Surface Atmospheric Radiation Budget (SARB) working group update

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17th CERES Science team meeting May 1-3, 2012

Outline of SARB update

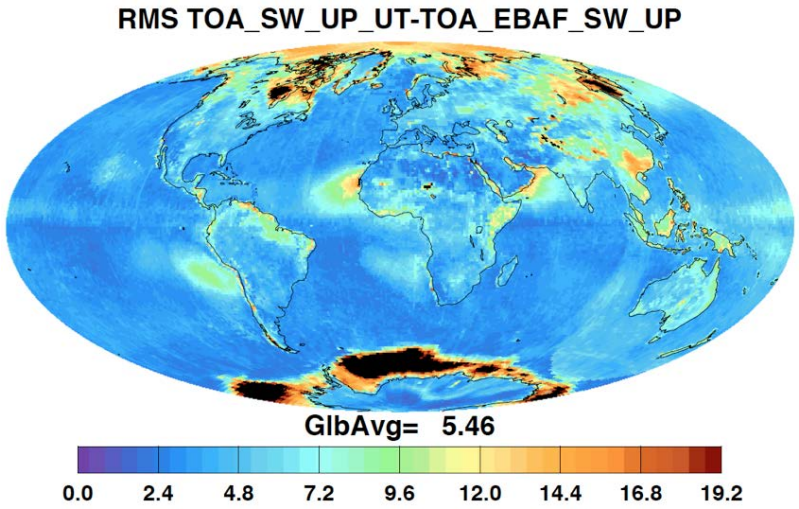
- EBAF-surface product
- CRS1deg-Month
- Ed4 surface albedo history map (A. Radkevich's presentation in the SARB working group meeting for a supplementary clear-sky recognition algorithm)
- Analysis of contributions of cloud and atmospheric property variability to TOA and surface irradiance anomalies (F. Rose's presentation in the SARB working group meeting)
- Ed4 validation plan
- MATCH aerosol transport model (D. Fillmore's presentation in the SARB working group meeting)

EBAF-surface product

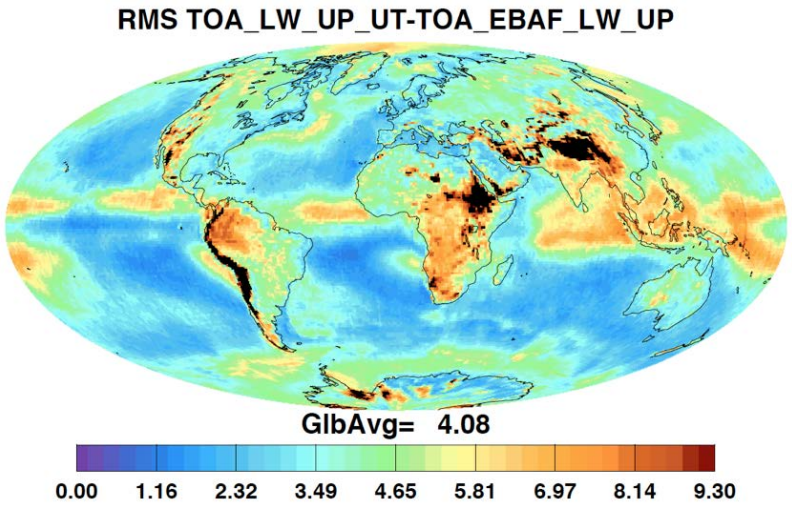
- Irradiance data inputs
  - Ed2 SYN1deg-Month, and EBAF2.6r
- Adjust cloud and atmospheric properties to match TOA shortwave and longwave irradiances with CERES-derived irradiances using a Lagrange multiplier approach
- Surface irradiance adjustments are computed with a 1D model based on cloud and atmospheric property adjustments
- EBAF-surface2.6r product (monthly 1°×1°) from March 2000 through Feb. 2010 is available (D. Doelling's presentation)

TOA irradiances to be adjusted

SW up RMS EBAF – SYN1deg



LW up RMS EBAF – SYN1deg



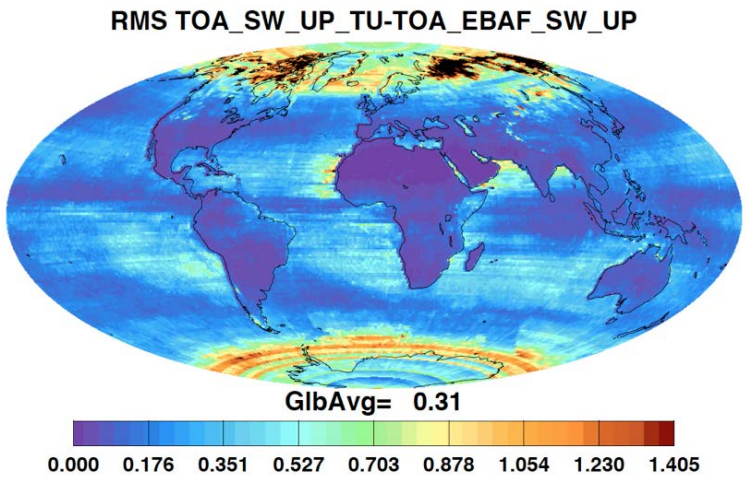
Use a Lagrange multiplier method and TOA SW and LW differences to determine Cloud and atmospheric property adjustments based on their uncertainty estimate

Observation-based Uncertainty Estimate

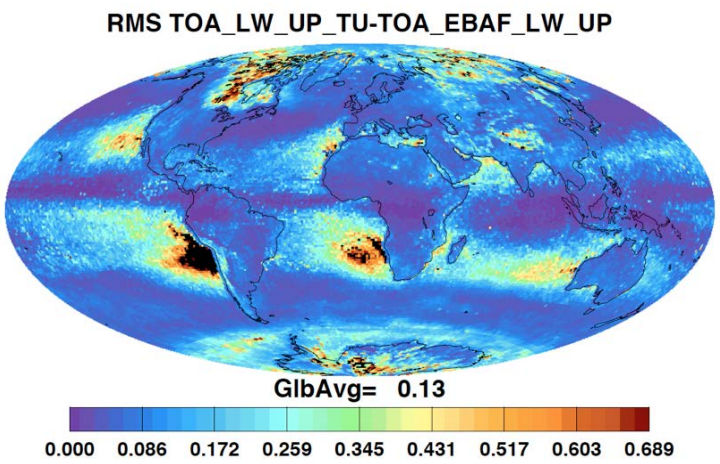
Variables	Method and data source	Resolution
Upper tropospheric relative humidity	Difference between AIRS-derived and from reanalysis (GEOS-4 or 5)	Monthly 1° zonal grid. Pre-adjustment
Surface skin temperature	Difference between AIRS-derived and reanalysis (GEOS-4 or 5)	Monthly 1° zonal grid. Climatology before 200209
Surface air temperature	Difference between AIRS-derived and reanalysis (GEOS-4 or 5)	Monthly 1° zonal grid. Climatology before 200209
Precipitable water	Difference between AIRS-derived and reanalysis (GEOS-4 or 5)	Monthly 1° zonal grid. Climatology before 200209
Aerosol optical thickness	Aeronet/MODIS validation based estimate	Global Land (15%), Global Ocean (10%) separately
Surface albedo	Estimate.	Global land, global ocean global cryosphere separately
Cloud fraction	Difference between CALIPSO- CloudSat-derived and MODIS-derived values (Kato et al. 2011)	Monthly 1° zonal grid, land ocean separately
Cloud optical thickness	Derived from MODIS by two different cloud algorithms (Ed3-beta2 standard and enhanced, Kato et al. 2011)	Monthly 1° zonal grid, land ocean separately, cloud type (high, mid, and low) dependent
Cloud top height	Difference between CALIPSO- CloudSat-derived and MODIS derived (Kato et al. 2011)	Monthly 1° zonal grid, land ocean separately, cloud type (high, mid, and low) dependent
Cloud base height	Difference between CALIPSO-CloudSat derived and MODIS-derived (Minnis et al. 2011)	Monthly 1° zonal grid, land ocean separately, cloud type (high, mid, and low) dependent
TOA shortwave irradiance	Estimate of Model Accuracy	Single global value ($0.5\ Wm^{-2}$)
TOA longwave irradiance	Estimate of Model Accuracy	Single global value ($0.5\ Wm^{-2}$)

TOA irradiance difference after adjustments

SW up RMS



LW up RMS

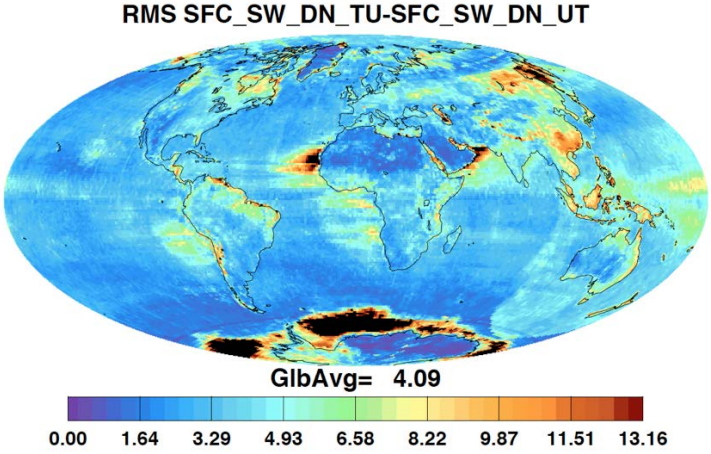


All-sky, modeled TOA irradiances for most regions agree with CERES-derived TOA irradiances (EBAF2.6r) very well

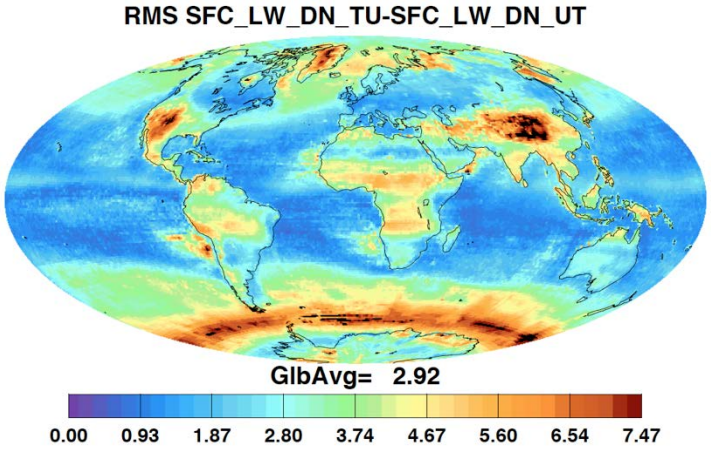
Adjustments of surface irradiances (RMS difference)

(after – before adjustments)

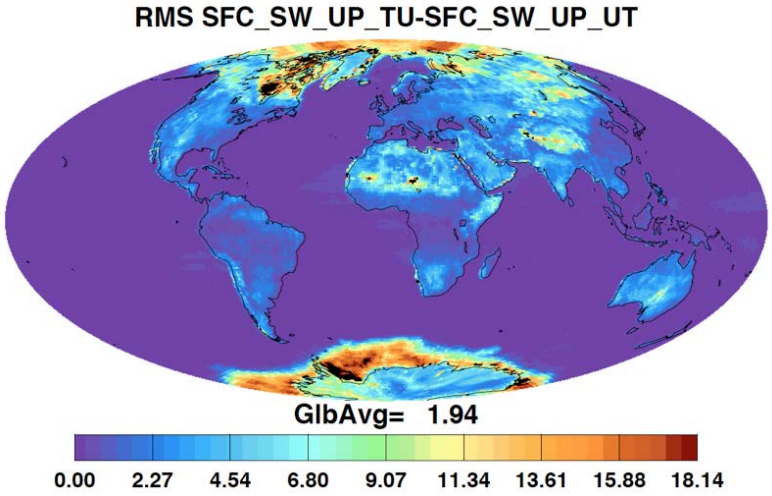
SW down (10Wm^{-2})



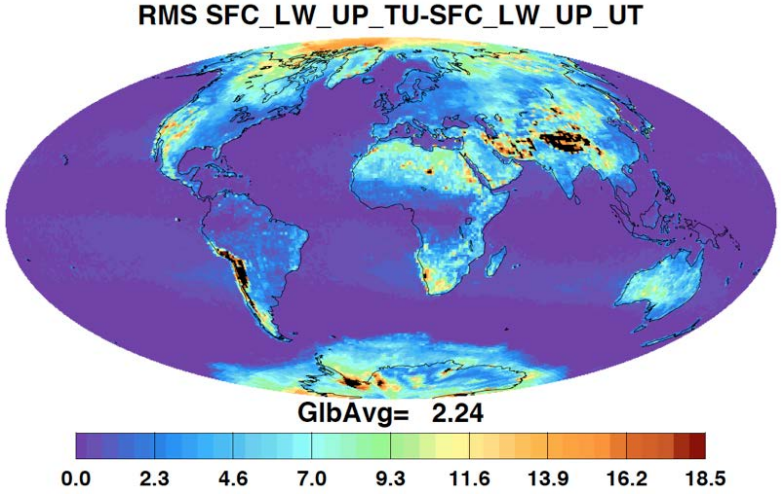
LW down (14 Wm^{-2})



SW up (11 Wm^{-2})



LW up (15 Wm^{-2})



Most surface irradiances are adjusted within their uncertainty

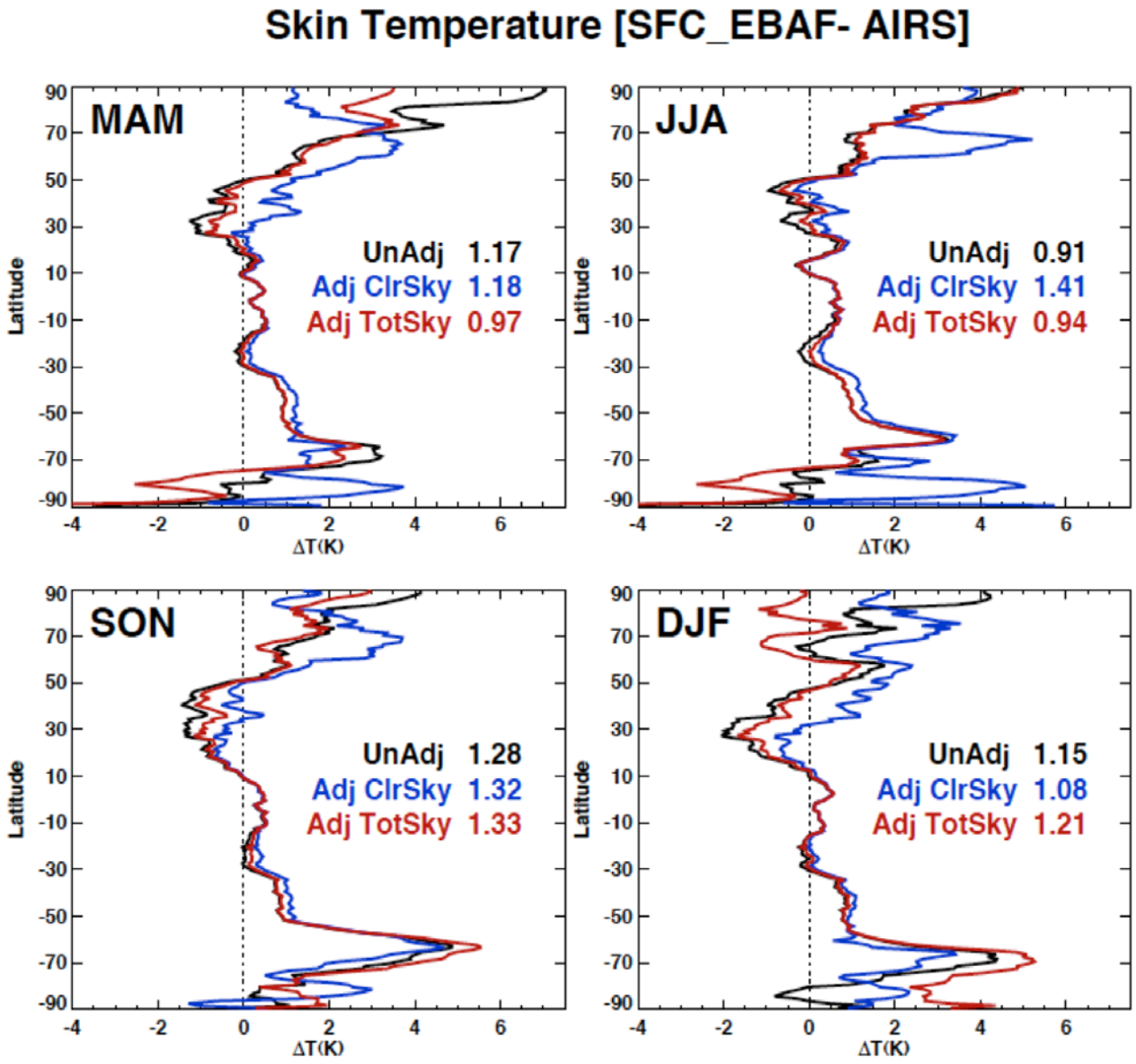
Surface irradiance uncertainty in Wm^{-2} (1σ, k = 1)

		Mean value	Monthly gridded	Monthly zonal	Monthly global	Annual global
Downward longwave	Ocean+Land	345	14	11	7	7
Upward longwave	Ocean+Land	398	15	8	3	3
Downward shortwave	Ocean+Land	192	10	8	6	4
Upward shortwave	Ocean+Land	23	11	3	3	3

Kato et al. (2012)

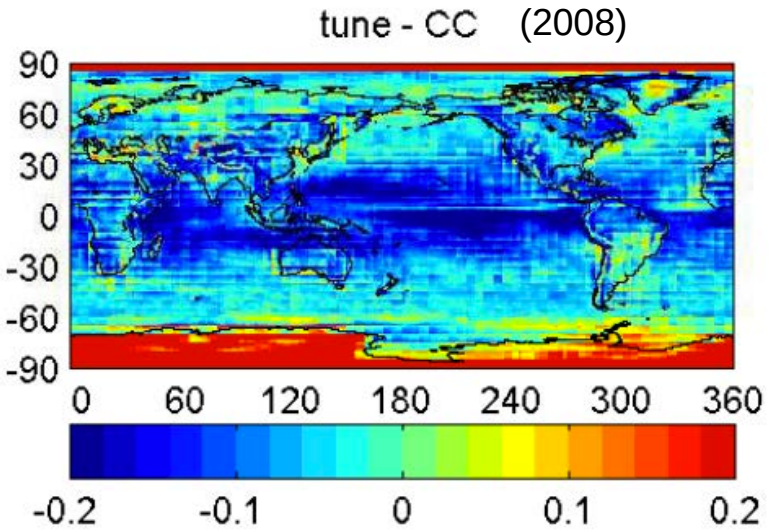
Skin temperature adjustments

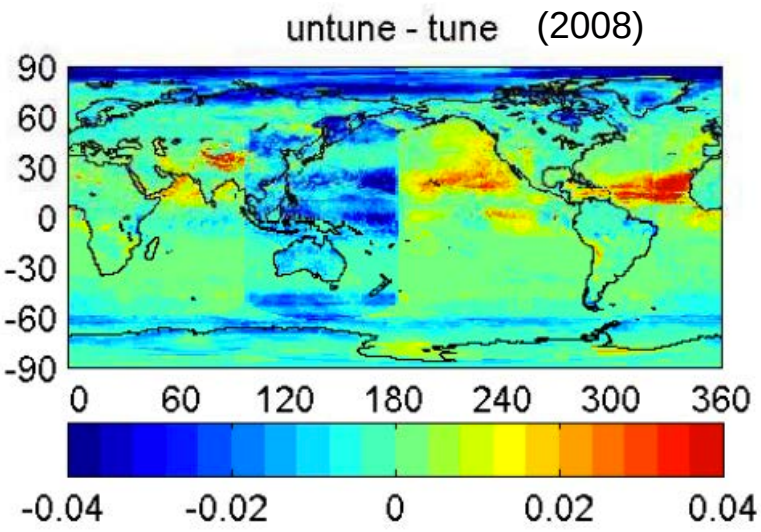
Comparison with AIRS-derived skin temperature



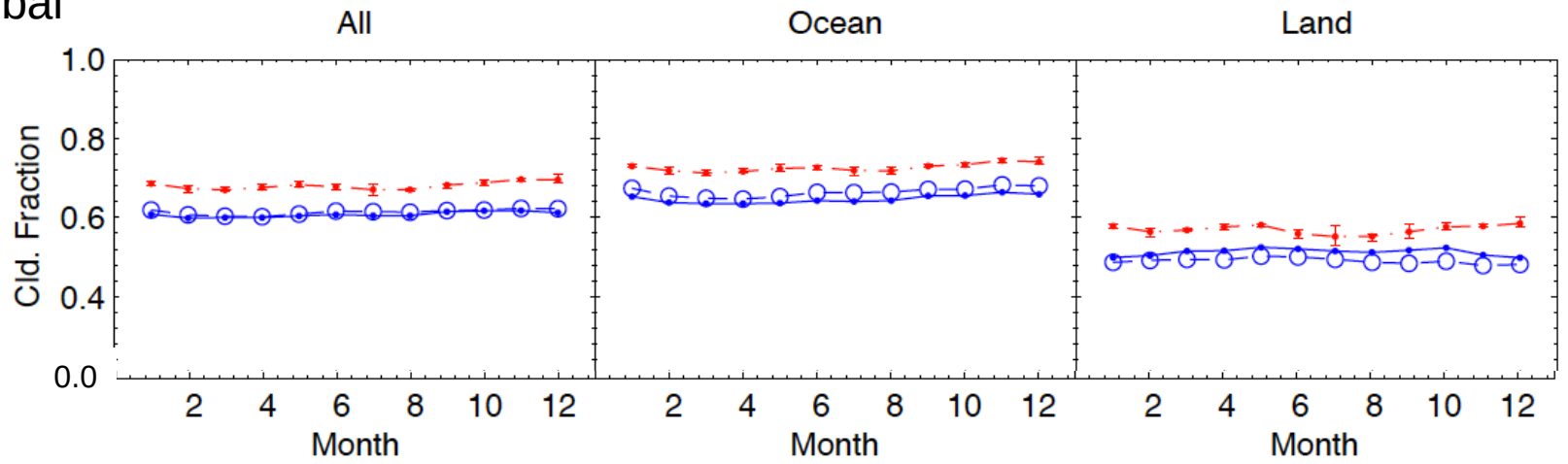
Cloud fraction adjustment

comparison with CALIPSO- CloudSat derived cloud fraction





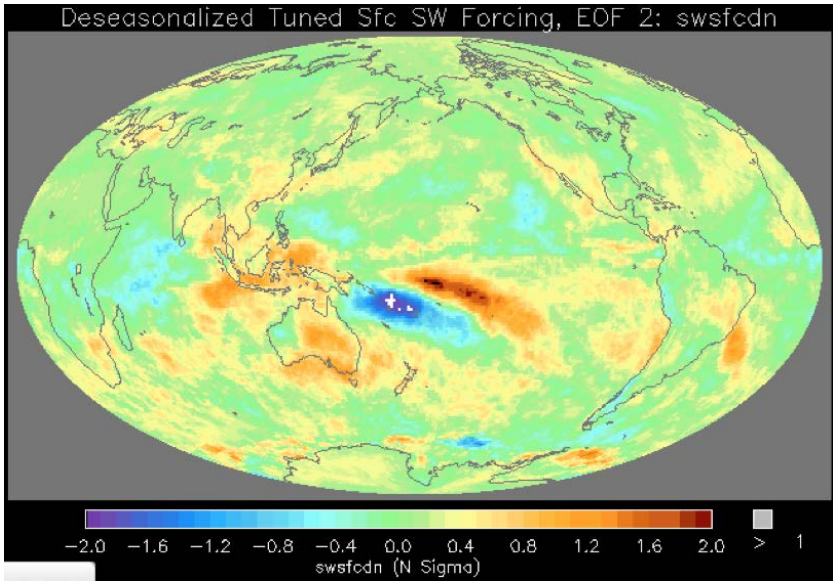
Global



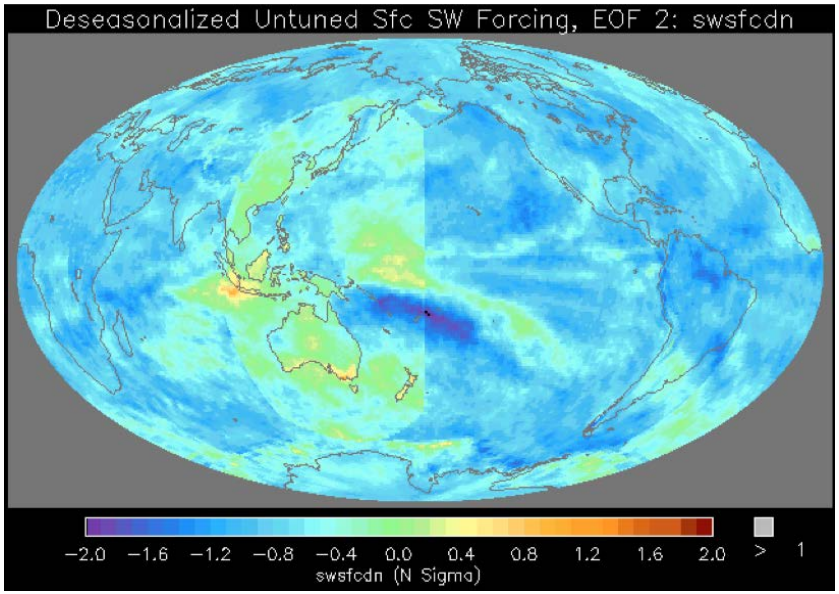
Red: CALIPSO CloudSat Closed-blue: EBAF-Surface Open-blue: SSF1deg_month

EOF analysis

After adjustment



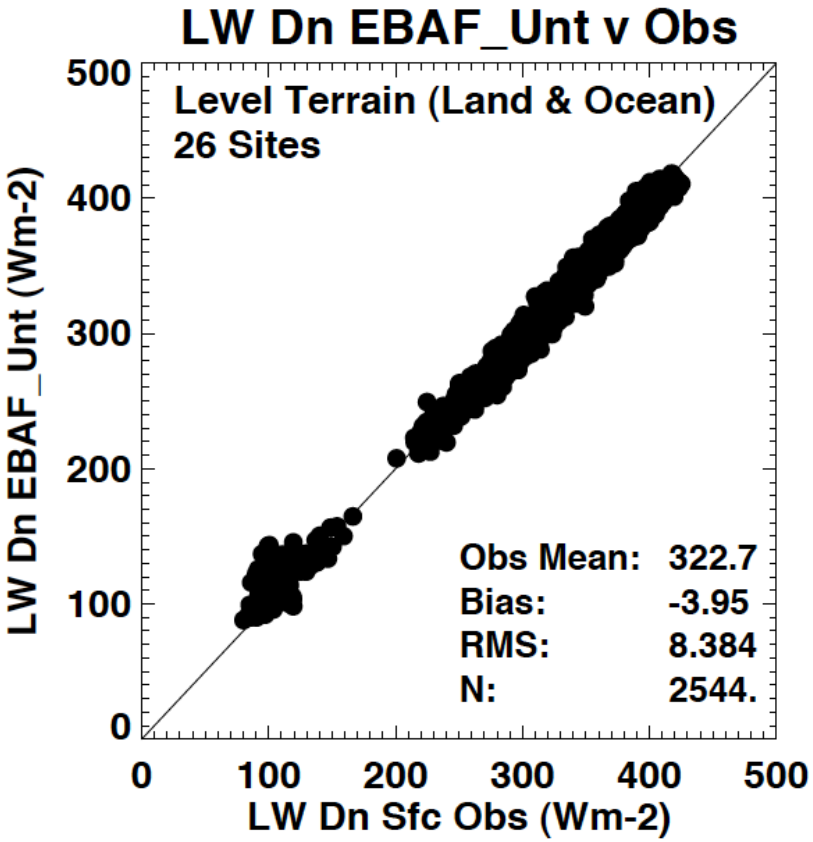
Before adjustment



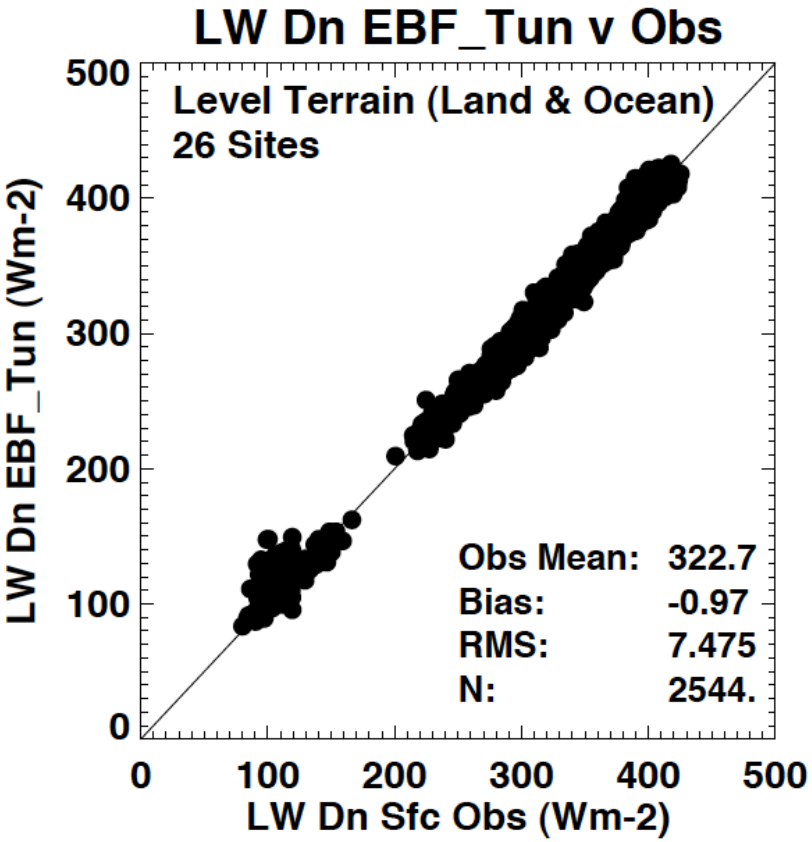
the second principal component computed with deseasonalized surface downward shortwave cloud effect (all-sky minus clear-sky irradiances) before and after adjustment.

Comparison with surface observations (Longwave)

Before adjustments



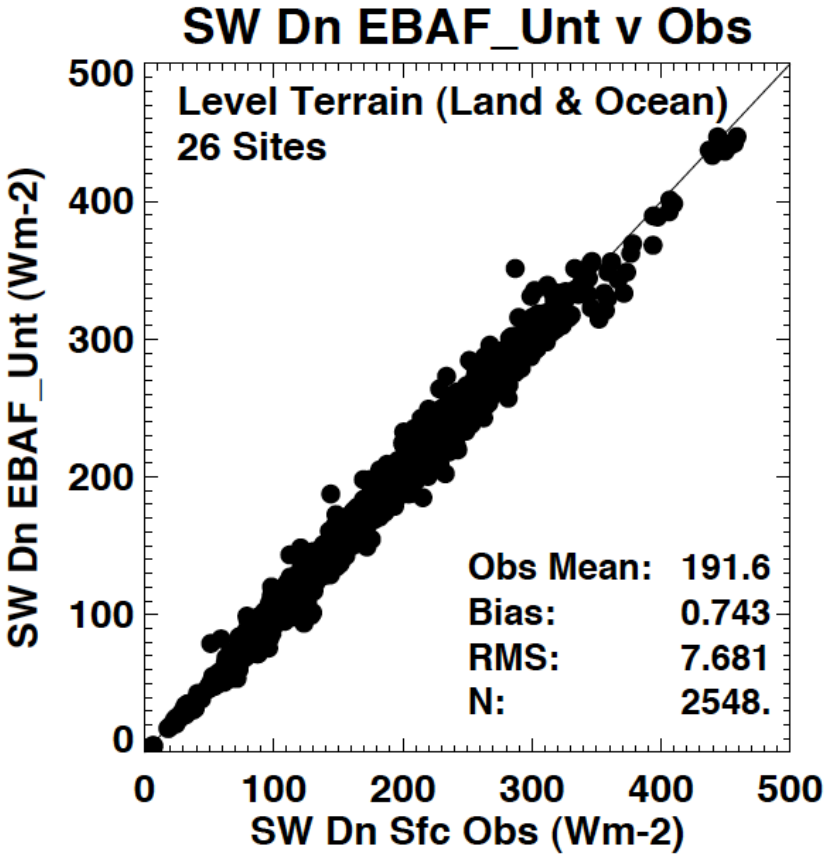
After adjustments



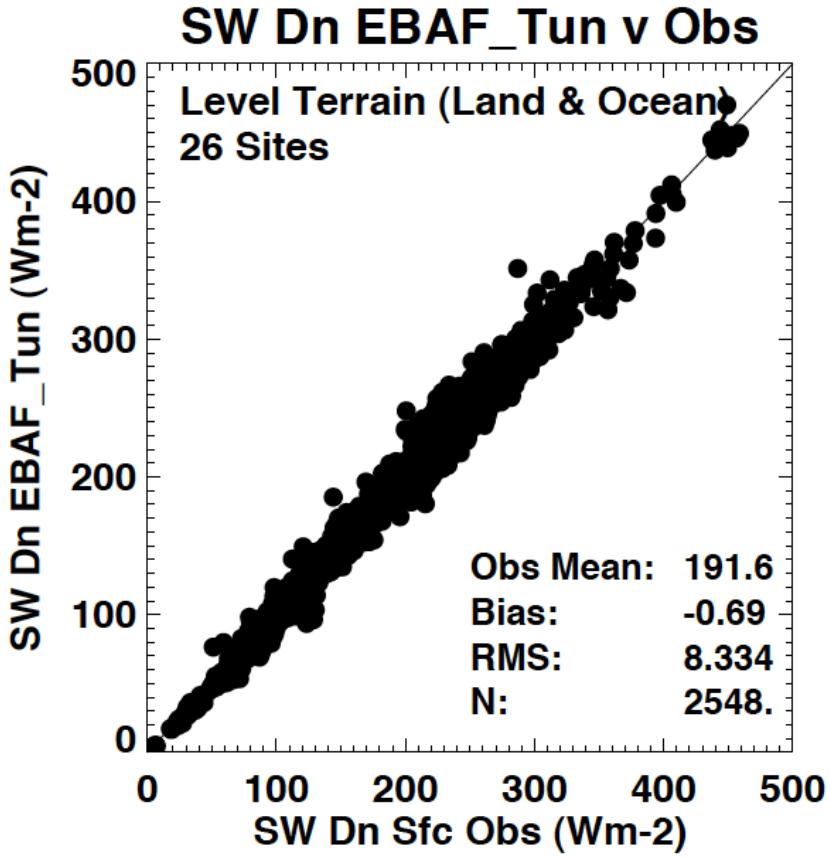
Monthly mean irradiance comparisons

Comparison with surface observations (shortwave)

Before adjustments



After adjustments



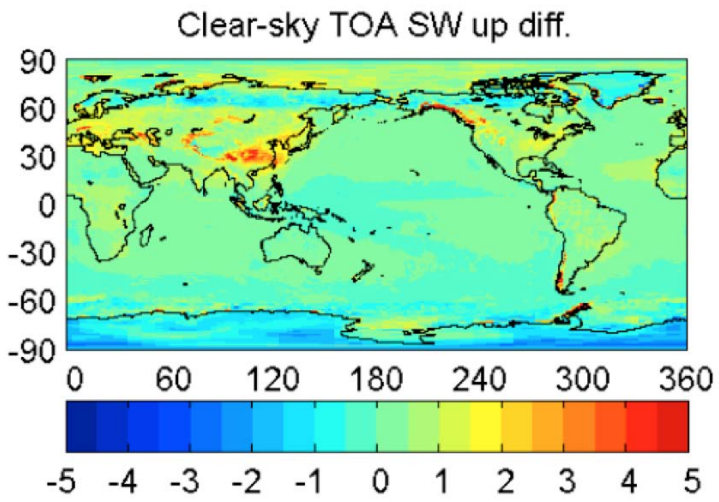
Monthly mean irradiance comparison

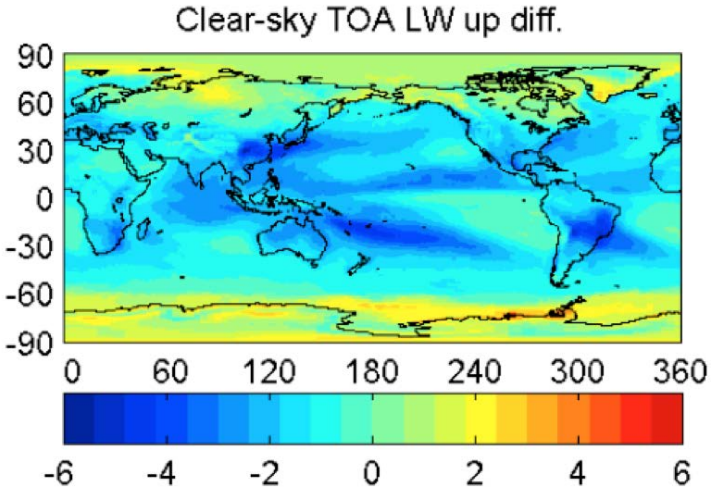
Surface radiation budget

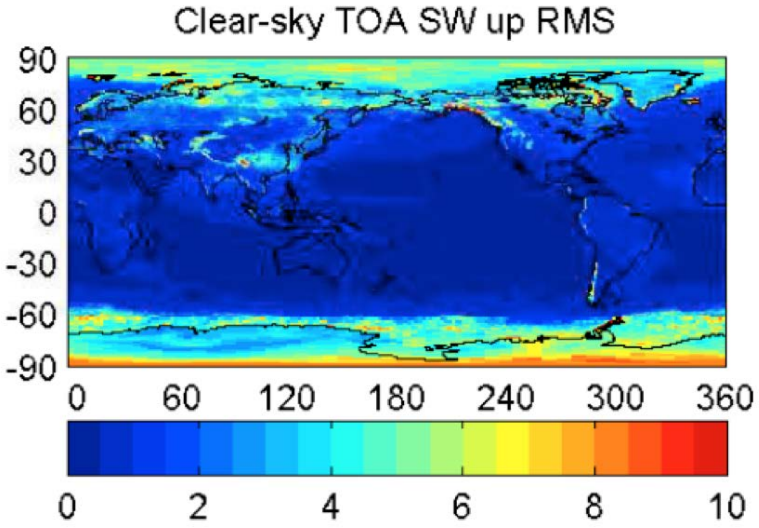
Irradiance component	Ed 2 SYN1deg-Month	Surface EBAF Ed2.6r
LW down (all-sky)	341.8	343.7
LW up (all-sky)	397.6	398.1
SW down (all-sky)	187.2	186.7
SW up (all-sky)	23.3	24.1
Net (all-sky)	108.1	108.3
LW down (clear-sky)	313.5	314.1
LW up (clear-sky)	396.6	398.3
SW down (clear-sky)	242.4	243.4
SW up (clear-sky)	28.7	29.6
Net (clear-sky)	130.6	129.6

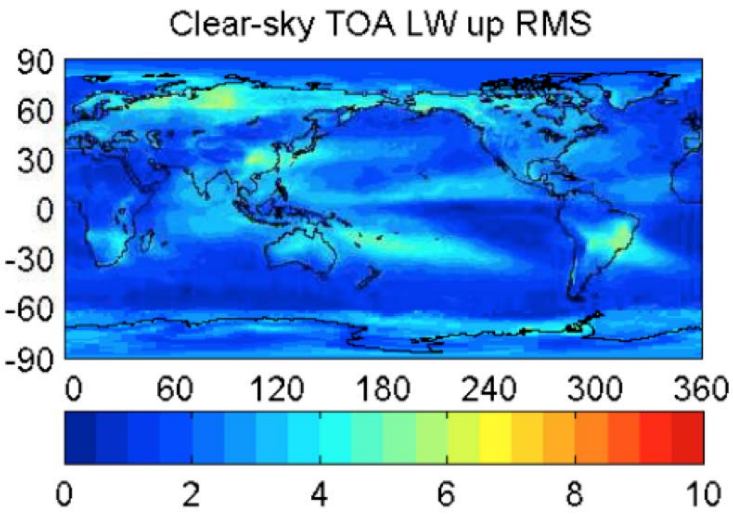
Clear-sky TOA irradiance

Cloud removed – Clear-sky weighted (~obs.)





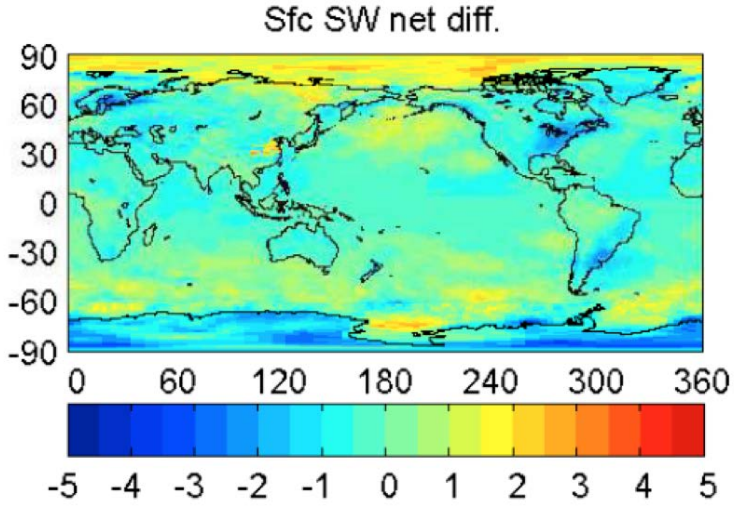


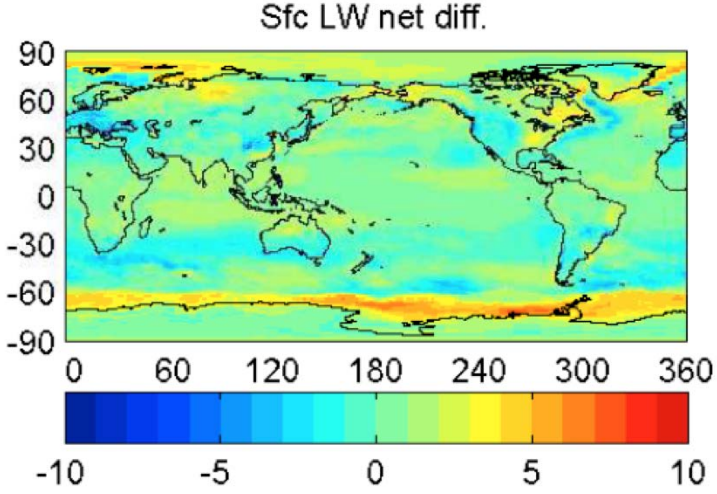


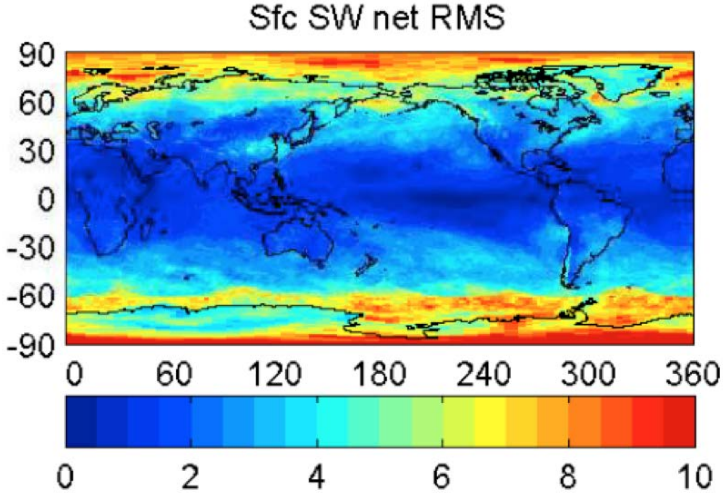
Clear-sky weighted gives dryer atmosphere

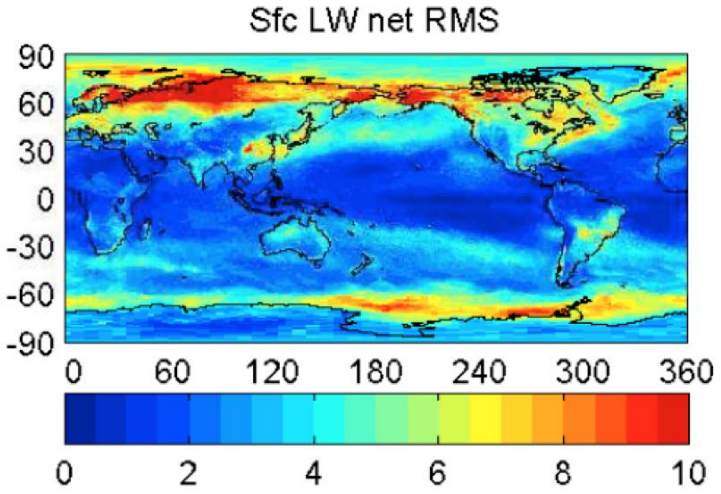
Clear-sky surface irradiances

Cloud removed – Clear-sky weighted (~obs.)







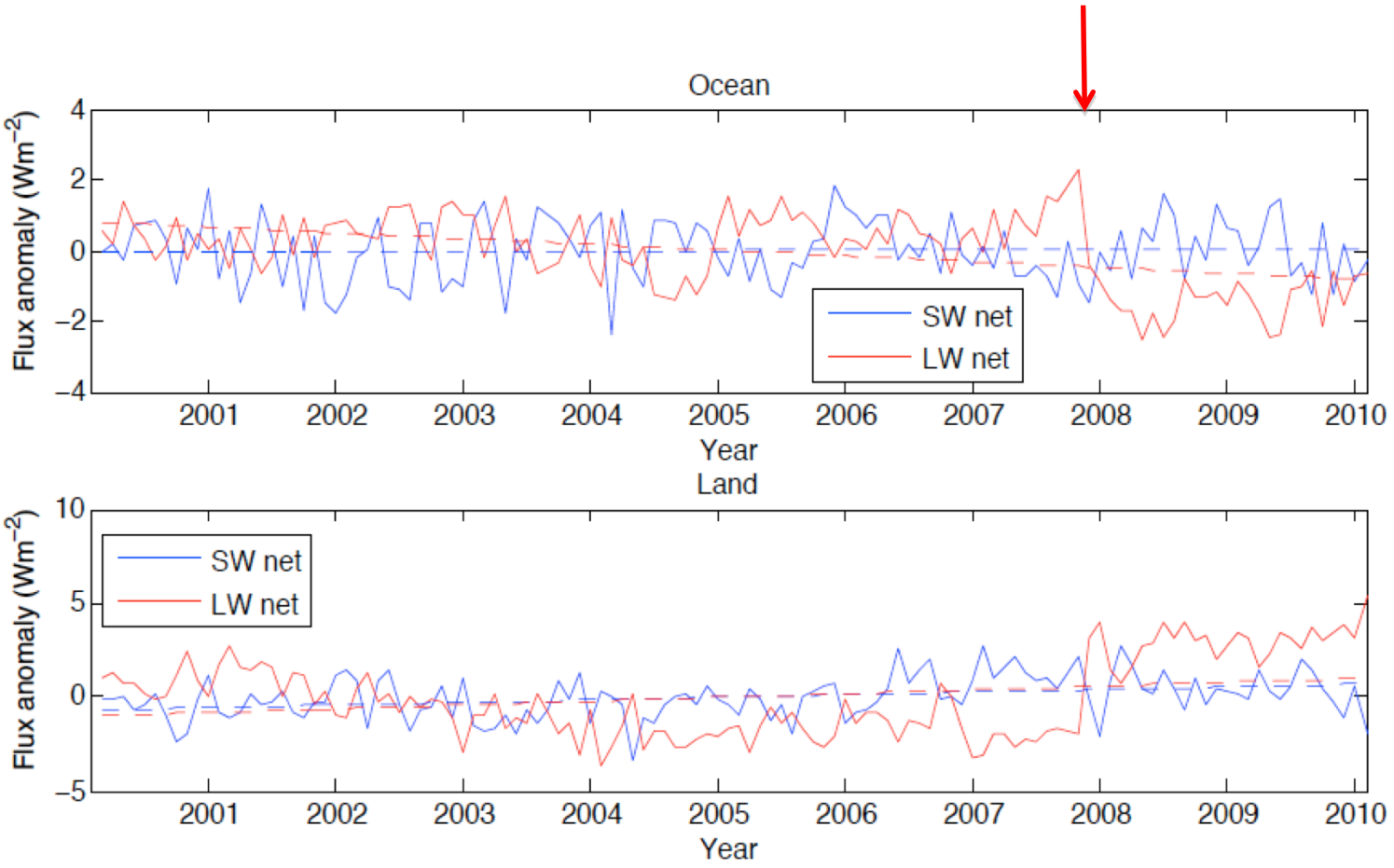


Global mean difference

Cloud removed – Clear-sky weighted

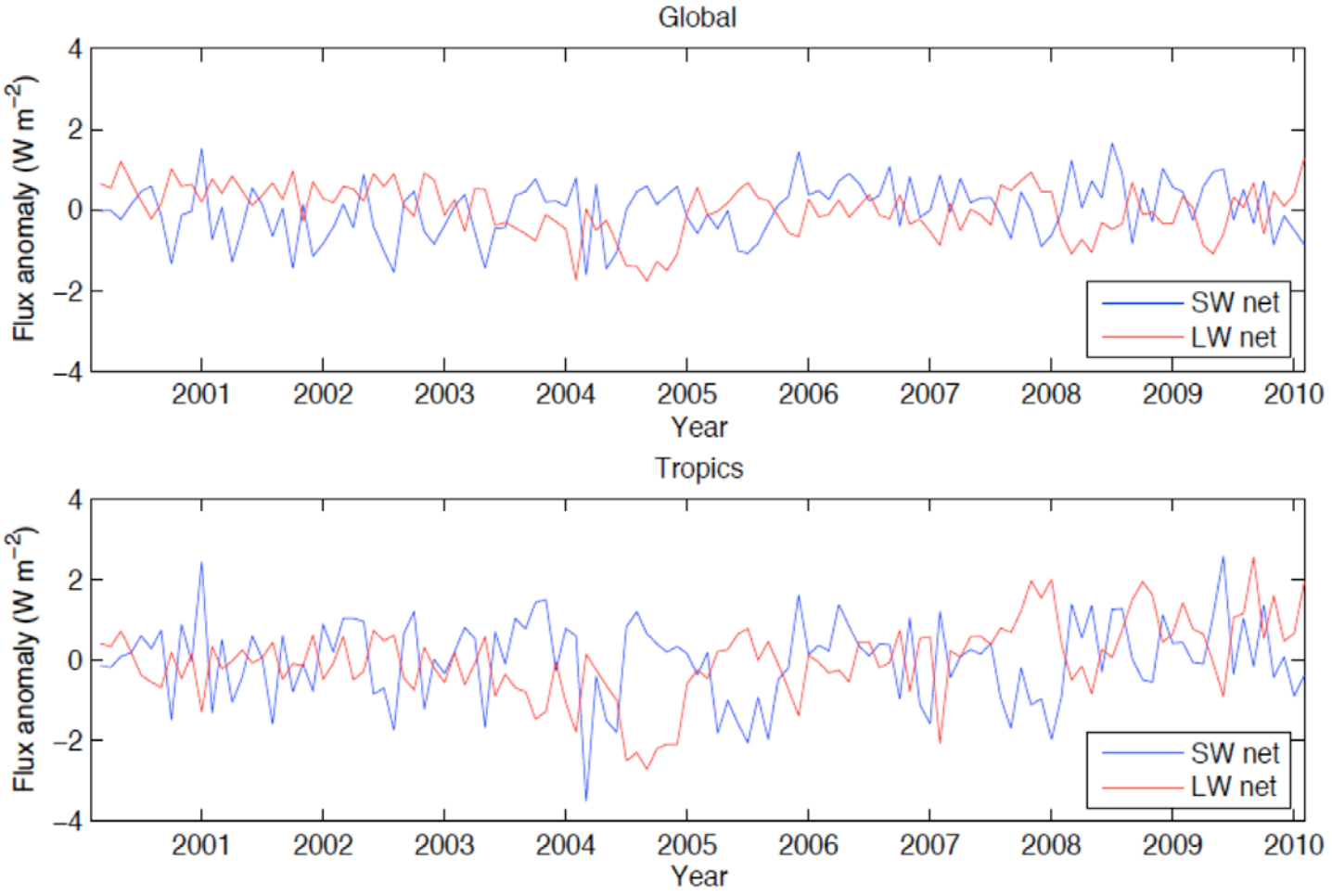
	Monthly			Annual	
	Mean	Std. dev.	RMS	Std. dev.	RMS
TOA SW up(Wm^{-2})	0.24	0.15	0.29	0.03	0.25
TOA LW up (Wm^{-2})	-1.25	0.15	1.26	0.09	1.25
Sfc. SW down (Wm^{-2})	-0.88	0.18	0.90	0.06	0.88
Sfc. SW up (Wm^{-2})	-0.04	0.09	0.10	0.02	0.05
Sfc. LW down (Wm^{-2})	1.63	0.34	1.67	0.07	1.63
Sfc. LW up (Wm^{-2})	0.42	0.33	0.53	0.04	0.42

Surface net Irradiance anomalies



Temperature and relative humidity profiles from GEOS-4 are replaced by GEOS-5 beginning Nov 2007

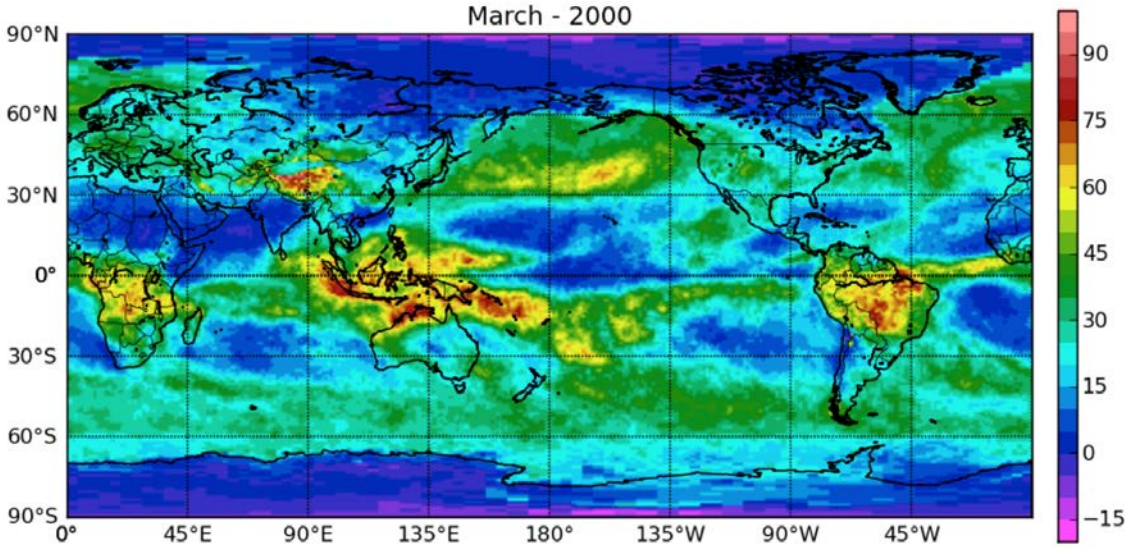
Irradiance anomalies



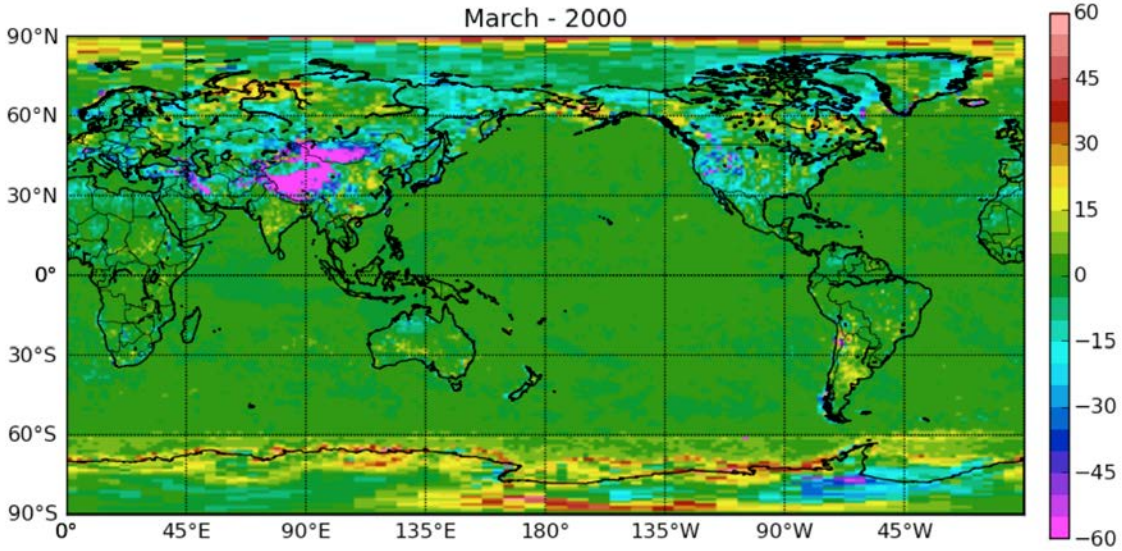
Discontinuity is not obvious in global and tropical anomaly time series

Surface upward longwave
All-sky minus Clear-sky (March 2000)

TOA
(EBAF)

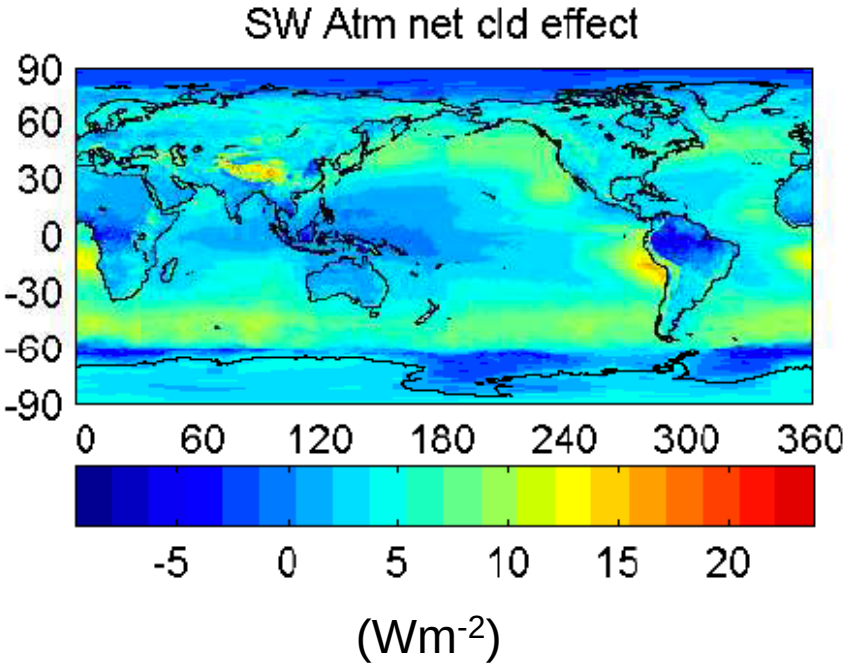


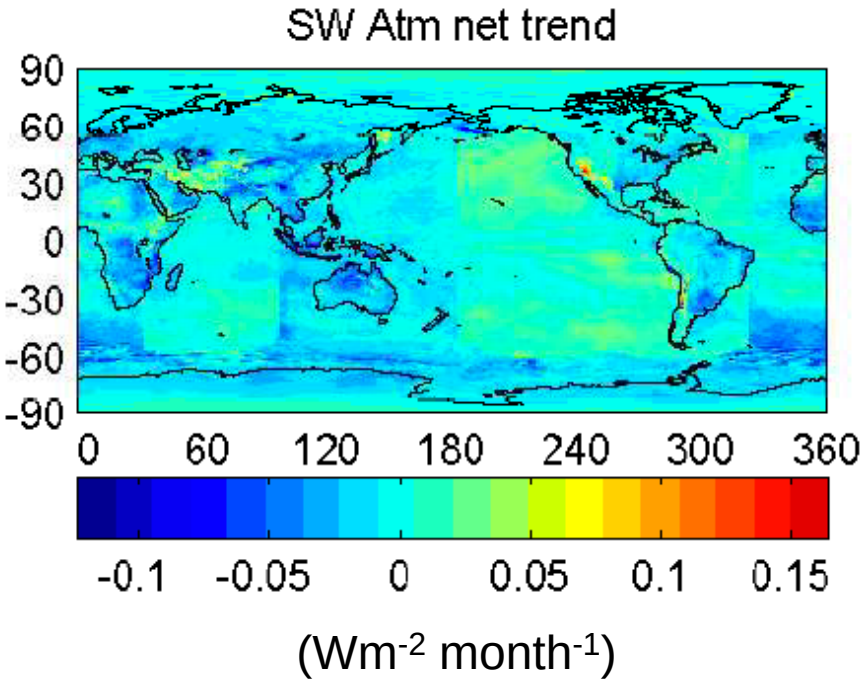
Surface
(EBAF-surface)



- TOA Irradiance
- Sampling
- Signal

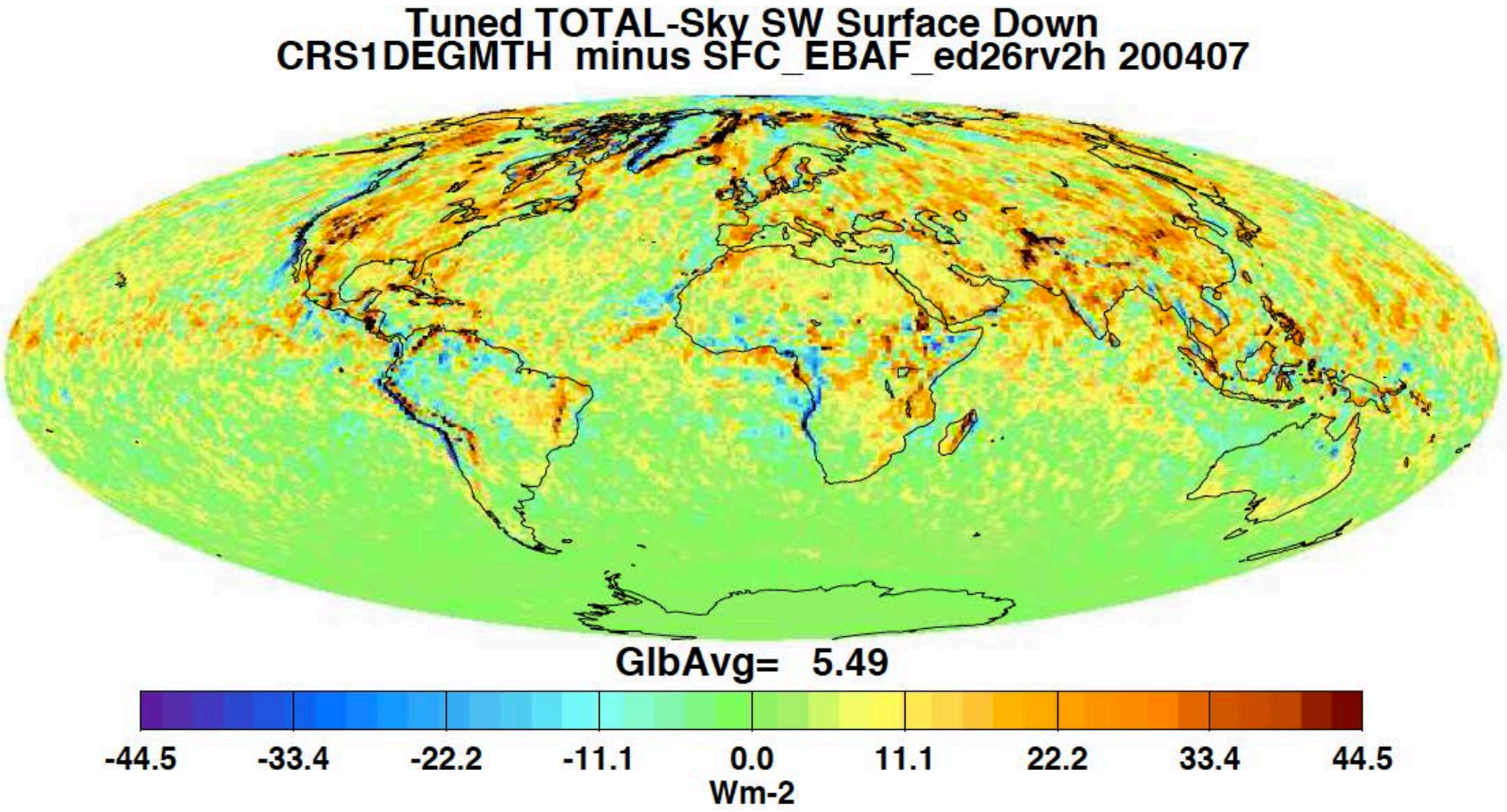
Geo artifacts





Geo artifacts are apparent in plots showing irradiance differences (i.e. net or cloud effects)

CRS1deg-Month



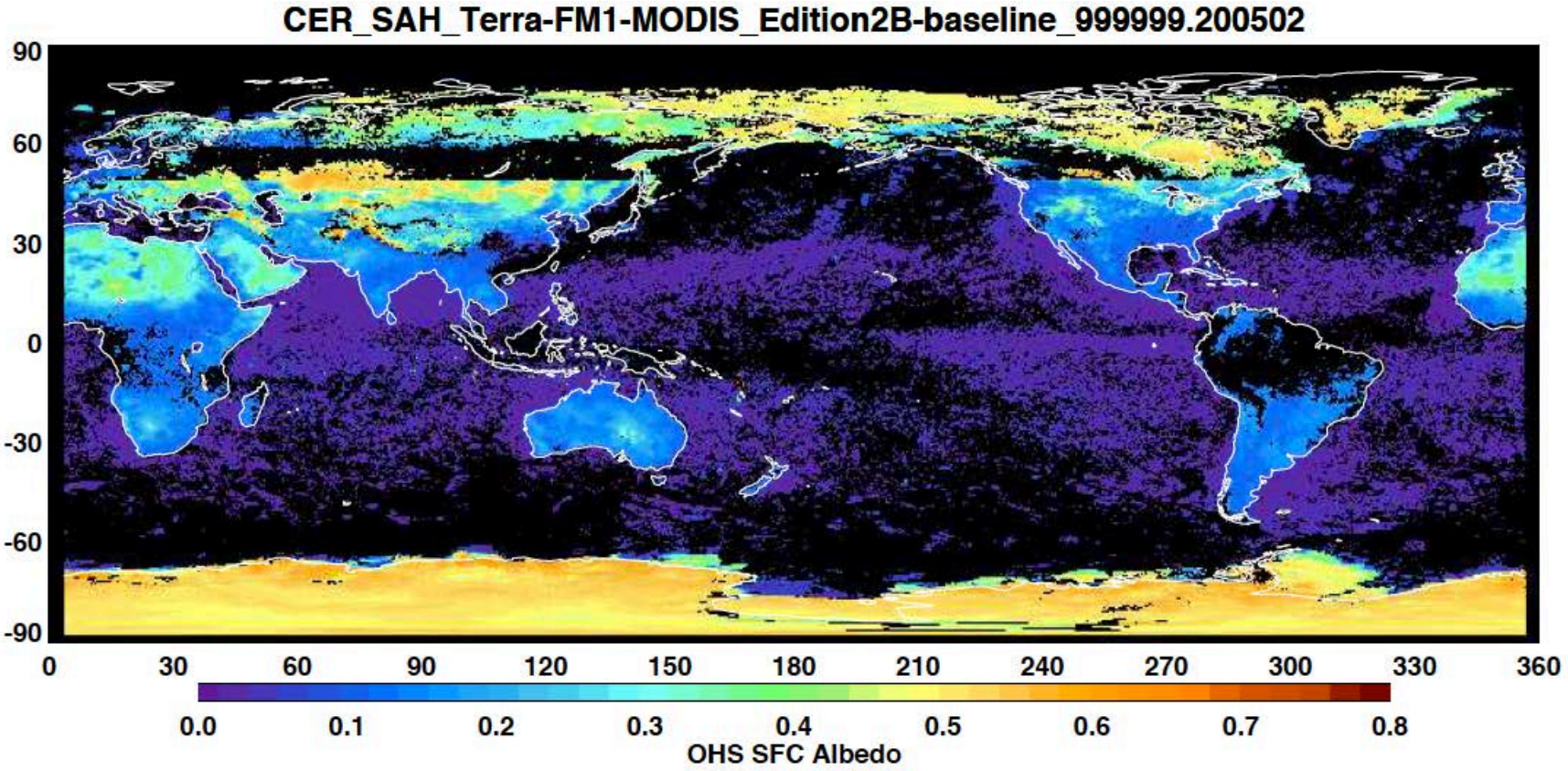
TOA modeled shortwave irradiance is not tuned to match SSF1deg-Month yet

Cryosphere Albedo History Map

Alex Radkevich SARB working group presentation for
a supplementary clear-sky recognition algorithm

Ed2 surface albedo history map

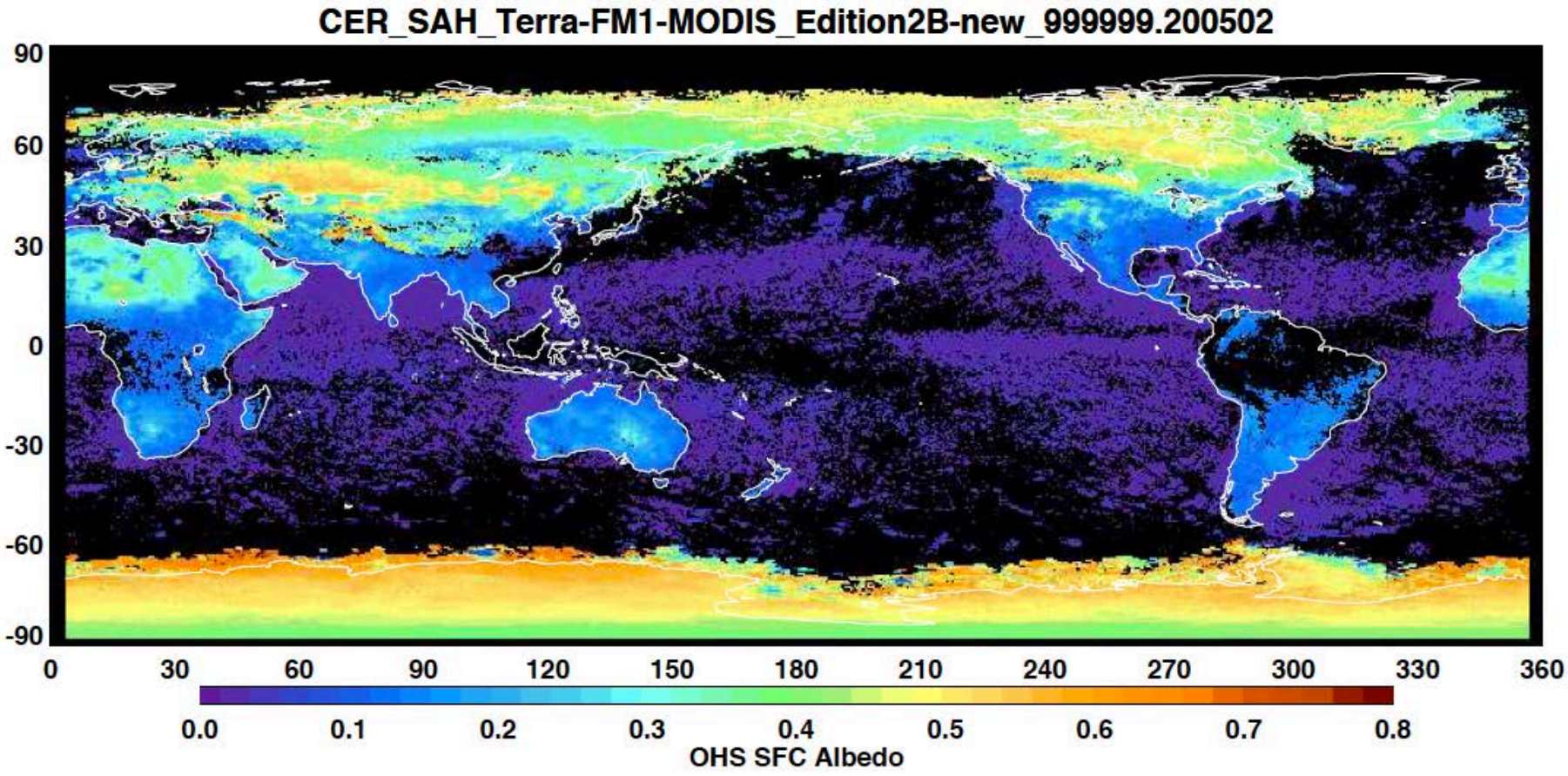
Overhead sun albedo



Not enough sampling in mid-latitude

Ed4 surface albedo history map

Overhead sun albedo

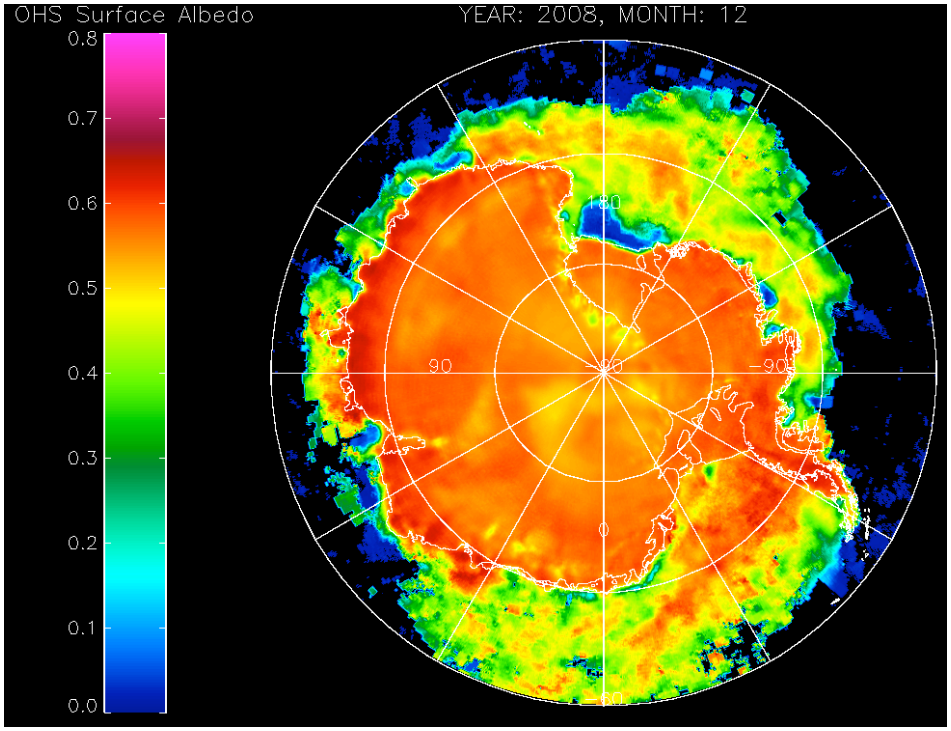


Most regions are filled by observational based surface albedos

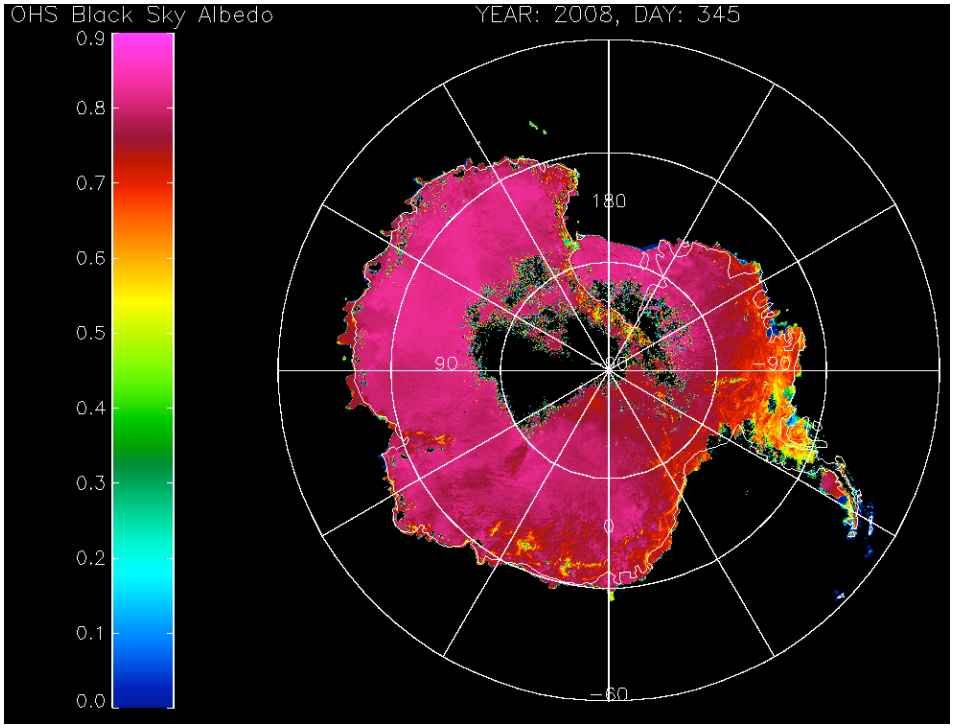
MODIS product vs. Ed4 albedo history map

Overhead sun surface albedo

Ed4 Surface albedo history map



MODIS surface albedo product



Sea ice surface albedo is absent in the MODIS albedo product

Ed4 validation plan

- CAVE: Irradiance observations at surface sites
- Ed4 validation
- Temperature and humidity comparison GEOS5 versus MERRA or ERA-interim
  - 1°×1° monthly standard pressure levels
- Surface temperature and humidity comparison with observations
  - Monthly hourly over surface sites

Publications

- Kato, S., N. G. Loeb, D. A. Rutan, F. G. Rose, S. Sun-Mack, W. F. Miller, and Y. Chen, 2012; Uncertainty estimate of surface irradiances computed with MODIS-, CALIPSO-, and CloudSat-derived cloud and aerosol properties, *Surv. Geophys*., Doi 10.1007/s10712-012-9179-x.
- Loeb, N. G., S. Kato, W. Su, T. Wong, F. G. Rose, D. R. Doelling, J. Norris, 2012; Advances in Understanding Top-of-Atmosphere Radiation Variability from Satellite Observations, *Surv. Geophys*.
- Rose, F., D. A. Rutan, T. P. Charlock, G. L. Smith, and S. Kato, 2012; An algorithm for the constraining of radiative transfer calculations to CERES observed broadband top of atmosphere irradiance, submitted to *J. Ocean. Atmos. Technol.*
- Clear-sky snow/sea ice identification algorithm description, in preparation
- EBAF-surface algorithm description, in preparation
- SYN1deg-Month algorithm description, in preparation

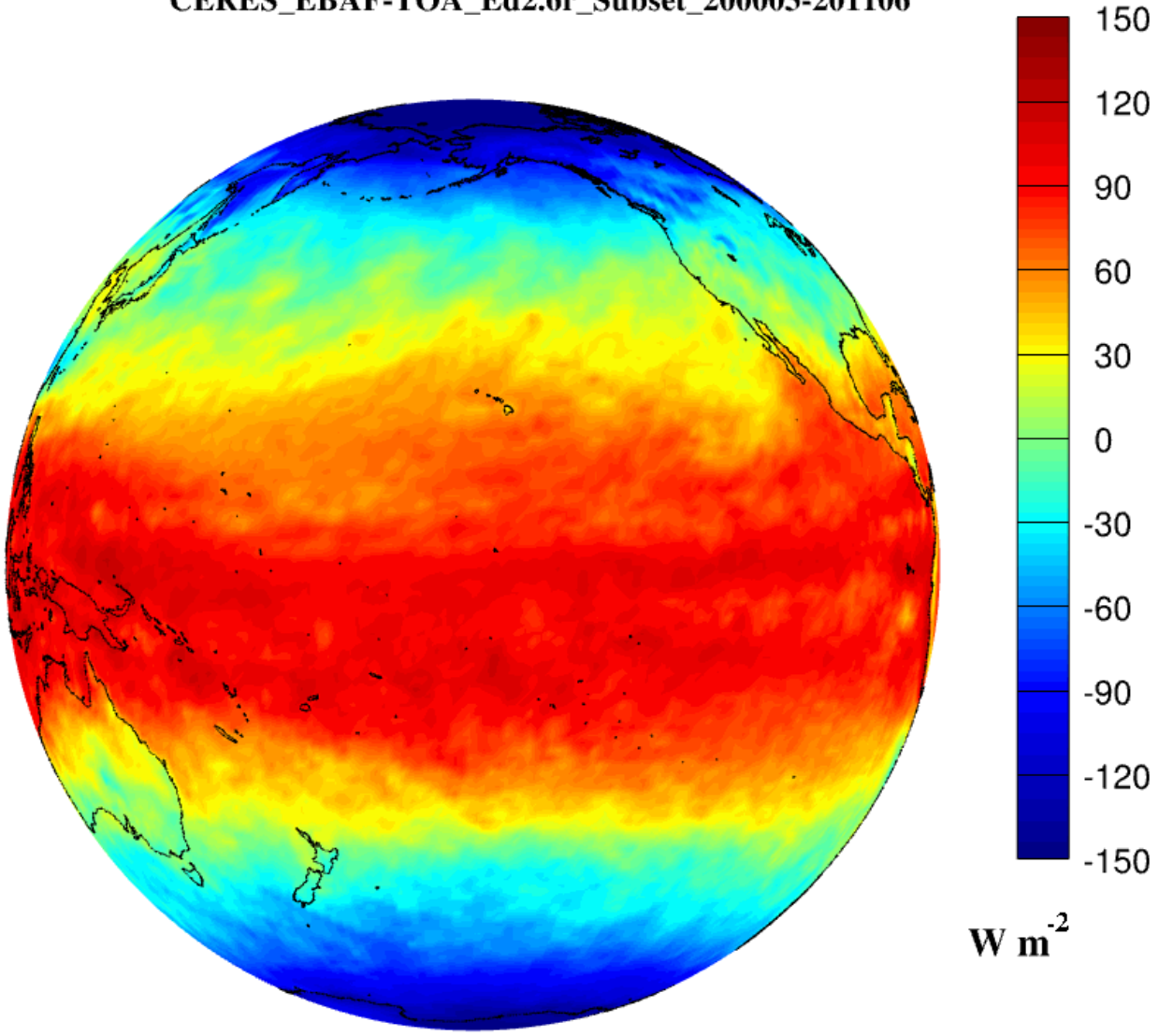
Summary of SARB update

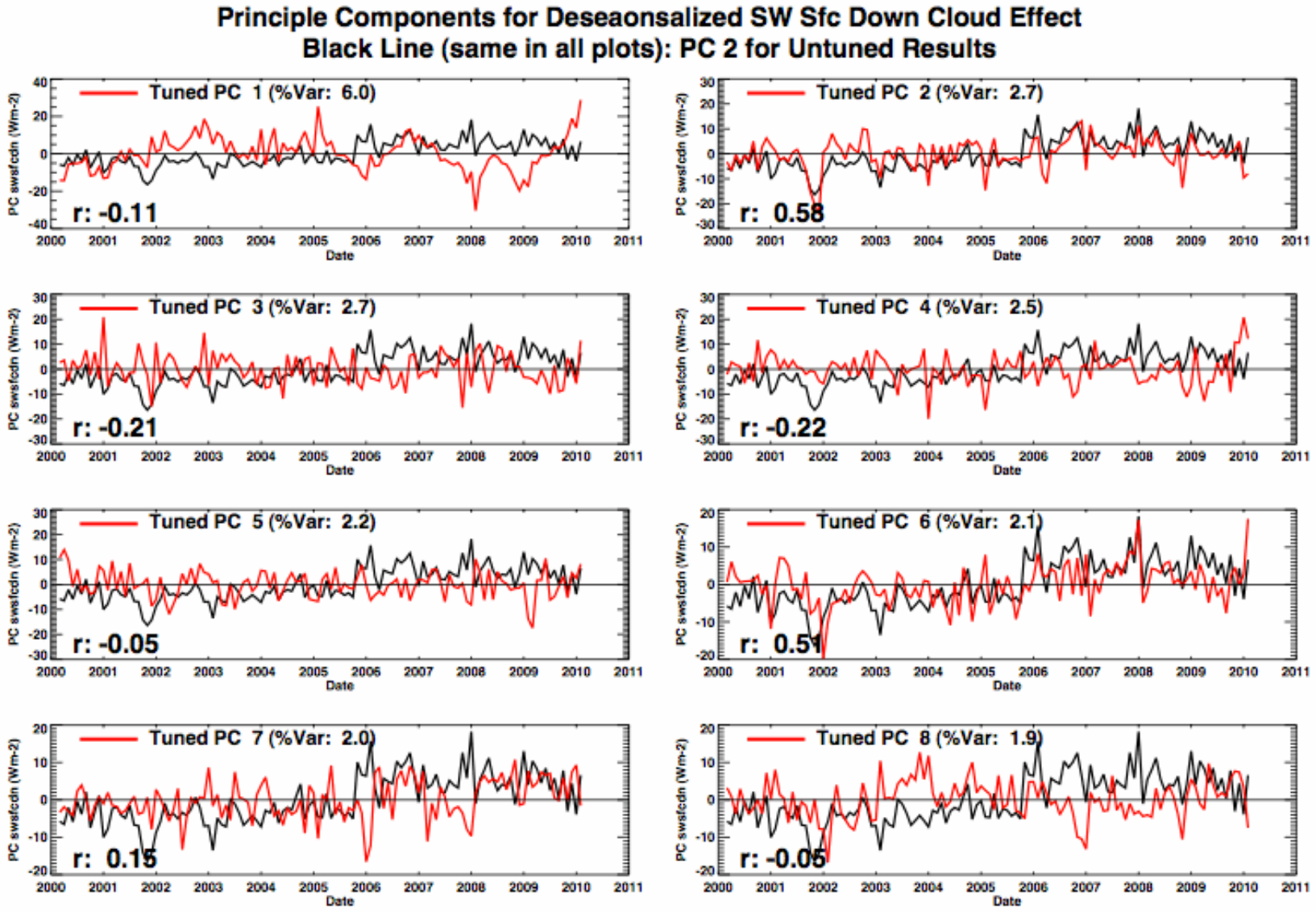
- EBAF-surface product (Ed2.6r from March 2000 through Feb. 2010) is available
- CRS1deg-Month is in progress
- Ed4 surface albedo history map algorithm has been developed
- Analysis tool of contributions of cloud and atmospheric property variability to TOA and surface irradiance anomalies has been developed
- Ed4 validation of including temperature and humidity comparisons is in progress
- MATCH aerosol transport model validation is in progress (SBIR phase 3)

TOA Net Flux, Month 1

Year 2000, March, Global Mean = 6.9 Wm^{-2}

CERES_EBAF-TOA_Ed2.6r_Subset_200003-201106



Back-ups

EOF analysis