Introducing GSICS

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On behalf of GSICS Research Working Group

Global Space-based Inter-Calibration System

- What is GSICS?
  - Global Space-based Inter-Calibration System
  - Initiative of CGMS and WMO
  - 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-calibration 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
  - 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

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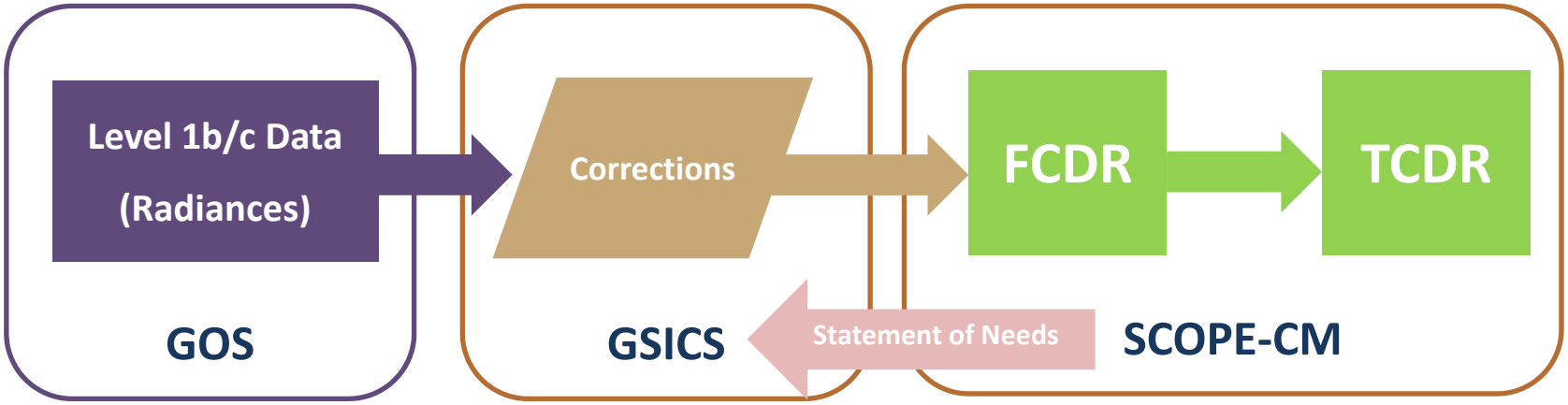
Who are the targeted users?

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/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
- Satellite Operators
  - Prelaunch instrument characterization guidelines
  - Cal/Val Plans
  - Best practices for instrument monitoring and improved calibration

➢ Affiliation with partner programmes

  - CEOS WGCV, GPM X-cal, GHRSST, GRUAN, etc...

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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 Procedure for Product Acceptance

- 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

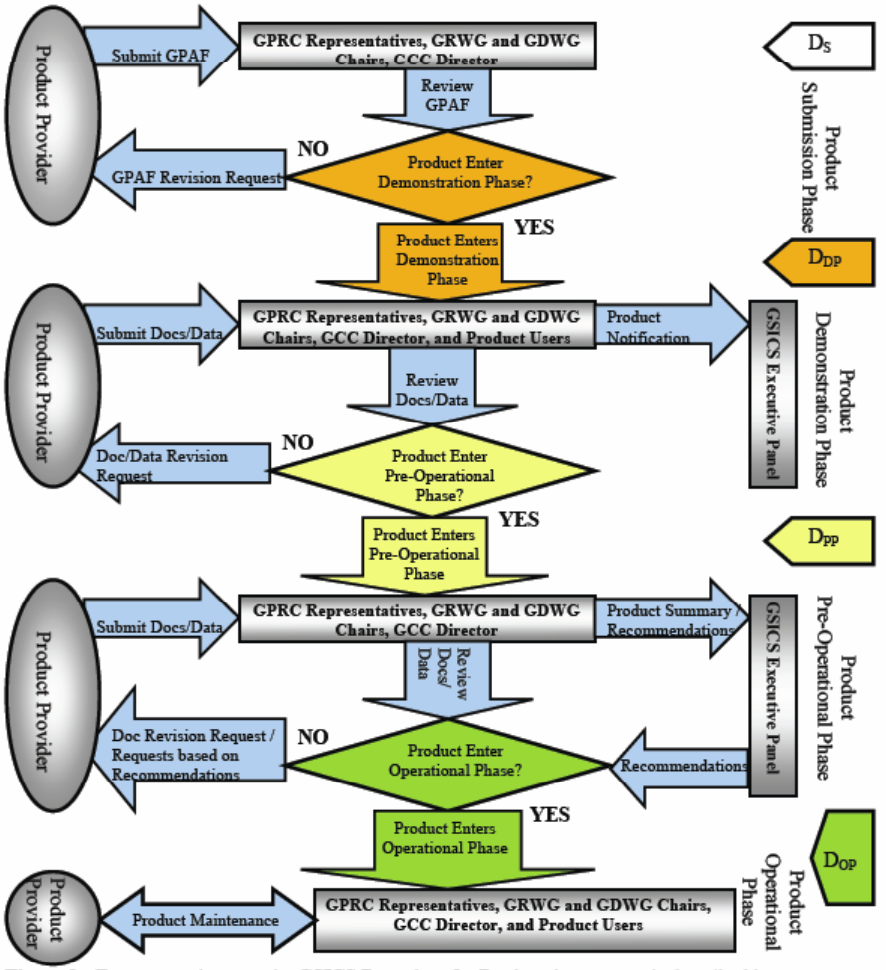

Figure 1: From top to bottom, the GSICS Procedure for Product Acceptance is described by four phases - Product Submission Phase, Demonstration Phase (DP), Pre-operational Phase (PP), and Operational Phase (OP) – and their review and revision cycles. The time markers at the far right, and their defined 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).

GEO-LEO IR Product Status 2013-04

GPRC	Monitored Instrument	Reference Instrument	GSICS NRT Correction	GSICS Re-Analysis Correction	GSICS Bias Monitoring
EUMETSAT	Meteosat-10} Meteosat-9 } -- Meteosat-8 } Meteosat-7 }	IASI	**Pre-operational** Demonstration	**Pre-operational** Demonstration	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 }				
	FY2D } -- FY2E }	IASI (+ AIRS)	In development	In development	Prototype
KMA	COMS	IASI (+ AIRS)	In development	In development	In development

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

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Comparison of Collocated GEO-LEO Radiances

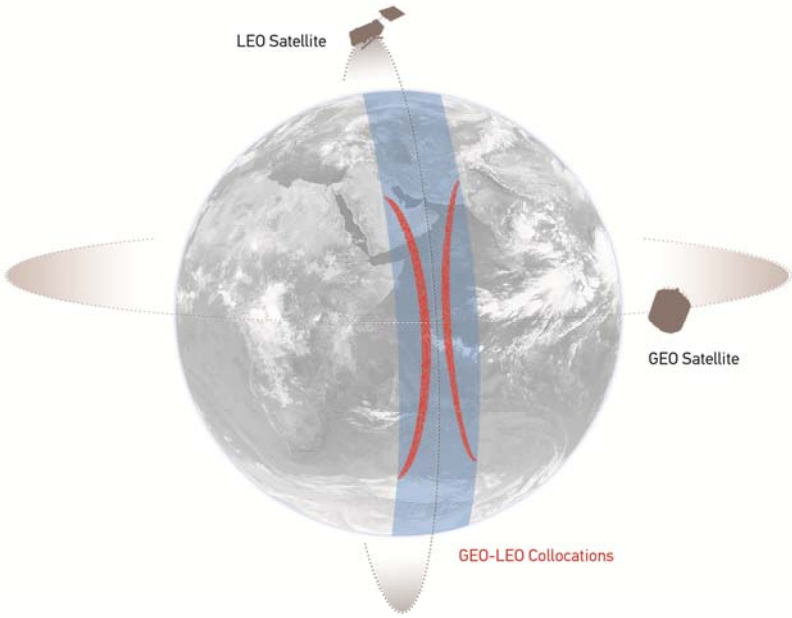
Simultaneous near-Nadir Overpass of GEO imager and LEO sounder

- 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

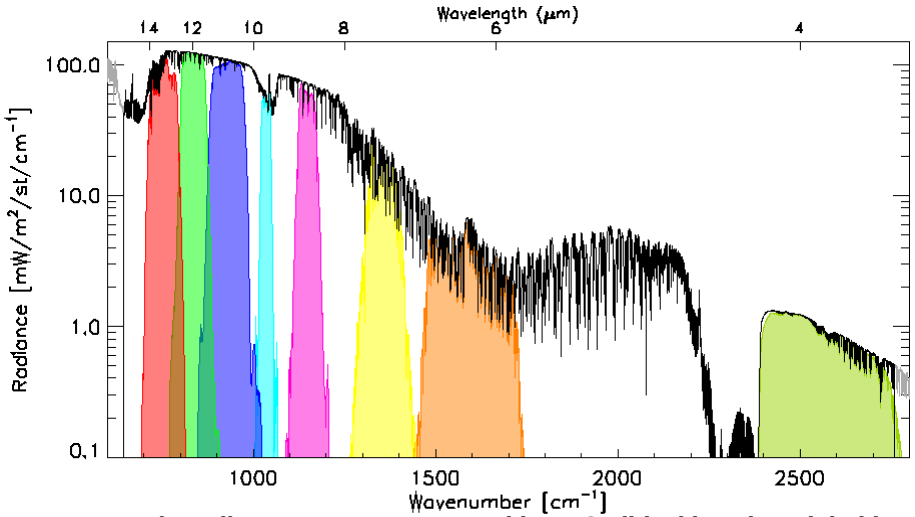


Schematic illustration of the geostationary orbit (GEO) and polar low Earth orbit (LEO) satellites and distribution of their collocated observations.

Data Transformations
(Spectral and Spatial)

•Spectral Convolution:

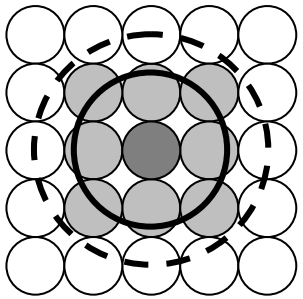
- Convolve LEO Radiance Spectra with GEO Spectral Response Functions
- to synthesise radiance in GEO channels



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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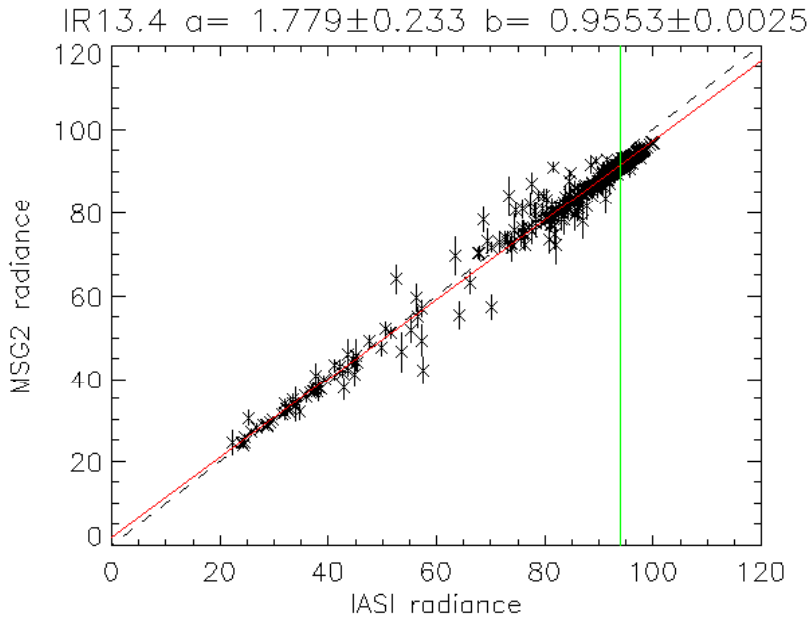
Comparison by Regression

- 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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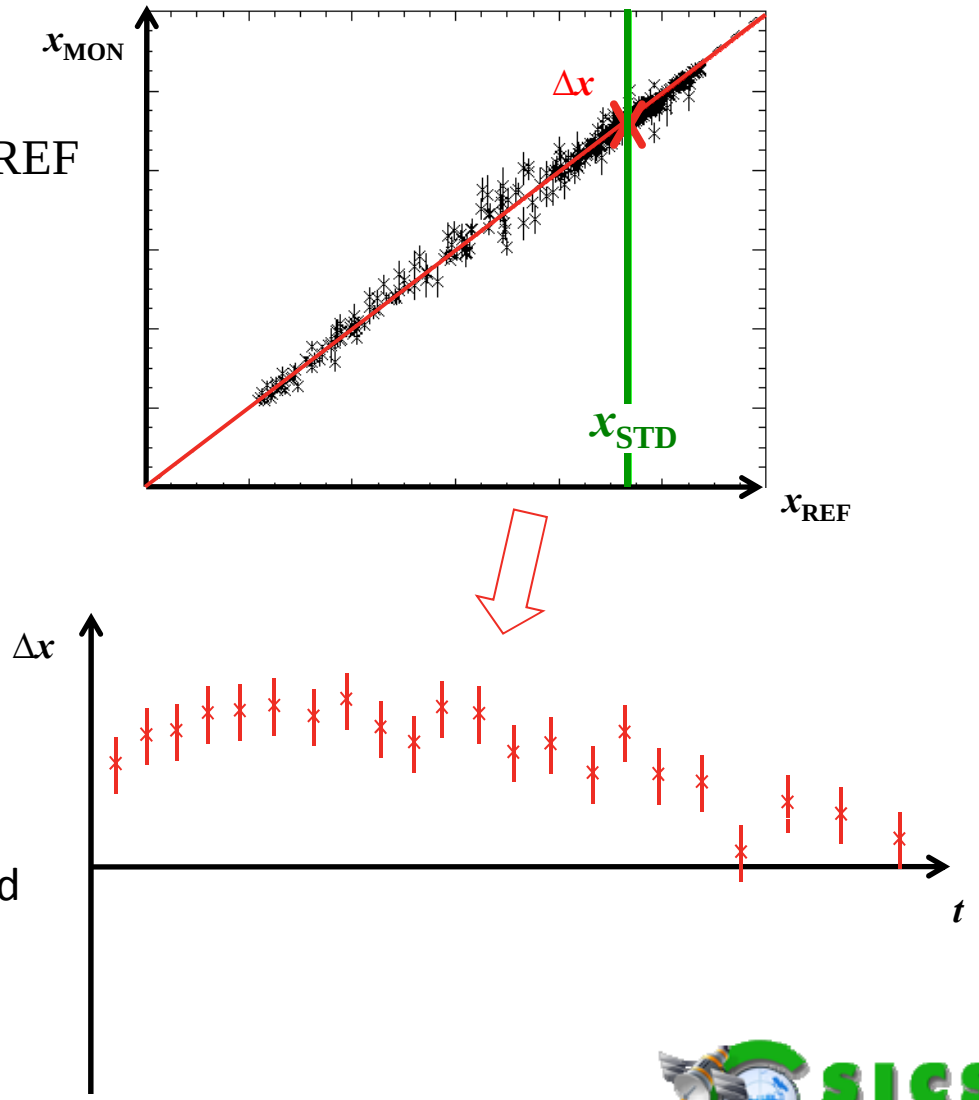
GSICS Products: (1/3) Bias Monitoring

- 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



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

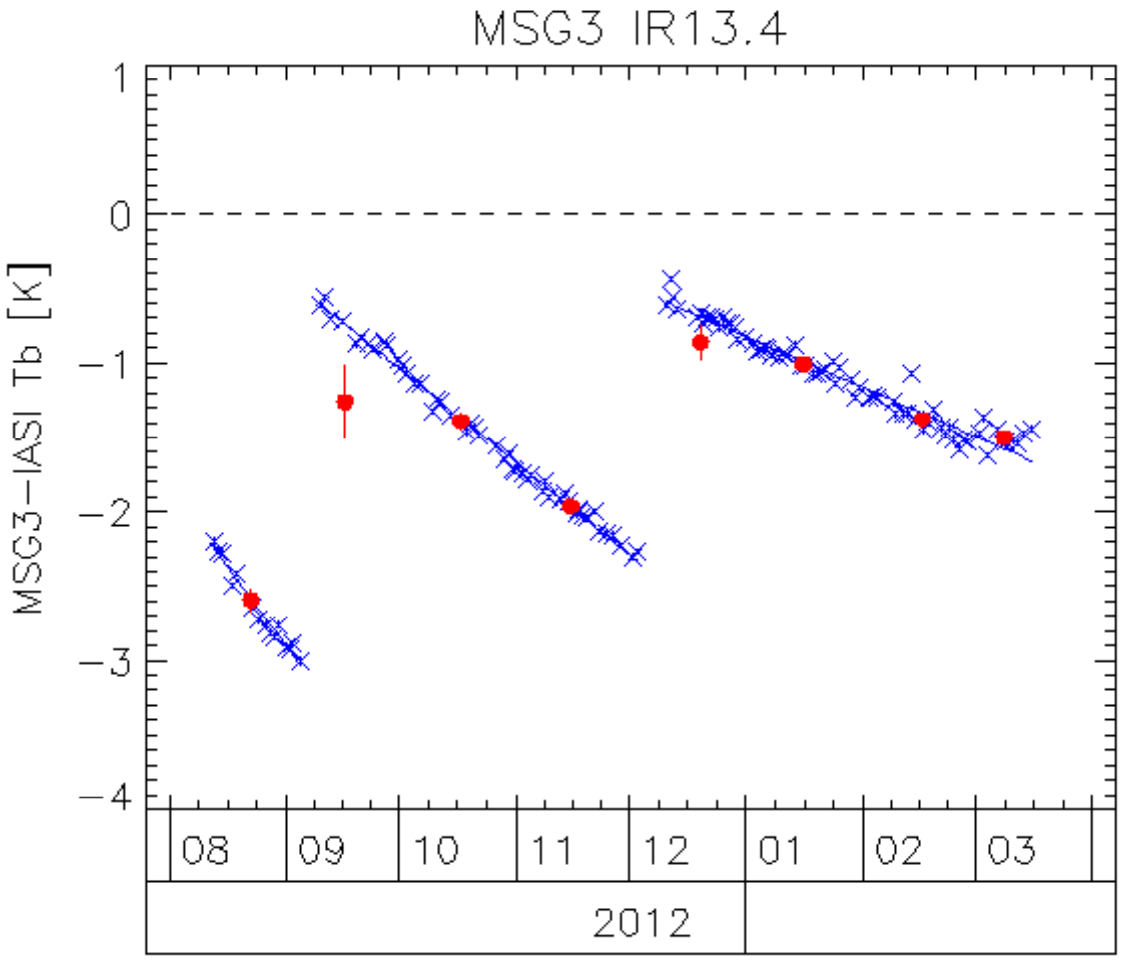
Time: 2215

Display: Time Series Plot

Legend

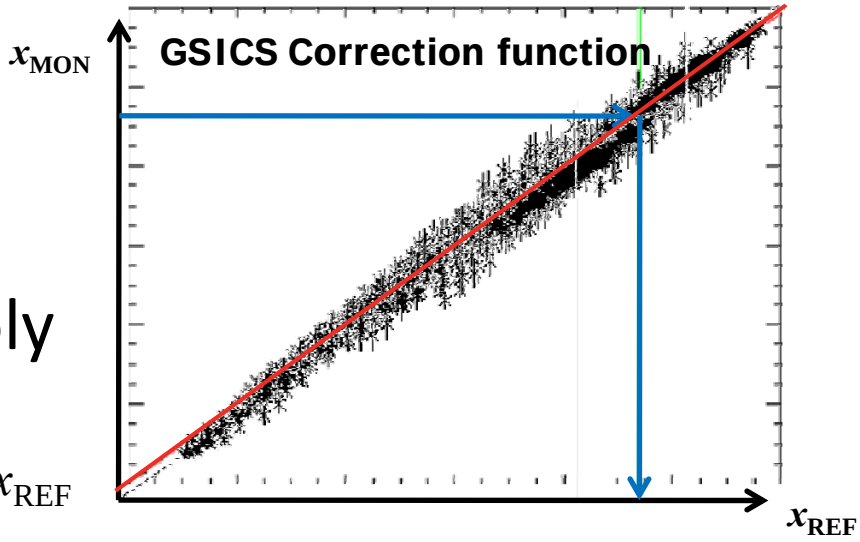
- Bias fitted at T_{bref} from 1 night-time overpass
- Bias fitted at T_{bref} from 1 day-time overpass
- Monthly mean Bias from all night-time data
- Trend in night-time data

Error bars: 1-σ uncertainty



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

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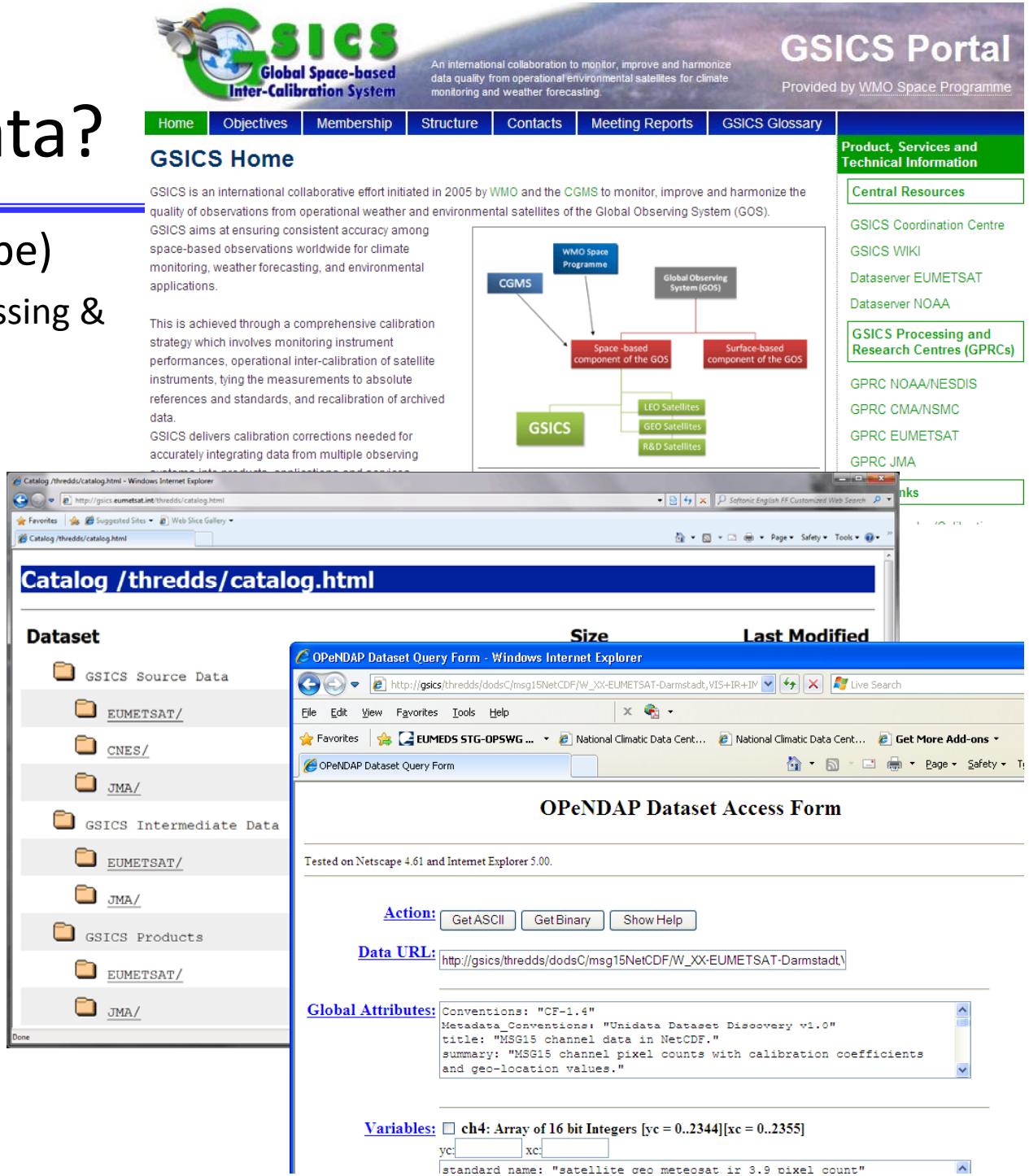
Where to get the data?

- 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

GSICS Product Developments 2012

- GSICS Corrections for GEO-LEO IR
  - Now Pre-Operational for Meteosat (EUMETSAT) & GOES (NOAA)
  - Nearly Pre-Operational for MTSAT (JMA)
  - Using MetopA/IASI as reference
- Developing GSICS Products for GEO-LEO VIS:
  - Deep Convective Clouds (DCC)
  - Ocean Targets (Rayleigh Scattering)
  - Lunar & other methods (deserts, liquid water cloud, …)
- Special Issue

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GSICS Product Development Plan 2013

- GSICS Corrections for GEO-LEO IR:
  - Operational Mode for Meteosats, GOES & MTSAT
  - Prototype for other GEOs
  - Delta Correction to transfer MetopA/IASI to MetopB/IASI
  - Quantifying diurnal cycle uncertainties
- GSICS Products for GEO-LEO VIS:
  - Deep Convective Clouds (DCC) -> Demonstration Mode
  - Lunar -> Prototype
  - Ocean Targets (Rayleigh Scattering) + LEO-LEO -> Prototype
  - Other methods -> continue developments
- GSICS Guidelines:
  - How to select a reference instrument
  - How to specify Spectral Band Adjustment Factors (IR+VIS)

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GSICS Research Working Group – Sub-Groups

- Define GRWG Sub-Groups
  - to development of inter-calibration products
  - or review algorithms developed by 3rd parties
  - and help ensure GSICS principles, file naming and variables conventions, etc are followed
  - for specific classes of instruments and/or applications.
- Sub-Group chairs shall be responsible for
  - coordinating development and/or review
  - organising & chairing portions of agenda of
  - annual GRWG meeting & web meetings related to their topic,
  - Monitoring actions related to the development of inter-calibration products
  - Reporting progress to Exec Panel & Users' Workshops – or through GRWG Chair

- Possible Sub-Groups:
  - Microwave
    - Formed, but inactive
  - Visible/Near Infrared
    - Chair: D. Doelling (NASA)-TBC
  - Thermal Infrared
    - Chair: TBD
  - Archive Re-Calibration
    - Generate FCDRs for historic inst.
  - Synthetic Observations
    - e.g. NWP+RTM
  - Hyperspectral IR?
  - UV?
  - ?

Thank You