

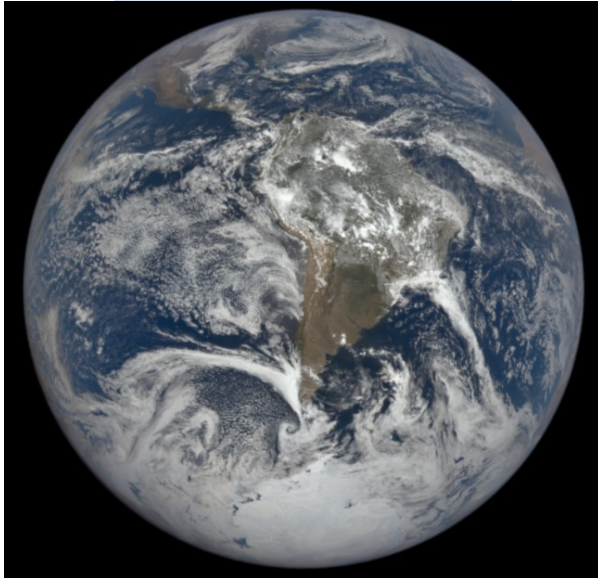
Utilizing the DSCOVr EPIC imager as a calibration invariant target

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DSCOVER EPIC

Dec 23, 2020, 16:30 GMT



June 23, 2021, 9:01 GMT



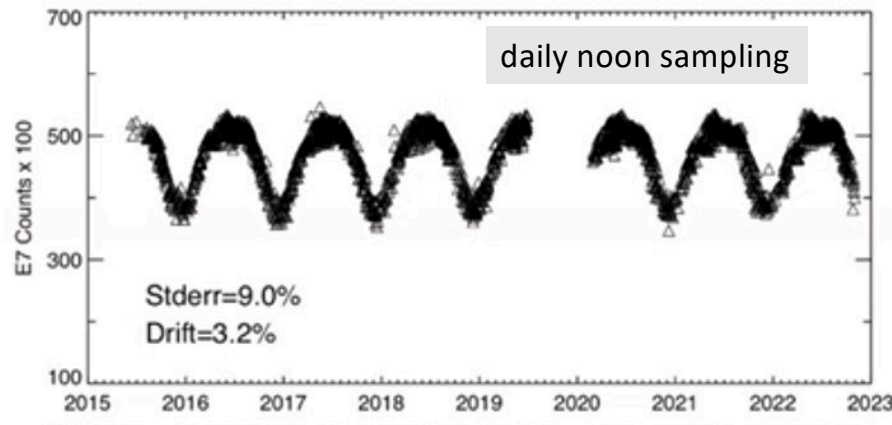
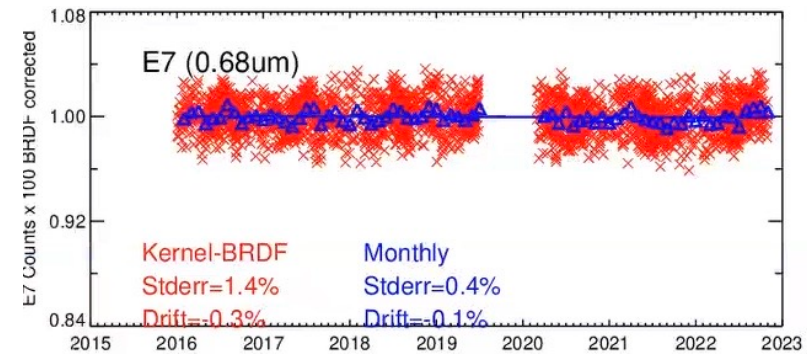
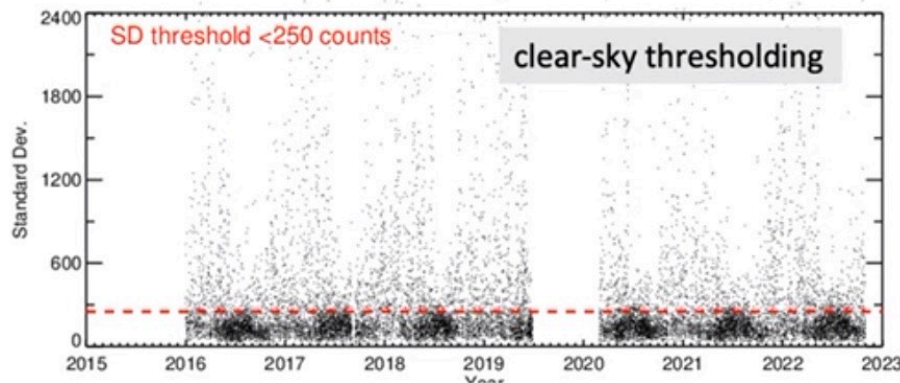
EPIC false color images based on the 0.48 μ m, 0.55 μ m and 0.64 μ m channels

- DSCOVR spacecraft is located at L1 1.5M-km from Earth
- Observes the sunlit Earth disk in near backscatter position
- The CCD detector array (2048x2048) takes between 10-22 images per day, allowing each region to be observed over multiple local hours per day
- Unlike a geostationary satellite imager, the nadir solar view is at the center of the image
- EPIC CCD has 10 RSB channels and no IR channels including the 0.48 μ m, 0.55 μ m, 0.64 μ m and 0.76 μ m channels facilitated by a filter wheel
- 18-km nadir pixel
- operational July 2015 till present
- It has no onboard calibration systems

Utilizing the DSCOVR EPIC imager as a calibration invariant target

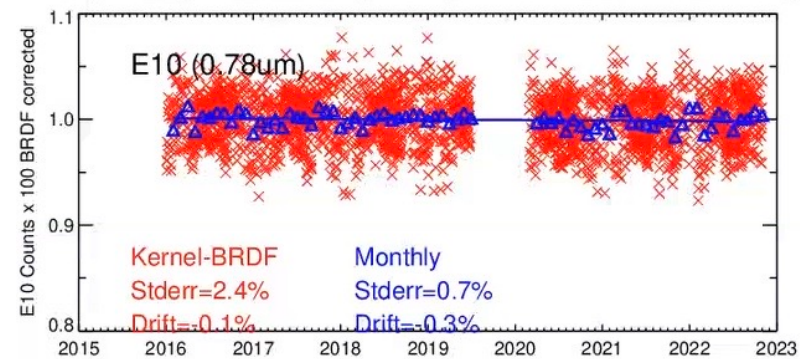
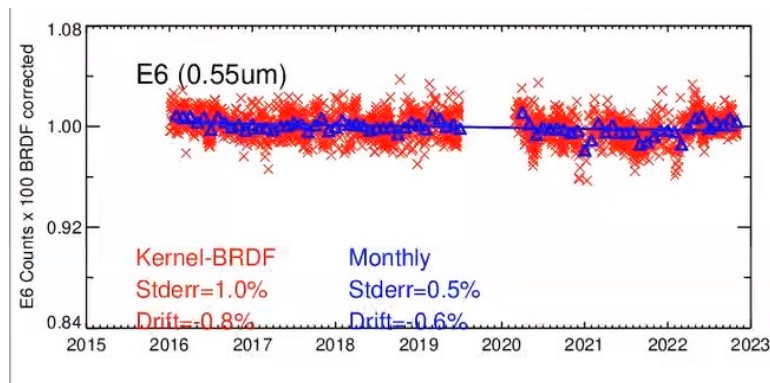
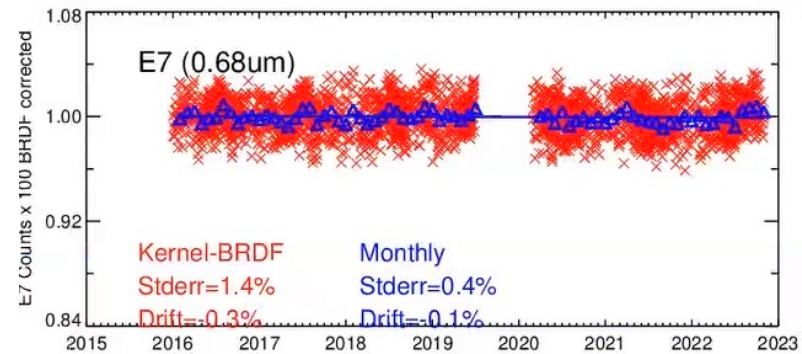
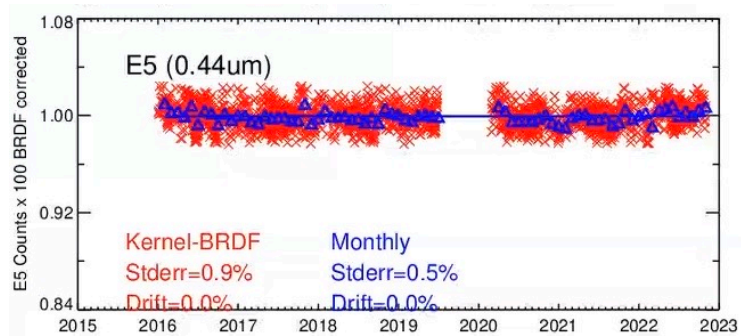
- The EPIC imager is radiometrically very stable
 - Only takes between 10-22 images per day otherwise the optics are shut
 - EPIC observations over Libya-4 and DCC PICS show the instrument to be stable without onboard calibration systems
- The EPIC imager observes Earth regions multiple times per day
 - This allows the EPIC imager to be ray-matched with sun-synchronous imagers over many local hours, for example Terra (10:30AM) and Aqua (1:30PM)
- The EPIC imager can then validate the stability of the MODIS and VIIRS sensors between 2016 to 2022
- The EPIC imager can validate the radiometric scaling factors between MODIS and VIIRS
 - The CERES project radiometrically scales Terra-MODIS, NPP-VIIRS and N20-VIIRS with Aqua-MODIS as the calibration reference sensor

EPIC Libya-4 PICS methodology for $0.65\mu\text{m}$



- Use a 100-km region over the Libya-4 site
- The EPIC V3 navigation accuracy is within $\sim 20\text{-km}$ at nadir
- EPIC V2 has a navigation accuracy within $\sim 50\text{km}$
- Use a spatial standard deviation < 250 counts to identify Libya-4 clear-sky events
- obtain the closest daily noon image
- Use Roujean Kernel BRDF Model to remove angular effects

EPIC Libya-4 results

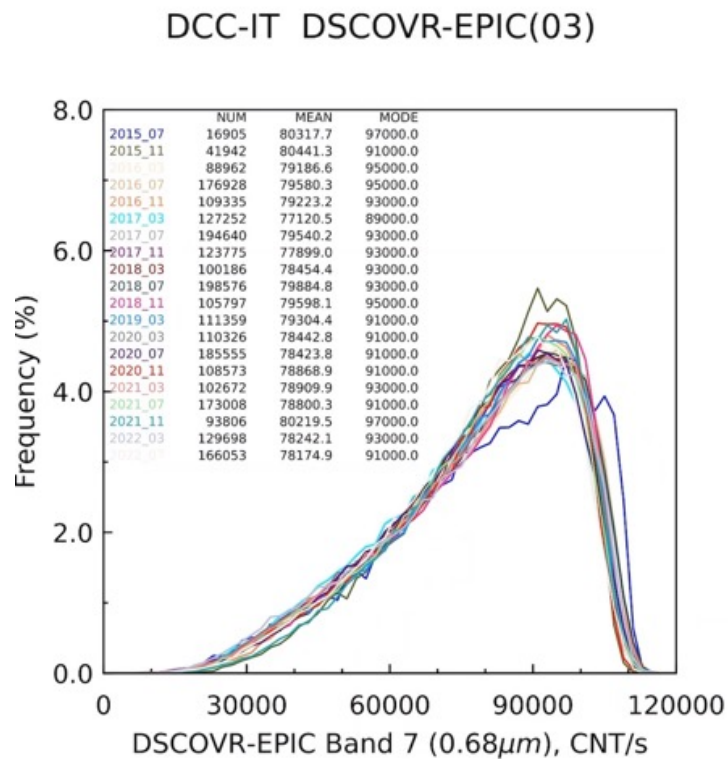


Libya-4 PICS indicates that E6 may have a significant trend, other channels show insignificant trends

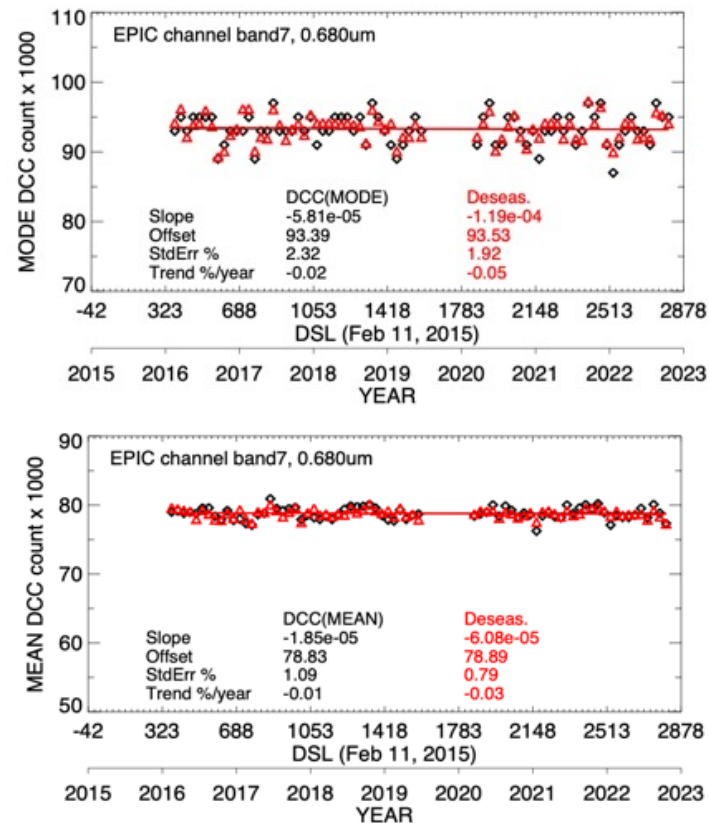
EPIC DCC-IT methodology

- Use the MODIS or VIIRS time and angle matched with EPIC 0.25° grid cells used for EPIC/MODIS and EPIC/VIIRS inter-calibration dataset
 - This allows the same local time sampling over the EPIC record, since Terra, Aqua, NPP and N20 are sun-synchronous satellites
- Identify the EPIC DCC targets with an imager BT<220K
- Histogram the EPIC DCC grid cell reflectances
- Plot the monthly mean and mode EPIC DCC reflectance over time

EPIC DCC invariant target methodology

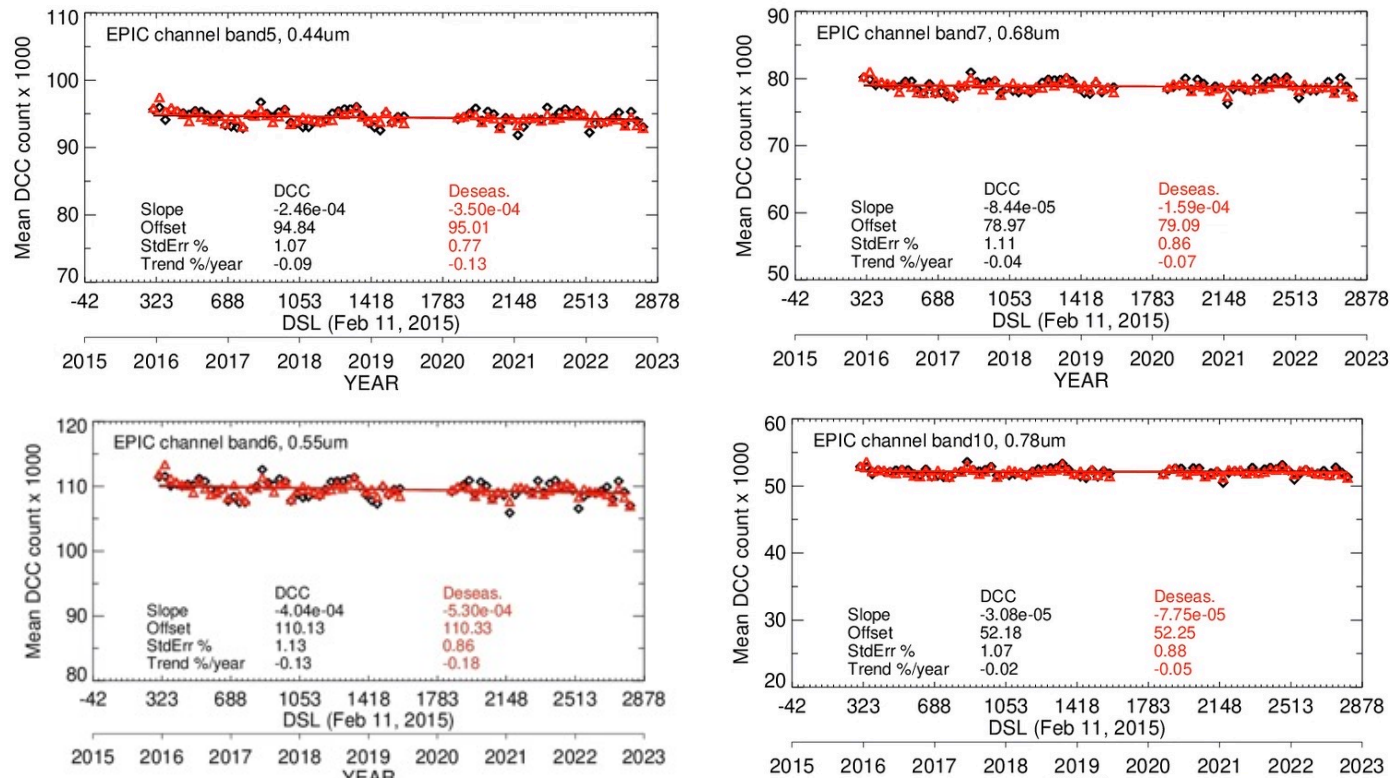


LEO_Overpasses_Used = AQUA, NPP
100.0 < BT_{11um} < 220.0



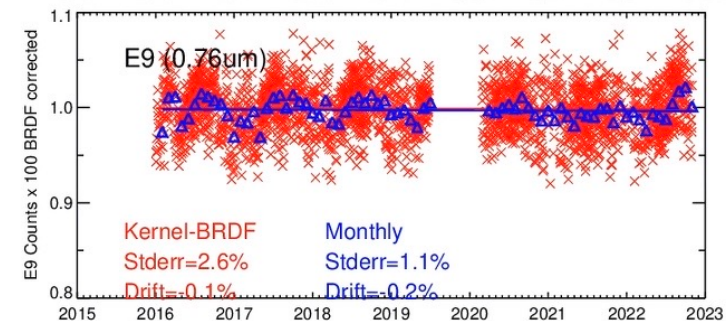
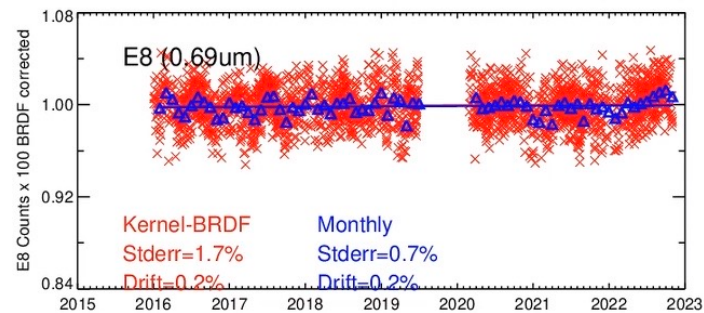
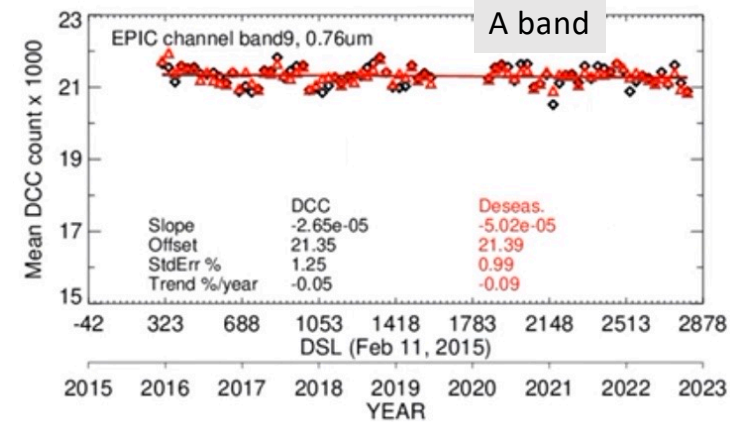
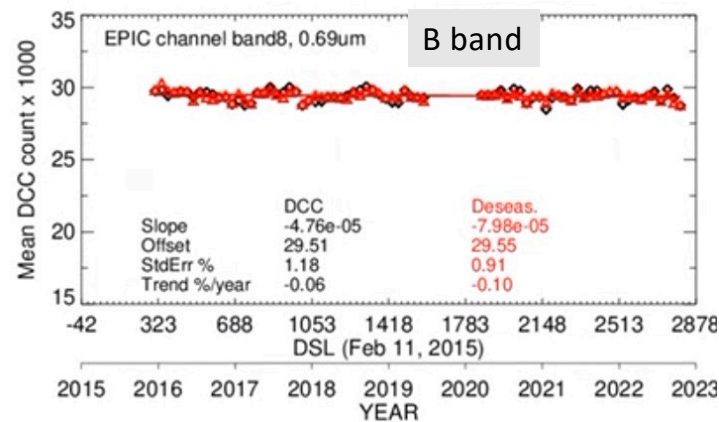
- Use the mean DCC reflectance to monitor stability because it has scatter
- Deseasonalize the DCC mean counts to reduce the temporal standard error

EPIC DCC-IT results



Libya-4 PICS indicates that E5 and E6 may have a significant trend, other channels show insignificant trends

EPIC oxygen A and B absorption band stability



These are strong absorption bands and both DCC-IT and Libya-4 can monitor the stability of these bands

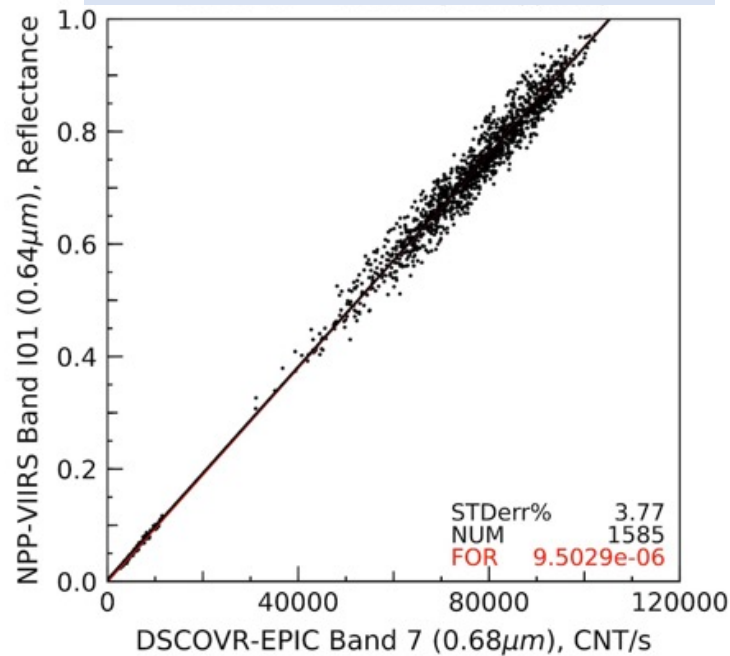
Comparison of EPIC DCC-IT and Libya-4 stability

%/year	DCC-IT	Libya-4
0.44	-0.13	0.00
0.55	-0.18	-0.09
0.68	-0.07	-0.02
0.69	-0.10	0.03
0.76	-0.09	-0.03
0.78	-0.05	-0.04

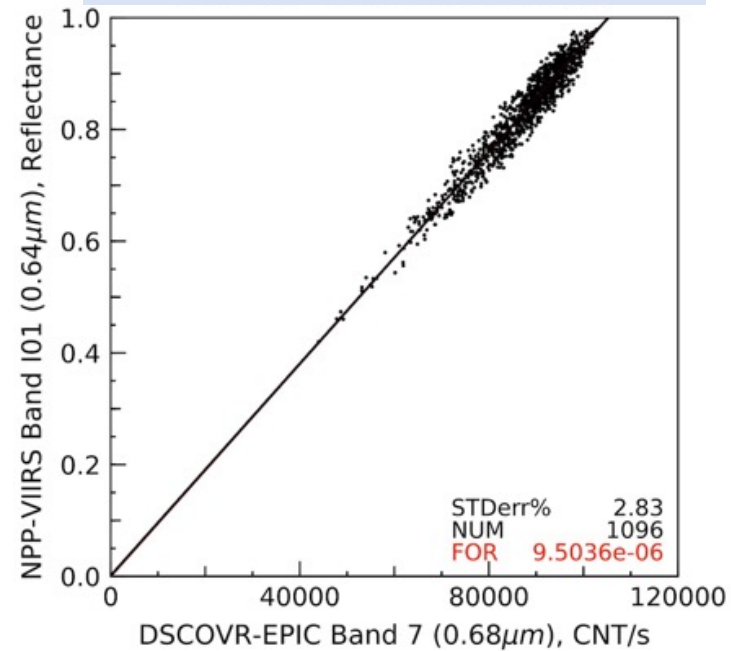
EPIC and NPP-VIIRS ATO-RM and DCC-RM ray-match Inter-calibration

VIIRS time and angle matched with EPIC 0.5° grid utilizing the 12-22 images per day

ATO-RM EPIC and NPP 0.65 μ m
August 2020

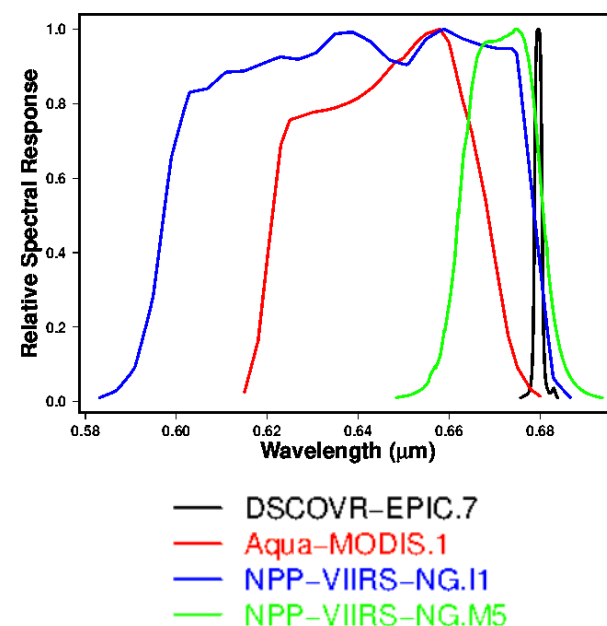
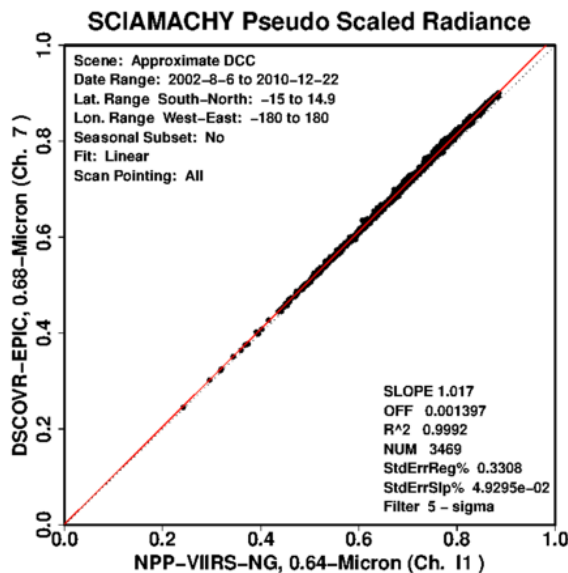
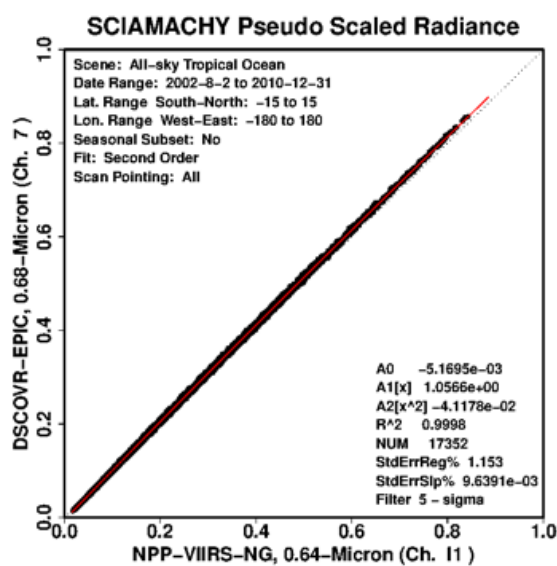


DCC-RM EPIC and NPP 0.65 μ m
August 2020



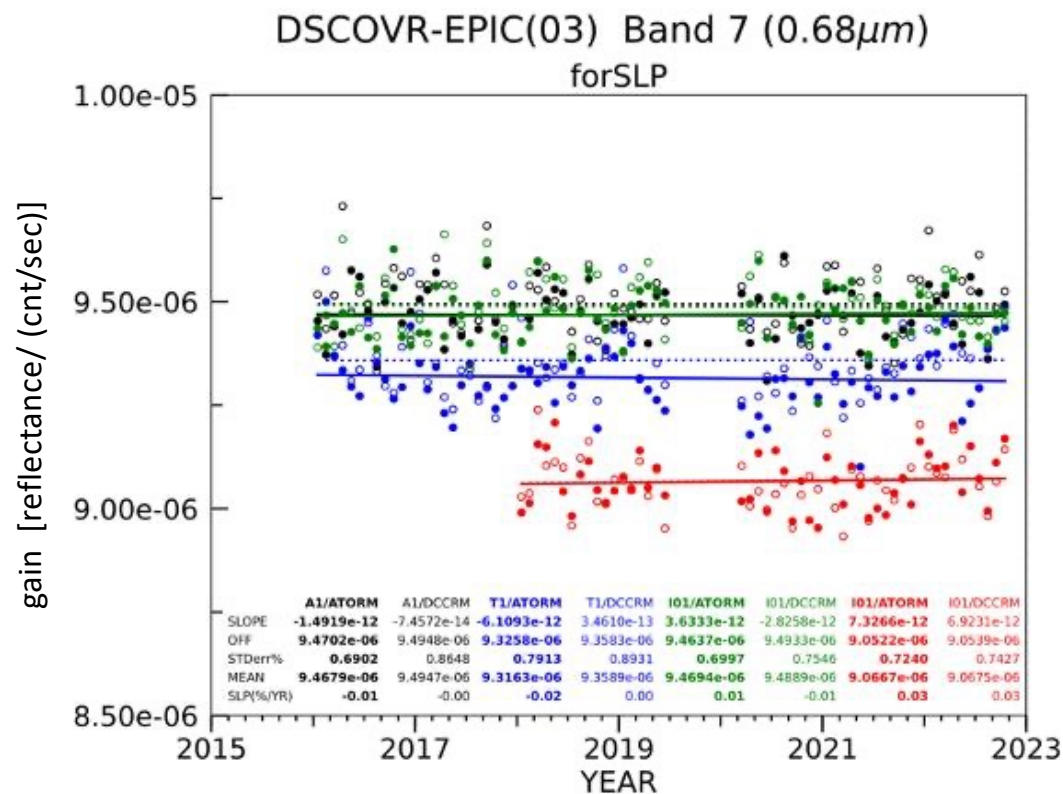
SBAF

These SBAFs can be found on the NASA-LaRC SCIAMACHY SBAF tool (<https://satcorps.larc.nasa.gov/cgi-bin/site/showdoc?mnemonic=SBAF>).



Note the EPIC narrow spectral response function (SRF), this maybe challenging to derive a proper SBAF

E7 Terra/Aqua/NPP/N20 timelines



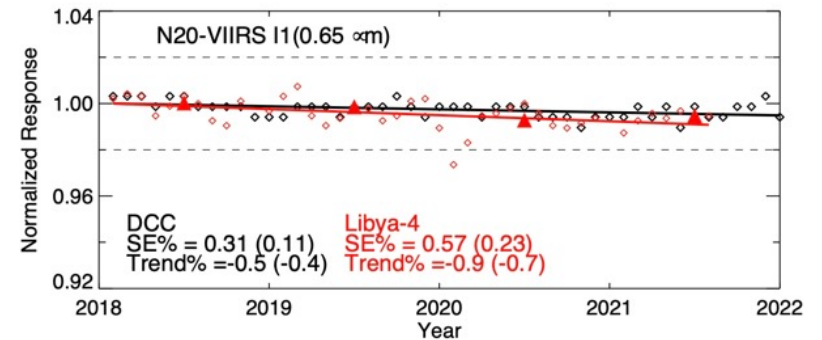
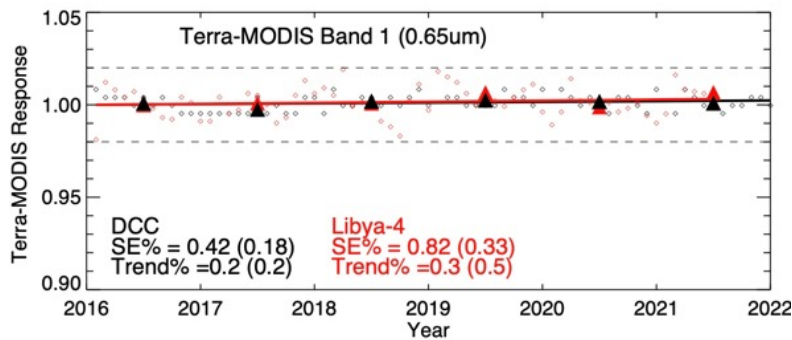
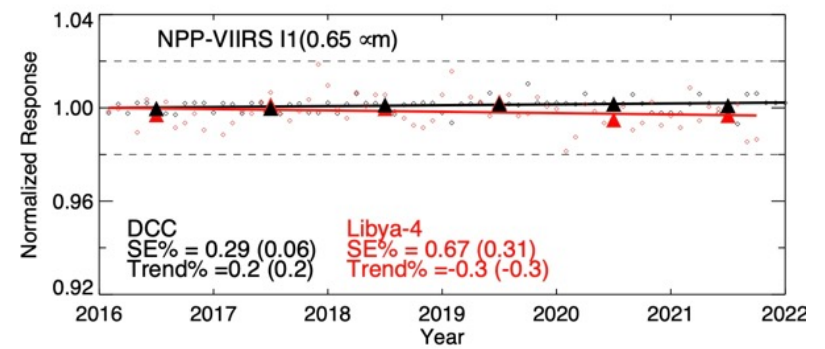
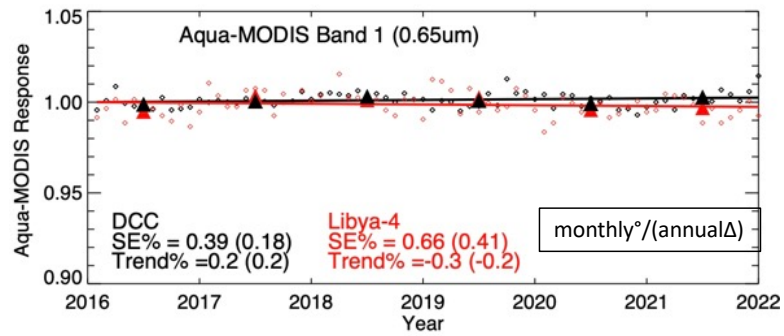
Aqua-MODIS
Terra-MODIS
NPP-VIIRS
N20-VIIRS

ATO-RM • —
DCC-RM. °-----

note the consistency
between ATO-RM and
DCC-RM gains

Δ

MODIS/VIIRS 0.65 μ m stability plots



Comparison of EPIC and PICS based MODIS and VIIRS trends

0.65 μ m (%/yr)	Imager DCC	Imager Libya-4	EPIC ATO-RM
Terra-MODIS	0.03	0.05	-0.02
Aqua-MODIS	0.03	-0.05	-0.01
NPP-VIIRS	0.03	-0.05	0.01
N20-VIRS	-0.08	-0.15	0.03

N20-VIIRS and Aqua-MODIS ATO-RM and DCC-RM intercalibration methodology

ATO-RM

- Grid both the MODIS and VIIRS visible pixel ocean reflectances into 0.5° latitude by longitude grids
- Angle-match the MODIS and VIIRS gridded regions
- Apply an ATO-based spectral band adjustment factor (SBAF) to the VIIRS reflectances in order to match the MODIS spectral response function (see lower-right section on SBAF)

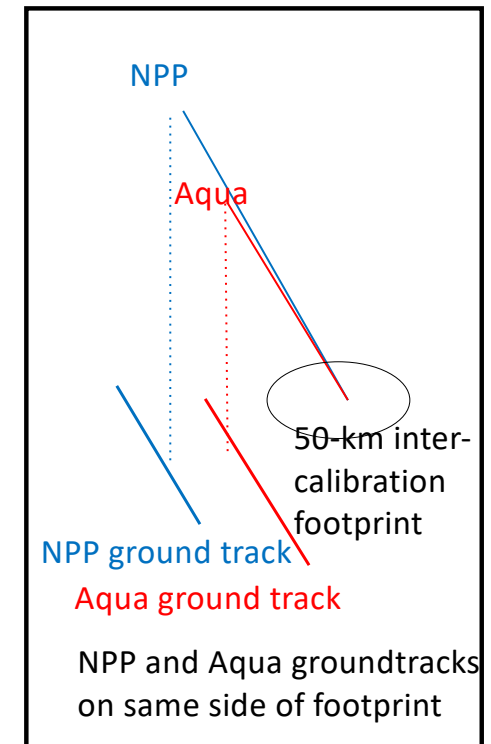
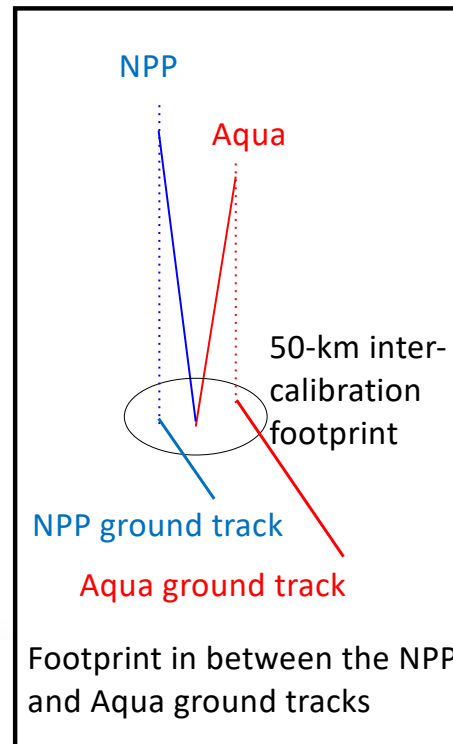
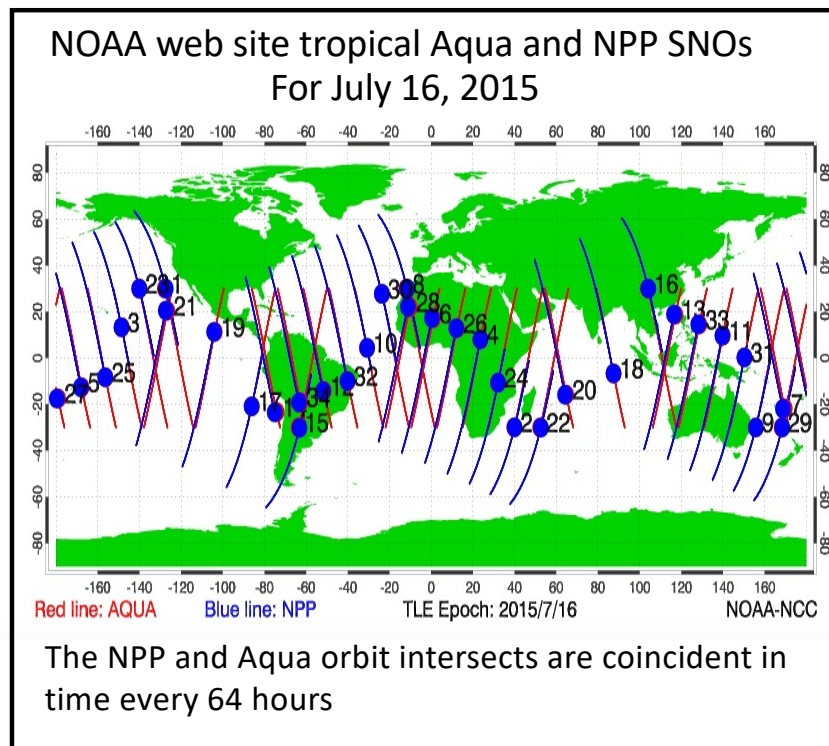
DCC-RM

- Find the coldest 11 μm brightness temperature (BT) pixel in a granule and average all the visible pixel reflectances within a 30-km diameter
- Only use BT < 205 K
- $\sigma_{\text{Ref}} < 5\%$
- $\sigma_{\text{BT}} < 1 \text{ K}$
- Repeat and find the next coldest pixel until all DCC cells in the granule have been identified
- Angle-match the MODIS and VIIRS 30-km DCC cells
- Apply DCC-based SBAF

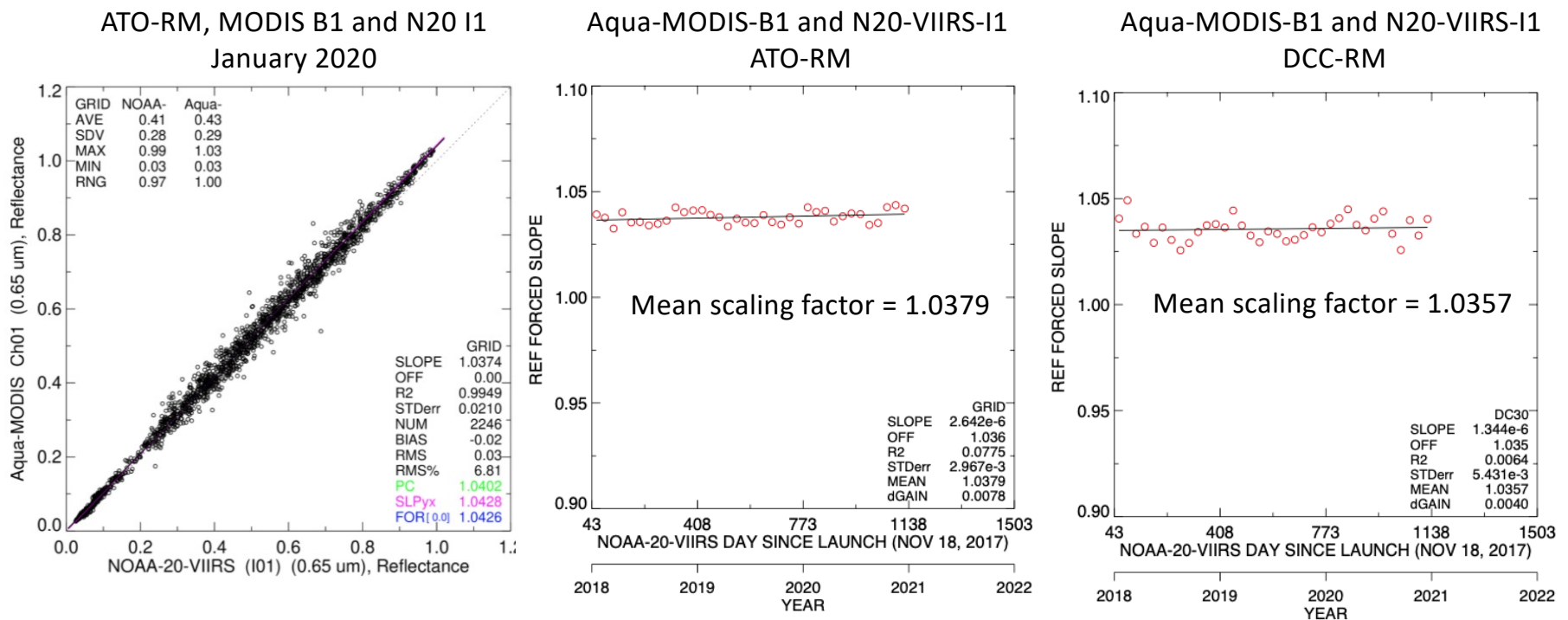
Once the data is matched for either method, then a force-fit linear regression is performed on a monthly basis between a MODIS channel and the analogous VIIRS channel to get a gain. To radiometrically scale VIIRS to MODIS, the VIIRS data is on the x-axis with the MODIS data being on the y-axis. Then a regression is performed on the monthly gains over time to get the scaling factor.

MODIS and VIIRS tropical ATO-RM and DCC-RM algorithm

Tropical Ray-matching geometry

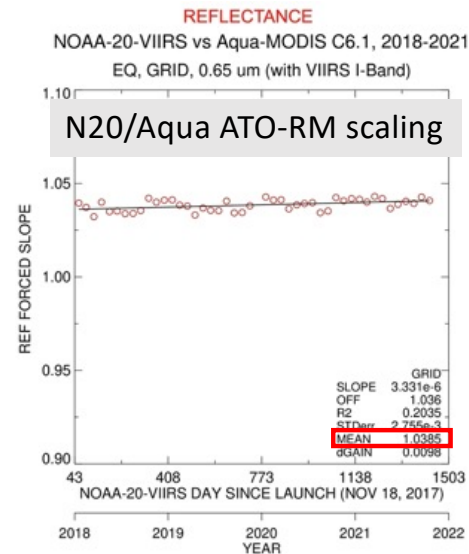
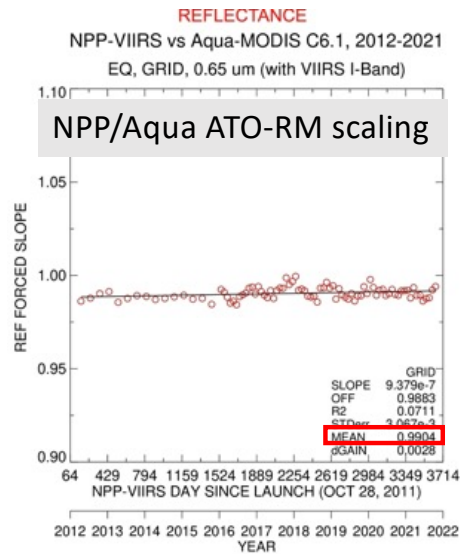


N20-VIIRS and Aqua-MODIS ATO-RM and DCC-RM intercalibration methodology

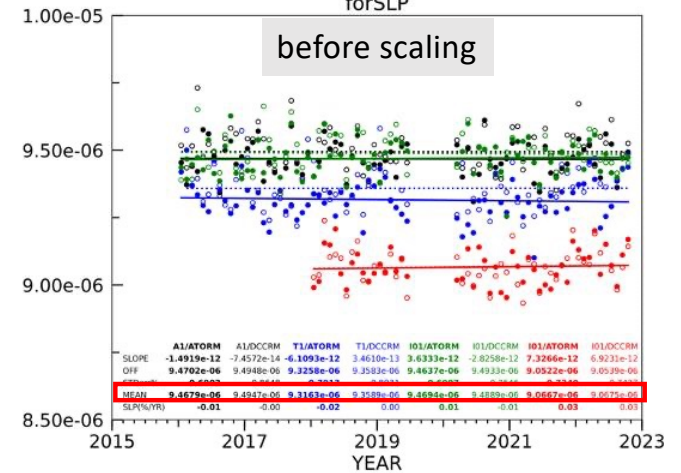


In the above example, the ATO-RM and DCC-RM mean scaling factors are within 0.2%

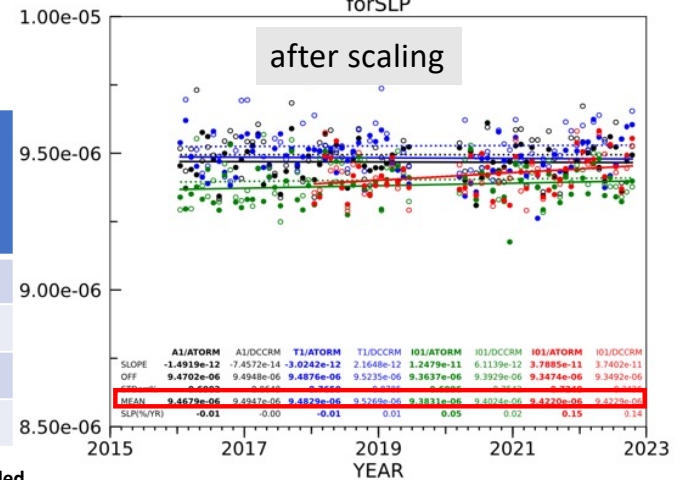
Validate Aqua/VIIRS scaling with EPIC



DSCOVR-EPIC(03) Band 7 (0.68μm) forSLP tight spatial



DSCOVR-EPIC(03) Band 7 (0.68μm) forSLP



	From EPIC Before scaling Aqua/VIIRS gain ratios	Inverse Aqua/VIIRS Scaling factors	Aqua/VIIRS gain ratios * VIIRS/AQUA Scaling factors	From EPIC After scaling Aqua/VIIRS gain ratios
Aqua&NPP ATO-RM	0.9999	1/0.9904	1.0097	1.0091
N20&Aqua ATO-RM	1.0442	1/1.0385	1.0055	1.0049
NPP&Aqua DCC-RM	1.0006	1/0.9904	1.0103	1.0099
N20&Aqua DCC-RM	1.0471	1/1.0385	1.0082	1.0076
$\text{Aqua/VIIRS}_{\text{unscaled}} * (1/\text{Aqua/VIIRS}) = \text{Aqua/VIIRS}_{\text{scaled}}$				

Conclusions

- Due to the exceptional calibration stability of the DSCOVR EPIC sensor it can be used as an invariant Earth target
 - Stability was 0.4 % per decade based DCC-IT except for the 0.55 channel
- EPIC observations can be inter-calibrated or ray-matched with many sun-synchronous measurements across all local hours
- EPIC can be used to monitor the sensor stability and sensor to sensor radiometric scaling factors