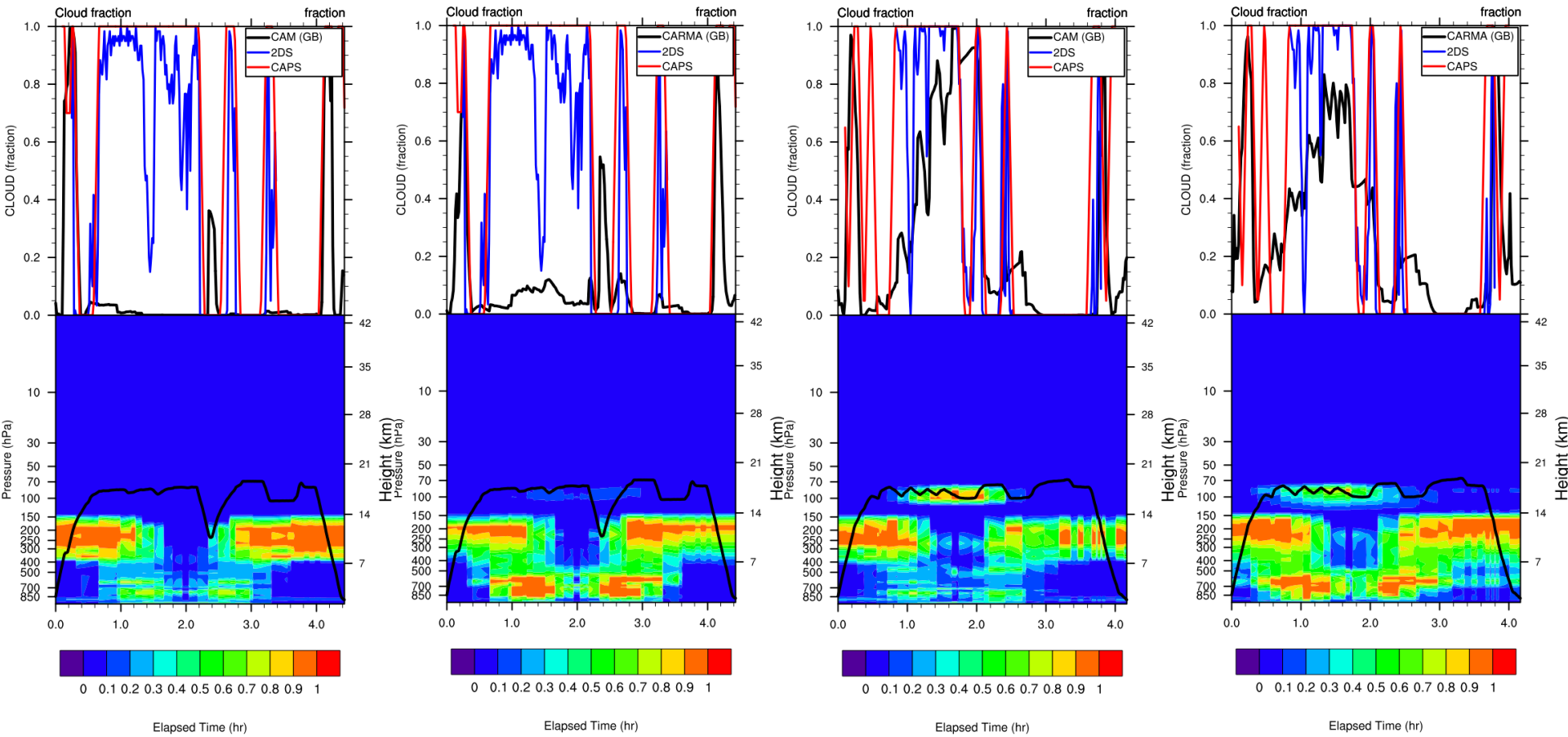
CR-AVE, Cloud Fraction

01 Feb 2006

02 Feb 2006

CAM

CAM/CARMA

CAM

CAM/CARMA