Applying CERES ADMs to ERBE Data

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CERES Science Team Meeting

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Project Overview

- **Funded by NOAA Climate Data Record (CDR) .**
  - **Produce "CERES-Like" data products from NOAA-9/10 ERBE Scanner measurements**
    - **Collocate retrieved cloud properties from AVHRR (P. Minnis PI in a separate CDR project)**
    - **Reprocess NOAA-9/10 ERBE data using CERES angular distribution models (ADMs)**
    - **Compute surface irradiances**
  - **Processed 10 months from 1985 and entire 12 months from 1986 of NOAA-9 scanner data into SSF and SSF-1Deg Month products.**

ERBE and CERES Processing

- **Scene Identification**
  - ERBE algorithm used Maximum Likelihood Estimate (MLE) method to identify the scene type.
  - CERES uses Imager measurements to identify the scene types.
- **Unfiltering**
  - Process of removing instrument spectral response on observed radiance
  - Unfiltering algorithm in ERBE and CERES are different and use different spectral databases.
- **Inversion** (Convert radiance to irradiance)
  - ERBE ADMs are developed based on Nimbus-7 ERB data for 12 broad scene types
  - CERES-AQUA ADMs are used to reprocess the ERBE NOAA-9 scanner data.

CERES-Like ERBE - NOAA-9 SSF

Instantaneous – Monthly Gridded (April – 1986)

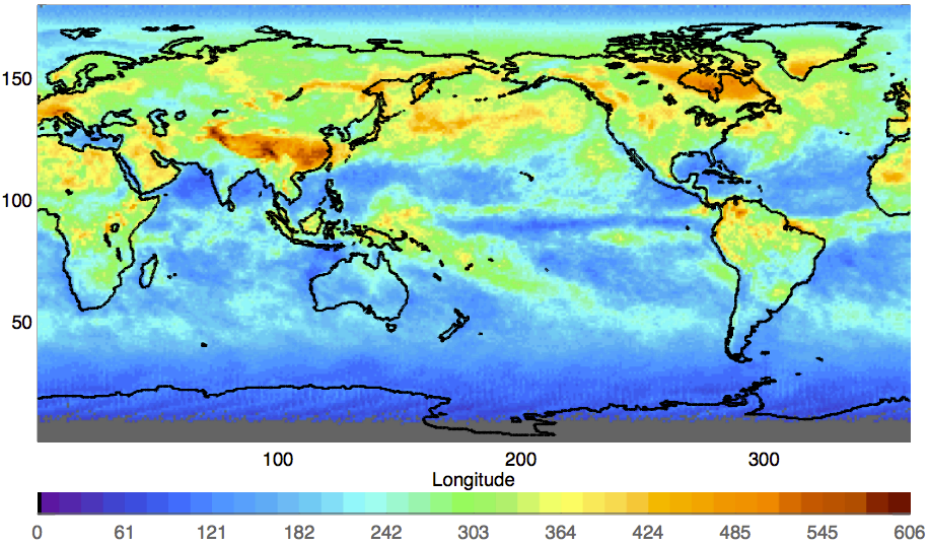


Fig 1: Day Shortwave TOA Flux (W/m2)

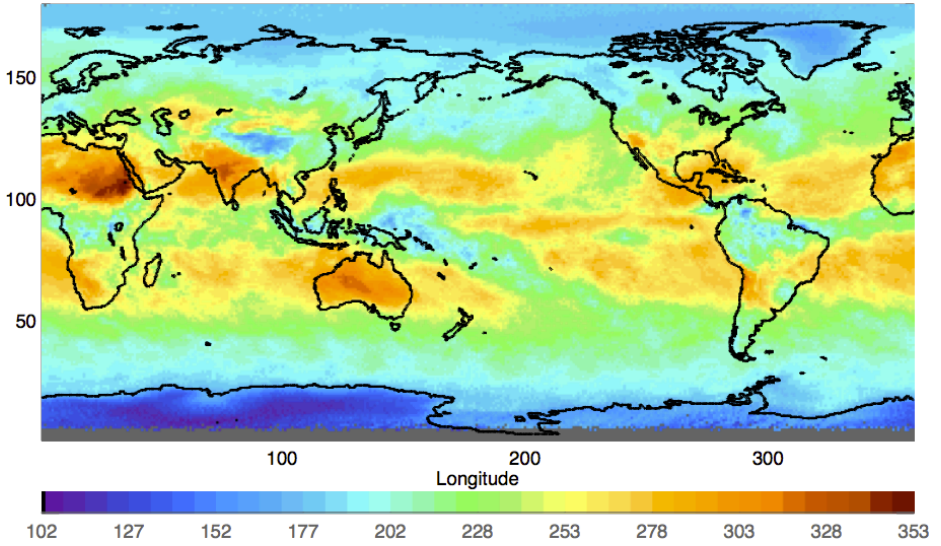


Fig 2: Day Longwave TOA Flux (W/m2)

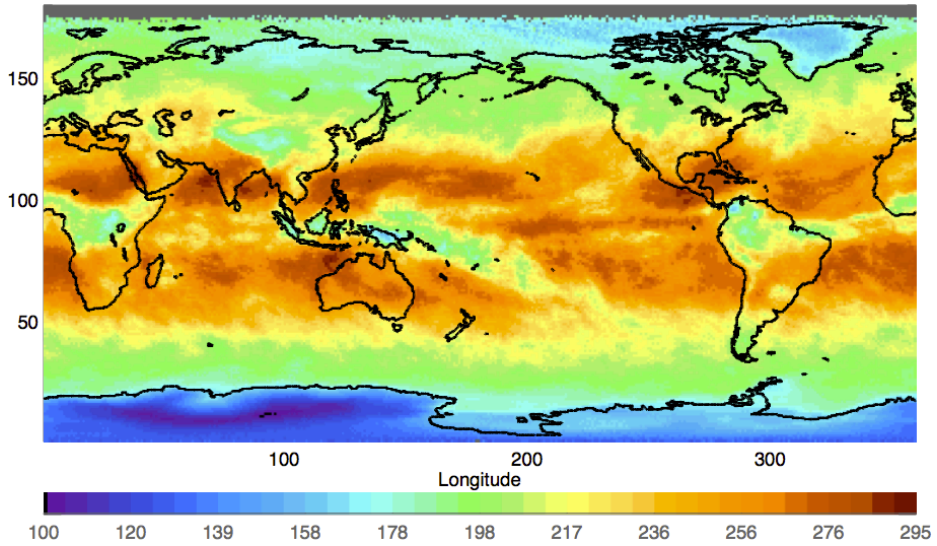


Fig 3: Night Longwave TOA Flux (W/m2)

Month (1986)	Monthly Global Mean TOA Flux (W/m^2)		
	Day Shortwave	Day Longwave	Night Longwave
APR	232.0	233.3	228.1
JUL	213.9	243.5	235.6
OCT	217.3	236.2	232.0
DEC	226.1	231.2	227.5

Monthly Global Mean of TOA Flux

NOAA-9 SSF & NOAA-9 S8 Products (Matched* Footprints)

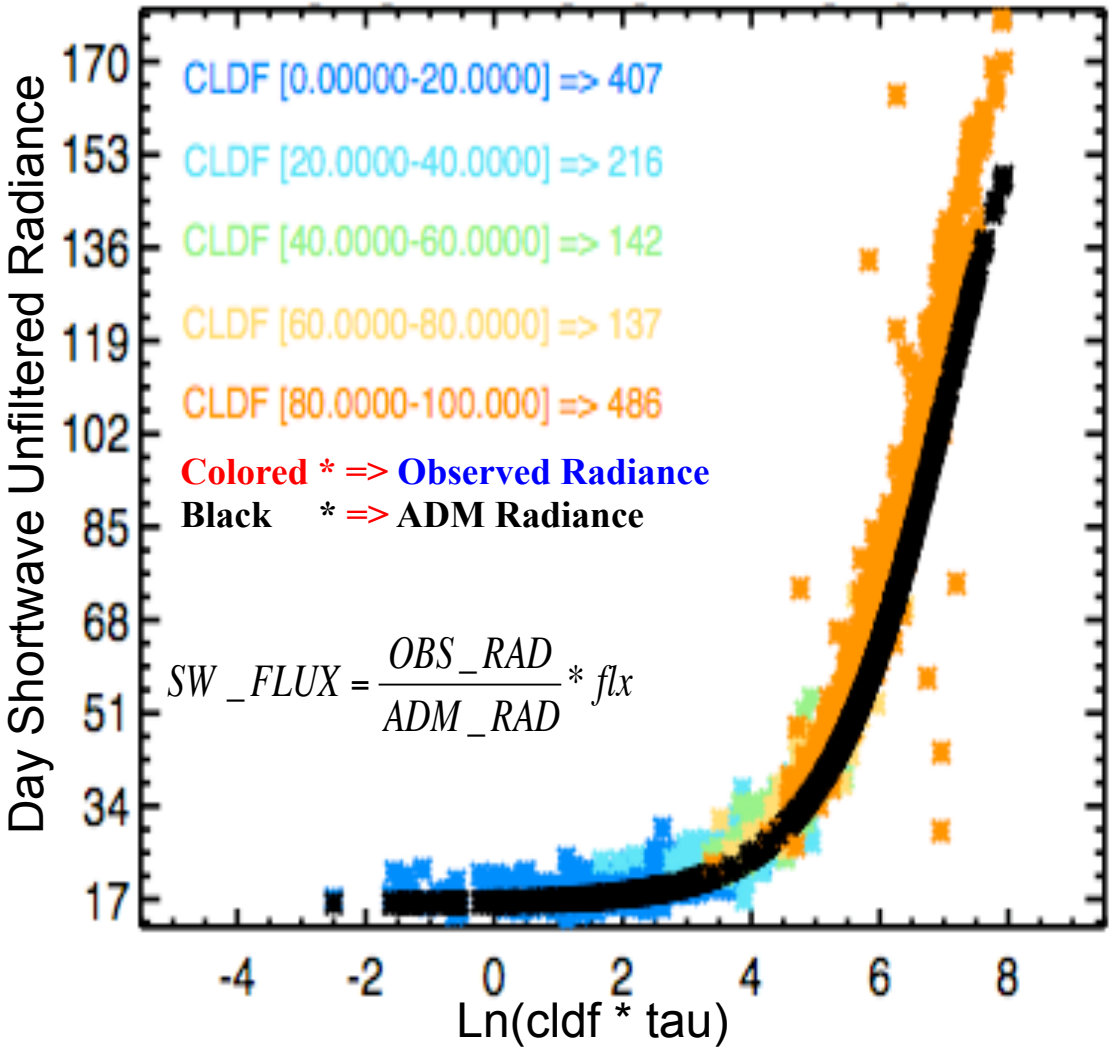
Month	Data Products	Day Shortwave (W/m^2)	Day Longwave (W/m^2)	Night Longwave (W/m^2)	Day Shortwave % DIFF	Day Longwave % DIFF	Night Longwave % DIFF
Apr-86	ERBE-S8	226.1	232.3	229.9	2.75	0.43	-0.78
	ERBE-SSF	232.3	233.3	228.1			
Jul-86	ERBE-S8	209.5	242.6	237.5	2.22	0.36	-0.81
	ERBE-SSF	214.1	243.5	235.6			
Oct-86	ERBE-S8	211.9	235.5	234.0	2.68	0.26	-0.83
	ERBE-SSF	217.6	236.1	232.0			
Dec-86	ERBE-S8	220.0	230.7	229.4	2.94	0.24	-0.82
	ERBE-SSF	226.4	231.2	227.5			

(*Match footprints in S8 and SSF, then compute global monthly means.)

ADM Radiance & Observed Radiance

NOAA-9 (Observed Radiance), CERES-Aqua (ADM Radiance)

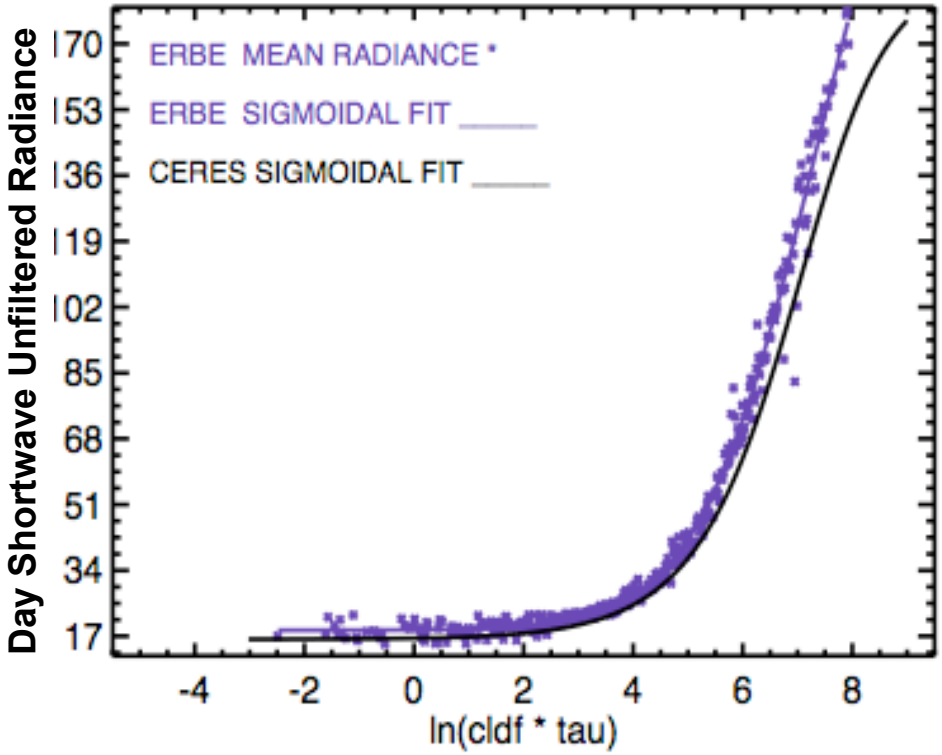
- **Figure 1 shows the plot for ADM unfiltered radiance and Observed unfiltered radiance with natural log of product of cloud fraction and optical depth.**
- **For a given cloud optical depth, the observed radiance is higher compared to ADM radiance, resulting in brighter estimate of SW Flux.**
- **Thus, improving the SW flux estimate requires adjustment in the cloud optical depth.**

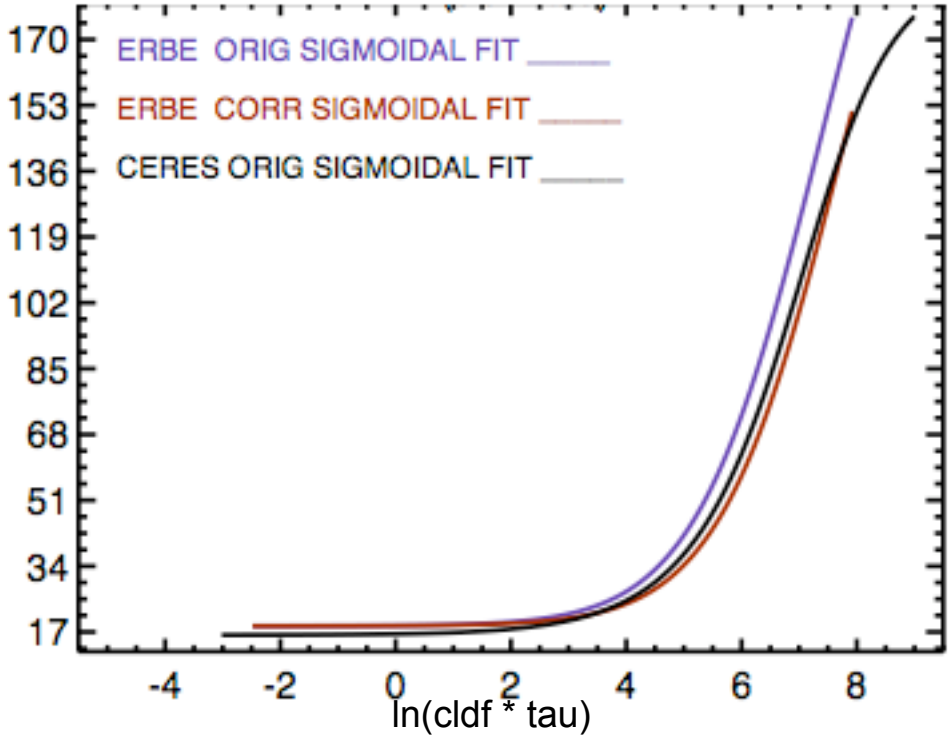


- **Solar Zenith => (46-48)^0**
- **Viewing Zenith => (28-30)^0**
- **Relative Azimuth => (40-42)^0**

Five-Parameter Sigmoidal Fit

Cloud Optical Depth Adjustment





$$I = I_0 + \frac{a}{[1 + e^{-(x - x_0)/b}]^c}$$

Sigmoidal Coefficients [ISZ(24), IVZ(15), IRZ(12)]							
	a	b	c	x0	I0	XMIN	XMAX
CERES	171.8592	0.7570	0.6637	7.3698	16.1993	-3.04	9.00
ERBE	268.1242	1.2637	1.4059	6.9447	18.5351	-2.50	7.92

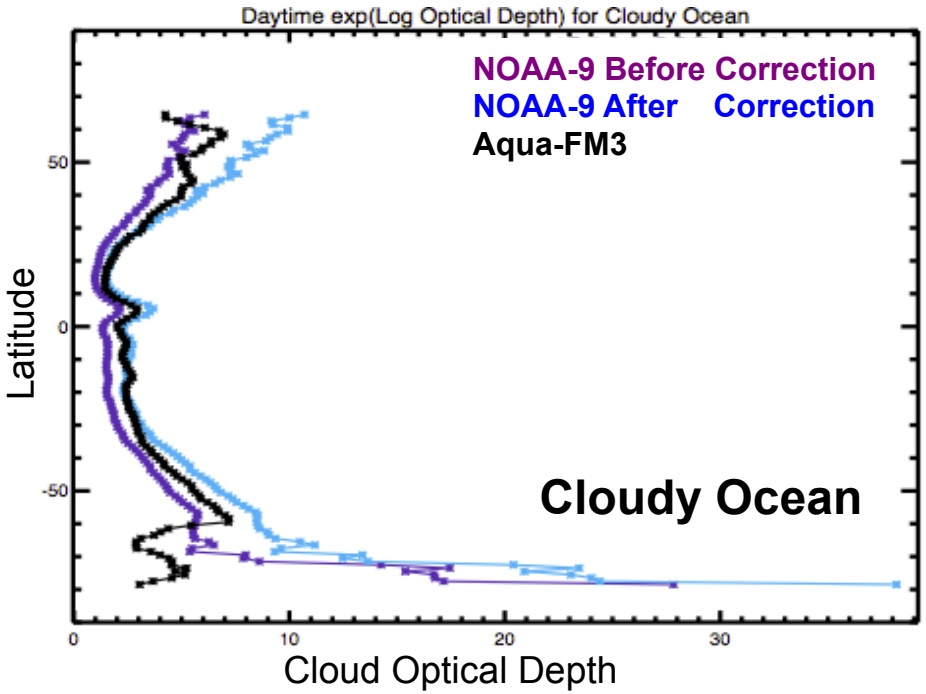
Cloud Optical Depth

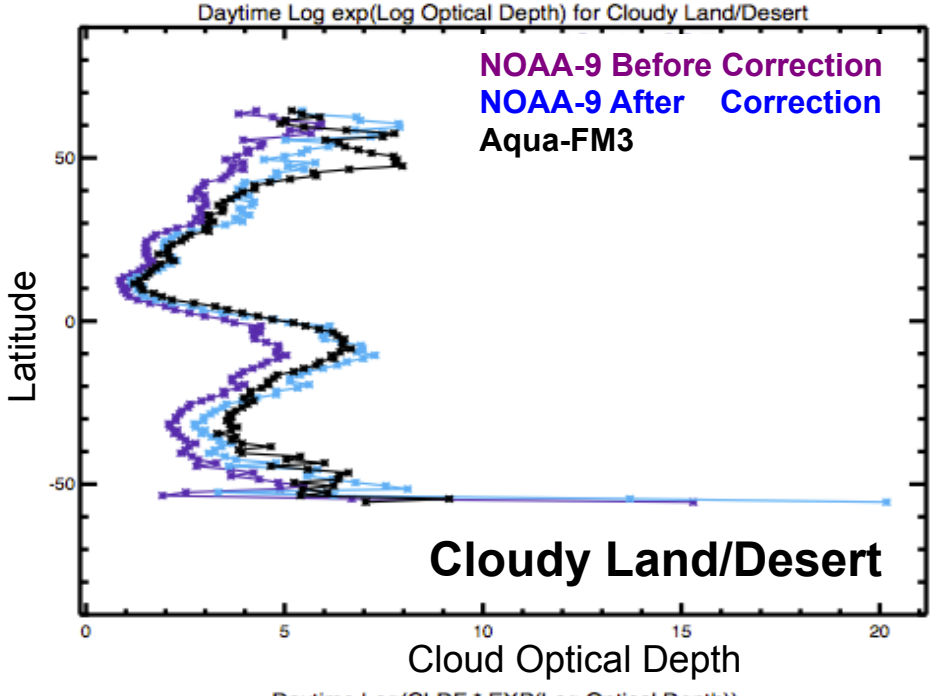
Adjustment Factor

- Individual Adjustment factor is estimated for
  - Cloud types
  - *Angular Bins
- Developed adjustment factor for
  - Cloudy ocean
  - Cloudy land/desert.
- Four months of NOAA-9 scanner data is used
  - Apr, Jul, Oct, Dec, 1986

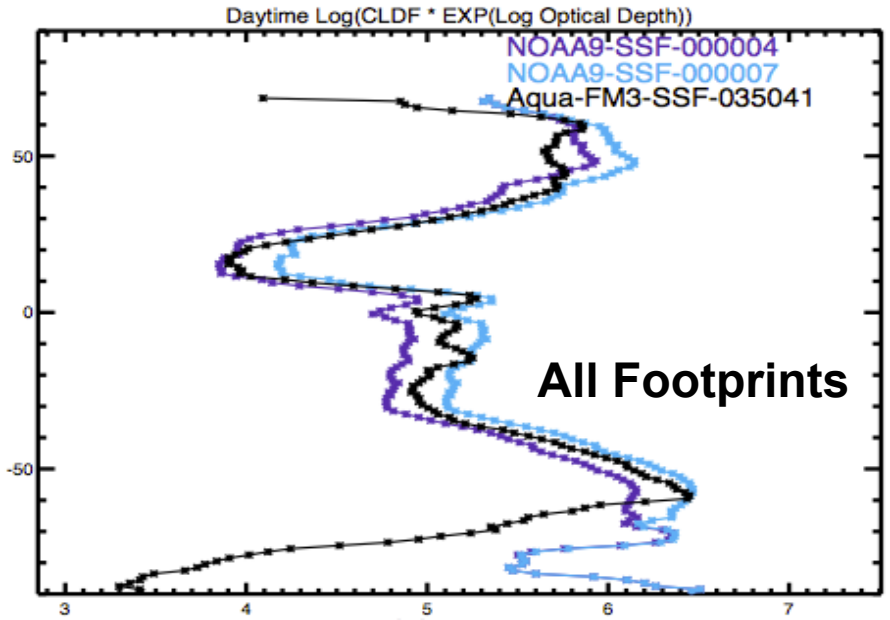
* If data is not sufficient to derive the adjustment factor for an angular bin, the average over all angular bins is used.

Cloud Optical Depth Adjustments



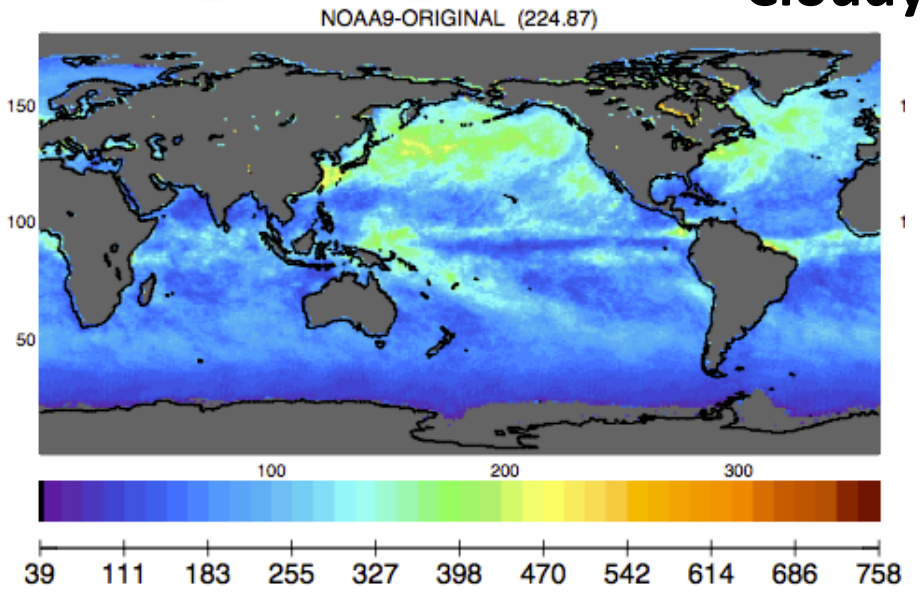


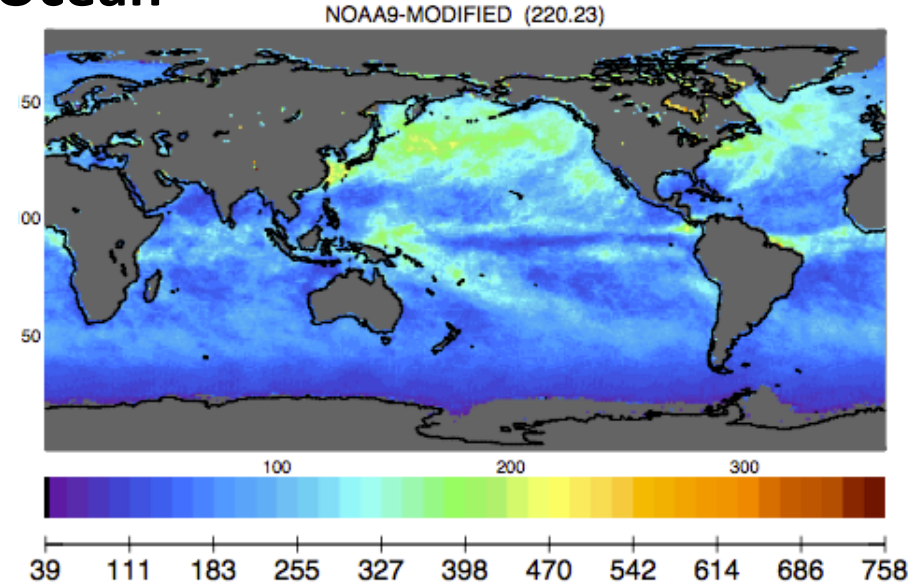
- **Figure shows zonal optical depth for December. Zonal mean cloud optical depth for NOAA-9 (1986) scanner in violet is without applying the correction, while blue is after applying the correction, and black is for CERES Aqua (2009).**

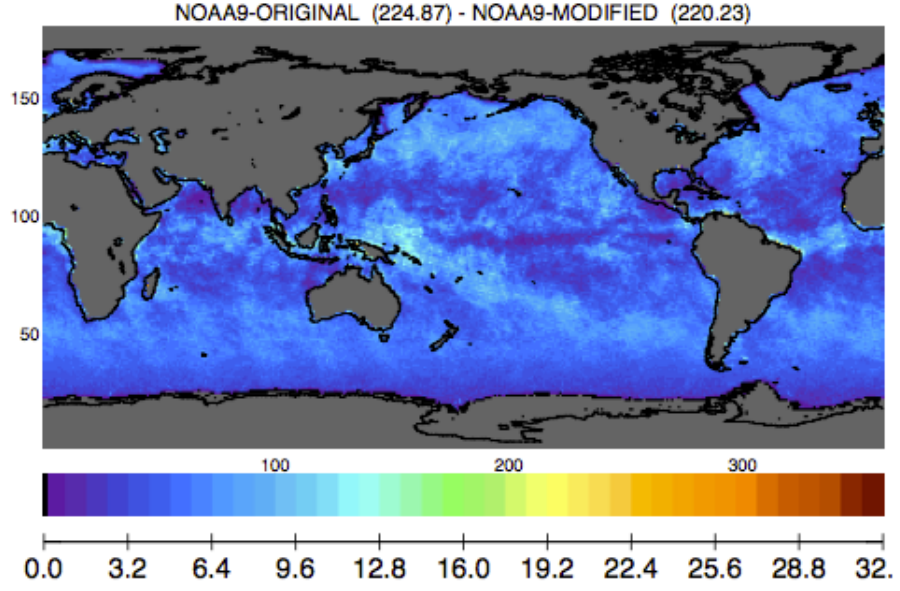


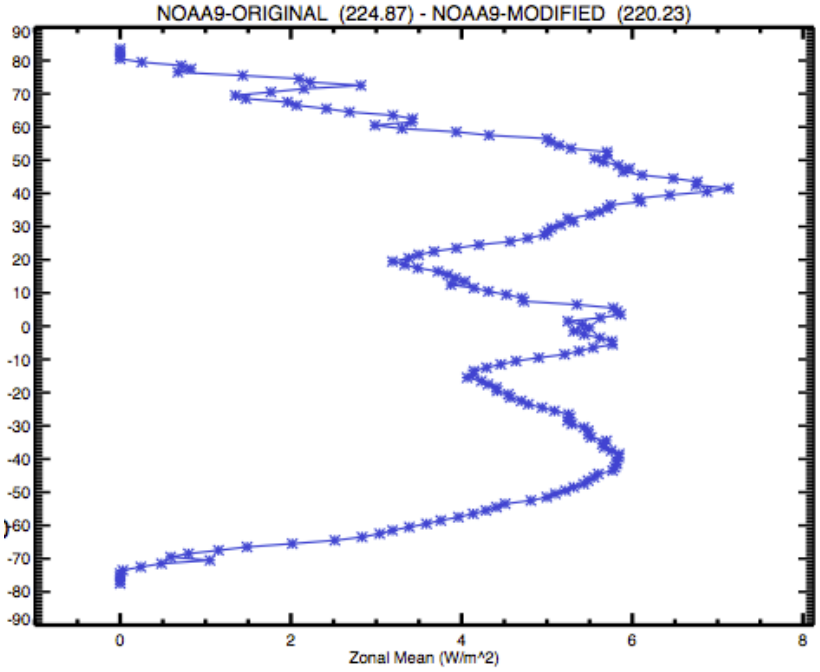
TOA Shortwave Flux (Apr, 1986)

Cloudy Ocean



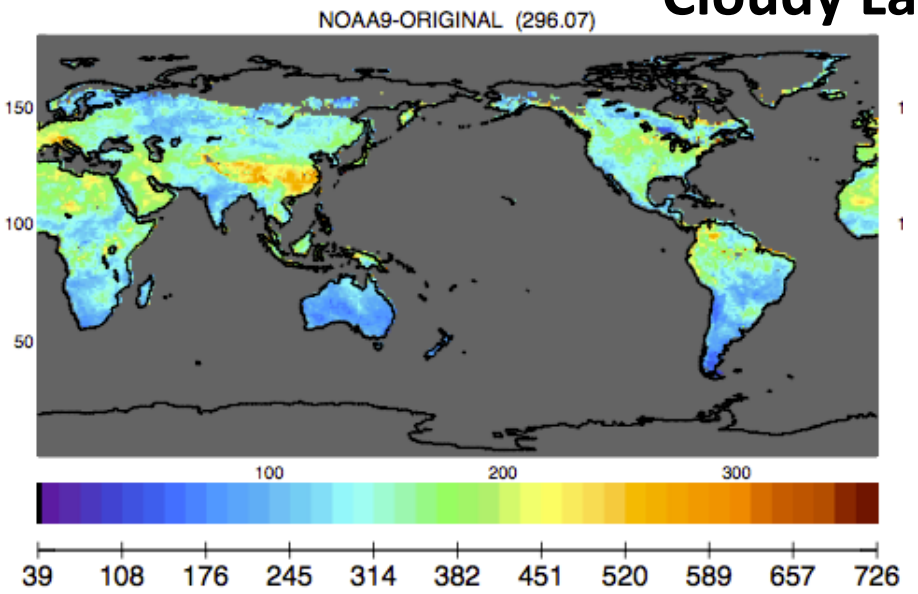


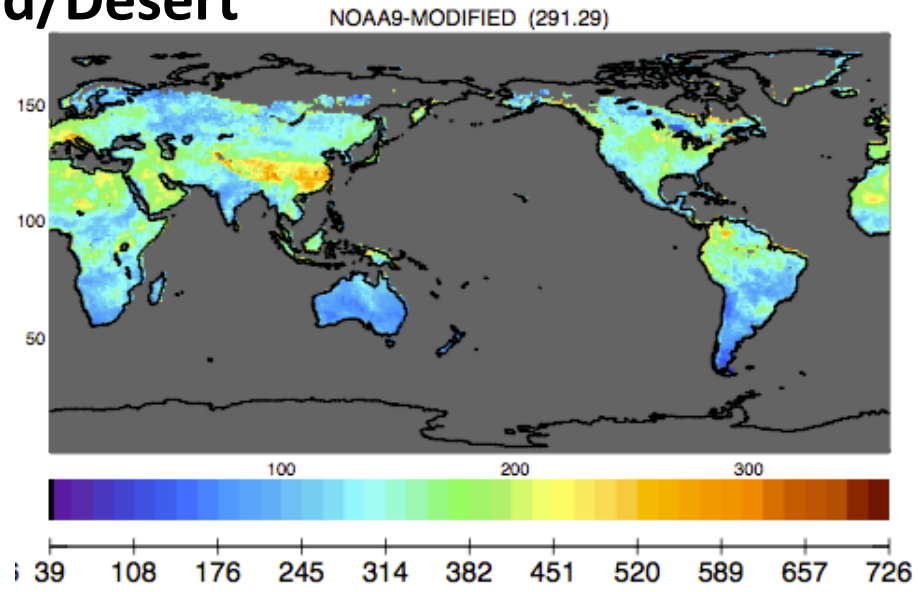


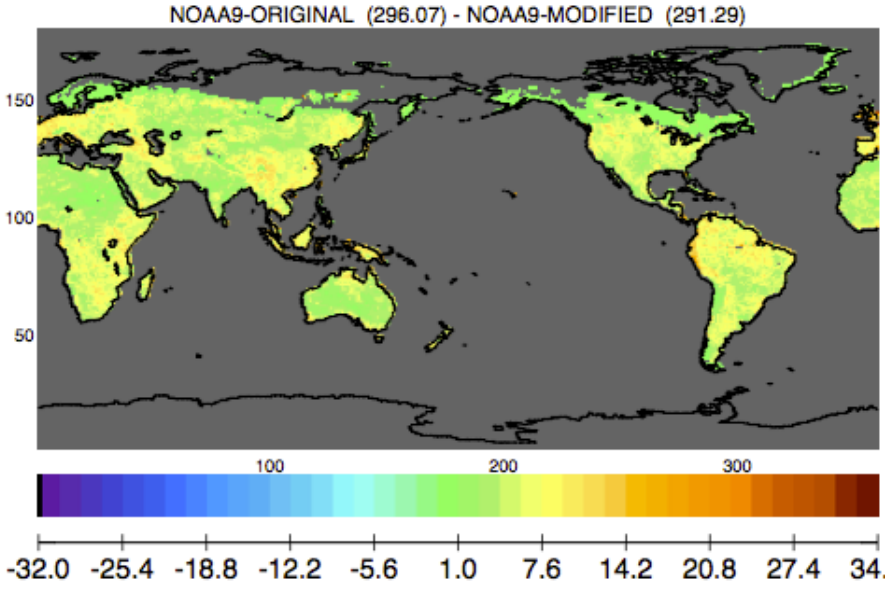


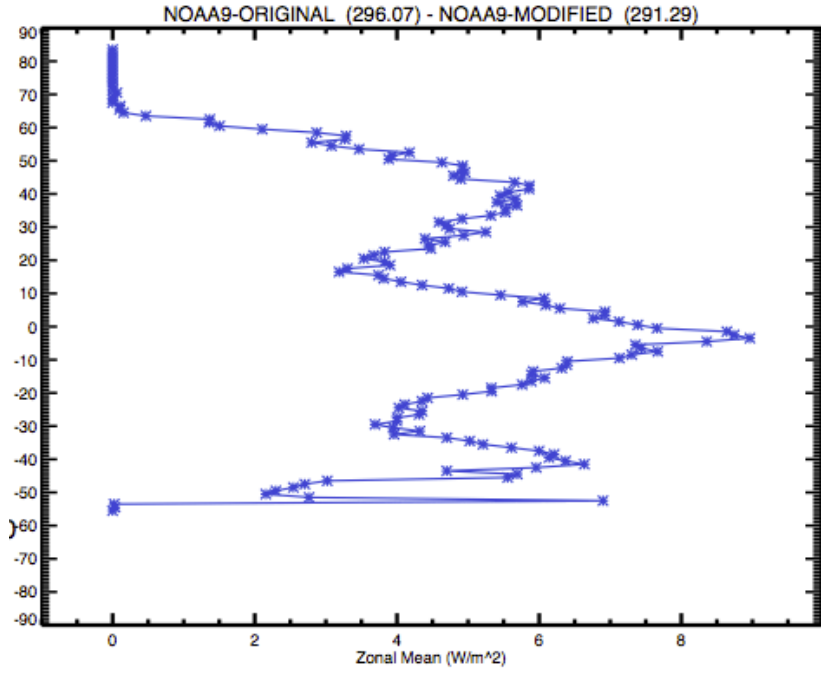
TOA Shortwave Flux (Apr, 1986)

Cloudy Land/Desert









Monthly Global Mean of TOA Flux

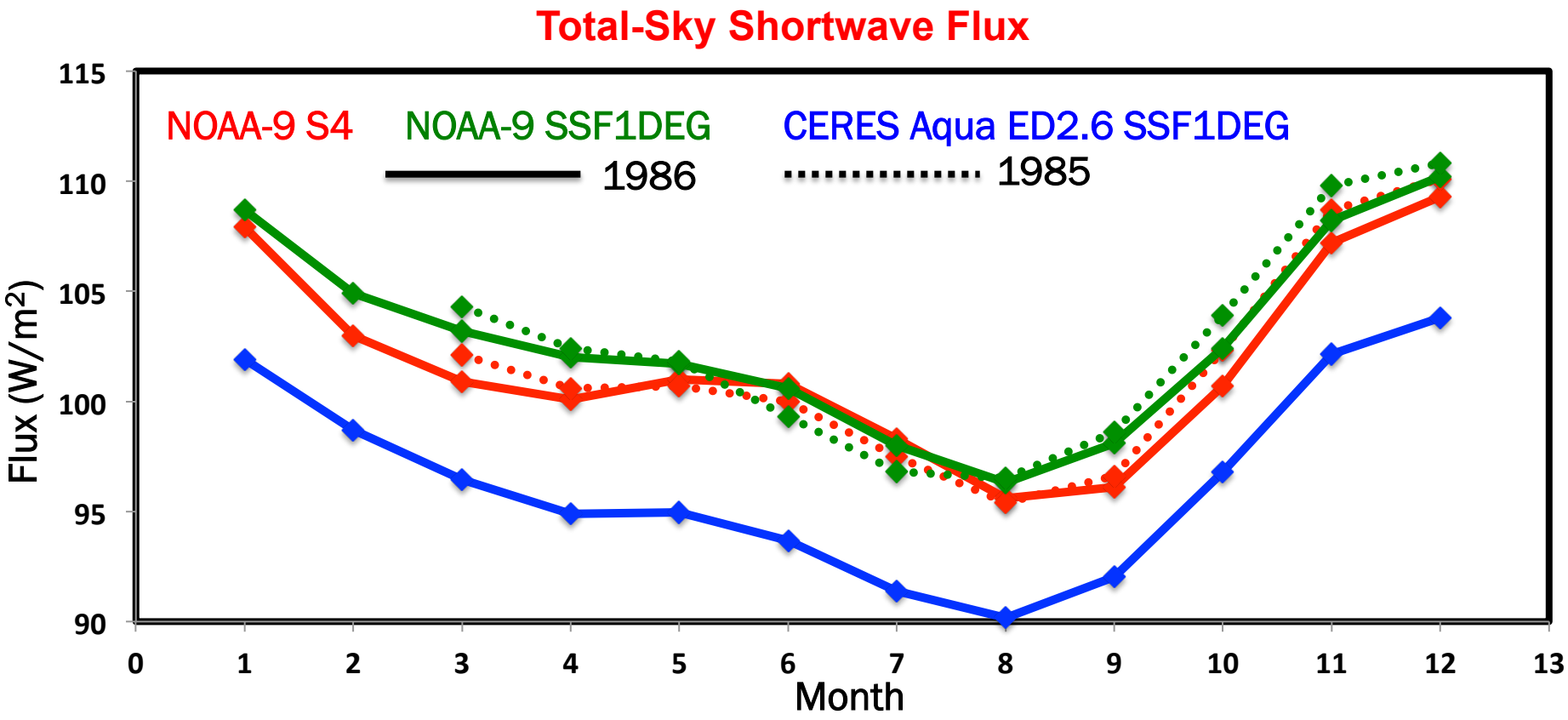
NOAA-9 SSF & NOAA-9 S8 Products (Matched* Footprints)

Month	Data Products	Before Applying Correction			After Applying Correction		
		Day Shortwave (% DIFF)	Day Longwave (% DIFF)	Night Longwave (% DIFF)	Day Shortwave (% DIFF)	Day Longwave (% DIFF)	Night Longwave (% DIFF)
Apr-86	ERBE-S8	2.75	0.43	-0.78	1.40	0.49	-0.78
	ERBE-SSF						
Jul-86	ERBE-S8	2.22	0.36	-0.81	0.83	0.41	-0.81
	ERBE-SSF						
Oct-86	ERBE-S8	2.68	0.26	-0.83	1.60	0.32	-0.83
	ERBE-SSF						
Dec-86	ERBE-S8	2.94	0.24	-0.82	1.74	0.29	-0.81
	ERBE-SSF						

Year Average Results	Day Shortwave (% Diff)	Day Longwave (% Diff)	Night Longwave (% Diff)
Average	1.08	0.41	-0.82
Standard Deviation	0.37	0.06	0.03

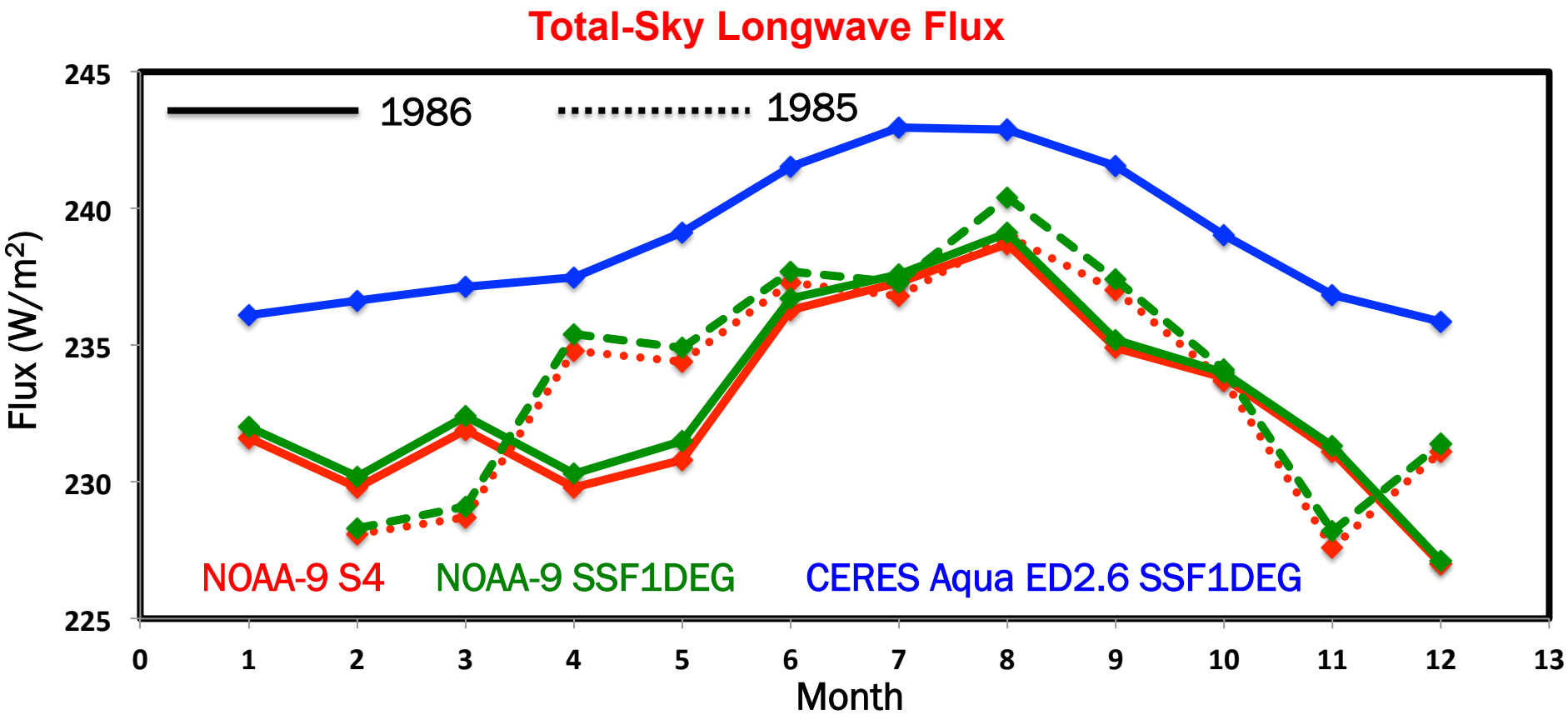
(*Match footprints in S8 and SSF, then compute global monthly means.)

Time Series of SSF1DEg Monthly Global Mean TOA Flux



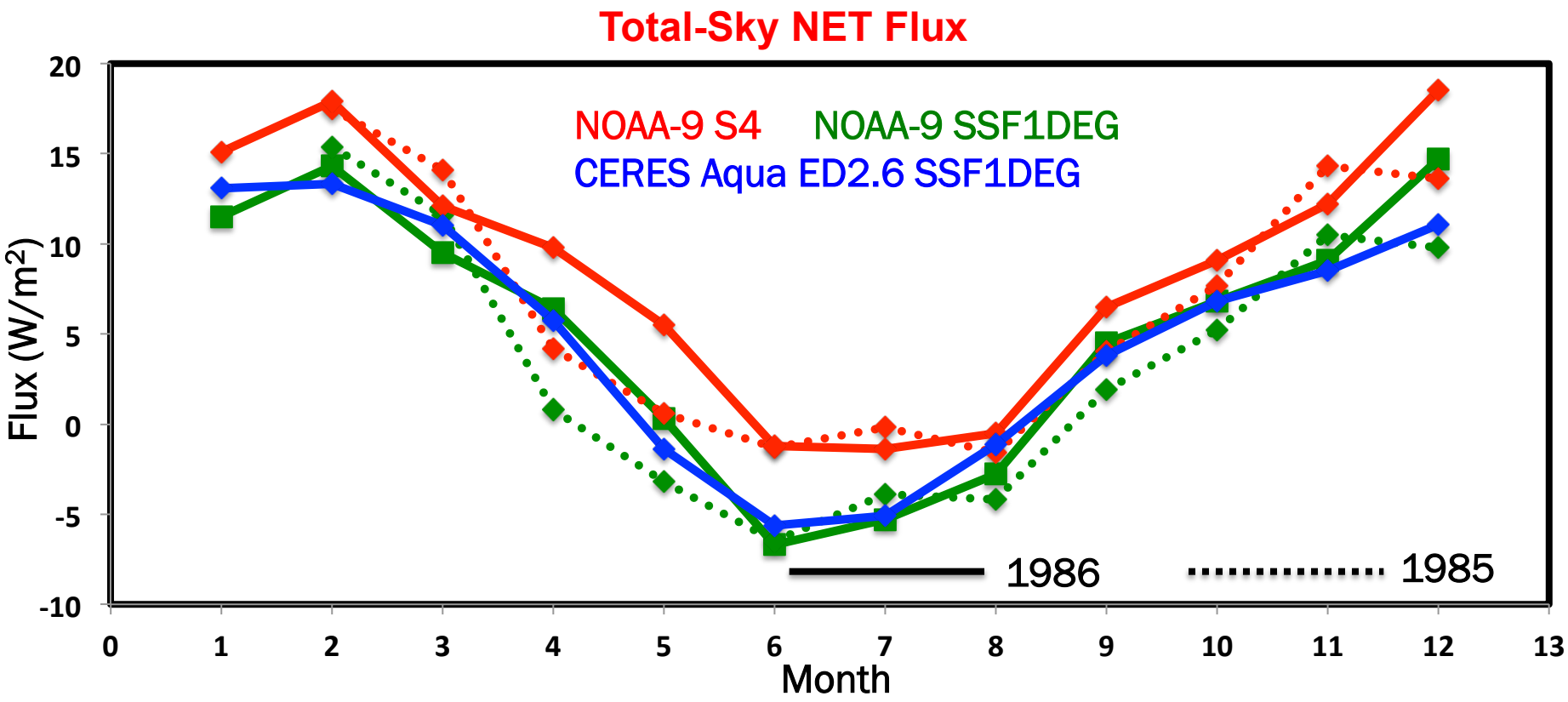
Year Average Results	NOAA-9 S4 (W/m²)	NOAA-9 SSF1DEG (W/m²)	CERES-Aqua SSF1DEG (W/m²)
Average	101.9	103.0	96.4
Standard Deviation	4.6	4.6	4.5

Time Series of SSF1DEg Monthly Global Mean of TOA Flux



Year Average Results	NOAA-9 S4 (W/m²)	NOAA-9 SSF1DEG (W/m²)	CERES-Aqua SSF1DEG (W/m²)
Average	233.1	233.6	238.9
Standard Deviation	3.3	3.4	2.7

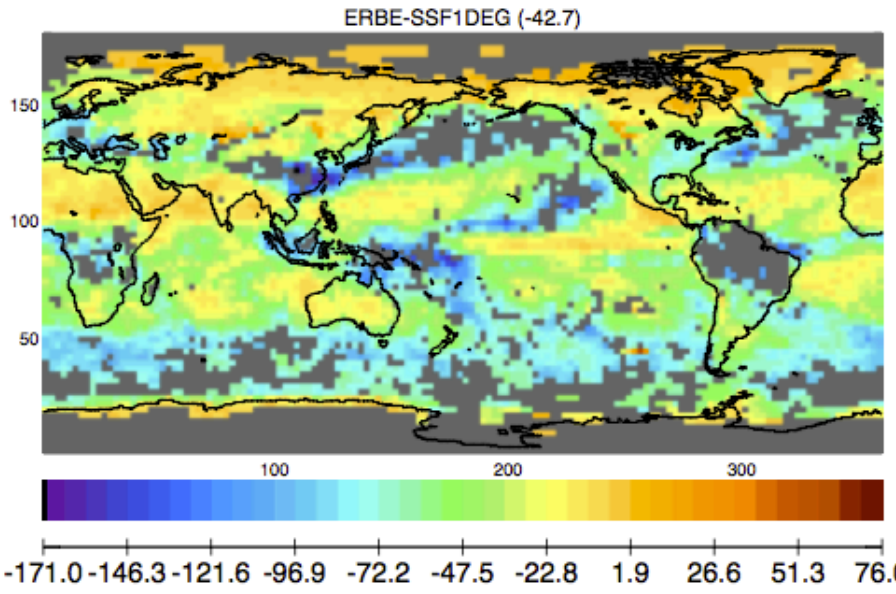
Time Series of SSF1DEg Monthly Global Mean of TOA Flux

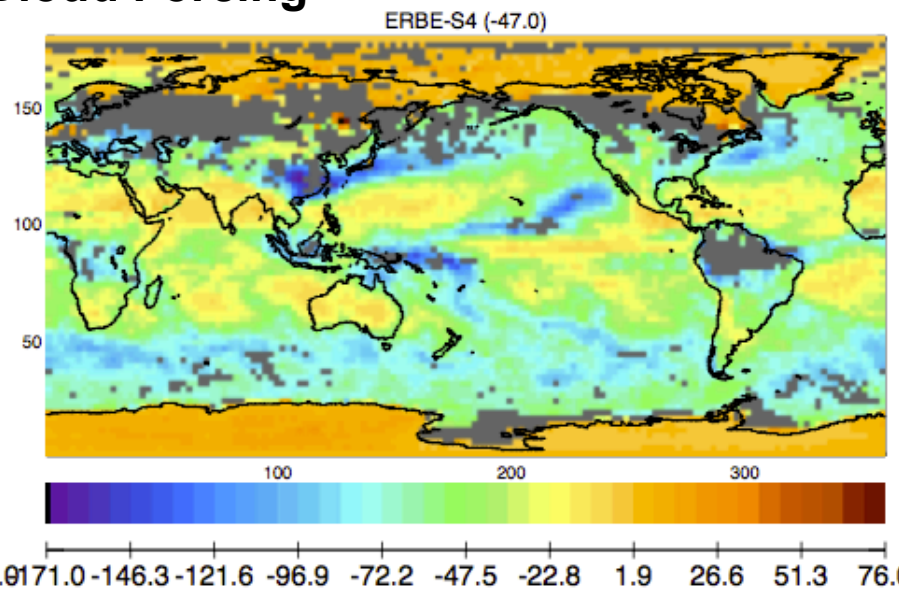


Year Average Results	NOAA-9 S4 (W/m²)	NOAA-9 SSF1DEG (W/m²)	CERES-Aqua SSF1DEG (W/m²)
Average	8.0	4.6	5.0
Standard Deviation	7.0	7.3	6.9

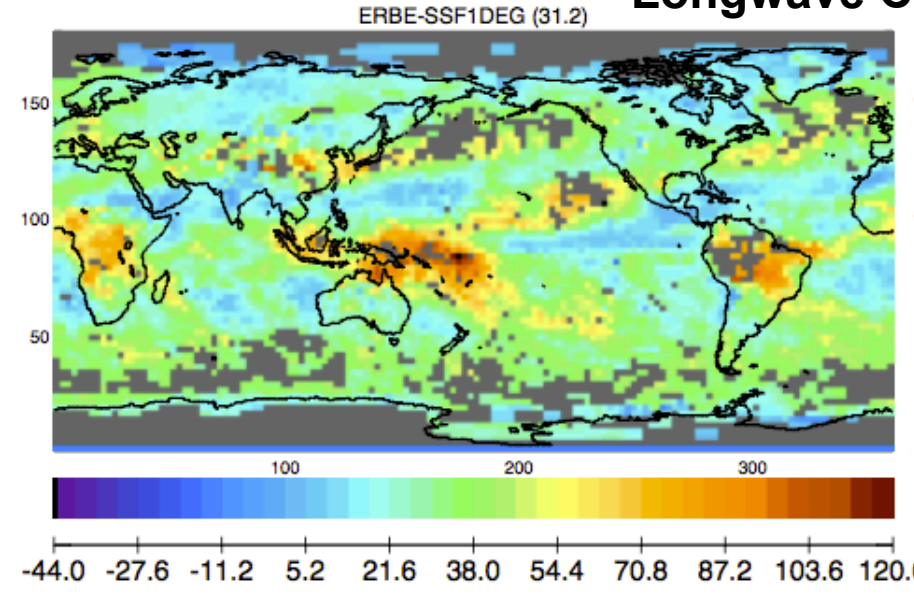
Cloud Forcing (Apr, 1985)

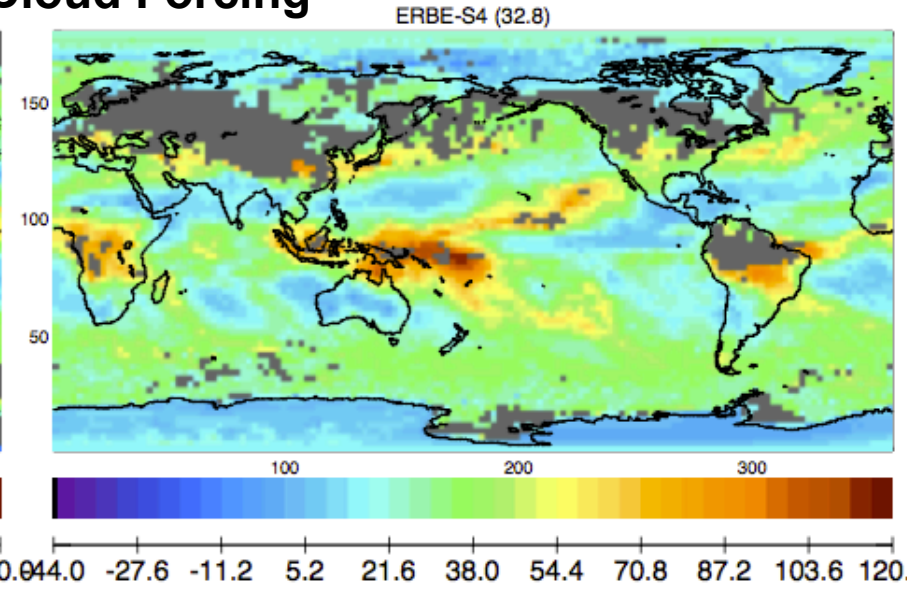
Shortwave Cloud Forcing





Longwave Cloud Forcing





Summary and Conclusions

- **Comparison of 2 years of NOAA-9 scanner SSF and S8 instantaneous global monthly mean suggest that the TOA flux in SSF is:**
  - **1.1% brighter in day shortwave channel**
  - **0.4% warmer in day longwave channel**
  - **0.8% colder in night longwave channel**

- **Comparison of NOAA-9 scanner SSF1DEG and CERES-Aqua SSF1DEG global monthly mean suggest that TOA total-sky flux for NOAA-9 is:**
  - **Brighter for shortwave channel (6.6 Vs 5.5 W/m^2)**
  - **Colder for longwave channel (5.3 Vs 5.8 W/m^2)**