Evaluating the Potential Impact of RRTMG/McICA in the NCAR Community Atmosphere Model, CAM3.5

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How Well Do RRTM and RRTMG Compare to LBLRTM and IPCC GCM Radiation Codes?

Evaluated with greenhouse gas radiative forcing calculations with AER models (Iacono et al., 2008) and IPCC GCM codes (Collins et al., 2006) at TOA, 200 mb, and the surface.

Greenhouse Forcing Cases

Case	CO_2 (ppmv)	CH_4 (ppbv)	N_2O (ppbv)	CFC-11 (pptv)	CFC-12 (pptv)	H_2O
2 x CO_2	287 → 574	---	---	---	---	---
GHGs 1860→2000	287 → 369	806 → 1760	275 → 316	0 → 267	0 → 535	---
CH_4 & CFCs 1860→2000	---	806 → 1760	---	0 → 267	0 → 535	---
1.2 x H_2O	---	---	---	---	---	1.0 → 1.2

Longwave Radiative Forcing

		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
CAM3	F_{CAM3}	1.41	1.36	0.82	12.08
IPCC+	$<F_{GCM}>$	1.12	1.21	0.74	11.95

** AER line-by-line and broadband model radiative forcing (Iacono et al., 2008)*
+ IPCC GCM mean radiative forcing $<F_{GCM}>$ (Collins et al., 2006)

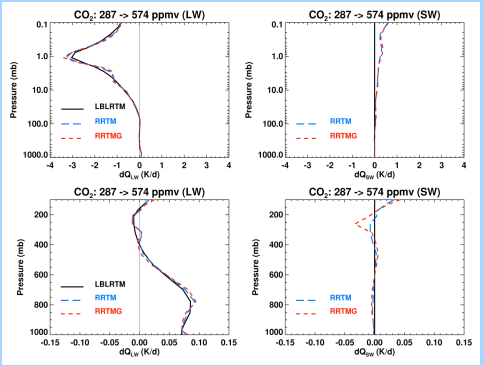
Shortwave Radiative Forcing

		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
CAM3	F_{CAM3}	-0.23	-0.10	0.00	-5.92
IPCC+	$<F_{GCM}>$	-1.47	-0.49	0.00	-4.89

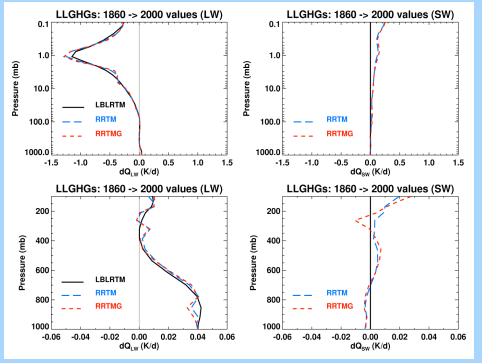
** AER line-by-line and broadband model radiative forcing (Iacono et al., 2008)*
+ IPCC GCM mean radiative forcing $<F_{GCM}>$ (Collins et al., 2006)

How Well Do RRTM and RRTMG Calculate Heating Rate Perturbations?

Heating Rate Change for 2 x CO_2



Heating Rate Change for CO_2, CH_4, N_2O and CFCs increased from 1860 to 2000 values

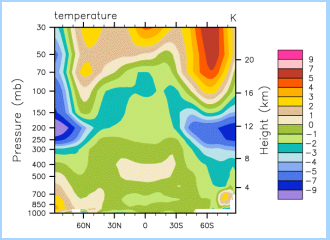


What is the Status of Implementing RRTMG/McICA into CAM3.5?

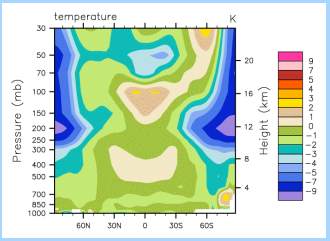
- **RRTMG is integrated and functioning in CAM3.5,**
- **Modified climate model is not retuned, but it is running in multi-year simulations (sample output below and right),**
- **Definitive impact simulations are not yet possible since present aerosol and SW cloud optical properties in CAM are not easily adaptable to RRTMG,**
- **New aerosol and cloud optics are under development; these will be adapted for AER radiation,**
- **NCAR will include RRTMG in ongoing internal testing and development of CAM4.**

What is the Impact of RRTMG on Annual Temperature in CAM3.5?

CAM3.5 - ERA40 Zonal Temperature



CAM3.5/RRTMG - ERA40 Zonal Temperature



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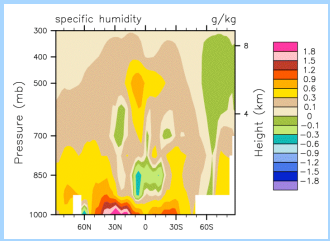
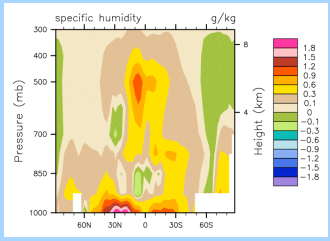
What is the Impact of RRTMG on Annual Moisture in CAM3.5?

CAM3.5 - ERA40 Zonal Temperature



CAM3.5/RRTMG - ERA40 Zonal Temperature



Summary

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• RRTM and RRTMG are shown to calculate surface radiative forcing and heating rate profile changes very close to LBL results (Iacono et al., 2008),

• AER broadband models provide better forcing values than the mean IPCC GCM forcing in most cases examined, though some minor discrepancies (related to very low CH_4 and N_2O values) are being investigated,

• RRTMG/McICA is being tested in CAM3.5, and it remains a strong candidate to become the radiation model in CAM4,

• Preliminary CAM/RRTMG simulations show positive impacts on zonal temperature (especially in the stratosphere), and small changes in moisture

References:
Collins, W.D., et al.,(2006), Radiative forcing by well-mixed greenhouse gases: Estimates from climate models in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4), *J. Geophys. Res.*, 111, D14317, doi:10.1029/2005JD006713.
Iacono, M.J., J.S. Delamere, E.J. Mlawer, M.W. Shephard, S.A. Clough, and W.D. Collins, (2008) Radiative forcing by long-lived greenhouse gases: calculations with the AER radiative transfer models, submitted to *J. Geophys. Res.*