



Infrared and Visible Optical Sensors (IVOS)  
Subgroup to the Working Group on  
Calibration and Validation (WGCV)

# On-orbit Performance of S-NPP and N-20 VIIRS

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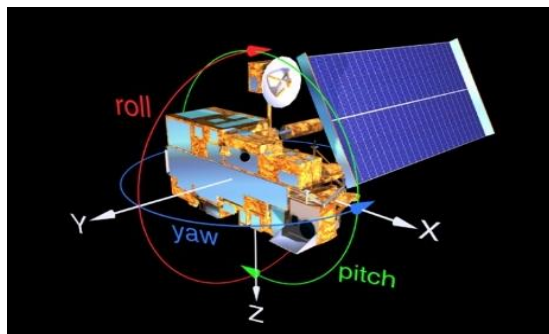
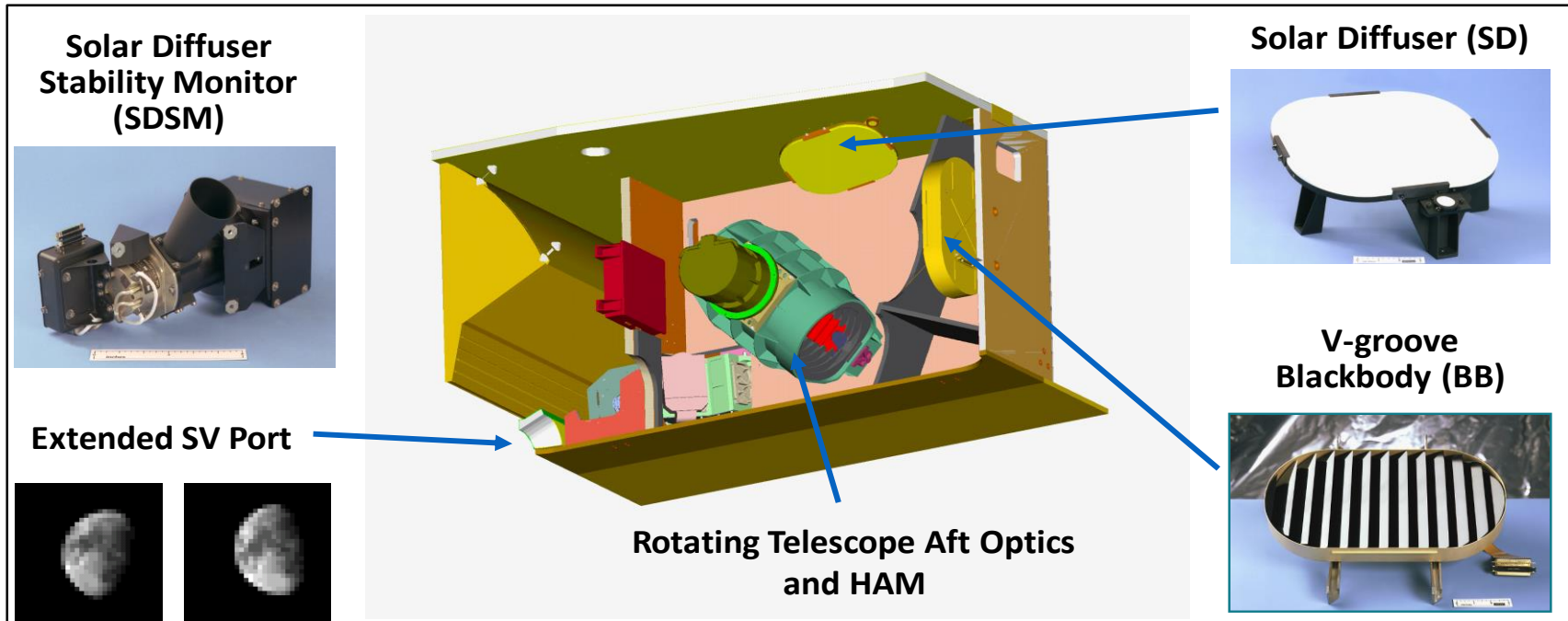
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# Outline

- **On-orbit Calibration Methodologies**
- **Calibration Performance Assessments**
  - Reflective Solar Bands (RSB)
  - Thermal Emissive Bands (TEB)
  - Day/Night Band (DNB) Stray Light Correction
- **Challenges and Future Efforts**

# VIIRS On-orbit Calibration and Characterization

## On-board Calibrators (OBC)

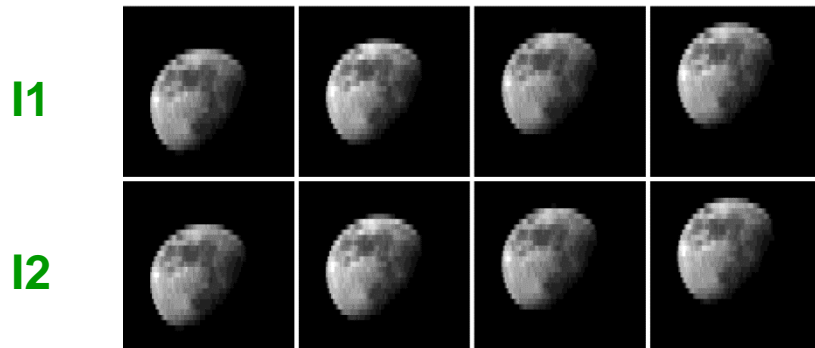


- 22 spectral bands: 0.4 to 12.2  $\mu\text{m}$  (RSB, TEB, DNB)
- M (1-16)/I (1-5)/DNB resolution: 750/375/750 m
- Dual gain bands: M1-5, M7, M13
- DNB: 3 gain stages (H/M/L)

# VIIRS Lunar Calibration

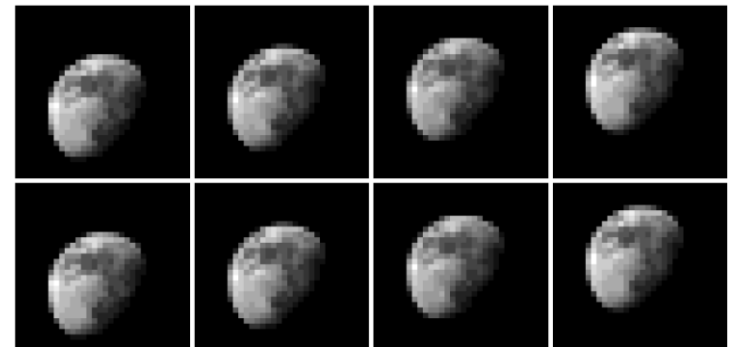
- Track RSB calibration stability
- Regularly scheduled at the same phase angles (S/C roll maneuvers; different aggregation zones for S-NPP and N-20)
- **N-20 and S-NPP lunar observations are made ~50 min apart**

N-20 VIIRS Lunar Images (3/17/19)



Scans →

S-NPP VIIRS Lunar Images (3/17/19)

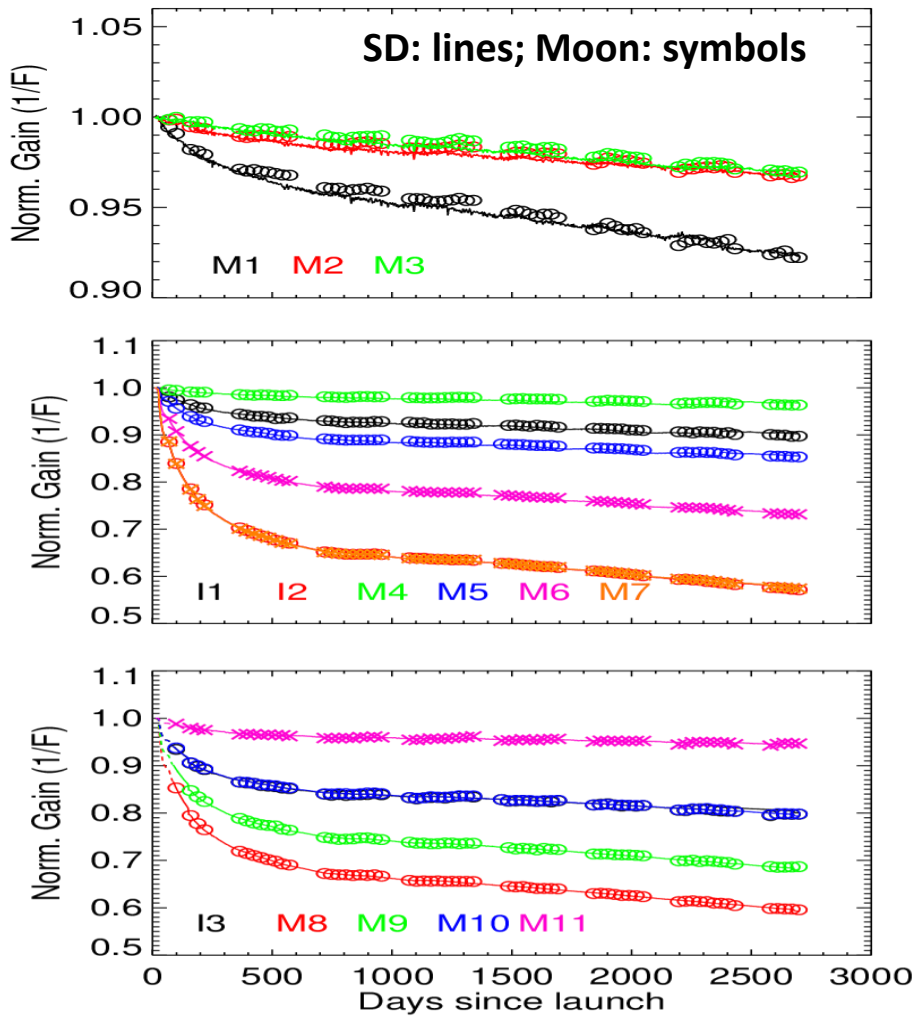


Scans →

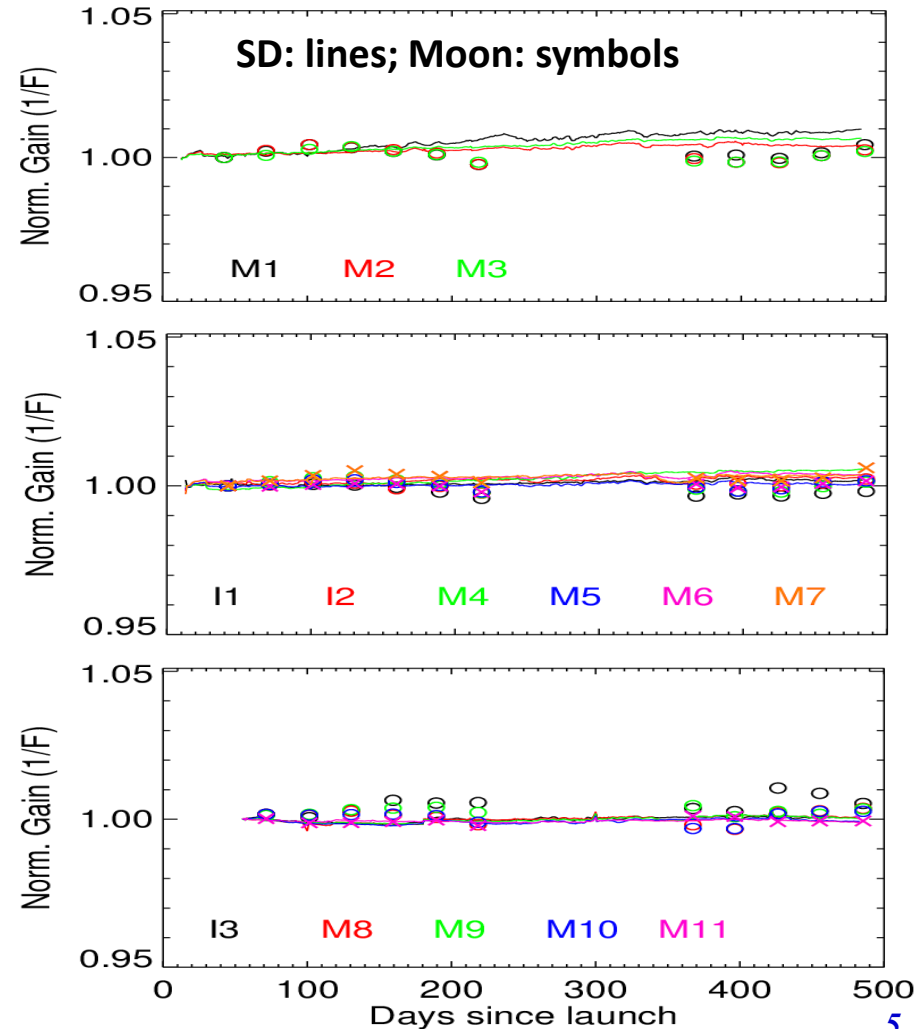
# Spectral Band Responses: RSB

- S-NPP: large changes in NIR/SWIR wavelengths
- N-20: extremely stable for VIS/NIR/SWIR

## S-NPP VIS, NIR, and SWIR Responses

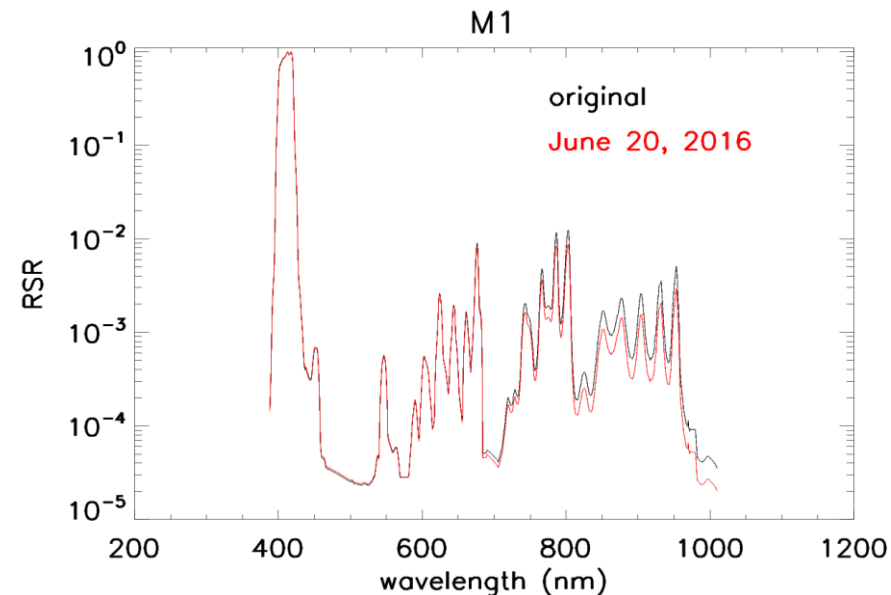
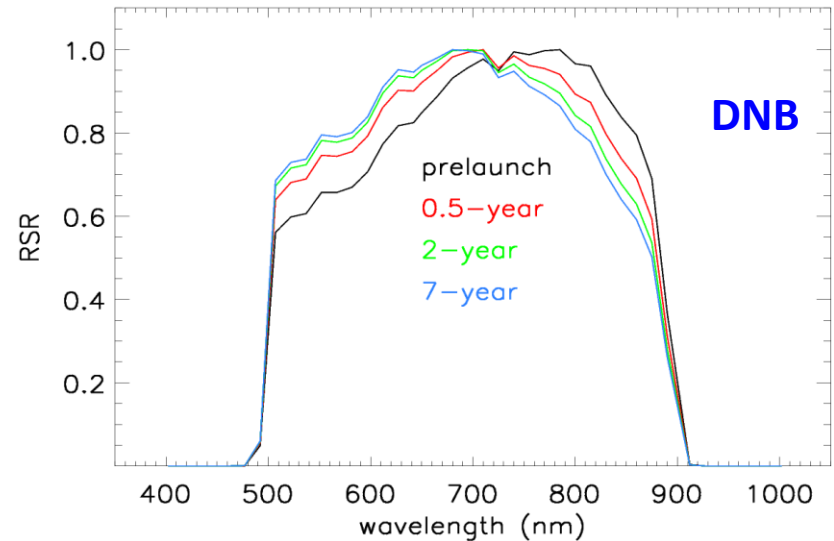
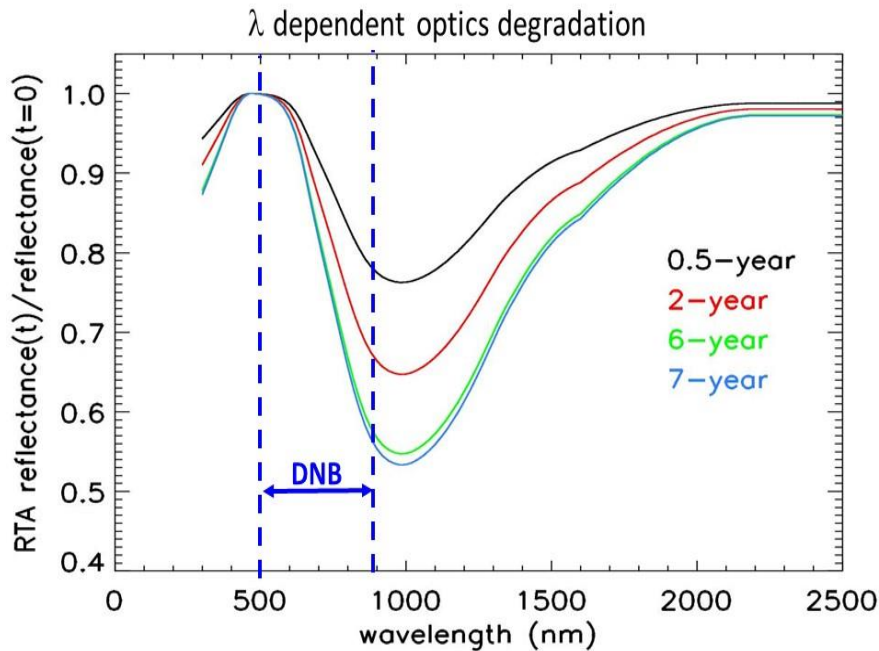


## N-20 VIS, NIR, and SWIR Responses



# On-orbit Modulated RSR for S-NPP VIIRS

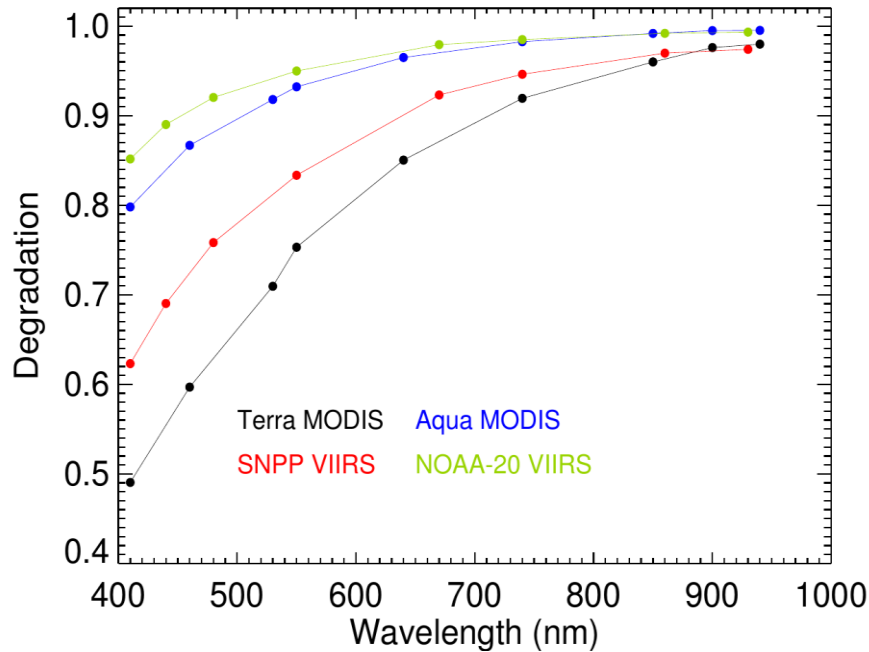
- Large impact for DNB (broad bandwidth)
- Impact for bands with OOB responses



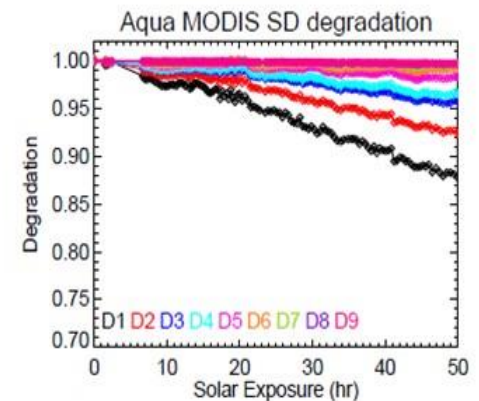
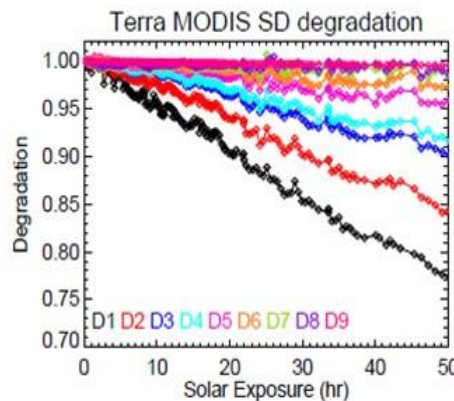
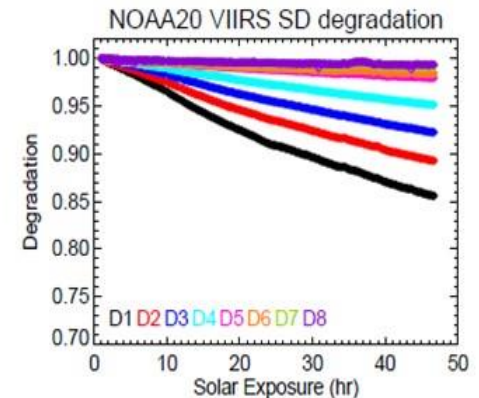
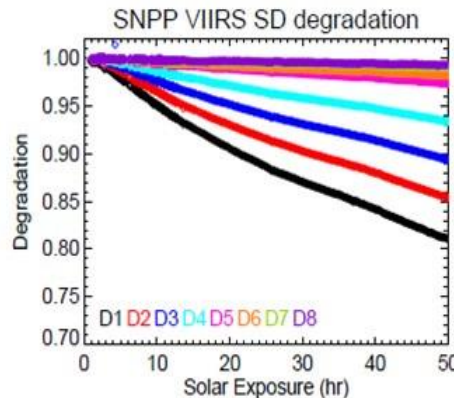
- Modulated RSR has been applied to NASA L1B
- NOAA will also apply this in S-NPP VIIRS SDR reprocessing

# SD On-orbit Degradation

- SD degradation as a function of wavelength: larger at shorter wavelengths
  - VIIRS has no SD door; Terra MODIS SD door fixed at “open” at L+2.5 yr.
- SD degradation as a function of solar exposure time: S-NPP is more closer to T-MODIS and N-20 is more closer to A-MODIS

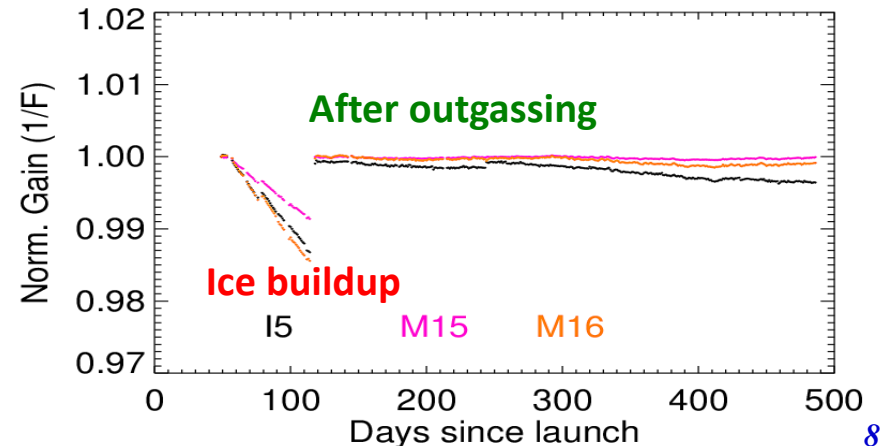
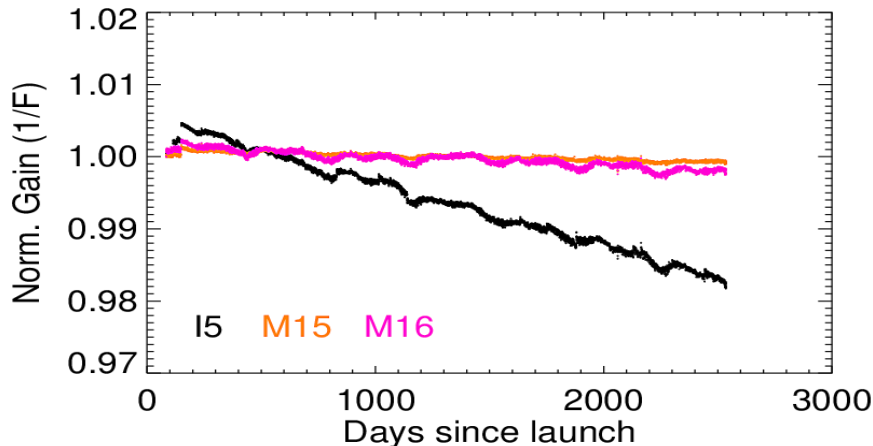
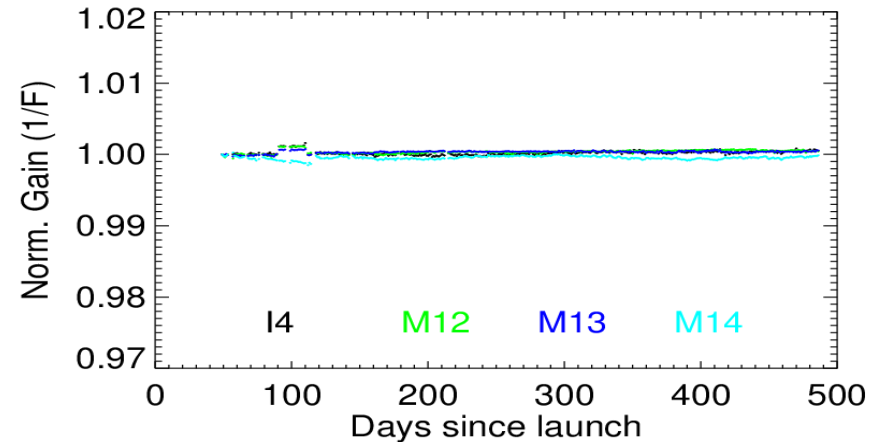
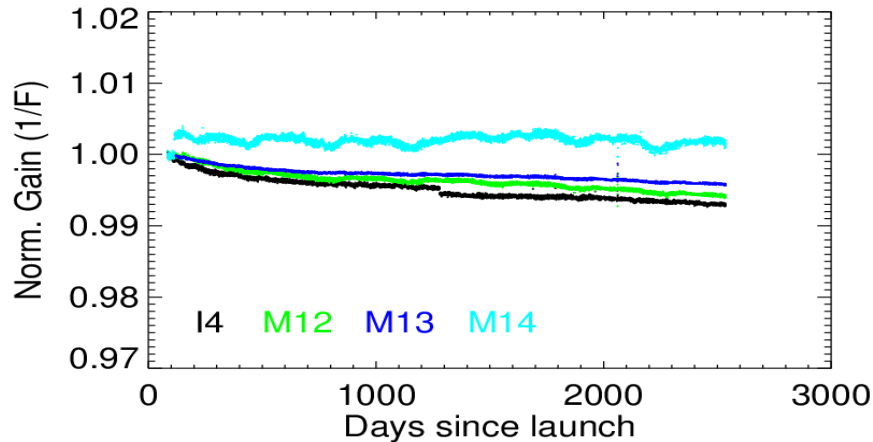


19 years. 17 years, 7 years, 1 year



# Spectral Band Responses: TEB

- Both S-NPP and N-20 TEB responses have been very stable
- **N-20:** initial ice buildup on the LWIR dewar window was removed with a mid-mission outgassing (MMOG) performed on 03/12/19

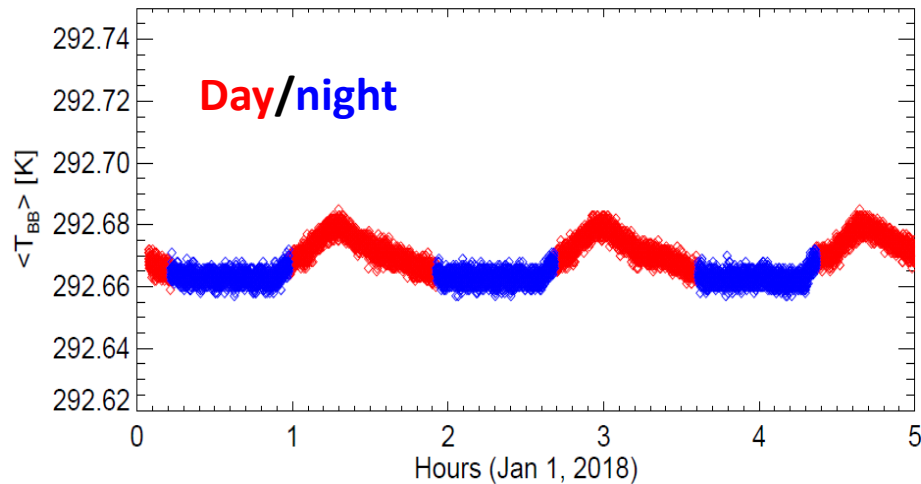




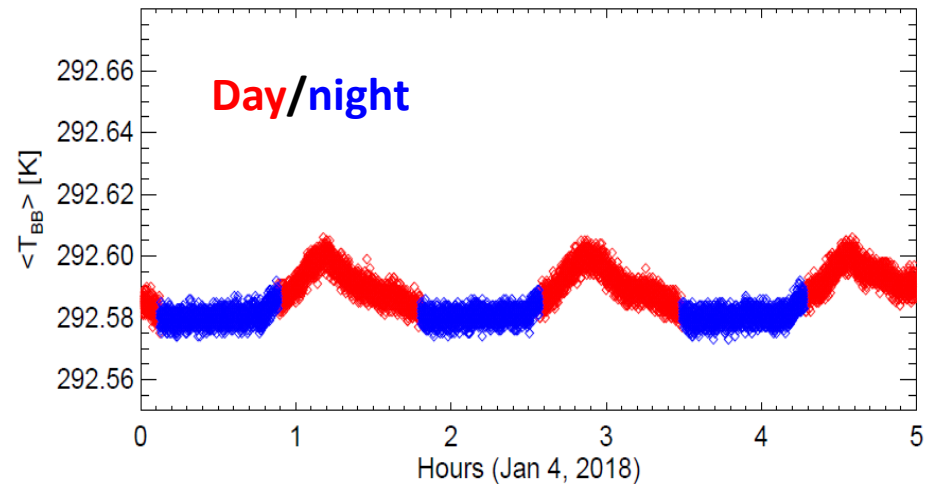
# On-board BB Stability

- On-board BB is nominally controlled at 292.5 K
- T\_BB long-term stability has been maintained to within a few mK
- T\_BB short-term stability and uniformity: 10 - 30 mK (more stable in night orbits)

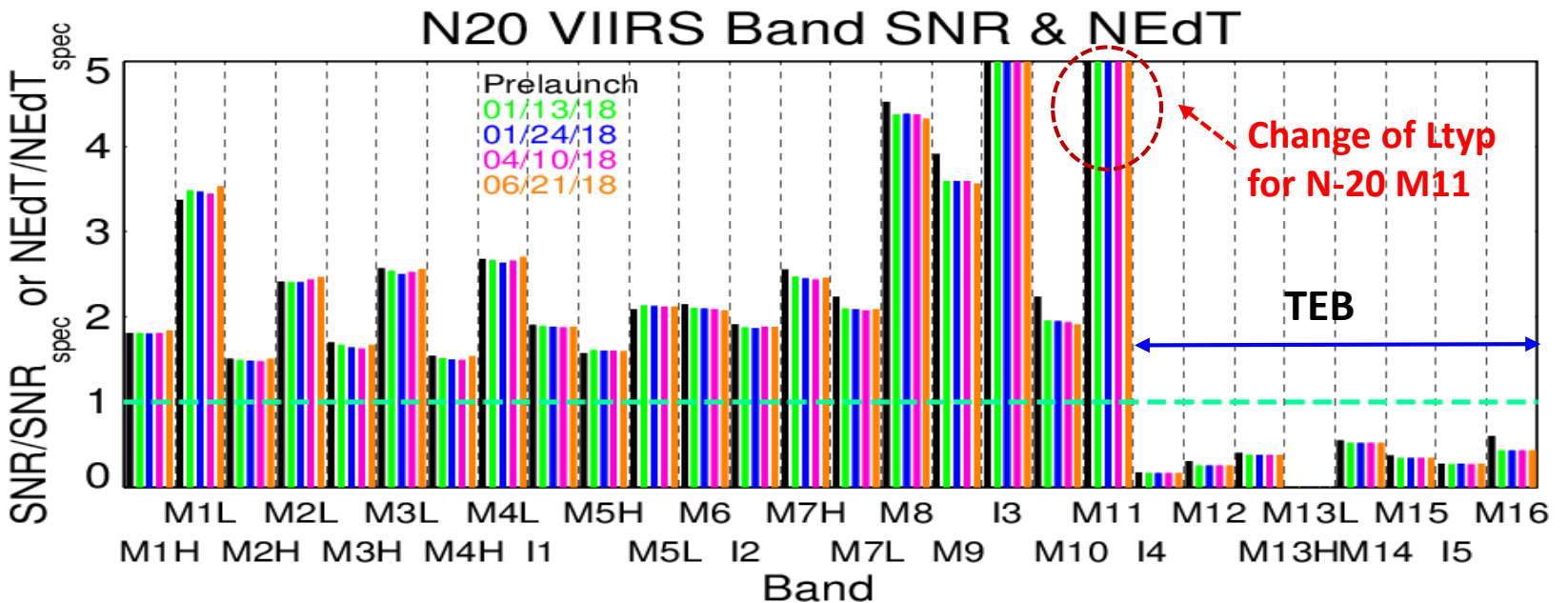
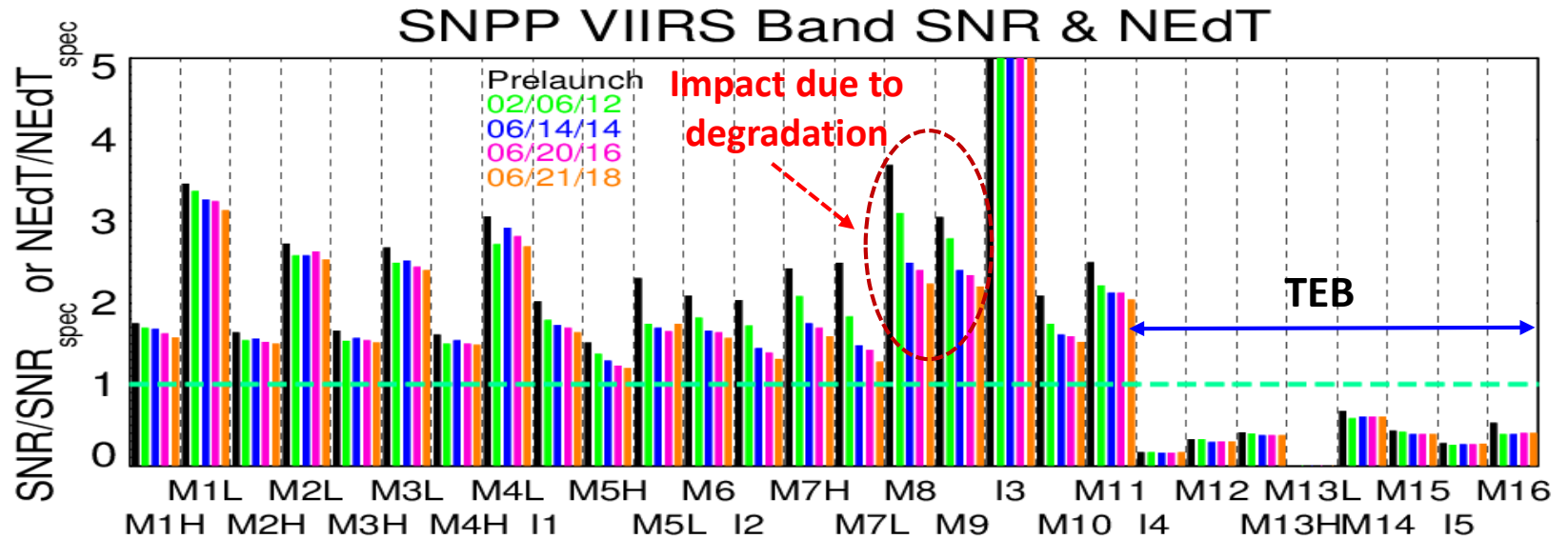
S-NPP T\_BB



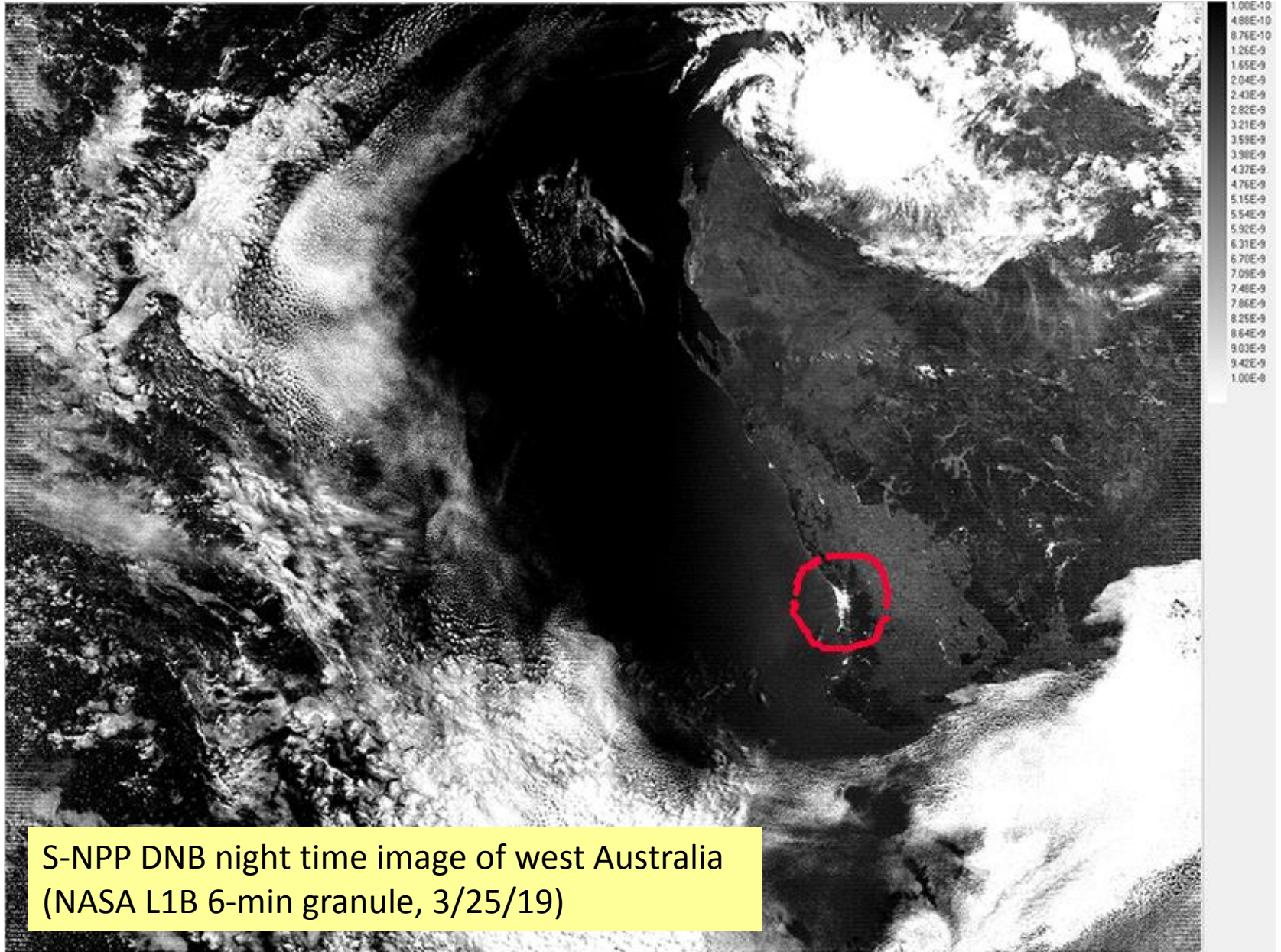
N-20 T\_BB



# Noise Characterization: RSB SNR & TEB NEdT



# VIIRS Day Night Band



# DNB Stray Light – Before Correction

S-NPP: 08:35:00, 07/13/18 (N. America)



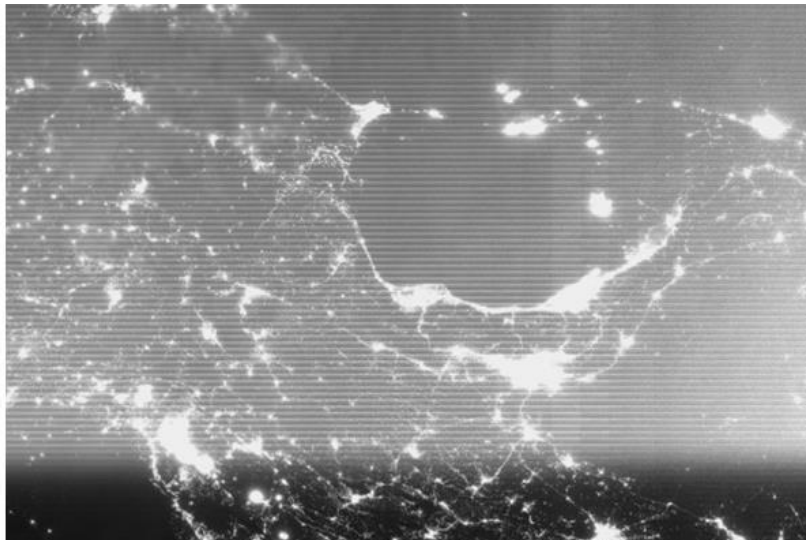
N-20: 07:44:45, 07/13/18 (N. America)



S-NPP: 22:06:59, 07/13/18 (Europe)



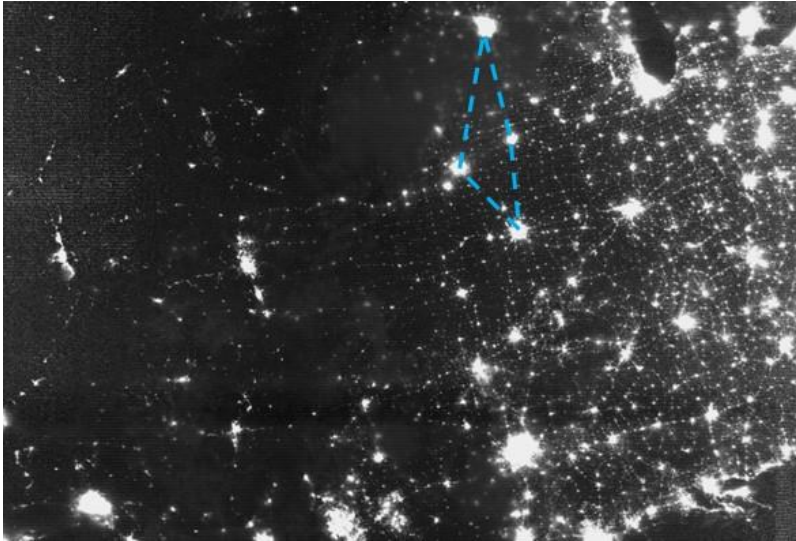
N-20: 22:58:11, 07/13/18 (Europe)



# DNB Stray Light – After Correction

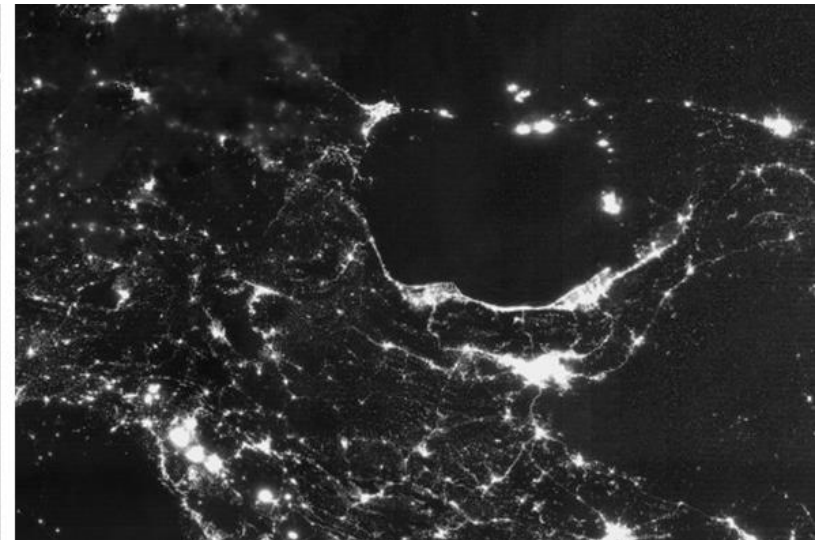
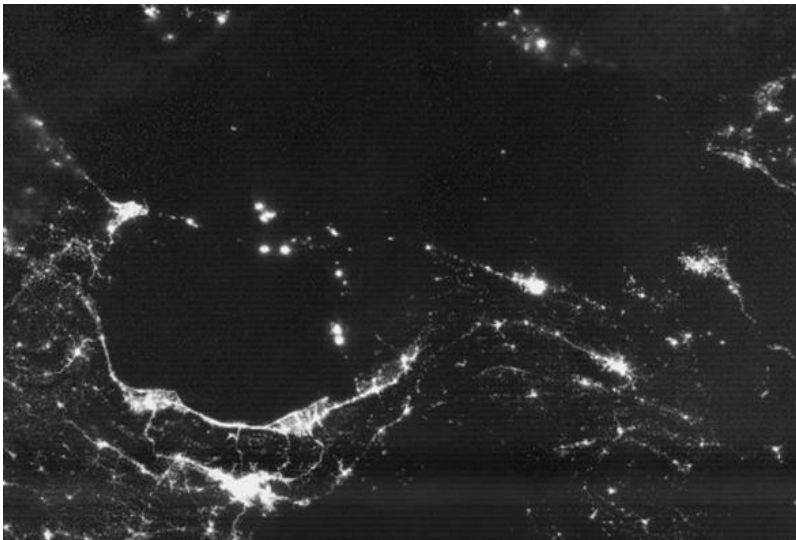
S-NPP: 08:35:00, 07/13/18 (N. America)

N-20: 07:44:45, 07/13/18 (N. America)



S-NPP: 22:06:59, 07/13/18 (Europe)

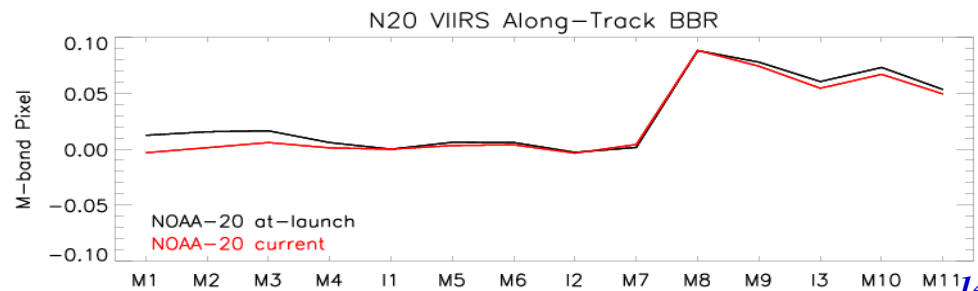
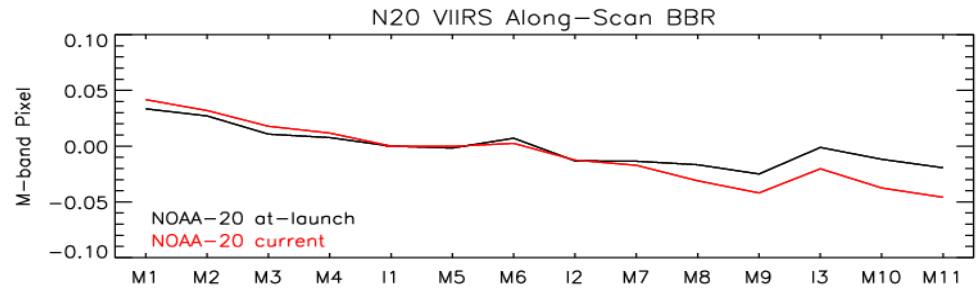
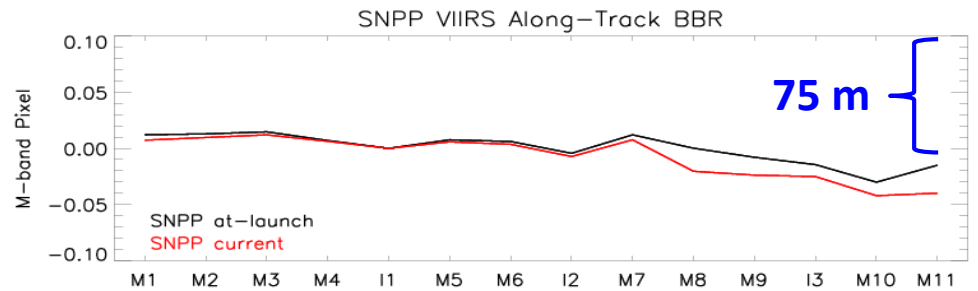
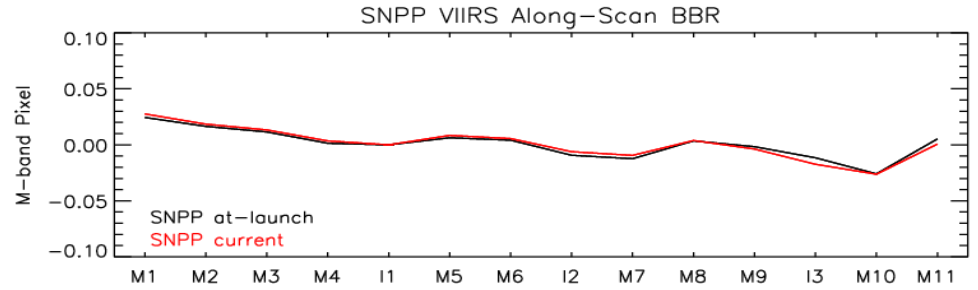
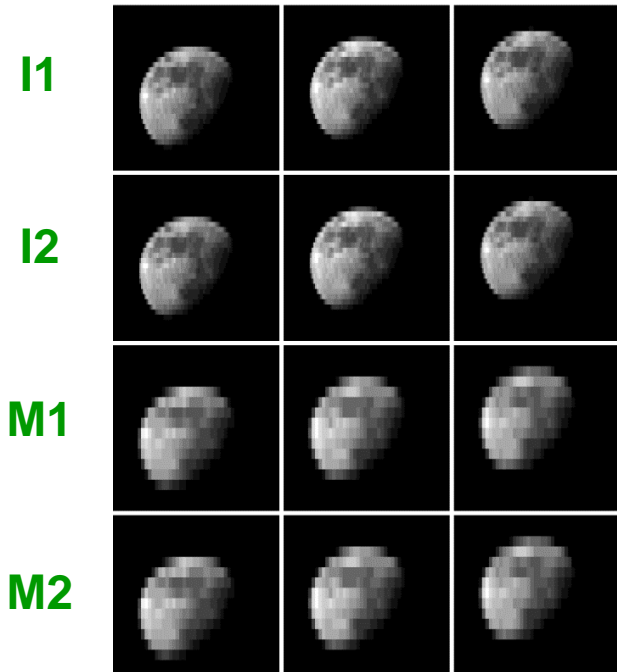
N-20: 22:58:11, 07/13/18 (Europe)



Images processed by H. Chen (VCST)

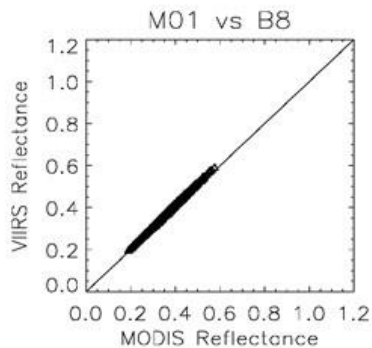
# Band-to-Band Registration (BBR)

- BBR (characterized using lunar observations)
- Stable for both S-NPP and N-20 in along-scan and along-track directions.

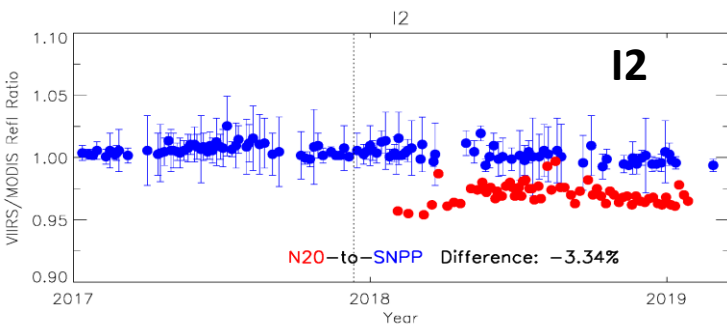
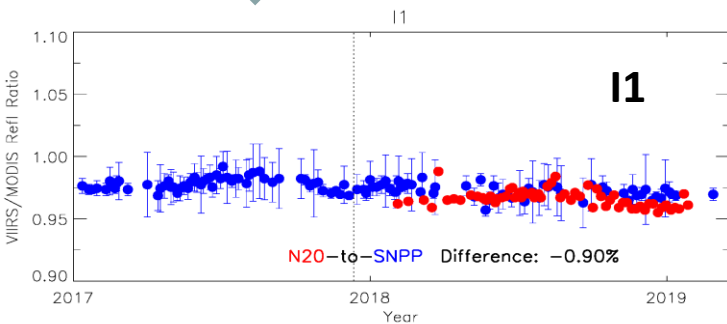


# Challenges and Future Efforts

**SNO**



Pixel-by-pixel match



**Libya 4 Desert**



20 x 20 km

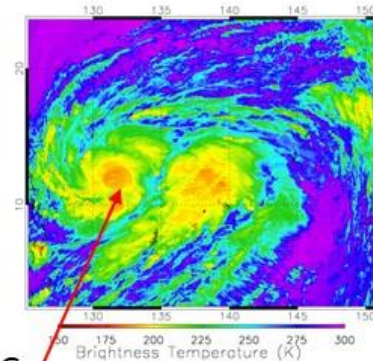
Crossing time (16-D)  
N20/SNPP ~11:30  
A-MODIS: ~11:40

**Dome C**



Image from NOAA/NCDC  
Paleoclimatology  
Program

**DCC**



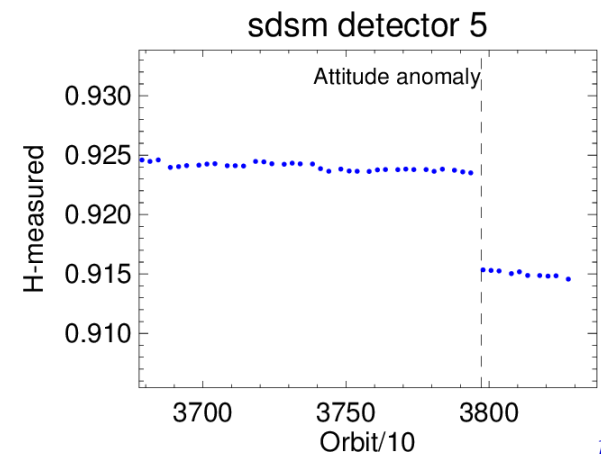
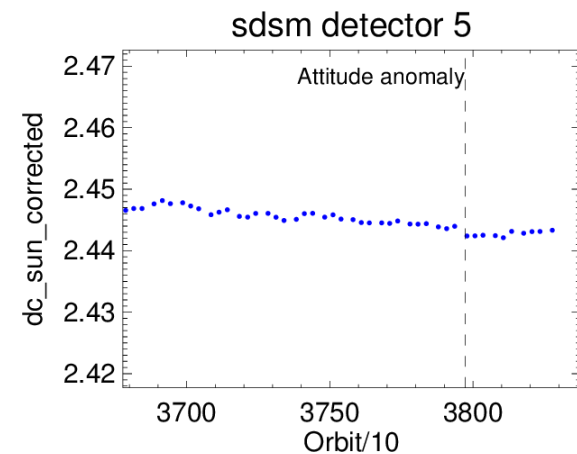
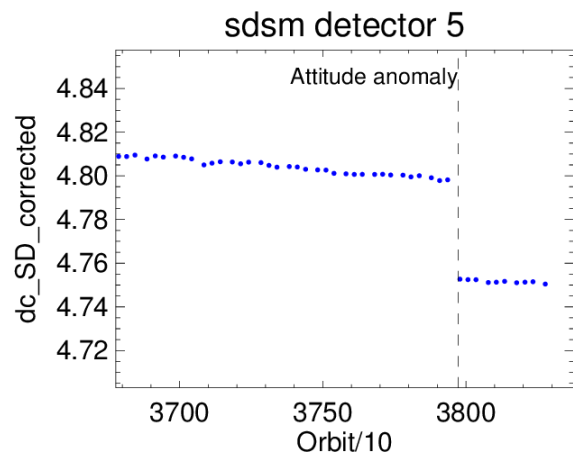
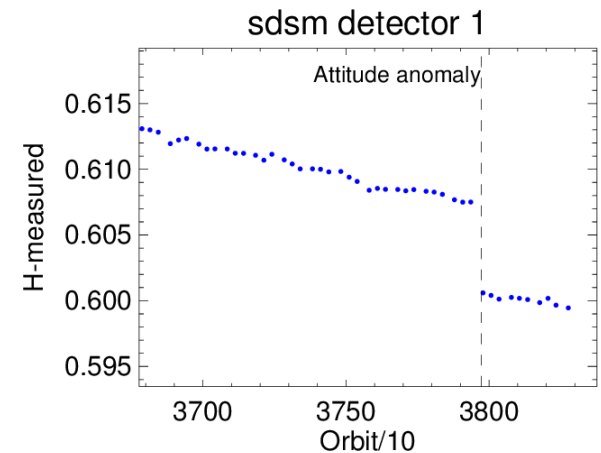
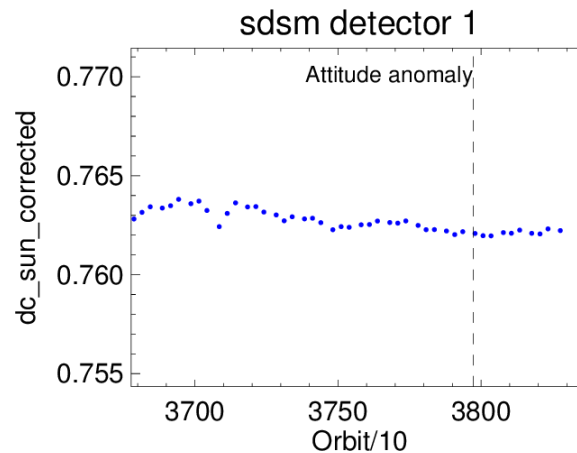
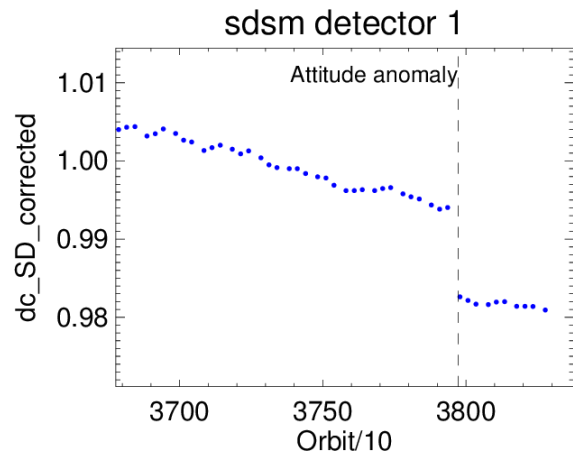
Uniform pixel bins  
with BT(11 $\mu$ ) < 205K

## N-20 and S-NPP Reflectance Difference (IDPS)



# Altitude anomaly (2019-02-24)

- S-NPP VIIRS reported an attitude anomaly on 2019-02-24, 21:16-21:26 UTC
- About a 1% drop in the SD signal during the SDSM calibration after 2019-02-25
- The anomaly affects the SD view signal but not the Sun view signal





# Challenges and Future Efforts

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- **Calibration consistency between S-NPP and N-20 VIIRS**
  - Noticeable calibration differences for the reflective solar bands
  - More efforts for better understanding and development of mitigation strategies (NASA and NOAA)
- **Accuracy of SD degradation over time**
  - Use of lunar time series (for all spectral bands)
- **Potential changes in sensor response versus scan-angle (RVS)**
  - Dedicated long-term effort to monitor EV data at different AOIs
  - Lessons from MODIS RVS characterization
- **Joint effort to support data reprocessing**
  - Calibration improvements
  - Use of consistent calibration LUTs

# VIIRS and MODIS Spectral Bands

16 Moderate (radiometric) bands, 5 Imaging bands, 1 DNB

VIIRS Band	Spectral Range (um)	Nadir HSR (m)	MODIS Band(s)	Range	HSR
DNB	0.500 - 0.900				
M1	0.402 - 0.422	750	8	0.405 - 0.420	1000
M2	0.436 - 0.454	750	9	0.438 - 0.448	1000
M3	0.478 - 0.498	750	3 10	0.459 - 0.479	500
				0.483 - 0.493	1000
M4	0.545 - 0.565	750	4 or 12	0.545 - 0.565	500
				0.546 - 0.556	1000
I1	0.600 - 0.680	375	1	0.620 - 0.670	250
M5	0.662 - 0.682	750	13 or 14	0.662 - 0.672	1000
				0.673 - 0.683	1000
M6	0.739 - 0.754	750	15	0.743 - 0.753	1000
I2	0.846 - 0.885	375	2	0.841 - 0.876	250
M7	0.846 - 0.885	750	16 or 2	0.862 - 0.877	1000
				0.841 - 0.876	250
M8	1.230 - 1.250	750	5	SAME	500
M9	1.371 - 1.386	750	26	1.360 - 1.390	1000
I3	1.580 - 1.640	375	6	1.628 - 1.652	500
M10	1.580 - 1.640	750	6	1.628 - 1.652	500
M11	2.225 - 2.275	750	7	2.105 - 2.155	500
I4	3.550 - 3.930	375	20	3.660 - 3.840	1000
M12	3.660 - 3.840	750	20	SAME	1000
M13	3.973 - 4.128	750	21 or 22	3.929 - 3.989	1000
				3.929 - 3.989	1000
M14	8.400 - 8.700	750	29	SAME	1000
M15	10.263 - 11.263	750	31	10.780 - 11.280	1000
I5	10.500 - 12.400	375	31 or 32	10.780 - 11.280	1000
				11.770 - 12.270	1000
M16	11.538 - 12.488	750	32	11.770 - 12.270	1000



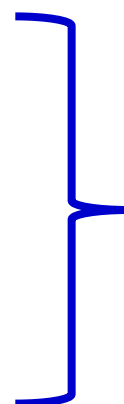
1 DNB  
HG/MG/LG



14 RSB  
(0.4-2.3 μm)



Dual Gain Bands:  
M1-M5, M7, M13



7 TEB