GEO imager inter-calibration needs and priorities

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CLARREO Pathfinder (CPF) Inter-Calibration Workshop
September 28, 2016
GSICS recommended incoming solar spectra web meetings

• Currently satellite based L1B radiance data products are based on various solar spectra.
  • The spectra used for these products are not easily found or documented
  • Product radiance differences will be a function of solar spectra

• The GSICS and CEOS communities would like to recommend a solar spectra for
  • A standard solar spectra for satellite product radiances
  • The same spectra for use in characterizing Moon and Earth targets
  • The spectra need not be perfect, but to start the effort of using the recommended spectra for harmonization among satellite products
GSICS/CEOS to have web meetings to consensus among the solar community

• First web meeting

GSICS/CEOS web meeting on Reference Solar Spectrum
Thursday, 1. December 2016
12:30 | Europe Time (Berlin, GMT+01:00) | 2 hrs 30 mins

Meeting number
(access code):
956
448
238

Join by phone
Global call-in numbers: https://eumetsat.webex.com/eumetsat/globalcallin.php
0800-051-3810 Call-in toll-free number (UK)
+44-203-478-5289 Call-in toll number (UK)
Toll-free calling restrictions
• GOES-R has launched Nov 19, 2016, GOES-S launch in 2018
• Met-11 (0E) to replace Met-10 in March 2018
• Himawari-9 (140E) launched Nov 1, 2016
• MTSAT-2 (145E) decommissioned in Dec 4, 2015
• GERB on Meteosat 8-11
• FY-4A, to launch in Dec. 2016, 3 axis stabilized, AGRI imager has 14 channels, 0.5km to 4km resolution, FD every 15 minutes, GIIRS imager, IR hyperspectral sounder (15km) over China
• KOMPSAT-2A to launch in 2018, imager similar to GOES-R
• Met-8 (41.5E) beginning Sept 21, 2016,
• Met-7 (57E) decommissioned end of 2016
• INSAT-3DR (74E) launched on Sept 8, 2016
• FY-4A to launch in early 2017
Preferred CLARREO inter-calibration strategy to calibrate the GEO record

- GSICS Geostationary (GEO) visible calibration strategy
  - Use the Moon and Deep Convective Clouds as visible calibration targets
  - All GEOs observe the moon without any maneuvers
  - All GEOs observe DCC within their field of view
- Characterize the moon as an Invariant Target
  - Characterize Earth targets, DCC, desert sites, all-sky tropical ocean, etc, for SBAF
- During 2020 perform CLARREO/GEO inter-calibration over each of the 5 GEO domains
  - Priority, one GOES-R and GERB/Meteosat
  - Characterize during 2020 the DCC domain mean reflectance over the 5 domains
  - Validate the CERES MODIS/GEO and VIIRS/GEO ray-matched inter-calibration
- During 2020 perform CLARREO/Aqua-MODIS, CLARREO/NPP-VIIRS, and CLARREO/JPSS-1-VIIRS inter-calibration
  - The MODIS and VIIRS record will be tied to the calibration of CLARREO
  - Use MODIS/GEO and VIIRS/GEO ray-matched inter-calibration to validate the GSICS calibration approach over the 20 year GEO record
SCIAMACHY spectral band adjustment factor (SBAF)

• Derive SCIAMACHY footprint pseudo sensor radiances pairs by convolving the sensor spectral response function with the SCIAMACHY hyper-spectral radiances

• Regress the sensor pseudo radiances pairs to determine SBAF
  • Increase the regression order until there is no reduction in the regression standard error
  • The SBAF is then dependent on the radiances value, over clear-sky the SBAF is based on the fit over dark radiances

• Assume that the footprint pseudo sensor radiances pairs are representative the conditions during inter-calibration events

• Use the NASA-Langley SBAF tool
  • https://www-angler.larc.nasa.gov/cgi-bin/site/showdoc?mnemonic=SBAF
SCIAMACHY SBAF

The DCC and desert SBAF is 1.038 and 0.984, respectively.
Collect CLARREO spectra over calibration sites

• Would like to have geometry similar to the GEO view of the calibration site.
  • Have a few targets over each GEO domain
  • These can then be used historically

• Similar for sun-synchronous orbit
  • Would need to have similar geometry as historical measurements of the site
DCC Invariant target methodology

• Large ensemble statistical model
• DCC near Lambertian solar diffusers for view and solar angles less than 40°
  • Convert the DCC radiance to an overhead sun radiance using the Hu DCC BRDF model
• Identify monthly all DCC pixels over the domain
  • Use GEO or MODIS IR 11µm imager, BT<205K
• Histogram all of the pixel level DCC overhead sun radiances and determine the PDF mode radiance.
• Compute the GEO calibration coefficients by monitoring the drift of the monthly GEO PDF mode radiances, which represents the visible degradation of the sensor
DCC identification

- $T(11\mu m) < 205^\circ K$, $\sigma T(11\mu m) < 1^\circ K$, $\sigma (0.65\mu m) < 3\%$, SZA<40°, VZA<40° (use GEO imager for IR for CLARREO)

- Between 40k and 250K GOES-12 pixels are identified monthly
GOES-12 (0.65µm) DCC monthly PDFs

Monthly PDFs

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- Monthly PDF modes and means show a decrease, which indicates that GOES-12 is degrading over time
The VIIRS I1 NASA LandPeate calibrated radiances appear stable over time. The PDF mode has a smaller standard error than the mean in this case.
Characterize DCC over GEO domains

- Use all nadir sampling over each GEO domain
  - Get without special operations
- Derive GEO DCC spectral BRDF for CLARREO calibration transfer to GEOs
  - May want to do some off nadir sampling to obtain sufficient sampling over view range
  - DCC over land need to be characterized by local time
- Will not compete with the 1:30 sun-synchronous orbit inter-calibration
MODIS/GEO inter-calibration: All-sky Tropical Ocean Methodology

• Grid the within 15 minute MODIS and GEO pixel-level radiances into 0.5° latitude by 0.5° longitude grid over the GEO domain

• Angular match within 5° the view and azimuthal angle for clear-sky and gradually increase the tolerance to 15° view and azimuthal angle (GAM) for bright clouds
  • Clear-sky is more anisotropic and requires a strict angle matching, whereas bright clouds are more Lambertian and can allow for more tolerant angle matching
  • Most of the sampling over clear-sky, which is more anisotropic than over bright clouds

• Apply an all-sky tropical ocean SCIAMACHY hyper-spectral based spectral band adjustment factor (SBAF) to account for spectral band difference
MODIS/GEO inter-calibration: All-sky Tropical Ocean

Goess-13/Aqua-MODIS for April 2011

Red line = linear regression through the space clamp offset (force fit)
Black line = linear regression
Under perfect ray-matching conditions the force fit and the linear regression should be equal

• The lax angular matching, not accounting for spectral band differences, bias = 2.6%
GEO/CLARREO calibration

• Would get Earth view CLARREO radiances during nadir operational and pointing sampling for inter-calibration
  • New GEO imagers have 10 minute scanning, so inter-calibration events will always be time matched

• To test CERES GEO/VIIRS inter-calibration methodology
  • New GEO imagers will have similar bands to VIIRS

• For GERB on Meteosat
  • Would need pointing to reduce inter-calibration uncertainty to evaluate GERB SRF degradation, etc
MTSAT-2, July 20, 2011, 2:32 GMT, 1-km visible image

- The cyan lines indicate a 1° latitude by 1° longitude grid
MODIS/GEO inter-calibration: for DCC and ATO methods

MTSAT-2/Aqua-MODIS, Jan. 2013

• Most of DCC radiance pairs fall along the force fit line
• Both the 30-km and 10-km DCC core diameters force fit gains are very consistent
Comparison of DCC and desert invariant target and MODIS/GEO ATO and DCC inter-calibration methods

- Validate that the Aqua-MODIS DCC mode radiance equals the Meteosat-10 DCC mode radiance over the Met-10 domain
  - thereby validating that the DCC mode algorithm properly transferred the calibration reference
- All calibration methods are within 0.4%, DCC RM and mode within 0.2%

ATO: All-Sky Ocean Ray Matching
DCC (RM): DCC ray-matching
Libya-4: Based on Met-9 Libya-4 model
DCC (Mode): DCC mode radiance method (GSICS)
Comparison of DCC and desert invariant target and MODIS/GEO ATO and DCC inter-calibration methods

- All calibration methods are within 0.4%, except for MTSAT-2 at 0.7%
- All DCC calibration methods are within 0.3%
Preferred CLARREO inter-calibration strategy to calibrate the GEO record

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