Derivation of Broadband Fluxes using Narrowband-to-Broadband Conversions

M.M. Khaiyer, D.R.Doelling, R. Palikonda, Y. Yi
Analytical Services and Materials, Inc.

P. Minnis

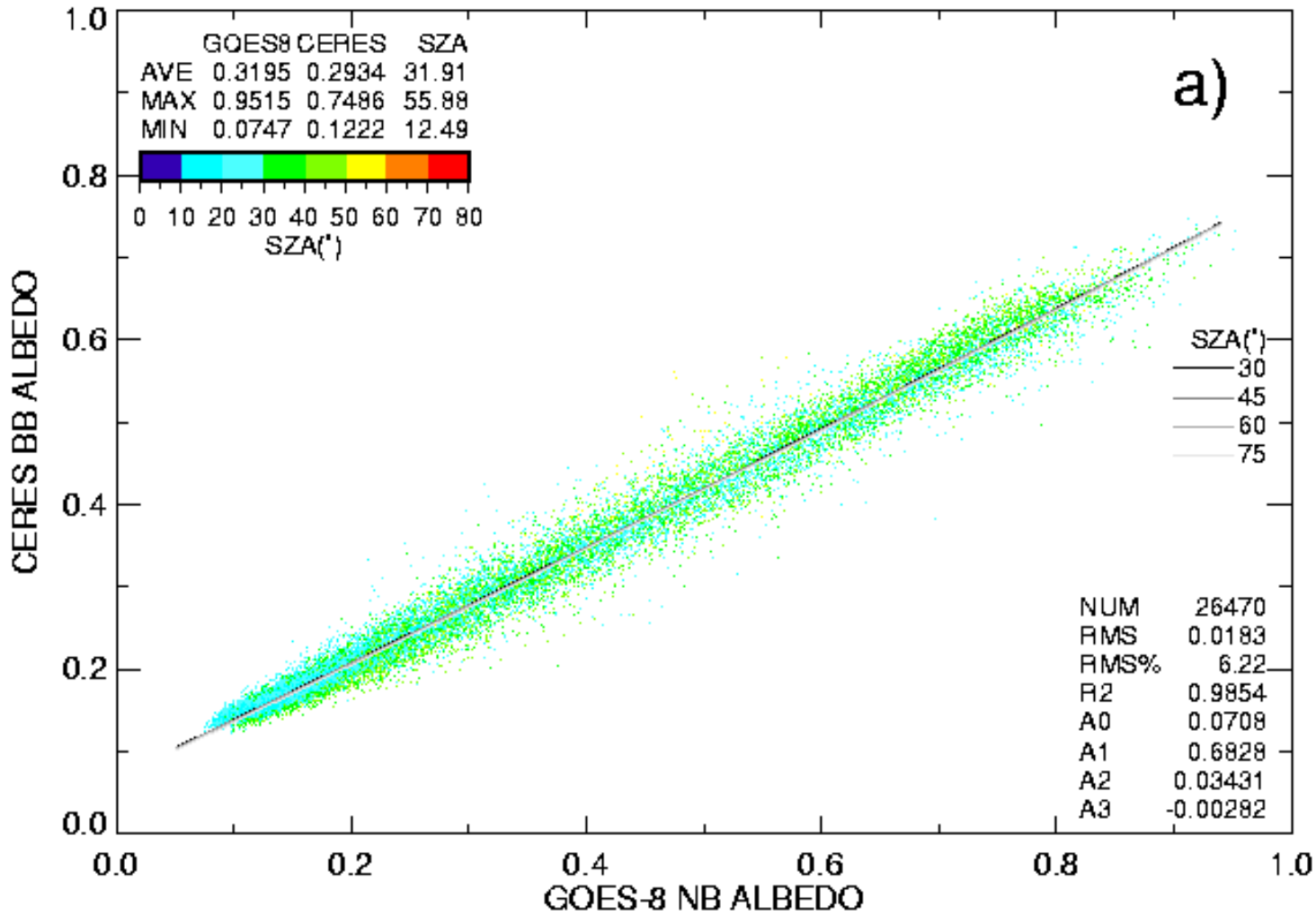
National Aeronautics and Space Administration Langley Research Center

Climate Science Branch

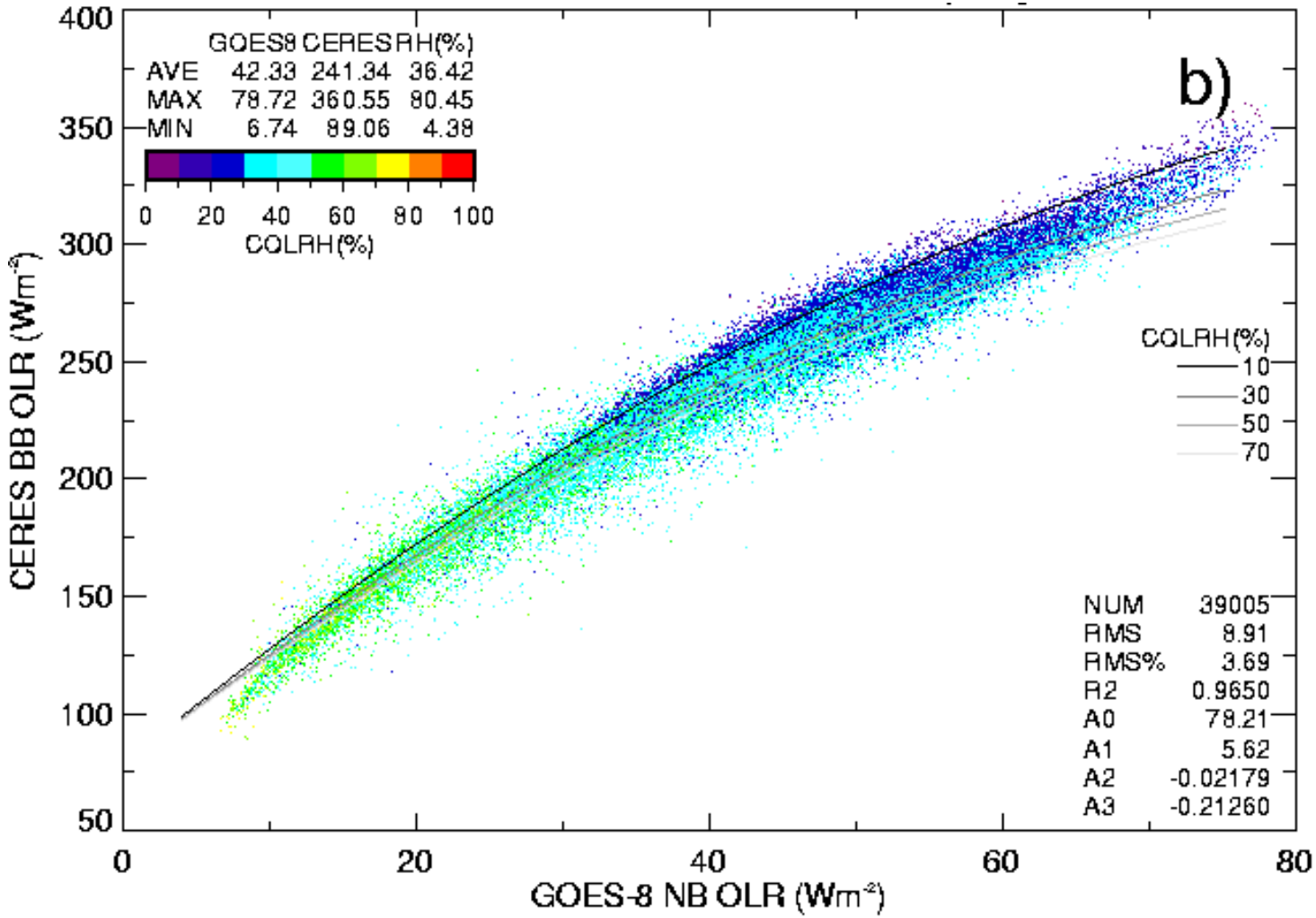
Methodology

- BB fluxes from Terra CERES FM-1 or FM-2 scanner matched with the GOES NB fluxes
  - CERES 20-km Single Scanner Footprint TOA/Surface Fluxes & Clouds (Geier et al, 1999)
  - SSF footprint data averaged into 1°grid: Monthly Gridded Surface Fluxes and Clouds (SFC)
  - CERES FM-1 or 2 SFC fluxes (cross-track mode only) matched to 1° GOES NB fluxes within ±15 minutes, at CERES VZA < 65°, GOES VZA < 70°
  - Convert NB flux to BB using empirical equations:
    - $SW_{bb} = a_0 + a_1*S_{nb} + a_2*S_{nb}^2 + a_3*\ln(1/csza))$ (1)
      where SW_{bb}= SW BB flux, S_{nb} = SW NB flux, csza=cos(SZA)
    - $OLR_{bb} = A_0 + A_1*L_{nb} + A_2*L_{nb}^2 + A_3*L_{nb}*\ln(colRH)$ (2)
      where OLB_{bb} = LW BB flux, L_{nb}=LW NB flux, and colRH=col-weighted RH
- Domains for matching:
  - Southern Great Plains (SGP) Domain
    - 32°-42°N, 91°W-105°W
    - GOES-8 data from April 2000-March 2003
    - Rapid Update Cycle (RUC) model analyses provide vertical profiles
  - Darwin Tropical Western Pacific (DTWP) Domain
    - 0°N – 17°S, 125°E-136°E (*Expanded 121°E-140°E*)
    - GOES-9 data from June 2004-May 2005; MTSAT Nov-Dec05
    - Meteorological Ozone and Aerosol (MOA) atmospheric profiles

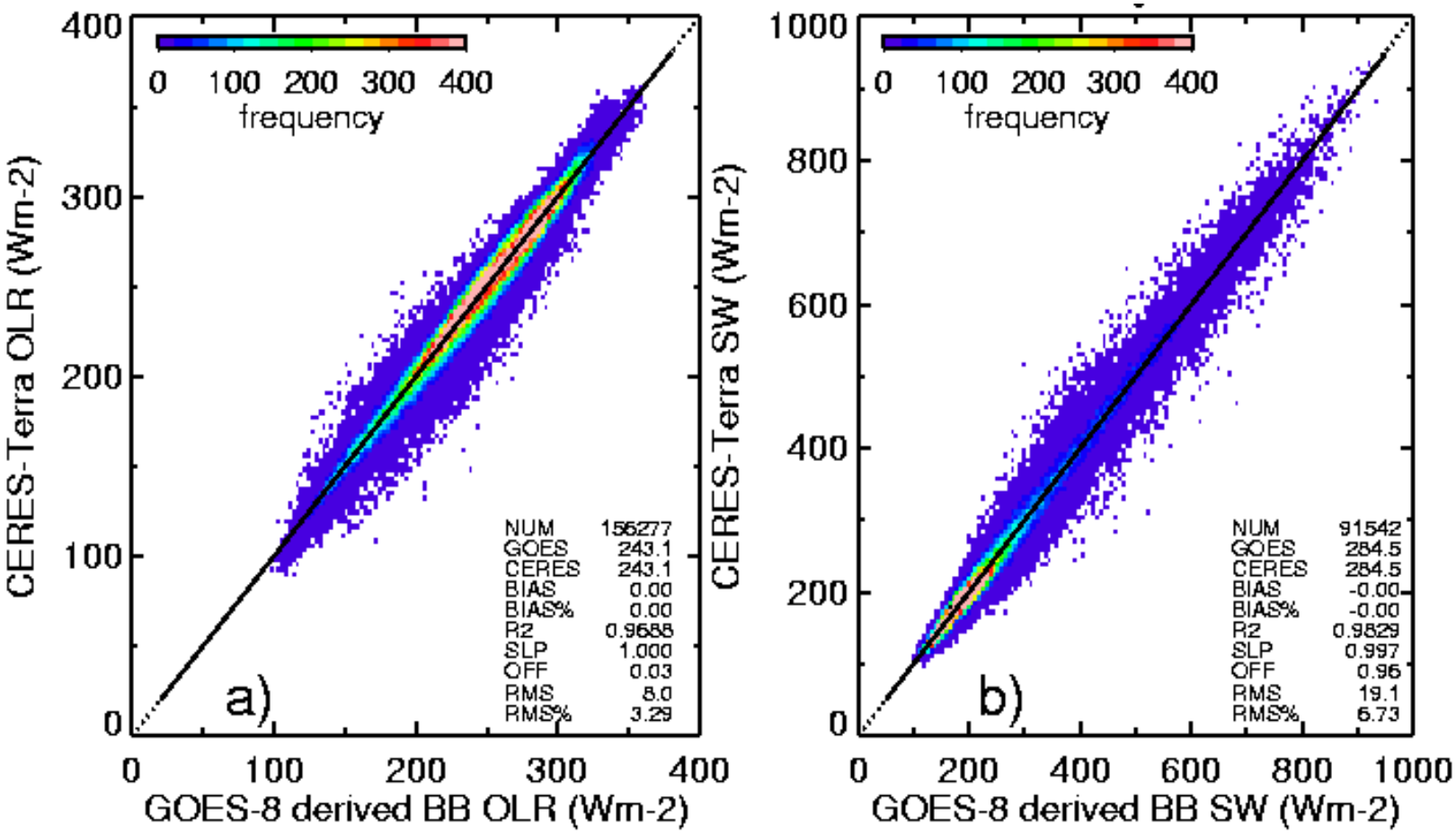
GOES-8 Narrowband vs CERES Broadband Albedo



GOES-8 Narrowband vs CERES Broadband LW Flux



ARM SGP GOES-8 Derived BB Fluxes vs CERES



VISST 1 Degree BB SW/LW Errors

	Dates	Old Bias	Old RMS	New Bias	New RMS
G8 OLR	4/00-3/03	1.4%	3.6%	0.0%	3.3%
G9 OLR	6/04-5/05	2.4%	3.9%	0.0%	2.9%
G10 OLR*	3/05-11/05	2.1%	3.1%	0.2%	3.0%
G10 OLR	3/05-11/05	2.1%	3.1%	0.0%	2.9%
G12 OLR*	3/05-11/05	3.9%	3.5%	1.8%	3.3%
G12 OLR	3/05-11/05	3.9%	3.5%	0.0%	3.3%
G8 SW	4/00-3/03	5.3%	6.9%	0.0%	6.7%
G9 SW	6/04-5/05	-9.5%	13.4%	0.0%	10.8%
G10 SW*	3/05-11/05	2.5%	7.2%	-2.1%	7.2%
G10 SW	3/05-11/05	2.5%	7.2%	0.0%	7.1%
G12 SW*	3/05-11/05	5.3%	7.1%	0.4%	6.9%
G12 SW	3/05-11/05	5.3%	7.1%	0.0%	6.8%

*** indicates the "new" values are for the GOES8 NB-BB coefficients, as validation.**

Narrow-band to broadband TOA flux conversion

M.M. Khaiyer

Surface radiative fluxes retrieved from VISST: validation and some recent developments

P. K. Chan, M.M. Khaiyer, D. R. Doelling, M. L. Nordeen,
J. K. Ayers, R. Palikonda

Analytical Services and Materials, Inc.

P. Minnis

National Aeronautics and Space Administration Langley Research Center

Climate Science Branch

Introduction - Methodology

- Algorithms used: similar to those used in CERES processing
  - (1) SW:
    Li-Leighton(LL) - clear sky
    Langley Parameterization Shortwave Algorithm (LPSA) - all-sky

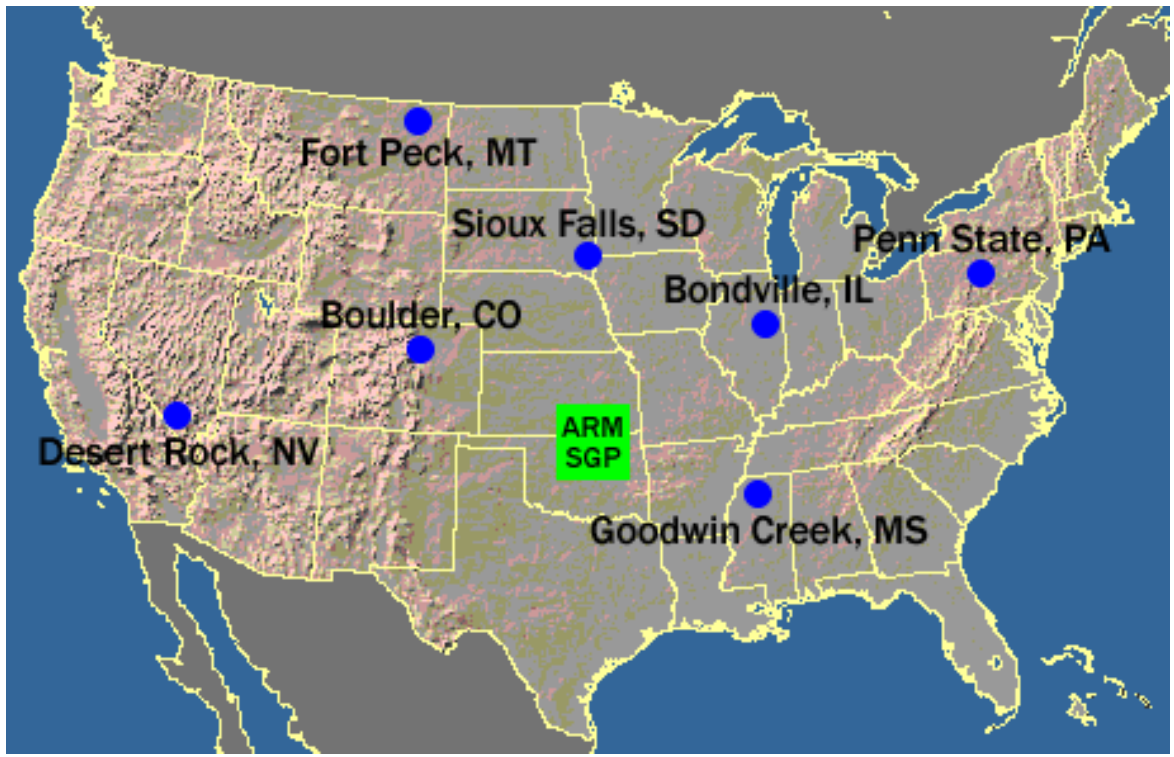
    Input parameters: broadband TOA albedo, solar zenith angle, total cloud amount, cloud optical depth, column water amount, aerosol optical depth, column ozone amount, ERBE scene type, sfc pressure
  - (2) LW**:**
    Inamdar - Ramanathan algorithm: clear sky
    Langley Parameterization Longwave Algorithm (LPLA) - all-sky
    Input parameters: clear sky OLR, cloud amounts (liquid, ice), cloud base, cloud emissivity, temperature and humidity profiles, surface emissivity, sfc type, sfc temp
- Domains for real-time retrieval:
  Darwin, continental United States (CONUS region), tropical western Pacific, western Europe

Introduction

- Data sources
  - Temp and humidity profiles: RUC (Rapid Update Cycle) data at 1-hr interval
    (Clear sky Tsfc: from correlated-K method)
    (Assume cloudy sky Tsfc = Tair (lowest level))
  - Cloud (amount, base, optical depth, cloud emissivity), TOA albedo, clear sky OLR: VISST products / GOES-12 (http://angler.larc.nasa.gov/satimage/products.html)
  - Aerosol optical depth: MATCH (Model of Atmospheric Transport and Chemistry) climatology
  - Ozone amount: TOMS
  - surface emissivity: MODIS

Validation of satellite retrieved surface fluxes

- 4 seasonal months in 2004, 7 SURFRAD sites (http://www.srrb.noaa.gov/surfrad/)
- Satellite retrievals use VISST cloud parameters from pixels within 10km radius of the SURFRAD sites
- SURFRAD measurements are 9-minute averages centered at satellite image time



SW↓ - clear sky

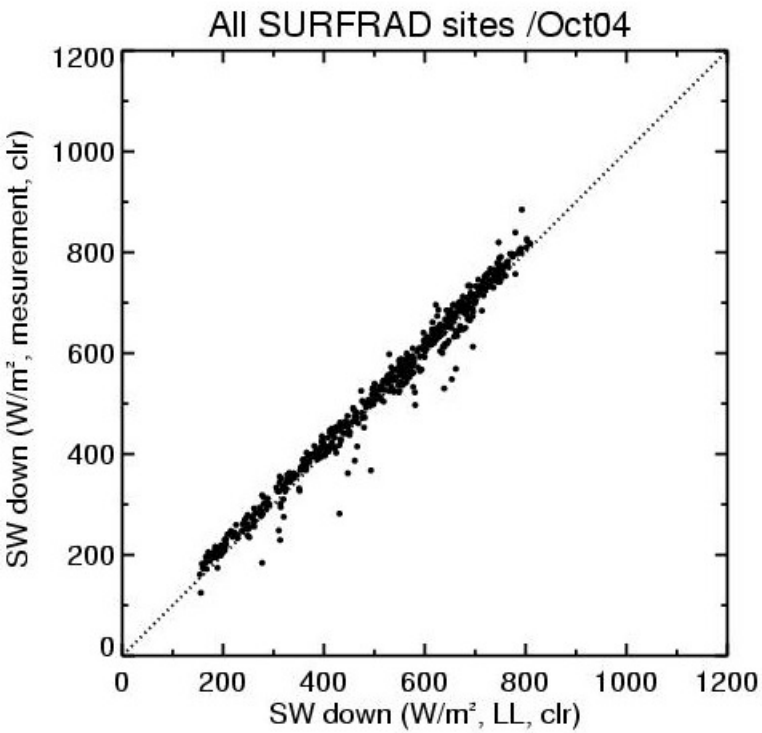


Table 1. Clear sky SW↓ retrieval

Seasons	LPSA		LL	
	Bias (%)	RMS (%)	Bias (%)	RMS (%)
winter	-4.2	7.9	-4.0	7.3
spring	-2.8	6.1	-2.2	5.7
summer	-1.9	9.1	-1.6	8.2
fall	-3.4	5.4	-1.8	4.7

(Bias = retrieval - measurement)

- both LL and LPSA retrievals agree well with observation (mean bias < 3%, mean rms ~ 7%)

SW↓ - cloudy

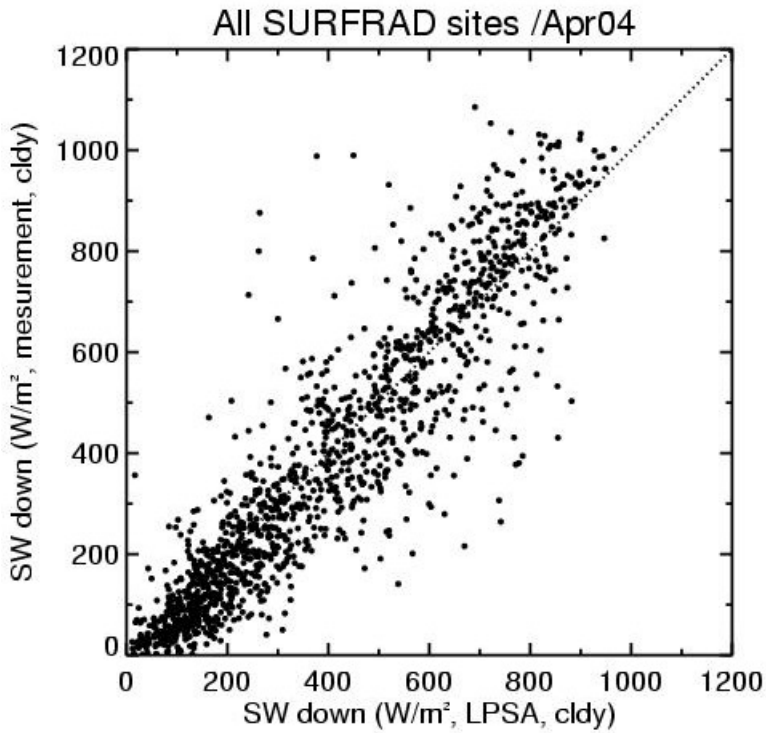


Table 2. LPSA cloudy sky SW↓

Seasons	Bias (%)	RMS (%)
winter	1.9	28.9
spring	2.6	28.0
summer	3.9	30.1
fall	4.3	32.8

- Large scatter probably due to different geometry of satellite retrieval and sfc measurement

LW↓ - clear sky

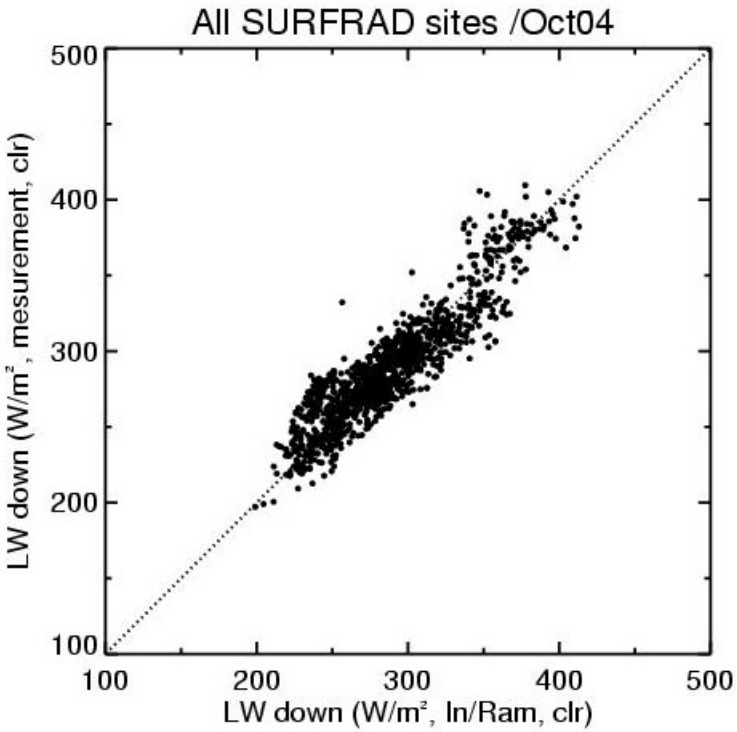


Table 3. Clear sky LW↓

Seasons	LPLA		InRa	
	Bias (%)	RMS (%)	Bias (%)	RMS (%)
winter	-4.2	9.2	3.3	9.0
spring	-0.6	8.0	3.6	8.7
summer	-2.4	5.6	-0.1	5.5
fall	-3.6	6.2	-0.1	5.4

- Better agreement in summer than in winter.

  (Large spatial variation in temp field in winter. RUC data may not be good enough to capture the changes in temp.)

LW↓ - cloudy sky

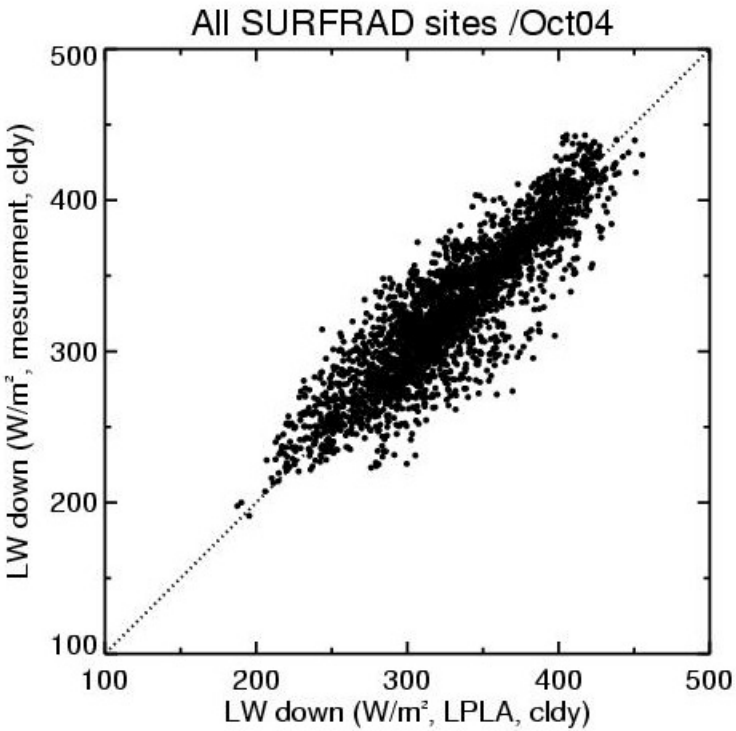


Table 4. LPLA cloudy sky LW↓

Seasons	Bias (%)	RMS (%)
winter	0.7	10.4
spring	2.4	8.9
summer	1.5	6.4
fall	0.5	6.7

- Large scatter probably due to
  - different geometry of satellite retrieval and sfc measurement
  - uncertainty in cloud base (In mid-latitude winter, varying cloud base by 300mb can change LW↓ by 50 W/m^2)

LW↑ - clear sky

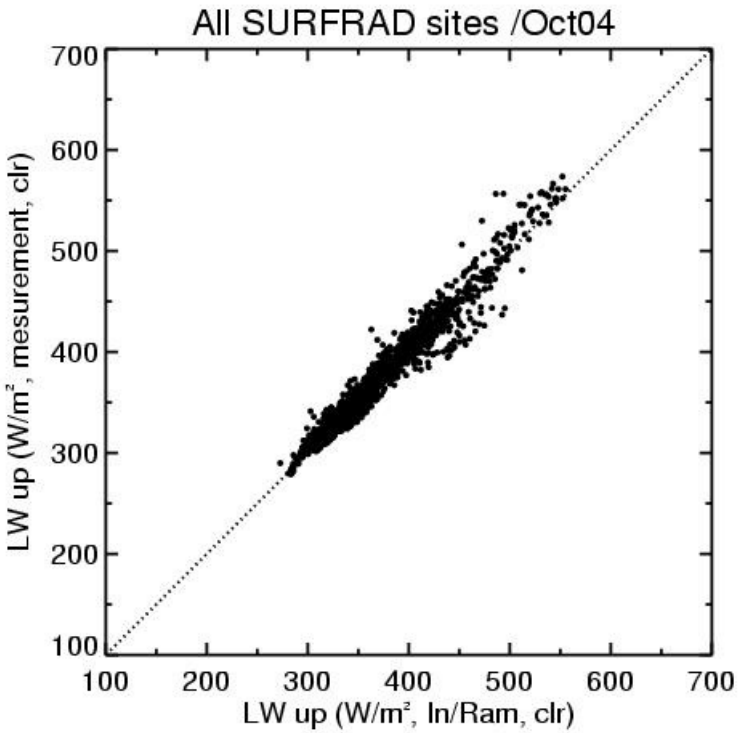


Table 5a. Clear sky LW↑

Seasons	LPLA		InRa	
	Bias (%)	RMS (%)	Bias (%)	RMS (%)
winter	-2.3	3.8	-1.7	3.4
spring	-2.5	4.1	-1.6	3.7
summer	-3.2	5.3	-2.4	4.8
fall	-1.4	3.4	-0.8	3.1

- Clear sky LW↑ retrieval agree well with sfc measurement (bias ~2%, rms ~ 4%)

LW↑ - cloudy sky

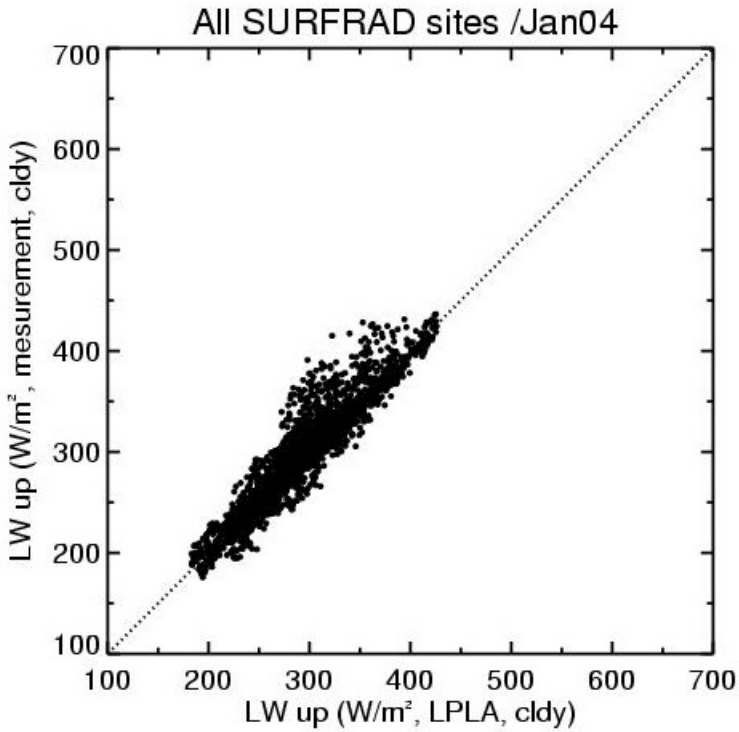


Table 5. LPLA cloudy sky LW↑

Seasons	Bias (%)	RMS (%)
winter	-1.3	4.6
spring	-3.1	6.9
summer	-3.5	6.6
fall	-1.6	4.8

- winter results better than summer

(Assume Tsfc= Tair under cloudy sky, (Tsfc - Tair) smaller in winter than in summer)

- expect larger error in region with thin clouds (e.g., Desert Rock)

Summary

Table 6. Averages over 7 SURFRAD sites and 4 seasons

	Clear		Cloudy	
	Bias (%)	RMS (%)	Bias (%)	RMS (%)
SW↓ (LPSA)	-1.4	7.6	5.5	30.9
SW↓ (LPLA)	-2.4	6.5		
SW↓ (InRa)	-0.8	6.6		
LW↓ (LPSA)	-2.7	7.3	1.3	8.1
LW↓ (LPLA)	1.7	7.2		
LW↓ (InRa)	1.7	7.2		
LW↑ (LPSA)	-2.4	4.1	-2.4	5.7
LW↑ (LPLA)	-1.6	3.8		
LW↑ (InRa)	-1.6	3.8		

Table 6. Averages over 7 SURFRAD sites and year

- SW↓retrieval (clear sky) and LW↓↑(clear and cloudy sky) agree quite well with sfc measurement (bias ≤ 3%, rms ≤ 8%)

Summary

- More comparisons with sfc radiative flux measurements at other sites (e.g., Darwin, European sites)

- Ready for real-time surface flux retrieval (Darwin, CONUS, TWP, W. Europe)
  - retrieval at hourly or 30-min interval, 0.5 deg grid
  - fast

- Cloudy sky LW↑ retrieval can be improved by using better sfc temp. Future analysis will use sfc temperature from parameterizaton relating sfc temp, hour of day, cloud amount, cloud optical depth, humidity and wind speed.

- Cloudy sky LW↓ retrieval
  - VISST cloud base heights will be evaluated with lidar and ceilometer measurements at ARM SGP site and ASOS sites
  - the impact of multi-layer cloud retrievals (better cloud base) will be examined

LPSA_SW↓ (September 27, 2006)

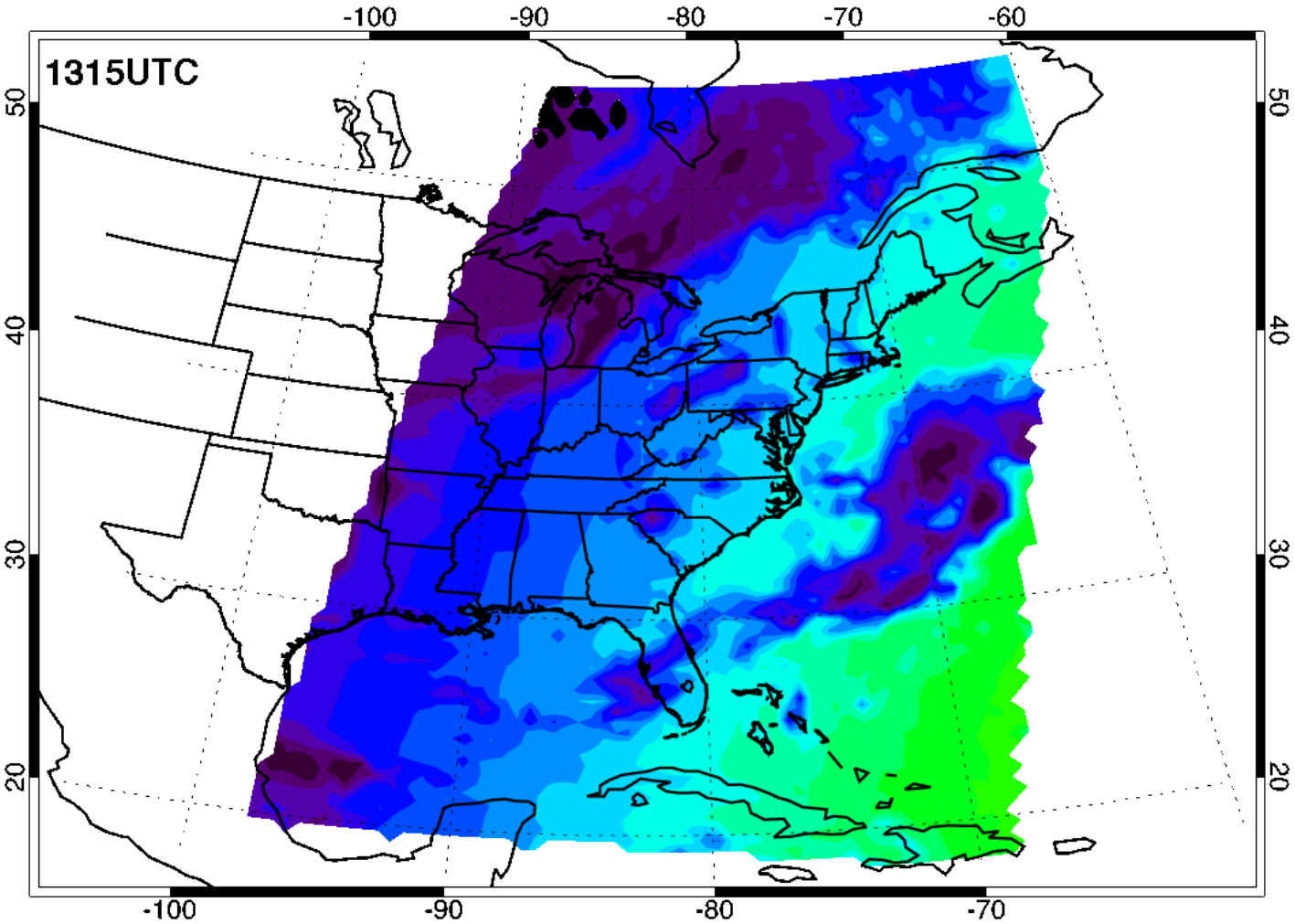


Table 8. SURFRAD site information

Station	Abbreviation	Latitude	Longitude	Elevation (m)
Fort Peck, MT	fpk	48.31N	105.10W	634
Sious Falls, SD	sxf	43.73N	96.62W	473
Penn State, PA	psu	40.72N	77.93W	376
Boulder, CO	tbl	40.13N	105.24W	1689
Bondville, IL	bon	40.05N	88.37W	213
Desert Rock, NV	dra	36.63N	116.02W	1007
Goodwin Creek, MS	gwn	34.25N	89.87W	98