NOAA-20 VIIRS based reference DCC radiances for GEO domains

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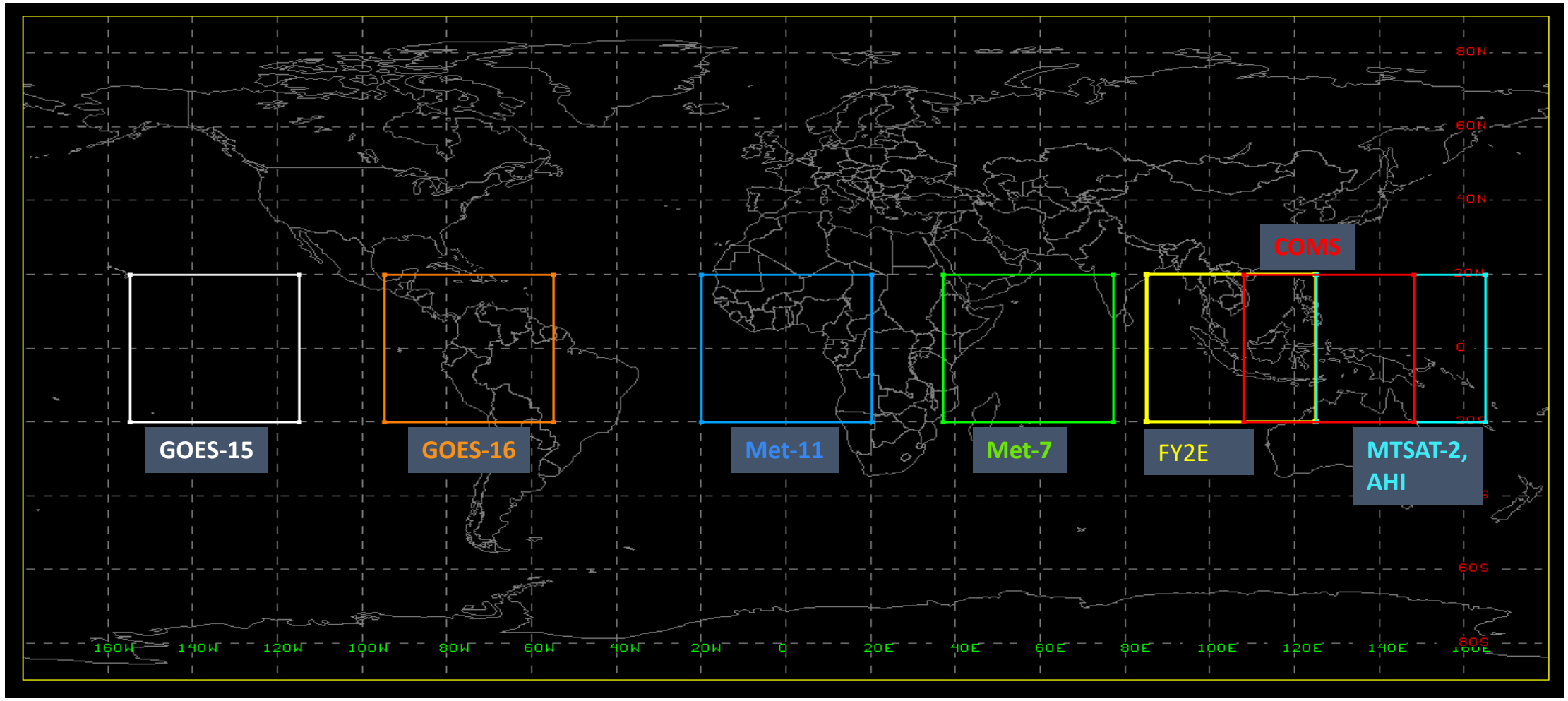
Objectives

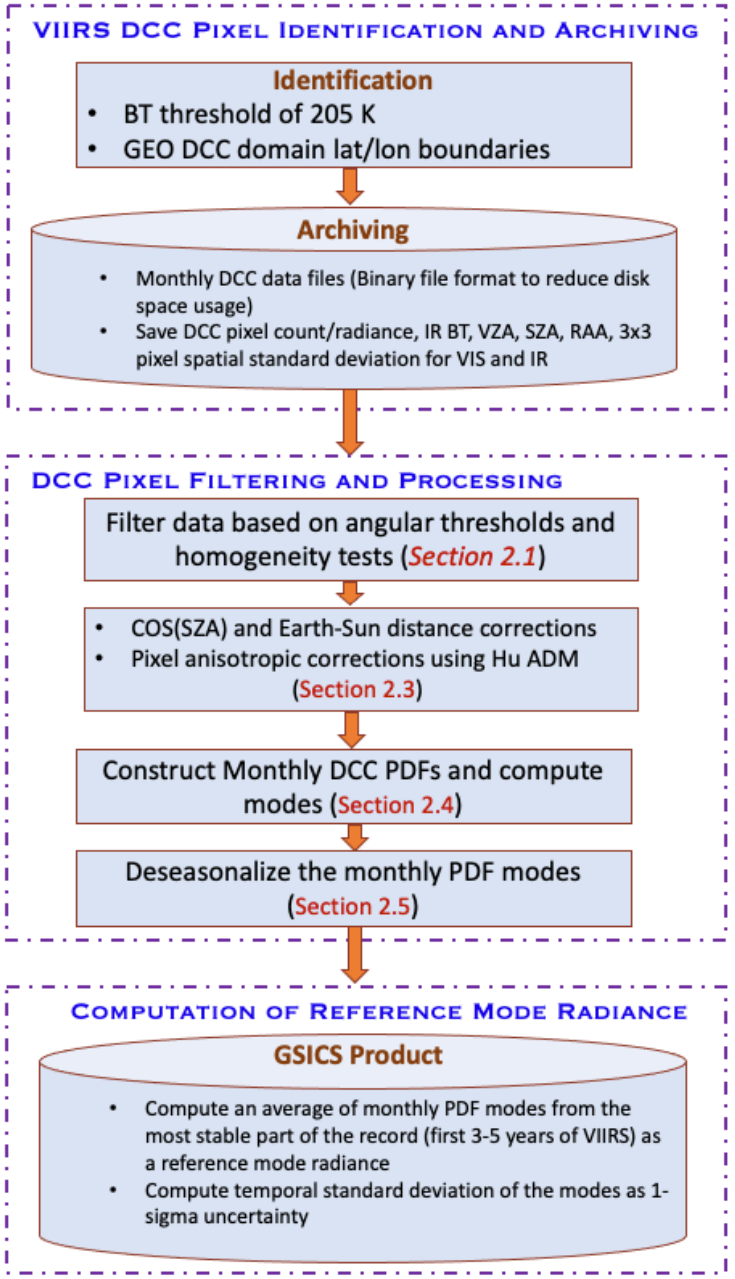
- *GSICS VIS/NIR group uses the NOAA-20 VIIRS L1B reflectance as the reference until CLARREO sensor becomes the reference*
- *Characterize tropical DCC response at the top-of-atmosphere using the latest dataset (Collection 2.1) of NOAA-20 VIIRS L1b radiances from NASA Land SIPS*
  - *The NASA and NOAA calibration are mostly within 0.2%*
- *Provide GEO-domain-dependent reference DCC mode and mean values based on reflective solar bands measurements from VIIRS to facilitate consistent radiometric scaling of GEO imagers using DCC-IT*
  - *There is a very small spatial variation across the tropics*

GEO Imagers DCC Identification Domains

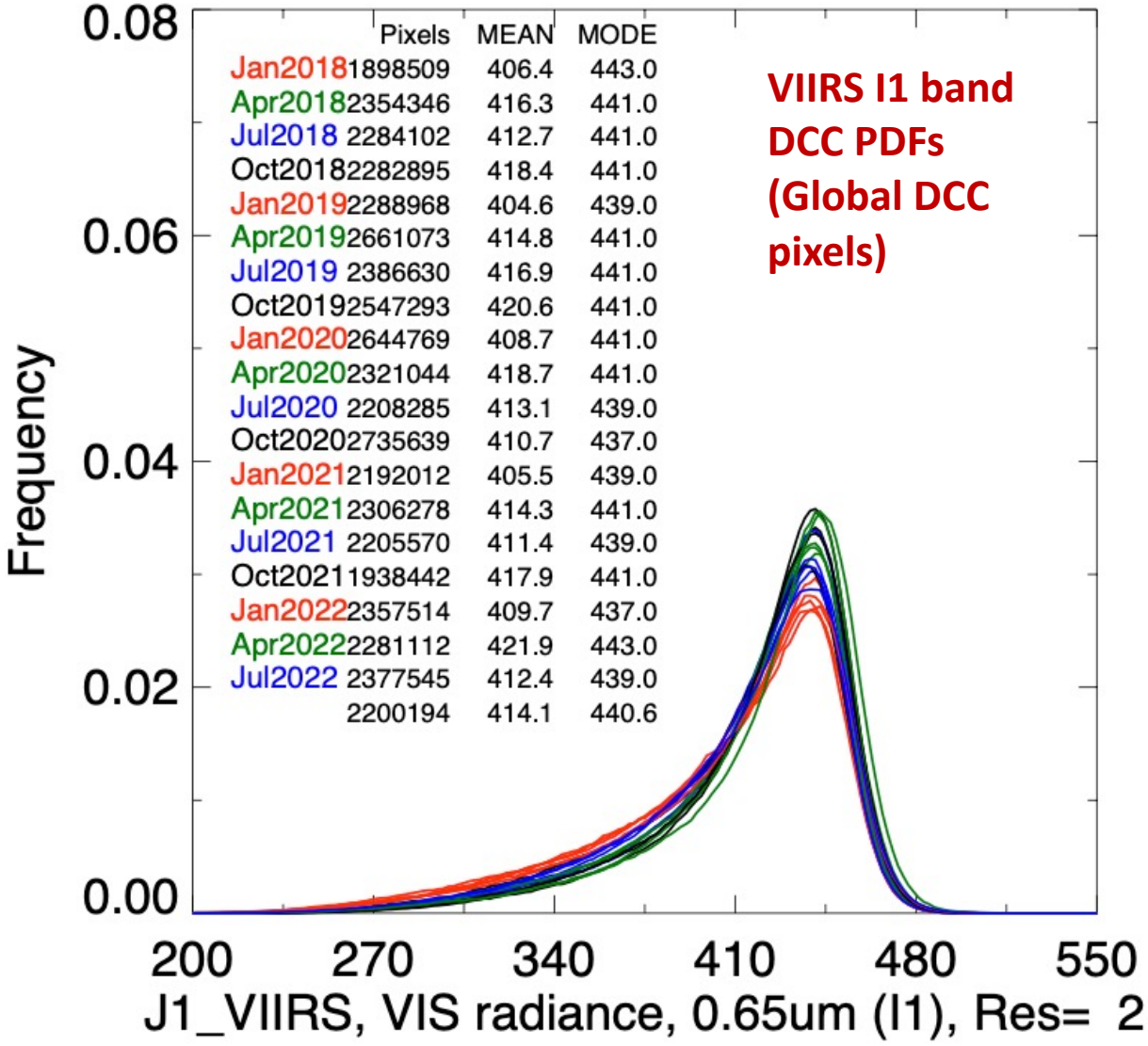


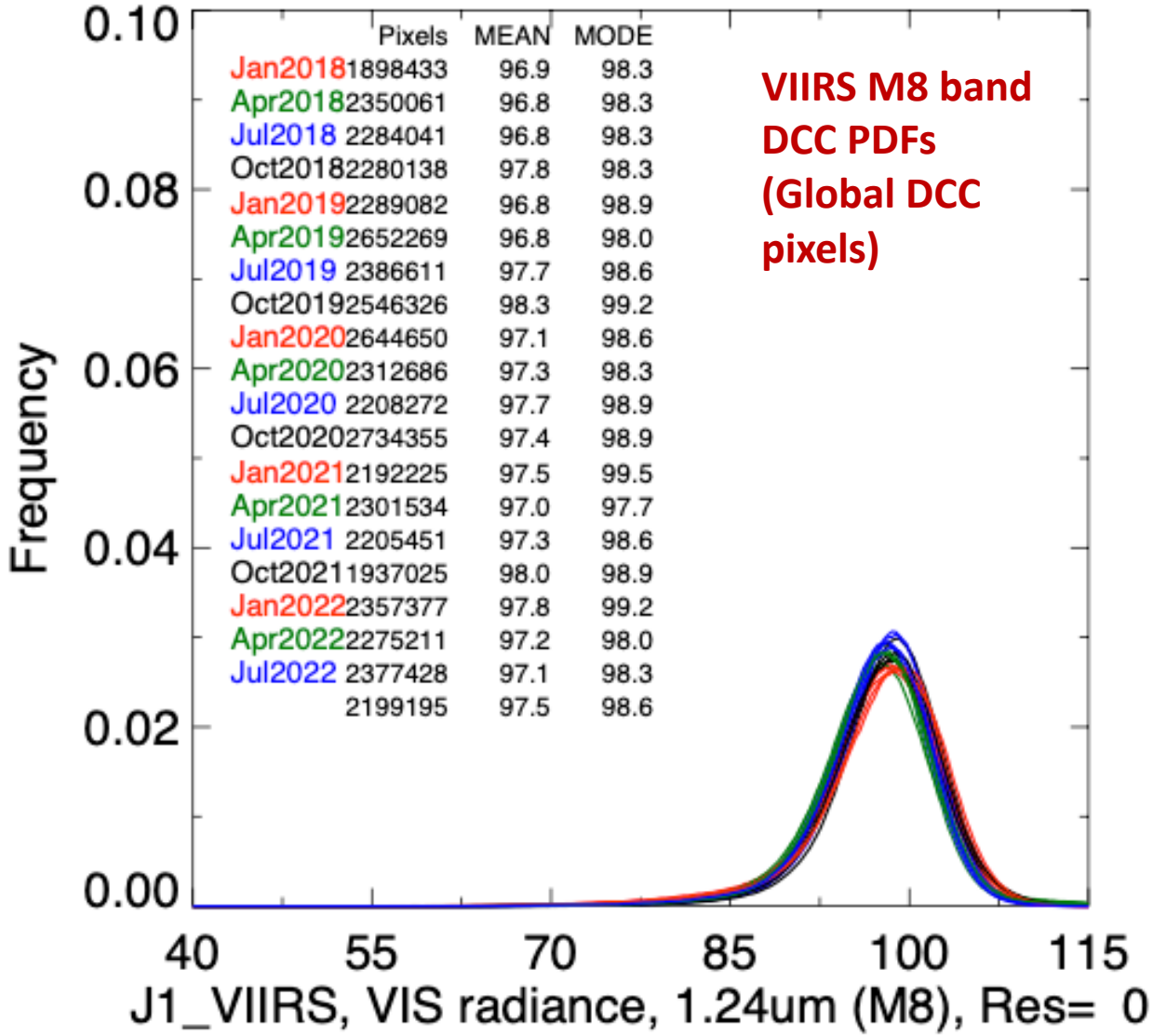
- ±20° Lat/Lon from the GEO sub-satellite point

DCC Characterization using NOAA-20 VIIRS

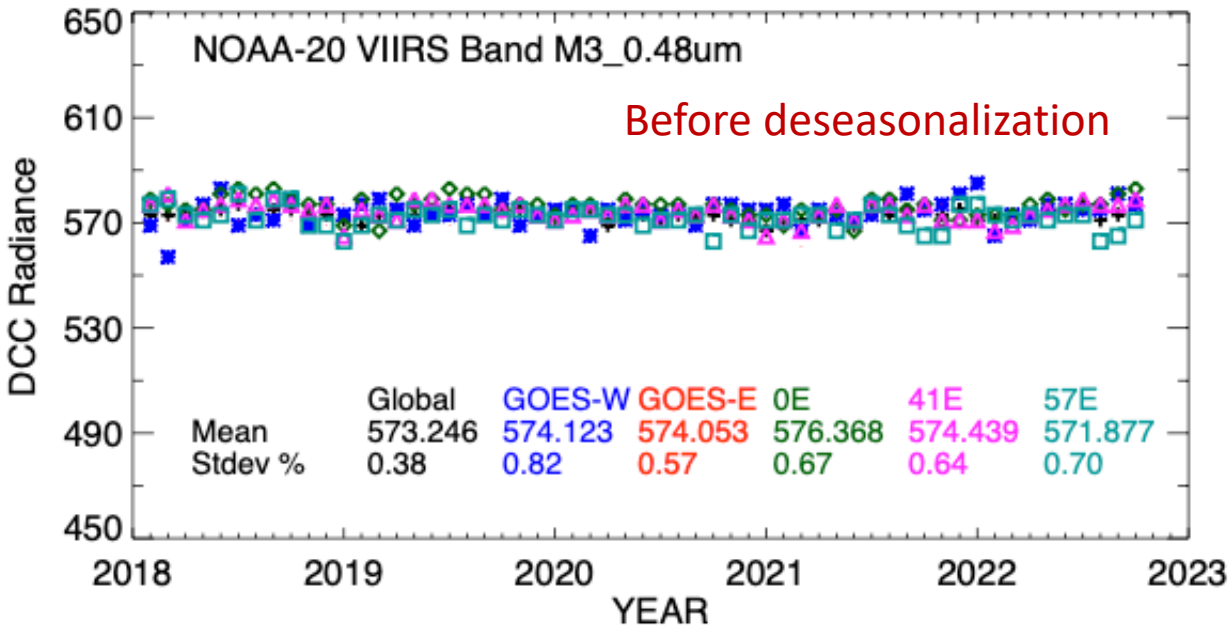


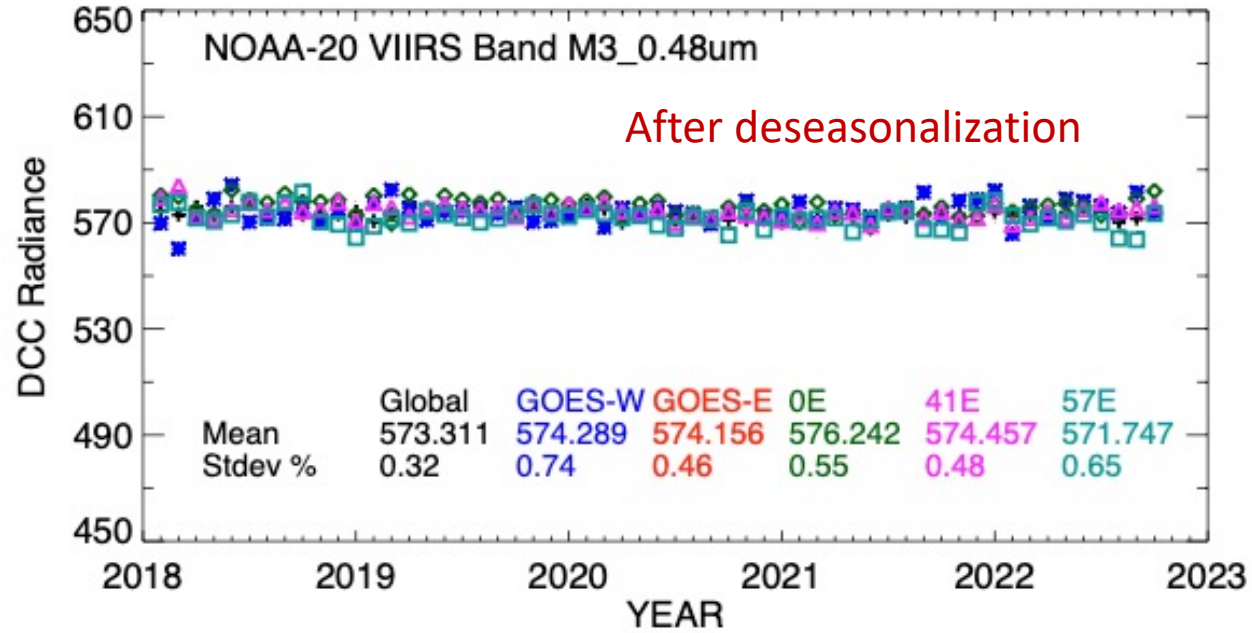
- Identify DCC pixels within GEO domain using M15 (10.8 µm) BT < 205 K
- Filtering
  - *Spatial homogeneity tests for filtering DCC edges*
    - $\sigma_{VIS} < 3\%$ *and* $\sigma_{BT} < 1K$ *for the* 3x3 pixel block surrounding a DCC pixel
  - *Angular thresholds for capturing the most Lambertian part of DCC*
    - SZA < 40°, VZA < 40°, 10° < RAA < 170°
- Anisotropic Corrections
  - *Apply COS(SZA) and Earth-Sun distance corrections*
  - *Apply Hu Angular Direction Model (ADM) to scale all DCC pixel radiances (wavelengths < 1 µm) to a common set of solar and viewing conditions*
  - *For **wavelengths > 1 µm**, use SNPP-VIIRS based empirical BRDF for anisotropic corrections*
  - *Compile DCC pixels into monthly probability distribution functions (PDFs) and compute their statistical mean and mode values*
- Derive mean and standard deviation of monthly DCC mean/mode timeseries
  - Use the most stable record of the reference instrument (first 3-5 years)
  - **Use Mode as a reference for *wavelengths < 1 µm***
  - **Use Mean as a reference for *wavelengths > 1 µm***
- *This study provides reference DCC mode/mean values for **ten** reflective solar wavelengths over **nine** GEO domains*

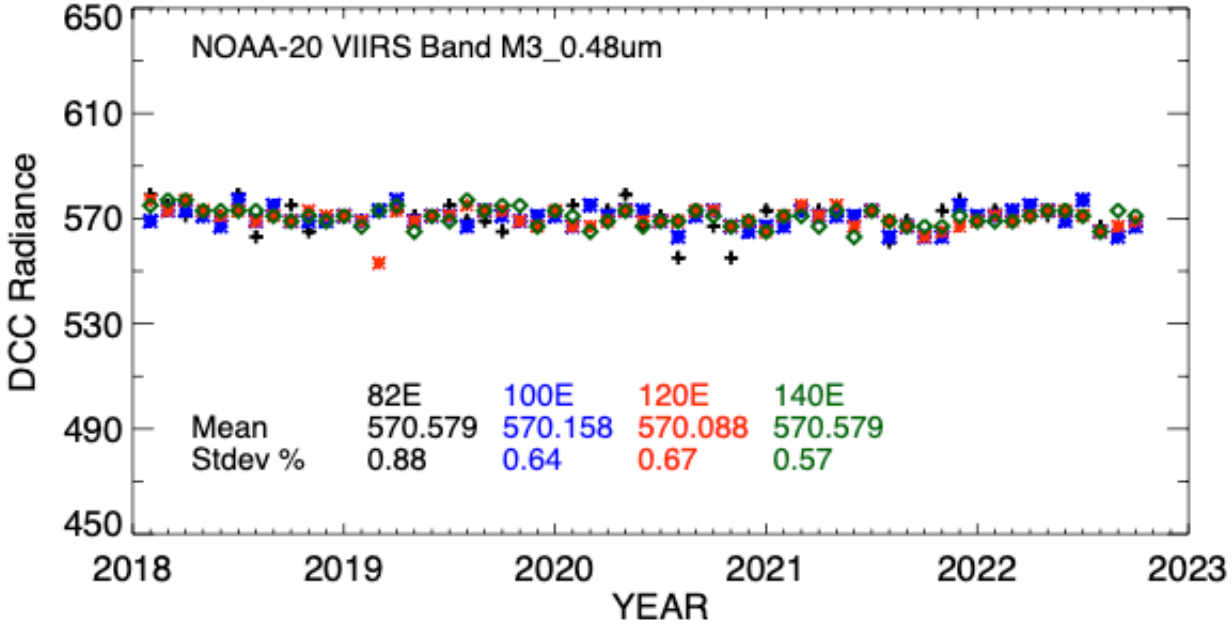


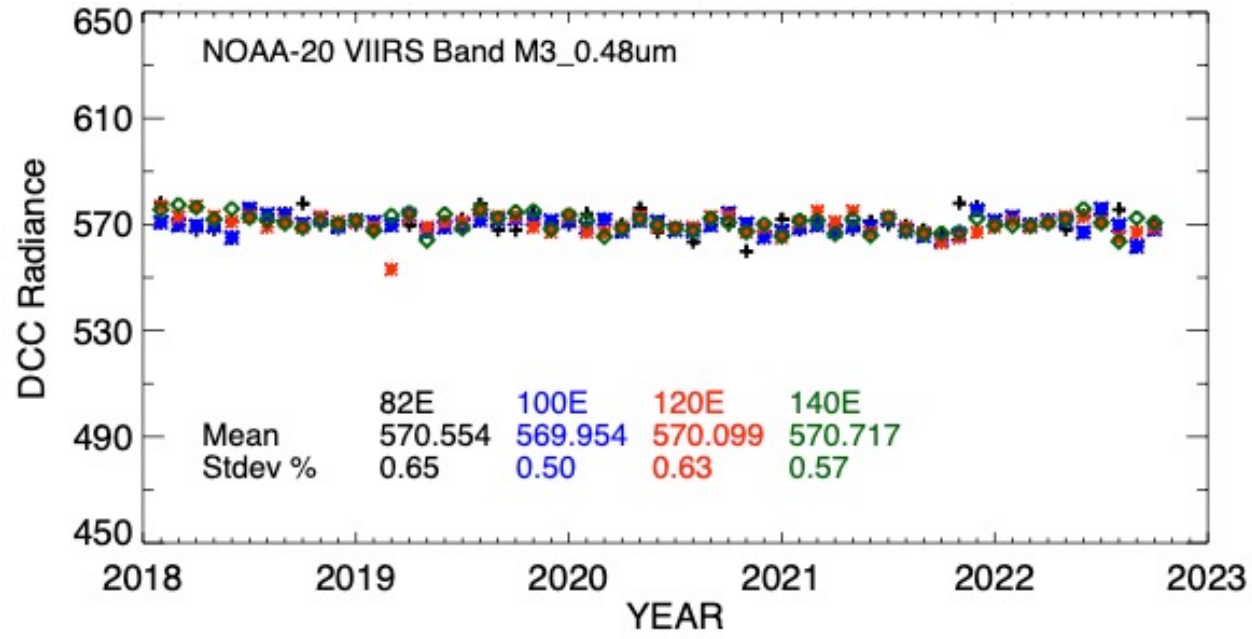


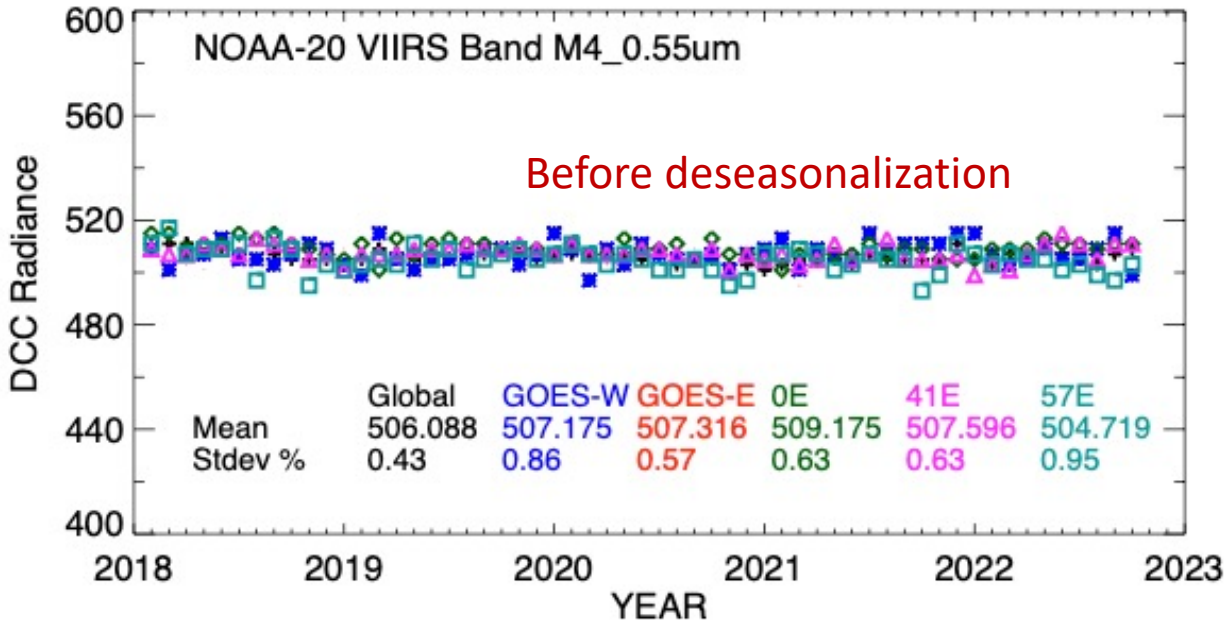
This study uses NOAA-20 VIIRS L1B
Collection 2.1 products from NASA Land SIPS

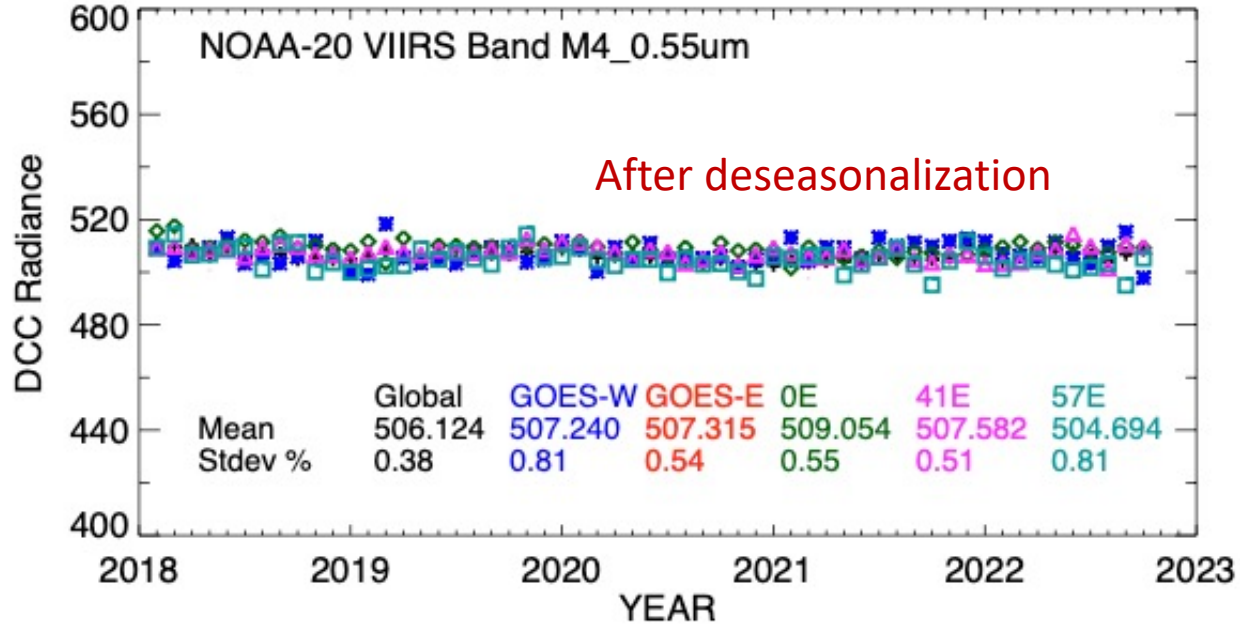

NOAA-20 VIIRS Band M3_0.48um
Before deseasonalization
DCC Radiance
YEAR
650
610
570
530
490
450
2018
2019
2020
2021
2022
2023
Global GOES-W GOES-E 0E 41E 57E
Mean 573.246 574.123 574.053 576.368 574.439 571.877
Stdev % 0.38 0.82 0.57 0.67 0.64 0.70

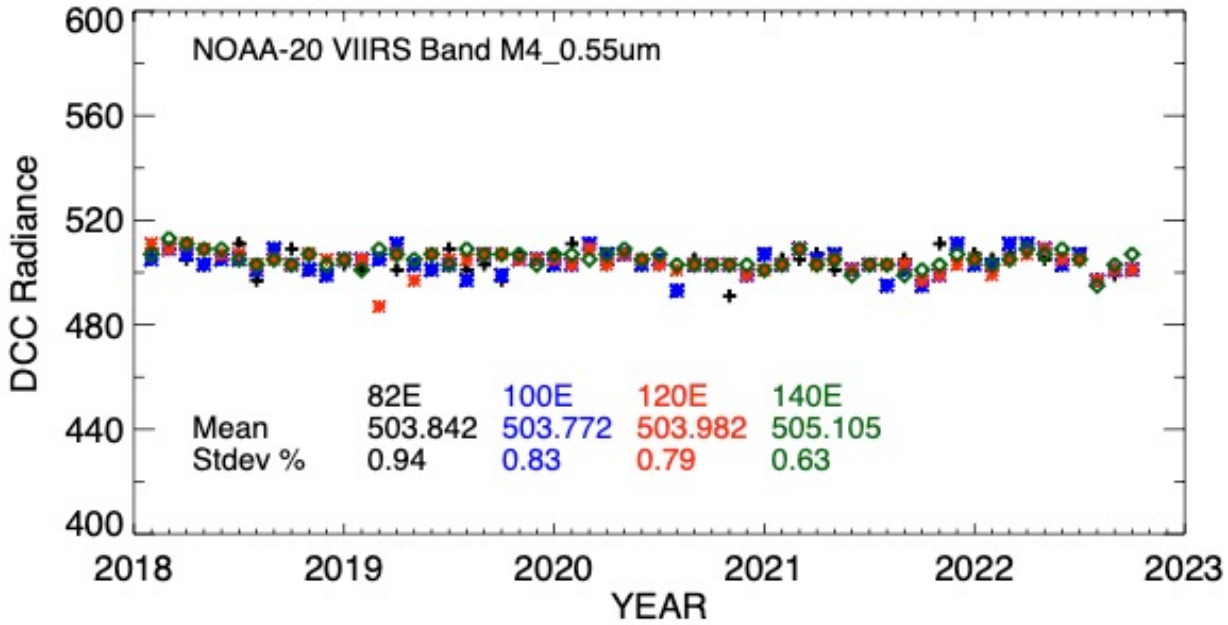

NOAA-20 VIIRS Band M3_0.48um
After deseasonalization
DCC Radiance
YEAR
650
610
570
530
490
450
2018
2019
2020
2021
2022
2023
Global GOES-W GOES-E 0E 41E 57E
Mean 573.311 574.289 574.156 576.242 574.457 571.747
Stdev % 0.32 0.74 0.46 0.55 0.48 0.65

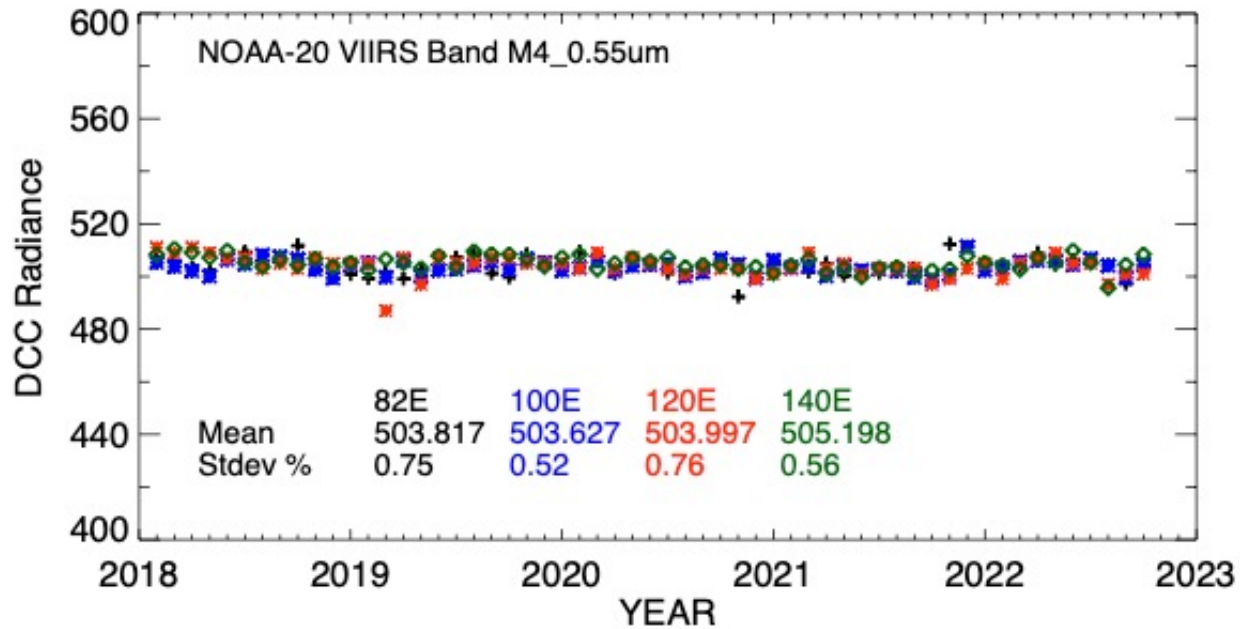

NOAA-20 VIIRS Band M3_0.48um
DCC Radiance
YEAR
650
610
570
530
490
450
2018
2019
2020
2021
2022
2023
82E 100E 120E 140E
Mean 570.579 570.158 570.088 570.579
Stdev % 0.88 0.64 0.67 0.57

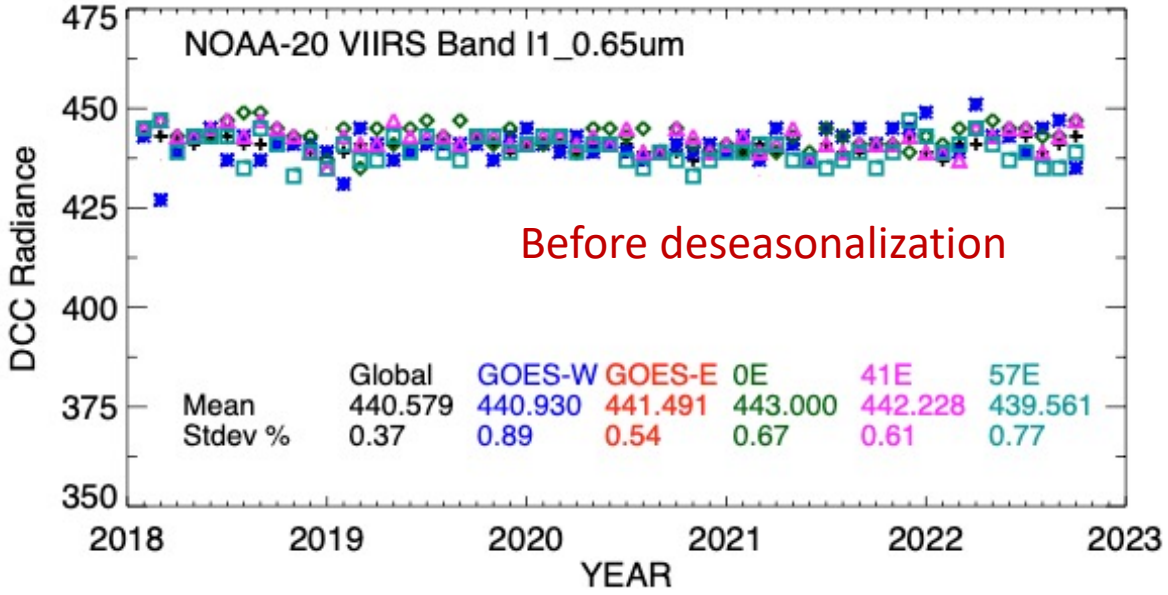

NOAA-20 VIIRS Band M3_0.48um
DCC Radiance
YEAR
650
610
570
530
490
450
2018
2019
2020
2021
2022
2023
82E 100E 120E 140E
Mean 570.554 569.954 570.099 570.717
Stdev % 0.65 0.50 0.63 0.57

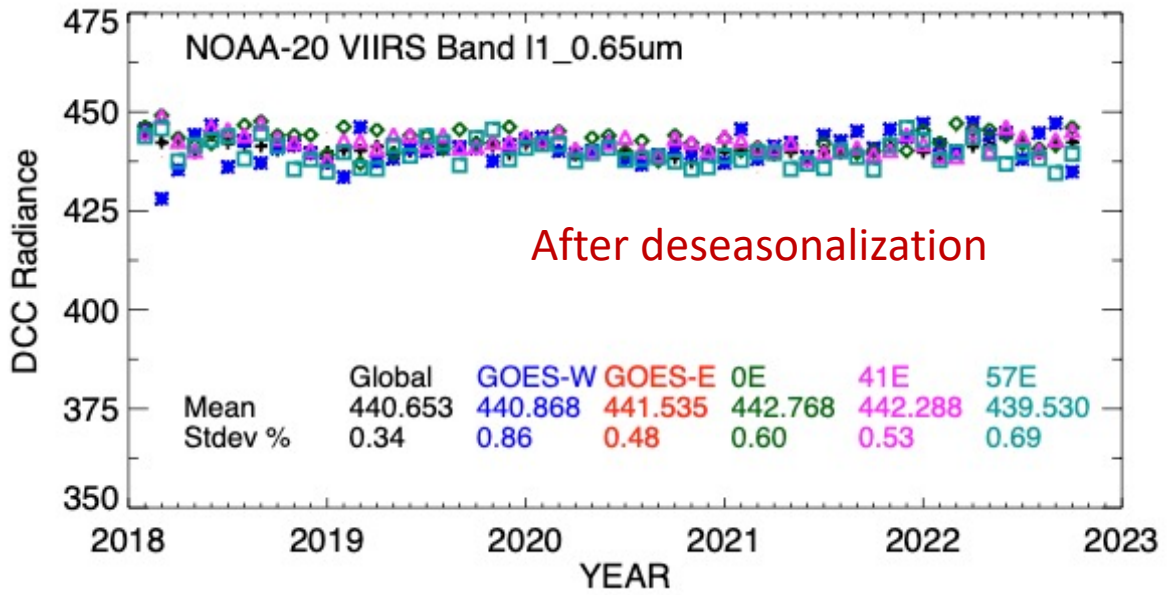

NOAA-20 VIIRS Band M4_0.55um
Before deseasonalization
DCC Radiance
YEAR
Global GOES-W GOES-E 0E 41E 57E
Mean 506.088 507.175 507.316 509.175 507.596 504.719
Stdev % 0.43 0.86 0.57 0.63 0.63 0.95

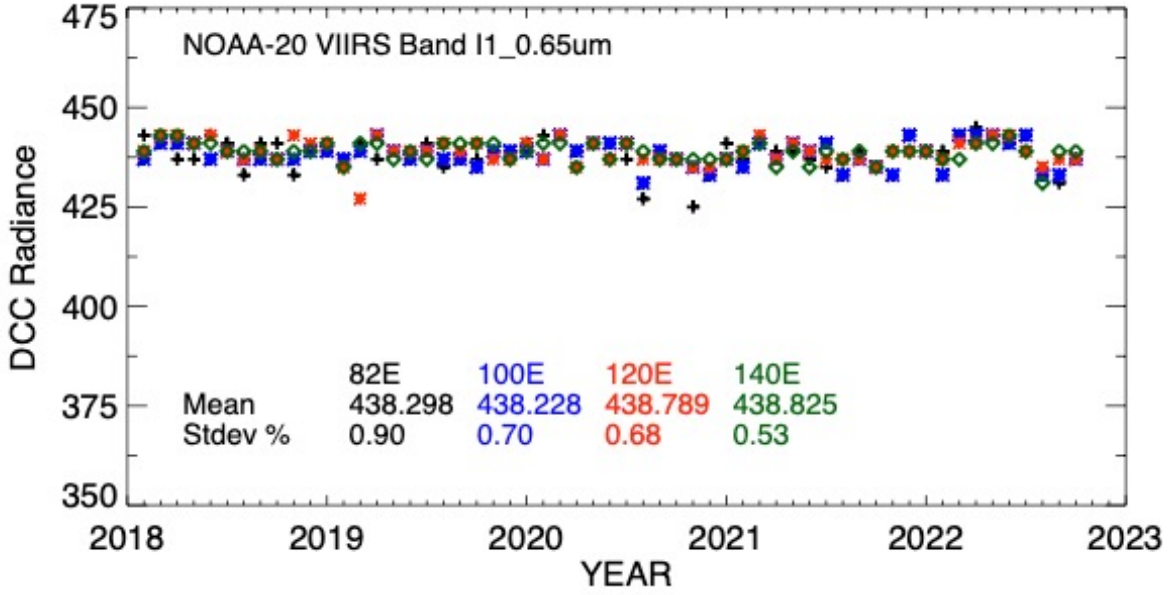

NOAA-20 VIIRS Band M4_0.55um
After deseasonalization
DCC Radiance
YEAR
Global GOES-W GOES-E 0E 41E 57E
Mean 506.124 507.240 507.315 509.054 507.582 504.694
Stdev % 0.38 0.81 0.54 0.55 0.51 0.81

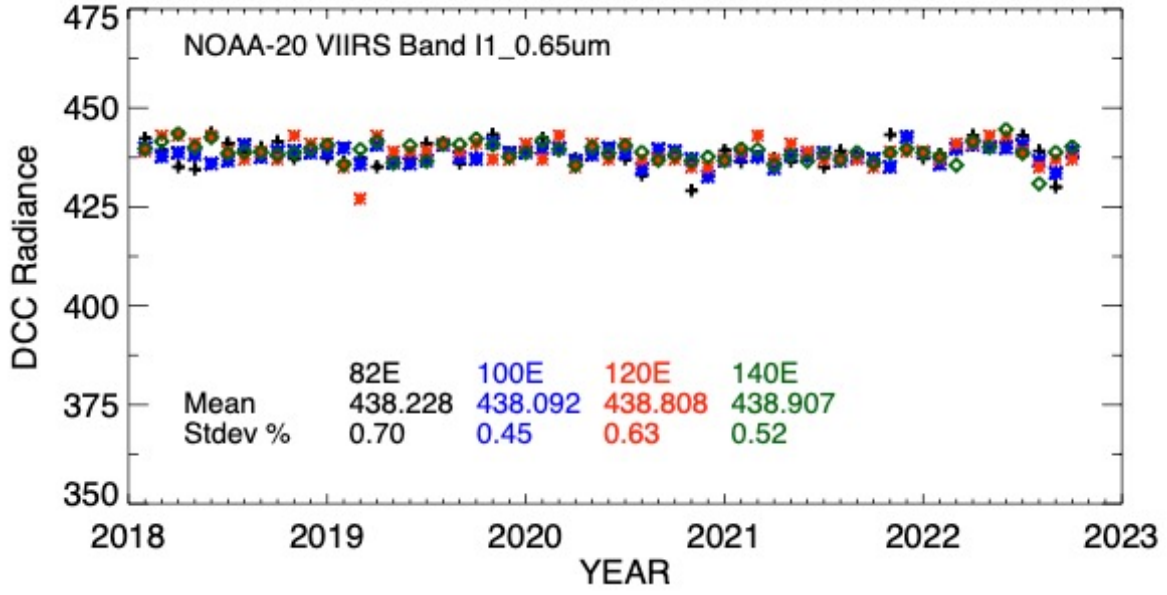

NOAA-20 VIIRS Band M4_0.55um
DCC Radiance
YEAR
82E 100E 120E 140E
Mean 503.842 503.772 503.982 505.105
Stdev % 0.94 0.83 0.79 0.63


NOAA-20 VIIRS Band M4_0.55um
DCC Radiance
YEAR
82E 100E 120E 140E
Mean 503.817 503.627 503.997 505.198
Stdev % 0.75 0.52 0.76 0.56

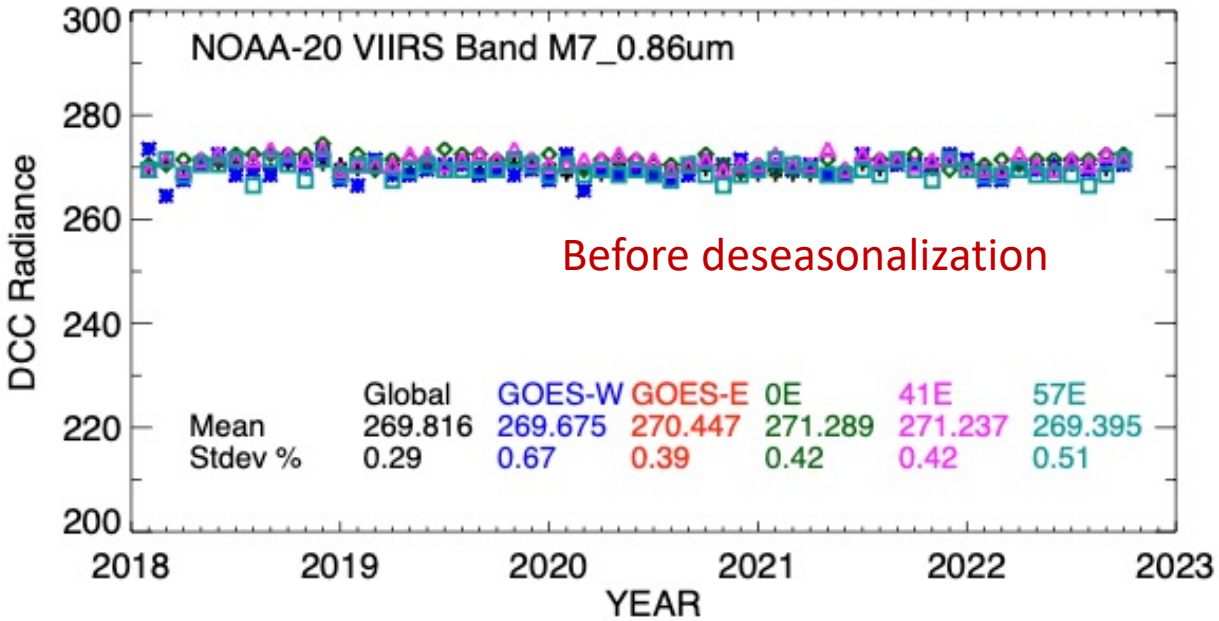


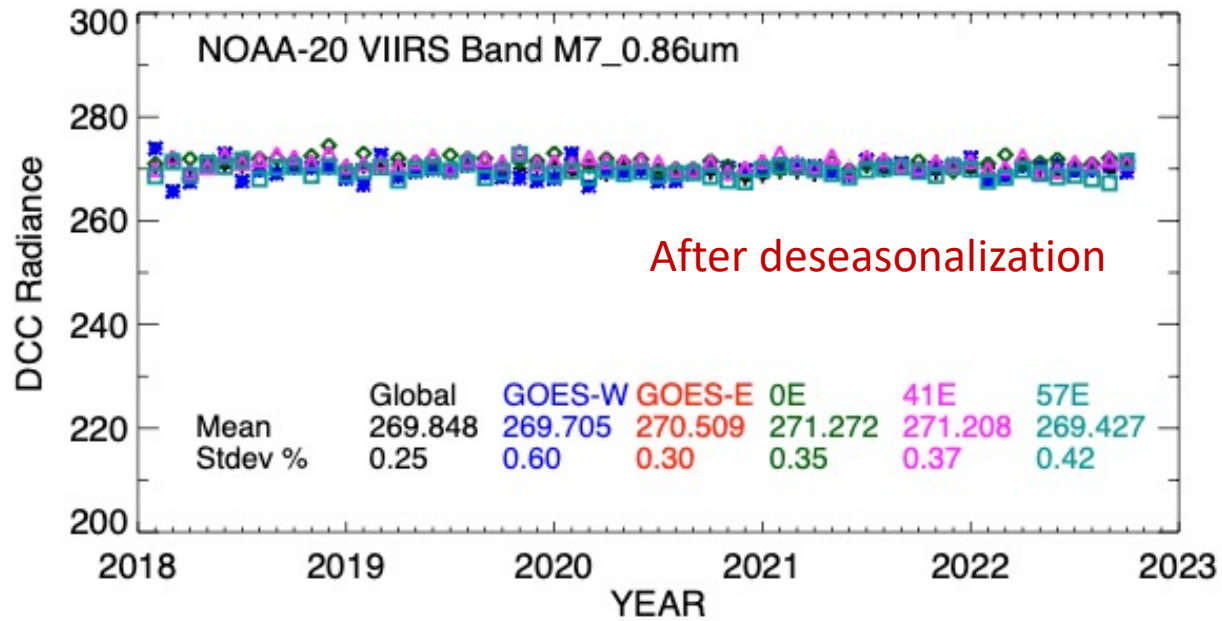


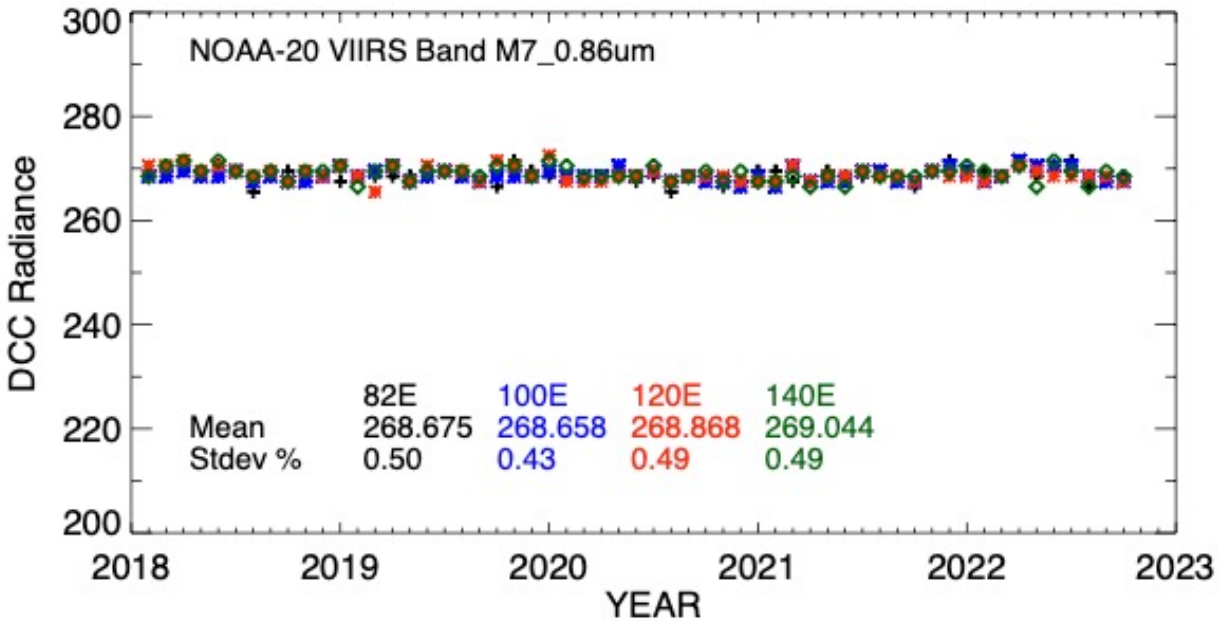


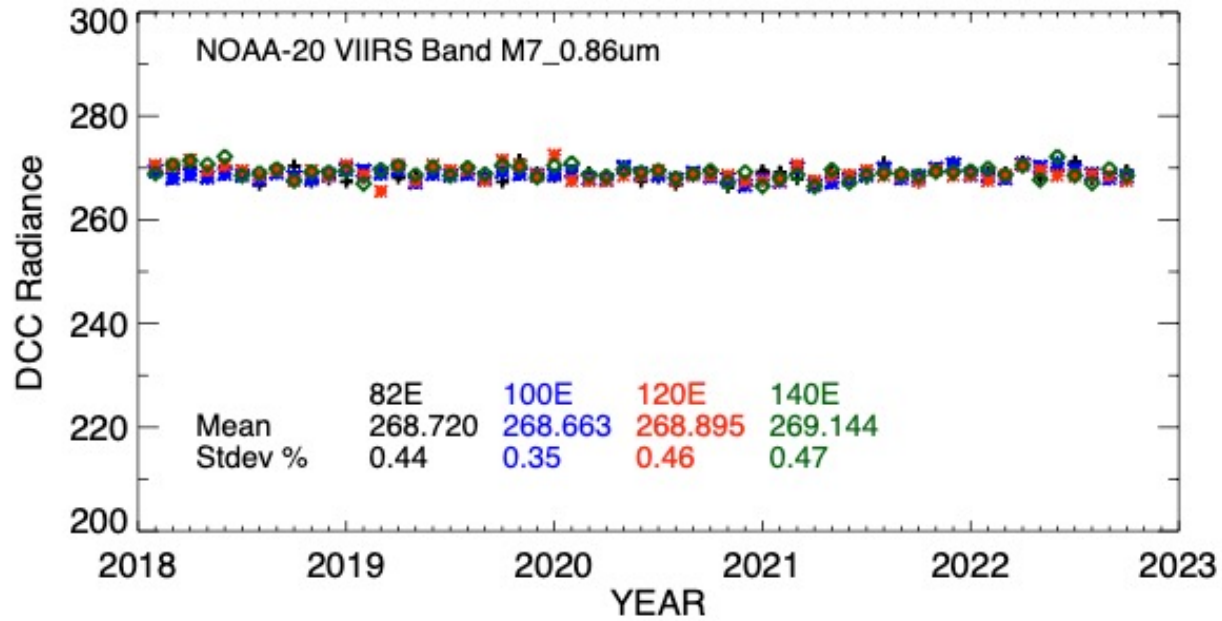


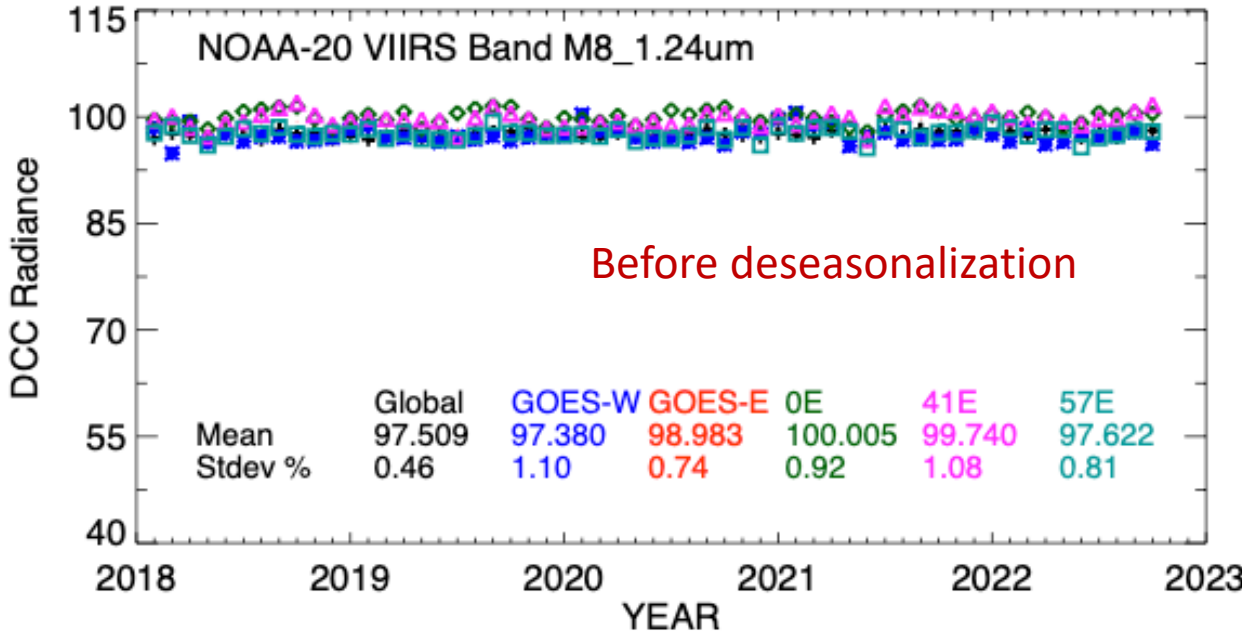
- ***Regional variation of DCC mode is ~1%***
  - ***brightest over 0°E longitude***
  - ***DCC radiances near TWP are lower***

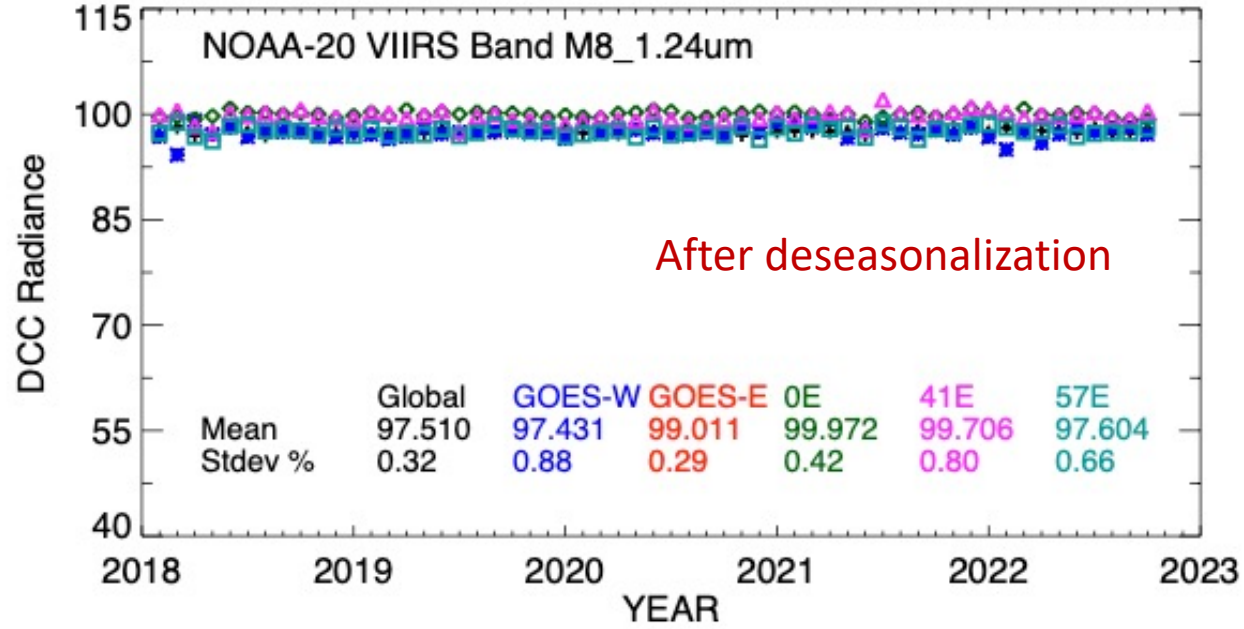

NOAA-20 VIIRS Band M7_0.86um
DCC Radiance
YEAR
Before deseasonalization
Global GOES-W GOES-E 0E 41E 57E
Mean 269.816 269.675 270.447 271.289 271.237 269.395
Stdev % 0.29 0.67 0.39 0.42 0.42 0.51

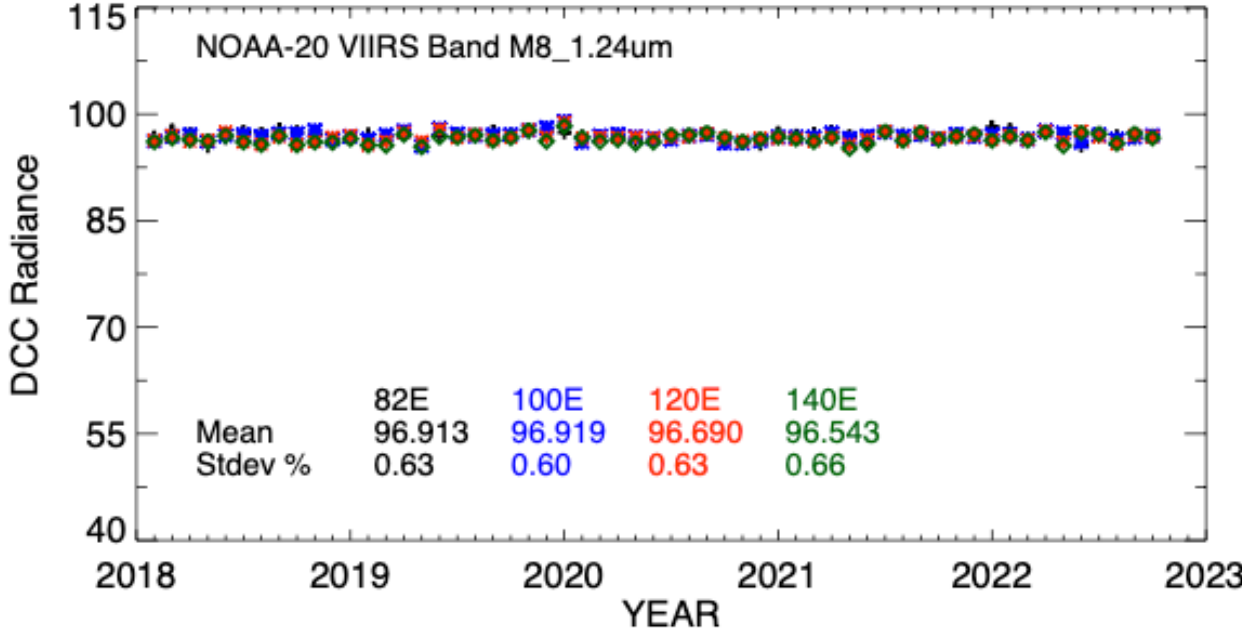

NOAA-20 VIIRS Band M7_0.86um
DCC Radiance
YEAR
After deseasonalization
Global GOES-W GOES-E 0E 41E 57E
Mean 269.848 269.705 270.509 271.272 271.208 269.427
Stdev % 0.25 0.60 0.30 0.35 0.37 0.42

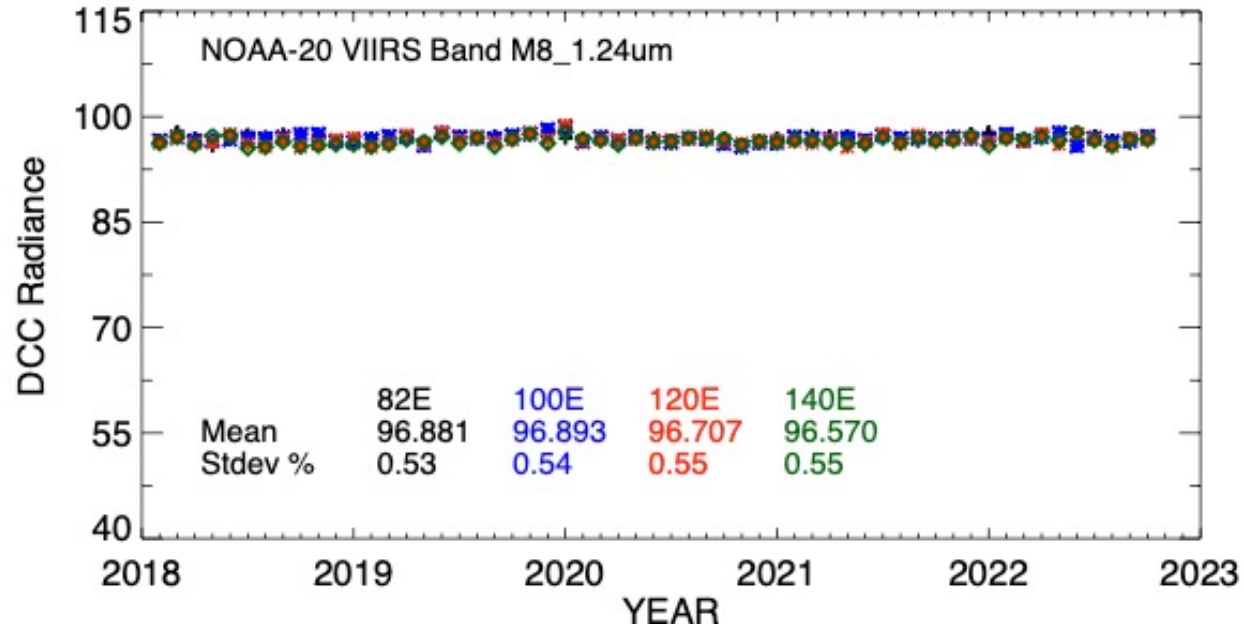

NOAA-20 VIIRS Band M7_0.86um
DCC Radiance
YEAR
82E 100E 120E 140E
Mean 268.675 268.658 268.868 269.044
Stdev % 0.50 0.43 0.49 0.49

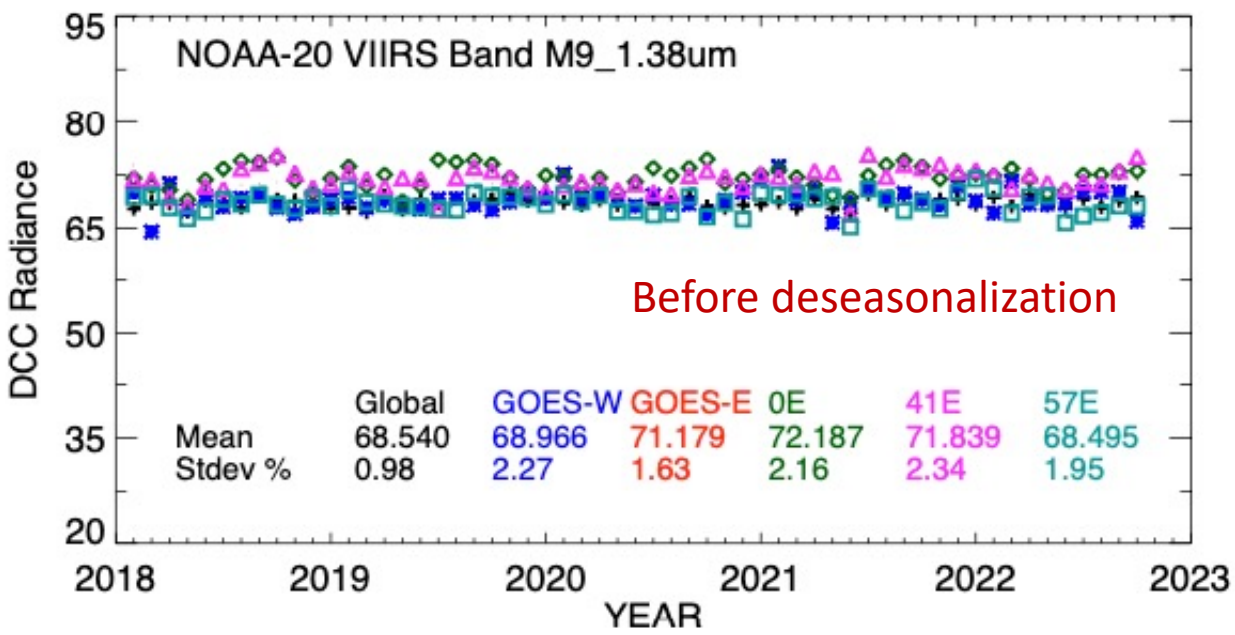

NOAA-20 VIIRS Band M7_0.86um
DCC Radiance
YEAR
82E 100E 120E 140E
Mean 268.720 268.663 268.895 269.144
Stdev % 0.44 0.35 0.46 0.47

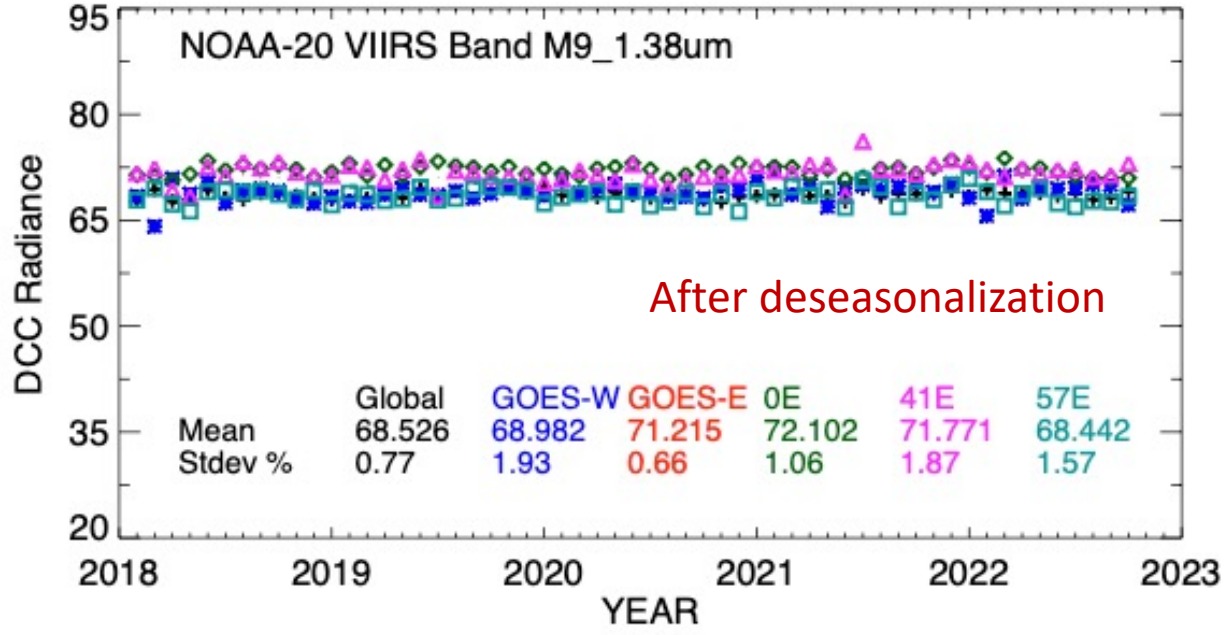

NOAA-20 VIIRS Band M8_1.24um
Before deseasonalization
DCC Radiance
YEAR
Global GOES-W GOES-E 0E 41E 57E
Mean 97.509 97.380 98.983 100.005 99.740 97.622
Stdev % 0.46 1.10 0.74 0.92 1.08 0.81

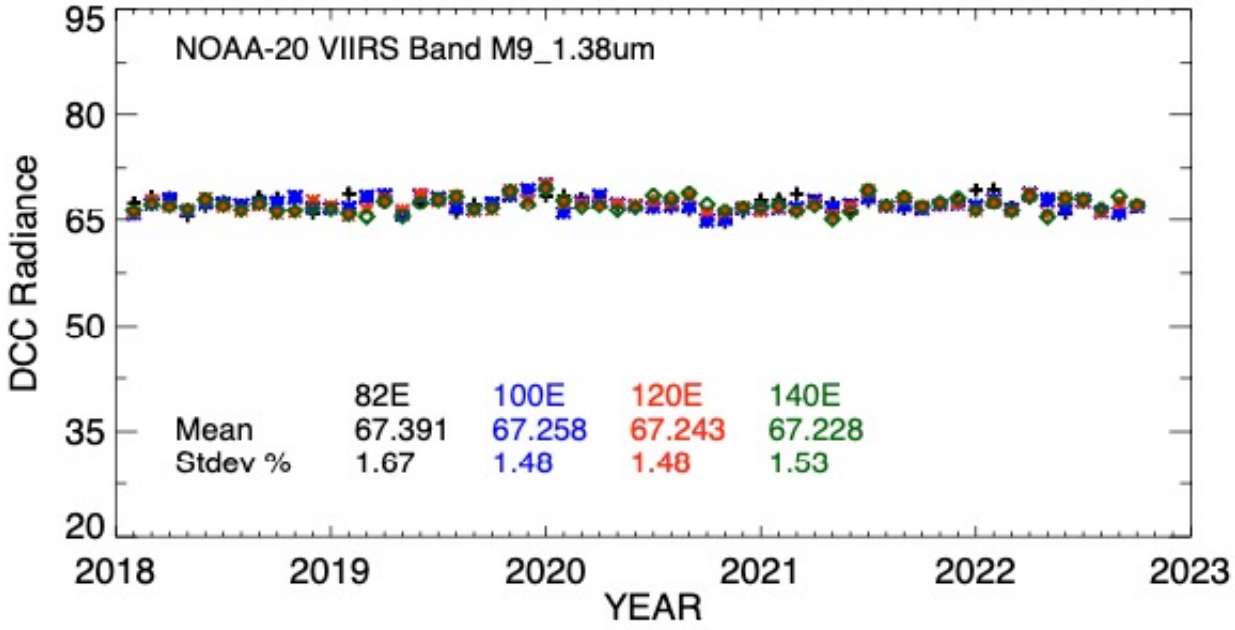

NOAA-20 VIIRS Band M8_1.24um
After deseasonalization
DCC Radiance
YEAR
Global GOES-W GOES-E 0E 41E 57E
Mean 97.510 97.431 99.011 99.972 99.706 97.604
Stdev % 0.32 0.88 0.29 0.42 0.80 0.66

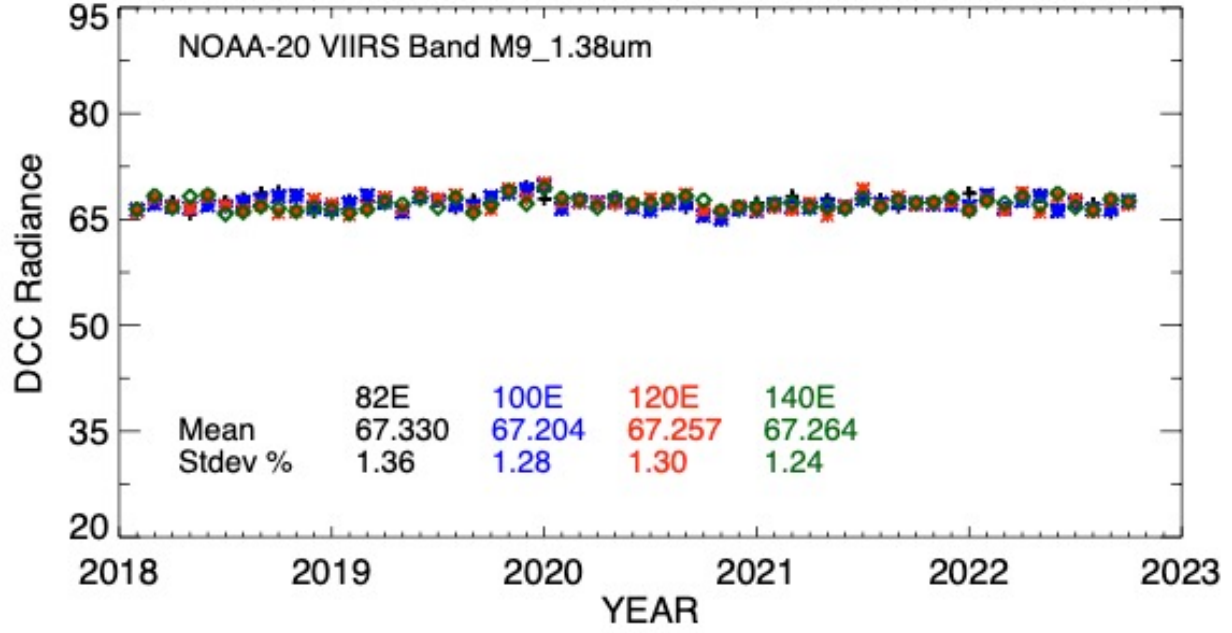

NOAA-20 VIIRS Band M8_1.24um
DCC Radiance
YEAR
82E 100E 120E 140E
Mean 96.913 96.919 96.690 96.543
Stdev % 0.63 0.60 0.63 0.66

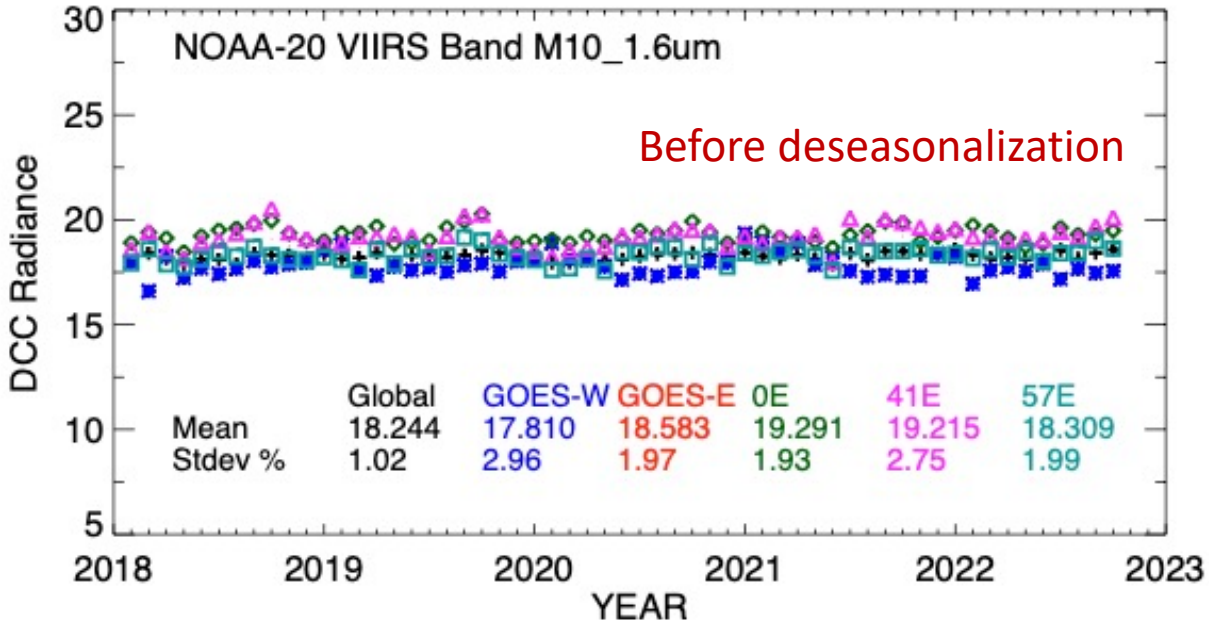

NOAA-20 VIIRS Band M8_1.24um
DCC Radiance
YEAR
82E 100E 120E 140E
Mean 96.881 96.893 96.707 96.570
Stdev % 0.53 0.54 0.55 0.55

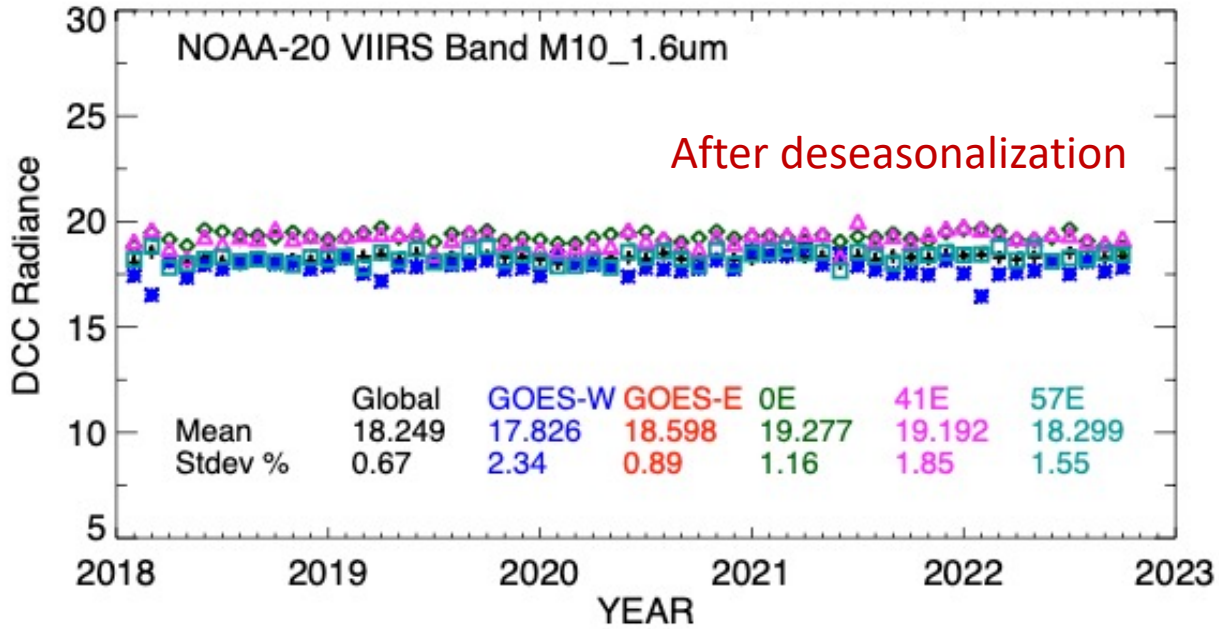

NOAA-20 VIIRS Band M9_1.38um
Before deseasonalization
Global GOES-W GOES-E 0E 41E 57E
Mean 68.540 68.966 71.179 72.187 71.839 68.495
Stdev % 0.98 2.27 1.63 2.16 2.34 1.95
DCC Radiance
YEAR

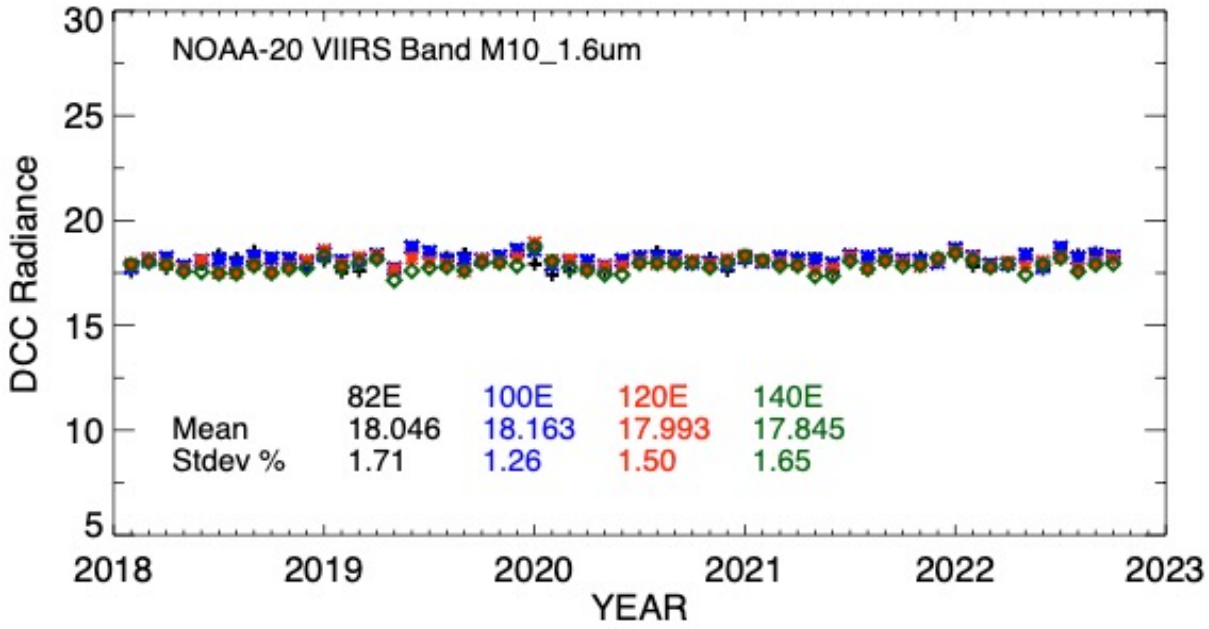

NOAA-20 VIIRS Band M9_1.38um
After deseasonalization
Global GOES-W GOES-E 0E 41E 57E
Mean 68.526 68.982 71.215 72.102 71.771 68.442
Stdev % 0.77 1.93 0.66 1.06 1.87 1.57
DCC Radiance
YEAR

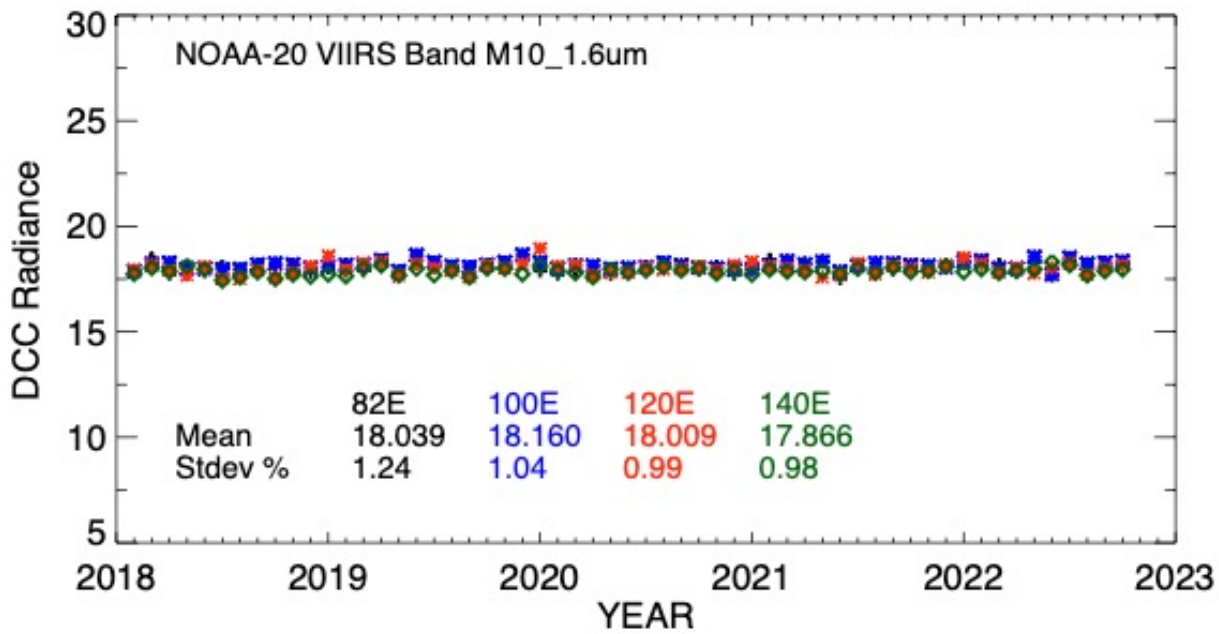

NOAA-20 VIIRS Band M9_1.38um
82E 100E 120E 140E
Mean 67.391 67.258 67.243 67.228
Stdev % 1.67 1.48 1.48 1.53
DCC Radiance
YEAR

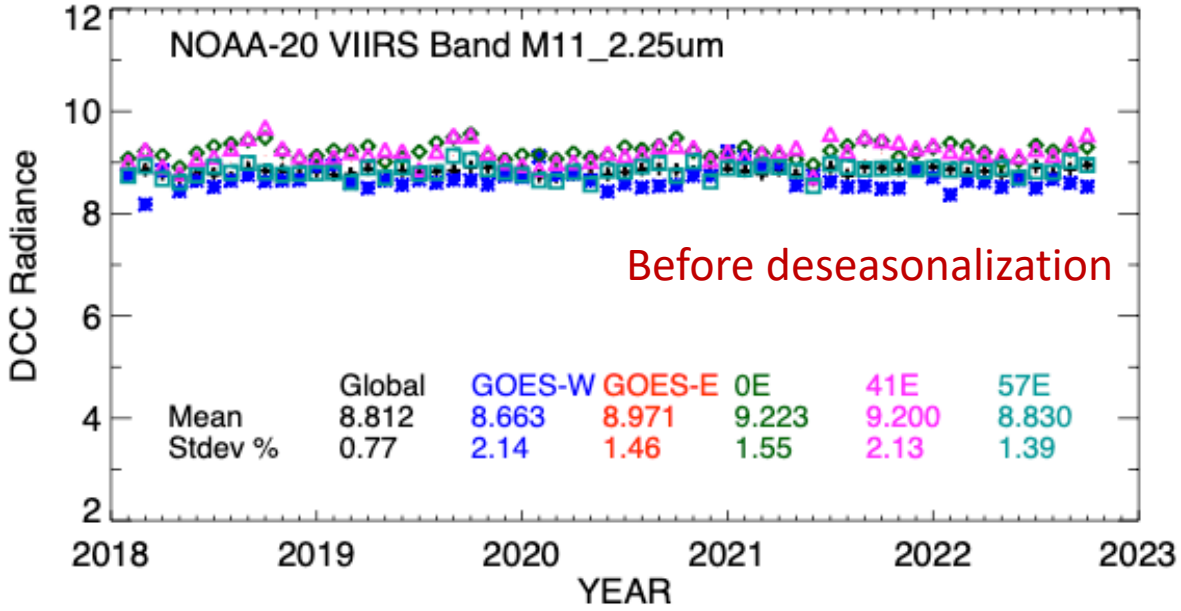

NOAA-20 VIIRS Band M9_1.38um
82E 100E 120E 140E
Mean 67.330 67.204 67.257 67.264
Stdev % 1.36 1.28 1.30 1.24
DCC Radiance
YEAR

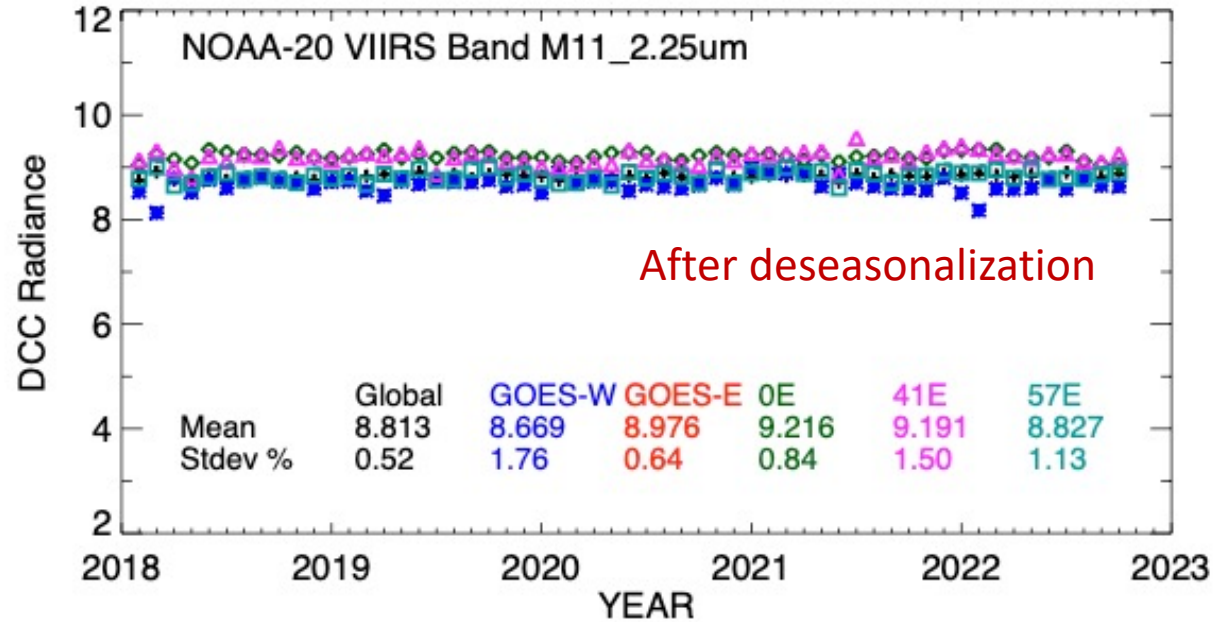

NOAA-20 VIIRS Band M10_1.6um
Before deseasonalization
DCC Radiance
YEAR
Global GOES-W GOES-E 0E 41E 57E
Mean 18.244 17.810 18.583 19.291 19.215 18.309
Stdev % 1.02 2.96 1.97 1.93 2.75 1.99

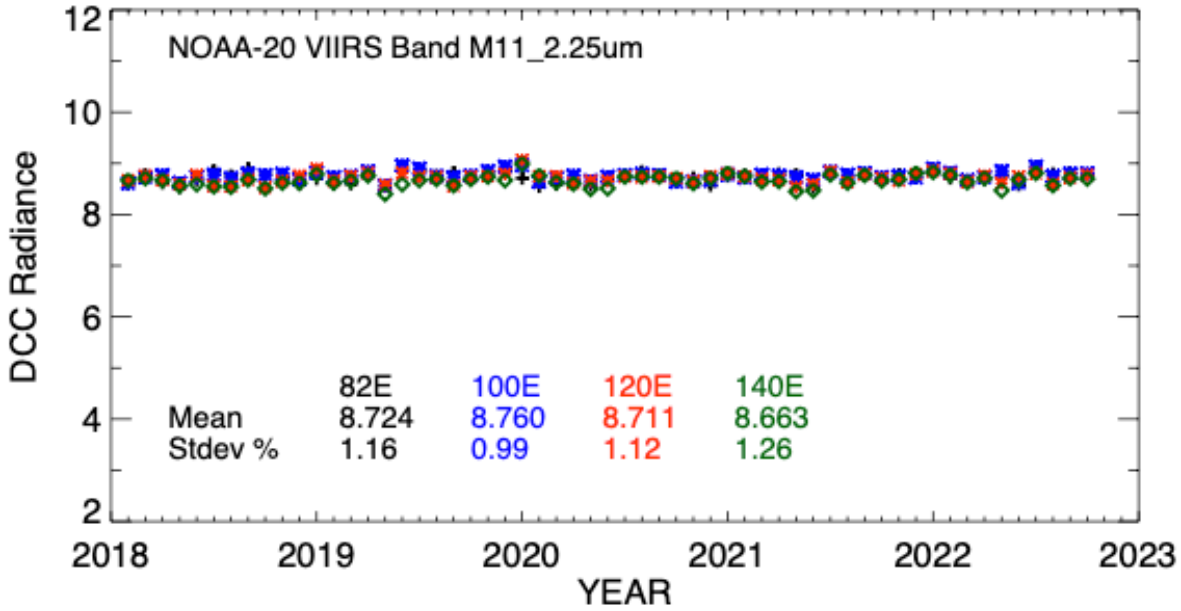

NOAA-20 VIIRS Band M10_1.6um
After deseasonalization
DCC Radiance
YEAR
Global GOES-W GOES-E 0E 41E 57E
Mean 18.249 17.826 18.598 19.277 19.192 18.299
Stdev % 0.67 2.34 0.89 1.16 1.85 1.55

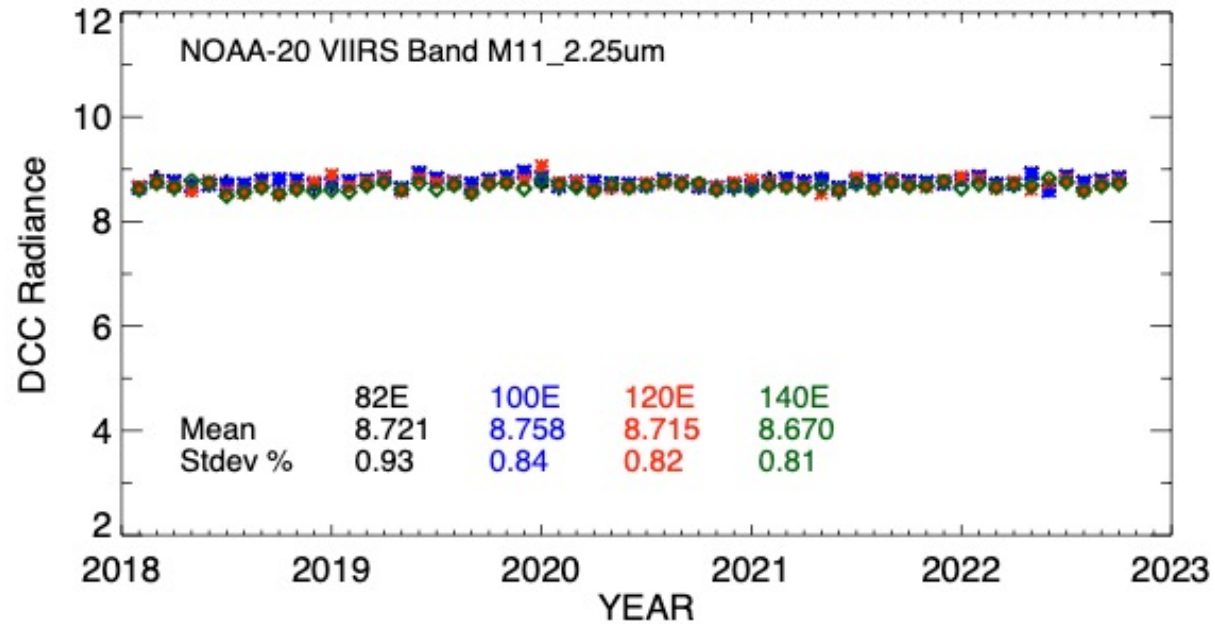

NOAA-20 VIIRS Band M10_1.6um
DCC Radiance
YEAR
82E 100E 120E 140E
Mean 18.046 18.163 17.993 17.845
Stdev % 1.71 1.26 1.50 1.65


NOAA-20 VIIRS Band M10_1.6um
DCC Radiance
YEAR
82E 100E 120E 140E
Mean 18.039 18.160 18.009 17.866
Stdev % 1.24 1.04 0.99 0.98


NOAA-20 VIIRS Band M11_2.25um
Before deseasonalization
DCC Radiance
YEAR
Global GOES-W GOES-E 0E 41E 57E
Mean 8.812 8.663 8.971 9.223 9.200 8.830
Stdev % 0.77 2.14 1.46 1.55 2.13 1.39


NOAA-20 VIIRS Band M11_2.25um
After deseasonalization
DCC Radiance
YEAR
Global GOES-W GOES-E 0E 41E 57E
Mean 8.813 8.669 8.976 9.216 9.191 8.827
Stdev % 0.52 1.76 0.64 0.84 1.50 1.13


NOAA-20 VIIRS Band M11_2.25um
DCC Radiance
YEAR
82E 100E 120E 140E
Mean 8.724 8.760 8.711 8.663
Stdev % 1.16 0.99 1.12 1.26


NOAA-20 VIIRS Band M11_2.25um
DCC Radiance
YEAR
82E 100E 120E 140E
Mean 8.721 8.758 8.715 8.670
Stdev % 0.93 0.84 0.82 0.81

No Deseasonalization

NOAA-20 VIIRS based reference DCC radiance for GEO domains (based on ~5 years of observation)										
Band	**Global**	**GOES-W**	**GOES-E**	**0E**	**41E**	**57E**	**82E**	**100E**	**120E**	**140E**
M3_0.48um	573.2456	574.1228	574.0526	576.3684	574.4386	571.8772	570.5789	570.1579	570.0877	570.5789
M4_0.55um	506.0877	507.1754	507.3158	509.1754	507.5965	504.7193	503.8421	503.7719	503.9825	505.1053
M5_0.67um	431.1404	432.2632	431.6316	433.7368	432.8596	430.4386	429.1754	429.386	429.7018	430.2982
M7_0.86um	269.8158	269.6754	270.4474	271.2895	271.2368	269.3947	268.6754	268.6579	268.8684	269.0439
M8_1.24um	97.5093	97.3802	98.9833	100.0054	99.7398	97.6216	96.9128	96.9186	96.6897	96.5428
M9_1.38um	68.5403	68.9661	71.1788	72.187	71.839	68.4947	67.3912	67.2577	67.2432	67.2275
M10_1.6um	18.2439	17.81	18.5833	19.2909	19.2149	18.3093	18.0465	18.163	17.993	17.8447
M11_2.25um	8.8123	8.663	8.9709	9.2233	9.2	8.83	8.7239	8.7604	8.7105	8.663
I1_0.65um	440.5789	440.9298	441.4912	443	442.2281	439.5614	438.2982	438.2281	438.7895	438.8246
I3_1.6um	17.9872	17.5449	18.3182	19.0135	18.9414	18.0521	17.7944	17.9093	17.7444	17.5982

1-sigma uncertainty based on temporal standard deviation (%)										
Band	**Global**	**GOES-W**	**GOES-E**	**0E**	**41E**	**57E**	**82E**	**100E**	**120E**	**140E**
M3_0.48um	0.3849	0.8223	0.5706	0.666	0.6371	0.6995	0.8756	0.6357	0.6665	0.5727
M4_0.55um	0.4295	0.8636	0.5664	0.6311	0.6317	0.9456	0.9398	0.8279	0.7906	0.6324
M5_0.67um	0.36	0.7852	0.5819	0.5756	0.5229	0.712	0.8037	0.6126	0.6611	0.5306
M7_0.86um	0.2901	0.6653	0.3854	0.4164	0.4211	0.5092	0.5029	0.4267	0.4851	0.492
M8_1.24um	0.461	1.1009	0.7363	0.9202	1.0797	0.8107	0.6252	0.6014	0.6299	0.6628
M9_1.38um	0.984	2.2744	1.6343	2.1611	2.3366	1.9472	1.6673	1.482	1.4798	1.5325
M10_1.6um	1.0155	2.9558	1.9669	1.927	2.7499	1.986	1.7073	1.265	1.5017	1.648
M11_2.25um	0.7705	2.1389	1.4612	1.5509	2.1309	1.3921	1.1617	0.9902	1.1209	1.2568
I1_0.65um	0.3713	0.8948	0.5433	0.6718	0.6149	0.7679	0.9023	0.6994	0.6765	0.5329
I3_1.6um	1.0141	2.859	1.9305	1.8845	2.702	1.9584	1.6925	1.2689	1.5138	1.6518

With Deseasonalization

NOAA-20 VIIRS based reference DCC radiance for GEO domains (based on ~5 years of observation)										
Band	**Global**	**GOES-W**	**GOES-E**	**0E**	**41E**	**57E**	**82E**	**100E**	**120E**	**140E**
M3_0.48um	573.3106	574.2886	574.1561	576.2417	574.4566	571.7466	570.5536	569.9536	570.099	570.7167
M4_0.55um	506.1241	507.2404	507.3154	509.054	507.582	504.6942	503.8166	503.6269	503.9973	505.1976
M5_0.67um	431.1717	432.3336	431.6643	433.5389	432.783	430.4023	429.1947	429.1932	429.7318	430.409
M7_0.86um	269.8475	269.7048	270.5088	271.2723	271.2081	269.4268	268.7202	268.6634	268.8952	269.1443
M8_1.24um	97.5102	97.4311	99.0111	99.9722	99.7063	97.6039	96.8815	96.8926	96.707	96.5699
M9_1.38um	68.5258	68.9824	71.2152	72.1015	71.7712	68.4424	67.3299	67.204	67.2569	67.2638
M10_1.6um	18.2495	17.826	18.598	19.2765	19.1919	18.2991	18.0388	18.1599	18.0086	17.8656
M11_2.25um	8.8133	8.6687	8.9759	9.216	9.1906	8.8266	8.7207	8.7579	8.7153	8.6702
I1_0.65um	440.6533	440.868	441.5347	442.7679	442.2879	439.5295	438.2284	438.0925	438.8077	438.9072
I3_1.6um	17.9934	17.5606	18.3323	18.9992	18.9191	18.0429	17.7872	17.9074	17.7608	17.6196

1-sigma uncertainty based on temporal standard deviation (%)										
Band	**Global**	**GOES-W**	**GOES-E**	**0E**	**41E**	**57E**	**82E**	**100E**	**120E**	**140E**
M3_0.48um	0.3224	0.7362	0.4648	0.5545	0.4794	0.6457	0.6529	0.4954	0.6257	0.5707
M4_0.55um	0.3828	0.8147	0.539	0.55	0.5102	0.812	0.7524	0.5202	0.7637	0.5621
M5_0.67um	0.3014	0.7365	0.4421	0.4593	0.3891	0.6223	0.5968	0.445	0.6345	0.5113
M7_0.86um	0.2532	0.6018	0.2988	0.3525	0.3681	0.4237	0.4422	0.3526	0.4553	0.4666
M8_1.24um	0.323	0.884	0.2876	0.4206	0.8008	0.6556	0.529	0.5354	0.5533	0.5497
M9_1.38um	0.768	1.9258	0.6587	1.0579	1.8741	1.5701	1.3559	1.2823	1.3041	1.2425
M10_1.6um	0.6682	2.3391	0.8873	1.1625	1.8501	1.5523	1.2395	1.0369	0.9909	0.9824
M11_2.25um	0.5209	1.765	0.6386	0.8359	1.5041	1.1304	0.9324	0.8365	0.8199	0.8054
I1_0.65um	0.3432	0.8554	0.4763	0.6018	0.5274	0.6881	0.7027	0.453	0.6328	0.5237
I3_1.6um	0.7027	2.215	0.854	1.1647	1.8416	1.5651	1.2669	1.0557	0.9961	0.9982

Summary

- Calibration of NOAA-20 VIIRS reflective solar bands is stable in Collection 2.1 dataset
- Deseasonalization reduces temporal variability in the DCC timeseries, especially for wavelengths greater than 1 µm