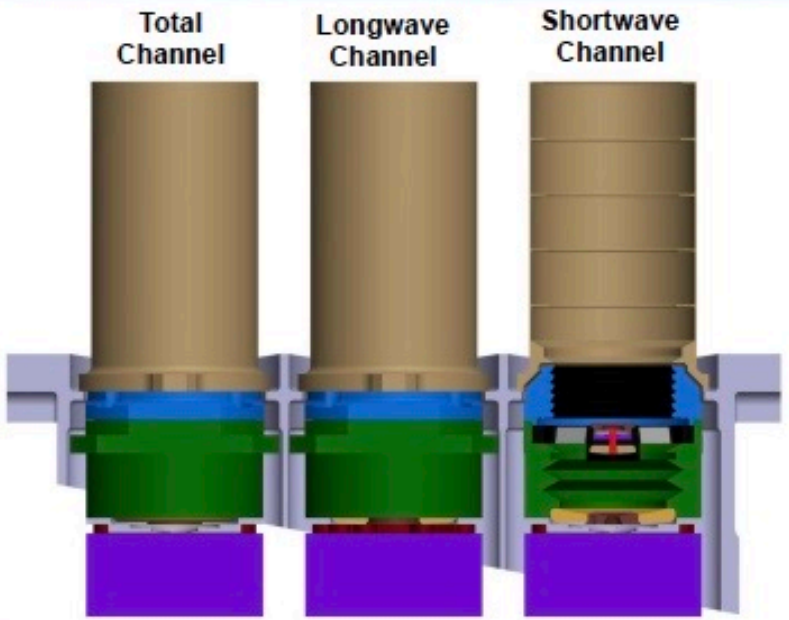
DCC stability analysis of CERES-SW broadband fluxes

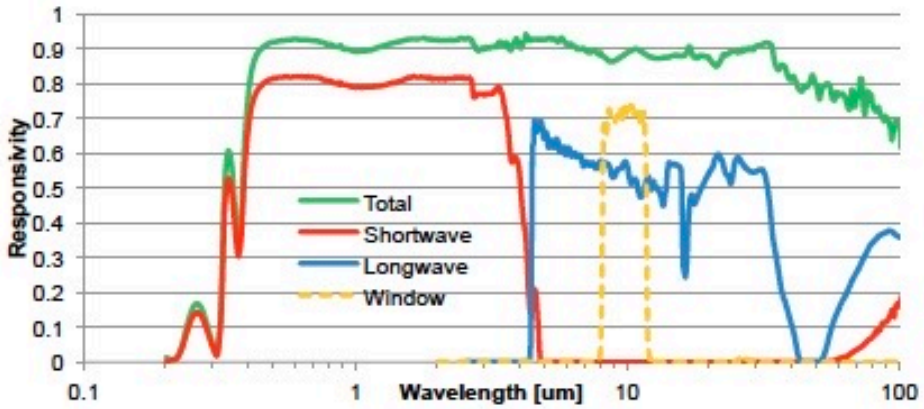
Mohan Shanker, Natividad Smith, Dave Doelling

GSICS VIS/NIR February 10, 2022, monthly web meeting

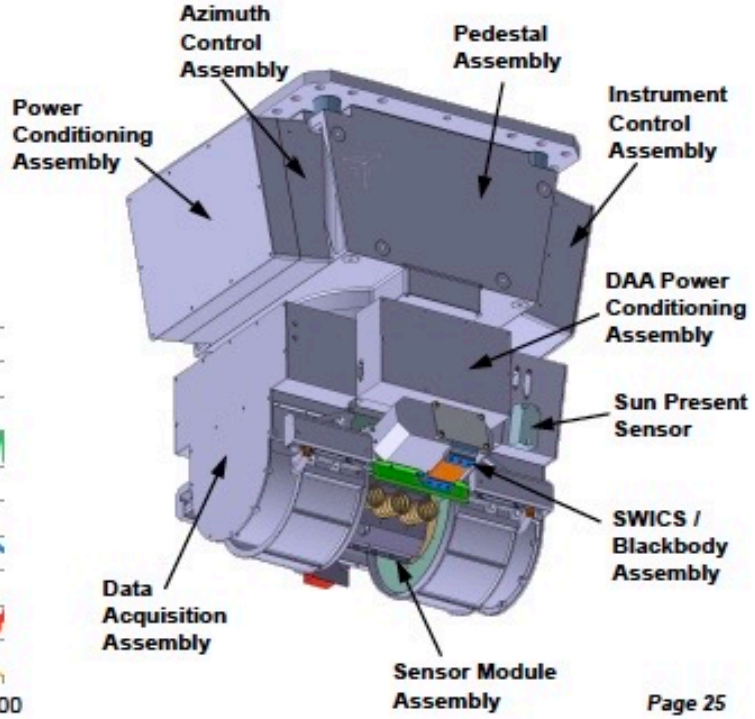
CERES Sensor Module Assembly

Clouds and the Earth's Radiant Energy System





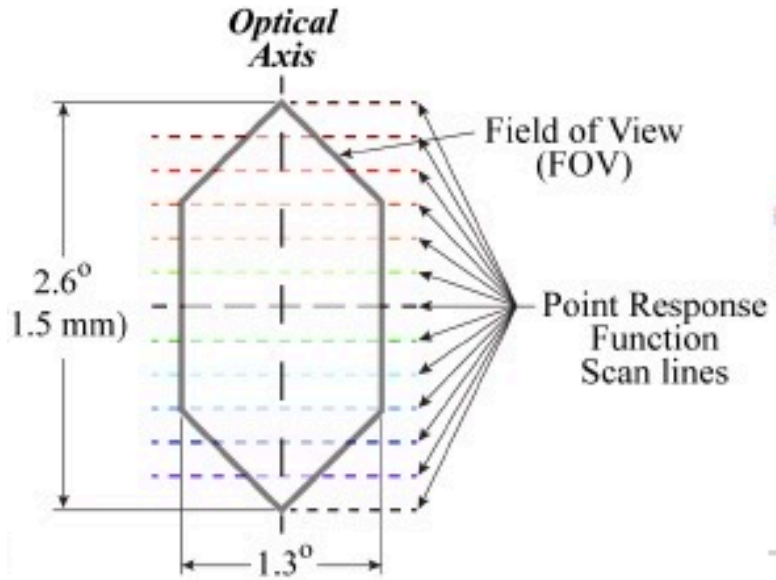
- **Three sensor assemblies**
  - Two-element reflective telescope
  - Stray light baffle
  - Pair of thermistor bolometer flakes (not a photon counting sensor)
- **Sensors are ~1 in. Diameter ~2.5cm**
- **Responsive from 0.3 µm to >100 µm**

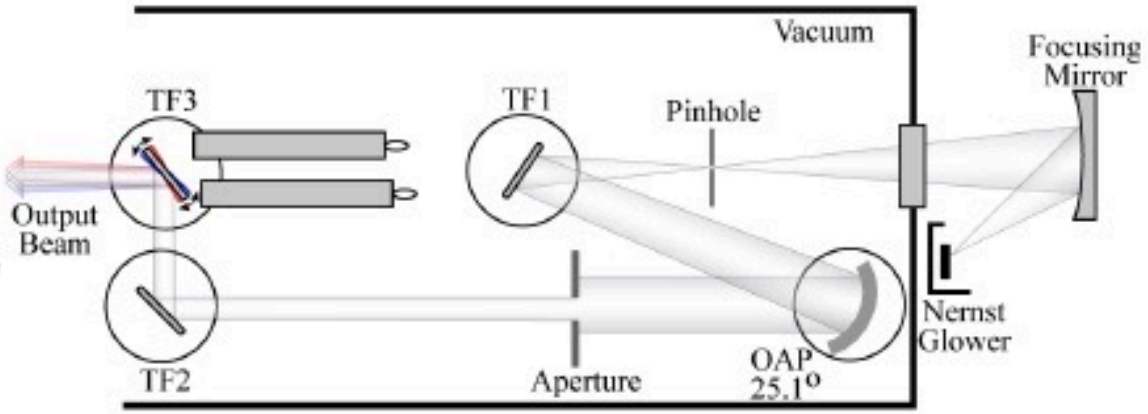


The spectral response must be "unfiltered" to be uniform across the SW broadband spectra, 0.3µm<SW<5µm

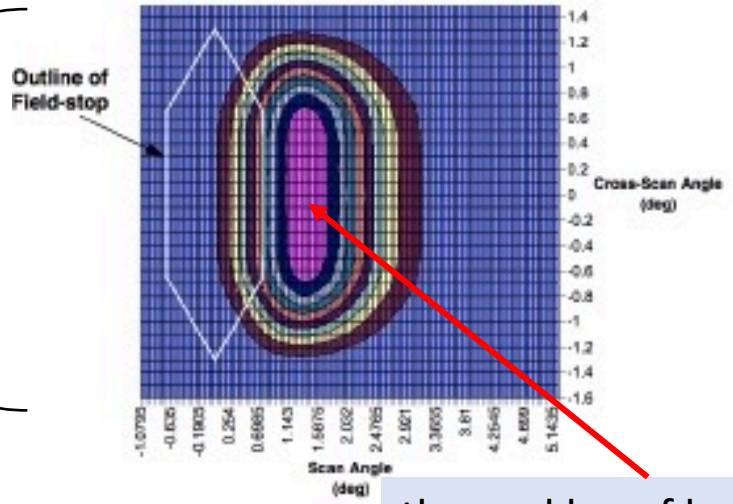
Point Response Function Source

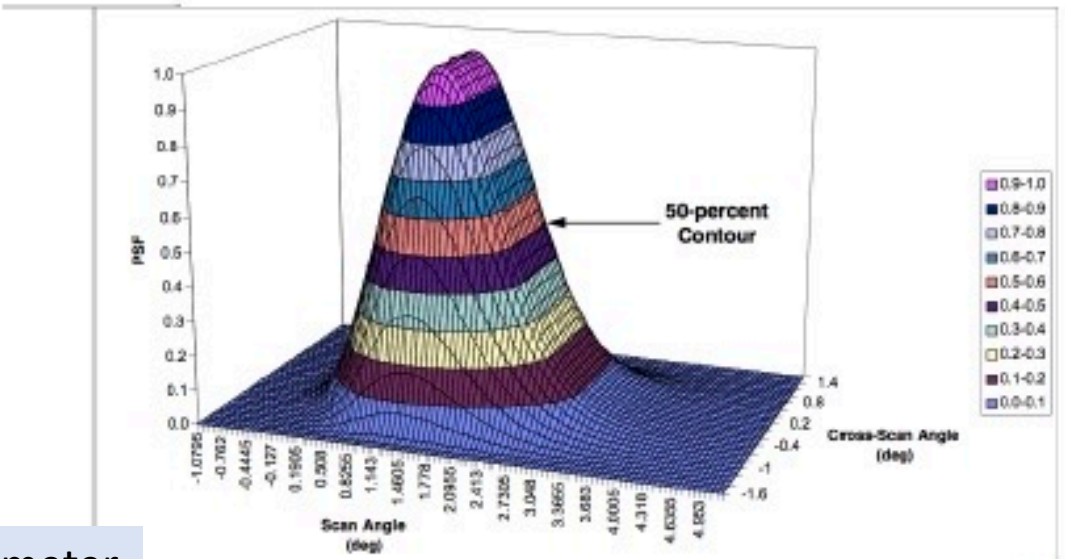
Clouds and the Earth's Radiant Energy System





20-km Aqua/Terra



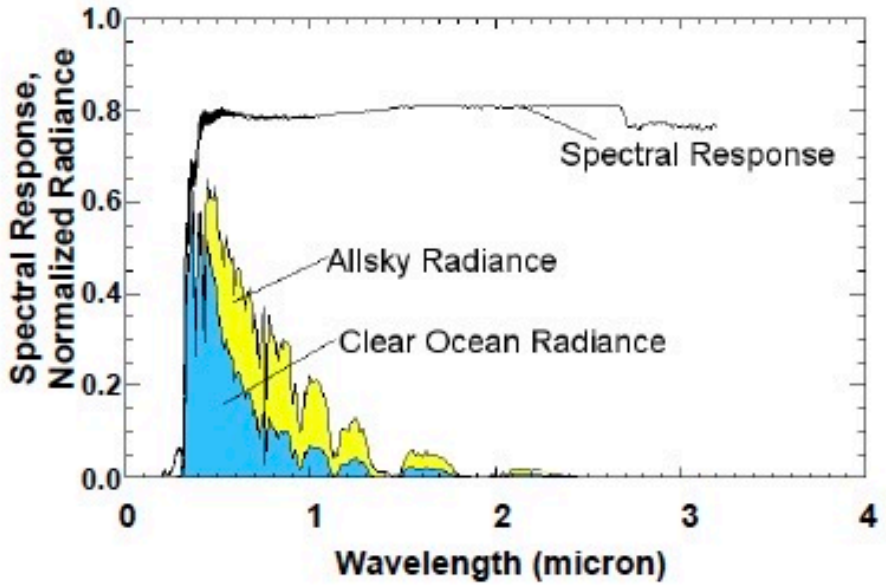


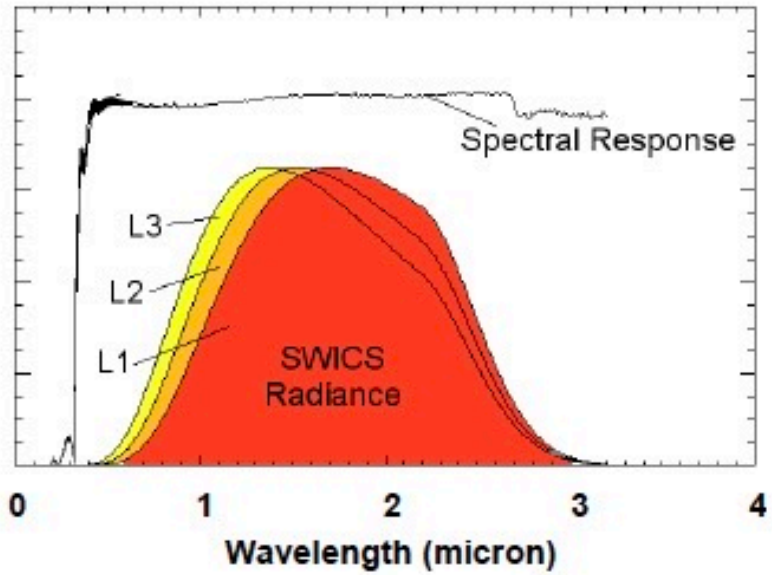
thermal lag of bolometer

Spectral Coverage of Cal Sources

Clouds and the Earth's Radiant Energy System

Make certain the spectral content of your cal sources adequately represent the content of your science targets….





$$f^{sw}_{allsky} \text{ change} \approx -2\%$$

$$f^{sw}_{swics} \text{ change} \approx -0.1\%$$

spectral darkening of the optics for SW wavelengths
Use clear-sky ocean to correct

The Lamp is the primary calibration source
the Mirror Attenuator Mosaic (MAM) solar diffuser did not work to specifications

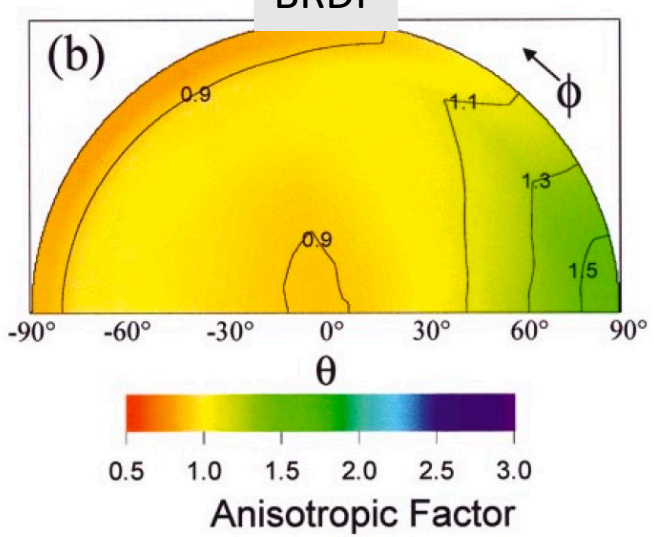
CERES Flight Radiometric Validation Activities

Clouds and the Earth's Radiant Energy System

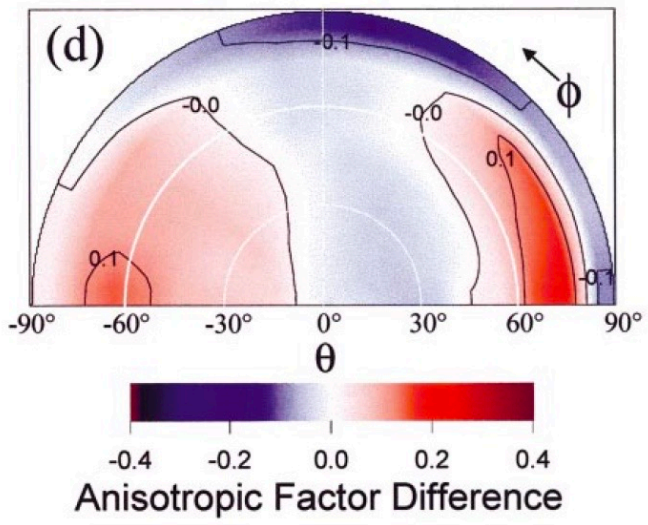
		Product	Spatial Scale	Temporal Scale	Metric	Spectral Band
On-Board	Internal BB	Filtered Radiance	N/A	N/A	Absolute Stability	TOT, WN
	Internal Lamp	Filtered Radiance	N/A	N/A	Absolute Stability	SW
	Solar	Filtered Radiance	N/A	N/A	Relative Stability	TOT, SW
Vicarious	Theoretical Line-by-Line	Filtered Radiance	> 20 Km	Instantaneous	Inter-Channel Theoretical Agreement	TOT, WN
	Unfiltering Algorithm Theoretical Validation	N/A	N/A	N/A	N/A	TOT, SW, WN
	Inter-satellite (Direct Comparison)	Unfiltered Radiance	1-deg Grid	1 per crossing	Inter-Instrument Agreement, Stability	TOT, SW, WN
	Globally Matched Pixels (Direct Comparison)	Unfiltered Radiance	Pixel to Pixel	Daily	Inter-Instrument Agreement	TOT, SW, WN
	Tropical Mean (Geographical Average)	Unfiltered Radiance	20N – 20S	Monthly	Inter-Channel Agreement, Stability	TOT, WN
	DCC Albedo	Unfiltered Radiance	>40 Km	Monthly	Inter-Instrument agreement, Stability	SW
	DCC 3-channel	Unfiltered Radiance	>100 Km	Monthly	Inter-Channel consistency, stability	TOT, SW
	TIme Space Averaging	Fluxes	Global	Monthly	Inter-Instrument Agreement	LW, SW
	Lunar Radiance Measurements	Filtered Radiance	Sub Pixel	Quarterly	Inter-Instrument Agreement	LW, SW, WN

CERES BB angular directional models (BRDF)

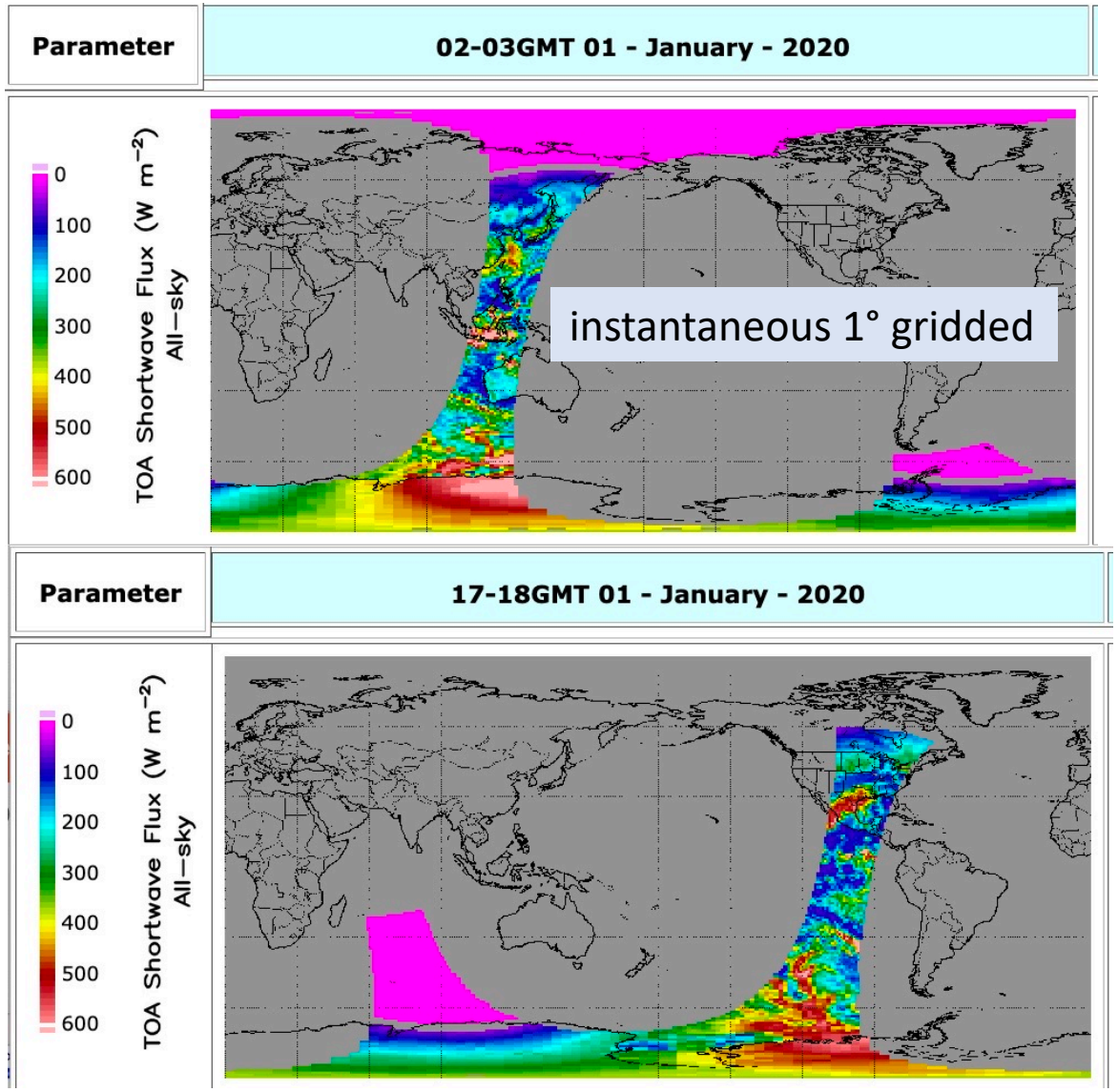
BRDF



ice cloud, 20<COD<25

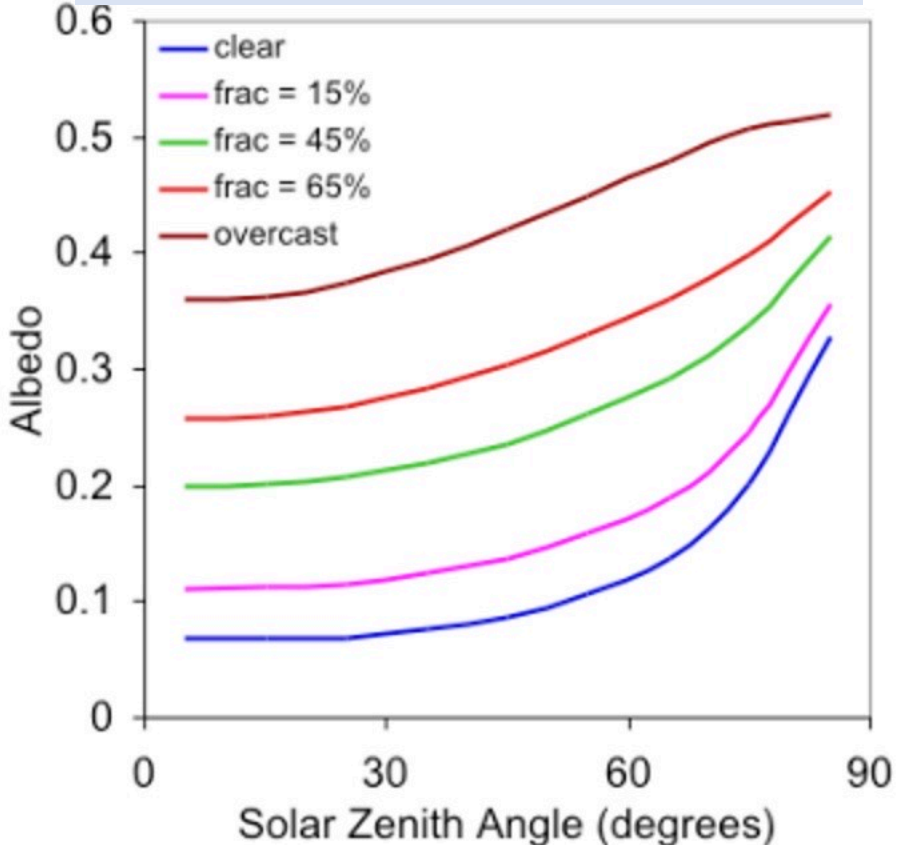


difference between ice and water cloud

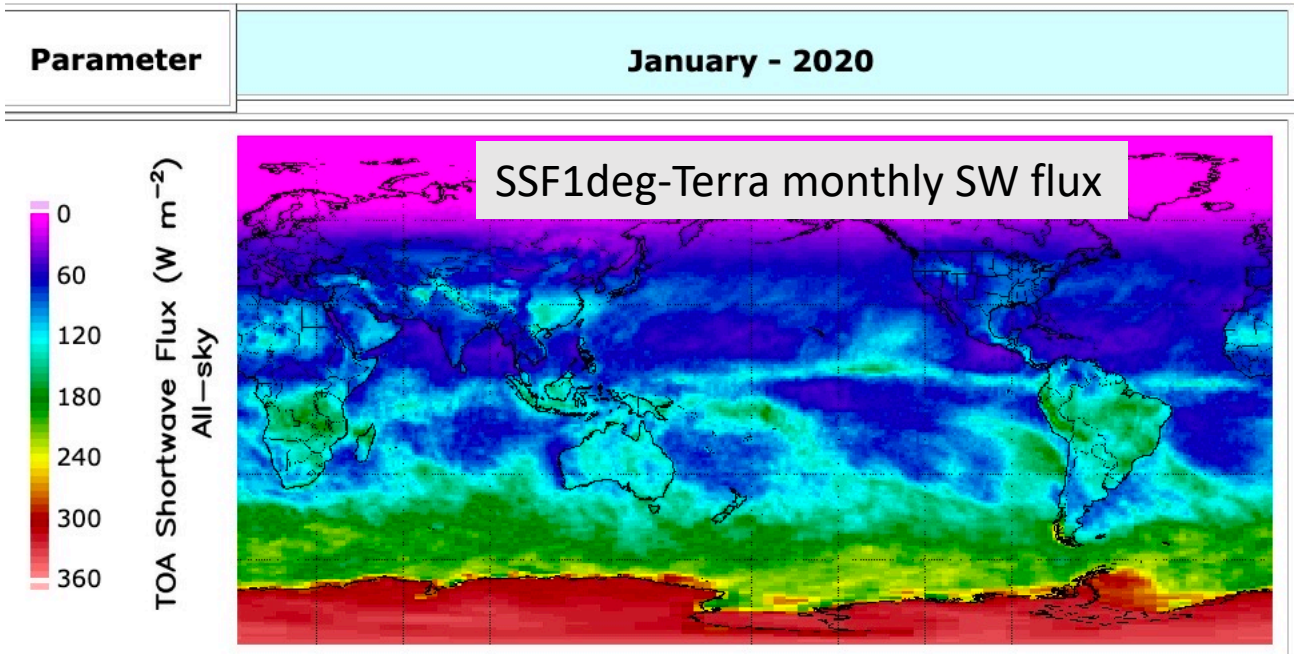


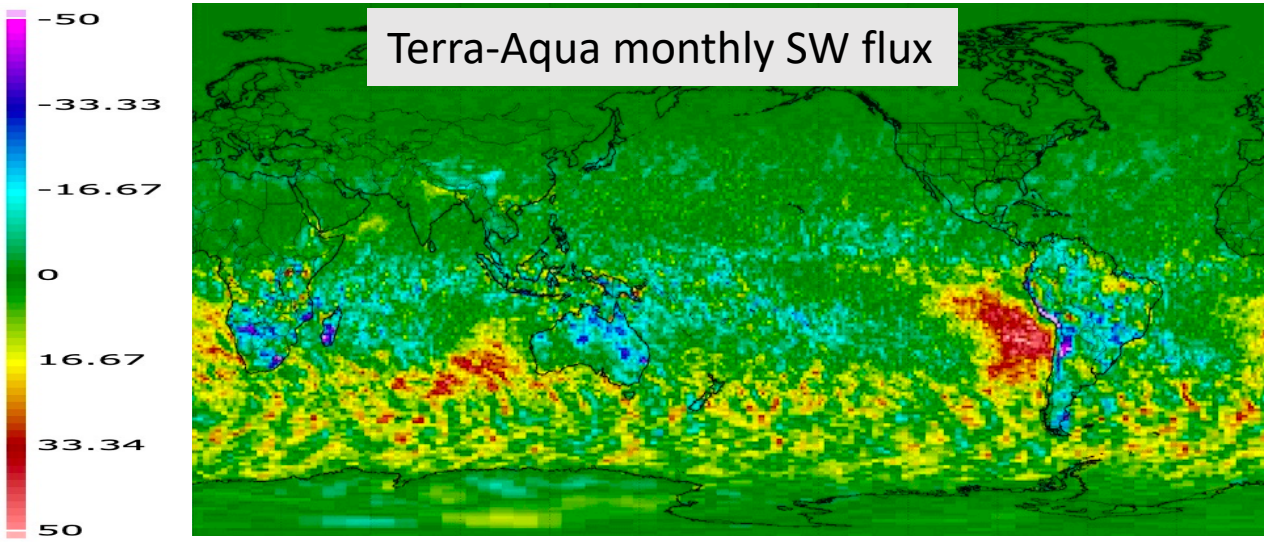
CERES time and space averaging

cloud optical depth = 11, ice cloud, by cloud fraction diurnal SW models applied to the instantaneous regionally averaged SW flux to compute the daily SW flux



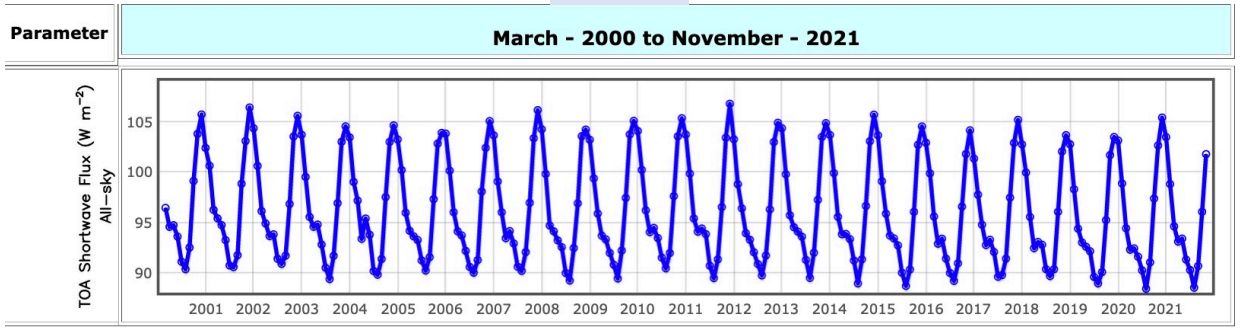
Monthly averaged regional SW fluxes needed to compute global mean



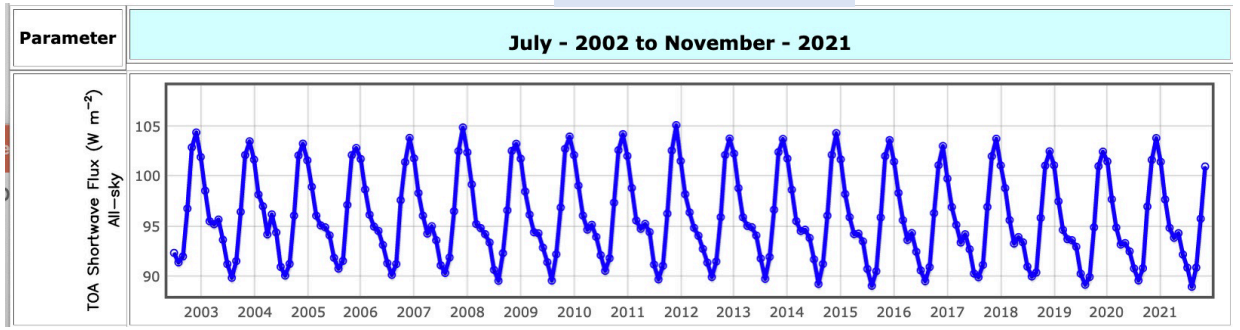


Terra and Aqua global mean SW fluxes

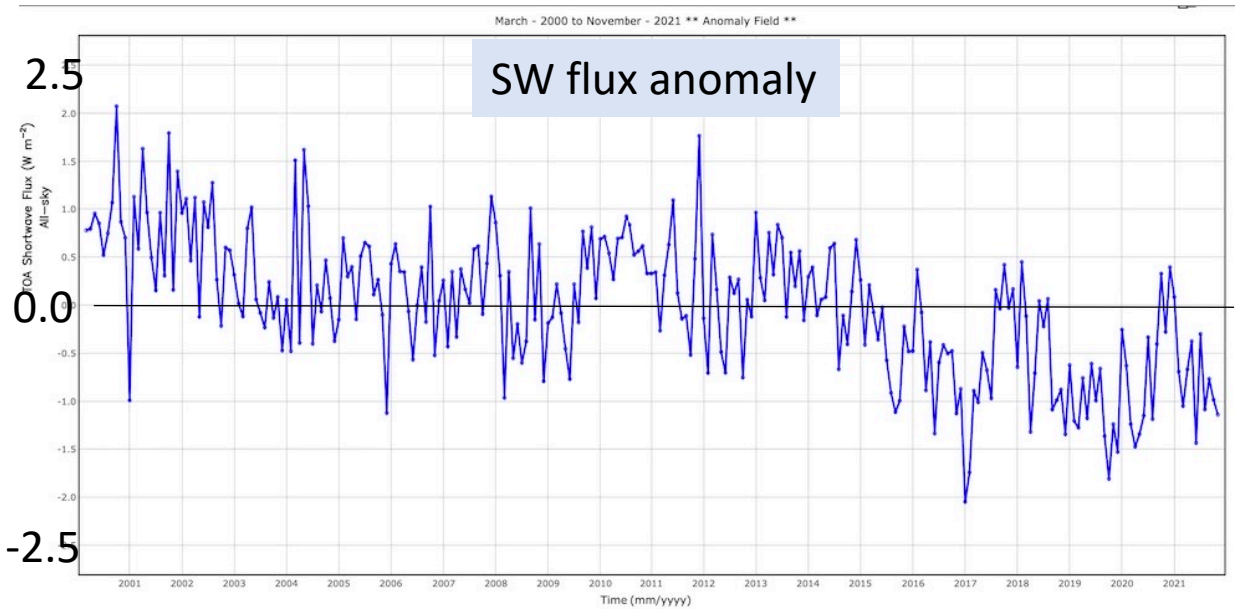
Terra



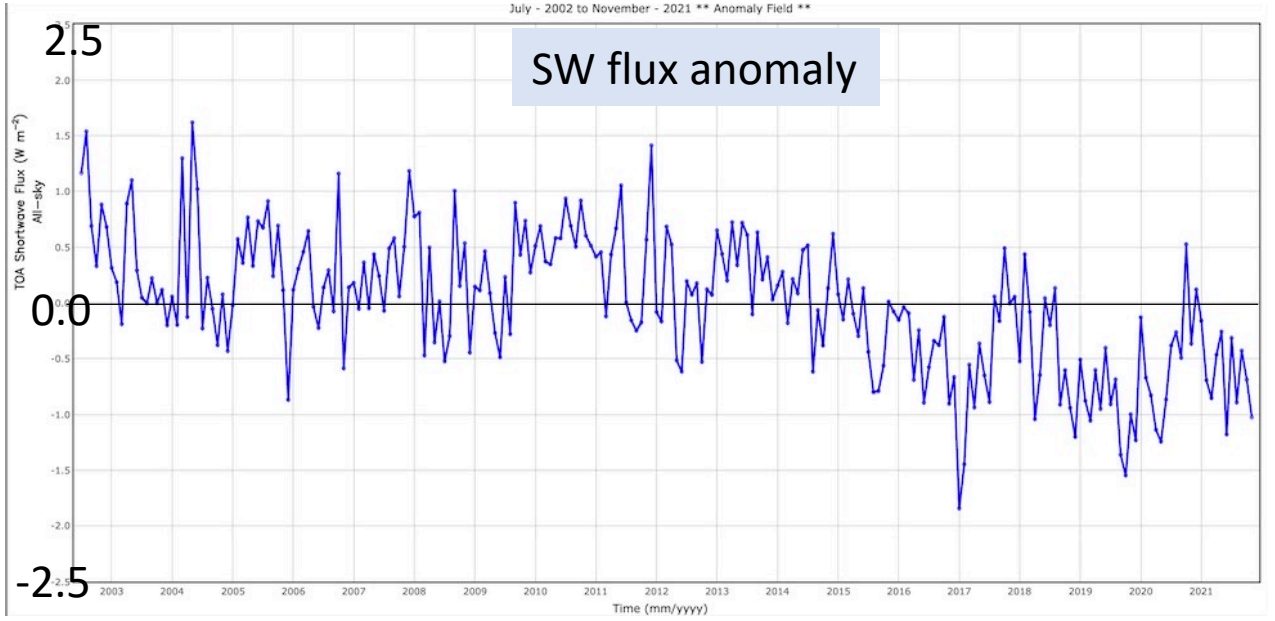
Aqua SW flux



SW flux anomaly



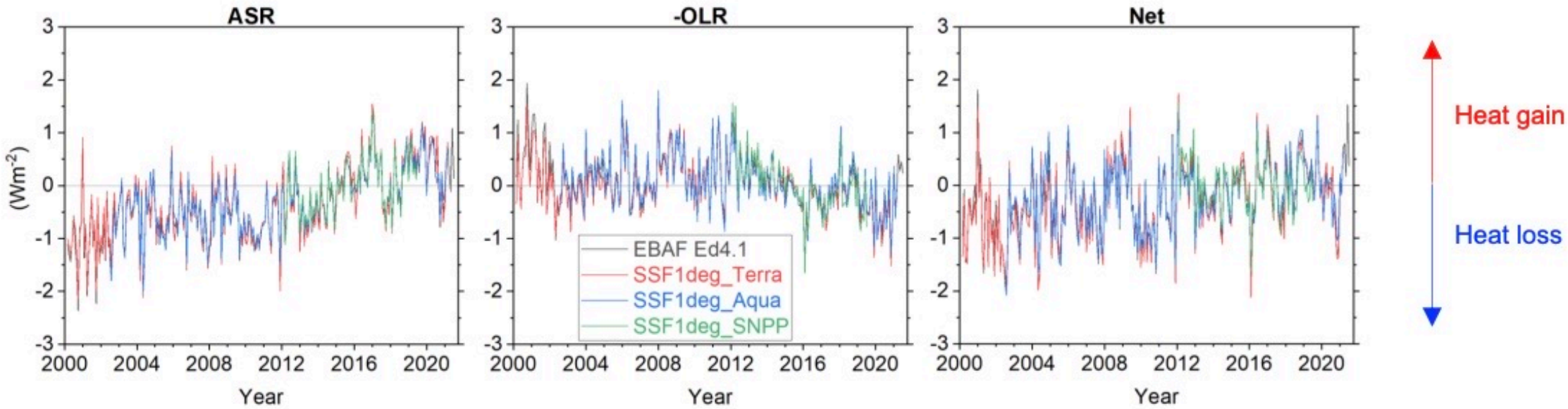
SW flux anomaly



These are two independent CERES sensors

Global Mean All-Sky TOA Flux Anomalies

(Relative to Climatology for 02/2012-09/2019)



EBAF Trends (03/2000-07/2021)		
0.68 ± 0.14 Wm^{-2} per decade	-0.28 ± 0.14 Wm^{-2} per decade	0.40 ± 0.17 Wm^{-2} per decade

ASR = Absorbed Solar Radiation = Solar Incoming (TSI) – Reflected SW (CERES observed)
Note that the Terra, Aqua and NPP monthly ASR anomalies (temporal variability) is very correlated
The 3 independent CERES instrument global monthly SW means are identically trending

CERES Flight Radiometric Validation Activities

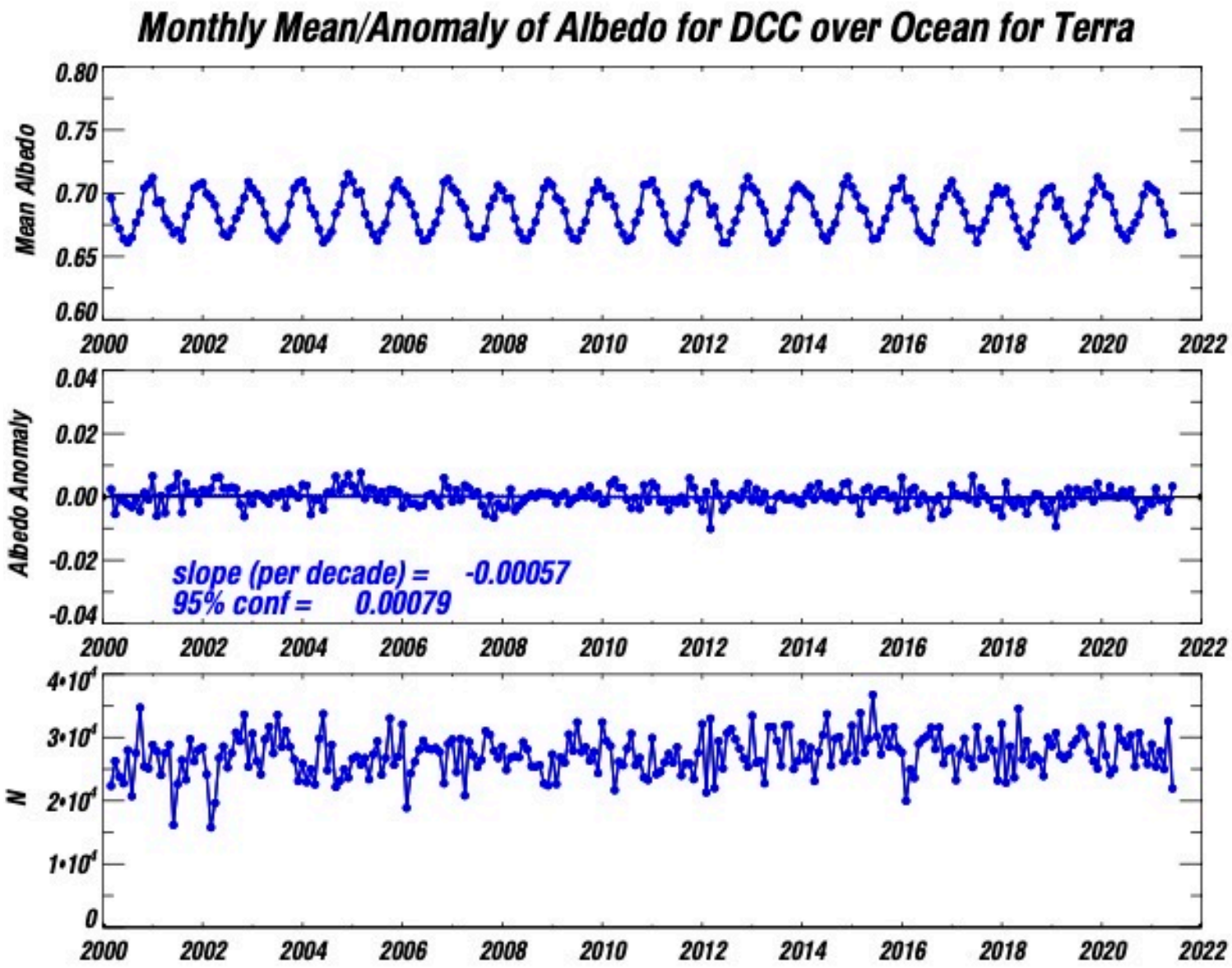
Clouds and the Earth's Radiant Energy System

		Product	Spatial Scale	Temporal Scale	Metric	Spectral Band
On-Board	Internal BB	Filtered Radiance	N/A	N/A	Absolute Stability	TOT, WN
	Internal Lamp	Filtered Radiance	N/A	N/A	Absolute Stability	SW
	Solar	Filtered Radiance	N/A	N/A	Relative Stability	TOT, SW
Vicarious	Theoretical Line-by-Line	Filtered Radiance	> 20 Km	Instantaneous	Inter-Channel Theoretical Agreement	TOT, WN
	Unfiltering Algorithm Theoretical Validation	N/A	N/A	N/A	N/A	TOT, SW, WN
	Inter-satellite (Direct Comparison)	Unfiltered Radiance	1-deg Grid	1 per crossing	Inter-Instrument Agreement, Stability	TOT, SW, WN
	Globally Matched Pixels (Direct Comparison)	Unfiltered Radiance	Pixel to Pixel	Daily	Inter-Instrument Agreement	TOT, SW, WN
	Tropical Mean (Geographical Average)	Unfiltered Radiance	20N – 20S	Monthly	Inter-Channel Agreement, Stability	TOT, WN
	DCC Albedo	Unfiltered Radiance	>40 Km	Monthly	Inter-Instrument agreement, Stability	SW
	DCC 3-channel	Unfiltered Radiance	>100 Km	Monthly	Inter-Channel consistency, stability	TOT, SW
	TIme Space Averaging	Fluxes	Global	Monthly	Inter-Instrument Agreement	LW, SW
	Lunar Radiance Measurements	Filtered Radiance	Sub Pixel	Quarterly	Inter-Instrument Agreement	LW, SW, WN

Criteria for selecting DCC

- **Uses SSF data**:
  - Consider all footprints with VZA, SZA < 40 deg,
  - Latitude bands: 30 N-S, Over Ocean.
  - Cloud Fraction must be 100%
  - Use MODIS/VIIRS 11um channel to identify footprints with brightness temperature <210K.
  - WN channel filtered radiance < 1 $Wm^{-2}sr^{-1}um^{-1}$

Terra Edition 4 X-track only DCC Albedo- Monthly average

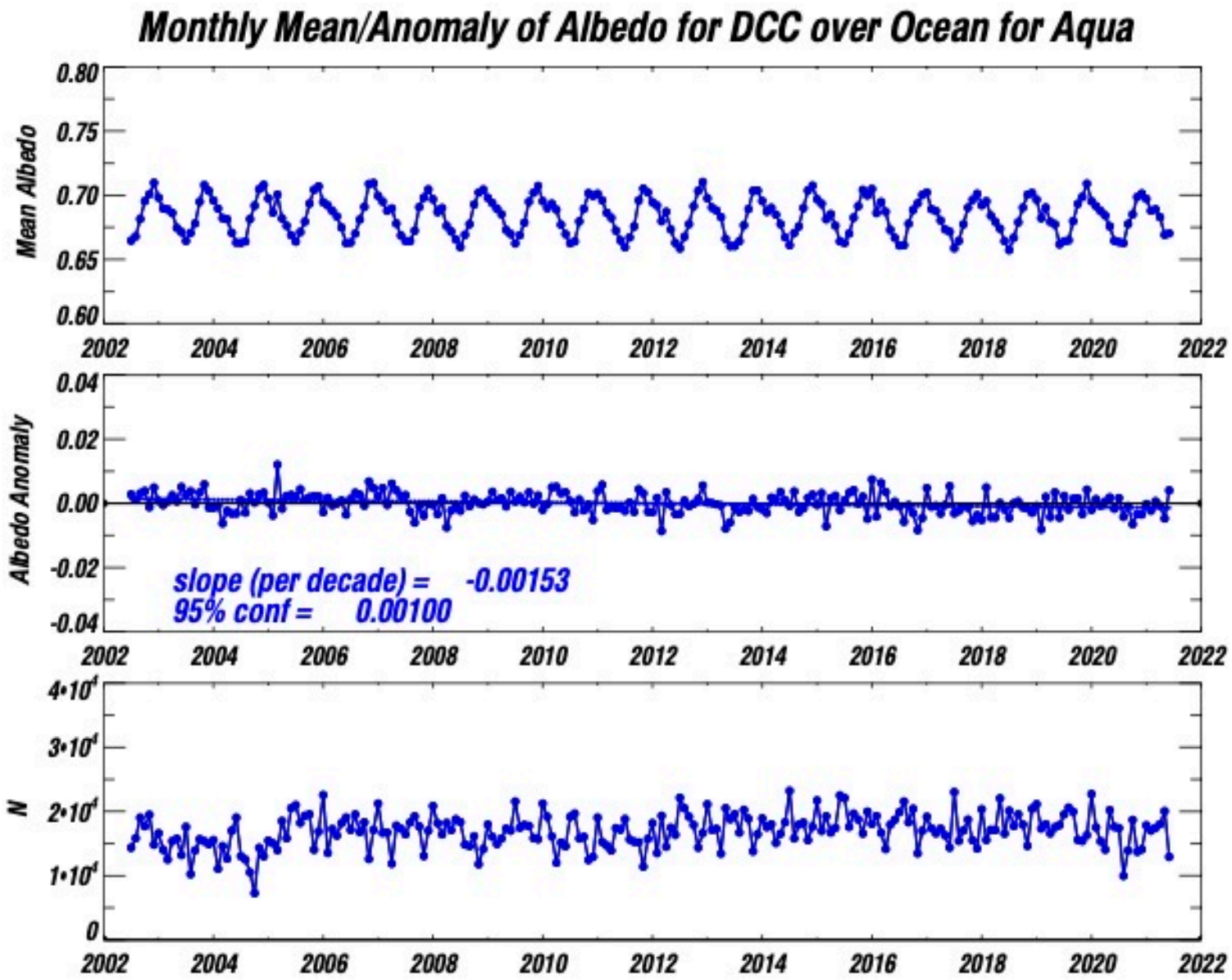


DCC Albedo
Mar 2000- Jun 2021

Deseasonalized Anomaly
Mar 2000- Jun 2021

No. of Samples
Mar 2000- Jun 2021

Aqua Edition 4 X-track only DCC Albedo- Monthly average

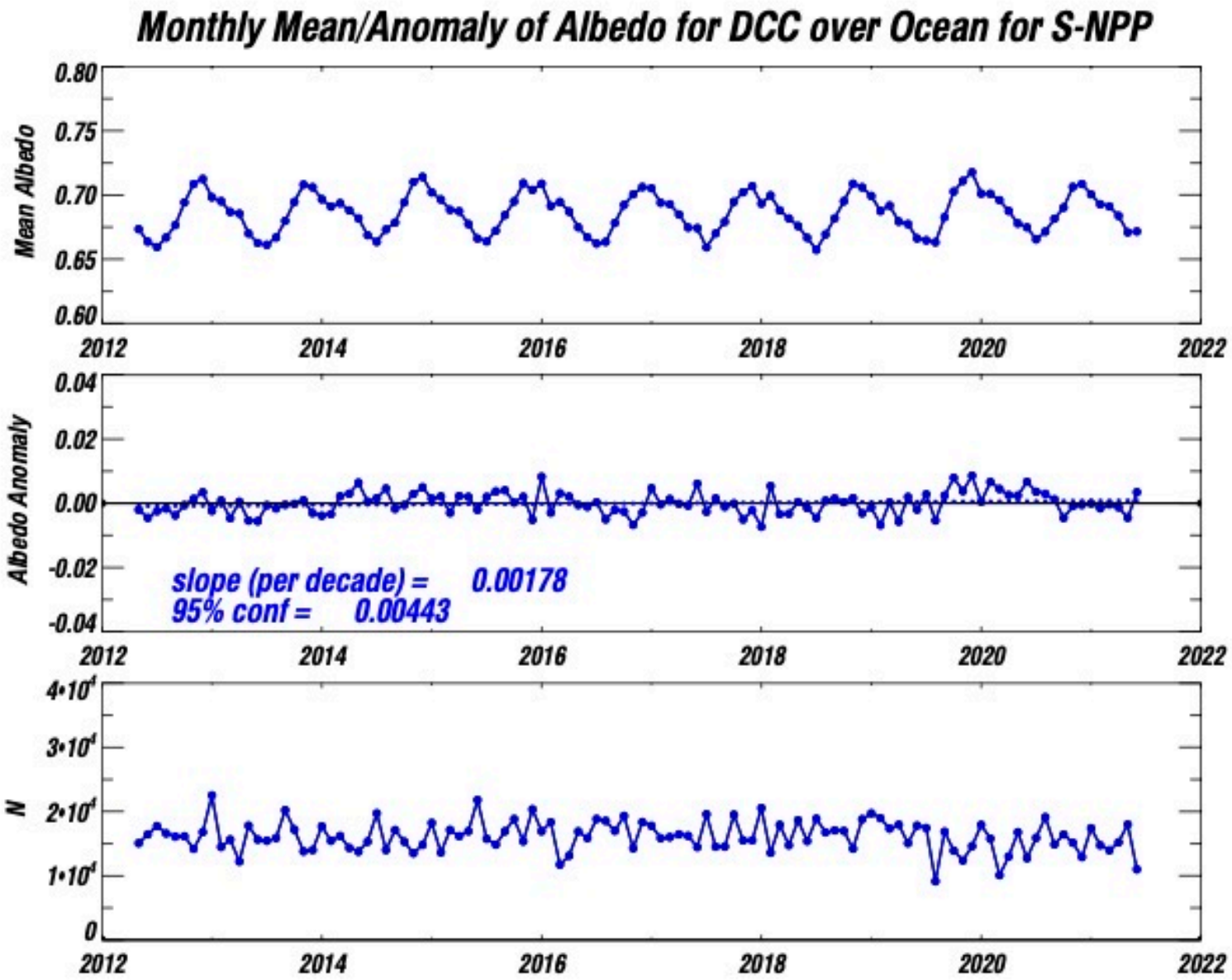


DCC Albedo
Jul 2002- Jun 2021

Deseasonalized Anomaly
Jul 2002- Jun 2021

No. of Samples
Jul 2002- Jun 2021

S-NPP Edition 2 DCC Albedo- Monthly average



DCC Albedo
May 2012- Jun 2021

Deseasonalized Anomaly
May 2012- Jun 2021

No. of Samples
May 2012- Jun 2021

Long—term Albedo averages

May 2012-April 2021		
	Albedo	**Percent Diff (from S-NPP)**
S-NPP	0.6864	
Aqua	0.6830	-0.495
Terra	0.6854	-0.146

Jul 2002-Jun 2021		
	Albedo	**Percent Diff (from Aqua)**
Aqua	0.6838	
Terra	0.6857	0.278

Terra is in a 10:30 AM orbit and Aqua and NPP are in a 1:30PM orbit, the ocean DCC albedo is similar across local hours

Conclusions

- DCC targets are effective to track the stability of SW broadband sensors
  - Verified that CERS instrument spectral degradation was accounted for
  - The SWICS lamps and internal blackbody are working properly as onboard calibration systems
- Ocean DCC targets can be used to compare the absolute calibration differences between CERES SW sensors
- The whole Earth can be used as a target by assuming that the temporal (monthly) natural variability should be similar across analogous sensors