Accuracy of Radiative Transfer Schemes in Global Modeling: The AeroCom A2 TROP/ARCTIC Experiment: First Results

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Participating Models

Many thanks to the contributing models thus far:

- GENLN2-DISORT LBL (CICERO; Gunnar Myhre)
- DISORT (CICERO; Gunnar Myhre)
- libRadtran (Finnish Meteorological Institute; Jani Huttunen)
- RRTMG-SW (GSFC; Lazaros Oreopoulos and Dongmin Lee (Soul National University))
- Edwards and Slingo (U. Reading; Bethan Harris and Claire Ryder)

There's still room for more results if you would like to contribute!

Motivation

- Assess solar radiative transfer schemes in AeroCom global models.
  - Inter-compare AeroCom model solar radiative transfer schemes *without aerosols or clouds* given standard atmospheres and surface albedo.
  - Useful to see how each model treats Rayleigh scattering, ozone absorption, and water vapor absorption.
  - Will facilitate analysis of AeroCom Prescribed Forcing Experiments (i.e. A2 CTRL, A2 ZERO, A2 FIX, A2 PRE)
  - We encourage models, particularly those participating in the above experiments, to submit to this experiment!

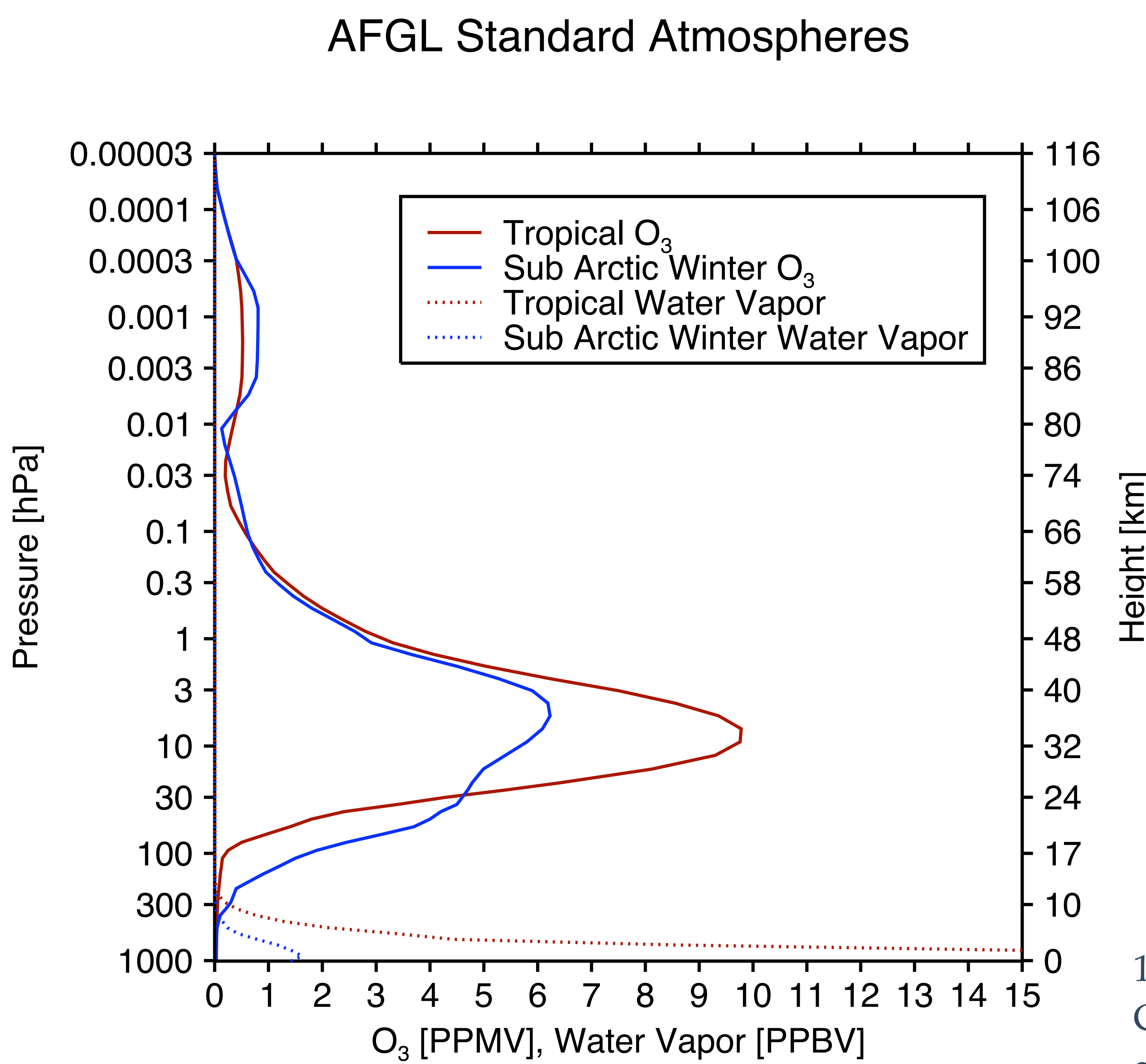
Case 1 Setup: Rayleigh Scattering Atmosphere

- Use the same GCM/CTM as set up for the AeroCom A2-ZERO experiment, or standalone radiation codes.
- Prescribe O_3 and water vapor profiles from provided AFGL standard atmospheres.
- Prescribe surface albedo at 0.2 globally.
- Run 2 one-day (01 Jan 2006) simulations with instantaneous output at **one** model time-step for:
  - Tropical AFGL standard atmosphere
  - Sub-arctic Winter AFGL standard atmosphere
- Compare broadband and visible surface fluxes (normalized by top-of-the atmosphere flux) at SZA of 30 and 75.

Case 2 Setup: Prescribed aerosols

- Prescribe the following
  - O_3 and water vapor profiles from provided AFGL standard atmospheres.
  - AOT = 0.2 at 550 nm (lowest 2 km)
  - Asymmetry Factor (*g*) of 0.7 (wavelength independent)
  - Ångstrøm Exponent of 1.0
- Consider two aerosol cases:
  - Scattering: single scattering albedo $\omega_0 = 1.0$ (wavelength independent)
  - Scattering: single scattering albedo $\omega_0 = 0.8$ (wavelength independent)
- Again consider SZA of 30 and 75 degrees

AFGL Profiles



1-km Resolution: 0-120 km
Corresponding pressure levels also given.

Diagnostics

- **6** diagnostic fields for each case:
  - Shortwave downwelling (*direct* + *diffuse*) flux at the top of the atmosphere in clear sky.
  - Shortwave downwelling (*direct* + *diffuse*) surface flux in clear sky
  - Shortwave downwelling *diffuse* surface flux in clear sky
  - Visible downwelling (*direct* + *diffuse)*
  - Visible downwelling (*direct* + *diffuse*) surface flux in clear sky
  - Upwelling flux at the top of the atmosphere in clear sky
- Diagnostics should be instantaneous at **one** model time-step.
  - This could be the first time step, but at noon UTC is preferred.
- Data should be in netCDF format following the CF convention
  - Summary of diagnostics via AeroCom website under DIRECT FORCING diagnostics package (http://nansen.ipsl.jussieu.fr/AEROCOM/AEROCOM_diagnostics.xls)
  - CMOR rewriting tool (http://www-pcmdi.llnl.gov/software-portal/cmor/)
  - AeroCom A2 Experiment CMOR tables (http://www-lscedods.cea.fr/aerocom/CMOR)
- In total, report only **36** numbers!

Analysis

- Following: *Halthore et al.* [2005], Intercomparison of shortwave radiative transfer codes and measurements, *J. Geophys. Res.*, *110,* D11206, doi: 10.1029/2004JD005293.

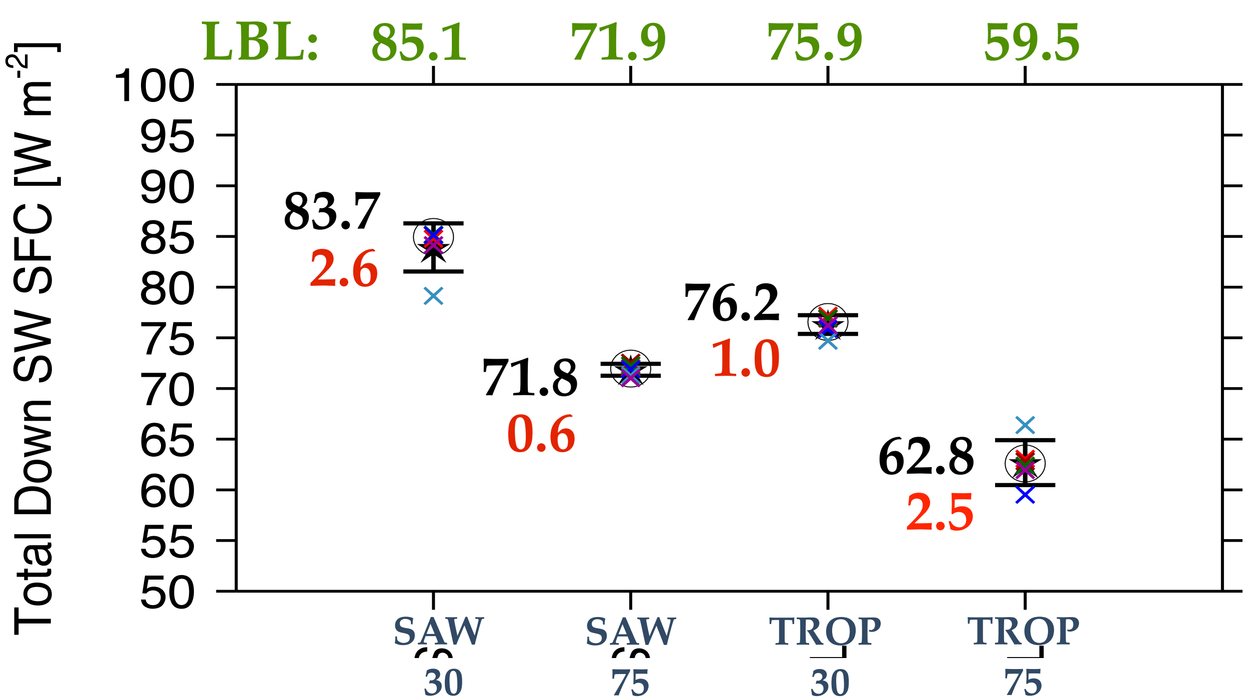
- Will examine provided global results at two chosen sun elevations (solar zenith angles of 30° and 75°) for each of the two standard atmospheres.
  - **Because not all models use the same wavelength bands, we normalize by the TOA downwards flux for the bands provided.**

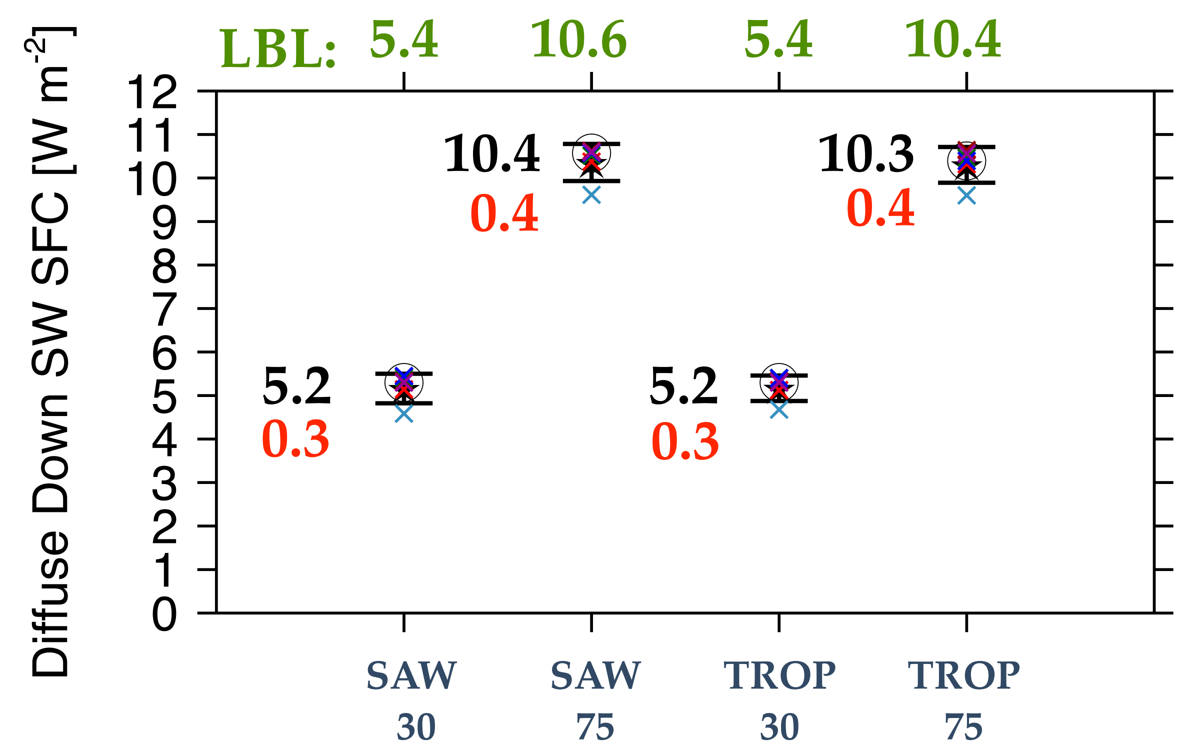
- Interest from DOE ARM program to archive these results along with the *Halthore et al.* [2005] results as well as other model inter-comparison results (Warren Wiscombe and Alice Cialella, ARM EXternal Data Center (XDC), *personal communication*)

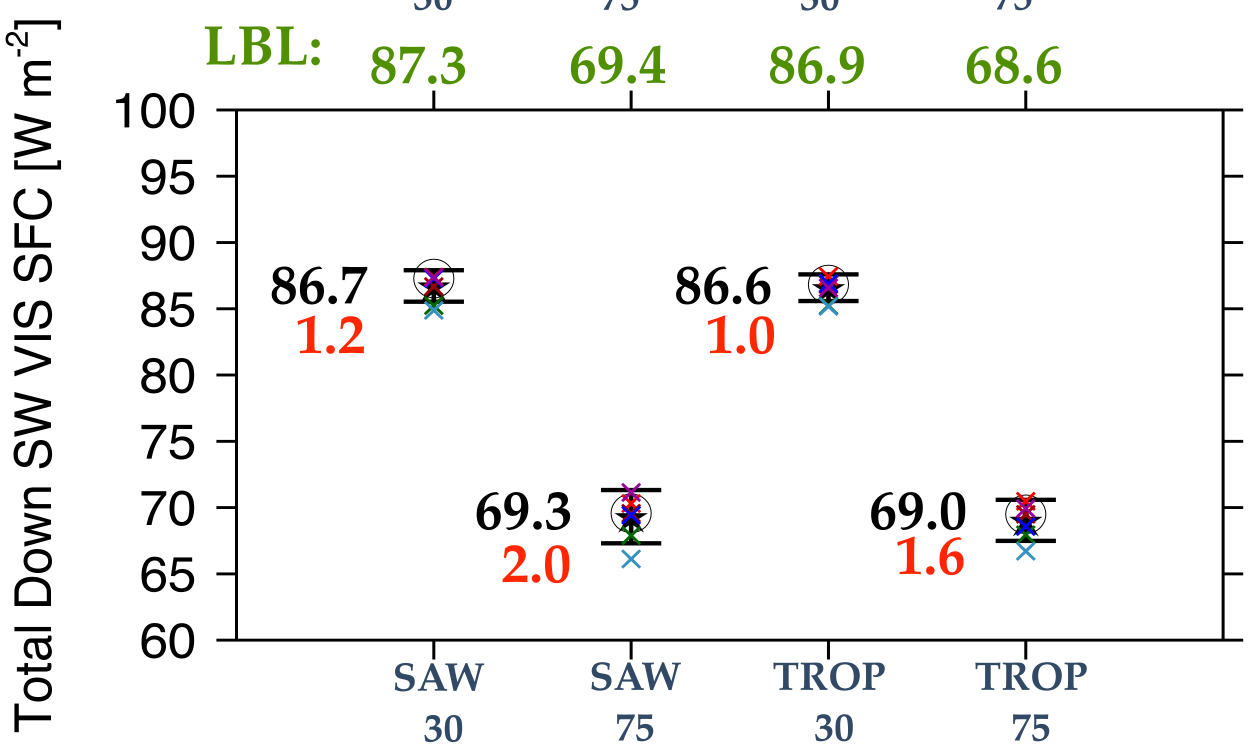
- Time frame for submission: As soon as you can!

Case 1: Clear-Sky

- 0.2-12.195 µm — GSFC: RRTMG-SW
- 0.3-5.0 µm — DISORT
- 0.2-5.0 µm — GENLN2_DISORT
- 0.28-4.6 µm — libRadtran
- 0.2-10 µm — Reading: Edwards & Slingo (6 bands)
- 0.2-10 µm — Reading: Edwards & Slingo (220 bands)





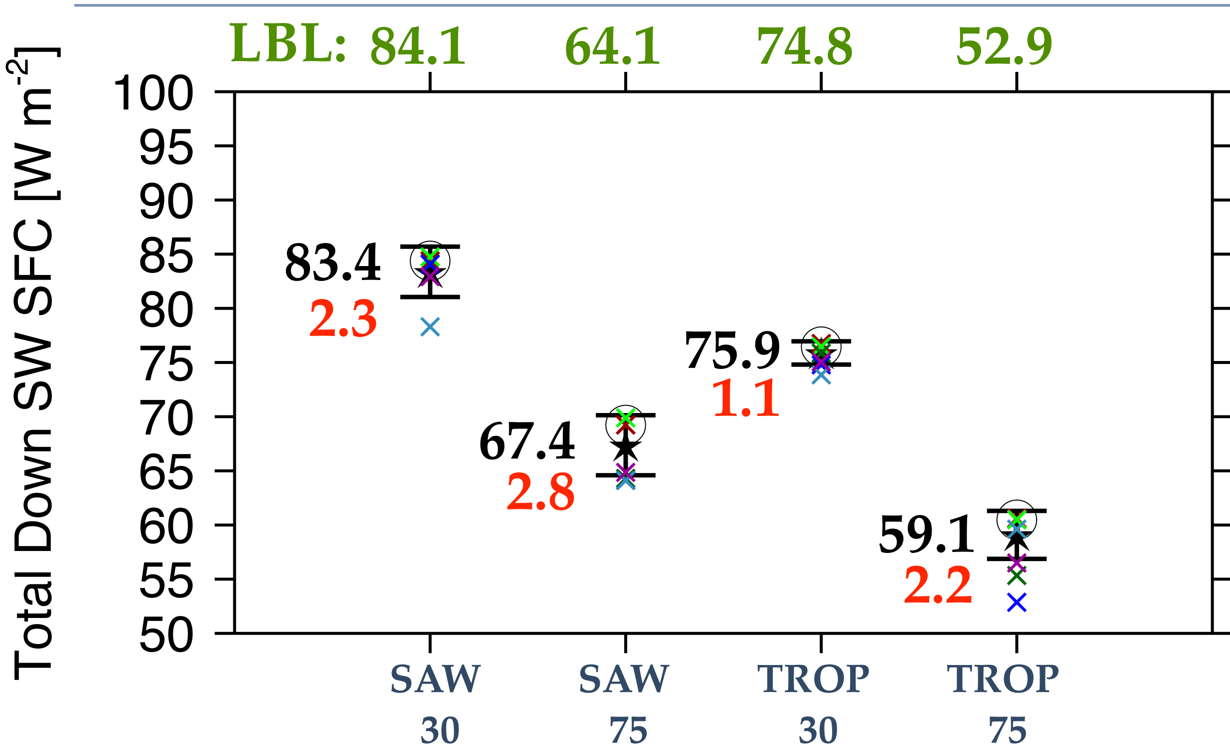


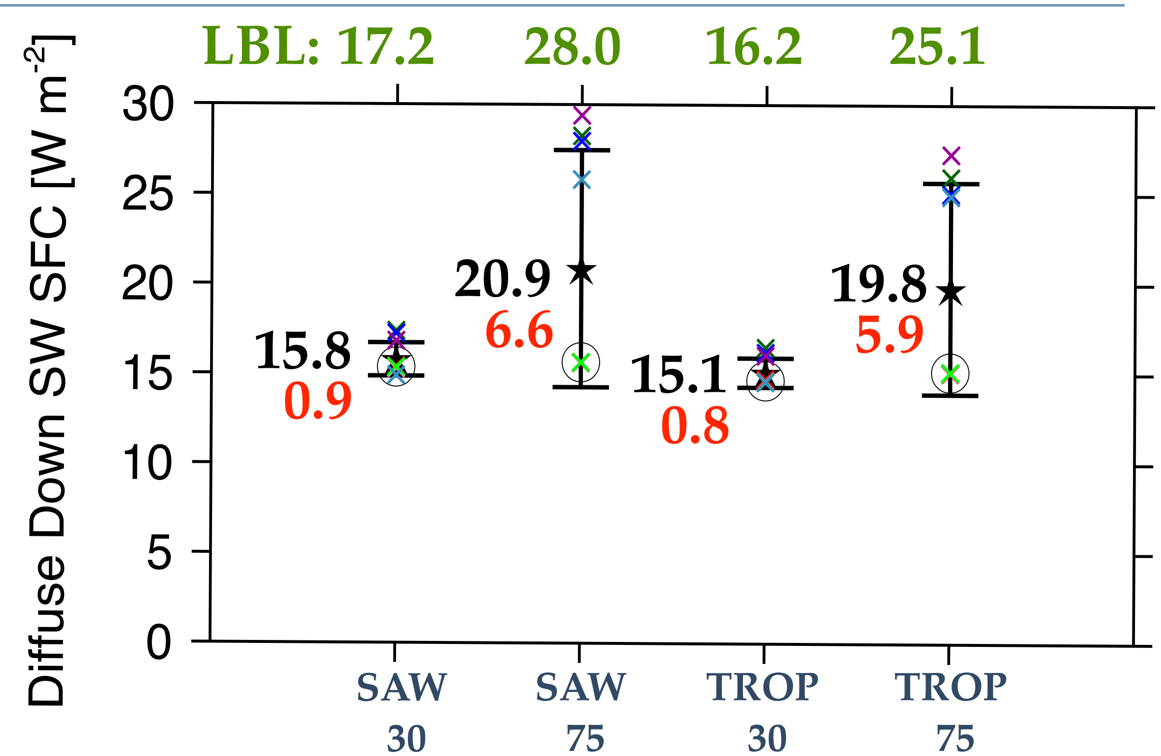
For the VIS band (left):

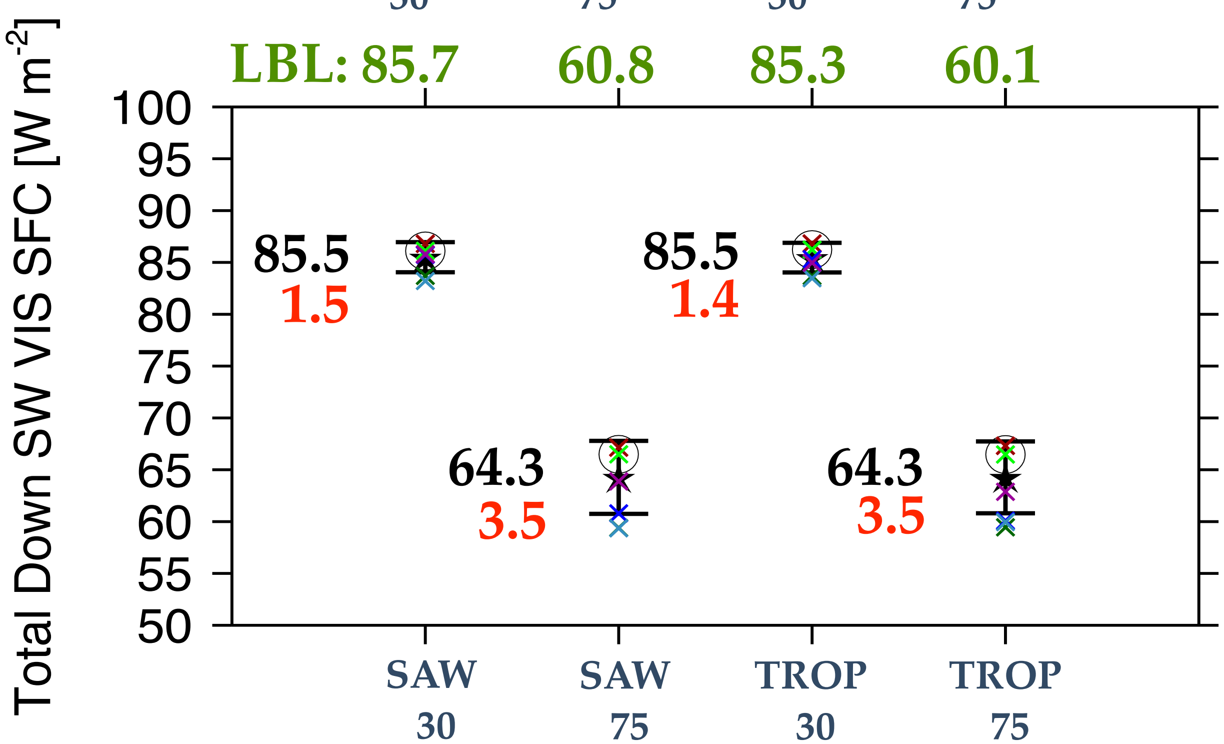
- 0.2-0.778 µm — GSFC: RRTMG-SW
- 0.2-0.625 µm — GSFC: RRTMG-SW
- 0.2-5.0 µm — GENLN2_DISORT
- 0.28-0.7 µm — libRadtran
- 0.2-0.69 µm — Reading: Edwards & Slingo (6 bands)
- 0.2-0.7042 µm — Reading: Edwards & Slingo (220 bands)

Case 2a: Scattering Aerosol

- GSFC: RRTMG-SW
- DISORT
- GENLN2_DISORT
- libRadtran
- Reading: Edwards & Slingo (6 bands; k_{ext}=2.0e2)
- Reading: Edwards & Slingo (6 bands; k_{ext}=1.1e4)
- Reading: Edwards & Slingo (220 bands; k_{ext}=2.0e2)
- Reading: Edwards & Slingo (220 bands; k_{ext}=1.1e4)





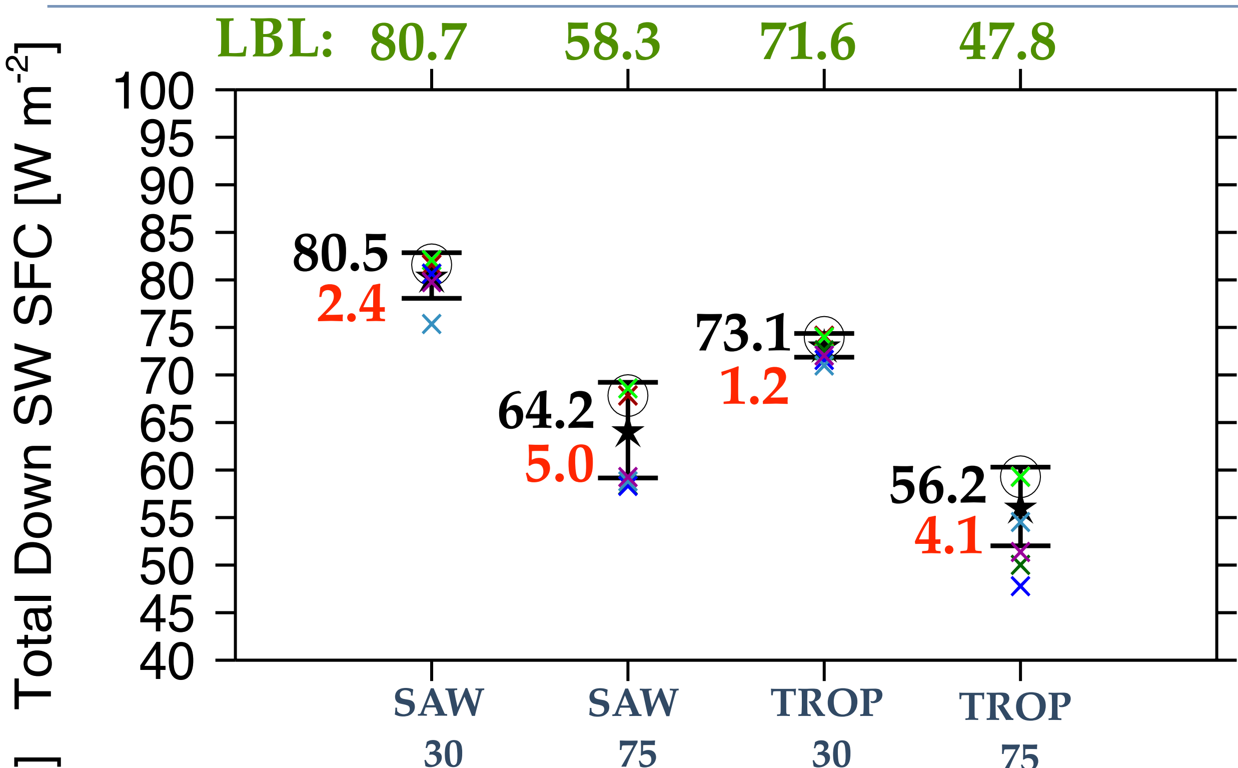


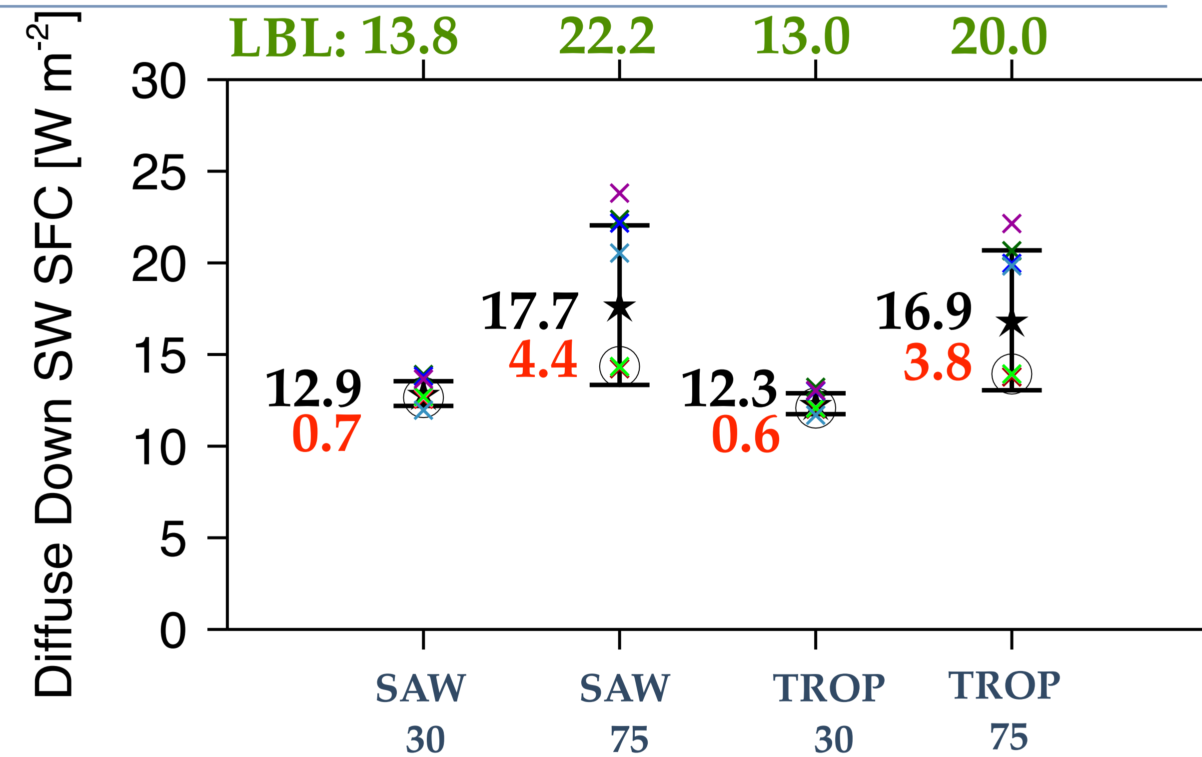
For the VIS band (left):

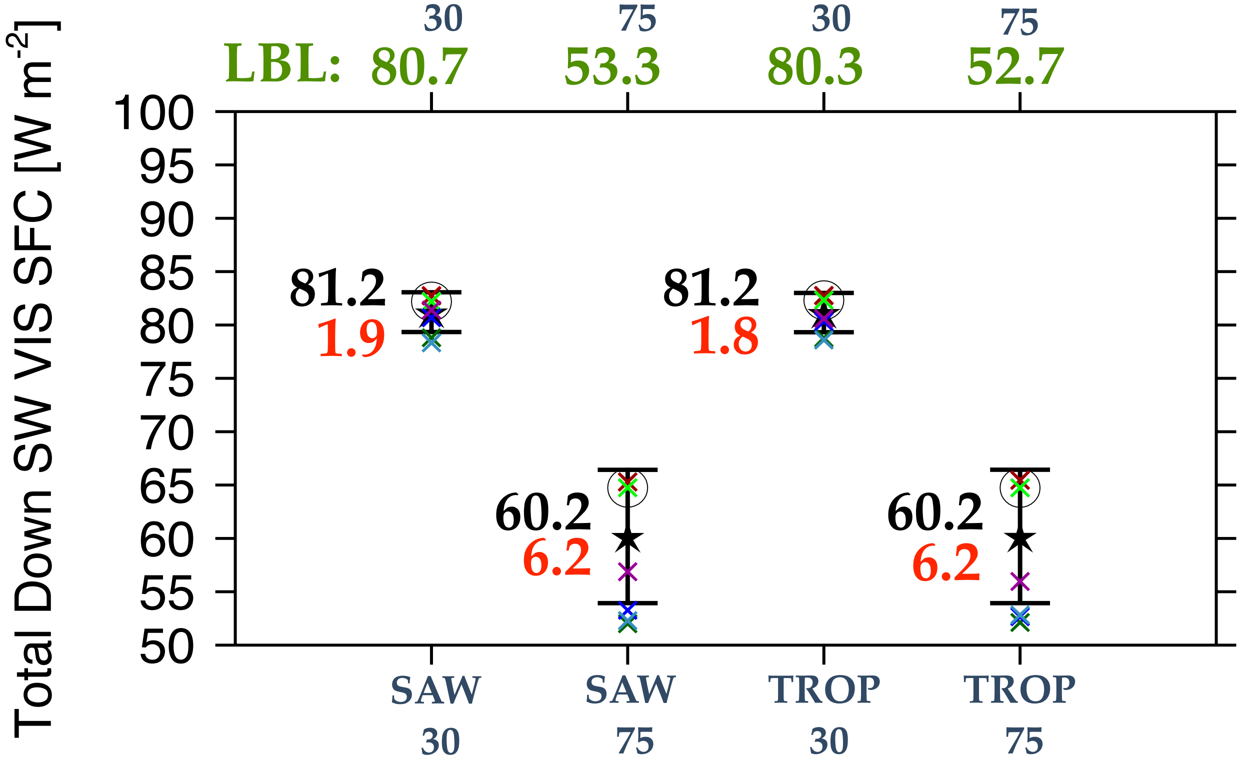
- GSFC: RRTMG-SW 0.2-0.778 μm
- GSFC: RRTMG-SW 0.2-0.624 μm
- GENLN2_DISORT
- libRadtran
- Reading: Edwards & Slingo (6 bands; k_{ext}=2.0e2)
- Reading: Edwards & Slingo (6 bands; k_{ext}=1.1e4)
- Reading: Edwards & Slingo (220 bands; k_{ext}=2.0e2)
- Reading: Edwards & Slingo (220 bands; k_{ext}=1.1e4)

Case 2b: Absorbing Aerosol

- GSFC: RRTMG-SW
- DISORT
- GENLN2_DISORT
- libRadtran
- Reading: Edwards & Slingo (6 bands; k_{ext}=2.0e2)
- Reading: Edwards & Slingo (6 bands; k_{ext}=1.1e4)
- Reading: Edwards & Slingo (220 bands; k_{ext}=2.0e2)
- Reading: Edwards & Slingo (220 bands; k_{ext}=1.1e4)







For the VIS band (left):

- GSFC: RRTMG-SW 0.2-0.778 µm
- GSFC: RRTMG-SW 0.2-0.624 µm
- GENLN2_DISORT
- libRadtran
- Reading: Edwards & Slingo (6 bands; k_{ext}=2.0e2)
- Reading: Edwards & Slingo (6 bands; k_{ext}=1.1e4)
- Reading: Edwards & Slingo (220 bands; k_{ext}=2.0e2)
- Reading: Edwards & Slingo (220 bands; k_{ext}=1.1e4)

TOA Aerosol Radiative Forcing [W m^{-2}]: Scattering Aerosols

Model	SAW 30	SAW 75	TROP 30	TROP 75
LBL GENLN2_DISORT	**-8.7**	**-20.6**	**-8.2**	**-17.6**
E&S (200 band k_{ext}=1e[4])	-3.1	-7.9	-3.1	-7.2
E&S (200 band k_{ext}=2e[2])	-3.1	-7.9	-3.0	-7.3
E&S (6 band k_{ext}=1e[4])	-2.8	-7.6	-2.8	-6.8
E&S (6 band k_{ext}=2e[2])	-2.9	-7.6	-2.8	-6.9
DISORT	-7.6	-19.7	-7.5	-18.9
RRTMG-SW	-10.7	-17.2	-10.2	-15.7
MEAN	**-5.0**	**-11.3**	**-4.9**	**-10.5**
STDDEV	**3.1**	**5.1**	**2.9**	**4.9**

TOA Aerosol Radiative Forcing [W m^{-2}]: Absorbing Aerosols

Model	SAW 30	SAW 75	TROP 30	TROP 75
LBL GENLN2_DISORT	**+11.5**	**-7.1**	**+10.0**	**-6.1**
E&S (200 band $k_{ext}=1e^4$)	12.6	-4.2	11.7	-3.8
E&S (200 band $k_{ext}=2e^2$)	12.8	-4.1	11.6	-3.9
E&S (6 band $k_{ext}=1e^4$)	12.3	-4.0	11.3	-3.7
E&S (6 band $k_{ext}=2e^2$)	12.4	-4.0	11.2	-3.7
DISORT	10.4	-7.0	9.8	-6.8
RRTMG-SW	9.7	-5.9	8.7	-5.5
MEAN	**11.7**	**-4.9**	**10.7**	**-4.6**
STDDEV	**1.3**	**1.3**	**1.2**	**1.3**

Summary

- This simple experiment shows that there is a diversity in radiative transfer codes *even in the clear sky.*

- This diversity typically increases as aerosols are included, and as SZA increases.

- This, of course, has consequences for calculations of aerosol direct radiative forcing.

This Many thanks again to the contributing models thus far!

There's still room for more results if you would like to contribute!

Preliminary Results: ECHAM5 (offline)

	ECHAM5*		*Halthore et al.* [2005] (Table 2**)	
AFGL Tropical Profile	Direct SFC Broadband SW Down [W m^{-2}]	VIS SFC SW Down [W m^{-2}]	Direct SFC Broadband SW Down [W m^{-2}]	VIS SFC SW Down [W m^{-2}]
μ_0	0.68-4.0 µm	0.185/0.25-0.68 µm	0.28-5.0 µm	0.2-0.7 µm
75°	133.8	71.5	184.8 (±1.89)	81.7 (±10.78)
30°	507.1	409.2	848.5 (±0.68)	425.1 (±3.59)

****Courtesy Daniel Klocke (MPI)***

**Average irradiance of 16 radiation codes, including LBL codes (± Std. Dev. as a % of Mean)