2015 STAR ICVS
instrument Performance Review
Session 2 – Advanced Science for ICVS

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

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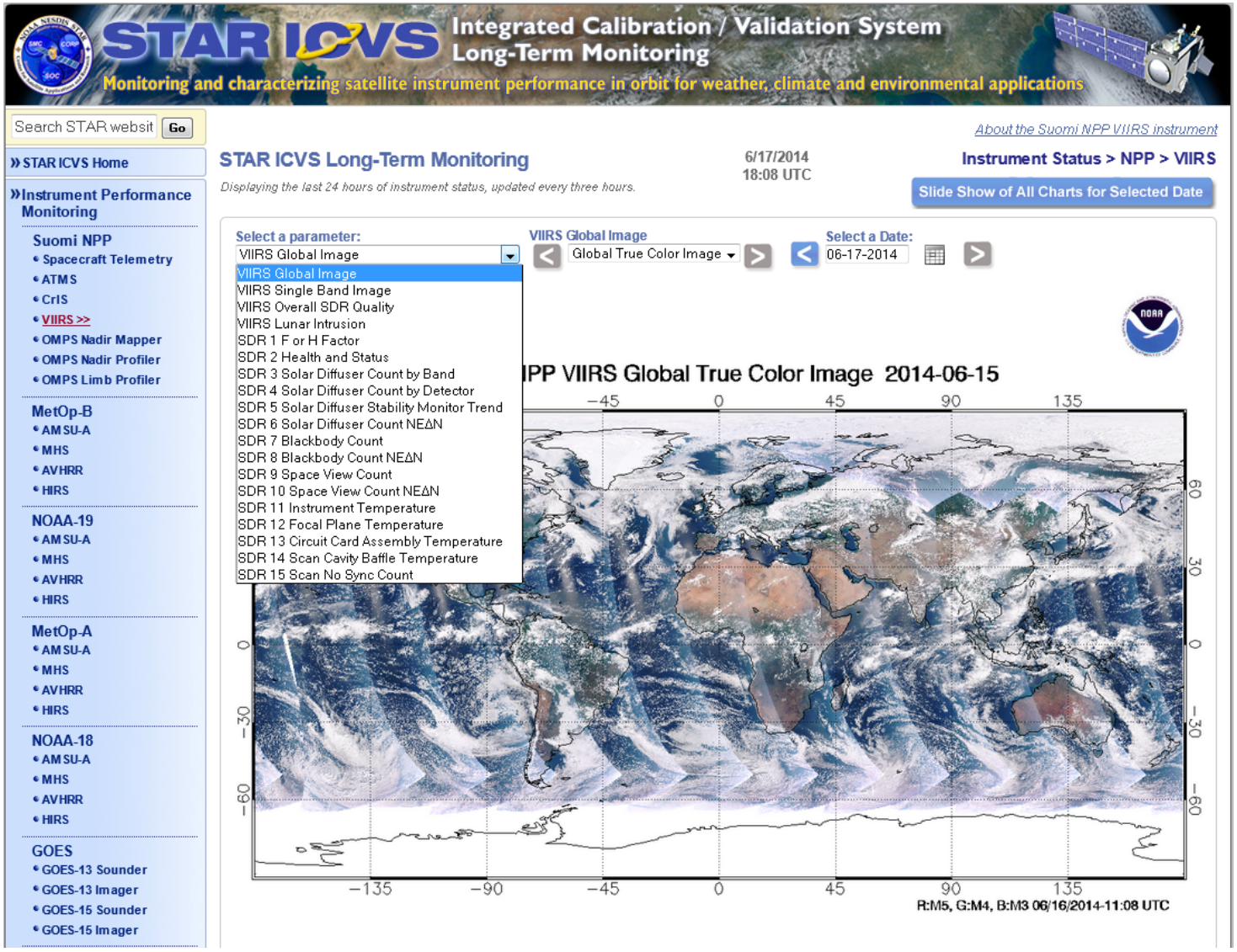
Outline

- Motivation
- Introduction
- VIIRS Radiometric Calibration
  - H-factor: Solar Diffuser degradation factor
  - F-factor: Radiometric calibration coefficient
- F-factor Ratio Comparisons
  - Operational F-factor Vs. NOAA ICVS F-factor
- Summary

Motivation

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



Motivation

Parameters	Descriptions	Dimensions	Usage
Global Image	Global true color image and single band image	38	VIIRS Imagery/Products
Telemetry/Temperature	BB, RTA, cavity, HAM, FPA, cooler, Mainframe, Circuit Card Assembly, instrument current/voltage	41	Instrument Healthy status
SD Counts	VIIRS observation DN of Solar diffuser for band I1~I3, M1~M11, DNB over band average	14 bands	Degradation trending
SD NEΔN	Noise NEΔN for SD signal of solar bands	14 bands	SNR trending
SD Counts	VIIRS observation DN of Solar diffuser I1~I3, M1~M11, DNB over detector average	14 bands *32d	degradation for Detector uniform
SDSM signal	SDSM signal of SD and Sun in every orbit	8 bands	SD trending
SV Counts	VIIRS observation Space view DN for 22 bands	22 bands	Background signal trending
SV NEΔN	Dark Noise NEΔN for Space view signal	22 bands	Dark noise signal
BB Counts	VIIRS observation Blackbody DN for 22 bands	22 bands	IR gain derivation
BB NEΔN	Noise NEΔN for black body signal	22 bands	IR NEDT derivation
F/H factors	Degradation of Solar bands based on SD signal/SDSM and TEB	19	RSB/TEB degradation
IR NEΔT	Noise equivalent temperature for IR bands M4, M5, M12-M16	7 IR bands	IR bands noise
IR Calibration Gain	Calibration gains for IR bands M4, M5, M12-M16	7 IR bands	IR bands calibration trending
SDR Quality Flag	SDR data product quality flags	22 bands	Check SDR data quality

*** 271 trending plots are generated in near real time**

Motivation

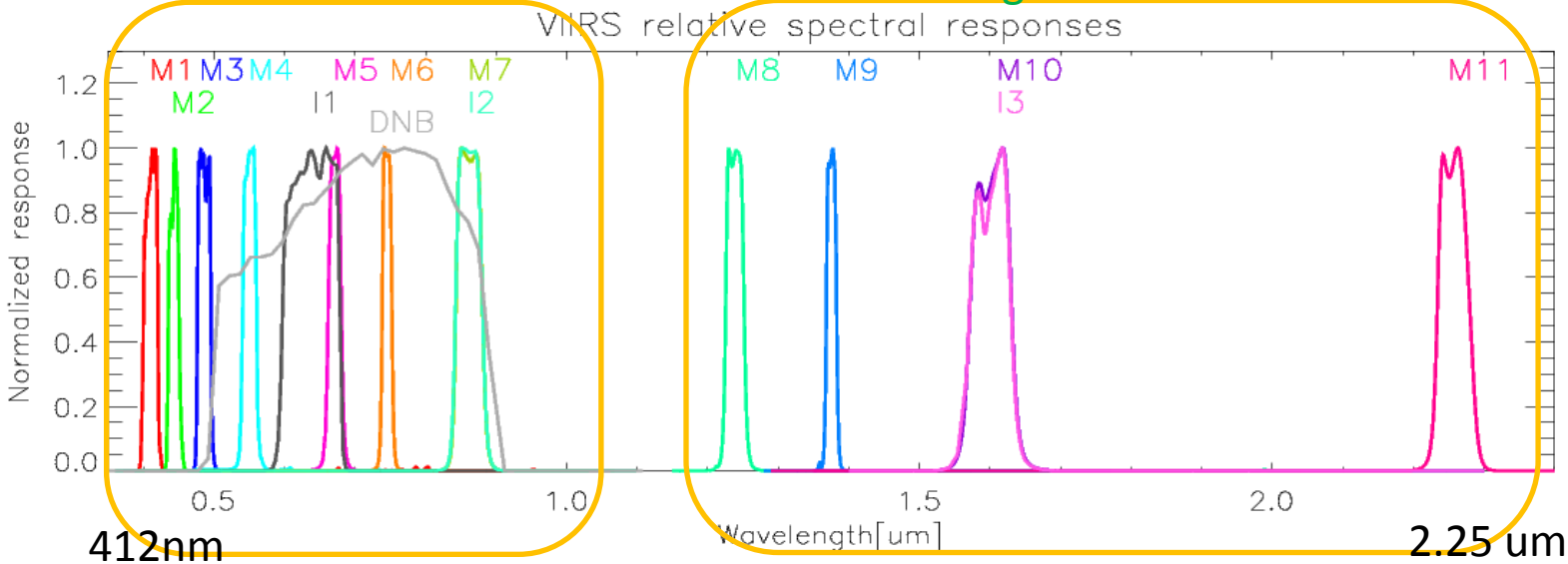
- H/F-factors are key radiometric parameters.
  - Linearly related to product radiance or reflectance.
- The operational H factor has stopped updating in Oct 2014.

Motivation

- 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

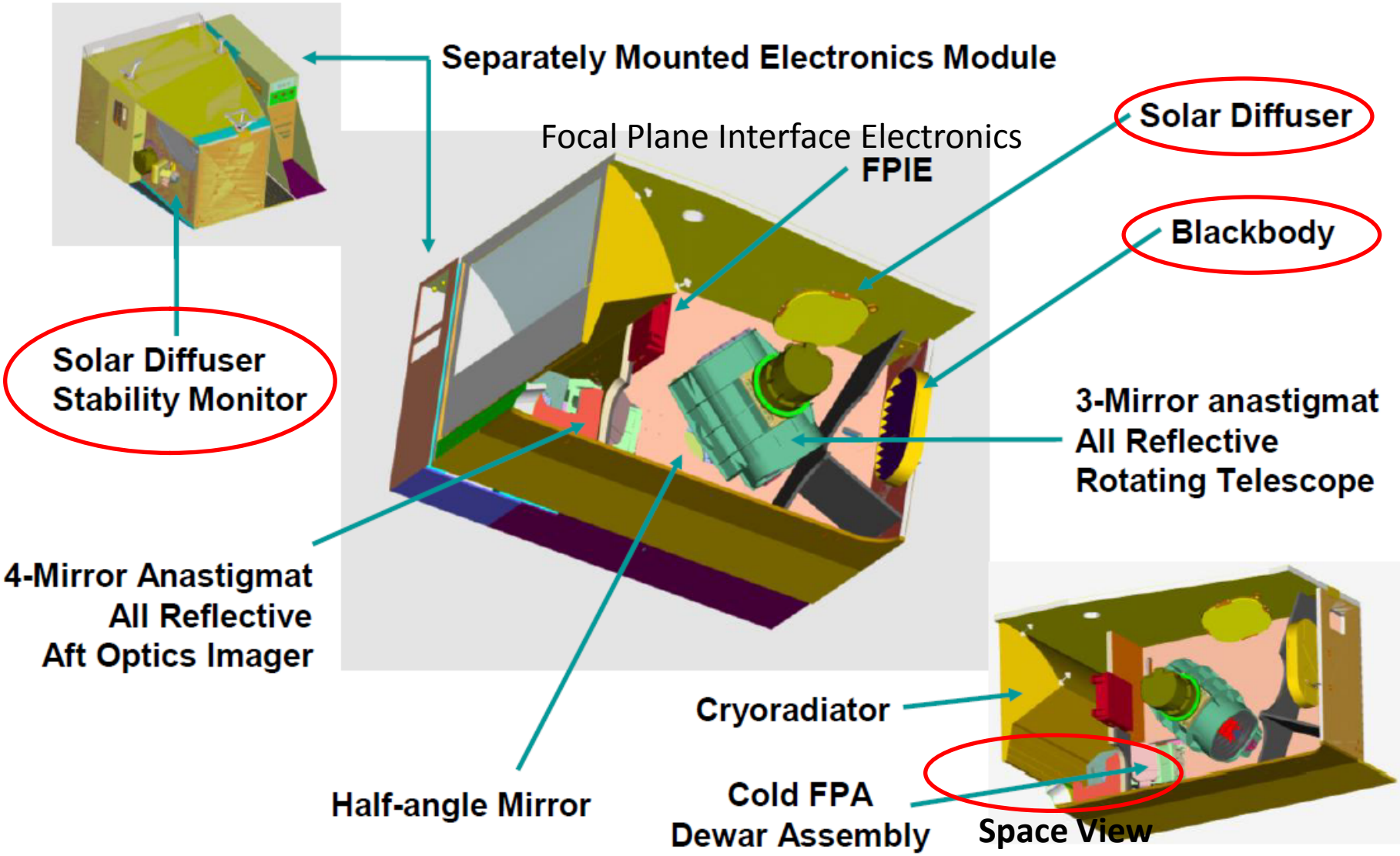
H factor = 1 (no degradation)
Still using SD for calibration



412nm

2.25 um

Introduction



From VIIRS Radiometric ATBD.

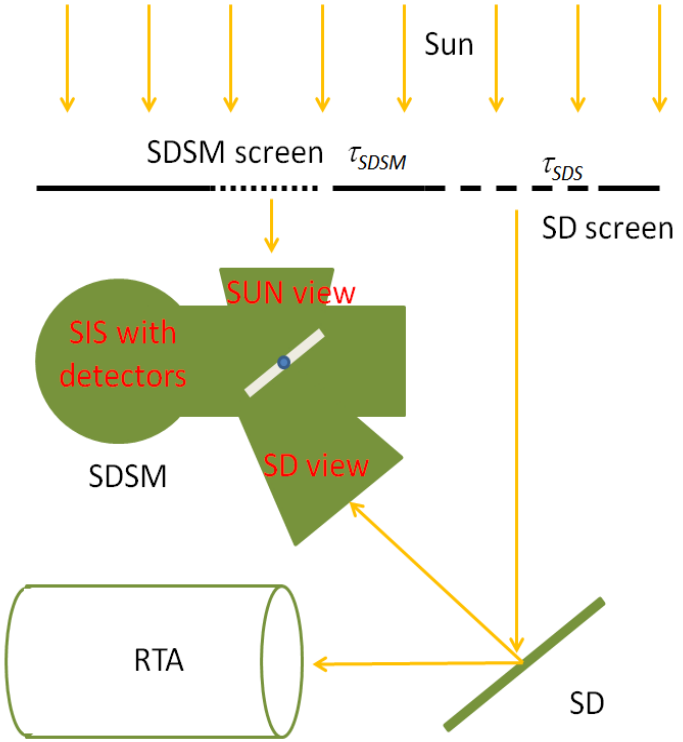
VIIRS Radiometric Calibration: H-factor

- H: Solar Diffuser (SD) degradation factor.
  - Measured by Solar Diffuser Stability Monitor (SDSM)

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

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

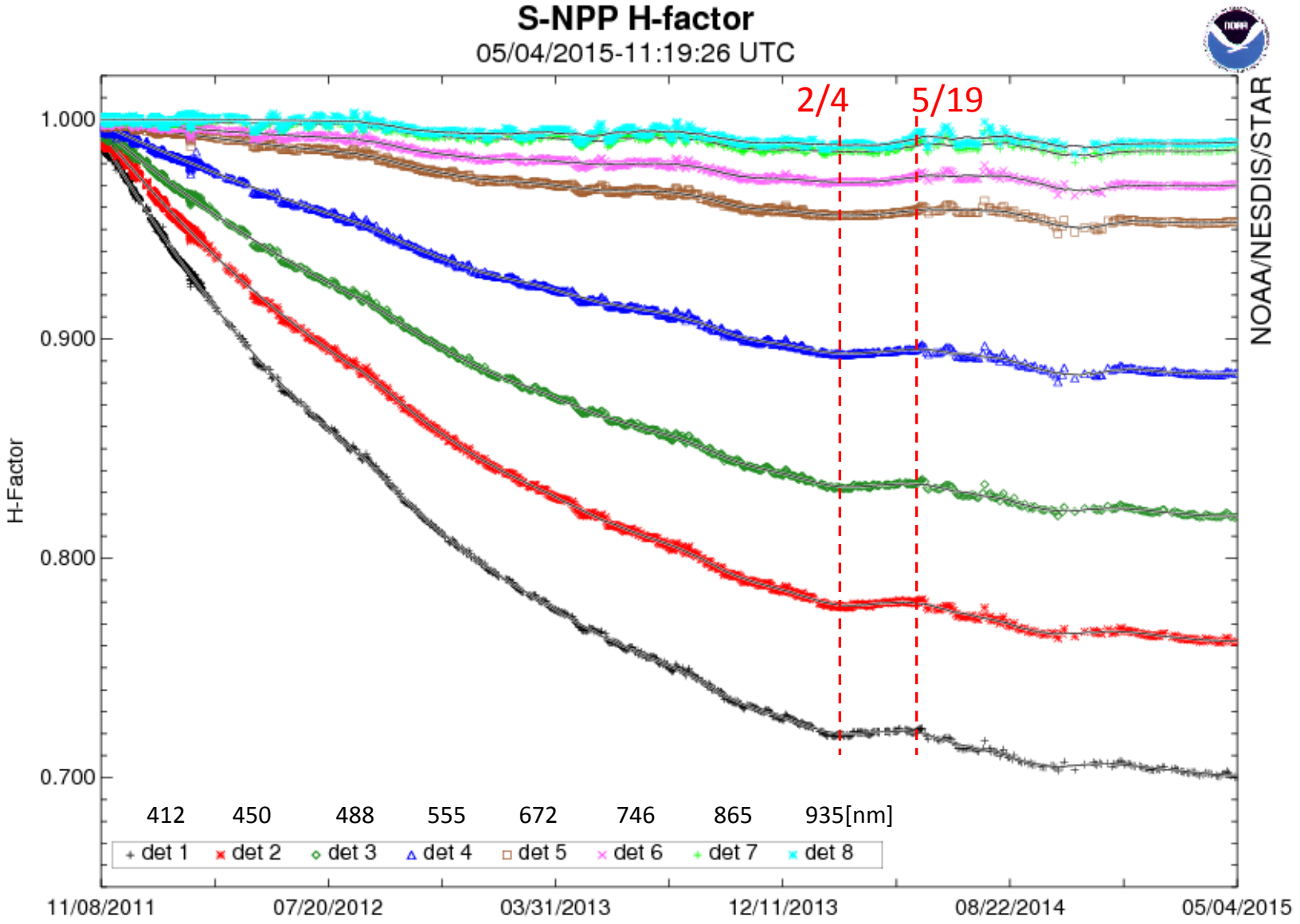
$$H_{Norm}(t) = \frac{H(t)}{H(t_0)}$$



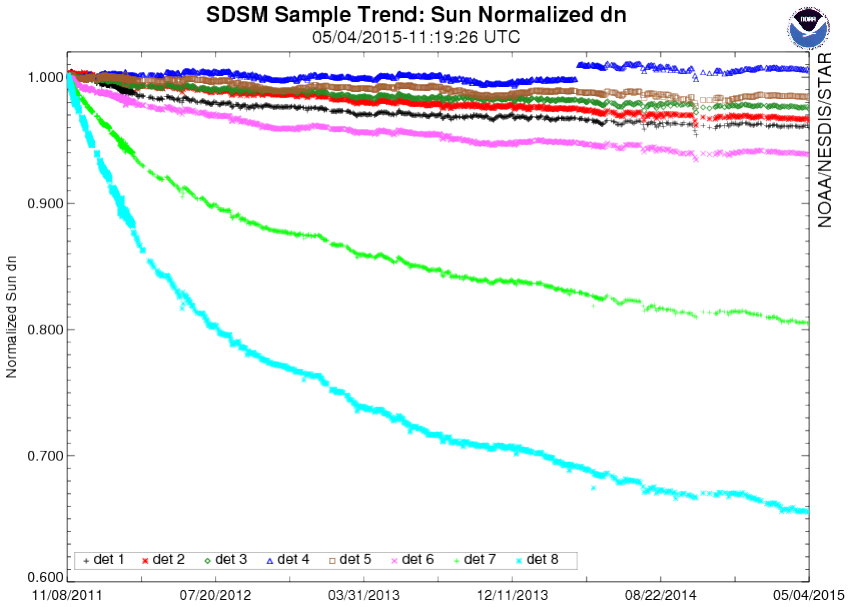
VIIRS Radiometric Calibration: H-factor

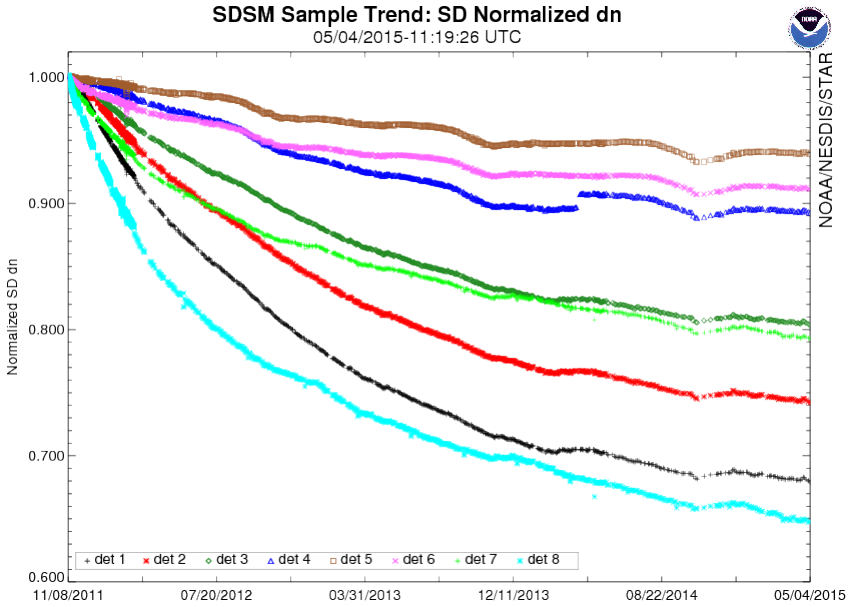
- Sweet Spot for SDSM
  - Sun elevation angles between -0.7 and 0.7 degrees
  - Sun azimuth angles between -15.0 and 2.0 degrees
- Sweet Spot for SD
  - Sun declination angles between 15.0 and 18.5 degrees
  - Sun azimuth angles between 13.6 and 44.2 degrees
- 1.3 million OBCIP files were tested (as 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.

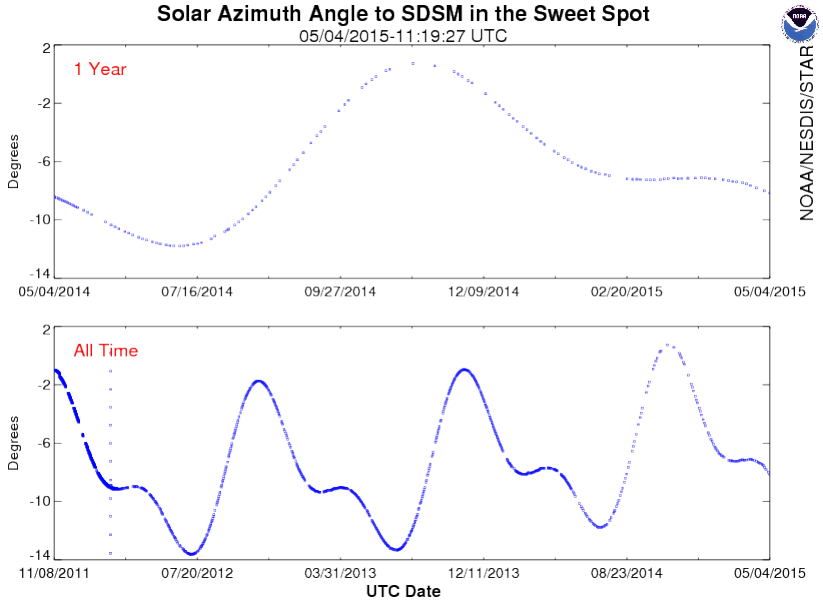
VIIRS Radiometric Calibration: H-factor

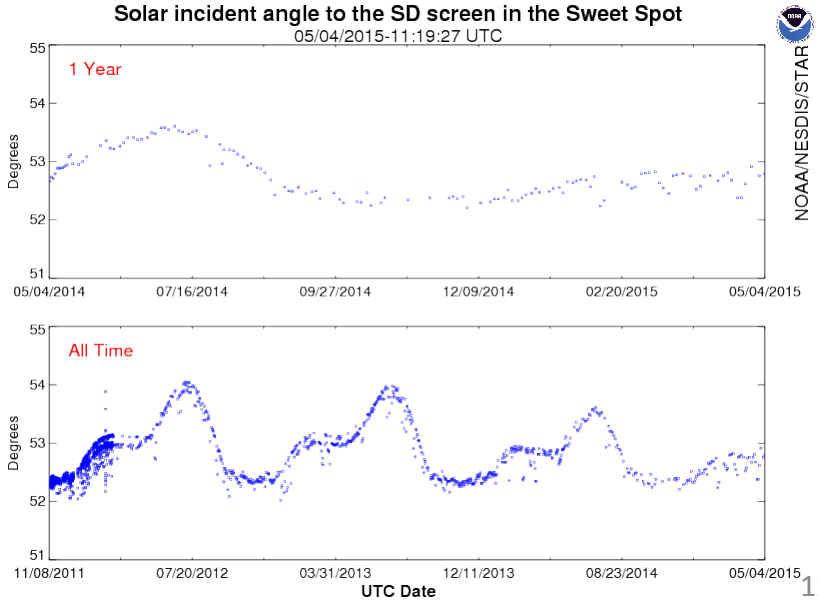


VIIRS Radiometric Calibration: H-factor









VIIRS Radiometric Calibration: F-factor

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

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

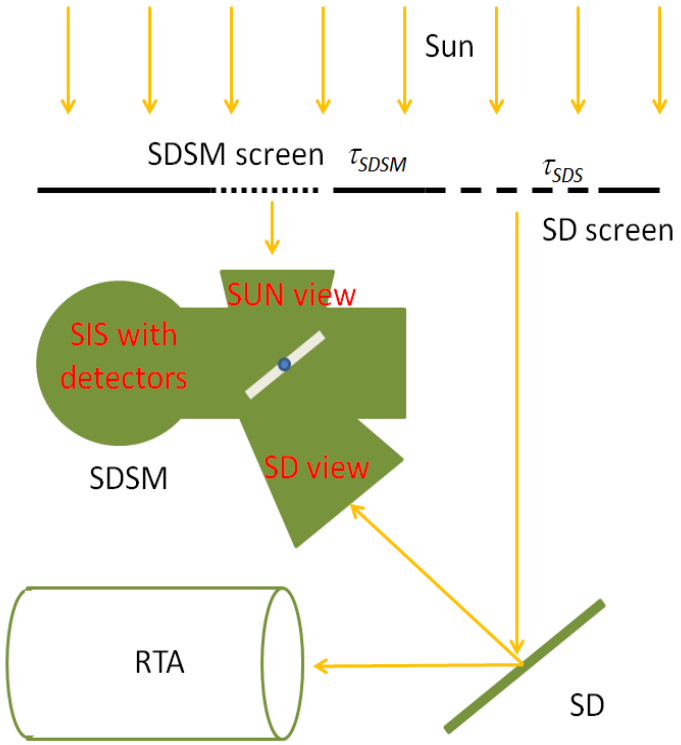
$$F = \frac{L_{Sun\_Model}}{L_{Sun\_Observation}} = \frac{Computed\_L_{Sun}}{Observed\_L_{Sun}}$$

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

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

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

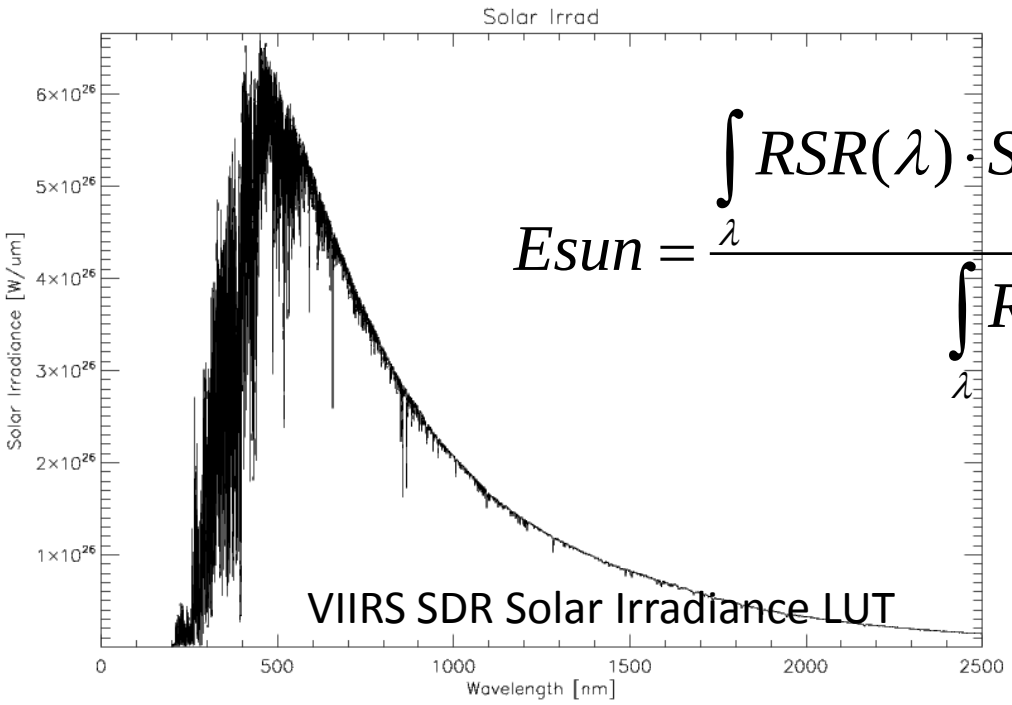
$$H(t) = \frac{dc_{SD} \cdot \tau_{SDSM}}{dc_{SUN} \cdot BRDF(t_0) \cdot \tau_{SDS} \cdot \cos(\theta_{inc}) \cdot \Omega_{SDSM}}$$



dn: VIIRS bias removed response
dc: SDSM bias removed response

VIIRS Radiometric Calibration: F-factor

- Esun
  - Solar irradiance upon a surface with its normal pointing toward the sun.
  - Modulated by the band Relative Spectral Response (RSR).



$$Esun = \frac{\int_{\lambda} RSR(\lambda) \cdot Solar\_Irrad(\lambda) d\lambda}{\int_{\lambda} RSR(\lambda) d\lambda} / 4\pi R^2$$

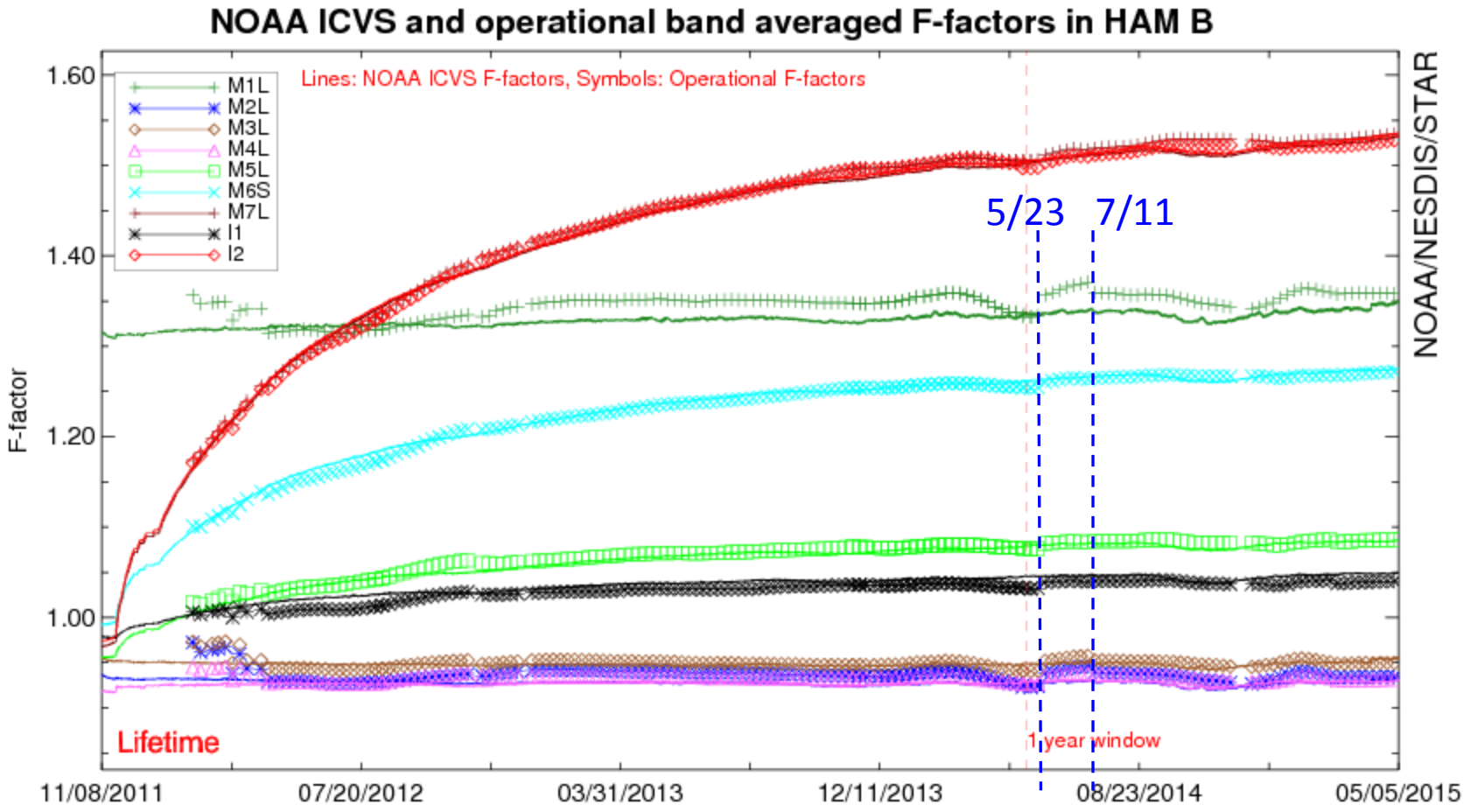
VIIRS Radiometric Calibration: F-factor

- C coefficients are dependent on
  - Ta: detector temperature, Telec: electronics Temp.
  - C0, C1, and C2 are need to be derived in each scan, gain, ham, detector and band.
- The Solar incident angle (θ_{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.

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

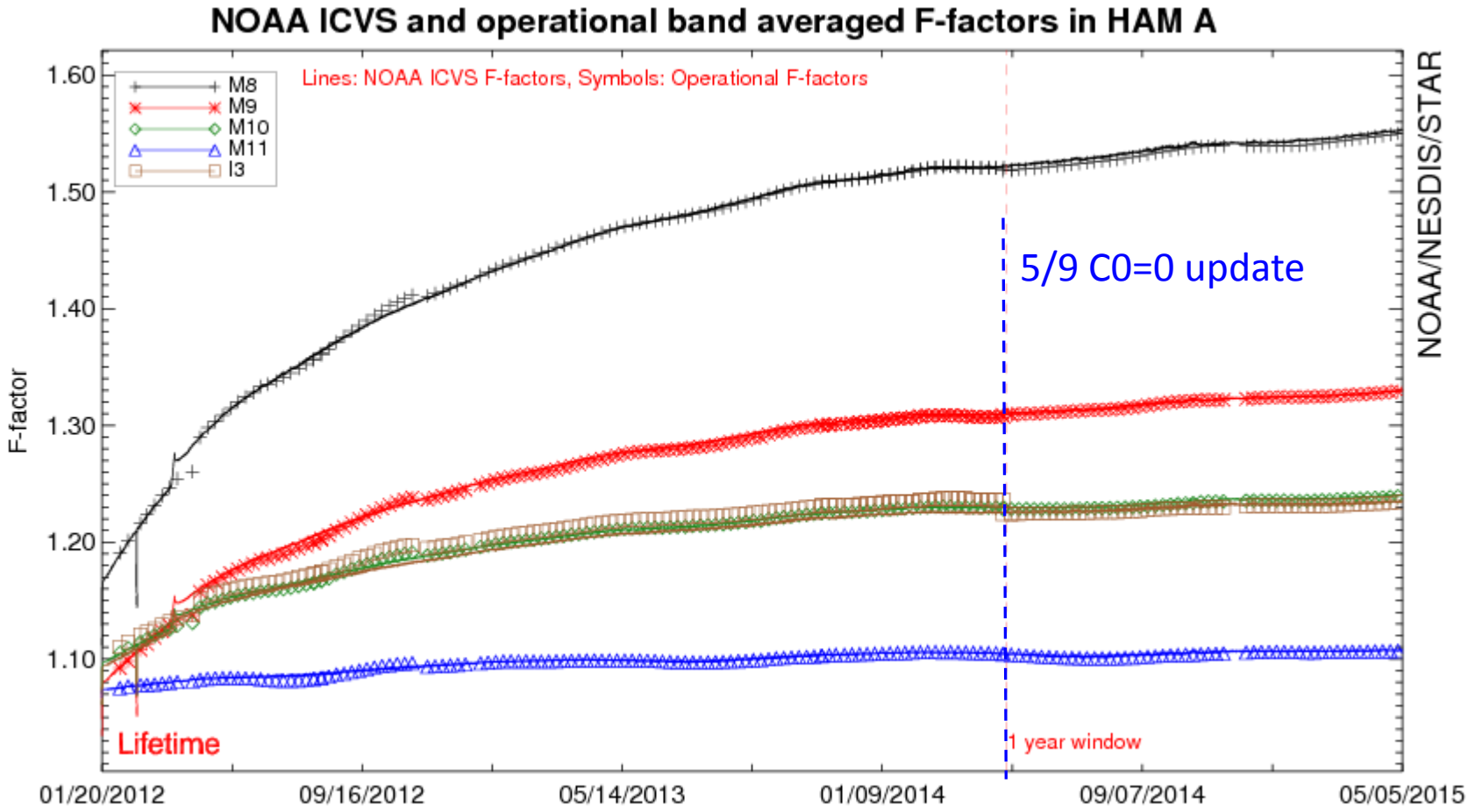
VIIRS Radiometric Calibration: F-factor

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



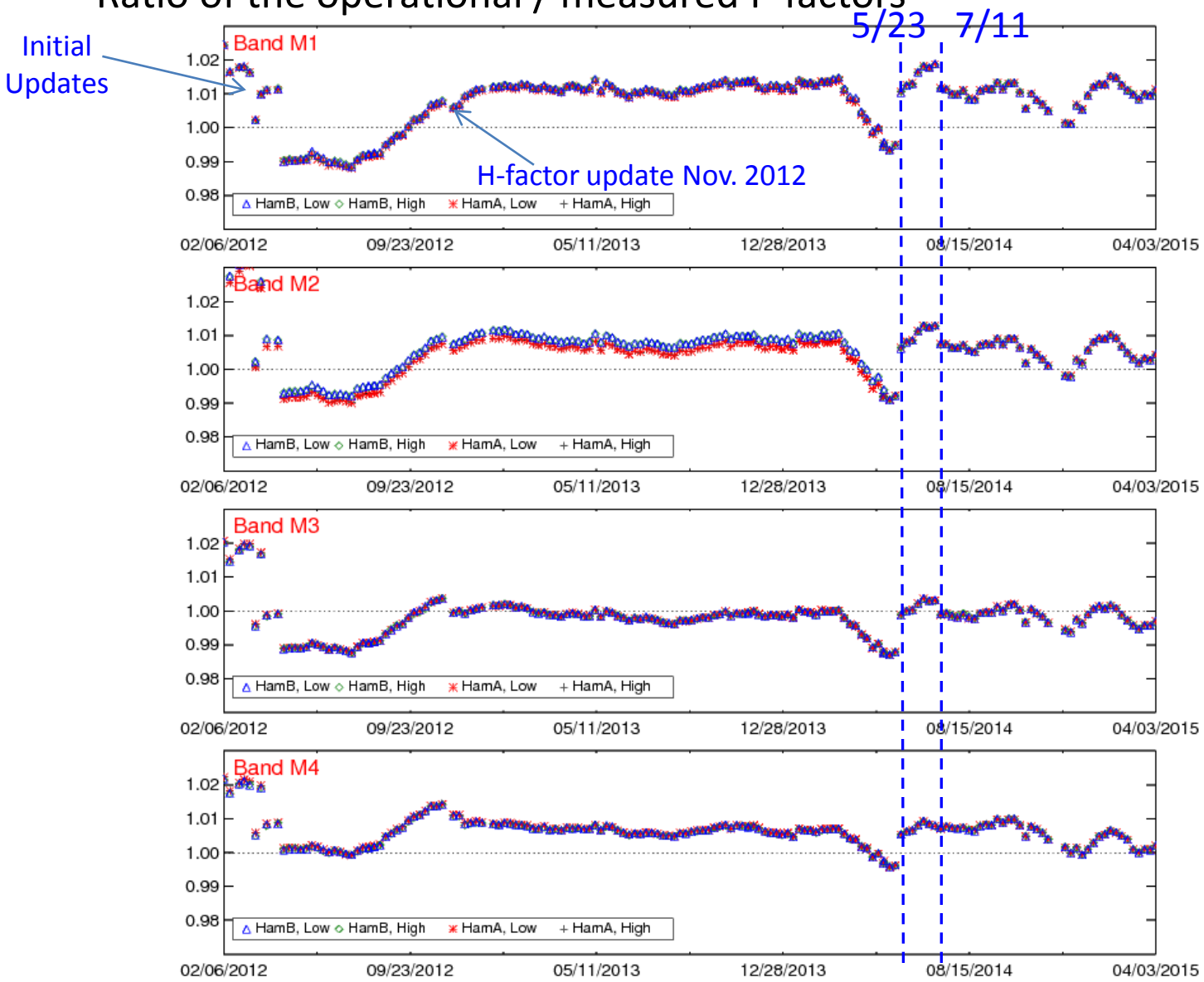
VIIRS Radiometric Calibration: F-factor

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



F-factor Ratio Comparisons

- Ratio of the operational / measured F-factors



F-factor Ratio Comparisons

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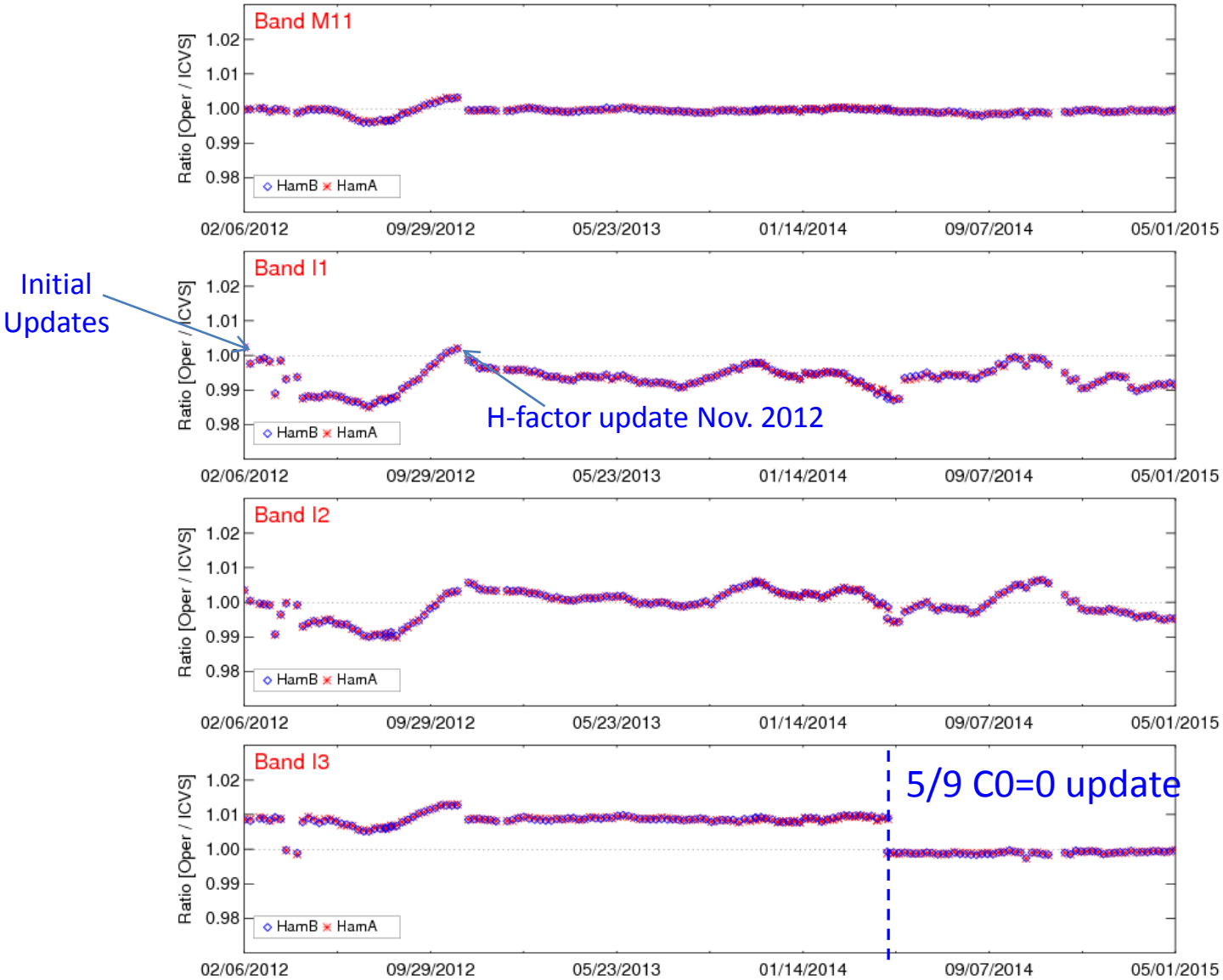
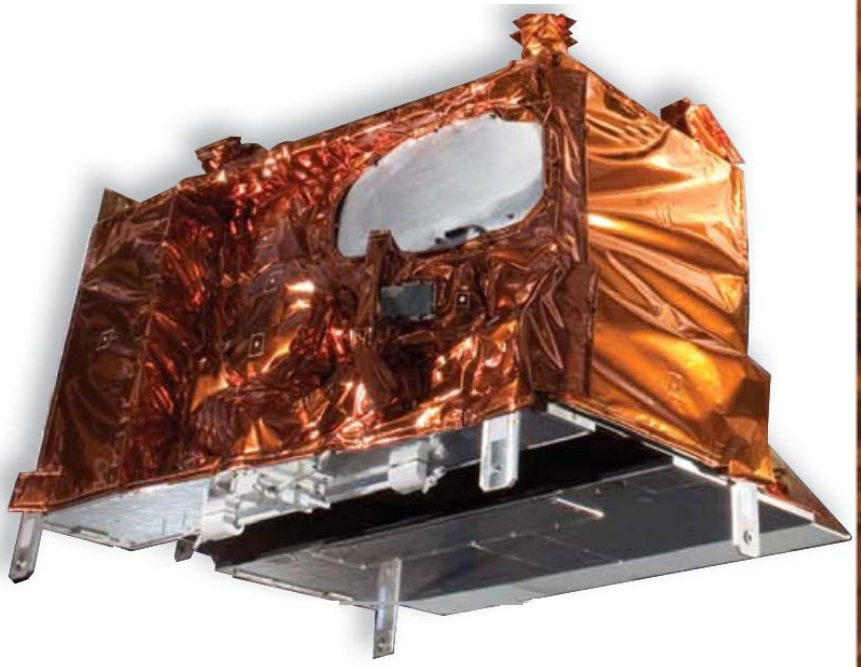


Summary

- 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.

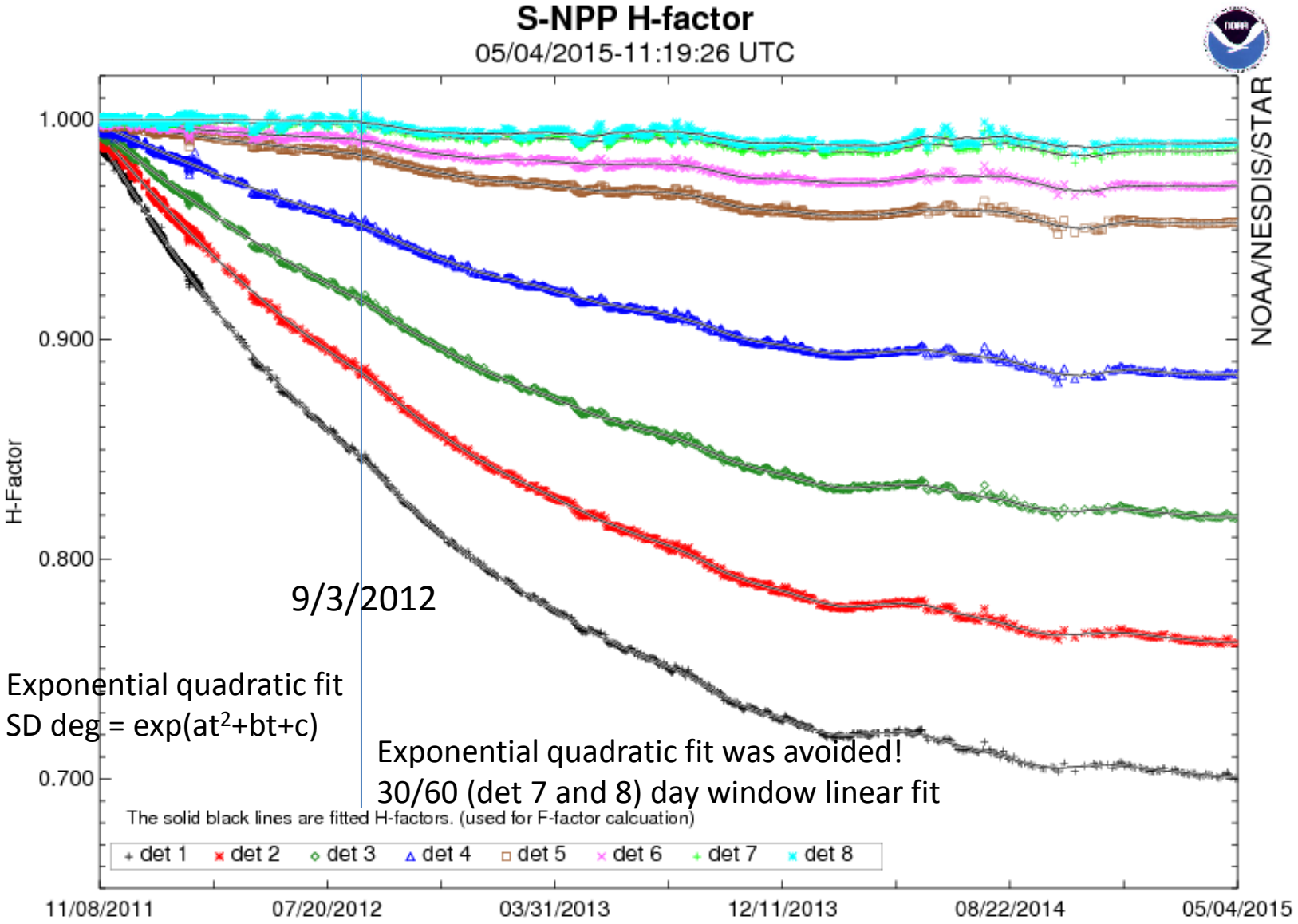
Backup Slides

Backup



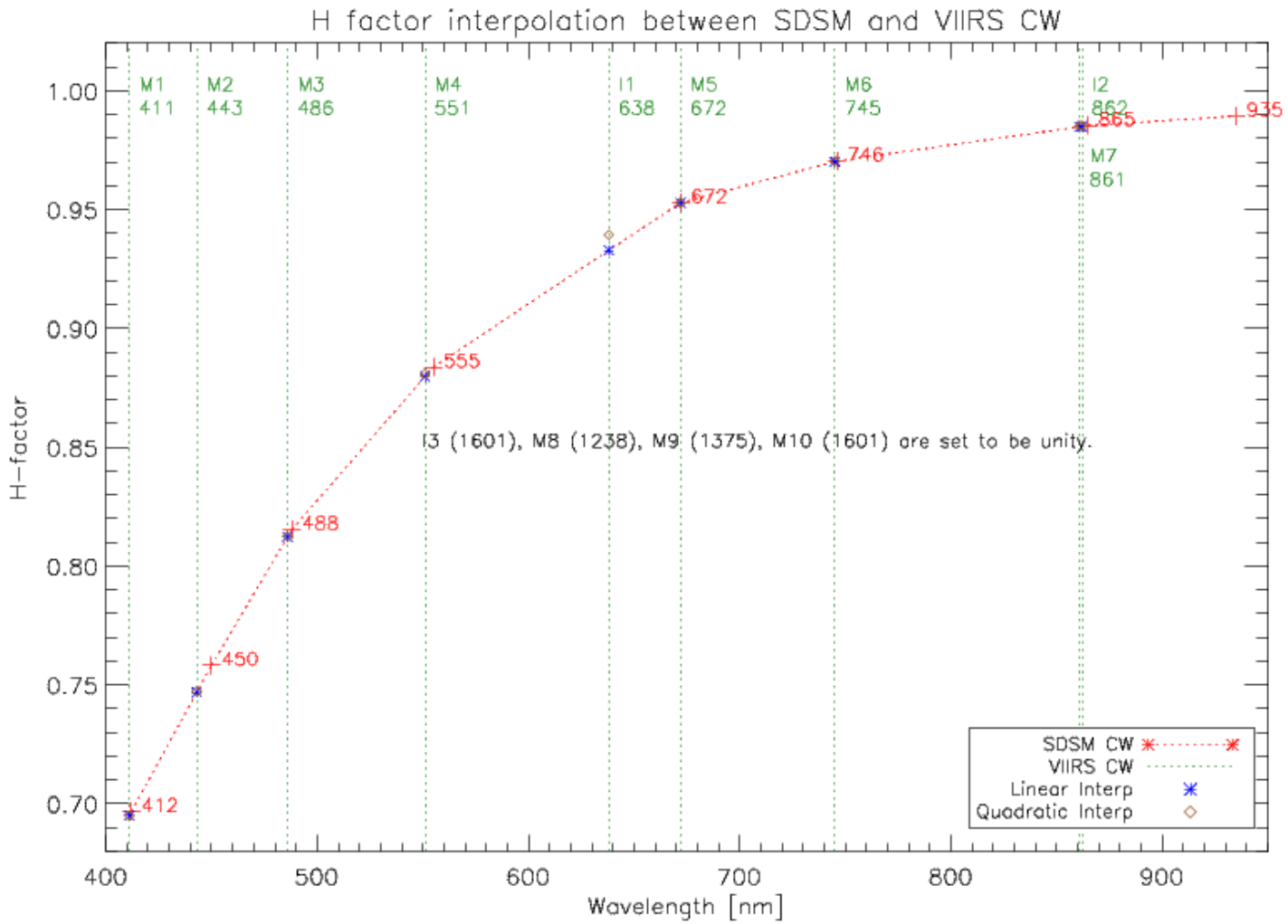
http://npp.gsfc.nasa.gov/images/VIIRS_DS152%20Approved%208-10-11.pdf

Backup


S-NPP H-factor
05/04/2015-11:19:26 UTC
NOAA/NESDIS/STAR
H-Factor
1.000
0.900
0.800
0.700
9/3/2012
Exponential quadratic fit
SD deg = exp(at²+bt+c)
Exponential quadratic fit was avoided!
30/60 (det 7 and 8) day window linear fit
The solid black lines are fitted H-factors. (used for F-factor calcuation)
det 1
det 2
det 3
det 4
det 5
det 6
det 7
det 8
11/08/2011
07/20/2012
03/31/2013
12/11/2013
08/22/2014
05/04/2015

Backup

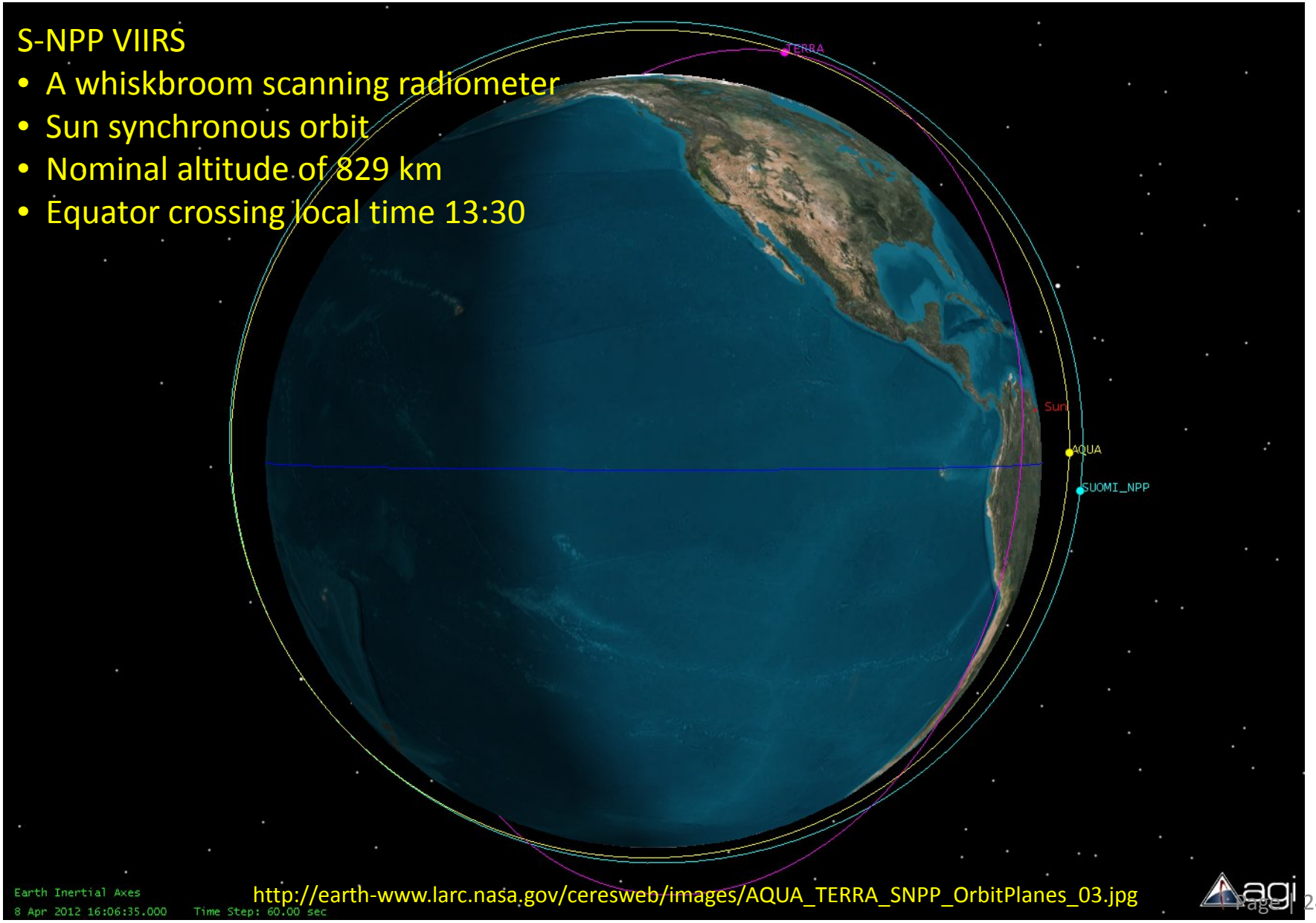
- H-factor Spectral Domain Interpolation



Introduction

S-NPP VIIRS

- A whiskbroom scanning radiometer
- Sun synchronous orbit
- Nominal altitude of 829 km
- Equator crossing local time 13:30



http://earth-www.larc.nasa.gov/ceresweb/images/AQUA_TERRA_SNPP_OrbitPlanes_03.jpg