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GSICS activities in support of Multi-Mission Cal/Val

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GSICS Activities in Support of Multi-Mission Cal/Val

- Introducing GSICS
- Infrared Channels' Calibration
- Visible/Near-Infrared Channels' Calibration
- Reflective Solar Spectrometer Sub-group
- Future Outlook

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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-comparison system
    - Initially for GEO-LEO Inter-satellite calibration
    - Being extended to LEO-LEO
    - Using external references as necessary
  - Best practices for calibration & characterisation
- **This will allow us to:**
  - Improve consistency between instruments
    - Towards Interoperability
  - Reduce bias in Level 1 and 2 products
  - Support Cal/Val of new instruments
  - Provide traceability of measurements
  - Retrospectively re-calibrate archive data
  - Better specify future instruments

GSICS
Global Space-based Inter-Calibration System

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

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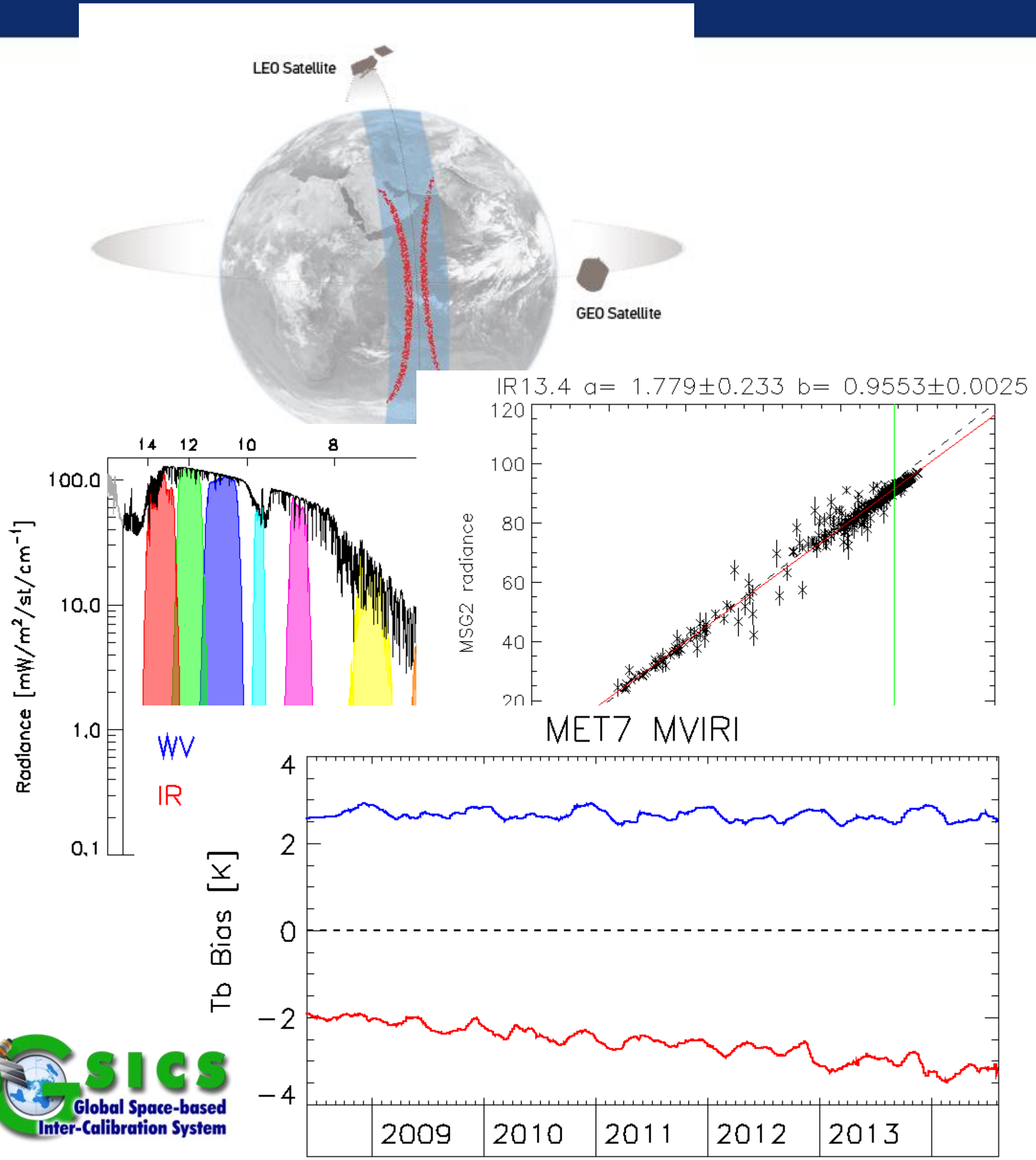
GSICS Corrections for GEO imagers' IR channels

- Collocate in Space, Time, Angle
  - "Simultaneous Nadir Overpasses" (SNOs)
  - Tie to contemporaneous reference
  - With very small uncertainty
- Hyperspectral Reference (IASI)
  - Spectral Convolution
  - Can diagnose SRF errors
- Compare
  - Regression of collocated radiances
- Generate GSICS Correction
  - Updated daily
  - EUMETSAT GSICS Server
- Evaluate & Monitor Bias



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Monitoring of Reflective Solar Bands' Calibration

- Spectral interval = 350nm – 2500nm
- Various approaches in place at EUM:
  - Vicarious Calibration

    ➔ Model top-of-atmosphere radiance (= reference) above some targets and compare observation against that reference
  - Inter-calibration:

    ➔ Transfer the calibration from a reference instrument (e.g. Aqua MODIS or NOAA-20 VIIRS) to a monitored instrument (e.g. SEVIRI).
- In both cases ➔ Need to find a target stable in time and homogeneous in space to transfer the calibration from a reference instrument (concept of pseudo-invariant target)

Deep Convective Clouds
Moon
Oceans
Deserts

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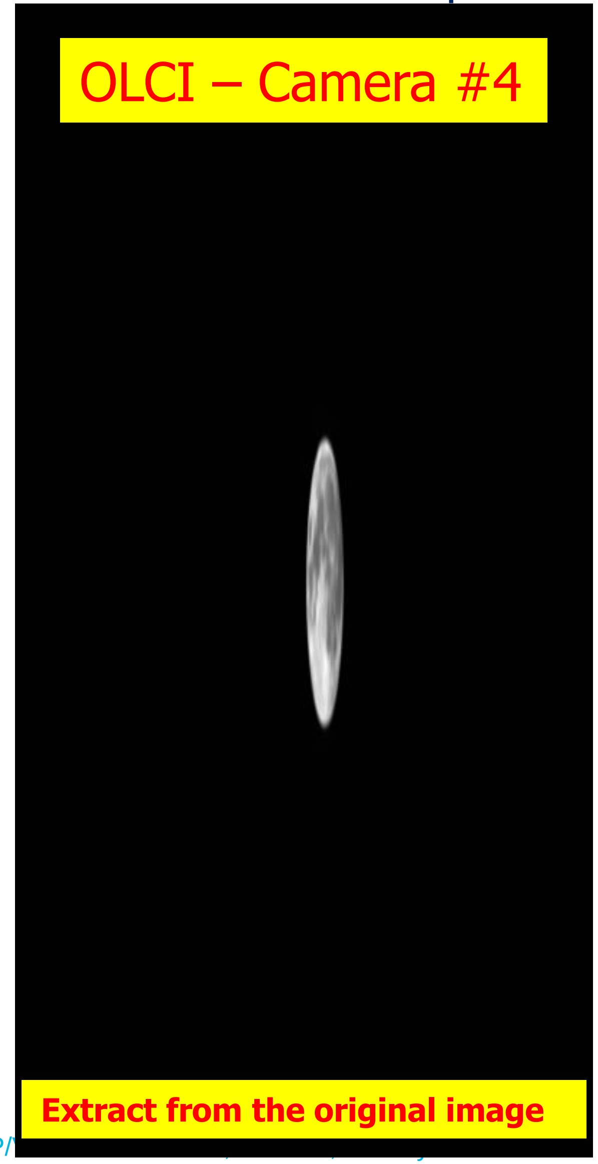
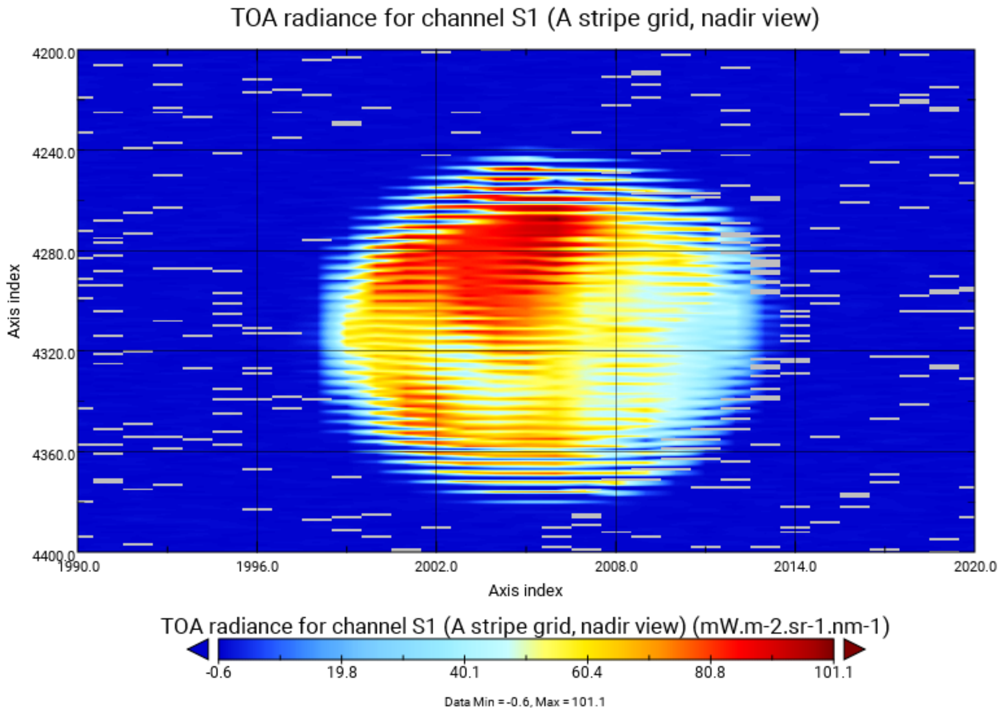
S-3 OLCI and SLSTR

Dedicated Moon acquisition with Sentinel-3B (manoeuvre on 27.7.2018)

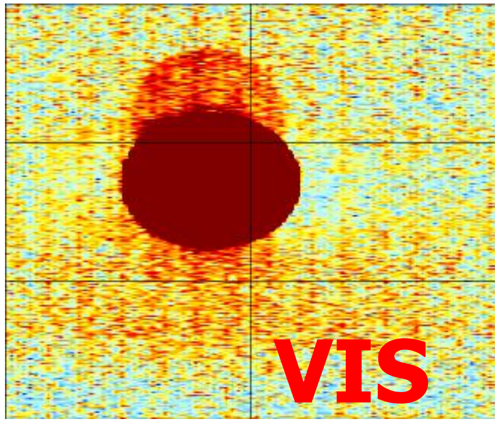


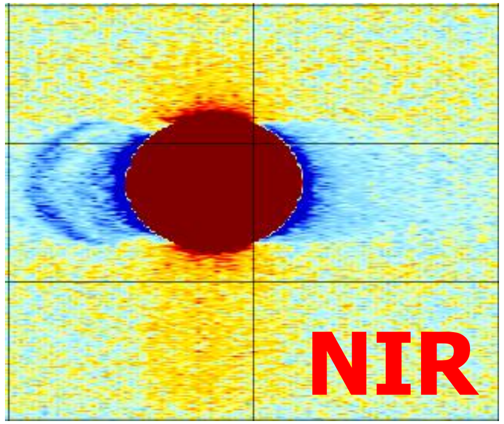
SLSTR Nadir view – S1 (0.555 µm)



S-3B Camera #4

Stray light analysis



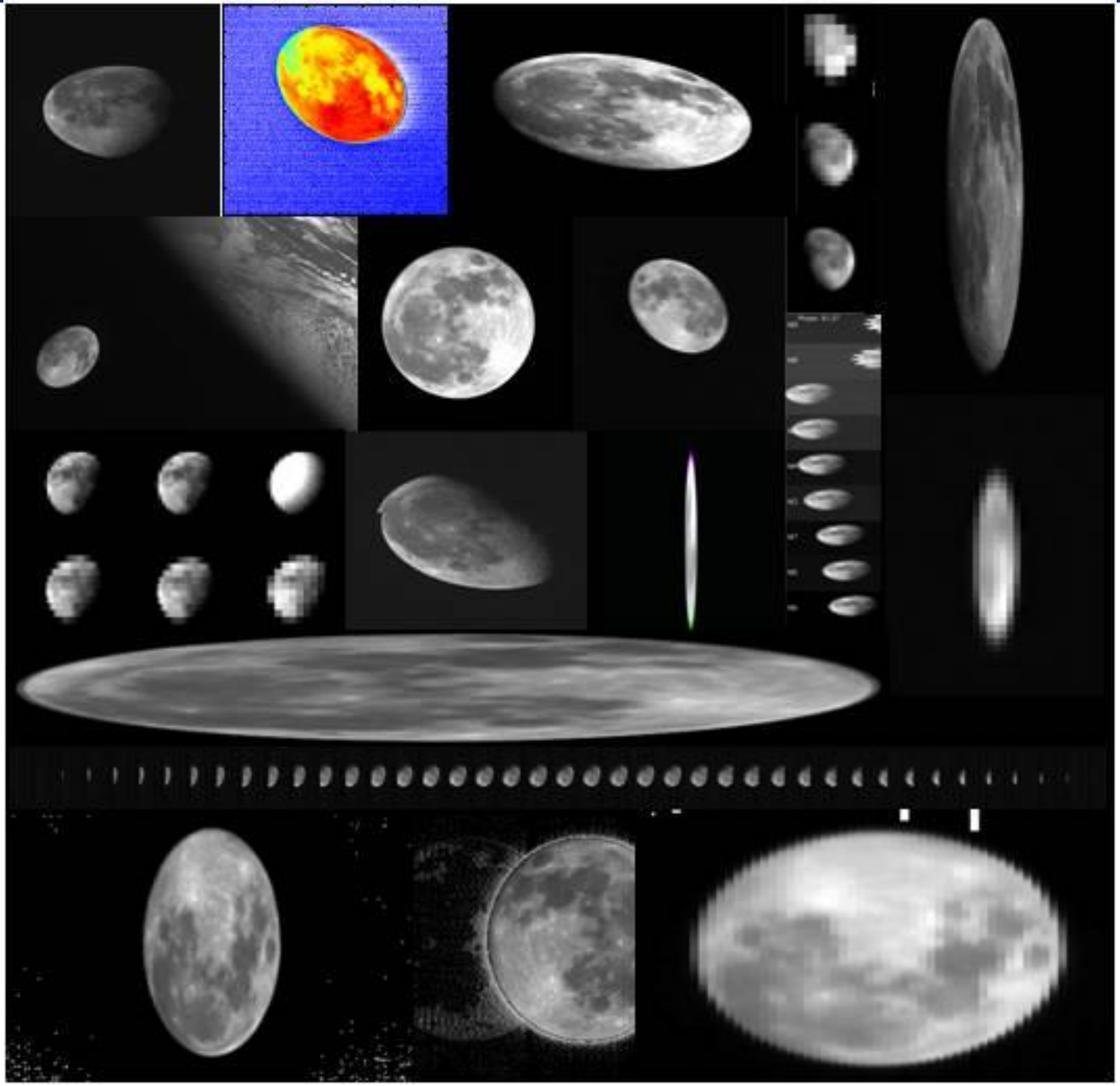


EUMETSAT efforts in lunar calibration

Purpose = increase monitoring capabilities for reflective solar bands

Some major achievements:

- EUMETSAT implemented its own version of the USGS ROLO model
- Endorsed as the international reference for lunar calibration ➔ became the GSICS Implementation of the ROLO (GIRO) model
- One unique tool with standardized input/output to handle all kind of instruments with moon acquisitions capabilities.



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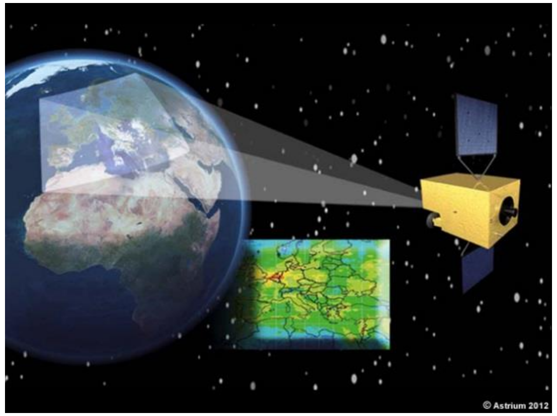
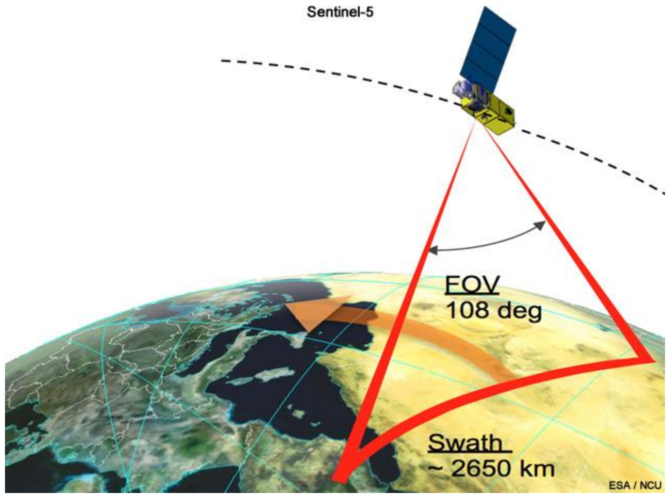
Reflective Solar Spectrometer Sub-Group



- *Focus:* UV/Vis/Near-infrared/Shortwave infrared hyperspectral observations:
- EUMETSAT & Copernicus missions: GOME-2, MTG-S Sentinel-4, EPS-SG Sentinel-5, CO_2M … many others.
- Extending current GSICS VIS/NIR algorithms

<u>Activities for Reflective Solar Spectrometers</u>

- Solar Spectrum comparison and reference
- White Paper on Ground-based Characterisation
- Cross-comparison during match-ups
  (LEO vs LEO Simultaneous Nadir Overpass,
  Chasing Orbits (Opportunistic Formation Flying,
  LEO under flights of GEO)
- Cross-comparison at Target Sites
  (Sahara, Pacific, Ice sheets, Salt pans …)
- Cross-calibration below 300nm



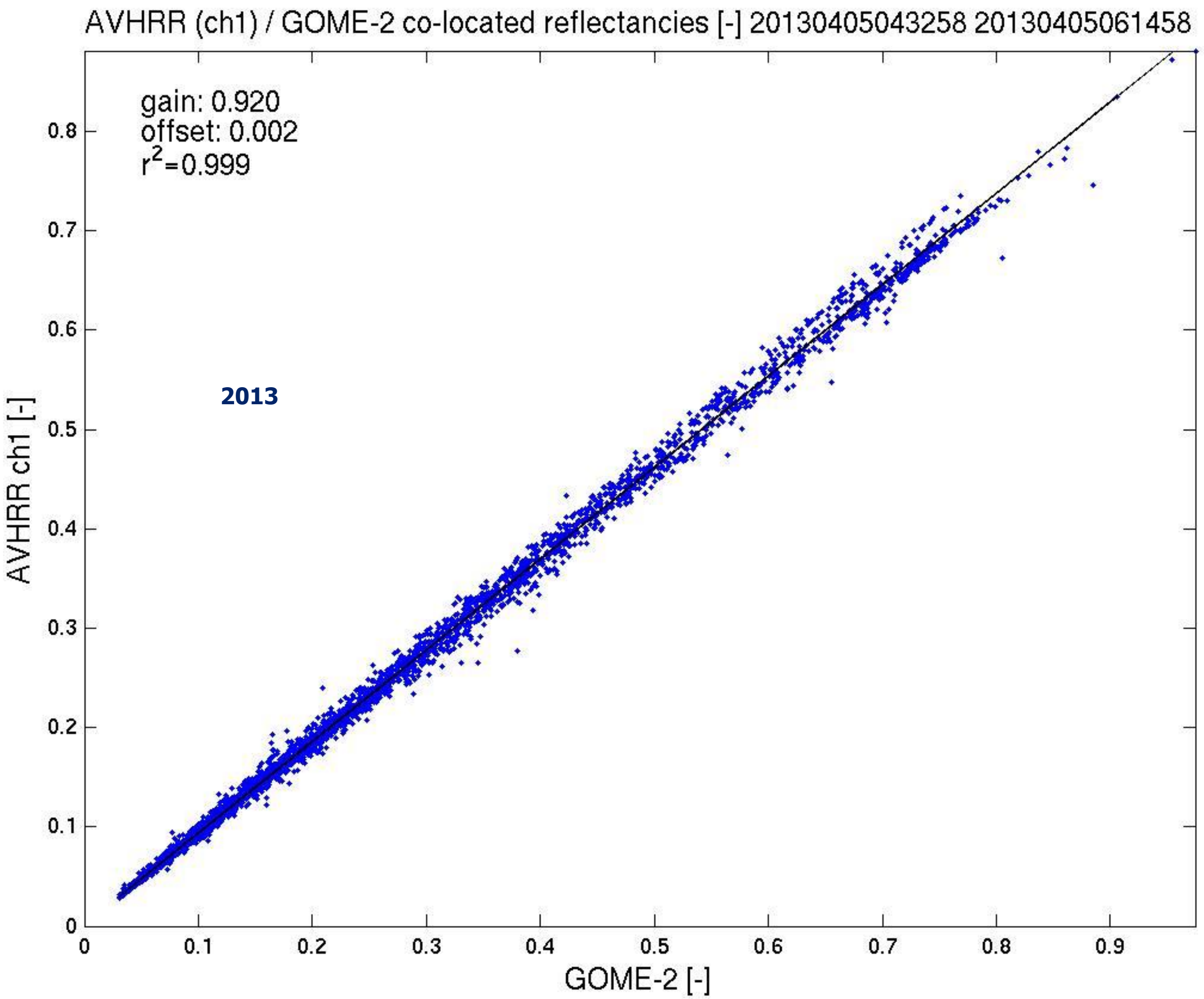
Examples of Inter-Calibration and In-Orbit Validation

- Same platform (B. Latter RAL & R. Lang EUMETSAT) Reflectance from Metop-A AVHRR and GOME-2
- Simultaneous Nadir Overpass LEO with LEO (J. Niu NOAA) NO_2 from Aura OMI and Metop-A GOME-2
- Underpass LEO with GEO (R. Lang EUMETSAT)Reflectance from MSG-3 SEVIRI and Metop-B GOME-2
- Underpass LEO with L-1 (A. Marshak NASA) Radiance/Irradiance DSCOVR EPIC and S-NPP OMPS NM
- Formation Flying (Chasing Orbits) TropOMI and S-NPP OMPS, Opportunistic for EOS-AURA and S-NPP or NOAA-20.
- Antarctic Ice Target Multiple Sensors (G. Jaross et al. NASA) Antarctic Ice reflectivity for TOMS, SBUV/2, OMI, OMPS NM
- Equatorial Pacific Statistics (L. Flynn NOAA) V8 Algorithm for Metop-A, -B GOME-2 and S-NPP and NOAA-20 OMPS NM.
- Land Targets (S. Taylor NASA) Amazon minimum reflectivity for TOMS, SBUV/2, OMI, OMPS Nadir Mapper
- Reflective Channel Consistency Internal Check Aerosol Index statistics, maximum and minimum reflectivity
- Ozone Profile Channels Multiple Sensors (NASA SBUV/2 Ozone Profile CDR Team) V8 algorithm initial residuals for profile channels for SBUV(/2) and S-NPP OMPS NM
- Observed minus Forecast Most assimilation groups track the OmF biases for Ozone assimilations.

GOME-2 / AVHRR reflectivity inter-calibration

AVHRR Ch 1/ Metop-A

GOME-2 FM3
Metop-A



AVHRR channel 1 to GOME-2/Metop-A gain in reflectivity <8% (AVHRR < GOME-2)

2011 - 2013

see GSICS Quarterly Newsletters, vol 5, number 3, *Latter et al.*

spatial aliasing accounted for

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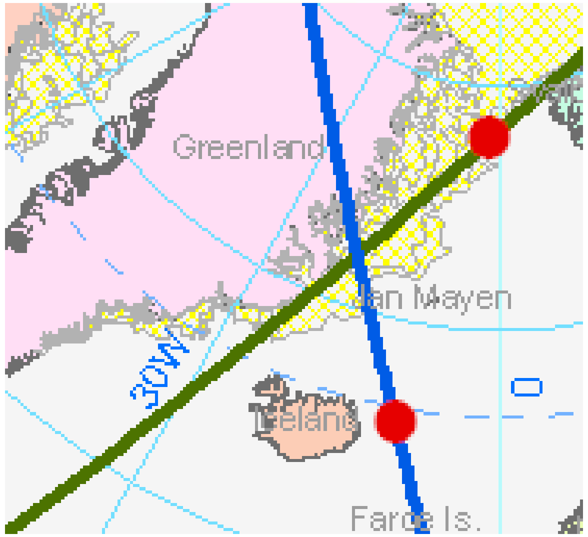
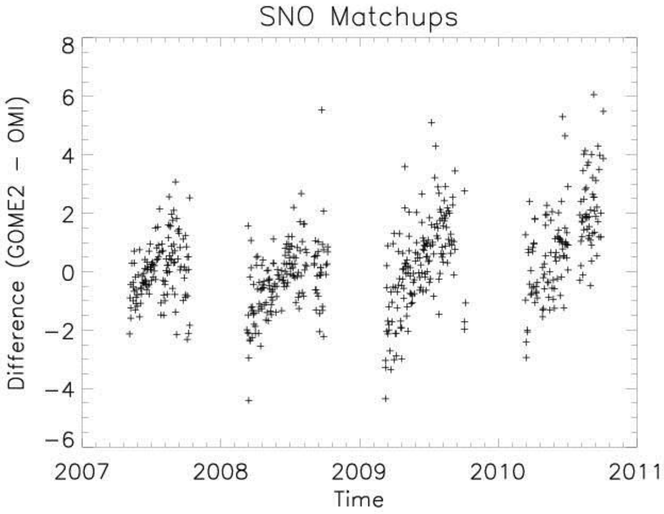
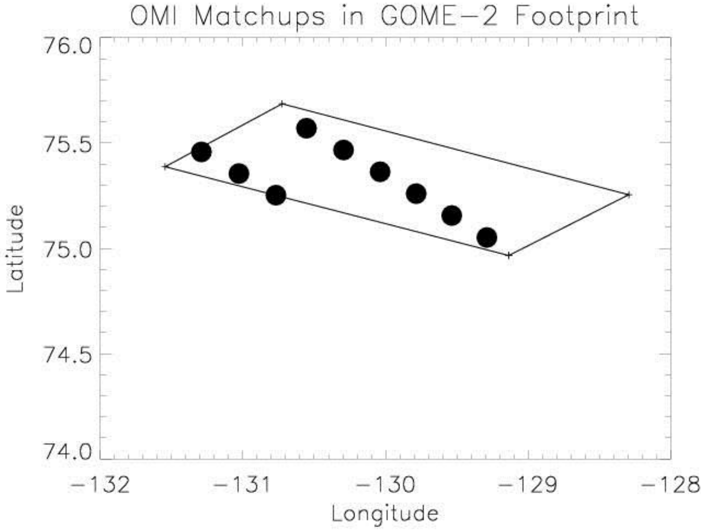
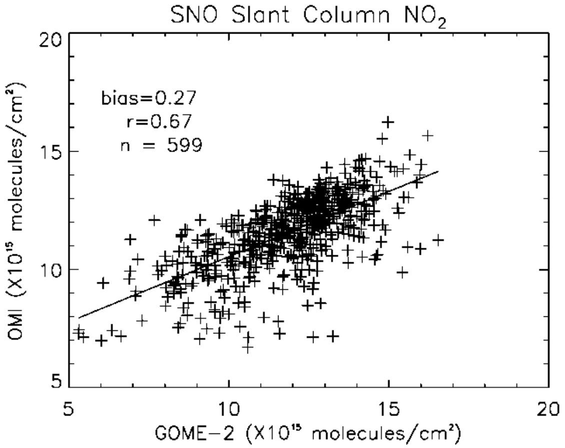
Aura OMI / Metop-A GOME-2 SNO



Simultaneous Nadir Overpass (SNO) analysis shows agreement between OMI and GOME-2 when they are sampling the same atmosphere at the same time.







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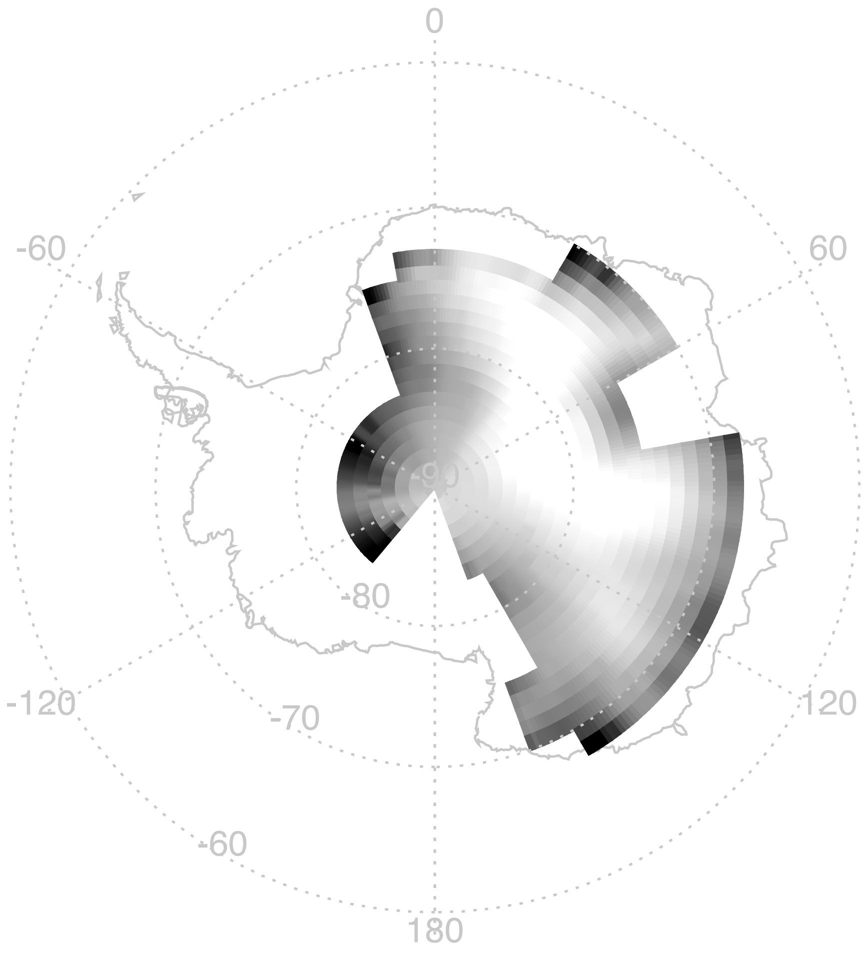
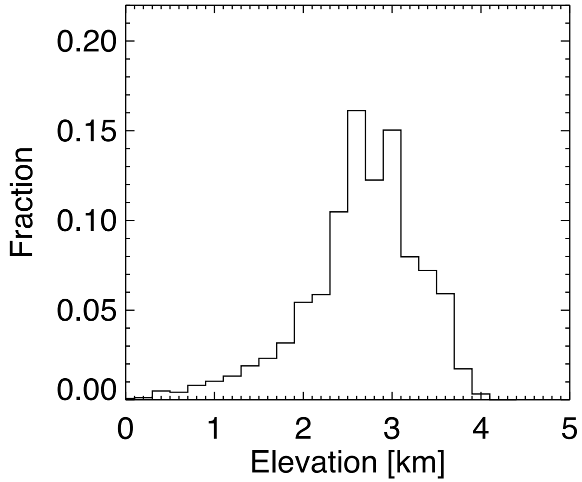
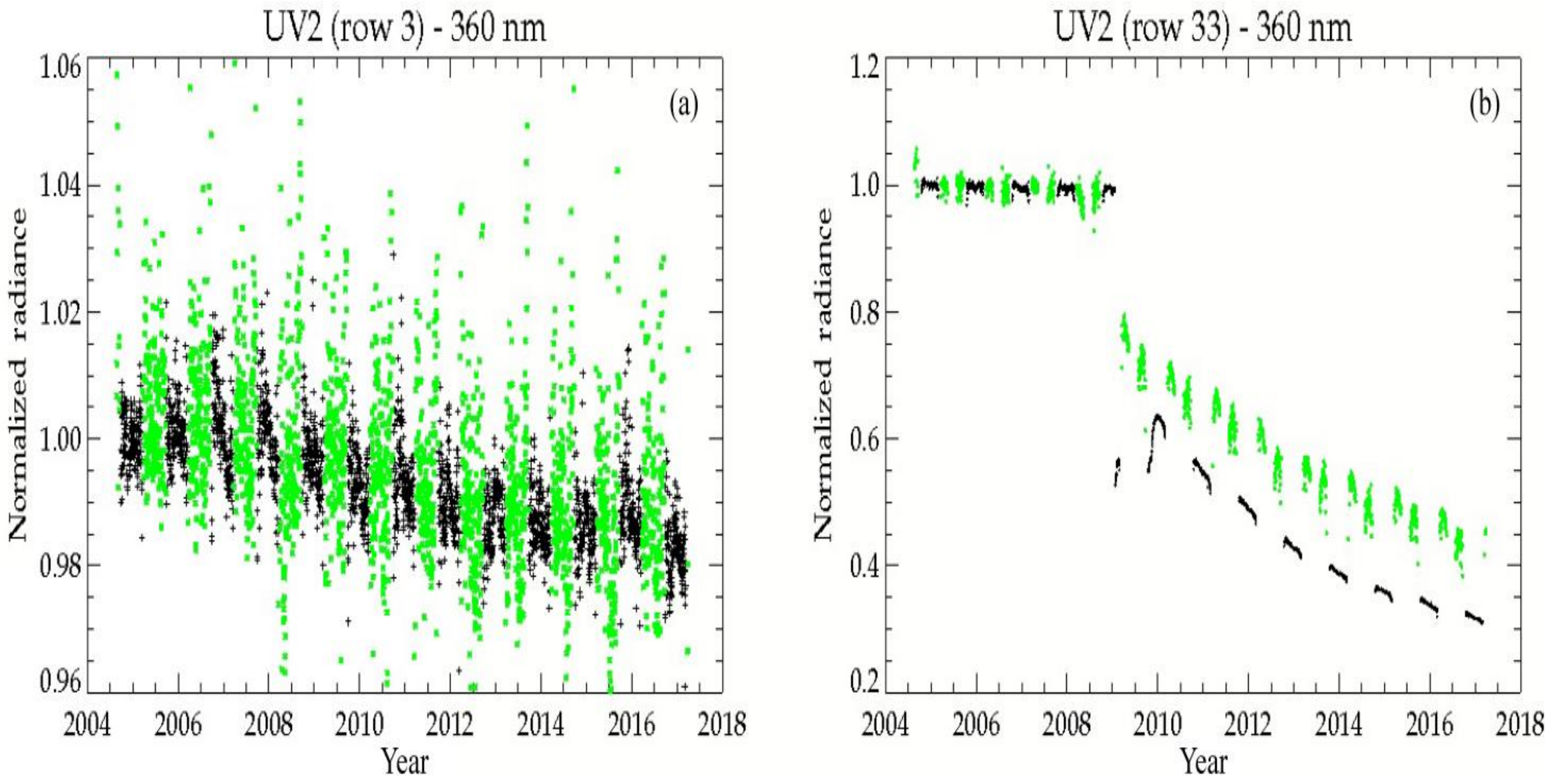
Ice Radiance Region (Antarctic)





Ice Radiances, D. Haffner, NASA (SSAI)



Green – Greenland
Black – Antarctica

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Now there is also polarization

- New Dimension = New Challenge:
  - Calibrating Instrument Polarisation
    - useful for polarimeters (e.g. 3MI)
    - but also standard sensors
  - Radiometric ➔ Vicarious Calibration

- Developing calibration algorithms
  - Extend vicarious techniques
  - Collaboration with CNES and LOA

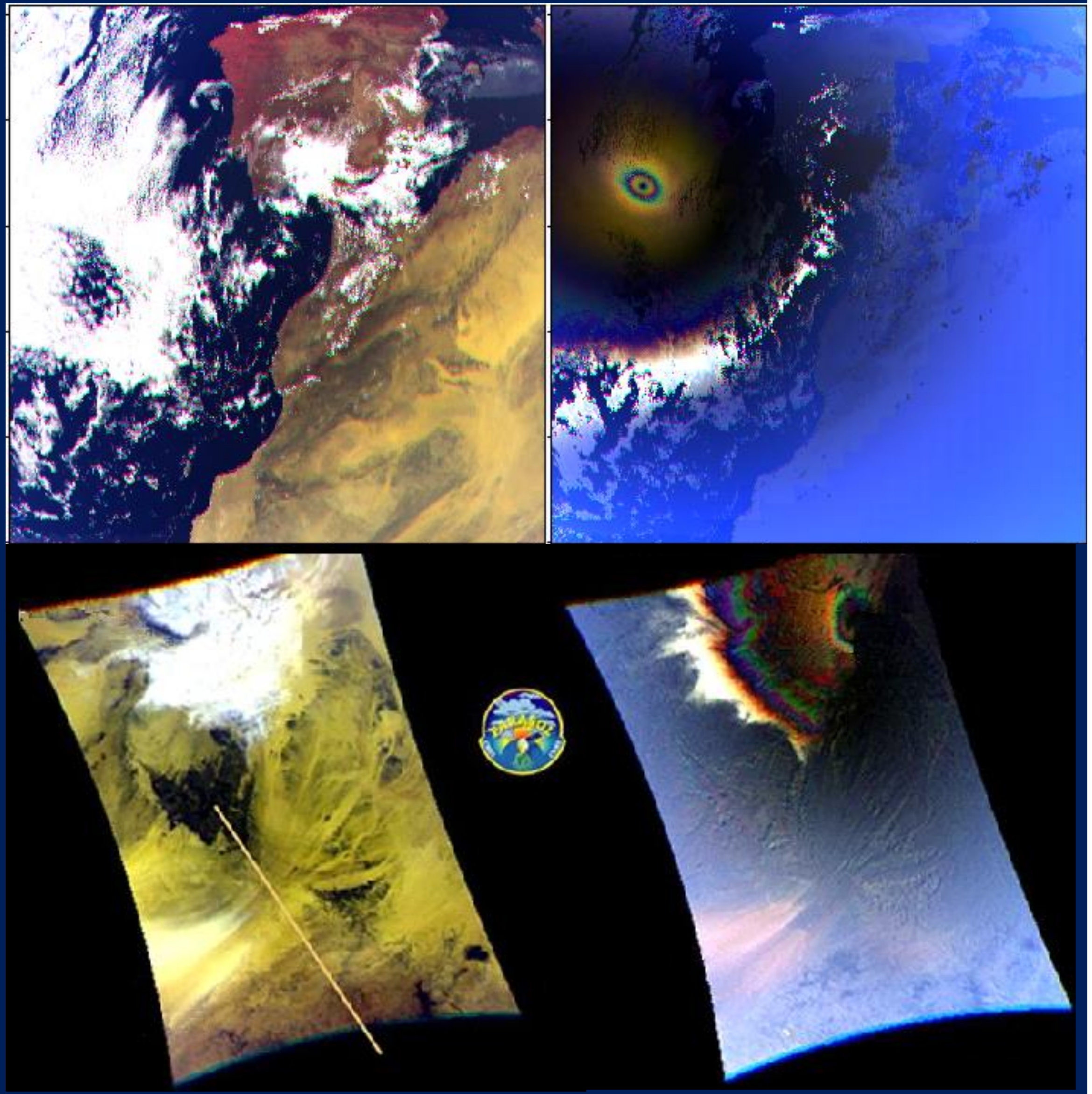
- Then develop inter-calibration
  - through GSICS
    - of polarimeters' sensitivity
    - of the polarization
  - to harmonise L1 data with other polarimeters
  - Starting generation of polarimeters:

  S-GLI/GCOM-C, CMA, ISRO, NASA…

Natural light (RGB) | Polarized Light (RGB)

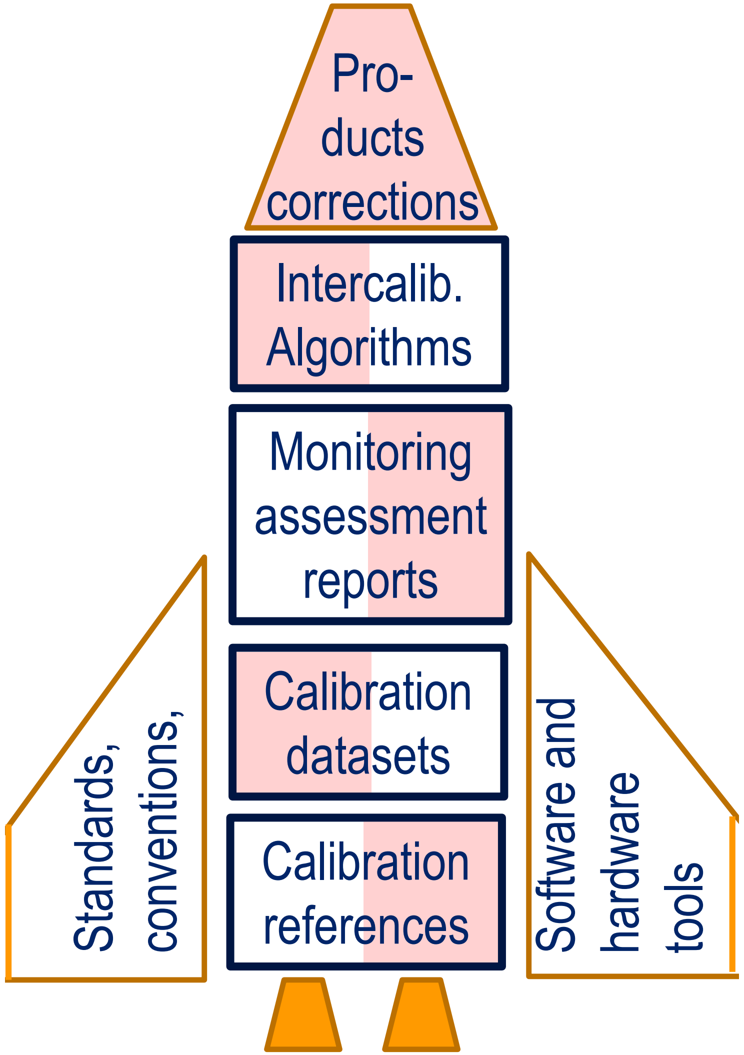
3MI Test Data Set

PARASOL (Courtesy CNES)



GSICS Deliverables

- GSICS Products for users of satellite data
  - including calibration corrections/coefficients
  - corrects calibration to be consistent with reference
- GSICS Algorithms
  - which describe inter-calibration processes
- GSICS Monitoring
  - Reports, assessments
- GSICS Reference datasets
  - including Solar spectrum, …
- GSICS Tools
  - for use by inter-calibration developers
- GSICS Recommendations
  - standards, conventions and guidelines,
- GSICS User Services, information



Slide Courtesy of J. Laffeuille

To think about?

Choices for Calibration Goals:

- Absolute calibration to traceable standards
- Relative calibration – radiance to radiance; solar to solar; reflectivity to reflectivity using standard scene or target, the moon, with statistical evaluation
- Calibrate to radiative transfer forward model specification of truth
- Calibrate to product retrieval algorithm
- Calibrate to model, OmF, forward model, truth,

Calibration Purposes:

Improve retrieval products
Track stability, monitor instrument performance, make CDRs
Identify biases and shifts
Improve consistency for applications

Summary

- Within GSICS methods are developed for
  - vicarious calibration and
  - inter-calibration
- To monitor & complement on-board calibration
  - for operational support
  - to support Cal/Val
  - to allow inter-operability
  - to support the production of monitoring information and reports
- The “Reflective Solar Spectrometer Subgroup” will
  - extend these activities to support hyperspectral instruments operating in the UV-Vis-NIR-SWIR spectral range

Input from the AC-VC community on prioritisation of activities is welcome