Global Space-Based Inter-Calibration System: An Operational Satellite Monitoring Framework

By Manik Bali, University of Maryland

Contributions from
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Contents

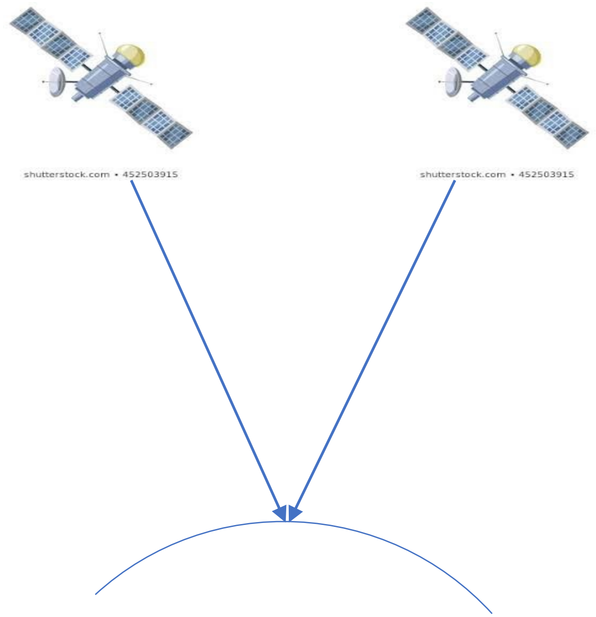
Introduction

The Global Space Based Inter-Calibration System (GSICS) is a consortium of satellite agencies that have come together to monitoring in-orbit satellites instrument performance, build algorithms to estimate calibration biases, and apply adjustments to correct for them.

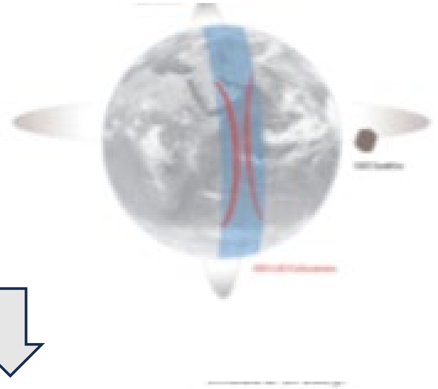
EUMETSAT CNES JMA
NOAA CMA KMA
ISRO NASA WMO
USGS NIST JAXA
ROSHYDROMET IMD ESA
ROSCOSMOS

GSICS Coordinates Calibration activities across member agencies

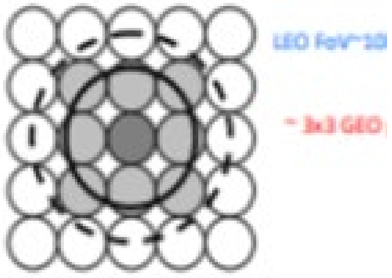
GSICS Algorithms



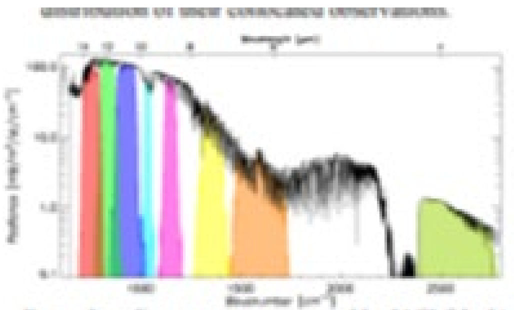
Simultaneous near-Nadir Overpasses of GEO imager and LEO sounder.
Select Collocations:
Spatial, temporal and geometric thresholds.



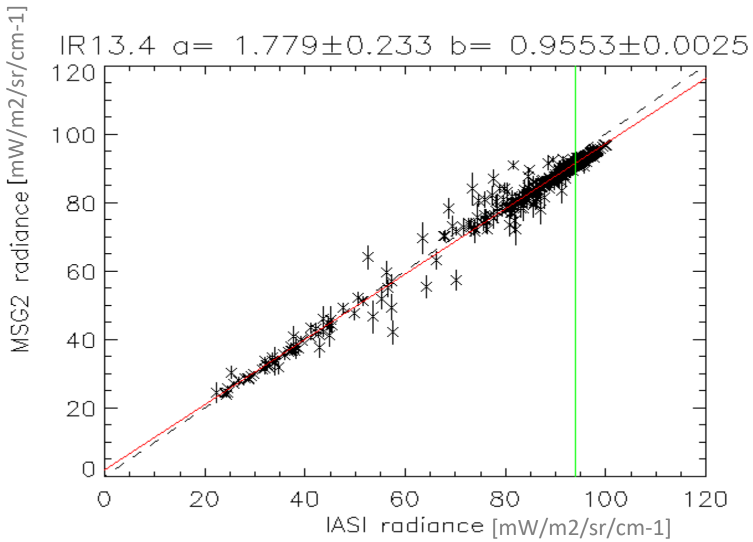
Spatial Averaging:
Average GEO pixels in each LEO FoV with Standard Deviation of GEO pixels as weight.



Spectral Convolution:
Convolve LEO Radiance Spectra with GEO Spectral Response Functions to synthesise radiance in GEO channels.



Example radiance spectra measured by IASI (black), convolved with the Spectral Response Functions of SEVIRI channels 3-11 from right to left (colored shaded areas).

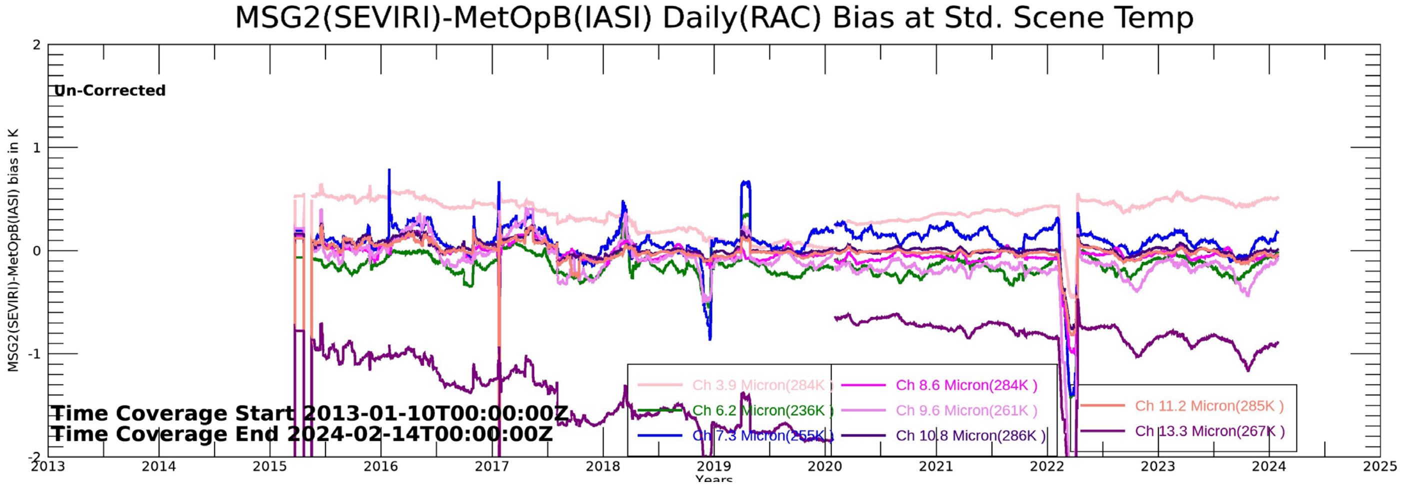


Most GSICS BIAS Monitoring product are the regression coefficients

Click Notebook here to see
Convolution Code
Simultaneous Nadir Overpass

Image Curtsey : Tim Hewison, EUMETSAT

GSICS Inter-Calibration Products

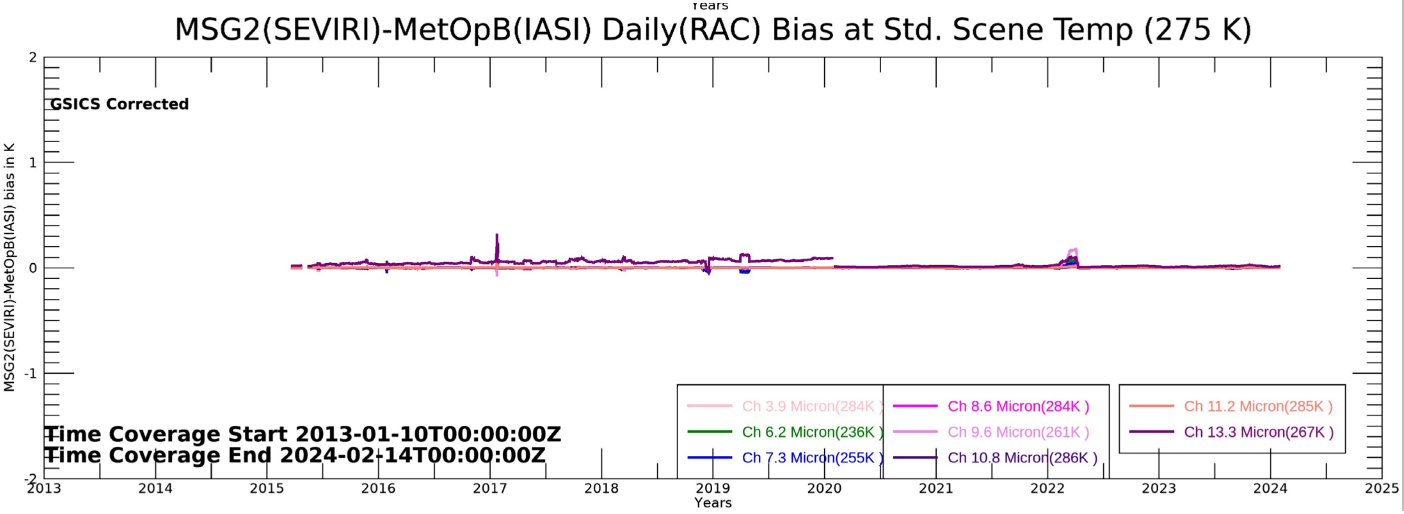


Equation 1: $L_{GEO} = a_r + b_r L_{LEO}$

The relationship in Equation 1 can be inverted to apply the regression coefficients, a_r and b_r, to convert GEO radiances, L_{GEO}, into radiances consistent with the LEO reference instrument, $\hat{L}_{LEO}$,

Equation 2: $\hat{L}_{LEO} = +\frac{1}{b_r}L_{GEO} - \frac{a_r}{b_r}$, together with the estimated uncertainty:

Equation 3: $[u(\hat{L}_{LEO})]^2 = [(L_{GEO} - a_r)u(b_r)]^2 + \left[\frac{u(a_r)}{b_r}\right]^2 - 2\frac{(L_{GEO} - a_r)}{b_r}u(a_r, b_r)$.



GCC GSICS Coordination Center
Establishing product quality assurance, charting progress, and communicating accomplishments across the GSICS program and beyond
Hosted for GSICS at the NOAA/NESDIS Center for Satellite Applications and Research
GSICS Global Space-based Inter-Calibration System

GCC Home > GSICS Product Catalog

GSICS Product Catalog

Show 100 entries   Search: Typing any text will filter displayed products

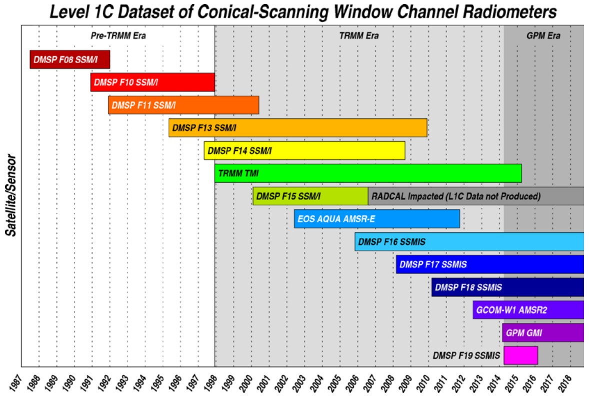
Product Type	Algorithm Type	Data Producer	Maturity Level	Monitored Instrument	Reference Instrument	Version	Data Start Date	Data End Date	Docs / Data Links
Near Real Time Correction (DCC)	GEO-LEO VIS	EUMETSAT	Demonstration	MSG-1 SEVIRI	Aqua MODIS	1	2016-09-09	2018-06-17	Docs Data
Near Real Time Correction (DCC)	GEO-LEO VIS	EUMETSAT	Demonstration	MSG-4 SEVIRI	Aqua MODIS	1	2018-05-07	Present	Docs Data
Near-Real Time Correction	GEO-LEO IR	JMA	Demonstration	Himawari-8 AHI	IASI-A	1	2017-10-30	2021-10-15	Docs Data
Near-Real Time Correction	GEO-LEO IR	JMA	Demonstration	Himawari-8 AHI	IASI-B	1	2017-10-30	2022-12-13	Docs Data
Near-Real Time Correction	GEO-LEO IR	JMA	Demonstration	Himawari-9 AHI	IASI-B	1	2022-09-27	Present	Docs Data
Near-Real Time Correction	GEO-LEO IR	JMA	Demonstration	Himawari-8 AHI	Aqua AIRS	1	2017-10-30	2022-12-13	Docs Data
Near-Real Time Correction	GEO-LEO IR	JMA	Demonstration	Himawari-9 AHI	Aqua AIRS	1	2022-09-27	Present	Docs Data
Near-Real Time Correction	GEO-LEO IR	KMA	Demo	COMS Imager	IASI-A	1	2017-01-31	2020-04-01	Docs Data
Near-Real Time Correction	GEO-LEO IR	NESDIS	Preoperational	GOES-13 Imager	IASI-A	1	2013-01-16	Present	Docs Data
Near-Real Time Correction	GEO-LEO IR	NESDIS	Preoperational	GOES-15 Imager	IASI-A	1	2013-01-16	Present	Docs Data
Near-Real Time Correction	GEO-LEO IR	ISRO	Demonstration	INSAT-3D Imager	IASI-A	1	2016-02-19	Present	Docs Data
Near-Real Time Correction	GEO-LEO IR	ISRO	Demonstration	INSAT-3D Sounder	IASI-A	1	2016-02-19	Present	Docs Data
Near-Real Time Correction	GEO-LEO IR	EUMETSAT	Demonstration	Meteosat-7 MVIRI	IASI-A	3	2008-05-15	2017-03-27	Docs Data
Near-Real Time Correction	LEO-LEO IR	EUMETSAT	Prototype	Metop-A HIRS	IASI-A	3	2009-04-29	2021-04-11	Docs Data
Near-Real Time Correction	GEO-LEO IR	EUMETSAT	Operational	MSG-1 SEVIRI	IASI-A	3	2016-02-09	2021-11-15	Docs Data
Near-Real Time Correction	GEO-LEO IR	EUMETSAT	Operational	MSG-1 SEVIRI	IASI-B	3	2016-02-09	2022-10-27	Docs Data
Near-Real Time Correction	GEO-LEO IR	EUMETSAT	Operational	MSG-2 SEVIRI	IASI-A	1	2008-06-01	2021-11-15	Docs Data
Near-Real Time Correction	GEO-LEO IR	EUMETSAT	Operational	MSG-2 SEVIRI	IASI-B	1	02/09/2016	Present	Docs Data
Near-Real Time Correction	GEO-LEO IR	EUMETSAT	Operational	MSG-3 SEVIRI	IASI-A	1	2013-01-24	2021-11-15	Docs Data

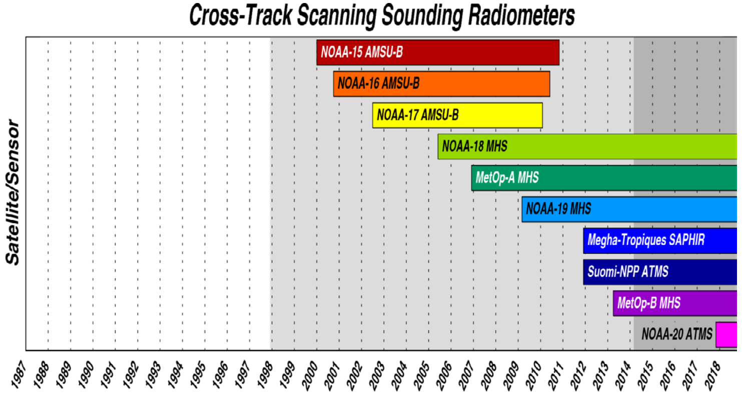
GSICS Has over 80 Inter-calibration Products on the Product Catalog
Monitored Instruments: Meteosat,INSAT, AVHRR,GK2A/COMS,Himawari

GSICS Deliverables

GSICS Deliverables are entities that are useful in instrument monitoring and calibration. We currently have four deliverables:

- Hyperspectral Reference Radiance in NetCDF Format by *Masaya Takahashi (JMA)*
- GEO-LEO Intermediate Collocation (Himawari/MTSAT V Hyperspectral, IR) by *Masaya Takahashi (JMA)*
- Spectral Response Function for GIRO (VIS) by *Masaya Takahashi (JMA)*
- Level 1C Inter-Calibration Tables by *Wes Berg(CSU) and Racheal Kroodsma (NASA)*





Agencies maintain GSICS Processing and Research Centers (GPRCs)

Agency	Instruments Monitored
GPRC NOAA	GOES -16/17/18
GPRC CMA	FY- C/2E/2F/2G/3C/4A/4B
GPRC EUMETSAT	Meteosat Series
GPRC JMA	Himawari-8/9
GPRC KMA	COMS , GK-2A
GPRC Roshydromet	Meteor-MSMR/IKFS Electro-NL
GPRC ISRO	INSAT-3D I/S/ 3R

GMI calibration references
Draper, D. W., D. A. Newell, F. J. Wentz, S. Krimchansky, and G. Skofronick-Jackson, 2015: The Global Precipitation Measurement (GPM) Microwave Imager (GMI): Instrument overview and early on-orbit performance. *IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens.*, 8, 3452–3462, doi:10.1109/JSTARS.2015.2403303.
Wentz, F. J. and D. Draper, 2016: On-orbit absolute calibration of the Global Precipitation Mission Microwave Imager, *J. Atmos. Oceanic Technol.*, 33, 1393–1412, doi:10.1175/JTECH-D-15-0212.1.

GSICS References

Channel	Reference Instrument/Record	Period	*Version*	Status	Major Events	GSICS Maturity	End Date	Recommendation to Users
Infrared	IASI-A			Deorbiting	End of Life Schedule		Apr 2021	Switch to IASI-B/C/ and Beyond for instrument monitoring
	IASI-B			Operational				
	IASI-C			Operational				
	NOAA-SNPP/CrIS			Instrument completes designed lifespan	Change of Electronics		July 22, 2021	Switch to Jx-CrIS for instrument monitoring
	NOAA-20/CrIS			Operational				
	NOAA-21/CrIS							
	AIRS			Operational				
	MODIS(AQUA)			2002 to 2018.				
VIS/NIR	NOAA-20/VIIRS		SDR Versions					
	NOAA-21/VIIRS							
Microwave	AMSU/MSU FCDR							
	NOAA-20/ATMS		SDR Version					
UV								

Glossary * Channel * Reference Instrument * Period (of best reference) * Version: The version of records that is best recommended (can be more than one) * Status: Most recent status of the reference instrument that can directly impac inter-calibration outcomes. * Major Event: Major events during the best lifetime of the reference instrument * GSICS Maturity: Three colors denoting (Green: If GSICS has formally designated it as GSICS Reference, Yellow: If recommende as a GSCICS reference).

GSICS Reference instruments are (VIIRS/CrIS/ATMS/IASI)

These are many times more stable than most of the concurrently flying instruments and retain most of their their pre-launch characteristics.

They also follow a QA4EO selection criterion.

In addition AMSU/MSU FCDR Used as a reference for MW

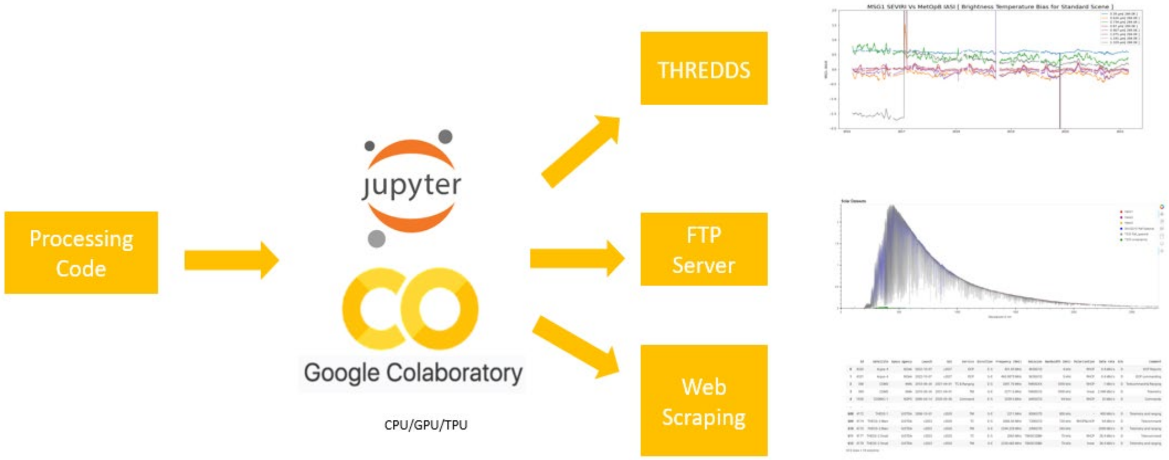
QA4EO is a CEOS/GSICS accepted Quality Assurance Standard/ GCC initiated the process to full fill this criterion

GSICS Notebooks: Delivering Code + Platform+ Data

Google Colab for GSICS

GSICS developers have created read and inter-comparison tools on Google Colab. This allows researchers to directly share processing code + data+ processing hardware in real-time with WMO member agencies

An instance of code and a python kernel is shared instantly. This enables us to directly use inter-comparision data and code and perform validations on the fly.



GSICS Notebooks: Analyzing and Comparing Solar Data Sets

Solar spectra irradiances have wide application including the following:

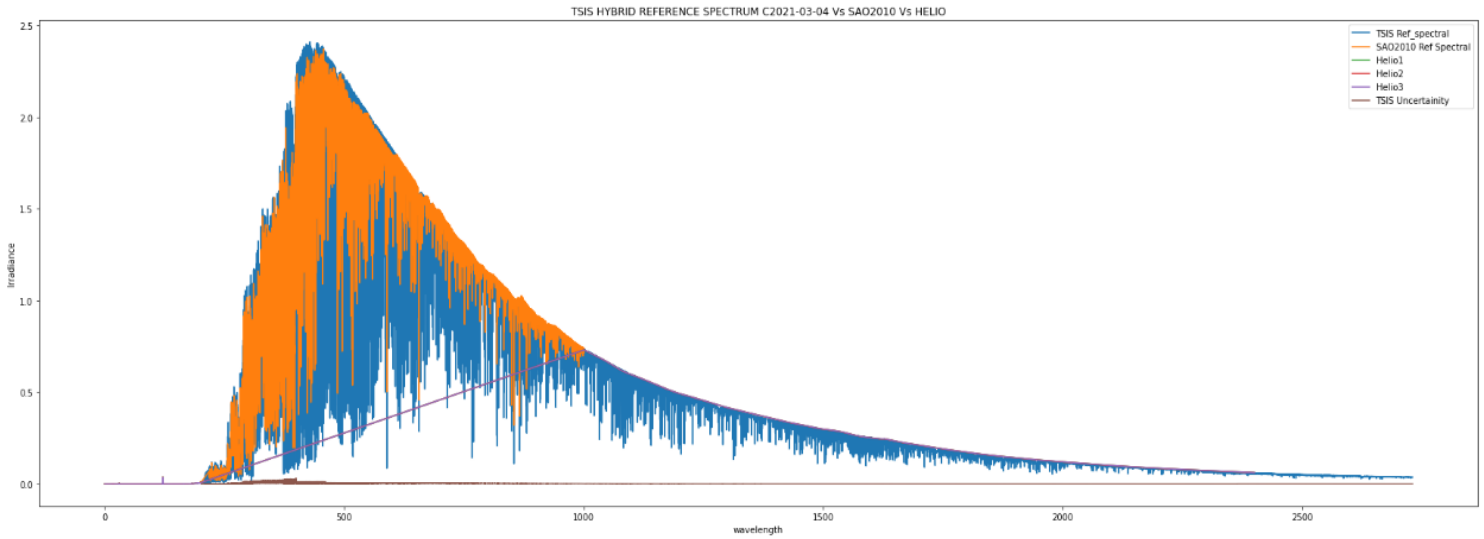
- Convert measured satellite radiance to reflectance
- Input in radiative transfer models for bandpass weighting
- Provide wavelength scale registration by using solar absorption lines
- Monitor radiometric stability monitoring, which requires a baseline solar spectrum to quantify instrumental changes
- Monitor radiometric calibration stability relative to the moon (indirectly rely on a solar reference spectrum)
- Track solar activity and compare to reference spectra

The code can read in Solar Data sets from multiple sources and compare them

- TSIS-1 *HSRS Version 2 (Recommended by GSICS)*
- SAO2010 Data set
- HELIO 1/2/3 Data Set

GSICS Solar Notebook

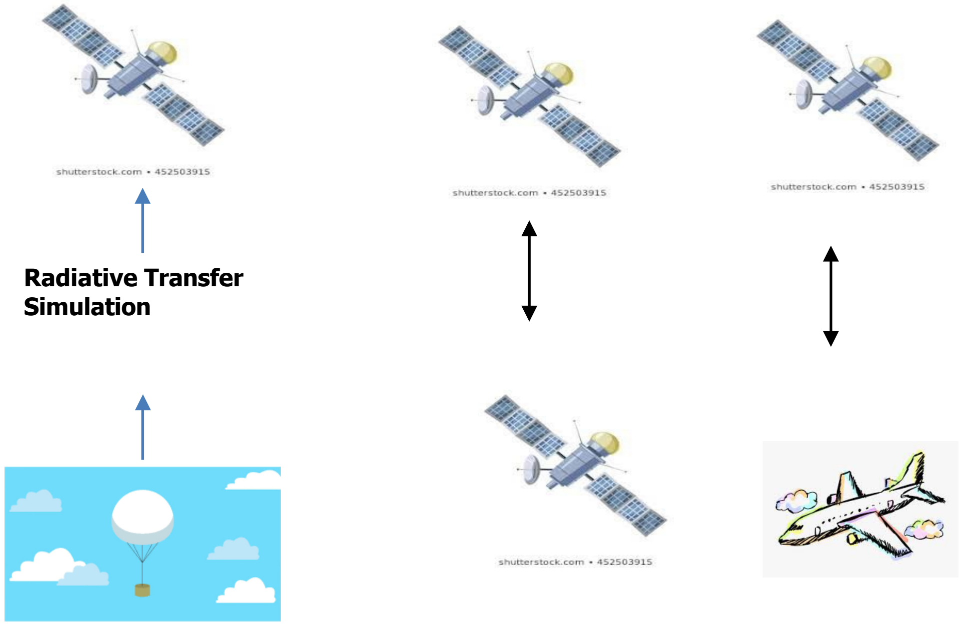
```
from datashader.colors import Sets1to3
from holoviews.streams import RangeXY
legend_dict = OrderedDict()
points = hv.Points(tsis_saod_heleo_df.sample(10000))

hv.extension('bokeh')
hv_obj = hv.opts(width=100, height=100)

soldatasets=['TSIS Ref_spectral','TSIS Uncertainity','Helio3','SAO2010 Ref Spectral','Helio1','Helio2',]
ccolors=['grey','green','orange','blue','red','purple']

color_key = {k: c for k, c in zip(soldatasets, ccolors[0:len(soldatasets)])}


lines={i: hv.Curve((tsis_saod_heleo_df['wavelength'].to_numpy(), tsis_saod_heleo_df[i].to_numpy()),'Wavelenght in nm', 'Irradiance').opts(fontscale=2, width=500, height=400, title='Solar Data Sets') for i in soldatasets}

linespread = dynspread(datashade(hv.NdOverlay(lines, kdims='k'), aggregator=ds.by('k', ds.count()),color_key=color_key))

#help(linespread)
for i in range(len(soldatasets)):
  c = soldatasets[i]
  legend_dict[c]=   hv.Points([0,0], label=c).opts(style=dict(color=color_key[c]) )

#linespread.opts(opts.RGB(width=1400,height=500))
dynamic = hv.util.Dynamic(hd.aggregate(points, width=13, height=13, streams=[RangeXY]),
                          operation=hv.QuadMesh) \
          .opts(tools=['hover'], alpha=0, hover_alpha=0.2)
#hover.tooltips = ['TSIS Ref_spectral','SAO2010 Ref Spectral','Helio1','Helio2','Helio3','TSIS Uncertainity']

(linespread*dynamic* hv.NdOverlay(legend_dict)).opts(width=1500,height=500).relabel("Solar Datasets")
```



Beyond Satellite-Satellite Inter-Calibration
Interoperability Platform [Inter-Compare Any two Observing Platforms]

The WMO Integrated Observing System (WIGOS) aims to integrate all the observing platforms and achieve interoperability.

- GSICS is now a component of the WIGOS System.
- GSICS should be interoperable with other Measuring platform of the WIGOS System

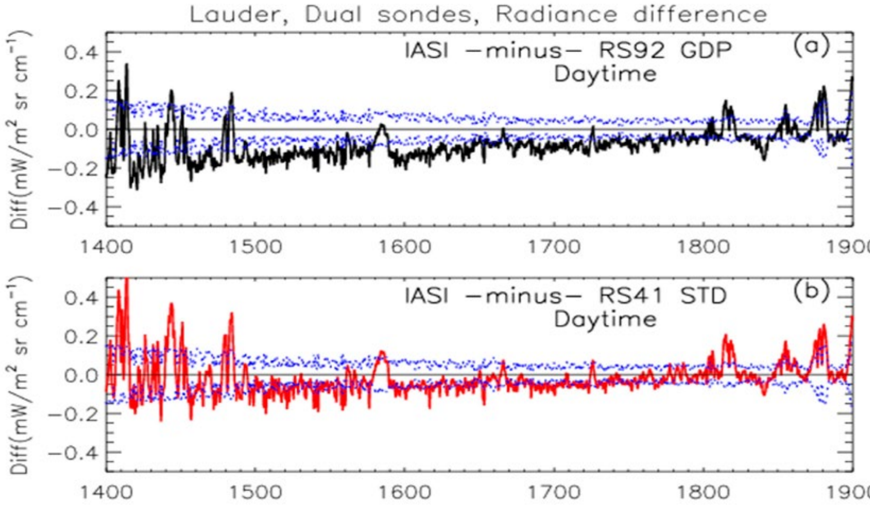


PyTROLL | Typhon 0.8.0dev | Satpy stable

ARTS The Atmospheric Radiative Transfer Simulator

1. Read in GTS/WIS data
2. Reads in most of Satellite L1 data formats (EPS, GVAR, HDF, NetCDF, AVHRR LAC/GAC/FRAC)
3. Capable of performing Radiative Transfer Model simulations in ***IR, VIS, MW*** shall be in UV (with limb simulation)
4. *Compare observing systems (Sat Vs Sat, Sat Vs Model, Sat Vs (Model+ Baloon), Satellites Vs Aircraft*

Modules SATPY+PYTROLL+PYGAC+TYPHON+CODA+MINICONDA+RT MODELS (ARTS, CRTM)



Reference: Sun, B.; Calbet, X.; Reale, A.; Schroeder, S.; Bali, M.; Smith, R.; Pettey, M. Accuracy of Vaisala RS41 and RS92 Upper Tropospheric Humidity Compared to Satellite Hyperspectral Infrared Measurements. *Remote Sens.* 2021, *13*, 173. https://doi.org/10.3390/rs13020173

UV / Vis / NIR Spectrometer Subgroup: Focused Activities

- Compare solar measurements from all of the instruments.
  - Example: The Working and Reference Diffuser System on the Ozone Mapping and Profiler Suite (OMPS) series of instruments are providing very good tracking of in-orbit degradation / brightening. Models of solar activity, wavelength shifts and wavelength dependent degradation explain measurements at the 0.1-% level,
- Compare Earth Radiances over targets.
  - Example: Monitoring of measurement residuals over a latitude / longitude box in the Equatorial Pacific provide confirmation of performance over the last 12 years.
- Compare by using forward models.
  - Example: Comparisons of initial residual for OMPS Nadir Profilers allowed the development of calibration adjustments to “homogenize” the Level 2 products from S-NPP and NOAA-20.

Slide Courtesy: Lawrence E Flynn/NOAA

OMPS Nadir Profiler Working Solar Measurements

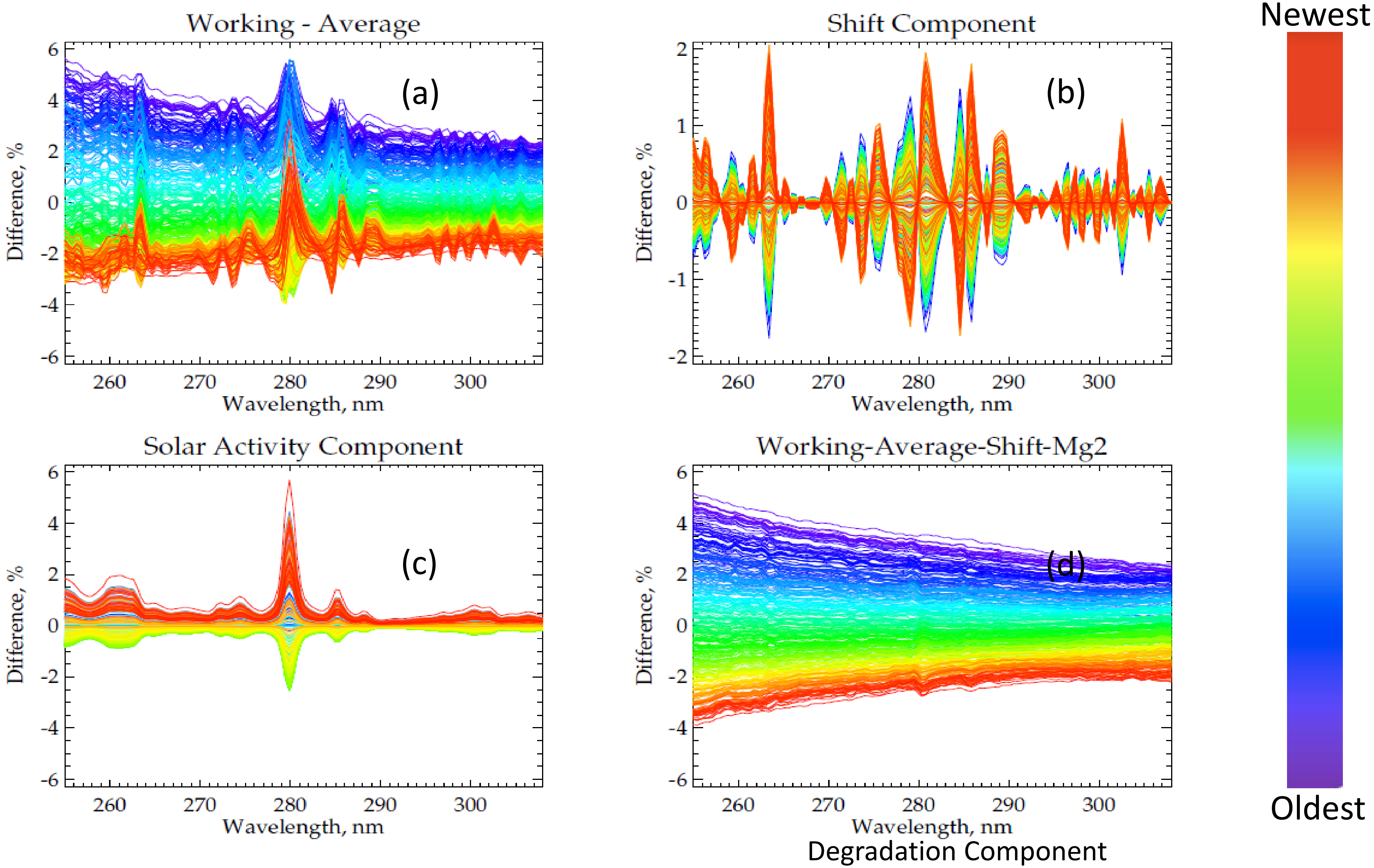
(a) 12 years of S-NPP OMPS NP bi-weekly Working Diffuser Soar measurements compared to their average.

(b) Wavelength Shift Patterns. Wavelength shifts track optical bench annual thermal variations.

(c) Solar Activity Patterns. Patterns are Mg II scale factors and track Solar activity.

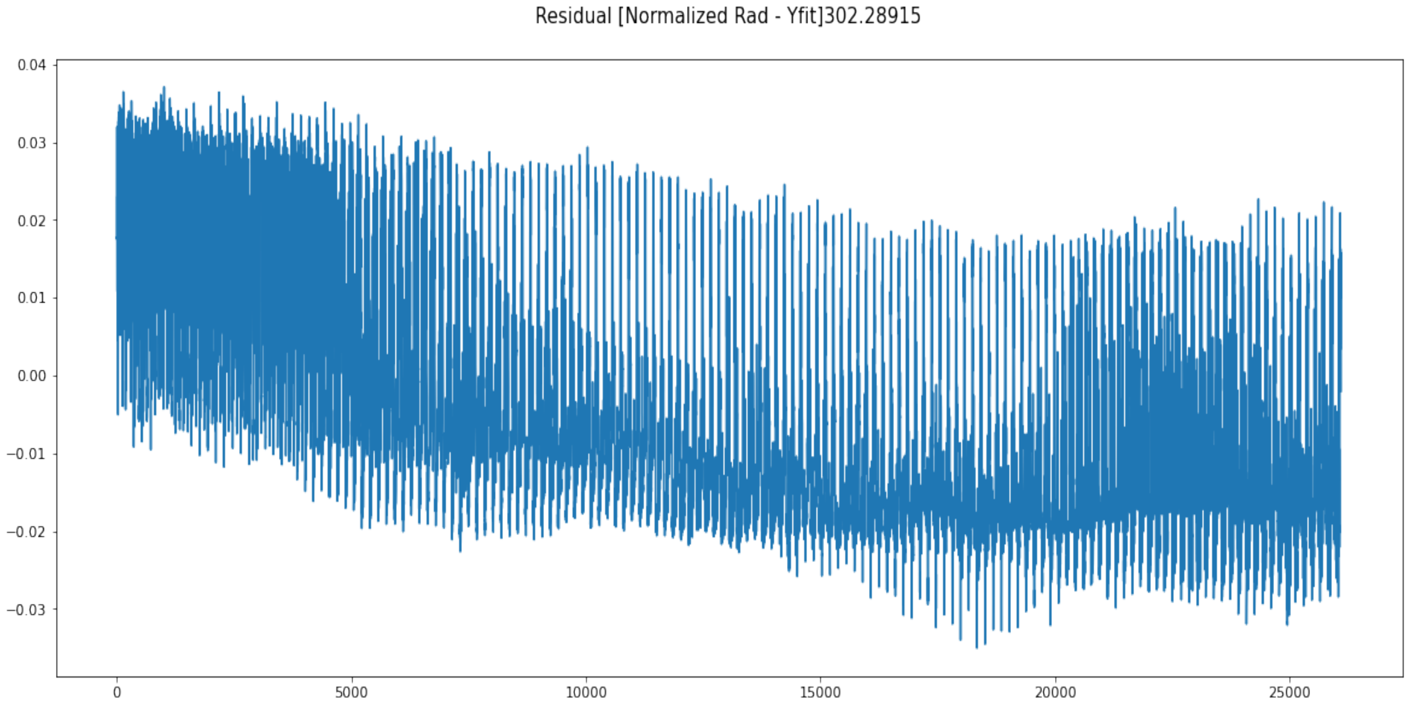
(d) Differences after subtracting the shift and activity patterns. This shows the combined degradation of the working diffuser and the instrument's optical throughput.

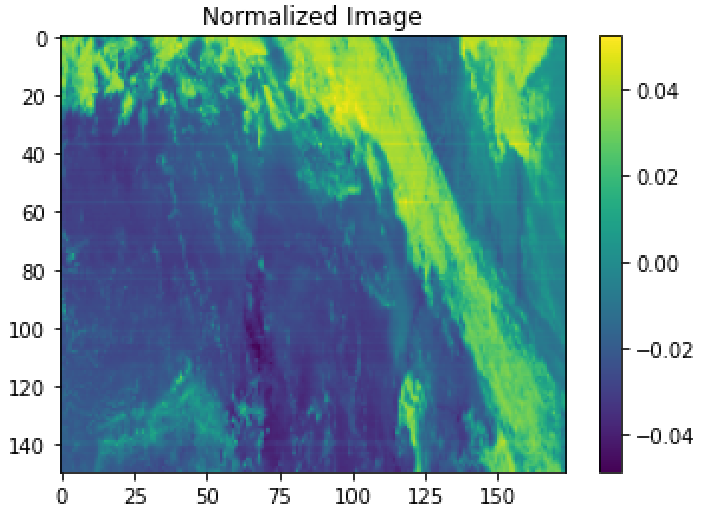
Note: The working diffuser's exposure is 26 times the reference exposure for used annually.

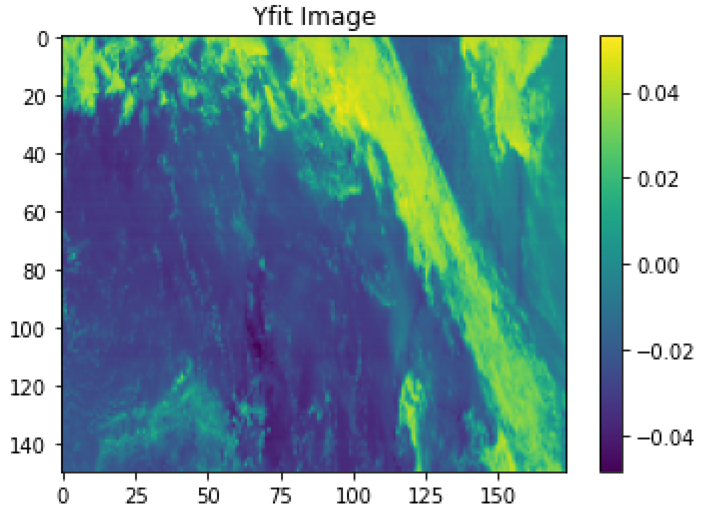


New opportunities for GEO / LEO Comparisons

A Principle Component Analysis of The Geostationary Environment Monitoring Spectrometer (GEMS) measurements was used to reveal the main features of the GEMS data and reconstruct the test images. This analysis will be extended to the recently launched TEMPO data. Comparisons of under-flights by LEO instruments has begun.







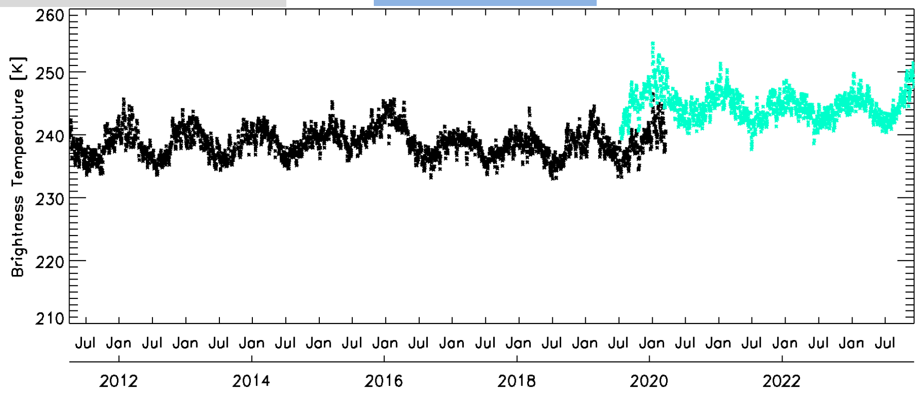
Recalibration and CDR

- Using the GSICS GEO-LEO IR algorithm to recalibrate KMA COMS/MI and GK2A/AMI
  - Euidong Hwang (KMA)
  - COMS : 2011.04. ~ 2020.03., GK2A: 2019.07. ~
  - Re-calibration results show stability and consistency.

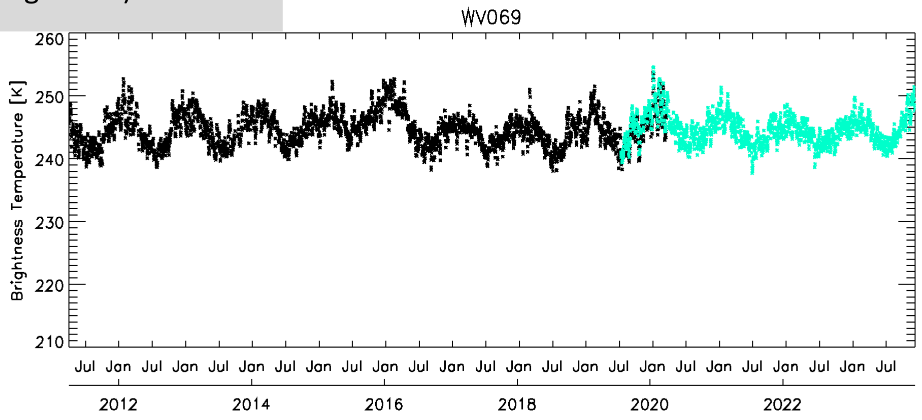
- The efforts has been made to bridge the SSU and hyperspectral sounders extend climate data records for stratospheric temperature monitoring
  - Likun Wang (UMD)
  - A method is being developed to convert AIRS hyperspectral data into equivalent SSU observations.

Original TB

WV069



Recalibrated TB
(Applying SBAFs)

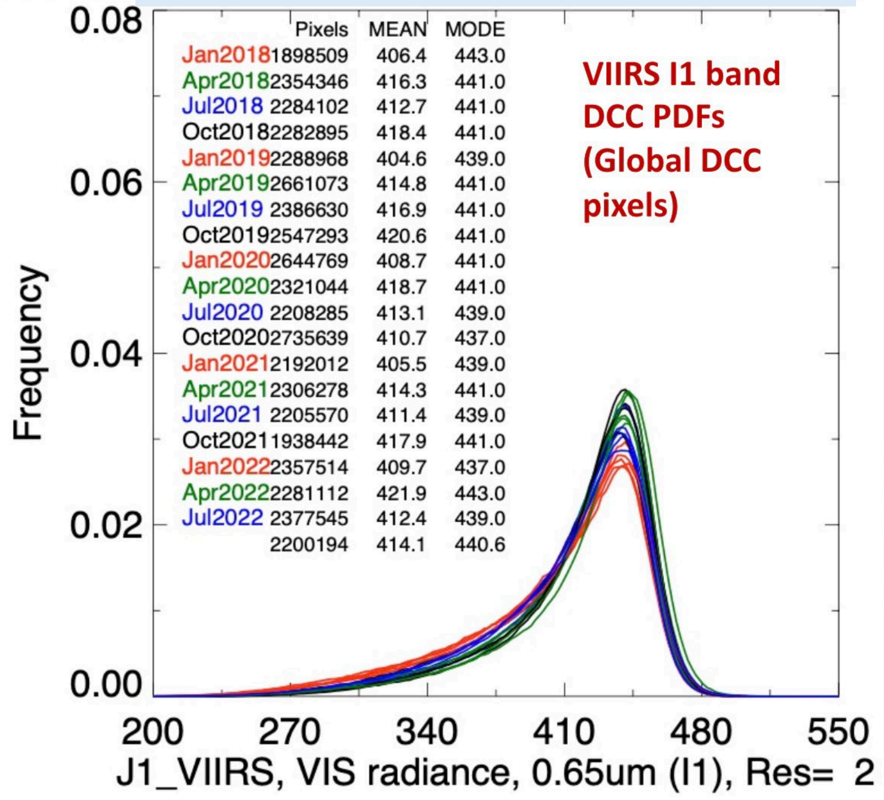


Slide Courtesy : Euidong Hwang, KMA/NMSC

GSICS VIS/NIR VIIRS/GEO DCC intercalibration

- The GSICS VIS/NIR reference instrument is NOAA-20 VIIRS
- The GSICS/CEOS recommended solar spectra is the TSIS-1 HSRS
- Use DCC to transfer the N20-VIIRS to the GEO imagers
  - Brightest, Near Lambertian, top of atmosphere targets, identified by cold BT
- Identify VIIRS and GEO imager deep convective cloud (DCC) pixels
  - <205K, svis<3%, sIR <1K, SZA < 40°, VZA < 40°, 10° < RAA < 170°
- Apply DCC BRDF to convert reflectance to a common angle condition
  - Hu Model for bands<1µm, and monthly regional band specific for bands>1µm
- Compile DCC pixel reflectances into monthly probability distribution functions (PDF) and compute mean and mode

N20 VIIRS I1 (0.65µm) DCC PDFs



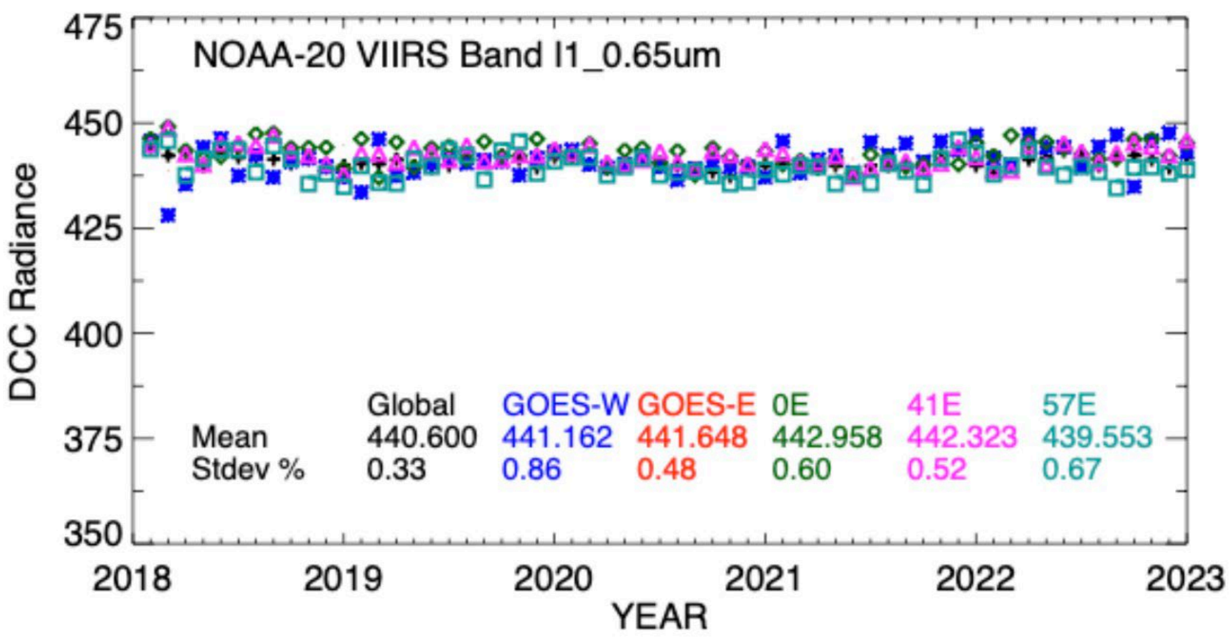
Note the consistency between the monthly PDFs

Slide Courtesy: Dave Doelling/NASA

GSICS VIS/NIR VIIRS/GEO DCC intercalibration

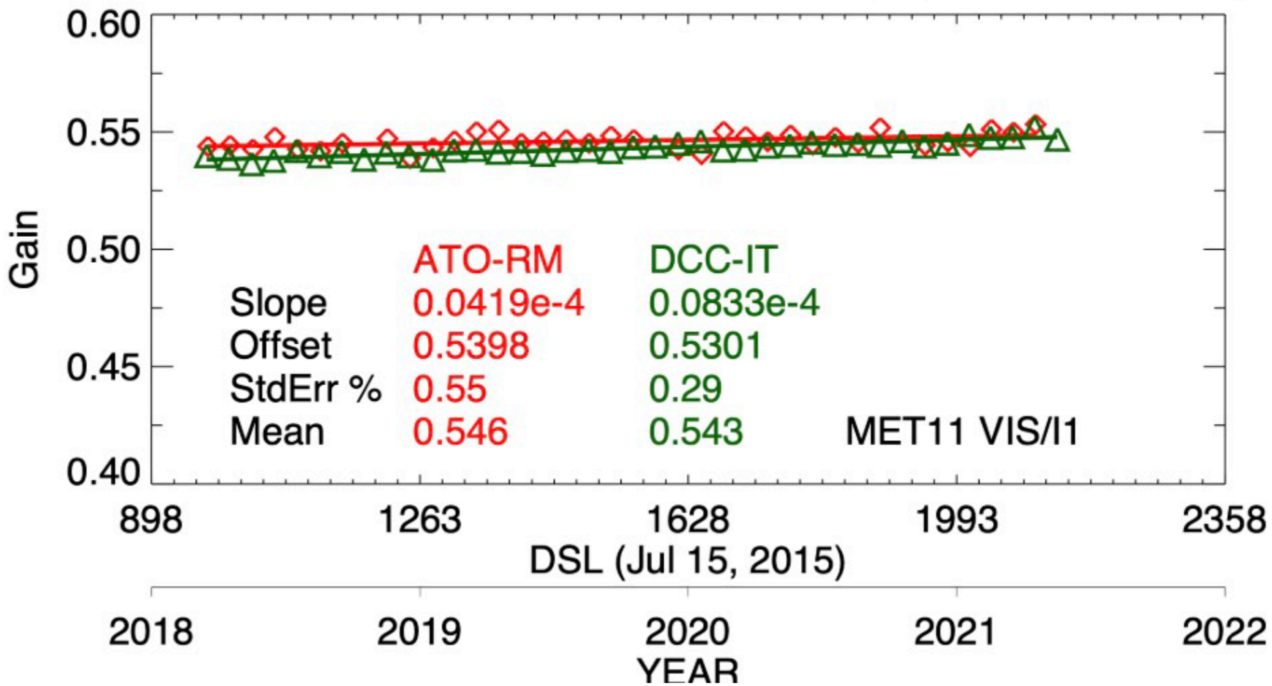
- The GEO imager and the NOAA-20 VIIRS PDF modes should be equal
  - account for the spectral response function differences, using SBAF tool
- The GEO image mean count and N20 PDF mode radiance is the calibration coefficient

The N20-I1 VIIRS DCC reference GEO domain radiance



Note the DCC brightness changes slightly by GEO domain

Met-11 0.65µm gain using DCC and ray-matching

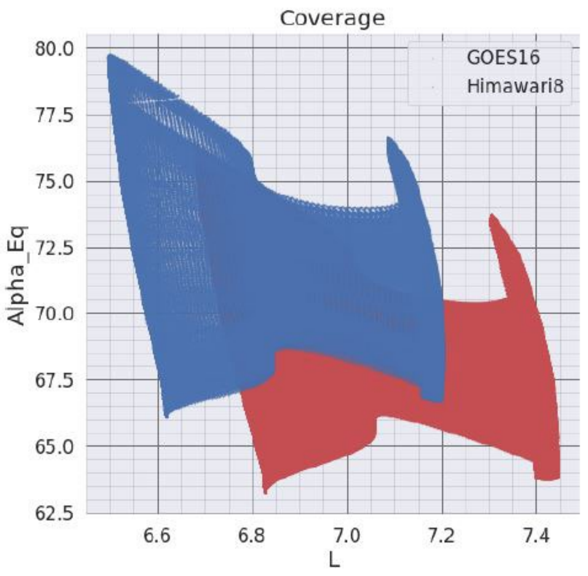


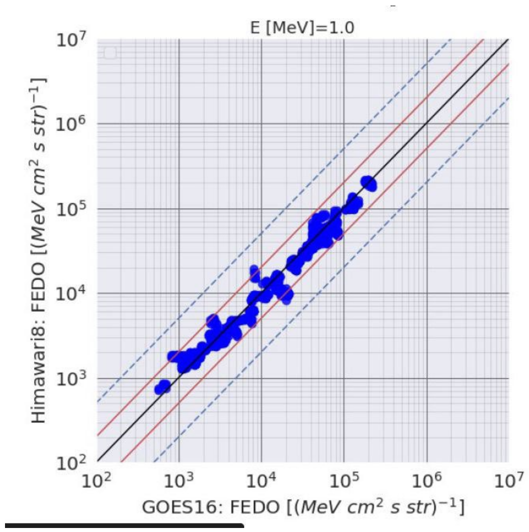
Note how similar the gains track between the methods

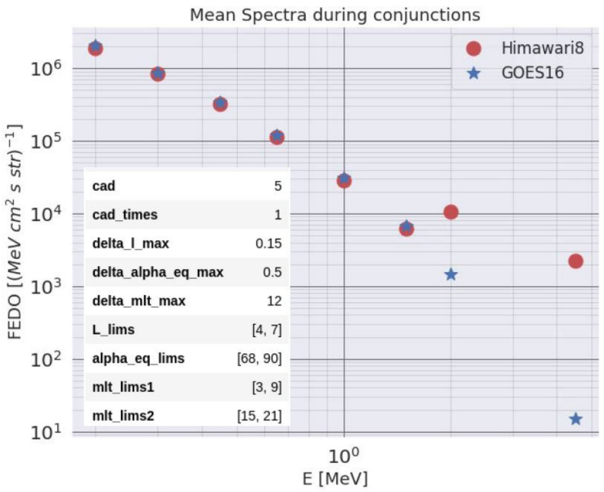
Slide Courtesy: Dave Doelling/NASA

GSICS GRWG space weather

- Currently, importance of space weather observation is growing. Because implementing space-based SWx observation to the operational space weather forecast model and application is essential, cross-calibration of the space weather sensor is necessary. Based on this background, space weather sub-group is established in GSICS GRWG since 2023.
- Because high energy particle observation in GEO is "**in-situ**" observation, it is difficult to realize the absolute measurement using the same reference, and the physical conjunction between individual satellites.
- We use "**magnetic conjunction (L^*, α_{eq})**" approach for cross-calibration of high energy particle sensor. We try to follow the standard data analysis procedure written by COSPAR/PRBEM. But there are several problems to be solved to apply this document for our cross-calibration.



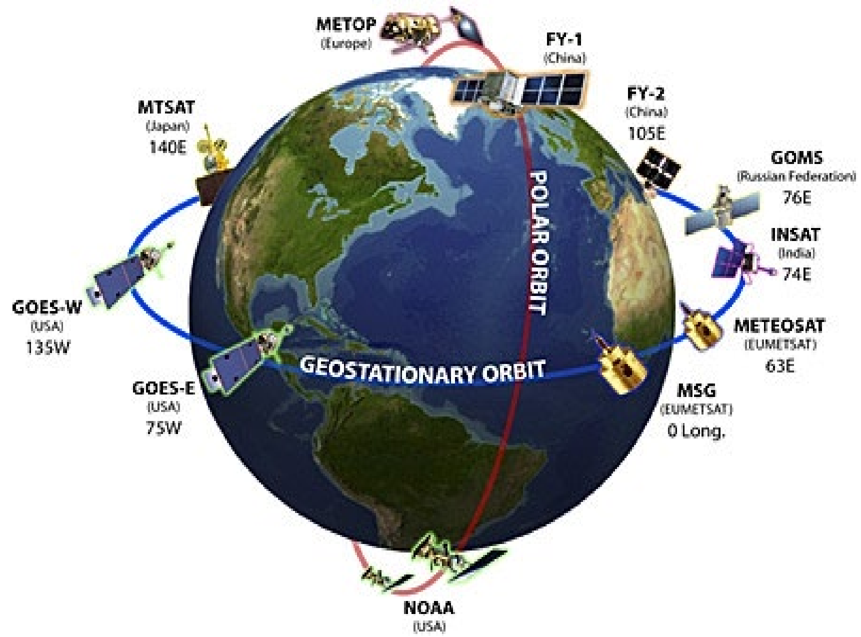




Special Issue On Space Weather of GSICS Newsletter planned for September 2024

Slide Courtesy: Tsutomu Nagatsuma

GSICS State of Observing System (SOS) at your finger tips



… and Many More….

State of Observing System [2023]
Mean Monitored Instrument - IASI-B Bias (K)

	3.8±.02µm	6.2±.02µm	6.95±.02µm	7.3±.02µm	8.7±.2µm	9.6±.02µm	10.7±.2µm	11.9±.3µm	12.3±.02µm	13.3±.02µm
MSG2 SEVIRI	0.490	-0.141	X	0.062	-0.047	-0.184	-0.007	-0.034	X	-0.903
MSG3 SEVIRI	0.570	-0.211	X	0.083	-0.064	-0.004	0.024	-0.013	X	-0.722
MSG4 SEVIRI	0.024	-0.099	X	0.168	0.084	0.117	0.082	-0.080	X	-0.405
Himawari-9 AHI	-0.006	-0.192	0.004	-0.131	-0.101	-0.227	-0.070	-0.082	-0.105	-0.193
GK2A	0.289	-0.018	-0.201	-0.040	0.116	-0.074	0.182	0.181	0.147	0.047

Temperature (K): 0.4, 0.2, 0.0, −0.2, −0.4, −0.6, −0.8

State of Observing System [2023]
Mean Drift (K/Yr)

	3.8±.02µm	6.2±.02µm	6.95±.02µm	7.3±.02µm	8.7±.2µm	9.6±.02µm	10.7±.2µm	11.9±.3µm	12.3±.02µm	13.3±.02µm
MSG2 SEVIRI	-0.067	-0.145	X	-0.166	-0.065	-0.193	-0.083	-0.079	X	-0.235
MSG3 SEVIRI	0.119	0.046	X	0.048	0.019	-0.014	-0.001	0.056	X	-0.001
MSG4 SEVIRI	-0.060	-0.148	X	-0.143	0.154	-0.034	-0.019	-0.062	X	-0.410
Himawari-9 AHI	0.017	-0.009	-0.000	-0.053	0.019	0.024	0.024	0.027	0.016	0.016
GK2A	-0.010	0.012	-0.006	-0.009	-0.012	0.039	0.049	0.040	0.028	0.019

Drift (K/Year): 0.1, 0.0, −0.1, −0.2, −0.3, −0.4

Click here to get code and latest State of Observing System

GSICS Newsletter

- Each year we publish four Issues of the GSICS Newsletter.
- Newsletter article are focused on Satellite Calibration (Pre-Launch Post Launch)
- Over 400 subscribers
- Access link https://www.star.nesdis.noaa.gov/smcd/GCC/newsletters.php
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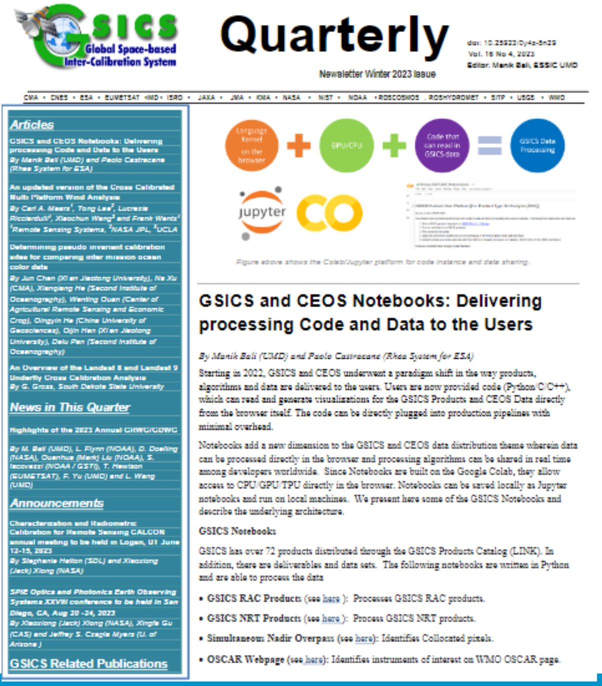
  Send an e-mail to **gccnewsletter-subscribe@list.woc.noaa.gov** with the word **'subscribe'** in the subject line

To contribute contact Editor Newsletter

Can we have a CALCON Special issue ?


GSICS Quarterly
Newsletter Winter 2023 Issue
Vol. 16 No 4, 2023
Editor: Manik Bali, ESSIC UMD

Articles
GSICS and CEOS Notebooks: Delivering processing Code and Data to the Users
News in This Quarter
Announcements
GSICS Related Publications

GSICS and CEOS Notebooks: Delivering processing Code and Data to the Users

By Manik Bali (UMD) and Paolo Castracane (Rhea System for ESA)

Starting in 2022, GSICS and CEOS underwent a paradigm shift in the way products, algorithms and data are delivered to the users. Users are now provided code (Python/C/C++), which can read and generate visualizations for the GSICS Products and CEOS Data directly from the browser itself.


GSICS Quarterly
Newsletter Spring 2023 Issue
Vol. 17 No 1, 2023
Editor: Manik Bali, ESSIC UMD

Articles
News in This Quarter
Announcements
GSICS Related Publications

The GeoSTAR Geostationary Microwave Sounder

By Bjorn Lambrigtsen, Jet Propulsion Laboratory & California Institute of Technology

A geostationary microwave sounder, capable of providing continuous all-weather monitoring of temperature, water vapor, clouds, precipitation, and wind, would add tremendously to our ability to observe and predict dynamic atmospheric phenomena, such as hurricanes and severe storms, monsoonal moisture flow, atmospheric rivers, etc. Such a sensor is now feasible, enabled by technology that has been developed at the Jet Propulsion Laboratory (JPL).


GSICS Quarterly
Newsletter Summer 2023 Issue
Vol. 17 No 2, 2023
Editor: Manik Bali, ESSIC UMD

Articles
News in This Quarter
Announcements
GSICS Related Publications

Simulation of CrIS Radiances Accounting for Realistic Properties of the Instrument Responsivity That Result in Spectral Ringing Features

Recently, an article was published in Remote Sensing in 2023 [1] which provides a procedure for the simulation of radiances from the NOAA Cross-track Infrared Sounder (CrIS) Fourier Transform Spectrometer (FTS) to include spectral ringing effects caused by the finite-band, non-flat instrument spectral response to the incident radiation.


GSICS Quarterly
Newsletter– Fall 2023 Issue
Vol. 17 No 3, 2023
Guest Editor: Peng Zhang (CMA)

Special Issue on CMA
Articles
News in This Quarter
Announcements
GSICS Related Publications

Introduction on Chinese remote sensing satellites

By Chengli Qi, Ling Sun and Peng Zhang, (NSMC/CMA)

In the past few decades, China's space remote sensing technology has shown explosive development. Up to now, there are more than 60 civilian earth observation satellites in orbit, forming several Earth observation satellite series such as Fengyun, Haiyang, Ziyuan, Gaofen, Yaogan and Tianhui, which provide satellite remote sensing application services for meteorological and Marine monitoring and forecast, disaster prevention and reduction, resource exploration and mapping in China and around the world

Summary

- The Global Space Based Inter-Calibration System has created a framework to monitor in-orbit instruments.
- We have developed next generation platforms for sharing algorithms, data and build on them collaboratively.
- GSICS monitoring has helped identify anomalies, correct them and generate high quality reprocessed data.
- Cross calibration of Space Weather instruments has given new insights/causes of identifying instrument anomalies.
- New algorithms are being build that exploit Lunar viewing, account for calibration Non-linearity and also account for off nadir biases to give a full spectrum of instrument biases.

Multiple ways GSICS can work with CALCON Community: Share algorithms, data sets, joint meetings, Newsletter …

Summary of links to GSICS pages and tools

1. GGSICS Product Catalog: https://www.star.nesdis.noaa.gov/smcd/GCC/ProductCatalog.php
2. GSICS WIKI http://gsics.atmos.umd.edu/wiki/Home
3. GSICS Google Group https://groups.google.com/g/gsics-dev
4. GSICS Newsletter: Send an e-mail to gccnewsletter-subscribe@list.woc.noaa.gov
5. GSICS Product Status registration: Register here
6. Bash script to download GSICS Data http://gsics.atmos.umd.edu/bin/view/Development/DownloadGSICSProducts
7. Series of notebooks to read, view and process GSICS Data and Deliverables from the browser in a collaborative ecosystem
    - DCC Product notebook
        - This notebook reads DCC products and plots and lists them
    - GIRO SRF notebook
    - GSICS Product RAC notebook and NRT notebook

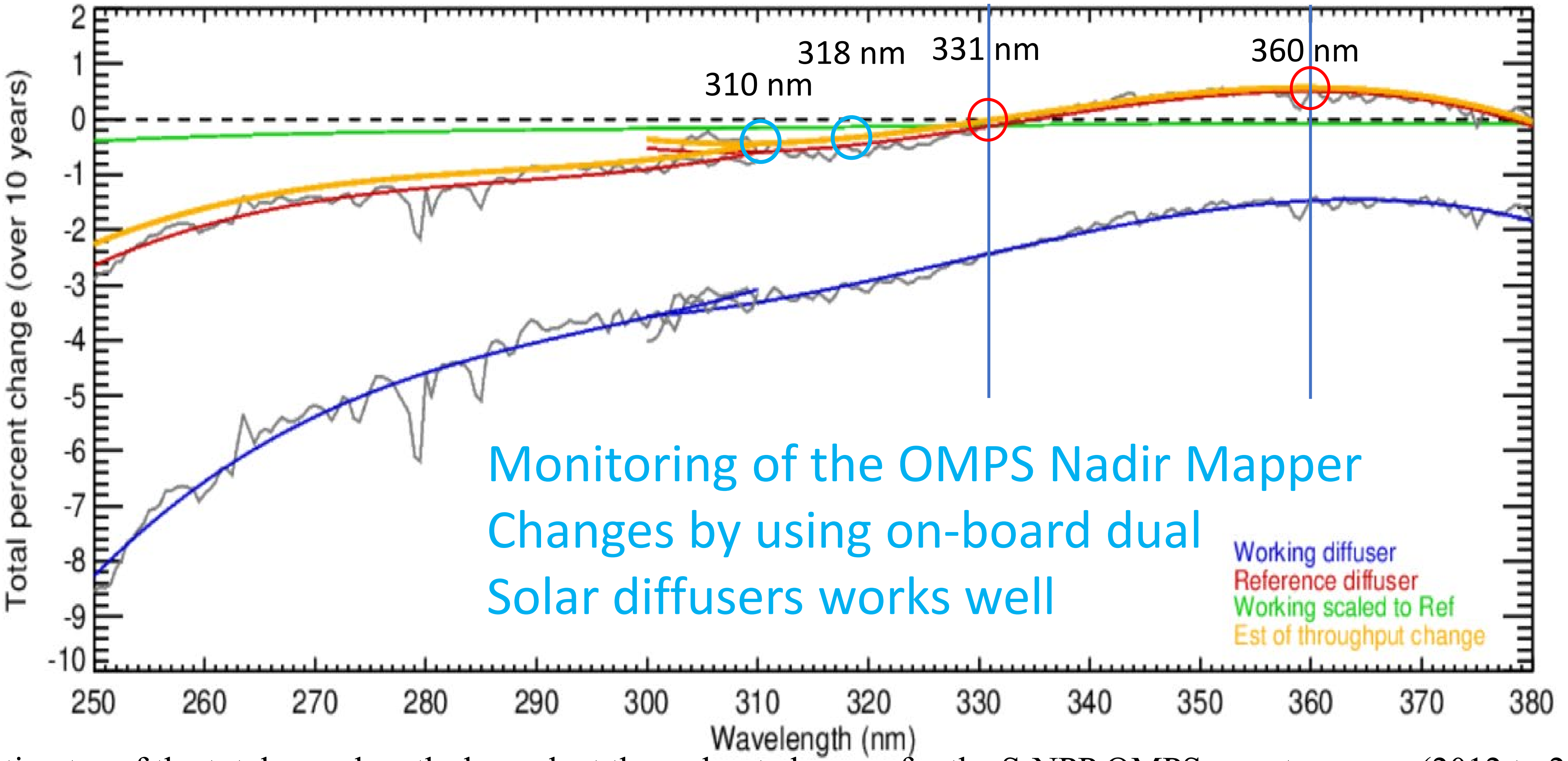
8. Plotting Tool http://gsics.tools.eumetsat.int/plotter

9. Tools have been built to achieve platform inter-operability

10. Inter-operability platform (multiple satellite formats, acquisition platforms) has been established at University of Maryland

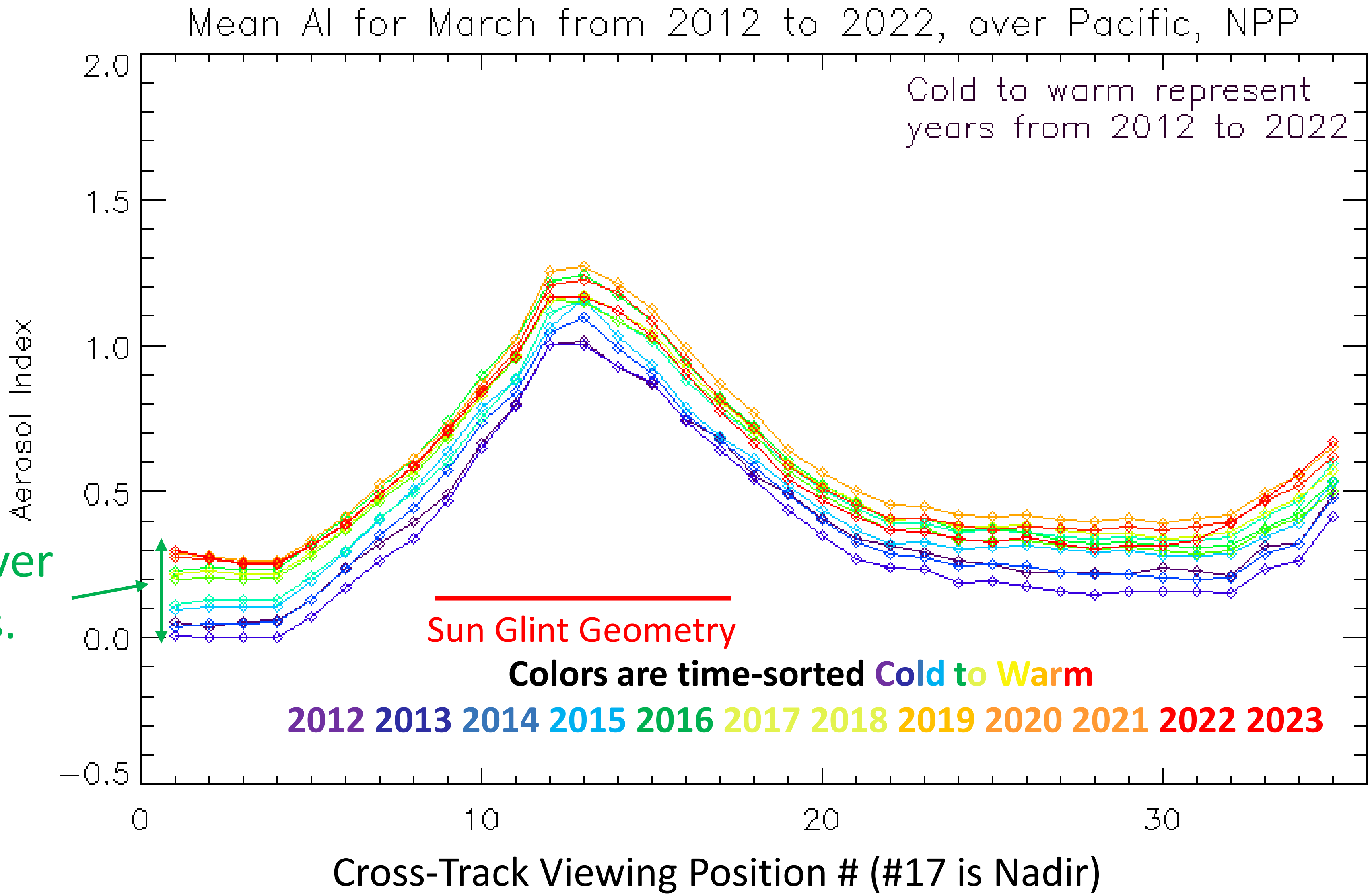
Members are welcome to use the tools build by GSICS

THANK YOU



Relative trend over 11 years for 360 nm versus 331 nm.

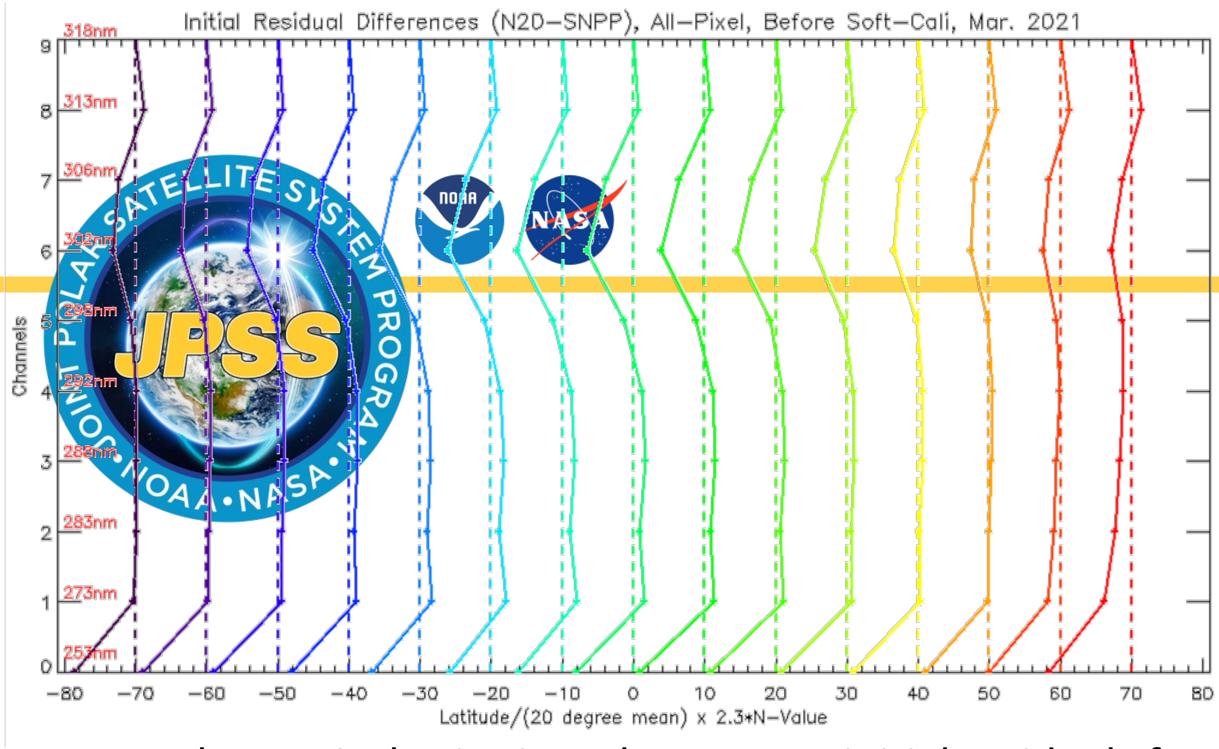
Estimates of the total wavelength-dependent throughput changes for the S-NPP OMPS over ten years (2012 to 2022). The blue curve is from linear fits of the changes of the bi-weekly solar measurements from the working diffuser. The red curve is from linear fits of the changes of the annual solar measurements from the reference diffuser. The green curve is a scaling of the blue curve accounting for the difference in exposure frequency for the reference versus the working diffusers. The orange curve is the red curve minus the green curve. It gives an estimate of the throughput degradation for the shared optical path for the radiance measurements. Notice that the instrument throughput changes for the OMPS NM (300 nm to 380 nm) are well within the +-1% level. (This figure was created and provided by Colin Seftor of SSAI for the NASA GSFC Ozone Team.)



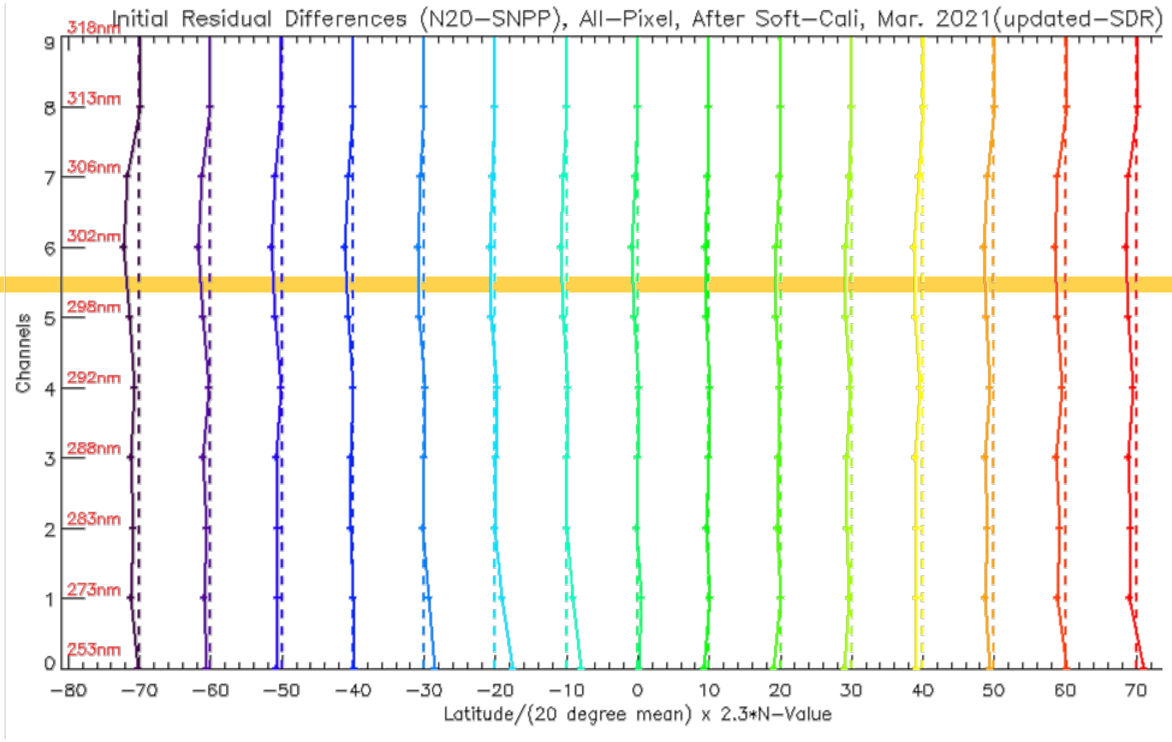
UV Aerosol Index 331/360 nm Pair

Cross-track dependence over the Equatorial Pacific of the Aerosol Index for S-NPP for March for 11 years Cold to Warm. The cross-track pattern for the Aerosol Index is also very stable year-after-year and the absolute values are stable at the 0.4 level. The figure on Slide 7 show (two ◯'s) a trend in the instrument throughput for the 360 nm channel relative to 331 nm which has not been adjusted in any calibration, so some time dependence in this figure is not unexpected.

Global Zonal Mean Comparison of Initial Residuals between NPP and N20 before Soft Calibration



Global Zonal Mean Comparison of Initial Residuals between NPP and N20 after Soft Calibration



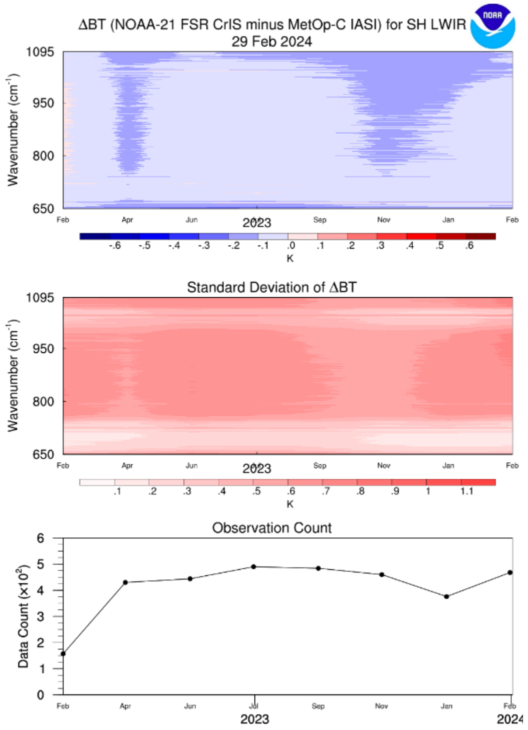
The vertical axis gives the average initial residuals for each channel from short to long. The zero lines for each latitude are at the latitude on horizontal axis. The units relative to the zero line give the residual differences in %.

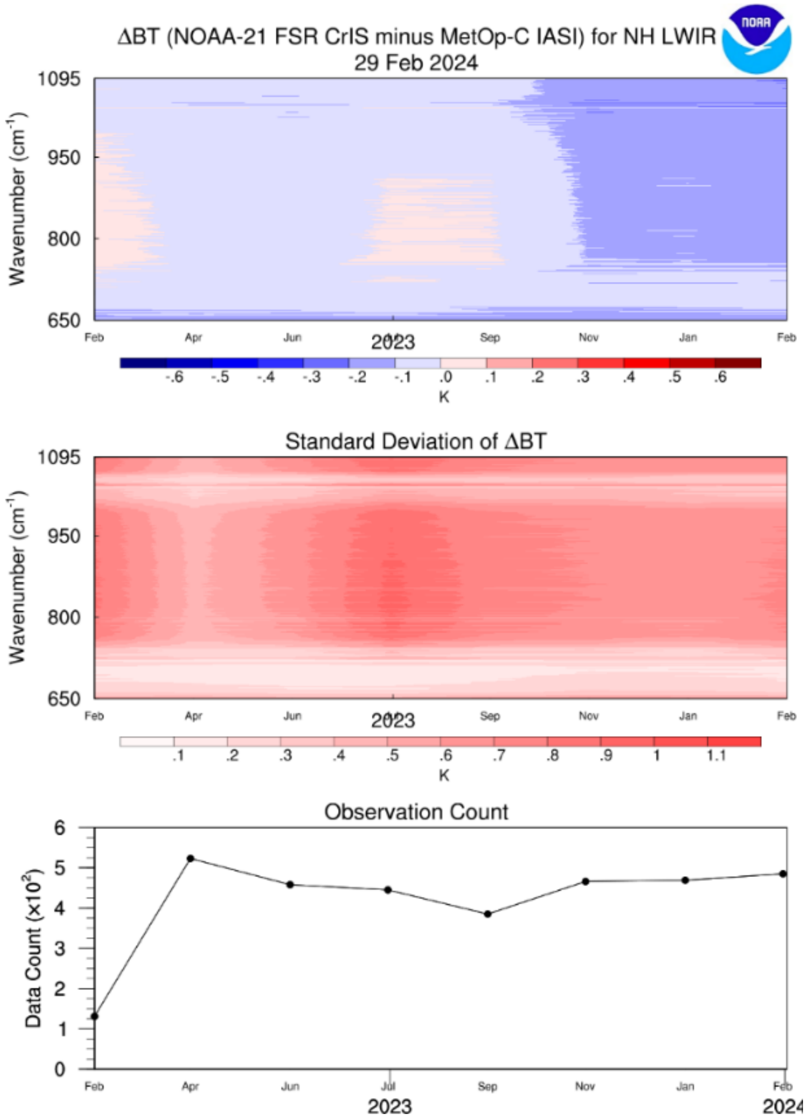
The Initial Measurement Residuals from the Version 8 Ozone Profile retrieval algorithm applied to the S-NPP and NOAA-20 Ozone Mapping and Profiler Suites (OMPS) for March 2021 averaged 20-degree latitude bands are used to compare the radiance / irradiance ratios at ten channels from 253 nm to 318 nm. The relative biases for the Equatorial latitudes in the figure on the left are used to estimate ten adjustments to the NOAA-20 calibration for use globally. After applying this set of adjustments, the results on the right show that there is good agreement globally.

Model and Components for Solar Measurements

- Solar Activity Patterns (Scale Factors Relative to Mg II Index)
  - From bi-weeky working solar measurements (Up-Down-Up in Mg II Index)
  - From TSIS-1 HSRS daily solar pattern convolved with the instrument bandpass.
  - From PCA analysis of the solar record try to recognize the solar activity components.
- Wavelength Shift Pattern
  - From synthetic spectra with a range of shifts using the TSIS-1 HSRS and the bandpass
    - The relative shifts can be fit with a quadratic at each wavelength center.
    - Synthetic shift patterns do not account for pixel-based calibration gradients.
  - From centered differences using the measured spectra.
    - $Shift(wi) = [[Irrad(w_{i+1})-Irrad(w_{i-1})]/Irrad(w_i)]/[w_{i+1} - w_{i-1}]$
  - From PCA analysis.
- Degradation
  - Diffuser Degradation Linear or exponential in exposure time
  - Smooth functions of wavelength
  - Instrument throughput degradation
  - Assumption: Degradation rates per exposure for working and reference are equal.
- Bandpass and Wavelength Complications
- Mg II Indices and other information from Earth Radiances. (ICVS Link)

GSICS Reference: CrIS Vs IASI





GOES VS IASI inter-calibration