New Radiation

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And Many Others

[1]Supported by DOE/SciDAC
[2]Supported by NSF/NCAR
[3]Supported by DOE/ARM

New Radiation Parameterization

1. RRTMG – A New Radiation Code for CAM
   - Science Tests
   - Integration Tests
2. New Interface for Radiative Constituents
3. Condensed Phase Optics
   - Clouds
   - Aerosols
4. Schedule

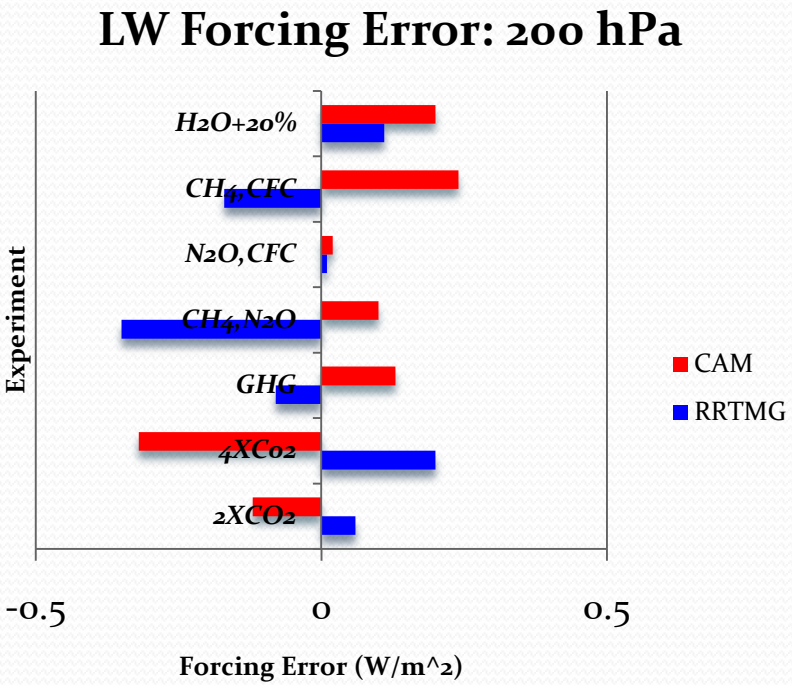
CAM Radiation

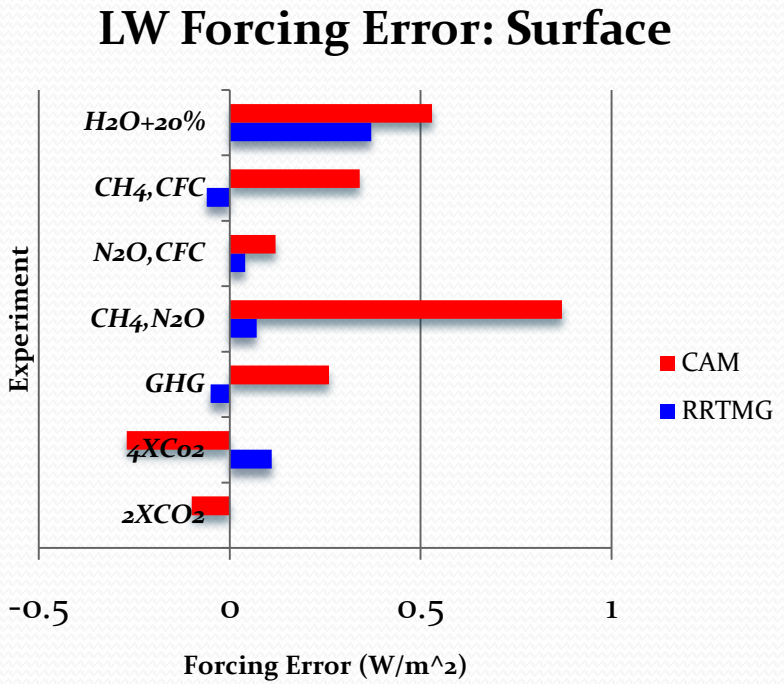
- Authors:
  - V. Ramanathan
  - Jeff Kiehl
  - Bruce Briegleb
  - Bill Collins
- Supported increasing complexity for 20 years.

RRTMG

- Correlated-k code for gases in LW and SW from AER
- Monte Carlo Independent Column Approximation for clouds
- Continually updated to latest spectroscopic data bases
- Much greater accuracy relative to LBL calculations
- Ongoing validation in radiative closure experiments (ARM BBHRP)
- Ozone optics validation through CCMVal

Climate Forcing Accuracy (RTMIP)*





LW Benchmark code is LBLRTM.

Experiments:

- *GHG ::* *1860->2000 (all species)*
- *CH4,N2O ::* *0 ppm -> 2000*
- *N2O, CFC ::* *1860 -> 2000*
- *CH4,CFC ::* *1860 -> 2000*

*Collins et al, 2006; Iacono et al 2008

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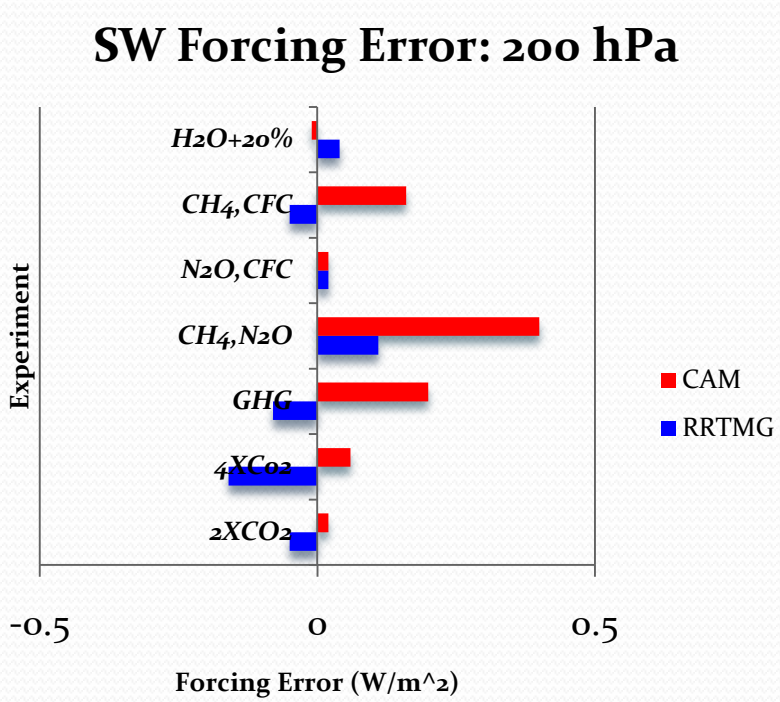
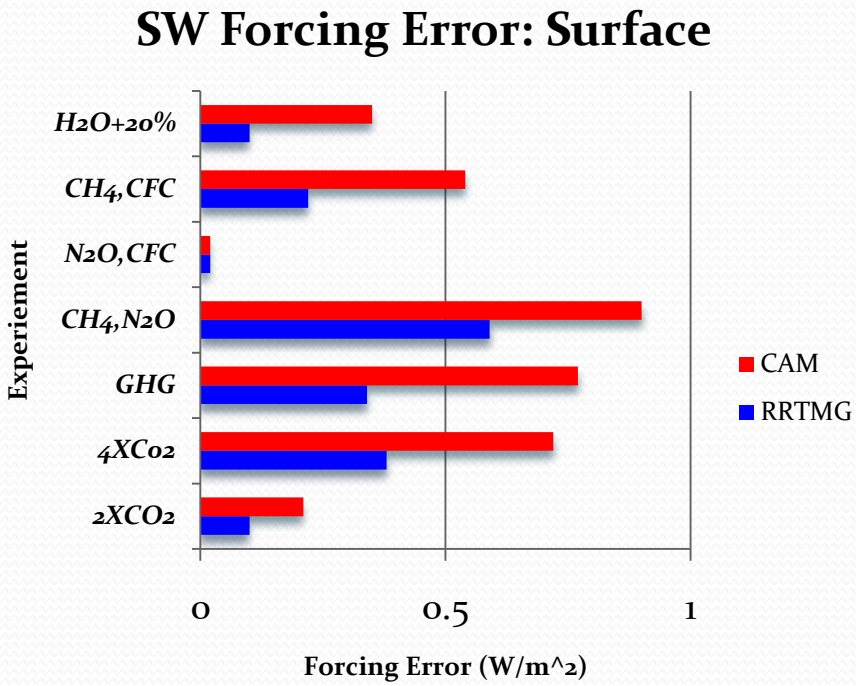




SW Benchmark code is CHARTS.

Experiments:

- *GHG ::* *1860->2000 (all species)*
- *CH4,N2O ::* *0 ppm -> 2000*
- *N2O, CFC ::* *1860 -> 2000*
- *CH4,CFC ::* *1860 -> 2000*

*Collins et al, 2006; Iacono et al 2008

Flux Differences (W/m^2)

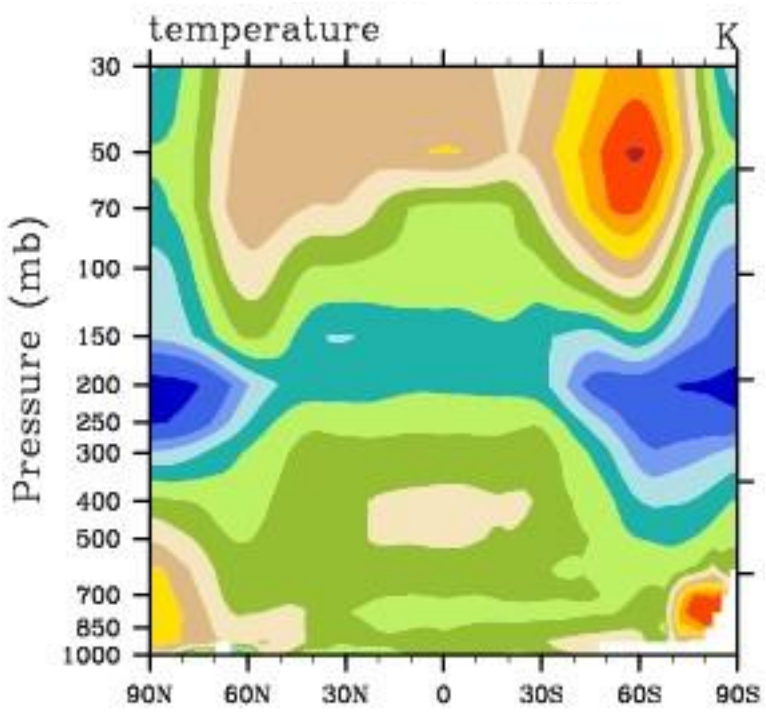
Global , 1 yr Means, No Aerosols, RT-coupled, Cloud Bugfix

	Top	RRTMG-CAM	Surface	RRTMG-CAM
Shortwave	Net Clear Sky	-1.4	Net All Sky	-3.2
	Cloud Force	-1.6		
Longwave	Net Clear Sky	-3.3	Net All Sky	-0.8
	Cloud Force	-3.0		
	NET	-2.7	NET	-2.7

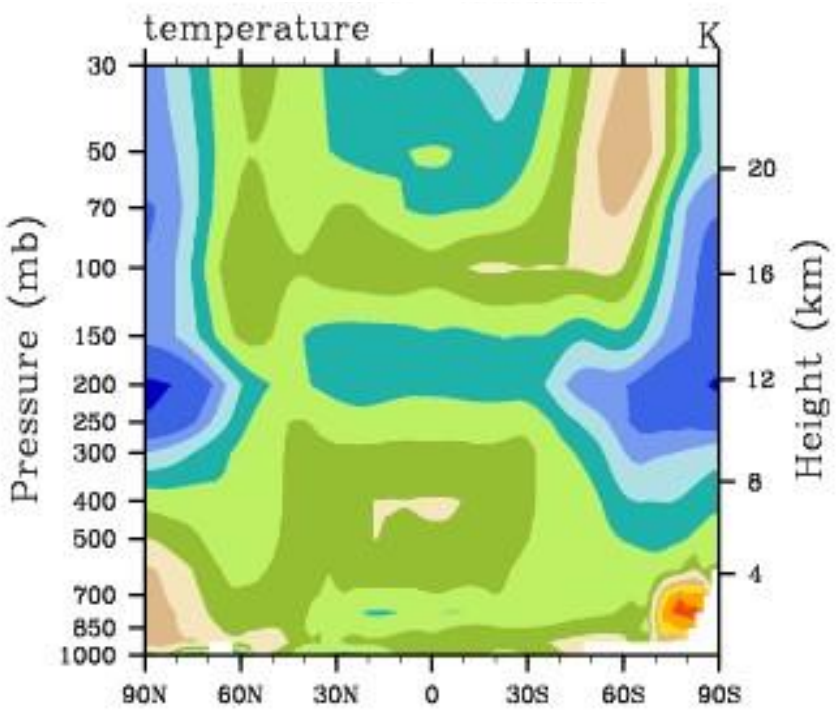
Top: let less solar in, less IR out.
Surface: less solar and radiates less IR.

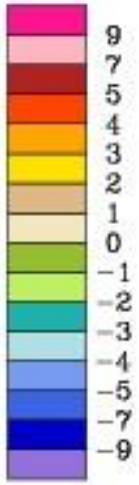
Climate Effects from New Radiation

CAM – ERA40



RRTMG-ERA40

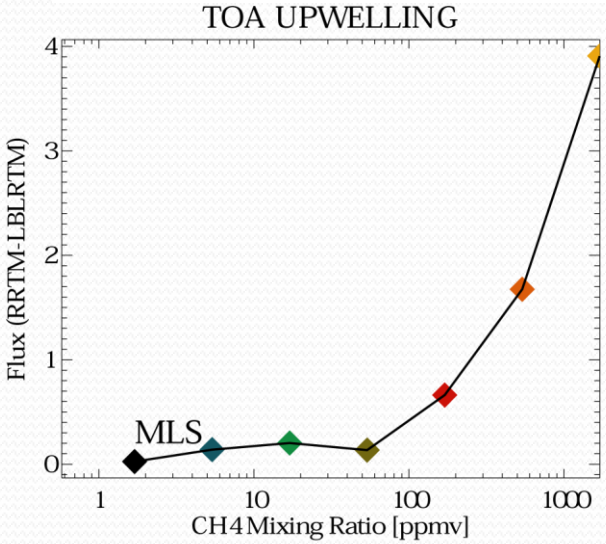


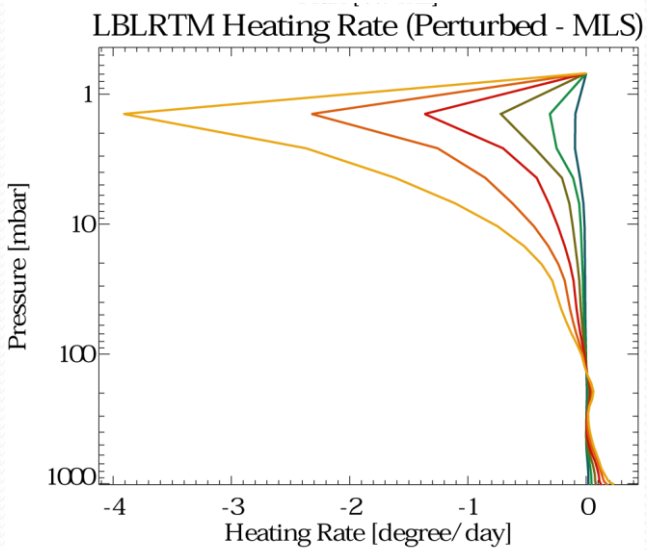


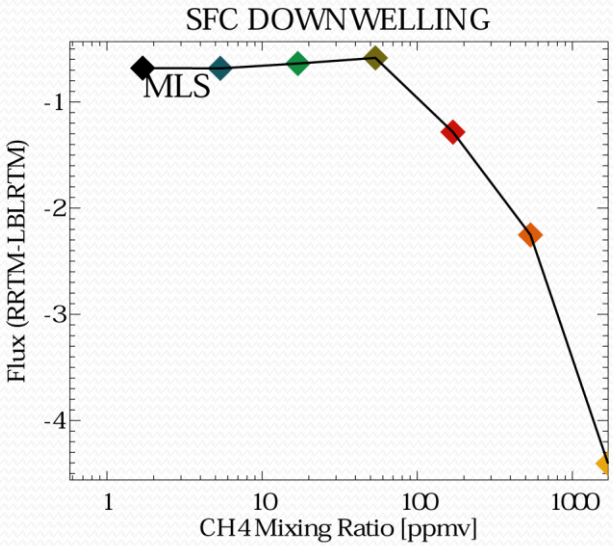
No Aerosols, Old CAM cloud optics, RT coupled

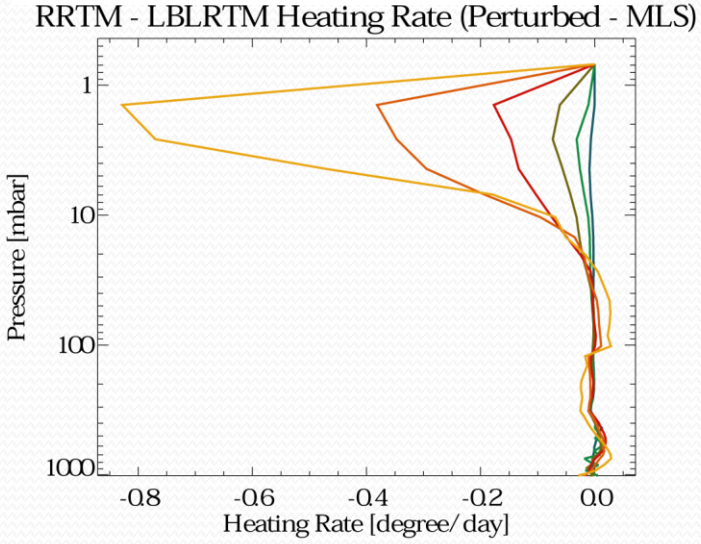
See Mike Iacono's Poster!

Methane Atmospheres



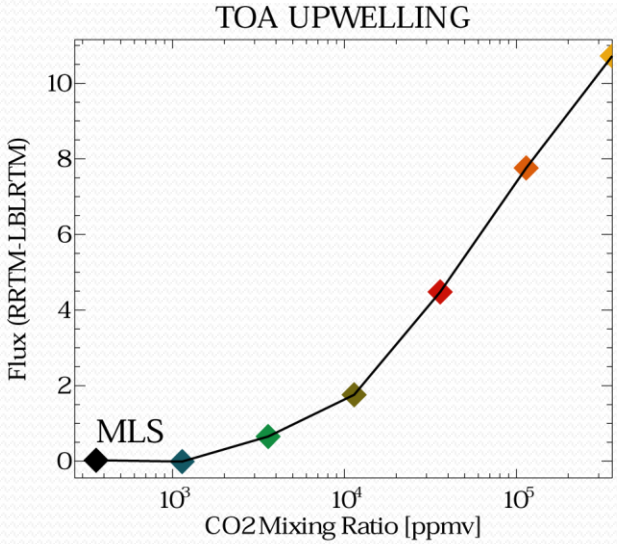


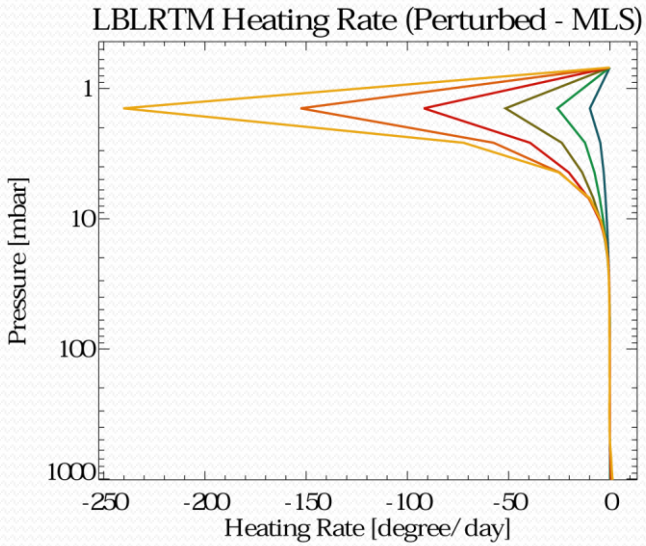


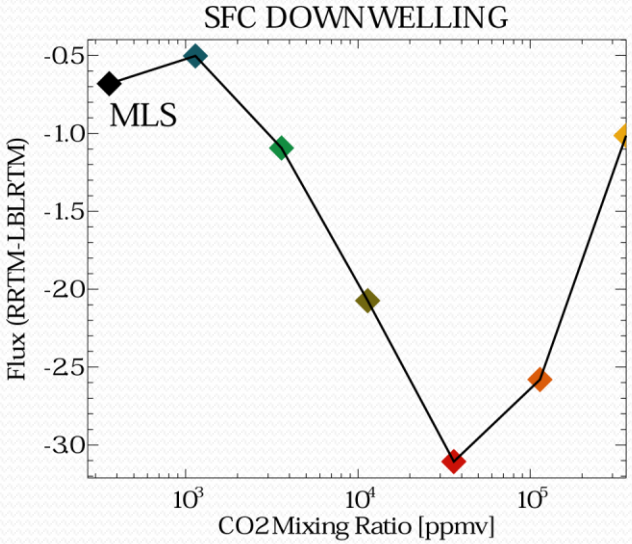


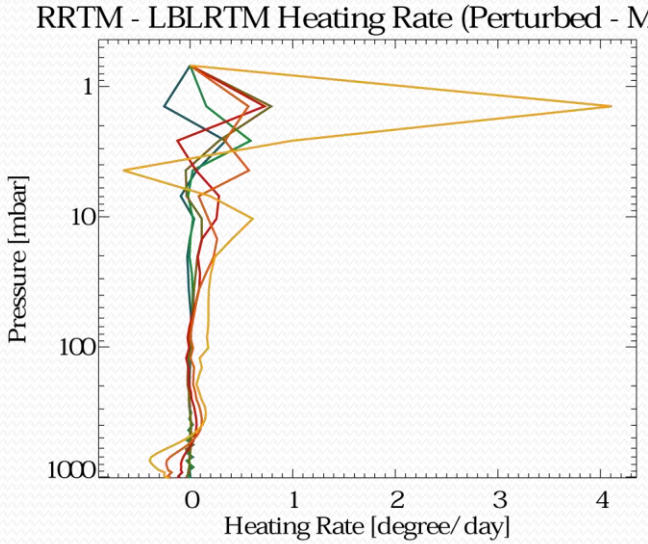
J. Delamere (AER)

CO_2 Atmospheres









J. Delamere (AER)

Integration Status
Condensed Phase Optics

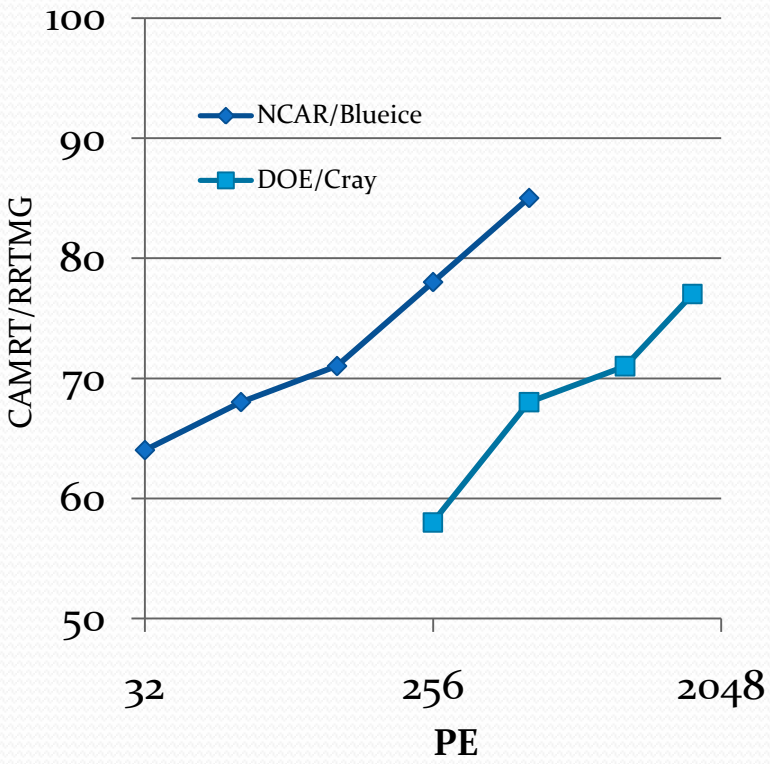
- Liquid Cloud Optics
  - Using CAM3.5 Optics
  - Constructed optics for MG Clouds
  - Implemented 1st cut of MG Cloud Optics
  - Need to include in-cloud liquid variability
- Ice Cloud Optics
  - Have Optics from David Mitchell
  - Need to be implemented and tested
- Aerosol optics not yet integrated with RRTMG

Software Integration Status

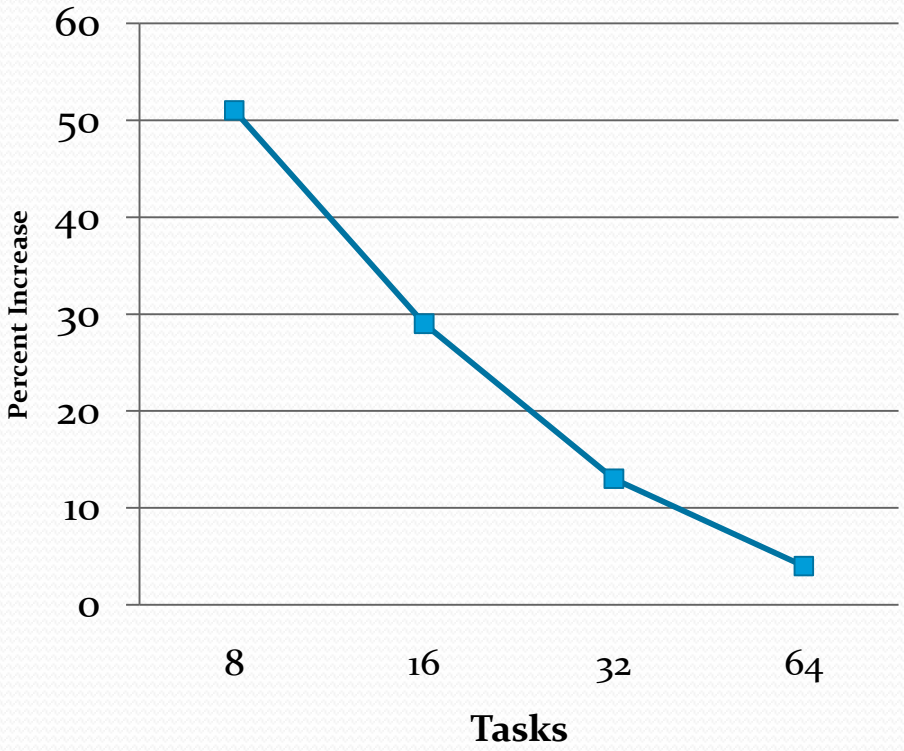
- Testing on NCAR machines relatively complete
- Testing ongoing on DOE machines
- Optimizations are ongoing
- Removing CAM-specific elements from RRTMG
- Soon to be part of trunk code as a configuration option

Computational Costs

Performance Ratio



Memory



Fv 1.9X2.5, no aerosols

*Brian Eaton, Pat Worley

Questions?

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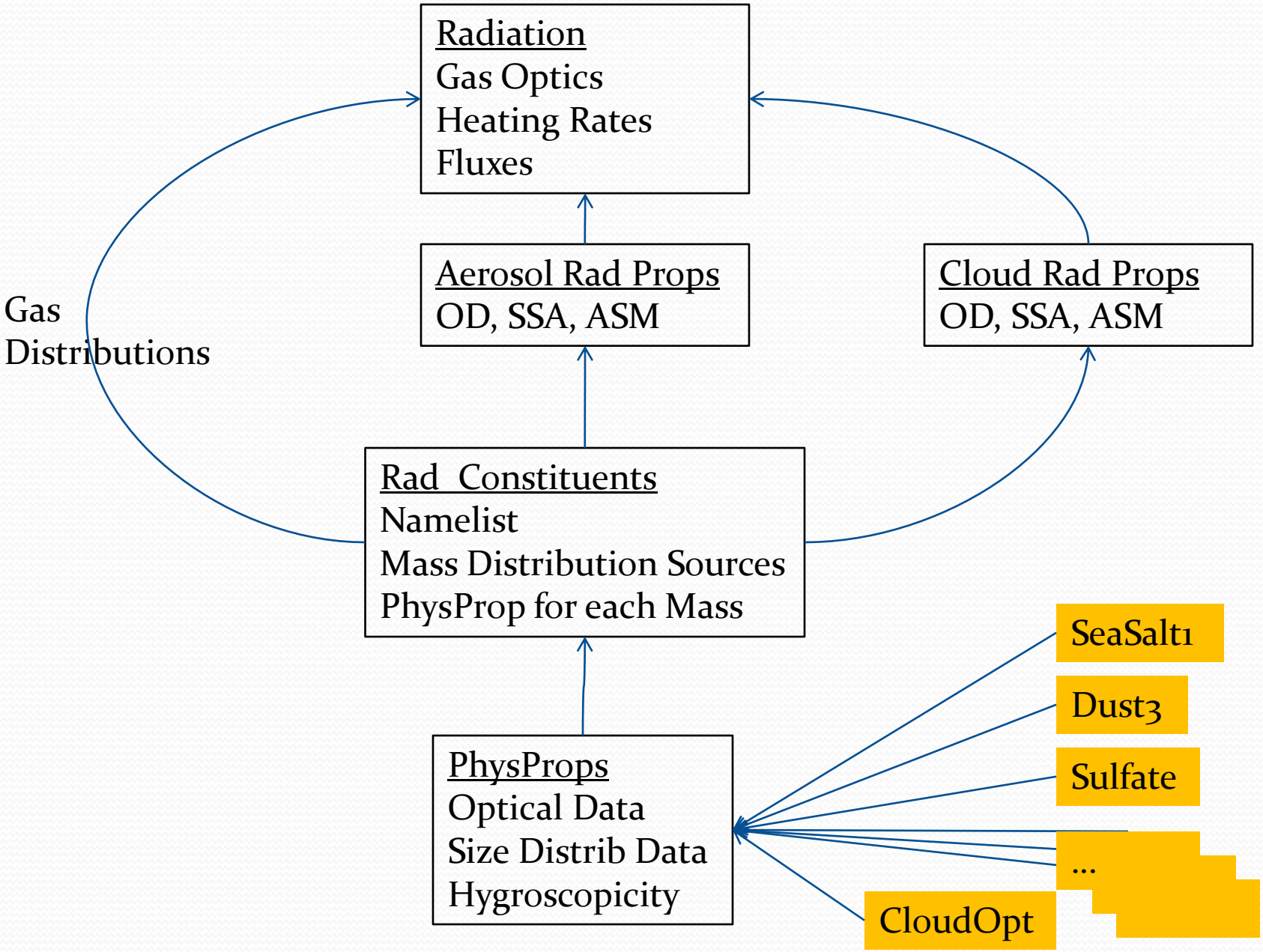
Interface for Radiative Constituents

- Implemented for both CAMRT and RRTMG
- Easy Forcing Computation
  - Namelist driven
  - Up to 10 diagnostic calls
  - Supports multiple representations
  - SW and LW
- Explicit specification of radiative constituents – nothing hidden
- Declaration of prognostic or diagnostic character of each species
- Explicit link between microphysics and optics of each condensed species
- Doesn't change answers

Example Namelist*

```
rad_climate="'D_O3:O3', 'D_O2:O2', 'D_CO2:CO2', \
        'D_N2O:N2O', 'D_CH4:CH4', 'D_CFC11:CFC11', \
        'D_CFC12:CFC12', 'P_Q:H2O', \
        'D_ocar1:/path/ocpho.nc', \
        'D_ocar2:/path/ocphi.nc', \
        'D_bcar1:/path/bcpho.nc', \
        'D_bcar2:/path/bcphi.nc' \
        'D_dust1:/path/dustv2b1.nc', \
        'D_dust2:/path/dustv2b2.nc', \
        'D_dust3:/path/dustv2b3.nc', \
        'D_dust4:/path/dustv2b4.nc', \
        'D_sulf:/path/sul.nc' "
```

*Created by build-namelist.


Radiation
Gas Optics
Heating Rates
Fluxes
Aerosol Rad Props
OD, SSA, ASM
Cloud Rad Props
OD, SSA, ASM
Gas
Distributions
Rad Constituents
Namelist
Mass Distribution Sources
PhysProp for each Mass
PhysProps
Optical Data
Size Distrib Data
Hygroscopicity
SeaSalt1
Dust3
Sulfate
...
CloudOpt

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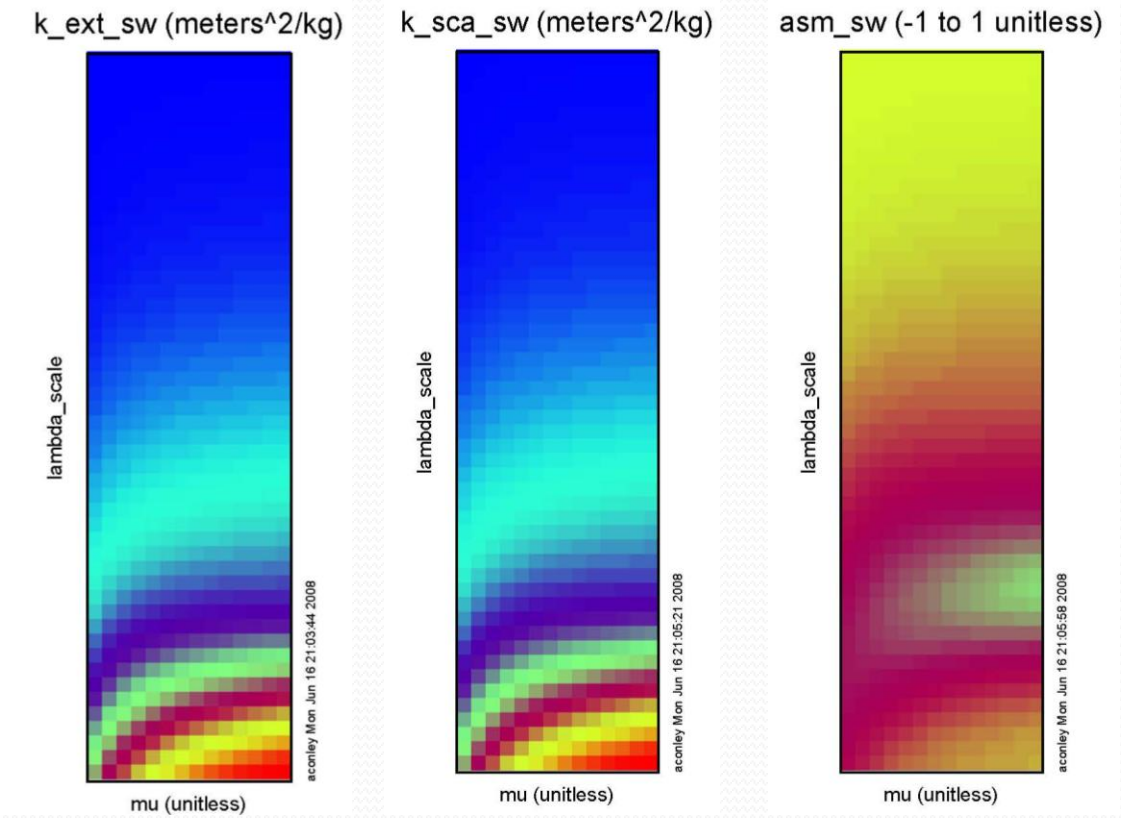
Condensed Phase Optics

1. All new optics target RRTMG
2. Clouds
   - Gamma size distribution liquid clouds (MG micro)
   - Ice Clouds (Mitchell Optics)
3. Aerosols
   - Target Species
   - Species Specifications
4. Requirements for Contributions

Liquid Cloud Optics

- Microphysics code (from Morrison and Gettelman) diagnoses in-cloud droplet distribution
- First version of optics is implemented
- Optical data compares well (when limited to specific case) to AER results
- Model testing on-going
- Meaning of in-cloud liquid water variability

Liquid Cloud Optics (visible)



Ice Cloud Optics

- Provided by David Mitchell (DRI)
- Parameterized in terms of Effective (radiative) diameter
- Effective diameter diagnosed by microphysics parameterization
- Computed using MADA code (Similar to FDTD in the case of no small mode crystals)

Aerosol Specification

- Dry Size Distribution (mean log(r), sigma(log(r)))
- Hygroscopic Growth Model
- Composition (internal/external mixture)
- Dry complex index of refraction (.2 -> 1000 micron)

Aerosol Status

- Optics for CCSM4 aerosols will probably be based on the BAM but are awaiting specs from AMWG
- (CAM3.5) Externally Mixed Species
  1. Tropospheric Sulfate (ammonium sulfate)
  2. Dust (4 bins)
  3. Carbonaceous (4 Species)
  4. Sea Salt (4 bins)*
  5. Volcanic Aerosol (Stratospheric H_2SO_4)
- (CAM3.5) Optics mostly based on OPAC (1998) data
- (CAM3.5) Optics not mapped to RRTMG bands

Aerosol Specification?

- CAM3 Optics Assumptions
- Emission/Transport/Deposition Assumptions
- MG Cloud Microphysics Assumptions
- Appear in Diverse Sections of Code – Rarely in file data

Volcanic Species

- Mass specification is broken in CAM3.5
- Chemists
  - Surface Area Density Distribution (time evolving)
  - Fixed Number
  - Prognostic Mass
- Climate/CAM
  - One bin with fixed size
  - Specified time evolving mass
- Welcome to join our discussion (ACD/CGD)

External Optical Contributions

- Reproducibility/Traceability
- Data and Methods Archived
- Spectrally resolved (SW and LW) and RRTMG-band:
  - Mass-specific Extinction
  - Mass-specific Absorption
  - Single-scattering Albedo
  - Asymmetry Parameter

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Schedule of Experiments

1. RRTMG, old cloud optics
2. Change to Mitchell Ice Optics
3. Change to MGC cloud optics
4. Add BAM Diagnostic aerosol forcing
5. Study and modifications from CCSM
6. CCSM/SOM runs
7. BAM interacting with microphysics (Which interactions?)

Future Work

- Offline Radiation
- Optics for internally mixed aerosols
- Move subcolumn generation out of radiation so that it can be coupled with subscale dynamics and perhaps in-cloud liquid water path variability
- Initialization step mie computation (run time?)
- Photolysis

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