RTMIP Forcing for the AER Models and Status of the RRTMG Applications

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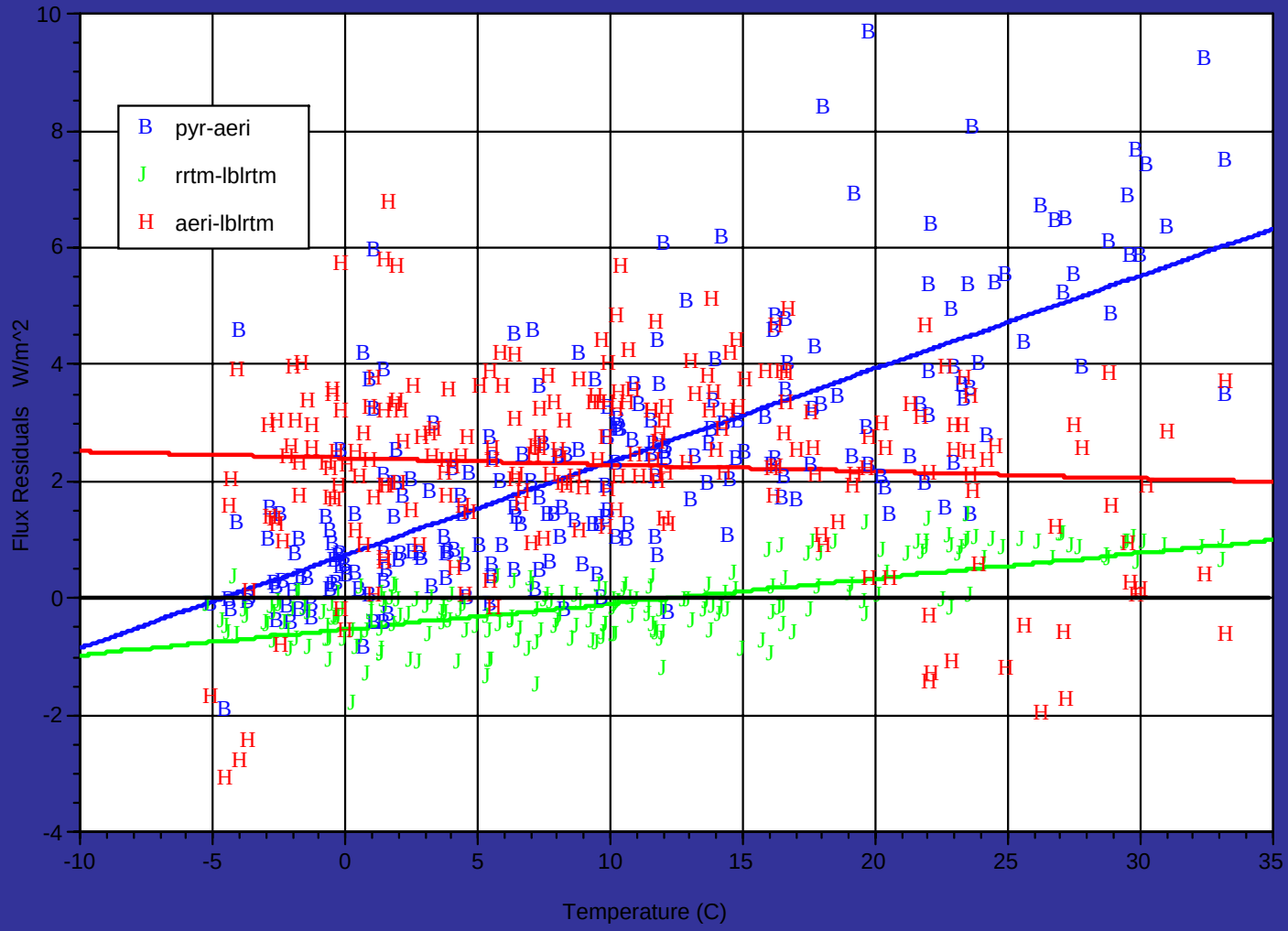
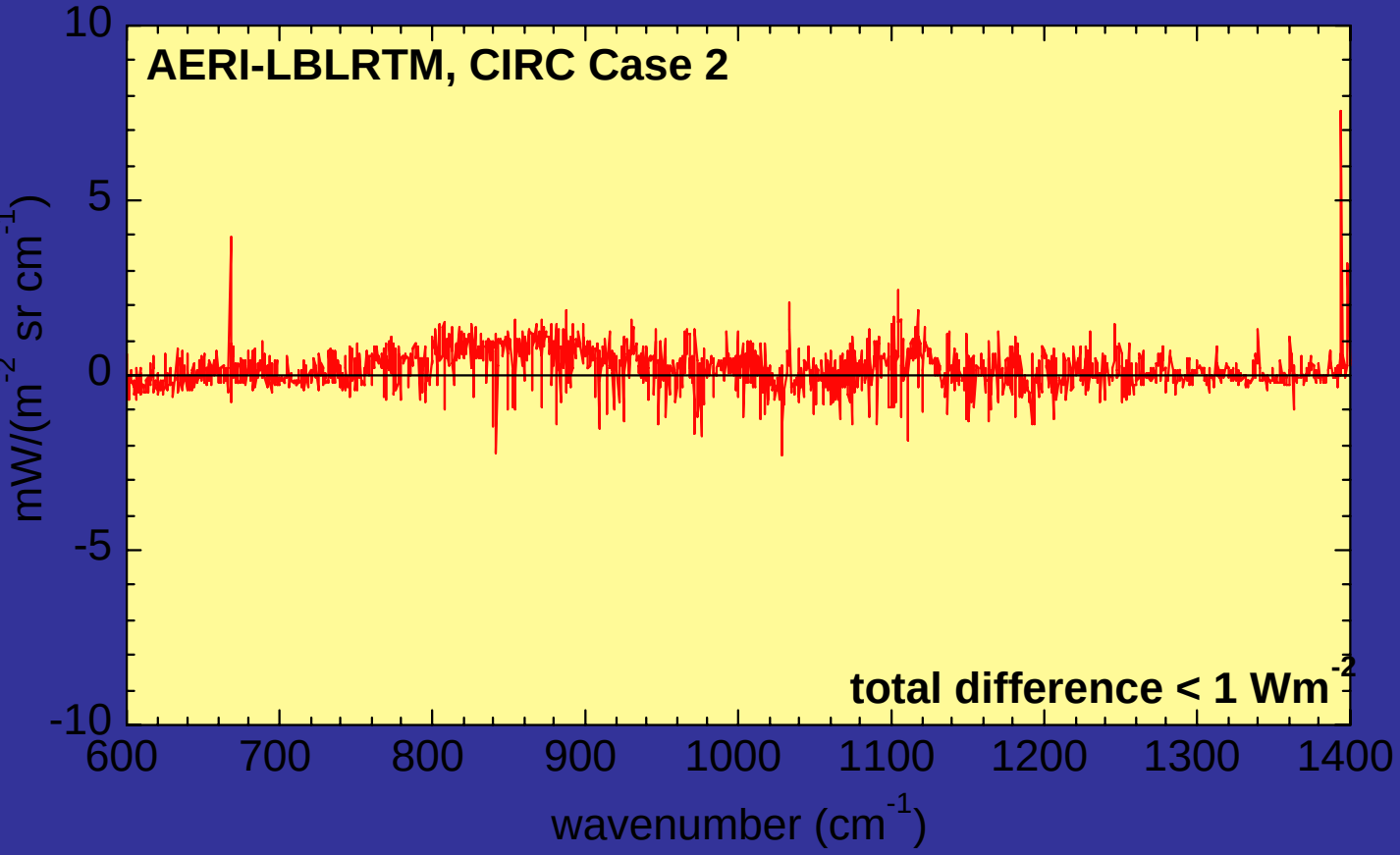
‘LW QME’ Analysis by Clough et al. (1997 data)

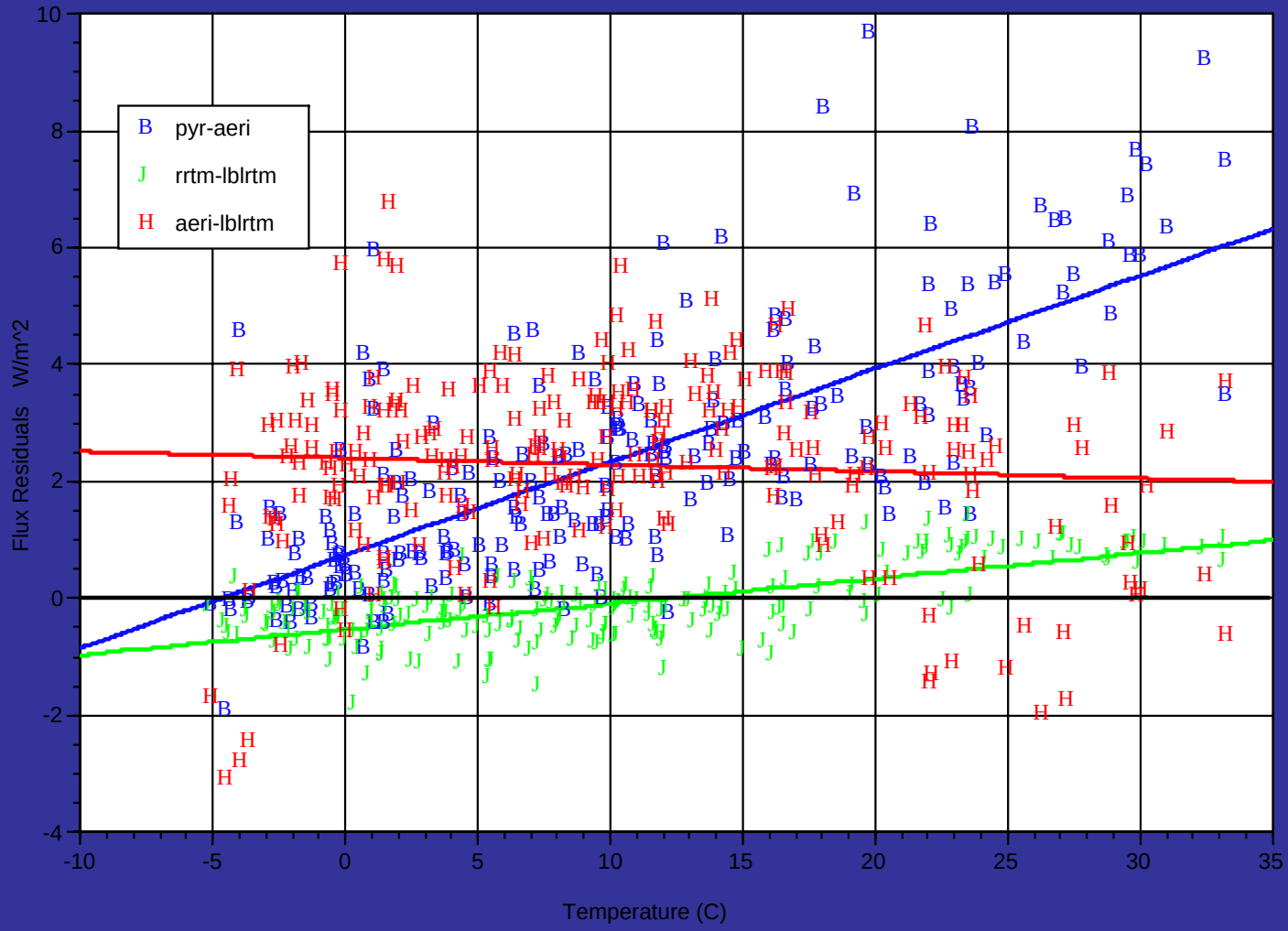


Spectral Residuals - 7/19/00 23:29



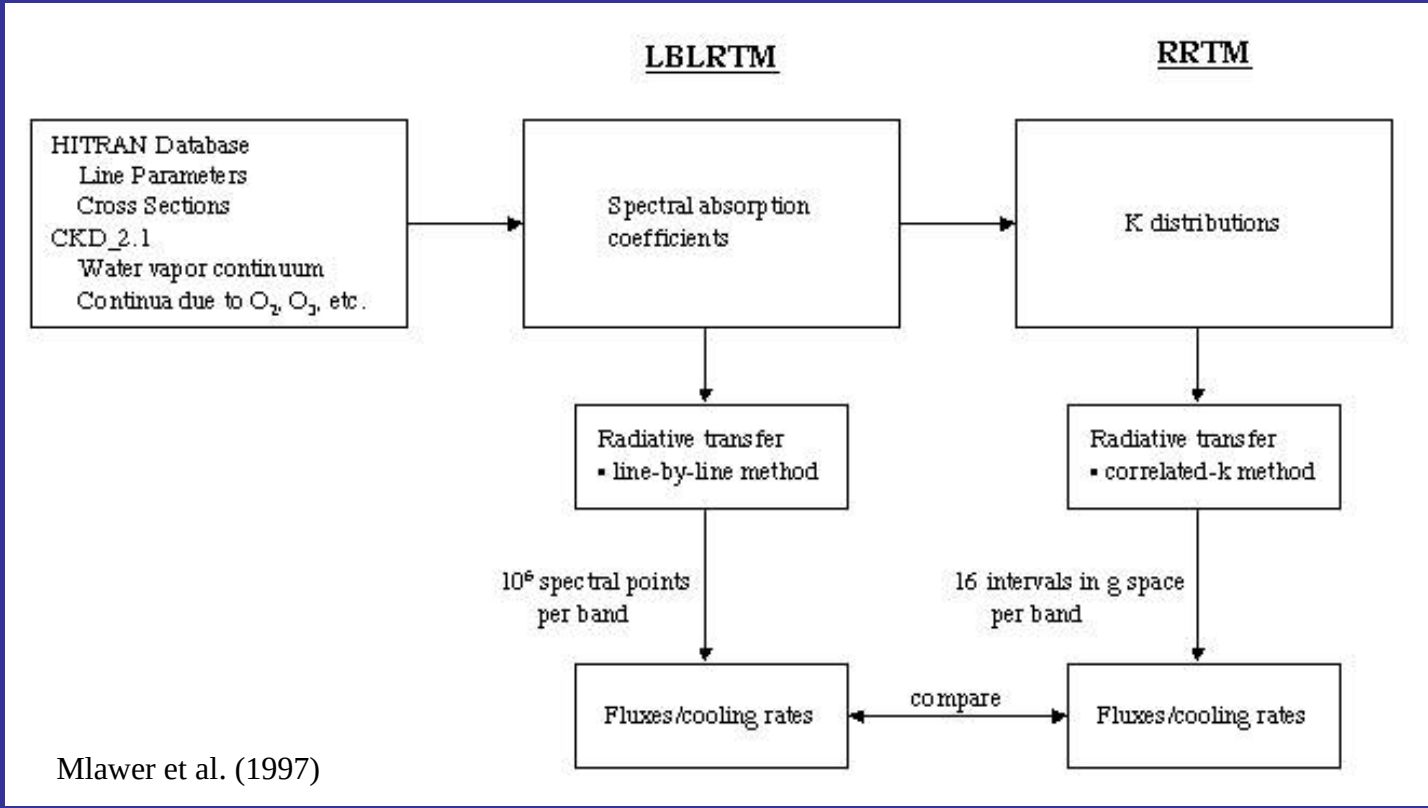
from Oreopoulos and Mlawer (2008)

‘LW QME’ Analysis by Clough et al. (1997 data)



Background: RRTM and RRTMG

RRTM



RRTMG Longwave: Spectral calculations 256 $\Rightarrow$ 140

Shortwave: Spectral calculations 224 $\Rightarrow$ 112

2-stream scattering

Overview

Ongoing RRTMG Implementations

- NCAR CAM3.6 $\rightarrow$ CAM4 (Summer 2009)
- NCAR WRF_3.0 $\rightarrow$ WRF_3.1 (Spring 2009)
- NCEP GFS/CFS $\rightarrow$ release date unknown
- NCEP RUC $\rightarrow$ using LW starting Nov 2008

AER Model Evaluation: RTMIP Radiative Forcing

- RTMIP: AR4 GCMs and LBL models (Collins et al. 2006)
- Calculated with LBLRTM, CHARTS, RRTM and RRTMG (Iacono et al. 2008)
- AER results now included in ARM RTMIP data archive

CAM4/RRTMG Status

- AER radiation fully implemented
- Testing several new cloud optics and aerosol treatments
- Retuning in progress for new physics
- CAM4 configuration not yet finalized

ARM-Supported Radiation for GCMs: RRTMG Applications

- GCMs
  1. ECMWF forecast model (using LW and SW)
  2. NCEP Global/Climate Forecast System (GFS, CFS) (using LW and testing SW)
  3. NCAR Community Atmosphere Model (CAM) (testing LW and SW)
  4. GFDL climate model (AM) (testing LW and SW)
  5. Max Planck Institute climate model (ECHAM5) (using LW)

- Mesoscale/Regional Models
  1. Weather Research and Forecasting (WRF/ARW) (using LW and testing SW)
  2. NCEP Rapid Update Cycle Forecast Model (RUC) (using LW)
  3. UC/CIRES Arctic regional climate model (ARCSyM) (using LW)

- ARM
  1. Single Column Models (Scripps, LLNL, etc.) (using LW)
  2. BBHRP (using SW)

- AER RT information and source code available at www.rtweb.aer.com

RTMIP Calculations with the AER Models

Clear Sky Radiative Forcing Cases: Based on MLS profile

Case	CO_2 (ppmv)	CH_4 (ppbv)	N_2O (ppbv)	CFC-11 (pptv)	CFC-12 (pptv)	H_2O[a]
2a-1a	287 → 369	---	---	---	---	---
2b-1a	287 → 574	---	---	---	---	---
3b-3a	287 → 369	806 → 1760	275 → 316	0 → 267	0 → 535	---
3a-1a	---	0 → 806	0 → 275	---	---	---
3b-3c	---	---	275 → 316	0 → 267	0 → 535	---
3b-3d	---	806 → 1760	---	0 → 267	0 → 535	---
4a-2b	---	---	---	---	---	1.0 → 1.2

Clear Sky Radiative Forcing: AER Models and IPCC GCMs

		Surface Longwave Radiative Forcing (Wm^{-2})			
Models	Field	2 x CO_2	GHGs 1860→2000	CH_4 & CFCs 1860→2000	1.2 x H_2O
AER*	F_{LBLRTM}	1.68	1.10	0.48	11.55
AER*	F_{RRTM_LW}	1.73	1.00	0.39	11.55
AER*	F_{RRTMG_LW}	1.79	1.05	0.42	11.92
IPCC+	$<F_{GCM}>$	1.12	1.21	0.74	11.95
IPCC+	$\sigma (F_{GCM})$	0.39	0.38	0.28	0.75

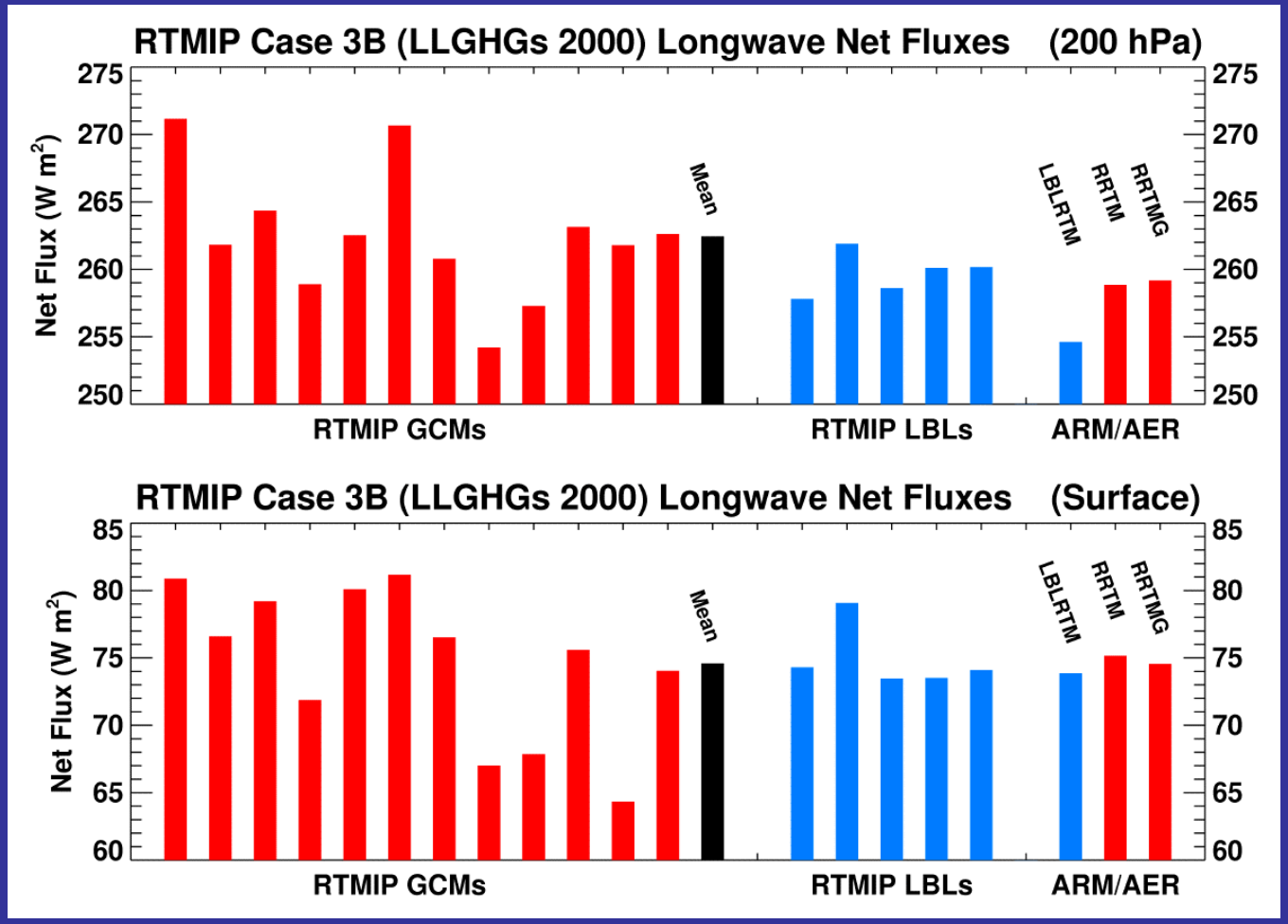
		Surface Shortwave Radiative Forcing (Wm^{-2})			
Models	Field	2 x CO_2	GHGs 1860→2000	CH_4 & CFCs 1860→2000	1.2 x H_2O
AER*	F_{CHARTS}	-0.95	-0.87	-0.54	-6.24
AER*	F_{RRTM_SW}	-0.59	-0.54	-0.33	-6.19
AER*	F_{RRTMG_SW}	-0.57	-0.53	-0.32	-6.14
IPCC+	$<F_{GCM}>$	-1.47	-0.49	0.00	-4.89
IPCC+	$\sigma (F_{GCM})$	1.40	0.46	0.00	0.98

+ Collins et al., *J. Geophys. Res*. (2006) [IPCC GCMs and LBL models]

* Iacono et al., *J. Geophys. Res*. (2008) [AER radiation models]

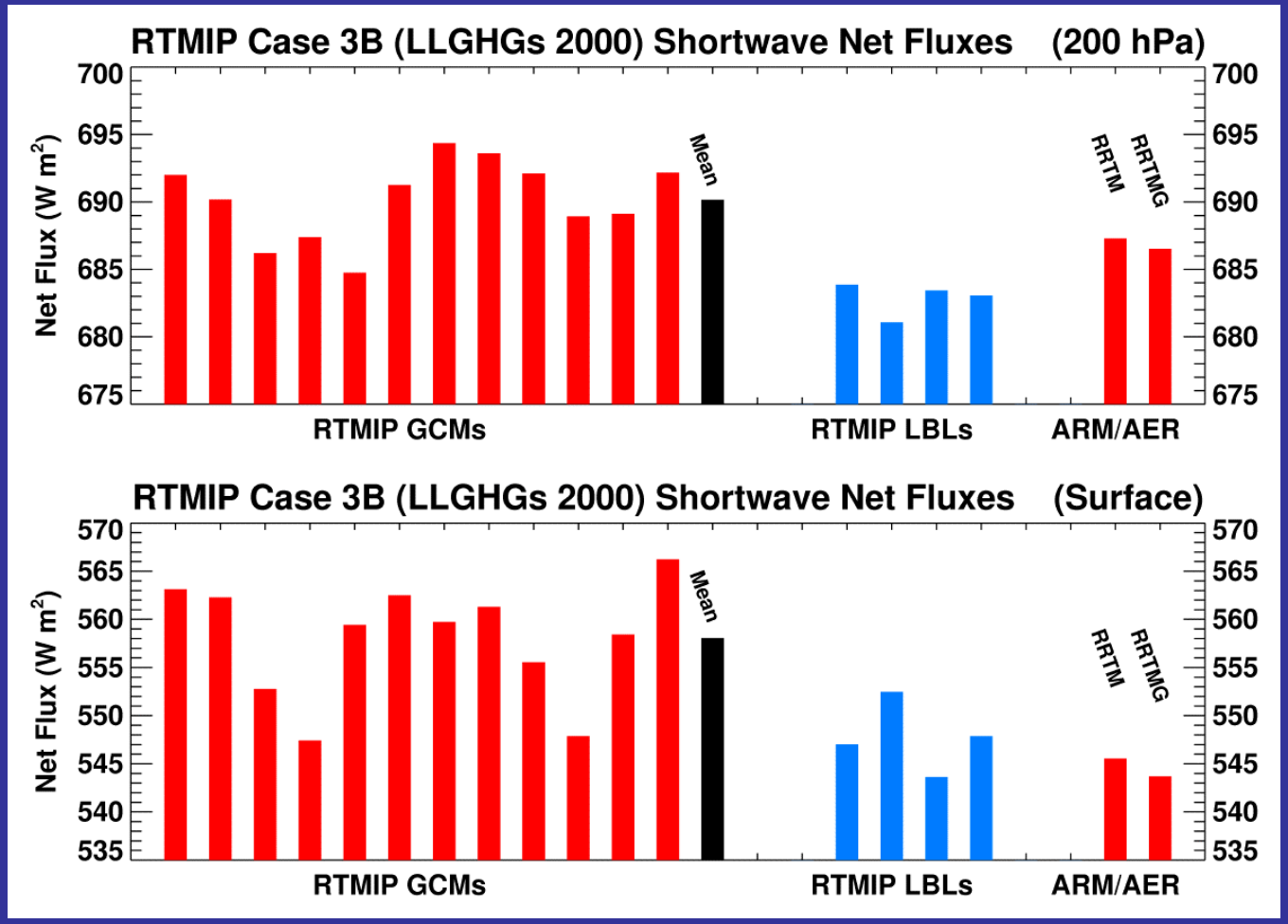
RTMIP Clear Sky Longwave Net Fluxes

Case 3B: Long-lived greenhouse gases at Year 2000 amounts



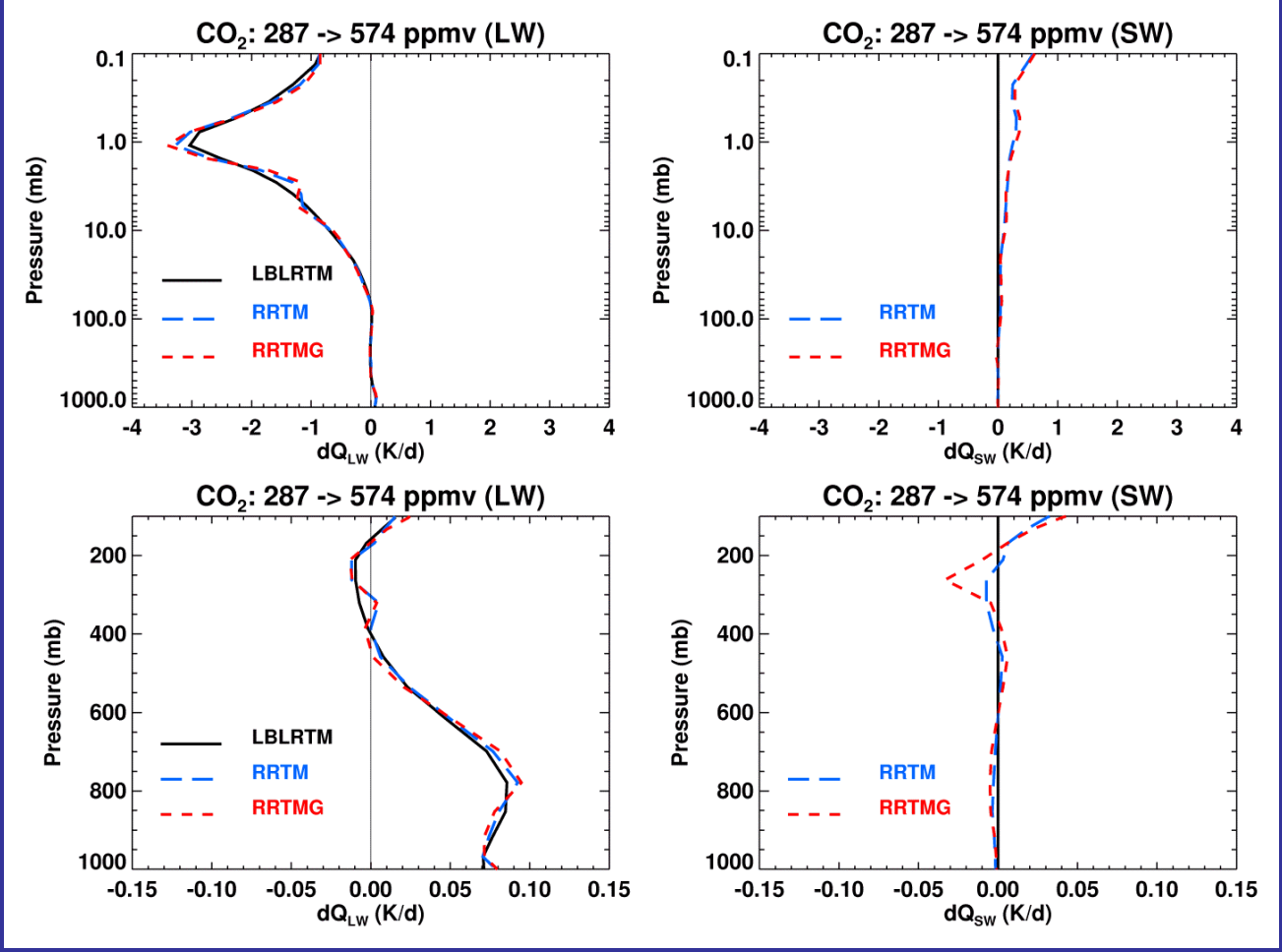
RTMIP Clear Sky Shortwave Net Fluxes

Case 3B: Long-lived greenhouse gases at Year 2000 amounts



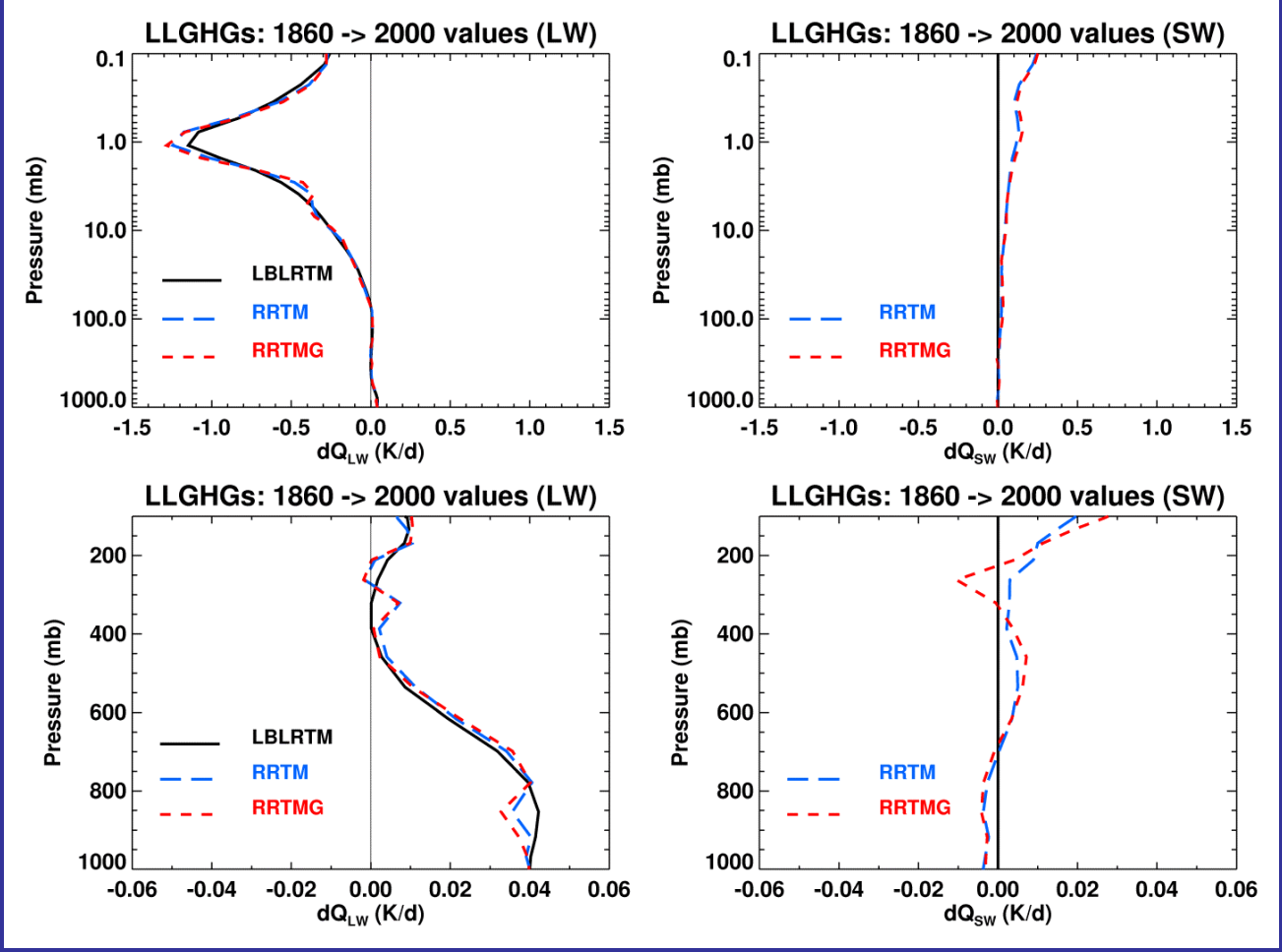
RTMIP Clear Sky Heating Rate Forcing, AER Models

Case 2B-1A: Doubled carbon dioxide



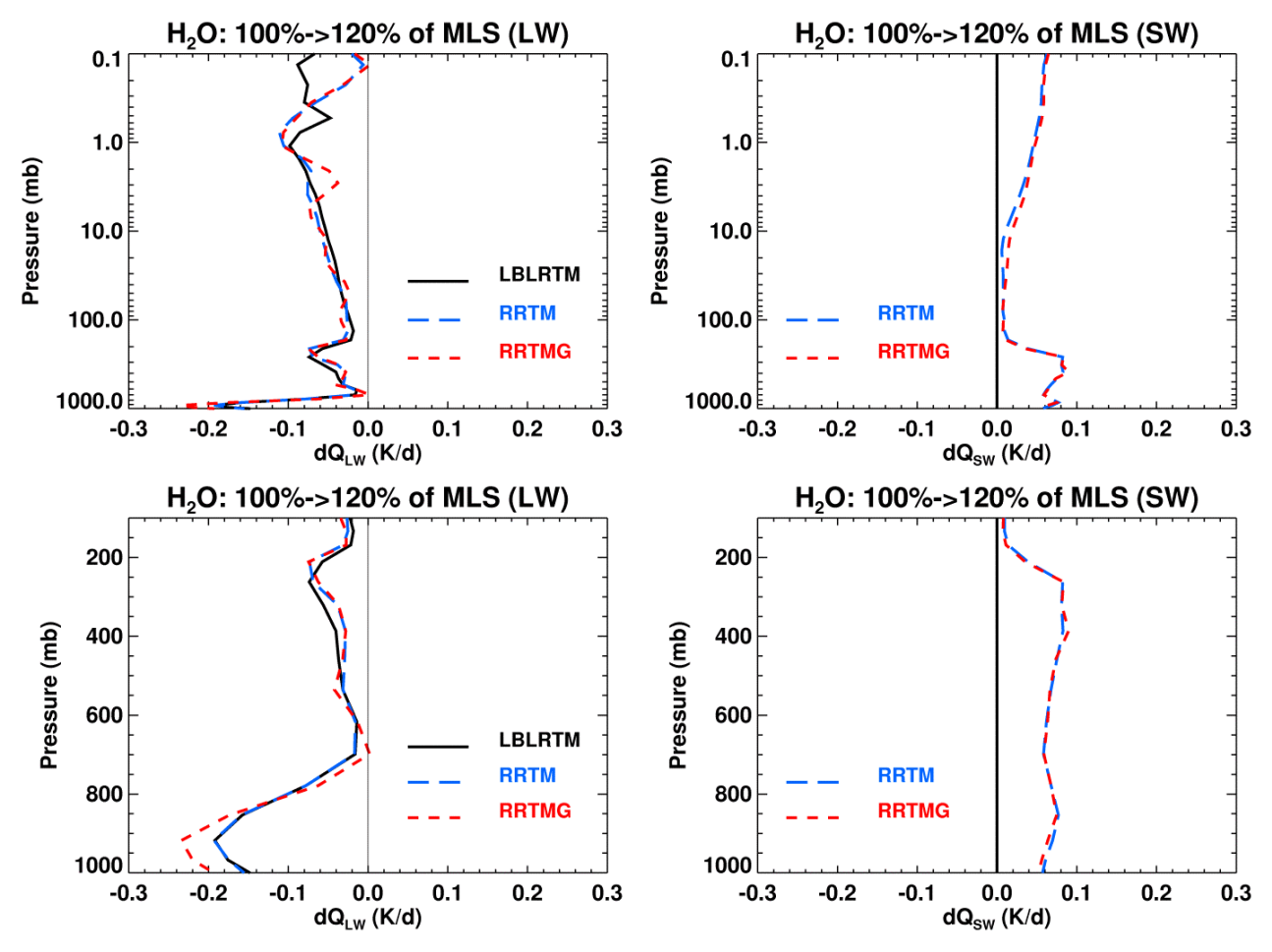
RTMIP Clear Sky Heating Rate Forcing, AER Models

Case 3B-3A: Long-lived greenhouse gases 1860 → 2000



RTMIP Clear Sky Heating Rate Forcing, AER Models

Case 4A-2B: 20% water vapor increase



WRF and CAM Implementation Update

WRF

- RRTMG_LW integrated, SW in progress
- AER will test impact on forecasts
- Provide modifications to NCAR (by 15 Dec deadline)
- New release in spring 2009

CAM

- RRTMG_LW and SW fully integrated at NCAR
- Simulations with several configurations are complete
- New cloud optics (Morrison-Gettelman, Mitchell)
- New modal aerosols (Ghan-Liu)
- Retuning in progress for various configurations

RRTM Longwave Radiation in RUC Upgrade
Effect on 2-m temperature forecasts

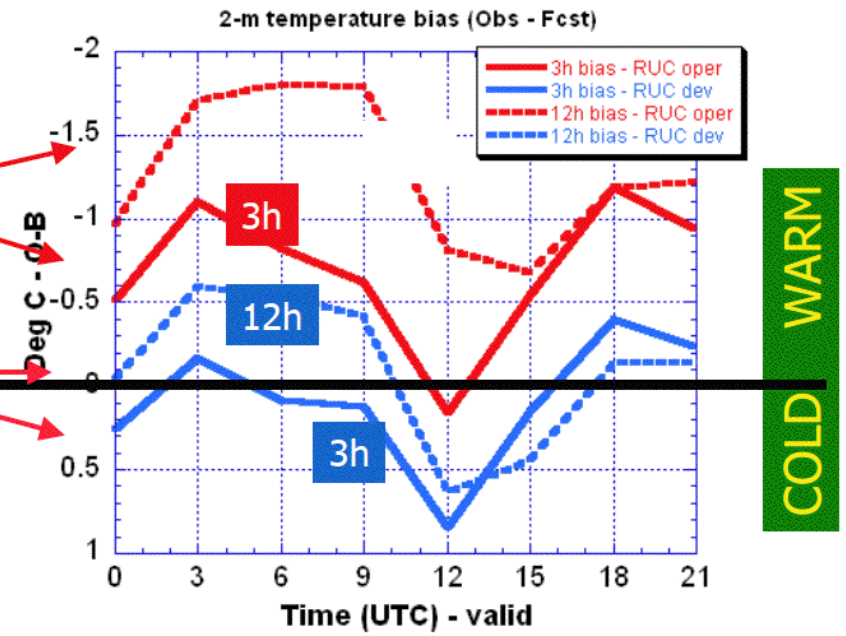
- Much decreased warm bias near surface

1-month comparison
14 May –13 June 07
Eastern US only

RUC oper – Dudhia LW

RUC para – RRTM LW

2-m temp bias (obs – forecast)



provided by Stan Benjamin (NOAA/GSD) and Geoff Manikin (NCEP/EMC)

CAM4 Test Configurations and Experiments

Three preliminary versions of CAM4 exist:

1) Main development trunk (RRTMG and old CAM_RT are options)
2) Model aerosol branch (includes RRTMG as default)
3) Boundary layer branch (includes RRTMG as default)

Version 1, CAM4 test configurations:

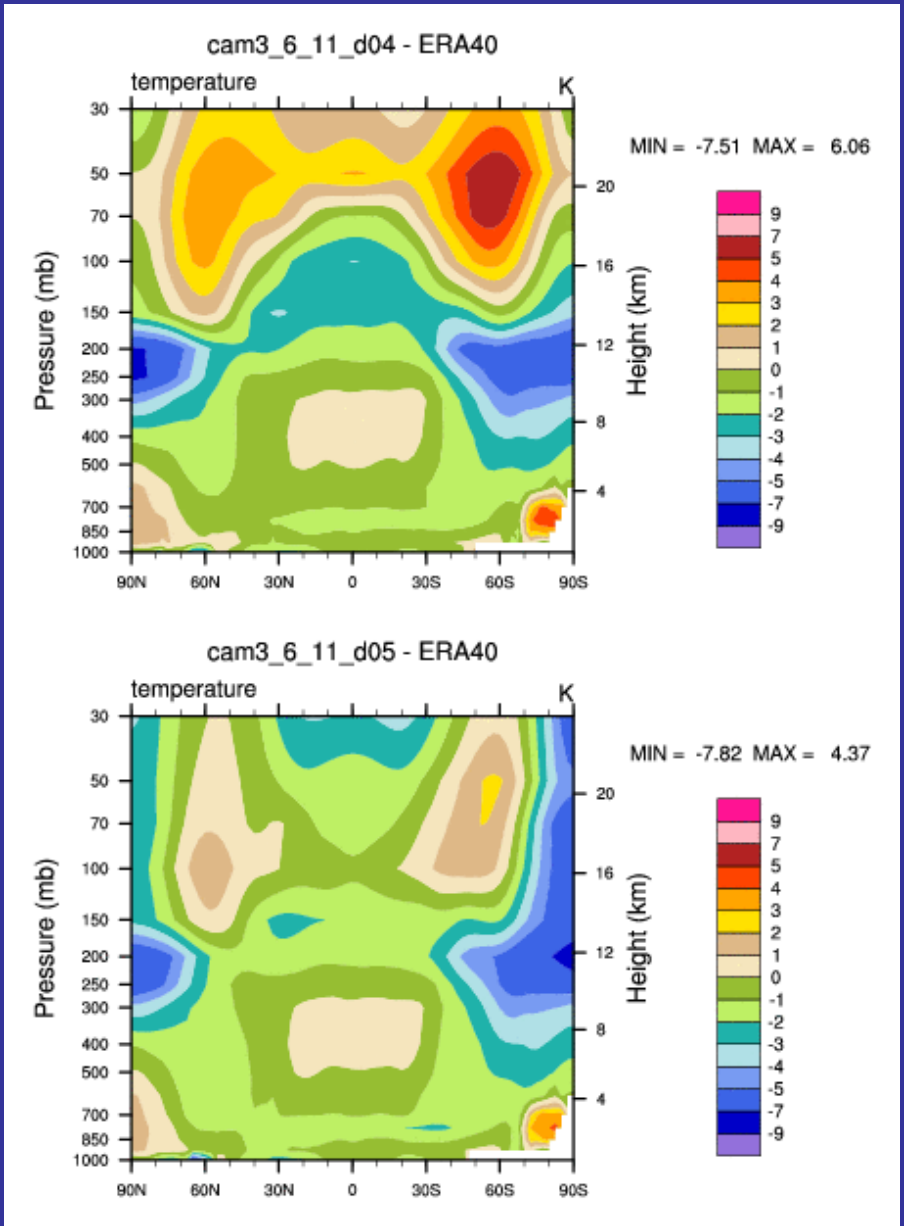
1) Case 0: CAM3.5 (CAM_RT and old bulk aerosols)
2) Case 1: C0 with MG microphysics
3) Case 2: C1 with AEROCOM emissions
4) Case 3: C2 with RRTMG replacing CAM_RT
5) Case 4: C3 with modal aerosols replacing bulk aerosols

Zonal Mean Temperature

CAM - ERA40

CAM/RRTMG - ERA40

Note: ERA40 also used RRTMG

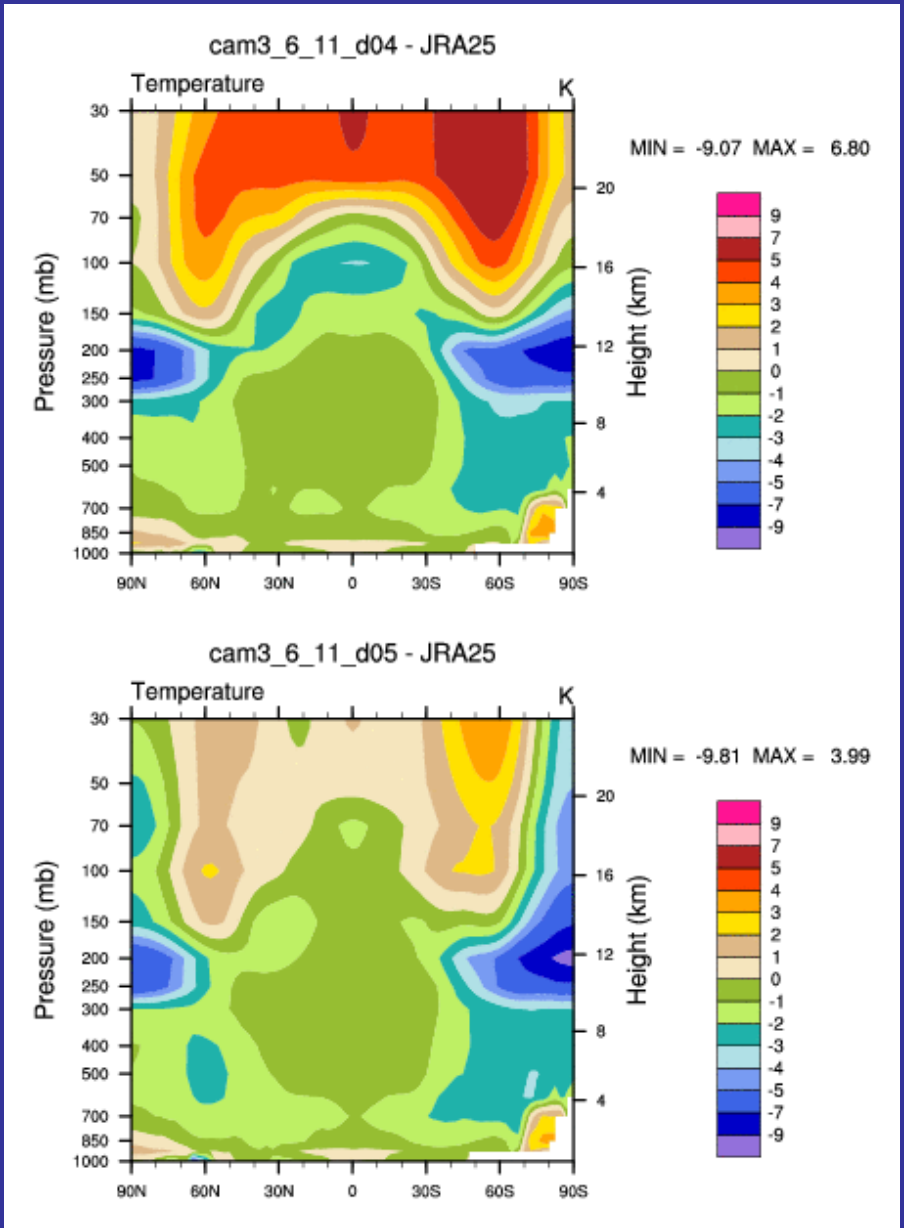


Zonal Mean Temperature

CAM - JRA25

CAM/RRTMG - JRA25

JRA: Japanese Reanalysis

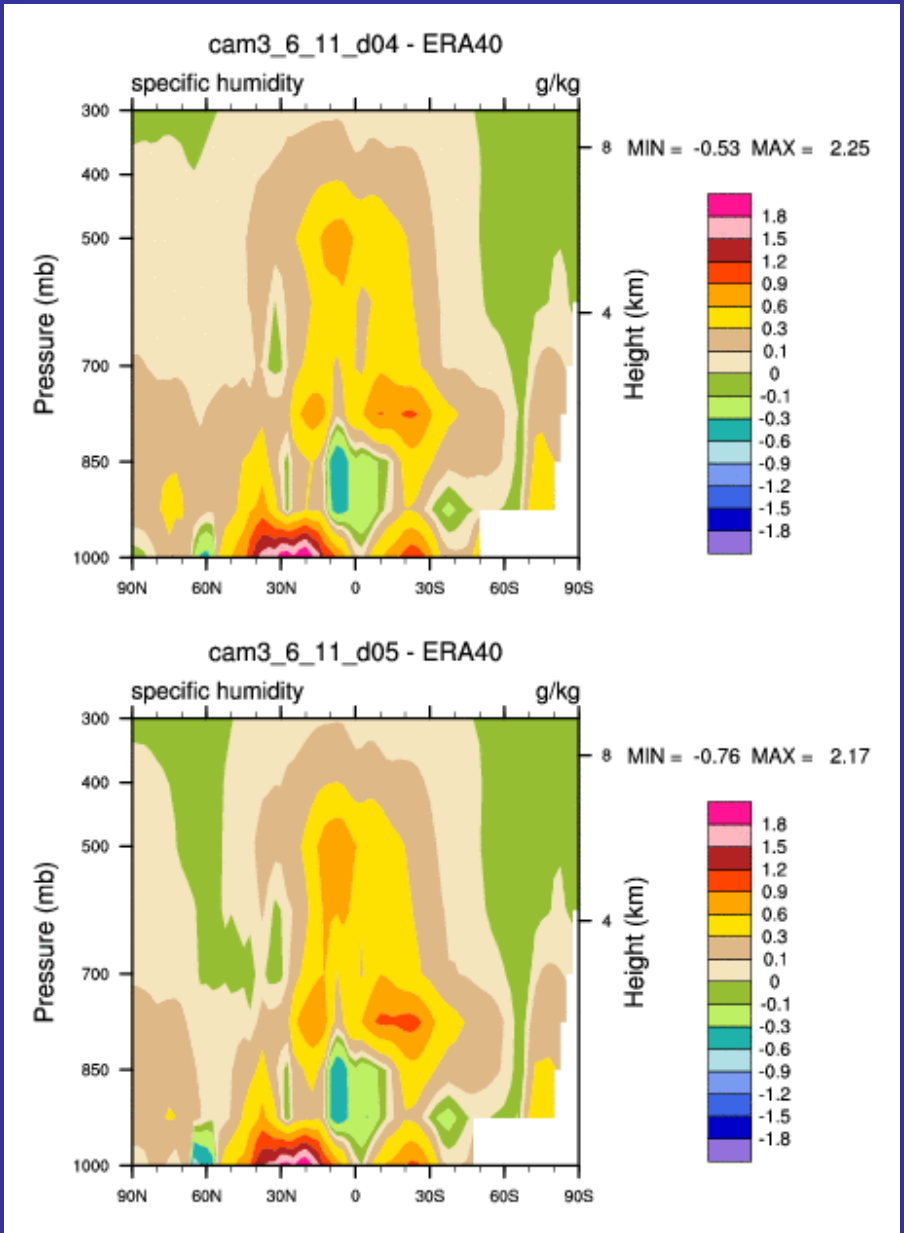


Zonal Mean
Specific Humidity

CAM - ERA40

CAM/RRTMG - ERA40

Note: Adjustments are ongoing, positive water bias may change; No impact from radiation

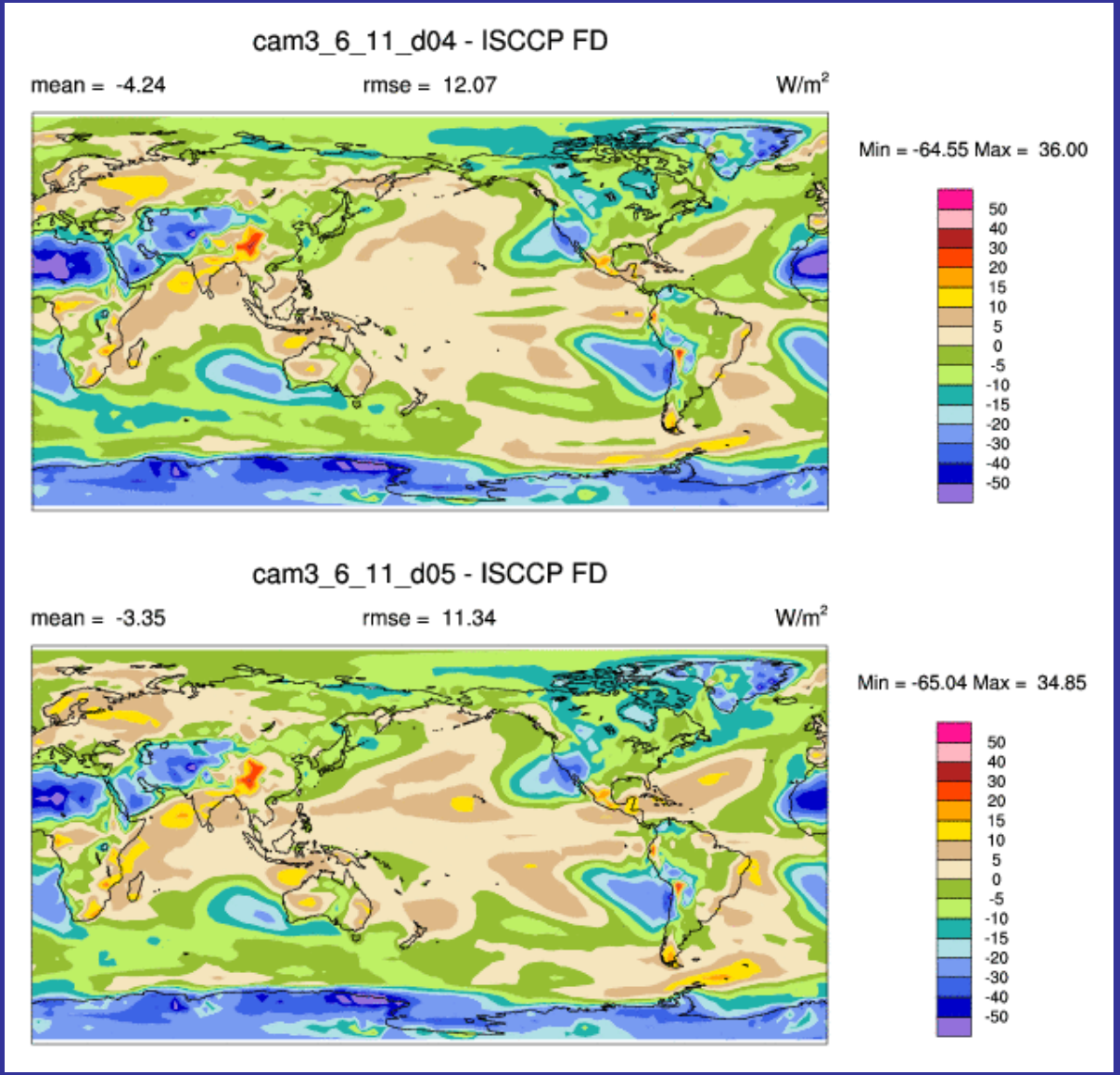


Downward Longwave Surface Flux

CAM - ISCCP

CAM/RRTMG - ISCCP

Note: Preliminary result

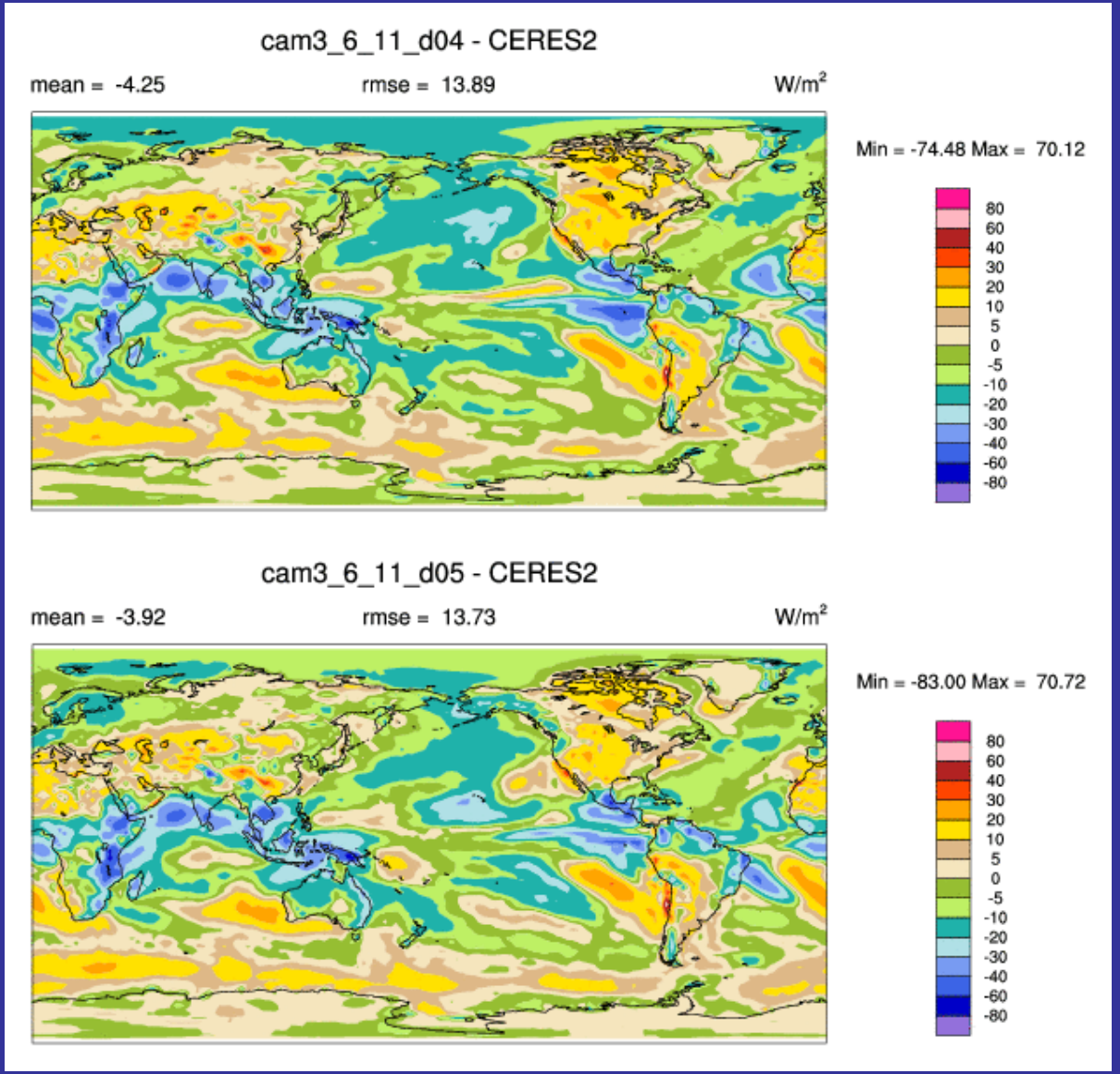


Net Shortwave TOA Flux

CAM - CERES2

CAM/RRTMG - CERES2

Note: Preliminary result

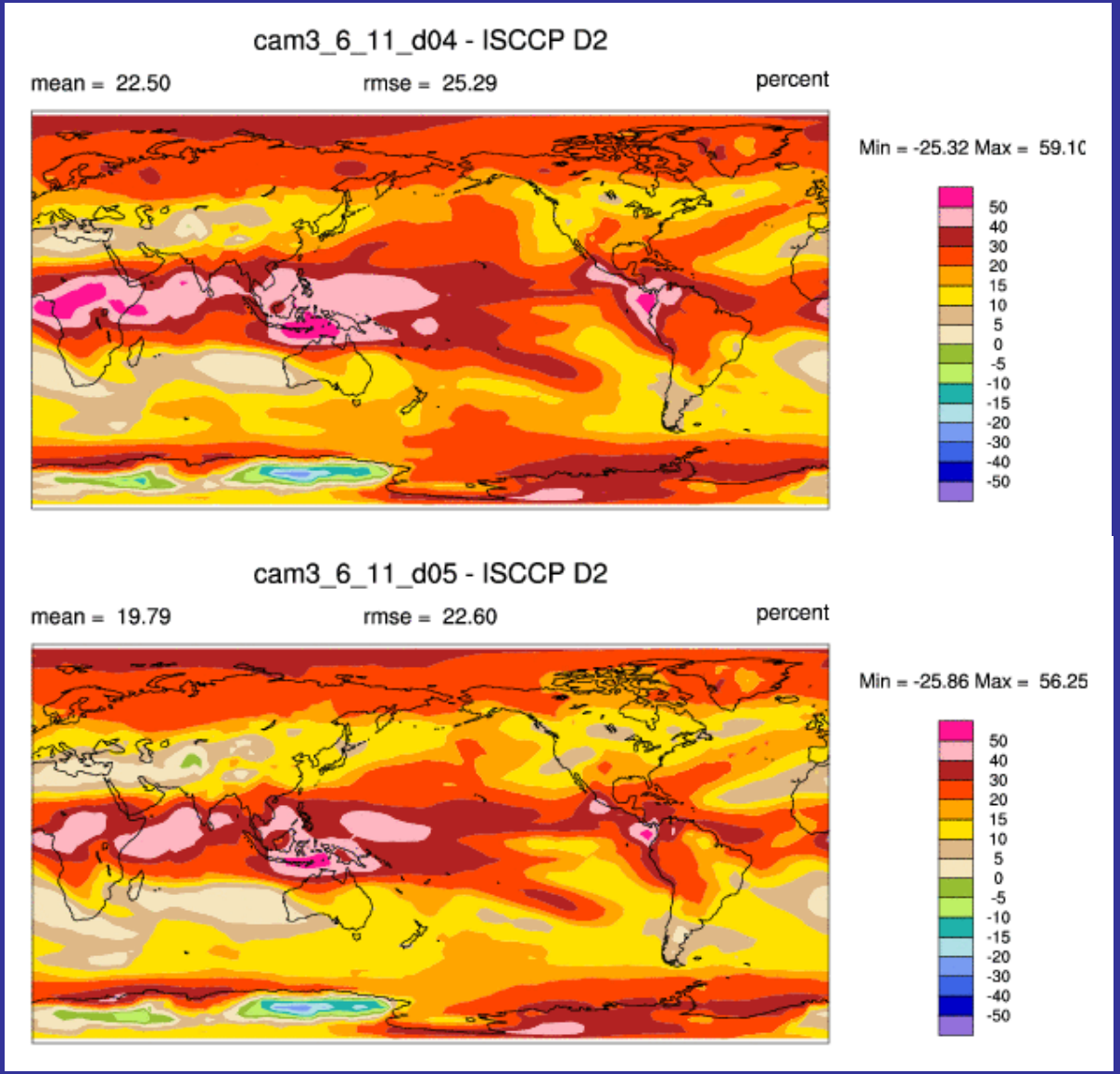


High-level Cloudiness

CAM - ISCCP

CAM/RRTMG - ISCCP

Note: Preliminary result



Summary

RTMIP Radiative Forcing for AER Models

- LBLRTM forcing close to RTMIP LBL models
- RRTM and RRTMG compare well with LBLRTM with a few exceptions (e.g. CH4 in LW; being corrected)
- AER models show improvement especially at surface relative to RTMIP GCMs
- AER calculations now in ARM RTMIP data archive

GCM Applications

- Spring 2009 WRF release may include AER LW and SW
- As of November 2008 RUC using RRTMG_LW
- NCEP adding AER SW to GFS and CFS
- Selection of CAM4 final configuration in progress