Radiative Processes for CAM4

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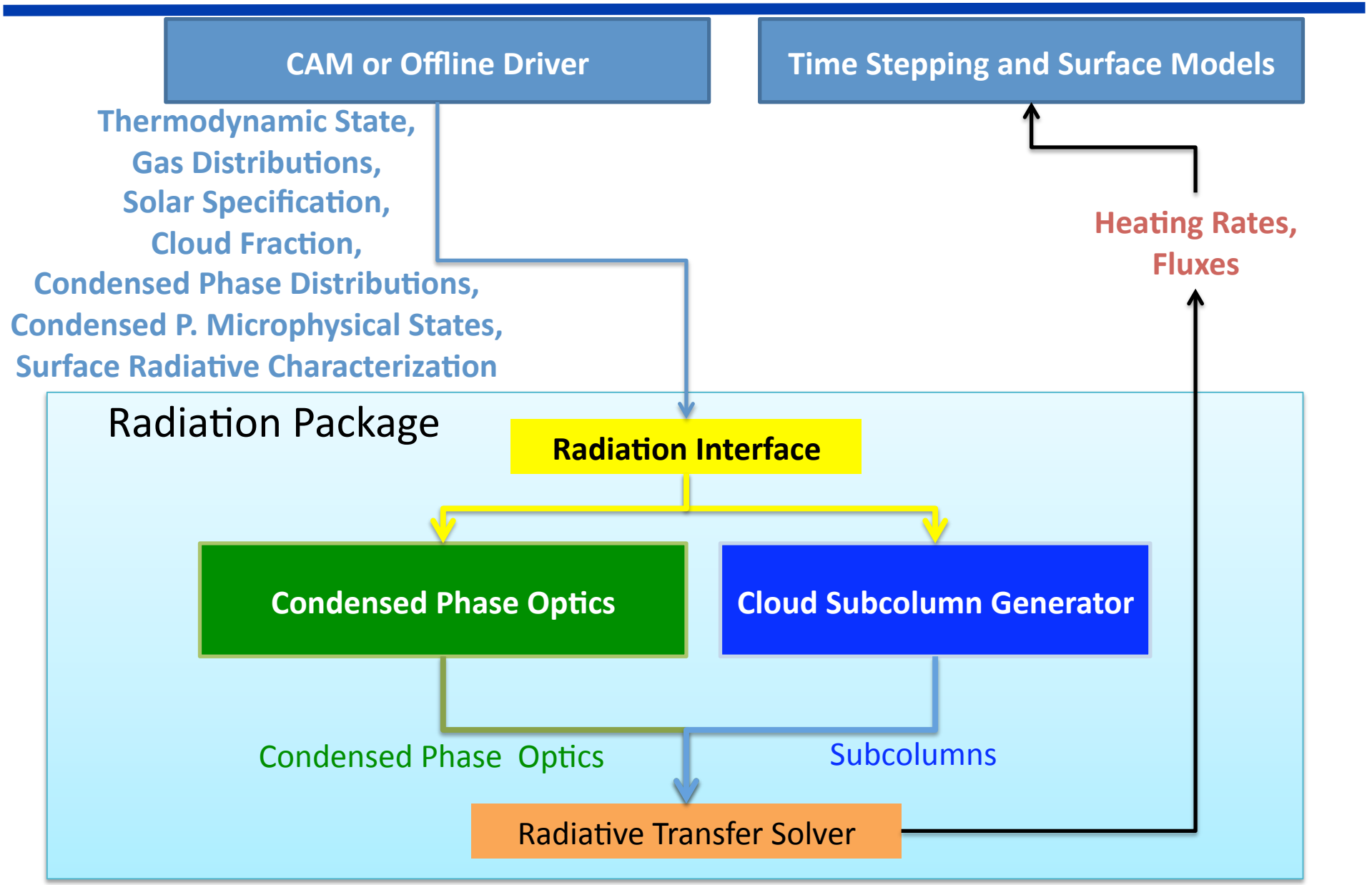
Schematic of new radiation



Current status

- RRTMG is default RT method for CAM & CCSM

- Developments last AMWG meeting:
  - Completion of integration of RRTMG with CAM
  - Development of optics for clouds and aerosols
  - Science tests to understand OLR bias for clear skies

Condensed phase optics

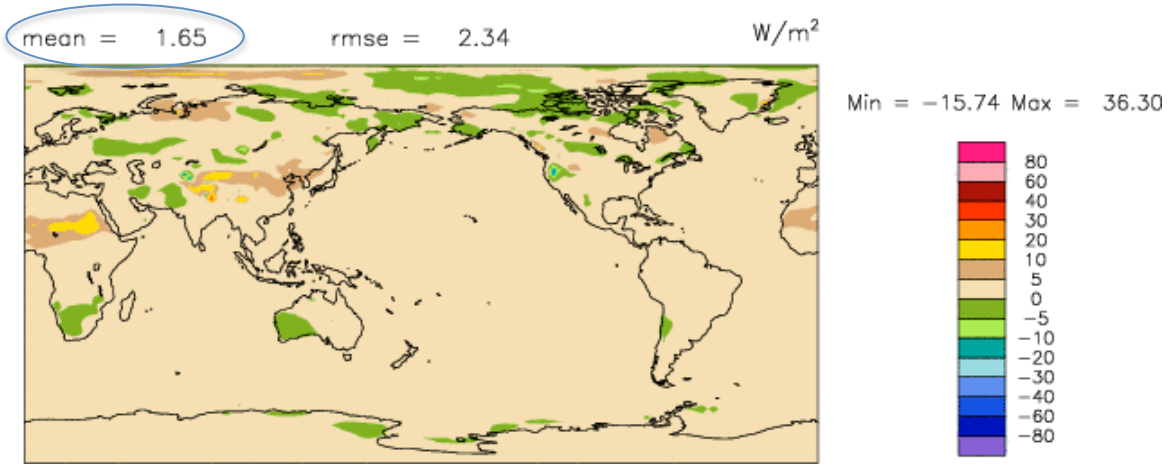
1. All new optics are designed for RRTMG

2. Cloud optics
   - Liquid cloud (MG µphysics): Conley optics
   - Ice cloud (MG µphysics): Mitchell optics

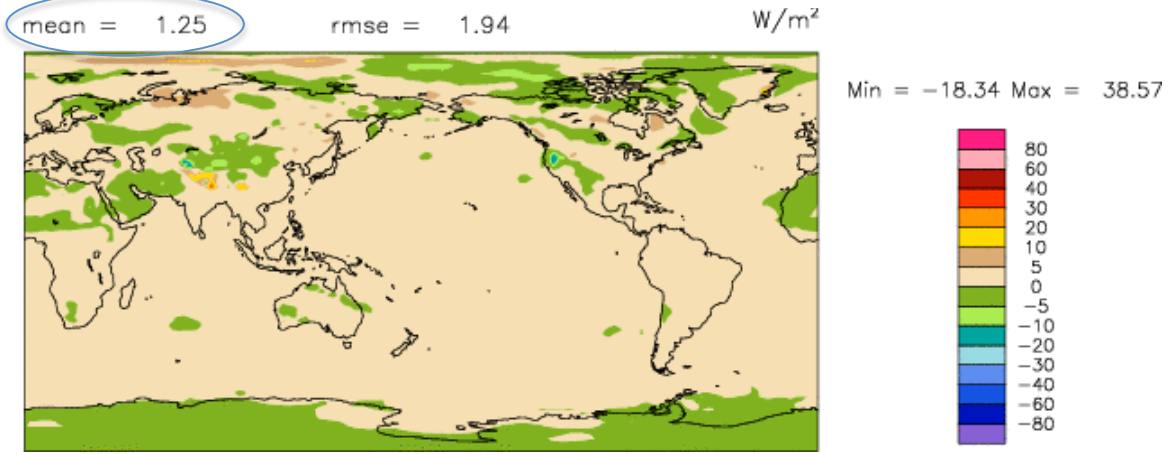
3. Aerosol optics
   - Bulk aerosol model: Ghan optics
   - Modal aerosol model: Ghan optics

New aerosol optics

TOA Clear-sky Shortwave: New – Old Optics

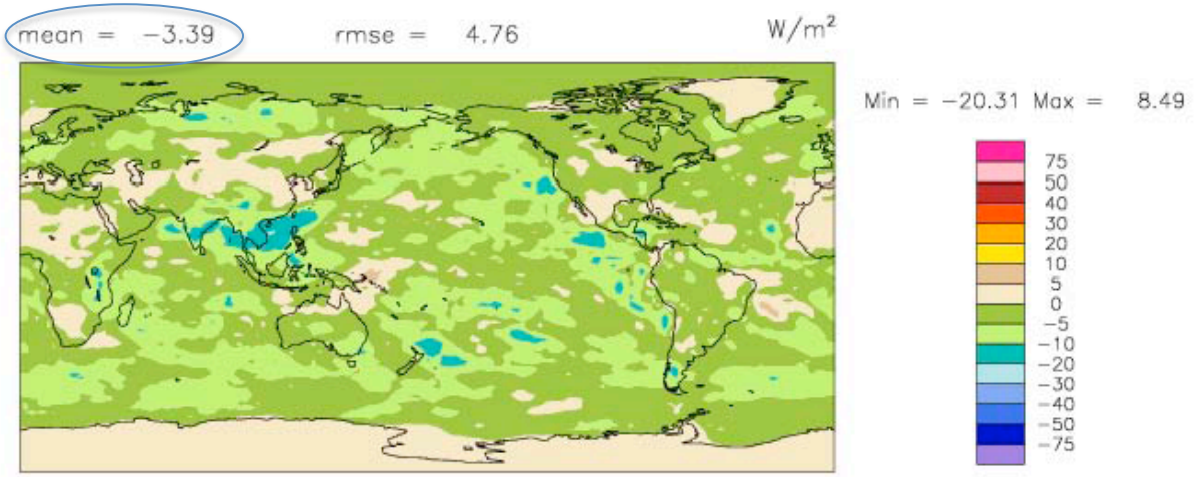


Surface Clear-sky Shortwave: New – Old Optics

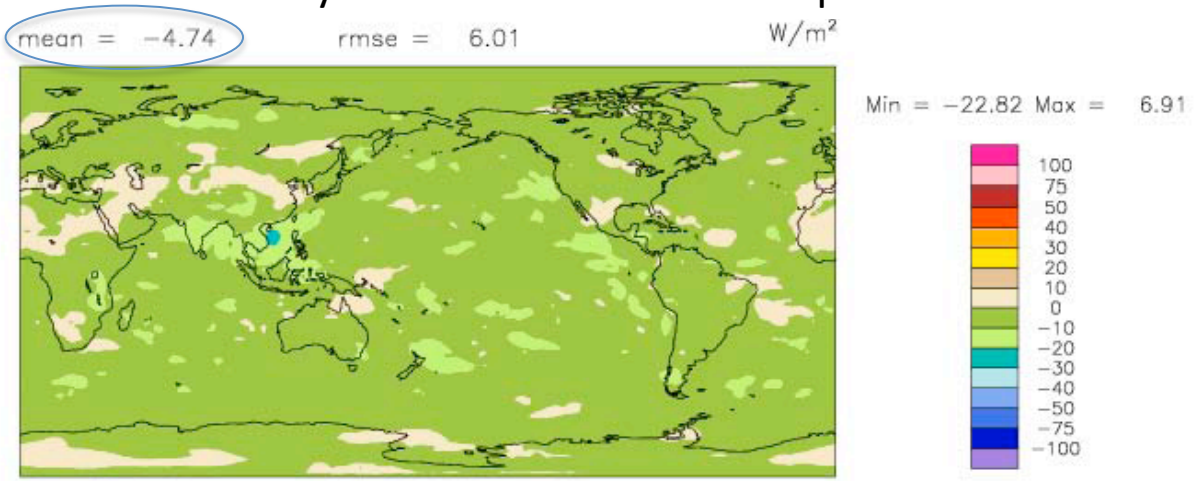


New cloud optics

TOA All-sky Shortwave: Old – New Optics



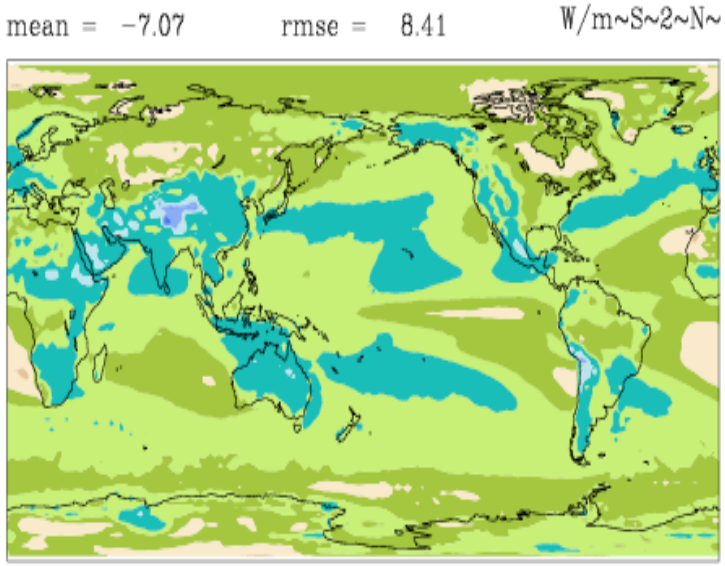
Surface All-sky Shortwave: Old – New Optics



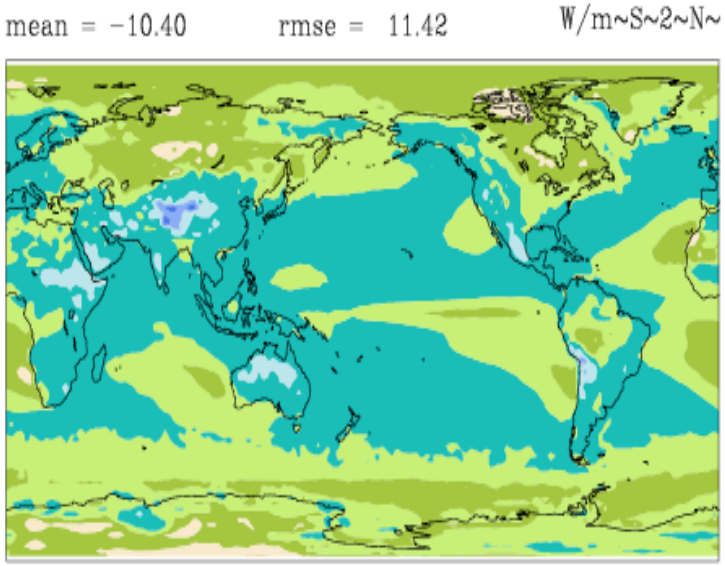
Both aerosol and cloud optics lower planetary albedo.

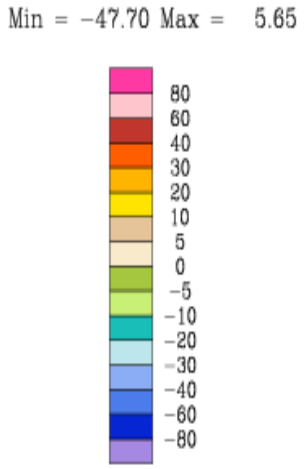
Issue: Bias in clear-sky OLR

CAMRT – CERES2
-7.07 W/m^2



RRTMG – CERES2
-10.40 W/m^2



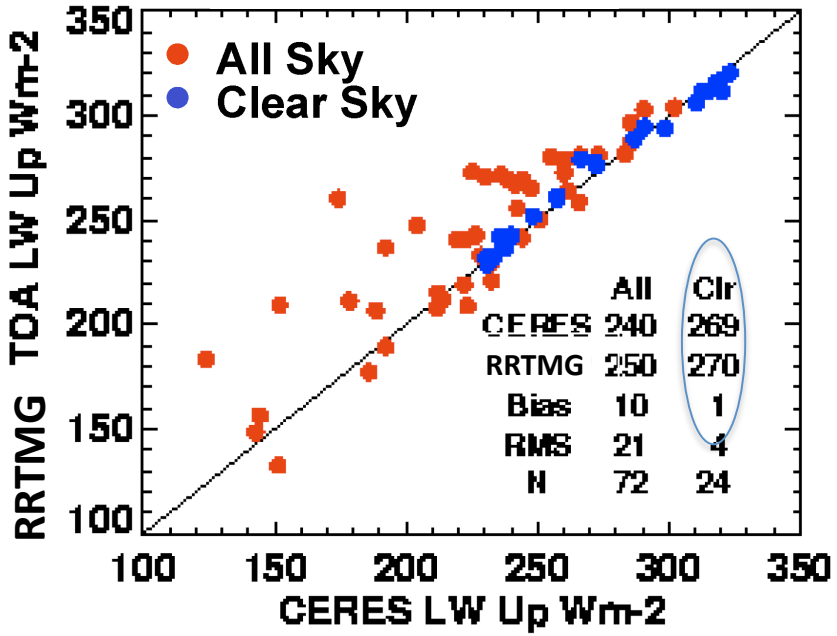


Hypotheses for origin of OLR bias

- Physics of RRTMG
- Integration of RRTMG with CAM
- Surface Boundary Condition
- Composition of Atmosphere

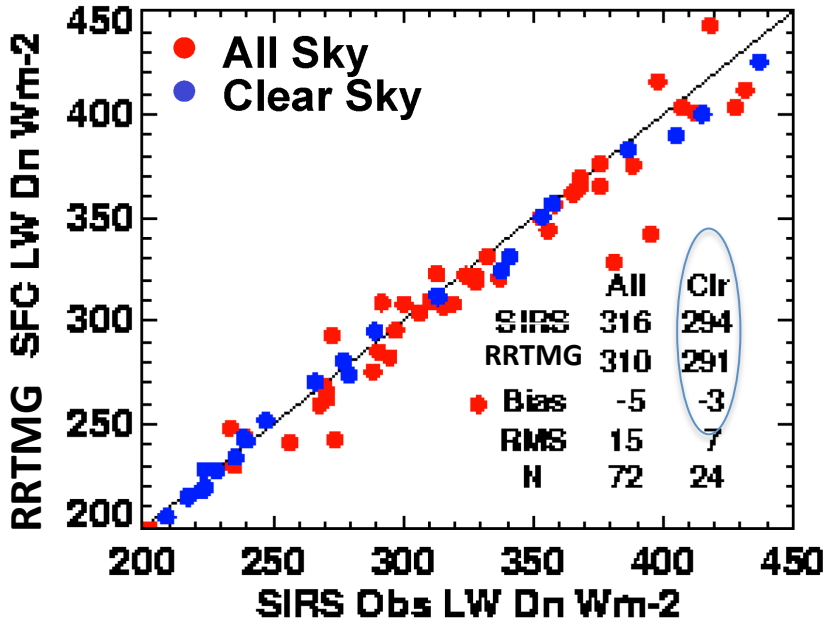
Evaluation using ARM & CERES

TOA Clear-Sky OLR



1 W/m^2 error relative to CERES

Surface Clear-Sky Flux

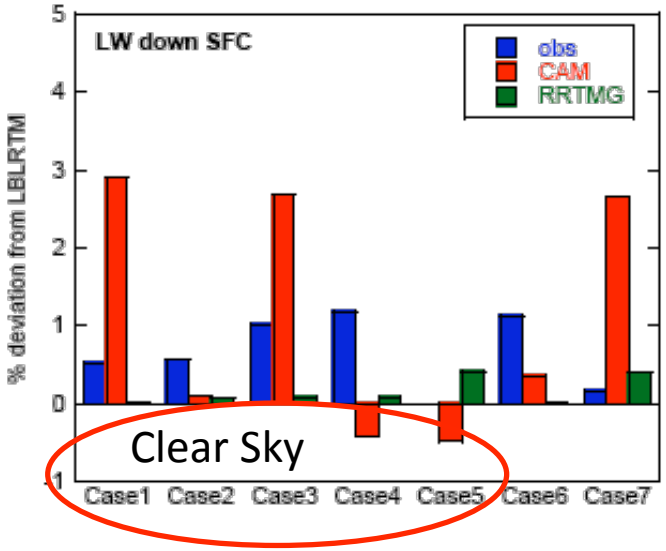


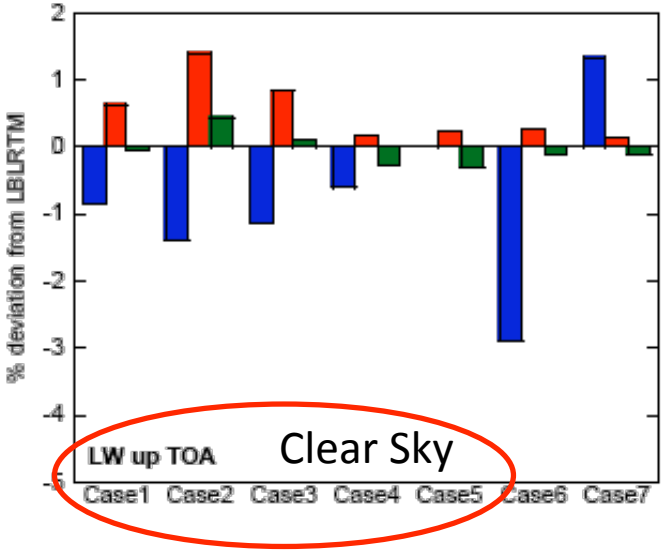
-3 W/m^2 error relative to ARM

Based on Observed Profiles

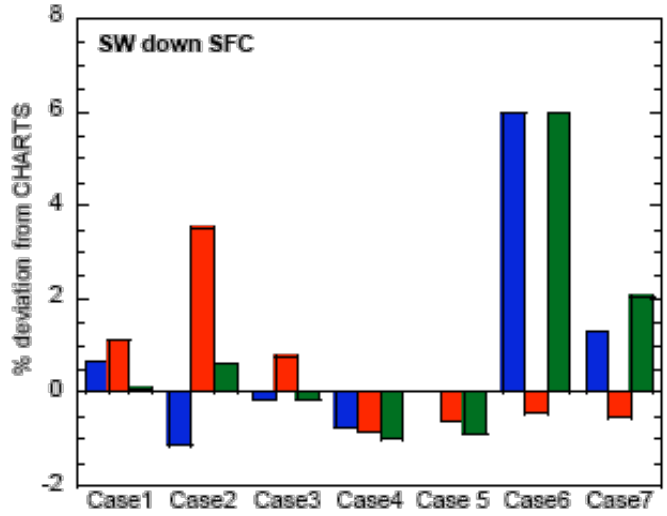
Dave Rutan and Tom Charlock (NASA)

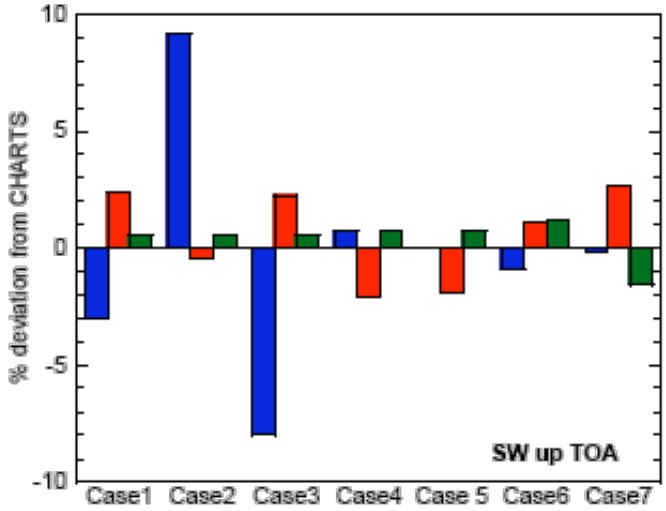
RRTMG vs. LBL Benchmarks





Errors in RRTMG are <1% relative.





Based on Observed Profiles

Lazaros Oreopoulos (NASA Goddard)

Physics Tests of RRTMG

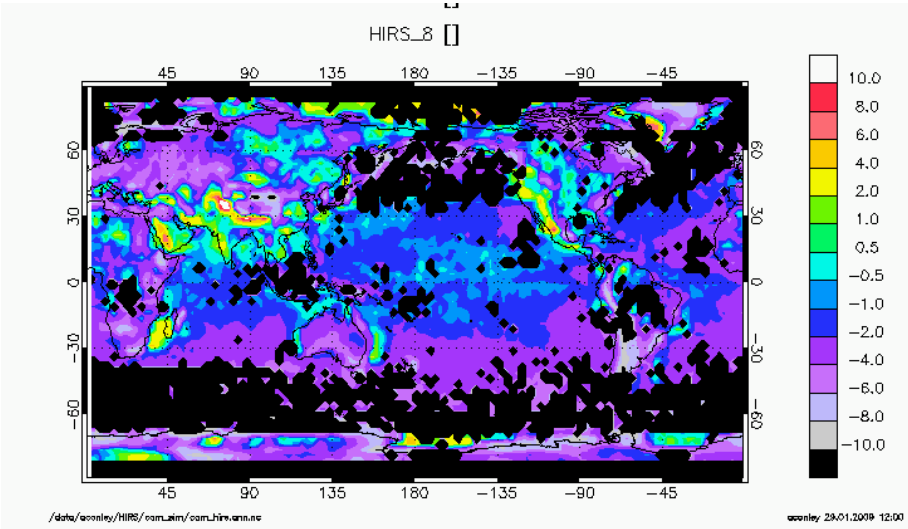
- RRTMG surface and TOA fluxes differ by < 1% from observations when using *in situ* observations of atmospheric and surface states.
- Bias is much smaller than that between CAM and CERES.
- These results imply that RRTMG fluxes are accurate when the atmospheric and surface states are accurate.

- Thus RRTMG is probably not the cause for the CAM bias.

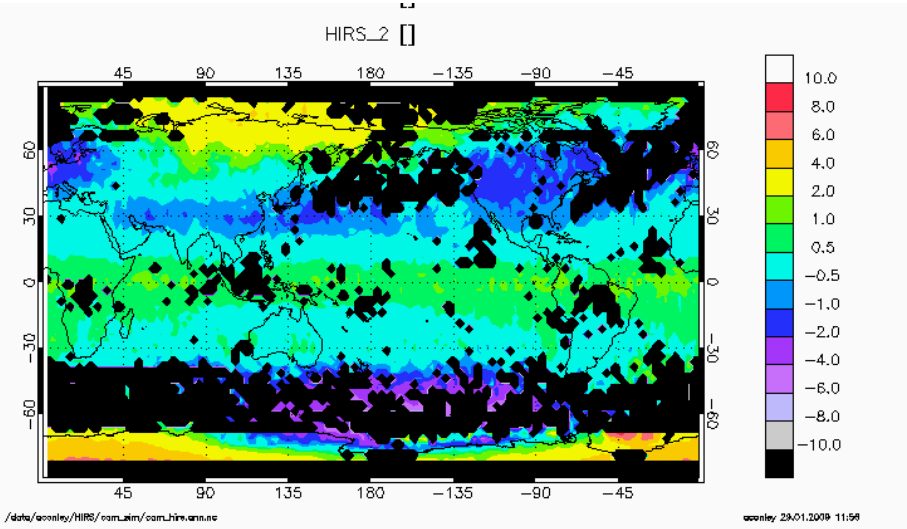
Note: For Circ case 1, RRTMG reproduces LBL LW fluxes to better than 0.1% at TOA and surface.

HIRS analysis of source of OLR bias

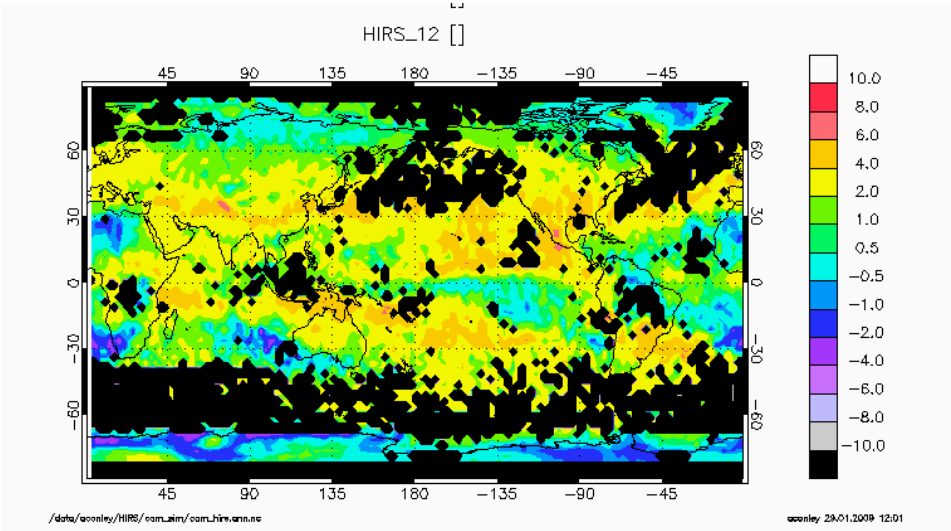
Surface temperature: HIRS-CAM



Upper trop. temperature: HIRS-CAM



Upper trop. H2O emission temperature: HIRS-CAM



In channels sensitive to upper trop. H2O, CAM underestimates the brightness temp. by 2-4K – too moist?

Development goals for 2009

- Introduce solar spectral variability (IPCC)
- Introduce volcanic radiative forcing (IPCC)
- Adapt MAM to new radiation framework
- Develop (multi-) Column Radiation Model
- Self-consistent treatment of upper atmosphere
- Integrate RRTMG with WACCM
- Study climatic effects of new radiation package