Top-of-Atmosphere Shortwave and Longwave Broadband Fluxes Derived using Various Satellites over ARM Domains

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Introduction

- Top-of-atmosphere (TOA) broadband (BB) longwave (LW) and shortwave (SW) fluxes essential for evaluating climate change & cloud-radiative interactions
- Current satellites measure the nonpolar Earth Radiation Budget (ERB) only at specific local times, providing a diurnally limited ERB, must expand ERB measurements to cover the diurnal cycle and provide higher spatial resolution than traditional ERB data
  - -CERES *Terra*: 1030/2230 LT *Aqua*: 0130/1330 LT
- Expand ERB measurements using geostationary (GEO) satellite
  - Convert narrowband (NB) fluxes to BB SW & LW fluxes using fits to CERES data
  - can estimate TOA fluxes 24/7, but there are also limitations:
  - no polar views, GEO calibration issues can render large areas uncovered
- Use polar-orbiting satellites (e.g. NOAA-xx series) to fill in GEO gaps
- NASA/Langley Cloud group routinely derives cloud & radiative parameters from various GEO satellites using VISST & SIST algorithms
  - -GOES-x vs CERES Terra NB-BB fits, accounting for season (SW & LW) & day/night (LW) routinely used to convert GOES NB to BB fluxes over ARM SGP

-OBJECTIVE

- Develop & assess fits for GEO (MTSAT-2) based on CERES over TWP, and preliminary fits for NOAA-9 based on ERBE for global coverage including hard-to-observe areas like Gan Island, NSA

Approach

- GEO: Match 1° average MTSAT-2 data to CERES SFC: 0-17°S, 121-140°E
  Fits: MTSAT-2 vs Terra CERES: Jan-Mar2012 (Wet Season) and May-Oct2011 (Dry Season)
  Compare results of both fits using 2011-2013 CERES Terra data
- POLAR: Match collocated AVHRR data with ERBE SSF footprints: global
  Fits: AVHRR vs NOAA-9 ERBE: Monthly 1986 data
  Compare results of monthly fits applied to Oct 2008 NOAA-18 AVHRR to CERES Aqua

Data & Methodology

ERB data: CERES and ERBE

A_{SW} = *SW albedo;* M_{LW} = *LW flux or OLR;* $M_{SW} = A_{sw} * E_o{}^*\mu_o$

E_o = *incoming SW flux,* μ_o = *cos(SZA), SZA = solar zenith angle*

GEO matching:

- CERES 1°grid instantaneous Gridded Surface Fluxes and Clouds (SFC):
  Terra Ed3 CERES FM-1/2 scanner BB fluxes A_{SW}, M_{LW}
  MTSAT-2 1°-avg calibrated 0.65-μm albedos A_{nb} and 10.8-μm fluxes M_{nb}
- Match 2011-2012 CERES & MTSAT-2 1° data within ±15 minutes of overpass time for CERES VZA < 65°

POLAR matching:

Collocated 1986 NOAA-9 ERBE & AVHRR footprint data for VZA < 65°

AVHRR A_{nb}, M_{nb} convoluted to match ERBE footprint A_{SW}, M_{LW}, for same time

Fit matched data to[1]:

$A_{SW} = a_0 + a_1{}^*A_{nb} + a_2{}^*A_{nb}{}^2 + a_3{}^*\ln(1/\mu_o)$ (1)

$M_{LW} = A_0 + A_1{}^*M_{nb} + A_2{}^*M_{nb}{}^2 + A_3{}^*M_{nb}{}^*\ln(\text{colRH})$ (2)

where colRH=column-weighted RH from MERRA/MOA profiles

- Apply 3rd-order correction to OLR

GEO (MTSAT2)-CERES SW & LW NB-BB Fits

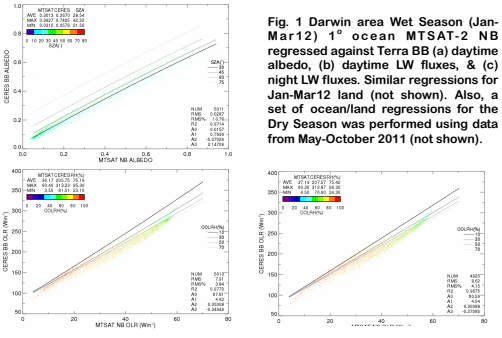
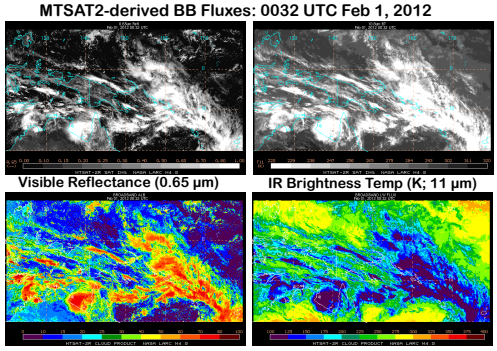


Fig. 1 Darwin area Wet Season (Jan-Mar12) 1° ocean MTSAT-2 NB regressed against Terra BB (a) daytime albedo, (b) daytime LW fluxes, & (c) night LW fluxes. Similar regressions for Jan-Mar12 land (not shown). Also, a set of ocean/land regressions for the Dry Season was performed using data from May-October 2011 (not shown).

GEO Results: TWP

MTSAT2-derived BB Fluxes: 0032 UTC Feb 1, 2012



Visible Reflectance (0.65 μm) | IR Brightness Temp (K; 11 μm)

BB SW TOA Albedo (%) | BB LW TOA Flux (Wm^{-2})

Fig. 2 MTSAT-2-derived BB albedo and LW flux over the Tropical Western Pacific region for 0032 UTC on February 1, 2012.

Validation with CERES

May-Oct 2011 MTSAT-2 vs Terra

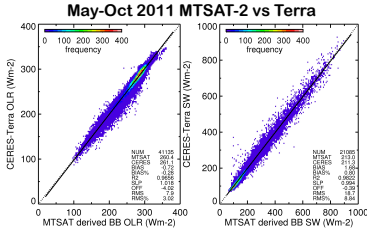


Fig. 3 MTSAT-2 fluxes derived using Dry Season May-Oct11 MTSAT-2 vs Terra NB-BB fits (LW left, SW right) compared to CERES Terra BB fluxes, for same time period. Validation was performed for Wet Season Jan-Mar12 as well (not shown).

Independent Assessment: GEO MTSAT-2 Wet and Dry Season fits vs Terra/Aqua

Table 1. Shows independent assessments of SW and LW biases/rms for fluxes derived using Wet Season fit applied to March 2013, and Dry Season fit applied to (May-July 2012) compared to CERES Ed3 Terra and Aqua.

	March 2013 (Wet Season Fit)		May-July 2012 (Dry Season Fit)	
	Terra (W/m^2)	Aqua (W/m^2)	Terra (W/m^2)	Aqua (W/m^2)
SW Bias (RMS)	-0.1 (25.7)	17.7 (50.1)	1.7 (19.5)	1.8 (20.3)
LW Bias (RMS)	-2.1 (7.9)	-1.9 (8.1)	-0.3 (8.3)	-0.3 (8.3)

POLAR (NOAA-9)-ERBE SW & LW NB-BB Fits

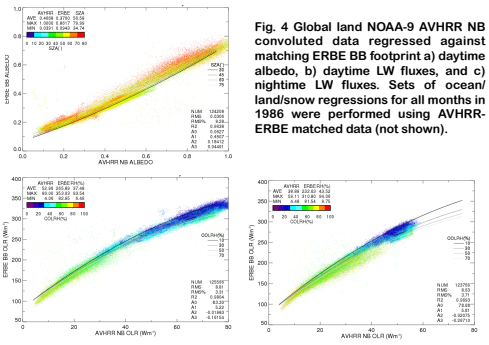
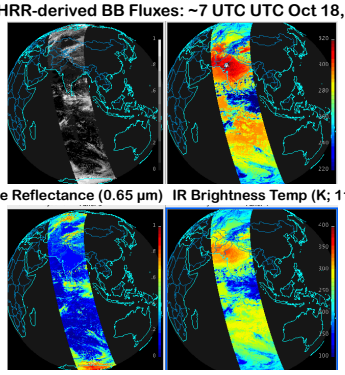


Fig. 4 Global land NOAA-9 AVHRR NB convoluted data regressed against matching ERBE BB footprint a) daytime albedo, b) daytime LW fluxes, and c) nightime LW fluxes. Sets of ocean/land/snow regressions for all months in 1986 were performed using AVHRR-ERBE matched data (not shown).

POLAR Results: Gan Island

AVHRR-derived BB Fluxes: ~7 UTC UTC Oct 18, 2008



Visible Reflectance (0.65 μm) | IR Brightness Temp (K; 11 μm)

BB SW TOA Albedo (%) | BB LW TOA Flux (Wm^{-2})

Fig. 5 Swaths of NOAA-18 AVHRR-derived BB albedo and LW flux over the region including Gan Island in the Indian Ocean, for ~7 UTC on October 18, 2008.

Independent Assessment: POLAR Oct86 fits vs Aqua

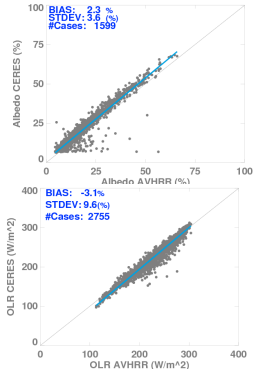


Fig. 6 Oct08 1 degree averaged AVHRR-derived BB albedo, derived using October 1986 NB-BB fits, compared to CERES Aqua BB SFC (1 deg) albedo over the Darwin region, within a 15 minute window (TOP). Bottom plot shows similar comparison, but with OLR. Biases for both are within a few percent.

Summary

- Produced NB-BB fits for both GEO (MTSAT-2) and POLAR (NOAA9) satellites to derive BB LW & SW TOA fluxes for various ARM domains
  - Accounted for seasonal, day-night, land-ocean (and snow for NOAA9) differences
  - Produced MTSAT-2 VISST results/TOA fluxes for Jan11-October 2013; most months currently in ARM archive; rest will be sent soon
- Future work:
  - Validate NOAA-18 AVHRR-derived results using POLAR NB-BB fits compared to CERES over all ARM domains
  - Improve NOAA-xx NB-BB fits by deriving for specific satellites, resgressing with additional channels:
    - 0.63, 0.83 um in SW
    - 10.8, 12.0 um in LW
  - Process NOAA-xx for 1978 – present using improved NOAA-ERBE/NOAA-CERES NB-BB fits
    - Allows for retrievals over NSA, Gan Island, other data-sparse areas of interest to ARM
    - -Re-derive GEO NB-BB fits for all available years, seasons of SGP GOES-8-14, TWP MTSAT-1/2

Website: (http://www-pm.larc.nasa.gov)