GSICS Products and Tools for scientific applications

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GSICS Coordination Center

Contents

- Introduction
- GSICS Monitoring Products
- GSICS Deliverables
- What are GSICS Notebook
  - Notebook for applying GSICS Corrections
  - Notebook for identifying collocated pixels
  - Notebook for comparing Solar Data Sets
- GSICS Inter-operability platform
- Conclusion and Summary of GSICS tools

GSICS Global Space-based Inter-Calibration System

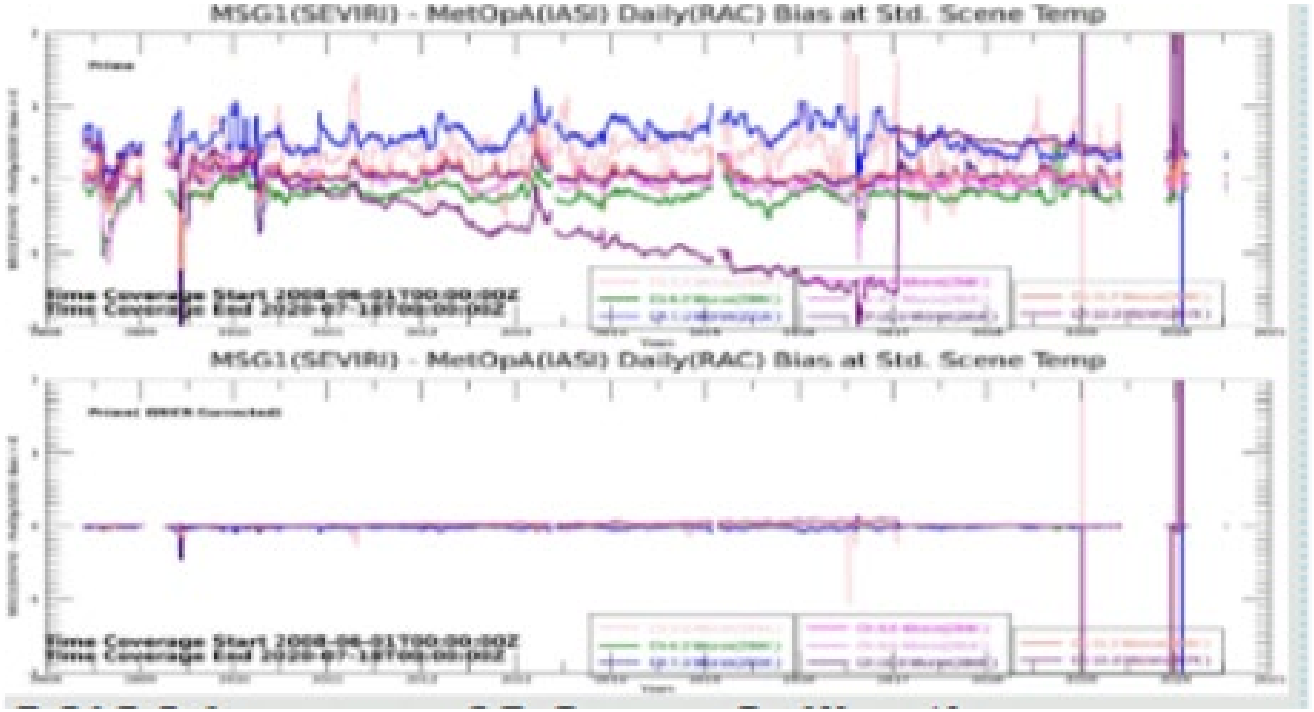
Introduction

Global Space Based Inter-Calibration System (GSICS) is a consortium of Satellite agencies that have come together for monitoring in-orbit satellites , document biases and build algorithms to correct them

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

GSICS Monitoring Products

https://www.star.nesdis.noaa.gov/smcd/GCC/ProductCatalog.php



- GSICS RAC Product Notebook
- GSICS NRT Product Notebook

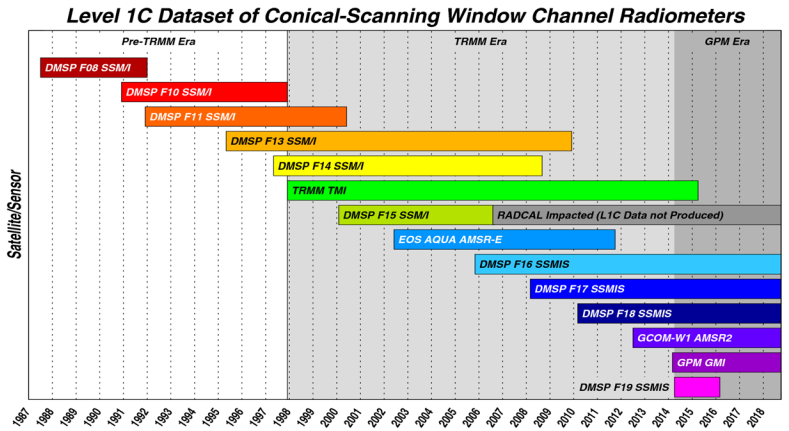
Metosat, GOES, MTSAT, COMS ISRO and AVHRR Series [ISCCP, GEO-RING]

Code can read inter-calibration coefficients and use them For correcting biases

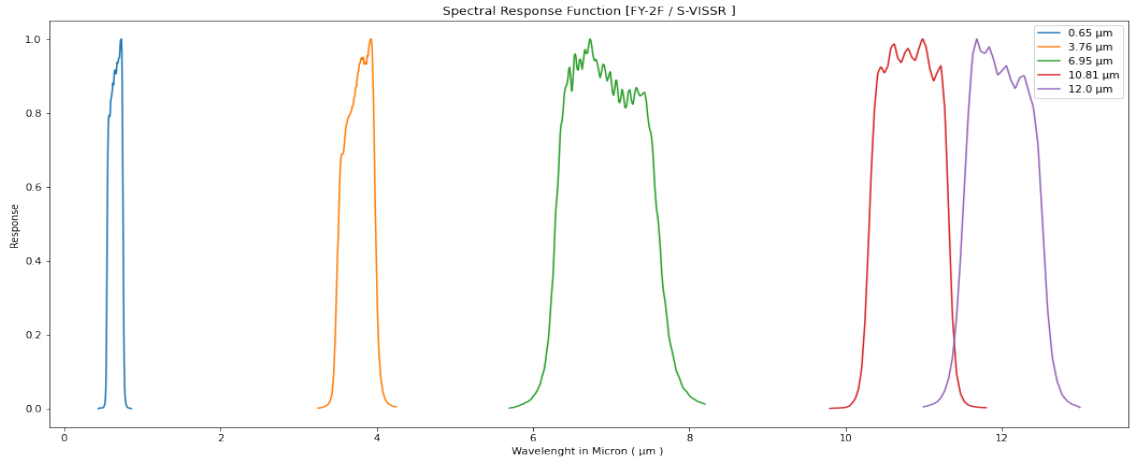
GSICS Deliverables

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

GPMX Tables



Spectral Response Functions



IASI Hyperspectral Radiance

Catalog http://gsics.eumetsat.int/thredds/catalog/metopb-iasi/catalog.html

Dataset	Size	Last Modified
MetOpB IASI Instrument		--
W_XX-EUMETSAT-Darmstadt,HYPERSPECT+SOUNDING,MetOpB+IASI_C_EUMP_20230315225519_54430_eps_o_l1.nc	286.5 Mbytes	2023-03-16T08:22:18.218Z
W_XX-EUMETSAT-Darmstadt,HYPERSPECT+SOUNDING,MetOpB+IASI_C_EUMP_20230315193223_54428_eps_o_l1.nc	296.9 Mbytes	2023-03-16T08:16:25.376Z
W_XX-EUMETSAT-Darmstadt,HYPERSPECT+SOUNDING,MetOpB+IASI_C_EUMP_20230314231607_54416_eps_o_l1.nc	284.4 Mbytes	2023-03-15T02:57:53.015Z
W_XX-EUMETSAT-Darmstadt,HYPERSPECT+SOUNDING,MetOpB+IASI_C_EUMP_20230314195327_54414_eps_o_l1.nc	290.7 Mbytes	2023-03-14T22:47:30.719Z
W_XX-EUMETSAT-Darmstadt,HYPERSPECT+SOUNDING,MetOpB+IASI_C_EUMP_20230313233703_54402_eps_o_l1.nc	280.2 Mbytes	2023-03-14T02:28:30.401Z

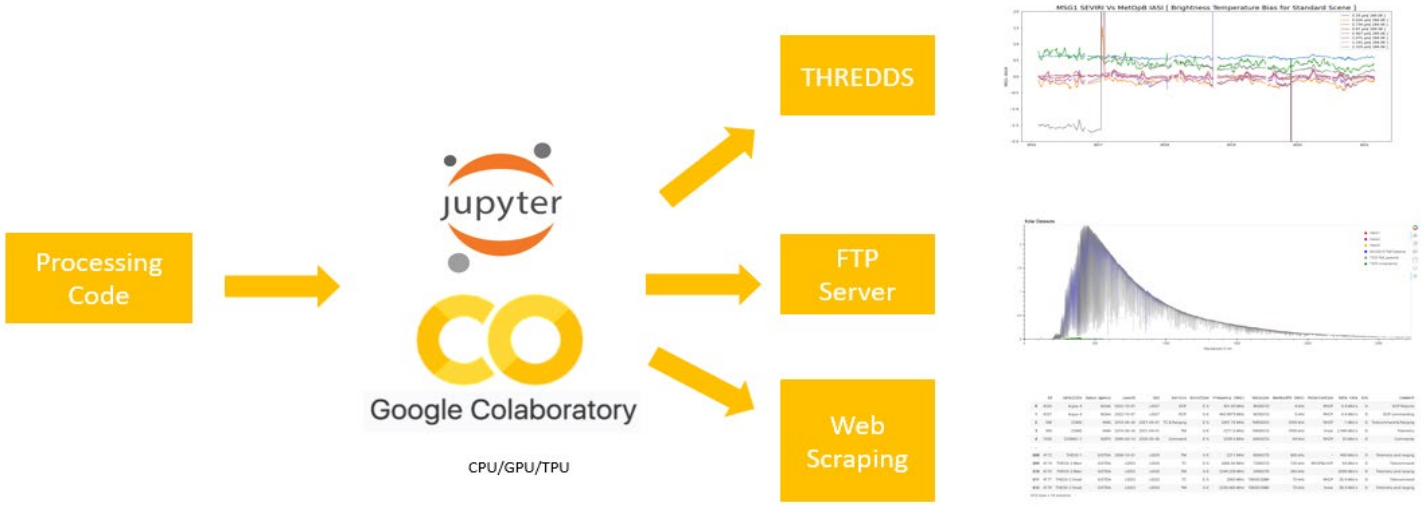
Global Space-based Inter-Calibration System

GSICS Notebooks

Google Colab for GSICS

GSICS has developed read and inter-comparison tools on Google Colab. This allows us 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.



Notebook for Comparing Data Sets

Solar spectrum data have wide applications

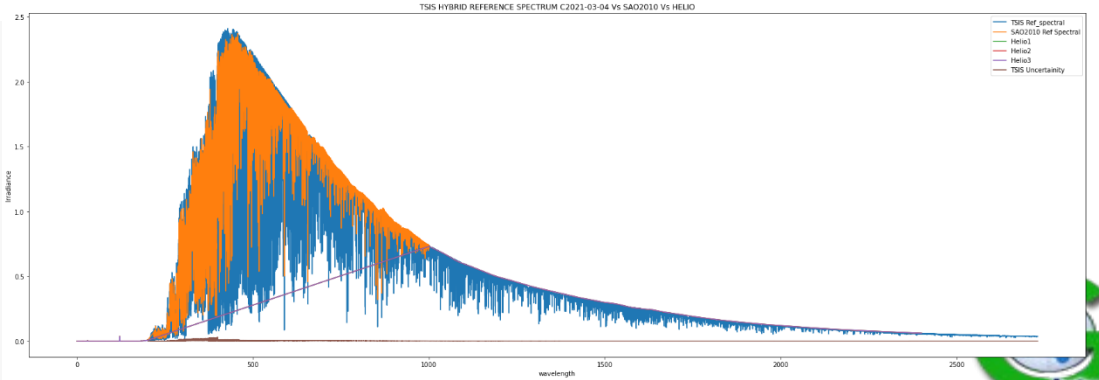
- It is used to convert measured satellite radiance to reflectance
- It is used as upper boundary condition in radiative transfer models
- Instruments such as GEMS, OMPS use solar absorption lines for wavelength calibration
- Also use the Sun for radiometric stability monitoring, which requires a baseline solar spectrum to quantify instrumental changes
- Instruments that monitor radiometric calibration stability relative to the moon indirectly rely on a solar reference spectrum to convert lunar radiance to reflectance using,
- Solar reference spectra also constrain solar irradiance variability models which climate models use to specify solar forcing of climate

Code can read Solar Data sets from multiple sources and compare them

- SAO2010 Data set
- HELIO 1/2/3 Data Set
- TSIS-1 *HSRS*

GSICS Solar Notebook

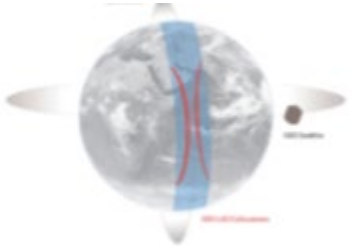
```
from datashader.colors import Set1to3
from holoviews.streams import RangeXY
legend_dict = OrderedDict()
points = hv.Points(tsis_saod_heleo_df.sample(10000))

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")
```



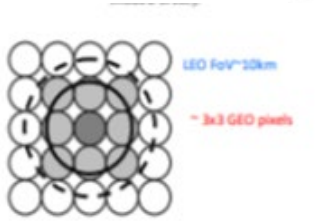
Notebook for identifying Collocated Pixels

Simultaneous Nadir Overpass

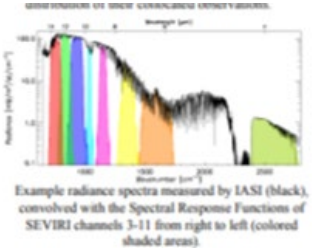
Simultaneous near-Nadir Overpasses of GEO imager and LEO sounder.
Select Collocations:
Spatial, temporal and geometric thresholds.



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



ctral Convolution:
volve LEO Radiance
ctra with GEO Spectral
ponse Functions to
hesise radiance in GEO
nels.



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).

Image Curtsey : Tim Hewison, EUMETSAT

Click Notebook here to see
Convolution Code
Simultaneous Nadir Overpass

```
for idx in range(0,len(overlap[1][:])):
            idx1=(overlap[0][idx] < lon1) &(  lon1< overlap[0][idx]+1 )& (overlap[1][idx] < lat1) &(  lat1< overlap[1][idx]+1 )
            idx2=(overlap[0][idx] < lon2) &(  lon2< overlap[0][idx]+1 )& (overlap[1][idx] < lat2) &(  lat2< overlap[1][idx]+1 )
            lon1_box=lon1[np.where(idx1)]
            lat1_box=lat1[np.where(idx1)]

            lon2_box=lon2.ravel()[np.where(idx2.ravel())]
            lat2_box=lat2.ravel()[np.where(idx2.ravel())]

            lonlat1=np.vstack((np.array(lon1_box),np.array(lat1_box)))
            lonlat2=np.vstack((np.array(lon2_box),np.array(lat2_box)))
            radius=5
            for npts1 in range(0,len(lonlat1[0][:])):
                 for  npts2 in  range(0,len(lonlat2[0][:])):
                      c=tuple((lonlat1[1][npts1],lonlat1[0][npts1]))
                      p=tuple((lonlat2[1][npts2],lonlat2[0][npts2]))
                      dis = distance.distance(c, p).km
                      if (dis < radius):
                          print("inside Cloudsat(Lon, Lat)=",lonlat1[0][npts1],",",lonlat1[1][npts1],"MHS(Lon, Lat)=",lonlat1[0][npts2],",",lonlat1[1][npts2])
                      else:
                          print("outside")

#        print(overlap[0][idx],overlap[1][idx])
#                          sc_dist = cdist(c1, c2, lambda u, v: geodist(u, v).meters)
```

```
outside
inside Cloudsat(Lon, Lat)= 147.16287 , 73.15961 MHS(Lon, Lat)= 147.4172 , 73.03299
outside
outside
outside
outside
outside
inside Cloudsat(Lon, Lat)= 147.14578 , 73.16804 MHS(Lon, Lat)= 147.4172 , 73.03299
outside
outside
```

SICS
obal Space-based
alibration System

GSICS Tools-Satellite data readers, Inter-comparison modules

Interoperability Platform

We present a python platform that is publicly available and has been created at the University of Maryland. This platform consists of the following modules

Capabilities of the interoperability platform

Typhon gives the capability to find collocated observations between any pair of observing systems of the WIGOS system

ARTS Radiative Transfer Model (Buehler, S. A et al 2018) gives the capability to perform Radiative Transfer simulations at infrared, microwave, and sub-millimeter wavelengths. ARTS simulations together with observing platform observations give ability to differing compare observing platforms

CODA Atmospheric Tool Box gives the ability to read in IASI-x EUMETSAT Polar System (EPS) format data.

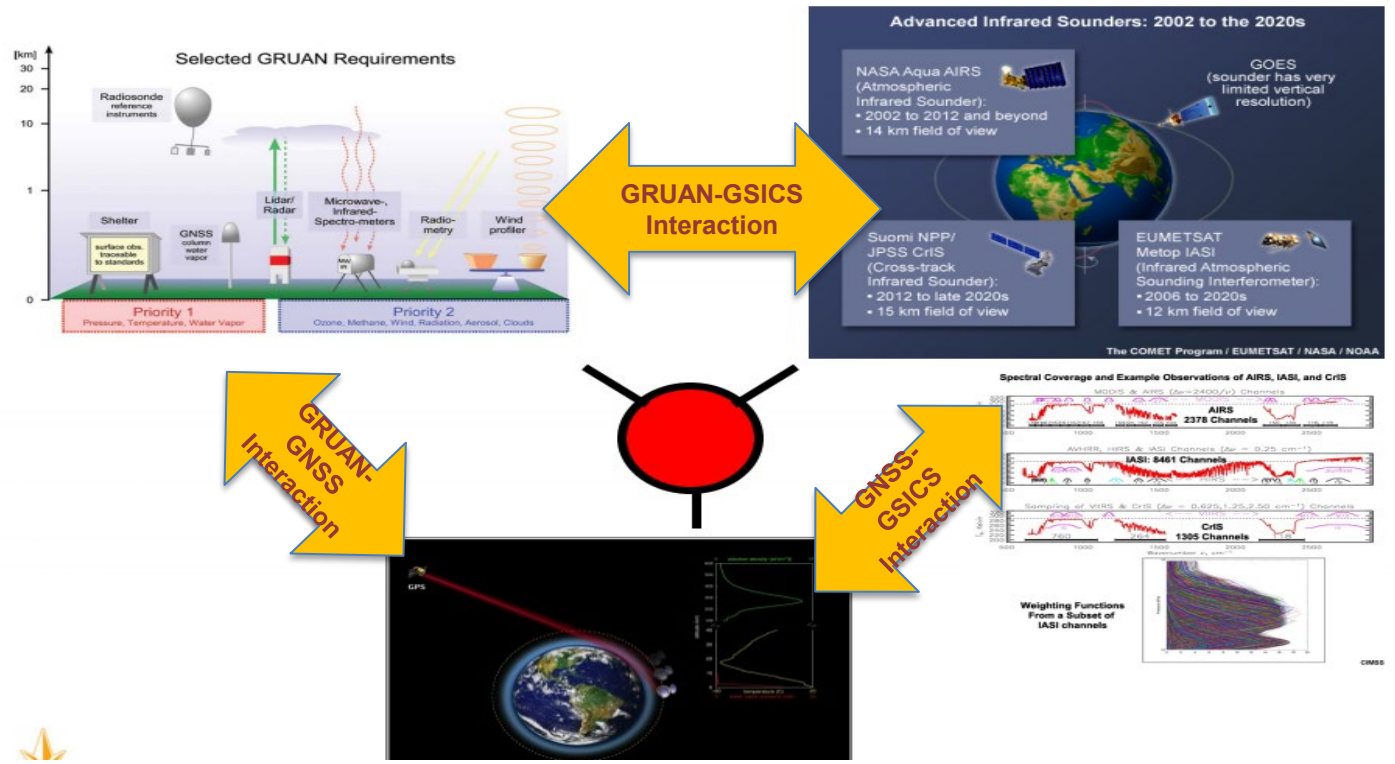
Pytroll and Satpy have readers for the AVHRR series, MetOp series, GMES, and JPSS mission satellites on satellites dating back to 1979.

Users have also contributed codes to the platform

This platform is currently available upon request on a University of Maryland Server
Docker Files buits can be constructed upon request

Suits large scale reprocessing applications

Inter-Operability [GRUAN-GSICS-GNSS]



Inter-Operability code scalable and can compare across heterogenous platforms

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

GSICS Global Space-based Inter-Calibration System

Summary more GICS tools

1. Bash script to download GSICS Data http://gsics.atmos.umd.edu/bin/view/Development/DownloadGSICSProducts
2. 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
3. Plotting Tool http://gsics.tools.eumetsat.int/plotter
4. GSICS Product Catalog: https://www.star.nesdis.noaa.gov/smcd/GCC/ProductCatalog.php
5. Tools have been built to achieve platform inter-operability
6. Inter-operability platform (multiple satellite formats, acquisition platforms) has been established at University of Maryland. Containers can be built
7. GSICS Product Status registration: Register here

Members are welcome to use the tools build by GSICS

We are open to your suggestions for building more tools to help you

THANK YOU

Summary of Tools and Applications

KMA GPRC web pages

- Landing page (AMI Cal/Val System)
  - Instrument Status (new)
  - Instrument Performance (new)
  - INR performance (new)
  - Quality Monitoring
  - GSICS performance
- Event log
  - Satellite Operation Events
  - Operation and Dissemination Schedule
  - Information of incomplete imagery
  - Data Outage

- Landing page: http://nmsc.kma.go.kr/enhome/html/main/main.do
- Event logging: http://nmsc.kma.go.kr/enhome/html/bbs/listNotice.do?bbsCd=00026

Maturity Matrix

Mission success is dependent upon quality assurance. Data Quality adds significantly to the values of datasets.

Because the commercial satellite sector grow, space agencies identified the need for systematic evaluation of commercial satellite data to understand how it may be integrated into their programmes.

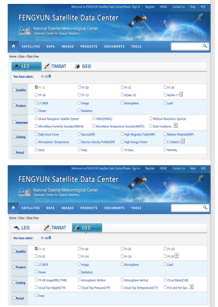
NASA launched the CSDA Project and ESA the EDAP project to meet this need.

NASA and ESA are working toward a comprehensive ESA-NASA Evaluation Framework that will include the utility of these data for Earth science research and applications

ESA Earthnet ⇔ NASA Commercial Smallsat Data Acquisition (CSDA) Program

CMA GDWG TASK: New satellite data sharing scheme

- WMO released the new data policy "WMO UNIFIED DATA POLICY";
- Following the "WMO UNIFIED DATA POLICY", the FY-3E and FY-4B satellite data sharing scheme was drawn up;
- International users were informed through the website of the National Satellite Meteorological Center, CMACast and e-mail.



17

CEOS Cal/Val Portal Overview

https://calvalportal.ceos.org

The CEOS CalVal portal serves as the main forum for exchange and information sharing for the CEOS Working Group on Calibration and Validation (**CEOS WGCV**).

it provides access to agreed **good practices** and Cal/Val **protocols** to the wider Earth Observation community within CEOS and beyond.

It connects users to **reference data** and **networks** and provides reliable, up-to-date and user-friendly information useful for Cal/Val tasks, facilitating data **interoperability** and performance assessment through an operational CEOS coordinated and internationally harmonised Cal/Val infrastructure consistent

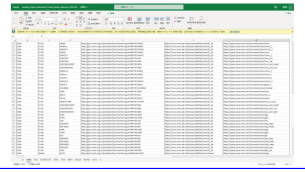
CMA GDWG TASK: CMA GPRC Website Operation

- Keep CMA GPRC Website Content updating:
  - GPRC Information
  - CMA GSICS product sharing (Thredds)
  - FengYun Satellites Instrument Operation Status (Landing Pages)
- CMA GDWG: Website construction and maintain

16

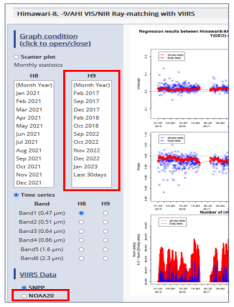
CMA GDWG TASK: Update of the Landing Pages for WMO-OSCAR

- Updating the list of new Instrument Calibration and Monitoring Landing Page addresses:
  - FY-3E: MERSI-LL, HIRAS-2, MWTS-3, MWHS, GNOS-2, WindRAD, SSIM, SIM-2, XEUVI, SWS/Tri-IPM, SWS/SEM/HEPD, SWS/SEM/IMS, SWS/SEM/FGM;
  - FY-4B: AGRI, GIIRS, GHI, SEP/HEPS, SEP-fields, SEP/MEPS, SEP/LEPS, FGM;
  - Tan-Sat: ACGS, CAPI;



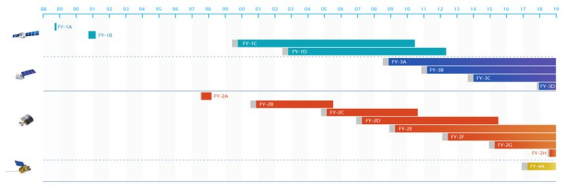
JMA GPRC web pages

- *Landing page (cal. portal)*
  - *Calibration monitoring*
    - *The monitoring web page started to post Himawari-9 full operational observation data in Dec. 2022.*
    - *The page based on the ray-matching approach started to support NOAA20/VIIRS in May 2022.*
  - *Navigation monitoring*
    - *The page started to support Himawari-9 in Sep. 2022.*
  - *Event logging*
  - *Instrument information*
- *Event logging*
  - *Information of incomplete imagery*
  - *Processing Events*
  - *Data Outage*



CMA GDWG TASK: Supporting RICH-CEOS Program

Goal for FY series: FCDR



GSICS Collaboration Servers

- One of the major activities of GDWG
- Providing dataset supporting data exchange/access to GSICS Deliverables
  - GSICS Inter-calibration Products (GSICS Correction, netCDF)
  - Intermediate data to generate products (e.g. GEO-LEO-IR collocation netCDF)
  - Source dataset (inputs to inter-calibration ATBD, e.g. LEO L1 data)
- 3 servers at CMA/EUM/NOAA
  - KMA/JMA products: sent to EUM
- Incorporation of ISRO to 4th Collaboration Server (incl. data synchronization among the servers) has been discussed

Defining GSICS Conventions for new GSICS Deliverables: GSICS netCDF Convention for SRF

Action at GSICS-EP-21: To request CGMS Task Force on Satellite Data and Codes to review a proposal of adding SRF to International Data Subcategory of Common Table C-13 of WMO Manual on Codes for coordination with WMO IPET-CM.

- Instrument spectral response function (SRF): characterizes the sensitivity of instrument's each spectral band
  - SRF is not an output of GSICS activities, but fundamental info for (inter-)calibration
- To support GRWG activities, a file format converter (python script) from individual SRF's original format (depending on the mission) to netCDF was developed by GDWG
- Convention proposed by GSICS is available on the Wiki, but there are remaining issues (this action is one of them)
- Background/Past discussions/Proposals on GSICS's SRF netCDF Convention
  - http://gsics.atmos.umd.edu/bin/view/Development/SrfNcdfConvention

GSICS File-naming Convention for SRF (2/2)

GDWG Membership

Affiliation	First Name	Last Name
CMA	Lin	Tian
ESA	Paolo	Castracane
EUMETSAT	Simon	Elliott
IMD	R.K.	Giri
IMD/Ministry of Earth Sciences	Kamaljit	Ray (Chair)
ISRO	Nitant	Dube
JMA	Arata	Okuyama
KMA	Tae-Hyeong	OH*
NOAA	Manik	Bali
ROSHYDROMET	Sergey	Uspensky
WMO	Heikki	Pohjola (Secretariat)

https://gsics.wmo.int/en/focal-points

Action Status [2022]

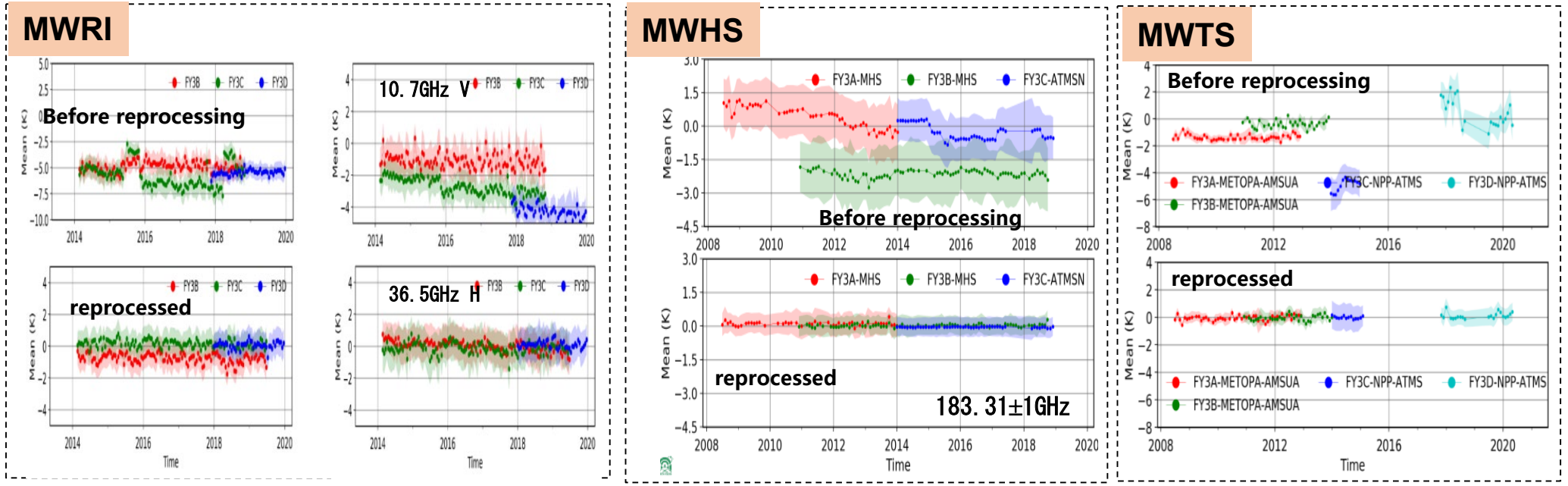
Action ID	Action	Status
A.GDWG.2022031.8	GDWG to contact GRWG/Tim Hewison to get information on Combing products	Ongoing
A.GDWG.20220316..9	GDWG to organize a webmeeting to discuss combined products	Closed
A.GDWG.20220316.1	IMD and ISRO to work on enhancing capabilities of RAPID to use visualize GSICS data	Open
A.GDWG.20220316.2	Discuss with GRWG if reprocessed data should be designated as a GSICS deliverable	Open
A.GDWG.20220316.3	GDWG members to inform GCC about the latest membership	Concurrent
A.GDWG.20220316.4	CMA to reveal use of GSICS coefficients in NWP processing	Open
A.GDWG.20220316.5	GDWG to contact GRWG to gather requirements for combined product	Closed
A.GDWG.20220316.6	GSICS members to contact Paolo (ESA) and provide feedback to EVDC	Closed
A.GDWG.20220316.6	GSICS-GDWG(Manik) to work closely with ESA (Paolo) to integrate GSICS notebooks into the ESA metrology notebooks	Closed
A.GDWG.20220316.7	IMD/ISRO Cal/Val portal link to be provided to ESA to be included in the CEOS Cal/Val portal	Closed

GDWG Plans for the upcoming year Activities

- GDWG to present a Work Plan at EP
- GSICS Data working group would continue to support the Research Working Group.
- Data Working Group aims to build more web based tools and engage the CAL/VAL communities with using GSICS Algorithms and Data sets.
- GDWG to support the new class of products planned by GRWG

THANK YOU

Reprocessing Dataset: Validation – Microwave instruments



THANK YOU