GSICS Reflective Solar Calibration Reference: from Aqua MODIS to S-NPP VIIRS

X. Xiong[1], A. Angal[1], J. Butler[1], C. Cao[2], D. Doelling[3], A. Wu[1], and X. Wu[2]

(1) NASA/GSFC; (2) NOAA NESDIS; (3) NASA/LaRC

Annual GRWG + GDWG Joint Meeting - Madison, WI, USA (March 20-24, 2017)

Acknowledgements

- GSICS Research Working Group (GRWG)
  - Tim Hewison, Sebastien Wagner, Tom Stone, Bertrand Fougnie, …
- NASA GSFC MODIS and VIIRS Characterization Support Team
  - Zhipeng Wang, Ning Lei, Junqiang Sun, and Jon Fulbright
- NASA LaRC CERES Calibration Team
- NOAA JPSS SDR Team
- NIST (Steve Brown)

Outline

- **Background**
  - What has been done?
- **Calibration Reference: from Aqua MODIS to S-NPP VIIRS**
  - MODIS and VIIRS Calibration Methodologies
  - Calibration Reference Transfer Approaches
  - S-NPP VIIRS: More Suitable as the GSICS Reference Sensor
- **Way Forward**
  - What should be done?

Background (1/3)

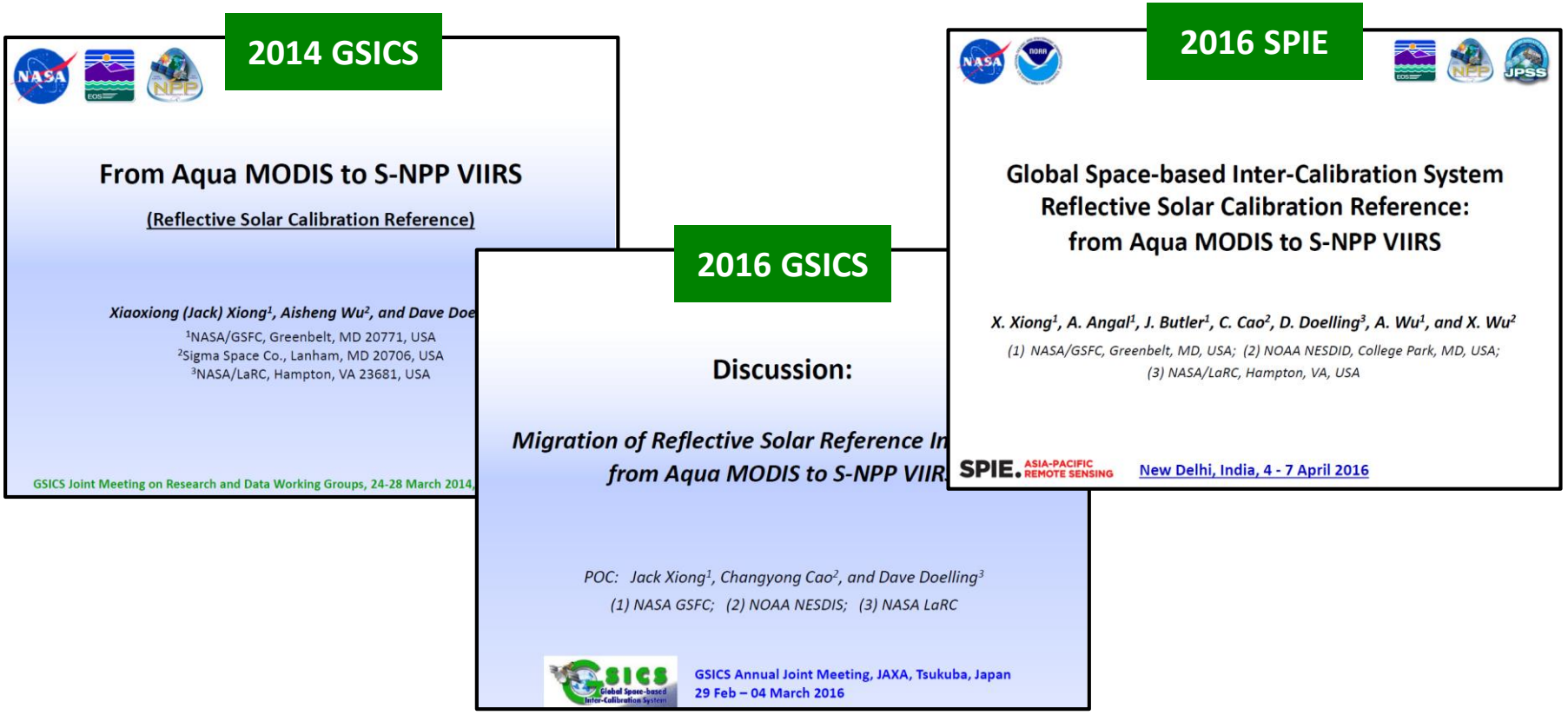
- **Aqua MODIS has been used as the reflective solar (RS) calibration reference by the GSICS community for a number of years**
  - Discussed in several GSICS meetings/workshops; documented in a number of GSICS related presentations/publications
  - "Best" characterized and validated earth-observing sensor at the time in terms of its calibration traceability and accuracy (±2% in reflectance)
    - ✓ On-board calibrators, including SD and SDSM
    - ✓ Monthly lunar observations through the entire mission
    - ✓ Better performance than Terra MODIS in the RS spectral region
  - Successfully operated since 2002 with mission extension likely beyond 2020 (through NASA HQ Senior Review – a peer review process); consistent and long-term data records with many applications
  - Dedicated efforts for instrument operation and calibration (MCST)
  - Nevertheless, …

Background (2/3)

- **S-NPP VIIRS should be used as the future RS calibration reference**
  - VIIRS was designed and built with strong MODIS heritage and lessons learned from MODIS operation and calibration
  - Same solar and lunar calibration approaches and methodologies as MODIS
  - Successfully operated since October 2011 with performance demonstrated as good as Aqua MODIS
  - S-NPP VIIRS provides critical linkage between data records derived from EOS Terra and Aqua MODIS and future JPSS VIIRS sensors
  - Dedicated calibration effort by NOAA and NASA, including data reprocessing
    - NASA VIIRS SDR and L1B Reprocessing – implemented and continuously improved (latest V2.0.0)
    - NOAA VIIRS SDR Reprocessing – planning/testing phase

Background (3/3)

- **<u>Previous effort</u> on moving from Aqua MODIS to S-NPP VIIRS as the new RS calibration reference**
  - Activities of both NASA (incl. its science community) and GSICS interests
  - Joint efforts from MODIS and VIIRS calibration teams and GRWG



Calibration Reference: Aqua MODIS to S-NPP VIIRS (1/3)

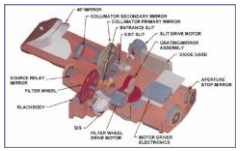
Calibration Methodologies

MODIS

VIIRS

Solar diffuser (SD) and solar diffuser stability monitor (SDSM) for RSB calibration

Spectroradiometric Calibration Assembly (SRCA) for sensor spectral and spatial characterization

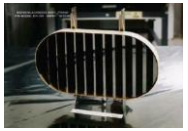


Solar Diffuser

SDSM

SRCA

Blackbody

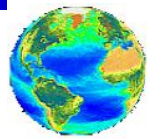


Scan Mirror

Space View

Reflectance-based Calibration (reference to SD BRDF)

Blackbody (BB) for TEB calibration



Lunar Calibration

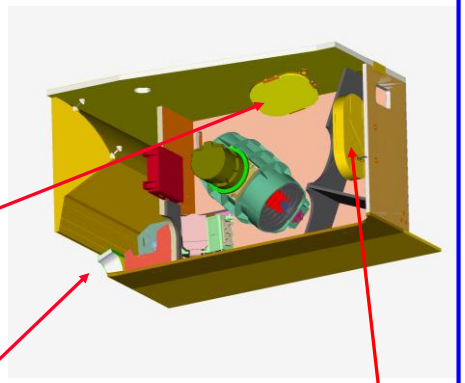
VIIRS: strong MODIS heritage

- Instrument Design (OBC)
- Operation
- Calibration

Solar Diffuser Stability Monitor

Solar Diffuser

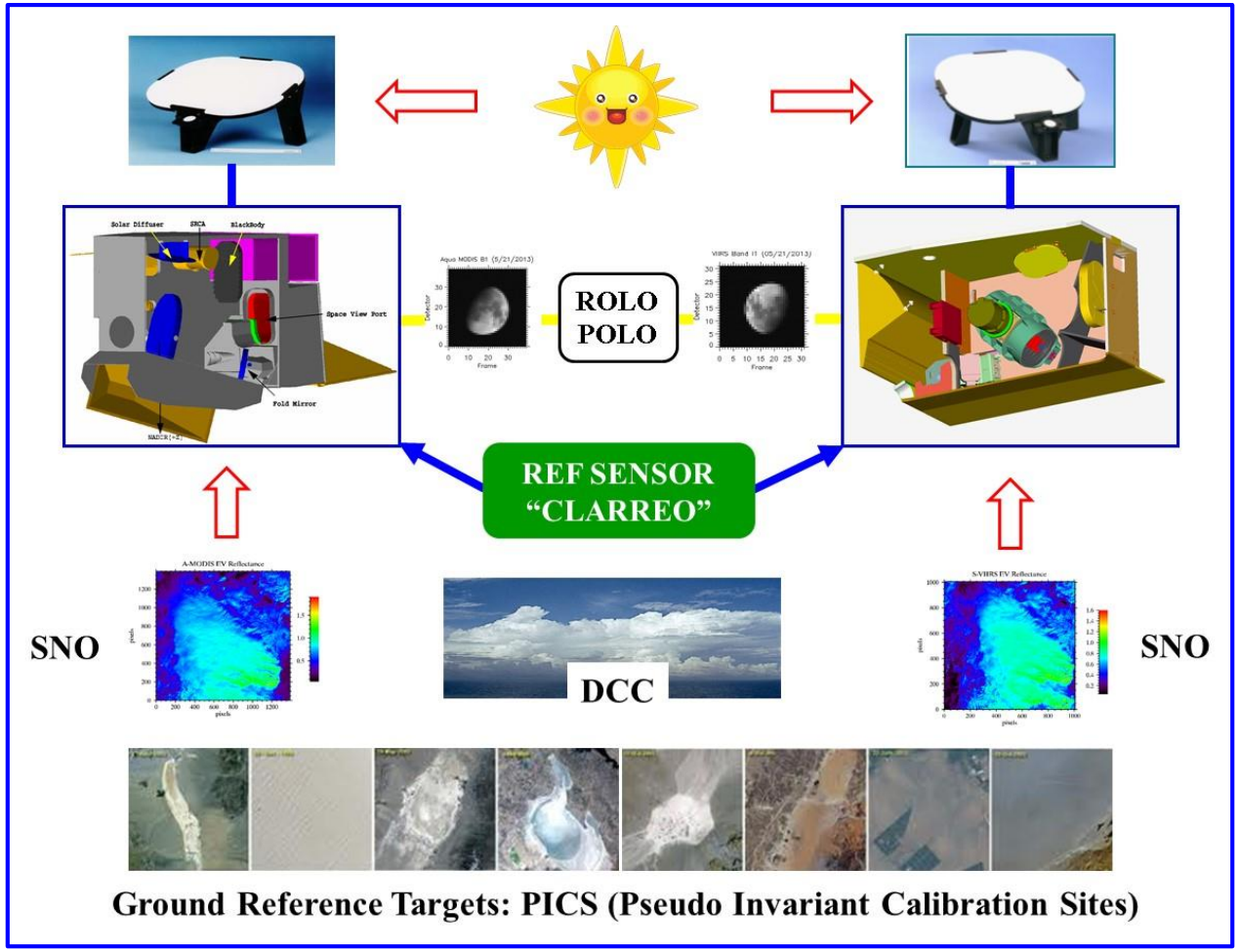
Extended SV Port



Blackbody

Calibration Reference: Aqua MODIS to S-NPP VIIRS (2/3)

Calibration Reference Transfer Approaches



Solar Calibration (Traceability)

Lunar Observations

Reference Sensor

SNO, DCC

Ground Targets

Calibration Reference: Aqua MODIS to S-NPP VIIRS (3/3)

Two most popular (if not the best) approaches to transfer calibration reference:

- DCC Method
  - MODIS: works for B1, B3-7, B18, and B26 (not for B2, B8-16, B17, and B19 due to saturation)
  - VIIRS: works for all bands except for M6 (roll over saturation)
  - Note: VIIRS uses dual gain bands; MODIS uses different bands for high and low gain measurements
- Lunar Calibration
  - MODIS: works for B1-B4, B8-B12, and B17-19 (not for SWIR bands due to crosstalk and a few other bands due to saturation)
  - VIIRS: works for bands
  - Note: relative approach has been developed and applied for MODIS bands with saturated lunar pixels

S-NPP VIIRS: More Suitable As the GSICS Reference Sensor

Way Forward (1/2)

What should be done?

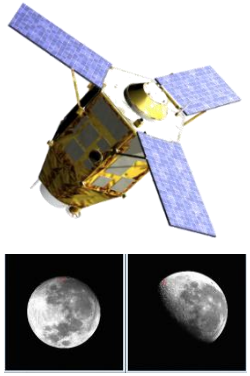
- Directly use S-NPP VIIRS as the calibration reference (suitable for relative new and future sensors)
- Derive inter-calibration coefficients from Aqua MODIS to S-NPP VIIRS (helpful for sensors already using Aqua MODIS as their calibration reference)
- Transfer reference sensor calibration to DCC and Moon via ROLO (good for all sensors)
- Establish calibration traceability and calibration transfer uncertainty

How to accomplish these tasks?

- Sensor by sensor
- Dedicated and coordinated efforts (resources)

Way Forward (2/2)

- **Implementation Considerations**
  - Solar spectral irradiance used by individual sensors
  - Sensor RSR, target BRDF, and atmospheric effect
  - Calibration stability of reference sensors
  - IR calibration accuracy impact for DCC
  - Use of lunar models (ROLO, POLO, GIRO)
    - ROLO: Robotic Lunar Observatory (from USGS)
    - POLO: Pleiades Orbital Lunar Observations (from CNES)
    - GIRO: GSICS Implementation of the ROLO (from GSICS)



- **Future improvements**
  - CLARREO Pathfinder
  - Improved lunar model (USGS and NIST effort)