A New Reference Instrument for Reflective Solar Inter-Calibration: from MODIS to VIIRS

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Motivations (**why?**)
- From MODIS to VIIRS

Calibration Approaches for MODIS and VIIRS (**make sense?**)

Inter-Calibration and Reference Transfer Approaches (**how?**)
- For most spectral bands, VIIRS is more suitable as a reference sensor for inter-calibration

Future Considerations (**what else?**)
Motivations

• **Aqua MODIS** has been (was) used as the reflective solar (RS) calibration reference for many years by many users, including GSICS community
  – “Best” characterized and validated earth-observing sensor at the time
    ✅ Extensive pre-launch calibration/characterization with lessons from Terra MODIS
    ✅ Traceable to NIST reflectance standard
    ✅ Stringent calibration requirements (±2% in reflectance)
    ✅ A set of on-board calibrators, including SD, SDSM, and SRCA
    ✅ Scheduled lunar observations through the entire mission
    ✅ Better performance than Terra MODIS in the RS spectral region
  – Successfully operated since 2002 with mission likely to be extended beyond 2023 (NASA HQ Senior Review, 2017)
  – Dedicated efforts for instrument operation and calibration (MCST)
  – Consistently produced long-term data records enabling a broad range of applications

• Many new missions/sensors have been launched and operated by different countries/agencies in recently years, including VIIRS, OLI, AHI, ABI, and sensors on Sentinels => need for a new reference instrument
Motivations

- **VIIRS** can and should be used as a new RS calibration reference
  - Designed with strong MODIS heritage by the same instrument vendor
  - Operated and calibrated based on lessons and strategies from MODIS
  - Applied similar solar and lunar calibration approaches and methodologies
  - S-NPP VIIRS, launched in 2011, provides critical linkage between data records derived from EOS Terra/Aqua MODIS and future JPSS VIIRS sensors
    - JPSS-1 launch: Nov 15, 2017
  - Dedicated calibration effort by NOAA and NASA, including data reprocessing
    - NASA VIIRS SDR and L1B reprocessing; NOAA VIIRS SDR reprocessing

- **Issues to be addressed**
  - For previous sensors already used Aqua MODIS as inter-calibration reference
  - For future sensors likely to use J1 or even J2/J3/J4 VIIRS for inter-calibration
    - Which VIIRS and what VIIRS data (from NOAA IDPS, NASA SIPS, ...)?
    - What about the Moon?
Solar diffuser (SD) and solar diffuser stability monitor (SDSM) for RSB calibration

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

Blackbody (BB) for TEB calibration

Reflectance-based Calibration (reference to SD BRDF)

Lunar Calibration

VIIRS: strong MODIS heritage
- Instrument Design (OBC)
- Operation
- Calibration

Similar Calibration Methodologies

MODIS

VIIRS
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)

- Lunar Calibration
  - MODIS: works for B1-B4, B8-B12, and B17-19* (*no matching VIIRS bands); relative approach for B13-16 due to saturation; xtalk correction needed for SWIR bands
  - VIIRS: works for all bands

**VIIRS is more suitable as the new GSICS reference sensor**
Future Considerations

What should be done?

- For previous sensors already used Aqua MODIS as reference: calibration consistency between Aqua MODIS and S-NPP VIIRS
- For future sensors likely to use J1 or J2/J3/J4 VIIRS as reference: calibration consistency between S-NPP and future JPSS VIIRS
- For current sensors: directly use S-NPP VIIRS
- Ideally, a set of inter-calibration coefficients from Aqua MODIS to S-NPP VIIRS and from S-NPP VIIRS to future JPSS VIIRS can be made available to all users (independently validated and reviewed)

Alternative approaches

- Transfer reference sensor (either MODIS or VIIRS) calibration to DCC and Moon (pros and cons)
- Future CLARREO or TRUTH type of instruments with significantly improved calibration traceability and accuracy, thus much reduced inter-calibration uncertainty

Coordinated efforts
What About the Moon?

• **Presentations in this workshop**
  - Lunar observations made and used by more and more sensors
  - Easy access to the lunar models
    - ROLO
    - GIRO
    - SELENE/SP
    - POLO: Pleiades Orbital Lunar Observations (CNES)

• **Potential improvements of lunar model (irradiance) absolute accuracy**
  - NASA effort (e.g. CLARREO)
  - NIST effort
  - USGS effort
  - Other efforts
Questions?