Radiation: CAM 4 -> CAM5

Andrew Conley

Spring AMWG, Wed Feb 10, 2010 4pm

Team

- Mike Iacono, Bill Collins, Andrew Conley, Brian Eaton
- David Mitchell, Steve Ghan, Andrew Gettelman, Hugh Morrison
- Jean-Francois Lamarque, Francis Vitt, Phil Rasch

CCSM AMWG Plan, June 2008

- Implement RRTMG as part of CAM/CCSM
- Diagnostic calls (10, based on namelist-specified atmospheres)
- Separate Microphysics from Radiation
- New Radiation Interface (Looking forward to moving MAM into framework)
- Condensed Phase Optics to match parameterizations (MG, Aerosols)
- Completed August 2009

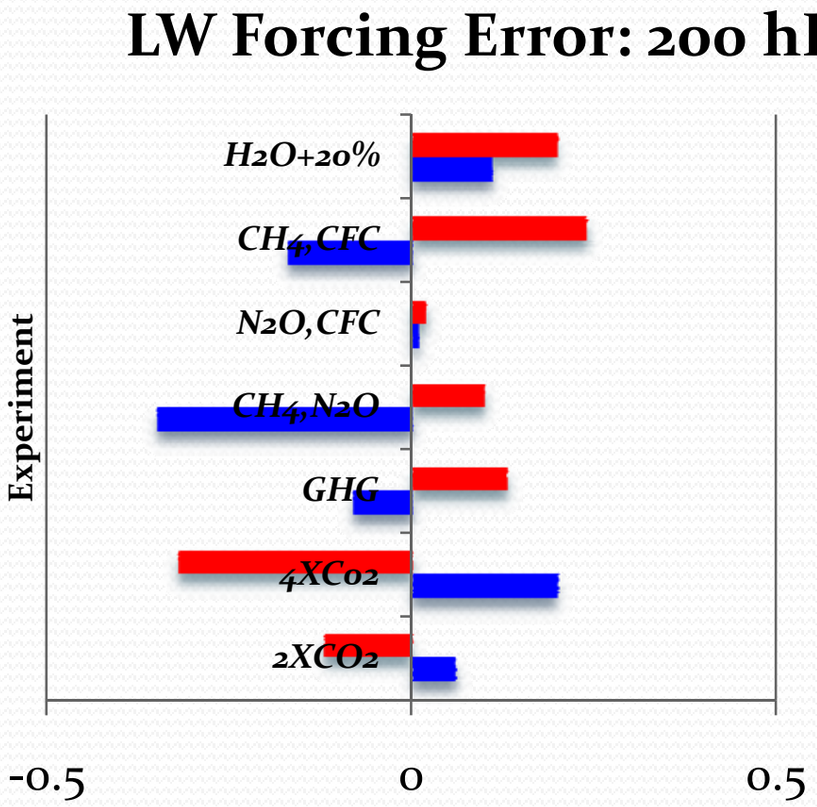
What Changed?

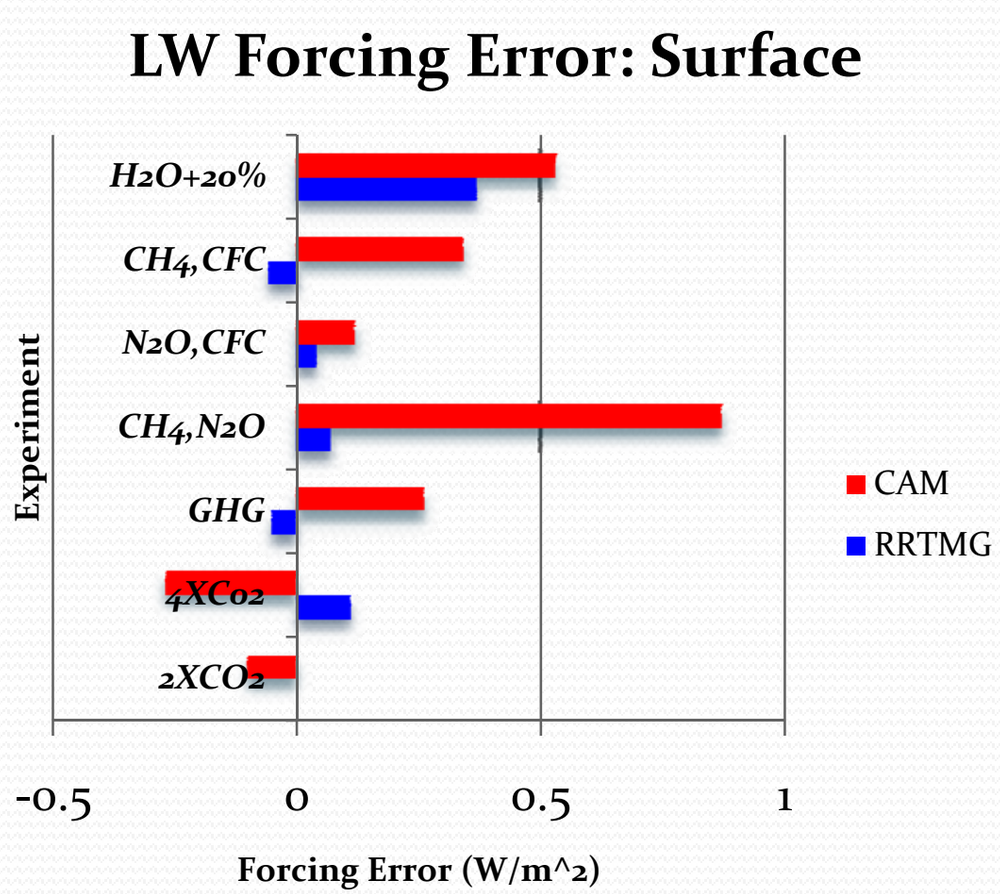
- Optics for Gases (RRTMG from AER/ISO/Verisk Analytics)
- Frequency Bands (Easier interface to IR Bands)
- RT Solver for SW and LW (RRTMG)
- Condensed Phase Optics
  - Ice & Liquid Clouds + Snow and Rain
  - Aerosols (Multiple Packages)
- Cloud Overlap (McICA) (RRTMG)
- New Solar Specification

CAM 4 -> 5 (What didn't change?)

- 2-stream solver for shortwave
- Flux-based integration in longwave (no scattering)
- 2 Bands for surface albedo specification
- Bulk mode aerosol optics are similar (Thanks to Steve Ghan)

Climate Forcing Accuracy (RTMIP)*





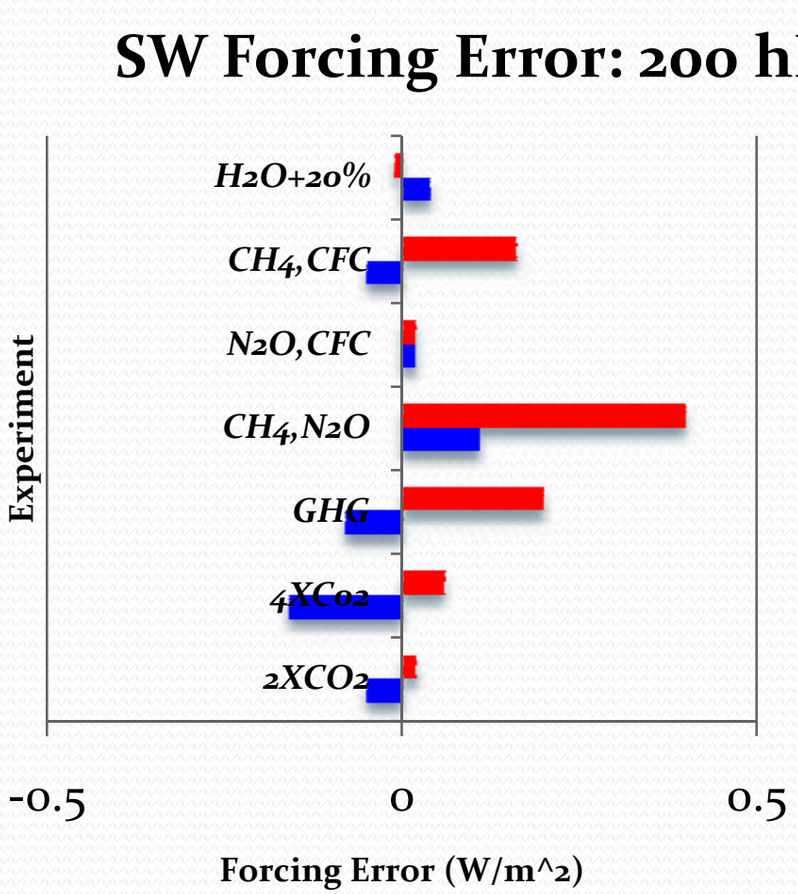
LW Benchmark code is LBLRTM.

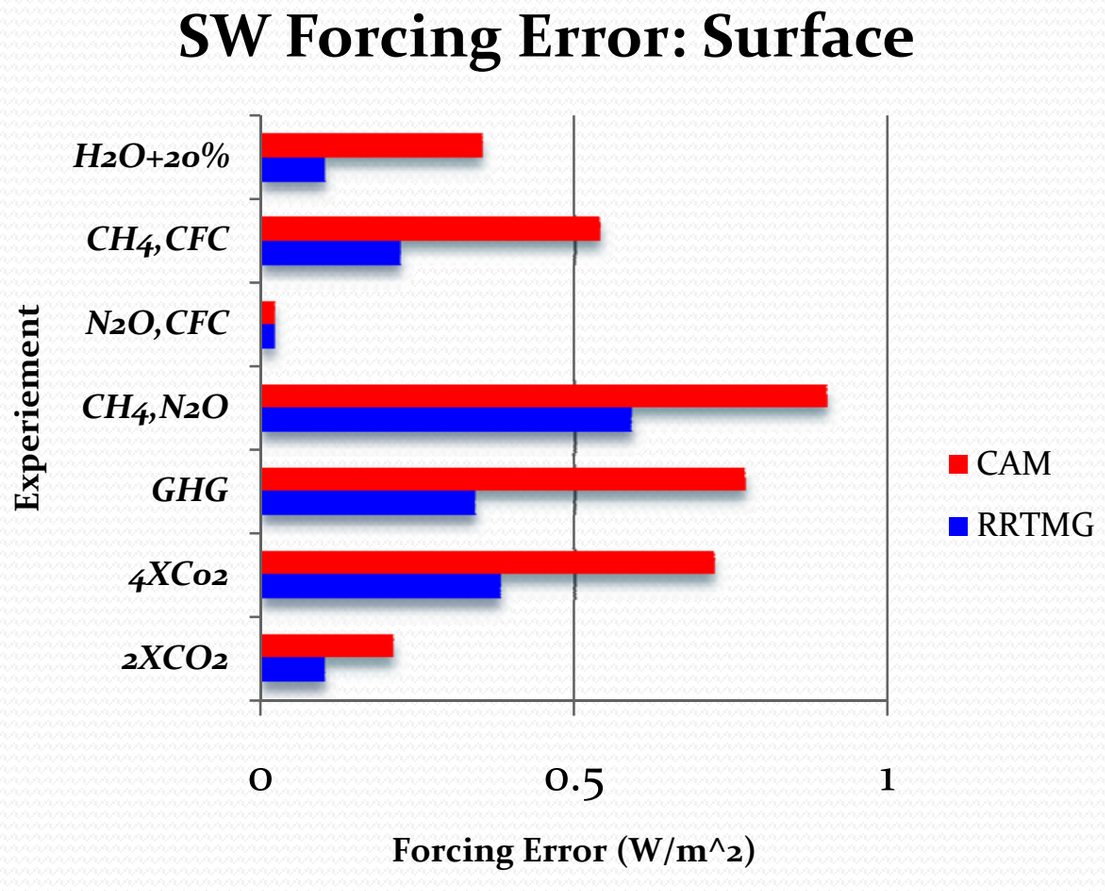
Experiments:

- *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

Climate Forcing Accuracy (RTMIP)*





SW Benchmark code is CHARTS.

Experiments:

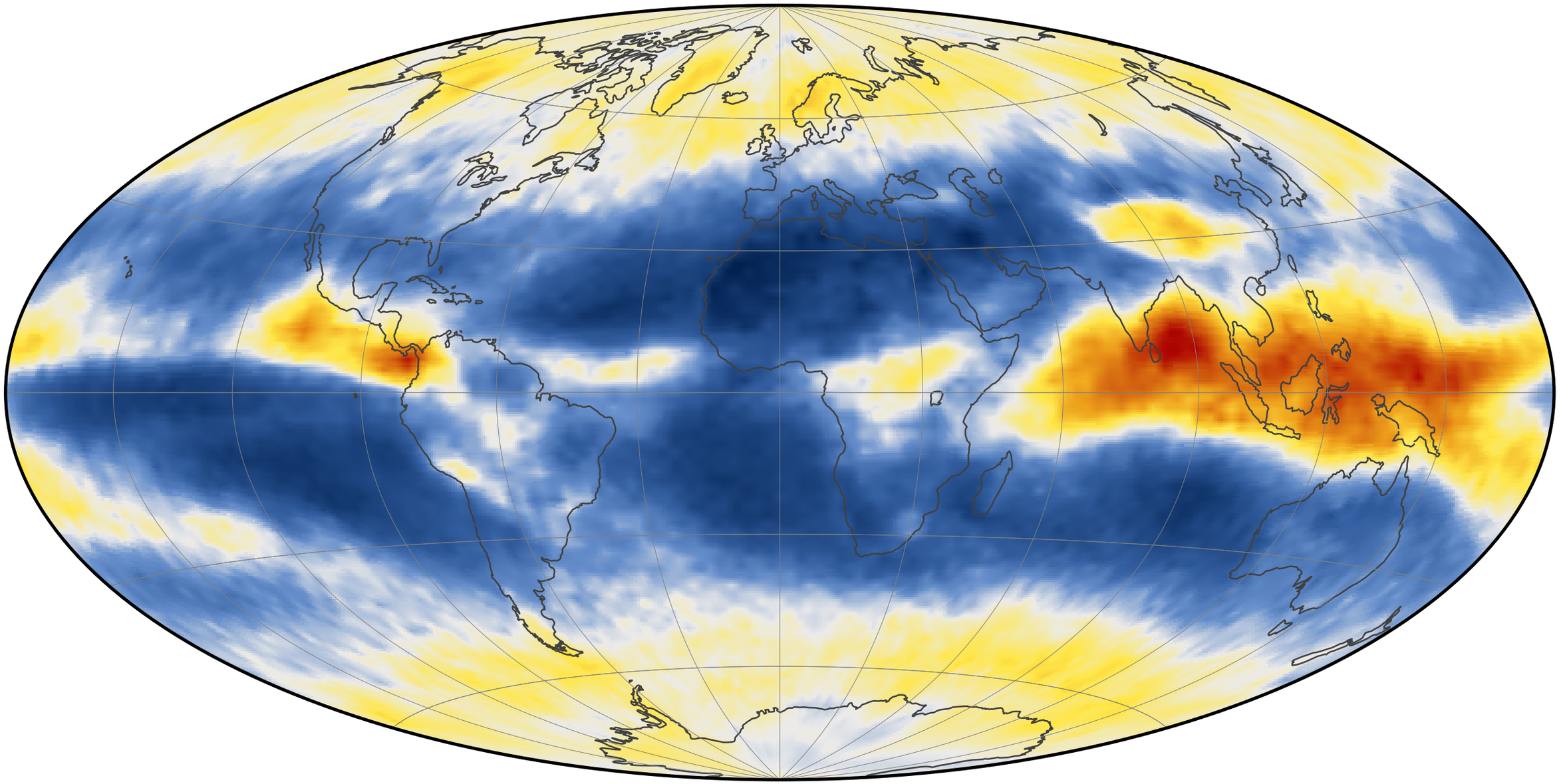
- *GHG :: 1860->2000 (all species)*
- *CH4,N2O :: 0 ppm -> 2000*
- *N2O, CFC :: 1860 -> 2000*
- *CH4,CFC :: 1860 -> 2000*

*Collins et al, 2006; Iacaono et al 2008

Net LW Flux

	Base: W/m^2	RRTMG - CAMRT
Top	221	-0.60
Surface	49	-1.39
Top/Clear	261	-3.08
Surface/Clear	81	-4.25
Cloud (Top)	40	-2.49

FLNT (RRTMG - CAMRT) (+- 4 W/m^2)

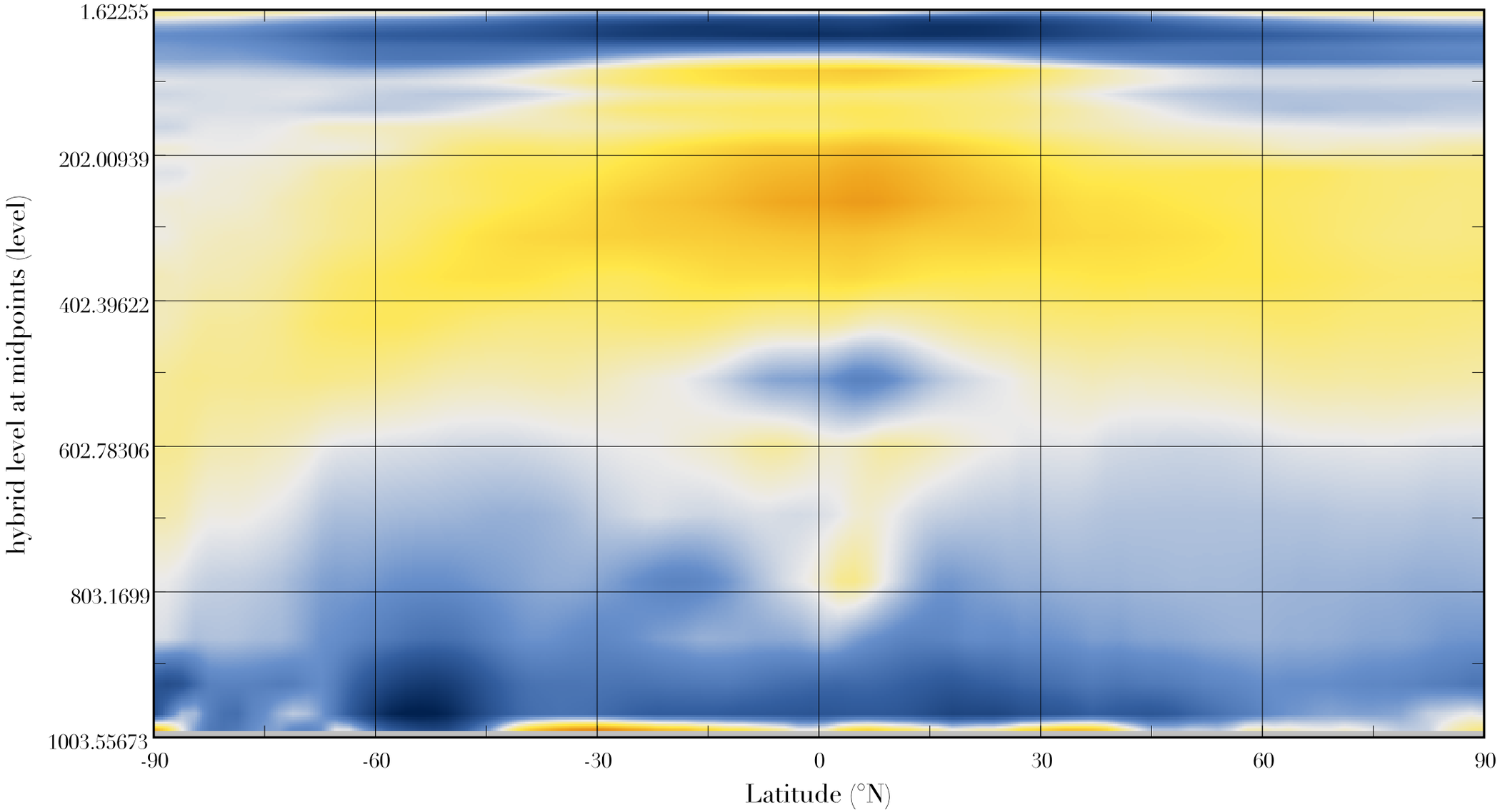


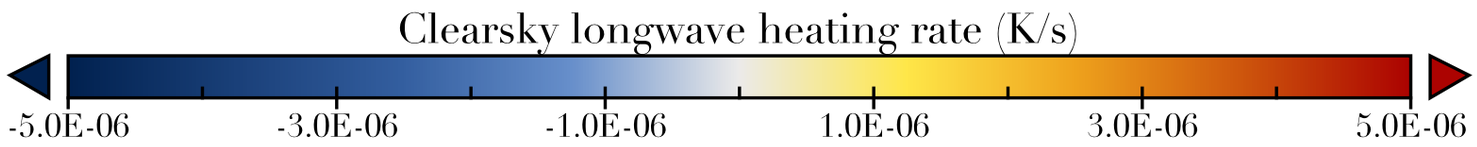
Net longwave flux at top of model (W/m2)

-4.0 -2.4 -0.8 0.8 2.4 4.0

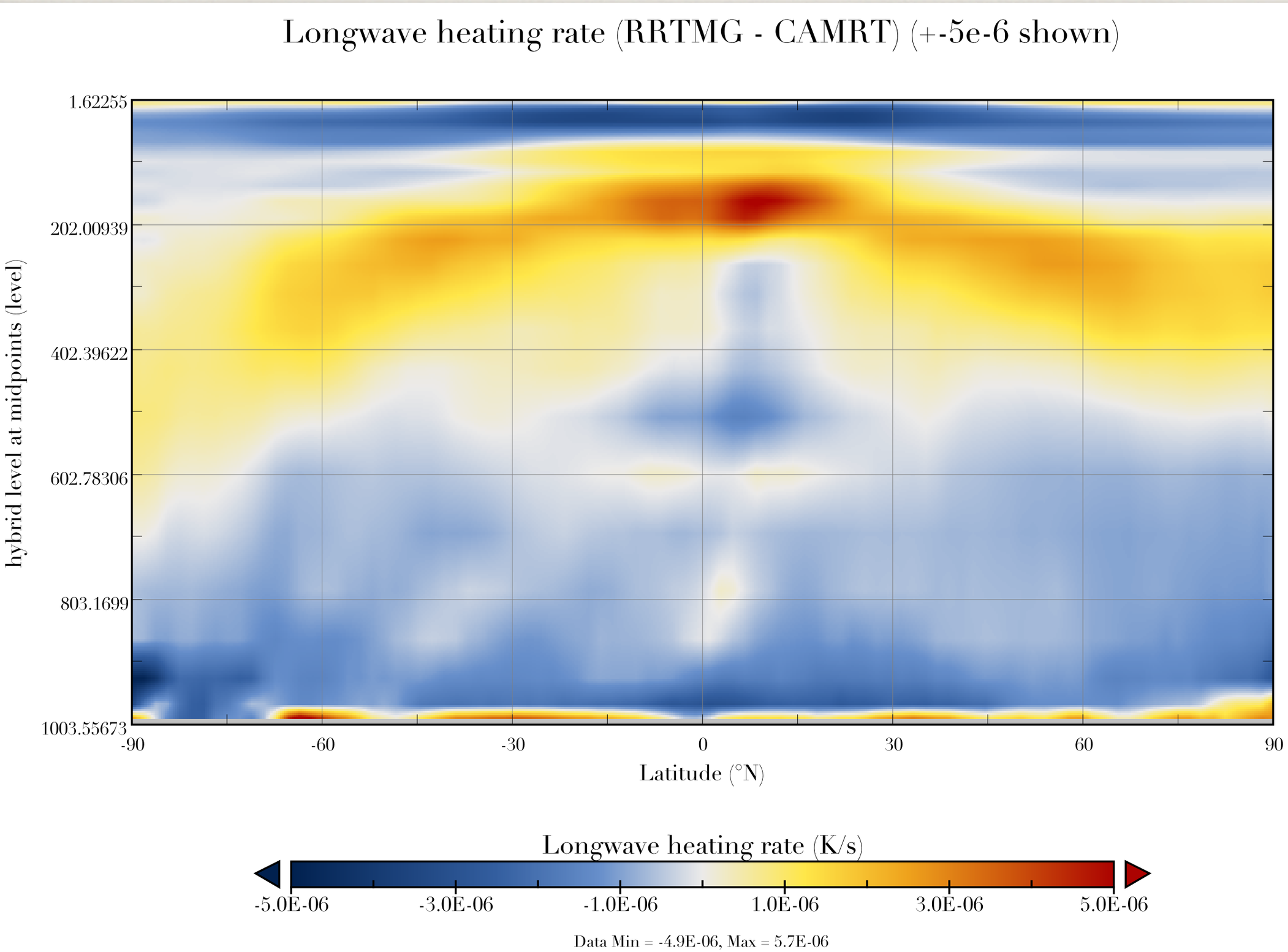
Data Min = -4.2, Max = 4.1

Clearsky longwave heating rate (RRTMG - CAMRT) (+-5e-6 shown)





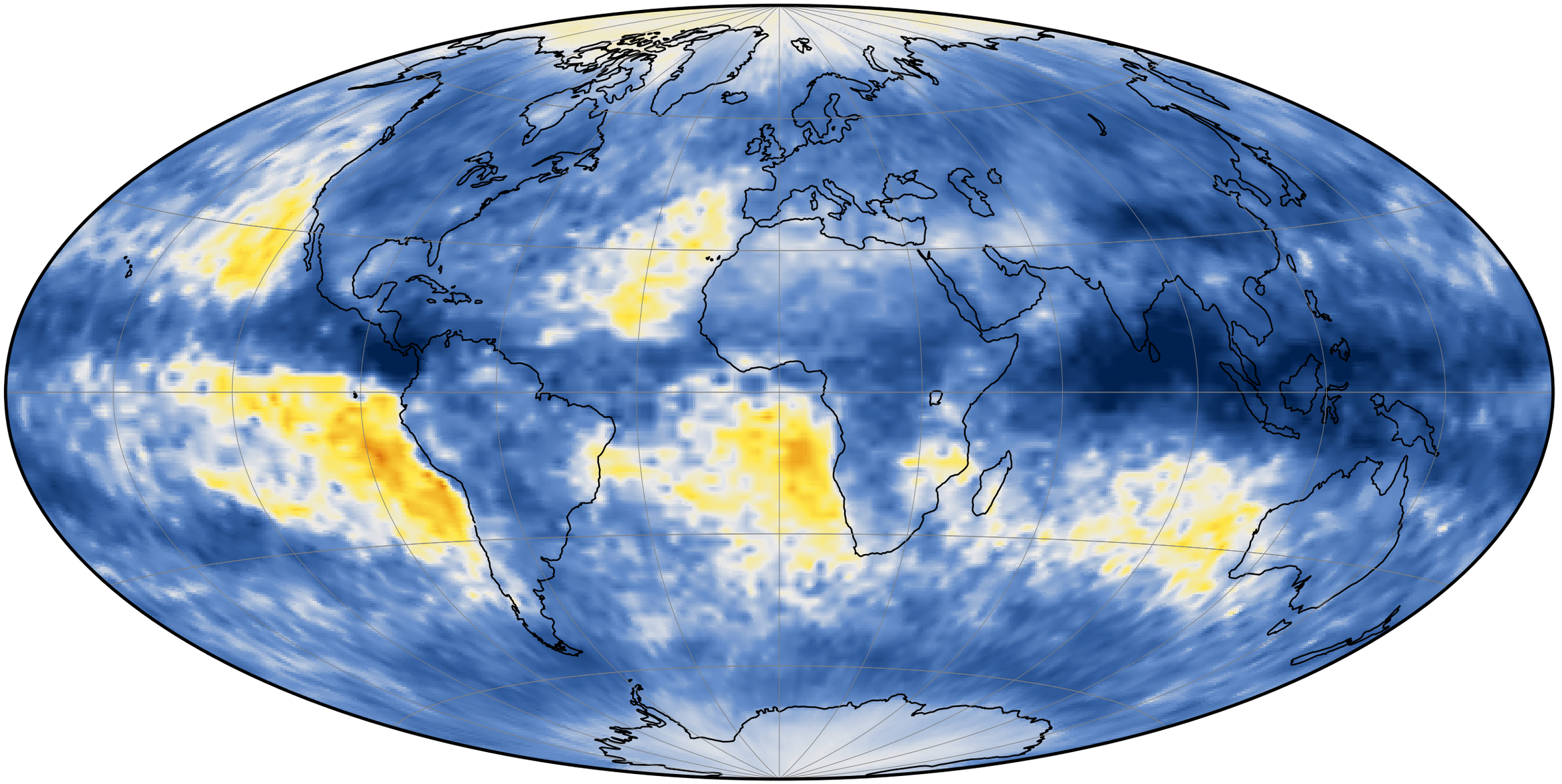
Data Min = -5.1E-06, Max = 2.9E-06


Longwave heating rate (RRTMG - CAMRT) (+-5e-6 shown)
hybrid level at midpoints (level)
1.62255
202.00939
402.39622
602.78306
803.1699
1003.55673
-90
-60
-30
0
30
60
90
Latitude (°N)
Longwave heating rate (K/s)
-5.0E-06
-3.0E-06
-1.0E-06
1.0E-06
3.0E-06
5.0E-06
Data Min = -4.9E-06, Max = 5.7E-06

Net SW Flux

	Base: W/m^2	RRTMG - CAMRT
Top	217	-4.33
Surface	142	-1.97
Top/Clear	288	-1.33
Surface/Clear	217	-1.47
Cloud (Top)	-71	-3.01

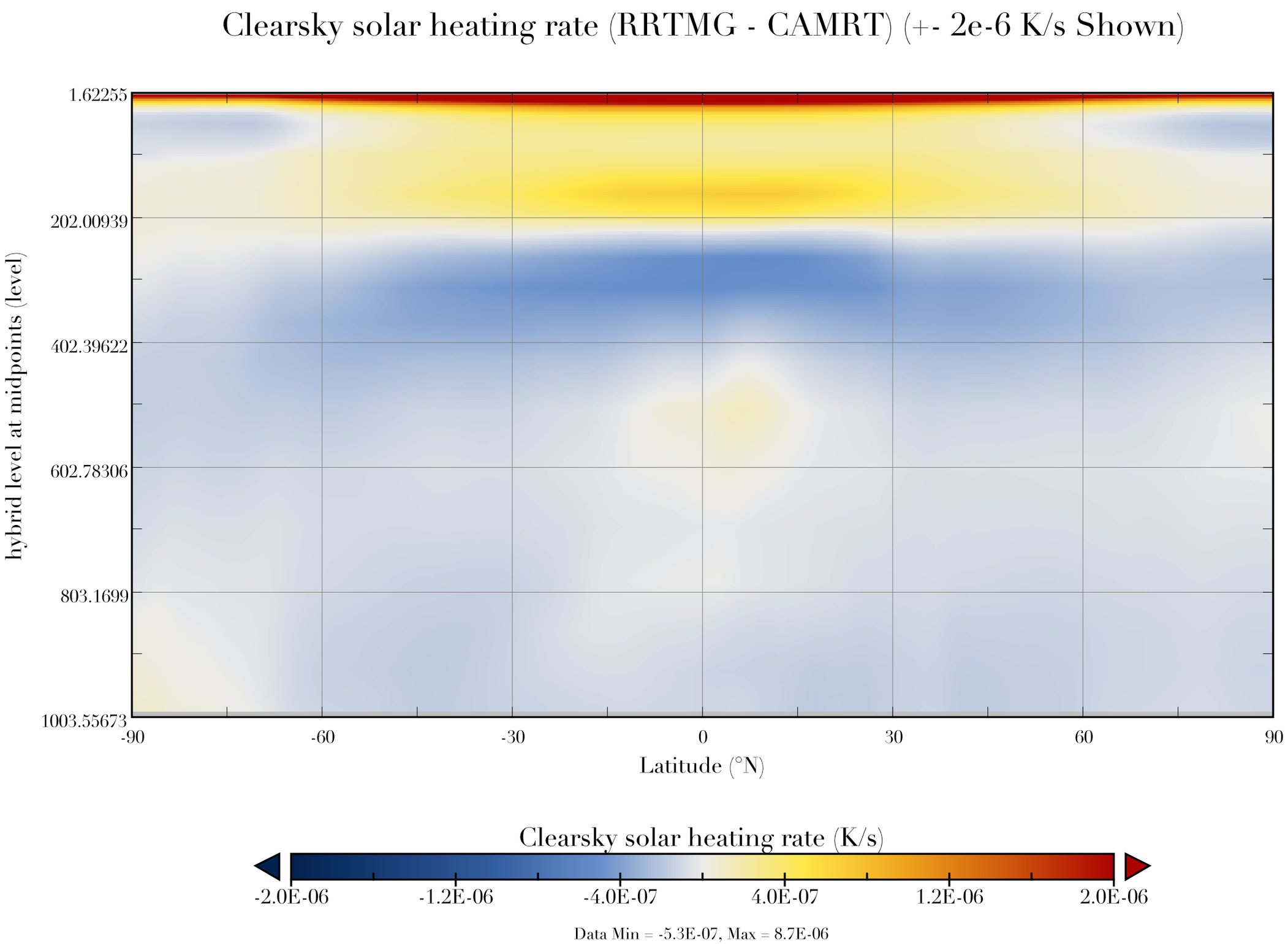
Net solar flux at top of model (RRTMG - CAMRT) (+-15 W/m^2 shown)



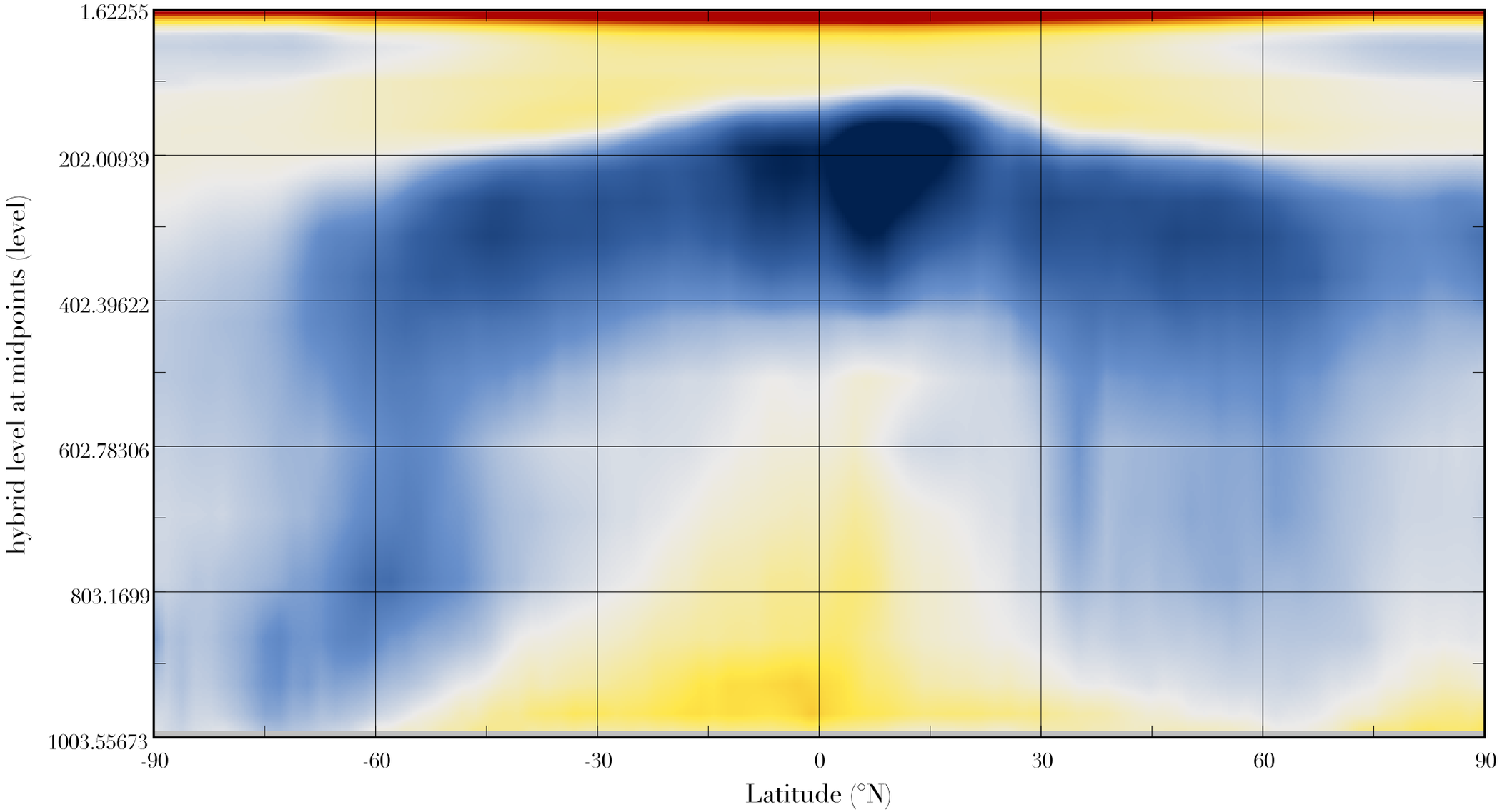
Net solar flux at top of model (W/m2)

-15.1 -9.1 -3.0 3.0 9.1 15.1

Data Min = -19.5, Max = 10.8


Clearsky solar heating rate (RRTMG - CAMRT) (+- 2e-6 K/s Shown)
hybrid level at midpoints (level)
1.62255
202.00939
402.39622
602.78306
803.1699
1003.55673
-90
-60
-30
0
30
60
90
Latitude (°N)
Clearsky solar heating rate (K/s)
-2.0E-06
-1.2E-06
-4.0E-07
4.0E-07
1.2E-06
2.0E-06
Data Min = -5.3E-07, Max = 8.7E-06

Solar heating rate (RRTMG - CAMRT) (+-2e-6 shown)



Solar heating rate (K/s)

-2.0E-06 -1.2E-06 -4.0E-07 4.0E-07 1.2E-06 2.0E-06

Data Min = -3.6E-06, Max = 8.5E-06

CAM5, since August 2009

- Change boundary: conservative scattering | scatter/abs in SW
- Change optics for cold dry air (unvalidated)
- Tried to move to most recent tag of rrtmg, but software engineering turned out to be too difficult
- PORT - Parallel Offline Radiative Transfer
- Volcanic Optics reimplementation on Track 5 branch
- New Solar Specification
- Suggested MAM and Cloud Interfaces

Future Opportunities of Interest

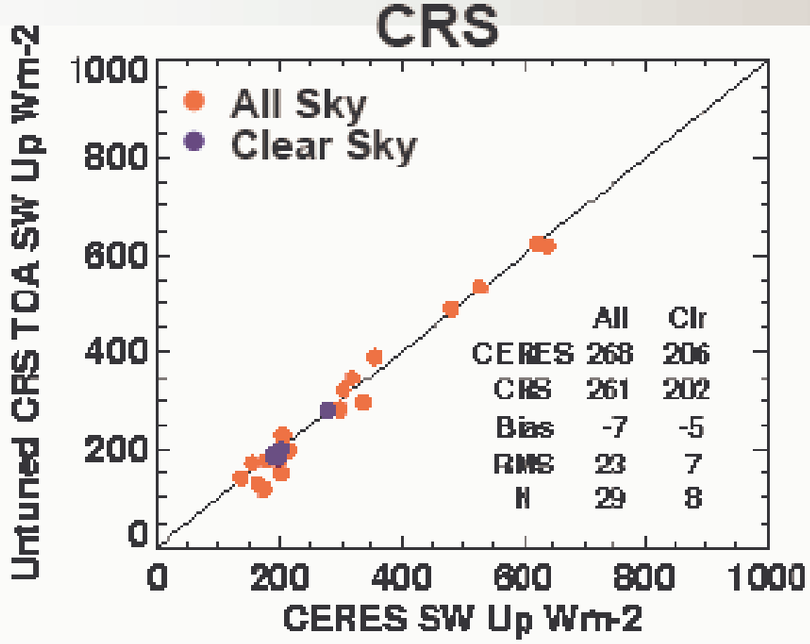
- Framework to test against line-by-line DisORT methods
- Separate Composition (state, microstate) from Optics/RT (MAM, Clouds)
- Remove sub-column assumptions from radiation
- Make water vapor and cloud correlation explicit, outside radiation
- Move radiation to mass-path specification rather than mmr-specification
- Climatology from WACCM between TOM/TOA
- LW Bias Anyone?

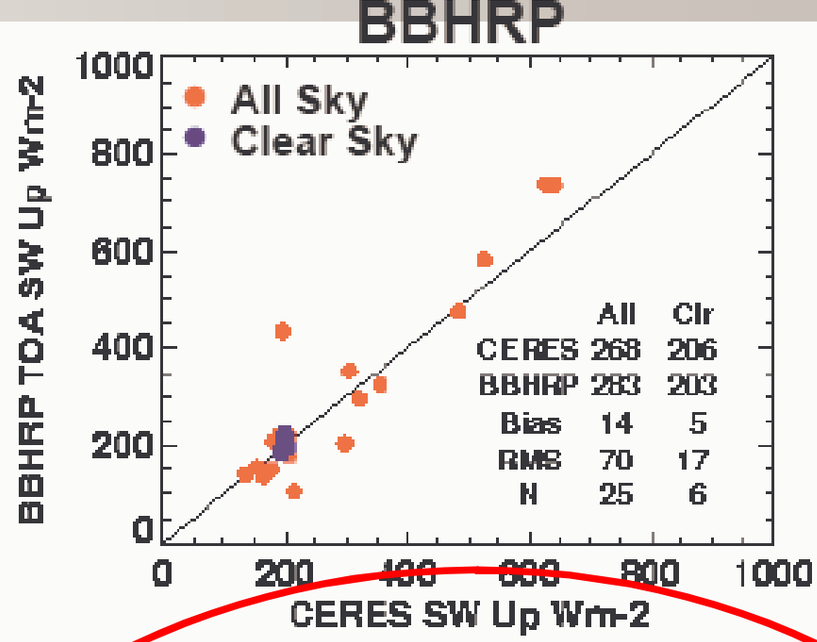
That’s all, folks!

About a 1 W/m^2 error Relative to CERES

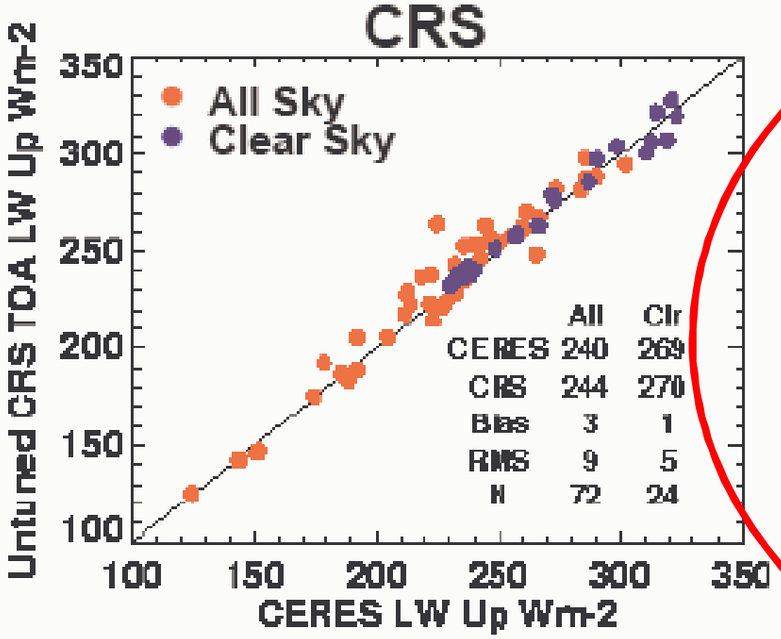
TOA Model to Observation (CERES)

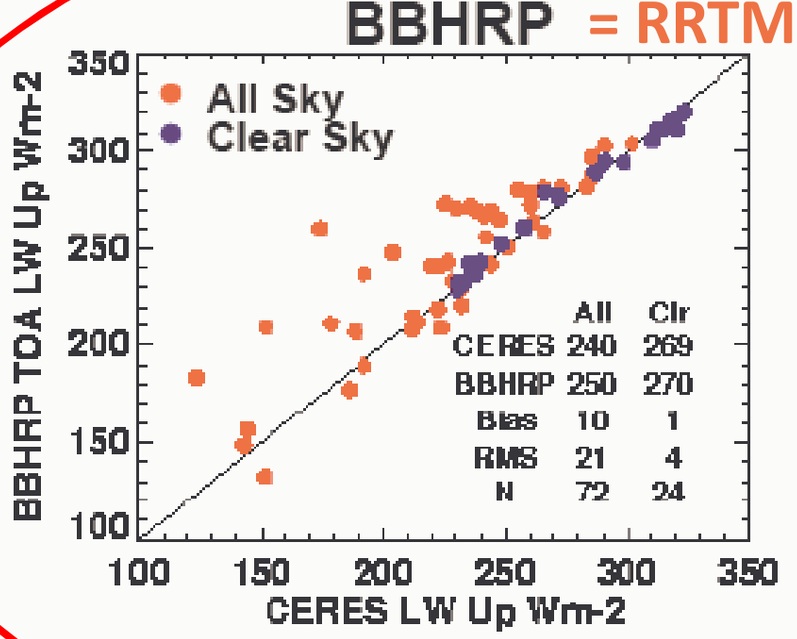
SW





LW



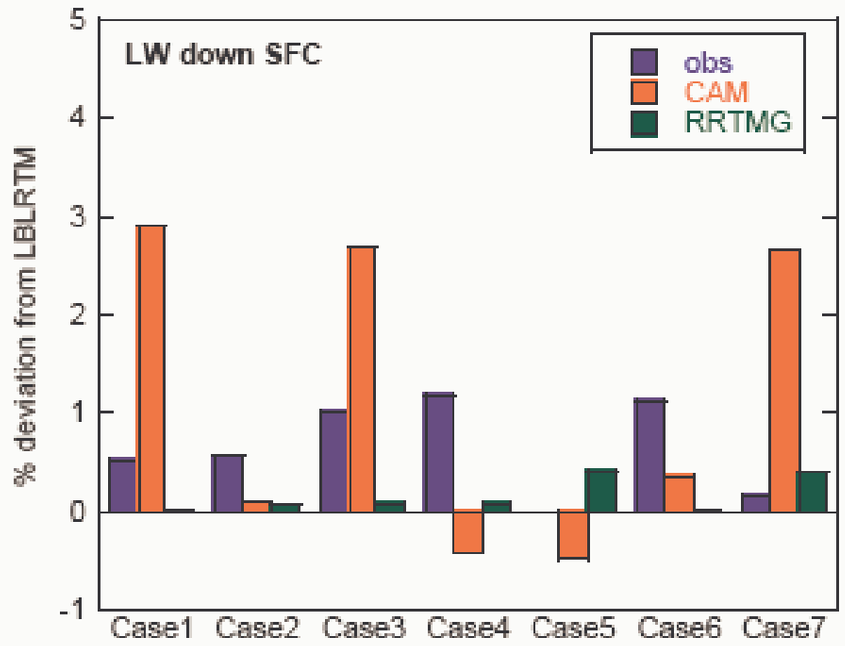


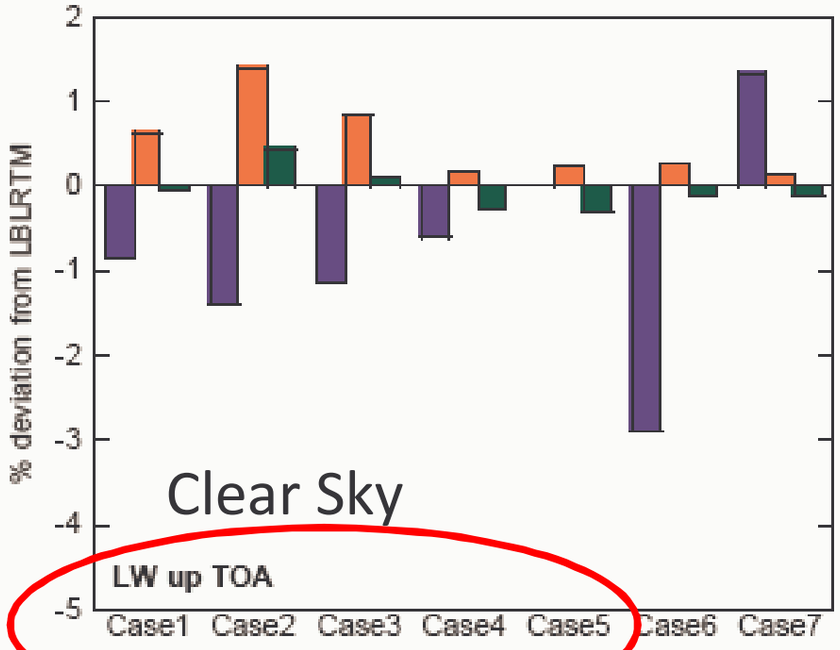
XVI ARM Science Team Meeting – Mar 27-31, 2006, Albuquerque, NM

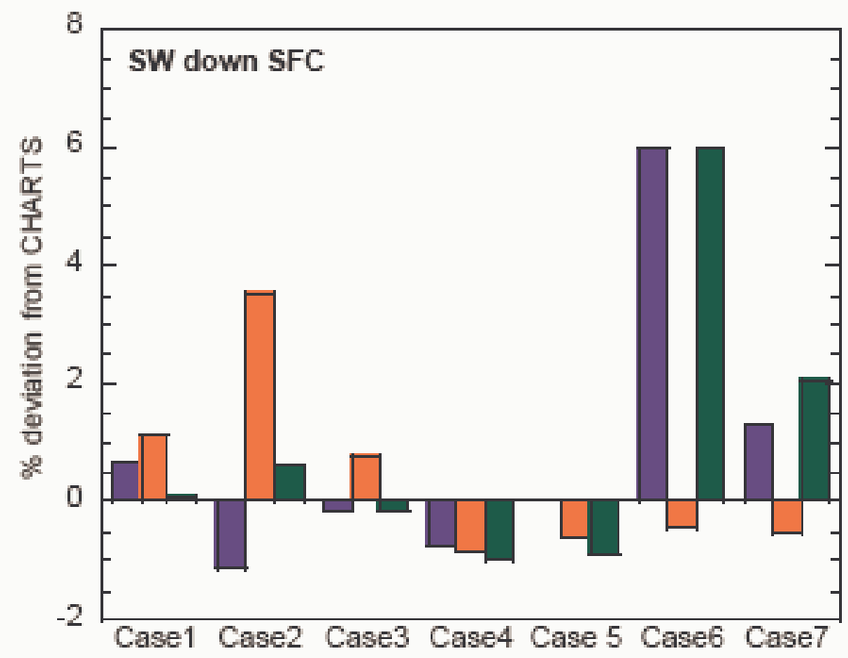
Based on Observed Atmos/Surf State

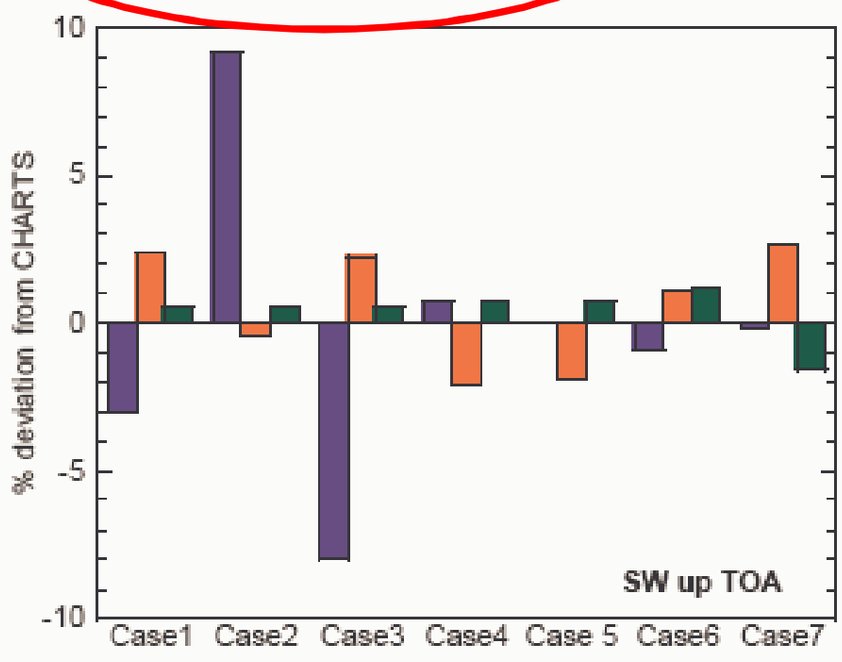
Dave Rutan and Tom Charlock

RRTMG vs Benchmark LBL Code









Based on Observed Atmos/Surf State

Lazaros Oreopoulos

Flux Differences (W/m^2)

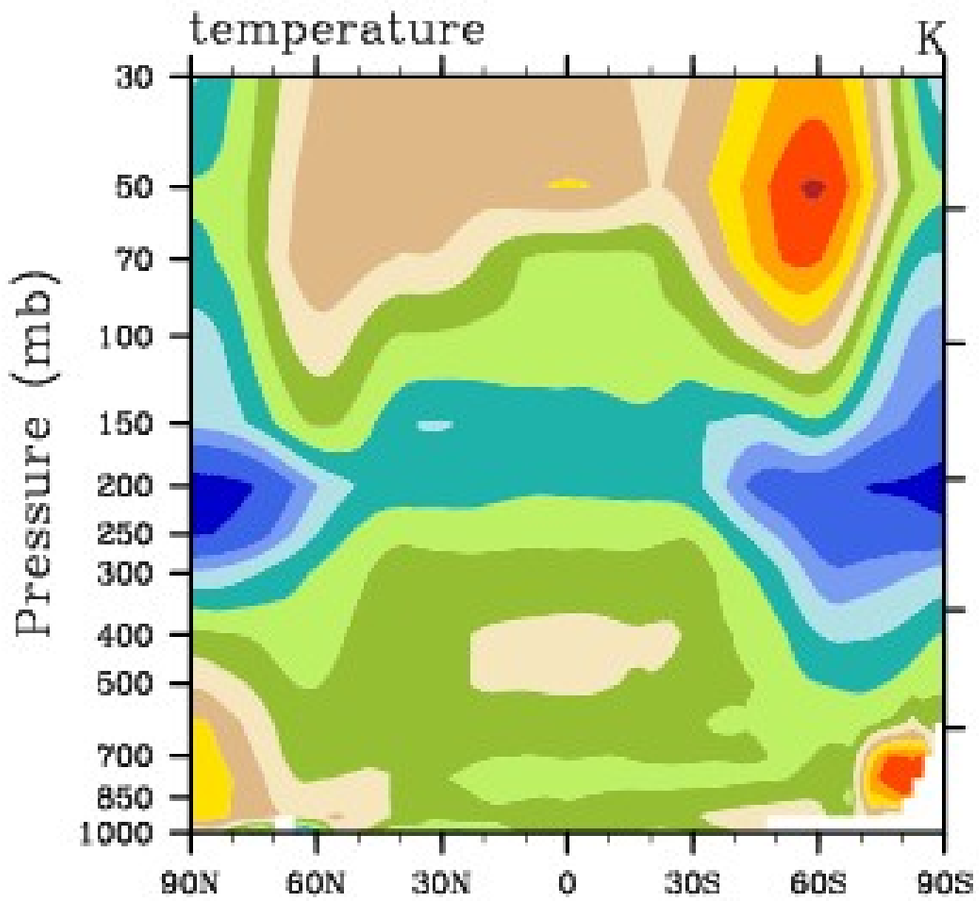
Global , 1 yr Means, No Aerosols, RT-coupled

	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

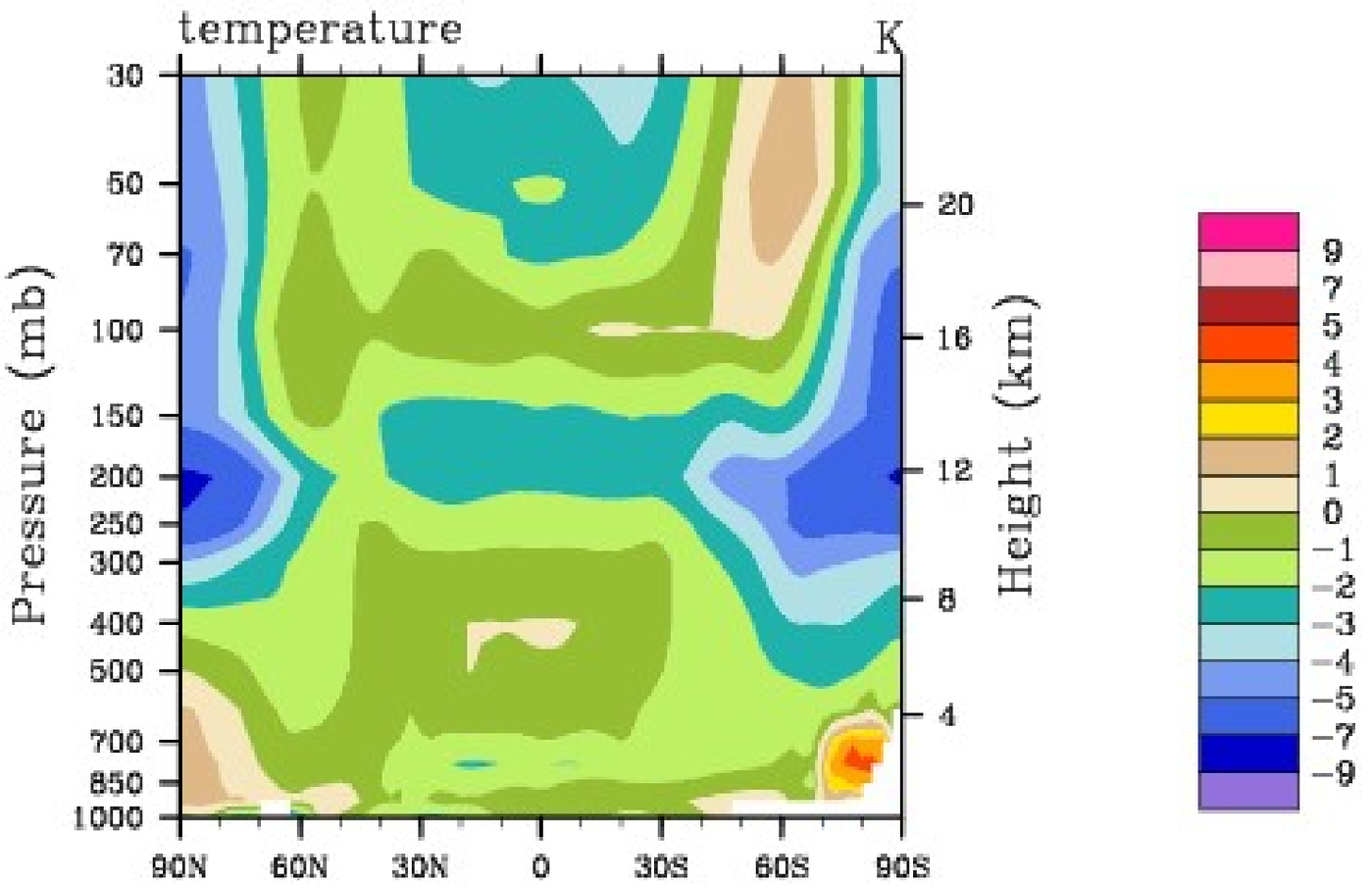
Top: let less solar in, less IR out.
Surface: less solar and radiates less IR.

Climate Effects from New Radiation

CAM – ERA40



RRTMG-ERA40



No Aerosols, Old CAM cloud optics, RT coupled

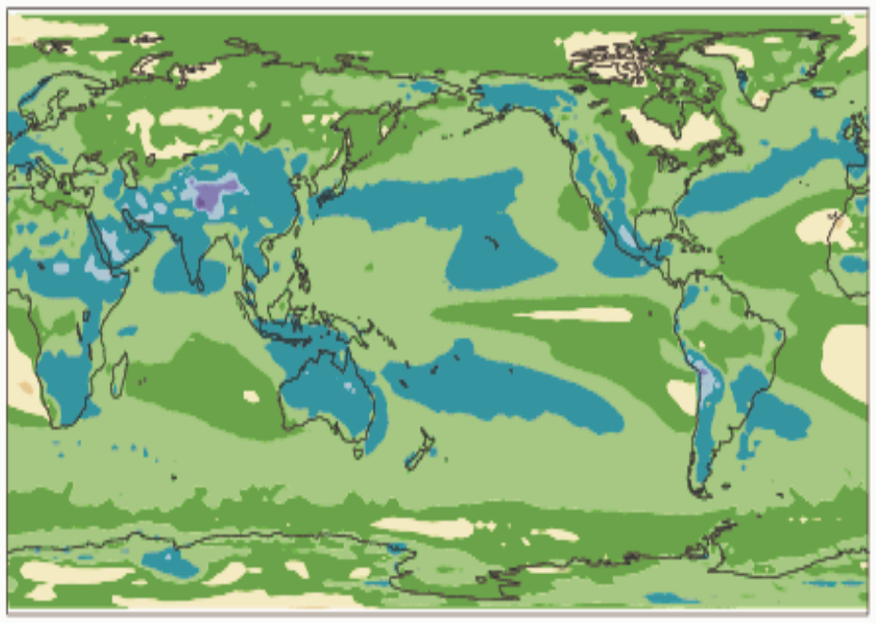
See Mike Iacono's Poster!

Top of Model Clear Sky Upwelling Longwave Flux Relative to CERES

(Originally presented Sept 20, 2008)

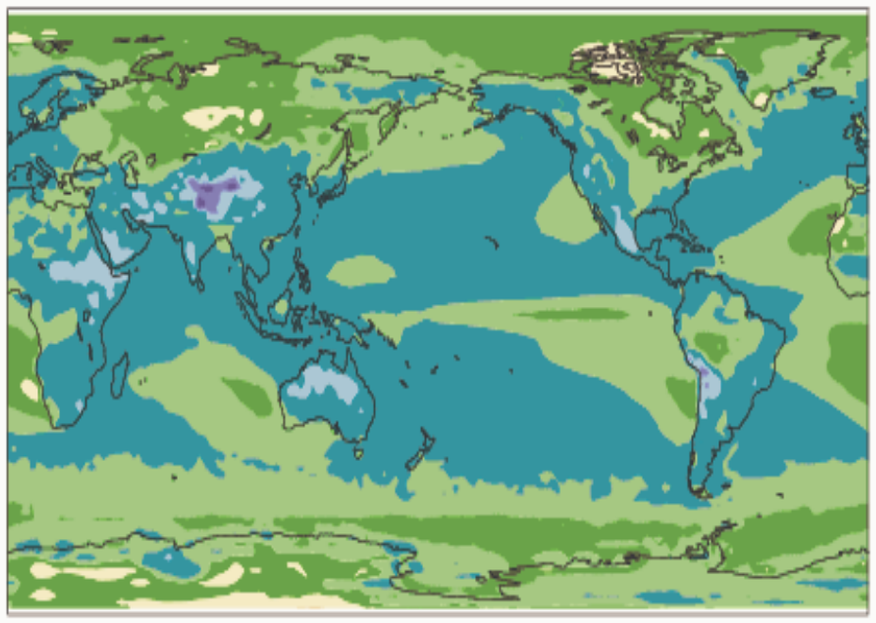
CAMRT – CERES2
-7.07 W/m^2

mean = −7.07 rmse = 8.41 W/m~S~2~N~

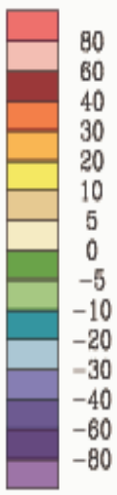


RRTMG – CERES2
-10.40 W/m^2

mean = −10.40 rmse = 11.42 W/m~S~2~N~



Min = −47.70 Max = 5.65



Interface for Radiative Constituents

- Implemented for both CAMRT and RRTMG
- Explicit specification of radiative constituents – nothing hidden
- Declaration of prognostic or diagnostic character of each species
- Namelist driven specification of multiple diagnostic calls to the radiation for forcing computation
- Explicit link between microphysics and optics of each condensed species
- Doesn't change answers