



NASA LaRC Spectral Band Adjustment Factor (SBAF) Online Calculation Tool Update

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GSICS Annual Meeting 2019

4 - 8 March 2019

Frascati, Italy

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Outline

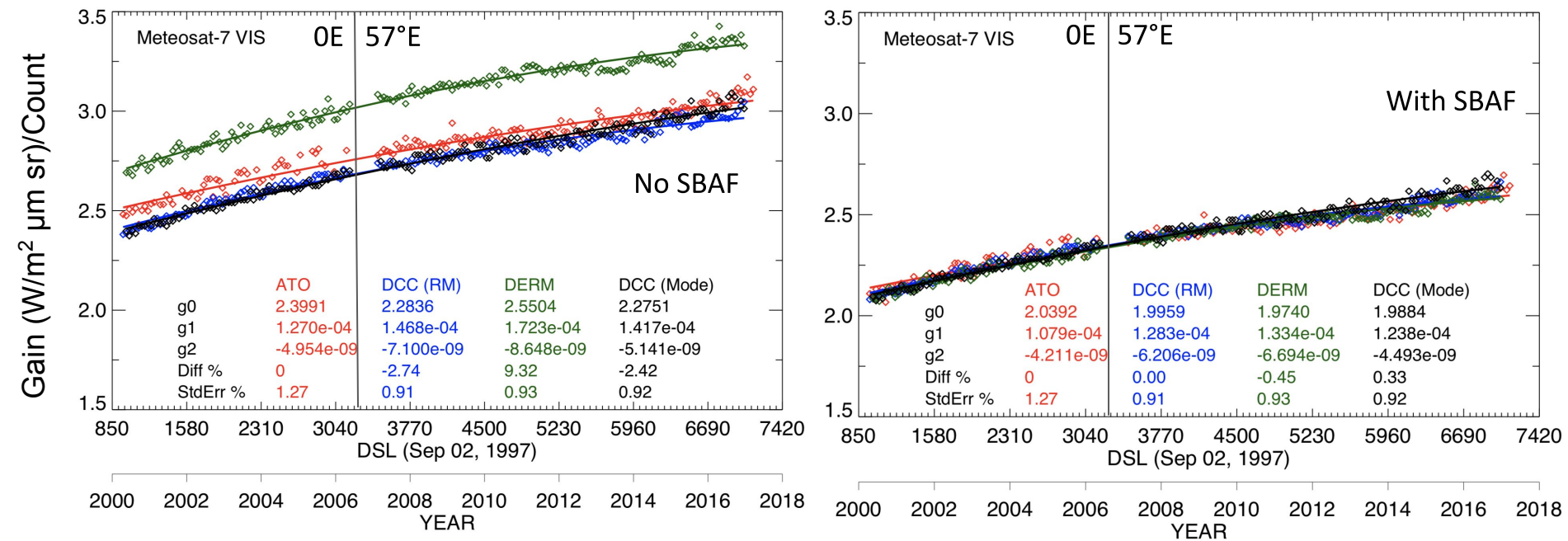
- Spectral Band Adjustment Factor (SBAF) Review
 - importance, theory, and applications
- NASA Langley SBAF and Spectral Plotting Tools
 - Key features and new developments
 - Double Spectral Filtering Highlight
- Spectral Filtering Use-case
- Extreme use case of SBAF tool
 - OSIRIS-REx to EPIC inter-calibration
- Summary



SBAF review: Why SBAF is important?

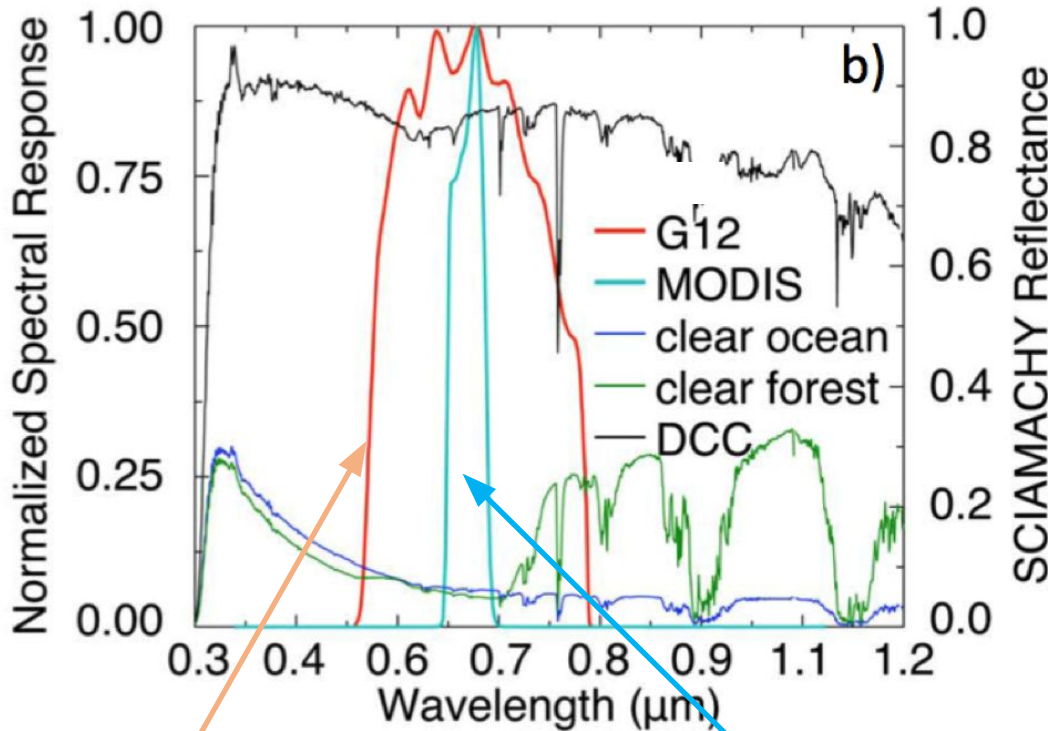
- Inter-calibration practices utilize different Earth scene types
- Reference and target sensors exhibit spectral differences
- Inter-calibration bias has two components: *absolute radiometric bias* and *spectrally induced bias*
- Accurate SBAF is required to quantify absolute radiometric bias

Meteosat-7 VIS calibration referenced to Aqua-MODIS C6.1 Band 1





SBAF calculation



Every Earth scene has a unique spectral signature

$$L_{p,tar} = \frac{\sum_n^{nbins} L_{s,n} \times RSR_{tar,n} \times (\lambda_n - \lambda_{n-1})}{\sum_n^{nbins} RSR_{tar,n} \times (\lambda_n - \lambda_{n-1})}$$

$$L_{p,ref} = \frac{\sum_n^{nbins} L_{s,n} \times RSR_{ref,n} \times (\lambda_n - \lambda_{n-1})}{\sum_n^{nbins} RSR_{ref,n} \times (\lambda_n - \lambda_{n-1})}$$

Derive **reference-** and **target-**sensor *pseudo* radiance/reflectance (L_p) via hyperspectral convolution over each RSR to account for band difference/out-of-band absorption



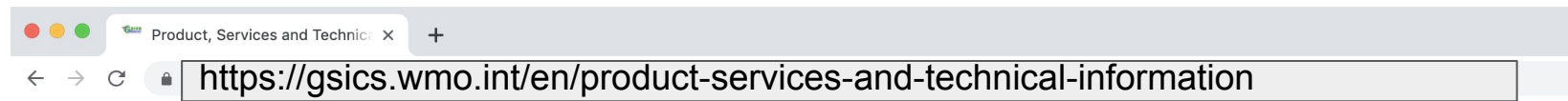
NASA LaRC SBAF tool features

- Based on actual hyperspectral satellite measurements taken from TOA
 - SCIAMACHY, Hyperion, GOME-2
- Over 30 predefined Earth scene selection (deserts, polar ice, DCC, all-sky tropical ocean, etc)
- Data subsetting control options
 - Unit : radiance and reflectance
 - Fit (SBAF) type : forced-fit, linear, 2nd and 3rd order regression
 - Angle allowance
 - Precipitable water allowance
 - Outlier cutoff
 - Fit/plot limits
 - Domain/time/season
- Double spectral filtering (**new**)

Special thanks to ESA, EUMETSAT, USGS, and NASA teams for help in obtaining, reading, and correcting their hyperspectral data.



NASA LaRC Calibration Webpage



Global Space-based Inter-Calibration System

An international collaboration to monitor, improve and



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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Basic Documents

NASA URL: https://cloudsway2.larc.nasa.gov/cgi-bin/site/showdoc?mnemonic=SAT_CALIB_USER

- + NASA Home
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 - + Science Directorate
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 - + References
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SEARCH LANGLEY + GO

NASA Fact

The Dryden Flight Research Center (DFRC) is NASA's center for aeronautical flight research and atmospheric flight operations. DFRC is chartered to research, develop, verify, and transfer advanced aeronautics, space and related technologies. It also serves as a backup landing site for the Space Shuttle and a facility to test and validate design concepts and systems used in development and operation of the Orbiters.

+ More NASA facts...

Satellite Calibration Page

Calibration Coefficients

- AVHRR Calibration Coefficients
- GEO Calibration Coefficients
 - Pre-CERES_1.0 Link
 - Pre-CERES_2.0 Link
 - CERES-Ed4
 - CERES-Updated-Realtime

Imager Scaling Factors

- Terra to Aqua MODIS Scaling Factors (VIS/NIR/SWIR)
- Terra to Aqua MODIS Scaling Factors (IR)
- Terra MODIS C6 to C5 Scaling Factors
- Aqua MODIS C6 to C5 Scaling Factors
- Terra MODIS C6 to C6.1 Scaling Factors
- Aqua MODIS C6 to C6.1 Scaling Factors
- NPP VIIRS V001 to V03110 Scaling Factors
- Terra MODIS C6.1 to C5 Scaling Factors
- Aqua MODIS C6.1 to C5 Scaling Factors

Imager Stability Plots

- Terra and Aqua MODIS Stability Plots

Spectral Band Adjustment Factors (SBAF)

- SCIAMACHY
- HYPERION
- GOME-2
- IASI
- AIRS

Spectral Plotting Tools

- SCIAMACHY
- HYPERION
- GOME-2

Tools

- Satellite Spectral Response Function (SRF) comparison tool
- Satellite Visible Band Solar Constant Comparison Tool
- IR Brightness Temperature Correction Coefficients for Conversion from Radiances

Publications



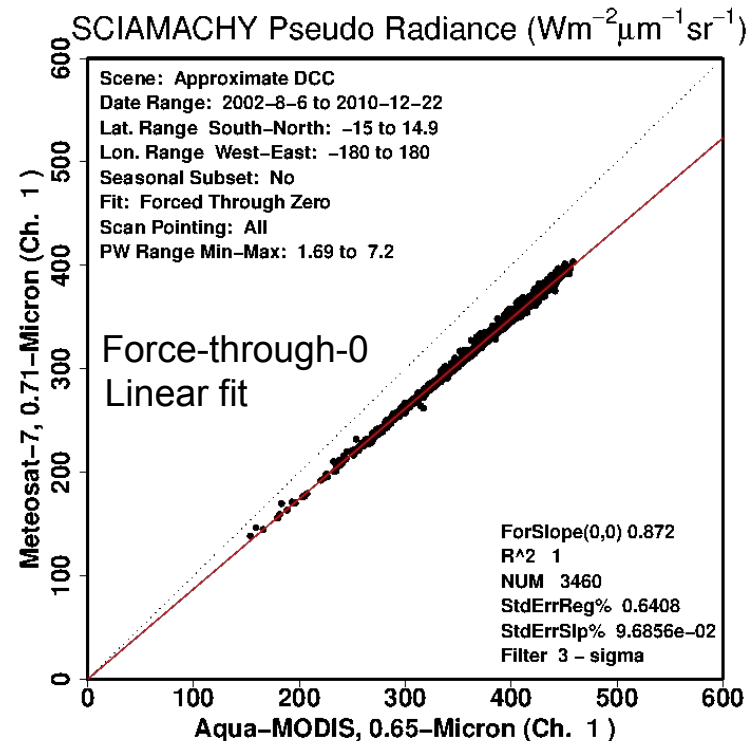
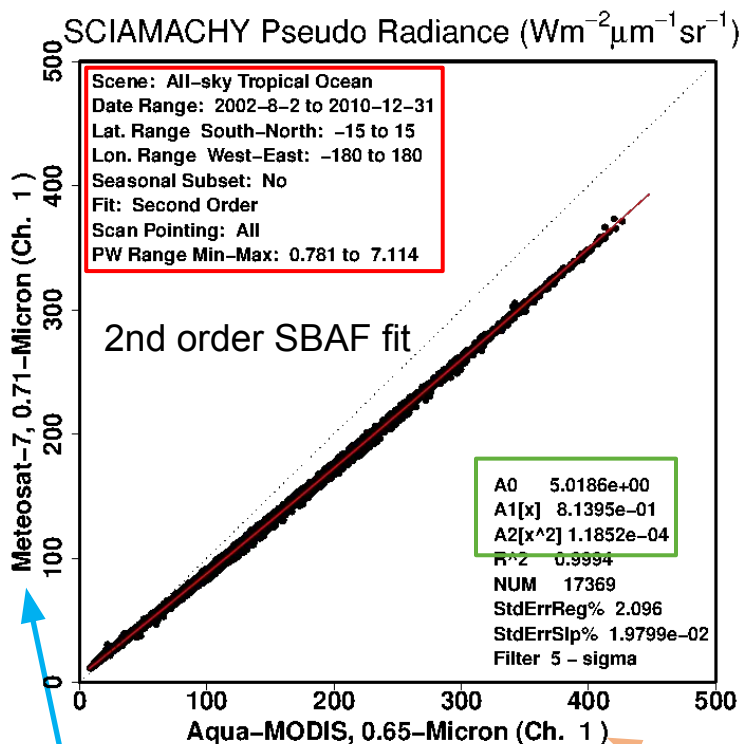
SCIAMACHY SBAF Calculation tool input



Earth Spectra (SCIAMACHY)	Reference (X-axis) SRF	Units	Regression/Subsetting/Plotting/Spatial/Date Controls
<ul style="list-style-type: none"> Arabia 1 Arabia 2 Badain Jaran Desert Dome C Greenland Central Greenland South Libya 1 Libyan Desert Niger 1 Sonoran Desert Uyuni Desert All-sky Tropical Land All-sky Tropical Ocean Clear-sky Tropical Ocean Marine Water Cloud Marine Ice Cloud Approximate DCC Precise DCC North Pole South Pole Global Evergreen Needleleaf Forest Evergreen Broadleaf Forest Deciduous Needleleaf Forest Deciduous Broadleaf Forest Mixed Forests Closed Shrublands Open Shrublands Woody Savannas Savannas Grasslands Permanent Wetlands Croplands Cropland/Natural Vegetation Barren 	<ul style="list-style-type: none"> ATS-2 Aqua-MODIS Aqua-MODIS-MCST CERES-BB COMS-1 DSCOVR-EPIC EO-1-ALI FY-2C FY-2D FY-2E FY-4 GMS-1 GMS-2 GMS-3 <p>Central Wavelength: 0.65 Micron (1)</p> <p>Target (Y-axis) SRF</p> <ul style="list-style-type: none"> GOES-11 GOES-12 GOES-13 GOES-14 GOES-15 GOES-16 GOES-17 GOES-5 GOES-6 GOES-7 GOES-8 GOES-9 Himawari-8-AHI Himawari-9-AHI <p>Central Wavelength: 0.63 Micron (1)</p>	<ul style="list-style-type: none"> Pseudo Radiance Pseudo Scaled Radiance <p>Spectral Filter 1</p> <p>Min μm 1: 0.24 Max μm 1: 1.75</p> <p>Min Rad 1: 0.0 Max Rad 1: 1000.0</p> <p>Min Ref 1: 0.0 Max Ref 1: 1.0</p> <p>Spectral Filter 2</p> <p>Min μm 2: 0.24 Max μm 2: 1.75</p> <p>Min Rad 2: 0.0 Max Rad 2: 1000.0</p> <p>Min Ref 2: 0.0 Max Ref 2: 1.0</p>	<p>Force Fit Linear 2nd Order 3rd Order</p> <p>Min AZA: 103.00 Max AZA: 156.40</p> <p>Min SZA: 25.40 Max SZA: 60.90</p> <p>VZA: 0-30</p> <p>Min PW: 0.355 Max PW: 3.106</p> <p>σ-cutoff: 5.</p> <p>Fit Min X: 0. Fit Max X: 1.</p> <p>Plot Min X: 0. Plot Max X: 1.</p> <p>Start: Jun 5 2003 End: Mar 25 2010 Seasonal <input type="checkbox"/></p> <p>Close</p> <p>W -114.5 -114.3 E N 32.20 32.00 S</p> <p>Plot</p>



SBAF calculation example



$$L_{p,tar} = \frac{\sum_n^{nbins} L_{s,n} \times RSR_{tar,n} \times (\lambda_n - \lambda_{n-1})}{\sum_n^{nbins} RSR_{tar,n} \times (\lambda_n - \lambda_{n-1})}$$

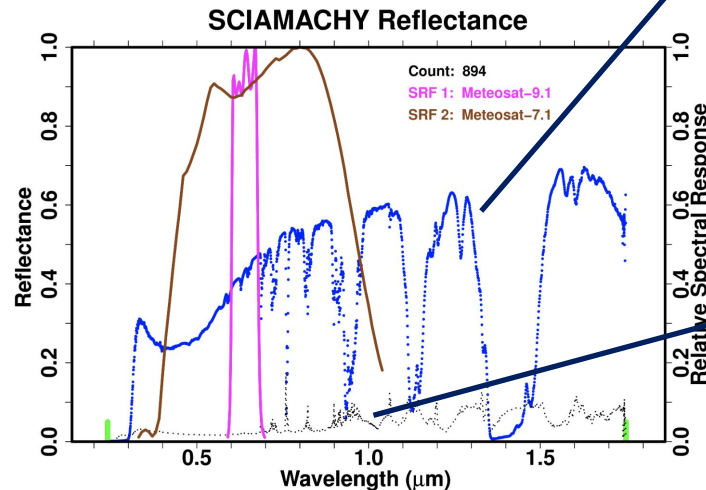
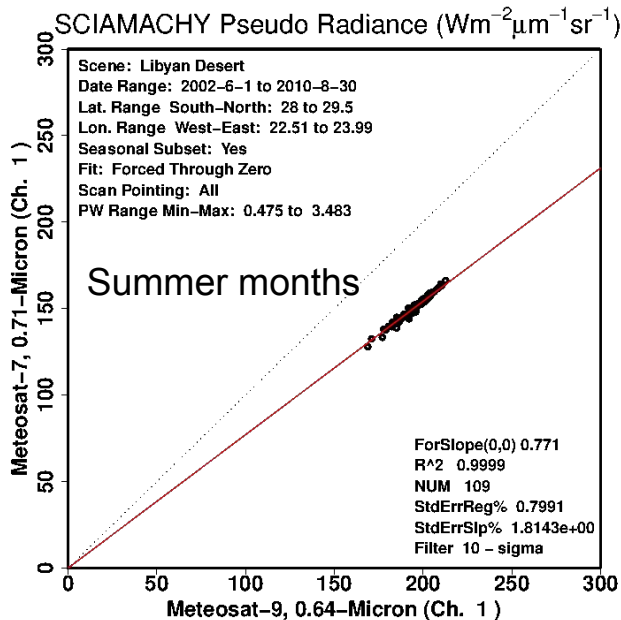
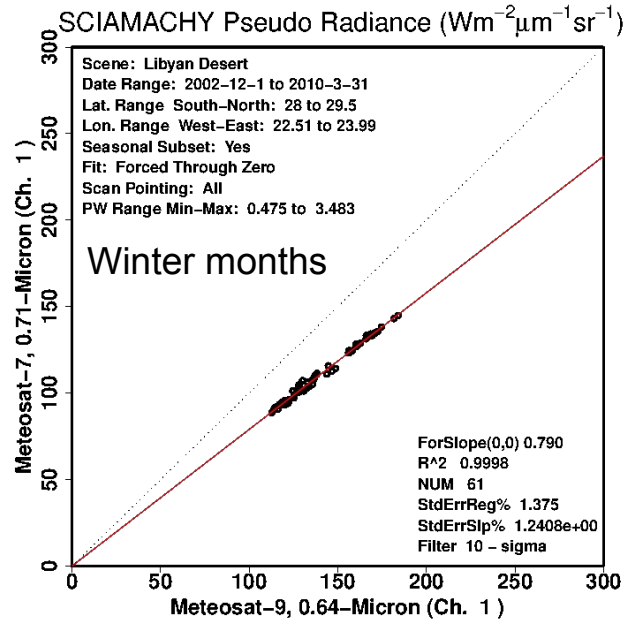
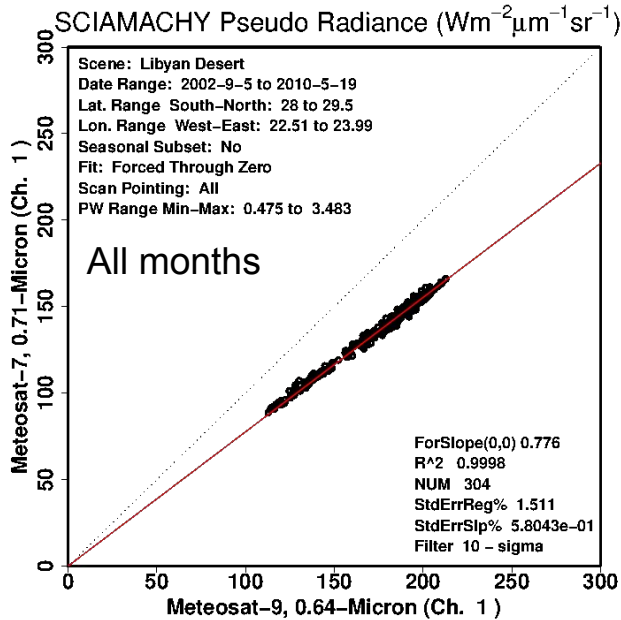
$$L_{p,ref} = \frac{\sum_n^{nbins} L_{s,n} \times RSR_{ref,n} \times (\lambda_n - \lambda_{n-1})}{\sum_n^{nbins} RSR_{ref,n} \times (\lambda_n - \lambda_{n-1})}$$

Regression coefficient(s) define the SBAF

$$L_{Meteosat-7-equivalent} = A2 \times L_{Actual,MODIS}^2 + A1 \times L_{Actual,MODIS} + A0$$



Seasonal SBAF



Libyan Desert Mean reflectance spectra

Standard deviation

- Spectral signature can vary over the same PICS with seasons
- Met-9/Met-7 SBAF over Libyan Desert can vary by **~2.5%**
- Seasonal SBAF can reduce uncertainty by excluding days that fall outside the specified month/day limit



SCIAMACHY Spectra Plotting tool

Earth Spectra (SCIAMACHY)	SRF 1	Units	Spectral Filter 1	Location/Date
Arabia 1	ATS-2	Radiance	Min μ m 0.24	North
Arabia 2	Aqua-MODIS	Scaled Radiance	Max μ m 1.75	32.20
Badain Jaran Desert	Aqua-MODIS-MCST			West -114.5 -114.3 East
Dome C	CERES-BB			32.00
Greenland Central	COMS-1	Angles		South
Greenland South	DSCOVR-EPIC	Min AZA 103.00	Min Rad 1 0.0	Start Date 01/01/2002
Libya 1	EO-1-ALI	Max AZA 156.40	Max Rad 1 1000.0	End Date 12/31/2010
Libyan Desert	FY-2C			
Niger 1	FY-2D	Min SZA 25.40	Min Ref 1 0.0	
Sonoran Desert	FY-2E	Max SZA 60.90	Max Ref 1 1.0	
Uyuni Desert	FY-4			
All-sky Tropical Land	GMS-1	Min VZA 9.67	Spectral Filter 2	
All-sky Tropical Ocean	GMS-2	Max VZA 24.80	Min μ m 0.24	
Clear-sky Tropical Ocean	GMS-3		Max μ m 1.75	
Marine Water Cloud	Central Wavelength:			
Marine Ice Cloud	0.65 Micron (1)		Min Rad 2 0.0	
Approximate DCC			Max Rad 2 1000.0	
Precise DCC	SRF 2			
North Pole	GOES-10		Min Ref 2 0.0	
South Pole	GOES-11		Max Ref 2 1.0	
Global	GOES-12			
Evergreen Needleleaf Forest	GOES-13			
Evergreen Broadleaf Forest	GOES-14			
Deciduous Needleleaf Forest	GOES-15			
Deciduous Broadleaf Forest	GOES-16			
Mixed Forests	GOES-17			
Closed Shrublands	GOES-5			
Open Shrublands	GOES-6			
Woody Savannas	GOES-7			
Savannas	GOES-8			
Grasslands	GOES-9			
Permanent Wetlands	Himawari-8-AHI			
Croplands	Himawari-9-AHI			
Cropland/Natural Vegetation				
Barren	Central Wavelength:			
	0.63 Micron (1)			
				Plot

- Plot the average SCIAMACHY **Earth-reflected Spectra** for a chosen scene/PICS and unit type
- Overlay and convolve with chosen **spectral response functions (SRFs)**
- Yields SCIAMACHY-average SRF-defined **pseudo radiance/reflectance**

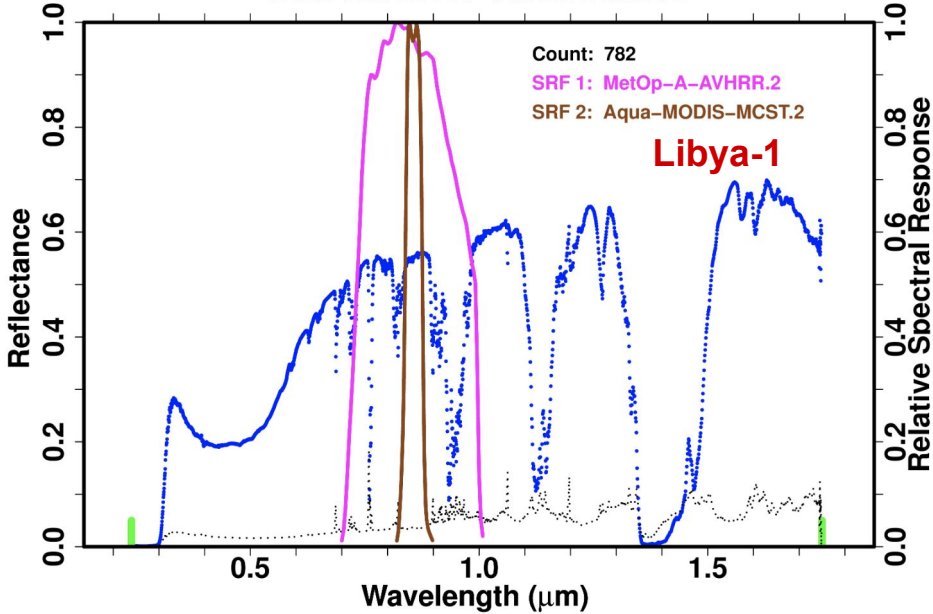
SCIAMACHY Spectra Tool Input



SCIAMACHY Spectra Plotting Tool Output



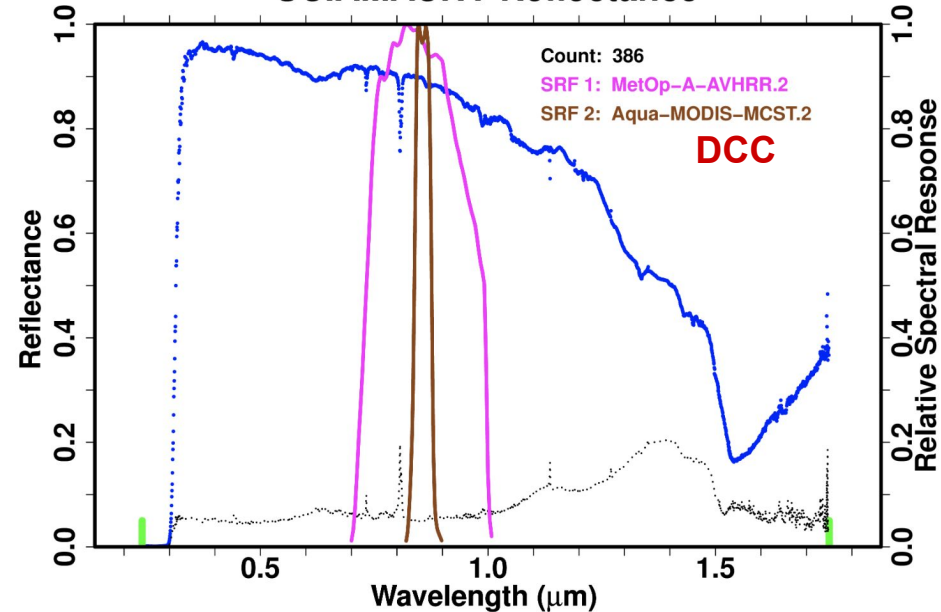
SCIAMACHY Reflectance



		Libya 1	
	Name	Pseudo_Radiance	Pseudo_Reflectance
SRF 1	MetOp-A-AVHRR.2	124.81	0.4653
SRF 2	Aqua-MODIS-MCST.2	140.73	0.5477

Note: Pseudo_Radiance Units: Watts per (meter²-steradian-micron)

SCIAMACHY Reflectance



		Precise DCC	
	Name	Pseudo_Radiance	Pseudo_Reflectance
SRF 1	MetOp-A-AVHRR.2	249.16	0.8821
SRF 2	Aqua-MODIS-MCST.2	246.49	0.8917

Note: Pseudo_Radiance Units: Watts per (meter²-steradian-micron)

- Raw SCIAMACHY Earth-reflected spectra (**blue dotted line**)
- Table shows mean **pseudo radiance and reflectance** values based on chosen SRFs
- **Black dotted line** indicates standard deviation of footprints



Spectral Filtering: Spectra Plotting tool

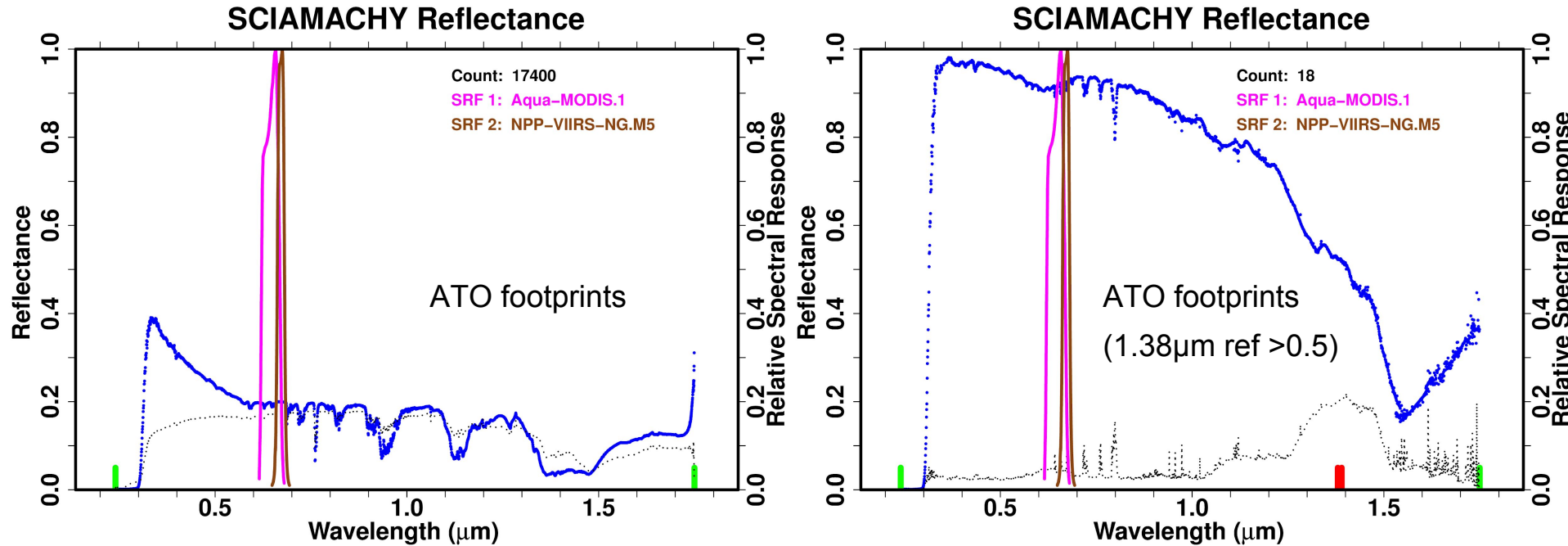


Earth Spectra (SCIAMACHY)	SRF 1	Units	Spectral Filter 1	Location/Date
Arabia 1	ATS-2	Radiance	Min μm 1 1.38	North
Arabia 2	Aqua-MODIS	Scaled Radiance	Max μm 1 1.40	15.00
Badain Jaran Desert	Aqua-MODIS-MCST			West -180.0 180.0 East
Dome C	CERES-BB		Min Rad 1 0.0	-15.00
Greenland Central	COMS-1	Angles	Max Rad 1 1000.0	South
Greenland South	DSCOVR-EPIC	Min AZA 37.52	Min Ref 1 0.05	Start Date 01/01/2002
Libya 1	EO-1-ALI	Max AZA 149.10	Max Ref 1 1.0	End Date 12/31/2010
Libyan Desert	FY-2C	Min SZA 23.10		
Niger 1	FY-2D	Max SZA 51.80		
Sonoran Desert	FY-2E	Min VZA 6.64	Spectral Filter 2	
Uyuni Desert	FY-4	Max VZA 27.00	Min μm 2 0.60	
All-sky Tropical Land	GMS-1		Max μm 2 0.65	
All-sky Tropical Ocean	GMS-2		Min Rad 2 0.0	
Clear-sky Tropical Ocean	GMS-3		Max Rad 2 1000.0	
Marine Water Cloud			Min Ref 2 0.4	
Marine Ice Cloud	Central Wavelength:		Max Ref 2 1.0	
Approximate DCC	1.63 Micron (6)			
Precise DCC				
North Pole	SRF 2			
South Pole				
Global				
Evergreen Needleleaf Fore	NOAA-6-AVHRR			
Evergreen Broadleaf Fores	NOAA-7-AVHRR			
Deciduous Needleleaf Fore	NOAA-8-AVHRR			
Deciduous Broadleaf Fores	NOAA-9-AVHRR			
Mixed Forests	NPP-VIIRS-GT			
Closed Shrublands	NPP-VIIRS-NG			
Open Shrublands	OCO-3			
Woody Savannas	SMS			
Savannas	Sentinel-2A-MSI			
Grasslands	Sentinel-2B-MSI			
Permanent Wetlands	TIROS-N-AVHRR			
Croplands	TRMM-VIRS			
Cropland/Natural Vegetati	Terra-MODIS			
Barren	Terra-MODIS-MCST			
	Central Wavelength:			
	1.60 Micron (M10)			

- Spectral filter allows exclusion of hyperspectral footprints that do not meet specified criteria
- Indicate the min/max allowable radiance or reflectance (or both) permitted within the chosen wavelength range
- Remove outliers, ensure pristineness, find narrow subset of broad dataset
- Use two spectral filters for better control of scene specification



Single Spectral Filtering Example



Extraction of DCC conditions from Raw SCIAMACHY all-sky tropical ocean (ATO) footprints

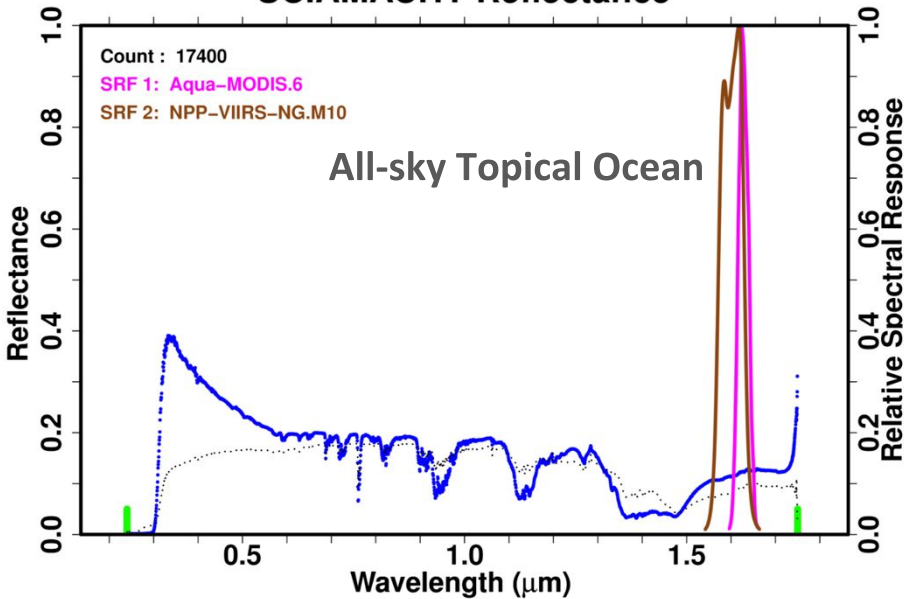
- DCC are the most reflective targets at 1.38μm wavelength
- Based on MODIS and VIIRS observations, DCC reflectance is ~0.5 at 1.38 μm band
- Limiting the ATO reflectance at 1.38μm to >0.5 results in a DCC spectra



Double Spectral Filtering Example



SCIAMACHY Reflectance



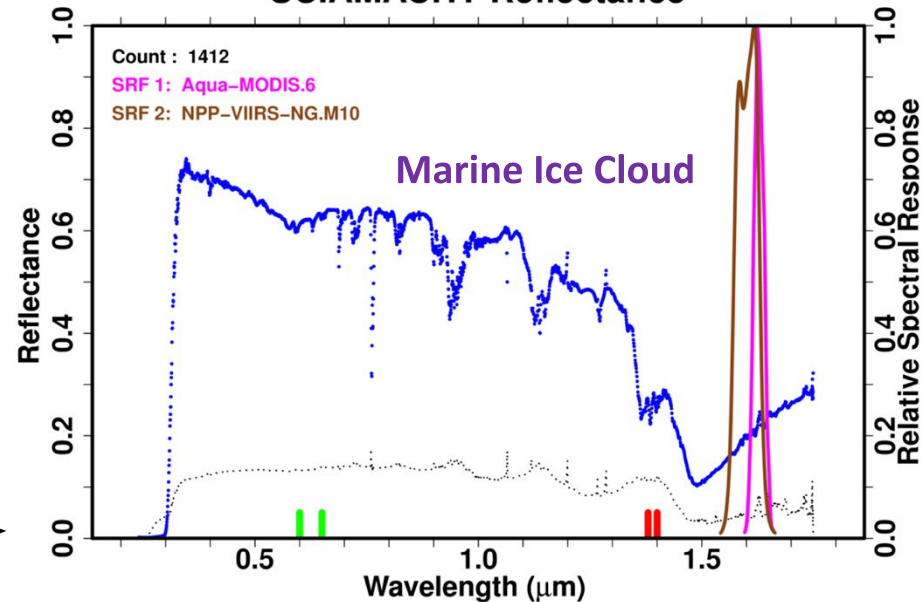
All-sky Tropical Ocean			
Name	Pseudo_Radiance	Pseudo_Reflectance	
SRF 1 Aqua-MODIS.6	7.448	0.1234	
SRF 2 NPP-VIIRS-NG.M10	7.333	0.1153	

Note: Pseudo_Radiance Units: Watts per (meter²-steradian-micron)

SF_Range	SF_Radiance	SF_Reflectance	
Spectral Filter 1 0.24 - 1.75	41.86	0.155	
Spectral Filter 2 0.24 - 1.75	41.86	0.155	

Note: SF_Radiance Units: Watts per (meter²-steradian-micron)
 Note: SF_Range Units: micron

SCIAMACHY Reflectance



All-sky Tropical Ocean			
Name	Pseudo_Radiance	Pseudo_Reflectance	
SRF 1 Aqua-MODIS.6	13.278	0.2201	
SRF 2 NPP-VIIRS-NG.M10	12.539	0.1971	

Note: Pseudo_Radiance Units: Watts per (meter²-steradian-micron)

SF_Range	SF_Radiance	SF_Reflectance	
Spectral Filter 1 1.38 - 1.4	24.141	0.2554	
Spectral Filter 2 0.6 - 0.65	278.280	0.6213	

Note: SF_Radiance Units: Watts per (meter²-steradian-micron)
 Note: SF_Range Units: micron

- Raw SCIAMACHY **all-sky tropical ocean (ATO)** Earth-reflected spectra filtered to look like **marine ice clouds (MIC)**
- Average radiance/reflectance within **each spectral filter range** also available
- Useful in scene selection for bands in which composition cannot be easily **distinguished** by radiance or reflectance thresholds
 - e.g., **1.6 μm**



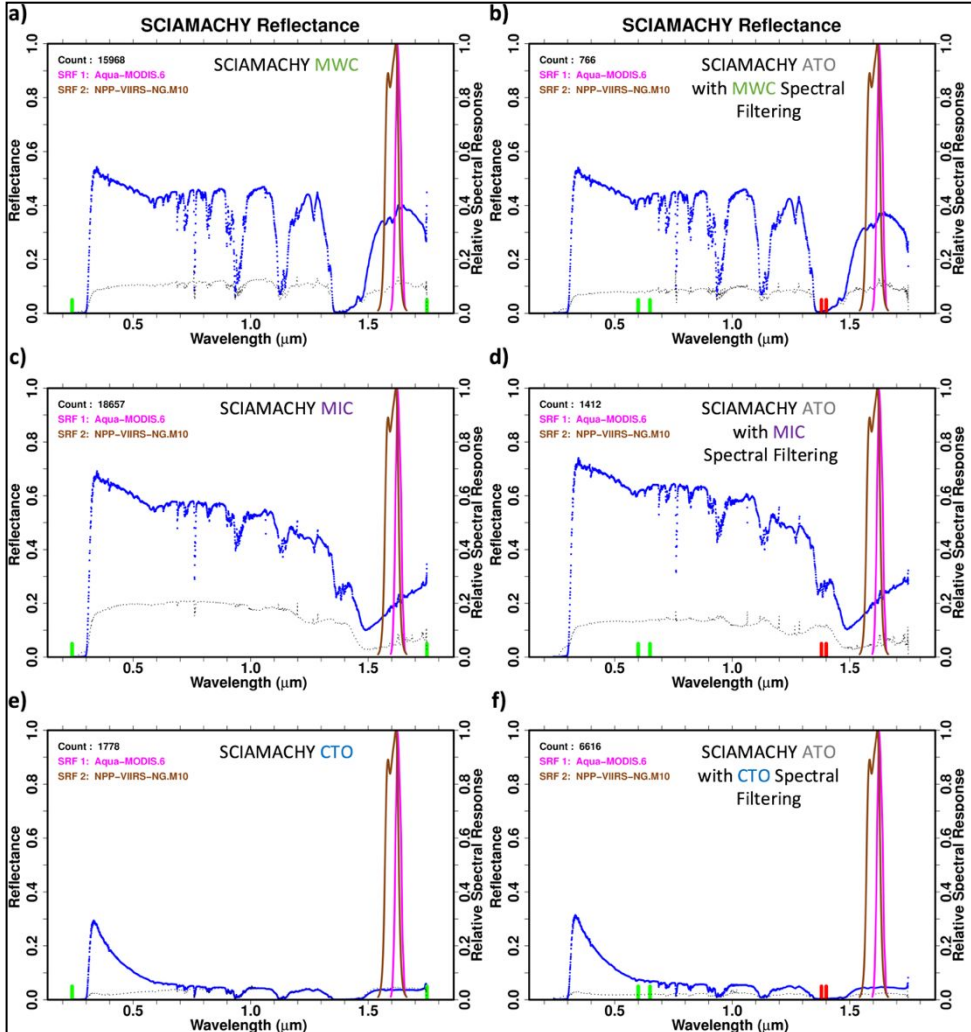
Scene Specification by Spectral Filter



CERES MODIS Cloud Properties

Spectral Filtering

- Left (a, c, e): SCIAMACHY spectra over CERES-identified **marine water clouds (MWC)**, **MIC**, and **clear-sky tropical ocean (CTO)**
- Right (b, d, f): **MWC**, **MIC**, and **CTO** scenes duplicated from spectral filtering of **ATO**



	Spectral Filter 1			Spectral Filter 2		
	Range (μm)	Min Ref.	Max Ref.	Range (μm)	Min Ref.	Max Ref.
MWC	1.38-1.40	0.00	0.05	0.60-0.65	0.30	1.00
MIC	1.38-1.40	0.05	1.00	0.60-0.65	0.40	1.00
CTO	1.38-1.40	0.00	0.05	0.60-0.65	0.00	0.11

Wavelength ranges and min/max reflectance values used for spectral Filters 1 and 2 to come up with the **MWC**-, **MIC**-, and **CTO**-equivalent scenes using **ATO** Earth-reflected spectra



SBAF Calculation by Spectral Filter



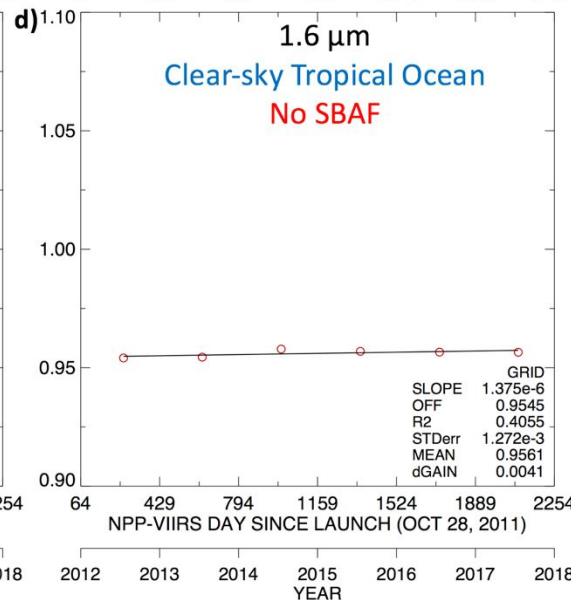
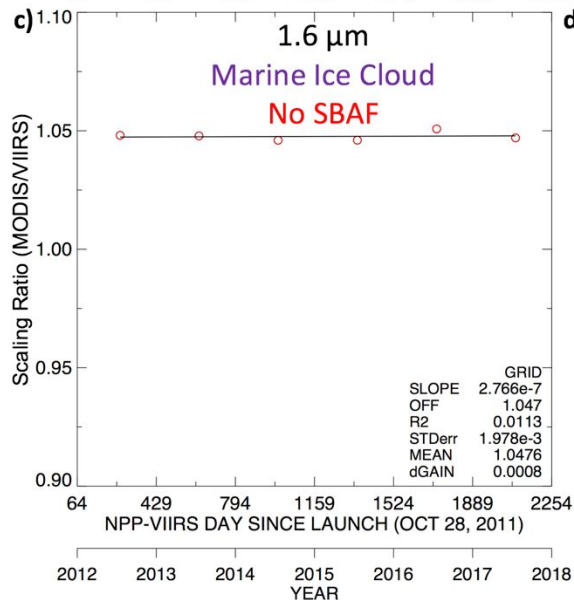
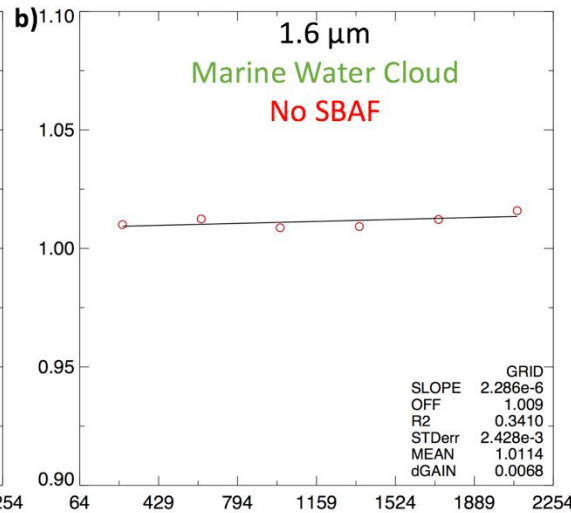
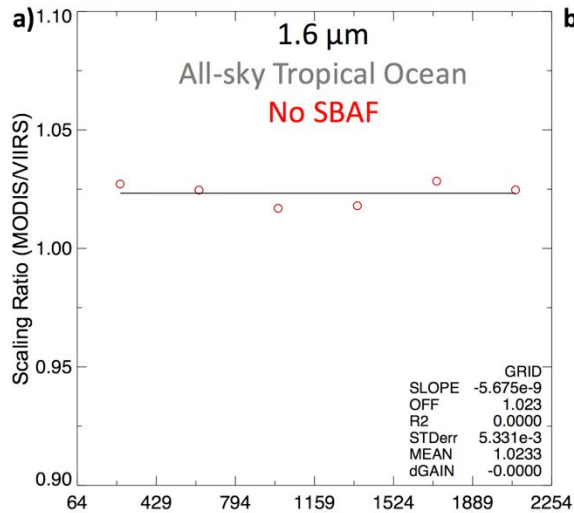
The screenshot shows the SBAF tool interface with the following sections:

- Earth Spectra (SCIAMACHY):** A list of scenes including Arabia 1, Arabia 2, Badain Jaran Desert, Dome C, Greenland Central, Greenland South, Libya 1, Libyan Desert, Niger 1, Sonoran Desert, Uyuni Desert, All-sky Tropical Land, All-sky Tropical Ocean, Clear-sky Tropical Ocean, Marine Water Cloud, Marine Ice Cloud, Approximate DCC, Precise DCC, North Pole, South Pole, Global, Evergreen Needleleaf Forest, Evergreen Broadleaf Forest, Deciduous Needleleaf Forest, Deciduous Broadleaf Forest, Mixed Forests, Closed Shrublands, Open Shrublands, Woody Savannas, Savannas, Grasslands, Permanent Wetlands, Croplands, Cropland/Natural Vegetation, and Barren.
- Reference (X-axis) SRF:** Includes SRFs like ATS-2, Aqua-MODIS, Aqua-MODIS-MCST, CERES-BB, COMS-1, DSCOVR-EPIC, EO-1-ALI, FY-2C, FY-2D, FY-2E, FY-4, GMS-1, GMS-2, and GMS-3. The central wavelength is set to 0.65 Micron (1).
- Target (Y-axis) SRF:** Includes SRFs like NOAA-6-AVHRR, NOAA-7-AVHRR, NOAA-8-AVHRR, NOAA-9-AVHRR, NPP-VIIRS-GT, NPP-VIIRS-NG, OCO-3, SMS, Sentinel-2A-MSI, Sentinel-2B-MSI, TIROS-N-AVHRR, TRMM-VIRS, Terra-MODIS, and Terra-MODIS-MCST. The central wavelength is set to 0.67 Micron (M5).
- Units:** Pseudo Radiance and Pseudo Scaled Radiance.
- Regression/Subsetting/Plotting/Spatial/Date Controls:** Includes Force Fit (Linear, 2nd Order, 3rd Order), Min AZA (37.52), Max AZA (149.10), Min SZA (23.10), Max SZA (51.80), VZA (0-30), Min PW (0.781), Max PW (7.114), σ -cutoff (4), Fit Min X (0), Fit Max X (600), Plot Min X (0), Plot Max X (600), Start (Aug 2 2002), End (Dec 31 2010), and Seasonal (unchecked).
- Spectral Filter 1 (highlighted in green):** Min μ 1 (1.38), Max μ 1 (1.40), Min Rad 1 (0.0), Max Rad 1 (1000.0), Min Ref 1 (0.05), Max Ref 1 (1.0).
- Spectral Filter 2 (highlighted in red):** Min μ 2 (0.60), Max μ 2 (0.65), Min Rad 2 (0.0), Max Rad 2 (1000.0), Min Ref 2 (0.4), Max Ref 2 (1.0).

- Employ same spectral filters in the SBAF tool
- SBAF regression plots include only hyperspectral footprints that satisfy both filters
- Use filters with calibration data (e.g., MODIS channels) to isolate desired scenes
- Same spectral filter for calibration data and SBAF should help ensure the SBAF is applicable to the target scene



Aqua-MODIS B6 /VIIRS M10 (1.6- μm) SCALING RATIO: NO SBAF



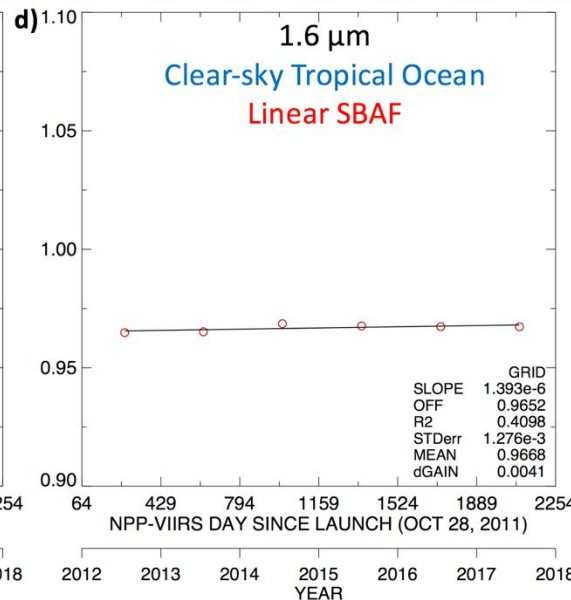
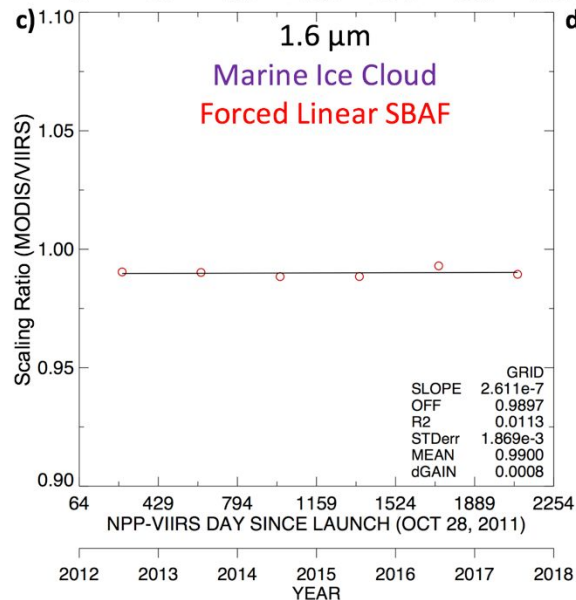
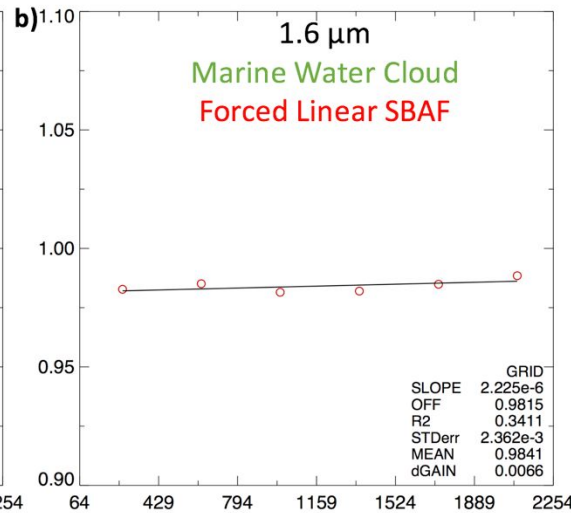
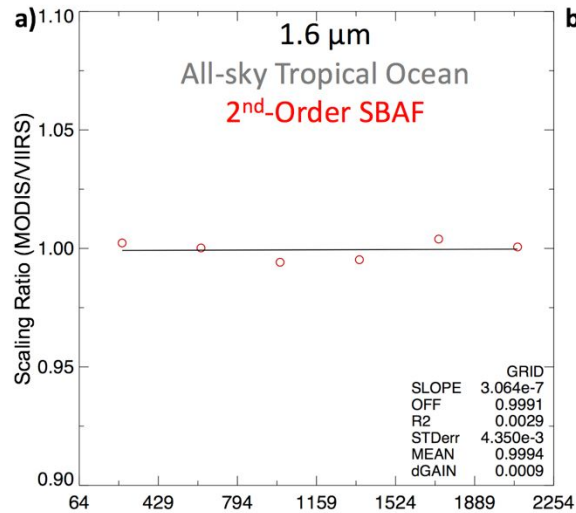
Mean Scaling Ratio

1.6 μm	ATO	MWC	MIC	CTO
No SBAF	1.0233	1.0114	1.0476	0.9561

- Average Aqua-MODIS and NPP-VIIRS SNO scaling ratio (MODIS/VIIRS) varies greatly depending on scene type
- Can we at least better-characterize the “all-sky” subset through spectral filtering and spectrally filtered SBAFs?
- If SBAFs were perfect, then the scaling ratio would be the same regardless of scene type



Aqua-MODIS B6 /VIIRS M10 (1.6- μm) SCALING RATIO: With SBAF



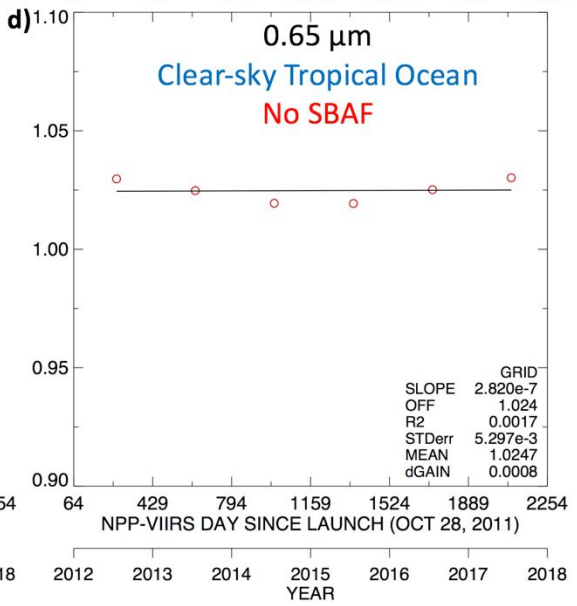
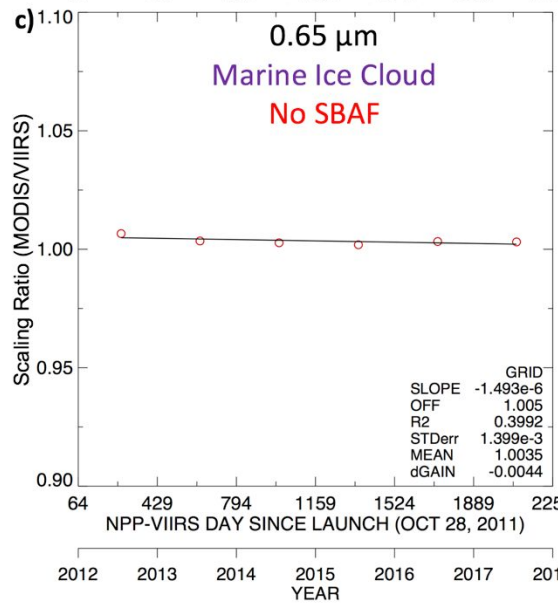
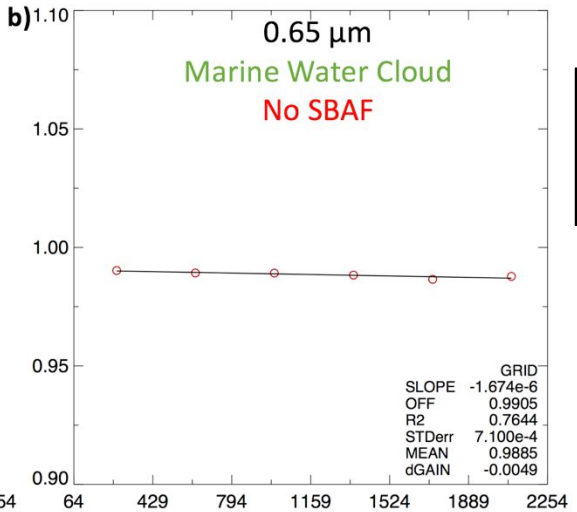
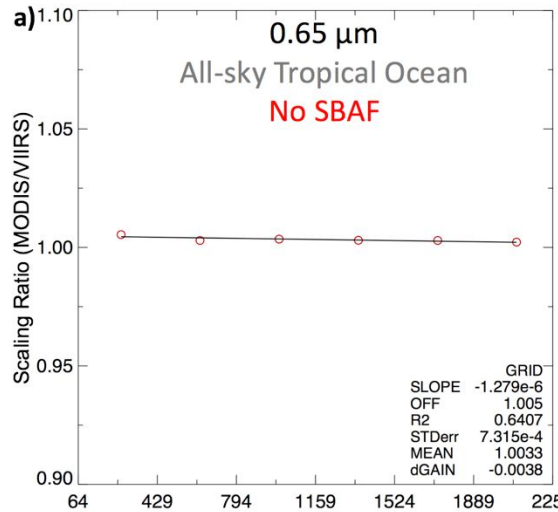
Mean Scaling Ratio

1.6 μm	ATO	MWC	MIC	CTO
No SBAF	1.0233	1.0114	1.0476	0.9561
With SBAF	0.9994	0.9841	0.9900	0.9668

- Spectrally filtered SBAFs help bring **MWC**- and **MIC**-based scaling ratios closer
- The **MIC** and **MWC** ratios show the same radiance values, but the 2nd-order **ATO** SBAF does not effectively characterize both scenes
- For **CTO**, the radiances are dark and cloud contamination would induce strong bias
- **SCIAMACHY** uses very large footprints and thus it is difficult to reliably find **CTO** adequate enough for this channel



MODIS B1/VIIRS M5 (0.65- μm) SCALING RATIO: NO SBAF



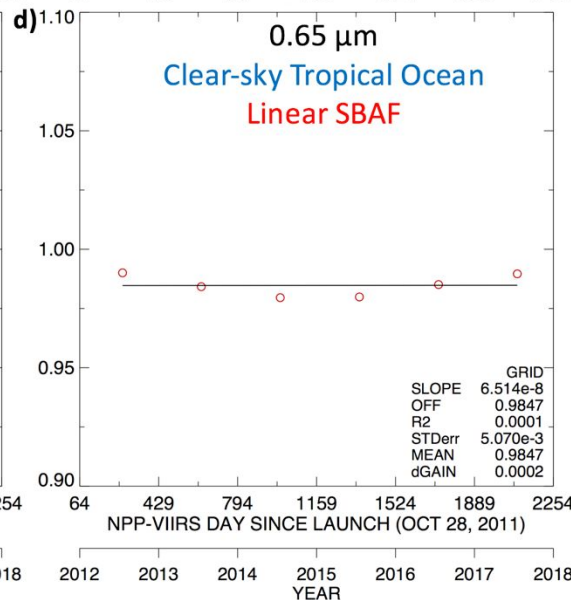
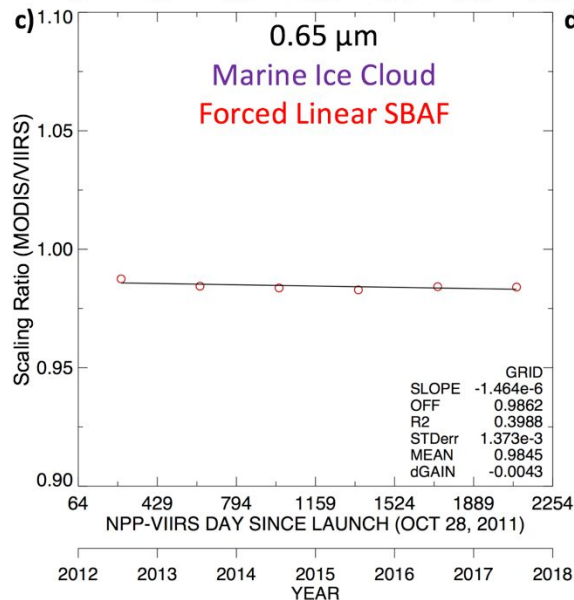
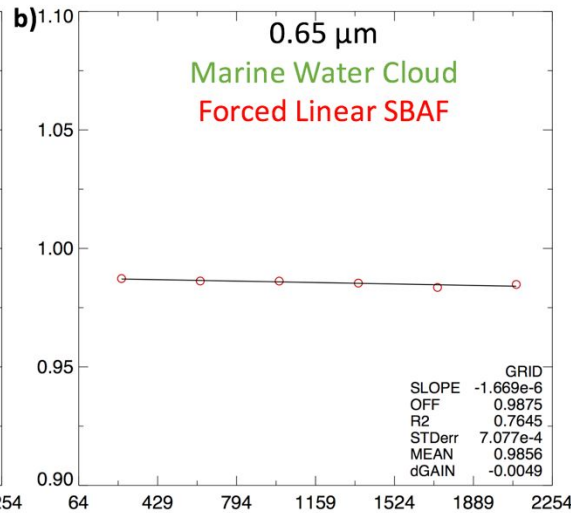
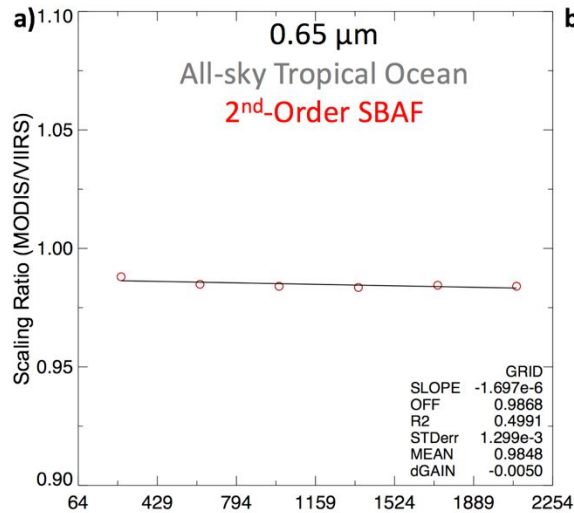
Mean Scaling Ratio

0.65 μm	ATO	MWC	MIC	CTO
No SBAF	1.0033	0.9885	1.0035	1.0247

- For 0.65- μm channel, pre-SBAF maximum scaling discrepancy is 3.7%
- Mean ratio standard deviation is 1.5%



MODIS B1/VIIRS M5 (0.65- μm) SCALING RATIO: WITH SBAF



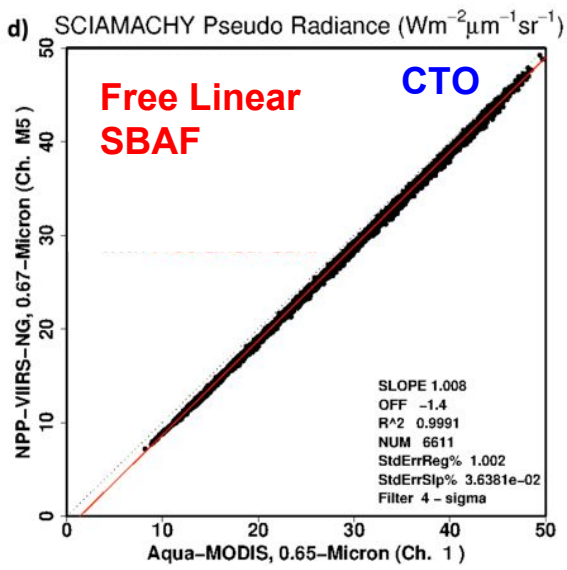
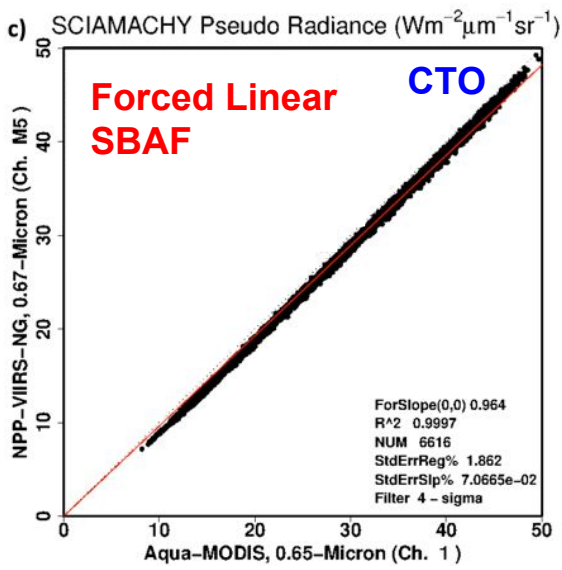
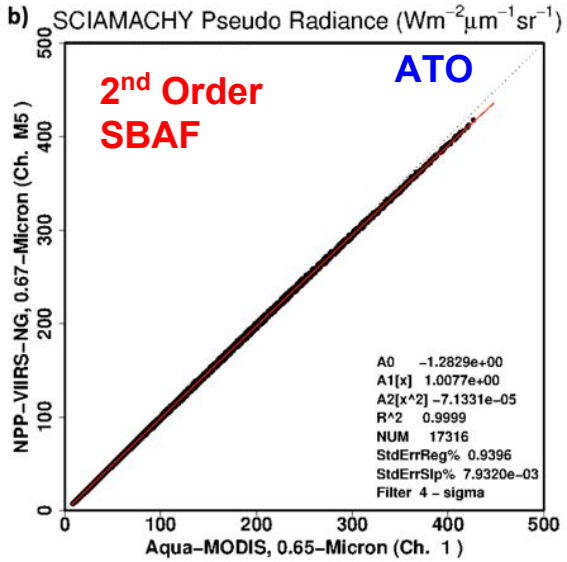
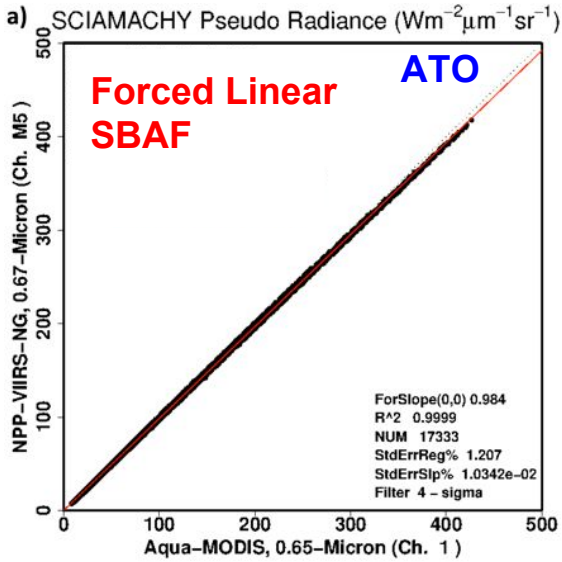
Mean Scaling Ratio

0.65 μm	ATO	MWC	MIC	CTO
No SBAF	1.0033	0.9885	1.0035	1.0247
With SBAF	0.9848	0.9856	0.9845	0.9847

- After SBAF, the maximum discrepancy is reduced to 0.1%
- Mean ratio standard deviation fell to 0.05%
- 2nd-order **ATO** SBAF yields values between **MWC** and **MIC**, which is expected if the single SBAF accurately represents both scene types



Choice of SBAF 'Degree of Polynomial'



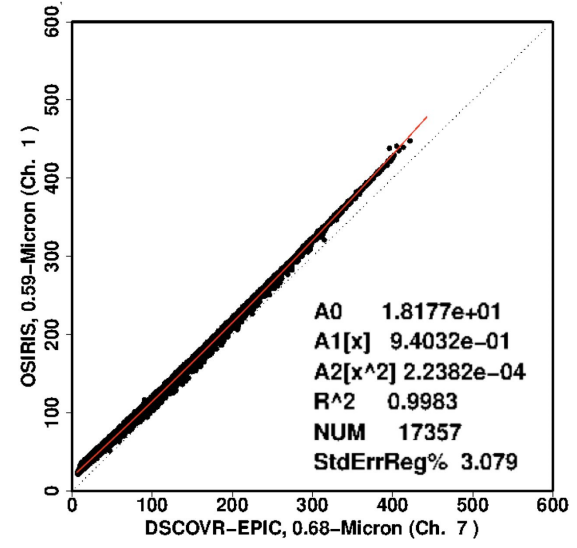
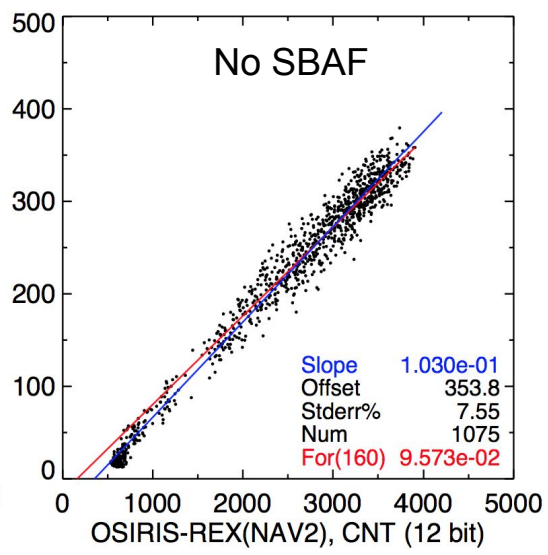
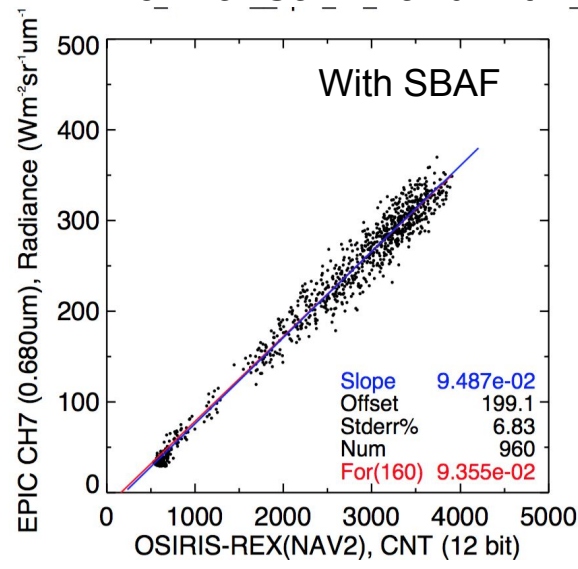
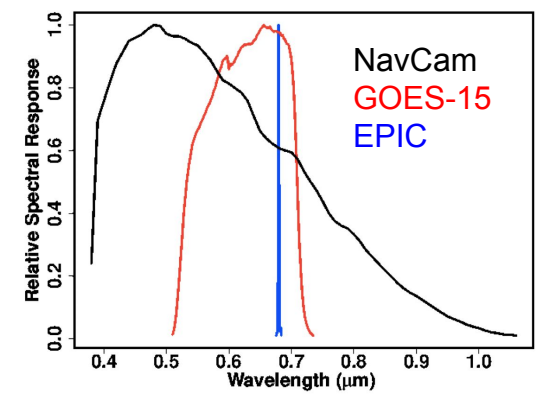
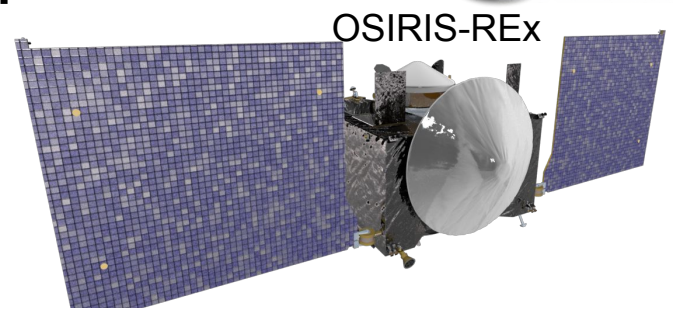
- User can select the regression type (degree of polynomial) that most effectively captures the variability of the pseudo radiance pairs
- The SBAF using linear regression forced through the origin (i.e. **Force Slope or 0th Order**) does not accurately characterize **ATO** nor **CTO** spectra
- **ATO** is better represented with a quadratic polynomial (i.e., **2nd Order**)
- **CTO** is better represented with a “free” linear regression (i.e., **Slope and Offset or 1st Order**)
- Better characterization results in **regression standard error** (STDErrReg%) improvement

STDErrReg%	ATO	CTO
Forced linear	1.207	1.862
1 st -Order	1.158	1.002
2 nd -Order	0.940	0.995



Extreme use case of SBAF

- OSIRIS-REx is a NASA asteroid study mission
- Goal is to obtain a sample from asteroid Bennu
- NASA LaRC's TISA calibration team has performed post-launch radiometric calibration of on-board NavCam imagers
- OSIRIS-REx acquired Earth viewed images during an Earth gravity assist flyby maneuver on September 22, 2017
- Ray-matched with calibrated radiances of GOES-15 and DSCOVER EPIC over ATO
- ATO and pre-launch calibrations agree within 3% for NavCam 1 and within 4% for NavCam 2.





Summary



- NASA LaRC's SBAF Tool enables accurately quantifying spectrally induced biases in cross-calibration of satellite sensors
- We will continue to develop and actively maintain/enhance open-access, on-demand calibration tools
 - Benefit to GSICS and the broader calibration community
- Tell us how these tools can be made more useful
 - Add new satellites SRFs to database
 - Additional subsetting options
 - Different output controls
- E.g., spectral filtering options arose from need to accurately distinguish scene conditions for a chosen channel based on energy level stratification at separate wavelengths
 - More accurate SBAF
 - More accurate radiometric inter-comparison