Preliminary Results on the Coupling of CAM with CLUBB

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Current CAM5 Physics

- Boundary Layer (Bretherton)
- Deep Convection (ZM)
- Shallow Convection (Park)
- Cloud Macrophysics (Park)
- Microphysics (MG)
- Radiation (RRTM)
- Aerosols (Modal)

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CLUBB

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- CLUBB = Cloud Layers Unified By Binormals
- First developed by Golaz et al. (2002), maintained by University of Wisconsin Milwaukee (Vincent Larson's group)
- "Incomplete" Third-order turbulence closure centered around an assumed PDF
- Cloud fraction, liquid mixing ratio, and higher-order turbulent moments are closed via a triple joint (temperature, moisture, and vertical velocity) assumed double gaussian PDF.
- Should provide a unified treatment of PBL and shallow moist convection

CAM-CLUBB

- UW PBL (Bretherton and Park), UW Shallow convection (Park and Bretherton), and Cloud macrophysics (Park) are all turned off
  - CLUBB is warm cloud parameterization, therefore still strip out a subroutine from Park macrophysics to compute ice cloud fraction
  - Detrainment of liquid water into environment still computed per Park macrophysics for deep convection
- CLUBB called after deep convection & before MG, currently with a 5 minute sub-timestep
- Predicted vertical velocity variance passed from CLUBB to MG for SGS vertical velocity needed for aerosol activation
- CLUBB drives the MG microphysics scheme (for both stratified and shallow convective cloud)

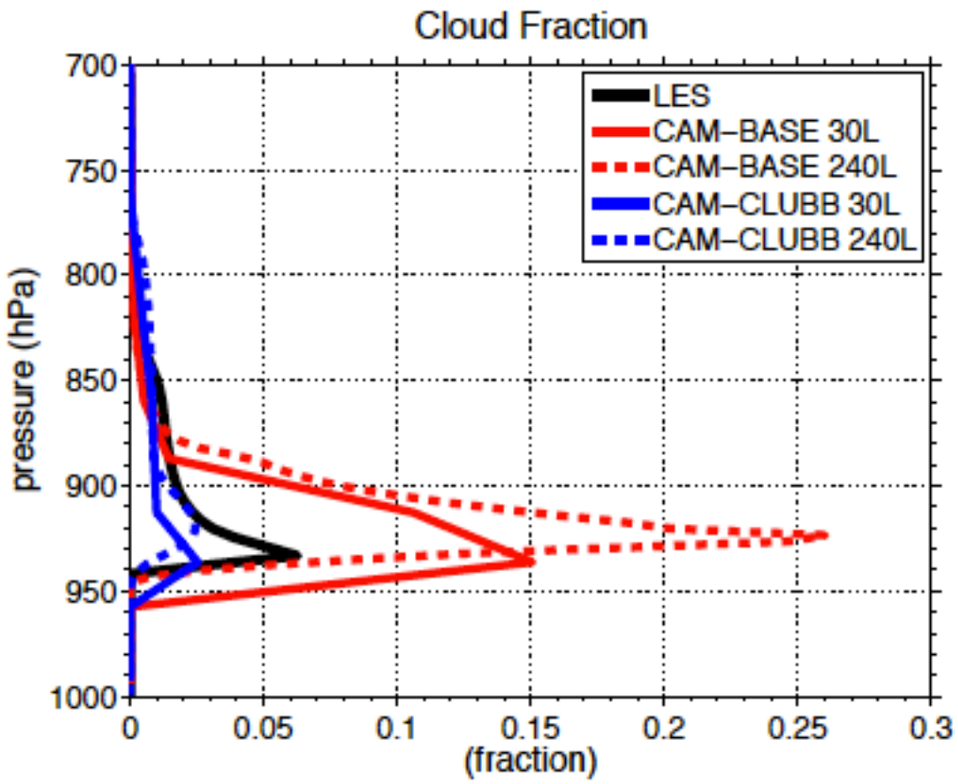
CAM-CLUBB Status

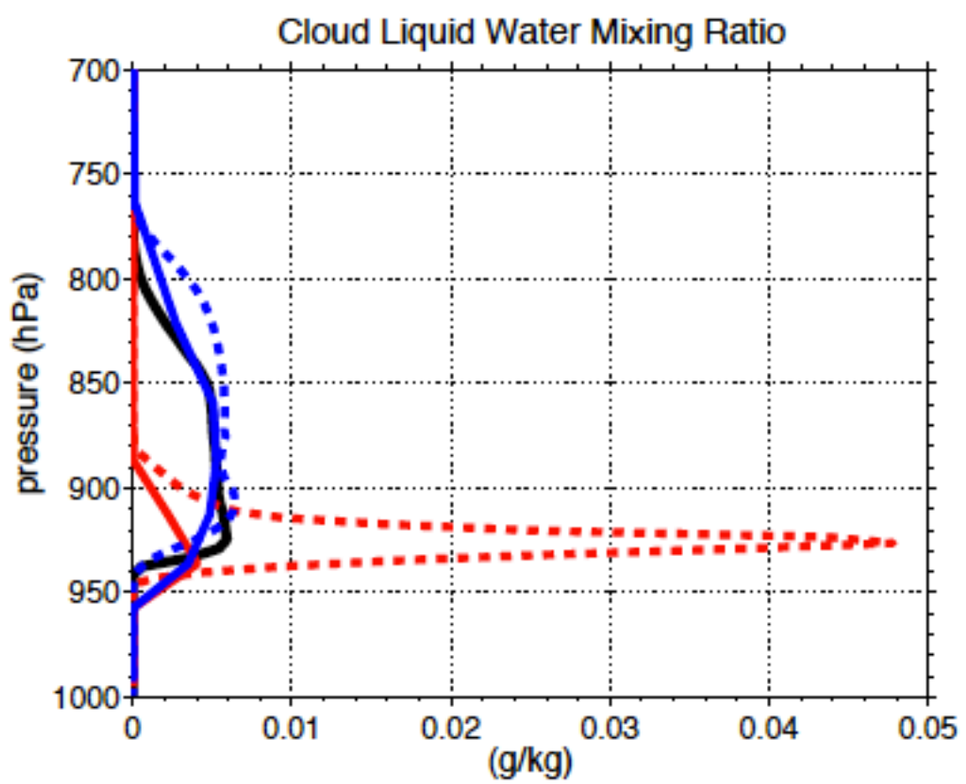
- Alive... but premature
- Runs stably in SCAM and globally
- Climate and low clouds resembles planet Earth
- Computational increase is 4% over CAM5*
- CAM-CLUBB code close to being on trunk (code review next couple weeks)
- Lots of science questions, uncertainty, testing, and work remain!

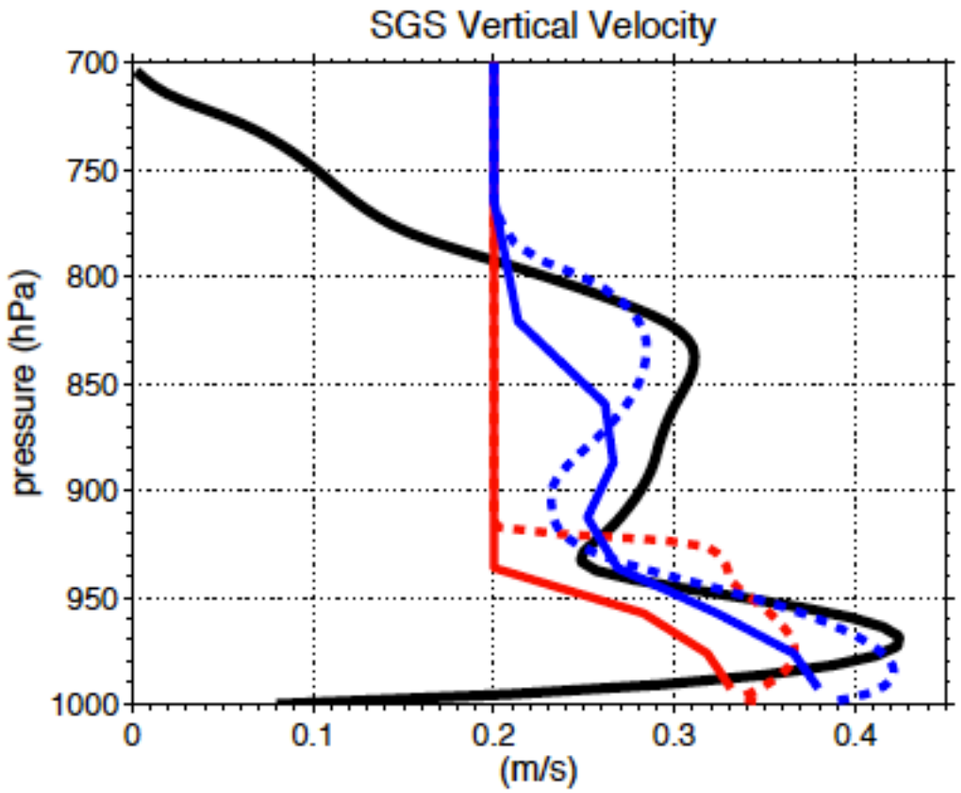
Single Column Testing

- SCAM-CLUBB tested on many boundary layer & deep convective regimes
  - Cumulus: RICO, BOMEX, ARM_CC
  - Stratocumulus: DYCOMS-RF01, DYCOMS-RF02, ATEX
  - Deep convection: GATE, TOGA, ARM97
  - Mixed phase: Storm tracks IOP

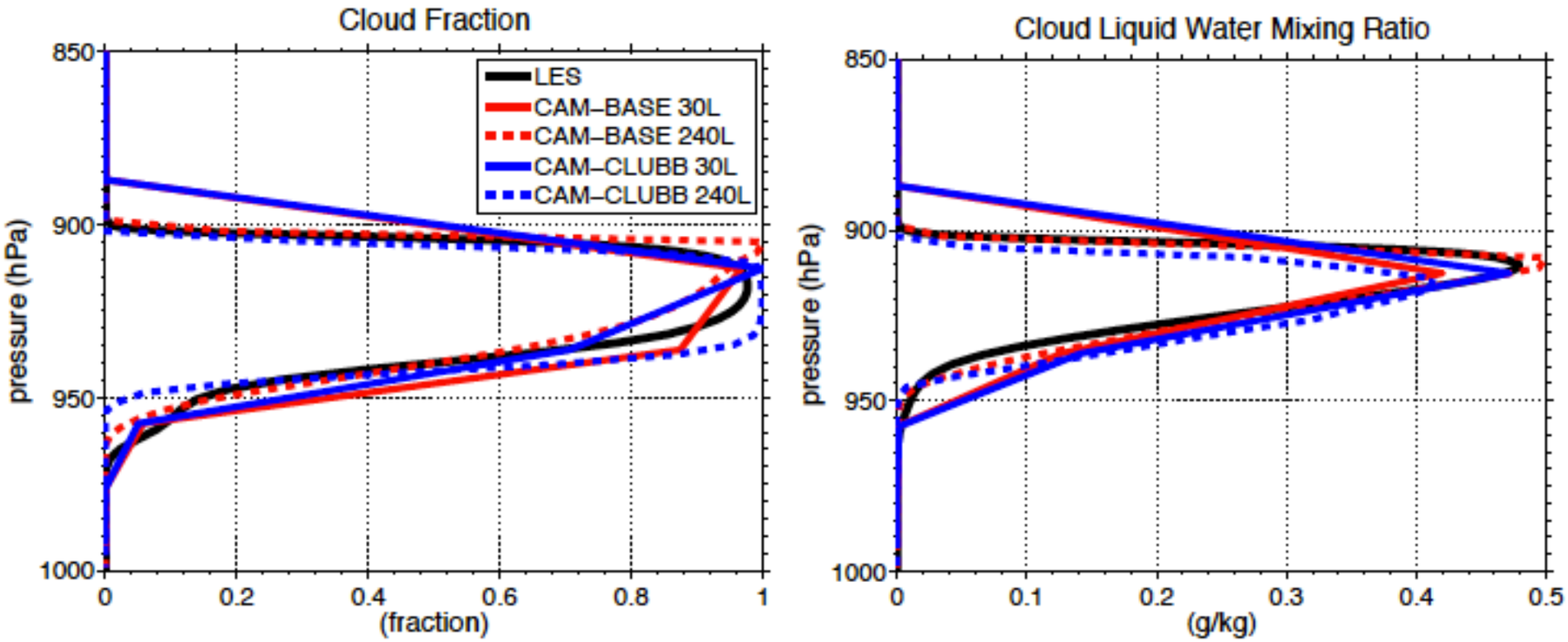
BOMEX - Shallow Trade Cu

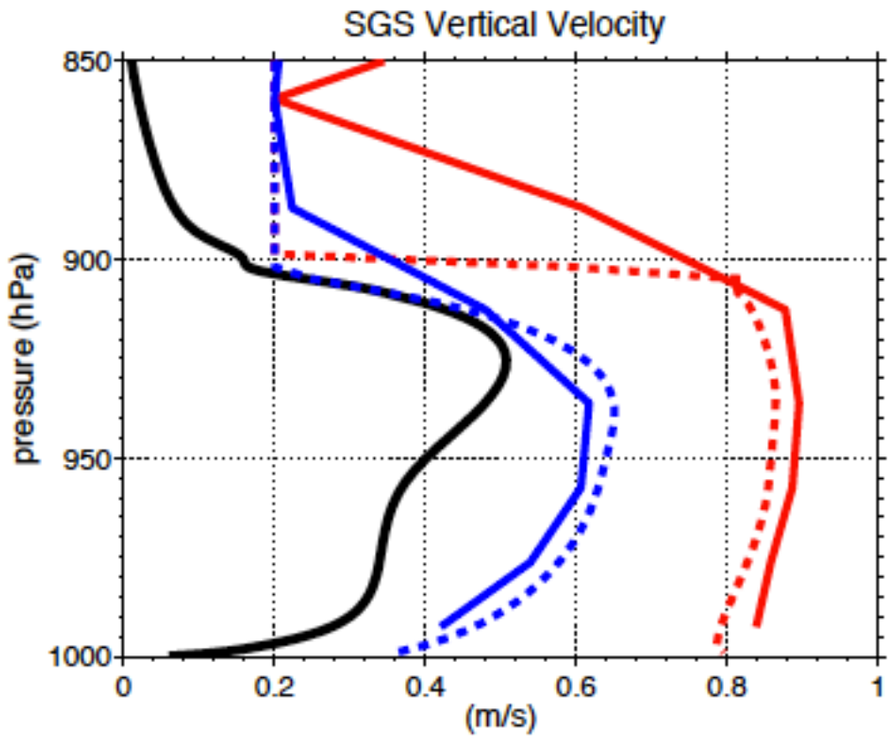






DYCOMS2-RF02 - Marine Sc



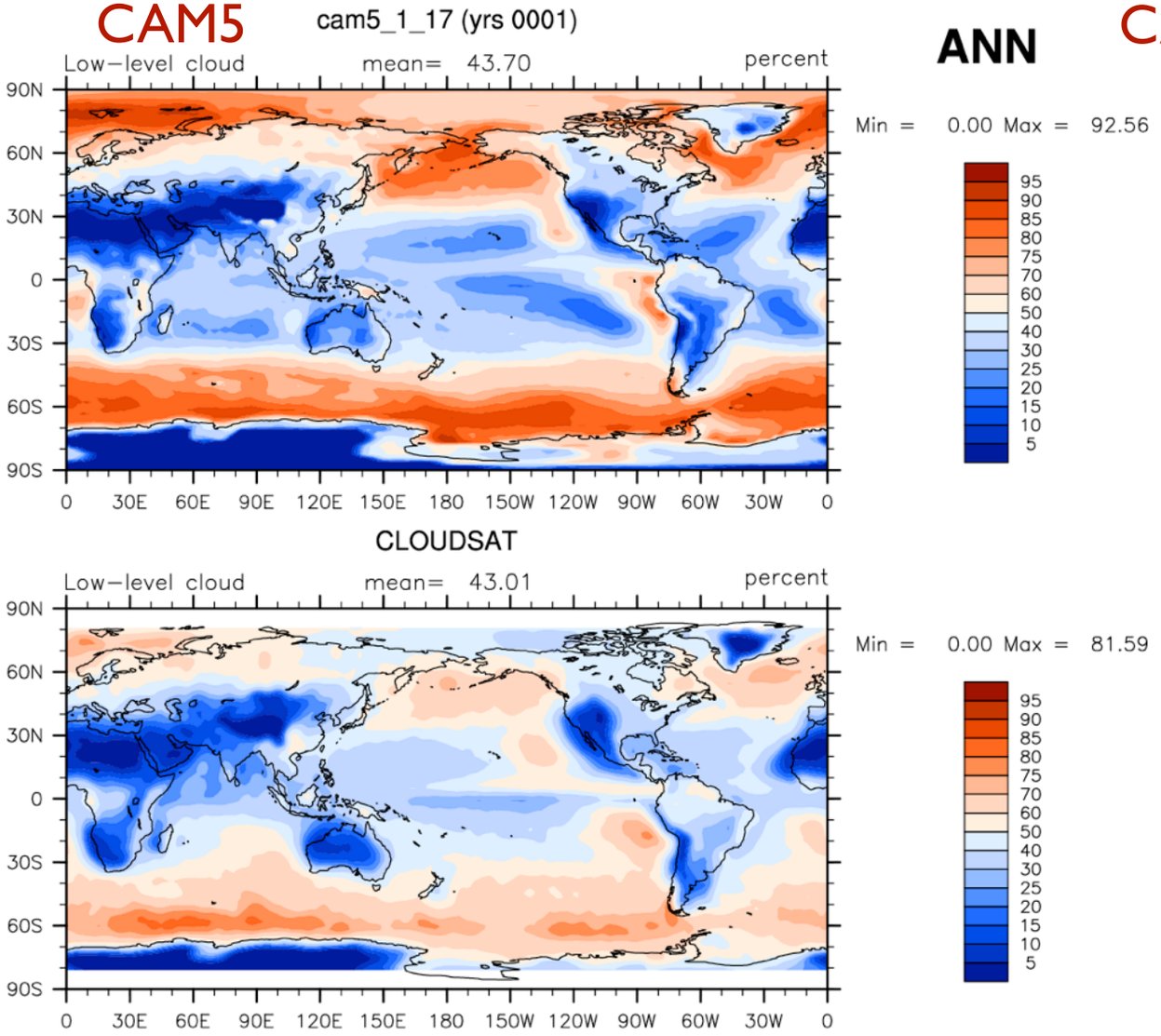


Current Issues/Questions We Are Facing Globally

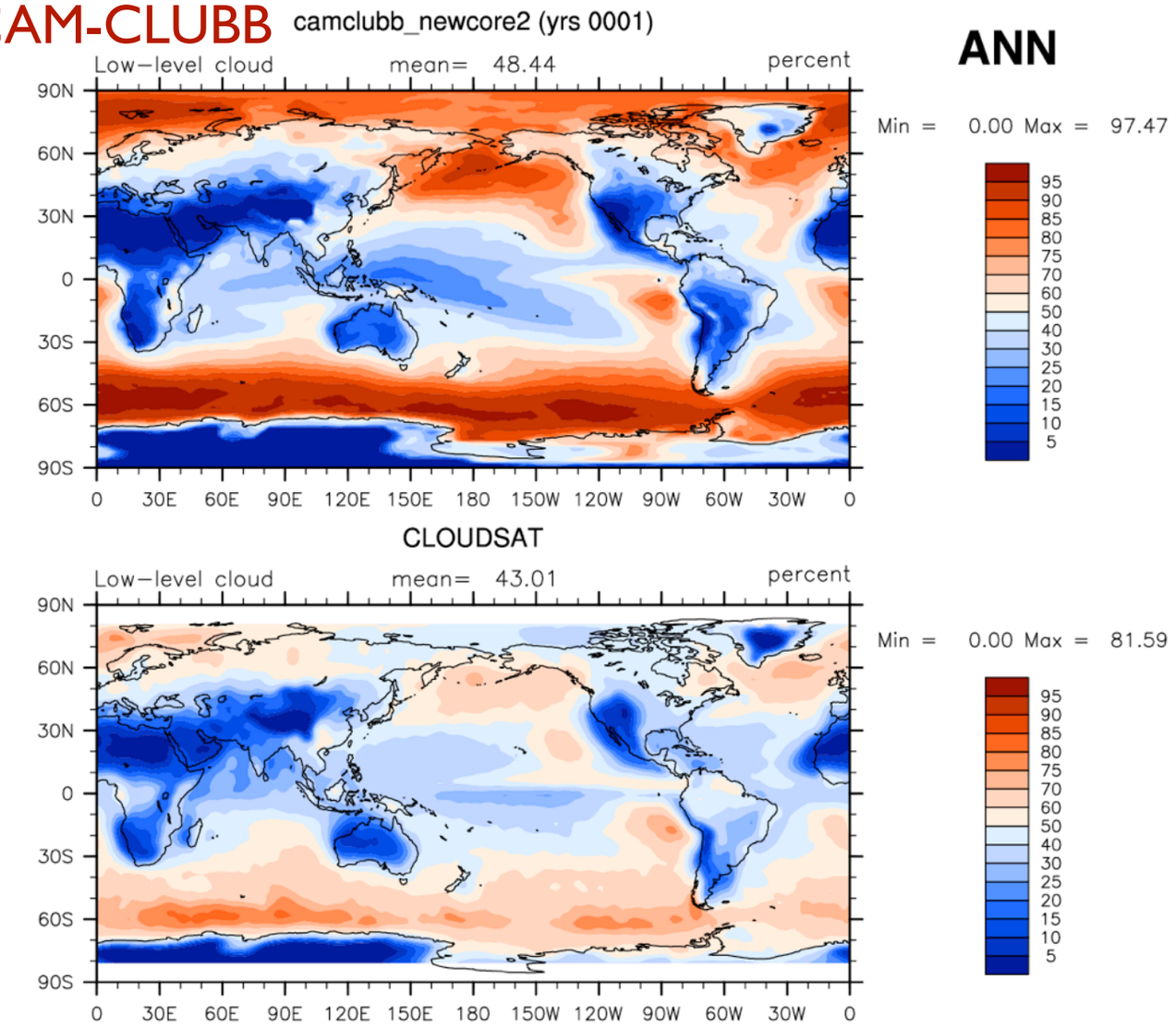
- Trade-Wind Cumulus do not precipitate enough via MG, leading to "anvils" at cumulus top and SWCF distributions that are not ideal
  - Work at UWM provides strong evidence that prognostic precipitation microphysics (i.e. Morrison microphysics) ameliorates this issue
  - Temporary kludge: Increase precipitation efficiency by tuning accretion rates
  - Long term solution (~6 months): Implementation of MG2 (prognostic precip)
- Storm track regions (especially SH), look wildly different than CAM-BASE
- Seasonal simulation of marine Sc is a persistent problem in CAM-CLUBB

Low Cloud Amounts

CAM5



CAM-CLUBB



CLOUDSAT

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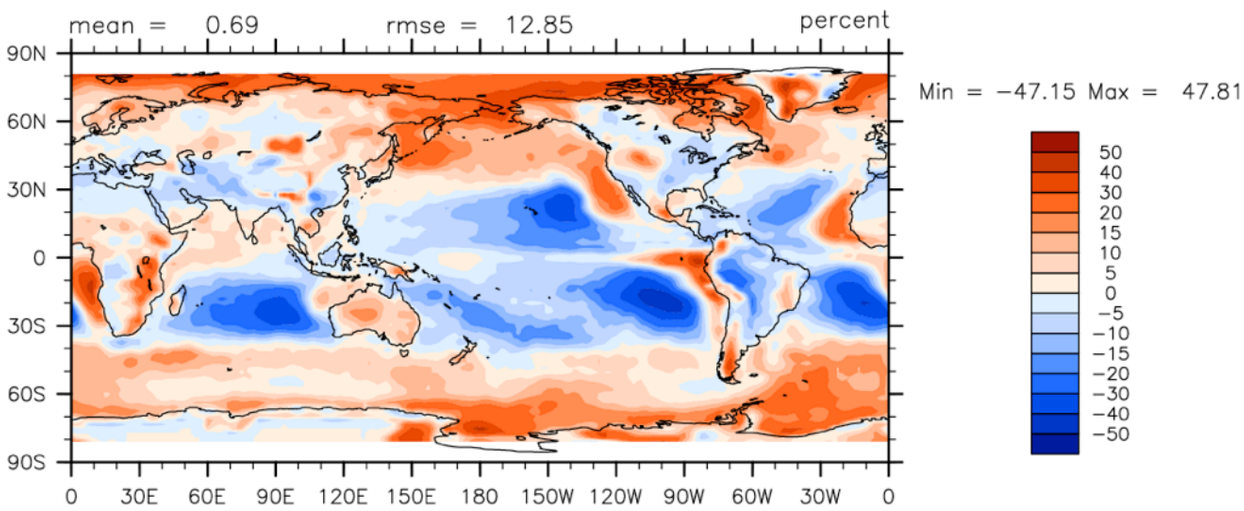
cam5_1_17 - CLOUDSAT



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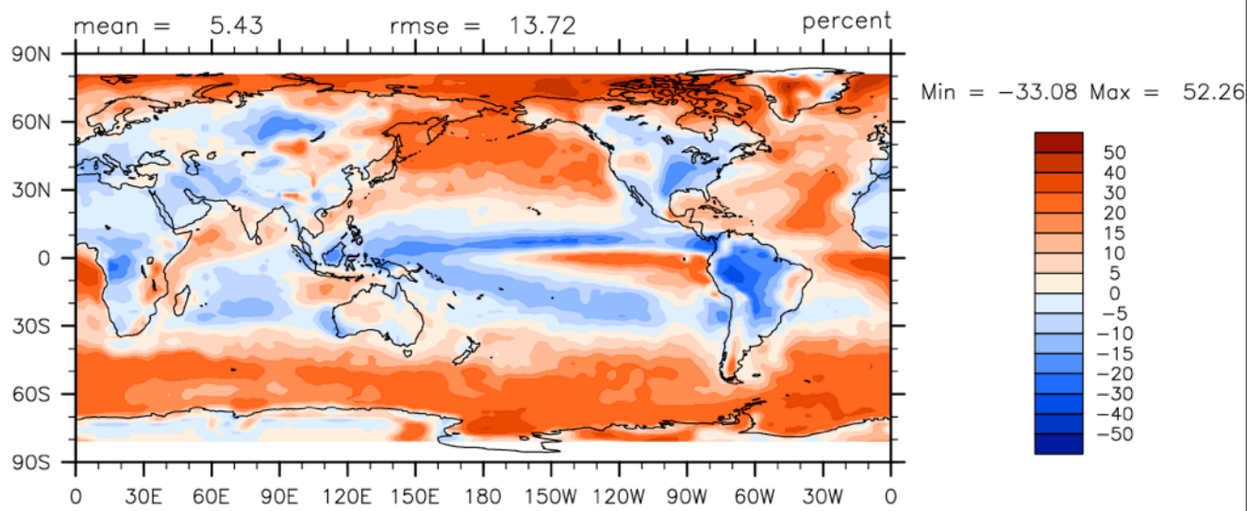
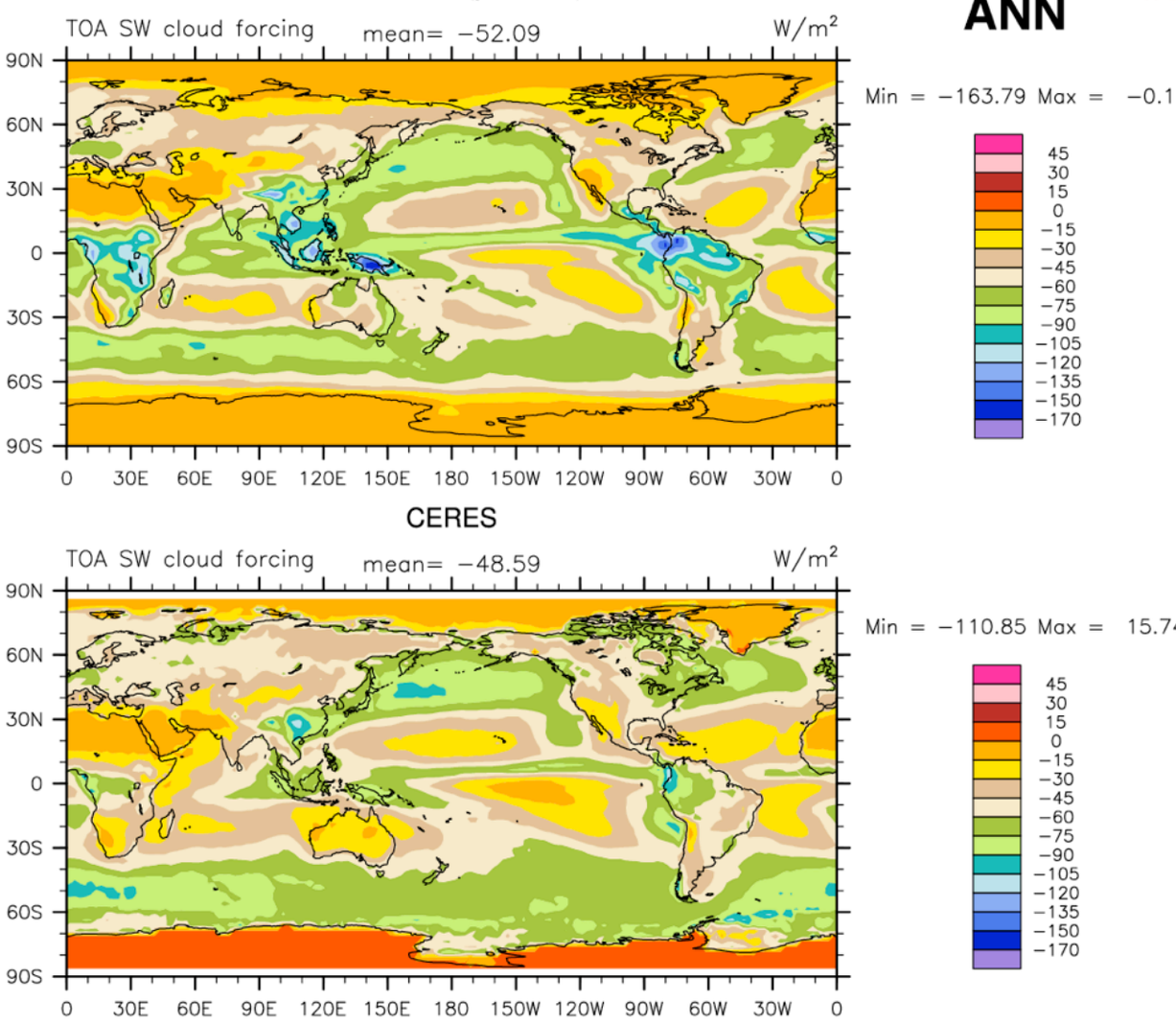


Shortwave Cloud Forcing

CAM5



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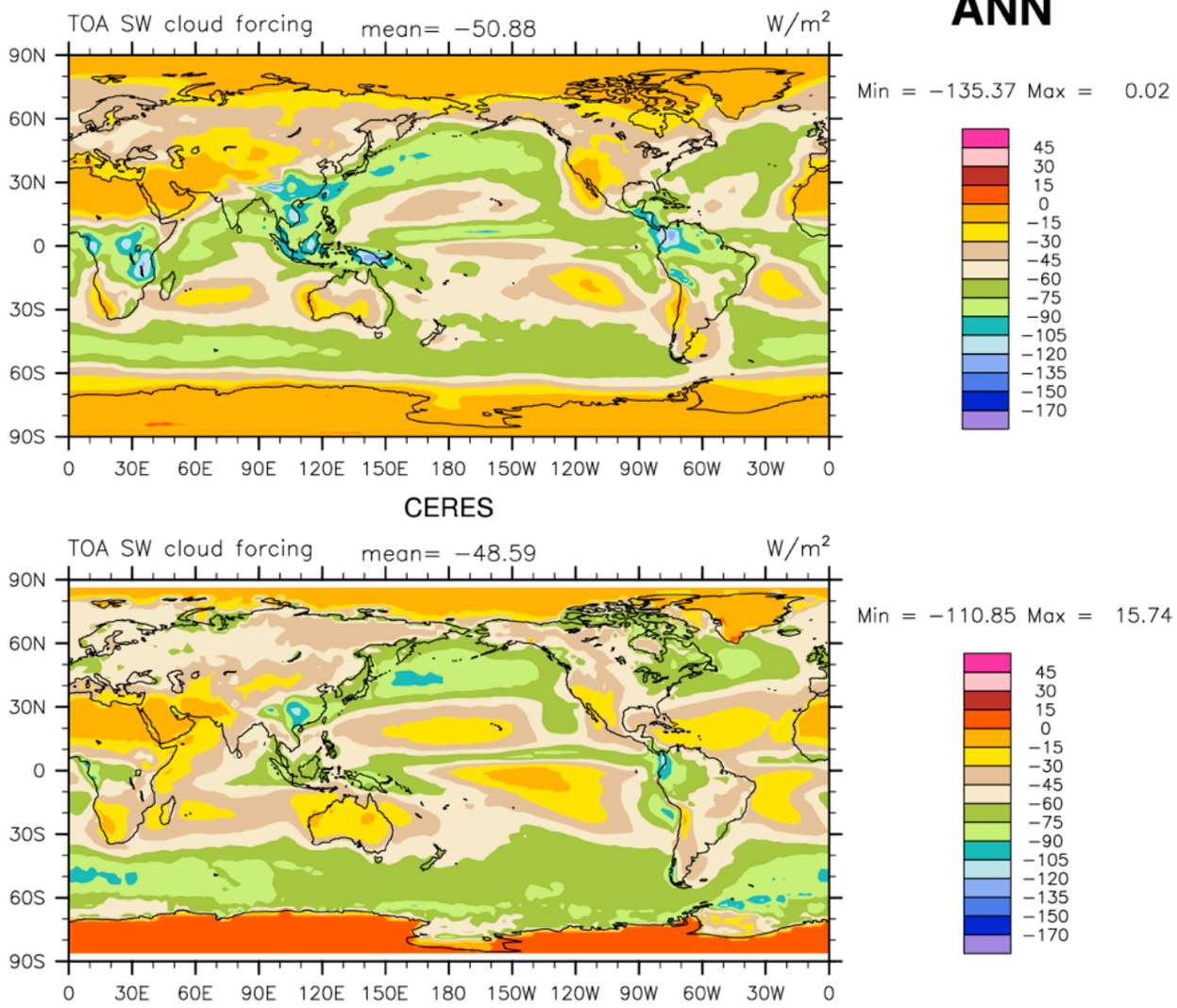

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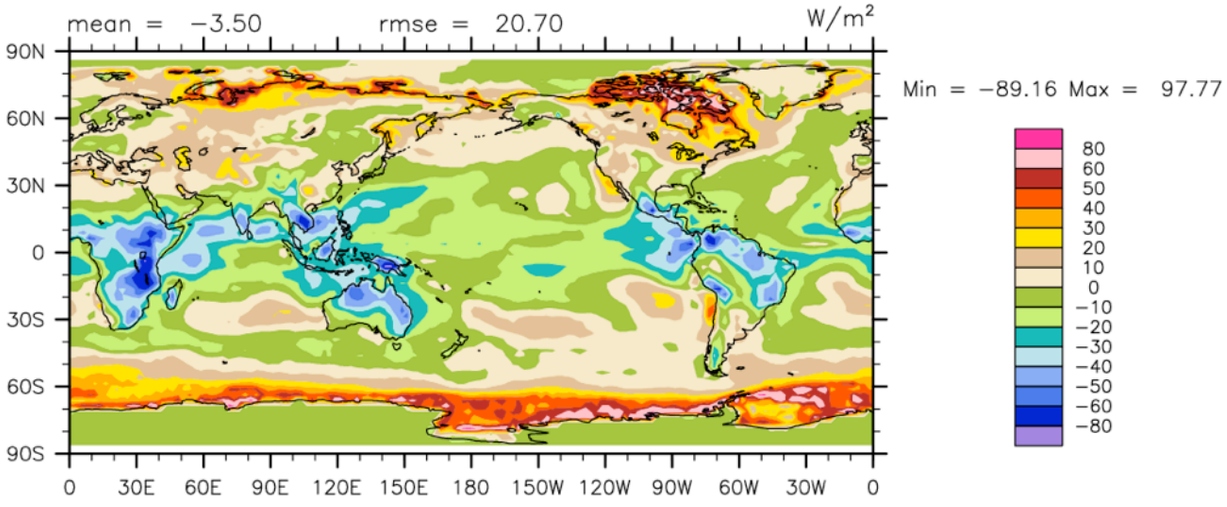

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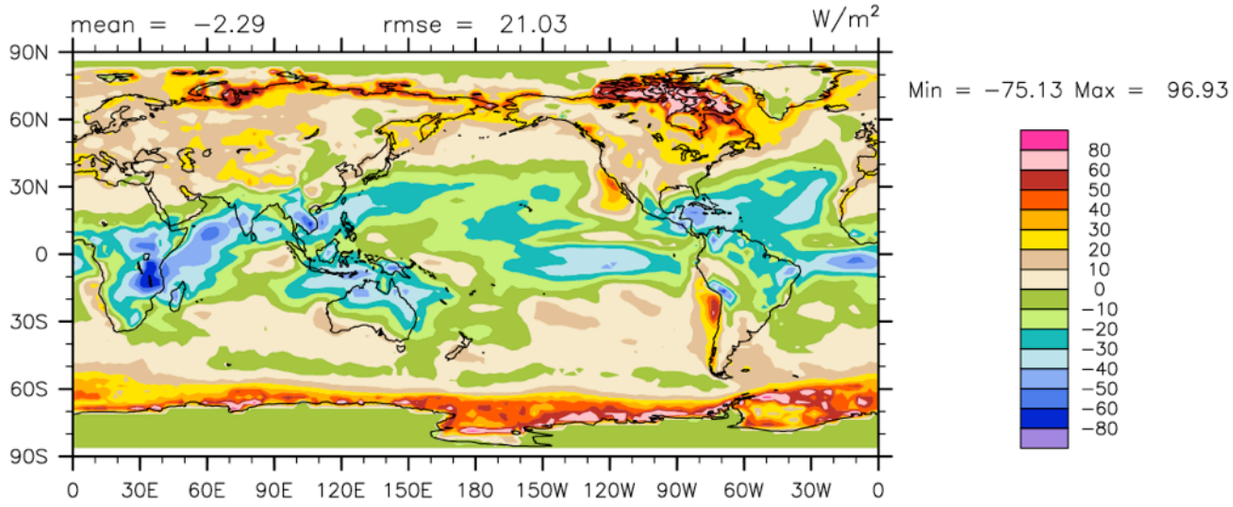
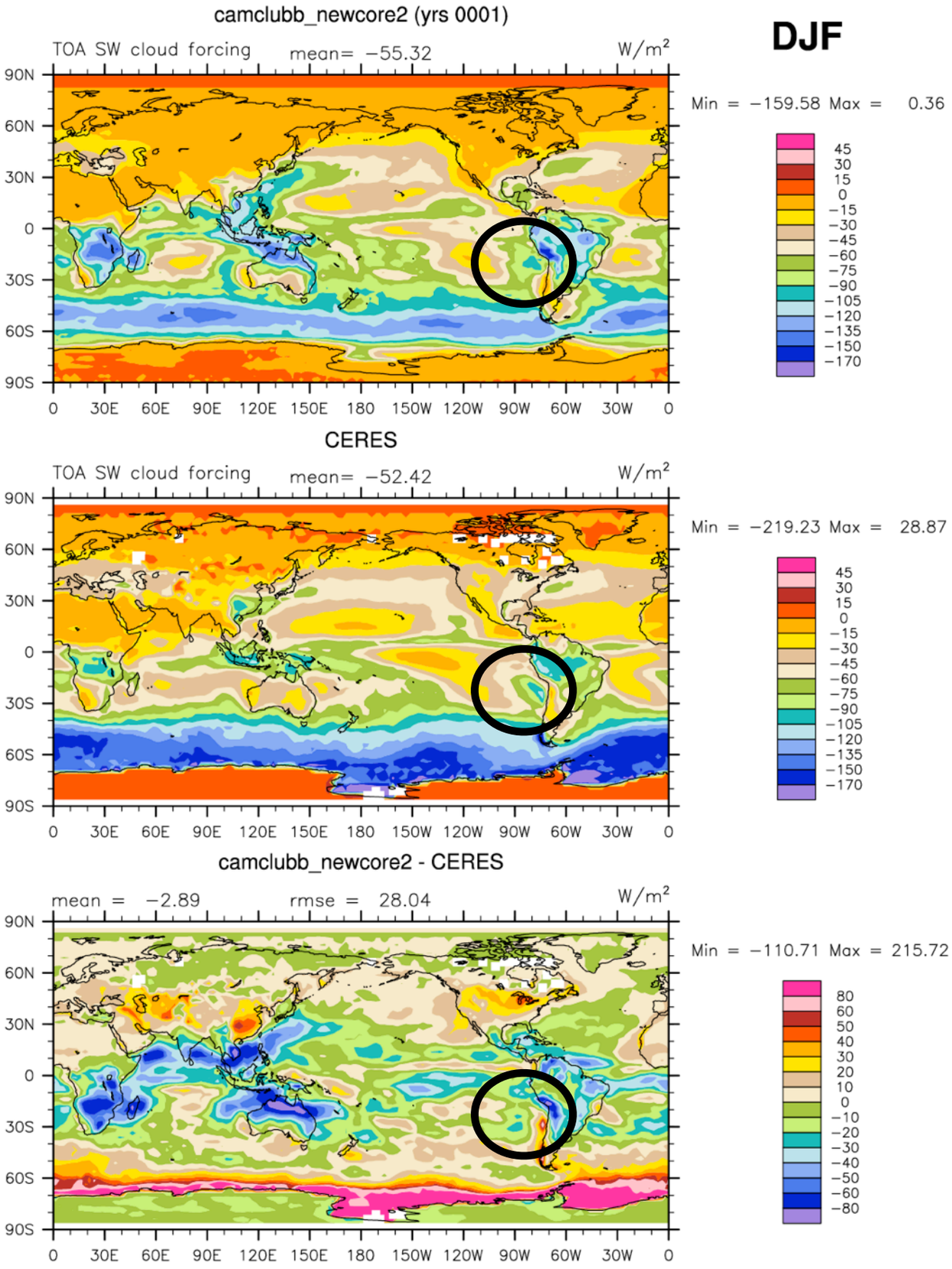


Problem: Seasonal Simulation of Sc

CAM-CLUBB



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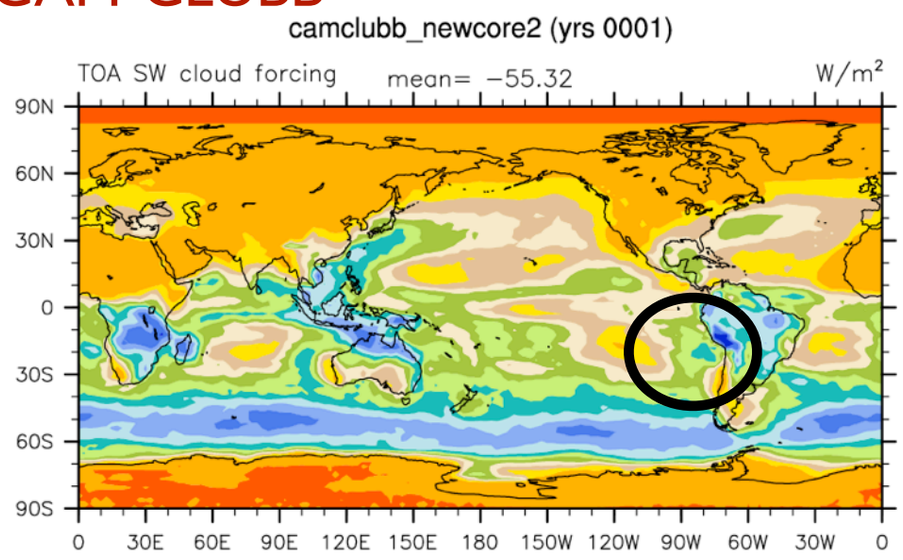

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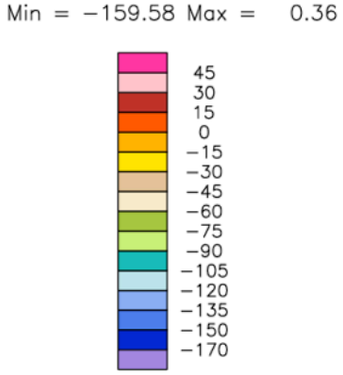

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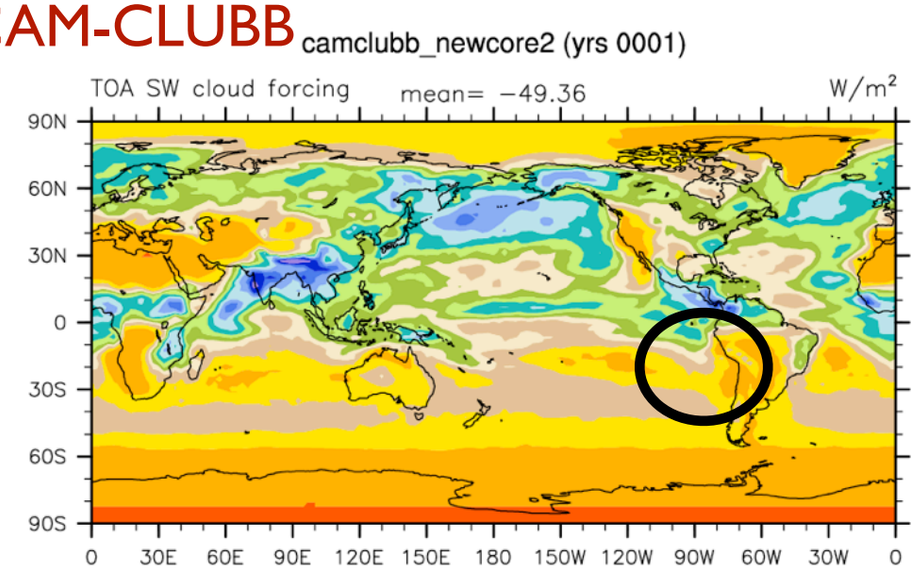

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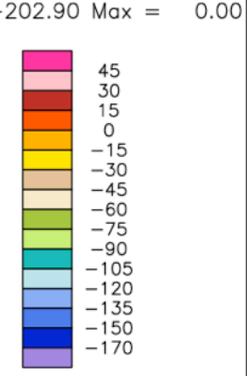

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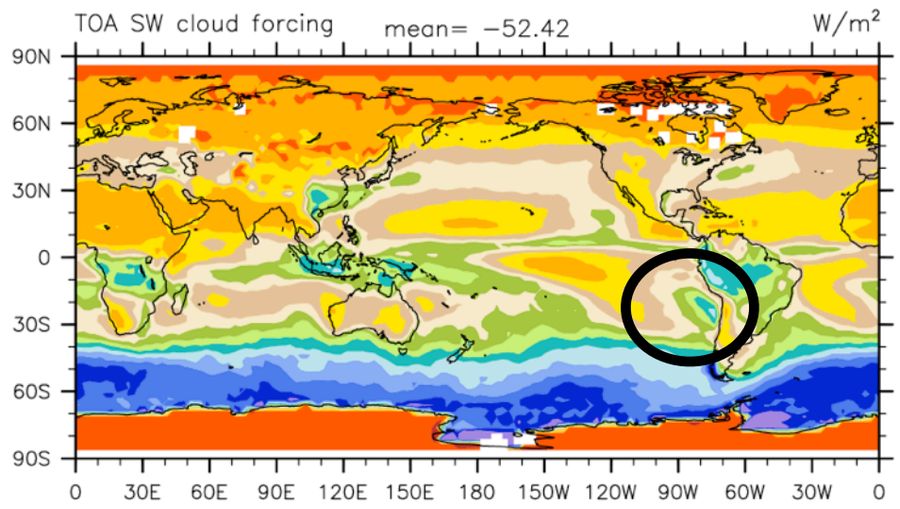

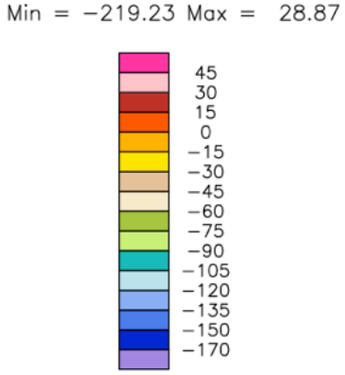

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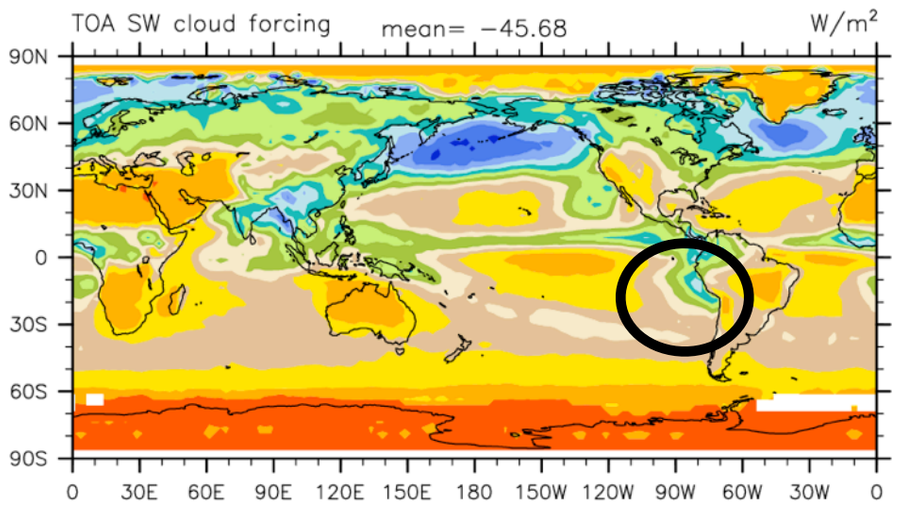

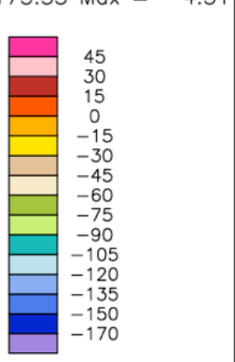

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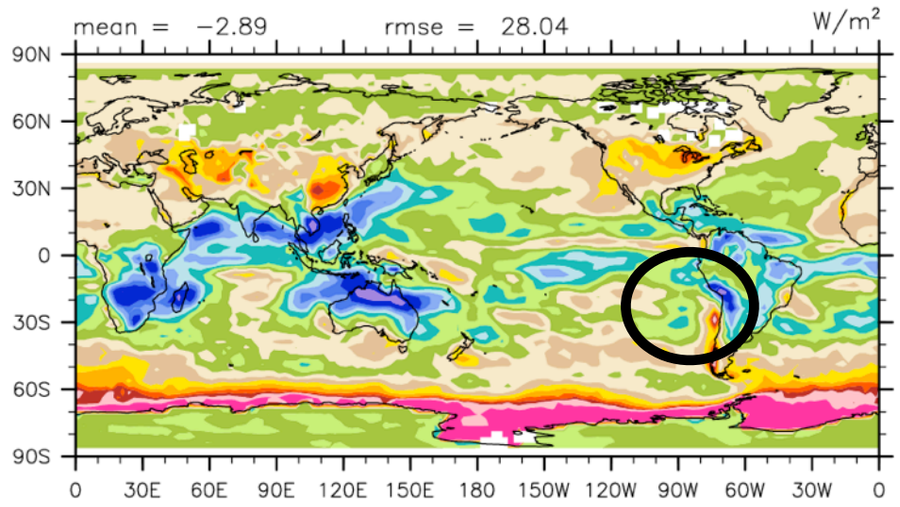

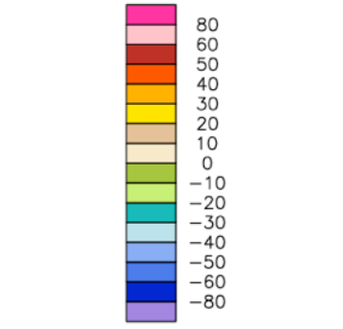

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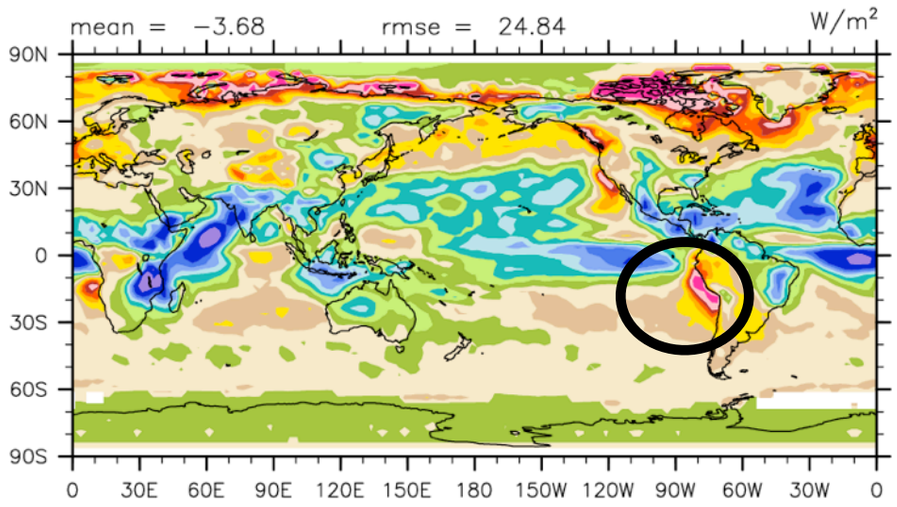
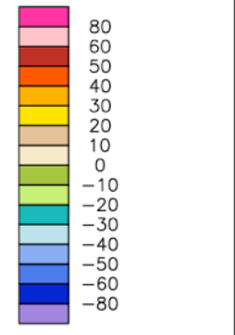
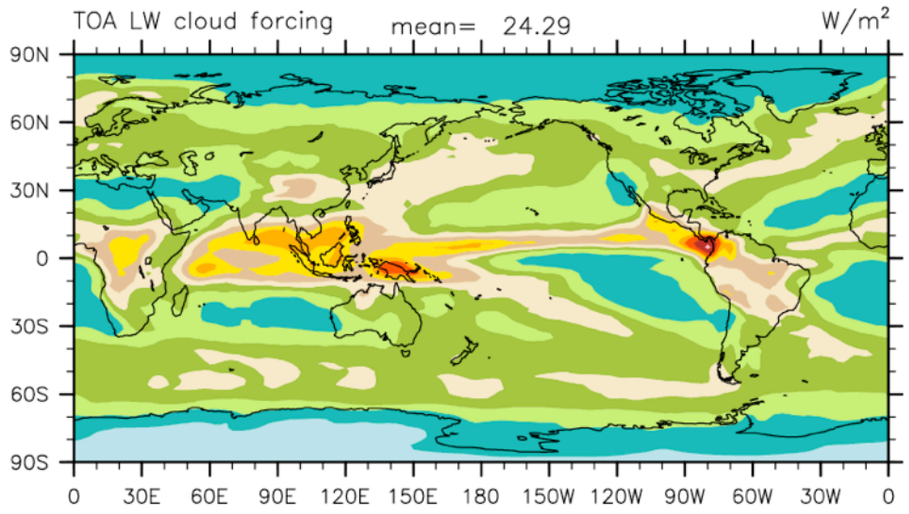




Longwave Cloud Forcing

CAM5

cam5_1_17 (yrs 0001)



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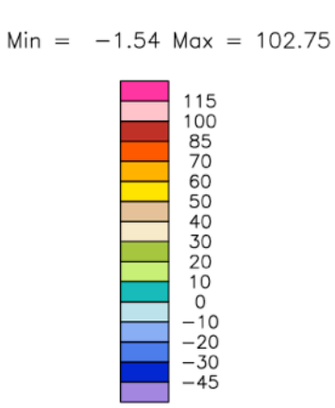

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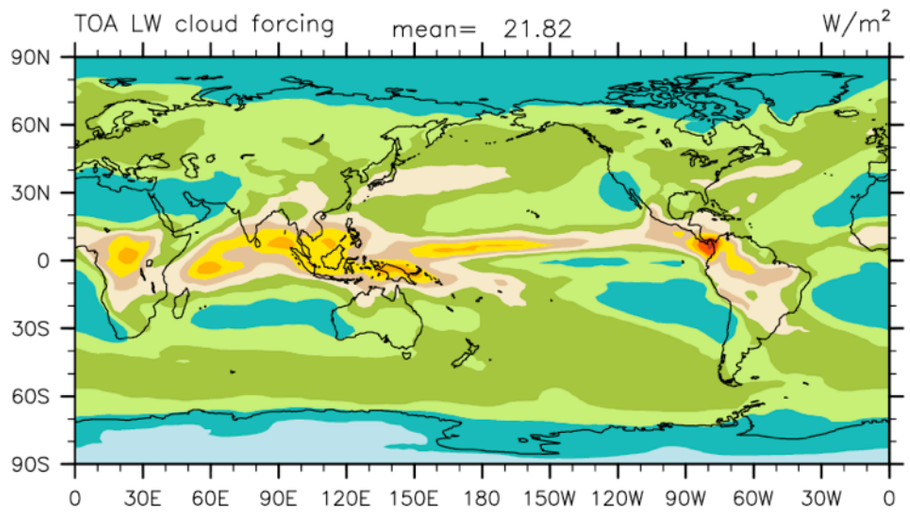

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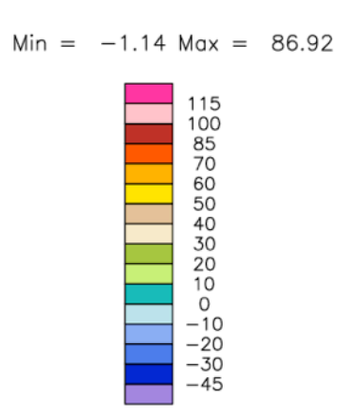

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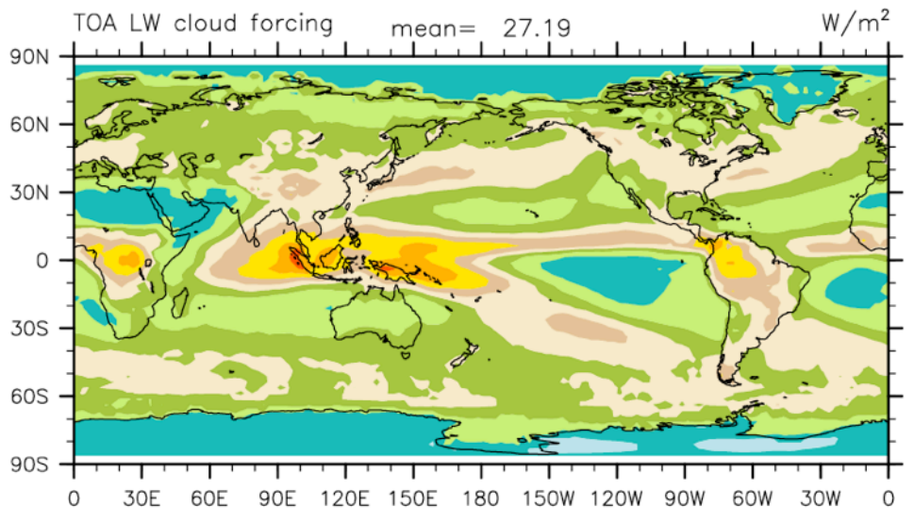

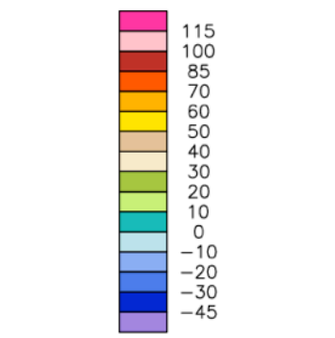

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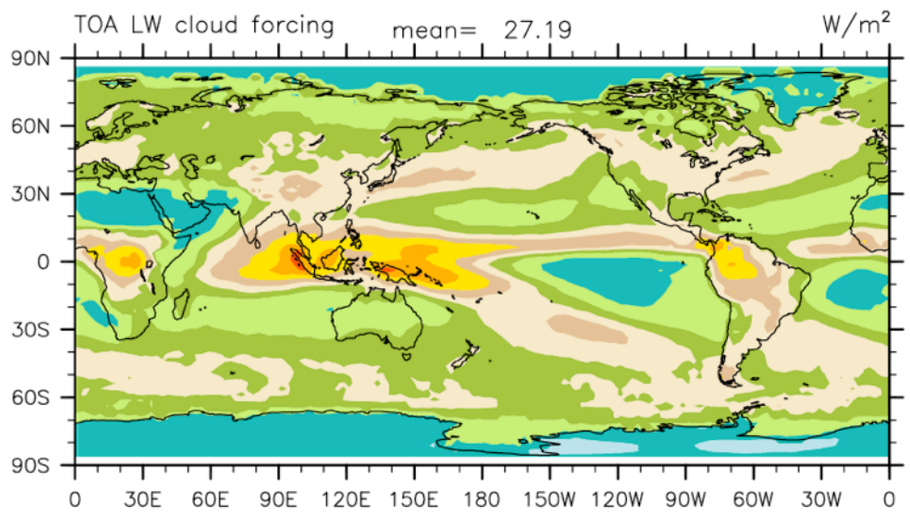

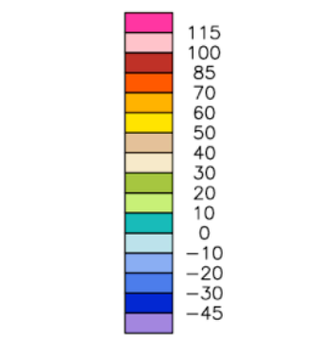

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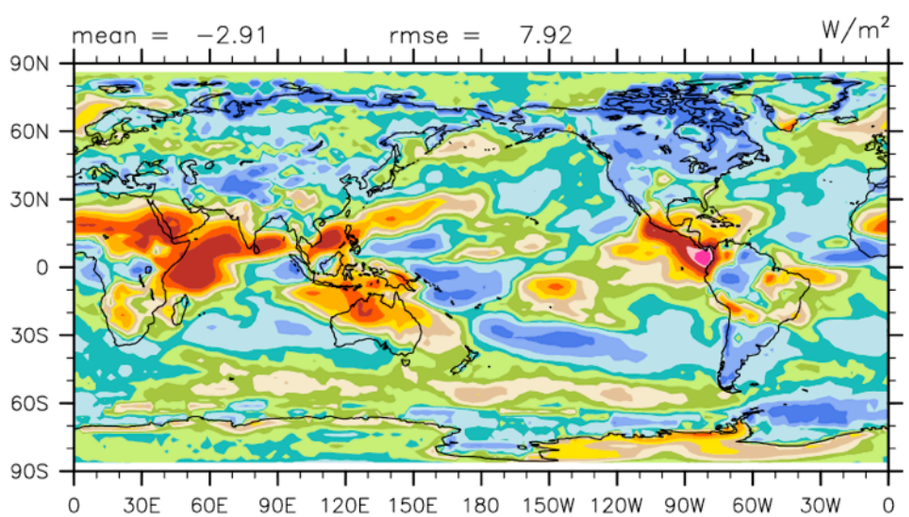

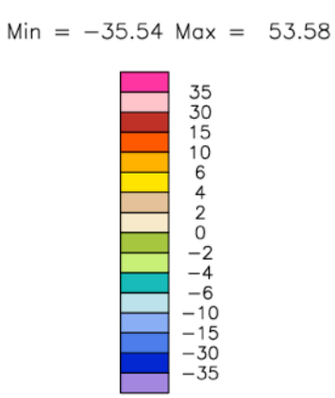

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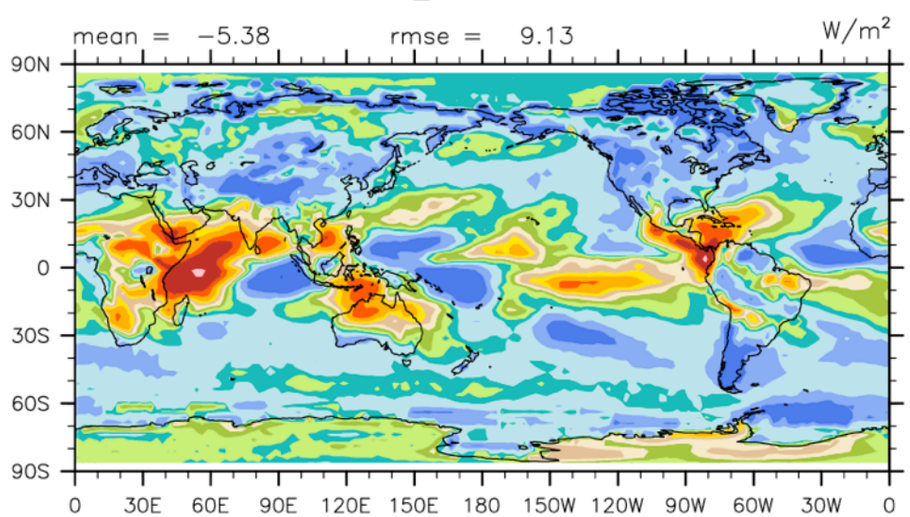
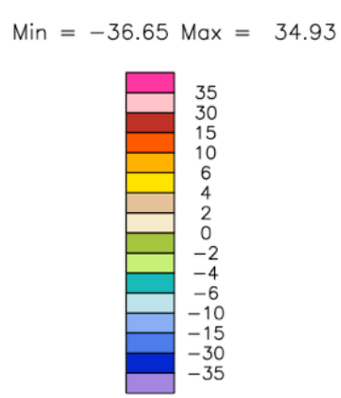
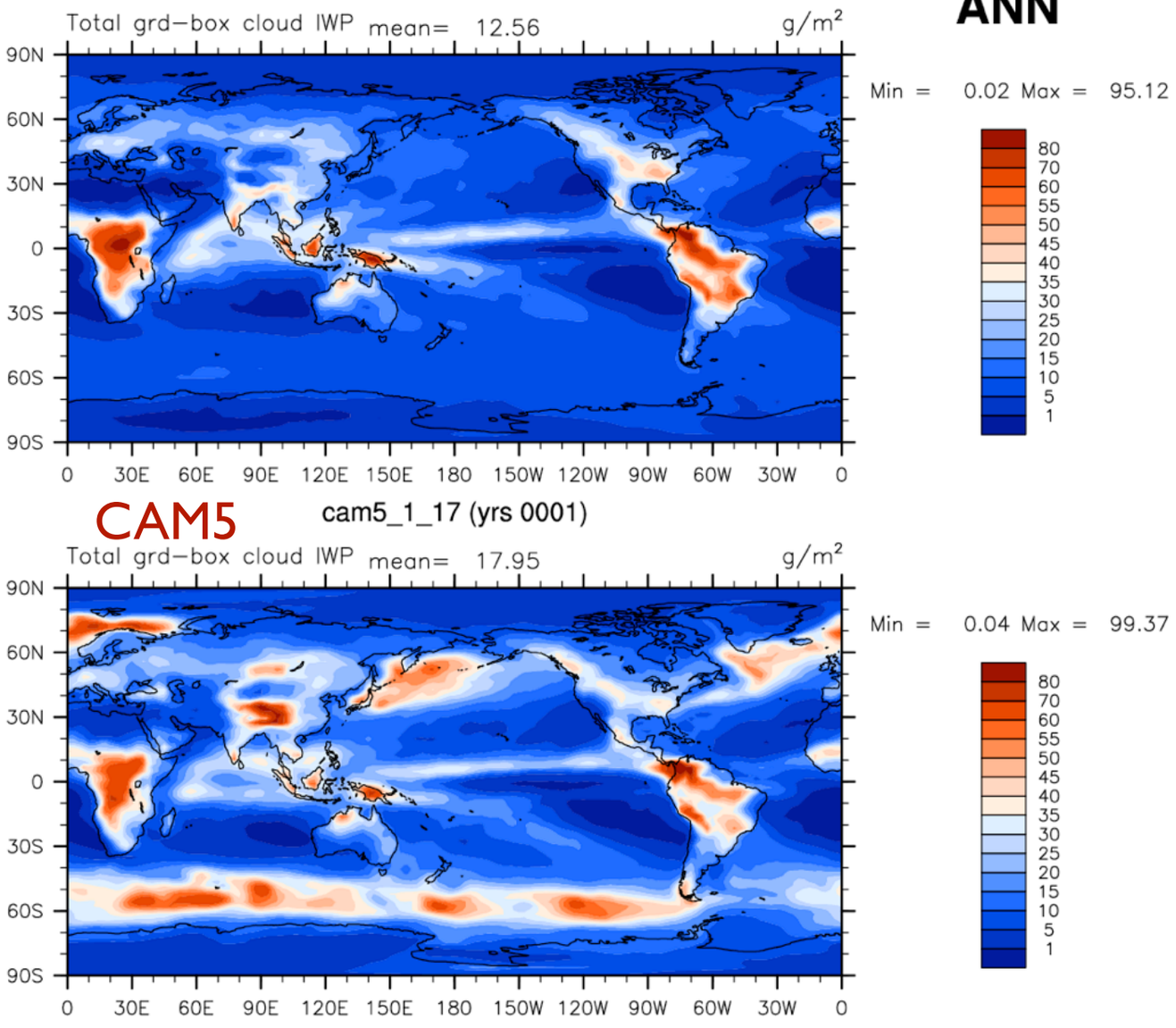




Ice Water Path

CAM-CLUBB camclubb_accre6 (yrs 0001)



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CAM5 cam5_1_17 (yrs 0001)

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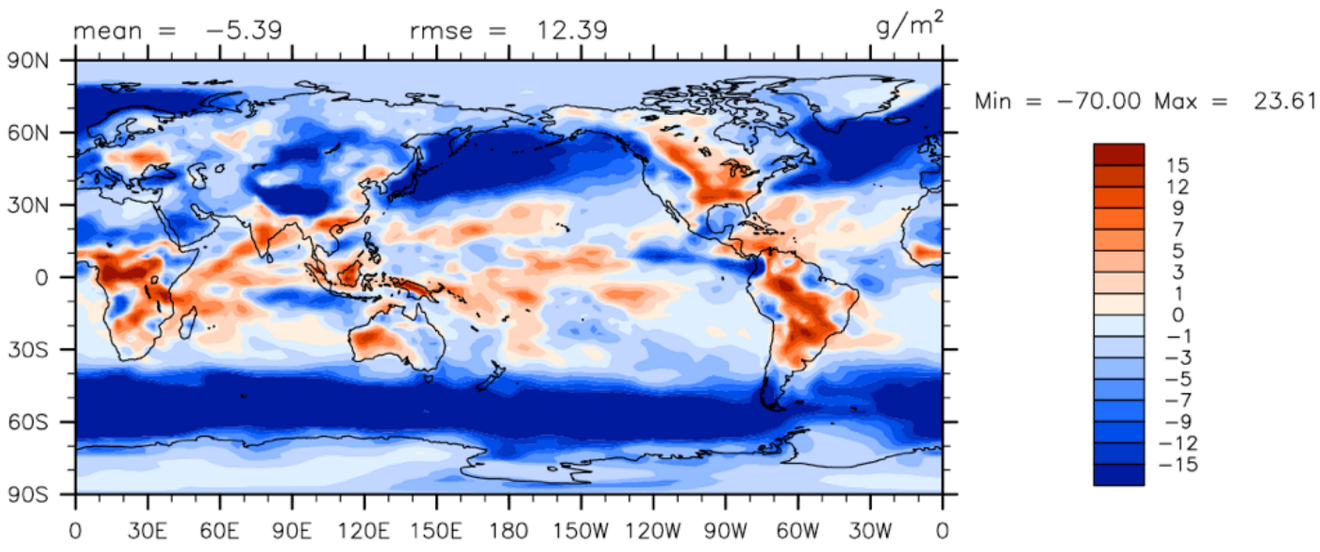
camclubb_accre6 - cam5_1_17



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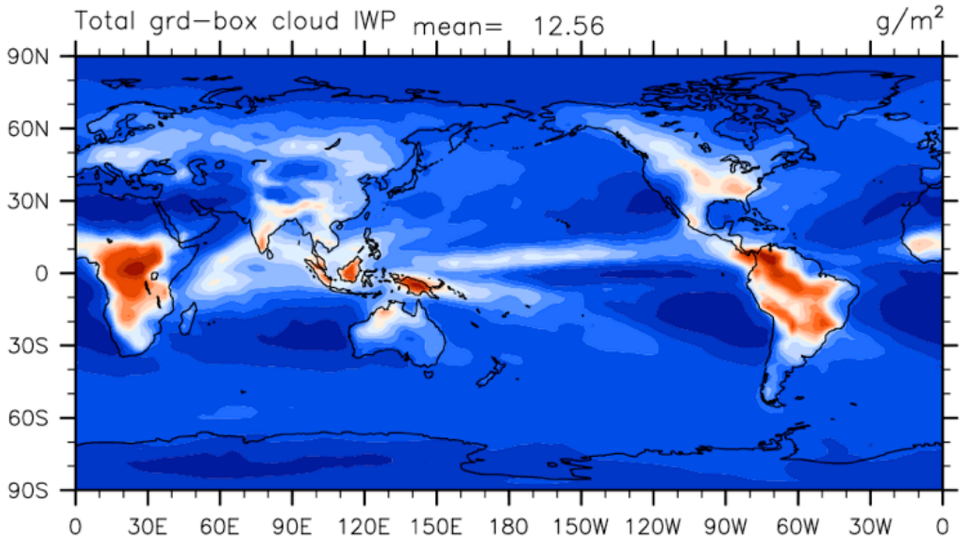
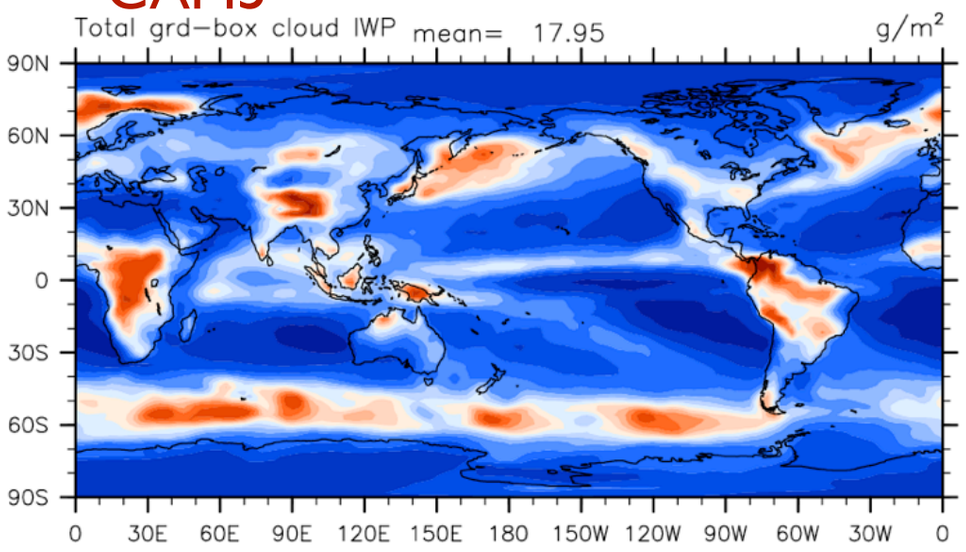
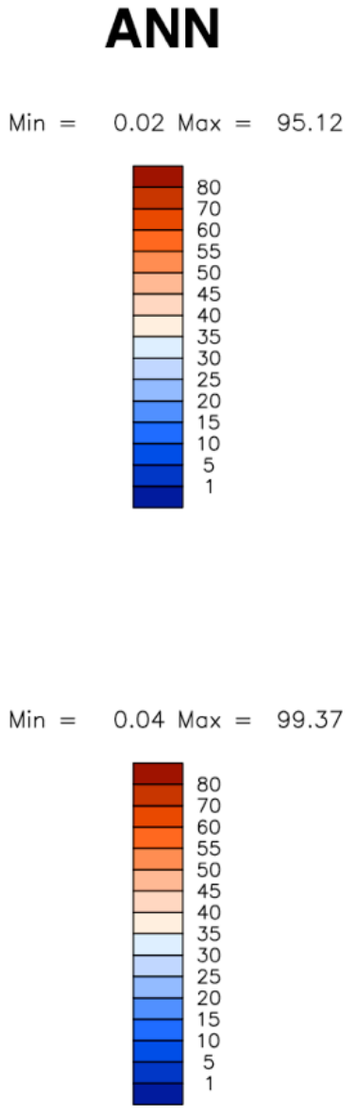
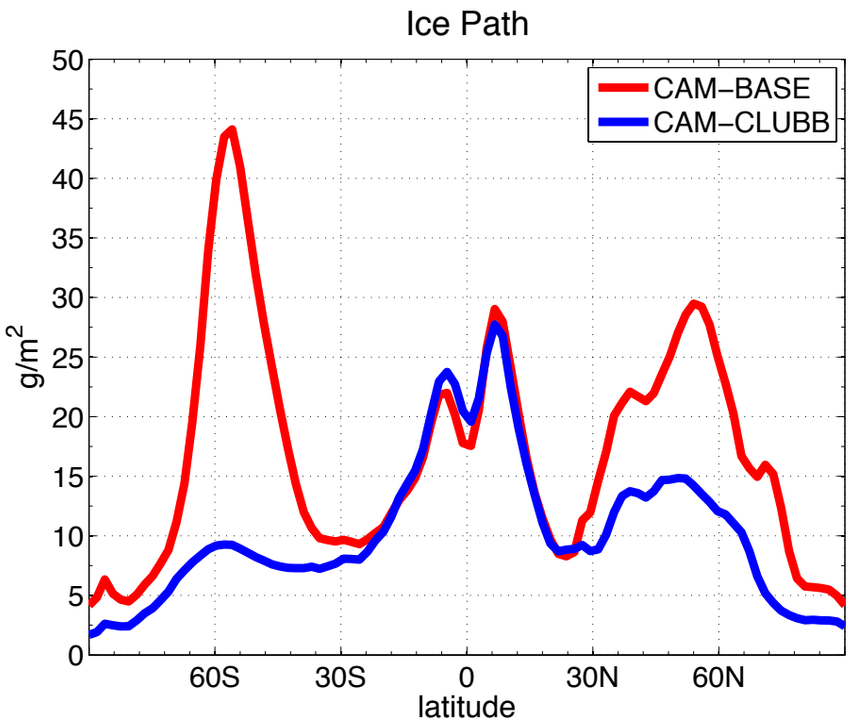
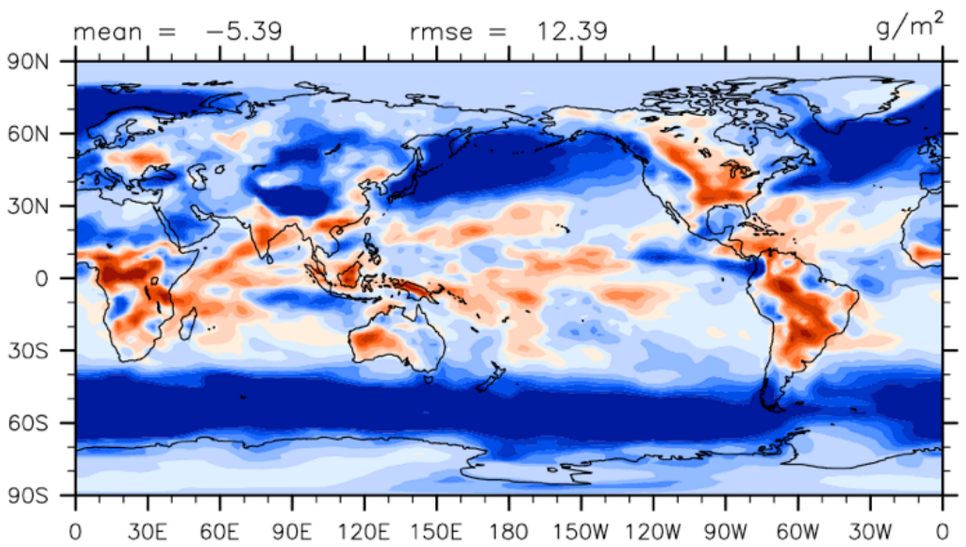
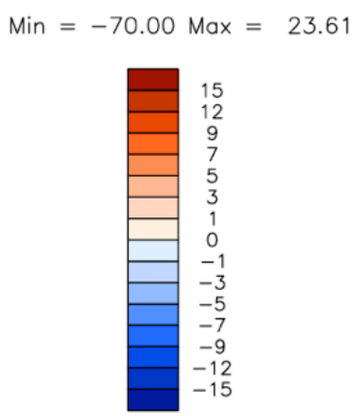




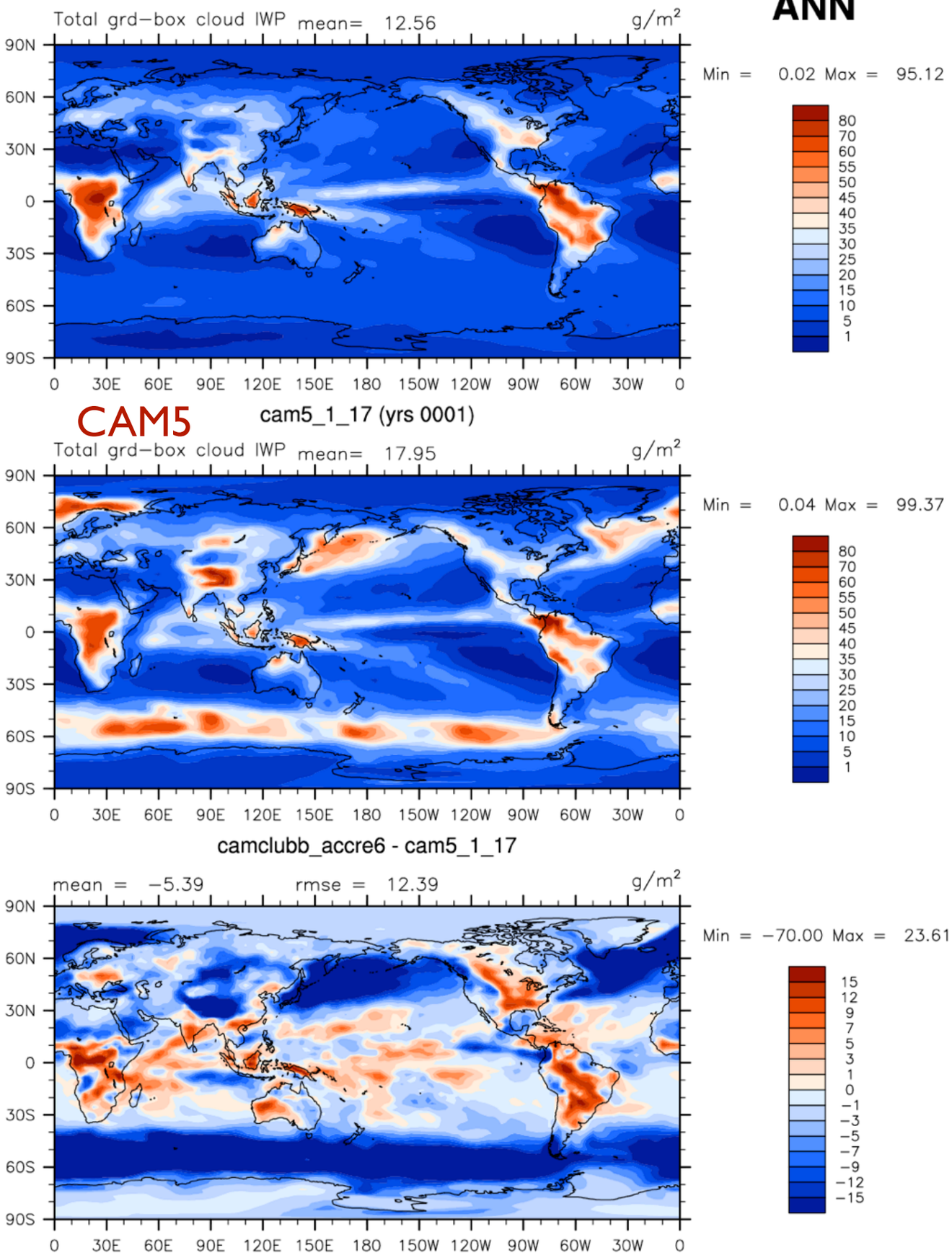


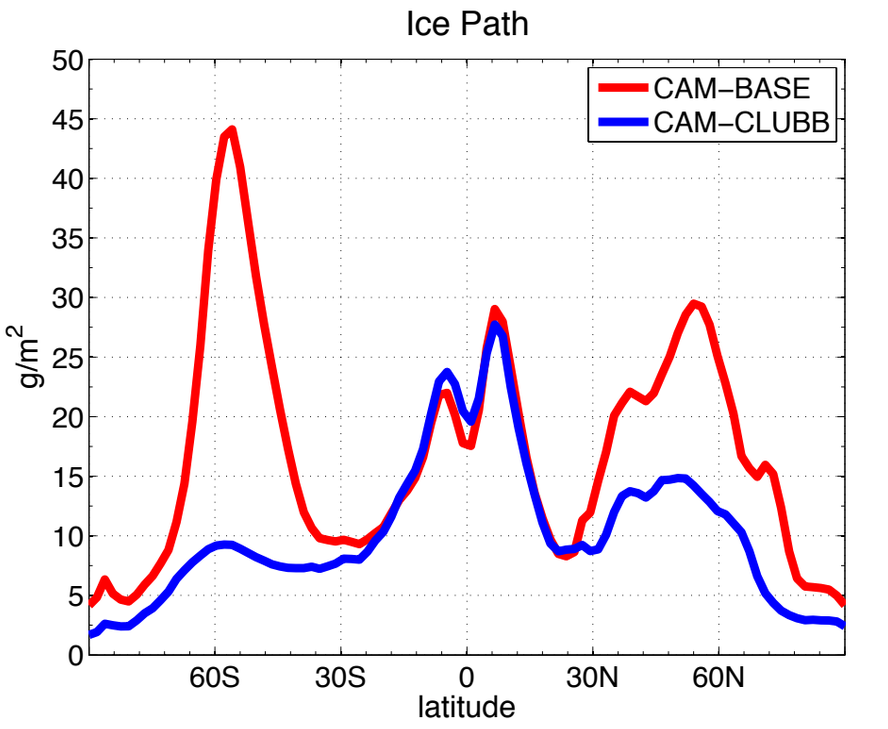


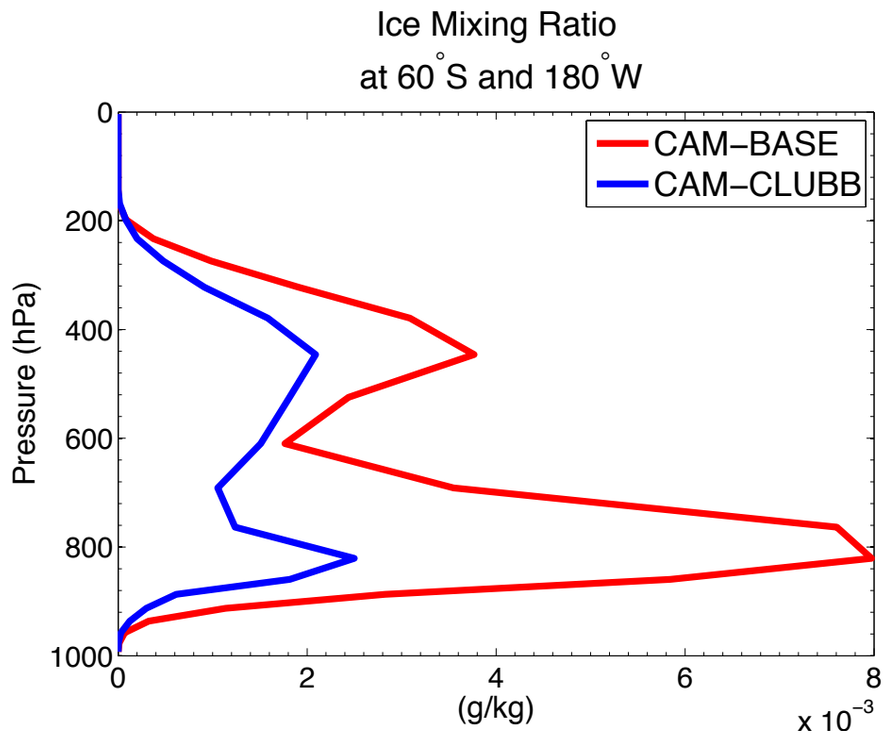


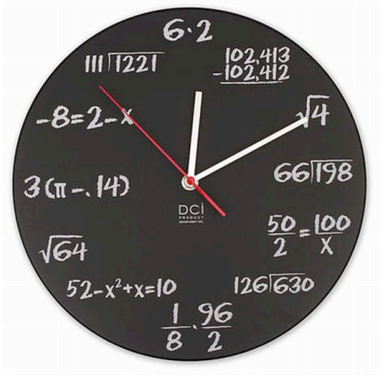


Ice Water Path

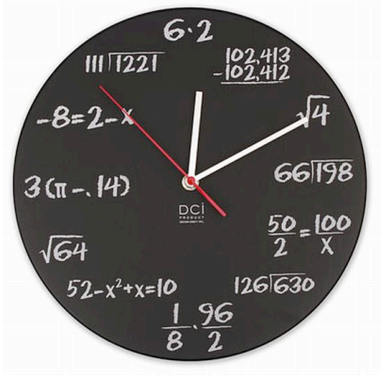








Summary & Future Plans



- CAM-CLUBB is alive but premature
- Within striking distance of CAM5 for many scoring metrics... but not quite there yet.
- Still several issues to address, can utilize SCAM (i.e. seasonal Sc, storm tracks)
- Future work will involve moving to sub-columns
- More astute examination with observations (i.e. COSP)
- Investigate aerosol indirect effects and climate sensitivity