Introducing GSICS and interactions with WGCV

Tim Hewison[1] and Jerome Lafeuille[2]

(1) EUMETSAT - Chair of GSICS Research Working Group

(2) WMO – Secretariat of GSICS Executive Panel

Outline

- Introduction to GSICS
  - emphasis on systematic generation of inter-calibration products
  - Members, Aims, Principles
- GSICS Products
  - Product Catalog, Examples
- GSICS structure
  - GCC + User Workshops
  - GDWG + servers, etc
  - GRWG + Sub-groups
- Interaction with WGCV
  - Past examples
  - Future Possibilities

GSICS Global Space-based Inter-Calibration System

GSICS and CGMS

- The main goal of CGMS is technical coordination among satellite operators supporting WMO programmes
- GSICS addresses one key aspect of this coordination:
  best practices to maximize mission usability and interoperability
- GSICS was jointly established by CGMS and WMO
  as an outcome of CGMS Working Group on satellite products
- GSICS members are CGMS member agencies (operational or R&D)
- GSICS reports annually to the CGMS plenary

Global Space-based Inter-Calibration System

- What is GSICS?
  - Global Space-based Inter-Calibration System
  - Effort to produce consistent, well-calibrated data from the international constellation of Earth Observing satellites
- What are the basic strategies of GSICS?
  - Improve on-orbit calibration by developing an integrated inter-comparison system
    - Initially for GEO-LEO Inter-satellite calibration
    - Being extended to LEO-LEO
    - Using external references as necessary
  - Best practices for prelaunch characterisation (with CEOS WGCV)
- This will allow us to:
  - Improve consistency between instruments
  - Reduce bias in Level 1 and 2 products
  - Provide traceability of measurements
  - Retrospectively re-calibrate archive data
  - Better specify future instruments

EUMETSAT CNES JMA

NOAA CMA KMA

ISRO NASA WMO

USGS NIST JAXA

ROSHYDROMET IMD ESA

GSICS Principles

- **Systematic** generation of **inter-calibration** products
  - for Level 1 data from **satellite sensors**
  - to **compare**, ***monitor*** and **correct** the calibration of *monitored* instruments to community references
  - by generating calibration corrections on a routine operational basis
  - with specified uncertainties
  - through well-documented, peer-reviewed procedures
  - based on various techniques to ensure consistent and robust results
- Delivery to users
  - Free and open access
  - Adopting community standards
- To promote
  - Greater understanding of instruments' absolute calibration, by analysing the root causes of biases
  - More accurate and more globally consistent retrieved L2 products
  - Inter-operability for more accurate environmental, climate and weather forecasting products

TRACEABILITY / UNBROKEN CHAINS OF COMPARISONS

GSICS Global Space-based Inter-Calibration System

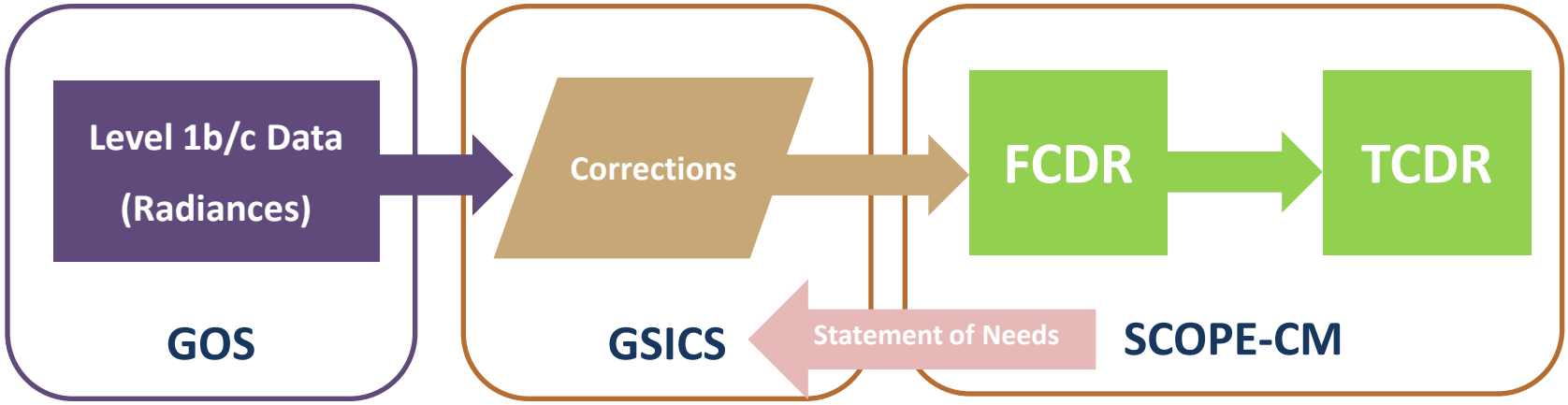
Who are the targeted users?

Any activity requiring well calibrated Level 1 data acquired by the satellites covered by GSICS

- **Level 2 products (geophysical parameters)**
- **Climate applications**

Example of user = the SCOPE-CM initiative (Sustained Coordinated Processing of Environmental Satellite Data for Climate Monitoring)

Scope ➔ generate multi-mission and global satellite climate data records (Fundamental CDRs & Thematic CDRs)



➔ The way toward operational production of high quality ECVs on a global scale

GSICS User Community

- Satellite Application Community
  - CDR generation for climate monitoring
    "SCOPE-CM" framework, national/international programs
    WCRP/GEWEX/ISCCP - (Planned beta-testing of GEO GSICS Corrections)
  - Reanalysis community for climate modelling (ECMWF reanalysis – 2012/15)
  - Operational NWP: direct radiance assimilation
  - Other users interested in accurate/consistent calibration
    to generate stable (composite) L2 quantitative products or imagery
- Satellite Operators
  - Prelaunch instrument characterization guidelines
  - Cal/Val Plans
  - Best practices for instrument monitoring and improved calibration

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Partner programmes

- Other calibration initiatives
  - CEOS WGCV, in particular IVOS
  - GPM X-cal
  - GRUAN
- Thematic application expert groups
  - GHRSST
  - IPWG ? ITWG ?

GSICS Products

- **GSICS Bias Monitoring**
  - Routine comparisons of satellite radiances against reference
- **GSICS Correction**
  - Function to correct issued radiances
  - For consistent calibration with reference
- **GSICS Reports & Guidelines**
  - Recommendations to modify practices
  - Design and Operation of future satellite instruments
- **For Operational Environmental Satellites**
  - ✓ Infra-red recalibration (GEO and LEO) (current operational satellites)
  - ✓ Visible and near-infrared recalibration (GEO and LEO)
  - ✓ Microwave – Conical & Cross-track Scanners (LEO)
  - ✓ Historic Instruments
  - ✓ Pre-Operational & Demo status
  - ✓ Near real-time and re-analysis
  - ✓ In development within GSICS
  - ✓ In development with GPM XCAL
  - ✓ In development at EUMETSAT…

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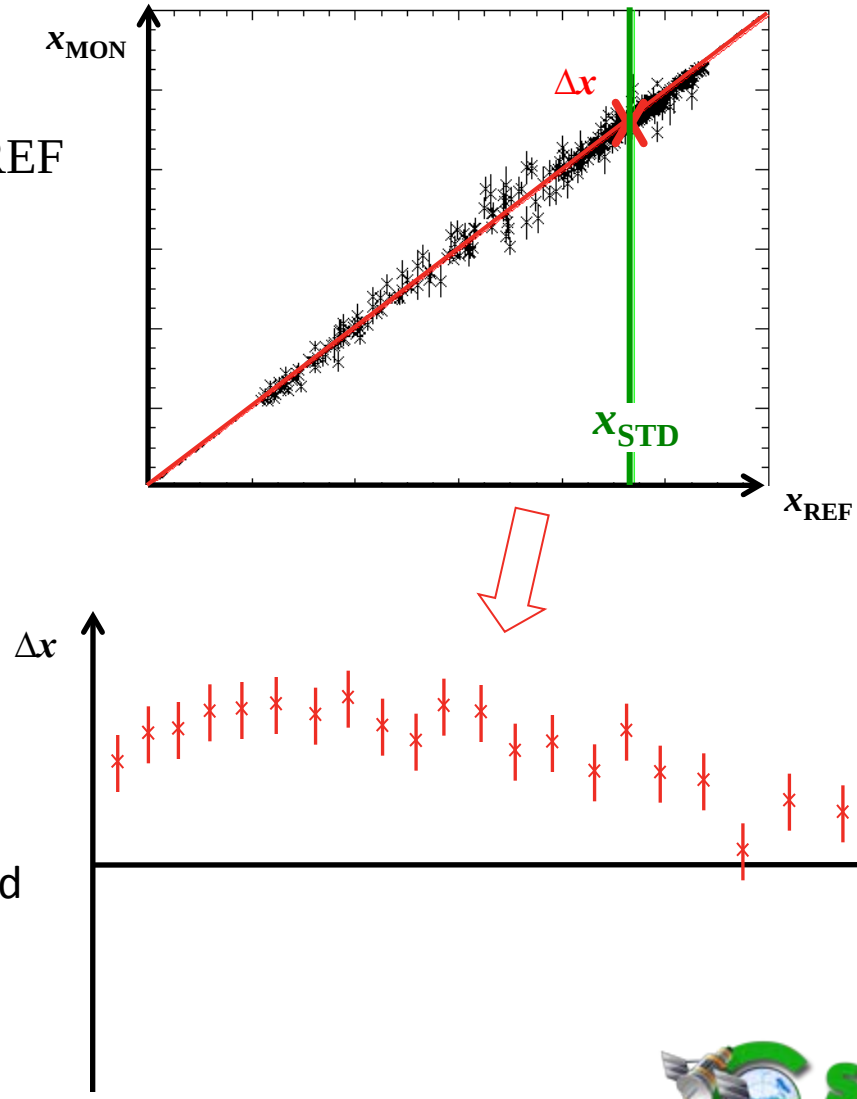
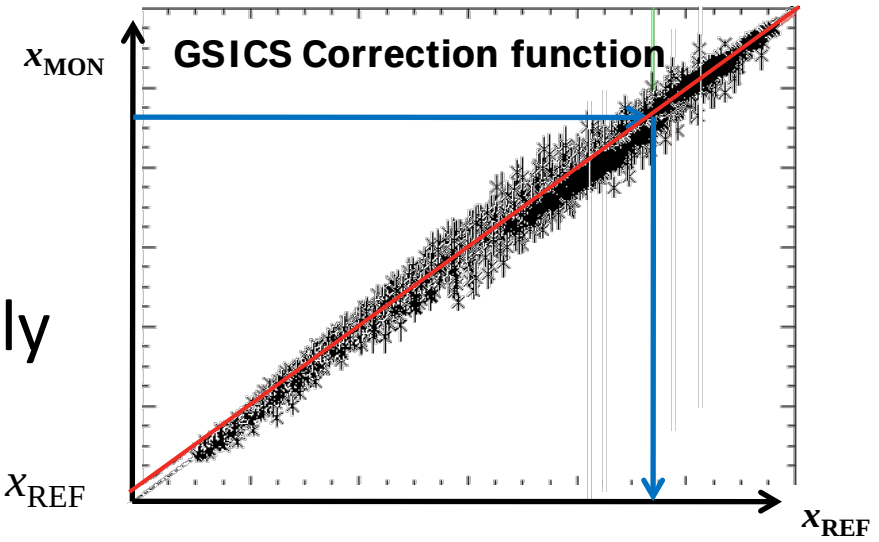
GSICS Products: (1/3) Bias Monitoring

- Comparing samples of x_{MON} , x_{REF}
  - Over fixed domain
  - Period (e.g. 1 orbit/1 day)
  - Typically ~ 1000 comparable samples/day
- Regression
- Calc bias, $\Delta x = x_{MON} - x_{REF}$
  - Δx at standard scene, x_{STD}
  - with uncertainty
- Plot time series of bias Δx
  - Compare recent results with long-term trend
  - Valuable for instrument monitoring



GSICS Products: (2/3) GSICS Correction

- Compare all x_{REF} , x_{MON} samples
  - over smoothing period (e.g. 2 weeks)
- Regression coefficients
  - with uncertainty (covariance)
- Provide a *function* users can apply
  - to convert level 1 data, x_{MON}
  - to be consistent with calibration of reference, x_{REF}
- Two versions:
  - Near Real-Time (asymmetric time window)
  - Re-Analysis (symmetric time window)



GSICS Products: (3/3) Guidelines

- Underlying assumption of GSICS Correction:
  - Small errors (e.g. SRF errors, blackbody temperature, ...) introduce small departures from 'true' calibration
  - If these are linearly related to a predictor (radiance, time, ...) we can apply empirical correction based on inter-calibration
- Guidelines can analyse GSICS products
  - to diagnose root causes of calibration errors
- Can derive recommendations to modify
  - operating practices (e.g. adopt new SRF definition),
  - pre-launch characterisation, etc.
- These GSICS Guidelines are distributed as written reports

GSICS Global Space-based Inter-Calibration System

GSICS Procedure for Product Acceptance

- Based on QA4EO
- Products progress from
  - Demonstration Mode
- Through
  - Pre-Operational Mode
- To
  - Operational Mode
- By a series of reviews
- Over period of ~1.5yr
- Subject to meeting acceptance criteria

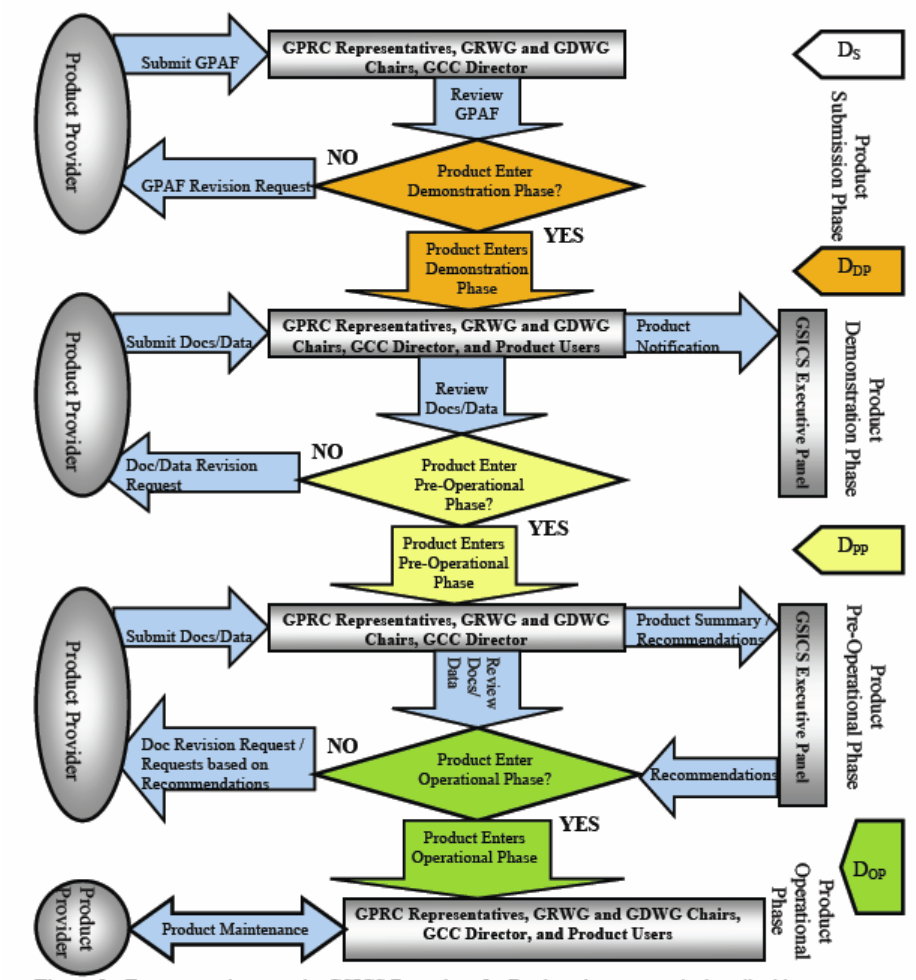


Figure 1: From top to bottom, the GSICS Procedure for Product Acceptance is described by four phases - Product Submission Phase, Demonstration Phase (DP), Pre-operational Phase (PP), and Operational Phase (OP) – and their review and revision cycles. The time markers at the far right, and their defined limits, are: date of submission (D_S); and the number of days from D_S to fulfill requirements to enter DP ($D_{DP} \leq D_S$+90days), PP ($D_{pp} \leq D_{DP}$+365days), and OP ($D_{OP} \leq D_{pp}$+180days).

Quality Indicators in GSICS Products

- GSICS Correction Coefficients include
  - Estimates of uncertainties and covariances
  - From weighted linear regression
  - Using spatial variance and radiometric noise of each collocated observation as weighting
- Shown as error bars in GSICS Bias Monitoring plots
- But many other processes introduce uncertainty
  - Systematic and Random
- Need to validate these *quality indicators*

GSICS Product Status 2014-02

GPRC	Monitored Instrument	Reference Instrument	GSICS NRT Correction	GSICS Re-Analysis Correction	GSICS Bias Monitoring
EUMETSAT	Meteosat-8 – 10 } Meteosat-7	Metop-A/IASI	Pre-operational	Pre-operational	Prototype
JMA	MTSAT-1R } MTSAT-2 }	IASI (+ AIRS)	Demonstration	Demonstration	Prototype
NOAA	GOES-13 & -15 Imager GOES-11 & -12 Imager	IASI (+ AIRS)	Pre-operational	Pre-operational Demonstration	Prototype
	GOES Sounder	IASI (+ AIRS)	In development	In development	In development
CMA	FY2C – E	IASI (+ AIRS)	In development	In development	Prototype
NOAA	AMSU/MSU	NOAA14/AMSU	In development	Pre-Operational	In development
NOAA Patmos-X	TIROS-N – NOAA – Metop /AVHRR	Aqua/MODIS	-	Demonstration	-

Full GSICS Product Catalog available at http://www.star.nesdis.noaa.gov/smcd/GCC/ProductCatalog.php

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Comparison of Collocated Radiances

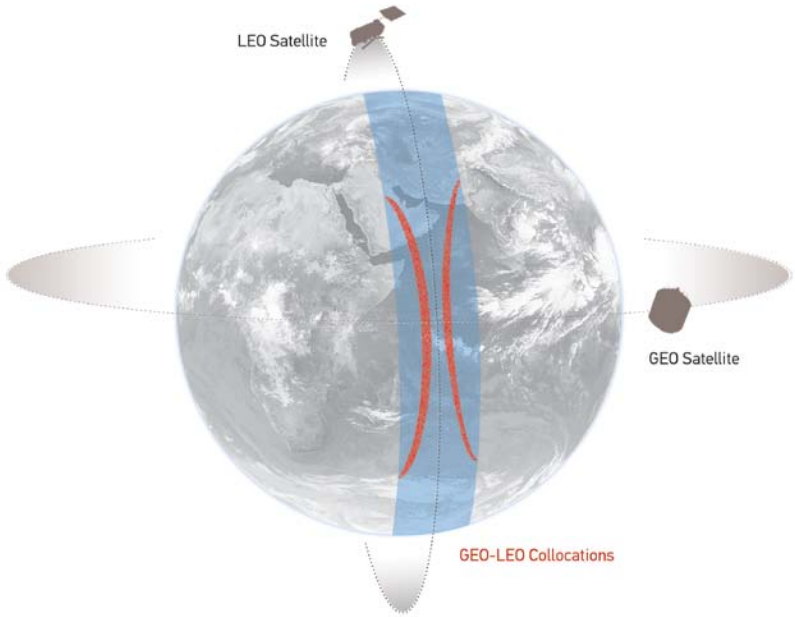
Simultaneous near-Nadir Overpass
of GEO imager and LEO sounder

- Collocation Criteria:
- ΔLat<35° ΔLon<35°
- Δt < 5 mins
- $\Delta \sec\theta$ < 0.01
(Atmospheric path diff.)

- Concentrated in tropics

~1000 collocations/orbit

~1 orbit/night



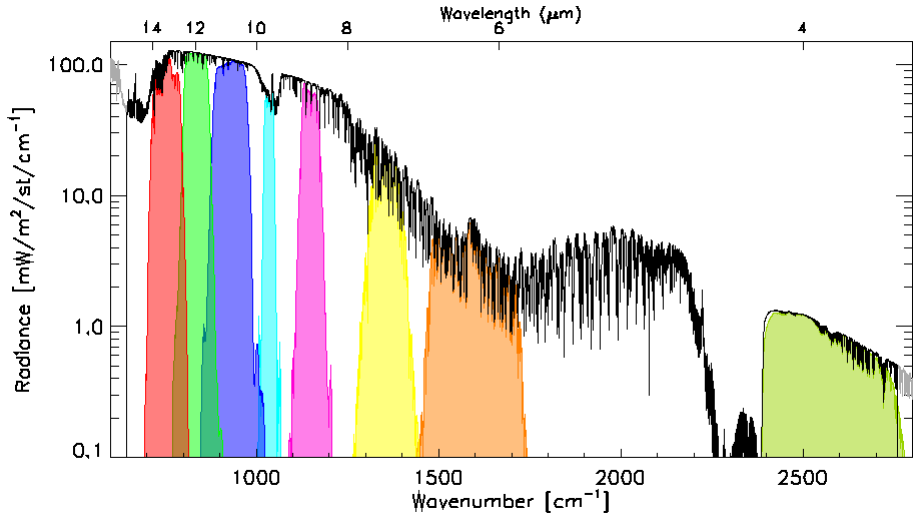
Schematic illustration of the geostationary orbit (GEO) and polar low Earth orbit (LEO) satellites and distribution of their collocated observations.

GSICS Global Space-based Inter-Calibration System

Data Transformations
(Spectral and Spatial)

•Spectral Convolution:

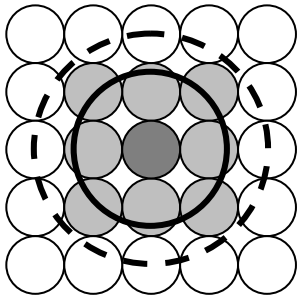
- Convolve LEO Radiance Spectra with GEO Spectral Response Functions
- to synthesise radiance in GEO channels



Example radiance spectra measured by IASI (black) and modeled by LBLRTM (grey), convolved with the Spectral Response Functions of SEVIRI channels 3-11 from right to left (colored shaded areas).
n.b. The IASI observations (645 – 2760 cm^{-1}) do not quite cover the full spectrum observed by SEVIRI.

•Spatial Averaging:

- Average GEO pixels in each LEO FoV
- Estimate uncertainty
  - –due to spatial variability
  - –as Standard Deviation of GEO pixels
- Use in weighted regression



LEO FoV~10km

~ 3x3 GEO pixels

Illustration of spatial transformation. Small circles represent the GEO FoVs and the two large circles represent the LEO FoV for the extreme cases of FY2-IASI, where *n*x*m*=3x3 and SEVIRI-IASI, where *n*x*m*=5x5.

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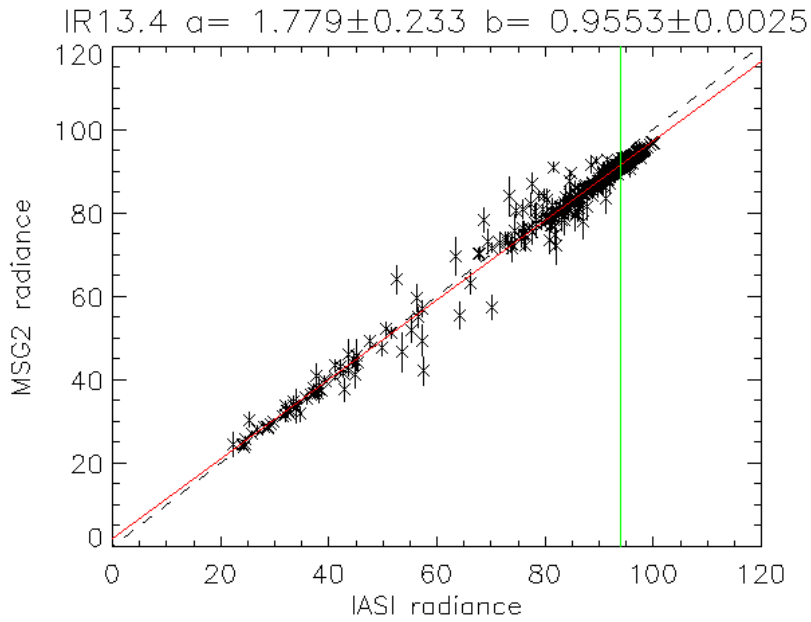
Comparison by Regression

- Compare collocated obs:
- GEO radiance
  - Spatially averaged
- Regressed against
- LEO radiance spectra,
  - convolved with GEO SRF
- Using Variance of GEO radiances + Noise
  - to estimate uncertainty on each collocation



Weighted linear regression of
$L_{GEO|REF}$ and $\langle L_{GEO} \rangle$
for Meteosat-9 13.4µm channel
based on single overpass of IASI

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Example of GSICS Bias Monitoring

From EUMETSAT: Time Series of Meteosat10-IASI Standard Biases [K]

This page shows prototype GSICS Bias Monitoring resulting of the inter-comparison of infrared channels of geostationary ▸ **Meteosat imagers** and the polar-orbiting ▸ **IASI** sounder from collocated observations. The plots show the relative biases between these instruments for standard radiances, corresponding to clear sky scenes over the ocean, in a standard atmosphere. The results from the ▸ **inter-calibration algorithm (PDF, 980 KB)** can also be downloaded as ▸ **GSICS Correction Coefficients (PDF, 79 KB)** in ▸ **netCDF format (PDF, 66 KB)** from ▸ **EUMETSAT's GSICS and Product Server**.

See the ▸ **GSICS Product Status Summary** for further details or visit our ▸ **GSICS page** for a comprehensive list of resources.

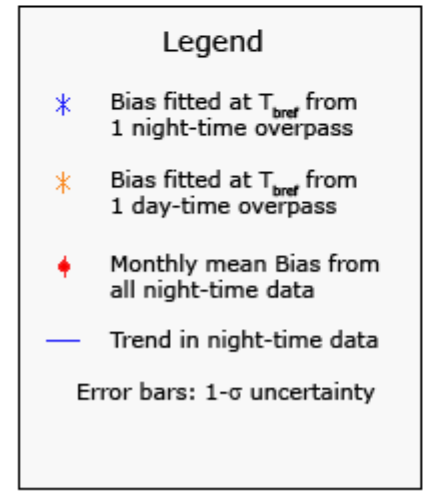
Satellite: Meteosat-10 SEVIRI

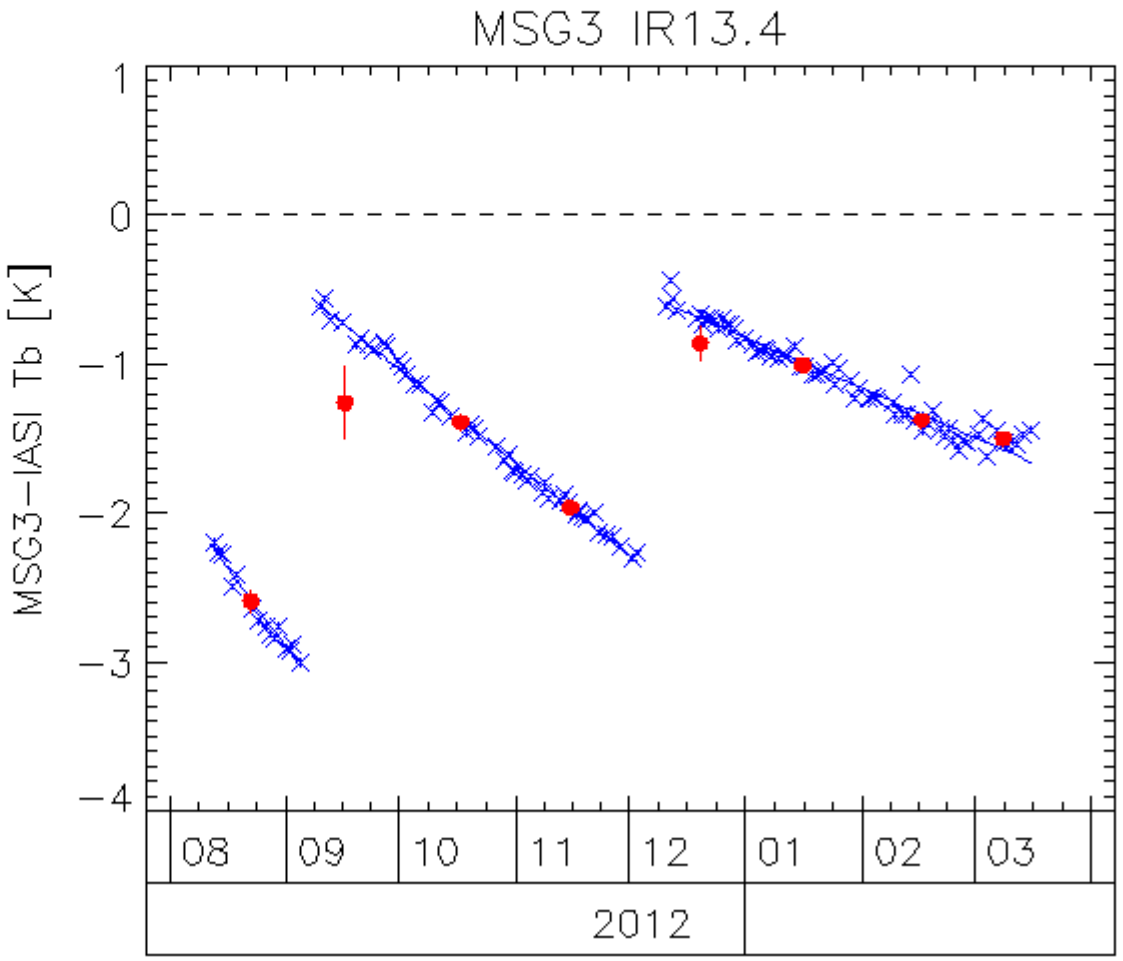
Channel: IR13.4

Date: Year 2013 Month 03 Day 17

Time: 2215

Display: Time Series Plot

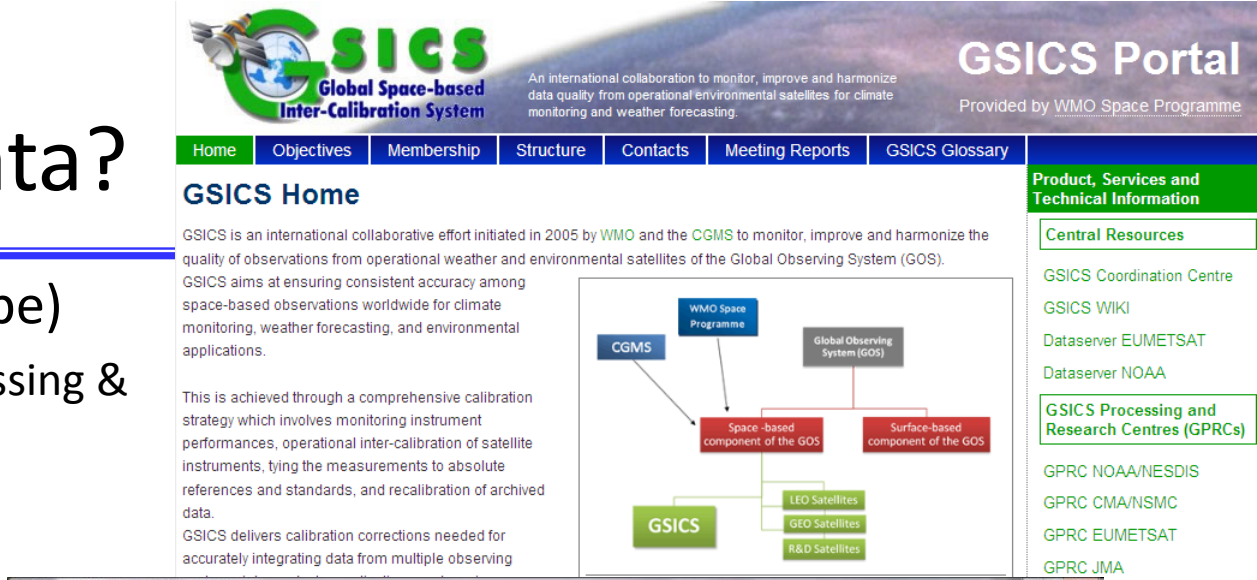


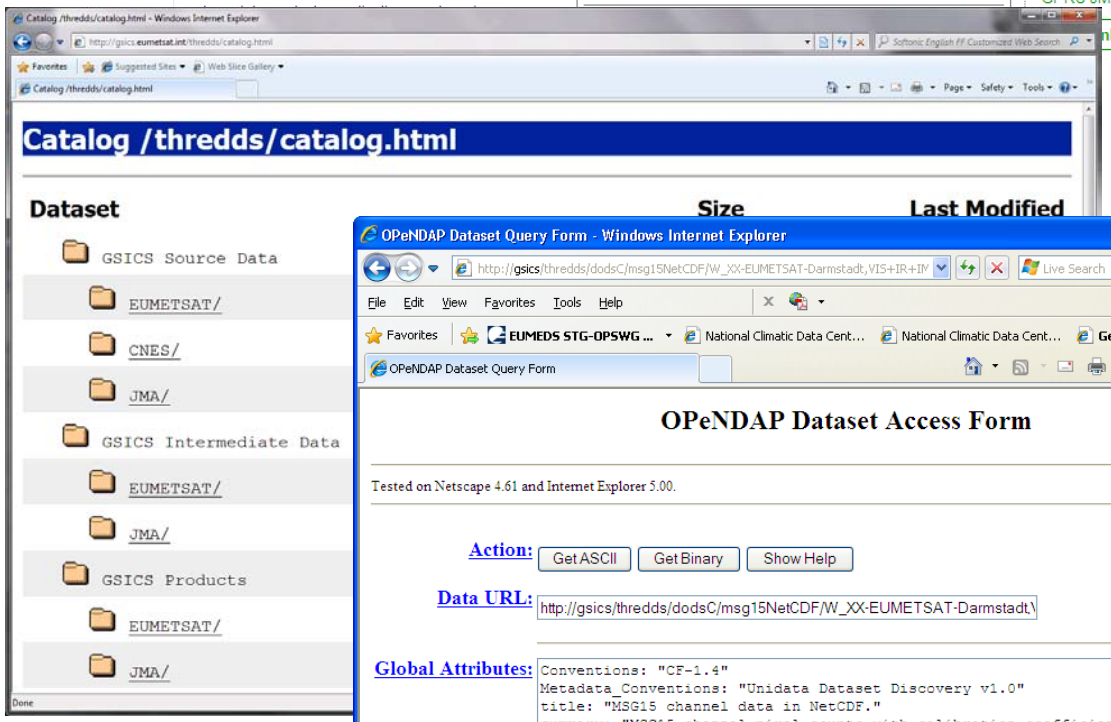


Where to get the data?

- GSICS Bias Monitoring (prototype)
  - Hosted on websites of GSICS Processing & Research Centres (GPRCs)
- GSICS Corrections
  - GSICS Data & Products Servers
  - THREDDS-based system
  - NetCDF format
  - WMO GTS standard file names
  - Unidata & CF conventions

See gsics.wmo.int for links





GTS = Global Telecommunication System
CF = Climate and Forecast

Cooperation with GSICS

Previous Examples

- NIST+NASA: Best Practice Guideline for Pre-launch Characterisation
- IVOS: Special Issue of TGARS
- IVOS: Cooperative development of vicarious methods/model val
- QA4EO: Design of GSICS Procedure for Product Acceptance

Future Possibilities

GSICS Global Space-based Inter-Calibration System

First GSICS Guideline document

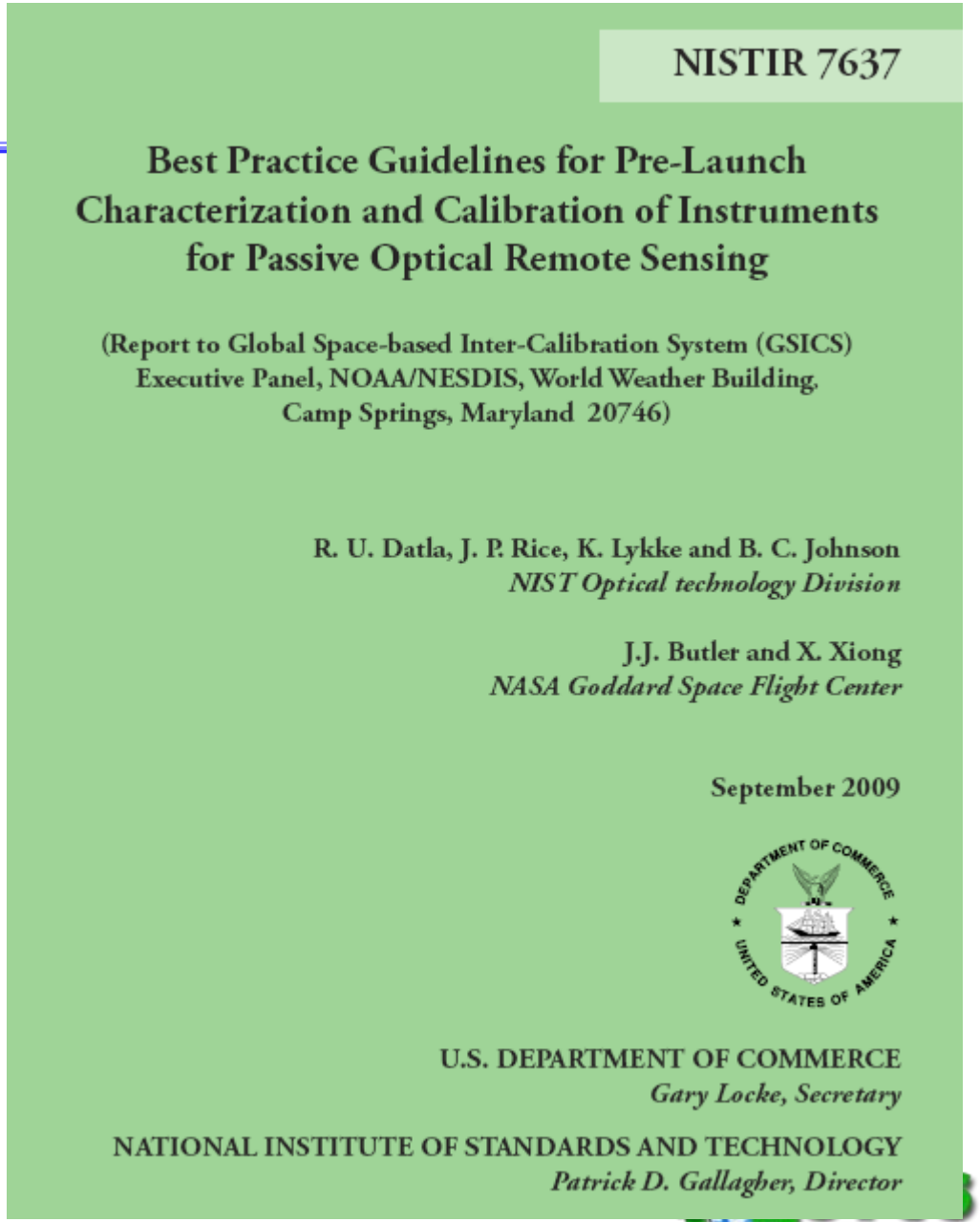
Best Practice Guidelines for Pre-Launch Characterization and Calibration of Instruments for Passive Optical Remote Sensing

Report to GSICS Executive Panel

R.U. Datla, J.P. Rice, K. Lykke and B.C. Johnson (NIST)

J.J. Butler and X. Xiong (NASA)

September 2009


NISTIR 7637

Best Practice Guidelines for Pre-Launch Characterization and Calibration of Instruments for Passive Optical Remote Sensing

(Report to Global Space-based Inter-Calibration System (GSICS) Executive Panel, NOAA/NESDIS, World Weather Building, Camp Springs, Maryland 20746)

R. U. Datla, J. P. Rice, K. Lykke and B. C. Johnson
NIST Optical technology Division

J.J. Butler and X. Xiong
NASA Goddard Space Flight Center

September 2009

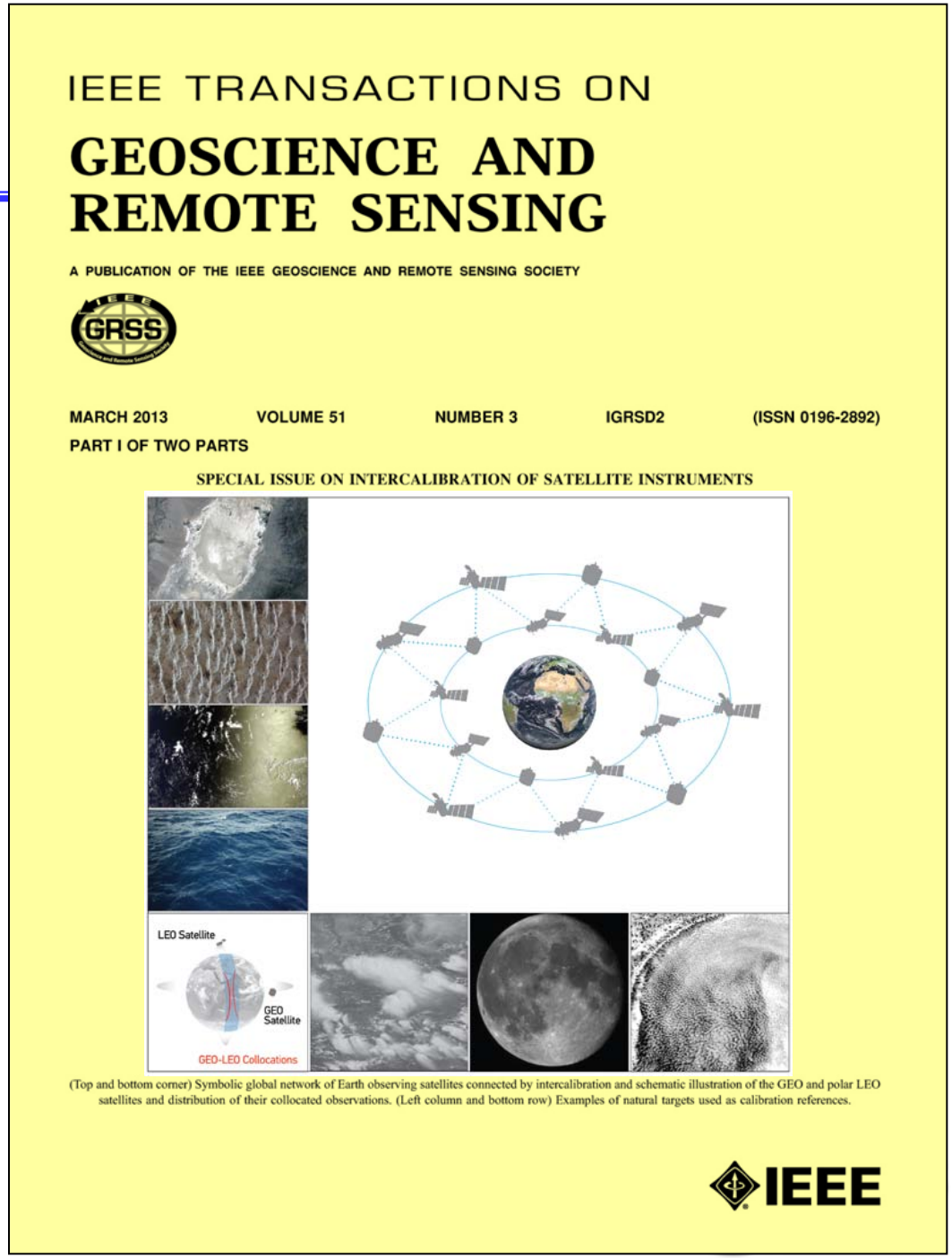
U.S. DEPARTMENT OF COMMERCE
Gary Locke, Secretary

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
Patrick D. Gallagher, Director

Global Space-based Inter-Calibration System

Special Issue on Satellite Inter-Calibration

- IEEE Transactions on Geoscience and Remote Sensing
- On inter-calibration of satellite instruments
- 5 Guest GSICS/IVOS Editors
- 40 papers – incl. 13 Open Access
  - From CAS, CMA, CNES, ESA, EUMETSAT, ISRO, JAXA, KMA, JMA, MIT, NASA, NOAA, SDSU, USGS, etc.
  - Covering AVHRR, AMSU, (A)ATSR, CLARREO, ETM+, FY-2 & -3B, GOES, HIRS, Hyperion, IASI, Jason-2/OSTM, MODIS, PROBA, SCAIMACHY, Sentinel-2, etc.
- Published March 2013



CEOS Cal/Val Portal

esa

Everything

Home | CEOS Cal/Val Sites | Docs & Forum | Data Access & Tools | News & Events | CEOS WGCV | Feedback | Welcome Tim Hewison | Sign Out

Infrared and Visible Optical Sensors Subgroup

CEOS-IVOS Libya-4 Workshop

Paris, France. 4-5 October 2012

Background

In the context of CEOS IVOS, the pseudo-invariant Libya-4 desert site is commonly used by several teams. A special workshop fully dedicated to the use of Libya-4 site for calibration purposes was organised by CNES in Paris on 4th and 5th October 2012.

The main topics were studies on "site characterization" (morphology, homogeneity, spectral behaviour, stability, BRDF) and on "calibration results" (inter-calibration, calibration monitoring....)

CEOS WGCV

- ACSG
- IVOS
  - IVOS 25
  - IVOS 24
  - IVOS 23
  - **IVOS Lybia 4 Workshop 2012**
  - IVOS Workshop 2010

GSICS Global Space-based Inter-Calibration System

GSICS Quality Assurance

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

Search STAR websites Go

- WMO GSICS portal
- GCC Home
- News
- GSICS Quarterly
- Meetings
- GSICS Quality Assurance >>
  - Product Acceptance Procedure
  - Standards and Best Practices
- Baseline Analyses
- Instrument Info Kiosk

GSICS Quality Assurance

As earnest work began to create the first GSICS product, the question arose of a GSICS product "stamp of approval."

This led the GSICS Coordination Center to draft a GSICS Procedure for Product Acceptance (GPPA), the role of which is to define and document product:

- Scope within the GSICS product portfolio;
- Theoretical basis, and implementation, distribution, and archive strategy; and
- Quality (uncertainty, quality indicators, etc).

The GSICS quality assurance program has been developed in conjunction with the Quality Assurance Framework for Earth Observations (QA4EO). The QA4EO is being established for the Group on Earth Observations (GEO) by the CEOS Working Group on Calibration/Validation as a general set of data quality assurance guidelines that can be applied throughout the earth observation community. At GSICS these guidelines have been tailored to meet the needs of GSICS quality assurance programs.

GSICS Global Space-based Inter-Calibration System

Possible Future GSICS-WGCV Cooperation

- Best Practice Guidelines
  - e.g. Traceability,
  - Calibration Uncertainty
- Glossary of calibration terminology
- Definition of Standards
- Specific interactions with WGCV Sub-Groups: IVOS, MWSG, ACC
  - Need for coordination
- Geolocation/navigation/rectification methodology & metrics
- Inter-comparison Campaigns – aircraft, ground-based support, etc.
  - Data exchange/analysis,
  - Offer to review campaign plans
- Intra-System Comparisons

GSICS Global Space-based Inter-Calibration System

Cross-cutting activities

EP-12.18	ESA (Bojan Bojkov) to report at GRWG on its survey on the state of the art for geolocation issues, and on ESA activity on this subject	Main.ESA(Bojkov)	01 Mar 2013

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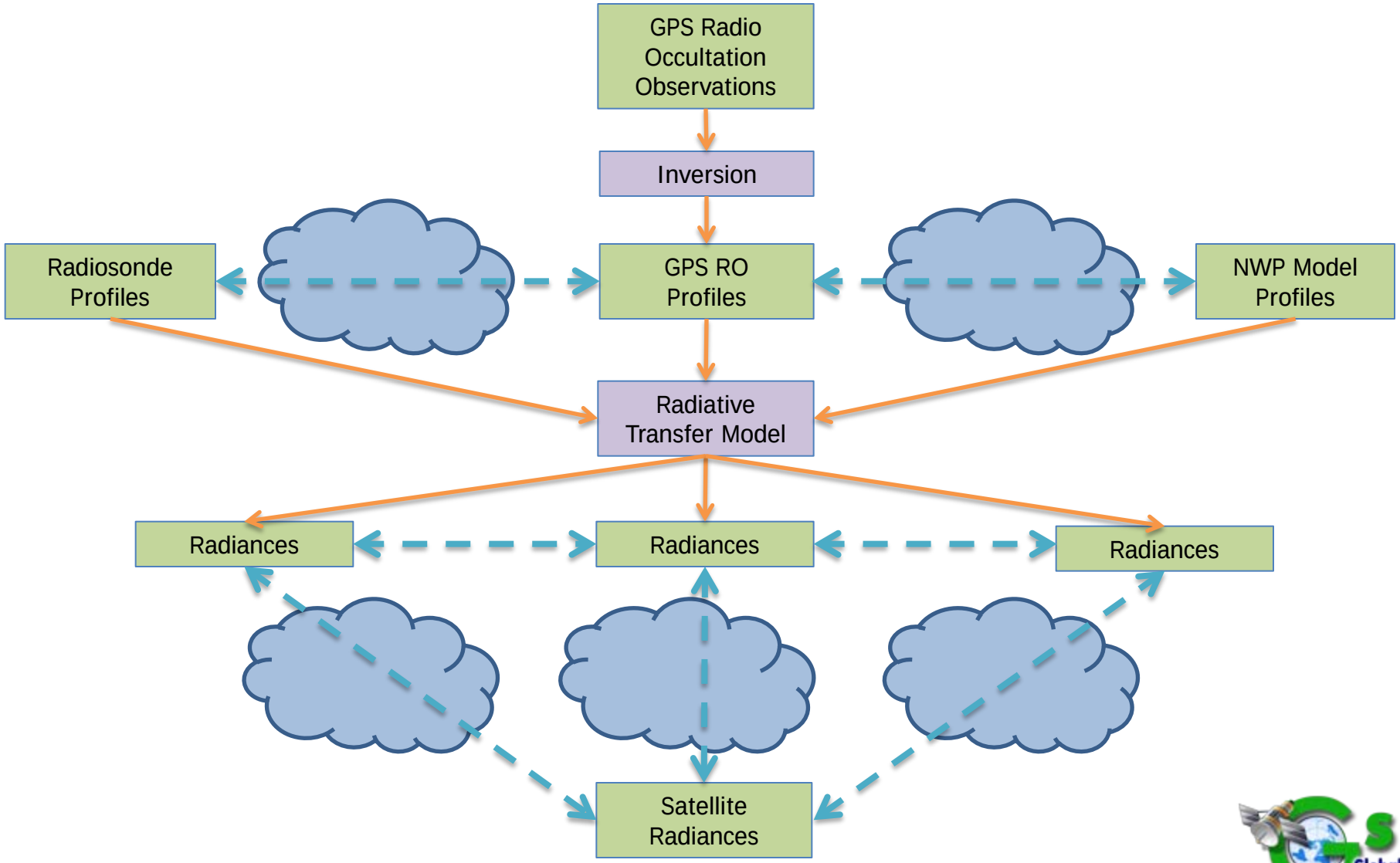
GRUAN-GSICS-GPSRO-NWP Interaction Concept



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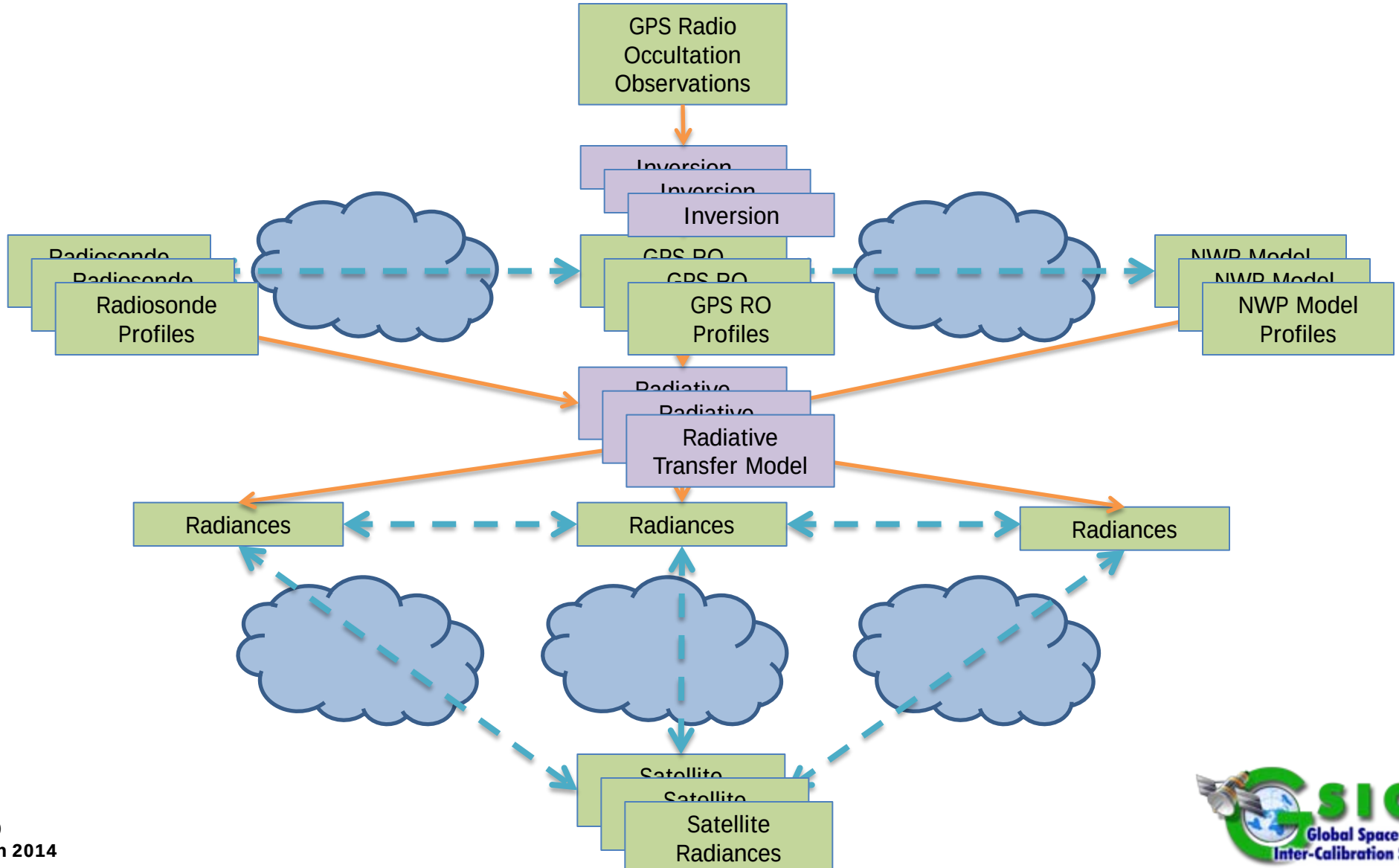

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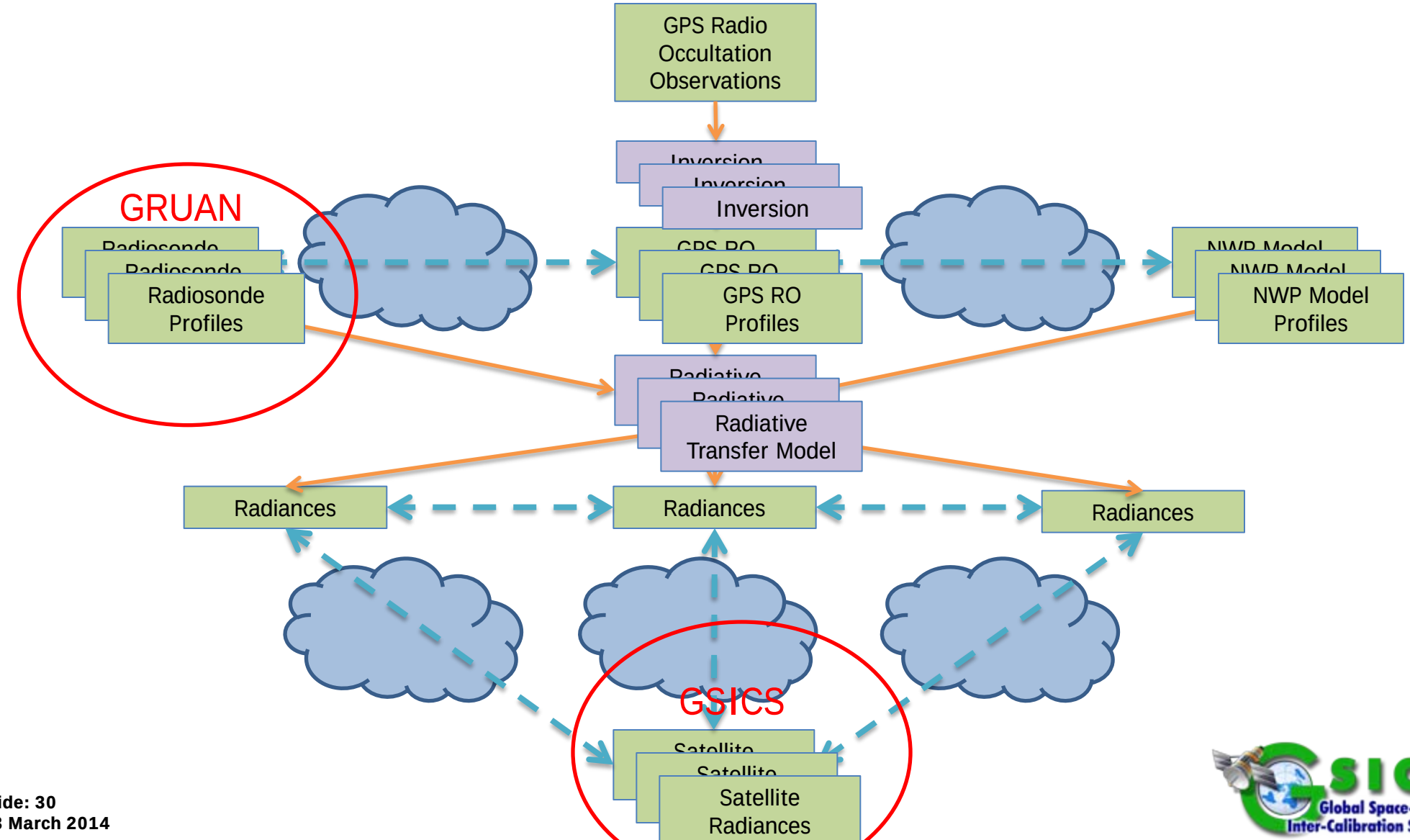

Thank You

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