



# From Aqua MODIS to S-NPP VIIRS

## (Reflective Solar Calibration Reference)

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# Outline

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- **Background**
- **Strategies and Approaches**
- **Preliminary Results**
- **Concluding Remarks and Future Work**

# Background

- **Aqua MODIS**

- A key instrument on NASA EOS Aqua spacecraft (other sensors on-board include AIRS, AMSU-A, HSB, AMSR-E, and CERES)
- Launched on May 04, 2002
- Predecessor: Terra MODIS (1999 to present)
- Spectral wavelengths: 0.4-14.5  $\mu\text{m}$  (36 spectral bands); 20 reflective solar bands (RSB) and 16 thermal emissive bands (TEB)
- Spatial resolutions (nadir): 250 m (2 bands), 500 m (5 bands), and 1 km (29 bands)

- **S-NPP VIIRS**

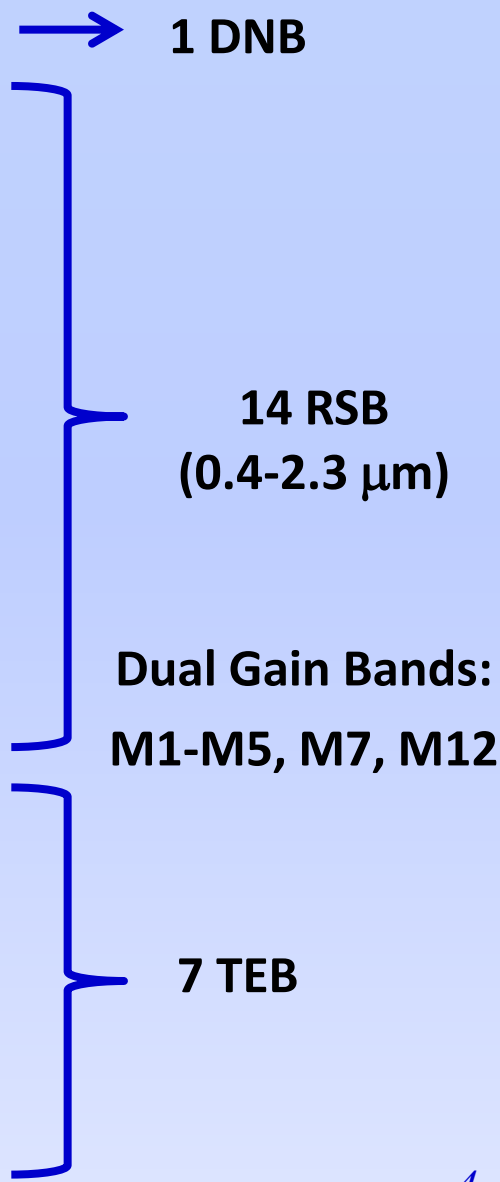
- A key instruments on S-NPP (others onboard are ATMS, CERES, CrIS, and OMPS)
- Launched in October 2011
- Follow-on instrument: JPSS VIIRS (J1 launch in 2017)
- Spectral wavelengths: 0.4-12.4  $\mu\text{m}$  (22 spectral bands); 14 reflective solar bands (RSB), 7 thermal emissive bands (TEB), and 1 day night band (DNB)
- Spatial resolutions: 375 m for I bands (5); 750 m for M bands (16) and DNB

**VIIRS was designed and built with strong MODIS heritage**

# MODIS and VIIRS Spectral Bands

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

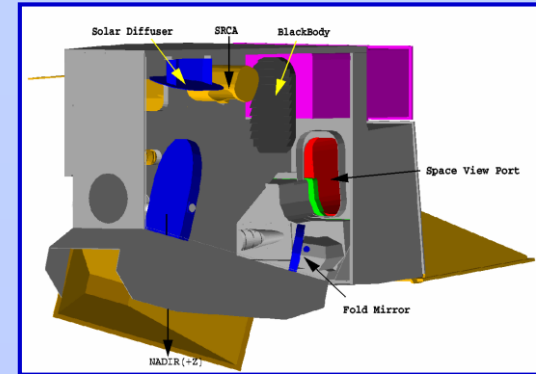
VIIRS Band	Spectral Range (um)	Nadir HSR (m)	MODIS Band(s)	Range	HSR
DNB	0.500 - 0.900				
M1	0.402 - 0.422	750	8	0.405 - 0.420	1000
M2	0.436 - 0.454	750	9	0.438 - 0.448	1000
M3	0.478 - 0.498	750	3 10	0.459 - 0.479 0.483 - 0.493	500 1000
M4	0.545 - 0.565	750	4 or 12	0.545 - 0.565 0.546 - 0.556	500 1000
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 0.673 - 0.683	1000 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 0.841 - 0.876	1000 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 3.929 - 3.989	1000 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 11.770 - 12.270	1000 1000
M16	11.538 - 12.488	750	32	11.770 - 12.270	1000



# On-board Calibrators (OBC)

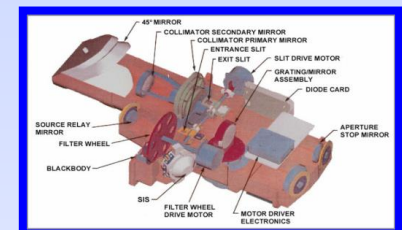
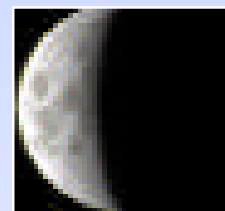
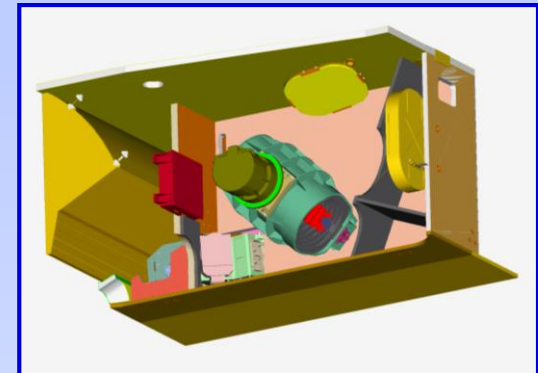
- **MODIS OBC**

- Solar Diffuser (SD)
- SD Stability Monitor (SDSM)
- Blackbody (BB)
- Space View (SV)
- **Spectroradiometric Calibration Assembly (SRCA)**



- **VIIRS OBC (MODIS heritage)**

- Solar Diffuser (SD)
- SD Stability Monitor (SDSM)
- Blackbody (BB)
- Space View (SV)



# MODIS and VIIRS On-board Calibration (RSB)

- **Solar Diffuser Calibration**

- MODIS SD and SDSM calibration regularly scheduled
- VIIRS SD calibration performed every orbit; SDSM daily operated
- Linear calibration algorithm for MODIS RSB
- Quadratic calibration algorithm for VIIRS RSB
- Linear calibration coefficients derived from SD observations
- SD degradation tracked by the on-board SDSM

- **Lunar Calibration**

- Regularly scheduled at the “same” phase angle
- Viewed through Space View (SV)
- Performed via spacecraft roll maneuvers
- Calibration referenced to the ROLO model

# MODIS to VIIRS Calibration Reference Transfer

- **Aqua MODIS (launched in May 2002)**
  - **Current Calibration Reference** (in reflective solar spectral region for GSICS and a number of earth-observing sensors)
- **S-NPP VIIRS (launched in October 2011)**
  - **Future Calibration Reference**
- **From MODIS to VIIRS**
  - VIIRS is a follow-on instrument to MODIS (designed and built by the same vendor)
  - Similar spectral hands
  - Both MODIS and VIIRS use SD and SDSM for VIS and NIR reflective solar on-orbit calibration
  - Both MODIS and VIIRS regularly make lunar observations
  - S-NPP VIIRS provides critical linkage between data records derived from EOS Terra and Aqua MODIS and future JPSS VIIRS sensors

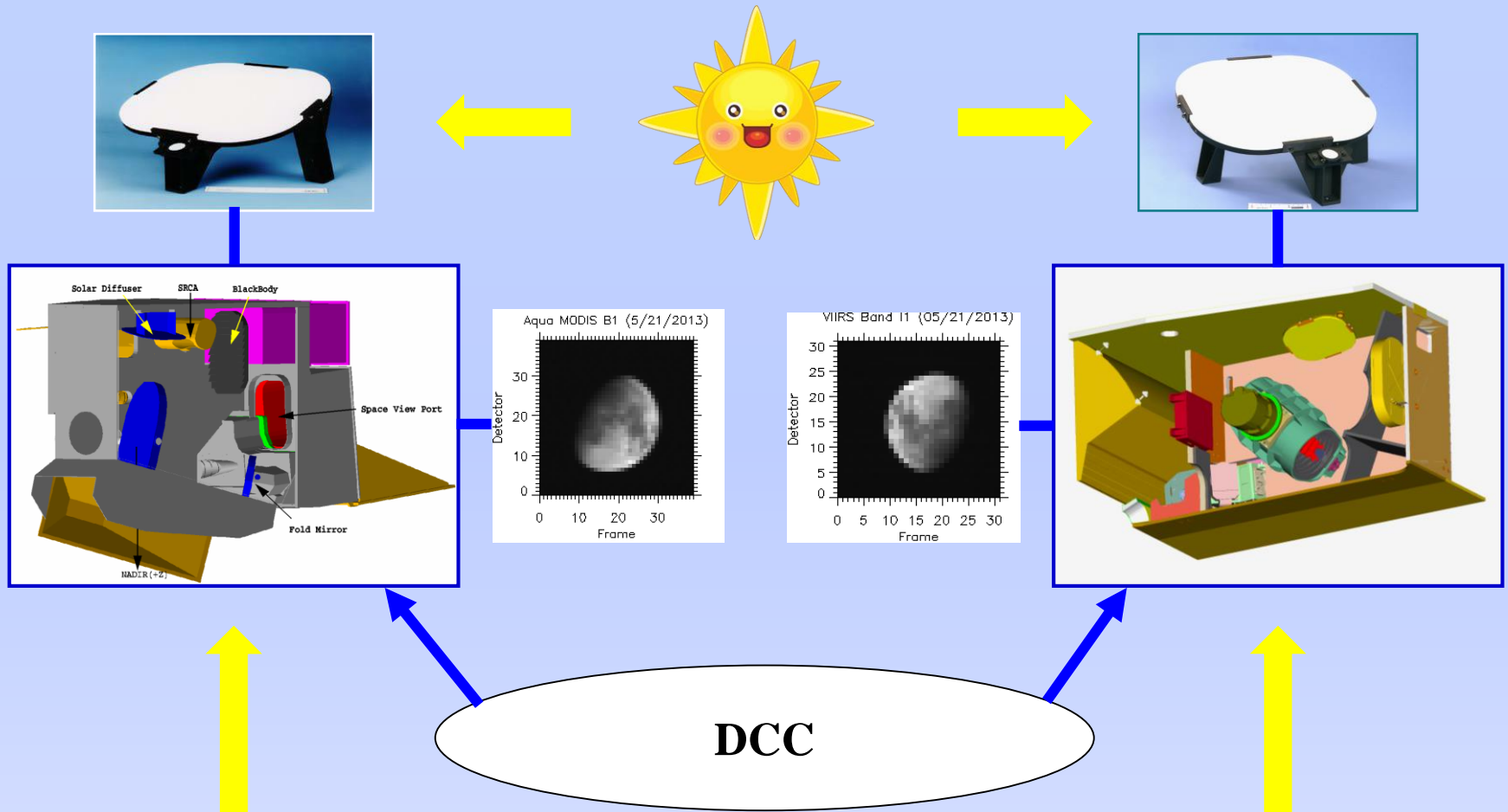
# Strategies and Approaches

- **Ground Reference Targets**
  - Dome C
  - Deserts
- **Deep Convective Cloud (DCC)**
  - Presentations by others
- **Lunar Observations**
  - Integrated lunar irradiance for each spectral band
- **SNO**
  - Including SNOs of MODIS and VIIRS using a third reference sensor (ideally a hyper-spectral radiometer)
- **Other Approaches**

**Different Approaches and Independent Analyses and Assessments**



# Strategies and Approaches



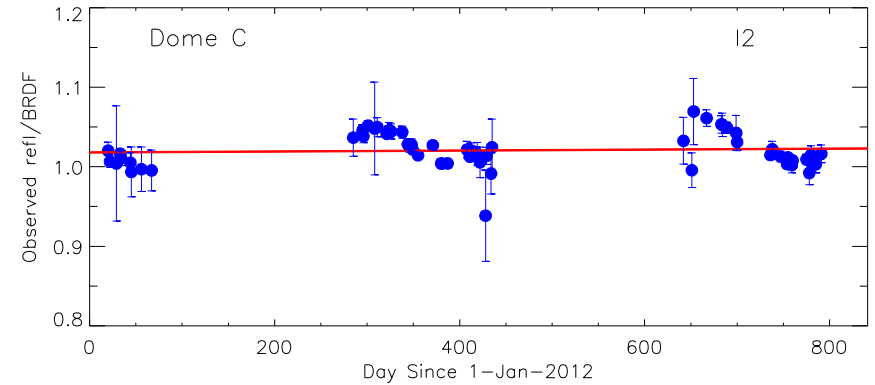
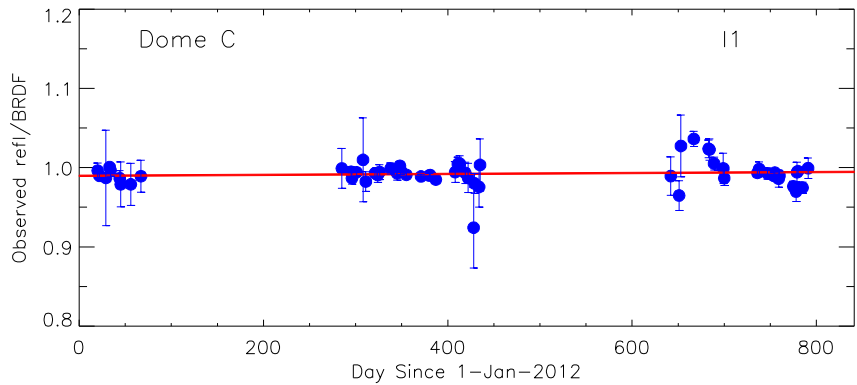
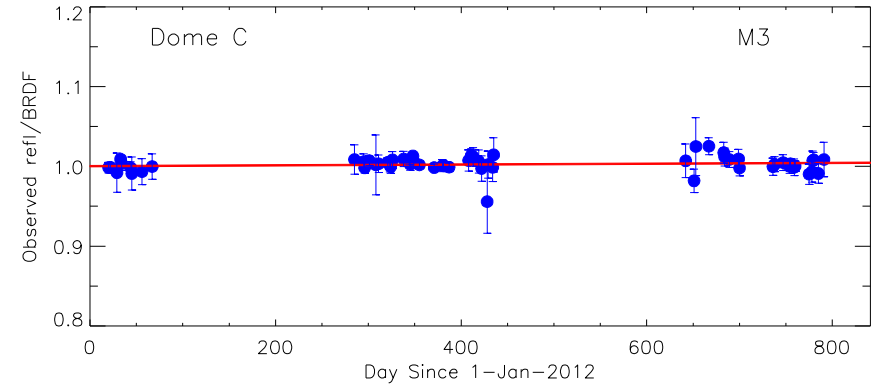
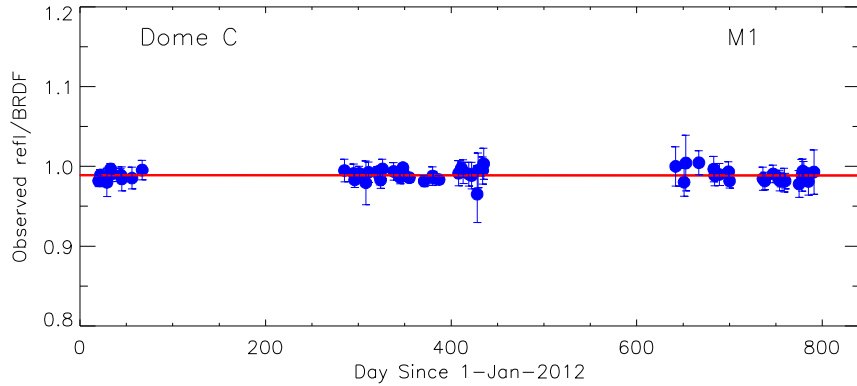
**Ground Targets (including SNO and using a reference sensor)**

# Preliminary Results

- **Ground Reference Targets**
  - Dome C
  - Deserts
- **Deep Convective Cloud (DCC)**
  - LaRC effort
- **Lunar Observations**
  - Integrated lunar irradiance for each spectral band
- **SNO**
  - Including SNOs of MODIS and VIIRS using a third reference sensor (ideally a hyper-spectral radiometer)

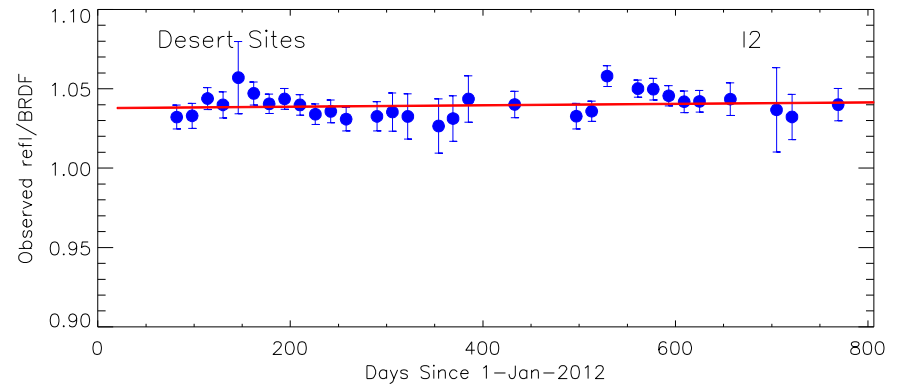
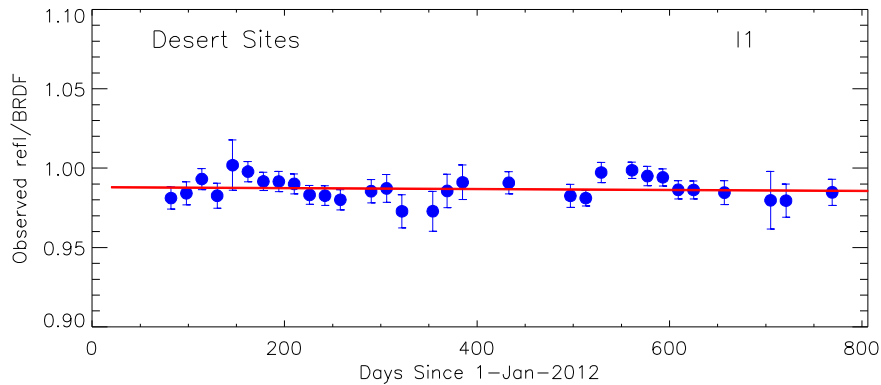
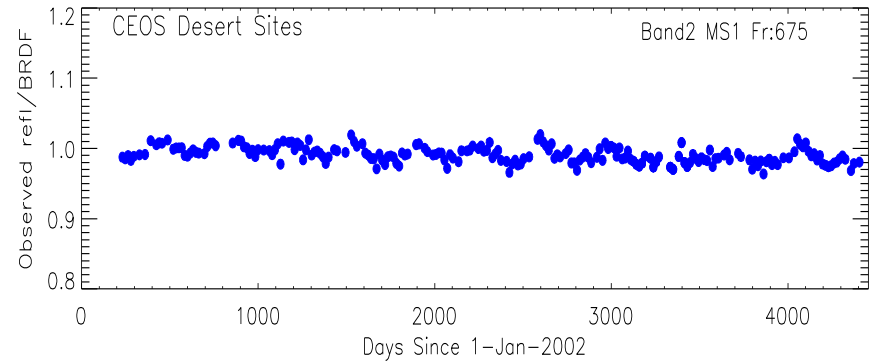
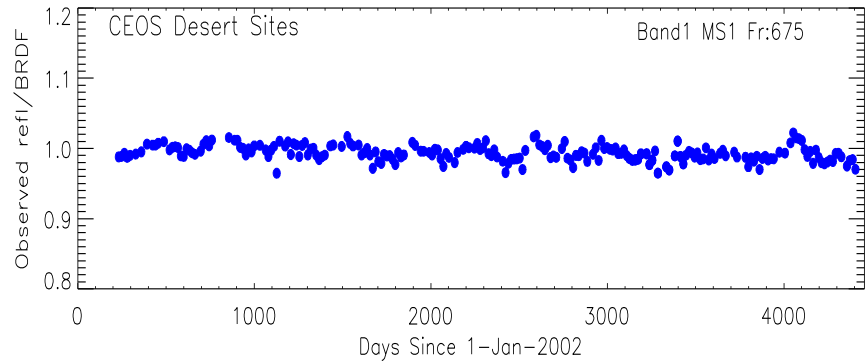
**Consideration: difference in sensors' relative spectral response (RSR)**

# Calibration Inter-comparison (Dome C)



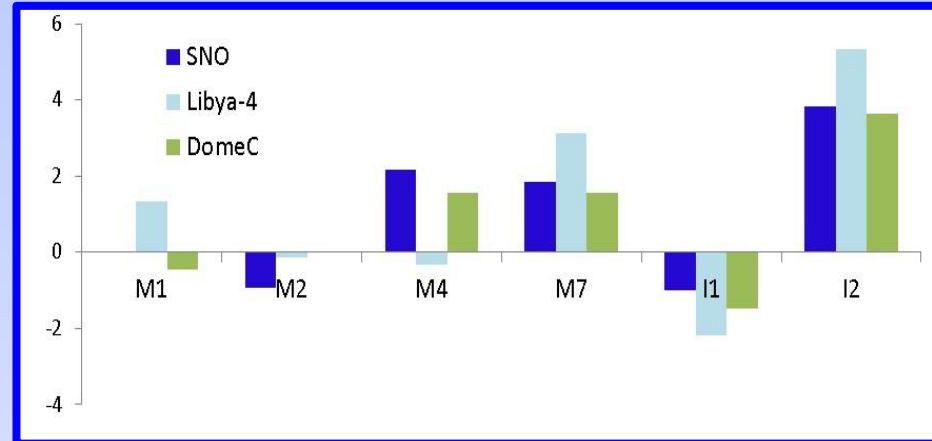
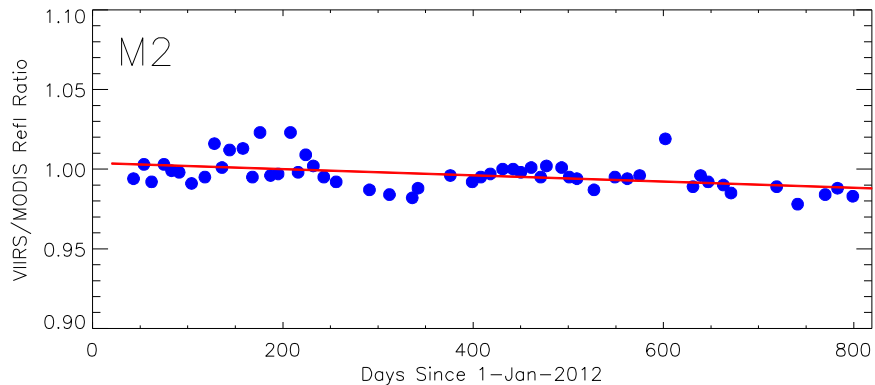
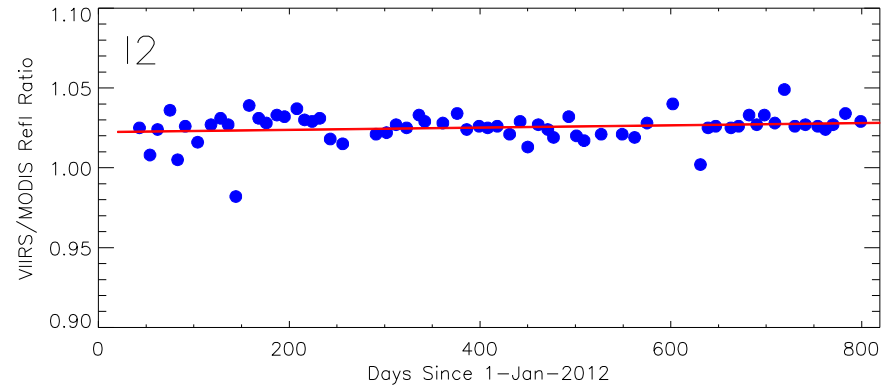
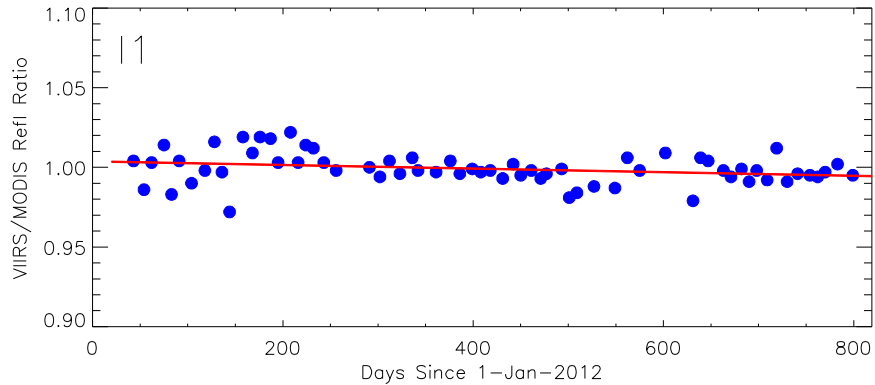
**BRDF based on Aqua MODIS Collection 6 L1B (surface specific)  
VIIRS data from re-processed SDR using VCST LUTs**

# Calibration Inter-comparison (Deserts)



**BRDF based on Aqua MODIS Collection 6 L1B (surface specific)  
VIIRS data from re-processed SDR using VCST LUTs**

# Calibration Inter-comparison (SNO)

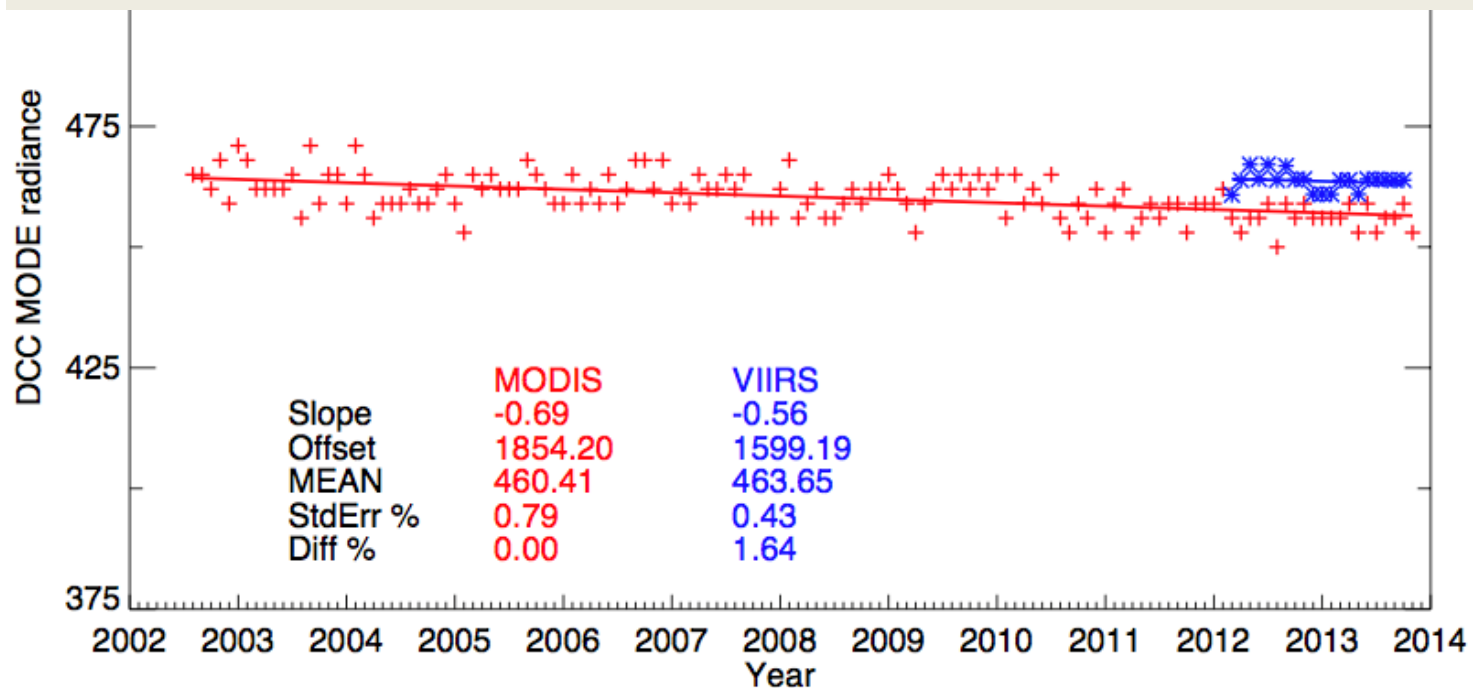


**MODIS data from Collection 6 L1B**  
**VIIRS data from re-processed SDR**

**VIIRS and MODIS reflectance differences (%) with RSR correction**

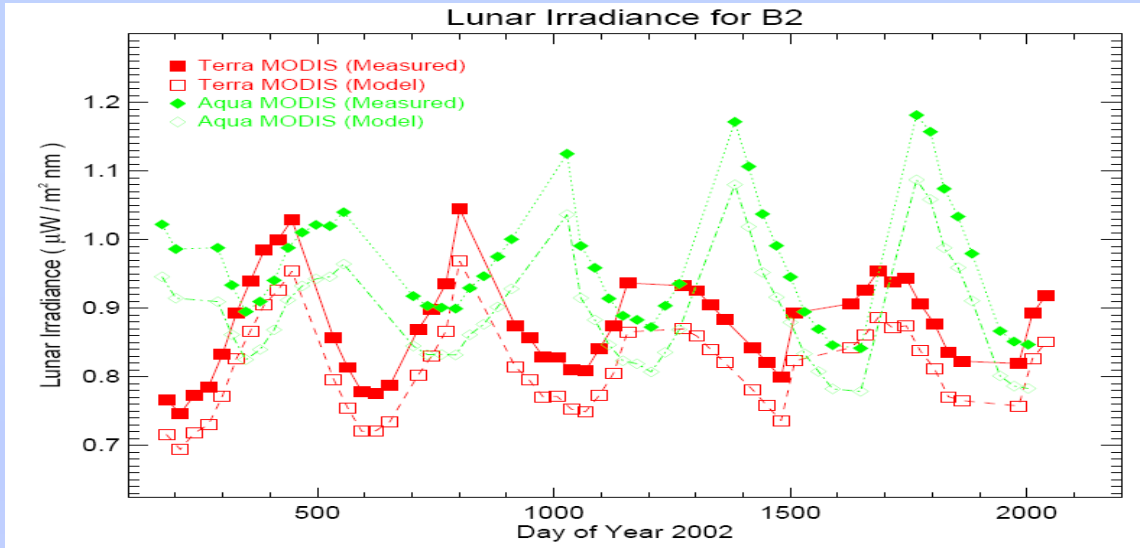
# Calibration Inter-comparison (DCC)

**NPP-VIIRS band M5 (Land PEATE) and Aqua-MODIS Band 1 (Collection 6)  
DCC approach used standard GSICS method over MTSAT GEO domain  
DCC SBAF applied to VIIRS to match MODIS**

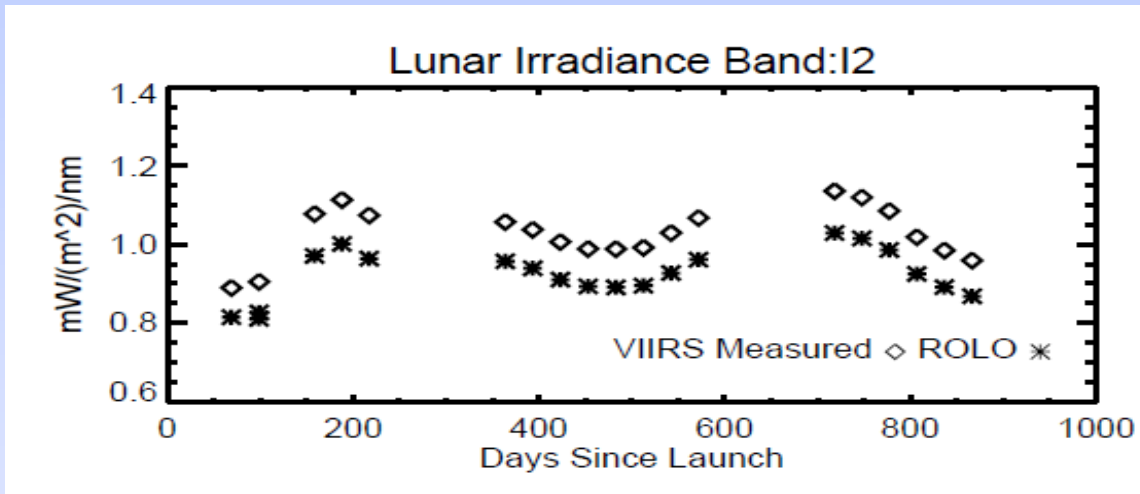


- A 1.64% radiance difference during overlap time period is observed and is within the 2% absolute calibration uncertainty of each instrument
- Note the VIIRS DCC mode radiance temporal variability is half of MODIS
- Differences have not been fully investigated, such as 11 $\mu$ m temperature differences, etc.

# Calibration Inter-comparison (Moon)



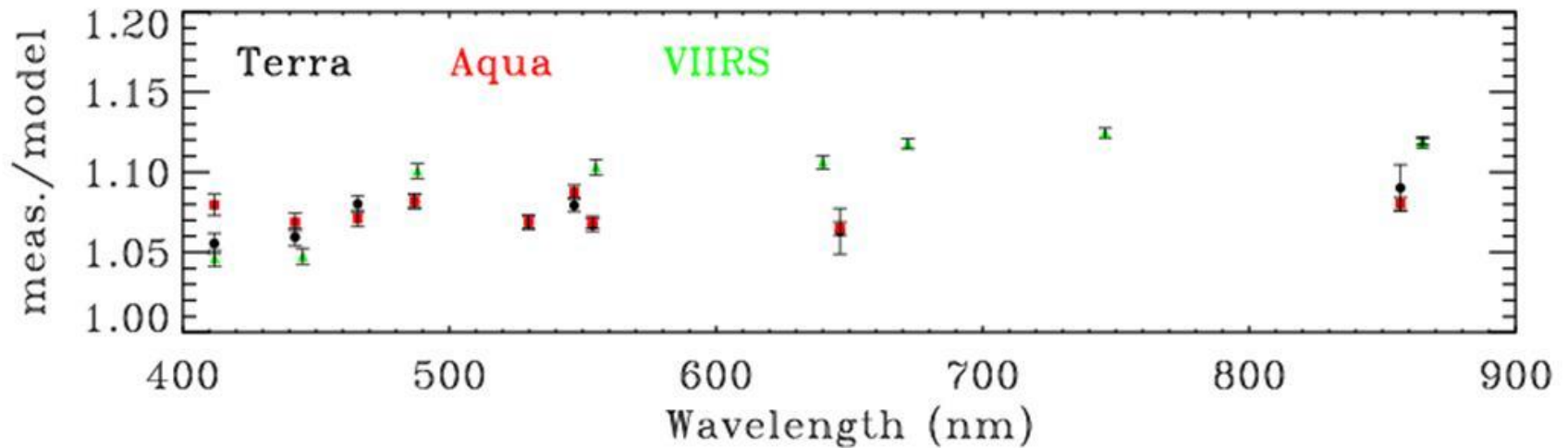
$$I_{\text{Meas\_Sensor-A}} / I_{\text{Model\_Sensor-A}}$$



$$I_{\text{Meas\_Sensor-B}} / I_{\text{Model\_Sensor-B}}$$

# Calibration Inter-comparison (Moon)

Compare sensor's  $I_{\text{Meas}}/I_{\text{model}}$



Issues to be addressed:

RSR different (IB and OBB)

Lunar view geometry different



# Concluding Remarks and Future Work

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- **Importance of calibration reference transfer from Aqua MODIS to S-NPP VIIRS**
- **Different approaches and strategies**
- **Preliminary effort and progress**
- **Future work**
  - Connect dots
  - Establish an unbroken chain of links with small (acceptable) uncertainty
  - Encourage different algorithms and approaches
  - Support independent analysis and peer review process