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

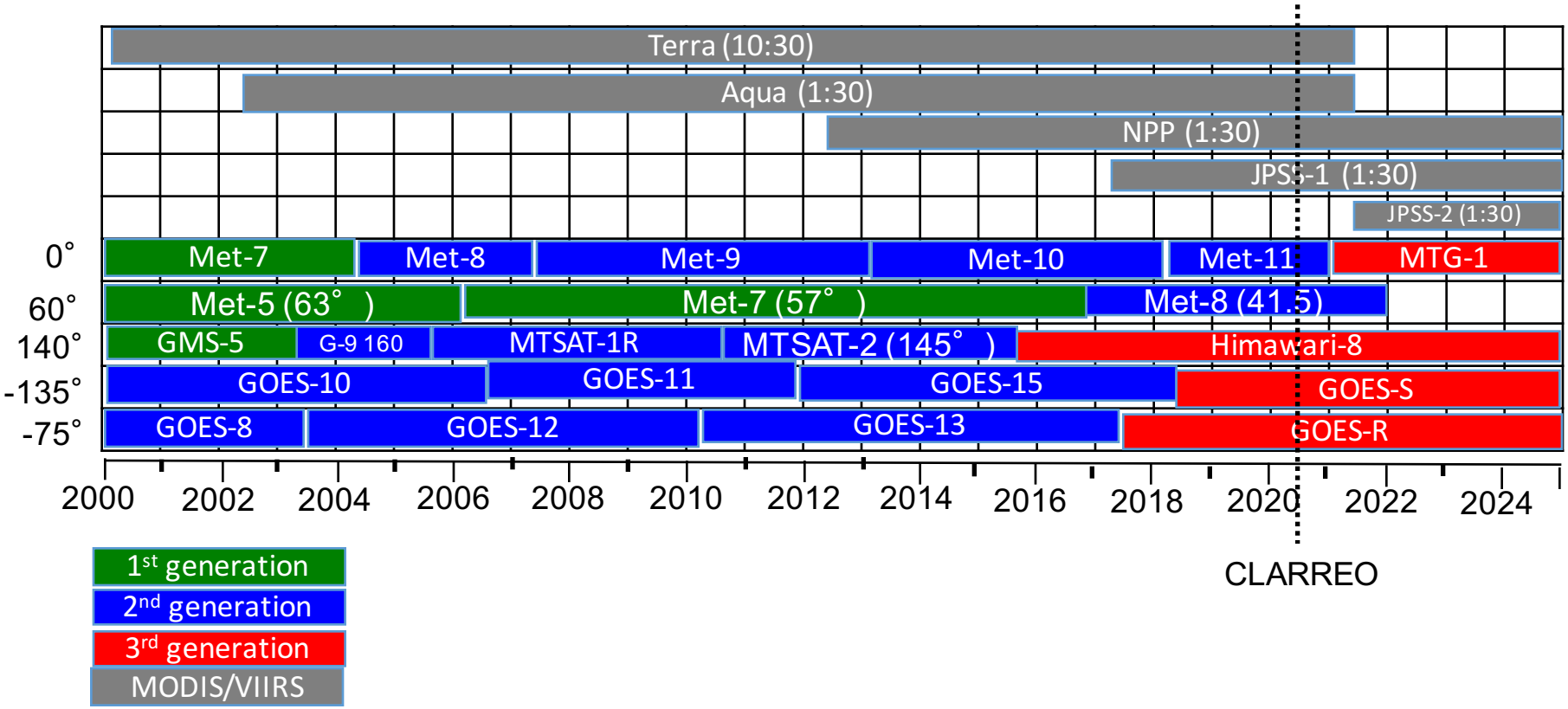
- First web meeting

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

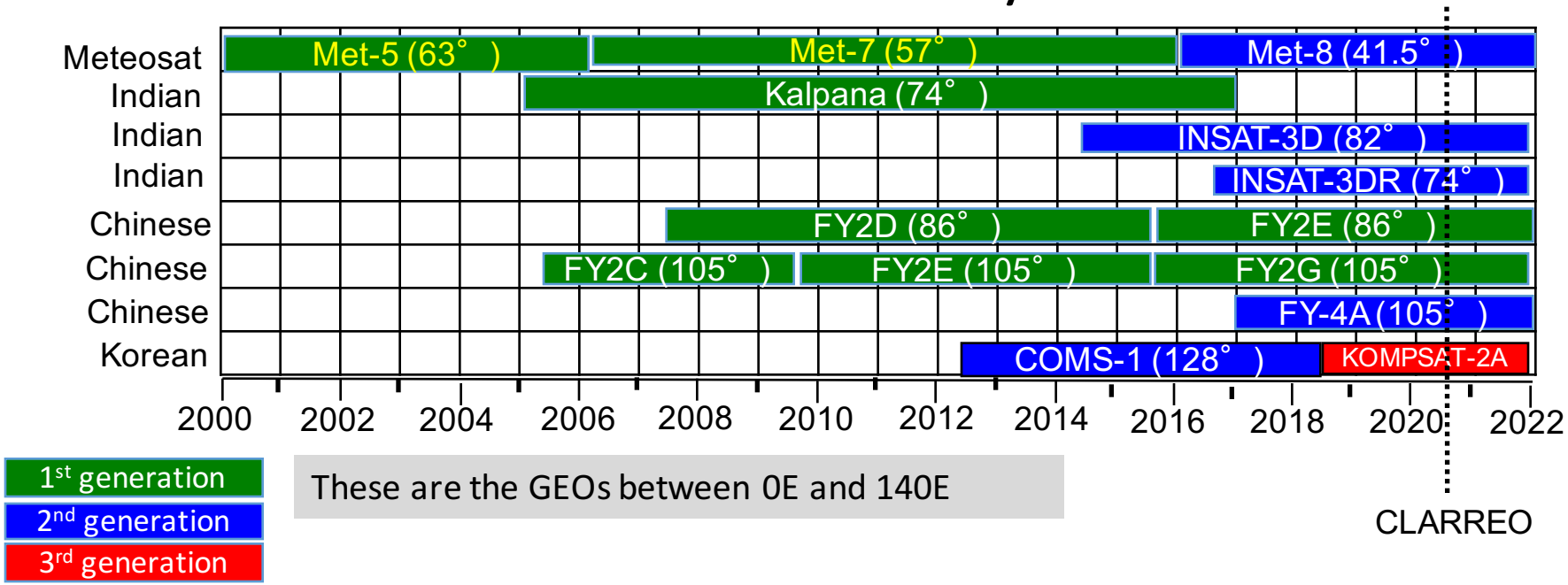
Join by phone
Global call-in numbers: https://eumetsat.webex.com/eumetsat/globalcallin.php
0800-051-3810 Call-in toll-free number (UK)
+44-203-478-5289 Call-in toll number (UK)
Toll-free calling restrictions

CERES record Geostationary Time Series



- 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

Indian Ocean Geostationary Time Series



These are the GEOs between 0E and 140E

- 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

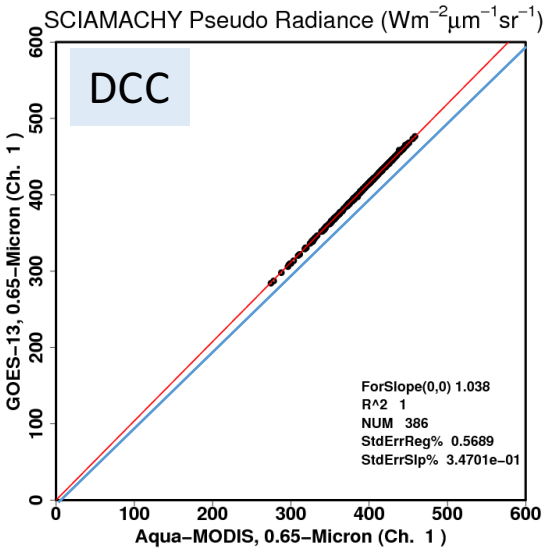
Preferred CLARREO inter-calibration strategy to calibrate the GEO record

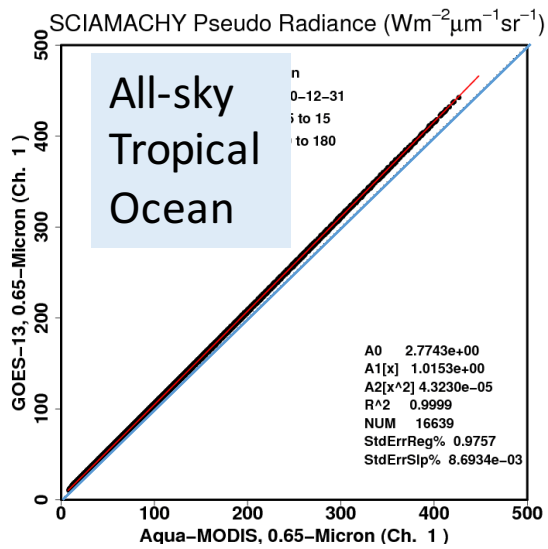
- GSICS Geostationary (GEO) visible calibration strategy
  - Use the Moon and Deep Convective Clouds as visible calibration targets
  - All GEOs observe the moon without any maneuvers
  - All GEOs observe DCC within their field of view
- Characterize the moon as an Invariant Target
  - Characterize Earth 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

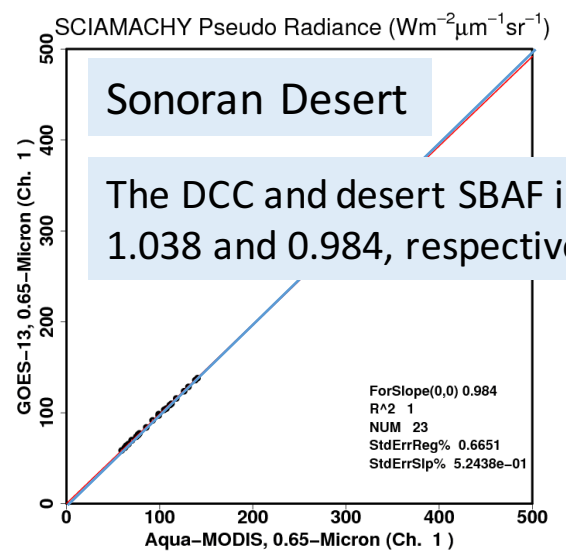
SCIAMACHY spectral band adjustment factor (SBAF)

- Derive SCIAMACHY footprint pseudo sensor radiance pairs by convolving the sensor spectral response function with the SCIAMACHY hyper-spectral radiance
- Regress the sensor pseudo radiance 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 radiance value, over clear-sky the SBAF is based on the fit over dark radiances
- Assume that the footprint pseudo sensor radiance 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

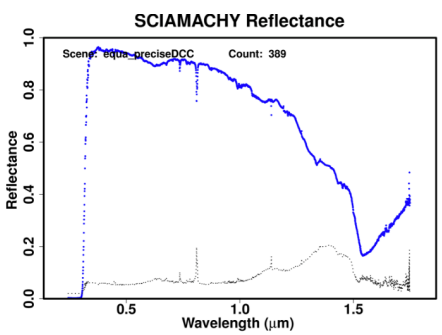
SCIAMACHY SBAF

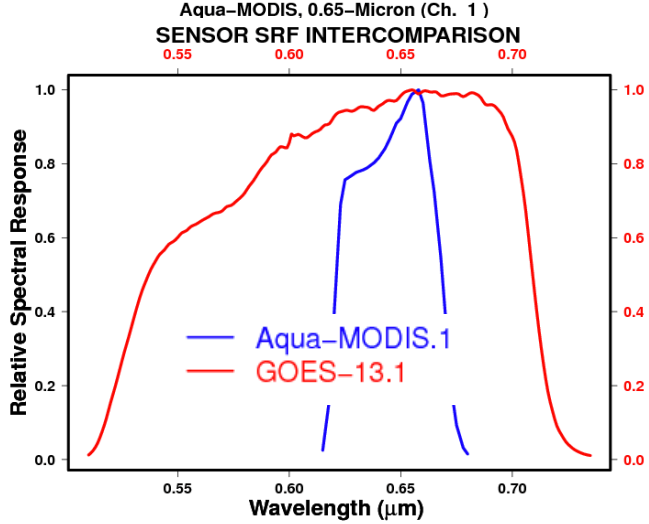


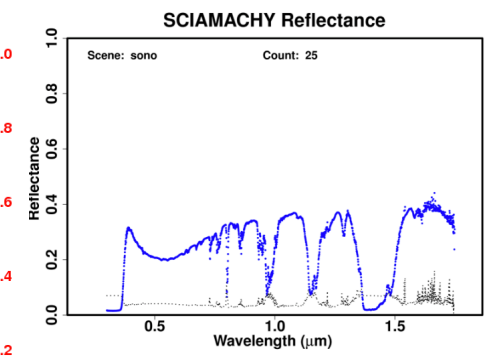




The DCC and desert SBAF is 1.038 and 0.984, respectively

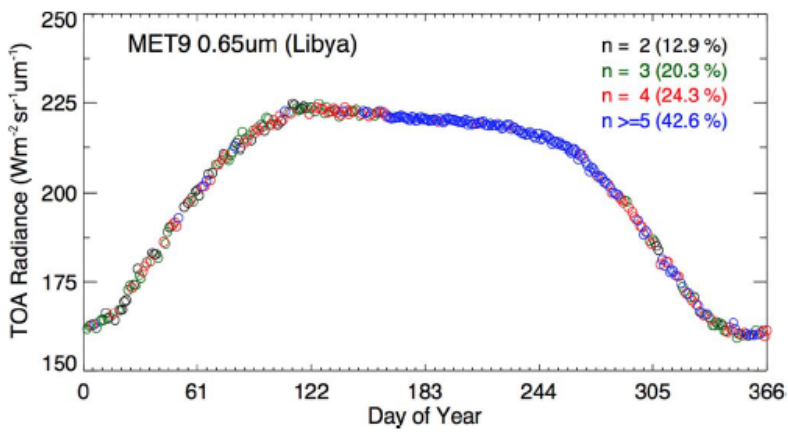






Collect CLARREO spectra over calibration sites

- 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

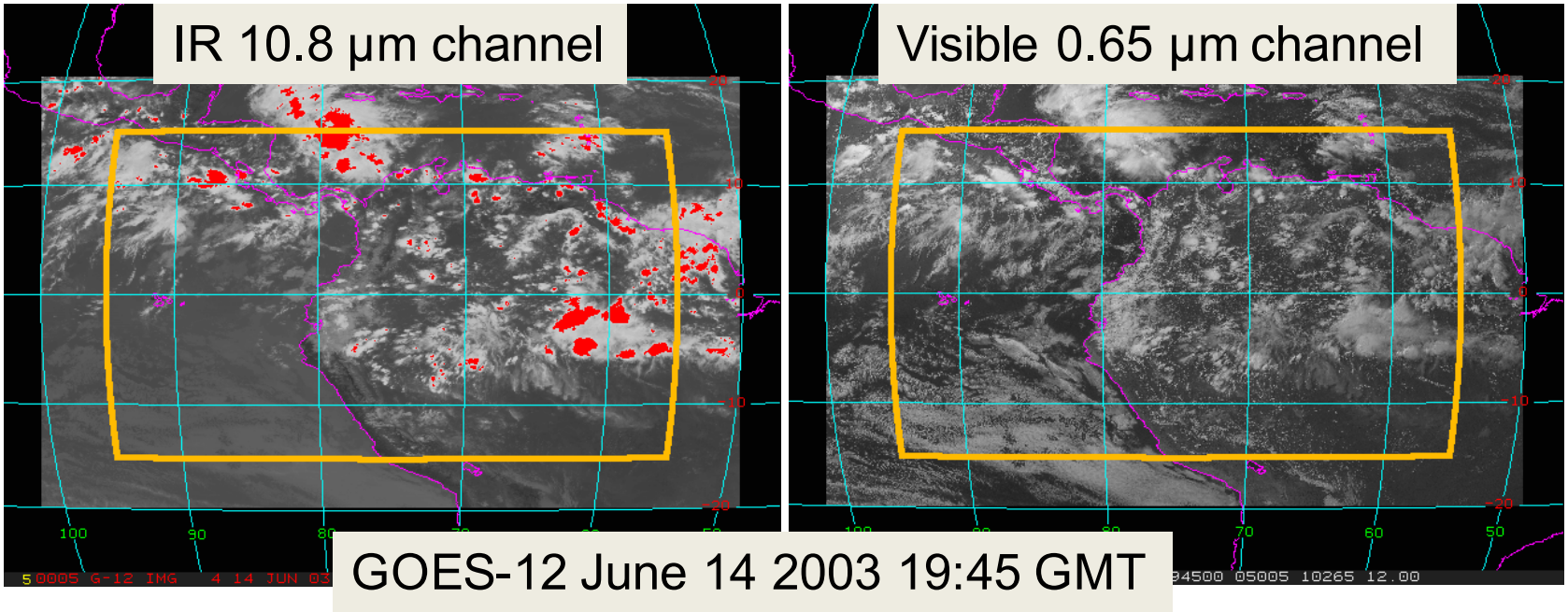


DCC Invariant target methodology

- 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(11µm)<205°K, σT(11µm) <1°K, σ(0.65µm)<3%, SZA<40°, VZA<40° (use GEO imager for IR for CLARREO)

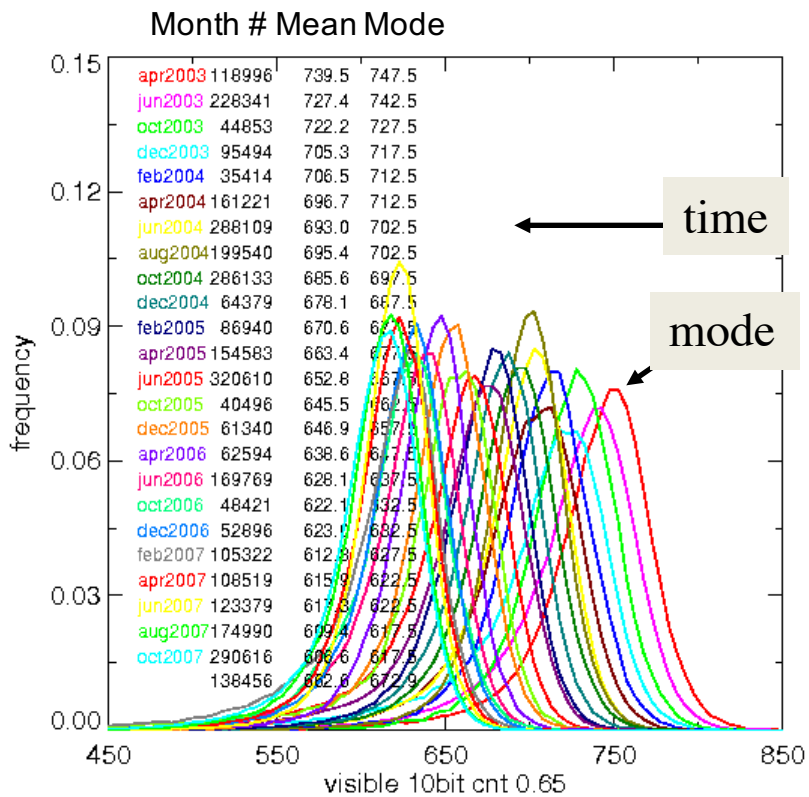


- Between 40k and 250K GOES-12 pixels are identified monthly

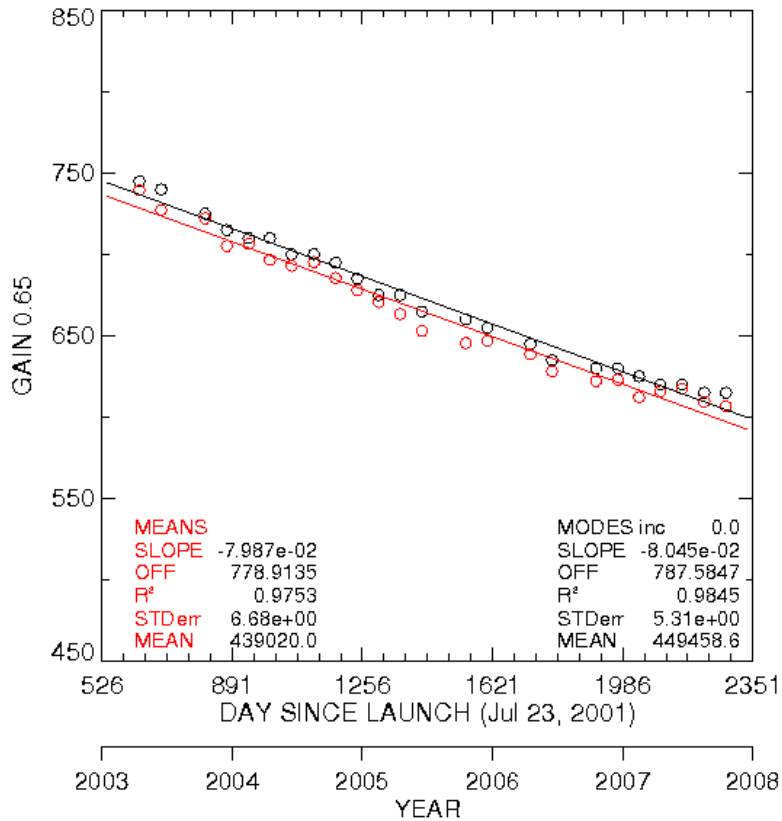
Doelling et al. 2011 (GSICS)

GOES-12 (0.65µm) DCC monthly PDFs

Monthly PDFS



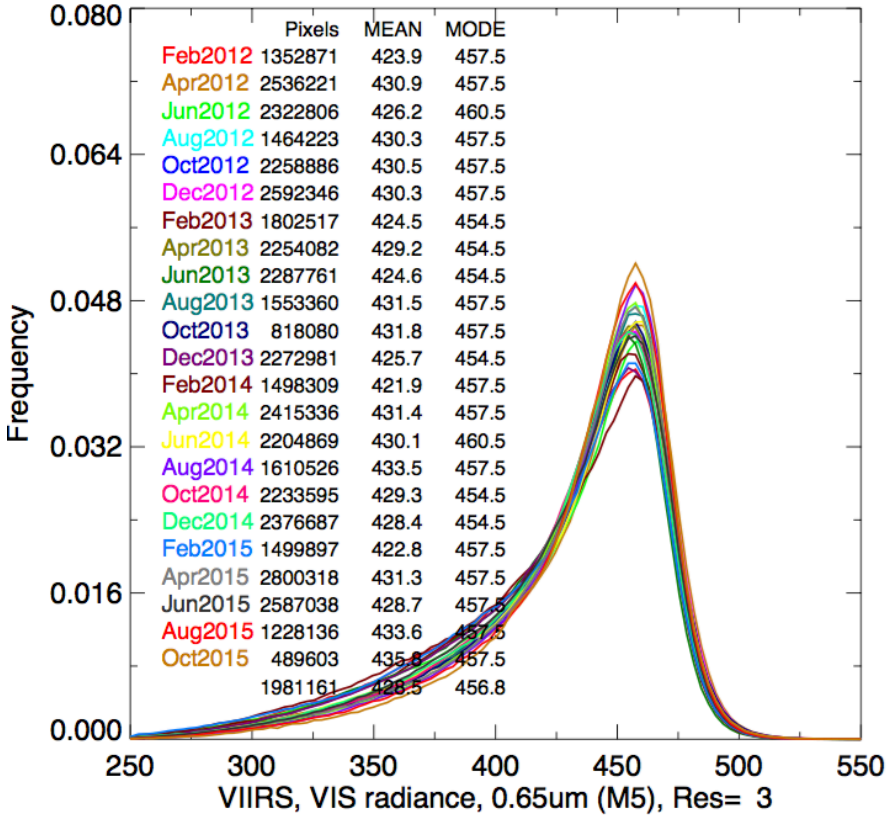
Monthly PDF modes and means

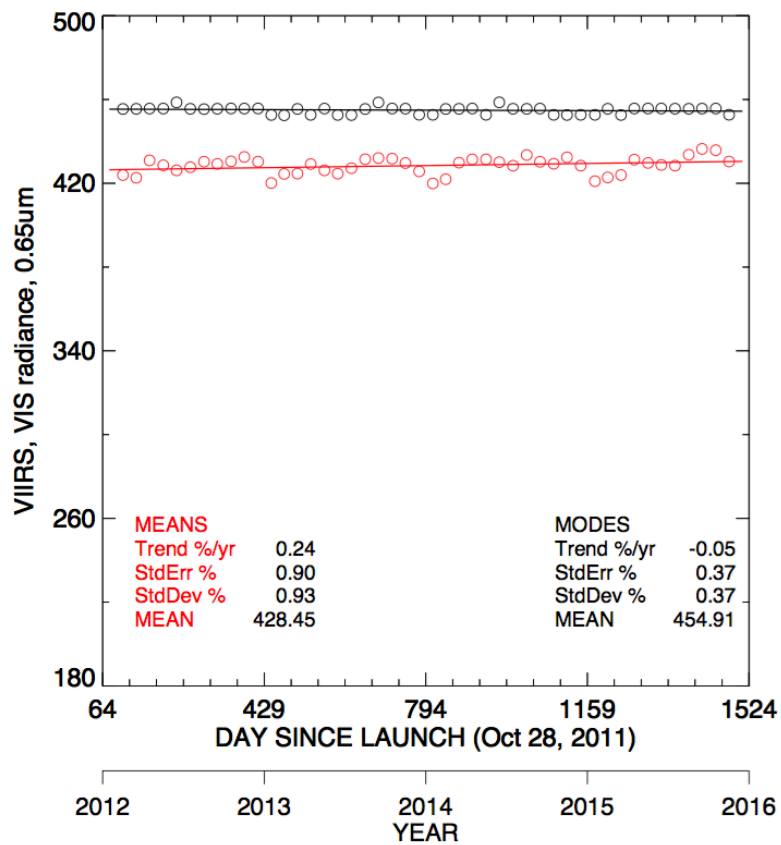


- Monthly PDF modes and means show a decrease, which indicates that GOES-12 is degrading over time

Bhatt et al. 2014

VIIRS I1 (0.65µm) DCC mode radiances





- 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

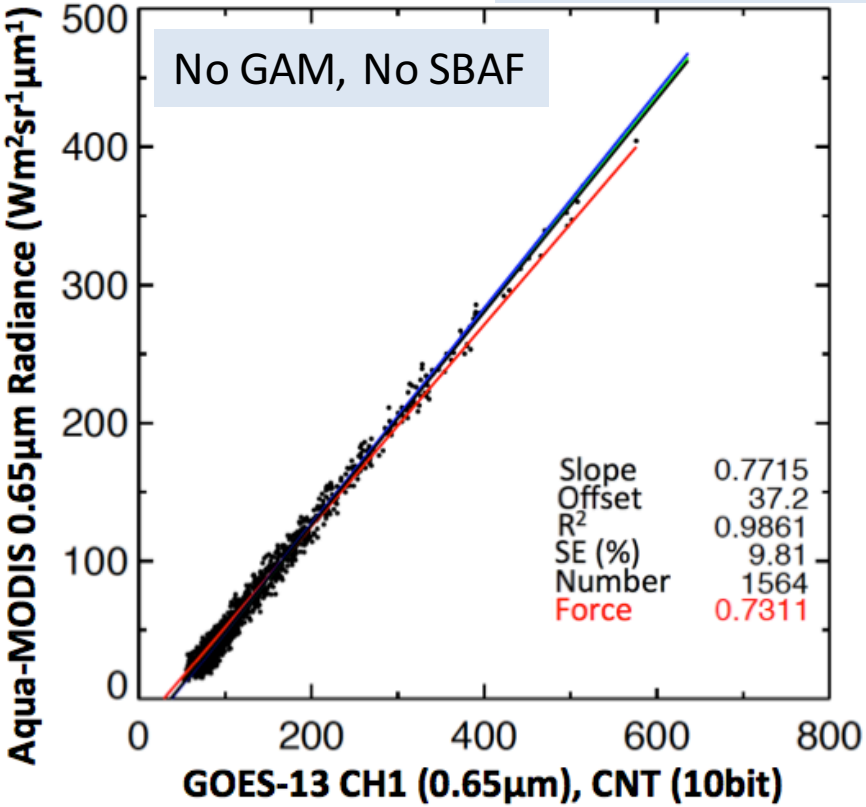
MODIS/GEO inter-calibration: All-sky Tropical Ocean Methodology

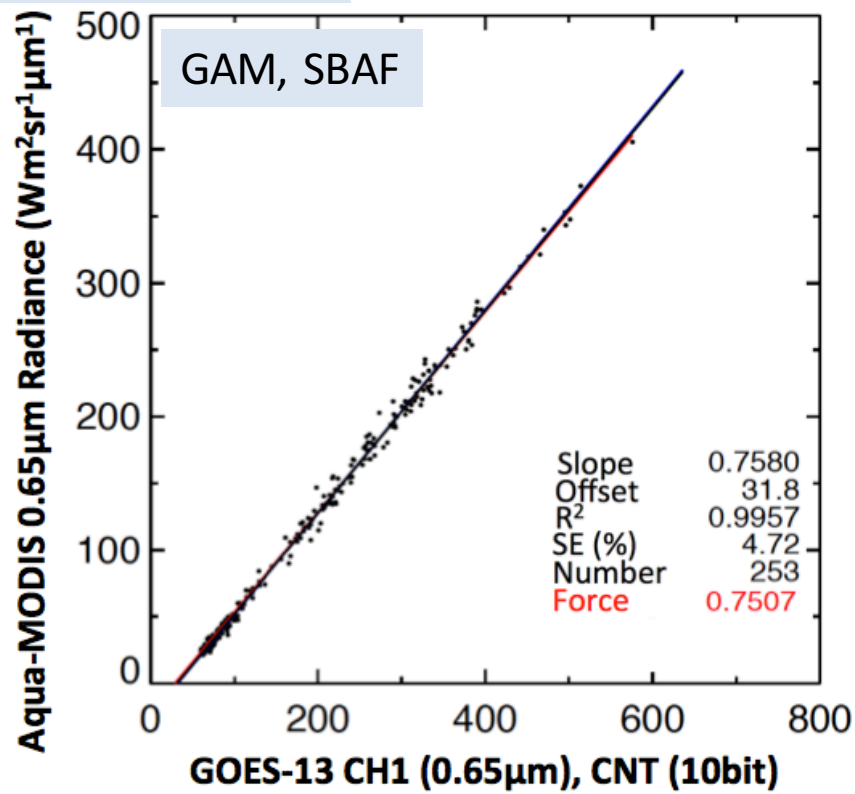
- Grid the within 15 minute MODIS and GEO pixel-level radiances into 0.5° latitude by 0.5° longitude grid over the GEO domain
- Angular match within 5° the view and azimuthal angle for clear-sky and gradually increase the tolerance to 15° view and azimuthal angle (GAM) for bright clouds
  - Clear-sky 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

Doelling et al. 2016, submitted

MODIS/GEO inter-calibration: All-sky Tropical Ocean

GOES-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

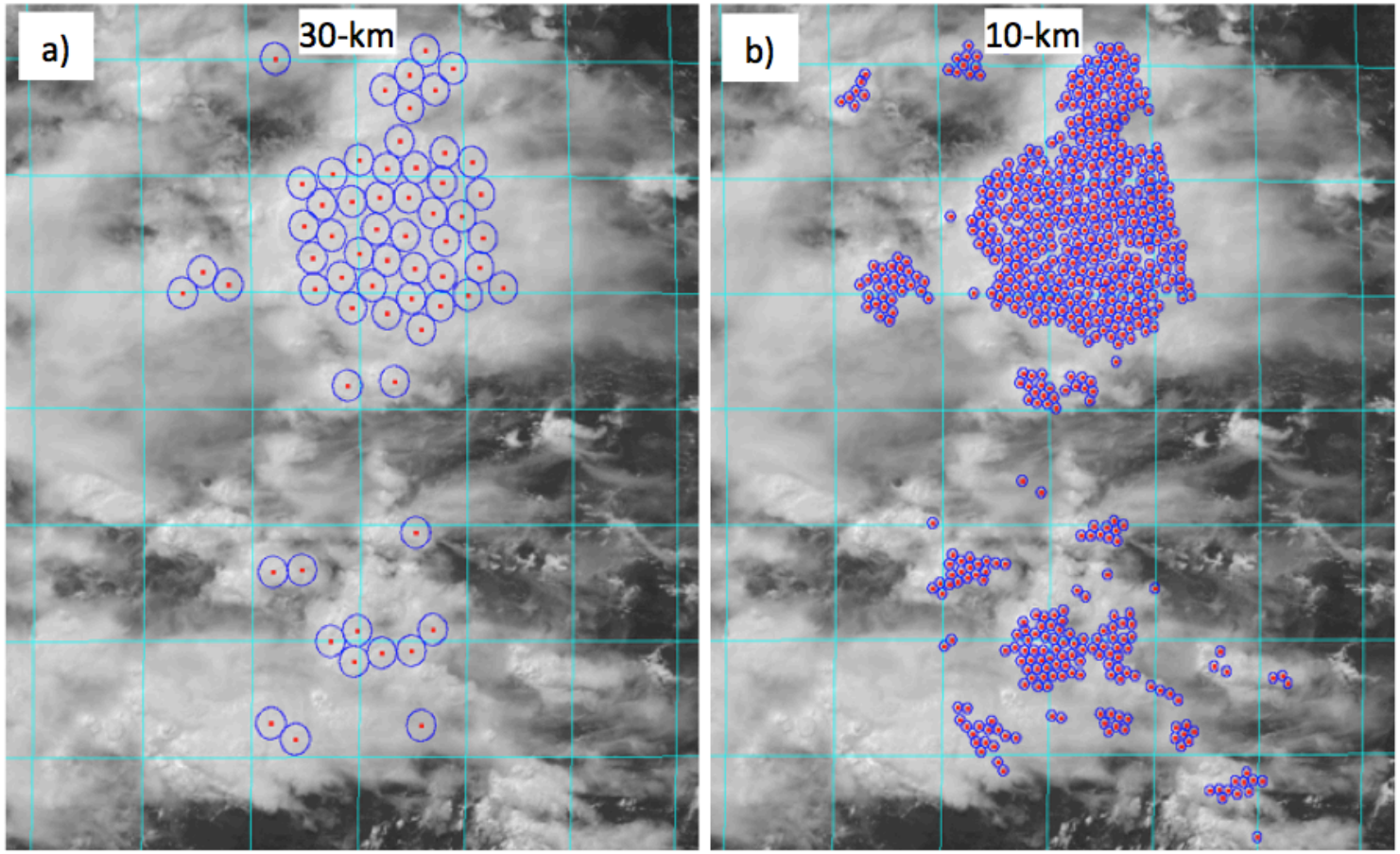
- The lax angular matching, not accounting for spectral band differences, bias = 2.6%

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

Doelling et al. 2016, submitted

MTSAT-2, July 20, 2011, 2:32 GMT, 1-km visible image

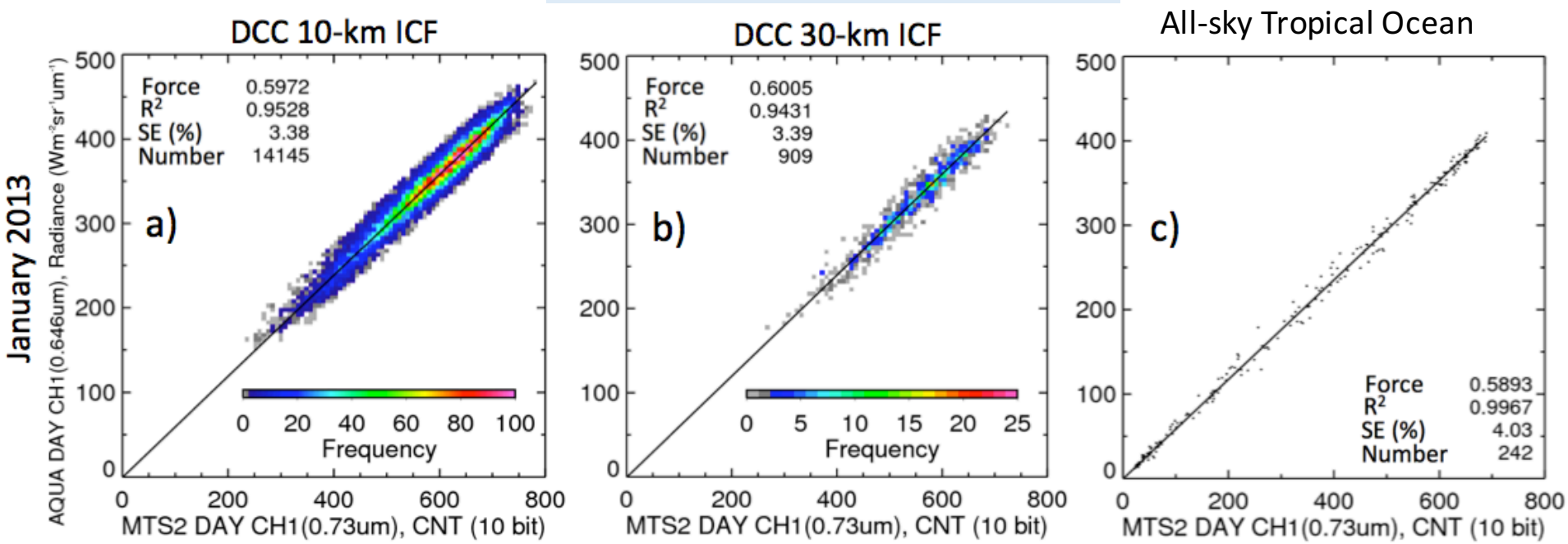


- The cyan lines indicate a 1° latitude by 1° longitude grid

Doelling et al. 2016, submitted

MODIS/GEO inter-calibration: for DCC and ATO methods

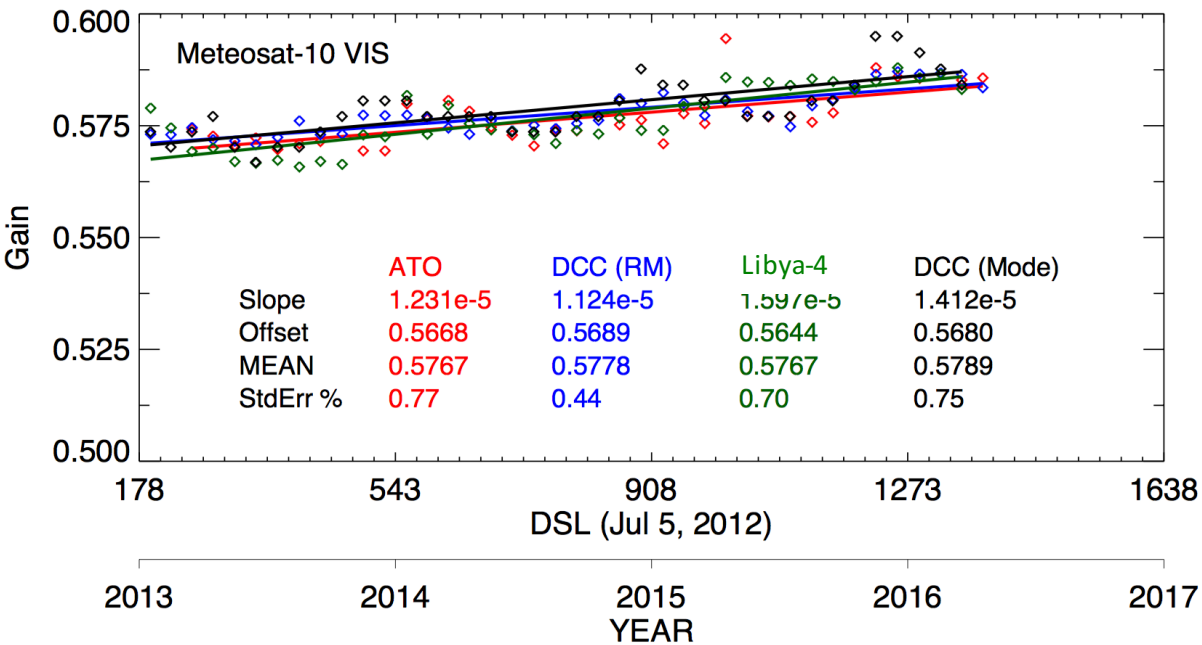
MTSAT-2/Aqua-MODIS, Jan. 2013



- 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

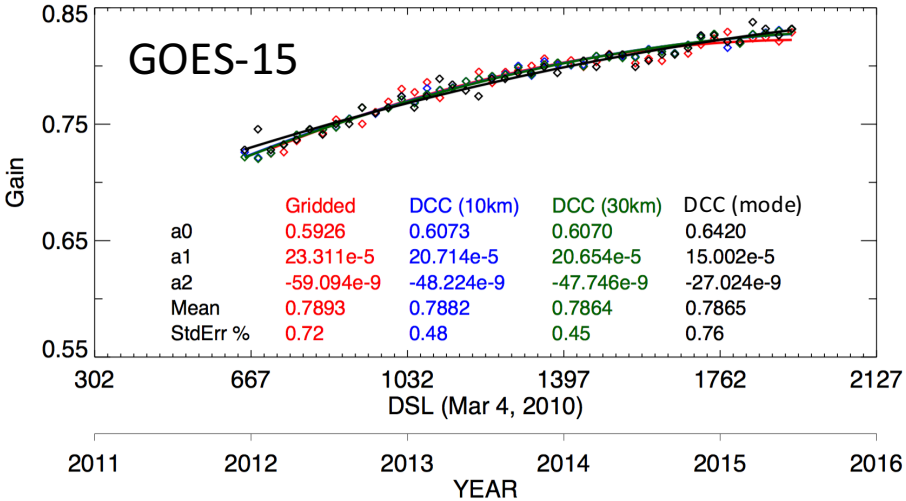
- Validate that the Aqua-MODIS DCC mode radiance equals the Meteosat-10 DCC mode radiance over the Met-10 domain
  - thereby validating that the DCC mode algorithm properly transfered the calibration reference
- All calibration methods are within 0.4%, DCC RM and mode within 0.2%

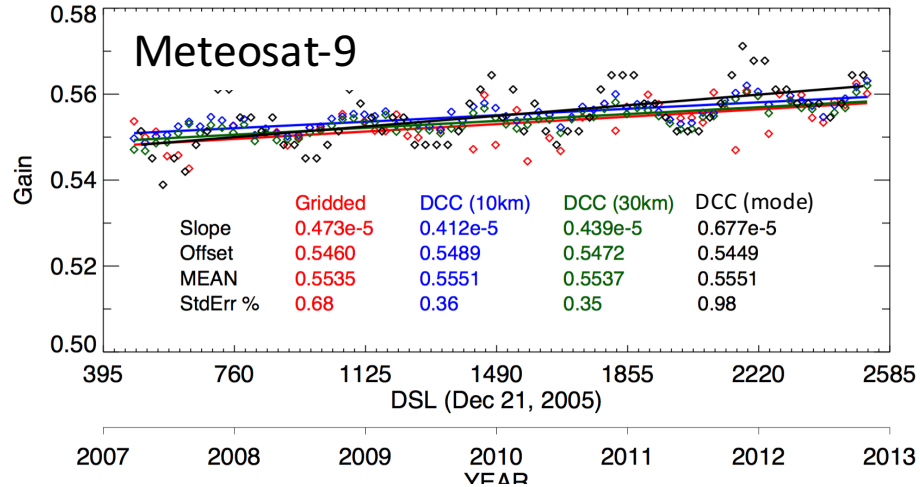


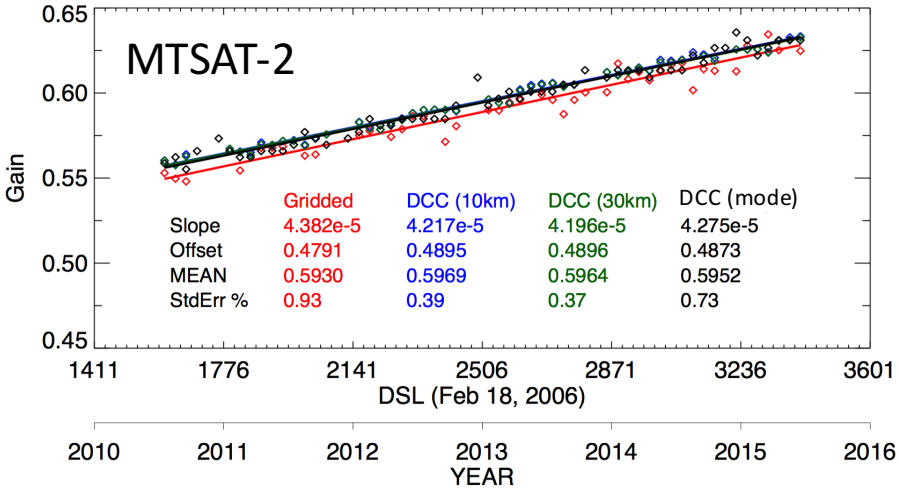
ATO: All-Sky Ocean Ray Matching
DCC (RM): DCC ray-matching
Libya-4: Based on Met-9 Libya-4 model
DCC (Mode): DCC mode radiance method (GSICS)

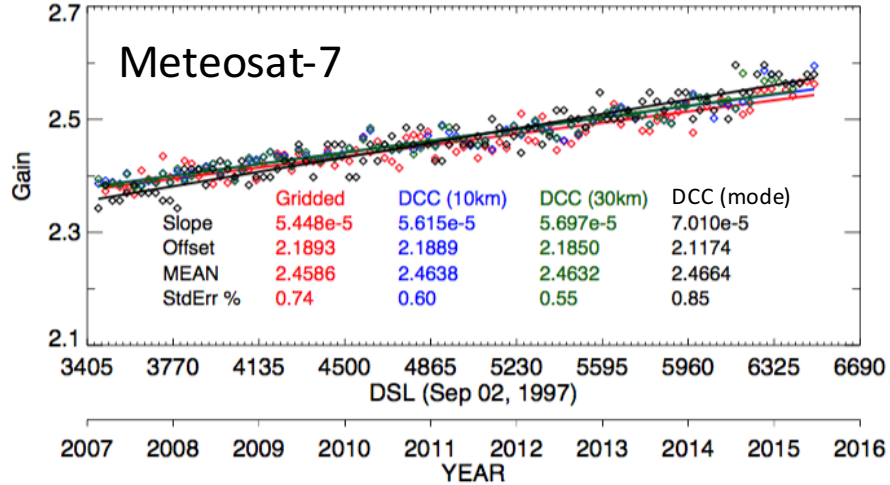
Doelling et al. 2016, in preparation

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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