BBHRP Assessment Part 1:
Clear Sky Analysis Using Ground and Satellite-based High Spectral Resolution Infrared Observations

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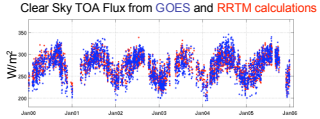
Extended BBHRP Methodology Results

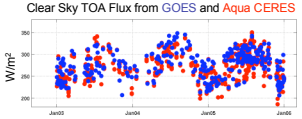
Introduction:
Surface and TOA analyses presented at last year's STM focused on 2002-2005, the time period including AIRS observations. This year the BBHRP clear sky methodology was extended at the SGP site to cover multiple years. MWR-scaled sondes combined with surface temperatures derived from pyrgeometer measurements provide input for RRTM (AER, Inc.) calculations of flux. This large dataset offers a robust statistical analysis of daily, seasonal, and long-term comparisons to assess our ability to compute and measure TOA and surface fluxes. TOA flux calculations using RRTM are compared to GOES fluxes (which is based on a regression with CERES).

Flux Results:

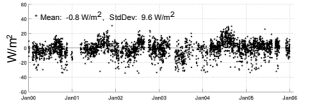
Clear Sky TOA Flux from GOES and RRTM calculations



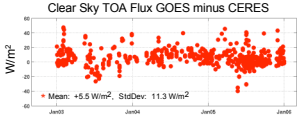
Clear Sky TOA Flux from GOES and Aqua CERES



Clear Sky TOA Flux GOES minus RRTM calculations

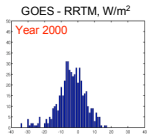


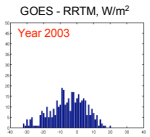
Clear Sky TOA Flux GOES minus CERES

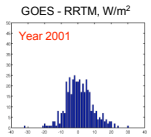


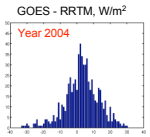
Clear Sky TOA Flux Comparison Statistics for GOES minus RRTM calculations

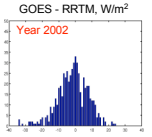
Year	Month	Method	Mean	Stdev	RMS	#Pnts	calculations
2000	MarAprMay	BBHRP group	-6.3	5.7	8.4	81	@sonde times
2000	MarAprMay	UW's mimic	-4.5	5.4	7.9	80	@sonde times
2000	full year	same code	-3.4	7.7	8.4	506	@sonde times
2001	full year		0.8	7.9	7.9	426	@sonde times
2002	full year		-1.5	8.8	9.0	567	@sonde times
2003	full year		-6.1	11.6	13.1	404	@sonde times
2004	full year		2.9	10.3	10.7	657	@sonde times
2005	full year		0.5	8.2	8.2	578	@sonde times
2000 - 2005	full years		-0.8	9.6	9.6	3140	@sonde times
2002Oct - 2005Dec	3.3 years	AIRS Ts,e BEflux Ts, e=1	-4.6 -4.7	8.3 8.3	9.5 9.5	200	@AIRS times

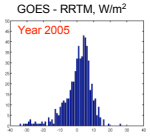


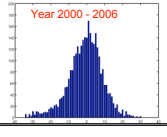




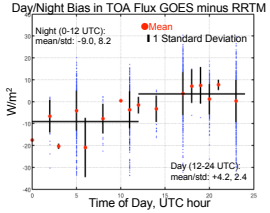




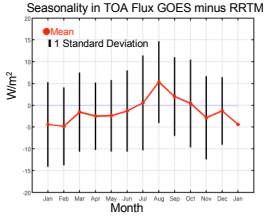




Day/Night Bias in TOA Flux GOES minus RRTM



Seasonality in TOA Flux GOES minus RRTM

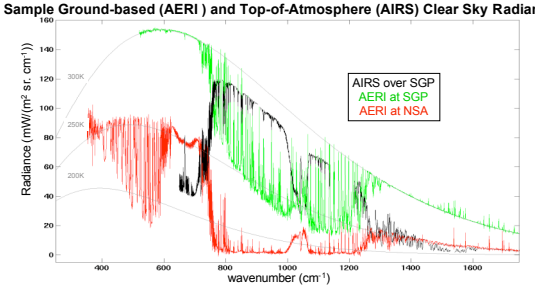


The six year mean flux difference between RRTM calculations and GOES is quite good, -0.8W/m², but masks inter annual biases which vary between -6 and 3 W/m². The day/night bias is on the order of 13 W/m². The GOES clear sky SGP TOA flux observations are 5 to 6 W/m² greater than CERES derived fluxes; the bias will be removed with the next GOES processing for the SGP site.

Introduction

The overall objective of this research is to support the ARM Broad Band Heating Rate Profile (BBHRP) measurement-model comparison effort that will couple heating rates based on ARM data more directly into SCM and GCM models. We are making use of high spectral resolution infrared satellite, aircraft, and ground based data for assessing the model parameterizations that are candidates for relating ARM time sequences to statistical cloud and radiation properties on the GCM grid cell scale. This poster presents our analyses of clear sky cases from the SGP site over multiple years. AIRS observations are used to assess the accuracy and representativeness of clear sky LBLRTM radiance calculations for the surface and Top-of-Atmosphere (TOA). Surface and TOA fluxes are then assessed by comparing LBLRTM/RRTM flux calculations to the surface (pyrgeometer) and TOA (GOES) flux observations used in BBHRP.

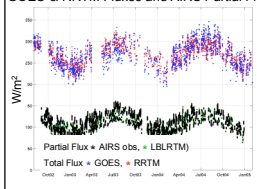
Sample Ground-based (AERI) and Top-of-Atmosphere (AIRS) Clear Sky Radiance



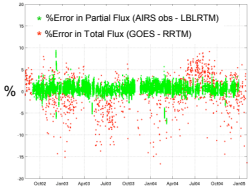
Using AIRS radiances to assess BBHRP Fluxes

Partial fluxes are computed from AIRS spectra by integrating over the AIRS spectral radiance coverage and weighting by a factor of pi (AIRS partial fluxes are ~40% of the total clear sky OLR). The percent error in AIRS partial flux (AIRS observations - LBLRTM) are then compared to percent error in BBHRP fluxes (GOES-RRTM).

GOES & RRTM Fluxes and AIRS Partial Fluxes



Percent Flux Errors



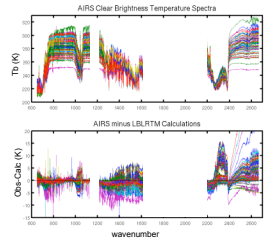
Conclusions:

- The BBHRP TOA flux closure (GOES-RRTM) has a mean of -6.3 W/m² and an RMS of 8.4 W/m² for the study period (March-May,2002). Extending to other years we find significant annual and seasonal differences, as well as differences between GOES and CERES observations.
- Comparison of observations and calculations of high spectral TOA radiance spectra (AIRS-LBLRTM) improve and quantify the uncertainties in the RRTM flux calculations.
- The percent error in partial flux derived from AIRS have an RMS approximately 4 times smaller than the percent error in OLR derived from GOES minus RRTM. This is likely due to a combination of upper level water vapor uncertainties (the far IR is not captured in the AIRS spectral coverage), our ability to determine clear cky cases, and GOES uncertainties. This will be one focus of future work.
- The results presented on this poster set the baseline assessment of our ability to compute and measure fluxes for clear sky conditions. We have found AIRS to be an essential resource for infrared closure experiments evaluating radiometric observations, radiative transfer models, and observations of the atmospheric state which drive the models. Our focus has now turned to cloudy conditions (see BBHRP Assessment Part 2: Cirrus Radiative Flux Study using Lidar,Radar/Aeri derived properties).

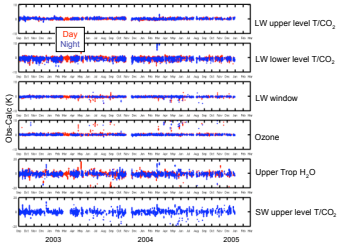
Radiance Closure Using AIRS

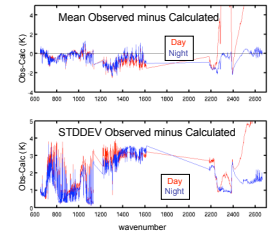
Introduction:
Clear sky AIRS observations over the SGP site from Sept 2002 to Mar 2005 are compared to LBLRTM(Ver9.2, HITRAN2004) radiance calculations. MWR-scaled radiosondes are interpolated to AIRS overpass times so that calculations would be coincident. The temperature soundings are appended with upper level atmospheric profiles from the ECMWF model output, total column ozone (from TOMS) are scaled to the US standard ozone profile, and Mauna Loa CO_2 concentrations are used. The TOA flux calculations using RRTM are compared to GOES (VISST, Feb.2006) and CERES fluxes. The RRTM flux calculations used AIRS derived surface temperatures and emissivities.

Spectral Results:

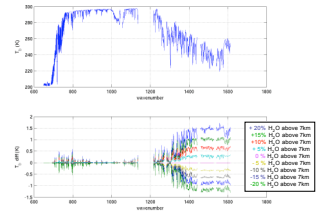


Time Series of Obs-Calc for various spectral regions





Impact of sample UTH perturbations on AIRS brightness temperatures

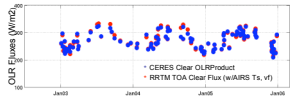


Seasonal biases in upper level T and CO_2 channels were removed by using ECMWF profiles above the sondes and the Mauna Loa CO_2 record. Using TOMS ozone scaled to the shape of the US std ozone profile reduced the residual error in the ozone channels. Adjusting the sondes by using ECMWF profiles above the sondes, TOMS ozone, and Mauna Loa CO_2 record did not significantly change the TOA flux biases.

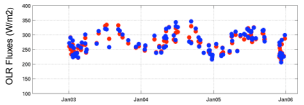
Flux Results:

GOES and CERES compared to RRTM Flux
(RRTM with MWR scaled radiosondes and AIRS retrieved surface properties)

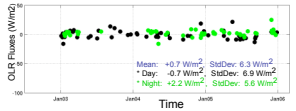
ARM SGP TOA Clear Fluxes



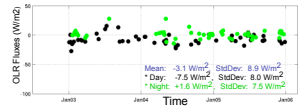
ARM SGP TOA Clear Fluxes

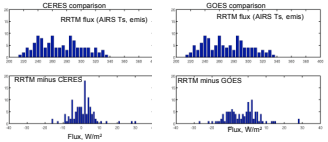


RRTM - CERES OLR Fluxes



RRTM - GOES OLR Fluxes





The RRTM flux biases for GOES and CERES are -3.1 and +0.7, and their standard deviations are 8,9 and 6.3 W/m², resp.

Acknowledgements

- Pat Minnis, Pat Heck, Mandy Khaiyer, Tony Clough, Eli Mlawer, the AIRS Project, the ARM infrastructure
- This work supported by DOE grant DE-FG02-90ER61057