EUMETSAT

TRUTHS potential role for climate data records

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TRUTHS Ambition

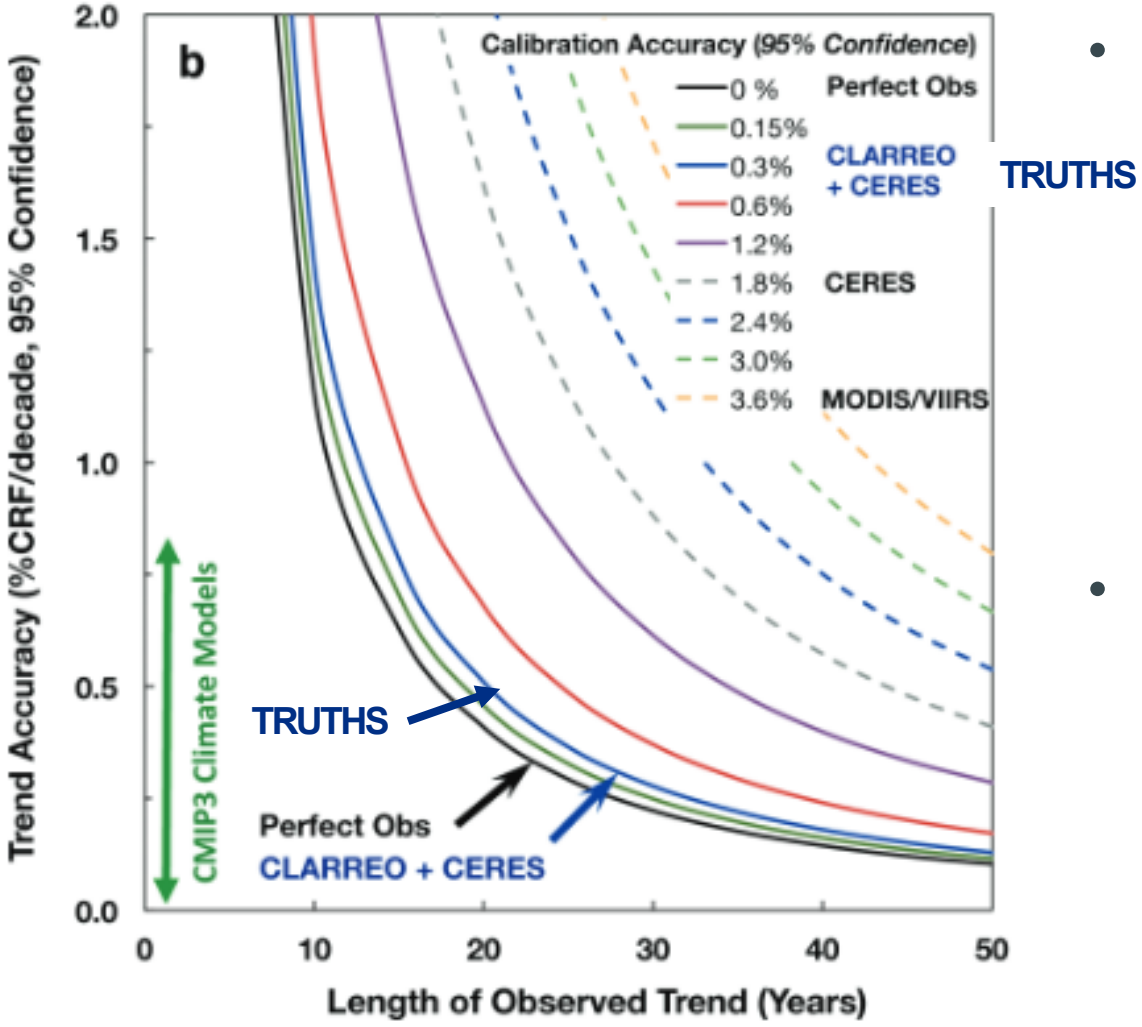
TRUTHS has two primary objectives to provide:

1. datasets of sufficient accuracy needed to observationally detect the signals of climate change (in the solar reflective domain) in the shortest possible time. Needed to critically test climate models and attribute the effects of climate change to geophysical processes by providing Top of the Atmosphere (ToA) measurements of incoming and reflected total and spectrally resolved solar radiation appropriately sampled and with uncertainties optimised to minimise time to detect a trend and consistent with goals of GCOS specified requirements.

2. the means to upgrade the performance of the EO system through delivery of an operational high accuracy L1 nadir-looking hyperspectral Earth-reflected radiance product with sufficient spatial (~50 m (Goal)), spectral (<8 nm), accuracy (Goal 0.3%, k = 2), and agility that allows it to match (or address) the observational radiometric characteristics of a wide range of Earth viewing sensors so that it can validate and/or upgrade their calibration by 'reference calibration' (Cal) from space, primarily to address climate measurement needs.

Fox and Green, 2020: Traceable Radiometry Underpinning Terrestrial- and Helio-Studies (TRUTHS): An Element of a Space-Based Climate and Calibration Observatory Remote Sens., 12, 2400; doi:10.3390/rs12152400

Detecting climate change



Wielicki, B. A., and Coauthors, 2013: Achieving Climate Change Absolute Accuracy in Orbit. *Bull. Amer. Meteor. Soc.*, **94**, 1519–1539, https://doi.org/10.1175/BAMS-D-12-00149.1.

- A decadal change in SW CRF of 1%/decade changes the Earth's radiation balance as much as the anthropogenic radiative forcing of 0.5 Wm^{-2}/decade expected over the next few decades (Solomon et al. 2007).

- A signal this large would take 12 years to detect with a perfect observing system. A smaller cloud feedback of half this magnitude (0.5%/decade) would require 17 years of observations at 95% confidence for a perfect observing system, and >20 years with a TRUTHS or accuracy of 0.3 - 1% (k = 2).

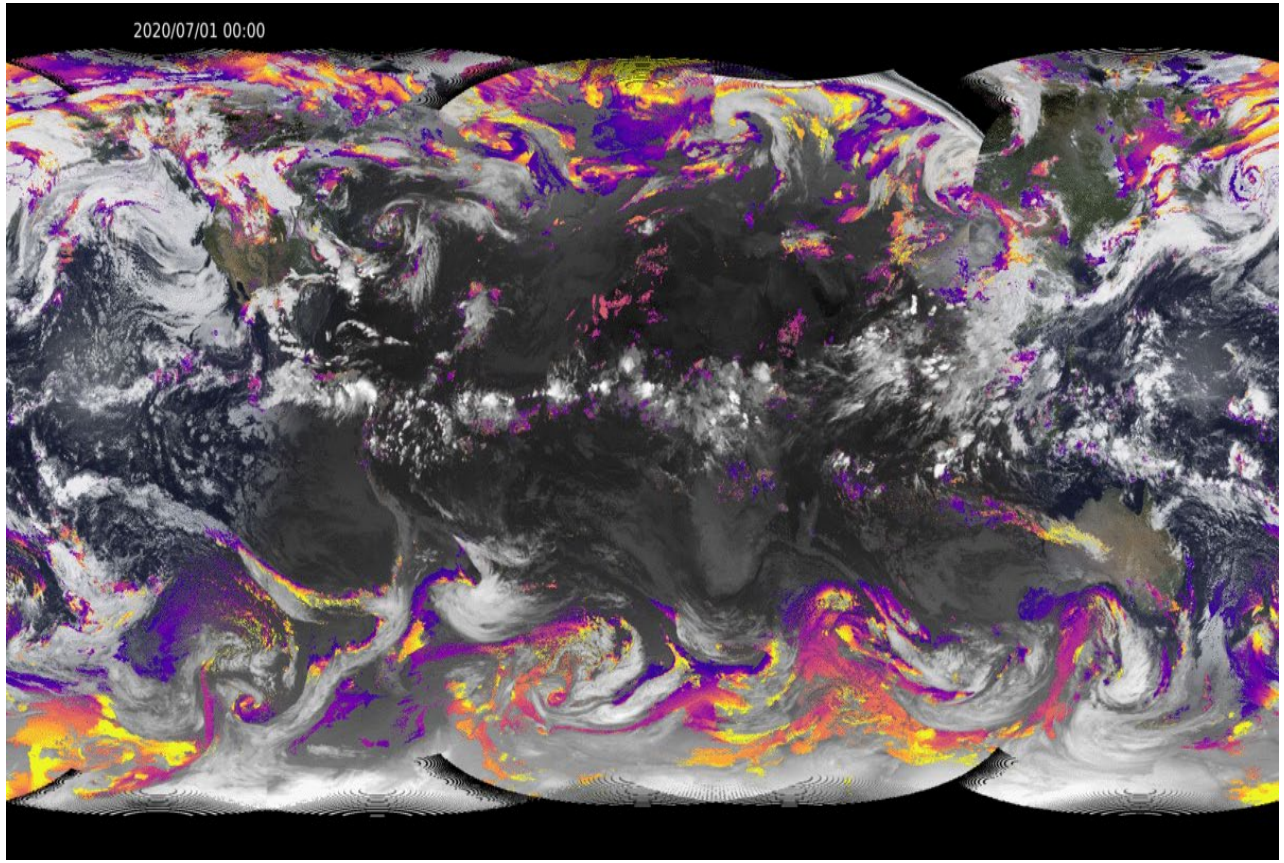
Continuity issue

- Earth Radiation Budget and traceable reference missions have mostly been or are planned as research missions, which often have no continuity
- The latest GCOS Implementation plan has an Action B1.5: *Establish a long-term space-based reference calibration system to enhance the quality and traceability of earth observations. The following measurables are to be considered: high-resolution spectral radiances in the reflected solar (RS) and infrared (IR) wave bands, as well as GNSS radio occultations.*
- CEOS/CGMS WGClimate has assessed the situation, which does not look rosy with CLARREO currently delayed to spring 2026 (with ISS operations stopping in 2030) and TRUTHS not being launched before 2030.
- It could be an option to try to bring reference missions based on the need stated by GCOS to the WMO WIGOS Vision 2050
- WMO INFCOM-3, 15-19 April 2024 requested an update to the WMO 2040 Vision, to be considered by INFCOM-4 in late 2026 and for adoption by the 20th World Meteorological Congress in 2027.
- The update is based on the WMO Rolling Requirements Review process that should then contain requirements related to such reference missions maybe at the level of ECVs. Note for the area of climate GCOS requirements are taken aboard
- The WIGOS vision is primarily used by CGMS as a basis from which member agencies select their commitments

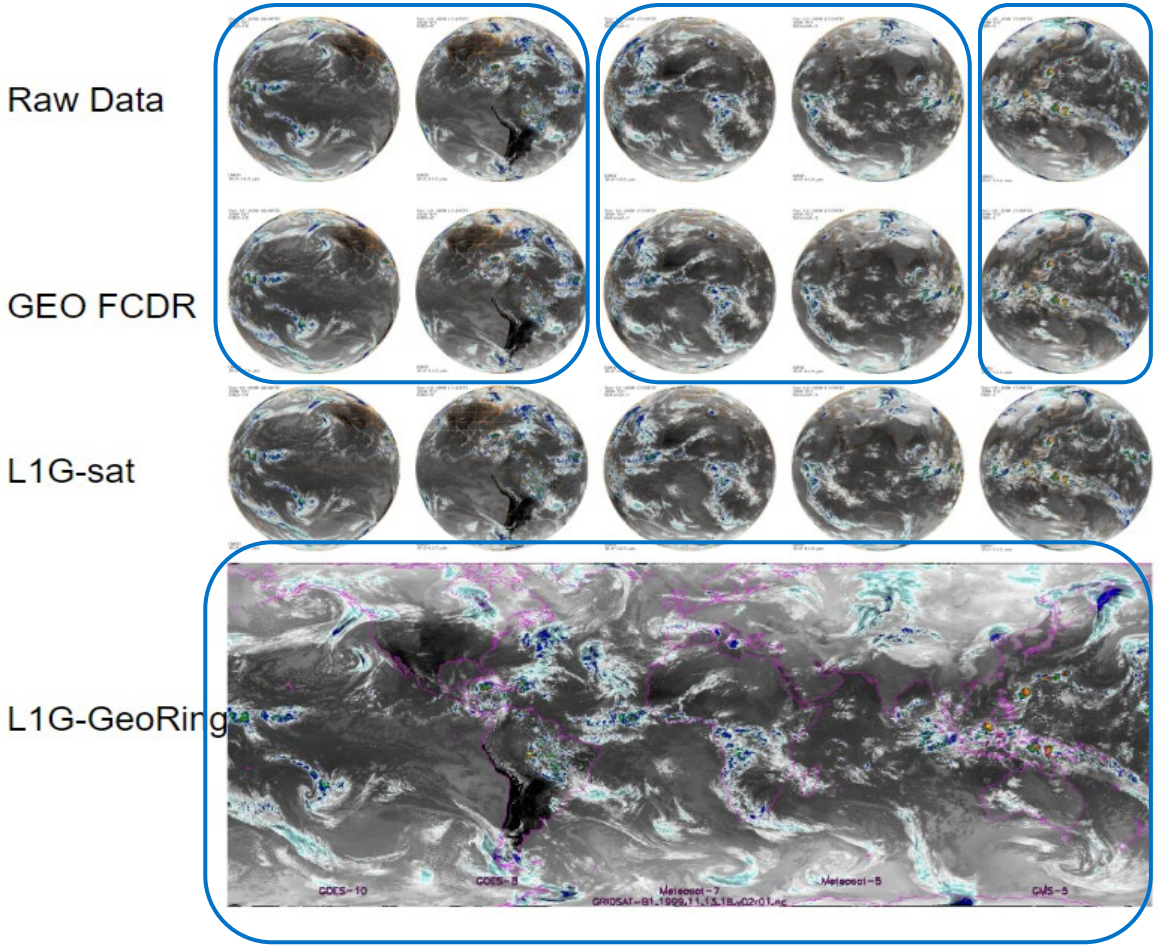
GEO-Ring application: ISCCP-NG

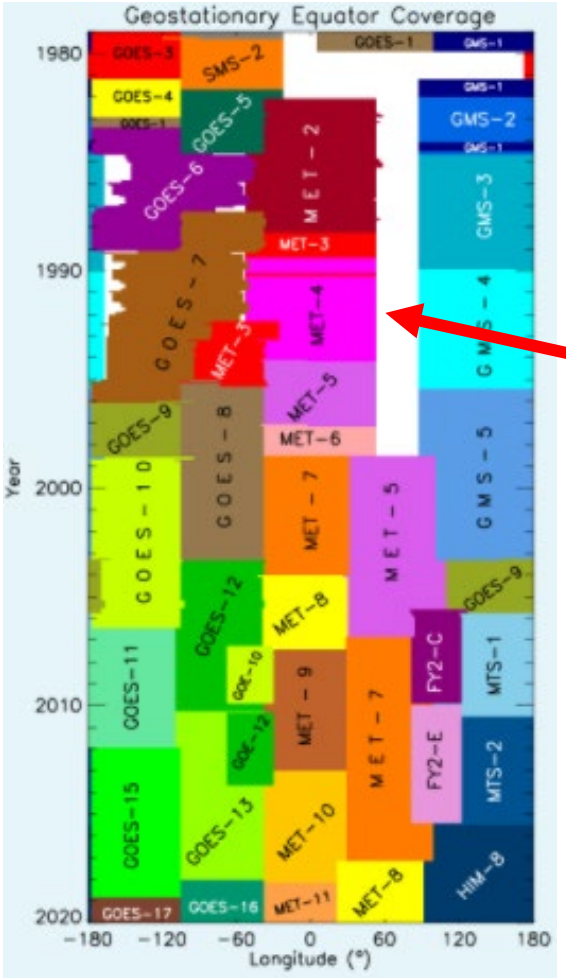
- ISCCP-NG uses the current GEO-Ring (SEVIRI, AHI, ABI, AMI)
- ISCCP-NG L1g is a prototype method to combine all sats into a seamless GEO-Ring. Code being developed by NESDIS (CIMSS), EUMETSAT and KMA. All are welcome
- Goal is to support cloud, aerosol, surface albedo, surface radiation flux, surface temperatures, AMVs, precipitation and other applications
- Nominal resolution is 30 min, 0.05° and all channels
- NOAA/NESDIS and EUMETSAT/CM-SAF have demonstrated use of ISCCP-NG L1g for cloud applications
- Prototypes for 2021 and 2023 available from UW/CIMSS

ISCCP-NG supercooled cloud detection (Martin Stengel, DWD)



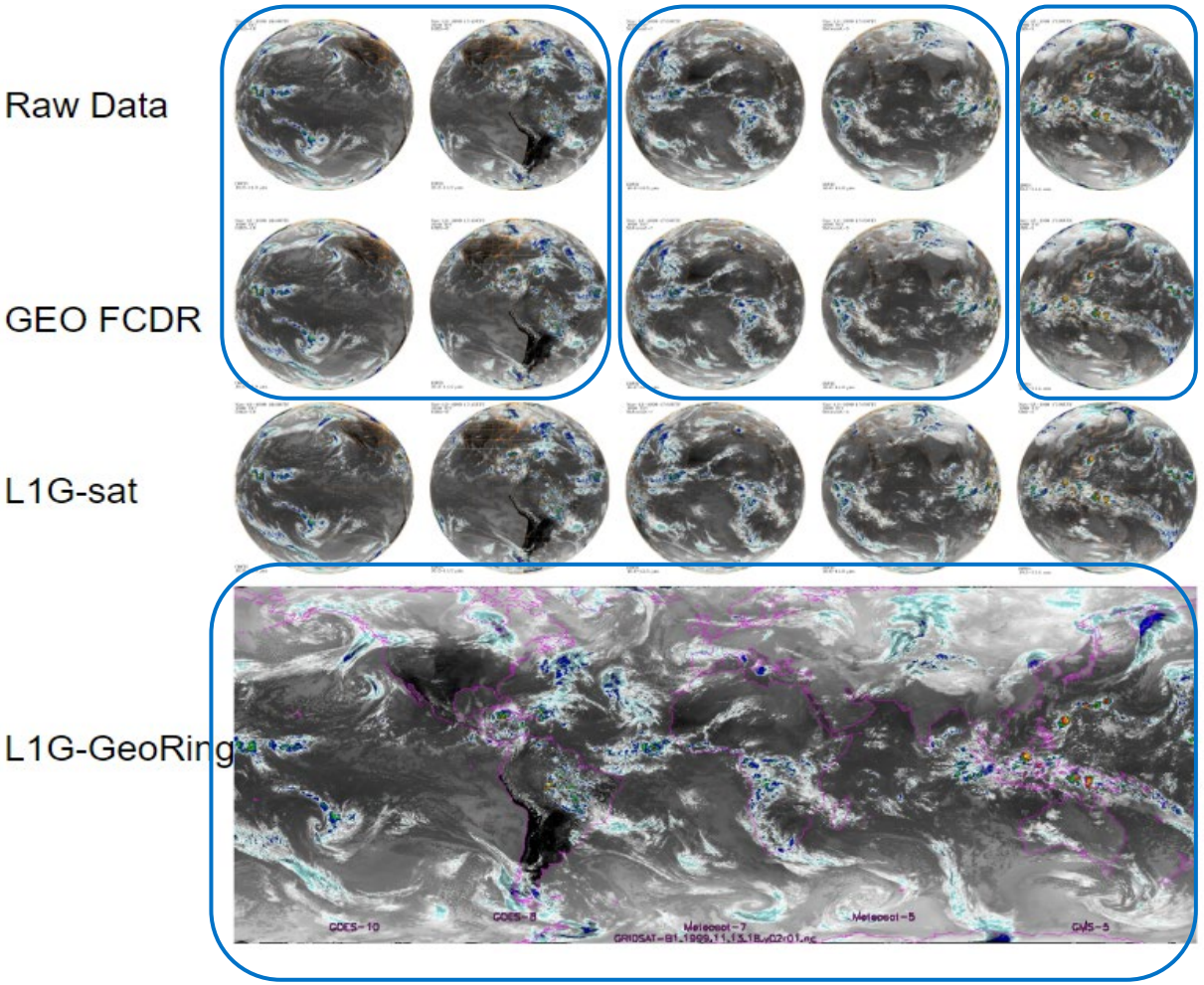
EUMETSAT-NOAA GEO-Ring project with JMA and IMD contributions





- GEO-Ring radiance data 1974-today and beyond
- Includes rescued data from SMS-1/2, GOES 1-7 and >10 years INSAT data
- Nominal resolution is 30 min, 0.05° and all spectral channels
- Project runs 2023-2027 and aims at best and longest radiance climatology ever
- First data 2025/2026

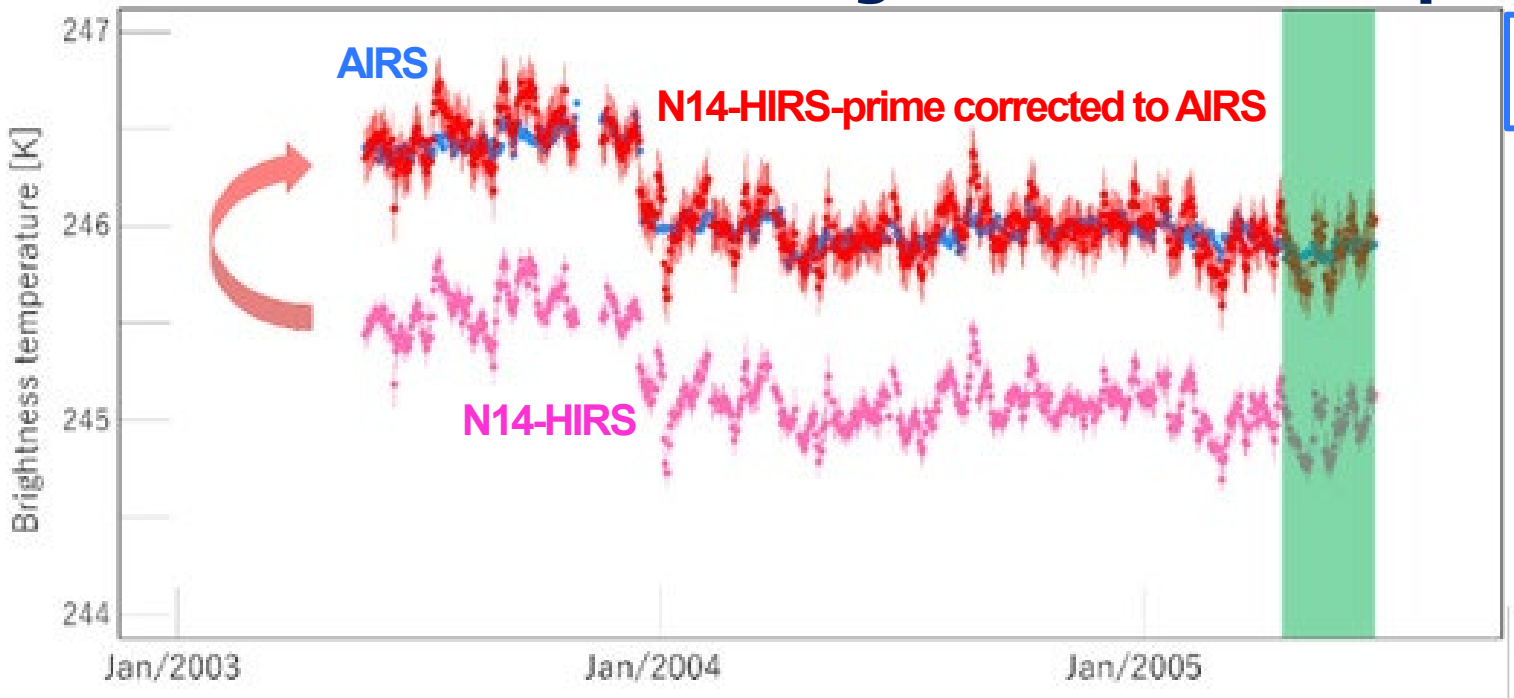
From single satellite raw data to global product



- Raw data: rescue activities, radiometric anomaly detection, navigation
- GEO FCDR: channel re-calibration, uncertainty characterisation, cross-calibration (rather easy for IR but complex for VIS), spectral band adjustment, validation
- L1G-sat: mapping on standard grid with fixed temporal sampling
- L1G-GeoRing: combination of L1G-sat into quasi-global product to be initially distributed by EUMETSAT, NOAA and maybe JMA with additional access for users within cloud compute systems if feasible

How to use TRUTHS for past measurements (1)

Anchoring calibration to a prime reference



$$L_1 = a_1 + b_1 \times DN$$

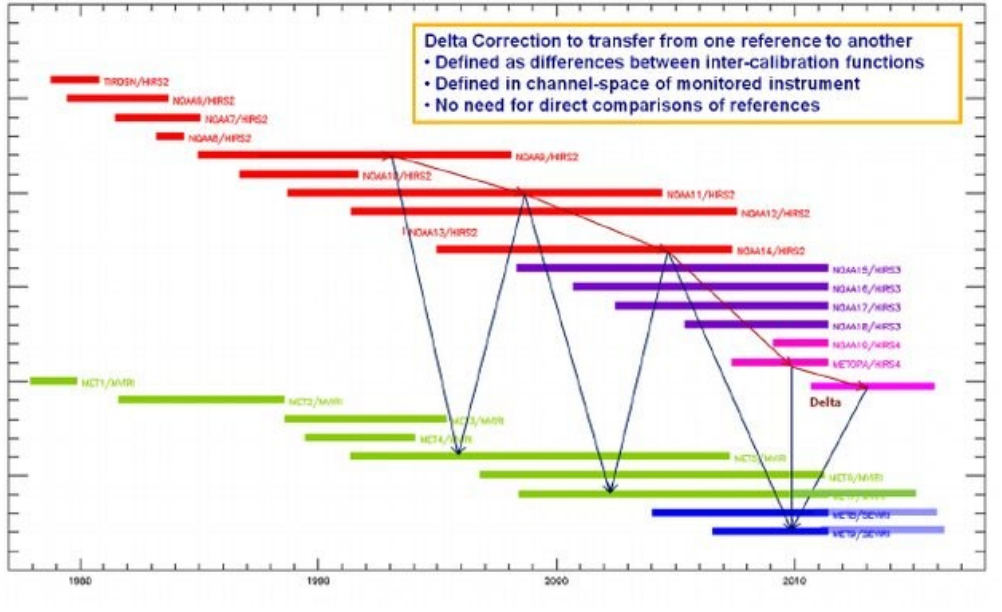
$$L_2 = a_2 + b_2 \times DN$$

$$L'_2 = a'_2 + b'_2 \times L_2$$

$$a'_2 = a_1 - a_2 \times b'_2 \qquad b'_2 = b_1/b_2$$

$$L'_3 = a'_2 + b'_2 \times (a'_3 + b'_3 \times L_3)$$

Recalibrated radiances of GOES-9/Imager WV channel derived from recalibration coefficients by Aqua/AIRS (blue) and those by NOAA-14/HIRS2 (pink), and the prime corrected NOAA-14/HIRS2 (red) using Aqua/AIRS as the prime satellite. The green shaded region represents the period where data was used to compute the prime correction parameters (John et al., 2019; Tabata et al., 2019)

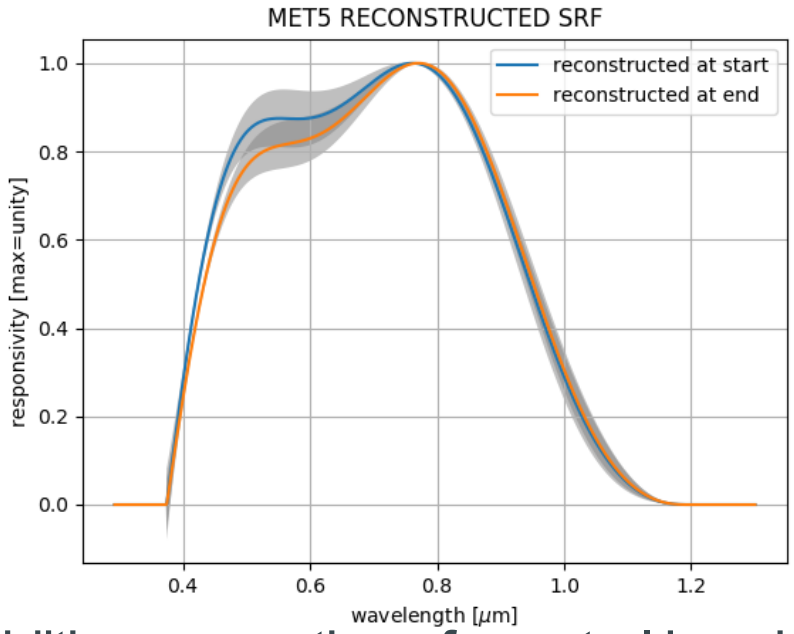


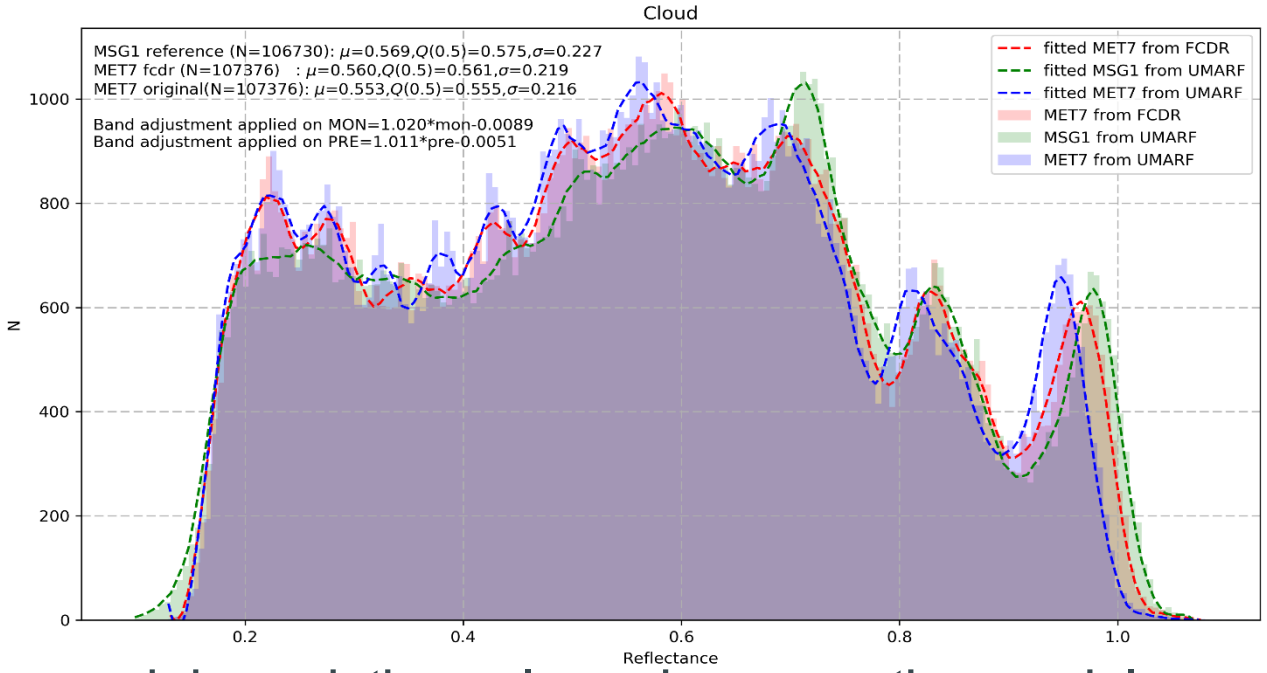
John, V.O.; Tabata, T.; Rüthrich, F.; Roebeling, R.; Hewison, T.; Stöckli, R.; Schulz, J. On the Methods for Recalibrating Geostationary Longwave Channels Using Polar Orbiting Infrared Sounders. Remote Sens. 2019, 11, 1171.

Tabata, T.; John, V.O.; Roebeling, R.A.; Hewison, T.; Schulz, J. Recalibration of over 35 Years of Infrared and Water Vapor Channel Radiances of the JMA Geostationary Satellites. Remote Sens. 2019, 11, 1189.

How to use TRUTHS for past measurements (2)

- Transfer the prime reference approach to the visible range using TRUTHS and/or CLARREO or other instruments being close to a reference might be considered but each satellite transition backwards adds uncertainty.
- Vicarious targets on the ground may have a too short record or do not have the needed stability to be used. The moon as an invariant target and some desert sites that are pseudo variant at scales of 40 years could potentially be used to validate the prime reference correction.





- In addition, correction of spectral band errors and degradations also using correction models for SRFs could involve TRUTHS spectral data

Summary

- TRUTHS will realise a reference mission with SI traceability, and that is what is really new about this mission
- To contribute to climate change detection directly the continuity issue would need to be addressed to enable long reference instrument time series
- It is suggested to approach the WMO, which will update the WIGOS Vision 2050 in the coming years, to achieve a climate-relevant entry on the GCOS need for SI-traceable reference calibration missions. This may help both TRUTHS and CLARREO
- It might be possible to use TRUTHS to recalibrate backwards in time using the prime reference approach and to propagate the uncertainty estimates from satellite to satellite. In addition, TRUTHS might be useful for developing spectral corrections for broadband channels of geostationary instruments or validating models that provide those. With this TRUTHS may become valuable in the future for improving data records such as the GEO-Ring radiances

Thank you!

Questions are welcome.