International Ocean Colour Science Meeting 2019
Advancing Global Ocean Colour Observations

NOAA VIIRS Calibration: Impact on ocean color products

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Website for VIIRS ocean color images and Cal/Val:
http://www.star.nesdis.noaa.gov/sod/mecb/color/

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NOAA VIIRS Calibration Approach

(Solar and Lunar Calibrations)

- Sun, J., M. Chu, and M. Wang, "On-orbit characterization of the VIIRS solar diffuser and attenuation screens for NOAA-20 using yaw measurements," Appl. Opt., 57, 6605–6619, 2018.
- Sun, J., M. Chu, and M. Wang, "Visible Infrared Imaging Radiometer Suite reflective solar bands on-orbit calibration using solar diffuser illuminated by scattered light through the nadir port," Appl. Opt., 57, 1273–1283, 2018.
- Sun, J. and M. Wang, "Crosstalk effect in SNPP VIIRS," Remote Sens., 9, 344, 2017. http://dx.doi.org/10.3390/rs9040344
- Sun, J., M. Chu, and M. Wang, "Degradation nonuniformity in the solar diffuser bidirectional reflectance distribution function," Appl. Opt., 55, 6001–6016, 2016.
- Sun, J., X. Xiong, E. Waluschka, and M. Wang, "Suomi National Polar-Orbiting Partnership Visible Infrared Imaging Radiometer Suite polarization sensitivity analysis," Appl. Opt., 55, 7645–7658, 2016.

Sun, J. and M. Wang, "Radiometric calibration of the VIIRS reflective solar bands with robust characterizations and hybrid calibration coefficients," Appl. Opt., 54, 9331–9342, 2015.

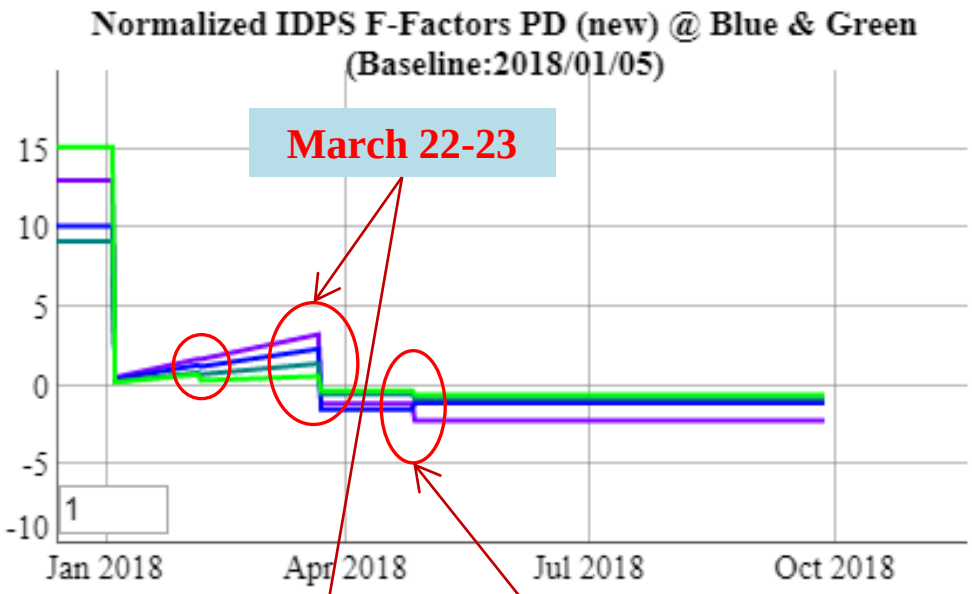
- Sun, J. and M. Wang, "On-orbit calibration of Visible Infrared Imaging Radiometer Suite reflective solar bands and its challenges using a solar diffuser," Appl. Opt., 54, 7210–7223, 2015.
- Sun, J. and M. Wang, "On-orbit characterization of the VIIRS solar diffuser and solar diffuser screen," Appl. Opt., 54, 236–252, 2015.
- Sun, J. and M. Wang, "Visible Infrared Imaging Radiometer Suite solar diffuser calibration and its challenges using solar diffuser stability monitor," Appl. Opt., 53, 8571–8584, 2014.

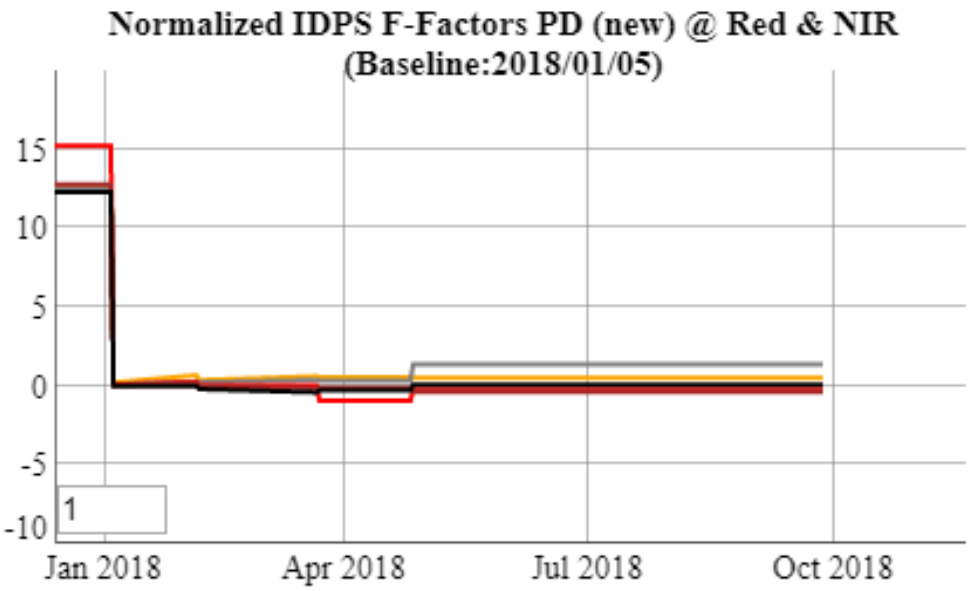
Summary of VIIRS Ocean Color EDR Products (NOAA-20 and SNPP)

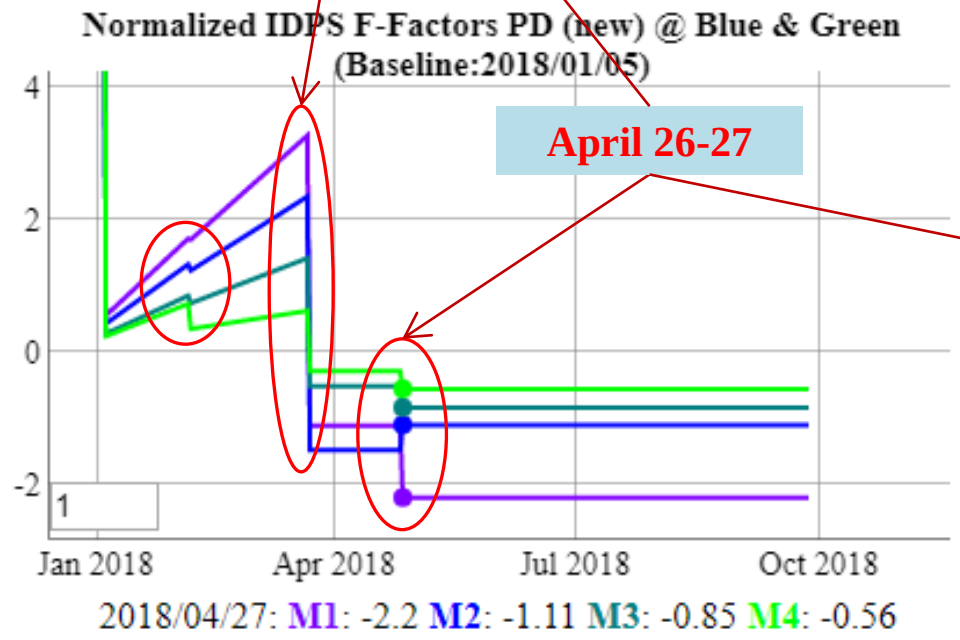
- **Inputs**:
  - VIIRS M1-M7, I1, and the **SWIR** M8, M10, and M11 bands SDR data
  - Terrain-corrected geo-location file
  - Ancillary meteorology and ozone data
- **Operational (Standard) Products (10)**:
  - Normalized water-leaving radiance (nL_w's) at VIIRS visible bands M1-M5, and **I1 (642 nm)**
  - Chlorophyll-a (Chl-a) concentration
  - Diffuse attenuation coefficient for the downwelling spectral irradiance at the wavelength of 490 nm, $K_d(490)$
  - Diffuse attenuation coefficient of the downwelling photosynthetically available radiation (PAR), $K_d(PAR)$
  - **QA Score** for data quality ($nL_w(\lambda)$ spectra) (*Wei et al.*, 2016)
  - Level-2 quality flags
- **Experimental Products (29):**
  - Inherent Optical Properties (IOP-a, IOP-a_{ph}, IOP-a_{dg}, IOP-b_b, IOP-b_{bp}) at VIIRS M2 or other visible bands (M1-M5) from the Quasi-Analytical Algorithm (QAA) (*Lee et al.*, 2002)
  - Photosynthetically Available Radiation (PAR) (*R. Frouin*)
  - Chl-a from ocean color index (OCI) method (*Hu et al.*, 2012; *Wang and Son*, 2016)
  - Others, e.g., user specific products (e.g., **Chl-a anomaly** and **Chl-a anomaly ratio**)

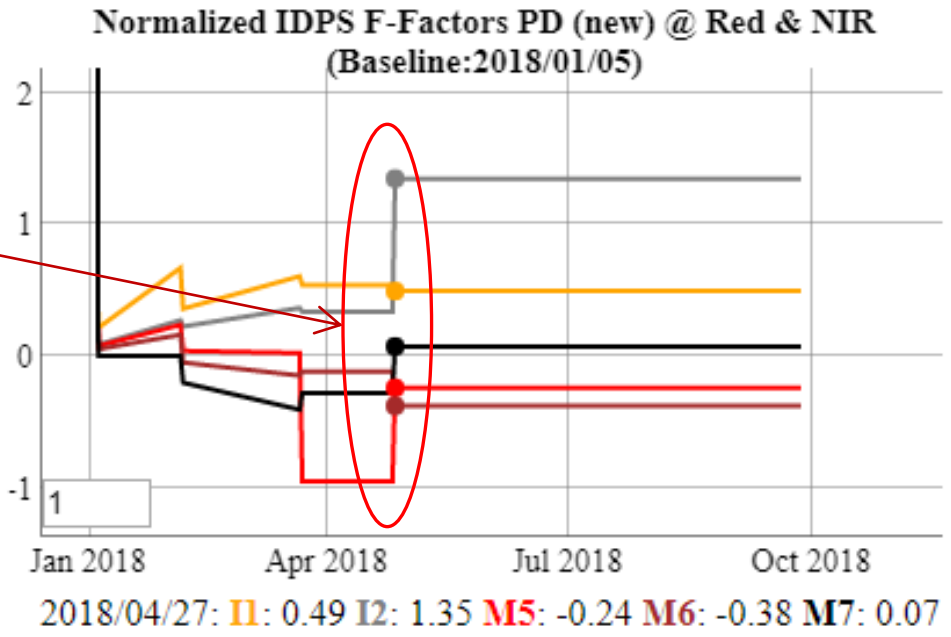
➢ Data quality of ocean color EDR are extremely sensitive to the SDR quality. It requires **~0.1%** data accuracy (degradation, band-to-band accuracy…)!

NOAA-20 IDPS Calibration F-Factors









The last big change was on April 27, 2018 and there has been no change on the NOAA-20 calibration.

VIIRS-NOAA-20 SDR before April 27, 2018 has some data quality problems!

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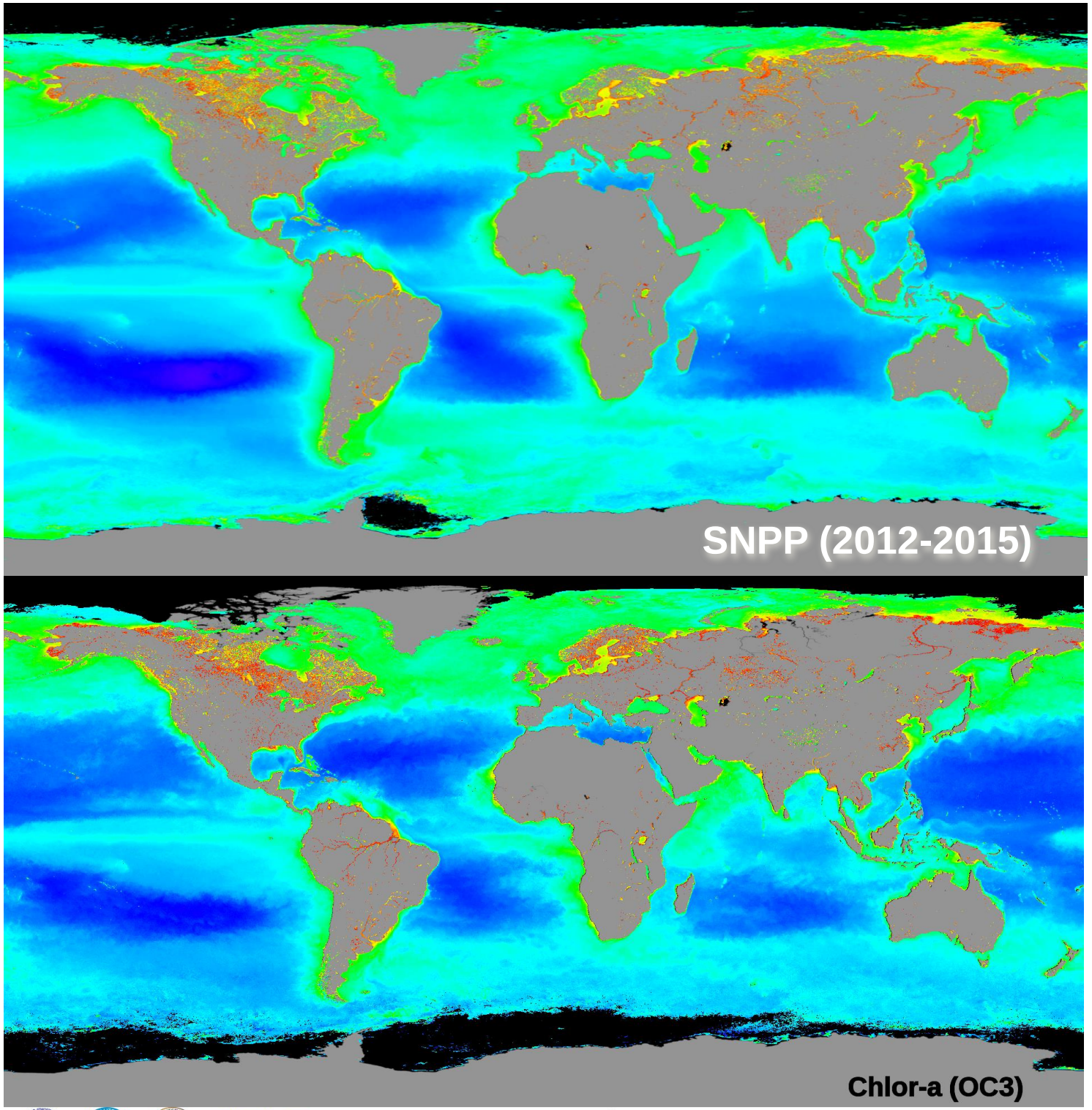
Effort on Producing VIIRS-NOAA-20 Global Ocean Color Products

- The VIIRS Ocean Color EDR team has made very significant effort on producing VIIRS-NOAA-20 ocean color products. We had some difficulties and challenges for the task mainly due to two factors (different from SNPP): (1) some sensor calibration issues leading to some SDR problems and (2) lack of sufficient number of high quality MOBY in situ data during the VIIRS-NOAA-20 mission period.

We decided to focus on the time period after April 27, 2018 for producing VIIRS-NOAA-20 ocean color products.

- Due to the lack of high quality MOBY in situ data, we are forced to vicariously calibrate VIIRS-NOAA-20 using the VIIRS-SNPP ocean color products (inter-sensor calibration) over the MOBY Hawaii site.
- In fact, mission-long VIIRS-NOAA-20 ocean color data have been reprocessed several times to have the most optimal vicarious gains for processing VIIRS data, in particular, for the time period after April 27, 2018.
- In addition, because VIIRS-NOAA-20 and VIIRS-SNPP have slightly different spectral band characteristics, a methodology has been developed and implemented in MSL12 to effectively account for the spectral band differences between two VIIRS sensors.

Climatology Chl-a from VIIRS-SNPP and VIIR-NOAA-20



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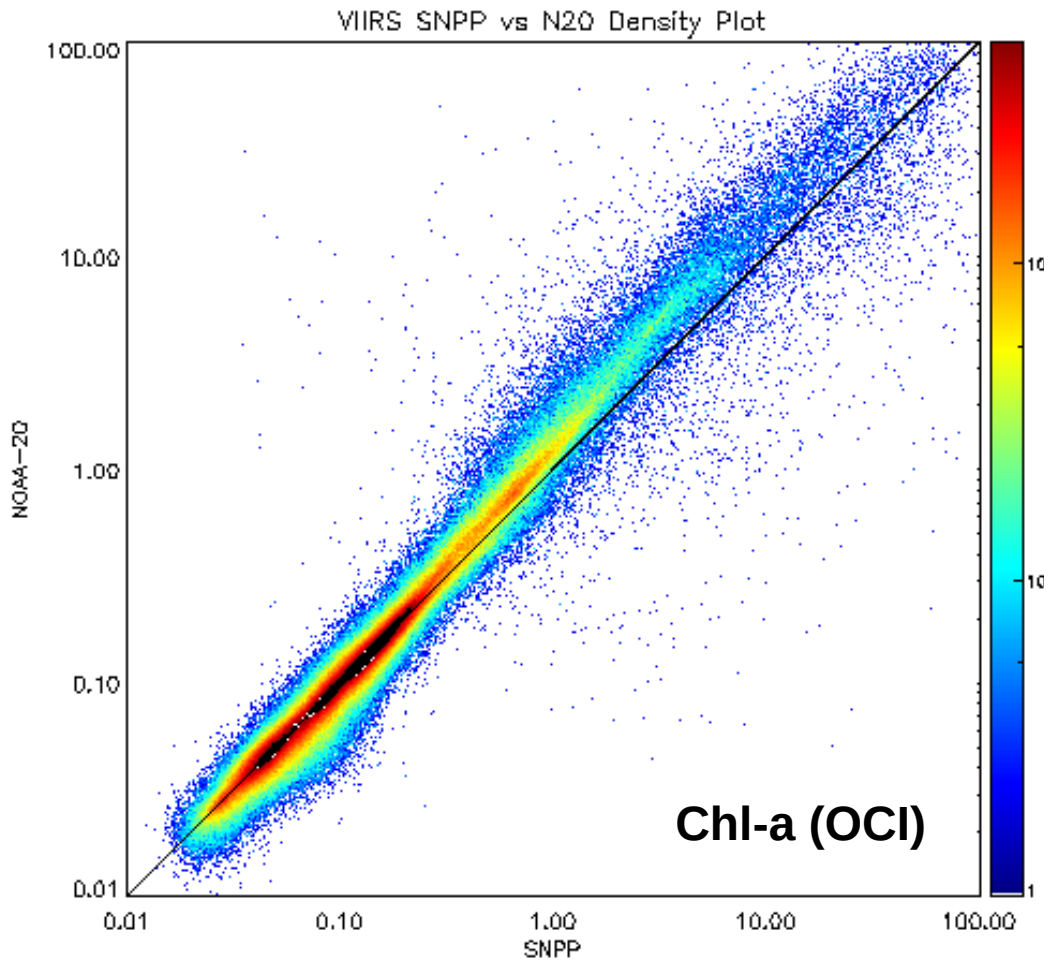
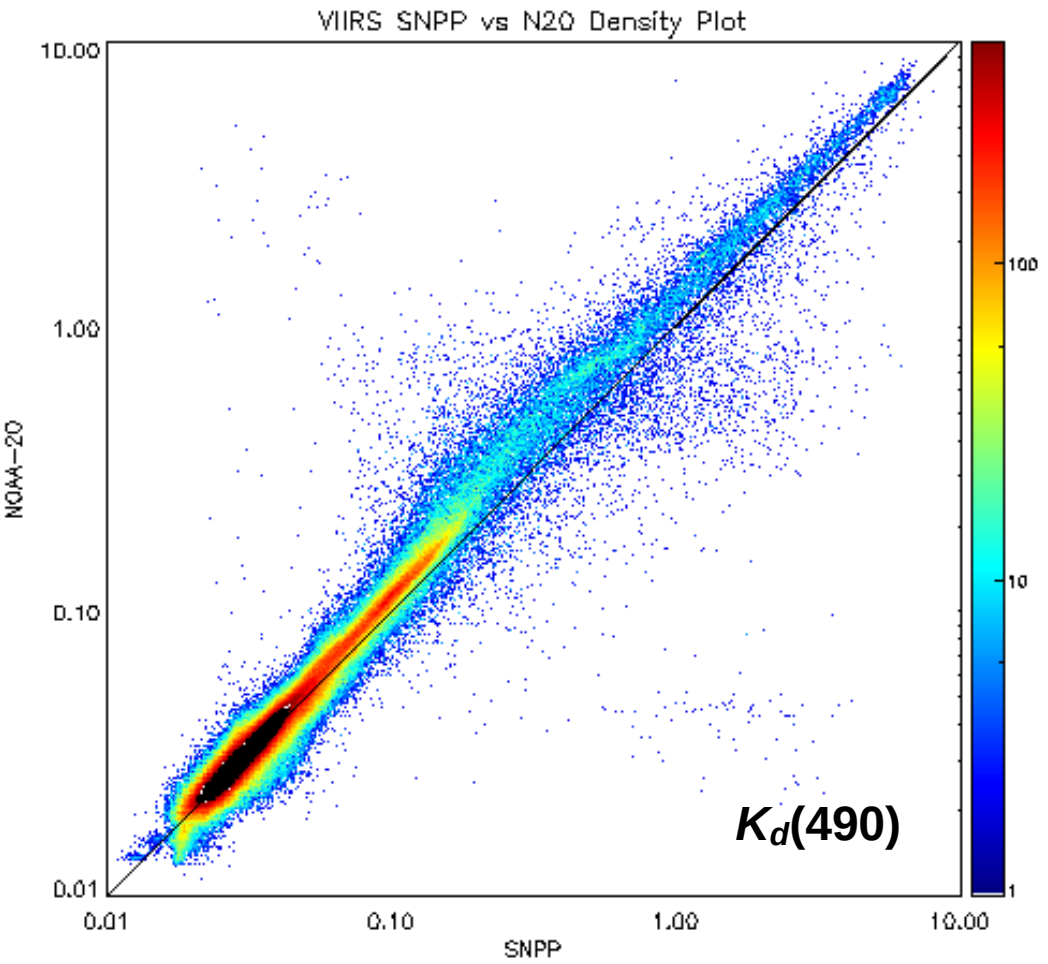
OC Performance: Chl-a & K_d(490)

(NOAA-20 Compared with SNPP)





Global Data on June 1, 2018 for All the data

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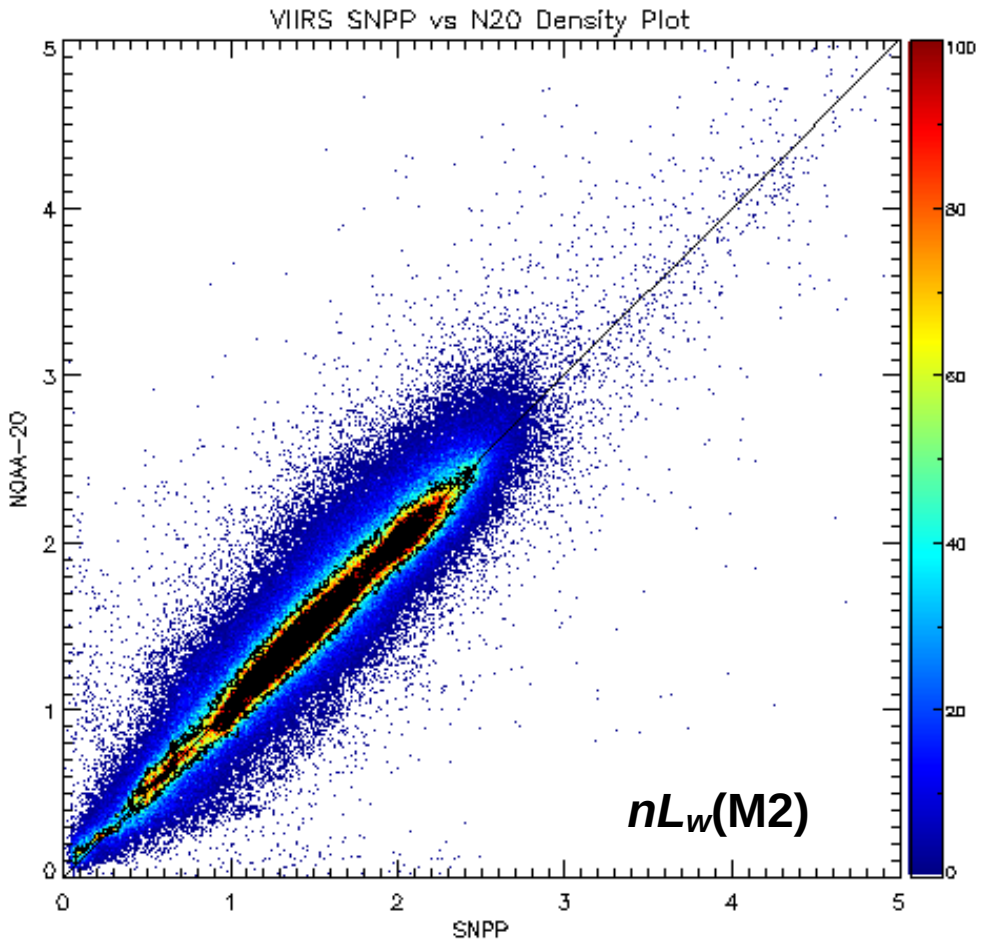
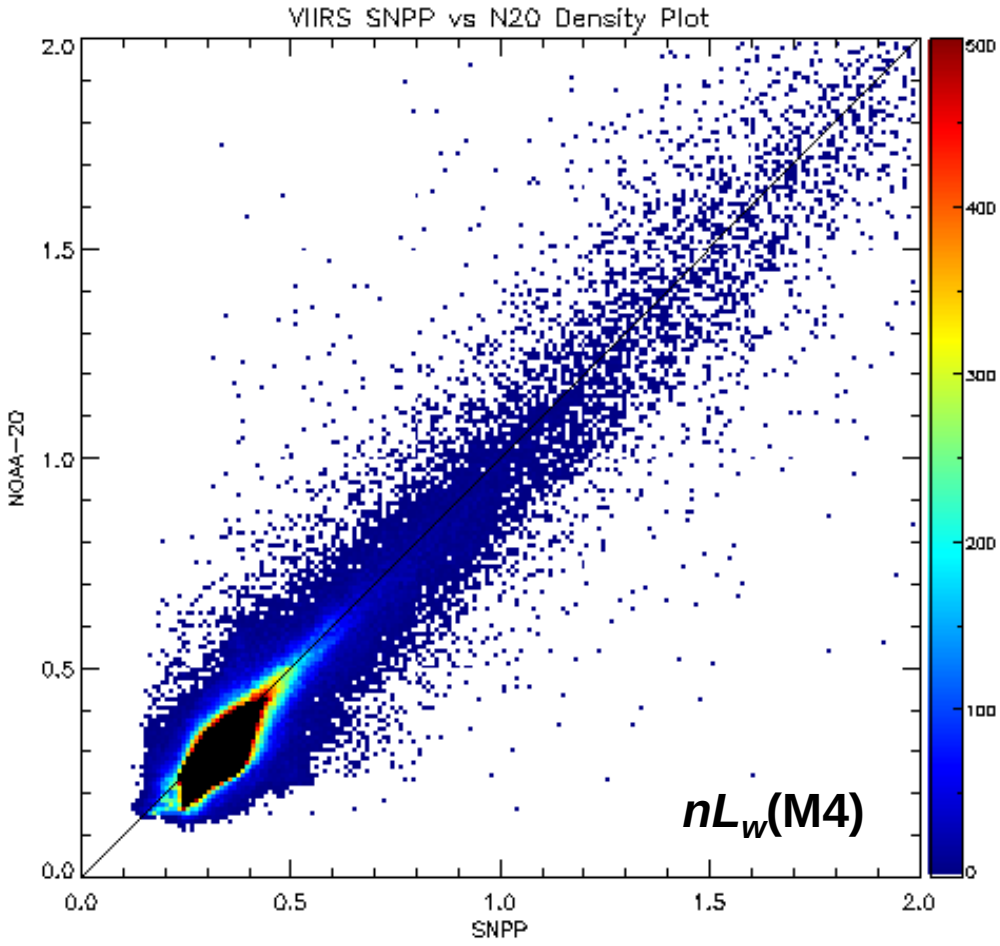
OC Performance: nL_w(M2) & nL_w(M4)

(NOAA-20 Compared with SNPP)





Global Data on June 1, 2018 for All the data

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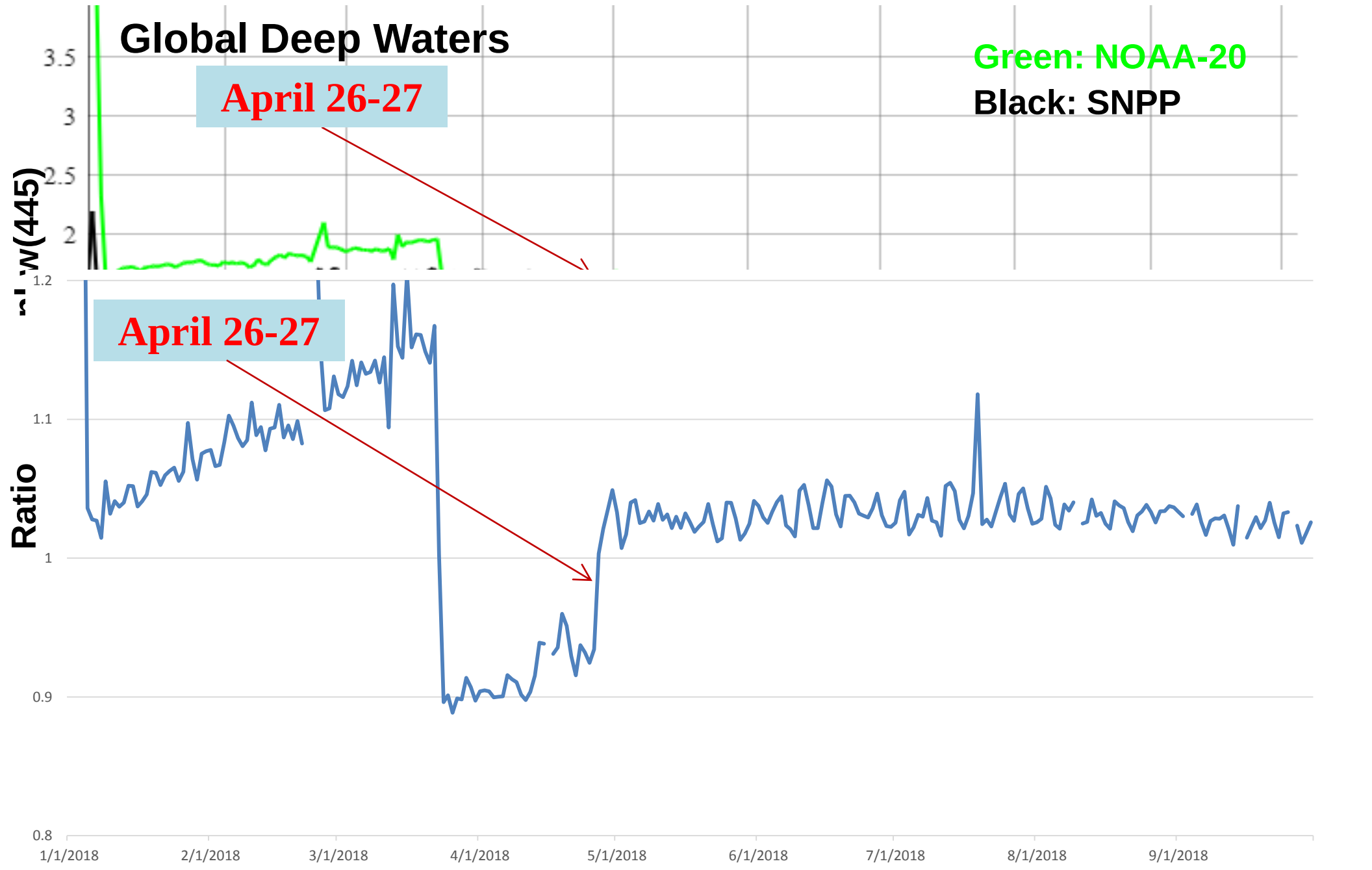
Global $nL_w(445)$ (Blue band) Performance

(NOAA-20 Compared with SNPP)



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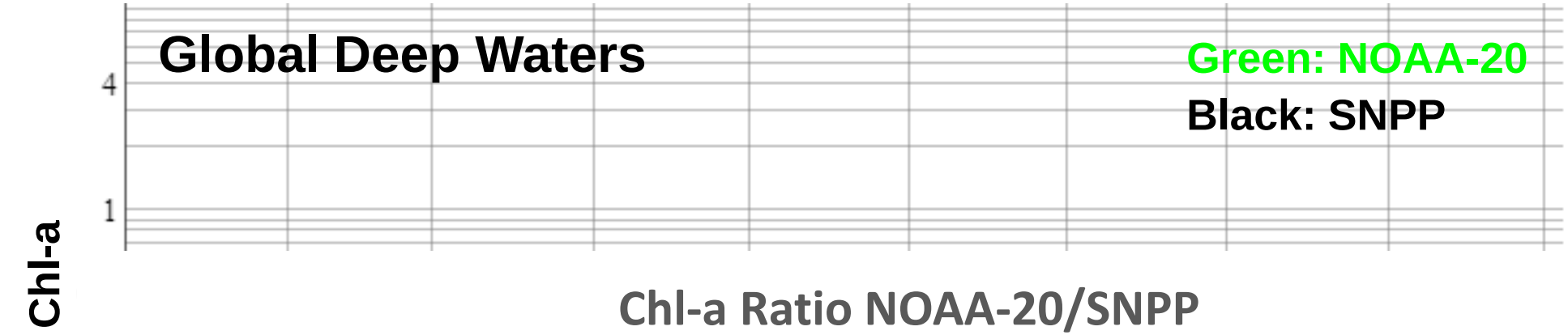
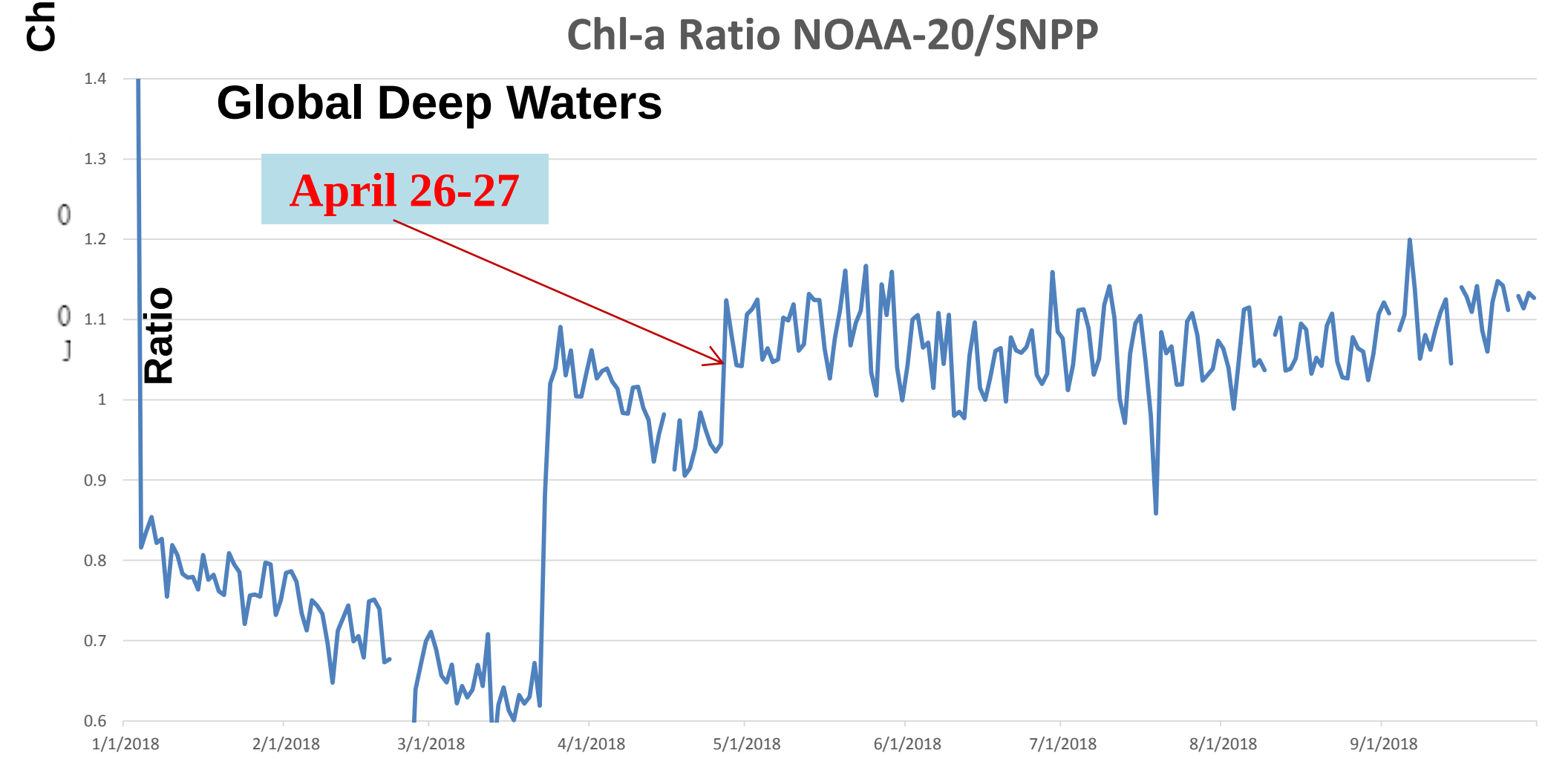
Global Chl-a Performance

(NOAA-20 Compared with SNPP)





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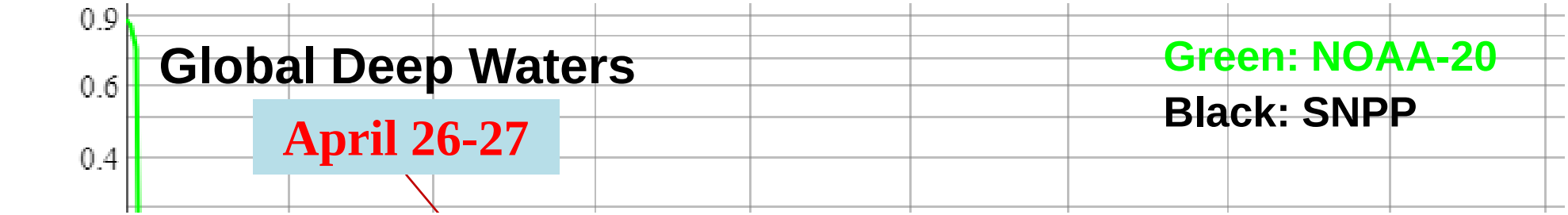
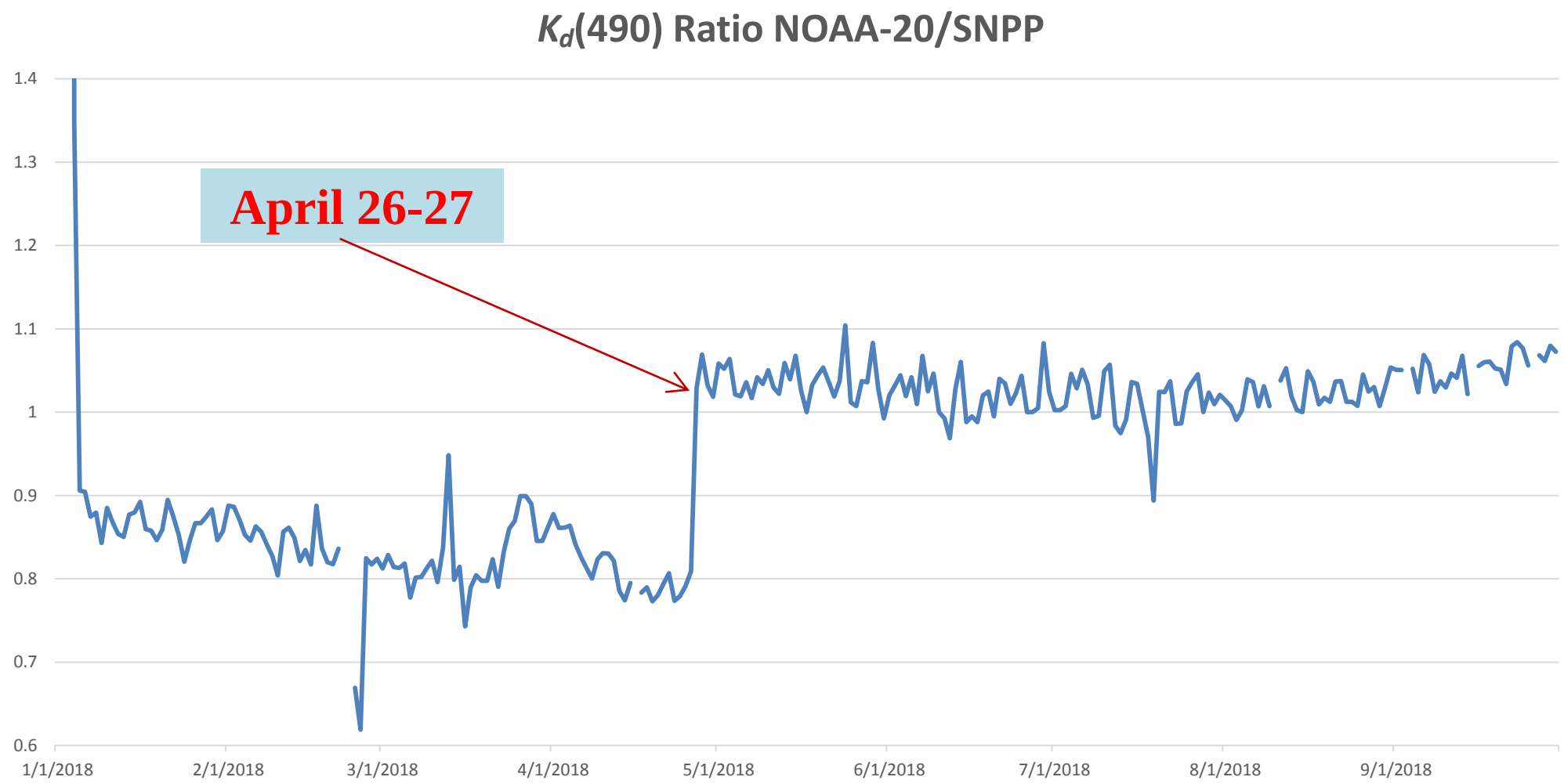
Global K_d(490) Performance
(NOAA-20 Compared with SNPP)





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Blue nL_w(M2) Statistics: Accuracy and Precision
(NOAA-20 Compared with SNPP)

Accuracy: Mean and Median of **Blue nL_w(M2)** NOAA-20/SNPP Ratio

Dates	Global Oligotrophic Waters		Global Deep Waters		Global Coastal/Inland Waters	
Parameter (Requirement)	**Mean** (5/10%)	**Median** (5/10%)	**Mean** (5/10%)	**Median** (5/10%)	**Mean** (N/A)	**Median** (N/A)
Before April 27	1.0526	1.0450	1.0802	1.0652	1.1197	1.0970
After April 27	**1.0294**	**1.0291**	**1.0314**	**1.0301**	1.0353	1.0337

Precision: Standard Deviation (STD) of **Blue nL_w(M2)** NOAA-20/SNPP Ratio

Dates	Global Oligotrophic Waters	Global Deep Waters	Global Coastal/Inland Waters
Parameter (Requirement)	**STD** (5/10%)	**STD** (5/10%)	**STD** (N/A)
Before April 27	0.1689	0.2483	0.3510
After April 27	**0.0102**	**0.0125**	0.0237

VIIRS-NOAA-20 Blue nL_w(M2) Meets the Requirements!

Chl-a Statistics: Accuracy and Precision
(NOAA-20 Compared with SNPP)

Accuracy: Mean and Median of **Chl-a** NOAA-20/SNPP Ratio

Dates	Global Oligotrophic Waters		Global Deep Waters		Global Coastal/Inland Waters	
Parameter (Requirement)	**Mean** (25/35%)	**Median** (25/35%)	**Mean** (25/30%)	**Median** (25/30%)	**Mean** (N/A)	**Median** (N/A)
Before April 27	0.9572	0.8319	0.8333	0.7757	0.7024	0.7121
After April 27	**0.9602**	**0.9606**	**1.0730**	**1.0712**	1.4692	1.4992

Precision: Standard Deviation (STD) of **Chl-a** NOAA-20/SNPP Ratio

Dates	Global Oligotrophic Waters	Global Deep Waters	Global Coastal/Inland Waters
Parameter (Requirement)	**STD** (30%)	**STD** (30%)	**STD** (N/A)
Before April 27	0.6300	0.2575	0.0982
After April 27	**0.0296**	**0.0477**	0.1195

VIIRS-NOAA-20 Chl-a Meets the Requirements!

Conclusion:
Ocean Color Data Performance Evaluation
(VIIRS-NOAA-20 compared with VIIRS-SNPP)

- VIIRS-SNPP ocean color data have been well validated, showing high data quality over global oceans. Thus, VIIRS-NOAA-20 ocean color data have been extensively compared and evaluated using VIIRS-SNPP global ocean color data (science quality data).
- VIIRS-NOAA-20 produced global daily, 8-day, and monthly ocean color data have been routinely compared with those from VIIRS-SNPP. They are very comparable, particularly after April 27, 2018. All the results have been routinely shown in the OC website (https://www.star.nesdis.noaa.gov/socd/mecb/color/index.php).
- In fact, the merged global daily Chl-a data from VIIRS-SNPP and VIIRS-NOAA-20 have been routinely produced, showing improved (e.g., coverage) and consistent results, e.g., no observable artifacts.
- VIIRS-NOAA-20 global ocean color data have been extensively evaluated compared with those from VIIRS-SNPP. Quantitative analysis has been carried out to provide statistics for data accuracy and precision (compared with VIIRS-SNPP).
- Because the evaluation criteria are based on the clear/open ocean waters, evaluation results from VIIRS-NOAA-20 derived ocean color products over global deep waters are specifically presented. Examples from daily comparisons are also presented.
- Our evaluation results show that after **April 27, 2018** VIIRS-NOAA-20 ocean color data quality meets the data Provisional (or even Validated) requirements. It is also determined that before **April 27, 2018** VIIRS-NOAA-20 ocean color data have some data quality issues due to the SDR calibration problems.

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