Assessment of S-NPP VIIRS Reflective Solar Band (RSB) Radiometric Calibration

May 8, 2015
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Motivation

Website is at http://www.star.nesdis.noaa.gov/icvs/status_NPP_VIIRS.php
## Motivation

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* 271 trending plots are generated in near real time
Motivation

• H/F-factors are key radiometric parameters.
  – Linearly related to product radiance or reflectance.
• The operational H factor has stopped updating in Oct 2014.
**Motivation**

- As a key parameter, H-factor needs to be monitored.
  - H-factor represents Solar Diffuser (SD) degradation over time.
  - SD is calibration source for Reflective Solar Bands (RSB) and Day and Night Band (DNB).
  - Ocean color group requires higher accuracy in short wavelength bands.
    - At low radiance level.

![H factor active bands and VIRS relative spectral responses](image)

- H factor = 1 (no degradation)
- Still using SD for calibration

**412nm**

**2.25 um**
Introduction

From VIIRS Radiometric ATBD.
• **H: Solar Diffuser (SD) degradation factor.**
  – Measured by Solar Diffuser Stability Monitor (SDSM)

\[
H(t) = \frac{dc_{SD} \cdot \tau_{SDSM}}{dc_{SUN} \cdot BRDF(t_0) \cdot \tau_{SDS} \cdot \cos(\theta_{inc}) \cdot \Omega_{SDSM}}
\]

\[
BRDF(t) = H_{Norm}(t) \cdot BRDF(t_0)
\]

\[
H_{Norm}(t) = \frac{H(t)}{H(t_0)}
\]
• Sweet Spot for SDSM
  – Sun elevation angles between -0.7 and 0.7 degrees
  – Sun azimuth angles between -15.0 and 2.0 degrees

• Sweet Spot for SD
  – Sun declination angles between 15.0 and 18.5 degrees
  – Sun azimuth angles between 13.6 and 44.2 degrees

• 1.3 million OBCIP files were tested (as of May 7, 2015).
  – Approximately 1,759 files were identified with SDSM motor movement within the ‘sweet spot’.
  – Each OBCIP file has SUN and SD observations.
VIIRS Radiometric Calibration: H-factor

S-NPP H-factor
05/04/2015-11:19:26 UTC

2/4       5/19
412        450           488         555         672          746          865         935[nm]
VIIRS Radiometric Calibration: H-factor

SDSM Sample Trend: Sun Normalized dn
05/04/2015 - 11:19:28 UTC

SDSM Sample Trend: SD Normalized dn
05/04/2015 - 11:19:28 UTC

Solar Azimuth Angle to SDSM in the Sweet Spot
05/04/2015 - 11:19:27 UTC

Solar incident angle to the SD screen in the Sweet Spot
05/04/2015 - 11:19:27 UTC
VIIRS Radiometric Calibration: F-factor

- **F**: Reflective Solar Band (RSB) Calibration coefficient.
- **H**: Solar Diffuser (SD) degradation factor.

\[
L_{EV} = \frac{F \cdot (c_0 + c_1 \cdot dn_{EV} + c_2 \cdot dn_{EV}^2)}{RVS_{EV}}
\]

\[
F = \frac{L_{Sun \_Model}}{L_{Sun \_Observation}} = \frac{\text{Computed \_} L_{Sun}}{\text{Observed \_} L_{Sun}}
\]

\[
F = \frac{\cos(\theta_{inc}) \cdot \left[ E_{sun} \cdot \tau_{sds} \cdot BRDF(t) \right] \cdot RVS_{SD}}{c_0 + c_1 \cdot dn_{SD} + c_2 \cdot dn_{SD}^2}
\]

\[
BRDF(t) = H_{Norm}(t) \cdot BRDF(t_0)
\]

\[
H_{Norm}(t) = \frac{H(t)}{H(t_0)}
\]

\[
H(t) = \frac{dc_{SD} \cdot \tau_{SDSM}}{dc_{SUN} \cdot BRDF(t_0) \cdot \tau_{SD} \cdot \cos(\theta_{inc}) \cdot \Omega_{SDSM}}
\]

dn: VIIRS bias removed response

dc: SDSM bias removed response
• Esun
  – Solar irradiance upon a surface with its normal pointing toward the sun.
  – Modulated by the band Relative Spectral Response (RSR).

\[
Esun = \frac{\int RSR(\lambda) \cdot Solar\_Irrad(\lambda) d\lambda}{\int RSR(\lambda) d\lambda} / 4\pi R^2
\]
VIIRS Radiometric Calibration: F-factor

• C coefficients are dependent on
  – C0, C1, and C2 are need to be derived in each scan, gain, ham, detector and band.

• The Solar incident angle ($\theta_{inc}$) is calculated from solar vector.

• The Responses Versus Scan (RVS) at SD observation angle is available as a LUT.

• 48,028 OBCIP files were identified as sweet-spot granules
  – Out of 1.3 million OBCIP files as of May 7, 2015.

$$F = \frac{\cos(\theta_{inc}) \cdot \left[ E_{sun} \cdot \tau_{sds} \cdot BRDF(t) \right]}{c_0 + c_1 \cdot dn_{SD} + c_2 \cdot dn_{SD}^2}$$
VIIRS Radiometric Calibration: F-factor

- RSB VisNir Bands
  - NOAA ICVS F-factors: Solid Lines (raw values)
  - Operational delivered F-factors: Symbols.

![Graph showing F-factor trends for RSB VisNir Bands]

- 5/23
- 7/11
VIIRS Radiometric Calibration: F-factor

• RSB SWIR Bands
  – NOAA ICVS F-factors: Solid Lines (raw values)
  – Operational delivered F-factors: Symbols.

5/9 C0=0 update

1 year window
F-factor Ratio Comparisons

- Ratio of the operational / measured F-factors

Initial Updates

H-factor update Nov. 2012

Band M1

Band M2

Band M3

Band M4
• Ratio of the operational / measured F-factors
• NOAA ICVS version of H/F-factors are successfully calculated.
• The H/F-factors are key parameters for radiometric accuracy.
• Significant changes of the operational H/F-factor are observed in 2014.
  – Due to H-factor updates on 5/23/2014 and 7/11/2014
  – Up to 1.5% in band M1
• The ICVS F-factors can be used for reprocessing of the entire S-NPP product.
Backup Slides
Backup

Exponential quadratic fit was avoided!

30/60 (det 7 and 8) day window linear fit

Exponential quadratic fit

SD deg = exp(at^2+bt+c)
• H-factor Spectral Domain Interpolation

H factor interpolation between SDSM and VIIRS CW

Wavelength [nm]

H-factor

M3 (486), M4 (551), M5 (672), M6 (745), M7 (861), M12 (935) are set to be unity.
S-NPP VIIRS
• A whiskbroom scanning radiometer
• Sun synchronous orbit
• Nominal altitude of 829 km
• Equator crossing local time 13:30