SNPP VIIRS Reflective Solar Bands On-orbit Radiometric Calibration Performance and Improvements

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VIIRS RSB On-orbit Calibration

TOA spectral hemispherical reflectance is estimated by (Eq. 81, ATBD vF)

$$\rho(\lambda_{\mathrm{B}}) = \frac{\pi F(B) \times \left(c_0 + c_1 dn_{\mathrm{EV}} + c_2 dn_{\mathrm{EV}}^2\right)}{\mathrm{RVS}\,(\theta_{\mathrm{EV}}, B)\cos\theta_{\mathrm{sun-earth}}\,\overline{E_{\mathrm{sun}}}\left(\lambda_{\mathrm{B}}, d_{\mathrm{sun\text{-}viirs}}\right)} \quad (1)$$

Focus: correctly calculate *F* (correction factor)

$$F = \frac{\int \mathrm{RSR}\,(\lambda, B, t) \times L_{\mathrm{SD}}\left(\lambda, t, \vec{\phi}\right)}{\left(c_0 + c_1 dn_{\mathrm{SD}} + c_2 dn_{\mathrm{SD}}^2\right) \times \int \mathrm{RSR}\,(\lambda, B, t)\, d\lambda} \quad (2)$$

L_{SD} : improved

$\mathrm{RSR}\,(\lambda, B, t)$: slightly improved

Improved Calculated Sunlit SD Spectral Radiance

$$L_{SD} = E_{sun}(\lambda)\cos(\theta_{SD-sun})\underbrace{\tau_{SAS}\,\mathrm{BRDF}_{RTA}(\lambda, t=0, \vec{\phi})}\underbrace{H_{RTA}(\lambda, t, \vec{\phi})} \quad (3)$$

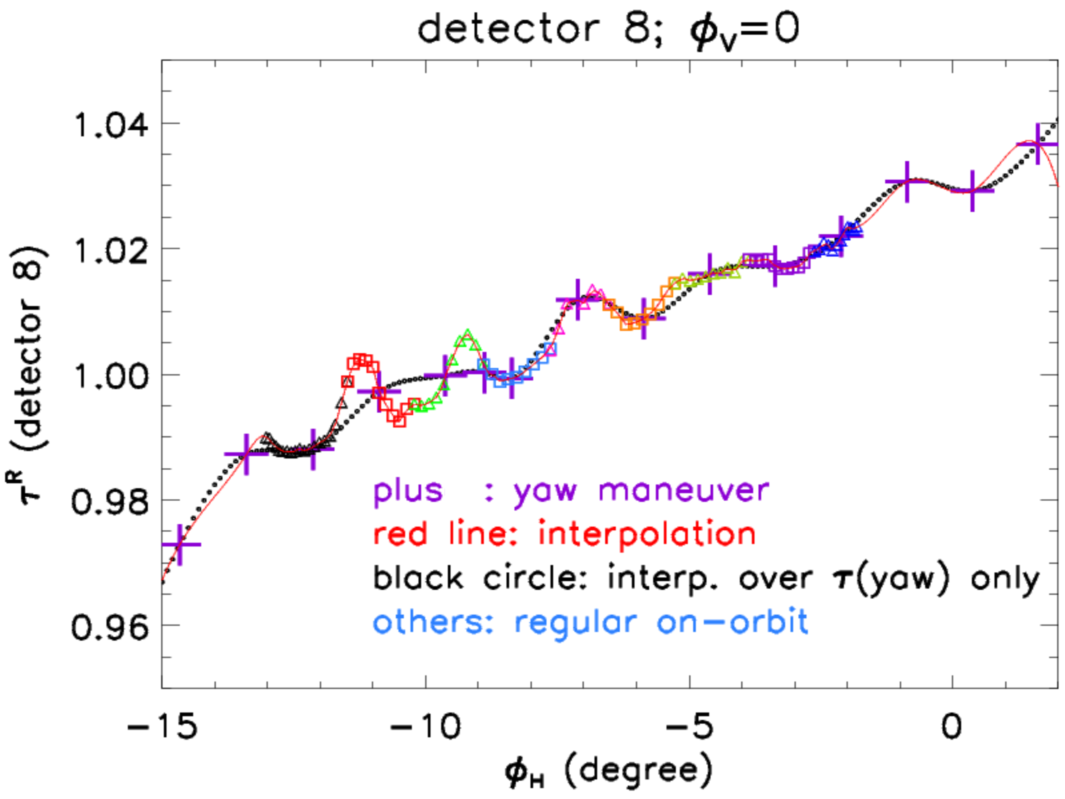
★ $H_{RTA}(\lambda, t, \vec{\phi})$ (SD BRDF degradation factor): biases removed and screen transmittances are more accurate (computed from H_{SDSM})

$\tau_{SAS}(\lambda, \vec{\phi})\mathrm{BRDF}_{RTA}(\lambda, t=0; \vec{\phi})$: one bias removed, 0.05% along solar azimuth direction

Improvements on H_{SDSM} : part 1

(1) SDSM screen transmittance is more accurately calculated

use both yaw maneuver and a small portion (~3-month) of regular data



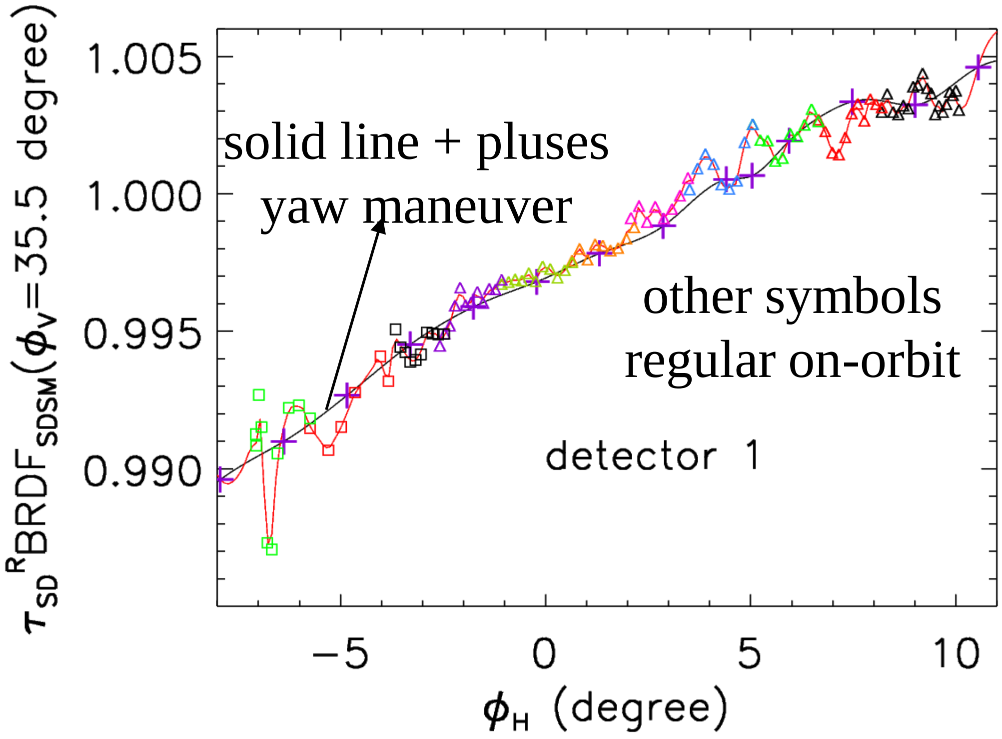
SDSM screen coord.

Improvements on H_{SDSM} : part 2

(2) Improved relative τ(SD)*BRDF(t=0; SDSM)

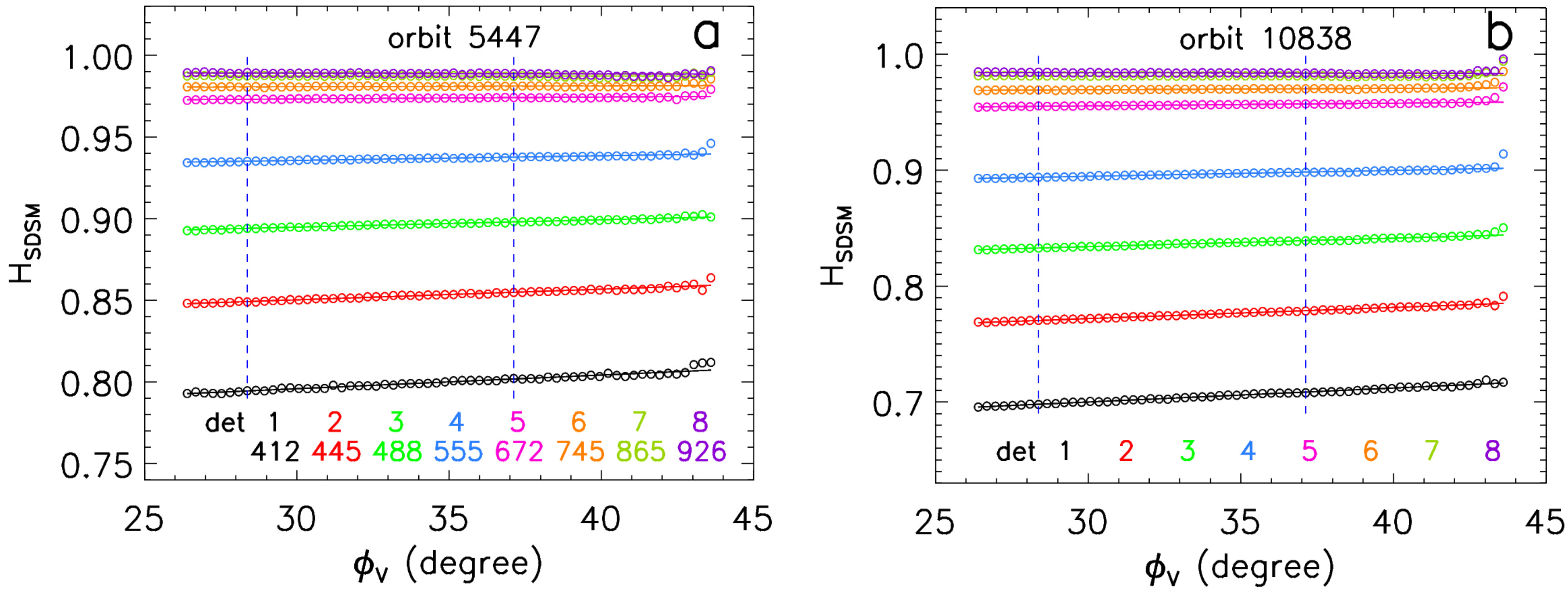
use both yaw maneuver and a small portion of regular data

and remove bias from the angular dependence of H_{SDSM}



SD coord.

Solar angular dependence of SD BRDF degradation factor



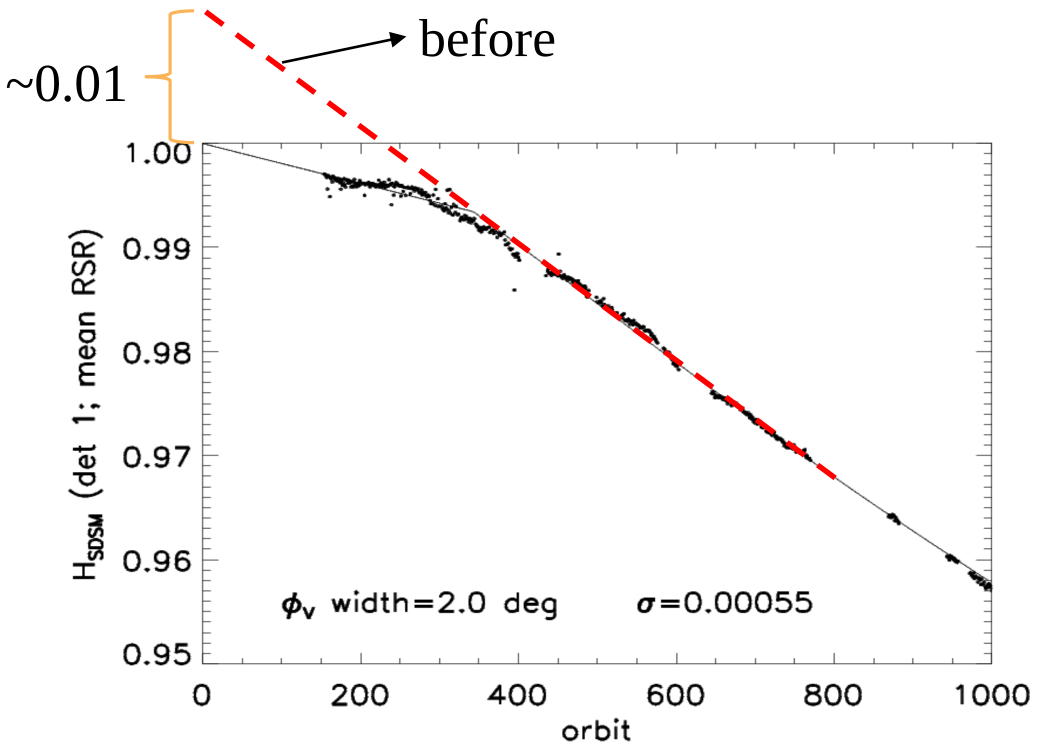
H_{SDSM} depends on solar vertical angle

- the dependence is stronger with smaller H_{SDSM}

Improvements on H_{SDSM} : part 3

(3) Rescale H_{SDSM}

effectively move up H_{SDSM} at the wavelength of 412 nm (M1) by about 1.0%

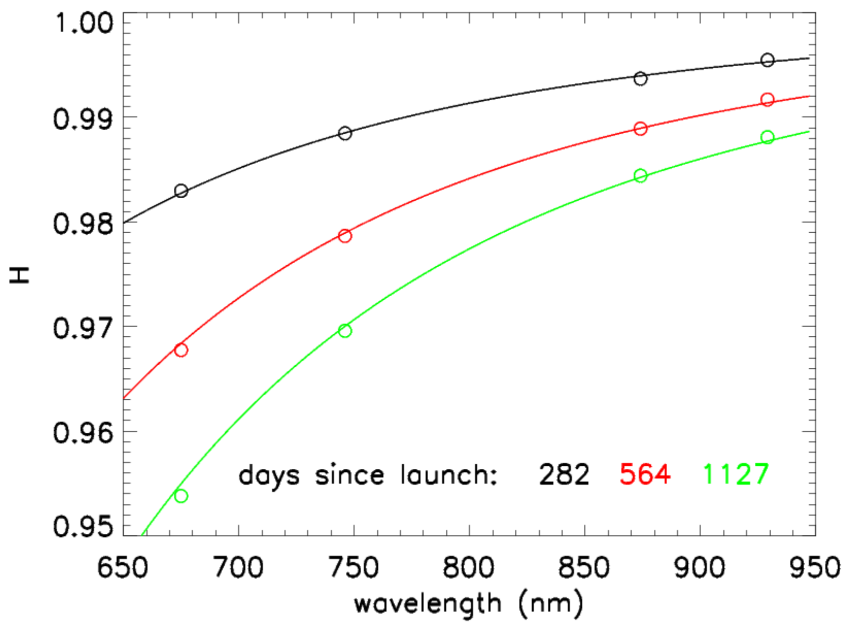


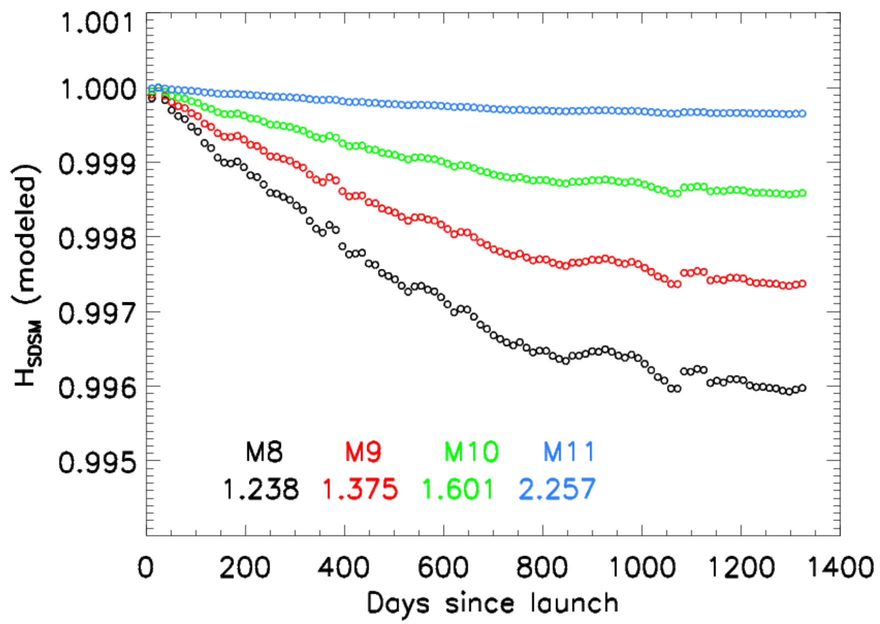
Improvements on H_{SDSM} : part 4

(4) Model H_{SDSM} at SWIR band wavelengths

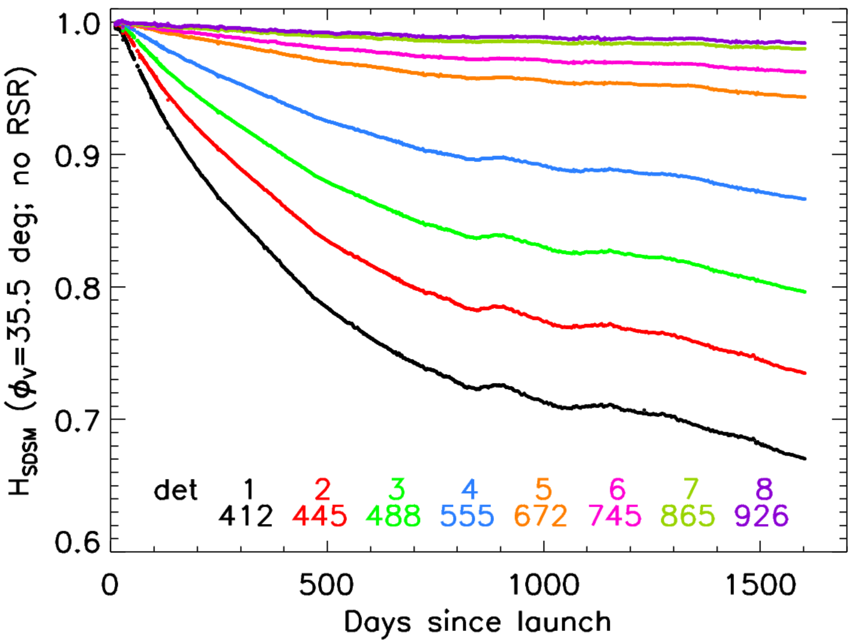
originally H_{SDSM}(SWIR wavelength)=1

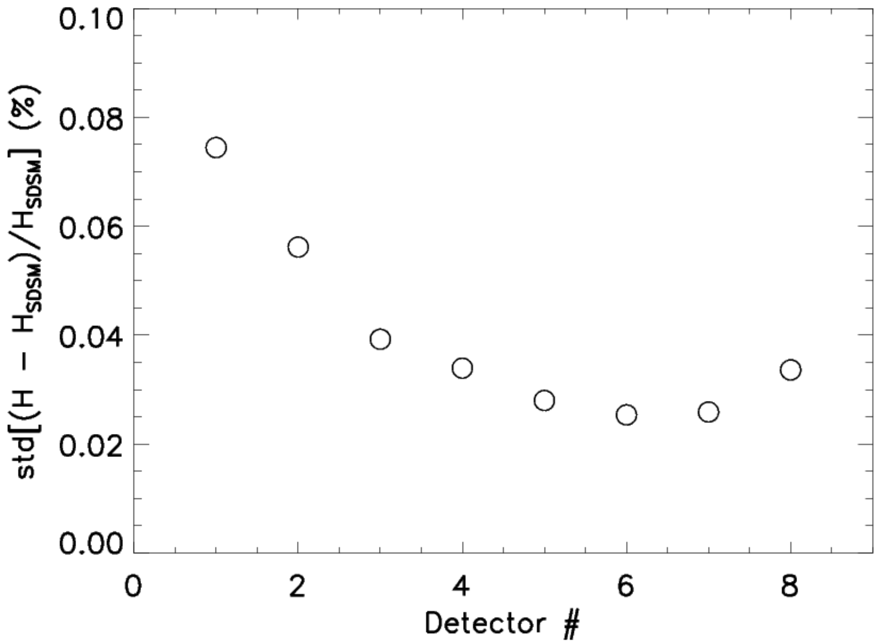
$$1-H(\lambda,t)=\frac{\alpha(t)}{\lambda^{4.07}} \qquad \alpha(t)=\left\langle (1-H(\lambda,t))\times\lambda^{4.07}\right\rangle_{\lambda=(\lambda_{\mathrm{det}\,5},\lambda_{\mathrm{det}\,6},\lambda_{\mathrm{det}\,7},\lambda_{\mathrm{det}\,8})}$$





Improved H_{SDSM} (SDSM SD view)





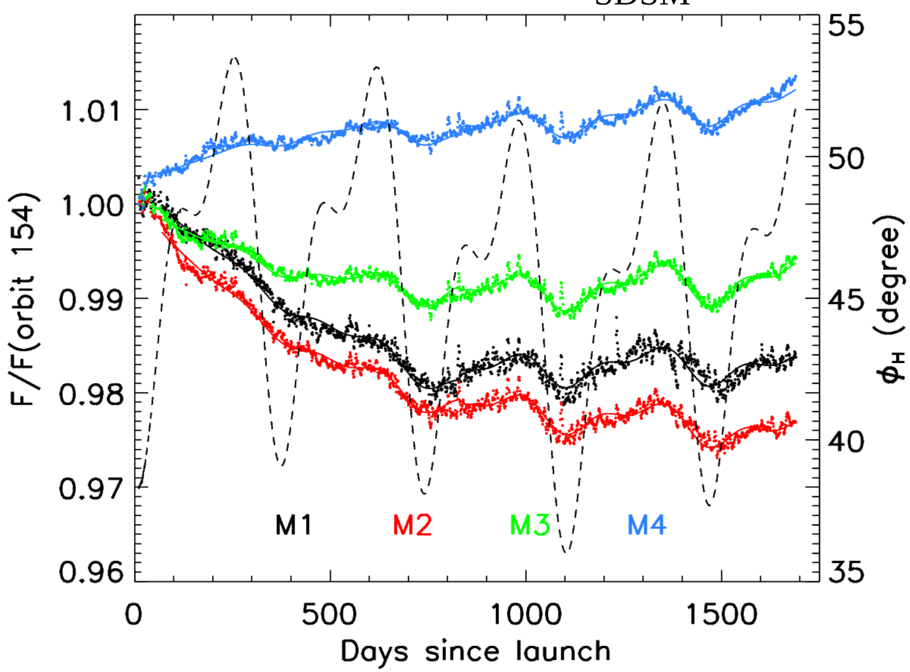
H_{SDSM} can be precisely measured with a relative error mainly in the mid to low 0.0001

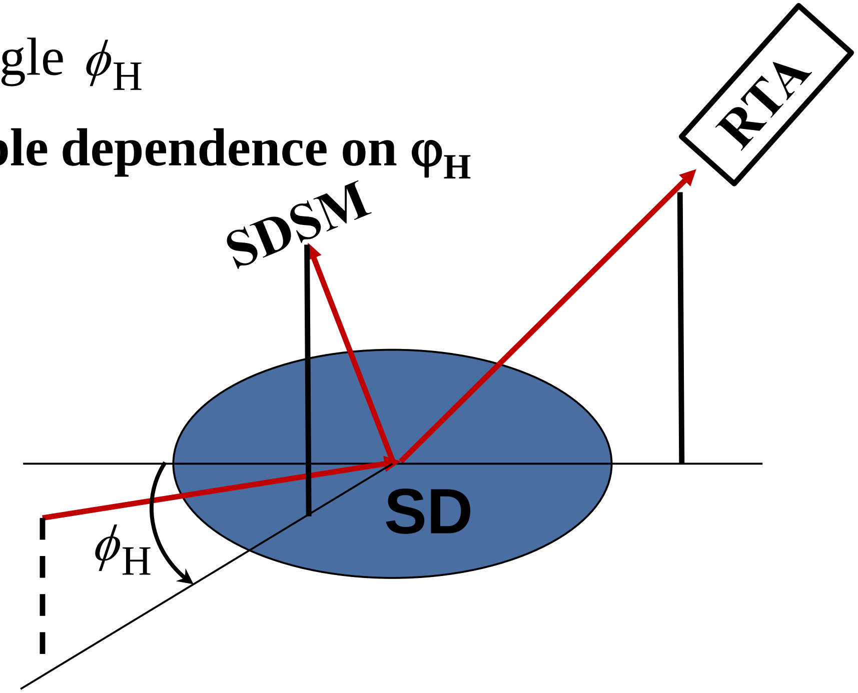
Improvements on H_{RTA} : part 1

(1) H_{RTA} dependence on solar azimuth angle ϕ_H

non-observable dependence on φ_H

F calculated with H_{SDSM}



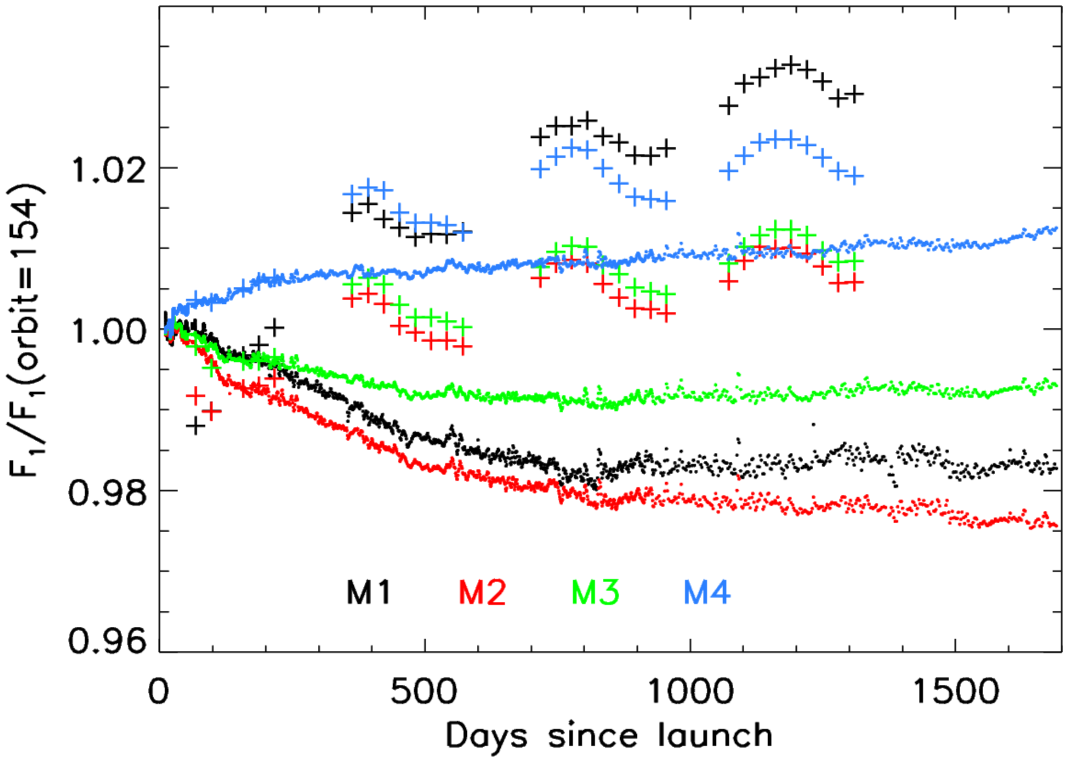


$$F \propto 1 + \beta(\lambda) * \left(H_{SDSM,\ mean\ RSR}(t_{mid}) - H_{SDSM,\ mean\ RSR}\right) * (\phi_H - 48.0°) \qquad (4)$$

Improvements on H_{RTA} : part 1

(1) H_{RTA} dependence on solar azimuth angle ϕ_{H}

$$F_1 = F / \left[1 + \beta(\lambda) * \left(H_{\mathrm{SDSM,\ mean\ RSR}}(t_{\mathrm{mid}}) - H_{\mathrm{SDSM,\ mean\ RSR}} \right) * (\phi_{\mathrm{H}} - 48.0°) \right] \qquad (5)$$



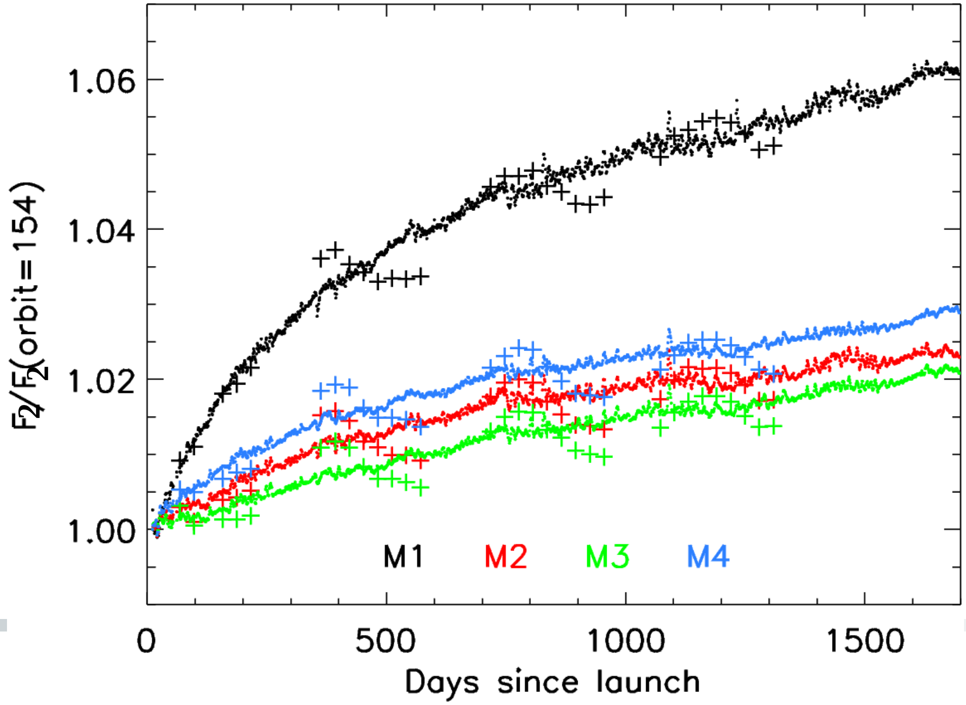
plus: lunar F
dot: SD F

Improvements on H_{RTA} : part 2

(2) H_{RTA} from H_{SDSM}: match scaled lunar results through least-squares fitting

(2.1) $$F_2 = F_1 \times [1 + \gamma(\lambda) * (1 - H_{SDSM})]$$ update RSR

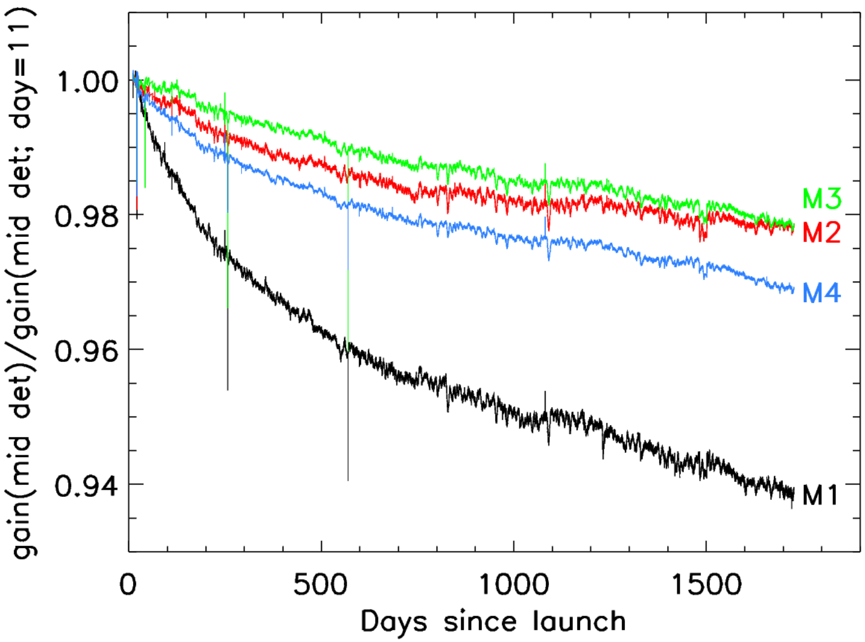
$$\boxed{H_{RTA} = H_{SDSM} \times \frac{[1 + \gamma(\lambda) * (1 - H_{SDSM})]}{1 + \beta(\lambda) * (1 - H_{SDSM}) * (\phi_H - 48.0°)}}$$ **F** (5)

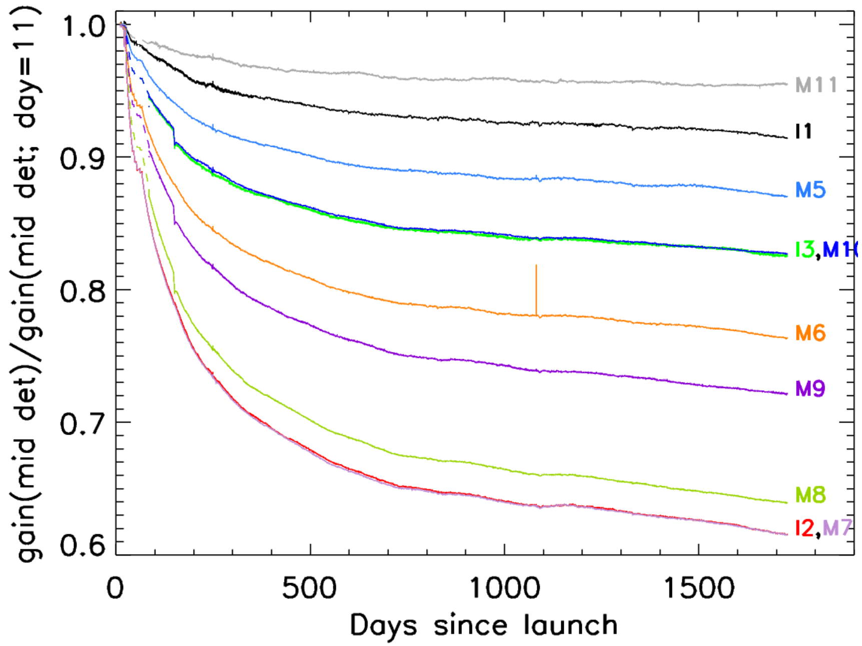


plus: lunar F
dot: SD F

Calculated Detector Gain

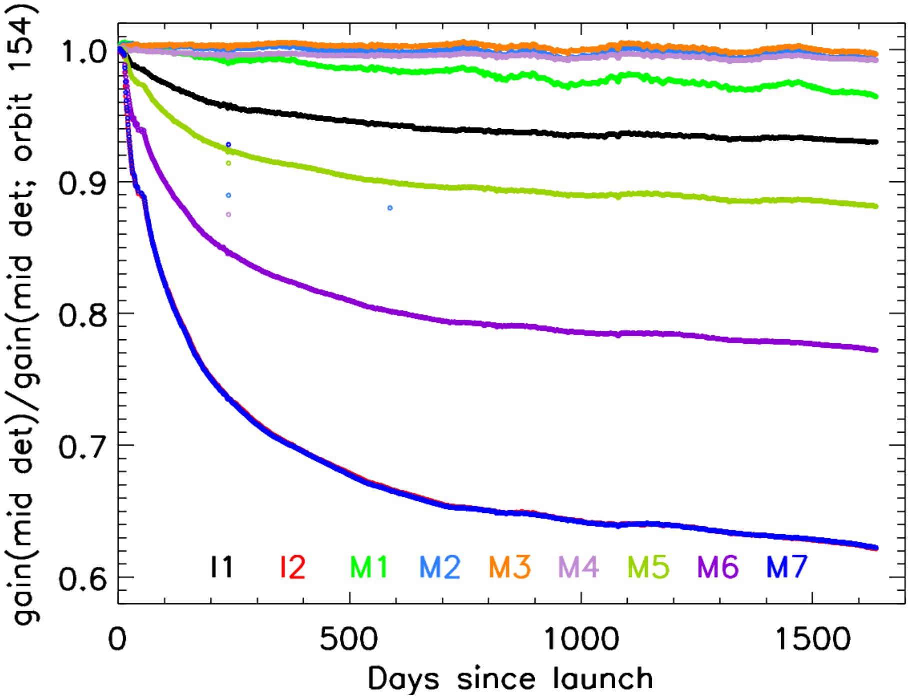
gain:=1/F



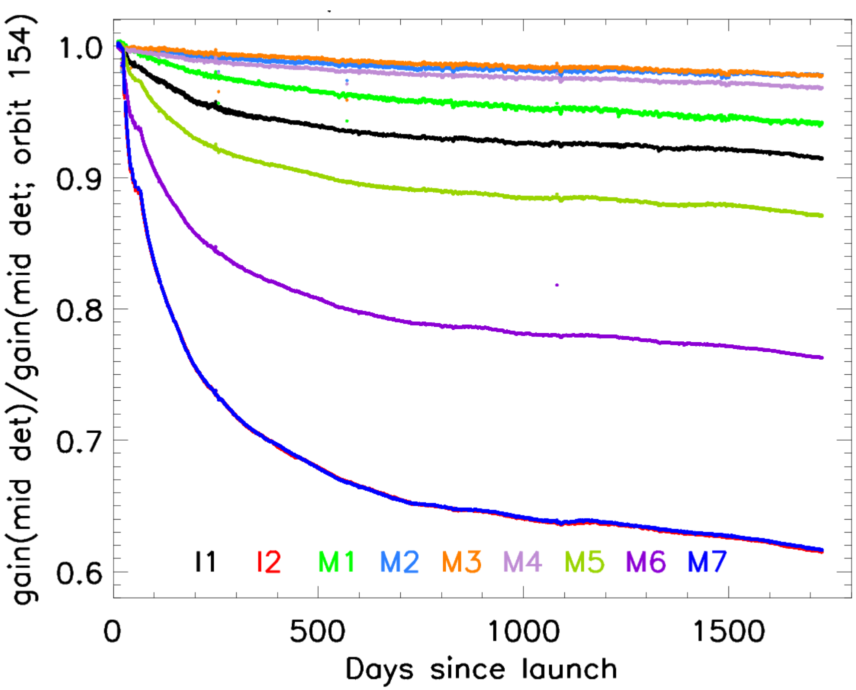


Calculated Gain: new vs old

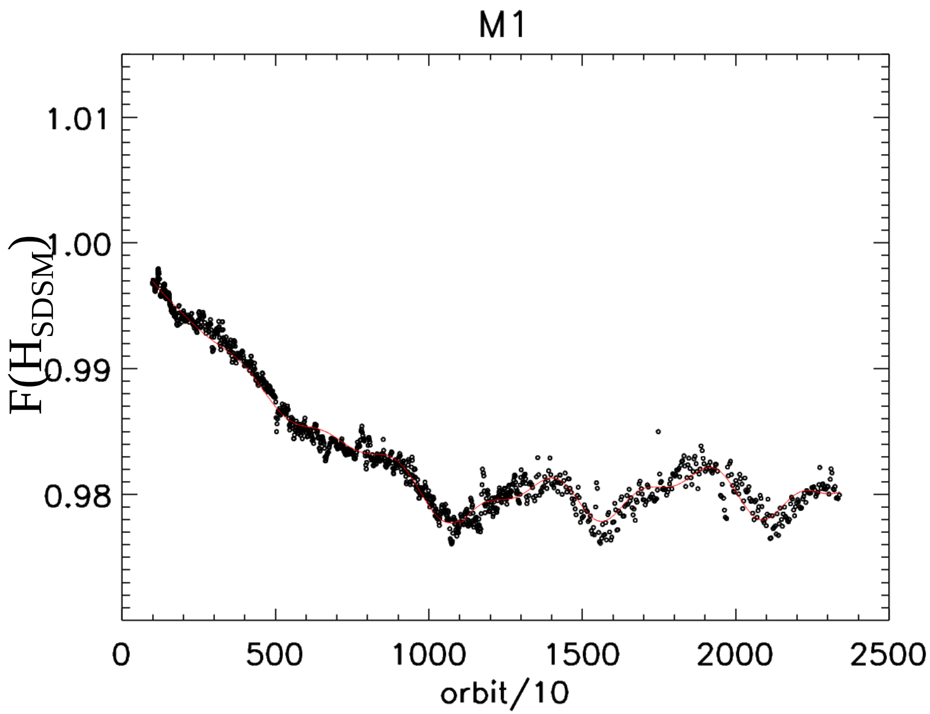
Old (last version)

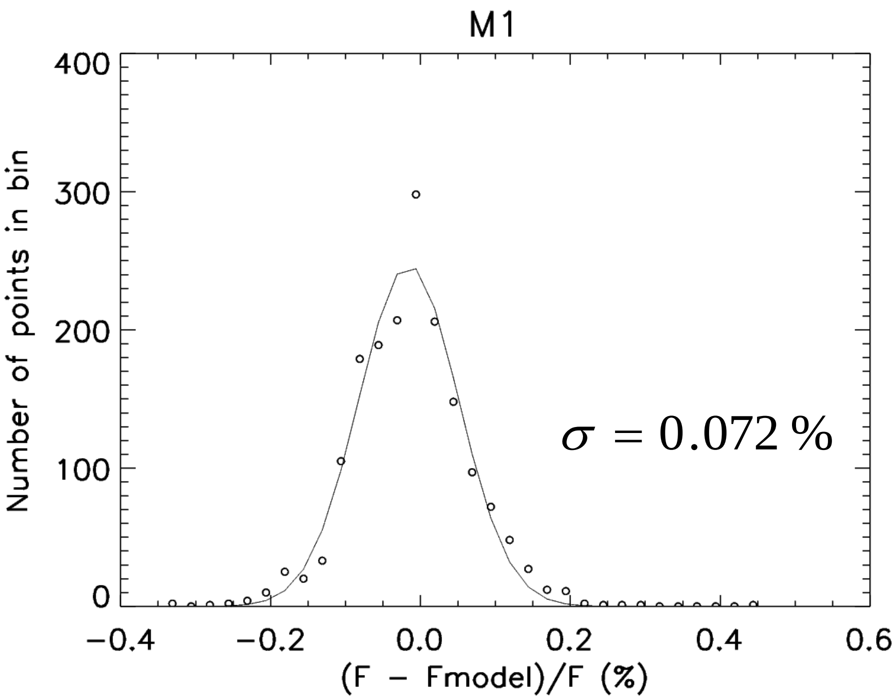


New (current version)



F Precision Estimation





M1:0.07%, M2:0.07%, M3:0.06%, M4:0.04%, I1:0.06%, …, M11:0.05%

Summary

- ***F* calculation accuracy has been improved**

  (1) removed yearly detector gain undulations (as large as 0.5% for M1)

  (2) removed biases (originally observed as large as 1.5% for M1) relative to lunar observations

  (3) removed bias due to incorrect H_{SDSM} normalization at t=0 (~1% for M1)

  (4) removed bias in the original $\tau_{SD}\,\mathrm{BRDF}_{RTA}(t=0)$ (>0.05%; yaw)

  (5) removed bias for the calculated SWIR band throughput (0.4% for M8)

  (6) improved accuracies in $\tau_{SD}^{R}\,\mathrm{BRDF}_{SDSM}(t=0)$ and τ_{SDSM}^{R} (yaw+non-yaw)

  ⇨ H_{SDSM} precision of 0.0003 to 0.0007

- ***F* precisions are around 0.05% on a per satellite orbit basis**

  (M1:0.07%, M2:0.07%, M3:0.06%, M4:0.04%, I1:0.06%, …, M11:0.05%)