Improvement of Broadband Shortwave and Longwave Fluxes over ARM Domains

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1.Introduction

• As part of a cloud and radiation product dataset, the NASA Langley Cloud Group provides broadband (BB) shortwave (SW) and longwave (LW) fluxes derived from geostationary operational environmental satellite (GOES) narrowband (NB) radiances
  – Available from May 1998 to August 2005
• Narrow-to-broadband (NB-BB) conversion technique based on regressing coincident co-located 1° averaged CERES BB and GOES NB fluxes. Regression coefficients unique for each domain (SGP, MASRAD, etc). Currently for GOES8 (Apr00-Mar03), there is only a single NB-BB fit based on Terra CERES data.
• SW: Comparisons with BBHRP fluxes revealed that SW fluxes derived using GOES8 fit compared well at Terra overpass time (1030 LT), but systematic differences occurred at other times
• LW: Comparisons with BBHRP fluxes revealed a diurnal dependency of the bias with good agreement at 1030 LT
• New fits needed to address these issues:
  – LW: seasonally, day and night
  – SW: seasonally, function of solar zenith angle (SZA) - SZA dependence from Meteosat GERB

2. SW Improvement

• Fig 1: New seasonal GOES8-Terra SGP SW NB-BB fits for summer and winter
  – seasonal NB-BB accounts for SGP vegetation cycle
  – Note: small dependency on SZA for Terra CERES fits. Older fits based on CERES TRMM & GOES showed a strong SZA dependency
• Fig 2: Current 4-season NB-BB fits yields a 0.4 W/m^2 bias (RMS 18.9 W/m^2) at Terra overpass times
• Terra CERES/GOES matches are limited in SZA range and may not resolve the functionality with SZA
• Use GERB/MSG9 NB to BB matches to derive the SZA coefficient.
  – 1°avgs of GERB BARG (Binned Averaged Rectified Geolocated) near-real time data used - may be of reduced accuracy compared to Edition GERB

3. SW Results

• Fig 3: Matched METEOSAT-9 (MSG) NB / GERB BB data and fits using July 2007 hourly images
  – SZA coefficient (A3) is 0.035
• Fig 4: Recomputation of GOES/CERES SGP NB-BB coefficients using GERB/MSG9 SZA coefficient (A3) value
• Fig 5: Diurnal variation in GOES BB albedo during Mar00-Feb01 using old & new fits
  – Note: increased albedos near sunrise and sunset should be more consistent with BBHRP product

4. LW Improvement

Examine GOES BB flux differences derived from day, night, and seasonal NB-BB regressions
• Fig 6: Day-night biases (Mar00-Feb01) from operational, all-inclusive LW fit: daytime bias is 0.3 W/m^2; RMS = 7.6 W/m^2 , nighttime bias is –4.7 W/m^2; RMS = 8.4 W/m^2
• Fig 7: Day and night NB-BB regression coefficients derived from summer (Jun-Aug00) and winter (Dec00-Feb01) data
  – Daytime has greater diurnal range & atmospheric structure that may be different at night
  – Note: difference between winter/summer coefficients not accounted for in operational all-inclusive fit
  – Secondary, 3rd order fit applied to LW NB-BB results to eliminate the low end bias

5. LW Results

• Fig 8: Improvements due to separate day-night LW fits. Comparison of Mar00-Feb01 CERES/GOES-8 OLR yields
Daytime bias = -0.1 W/m^2; RMS = 7.1 W/m^2
Nighttime bias = 0.0 W/m^2; RMS = 7.7 W/m^2

SW Improvement

SGP GOES8-Terra SW Seasonal NB-BB Fits

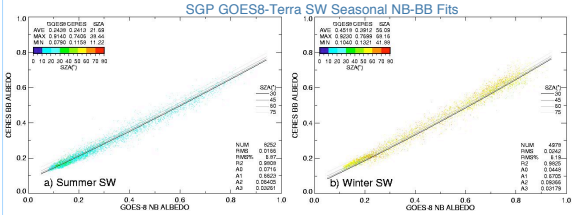

Figure 1(top). Derivation of SGP GOES8-Terra NB-BB SW flux fit, for a) summer b) winter. Fits for other 2 seasons are not shown. Coefficients A0,A1,A2,A3 (lower right hand corner) are used in multi-parameter fit to derive BB fluxes.

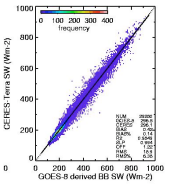

Figure 2 (right). Validation using improved 4 seasonal NB-BB fits applied for time period: Mar00-Feb01. Bias = 0.1% RMS = 6.4%. Conclusion: derived BB SW fluxes match well at Terra overpass times.

SW Results

Europe GERB-MSG9 SW Jul07 NB-BB Fit

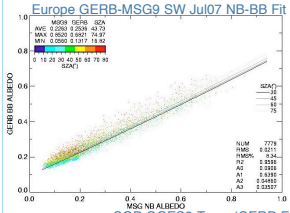

Figure 3. Derivation of a) GERB-MSG9 Jul07 NB-BB SW flux fit over Europe (land only, 39°-45°N; 4°W-17°E). GERB provides BB fluxes every 15 minutes. GERB/MSG spectral response functions slightly differently compared to GOES/CERES, thus, GERB compared to MSG NB hourly can provide information about change in BB albedo with SZA, enhancing the GOES-Terra fit which is limited in SZA range.

SGP GOES8-Terra (GERB-Enhanced) SW Seasonal NB-BB Fits

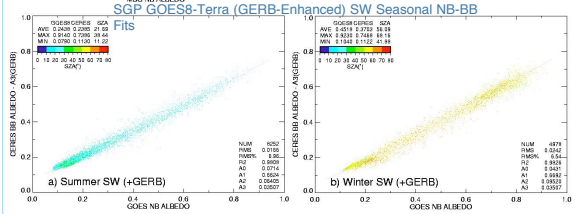

Figure 4. Derivation of GOES8-Terra fit enhanced using GERB SZA (A3) term for a) summer (Jun-Aug00), b) winter (Dec00-Feb01).

Comparison of BB Albedoes: Old and New SW NB-BB Fits

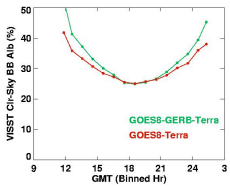

Figure 5. Comparison of BB albedos from Mar00-Feb01 derived using just basic GOES8-Terra fit (red) and enhanced GOES8-GERB/CERES fit (green). While the albedoes are the same near local noon, the SZA term from GERB yields an increase in magnitude of the diurnal variation in BBSW albedo; this should improve errors in GOES-based BB albedo around sunrise and sunset.

LW Improvement

Day and Night Bias in Operational LW NB-BB

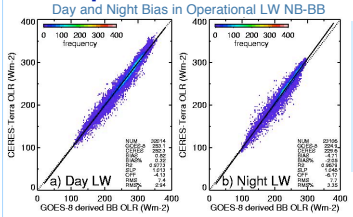

Figure 6. Comparison of operational SGP GOES-8 VISST-derived broadband LW from Mar00 -Feb01 (a) Daytime, (b) Nighttime. Daytime bias & RMS are 0.3% & 2.9%. Significant bias of -2.1% (RMS 3.4%) at night. These results indicate need for separate day & night LW NB-BB fits.

LW Results

SGP GOES8-Terra LW Seasonal, Day-Night NB-BB Fits

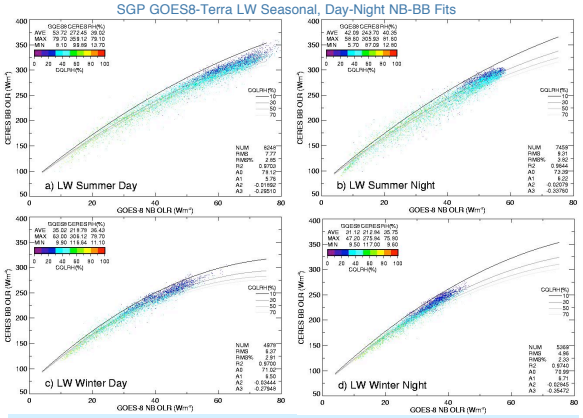

Figure 7. SGP GOES8-Terra CERES NB-BB LW flux fits for (a) summer days (b) summer nights, (c) winter days, d) winter nights. Fits for other 2 seasons not shown. Regression coefficients A0,A1,A2,A3 (lower right corner) used to derive GOES BB LW fluxes.

Improved Day-Night Results using new LW NB-BB

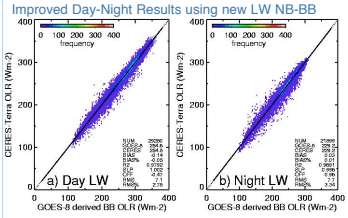

Figure 8. Comparison of SGP Mar00 –Feb01 GOES8-based LW for (a) Daytime, (b) Nighttime, using fits from Fig. 7. LW fits corrected with a 3rd order fit to account for low end bias. Day and night biases reduced to -0.1% and corresponding RMS errors drop to 2.8% & 3.3%. Night bias is significantly better than operational "one-fit" LW NB-BB approach. RMS slightly smaller.

6. Summary and Future Work

New CERES-GOES NB-BB LW conversion method developed using separate sets of seasonal and day/night coefficients for SGP. The old SGP LW nighttime bias of –4.7 W/m^2 is eliminated by using separate day-night fits; average RMS errors reduced to 7.4 W/m^2. Day-night-seasonal fits for SGP also showed improvement from the old one-fit approach. For Mar00-Feb01, the total LW bias improved from 0.8 W/m^2 to –0.1 W/m^2; RMS error dropped from 7.4 to 7.1 W/m^2. SW bias improved from 1.1 W/m^2 to 0.4 W/m^2 bias with minor improvement in the RMS error (not shown). GOES8-Terra SW NB-BB fit further enhanced to improve errors at non-Terra overpass times SZA term from a Jul07 GERB-MSG9 NB-BB fit over Europe. The results were used to better account for SZA dependence of GOES8-Terra fits, qualitatively improving derived BB albedo.
Future work will use a full year of GERB-MSG NB-BB, to account for both the green-up and brown-down phases of SGP SW NB-BB fits. SW fits will be compared with BBHRP and CERES TRMM flux dependencies. SGP LW NB-BB fit will also be evaluated with GERB-MSG9 LW NB-BB data. NB-BB fits will also be re-derived for other domains (e.g., MASRAD) using these updates.

References

Caldwell, T. E. and Co-authors, 2006: Clouds and the Earth's Radiant Energy System (CERES) Data Management System, Data Products Catalog, Release 4, Version 14. 214 pp.

Harries et al, 2005: The Geostationary Earth Radiation Budget Project, BAMS, Vol 86, No. 7, pp. 945-960

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