Application of CALIOP, CloudSAT, CERES, and MODIS (CCCM) to Evaluation of Standard "Passive-sensor-only" CERES CRS Results

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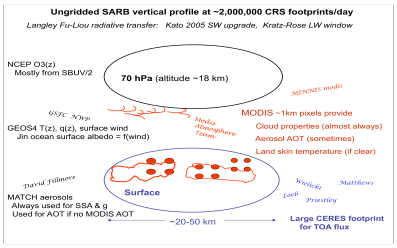
We compare the LW radiation in a product combining active and passive sensors (CCCM, see poster by Seiji Kato, et al) with LW from an analogous passive-sensor-only code (CERES Aqua CRS Surface and Atmosphere Radiation Budget SARB).

CRS is a set of radiative transfer calculations with the Langley Fu-Liou code; global and at the scale of 20-km CERES footprints. Inputs include clouds from MODIS (Minnis et al.), aerosols from the MODIS Atmosphere Team and the MATCH aerosol assimilation, and GEOS4 meteorological variables.

CCCM runs only at the smaller scale of CALIOP and CloudSAT. It uses a prototype CERES Edition 3 code for cloud retrievals with MODIS; those retrievals are further buttressed (for CCCM, but for not CRS) with the active sensors. The narrow CCCM track spans a small fraction of any given CERES FOV; it intersects only near-nadir CERES FOVs.

CRS and CCCM both use aerosols from MATCH, which itself assimilates MODIS AODs. But there is a big difference: The CRS height profiles of aerosols are from MATCH, while the CCCM height profiles used here are measured directly by CALIOP. This untuned run of CRS also uses proto-Edition 3 cloud inputs, but they are not adjusted by the active sensors.

The zonal mean, column-integrated aerosol forcing to LW cooling of the atmosphere, both all sky and clear sky, in CRS (passive sensors only) compares well with CCCM (active and passive). Cloud forcing to downward LW is significantly larger in CCCM than in CRS.



Cloud inputs include fractional area, height of top and base, optical depth, particle size, and phase.

MATCH aerosol assimilation provides aerosol height for 7 types (used to assign single scattering albedo as per OPAC classes and 2 size ranges of desert dust from A. Lacis).

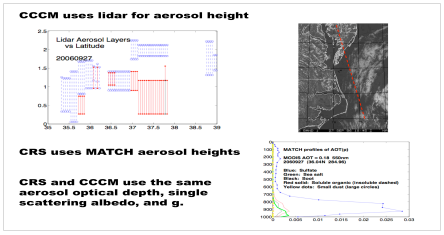
MODIS AOD retrievals in each CERES footprint are preferred, but the gridded MATCH AODs are used in most cases.

How good is the archived CRS/SARB?

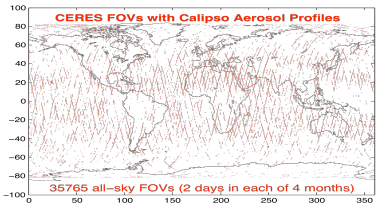
Aqua CRS Ed2B and Ed2C (Jul02-Dec06) within 25 km of ARM SGP sites Daytime-only analysis below All rows in table have 71191 samples

	Observed (W/m**2)	Untuned Bias	RMS
TOA SW up	268	4	26
OLR	255	-2	9
SW SFC down	589	8	101
SW SFC up	115	-20	48
LW SFC down	345	-12	19
LW SFC up	444	-8	30

David Rutan's CAVE home page (google "CERES CAVE") validates each of ~50 sites in detail each month.



Domain for comparison of CCCM and CRS



Fidelity of Simulated OLR (CRS and CCCM)

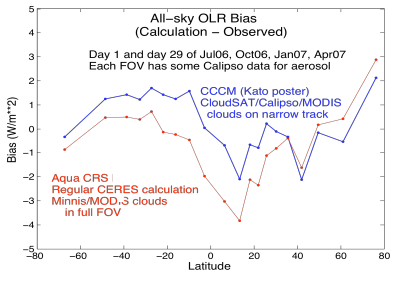
OBS = CERES measurement

OBS	Bias	RMS	Corr	N		
266.7	-1	7	0.98	35765	CRS	all sky
266.7	0	11	0.96	35765	CCCM	all sky
287.1	-3	9	0.96	6769	CRS	clear as per CRS
287.1	-2	12	0.93	6769	CCCM	" " " "
288.5	-3	10	0.95	5309	CRS	clear as per both
288.5	-2	12	0.92	5309	CCCM	" " " "

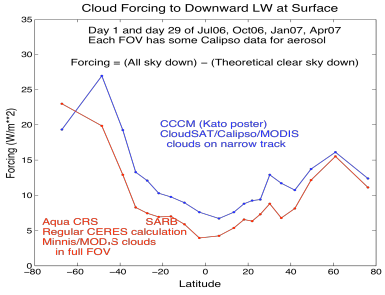
CCCM has larger RMS because the narrow track spans only a fraction of the CERES FOV observation to which it is compared.

We use only CCCM samples with CALIOP aerosol heights.

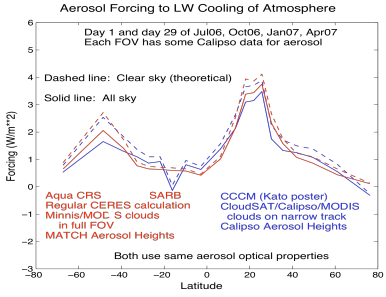
OLR Bias vs Latitude



Cloud Forcing to Downward LW



Aerosol Forcing to LW Cooling of Atmosphere



Bloom, S., A. da Silva, D. Dee, M. Bosilovich, J.-D. Chern, S. Pawson, S. Schubert, M. Sienkiewicz, I. Stajner, W.-W. Tan, M.-L. Wu, 2005: Documentation and Validation of the Goddard Earth Observing System (GEOS) Data Assimilation System - Version 4 . Technical Report Series on Global Modeling and Data Assimilation 104606 , 26. Document (10124 kb) http://gmao.gsfc.nasa.gov/systems/geos4/

T. P. Charlock, and F. G. Rose, D. A. Rutan, Z. Jin, and S. Kato, 2006: The Global Surface and Atmospheric Radiation Budget: An Assessment of Accuracy With 5 Years of Calculations and Observations, Proceedings 12th Conf. on Atmos. Radiation, Madison, WI, July 10-14.

Collins, W. D., P. J. Rasch, B. E. Eaton, B. V. Khattatov, J.-F. Lamarque, and C. S. Zender, 2001: Simulating aerosols using a chemical transport model with assimilation of satellite aerosol retrievals: Methodology for INDOEX. J. Geophys. Res., 106, 7313-7336.

Fu, Q., and K.-N. Liou, 1993: Parameterization of the radiative properties of cirrus clouds. J. Atmos. Sci., 50, 2008-2025.

Fu, Q, 1996: An accurate parameterization of the solar radiative properties of cirrus clouds for climate models, 9, J Clim., 2058-2082

Fu, Q., G. Lesins, J. Higgins, T. P. Charlock, P. Chylek, and J. Michalsky, 1998: Broadband water vapor absorption of solar radiation tested using ARM data. Geophys. Res. Lett., 25, 1169-1172.

Minnis, P., D. Wielicki, C. Trepte, S. Kato, S. Sun-Mack, Y. Chen, S. Gibson, G. Stephens, 2007: "Characterizing the radiation fields in the atmosphere using a cloud-aerosol-radiation product from integrated CERES, MODIS, CALIPSO and CloudSat data", IEEE Geoscience and Remote Sensing Symposium, 2007, Barcelona, Spain, doi:10.1109/IGARSS. 2007.4422909

Hess, M., P. Koepke, and I. Schult, 1998: Optical Properties of Aerosols and Clouds: The software package OPAC. Bull. Amer. Meteor. Soc., 79, 831-844.

Kato, S., F. G. Rose, and T. P. Charlock, 2005: Computation of domain-averaged irradiance using satellite-derived cloud properties. J. Atmos. Ocean. Tech., 22b, 146-164.

Kratz, D. P., and F. G. Rose, 1999: Accounting for molecular absorption within the spectral range of the CERES window channel. J. Quant. Spectrosc. Radiat. Transfer, 48, 83-95.

Minnis, P., D. F. Young, S. Sun-Mack, P. W. Heck, D. R. Doelling, and Q. Trepte, 2003: "CERES Cloud Property Retrievals from Imagers on TRMM, Terra, and Aqua" Proc. SPIE 10th International Symposium on Remote Sensing: Conference on Remote Sensing of Clouds and the Atmosphere VII, Barcelona, Spain, September 8-12, 37-48.

Rose, F., T. Charlock, Q. Fu, S. Kato, D. Rutan, and Z. Jin, 2006: CERES Proto-Edition 3 Radiative Transfer: Tests and Radiative Closure over Surface Validation Sites. Proceedings of 12th Conference on Atmospheric Radiation (ARM), 10-14 July 2006, Madison, Wisconsin.

Rutan, D. A., F. G. Rose, N. Smith, and T. P. Charlock, 2001: CERES/ARM Validation Experiment. Eleventh ARM Science Team Meeting Proceedings (Atlanta, 19-23 March 2001). 4 pp. Available at www.arm.gov under "Publications".

Stephens, G. L., D. G. Vane, R. J. Boain, G. G. Mace, K. Sassen, Z. Wang, A. J. Illingworth, E. J. O'Connor, W. B. Rossow, S. L. Durden, S. D. Miller, R. T. Austin, A. Benedetti, C. Mitrescu, and the CloudSat Science Team, 2002: The CloudSat mission and the A-TRAIN: A new dimension to space-based observations of clouds and precipitation. In Bull. Am. Met. Soc., 83, 1771-1790.

Tegen, I., and A. A. Lacis, 1996: Modeling of particle size distribution and its influence on the radiative properties of mineral dust aerosol. J. Geophys. Res., 101, 19,237-19,244.

Vaughan, M., S. Young, D. Winker, K. Powell, A. Omar, Z. Liu, Y. Hu, and C. Hostetler, 2004: "Fully automated analysis of space-based lidar data: an overview of the CALIPSO retrieval algorithms and data products", Proc. SPIE, 5575, pp. 16-30.

Wielicki, B. A., B. R. Barkstrom, E. F. Harrison, R. B. Lee, G. L. Smith, and J. E. Cooper, 1996: Clouds and the Earth's Radiant Energy System (CERES): An Earth Observing System Experiment. Bull. Amer. Meteor. Soc., 77, 853-868.

Winker, D. M., J. Pelon, and M. R. McCormick, 2003: "The CALIPSO mission: Spaceborne lidar for observation of aerosols and clouds", Proc. SPIE, 4893, pp. 1-11.

Aerosol forcing in the above sampled CALIOP domain is not a fair global representation. Mean forcing to the atmosphere above is 1.5 W/m**2; analogous forcing to downward LW at the surface is 2.2 W/m**2. For comparison with that 2.2 W/m**2 of the sampled CALIOP domain, note the smaller gridded CRS/FSW value of 1.29 W/m**2 for July 2006 below (and similarly small in other months).