NOAA-20 VIIRS reflective solar band calibration

VIIRS Characterization Support Team, NASA GSFC

(presented by Kevin Twedt)

March 3, 2021

RSB algorithm overview

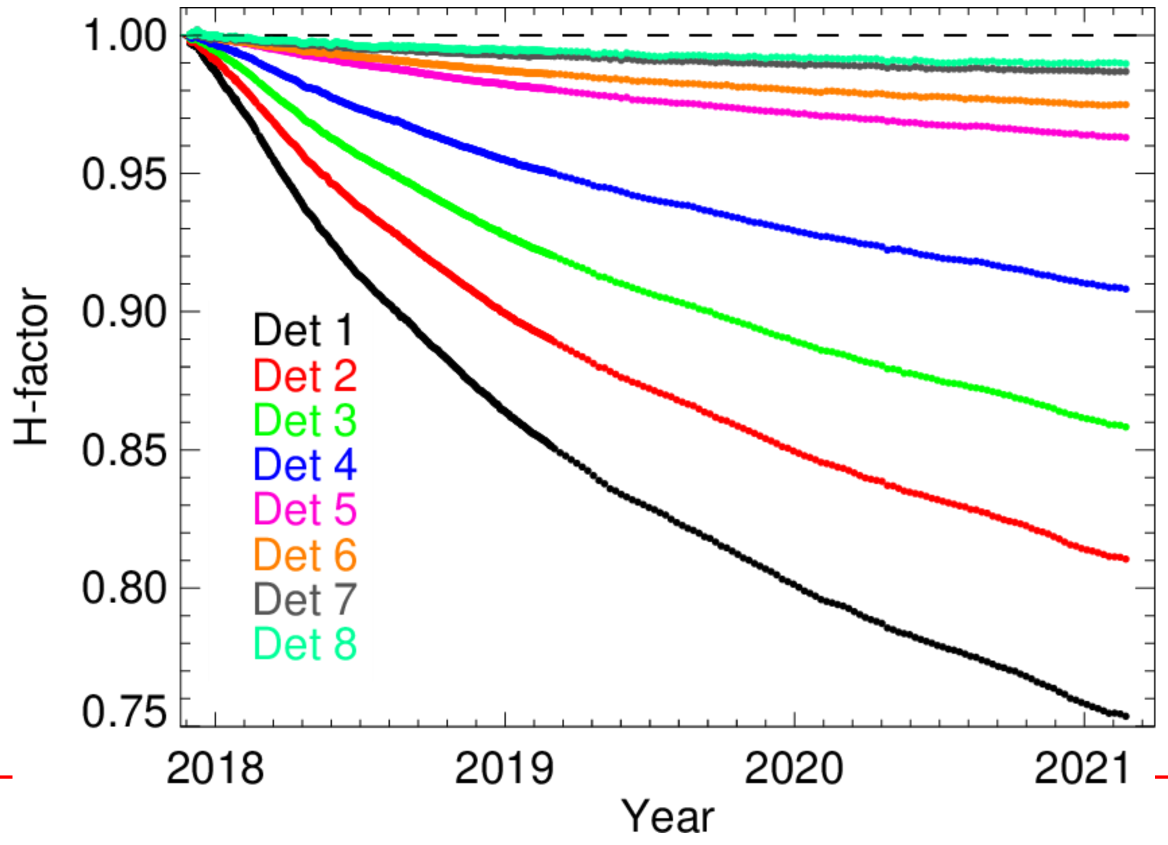
NASA N20 VIIRS RSB calibration algorithm is very similar to the algorithm used for many years for SNPP VIIRS. A few key points:

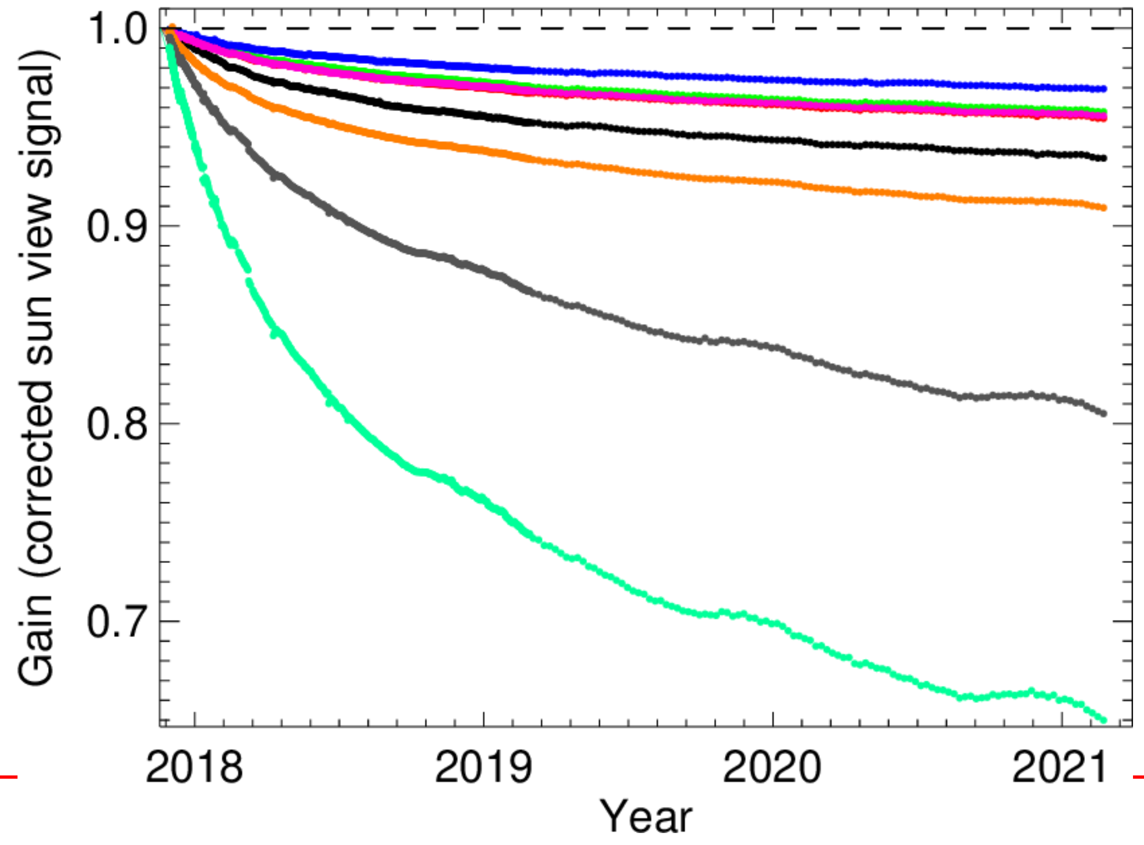
- Screen transmission functions improved using combination of yaw maneuver data and a select set of regular on-orbit data
- Calculate SD degradation at SWIR using a power-law fitting of NIR SDSM detector degradation and extrapolating to SWIR wavelengths
- Final F-factor is forced to match long-term trend of lunar F-factor using scaled versions of the SNPP lunar-SD F fitting coefficients
  - This is accomplished through studying the angular dependence of the SD degradation
  - Scaled SNPP coefficients have worked well so far

N20 F-factors remain very stable after more than 3 years on-orbit.
No recent changes to N20 RSB calibration or performance.

Measured H-factor

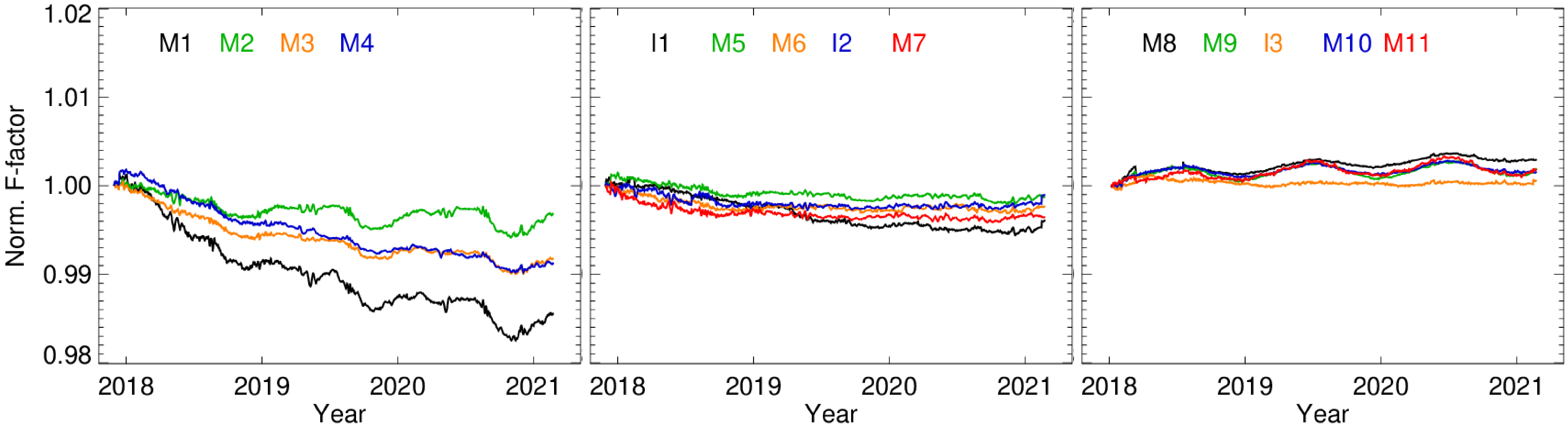
- H-factors (as measured from the SDSM view direction) show very smooth trends
  - Screen transmission functions improved using combination of yaw maneuver data and select on-orbit data
- H-factors slightly higher (less degradation) compared to same time period for SNPP VIIRS.
- SDSM detector degradation (corrected Sun view signal) similar to SNPP VIIRS





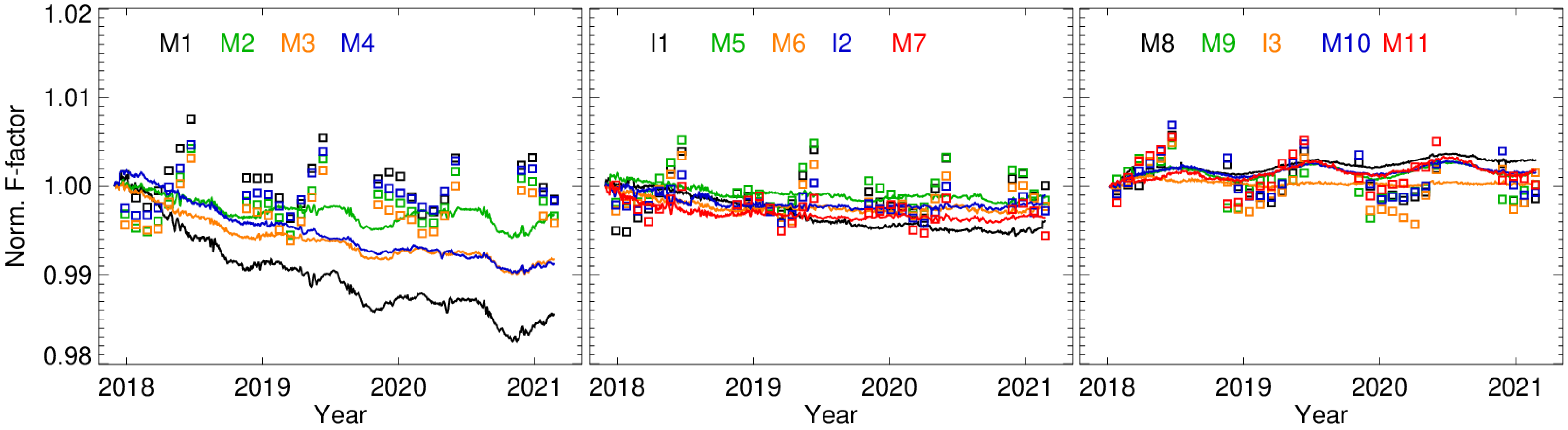
SD F-factor using measured H-factor

- SD F-factor calculated using measured H-factor
  - Band average values (HG only) over the whole mission
  - Normalized to initial on-orbit values.



Lunar F-factor

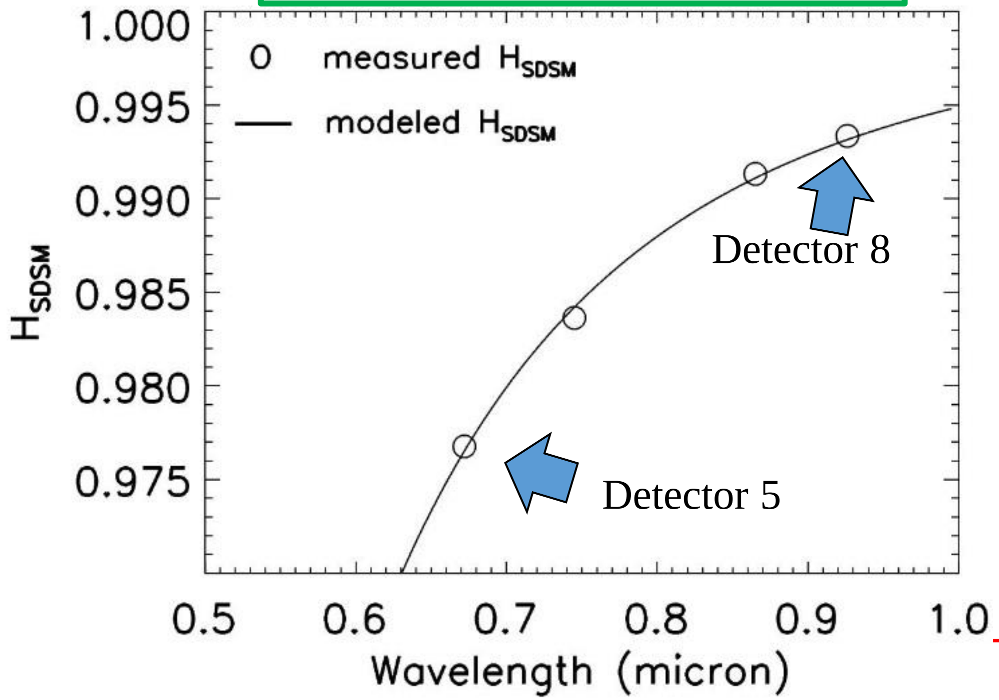
- Compare F-factors from SD to F-factors derived from lunar observations.
  - Clear divergence for short-wavelength bands (SD-lines; Lunar-squares)
  - M1: >1.5% after 3 years
  - Similar pattern to what was observed on SNPP, but smaller magnitude. This is understood to be primarily caused by difference between degradation at SDSM vs. RTA view directions. Note that RSR impacts are already included.

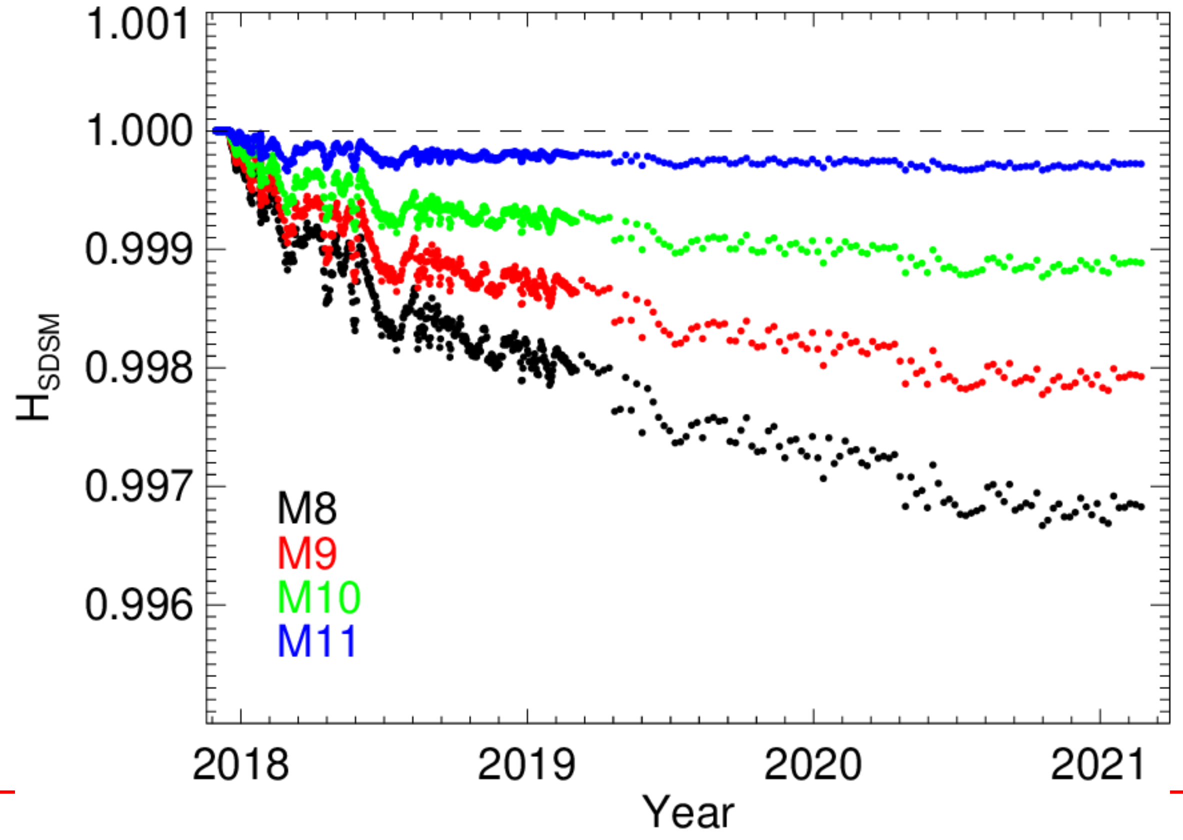


Adjustments to measured H-factor

1) Measured H-factors are combined with SDSM detector RSR knowledge to derive H_{SDSM} - the true H-factor from the SDSM view direction.
2) Values of H_{SDSM} for SDSM detectors 5-8 are fit to a power law function and extrapolated to derive SD degradation at SWIR wavelengths.

$$H_{\mathrm{SDSM}}(\lambda, t) = 1 - \frac{\beta_{\mathrm{H}}(t)}{\lambda^{\eta_{\mathrm{H}}(t)}}$$





Adjustments to measured H-factor

3) Trust long-term trends from lunar data and derive a correction to get H-factor from RTA-viewing direction instead of SDSM-viewing direction

- For SNPP, we fit the (lunar F)/(SD F) ratio to the function:

Correct long-term Lunar-SD divergence

$$R_{fit} = \frac{1 + \alpha_{\mathrm{RTA}}(\lambda) * (1 - H_{\mathrm{SDSM}})}{1 + \alpha_{\mathrm{H}}(\lambda) * (1 - H_{\mathrm{SDSM}}) * \left(\phi_{\mathrm{H,SD}}^{\mathrm{RTA}} - \phi_{\mathrm{H0}}\right)}$$

Additional correction for seasonal oscillations (solar azimuth angle)

- For N20, we do not yet use N20 lunar data directly. Instead, we apply the correction using scaled versions of SNPP fitting coefficients. The scale is based on an analysis of H-factor angular dependence.

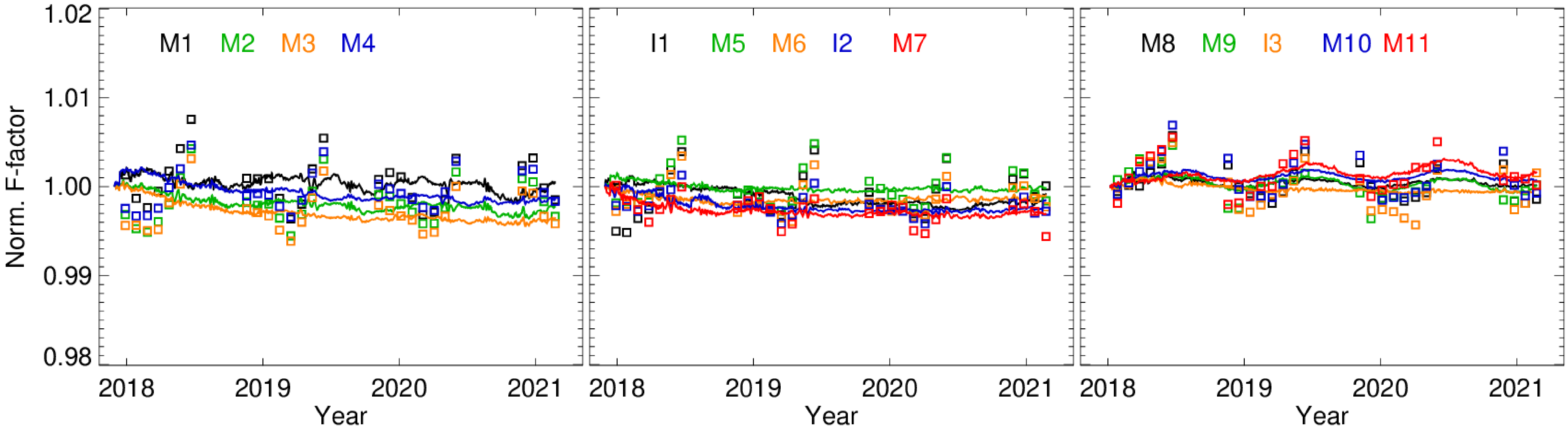
$$\boldsymbol{\alpha}_{\mathbf{RTA}}(\mathrm{N20}) = \frac{\mathbf{28}}{\mathbf{52}} \times \boldsymbol{\alpha}_{\mathbf{RTA}}(\mathrm{SNPP})$$

$$\boldsymbol{\alpha}_{\mathbf{H}}(\mathrm{N20}) = \frac{\mathbf{28}}{\mathbf{52}} \times \boldsymbol{\alpha}_{\mathbf{H}}(\mathrm{SNPP})$$

- Re-derive N20 SD F using $H_{RTA} = H_{SDSM} \times R_{fit}$

Final F-factors

- Final F-factors very stable on-orbit
  - Drifts $< 0.4\%$ for all bands. For most VIS/NIR bands, drifts from January 2019 to present are <0.1%.
  - Seasonal oscillations in M8-M11 up to 0.2%.
- SD F-factors calculated with H_{RTA} show very good agreement with long-term trends of Lunar F.
  - Scaled SNPP fitting coefficients do an excellent job of modeling SD-lunar differences seen in N20.
  - We plan to switch to directly fitting the N20 SD F to N20 Lunar F in the future, but the impact on F LUTs is expected to be small.

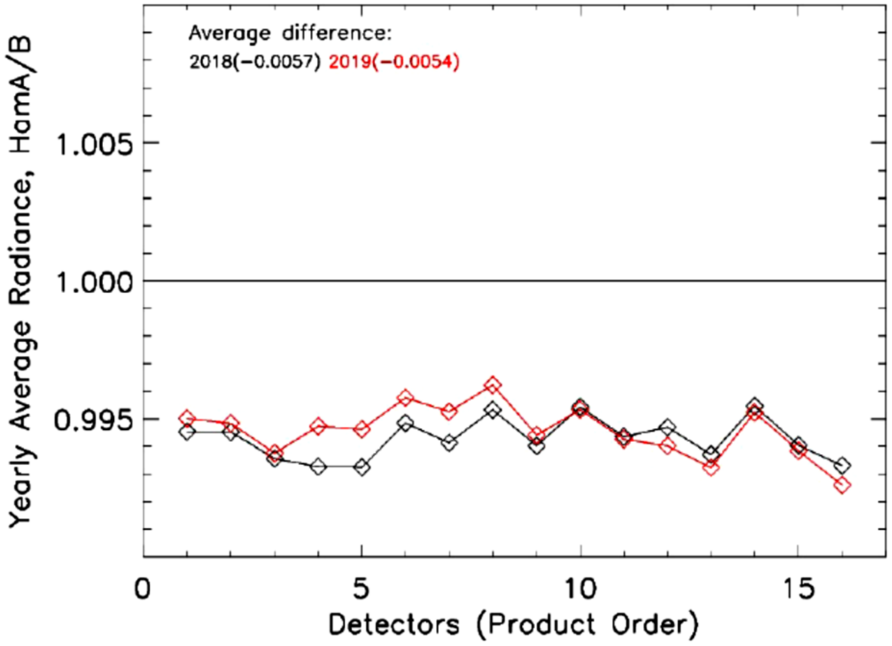


NASA L1B

- VCST LUTs
  - RSB F LUTs derived from fitting final SD F-factor measurements (calculated with H_{RTA}) – linear fit of most recent 1.5 years.
  - Forward updates to F-factor LUTs delivered as needed (currently about once every 6 months)
  - Unlike SNPP, N20 RSR LUTs continue to use pre-launch values with no on-orbit updates
- NASA Collection 2 L1B
  - Archive Set 5200 L1B available from LAADS DAAC
  - RSB F LUTs from VCST for C2 initially delivered in spring 2019
  - Update to pre-launch RVS function was delivered in July 2020. Impact on RSB is very small, $\approx 0.1\%$; larger impact for some TEB
  - Band I3 detector 29 continues to be calibrated but is flagged as noisy in L1B
- NASA Collection 2.1 L1B
  - Archive Set 5201 L1B reprocessing currently on-going (expected to complete late March).
  - RSB calibration is the same as C2. Only difference between C2 and C2.1 is that C2.1 uses the updated RVS LUT for entire mission.

Performance of L1B reflectance

- We routinely monitor reflectance of N20 C2 L1B using Libya 4 and DCC targets
  - Trends are stable for all bands
  - No indication yet of detector differences in N20 VIIRS reflectance
    - For SNPP VIIRS, detector differences existed in C1 L1B products due to detector-dependent SD degradation; a correction was applied for C2 L1B.
  - Small (0.5%) HAM-side difference in reflectance for M1 that is not yet understood



- SNPP-N20 VIIRS comparison
  - Monitor intercomparison trends using multiple approaches: SNO, desert sites, DCC, Dome-C.
  - VCST had a meeting with key NASA science team members on Dec. 18 to address the few percent reflectance differences between SNPP and N20 VIIRS RSB.
  - Discussions are on-going to determine the best way to mitigate or correct for these differences in NASA Level 2 science products.
  - See also MCST/VCST presentation at MODIS-VIIRS calibration workshop on Feb. 25.

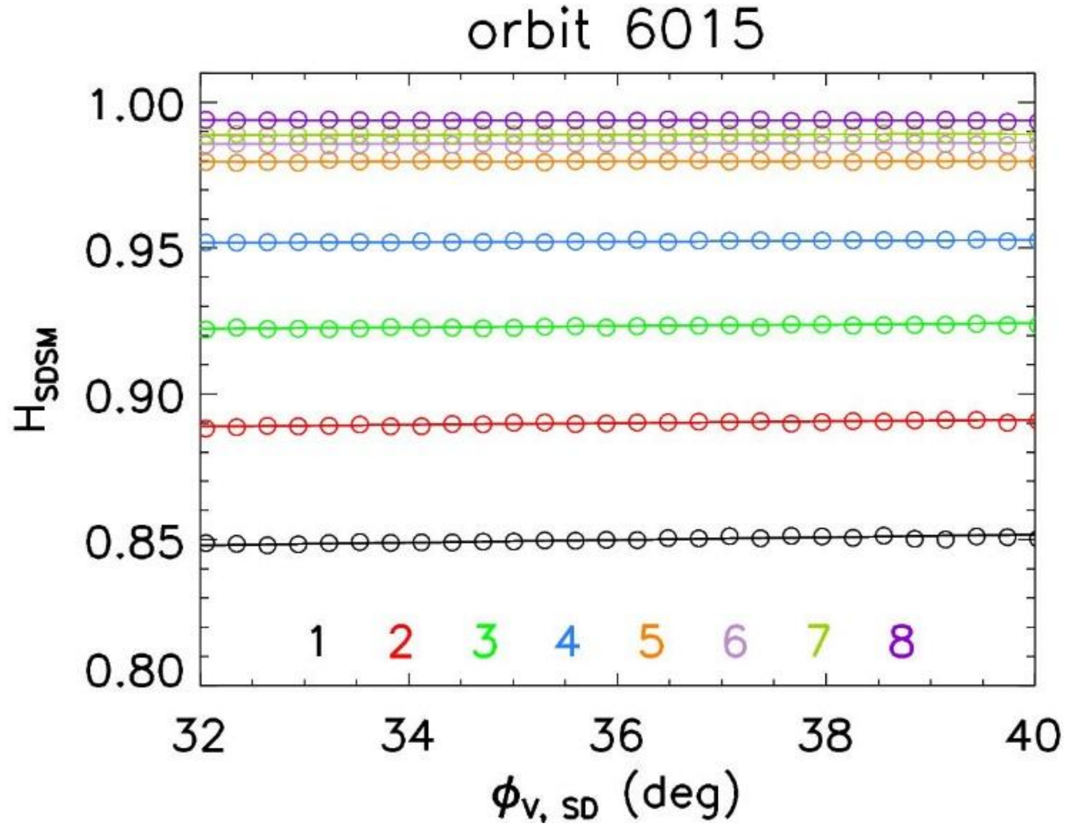
Summary

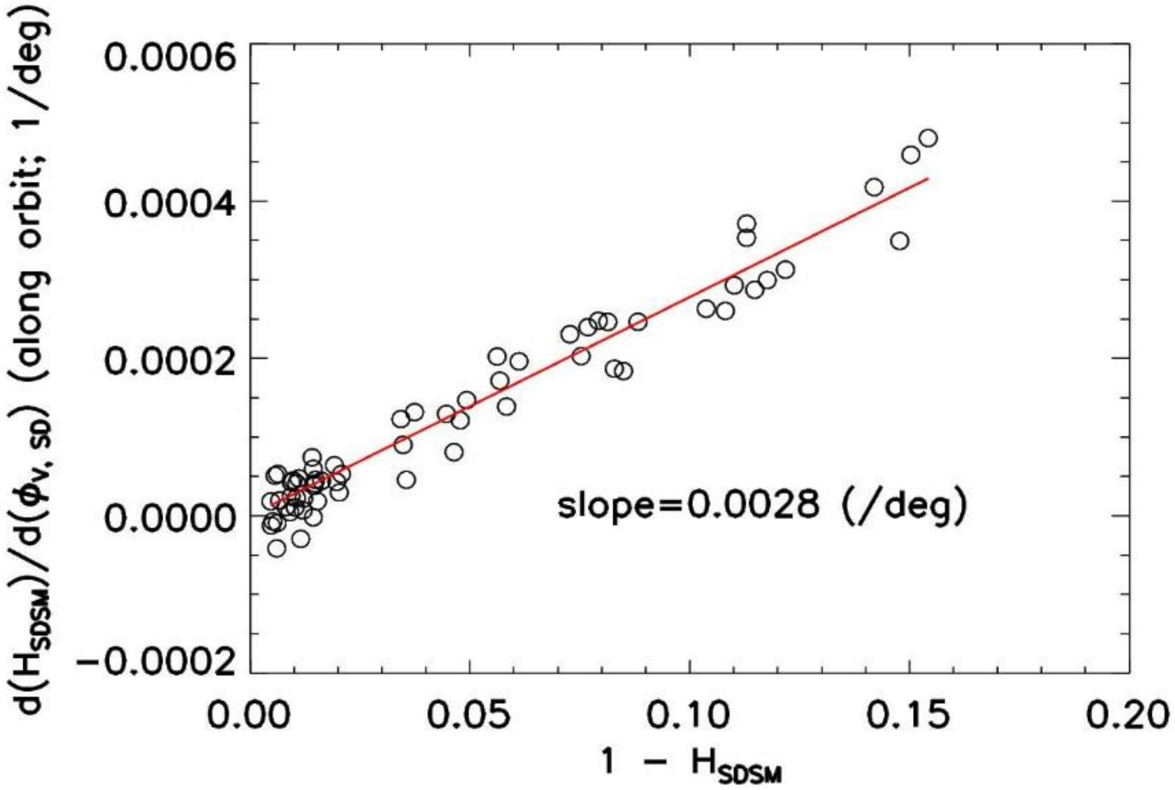
- RSB F-factors remain very flat with $< 0.4\%$ change over first 3 years of N20 mission.
- N20 VIIRS RSB calibration strategy closely follows SNPP calibration
  - Main difference is the use of scaled SNPP lunar/SD fitting coefficients applied to N20, rather than directly fitting N20 lunar/SD. We will switch to directly fitting N20 lunar data in the future.
- NASA Collection 2/2.1 L1B
  - C2 in production for > 1.5 years
  - Reflectance trends are stable as evaluated by typical Earth targets.
  - Work is on-going to address absolute reflectance differences between SNPP and N20 VIIRS, in coordination with NASA science teams.

BACKUP

H_{SDSM} angular dependence

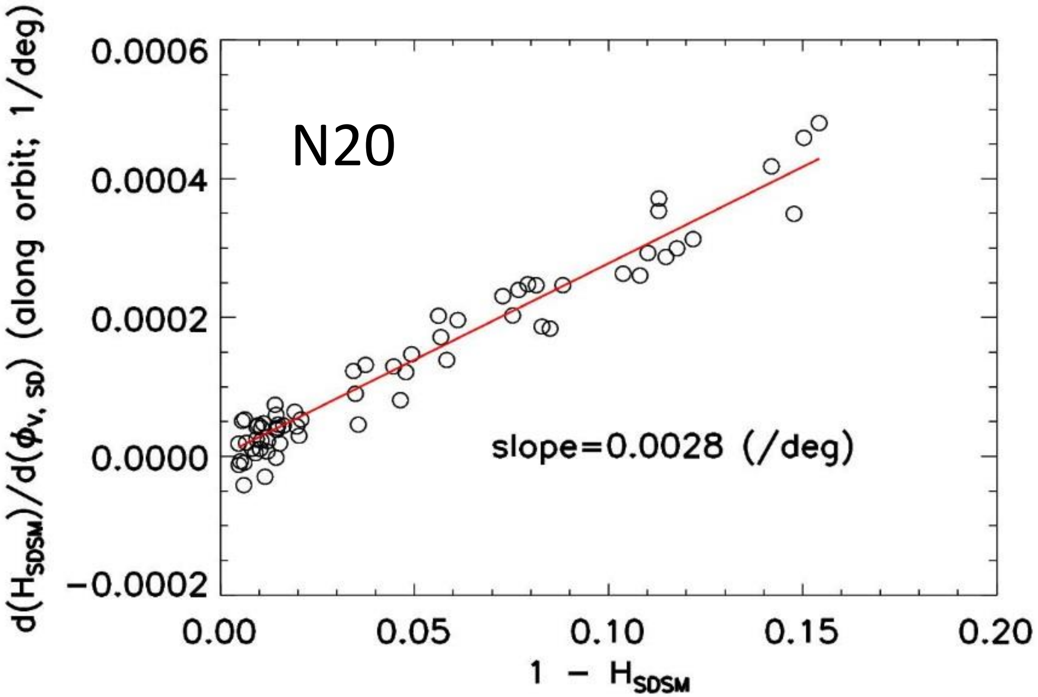
- H_{SDSM} varies slightly as a function of the SD-Sun angle, $\phi_{V,SD}$.
- The slope – change in H over change in angle – is well described by a linear function of $1 - H_{SDSM}$.

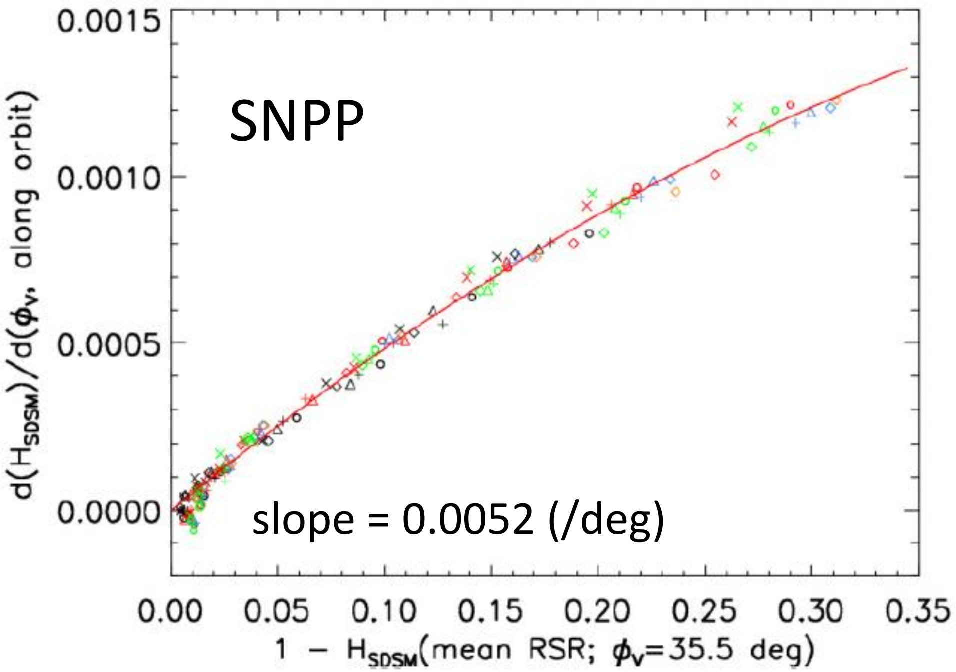




H_{SDSM} angular dependence

- Compare the slope of H angular dependence from N20 to SNPP: SNPP has a larger angular dependence by about a factor of 2.





- Use the N20/SNPP ratio of H angular dependence to scale the SNPP lunar/SD fitting coefficients.
- Critical assumption is that the divergence between the SD F-factor (with H_{SDSM}) and the Lunar F-factor is due to an angular-dependent degradation of SD and the inability of the SDSM to accurately track the degradation at the RTA viewing direction.

N20 H-factor along RTA direction

Apply the scaled fitting coefficients of SNPP to N20 and derive the H-factor along the RTA direction:

- $\mathrm{H}_{RTA} = H_{SDSM} \frac{1+\alpha_{\mathrm{RTA}}(\lambda)*(1-H_{\mathrm{SDSM}})}{1+\alpha_{\mathrm{H}}(\lambda)*(1-H_{\mathrm{SDSM}})*(\phi_{\mathrm{H,SD}}^{\mathrm{RTA}}-\phi_{\mathrm{H0}})}$

$$\boldsymbol{\alpha}_{\mathbf{RTA}}(\mathrm{N20})=\frac{\mathbf{28}}{\mathbf{52}} \times \boldsymbol{\alpha}_{\mathbf{RTA}}(\mathrm{SNPP})$$
$$\boldsymbol{\alpha}_{\mathbf{H}}(\mathrm{N20})=\frac{\mathbf{28}}{\mathbf{52}} \times \boldsymbol{\alpha}_{\mathbf{H}}(\mathrm{SNPP})$$

- Re-derive N20 SD F using H_{RTA}
- Difference between SD F calculated with $H_{measured}$ compared to H_{RTA} after 3 years on-orbit is:

M1	M2	M3	M4	I1	M8
1.6%	0.1%	0.5%	0.7%	0.4%	0.3%

All other bands <0.2%

M8 difference is due to SD degradation extrapolation to SWIR wavelengths. Lunar correction is not applied to SWIR bands.