Modeling ERBE WFOV Nonscanner dome degradation and reprocessing its radiation budget data from 1985 to 1998

Alok K. Shrestha
Seiji Kato, Takmeng Wong, Paul W Stackhouse, Fred Rose,
Walter F. Miller, Kathryn Bush, David A. Rutan,
Patrick Minnis, and David Doelling

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Project Overview

- Supported by NASA's Making Earth System Data Records for Use in Research Environments (MEaSUREs) program
  - Reprocess ERBE (NOAA-9, ERBS, NOAA-10) Wide-field-of-View (WFOV) Nonscanner radiation products
    - Implement Spectral Unfiltering by identifying surface and cloud properties over WFOV nonscanner footprints
    - Characterize dome degradation to estimate time and spectral dependent degradation factor to derive its spectral response function
  - Processed 14 Years (1985-1998) of ERBS WFOV nonscanner data.

ERBS WFOV SW Dome Transmission

- Fig (1.a) shows the original spectral response function (SRF) and (1.b) shows the time series of transmission for ERBS WFOV nonscanner shortwave (SW) dome
- The transmission in Fig (1.b) is derived from solar measurements and shows that it degraded approximately 8% over time
- The correction implemented in the historical processing assumed constant spectral degradation (gray assumption)
- However, recent development from analysis of CERES data indicates that transmissivity of shorter wavelength degrades faster suggesting a need for spectrally dependent degradation correction

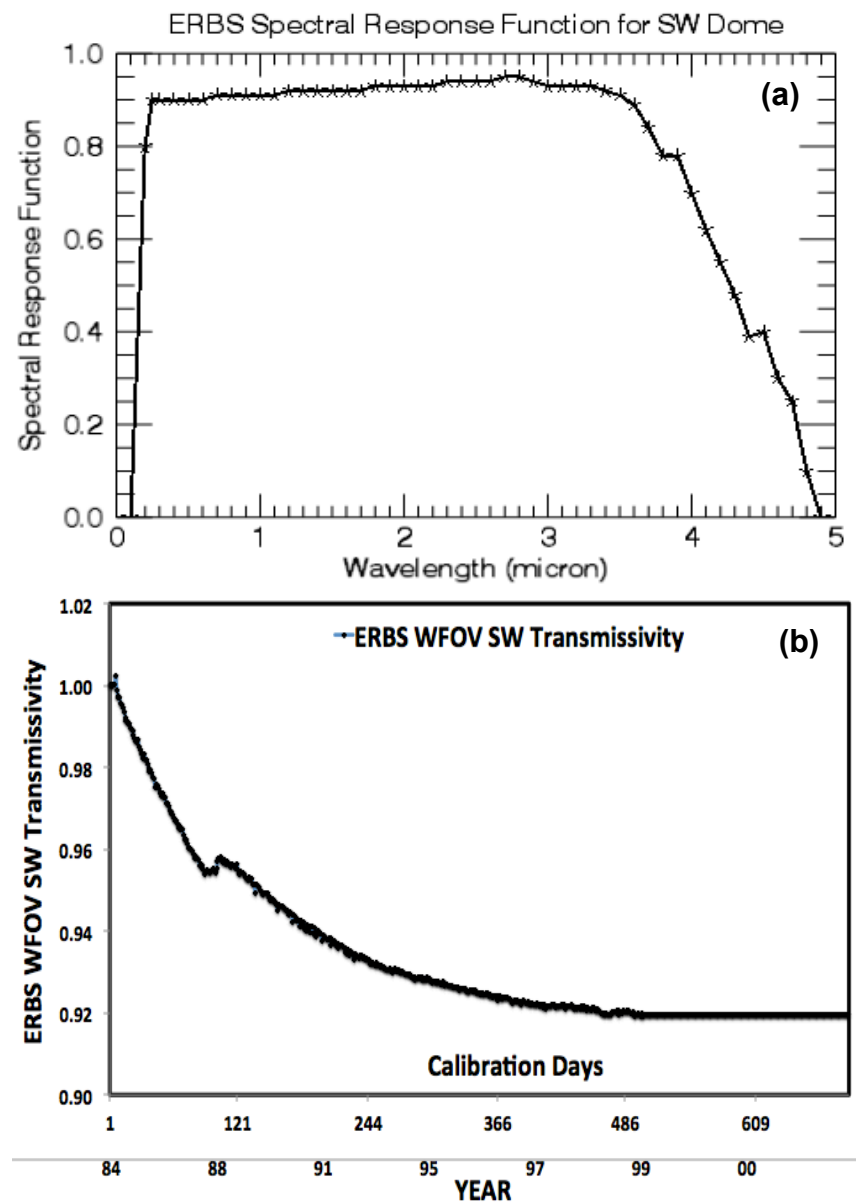


Fig. 1. **(a)** ERBS SW DOME Spectral Response Function
(b) Time Series of ERBS SW DOME Transmission

Motivations

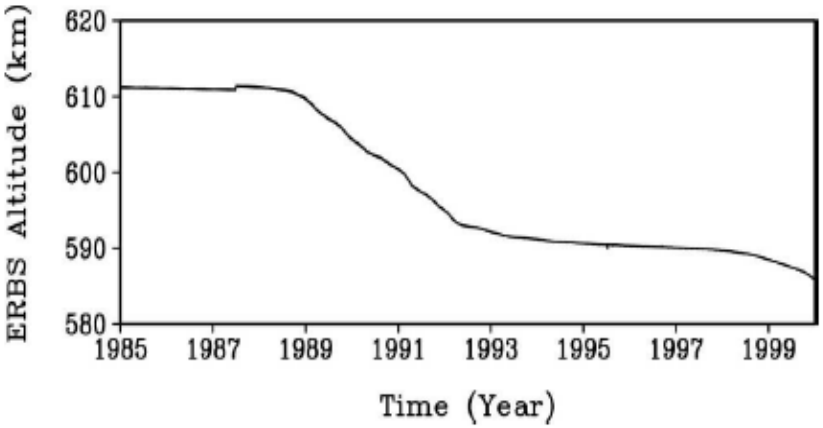


Fig. 2. Time Series of ERBS altitude (km) above sea level

- **Both Fig 2 and Fig 3 are extracted from Wong et. al. 2005**
  - Fig 2 shows that the ERBS altitude changes over time
  - Fig 3 shows an upward trend in the ERBS WFOV nonscanner day-minus longwave flux

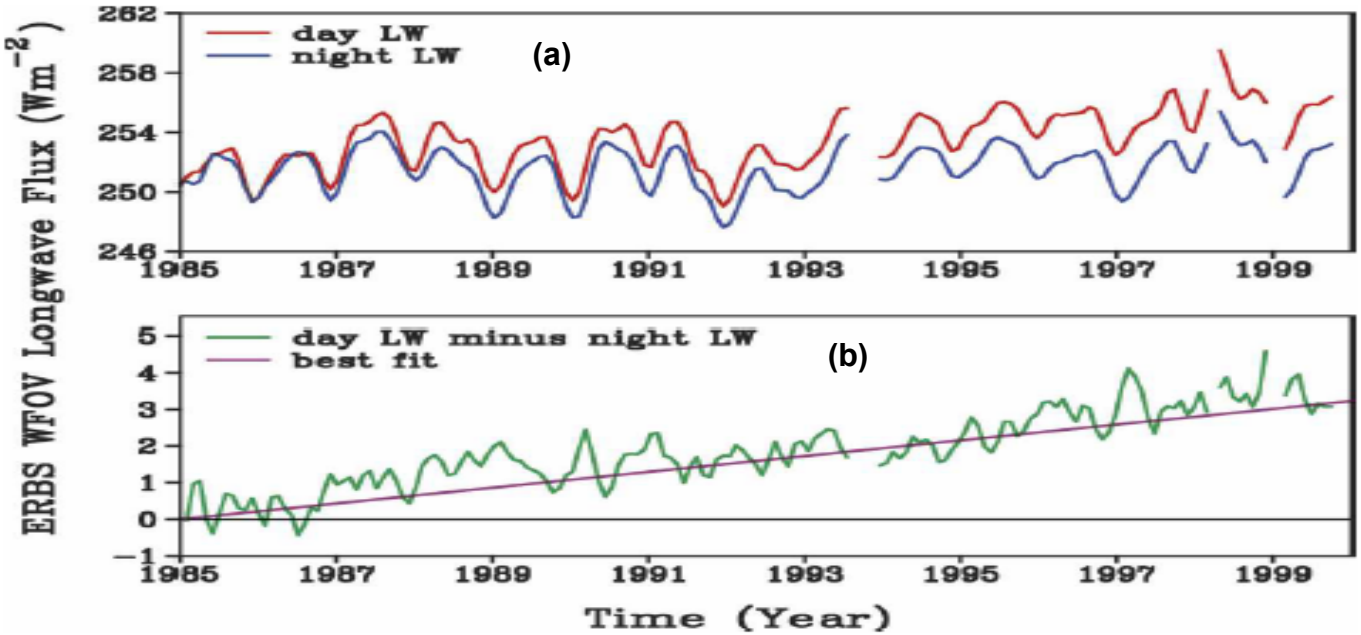


Fig. 3. Time series of ERBS WFOV nonscanner Edition3 tropical mean (20N to 20S) (a) daytime, nighttime (red, blue) longwave flux (red), and (b) day-minus-night longwave flux differences (green)

T Wong et. al, 2005, *Reexamination of the Observed Decadal Variability of the Earth Radiation Budget Using Altitude-Corrected ERBE/ERBS Nonscanner WFOV Data,* Journal of Climate**, 19, 4028-4040**

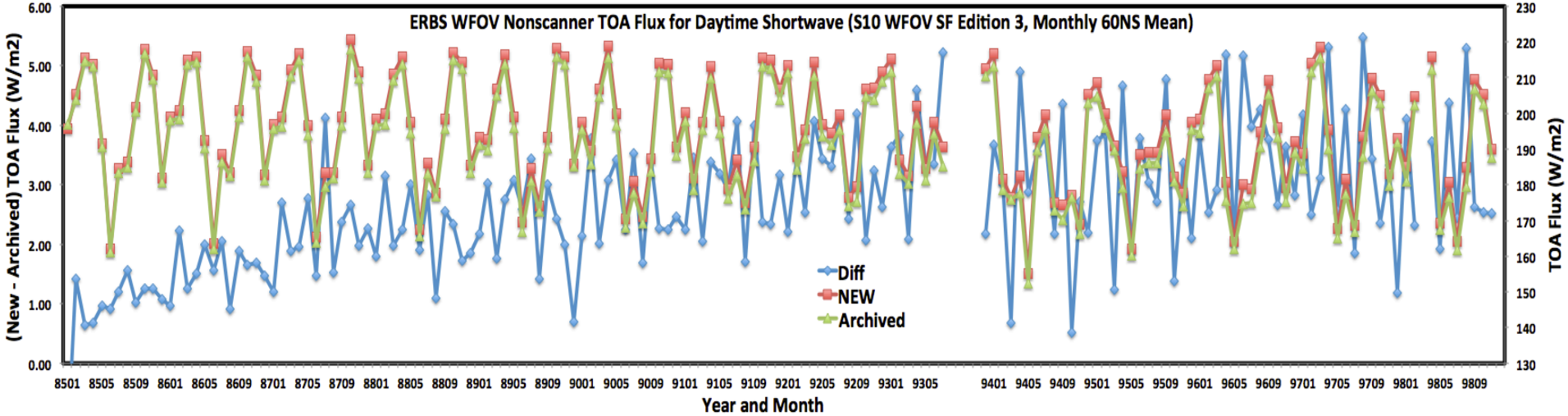
Results and Validation

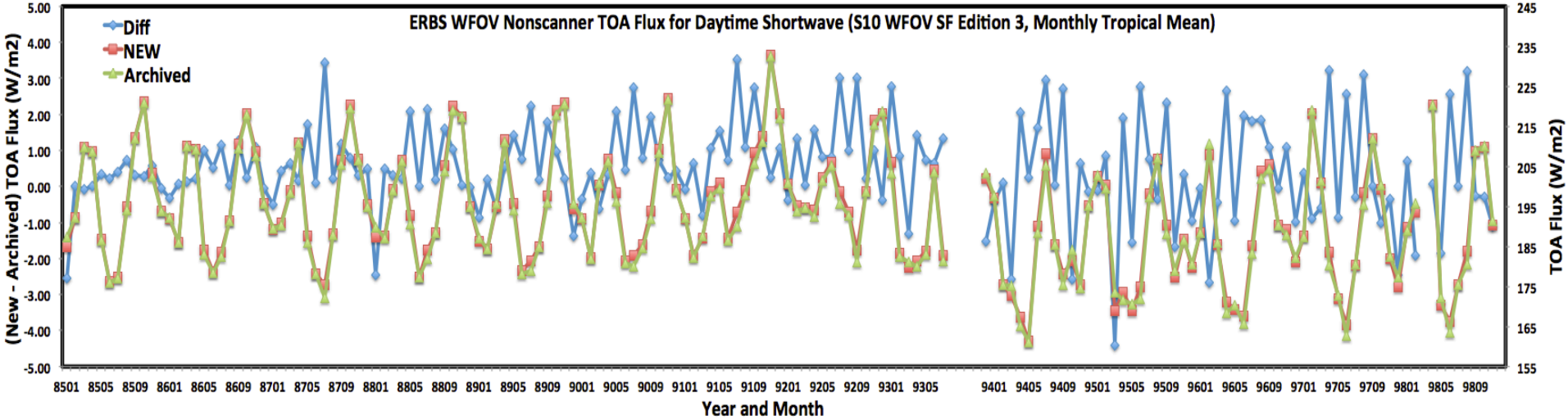
ERBS S10 (Monthly Averaged, (TISA))

- Archived S10 Edition3 (Processed on SUN-Fortran)
  - No spectral filtering but altitude-corrected
- S10 Edition3_Rev1
  - Users will need to apply the Rev1 revision adjustments to the archived Edition3 data to create the Edition3_Rev1 dataset.
- Reprocessed S10
  - Spectral filtering as well as altitude correction applied

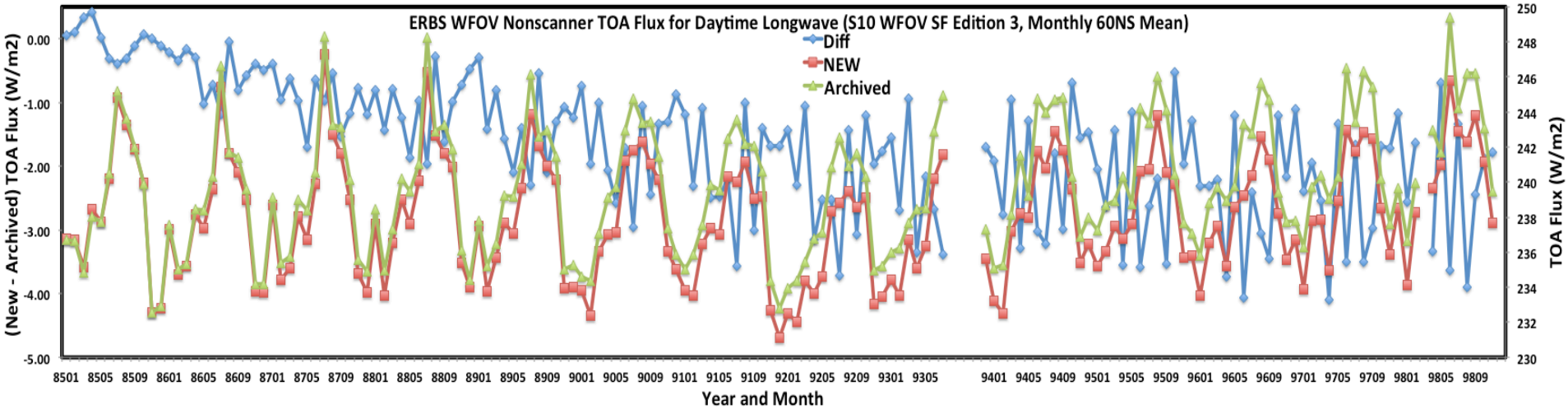
- ERBS S10 (Monthly Averaged – TISA)
  - Instantaneous Grid Box Data (IGB) (S10 Edition3)
  - Monthly Mean (MM) (S10 Edition3_Rev1)

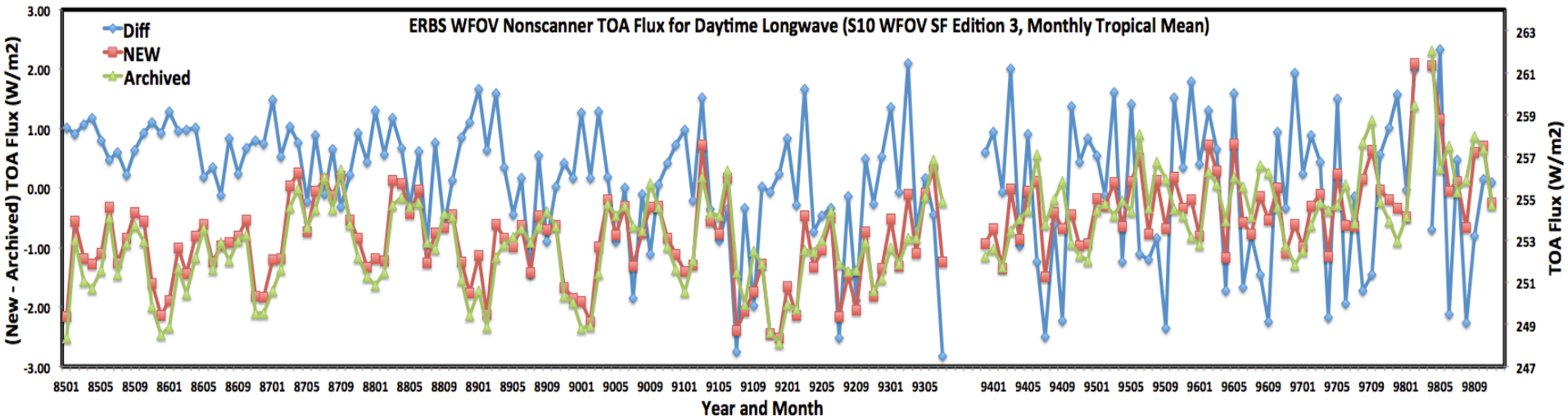
Monthly Mean of Daytime SW Flux - IGB



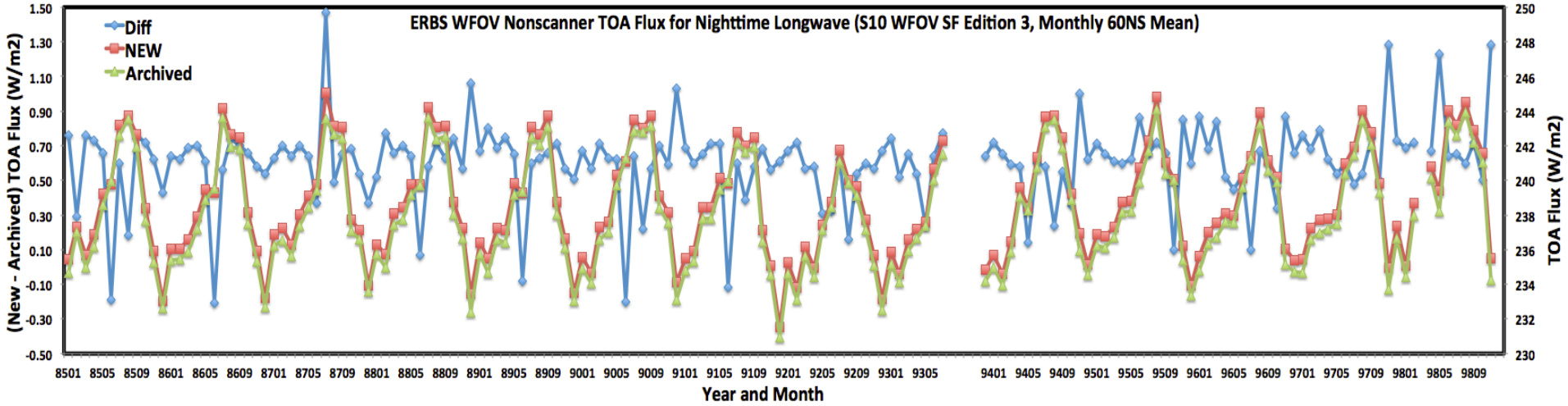


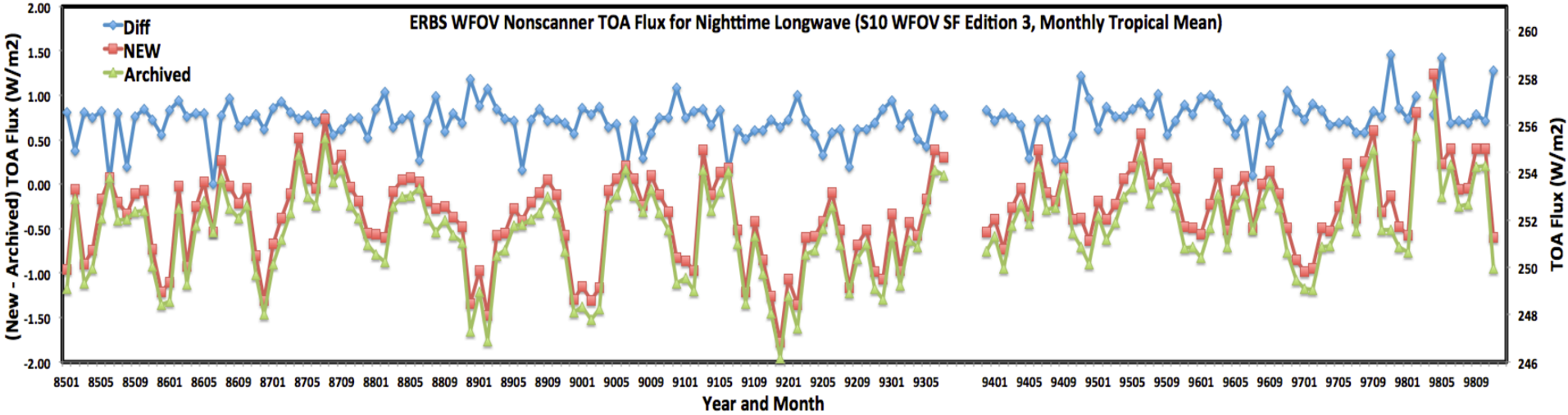
Monthly Mean of Daytime LW Flux - IGB



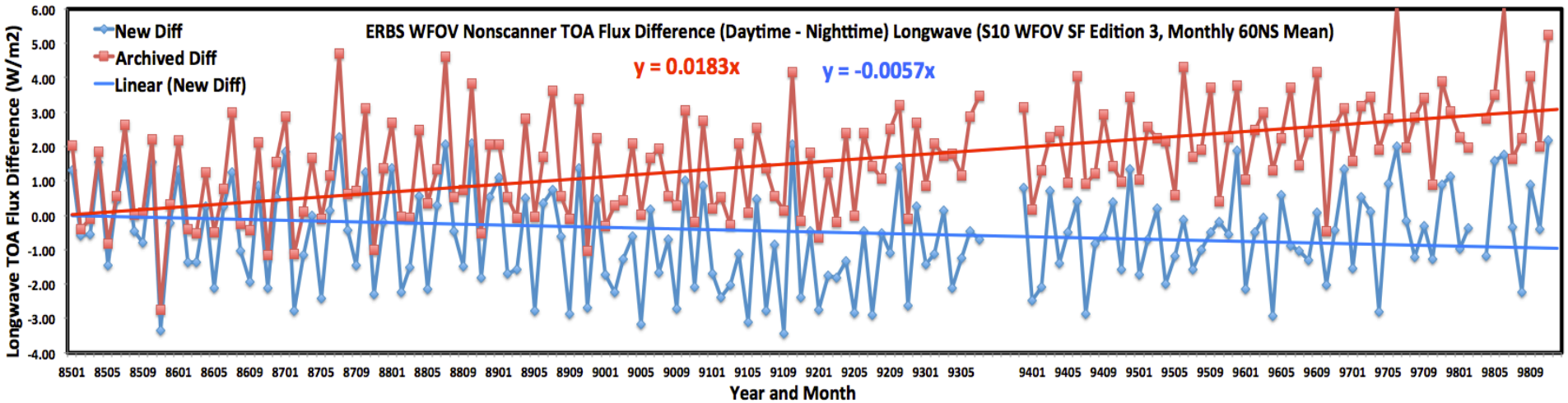


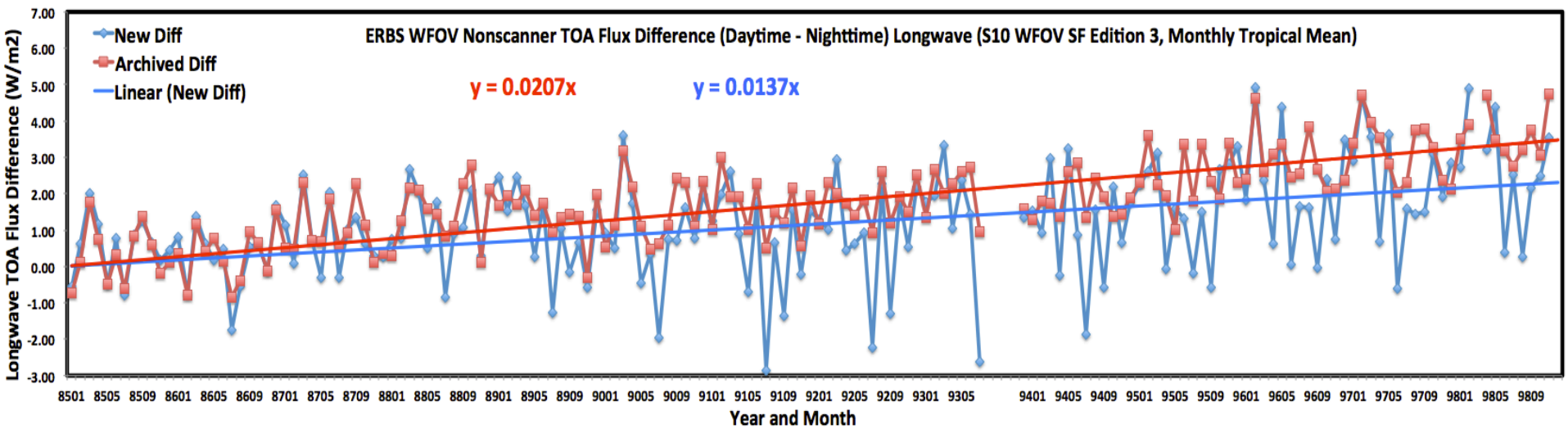
Monthly Mean of Nighttime LW Flux - IGB



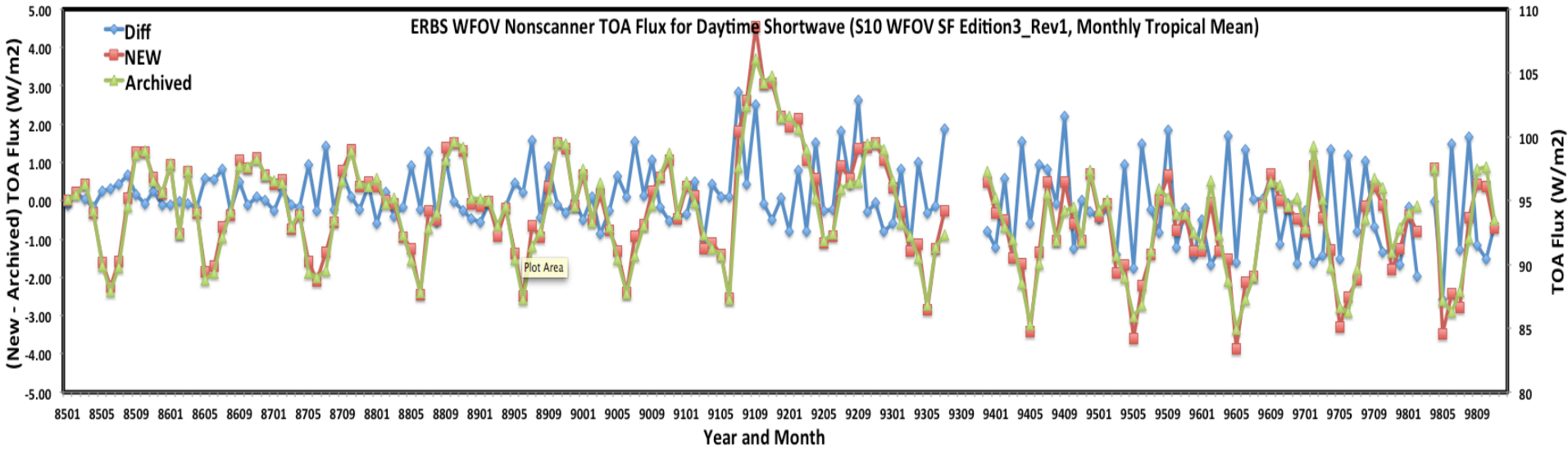


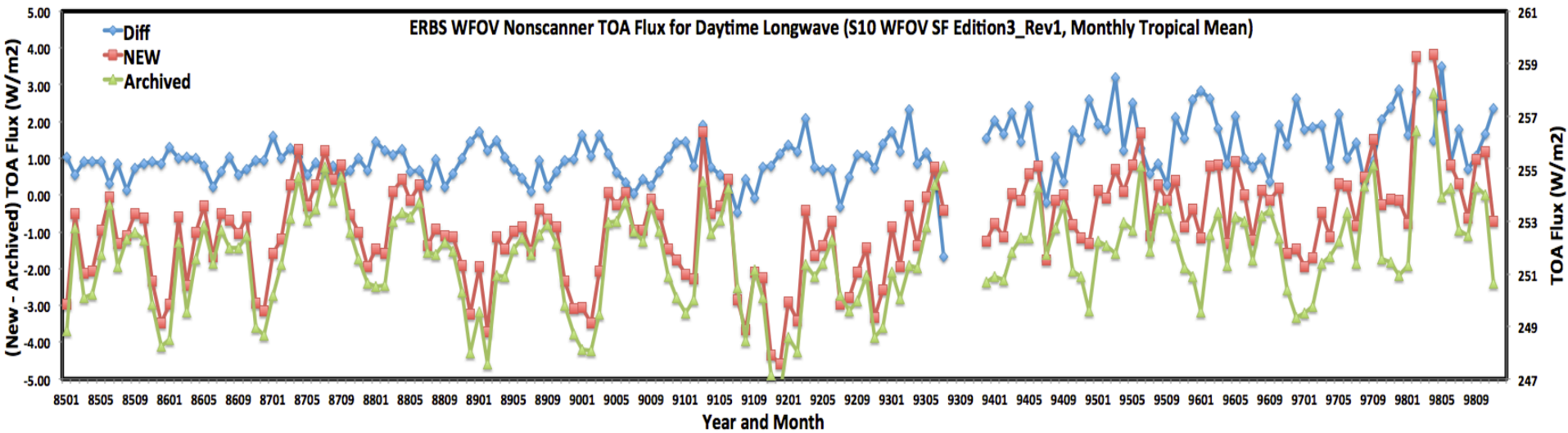
Monthly Mean of Day-minus-Night LW Flux - IGB



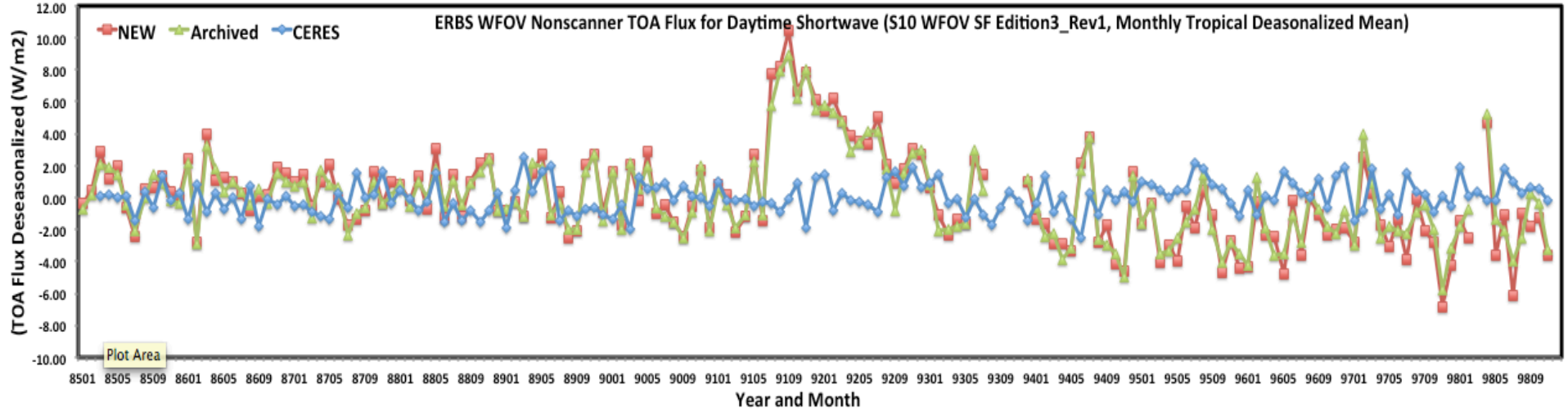


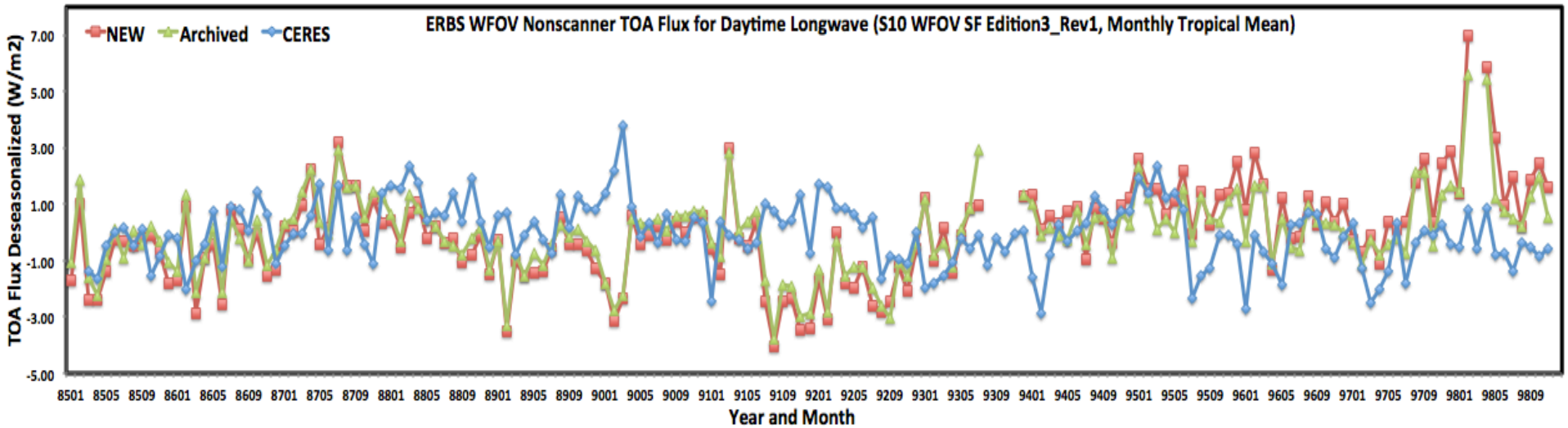
Monthly Mean Flux (Tropical – MM)





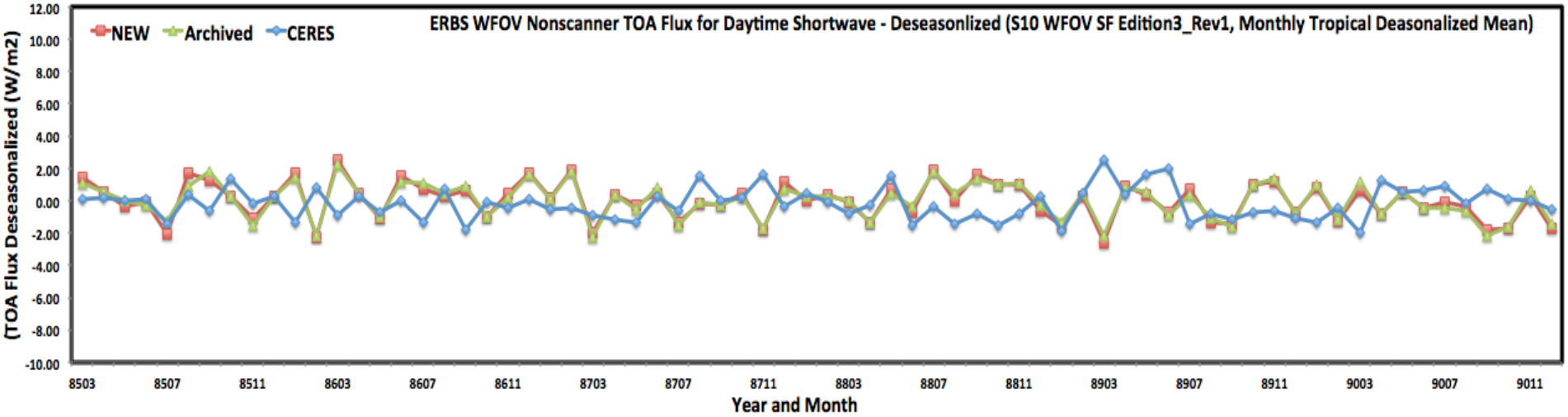
Deseasonalized Monthly Mean Flux (Tropical – MM)

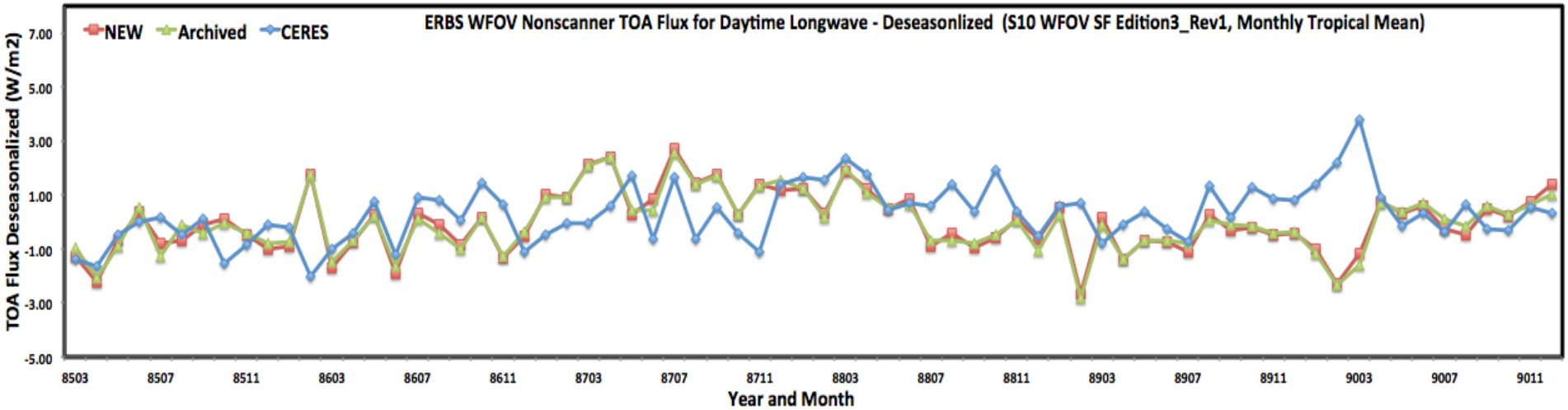




Standard Deviations	NEW	Archived	CERES
Shortwave	2.82	2.58	0.98
Longwave	1.66	1.44	1.10

Deseasonalized Monthly Mean Flux (Tropical – MM)





Standard Deviations	NEW	Archived	CERES
Shortwave	1.16	1.12	0.98
Longwave	1.13	1.12	1.10

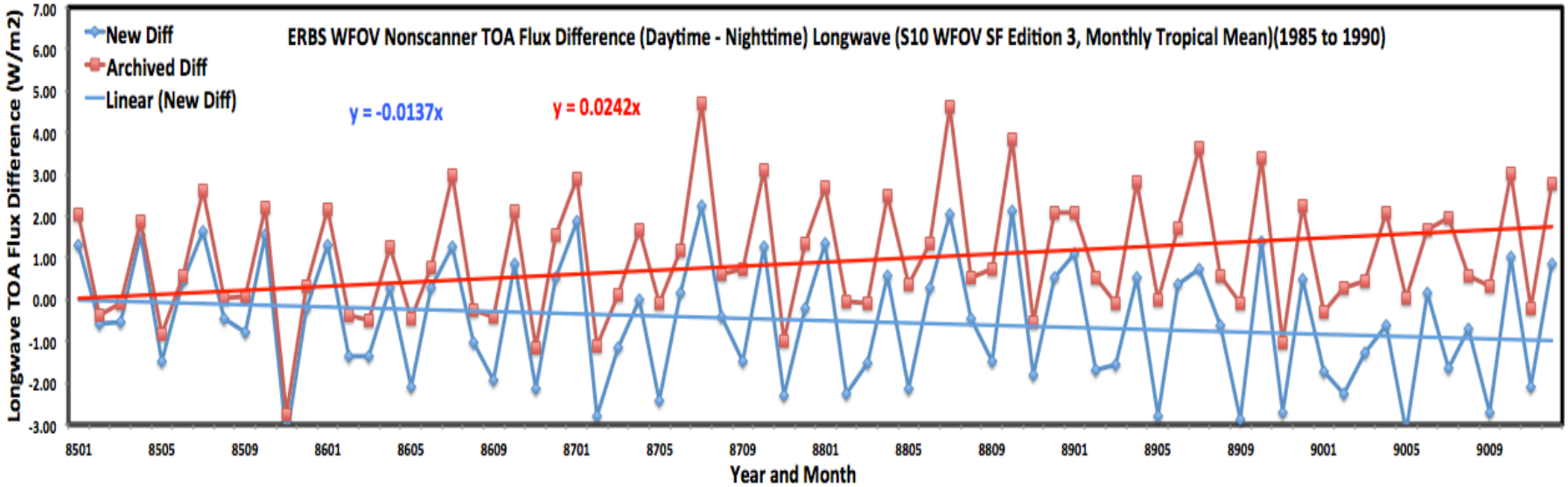
Conclusions

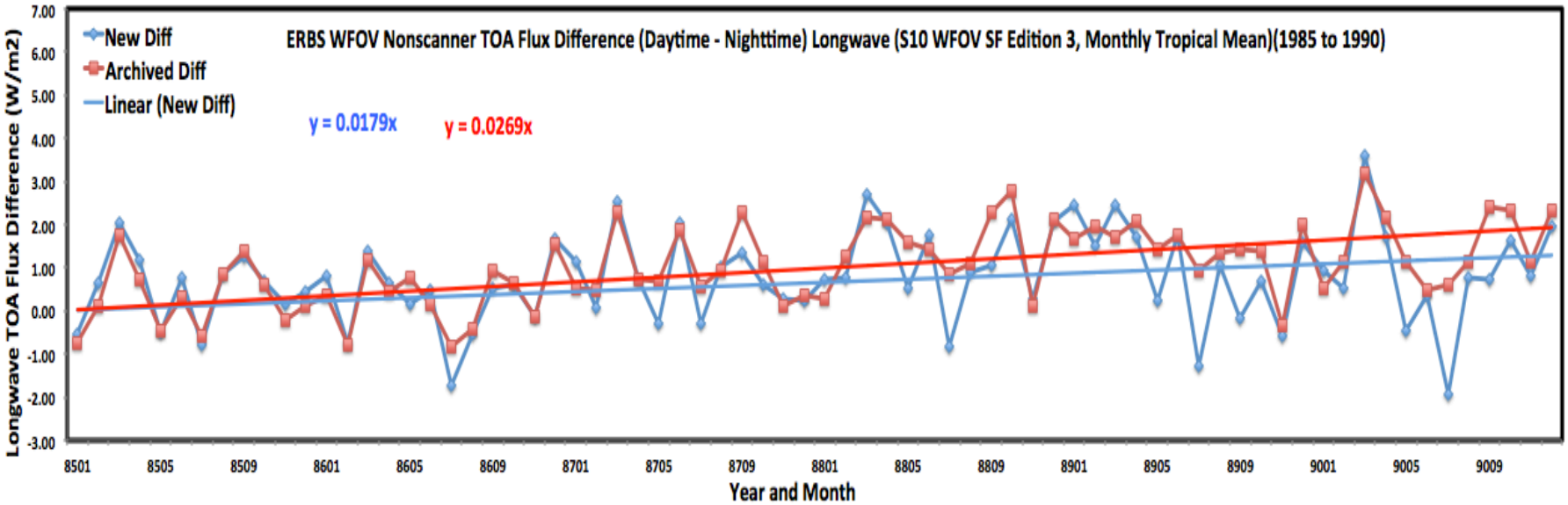
- **For 60 NS, the daytime-minus-nighttime longwave irradiance trend observed in the existing database is no longer seen after implementing the spectral unfiltering.**
- **The trend appears to still occur over the 20 NS though it is less compared to that in existing products.**
- **The technique to perform spectral unfiltering with time dependent spectral response appears promising for ERBE WFOV nonscanner as well.**

Future Plans

- **The occurrence of constant transmissivity after 1994 for ERBE WFOV SW nonscanner needs more investigation.**
- **Apply this technique to NOAA-9 and NOAA-10.**

Monthly Mean of Day-minus-Night LW Flux - IGB





Methodologies

- Following equation is used to model the spectral dependent degradation shown in Fig 4.a

$$srf_n(\lambda) = (1 - \beta * \exp(-\alpha * \lambda)) * srf_o(\lambda)$$

α = Degradation factor
β = 1

- The model is developed considering relatively higher degradation in the shorter wavelength. In addition, lower value α of corresponds to high degradation (red curve in Fig 4.a) and vice versa.

- Fig 4.b shows the time series of estimates of α. These α values are estimated based on the ERBS WFOV nonscanner SW dome transmission shown in Fig 3.b.

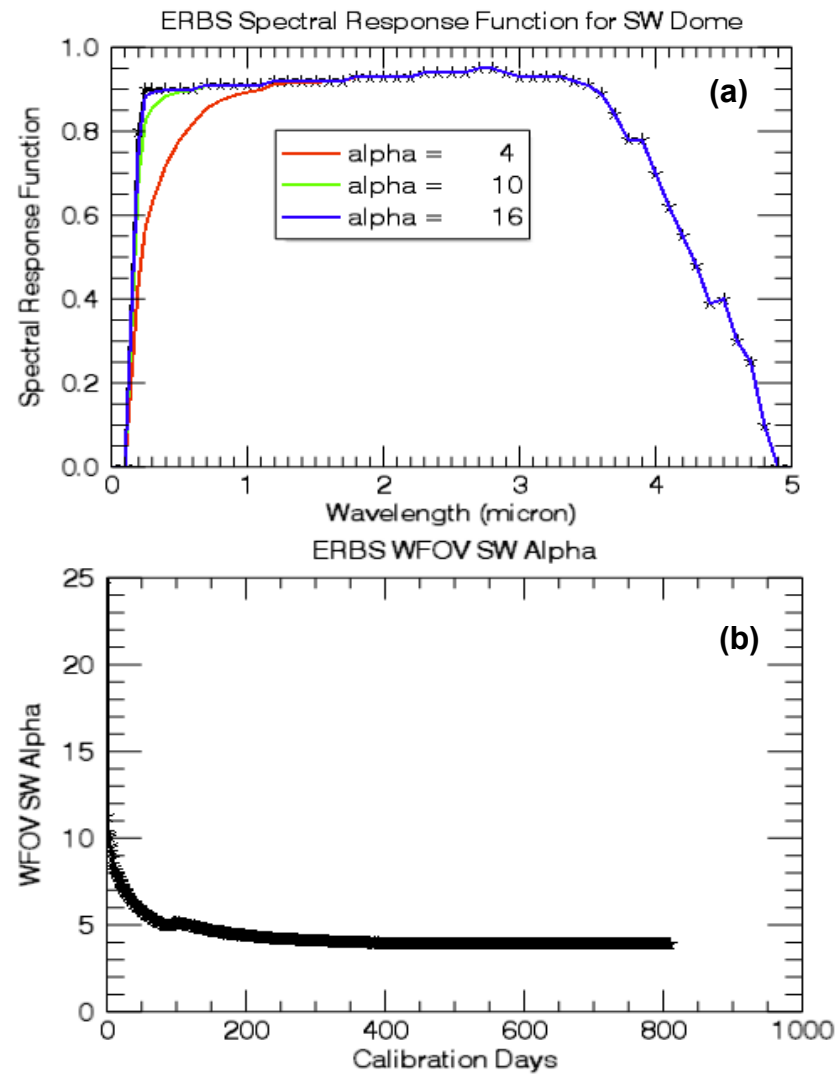


Fig. 4. **(a)** ERBS SW DOME Spectral Response Function
(b) Time Series of α for the given dome transmission

- Separate spectral response function is derived for each calibration day based on α by using the model equation shown above.

Methodologies

- Determine scene id and cloud fractions co-located with the WFOV nonscanner footprint
  - 1^0 by 1^0 fixed scene id
  - Cloud fractions provided by ISCCP
- Use modtran database in combination with time-dependent spectral response functions to derive sets of filtered and unfiltered radiances over various angles, surface types, and cloud fraction.

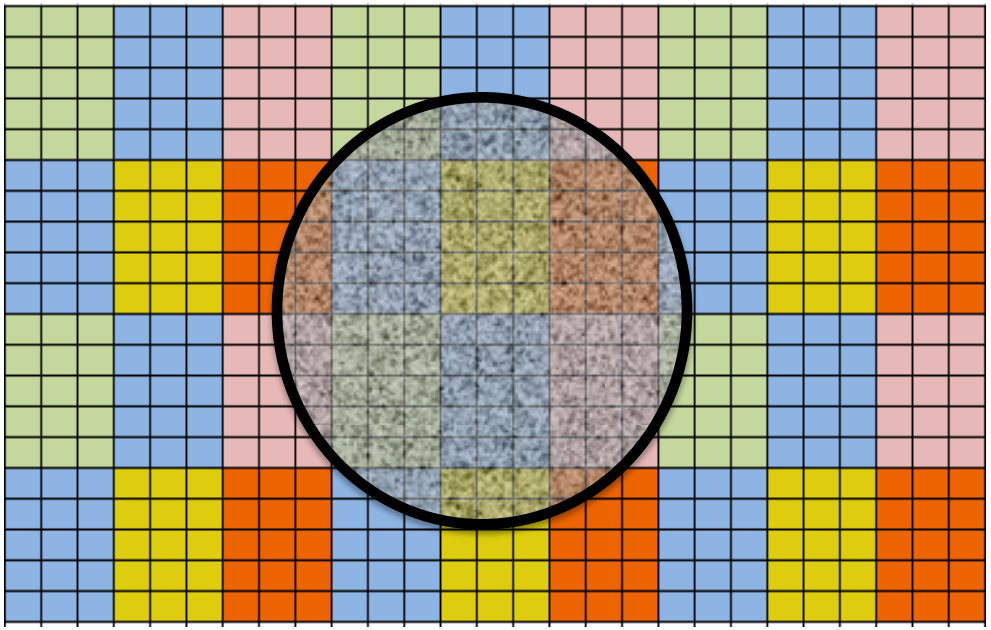


Fig. 5. Colocation of WFOV nonscanner footprint over 1^0 by 1^0 fixed scene id and cloud fraction provided by ISCCP

- Derive filter and unfiltered radiances for each angles at the 1^0 by 1^0 grid co-located with WFOV nonscanner footprints based on scene id and cloud fraction

- Integrate filtered and unfiltered radiances over all angles and compute the ratio of unfiltered to filtered radiance. This ratio is the spectral unfiltering coefficients for that footprints.

Results and Validation

ERBS S7 (Instantaneous, Footprint Level Data)

- Archived S7 (Processed on SUN-Fortran)
  - No spectral filtering and No altitude correction
- Reprocessed S7
  - Spectral filtering as well as altitude correction applied

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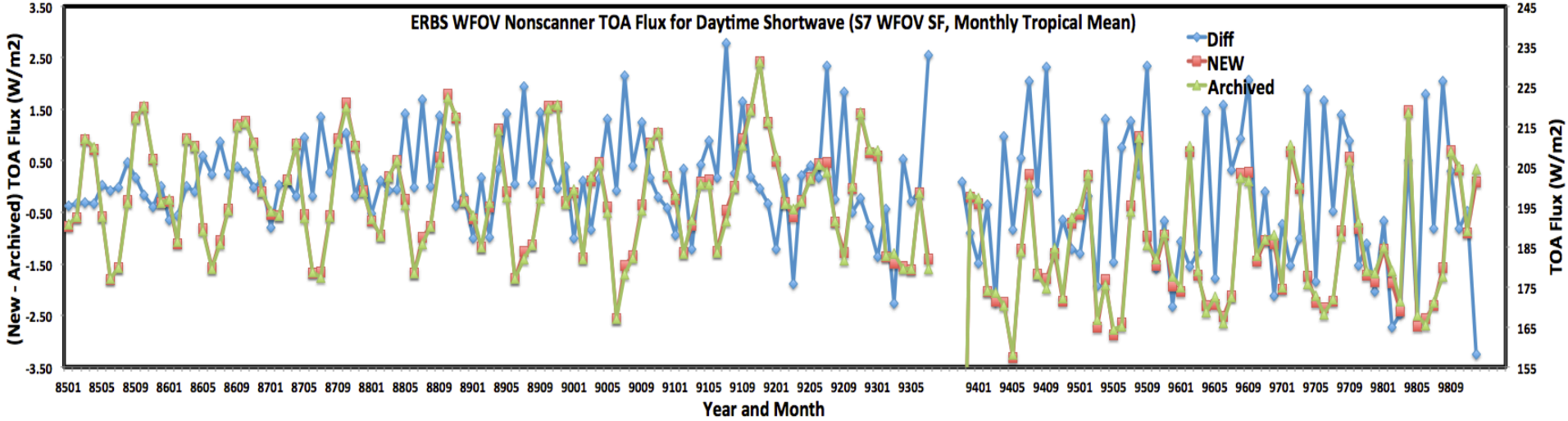
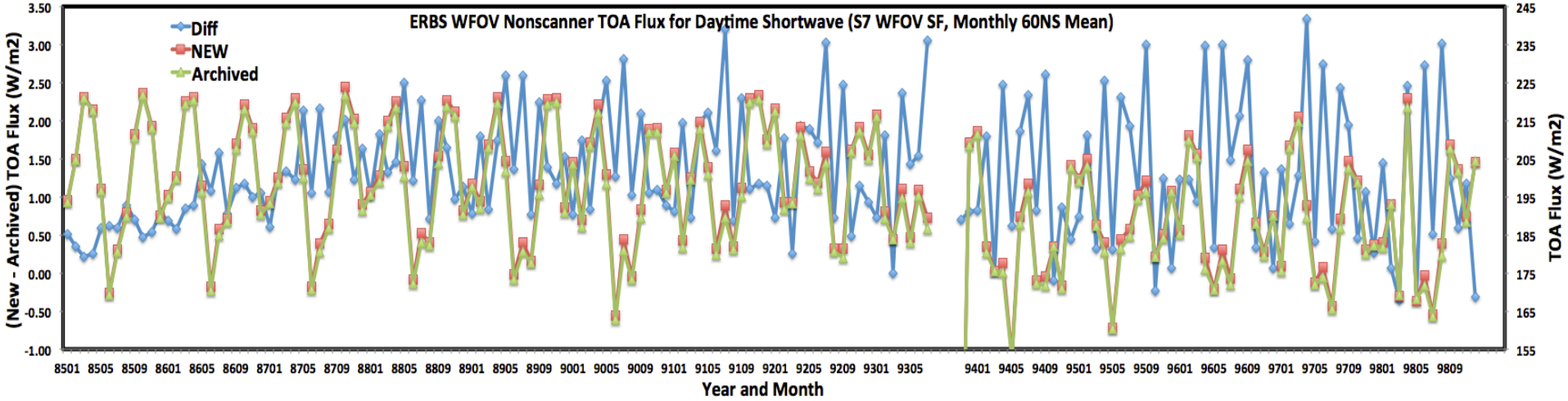
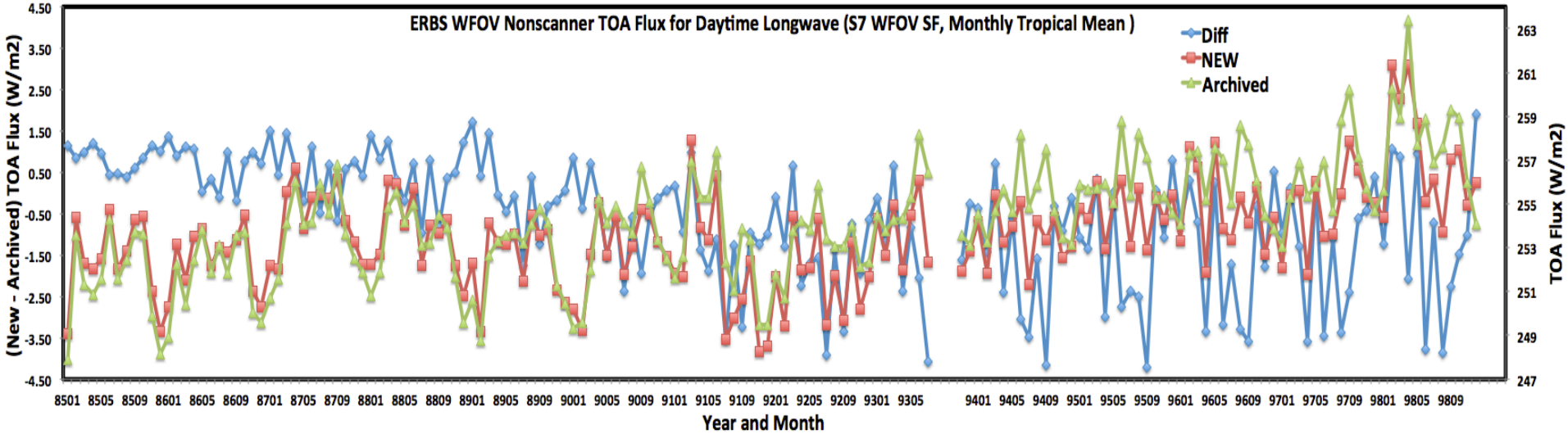
CERES_EBAF-TOA_Ed2.8_AreaAverageTimeSeries_deseasonalized_TOA_Flux

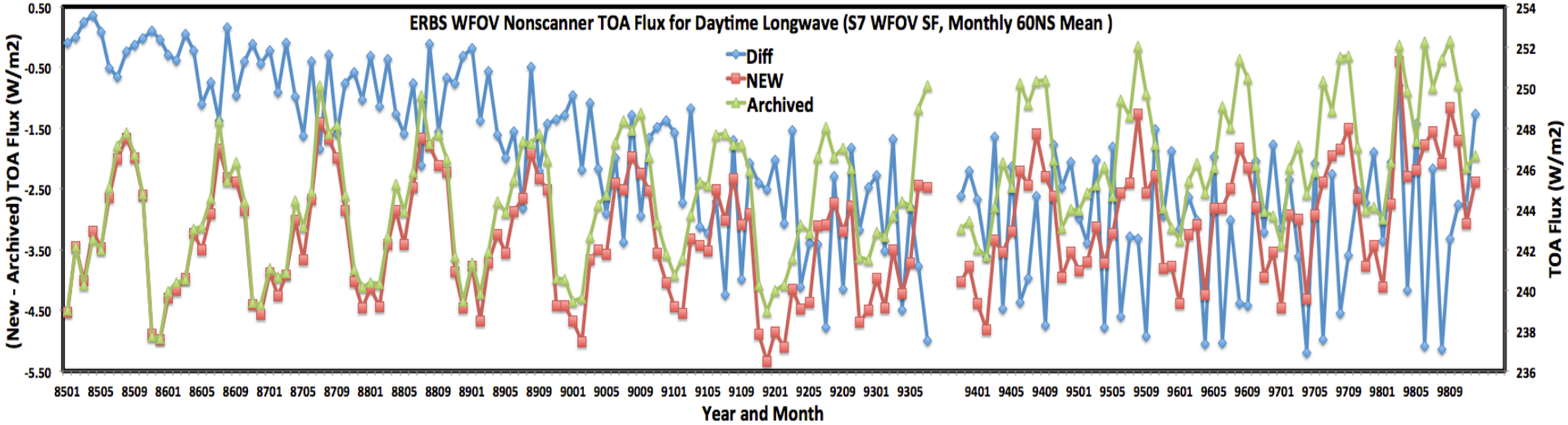
Monthly Mean of Daytime SW Flux (Matched Footprints)



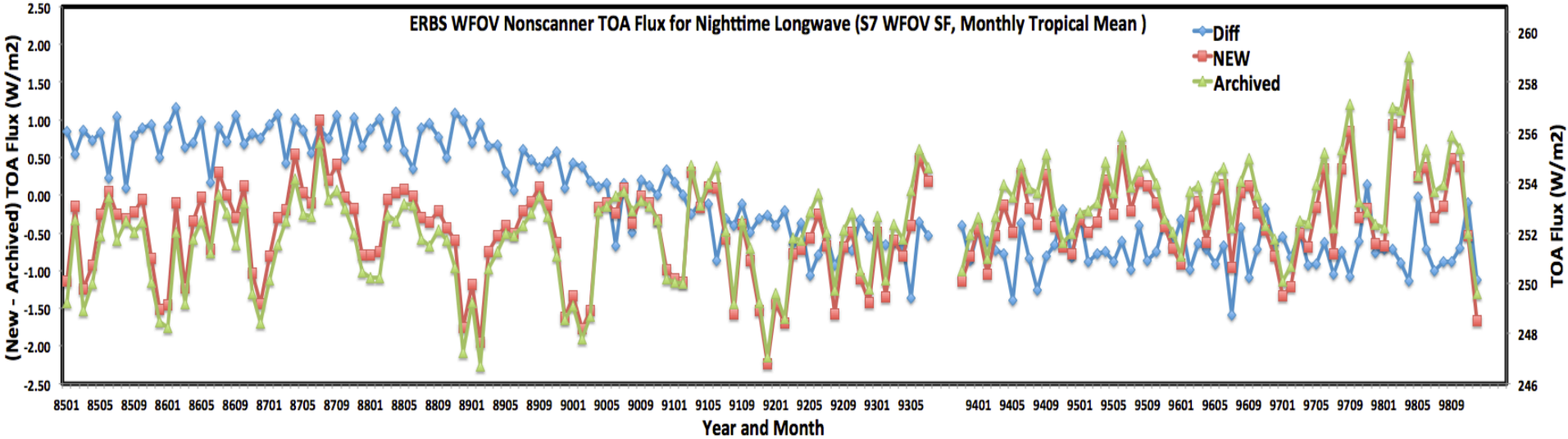


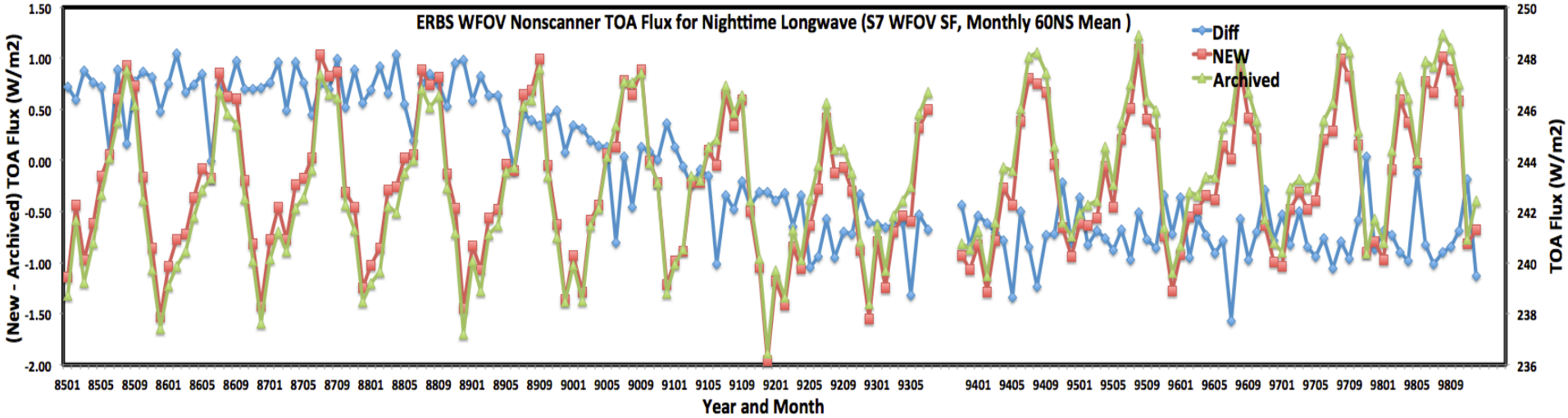
Monthly Mean of Daytime LW Flux (Matched Footprints)





Monthly Mean of Nighttime LW Flux (Matched Footprints)





Monthly Mean of Day-Minus-Night LW Flux (Matched Footprints)