Minutes of the 55th Meeting of the CEOS Working Group on Calibration and Validation (WGCV)

Chaired by USGS and hosted by ISRO
Hyderabad, Telangana, India

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Day 1: Tuesday 8th July, 2025

1.1 Welcome by ISRO: WGCV-55 Delegates

- Prakash Chauhan (ISRO NRSC Director) and Murali Krishan (ISRO NRSC Deputy Director) welcomed WGCV back to Hyderabad. The last time WGCV came to Hyderabad was the Joint WGCV-35 / WGISS-34 Plenary, hosted by ISRO in September 2012.
- Prakash highlighted the importance of WGCV in defining calibration protocols for various optical, SAR, thermal, and hyperspectral sensors, which are immensely beneficial to the global Earth Observation community.

1.2 - Welcome and Introduction

- Medhavy Thankappan (GA, WGCV Vice Chair) and Cody Anderson (WGCV Chair) welcomed all to the meeting and led a tour de table.

1.3 - Action Review

Harvey Jones (WGCV Secretariat) reported *[slides]*:

- The open actions from WGCV-53 and WGCV-54 were reviewed.
- Actions WGCV-53-19, WGCV-54-07, and WGCV-54-20, regarding coordination of WMO coordination with CEOS-FRM, were closed. They will be considered as input to the second FRM Assessment Framework exercise.
- Actions WGCV-54-01 and WGCV-54-02, were closed and will be continued under the WGCV SI-Traceable Satellite Task Team.
- Actions WGCV-54-08, WGCV-54-11, and WGCV-54-15, tasking the WGCV Subgroup chairs to communicate recent activities for promotion on the Cal/Val Portal, were superseded by action WGCV-55-01.

WGCV-55-01	WGCV Subgroup chairs to communicate subgroup activities to Paolo to be shared on the Cal/Val Portal at https://calvalportal.ceos.org/wgcv.	**WGCV-56**
WGCV-55-02	Paolo Castracane to work with Nigel Fox to establish on the Cal/Val Portal an IVOS database on radiometric calibration capabilities.	**Q4 2025**

- The deadline for action WGCV-54-18 was extended to Q4 2025.

WGCV-55-05	Medhavy Thankappan to work with subgroup chairs to review the Terms of Reference from the RadCalNet CEOS WGCV	**Q3 2025**

	review panel and identify suitable evaluators of the different types of submissions to the FRM Assessment Framework.	

- Action WGCV-54-21 regarding the LPV Subgroup Land Cover and Change Map Accuracy Assessment and Area Estimation Good Practices Protocol was closed. The document will be endorsed subject to the incorporation of minor feedback and review.

1.4 - ISRO's EO Programme in Brief

Prakash Chauhan (ISRO NRSC Director) and Girish Pujar (ISRO NRSC) reported *[slides]*:

- ISRO's first Earth Observation satellite was IRS-1A, launched in 1988. The agency currently operates two Resourcesat missions (R2 and R2A), RISAT-1A, Oceansat-3, SARAL, the Cartosat constellation, two meteorological satellites, as well as a number of international partnerships. All of these systems perform periodic calibration over standard vicarious calibration sites, ensuring consistency of observations over the satellites' lives.
- The New India Space Policy allows the private industry to participate in all space activities in India, and has seen a surge of more than 200 companies developing rockets, satellites, sensors, ground stations, services, and calibration and validation. The upcoming NISAR mission will be launched this month, and is expected to produce a host of biogeophysical products.
- ISRO is looking forward to the development of standards for hyperspectral EO datasets. From the climate perspective, Cal/Val becomes very important in building long term Essential Climate Variables (ECVs). The calibration factor needs to be stitched across many products and sensors. Analysis-Ready Data (ARD) is well received by space agencies; ISRO NRSC has begun providing CEOS-ARD compliant products.
- Newspace India Ltd (NSIL) addresses user requirements, and the Indian National Space Promotion and Authorisation Centre (IN-SPACe) aggregates user requirements across India.

Discussion

- Medhavy Thankappan (GA, WGCV Vice Chair) asked if the NISAR observation plan will limit S-band coverage to India. Prakash shared that both ISRO and NASA JPL teams have frozen the plan, although there is interest in S-band coverage beyond India, which may be possible.
- Given that India is a monsoon country, Divya Sharma (SatSure) asked if optiSAR is being considered by ISRO. In the downstream sector, using a combination of sensors creates more effort. Girish noted that some proven combined products already exist, and that OptiSAR is not currently planned.
- ISRO and the Ministry of Science and Technology are planning deep-sea mission requirements to enable observations from depths up to 4,000 metres below the sea surface, aimed at extracting information on seabed minerals, high-seas fisheries, and sea forecasting.
- Regarding the analysis of applications and requirements, Nigel Fox (NPL, IVOS Chair) asked if ISRO has been identified where uncertainty and accuracy in radiometry are a driving requirement from

customers. The SITSat Task Team is trying to find applications where uncertainty is driving requirements. Girish noted an increasing demand for fine-scale understanding, radiometric calibration, and stability from areas such as from plantations, early detection for water security, SAR rice mapping, phytoplankton retrievals from fisheries forecast models, and Sea Surface Temperature (SST) observations.

1.5 - CEOS Executive Officer Report

Steven Ramage (CEOS Executive Officer)* reported *[slides]*:

- The Committee on Earth Observation Satellites (CEOS) is over 40 years old, established in 1984, and has focused on global coordination to optimise societal benefit and decision making for space-based EO. CEOS is a reactive committee that responds to requests as a 'best efforts' organisation, has 34 space agency members and another 30 associates, and is currently chaired by the UK Space Agency. The long term priorities of CEOS notably support GCOS, the Sendai Framework for disaster risk reduction, GEO, and the UN Agenda for Sustainable Development.
- Steven toured the CEOS organisational structure, including the CEOS Chair, SEO, SIT Chair, Secretariat, Virtual Constellations, and Working Groups. More details can be read in the given slides. The CEOS Work Plan is reviewed and updated annually, which lists and tracks a number of deliverables for each CEOS group. An overview of the recent meeting of the CEOS Strategic Implementation Team (SIT-40) was shared, which is available in the slides.
- Currently, five to six agencies are looking to either join CEOS or transition from associates to members. There is a growing interest in CEOS, and the topic of calibration and validation within. The CEOS community convenes annually at CEOS Plenary, of which the 39th Plenary will take place in Bath, UK, from 4-6 November 2025.

1.6 - Geoscience Australia Agency Report

Medhavy Thankappan (GA, WGCV Vice Chair) reported *[slides]*:

- Geoscience Australia is based primarily in Canberra, Australia, and has three science divisions dedicated to Space; Minerals, Energy & Groundwater; Place and Communities. GA provides over five Petabytes of satellite data from as far back as 1988, and 7 PB of Copernicus data to the Indo-Pacific user community.
- The Alice Springs Ground Station, Australia's Landsat Ground Station, is being upgraded to host new infrastructure and advanced data processing capabilities to support the Landsat Next mission.
- CSIRO, Geoscience Australia, and the Bureau of Meteorology secured Australia's role as the 2026 CEOS Chair.
- CSIRO will provide Cal/Val services for Landsat Next, which will include bespoke sites in Australia that aim to be compliant with CEOS protocols such as RadCalNet and the FRM Assessment Framework.

Support for Landsat Next aquatic Cal/Val will be provided by the Dark-water Inland Observatory Network (DION) and the Lucinda Jetty Coastal Observatory.

- For SAR sensors, GA operates the Queensland Corner Reflector Array (QCRA) as well as the Yarragadee Corner Reflectors (YGCR).
- The Digital Earth Australia (DEA) 2025 field campaign is being conducted for surface reflectance validation with spectroscopic instruments, for drone-based lidar and multispectral measurements to validate waterbody, fractional cover, and burnt area products.
- GA are currently performing quality assessments for SAR ARD to develop NRB workflows and inform GA product decisions, which includes quality comparisons for geolocation and topography. The Sentinel-1 NRB product has been produced with NASA's OPERA-RTC ISCE3 workflow and will be submitted for CEOS-ARD self-assessment soon.

Discussion

- Paolo Castracane (ESA) is involved in CEOS SARCalNet, which would welcome a site submission from GA or ISRO. Medhavy indicated that a GA SARCALNET submission for the Queensland and Yaragadee corner reflectors will likely be ready by October.
- The alignment angles of the Queensland Corner Reflectors were discussed, regarding the possibility to align with other satellites. The corner reflectors in Queensland have had fixed alignment since 2014 and do not point to any particular mission. However, trihedral reflectors can compensate for some varied pointing angles.
- The drone-based sensors used for spectroscopic Cal/Val can cover large areas faster than backpack-mounted sensors, and are closer to the satellite spatial resolution. Santhi Sree added that a connection needs to be established between the ground sensor and drone in order to refer to the drone as 'ground based'. The CEOS Surface Reflectance Intercomparison Exercise for Vegetation (SRIX4Veg) recently had a protocol endorsed by WGCV, which describes the guidelines for drone based validation of surface reflectance measurements over vegetation.

1.7 - CSIRO Agency Report

Cindy Ong (CSIRO) reported *[slides]*:

- Approximately 250 km North of Perth, Australia, is the Pinnacles calibration site - a sand dune instrumented for optical calibration in the visible and shortwave infrared region. The site's main instrument, CIMEL, was removed and sent to NASA GSFC for repair and recalibration following damage in the harsh surrounding environment.
- More data is required to complete the site's RadCalNet submission. CNES are helping by sharing their data, and the site shows promising results for the photometer's irradiance and radiance calibration. The site was used during the EnMAP mission's commissioning phase. Measurements taken a few days after rain can affect radiances to a large extent, however this effect is also seen by EnMAP.

- The HyperInSPACE Community Processor (HyperCP) will process raw input radiometric data to derive remote sensing reflectances, uncertainty budgets, and normalised water leaving radiance. The automation will be finalised, FRM4STS protocols will be implemented for thermal radiometers, and the bio-optical database will be published and maintained.
- The Lucinda Jetty is supported by CSIRO as a HYPERNETS site. HYPSTAR aims to improve consistency checks and quality control of hyperspectral radiometric measurements, allow the evaluation of different sun and sky glint corrections, and intercompare uncertainty products. The project will synergise with Landsat Next through HyperCP for processing Lucinda HyperOCR, uncertainty comparisons, and evaluating consistency with new SeaPRISM observations radiometers.
- CSIRO and GA are working to operationalise a collection of in-situ data from three existing permanent Cal/Val sites, which aims to maintain a high duty cycle, minimise downtime, and align with CEOS best practice protocols.

Discussion

- Regarding adjacency effects between sand and vegetation, a participant asked how far the Pinnacles site measures from its mast. The Pinnacles site plans to use 30x30 m pixel resolution sensors. The surrounding sand dune area is quite dark, so anywhere within 80% of the target would have darker surrounding vegetation. The tower is 9m tall, and CNES found that at 60 m distance, the variation is ~2%. Regarding Hytronics for surface temperature, Cindy has explored potential land sites for surface temperature calibration aligned with the TRISHNA bands.

1.8 - ESA Agency Report

Philippe Goryl (ESA) reported *[slides]*:

- The EarthCARE mission was launched on 28 May 2024, and has since begun distribution of data. The mission aims to investigate interactions between clouds and aerosols and their role in Earth's radiation budget, collocated with measurements of solar and emitted thermal radiation. Four instruments onboard are operated in synergy, including a lidar, multispectral imager, radar, and radiometer. EarthCARE's first L1 data from CPR and ATLID shows the ability to penetrate deep into clouds, and observe snow and precipitation. The CEOS Best Practice Protocol For The Validation Of Aerosol, Cloud, And Precipitation Profiles (ACPPV) was instrumental for the validation of EarthCARE. The validation team is working on combining networks of airborne campaigns, satellite intercomparisons, assimilation, and in-situ networks.
- ESA's Biomass mission, a P-band SAR satellite with the objective to measure forest biomass, was launched on 29 April 2025. The mission will have two mission phases, dedicated to PolInSAR and TomoSAR. The mission delivered its first light imagery in June 2025, acquired over the Bolivian forest. The mission's commissioning phase is planned to conclude at the end of 2025.
- The Boundary-layer Air Quality-analysis Using Network of Instruments (BAQUNIN) is a ground-based site in Rome, Italy, instrumented for satellite Cal/Val, atmospheric monitoring/research, homogenise and distribute high quality data, and perform intercomparison and validation campaigns. Similarly,

ESA's Cal/Val Park is a supersite being developed for the Cal/Val of multispectral and hyperspectral missions. The site will be based in Tuscany, Italy, and will be set up from 2026.

1.9 - GISTDA Agency Report

Prayot Puangjaktha (GISTDA), Pawarin Kuha (GISTDA) reported *[slides]*:

- GISTDA has the mission to bring the benefits of space to Thai society and the global community, with a focus on upstream and downstream data, satellite manufacturing, space technology development, product innovation, and geo-informatics and management solutions.
- GISTDA currently operates THEOS-1, launched in October 2008, and THEOS-2, launched in October 2023, with THEOS-2A expected to join the constellation in 2026.
- THEOS-1 is expected to operate for another 3 to 5 years, and for THEOS-2 for 10 to 20 years. The missions support key applications such as agriculture, disaster monitoring, land and urban planning, natural resources, and national security. Planned future missions include THEOS-3 (VNIR and SWIR), THEOS-4 (SAR), and THEOS-5 (VHR).
- THEOS data is stored in Thailand's National Space Data Centre (NSDC). The site also downlinks and distributes data from over 20 optical and SAR partner missions.
- GISTDA performs radiometric and geometric calibration over test sites around the world. Cross-calibration for THEOS-1 radiometric gain and sensor degradation testing was performed against imagery from the SADE database at CNES.
- GCPs and aerial photos are used to validate the satellite geolocation accuracy. Over 4000 GCPs are established around Thailand, although none exist elsewhere around the world, which make global geometric calibration difficult. GISTDA invites CEOS Members to exchange GCP information and is willing to share the Thailand GCP data.

WGCV-55-06	Cody to invite the GISTDA Cal/Val team to participate in TMSG GCPIX, in support of accessing more GCP information for THEOS geometric calibration.	**COMPLETE**

- GISTDA is performing feasibility assessments to develop spatial test sites and is currently working on corner reflector test sites for the next generation of THEOS SAR satellites.
- The THEOS CEOS-ARD product can now be processed manually. Radiometric correction processing aims to involve RadCalNet and AeroNet data. The prototype products will be submitted for CEOS-ARD submission in September 2025. The team is facing challenges in meeting sub-pixel accuracy requirements for geometric correction, although this level of accuracy has been achieved for the THEOS-1 15 m product in Thailand. The required documents for CEOS-ARD submission are difficult to comprehend.

WGCV-55-07	Medhavy to clarify the submission and documentation requirements for CEOS-ARD self-assessment with the GISTDA	**Q2 2025**

	team.	

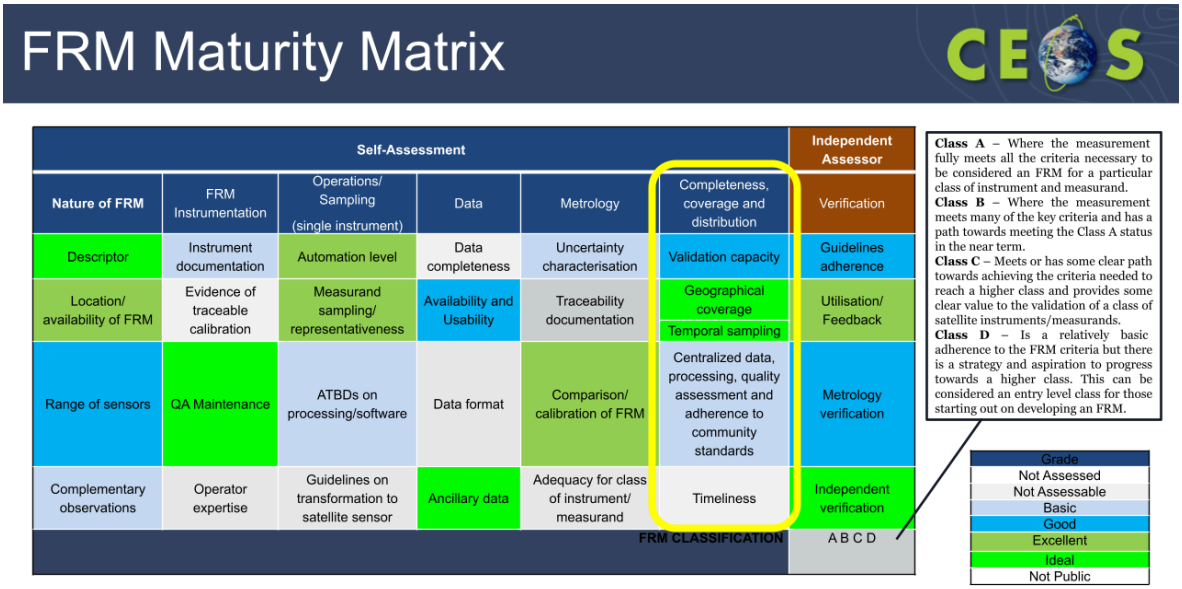
Discussion

- Nitant Dube (ISRO, WGISS Vice Chair) asked about the GCP network L1 tiling, specifically the types of DEMs used and their resolution, noting that sub-pixel uncertainty requires DEMs to match that resolution. He added that WGISS can support catalogue standardisation where needed. Prayot Puangjaktha (GISTDA) noted that for geometric correction of THEOS-2 imagery, a 24-metre resolution DEM is used for Thailand, while a 90-metre SRTM DEM is used globally. Additionally, THEOS-1 uses the GLOBE DEM with a resolution of approximately 1 kilometre worldwide.

1.10 - FRM Assessment Framework

Paolo Castracane (ESA) reported *[slides]*:

- The CEOS Fiducial Reference Measurement (CEOS-FRM) initiative represents the gold standard for reference measurements, and has been developed to highlight the need for well-characterised measurements tailored to post-launch Cal/Val of EO missions. The increase in commercial missions launching has reaffirmed the need for this data. WGCV has developed a framework to assess the maturity of FRM, for which guidelines for assessments are available at the CEOS Cal/Val Portal. Version 2 of the FRM Assessment Guidelines were recently released.
- FRMs are a suite of independent, fully characterised, and traceable measurements, tailored specifically to address the calibration and validation needs of a class of satellite borne sensor and that follow the guidelines outlined by the GEO/CEOS Quality Assurance framework for Earth Observation (QA4EO). The mandatory requirements for CEOS-FRM are traceability, independence from satellites under test, uncertainty budget, documented protocols, accessibility, representativeness, adequacy of uncertainty, and utility. The FRM endorsement process consists of a maturity matrix self-assessment and a WGCV board peer review.



- A new assessment category was added for 'completeness, coverage, and distribution,' which includes validation capacity, geographic and temporal coverage and sampling, centralised data, and timeliness.
- Actions from WGCV-54 were reviewed. Regarding WGCV-54-05, a tool has been completed and is currently under testing. A new template has been configured, with a few remaining aspects still to be finalised. Action WGCV-54-06, related to discussion of issues with the FRM Assessment Framework for the atmospheric domain, has been completed. For action WGCV-54-12, a second FRM exercise is planned, aiming to include RadCalNet, PGN, FRM4DOAS, and FRM4SM. The verification aspect of the maturity matrix tool is still in progress, with some inputs received through collaboration with WGISS.
- Discussions have started to include ground in-situ reference data. The concept of SITSats may also be applicable. Information and guidelines are available on the Cal/Val Portal. The first exercise was completed with input from several networks, leading to improvements in multiple framework guidelines. The second exercise will involve a broader set of users and verifier networks.

Discussion

- Girish Pujar (ISRO NRSC) asked whether an analytic hierarchy process is applied to connect each element of the framework and whether any quantification supports the potentially subjective role of the verifier. Paolo Castracane (ESA) noted that each question and answer corresponds to a level of maturity. There is a field where the user is invited to provide proof of what they are stating, with links to documentation. Nigel Fox (NPL, IVOS Chair) added that the verification process includes a one-time assessment, along with a mechanism for user feedback. Feedback from users can trigger reassessment of the data, effectively serving as a 'check on the verifier.'
- Nitant Dube (ISRO, WGISS Vice-Chair) asked if, similar to CEOS-ARD compliance, there is a recognised CEOS-FRM compliance. Nigel confirmed, noting that CEOS-FRM provides a standardised basis for assessing products. Originally, FRMs were defined for satellite Cal/Val, but there is growing interest

in extending to in-situ applications. The framework is structured with progressive grading, allowing providers to identify their starting point and advance over time.

WGCV-55-03	Paolo Castracane to organise a second FRM Assessment Framework exercise to include PGN, FRM4DOAS, and RadCalNet, ACTRIS, ISMN.	**Q4 2025**
WGCV-55-04	WGCV to confirm the readiness of operationalisation and conduct a pre-launch review of the FRM Assessment Framework, and to define candidates for operational usage of the tool e.g. HYPERNETS.	**WGCV-56**
WGCV-55-08	Paolo to work with the CEOS Communications Team to develop an FRM Assessment Framework logo and CEOS News article post.	**WGCV-56**

1.11 - Microwave Sensors Subgroup (MSSG) Report

Xiaolong Dong (CAS, MSSG Chair)* reported *[slides]*:

- MSSG is working on the retrieval and validation of high winds with combined active-passive microwave measurements, with a focus on extreme sea surface winds. These measurements are important for risk management authorities as well as the oceanic and atmospheric communities, however current scatterometer and radiometer observations are often inaccurate.
- Validation efforts focus on collocating data in storm-centric coordinates to improve storm centre location and enhance spatial representativeness, analysing sensor sensitivity under high winds, recalibrating radiometer brightness temperatures and radar NRCS, and reprocessing extreme wind data. Using the Haiyang-2 radiometer, an improved emissivity model and wind retrieval results were produced. The improved HY-2B product can be found at: https://osdds.nsoas.org.cn/home.
- Although scatterometer signals saturate at extreme winds, and the high-frequency radiometer signals are affected by rain, both active and passive sensors show great potential for the retrieval of extreme sea surface winds by applying high wind calibration and an improved emissivity model for low-frequency (C-band) brightness temperature.
- Using spaceborne passive microwave observations, sea surface pressure and column oxygen absorption data can be retrieved. The technique has all-weather and day capability with high spatiotemporal resolution and swath width, supports applications in numerical weather prediction (NWP), tropical cyclones, and global climate change. MSSG has developed retrieval algorithms for SSP optimised for high winds and combined observations from 60 GHz and 118 GHz radiometers. Reference data used include ERA-5 reanalysis, dropsondes, buoys, and ships. Validation is underway using combined observations from FY-3D MWTS-II and MWTS instruments.
- A new task proposal focuses on Cal/Val of GNSS-R and RO data, which provide vital atmospheric, ocean, and land surface information. MSSG aims to develop retrieval and validation methods for

these products. L-band RO delivers highly accurate measurements of time, excess phase, bending angle, refractivity, temperature, humidity, and pressure. Work done by CGMS applies to asset protection, contingency planning, data quality, shared access, and product development. The IROWG, now a permanent CGMS group, supports operational and research users of RO data. Cal/Val tasks include the reference occultation processing system (rOPS) and the radio occultation modelling experiment (ROMEX).

- Some GNSS-R and RO missions are not extensively calibrated, resulting in significant inconsistencies in L1 NRB cross sections over the ocean. It is urgent to establish a benchmark / best practice protocol for GNSS-R NBRCS over the ocean for intercalibration of different missions.
- The FRM4SLP initiative highlights the value of high-resolution sea level profiles enabled by Fully-Focused SAR (FFSAR) technology, which are essential for coastal altimetry and inland water monitoring, despite the lack of suitable in situ networks. UAV-mounted water level gauges are proposed for campaign-based calibration near satellite overpasses. Differences between FFSAR (used near coasts) and unfocused SAR (used in open ocean) may introduce biases, underscoring the need for cross-mode calibration. The FRM4ALT project stresses adherence to metrological standards and the importance of SI-traceable and sparse in-situ networks.
- Since SWOT's launch in 2022, wide-swath altimeters have become valuable for capturing mesoscale ocean dynamics and small inland water bodies, with standard resolutions of ~50 m. Calibration strategies are increasingly relevant for these systems.
- Space microwave radiometry is essential for acquiring high-quality Essential Climate Variables (ECVs). Achieving high-precision, traceable, and long-term consistent measurements requires major advancements in radiometric accuracy and cross-satellite consistency.

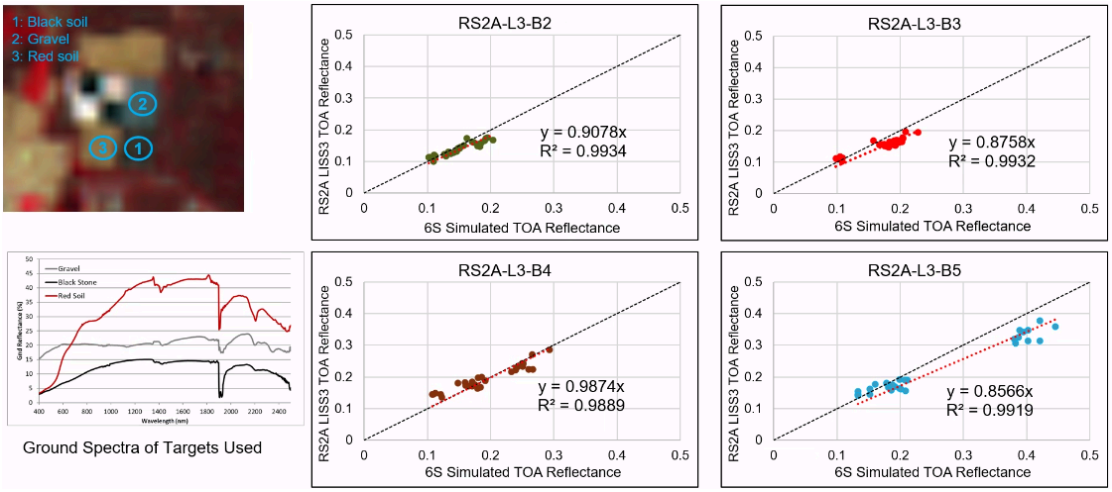
Discussion

- Nigel Fox (NPL, IVOS Chair) noted in the context of establishing a benchmark reference, it may be valuable to use the language of SITSats, suggesting a 'SITSat for the microwave domain' which could be included on the proposed SITSat website.

1.12 - ISRO Cal/Val Activities

Santhi Sree Basavaraju, K.N. Babu, and M.V. Ramana (ISRO) reported *[slides]*:

- ISRO is currently operating optical missions such as Resourcesat-2A, EOS-6, and INSAT-3DS, and microwave missions EOS-4 and EOS-6. New missions and capabilities include NISAR, TRISHNA, P-band SAR, and the NADIR portal which supports a network of in-situ measurements.
- Resourcesat-2A, launched in December 2016, is still operating today. Most of its data is accessible under ISRO's open data policy, including a harmonised time series product. GCPs are extrapolated using Cartosat data, with geometric calibration performed during the satellite's commissioning phase. Results of absolute calibration for RS2A were shared, from LISS-3 at the Shadnagar site from 2023-24:



- A degradation in TOA reflectance has been observed in the B5 band, which is being addressed in the data products. Cross-calibration between RS2A and Landsat-8/9 OLI showed a good alignment.

K.N. Babu (ISRO/SAC) reported:

- Calibration of Oceansat-3 (EOS-06), launched in November 2022, includes lunar and ocean-based vicarious calibration. Post-launch calibration revealed a ~6% relative difference between chlorophyll channels, and a 4–5% difference between simulated and measured NIR channels of OCM3.
- INSAT-3DS, launched in February 2024, has undergone calibration comparisons with MODIS datasets, showing largely valid calibration with changes following vicarious calibration. A desert target over the Little Rann of Kutch was measured in March 2024, from derived gain in the VIS and SWIR bands.
- Radiometric response monitoring for EOS-04 was conducted over the Yellapur forest, and the backscatter stability of EOS-06 was tested over Greenland, with comparisons against SCISAT-1, showing reduced cross-scan bias, although larger target heterogeneity is needed.
- The NISAR Cal/Val plan includes in-house trihedral corner reflectors deployed across India, with wide-swath calibration supported by nine sites nationwide. Three of the five corner reflectors installed in Antarctica were reoriented for NISAR in an ISRO expedition at the beginning of 2025.
- TRISHNA is a joint ISRO-CNES project aimed at monitoring global energy and water budgets, with secondary objectives including assessing urban heat islands, thermal anomalies, snowmelt runoff, and glacier dynamics.
- The calibration methodology used for INSAT will be applied to TRISHNA. Lunar imaging, a largely photo-invariant calibration target, will be performed during TRISHNA's commissioning phase.
- Data will be acquired over and compared to RadCalNet sites. Variations in the B2 Green band are currently within a 5% uncertainty. Proposed sites in India for regular Cal/Val include Kavaratti, Lanela, Little Rann of Kutch, Shadnagar, Challakere, and Gulmarg.
- The NADIR portal, an in situ data dissemination platform for Cal/Val data, is expected to be ready for presentation at the next WGCV meeting.

M.V. Ramana (NRSC) reported:

- NICES is an ISRO programme with a range of validation strategies to meet scientific requirements including the development of ECV and geophysical products. Intercomparison studies done by NICES include Chl-a measurements from Argo buoys and ESA's CCI compared to OCM-3 measurements, as well as EOS-06 wind product comparisons.
- A NASA cryogenic frost point hygrometer, capable of 100 m resolution in the stratosphere, is being deployed in India to help reduce uncertainties in upper-atmosphere measurements identified by cloud warming in INSAT-3D and MODIS/CALIOP intercomparisons.
- All-sky cameras are deployed to provide 360° zenith views to validate and improve cloud cover algorithms. Radiosondes are also used for atmospheric profiling, though are limited by drift.
- SST sensors were validated using SLSTR-retrieved data, which compared against NOAA's iQUAM in-situ measurements showed agreement in subsurface SST across all regions and times of day. All datasets are freely disseminated alongside in-situ datasets at NICES.

Discussion

- Medhavy welcomed NISAR site submissions to SARCalNet, and highlighted the importance of TIR sensor calibration as a collaborative CEOS topic. Santhi Sree noted that further work is needed to develop calibration standards for TIR missions.
- Divya Sharma (SatSure) asked about the scope and extent of geometric calibration concerns. Santhi Sree noted that standard GCPs over India have been measured at 2.5m and 5m resolution, although slight deviations remain in the harmonised product due to correction limitations.
- Pawarin Kuha (GISTDA) noted that THEOS-2 can perform lunar calibration but lacks formal guidelines regarding tilt angle and frequency. K.N. Babu added that calibration is typically done monthly at 7° tilt, with acquisitions timed around the full moon to account for lunar phase changes.
- Fabrizio Niro (ESA, LPV Subgroup Chair)) asked whether calibration sites characterise adjacency effects and target homogeneity, including spatial sampling around the sites. Santhi Sree noted that targets are artificially laid out and managed to maintain spatial variability, with data collected in a narrow window between 0.3 to 0.5 m and averaged over 5 by 5 m pixels.

1.13 - Infrared and Visible Optical Sensors (IVOS) Subgroup

Nigel Fox (NPL, IVOS Chair) reported *[slides]*:

- The IVOS mission is to ensure high quality Cal/Val for infrared and visible data from EO satellites and the validation of some higher level products, with particular focus on land surface reflectance, ocean colour, and surface temperature. Current projects include PICSCAR, RadCalNet, Sea Surface Temperature (SST) and Ocean Colour Comparisons, Vocabulary, Sensor pre-flight workshop, and uncertainty/traceability studies.

- IVOS-36 was hosted by JAXA and AIST in Tokyo, Japan, and discussed comparison tools, QA initiatives, Cal/Val methods and services, the impact of solar irradiance spectrum changes, GHG sensors, test sites, and moon sensor performance. AIST are using the Railroad Valley RadCalNet site, and identified some anomalies within their campaign. The DIMITRI and VICALOPS open-source Cal/Val comparison tools were also shared.
- In response to the New Space community request, IVOS developed the Product Validation Platform, which has identified key sites for validation and geospatial testing. Satellite providers are asked to regularly image these sites and store their data on our database. The calibration dashboard allows missions and references to be selected to evaluate the radiometric gain of the sensor against a defined reference.
- RadCalNet is a network of sites that characterise surface reflectance, calibrate data, and provide atmospheric products for clear-sky conditions every 30 minutes. Using radiative transfer models, outputs are processed into top-of-atmosphere (TOA) reflectances and made available through the RadCalNet portal, which currently serves 1320 users across five sites. While each site manages its own quality assurance and control, regular cross-comparisons ensure consistency across the network. New sites under review include EROS in South Dakota, GHNA in Gobabeb, and GOCN in the Gobi Desert. Sites under development include Pinnacles, Australia and Aeronet Ocean Colour.
- PICSAR has proven to be a stable reference target, showing consistency within ±0.5%, and efforts are underway to expand activities beyond Libya-4.
- A new proposal was presented on using drones for water quality validation, with potential to become future FRMs. ESA has since funded a small project to explore this approach, similar to previous work from the SRIX4Veg activity.
- Sensor performance is also being assessed using lunar observations, comparing models such as OLCI-A and Air-LUSI against LIME. While absolute biases exist between lunar models, internal consistency remains strong. EnMAP initially experienced mission drift, but performance has since stabilised.
- TIRCalNet is an initiative to extend RadCalNet capabilities to the thermal infrared (TIR) domain, with a focus on the TRISHNA and LSTM missions. Led by CNES and JPL, it aims to define site requirements and assess achievable uncertainties. Sites like La Crau and Lake Tahoe are being studied, with Tahoe noted as highly stable for TIR.
- IVOS is seeking volunteers to lead the Image Quality/Geometric focus group. The next IVOS meeting will be held at the University of Arizona from 1–5 September 2025.

Discussion

- A discussion was held regarding support for TIR in ERADIATE and BRDF in RadCalNet. ERADIATE currently supports wavelengths up to SWIR (2.5 microns), with plans to extend it to TIR. BRDF modelling is not yet incorporated in RadCalNet, and depends on site owner capabilities. The HYPERNETS site at Gobabeb may be able to provide BRDF information. The RadCalNet team may consider a questionnaire to agencies to identify potential user/agency needs.

- As we move towards FRMs, a key question is how to harmonise different approaches and establish consistent benchmarking. By documenting and evidencing methods and conducting comparisons, agencies can work towards consistency. A benchmark reference dataset for MTF is being considered. The upcoming TRUTHS mission will calibrate the moon with a verified uncertainty of 0.3% (current agreement is within 3–4%). The CEOS-PVP initiative aims to unify radiometric gain values from RadCalNet sites to create a stable 'virtual reference' for comparison.

WGCV-55-16	Nigel and the RadCalNet team to prepare a note for information to CEOS Plenary 2025, noting the importance to CEOS Agencies and New Space of supporting the maintenance and development of long-term Cal/Val infrastructure e.g. RadCalNet. WGCV IVOS seeks to connect with CEOS WGCapD to support developments in smaller agencies in regions where such sites may exist.	**Q3 2025**

Day 2: Wednesday 9th July, 2025

2.1 - Synthetic Aperture Radar Subgroup Report

Stephane Cote (CSA, SAR Subgroup Vice Chair)* reported *[slides]*:

- The 31st SAR Subgroup Workshop was held at ISRO SAC in Ahmedabad, India, from 12–15 November 2024, with 214 participants from space agencies, universities, government institutions, and commercial providers.
- Recent years have seen an increase in SAR Cal/Val themes, reflecting the widening scope of the WGCV SAR community and of the evolving needs of EO services and users for accurate SAR data. Topics included cross-calibration between SAR sensors and missions, as well as the calibration of higher-level products such as AIS, SAR interferometry, and geophysical parameter extraction.
- New topics introduced at the workshop included airborne system calibration, InSAR altimetry Cal/Val, AIS-based validation for vessel detection, and bistatic/multichannel SAR systems.
- The 2025 SAR Workshop will be hosted by SARLab at Simon Fraser University (SFU), with support from MDA Space, from 27-30 October at SFU's Harbour Centre in Vancouver, Canada.

Bruce Chapman (NASA-JPL, SARCalNet Lead)* reported on SARCalNet:

- SARCalNet is open to the public for registration, with access to the website, database, and submission templates. A first draft of the API description for querying the database has been posted on the SARCalNet website (https://www.sarcalnet.org/). Submissions to the site are welcomed and encouraged.
- Reviewers have been invited to curate SARCalNet submissions, check provided information against the submission templates, and iterate with the submissor to recover all additional information. The goal is to complete the process by October 2025.

- Methodologies for characterisation and calibration will also be reviewed, alongside a database of relevant literature links and a SAR Cal/Val glossary. These updates will be coordinated via GitHub.

Discussion

- Medhavy Thankappan (GA, WGCV Vice Chair) suggested informing WGCV members of recent SARCalNet assessments, as is done in CEOS-ARD when new compliant datasets are approved.

WGCV-55-09	Medhavy and Paolo to communicate with Bruce and Stephane that WGCV Membership should be notified when new SARCalNet site submissions are ready for approval. A step in the review and approval process for SARCalNet sites should include that WGCV membership is notified.	**Q3 2025**

2.2 - Land Product Validation (LPV) Subgroup Report

Fabrizio Niro (ESA, LPV Subgroup Chair) reported *[slides]*:

- This year, Fabrizio took over from Michael Cosh (USDA) as LPV Subgroup Chair. The vice-chair position remains vacant. LPV is organised into 12 focus groups, each addressing specific terrestrial essential climate and biodiversity variables.
- The LPV maturity framework supports harmonised validation of terrestrial ECVs and is structured around four key pillars: reference data, good practice protocols, reference satellite products, and online validation tools. LPV datasets and tools are available on the Cal/Val portal, and the LPV website is hosted by NASA at https://lpvs.gsfc.nasa.gov/.
- The last LPV Plenary was held at Living Planet Symposium in June 2025, which produced a number of recommendations to elaborate the LPV action plan over the 2025-2028 period.

WGCV-55-10	Fabrizio to share the updated LPV Subgroup Action Plan for 2025-28 with WGCV Members.

- 55 LPV supersites were initially defined in 2019 that meet a set of criteria, such as they have well-characterised canopy structure suitable for RTM-based validation and support the validation of at least three ECVs, with long-term operations. A review of supersite criteria and list of sites is underway to expand the list of variables, adding ET, GPP/NPP, SIF, include recent sites and networks (e.g., HYPERNETS, GBOV), assess spatial representativeness, and align with CEOS-FRM principles. Over 220 candidate sites have been identified to date. The review of supersites is expected to be completed by the end of 2025.

WGCV-55-11	Fabrizio to finalise and share the updated list of LPV Supersites list with WGCV Members.

- The biogeophysical focus group has proposed to revisit the LAI protocol released in 2014 to meet updated GCOS requirements and also include fAPAR and FCover variables. Originally designed around the 500 m MODIS resolution, the LAI protocol should now be adapted to higher-resolution

data (e.g. from Sentinel and Landsat) with a renewed focus on advancing technologies (mainly UAV) and uncertainty characterisation. A draft update to the protocol is underway with the initial step being a scientific review paper for submission to RSE.

- Networks such as ICOS are updating their protocols to better support satellite Cal/Val, notably for fAPAR and LAI. Ongoing discussion with the EO community led to a new initiative called NUBICOS, developed to align ICOS practices with satellite Cal/Val needs, which aims to adopt LPV protocols and CEOS-FRM standards as references to ensure greater compatibility.
- The Fire focus area recognises the lack of community protocols for BA, AF and FRP and focuses on high resolution, traceable data. Fire products, in particular FRP, are challenging to validate owing to the ephemerality of the phenomenon and the challenges in spatiotemporal mismatch, and there is a scarcity of field campaign data. A draft protocol for Burnt Area is being developed, with a first version planned by the end of the year. In parallel, a first draft of the FRP protocol is being elaborated in the frame of the ESA FRM4Fire project.
- Despite the increase in high-res land cover maps, accuracy estimates are often incomparable and strongly vary as a function of the landscape. An ensemble of validation datasets and a community protocol are needed for easier comparability. Version 1 of the Land Cover Protocol will be completed by the end of Summer 2025, and will serve as a reference document for land cover data providers.

Decision 01	WGCV endorsed the LPV Subgroup Land Cover Change assessment protocol, subject to incorporation of final feedback and a short WGCV review cycle, by October 2025.

- The existing LPV protocol for albedo, issued in 2019, is being updated to address new high-res GCOS requirements, incorporate best practices for BRDF and spectral albedo validation, and finalise the global downward radiation protocol. The plan is to have a first draft in 2026 and a final review by 2027.
- Soil moisture validation is increasingly focused on sub-kilometre products, driven by new technologies, upcoming missions, and downscaling or ML approaches. Root-zone soil moisture, critical for agriculture, is of growing interest too. The SM protocol, published in 2020, is currently being updated in the frame of the ESA FRM4SM-2 project, aiming at finalising the review by 2027.
- The Biomass Protocol was used as a foundation for GEO-TREES. This was set up to define, develop, and operate a global forest biomass reference system, stemming from the LPV protocol recommendations.
- Evapotranspiration (ET) is a new focus area in LPV, with relevance to agriculture, water management, and products across the public and commercial sector. The group is reviewing existing ET products and Cal/Val practices, identifying data and knowledge gaps, gathering community input, and drafting an outline protocol. The target is to have a first outline by the end 2025 and gather the scientific community in a dedicated Workshop to start drafting the protocol in 2026.
- The WGCV ACIX framework aims to understand the strengths and limitations of atmospheric correction algorithms and enhance their harmonisation. Initiated in 2016, ACIX-I focused on

Landsat-8 and Sentinel-2, and since ACIX-II, the initiative has expanded into three dedicated groups for Land, Water, and Cloud Mask (CMIX). ACIX-III compared current hyperspectral sensors PRISMA and EnMAP, using surface reflectance validation data from ground networks, mainly RadCalNet and HYPERNETS, and field campaigns. Two papers are planned for submission in 2025 following the finalisation of results. Future work will include the use of synthetic scenes generated with 3D RTM representing different land cover types and aerosol loadings to be used as reference data.

- CMIX-I identified a need to better define clouds and cloud classes, using physics based definitions, and found inconsistencies in reference datasets. CMIX-II improved the cloud definition and reference dataset, with a larger number of exercise participants, and inclusion of cloud shadow masks. The UMD/NASA SkyCam network has been developed to monitor cloud cover and conditions, with results expected by the end of 2025. The plan is to use this network as an additional reference dataset in the frame of CMIX-II.
- SRIX4Veg addresses growing interest in UAV for Cal/Val, through field campaigns and the publication of the SRIX4Veg protocol in early 2025. The joint LPV-IVOS protocol provides recommendations for UAV-based surface reflectance.

Discussion

- P.V. Jayasri (ISRO) asked whether the LPV subgroup covers all types of sensors, referencing SAR product validation such as NISAR SM. Fabrizio noted that LPV is sensor-agnostic and focuses on variable validation. GEO-TREES was also discussed, which aims to establish 100 core sites (60 tropical, 40 temperate), including some in India.
- MV Ramana (ISRO) asked about the use of synthetic scenes in ACIX-III, and whether satellite data and radiative transfer codes are used to fill gaps. Fabrizio noted that ACIX-III has a radiative representation of sites using 3D laser scanning as input to a 3D Monte Carlo radiative transfer model.
- Divya Sharma (SatSure) asked if there are standards to define biomass change, including deforestation and afforestation. Fabrizio noted that discussions are ongoing to include this, however, it will take time to build consensus within the community about the relevant validation practices for biomass changes. A dedicated workshop on validation practices for biomass is being considered to move forward in this respect.

2.3 - Pre-flight Calibration Workshop Outcomes and Next Steps

Nigel Fox (NPL, IVOS Chair) reported *[slides]*:

- The Workshop on Pre-flight Calibration and Characterisation of Optical Satellite Instruments was held at ESA-ESTEC in Nordwijk, Netherlands, from 19-22 November 2024. The workshop aimed to bring together practitioners involved in instrument development, calibration, and specification, with the goal to identify optimal calibration requirements for current and next-generation sensors.
- In the workshop's final discussions, the community consolidated key challenges, conclusions, and recommendations. For pre-flight calibration, challenges identified included unknown factors, sensor ageing, and the representativeness of the sensor measurand and its environment. Other issues were

development cycle time and budget constraints, thermal vacuum requirements, cost-benefit considerations, testing beyond expected maximum radiance levels, readiness for post-launch testing, and the use of heliostats.

- The end objective is to develop a community guidance document covering topics on future calibration, calibration principles and uncertainty, radiometric gain, spectral response functions, stray light, and thermal infrared. The guidance should include calibration requirements for each application and lessons learned. It must also stress that pre-flight activities, such as measuring and sharing spectral response functions, are essential to achieve an SI-traceable satellite. Details of the workshop and presentations can be found here.
- Each section of the guidance document will outline the purpose, benefits, current methods, challenges, and limitations of calibration and characterisation for that application, with references and real-world examples. Key recommendations include clear evidence of traceability and uncertainty, minimum requirements for different applications, practices for both ambient and vacuum conditions, and the need to involve calibration teams from mission planning through to end-of-life.

Discussion

- Shilpa Prakash (ISRO) and Nigel Fox (NPL) discussed the use of heliostats for pre-flight calibration. They allow the sun's light to be directed into a clean room for measurements, supporting missions using the sun as a calibration source and providing a convenient radiation source closely representing in-flight light. The use of heliostats, however, depends on the sensor's calibration location worldwide.
- A question was raised regarding common platforms for these instruments, and how to ensure that the calibration equipment itself is properly calibrated. Nigel noted that calibration is performed against an SI traceable reference using a transfer standard depending on the equipment size, at a laboratory traceable to a national metrology institute.
- Santhi Sree (ISRO) noted that at NPL India and SAC, instruments need to be sent off for calibration, which takes three to six months, and they are working to develop mutually agreed standards aligned with CEOS standards. Nigel noted that National Metrology Institutes perform regular instrument calibration but only guarantee calibration accuracy at the time of measurement.
- K.N. Babu (ISRO) noted that for ocean observations, tungsten lamps are used for lab calibration and the sun is used as an illumination target, though there are challenges with the blue spectral channels. Nigel shared that Deuterium and Xenon lamps can be used to cover the blue and ultraviolet spectral domains.

WGCV-55-12	Pre-flight Calibration Workshop team (Nigel, Albrecht, Philippe, Paolo) to develop a good practice guidance document to summarise the workshop's outcomes and recommendations.	**Q1 2026**

2.4 - SITSat Task Team Update

Nigel Fox (NPL, IVOS Chair) reported *[slides]*:

- The SITSat Task Team is a joint CEOS-GSICS initiative established in 2023, pursuing the SITSat motivation for unequivocal FRMs for satellite Cal/Val. The goal is to build a future system of systems that delivers interoperable and harmonised satellite ARD, with robust SI traceability to provide space agency-agnostic consistent calibration.
- SITSats enable direct calibration of satellites, which can then provide secondary calibration to other missions, creating a hierarchy of calibration within an interoperable system. The Task Team seeks to clearly define what qualifies as a SITSat, evidence requirements, support agencies developing SITSat missions, and foster collaboration on Cal/Val and data sharing.
- The simple SITSat definition is: "A space-based instrument making measurements of the Earth that can transparently evidence their metrological traceability to the international system of units (SI) with an uncertainty commensurate with the most demanding needs of climate https://doi.org/10.47120.
- A key challenge for the TRUTHS mission is delivering full, detailed uncertainty information for all sensor characteristics, particularly providing per-pixel uncertainty. This significantly increases the size of the 4TB daily product by a factor of 6 to 10. Current SITSats under development include CLARREO Pathfinder (NASA), TRUTHS (ESA), and Libra (CMA).
- The SITSat Task Team will plan to hold three virtual half-day meetings per year, along with one in-person meeting where feasible, ideally aligned with other major meetings. Activities include an updated Cal/Val portal page and wiki, communication strategy to clearly define what a SITSat is and how it differs from other satellites, and a white paper outlining the vision for a SITSat enabled observing system.

Discussion

- In a discussion, Nigel explained that SITSats need to quantify the uncertainty of measurements at the time they are made, either through onboard calibration or by linking to well-characterised and robust ground-based references. Currently, ground measurements alone are not sufficient to fully validate performance. TRUTHS mission plans to conduct airborne campaigns with thorough pre and post-flight calibration to address this. TRUTHS aims to replicate a ground calibration site in space. One remaining source of uncertainty is the stability of the onboard voltage reference over time.

2.5 - Terrain Mapping Subgroup (TMSG) Report

Peter Strobl (EC-JRC, TMSG Chair)* reported *[slides]*:

- The Ground Control Point Intercomparison Exercise (GCPIX) and Global Reference Grid Intercomparison Exercise (GRGIX) aim to improve standards and interoperability for grids. Tom Maiersperger (USGS, TMSG Co-chair) and Leo Laurentiis (ESA) have volunteered to co-chair the activity.

- WGCV's mandate for DEMIX is to compare major global DEMs and provide recommendations on the most suitable options by domain and region. An expected outcome is the development of consistent and comprehensive DEM terminology.
- A TMSG Plenary was held during the Geomorphometry conference last month in Perugia, Italy, where it was decided to dissolve the DEMIX subgroups. The team is considering adding code to the CEOS Organisational GitHub, plans to meet quarterly, and is seeking a new chair or co-chair.
- Questions for CEOS WGCV discussion and advice include:
  - What is 'DEMIX' and who owns it?
  - Do we want 'DEMIX tested' or 'Analysis-Ready' DEMs?
  - Can we give recommendations and in which name?
  - Where could we store/offer data and services (VisioTerra, CDSE)?
  - Who is in control?
- The first GCPIX was kicked off in April 2025, proposing steps to clarify relevant terminology, define assessment criteria, set threshold requirements, establish protocols and formats, and harmonise methods and sources. A Teams groups under ESA auspices has been set up and monthly meetings are convened.
- The GRGIX outline has been drafted aiming to clarify grid concepts, develop a comprehensive taxonomy of global grids, define specifications and metrics for grid categorisation, and build a database of major grid systems. Criteria for global grids include distortion metrics, structural properties, and numerical properties. Contributions to the exercise are welcomed. Kick-off is planned for Q3 2025.
- TMSG and all its activities are welcoming new participants at any time.

Discussion

- Nitant Dube (ISRO, WGISS Vice Chair) recalled the open action from WGCV-54/WGISS-58, regarding gridding recommendations for the architecture section of the Interoperability Handbook. Peter noted that a concrete gridding recommendation for gridding cannot yet be provided but preliminary results are expected in the next six months. Gridding decisions often lack transparency and justification, despite having major implications for interoperability. Peter intends to reflect these concerns in a draft write-up for the Interoperability Handbook.
- When asked if GRGIX would provide sensor recommendations, Peter noted the goal is to define systems of hierarchical grids across resolutions. Grids are influenced by Earth's surface rather than tailored to individual sensors. It is important to determine the best possible grid systems and then identify compatible sensors. Sensors like MODIS have specific grids and resolutions, and cross-calibration between different systems can introduce uncertainties. A recommendation for a common format would be valuable. Harmonising and directly resampling data into standard grids could address resampling challenges. Grid architecture is crucial to enabling future interoperability.

- A participant asked how gridding will affect small islands, and whether they are spherical or geoid based. Peter noted that grids will be based on an ellipsoid, as spherical grids introduce conversion issues. There is often a lack of documentation on the specific ellipsoid used, which can lead to inconsistencies. For small islands, the limited availability of GCPs especially under partial cloud cover poses challenges. However, stable shorelines could be used as GCPs.
- Another participant asked the typical extent of a grid cell, and Peter noted that they are determined by the refinement ratio within a discrete grid system used to tessellate the globe. One method to define and generate such grids is through hexahedral projections.

2.6 - Atmospheric Composition Subgroup (ACSG) Report

Jean-Christopher (BIRA-IASB, ACSG Chair) reported *[slides]*:

- The Tropospheric Ozone Activity VC-20-01, led by AC-VC with ACSG support, supports the IGAC Tropospheric Ozone Assessment Report-II (TOAR-II). The TOAR-II community papers are being published in a Copernicus Special Issue, now closed. The publication of TOAR-II assessment papers in *Phil. Trans. A*, including a satellite-based ozone assessment, is planned for the end of December 2025. TOAR-III ideas are being formulated, e.g., with potential to cover the impact of wildfires and wildland-urban interfaces, to use diurnal observations from geostationary sounders, and expanded use of AI for predicting surface ozone.
- Efforts to harmonise satellite tropospheric ozone data were published. This thin atmospheric layer can be measured by techniques such as slicing cloud cover. Other approaches calculate total column minus stratospheric contribution, while others derive tropospheric ozone column from nadir profiles. The study examined 16 different data records with harmonisation topics including vertical data representation, tropospheric top levels, surface pressure, spatial and temporal sampling, and a-priori information sources and contributions. Satellite data harmonisation reduces dispersion between the 16 datasets by approximately 10-40%.
- The best practices protocol for the validation of aerosol, cloud, and precipitation profiles (ACPPV) was endorsed at WGCV-54 and has now been finalised and published on the CEOS website, with a DOI address provided on Zenodo. The document provides a comprehensive study on best practices for space profiler validation, with new tools provided and knowledge/measurement gaps identified and filled.
- Joint activities and deliverables with the CEOS Atmospheric Composition Virtual Constellation (AC-VC) include GEMS AO, TEMPO MVP, and ESA/EUMETSAT joint AO for Sentinel-4 and Sentinel-5. These efforts involve L2 algorithm testing and intercomparisons, such as using GEMS for Sentinel-4 L2 prototype testing. International collaboration on FRMs and validation data includes joint airborne campaigns, expansion of the Pandora network, and the CINDI-3 MAX-DOAS campaign, with participation from other networks. International collaboration on the validation of GEMS, TEMPO and Sentinel-5P includes the PEGASOS and Geo-Ring projects as well as joint meetings.

- CINDI-3 is a semi-blind intercalibration and intercomparison campaign with an external referee that aims to intercalibrate instruments and assess their mutual consistency, get NDACC and ACTRIS-CREGARS certification for new instruments, and assess and improve FRM maturity for validating CEOS Air Quality and Ozone satellite constellations.
- As part of CINDI-3, 32 UV-Vis MAX-DOAS instruments were intercompared in Cabauw from May-June 2024. The aircraft-based SWING and ICAD instruments provided NO2 mapping and profiling in support to the campaign, with 4 flights from Rotterdam and 6 flights from Antwerp. The FRM4DOAS central processing was applied to 50% of the participating MAX-DOAS instruments. Preliminary evaluations show good agreement for NO2 and O4 measurements, while other gases like HCHO and HONO proved more challenging. It is planned to publish the campaign results in a special issue of AMT-ACP.
- Initial assessments of Version 1 of the CEOS-FRM Assessment Framework were published in 2024. Based on the feedback received, Version 2 adds a column to evaluate the completeness of validation capacity, ensuring networks capture the full range of measurand values and influencing quantities with appropriate sampling.
- ACSG is working on two main approaches for Cal/Val network design and evolution: a staggered approach distinguishing traceability validation, Level 2 product validation, and product-to-service validation; and a tiered approach categorising Cal/Val sites from high CEOS-FRM classes (end-to-end, full retrieval suite, user-oriented) to lower classes (global extension, specific).
- A new Global Atmosphere Watch (GAW) report was recently published by WMO, offering a critical review of global measurement needs for atmospheric composition monitoring and forecasting applications. A follow-up report dedicated to ozone column monitoring needs and gaps is planned for release before the next GAW symposium in April 2026, which will include a satellite validation needs section featuring contributions from ACSG. Several ACSG agencies also contribute to the NDACC strategy paper 2025 and the NDACC 35th Anniversary Symposium 2025 that will take place in Virginia Beach (VA) next October.
- The joint AC-VC-21 and ACSG meeting 2025 took place from 9-13 June in Takamatsu, Japan, hosted by NIES and co-hosted with IWGGMS-21. The agenda was well coordinated, featuring many interleaved activities. WGCV-ACSG sessions included presentations and discussions on Cal/Val needs for the constellations and operational validation capacity. A key topic of discussion was the integration of multi-constituent, multi-domain Cal/Val sites combining satellite L1B and L2 column validation with air quality, greenhouse gas, and ozone synergies.

Discussion

- Fabrizio Niro (ESA, LPV Chair) asked if an additional column for multi-constituents could apply to supersites, perhaps as a comparison. He noted the need for CEOS-FRM certification for individual measurements and to validate specific aspects of satellite retrievals. Evidence of compliance with CEOS-FRM is necessary, but requirements must be defined first. Developing this for the ESA Cal/Val park would be valuable. The focus is on defining validation site requirements to enable complete validation, with CEOS-FRM assessment more relevant at the individual measurement level. Paolo

Castracane (ESA) noted that the FRM applies to a matrix for a specific measurement, which can come from a site, supersite, or single measurement. Nigel Fox (NPL, IVOS Chair) added that in the initial classification, users define what the FRM applies to, likely a single measurand. For simplicity, different applications can be specified, but the defined "FRM for…" is what matters most.

- Paolo provided an example of Pandora for NO2 measurement, where other characteristics measured may differ. Jean-Christopher noted that validating surface NO2 over Rome using TROPOMI data requires validating NO2 with Pandora, stratospheric NO2 with zenith-sky MAX-DOAS, and profile validation using dropsondes or aircraft. Each has individual uncertainty requirements, then CEOS-FRM grading is applied accordingly.

2.7 - WGCV inputs to the WGISS Interoperability Handbook

Nitant Dube (ISRO, WGISS Vice Chair), Cody Anderson (USGS, WGCV Chair)* reported *[slides]*:

- Version 2 of the WGISS Interoperability Handbook was advanced at WGISS-59 in March 2025, and aims to guide organisations in developing interoperable data and services and assist in assessing their maturity. WGCV is developing the Quality Factor of the handbook, among other factors for Vocabulary, Architecture, Interface, and Policy.
- Each recommendation for the Quality Factor was reviewed:
  - CALVAL#1: Data providers should engage and participate in community calibration/validation groups such as CEOS WGCV (and its subgroups), WMO GSICS, JACIE, and VH-RODA.
  - CALVAL#2: The Measurand and Uncertainty of stated values should be included within all products, as they are key to communicating and understanding data quality.
    - It was noted that uncertainty should relate to a community-agreed reference, preferably SI-traceable. Addition of "Uncertainty to a reference (i.e. SI)" was agreed and added to the recommendation.
  - CALVAL#3: All products should have associated quality indicators, traceable to reference standards to allow users to assess usability of the data for their applications.
    - 'Quality indicators' address provider requirements for high level uncertainty and image/observation artefacts like cloud cover and dark pixels. 'Traceable to SI standards' is addressed by CALVAL#2, so it was removed from this recommendation.
  - CALVAL#4: Post-launch, Level-1 products should be calibrated using reference measurements, such as CEOS Fiducial Reference Measurements (CEOS-FRM).
    - This implies that L1 products should be calibrated with some external system. A more general approach would be less prescriptive. Inclusion of 'calibrated/validated' was agreed.
  - CALVAL#5: Community endorsed Cal/Val sites and reference networks should be used for satellite cross-comparison, such as CEOS Cal/Val sites, RadCalNet and SARCalNet.

- CALVAL#6: The Quality Assurance Framework for Earth Observation QA4EO developed by Group on Earth Observations (GEO) and endorsed by CEOS should be followed to enable interoperability and quality assessment of earth observation data.
  - Grammar: addition of 'the' Group on Earth Observations, capitalise 'Earth' and 'Observation' (see Peter Strobl's paper).
- CALVAL#7: The ESA/NASA/USGS Earth Data Assessment Project (EDAP) should be used for reporting metrics related to quality.
  - If the idea is to apply links to all missions, shouldn't it be CEOS? With the full process of endorsement by WGISS, WGCV, and endorsed at Plenary. Cody proposed: "The ESA/NASA/USGS Mission Quality Assessment Frameworks should be used for reporting quality and maturity metrics."
- CALVAL#8: The Joint Agency Commercial Imagery Evaluation (JACIE) Best Practices document should be used as a guideline for performing standard calibration and validation activities.
- CALVAL#9: CEOS Cal/Val portal should be used as a reference site for accessing agreed good practices and Cal/Val protocols for interoperability for Earth observation calibration and validation activities.
  - Addition of 'used as the reference site' for the Cal/Val Portal, and 'community agreed good practices'.

- The CEOS COAST Virtual Constellation left some suggestions on the Quality Factor. Their first suggestion is covered in the JACIE Best Practices, so no change is necessary. Suggestion #2 calls for uncertainty budget contributions from instrument, algorithm, and environmental sources. The recommendation's 'full description of uncertainty' should feature in the Handbook and is further elaborated by QA4EO. The third suggestion noted that Cal/Val practices should be 'reproducible and documented with access to datasets and code where possible,' which was agreed. Suggestion #4 distinguishes uncertainty between product levels, which is already covered by CALVAL#2, and suggestion #5 is covered by the quality indicator recommendation.
- OGC also left a recommendation to consider a new recommendation to leverage existing quality measure registers such as the ISO 19157-3 register under finalisation :

WGCV-55-17	Cody to respond to COAST-VC suggestions of the Interoperability Handbook, and to read the ISO standard 19157-3 to evaluate OGC's suggestion for quality measure registers.	**Q3 2025**

2.8 - Cal/Val Portal

Paolo Castracane (ESA) reported *[slides]*:

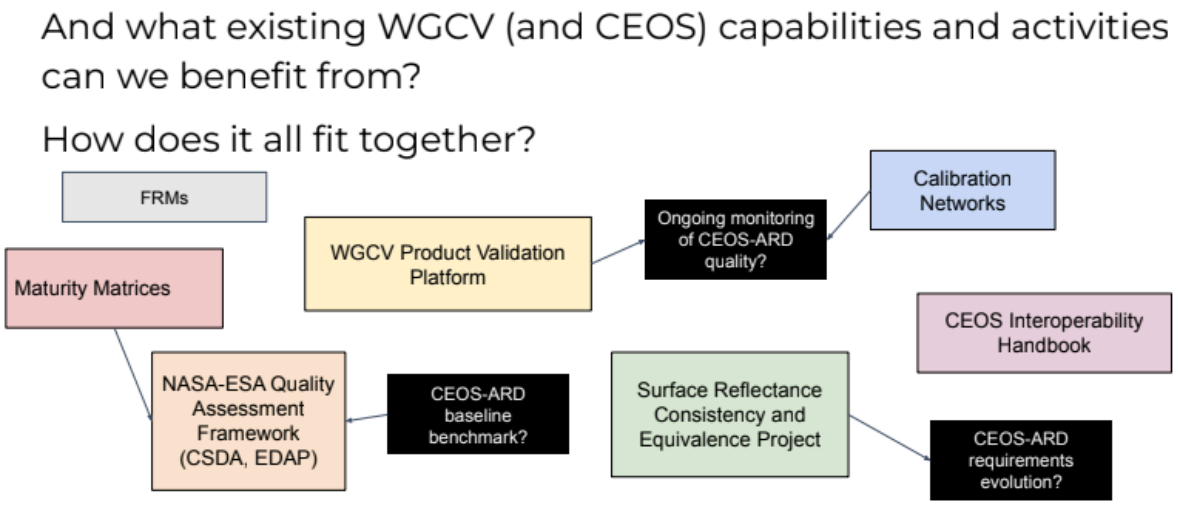
- The CEOS Cal/Val Portal serves as the main forum for exchange and information sharing for CEOS WGCV, providing access to agreed good practices and protocols to the CEOS and wider EO community.
- Actions taken at WGCV-54 for the portal included updates and promotion for each WGCV subgroup, an IVOS database of radiometric capabilities, and the merging of the Cal/Val Terms and Definitions Wiki into the KCEO GitHub repository.
- The FRM Assessment Framework Guidelines document Version 2 are available on the Cal/Val portal. Tools, services, and databases accessible on the Cal/Val Portal include the GROUNDED EO Database, a comprehensive database of biophysical variables, as well as the St3TART FRM Data Hub, an important validation source for Sentinel-3 altimetry data.
- The portal features announcements for workshops, including the upcoming WGCV SAR Workshop (27–30 October 2025, Vancouver, Canada).
- Several ongoing activities and updates on the portal include the FRM Assessment Framework page, SITSat pages, subgroup updates, Dictionary team work, and the Cal/Val Portal newsletter. Collaboration continues with CEOS WGISS teams on Data Management, Stewardship, Maturity Matrices, and Interoperability efforts. Outreach coordination is maintained with the CEOS Communications team, including contributions to the CEOS newsletter.

2.9 - CEOS-ARD Data Quality

Medhavy Thankappan (GA, WGCV Vice Chair), Matt Steventon (CEOS-ARD Secretariat)* reported *[slides]*:

- WGCV is a focal point for data quality within the CEOS-ARD context, especially in the 'FutureARD' vision. Originating from LSI-VC, CEOS-ARD has driven an agenda now extending beyond the land domain. The changing landscape has seen increased commercial sector involvement, evolving user and provider expectations, advancing technology, and a pressing need to deliver results.
- CEOS-ARD provides and maintains a set of Product Family Specifications (PFS) that enable data providers to conduct self-assessments based on Threshold and Goal requirements. The possibility of extending beyond this framework will be a key focus for the 2026 CEOS Chair.
- The CEOS-ARD team will present a consultation findings paper for endorsement at the 2025 CEOS Plenary, with a central focus on improved data quality. Questions for data quality include:
    - Do we need to introduce requirements for data quality?
    - Can we better support users to find products fit for purpose?
    - Do we need a framework for ongoing monitoring of these (L2/L3) qualities?
    - Do we need to be stricter in certain areas to drive practical interoperability?
- WGCV is the authority on data quality, with a huge collection of expertise, capabilities, tools, and software. WGCV's input will be critical to understand this future direction for CEOS-ARD to lower

barriers to EO uptake, enable new users, increase interoperability, increase user confidence, showcase institutional leadership, and encourage better community input.



Discussion

- Nigel Fox (NPL, IVOS Chair) noted that instead of this diagram, we could direct only to the CEOS Interoperability Handbook, especially since the goal of ARD is to support interoperability. The handbook already covers key quality factors, including QA matrices and Cal/Val information, and addresses most of the common issues and challenges.
- Nigel suggested defining three or four stages of ARD compliance: entry-level threshold, intermediate level requiring some level of CEOS interoperability, and a full implementation stage. This tiered approach could help guide different user communities depending on their needs. Medhavy Thankappan (GA, WGCV Vice Chair) noted that despite considerable efforts, we have not achieved a full interoperability objective. The conceptual stage of CEOS-ARD was to bring people onboard, and evolve and move towards operational implementation.
- Nitant Dube (ISRO, WGISS Vice Chair) noted that WGISS is working on Interoperability Demonstrators and suggested a collaborative initiative between WGISS, WGCV, and LSI-VC to develop an interoperability demonstrator. This would involve using a CEOS-compliant ARD product, developing the necessary software tools, and embedding WGCV's quality requirements into the process. The demonstrator could focus on Surface Reflectance, using CAL as a framework, to showcase a practical example for Future ARD.
- Fabrizio Niro (ESA) asked to what extent CEOS should define the quality of elements such as cloud masks, noting that this would require a rigorous assessment process similar to what EDAP is undertaking. Currently, the only defined quality requirements relate to multitemporal resolution and geolocation accuracy. Nigel added that under QA4EO, every dataset is required to include a quality indicator whereas CEOS-ARD does not. A numerical value should be specified to indicate uncertainty. Santhi Sree (ISRO) shared the emphasis and need for input datasets to provide prerequisite metrics for data quality in a common platform for standardising data quality review and auditing.

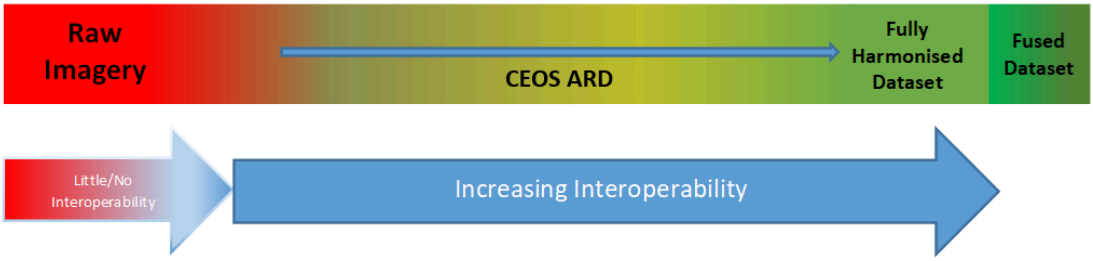
- Matt Steventon (CEOS-ARD Secretariat) noted that this initiative presents an opportunity to correct past shortcomings. While CEOS is not the only organisation working on ARD, it is committed to conducting its efforts in a transparent, inclusive, and open manner. It is important to ensure that everyone across CEOS contributes and aligns with the community's expectations for ARD.
- Nominations for the CEOS-ARD Data Quality definition writing team were received by Medhavy Thankappan (GA), Cody Anderson (USGS), Santhi Sree (ISRO), Hari Priya S (ISRO), Nigel Fox (NPL), Paolo Castracane (ESA), and Fabrizio Niro (ESA).

WGCV-55-13	WGCV team to write a definition of improved 'data quality' in the context of CEOS-ARD, as input to a consultation paper for SIT TW / Plenary. The data quality piece will be a central theme, so we should have a clear definition of improved data quality. The writing team will consist of Medhavy, Cody, Nigel, Fabrizio, Paolo, Santhi Sree, and Hari Priya.	**August 2025**

2.10 - Surface Reflectance Quality and Consistency

Josh Sixsmith (GA)* and Medhavy Thankappan (GA, WGCV Vice Chair) reported *[slides]*:

- Inconsistencies among Surface Reflectance (SR) products from different providers can limit the combined use of multi-sensor data. CEOS agencies' efforts, such as NASA's Harmonised Landsat Sentinel-2 (HLS) and ESA's Sen2Like projects, highlight the need for improved compatibility of SR measurements.



- By utilising multiple sensors that have undergone harmonisation and fusion processes, a denser time series becomes available. The Surface Reflectance Quality and Consistency project proposes building on the achievements of CEOS-ARD, with the main objective to define a surface reflectance measurand to ensure consistent quality, and to generate harmonised surface reflectance products from different sensors with comparable spectral bands. By ensuring a common foundational measurand, users have assurance that they are using consistent data and can extract insights more quickly. This approach provides cost savings to data providers and reduces duplication of effort.
- The desired model is that datasets from different sensors and viewing conditions are interoperable. This original concept was proposed at the ARD23 Workshop and further discussed within CEOS WGCV and LSI-VC. The group is currently undertaking a literature review to define and identify the

steps various providers take to create their datasets, will be followed by a review of potential gaps and sensitivities, and will culminate in the production and publication of a guidance document.

- The current literature themes identified include atmospheric correction algorithms and intercomparisons, BRDF normalisation, topographic correction, and traditional inter-sensor comparisons.
- Increasing data interoperability enables a denser time series, which opens up more analytical opportunities. For example, Sentinel-2D will complement the existing Sentinel-2 satellites along with the upcoming Sentinel Next Generation. The increase in data volume creates a more comprehensive field of analysis for users. Capturing these datasets in a dense time series can also complement data from other missions, provided they are harmonisable.

Discussion

- A participant asked if the project aims to characterise a better SR measurand for producers to build against, and Josh clarified that although every algorithm produces SR, they are not equivalent. The goal is to characterise a measurand by defining what quantities and corrections are required. It is important to address the issues users face and determine which corrections can adequately account for them.
- When asked how applicable BRDF corrections are for Landsat data, Josh noted that coarse resolution corrections (e.g. for MCD43A1) do not completely eliminate BRDF effects. For medium-resolution data like Landsat, the coarse resolution corrections still perform reasonably well. The general shape of the BRDF function leads to a noticeable reduction in viewing angle effects. Ideally, BRDF correction would be applied at the per-pixel level, but this remains technically challenging. There was discussion around applying BRDF windowing across scenes using localised regions, which may offer a more practical approach. Since current BRDF products are only available at coarse resolution, Josh suggested that future satellites could aim to provide BRDF parameters across different wavelengths. Increasing complementarity among sensors would be beneficial.
- Santhi Sree (ISRO) noted the need to identify necessary corrections without compromising products that do not currently include them, and asked what the policy would be in the context of CEOS-ARD. Josh explained that the group is currently working to define the required corrections, while recognising that at a broader level, many users are not interested in selecting specific corrections - they want data that is immediately useful for their applications.
- Shilpa Prakash (ISRO) asked about post-processing during SR product generation, specifically for atmospheric corrections. Josh noted that the assumption is to trust that providers have applied sufficient processing to make the data usable. The focus is not on the specific approach taken, rather on ensuring that the necessary corrections are applied and properly documented.
- Divya Sharma (SatSure) asked about validation approaches for harmonisation. In some downstream applications, changes in region-specific processing shift away from absolute references, potentially impacting geolocation. Josh noted that maintaining some level of consistency is key to enabling

sensor complementarity. They should produce data that is sufficiently aligned so that similar Cal/Val practices can be applied, while still allowing for flexibility and inter-system interoperability.

2.11- Report on the Surface Characterisation and Validation from Ground-Based Networks and Space Workshop 2025

Fabrizio Niro (ESA) and Nigel Fox (NPL) reported *[slides]*:

- Surface Reflectance (SR) is a common product of all satellite optical imaging sensors and serves as a key input to a wide range of processing. Niro et al., (2021) previously highlighted that SR products were at the lowest level in terms of validation maturity, mainly owing to the lack of consensus on the terminology, the disparity in algorithms and practices, and the scarcity of reference Cal/Val data . An ESA workshop was held in Lille, France from 21–22 May 2025, to review current SR retrieval methods and reference datasets, identify gaps and limitations, and develop recommendations and a roadmap.
- The agenda included contributions from ESA-funded initiatives such as GROSAT, ERADIATE, 3DREAMS, FRM4VEG, and HYPERNETS, as well as reports and feedback from RadCalNet and AERONET. The main discussion points surrounded definitions and terminology, retrievals and algorithms, validation methods, and reference datasets.
- Consensus was reached on HDRF and BRF, as the two basic SR quantities, HDRF being the only measurable quantity in the field and BRF the only surface-inherent property, with recommendations delivered for both ground based and satellite data. For ground-based systems, it was recommended to provide HDRF as the primary measurement, along with atmospheric data to enable derivation of BRDF. For satellite data, it was recommended that both HDRF and BRF be included.
- In the modelling approach, there is a need to move towards resolved surface and aerosol radiative coupling with joint retrieval methods. The 3DREAMS project demonstrated the impact of 3D effects in retrieving surface and aerosol properties at high spatial resolution (decametric scale) and under strict uncertainty requirements (<3%), and a recommendation was made to perform 3D simulations over RadCalNet, HYPERNETS, and the Cal/Val Park to better characterise adjacency effects. Validation methods are subject to the challenge of spatial upscaling. Issues with modelling approaches and UAVs should be addressed with a focus on RadCalNet and HYPERNETS sites. An ESA proposal is initially centred on a laboratory experiment using an artificial target to simulate BRF, measurement of HDRF using a UAV-mounted spectrometer survey, and comparison with simulated BRF.
- The next steps will be the preparation of a dedicated FRM-type of project (FRM4SR) to be started in 2026 to advance the FRM maturity of SR products, leveraging synergies across existing initiatives. Continued engagement through established networks is essential and should be supported by a dedicated working group that meets on a regular basis. Raising international awareness of the initiative is a key priority, with the aim of securing endorsement at the CEOS WGCV level, following the example of SRIX4Veg initiative. Collaboration and alignment with the CEOS ad hoc group on SR quality should also be pursued to ensure a shared strategic approach.

Day 3: Thursday 10th July, 2025

3.1 - Welcome and Session Overview

Medhavy Thankappan (GA) and Cody Anderson (USGS, WGCV Chair)* reported:

- CEOS Membership is typically confined to government agencies, and in light of the growing commercial space sector, WGCV and other CEOS groups are working to expand their coverage. Many WGCV subgroups are applicable to the commercial sector, notably IVOS, SAR, and LPV. There has been a lot of discussion surrounding ARD products and processing, which need to be open to commercial providers. Fora such as JACIE and VH-RODA have seen wide commercial participation in recent years. With the increasing number of commercial satellite launches over the past ten years, constraints on quality assurance are becoming more important. Establishing consistent quality among commercial systems is vital to realising the full potential of space-based datasets.

3.2 - NewSpace India LTD (NSIL)

Shiva Reddy (NSIL) reported *[slides]*:

- NSIL was established in 2019 with the mandate to act as an interface between ISRO and industry. In 2020, its mandate was enhanced by the Indian government's "Unlocking India's Potential in the Space Sector" space reform announcement. The organisation operates across five main domains: launch vehicle building and launch services, satellite manufacturing, satellite-based services, ground segment and mission support, and technology transfer and technical consultancy. Five future GSAT (Geosynchronous Satellite) missions are currently being developed, driven by user requirements and demands.
- EO data and value-added products are shared on the Bhoonidhi Portal, including data from Cartosat, Resourcesat, RISAT, and Oceansat missions. Microwave calibration targets employed include corner reflectors (trihedral and dihedral) with precise dimensions and characterised radar cross-section (RCS) across different frequency bands and polarisations. Natural targets, with reflectance values ranging from 8% to 70% in the VNIR spectrum, are used for radiometric calibration.
- For geometric calibration, the NRSC's site features a 70 m × 70 m white panel with contrasting edges, oriented at 6 degrees. NRSC has developed in-house facilities including a goniometer for BRDF characterisation of targets and an Active Radar Calibrator (ARC) for various SAR missions. Post-launch evaluation uses the site for periodic assessment of the radiometric and geometric performance of spaceborne optical sensors.
- NSIL is in the process of onboarding the Indian geospatial industry to generate value-added products across agriculture, water resources, and environment sectors. The Bhuvan platform-as-a-service is currently under development. NSIL is installing transponders to provide an end-to-end satellite information service for fisheries, enabling access to maritime boundaries.

- Commercial opportunities offered include low-cost access to space, EO data, international ground station services for IRS data, reselling of IRS products, geospatial applications, structured training, technology transfer and mission support, ground station turnkey projects, end-to-end satellite communication solutions.

Discussion

- It was noted that INSPACe functions as a regular promoter and enabler, operating independently under the Department of Space (DoS). It supports NGOs and facilitates non-commercial activities. NSIL, in contrast, is strictly tied to commercial companies, backed by ISRO and leveraging its expertise.
- Medhavy Thankappan (GA, WGCV Vice Chair) asked whether the delineation between commercial and non-commercial access on the Bhoodini portal is based on spatial resolution, and what geographical extent is featured. It was noted that data with resolution coarser than 5 m is freely available to the public, while finer-resolution and value-added data requires payment. Santhi Sree (ISRO) added that the primary focus is on Indian coverage. Requests for coverage outside India can be accommodated depending on availability. Although there is no systematic global coverage, scatterometer data from Oceansat (OCM) is available globally and will continue with future missions. K.N. Babu (ISRO) added a RadCalNet type of network will be developed for OCM, extending over land, and highlighted the importance of an impact report to demonstrate benefits for the commercial sector.
- Meenakshi Tomar (Azista) asked whether the fisheries transponder is similar to AIS and whether the data is accessible. Shiva noted that the data is private, shared voluntarily by fisheries. It supports disaster alerts, search and rescue operations, and maritime boundary crossings, communicated via a dedicated app.
- Ankur Singhai (KaleidEO) asked whether NSIL has a framework to assist new space companies, especially since setting up infrastructure takes time. Shiva encouraged companies to approach NSIL with detailed proposals, noting that support is provided on a case-by-case basis.
- Alok Parashar (Antaris Space) suggested integrating and advertising existing ISRO services within a structured framework to improve accessibility. Shiva noted that INSPACe would be involved in areas with commercial value and welcomed suggestions for developing a common support framework.

3.3 - SatSure

Divya Sharma reported *[slides]*:

- SatSure is a full-stack Earth intelligence company founded in 2017, combining EO, ML, big data, and cloud computing to develop actionable products and solutions. The company has received 18 million USD in funding and currently employs 160 staff. It has delivered solutions to the societal sector, earning recognition through awards such as Future Food Asia and the Agriculture Grand Challenge.

- SatSure operates across banking, financial services and insurance (BFSI), agriculture, infrastructure, government, and space sectors. Initially focused on downstream services, the company has developed offerings that support decision-making in critical sectors.
- Around 45% of India's workforce is employed in agriculture, yet many farmers remain outside the formal credit system and face challenges accessing finance. SatSure aims to bridge this gap by enabling access to formal credit for 10 million small and marginalised farmers by 2027. Crop monitoring EO products are used to derive information on farm boundaries, irrigation mapping, crop rotation patterns, and other land monitoring indicators.
- SatSure's crop classification framework can determine crop area, irrigation status, crop intensity, and yield estimation. Insights are delivered through SatSure's Sparta data platform, which stores its value-added products and provides tailored solutions for various stages of the farmer's credit lifecycle.
- SatSure's Sage platform provides farm-level insights and cropping history to generate risk layers, comparing farm performance with neighbouring plots across seasons. This helps bank managers assess land revenue potential and support loan decisions. SatSure also supports vegetation management, a highly cost intensive problem where infrequent lidar scans every five years fall short, particularly in wildfire prone areas.
- A few challenges SatSure experiences include spatial and spectral resolution limits, data gaps due to clouds or poor illumination, long development times, scalability issues, and a lack of labelled ground truth data. To overcome this, SatSure is exploring contrastive AI approaches, such as learning optical features from SAR data, though resolution mismatches remain a hurdle.

3.4 - KaleidEO

Ankur Singhai reported *[slides]*:

- KaleidEO is an EO payload manufacturer closely aligned with SatSure in prioritising data access. The initiative began with SatSure's downstream use case insights, which informed the design and development of in-house payloads. KaleidEO adopts a 'solution-first' approach, leveraging STAC standards and rapid prototyping using commercial off-the-shelf components. Payloads are integrated with a standardised platform developed in collaboration with SatSure.
- KaleidEO is developing a multispectral payload with a 65 km swath and 1 m resolution, with spectral bands selected based on SatSure's application areas. This wide coverage allows single-image captures of large cities. The payload is 'bus agnostic' and equipped with onboard AI/ML for faster insights, reduced turnaround time, and lower downlink costs. The second payload is an 11 km optical MS sensor with resolution as low as 0.5 m, designed for precise object identification. Together, the constellation avoids reliance on narrow-swath time composites, improving data quality.
- KaleidEO was the first Indian company to test edge computing in space and to design, develop, and flight-test a high-res MS payload via airborne testing. Edge processing enables onboard extraction of

features like road networks, and an in-orbit test with Spiral Blue achieved a 99% data reduction with 95% detection accuracy.

- Divya Sharma (SatSure) noted their interest in collaborating with CEOS to better understand image quality characterisation, access peer-reviewed reference products, and contribute to open data efforts for ARD standardisation and radiometric/geospatial assessments. They are seeking mentorship on both in-orbit and on-ground Cal/Val activities and expressed interest in actively participating in IVOS, CEOS-ARD, and pre-flight calibration discussions. Given their extensive collection of forestry and agriculture data, they are also keen to collaborate with the LPV Subgroup.

Discussion

- Medhavy Thankappan (GA, WGCV Vice Chair) asked about the process for the pre-flight calibration of data. Ankur Singhai (KaleidEO) noted that pre-flight calibration is a priority in payload development, and KaleidEO is actively engaging with ISRO and NSIL for support to define calibration requirements and test setups. They plan to incorporate insights from WGCV's pre-flight calibration workshop proceedings and are also working on defining onboard calibration needs.
- Divya Sharma (SatSure) noted a couple challenges include not having access to Level 0 data and requested archived data from NSIL, as well as ground truthing in the context of crop-specific analysis.
- When asked of the payload's repeat cycle, Ankur shared that a 14 day global coverage can be achieved with a 65 km swath. The team is currently assessing optimal coverage strategies within the satellite's five-year design life.
- Santhi Sree noted that when building your own payload, you must develop your own test setup. Each sensor generates raw and test data, including Level-0 data prior to processing. While this data exists, it is customised per sensor and is not usually made publicly available.
- Nitant Dube (ISRO, WGISS Vice Chair) highlighted the complexities of Cal/Val once a satellite is in orbit, and encouraged the use of CEOS WGCV resources such as best practices, and datasets like RadCalNet and SARCalNet to enhance system quality. For those using AI/ML techniques, it is essential to understand what has been done to the data. ISRO SAC has calibration capabilities, including TVAC chambers and other facilities, available on request. Divya noted that SatSure has started using RadCalNet data to better understand mapping workflows.
- NSIL maintains a repository of Cal/Val facilities, and KaleidEO is already in communication with them. SAC also develops Cal/Val processing algorithms and is willing to support improvements across the data pipeline.

3.5 - Azista Aerospace Ltd

Bharath Simba Reddy Pappula & Abhishek Patil reported *[slides]*:

- Azista Aerospace operations span electronics and defence, satellite manufacturing, subsystems and payloads, advanced composites, and satellite data processing and analytics. The company has seven locations across India.

- Its first satellite, Azista BST First Runner, was launched on 13 June 2023 aboard SpaceX's Transporter-8 mission. The satellite carries an optical payload operating between 514-531 km altitude, delivering a 6 m GSD with high radiometric fidelity. It captures data across seven bands in the VIS–NIR region, supporting vegetation indices, classification maps, water indices, and false colour composites.
- The Moon serves as one of the primary calibration sources for the mission. With a 180-second dwell time, the satellite can track moving ground objects and capture long-exposure night imagery.
- An overview of Azista's 100 and 200 spacecraft platforms, along with the Fineview payload, was presented.
- The team reported 95% compliance with CEOS-ARD standards, noting that cloud shadow masking is not yet implemented, but other metadata aligns well. Azista aims to fully meet ARD standards to enhance data interoperability.
- Various Cal/Val methods are currently being tested in-house. Data processing and dissemination are handled through their internal APRIL software, and future platforms will incorporate edge computing for real-time analytics.

Discussion

- Fabrizio Niro (ESA) asked whether the claimed 7% geometric accuracy could be evidenced. Bharath noted that they use four sources for calibration data, RadCalNet's Gobabeb site, Sentinel data which aligns with AFR bands, moon calibration for its radiometric and geometric consistency, and stellar calibration.
- Nitant Dube (ISRO, WGISS Vice Chair) noted that moon calibration phases are not always properly captured. ISRO performs moon calibration only on full moon days, but models now offer stable radiance estimates across different lunar phases. The raw data is publicly available and based on the ROLO V4 model.
- Nigel Fox (NPL) noted small errors in the ROLO original publication that have since been corrected. ESA's LIME model, available through the Cal/Val Portal, may be a more accessible alternative, and that all models provide similar relative shapes. The uncertainty in ROLO is estimated around 10%.
- It was noted that vicarious calibration has not been conducted due to lack of access to Indian GCPs, as requests to INSPACe proved costly. They currently rely on relative calibration using Sentinel data. Santhi Sree (ISRO) noted that GCPs are not easily applicable at 4.6 m resolution and recommended referencing Sentinel data instead. Santhi recommended cataloguing ground targets for traceability. Matching Sentinel bands is helpful for radiometric accuracy, but ground truth data is still necessary to ensure product quality.
- When asked if they use Digital Elevation Models (DEMs) for orthorectified products, the team acknowledged it will be more relevant for higher-resolution imagery. For now, accuracy is more reliable over flat terrain. Medhavy Thankappan (GA, WGCV Vice Chair) noted the importance of strong investment in pre-flight calibration to establish a baseline for ongoing monitoring once a satellite is in orbit.

3.6 - Pixxel

Rahul Raj reported *[slides]*:

- Pixxel is developing a 'health monitor for the planet' using hyperspectral satellites with 5 m spatial resolution and global coverage. Three satellites are currently in orbit, all launched earlier in 2024. Radiometric and spectral calibration is conducted in Pixxel's in-house clean rooms, with ISRO providing support for pre-flight calibration.
- Pixxel operates one controlled Cal/Val site in Madras, a 35 m square area equipped with radiometers, and photometers that are activated during satellite overpasses. They also utilise two additional FLARE network sites located in Japan and South Dakota (US), which provide enhanced radiometric data. Pixxel frequently uses USGS and RadCalNet sites, as well as spatial vicarious calibration locations like NRSC's site at Shadnagar. These efforts aim to bring Pixxel's satellite data closer to ground truth.
- The challenge with RadCalNet is the lack of continuous data availability. For instance, the most recent Gobabeb data accessible was from March 2025. Pixxel's hyperspectral sensors require finer spectral resolution with FWHM narrower than 10 nm, which RadCalNet currently does not support. FLARE sites are therefore used to fulfil this requirement. Pixxel's satellites also collect imagery from multiple look angles, raising the possibility of calibrating using angular data suggesting a potential for sites to collect such data at regular intervals.

Discussion

- Cindy Ong (CSIRO) commented on the global distribution of USGS sites, noting that Australia's Lake Frome is no longer used due to climate change impacts. She recommended the Pinnacles and Lake Lefroy sites instead. Regarding look-angle data, RadCalNet sites such as Gobabeb, La Crau, and Pinnacles are capable of collecting BRDF data, and metadata is made available equally across sites. However, to obtain angular data specifically, she advised contacting site operators directly e.g., NPL (Gobabeb) and CNES (La Crau). Cindy asked whether Pixxel had considered HYPERNETS sites to address spectral resolution constraints.
- Rahul noted that Nigel had facilitated Pixxel's access to HYPERNETS as beta users. Cindy added that while HYPERNETS was initially designed for aquatic sites, land-based sites are now being added, with Gobabeb as the first, and a HYPSTAR unit planned for deployment at Pinnacles.

3.7 - Antaris Space

Alok Parashar reported *[slides]*:

- Antaris Space, founded in 2021, is headquartered in Chennai, with manufacturing operations in Hyderabad and development based in Pune.
- The company aims to simplify the design, operation, and analysis of satellites and their data through a suite of integrated platforms. Design Studio is a tool to design satellite missions, payloads, and hardware integration. True Twin is a software-first digital twin that can simulate a virtual satellite's

operation, tasking data acquisition, telemetry, and downlink. Command Centre is a satellite operation software that provides flight controls, payloads, edge computing, and communications, and SatOS is space vehicle software.

- Antaris delivers full-stack solutions covering everything from EO mission development to end-user product dissemination. The company has provided software solutions for a number of satellite missions including JANUS-1,-2, and -3, Elevation-1, Drishti-1, Spike-1, and Space Hawk-1.

3.8 - Overview of WGCV Capabilities

Medhavy Thankappan, Cody Anderson (USGS)* reported *[slides]*:

- Medhavy provided an overview of CEOS, including its organisation, structure, Working Groups, and Virtual Constellations. The WGCV mission, subgroups, and open deliverables were shared. More details can be found at the CEOS website and the Cal/Val Portal.
- Recent workshops included JACIE 2025, VH-RODA 2024, WGCV SAR Workshop 2024, and the Pre-flight Calibration Workshop 2024.
- Resources and publications can be accessed through the CEOS publications page, the WGCV Subgroup webpages, and the Cal/Val Portal.
- WGCV contact details can be found in the given slides.

3.9 - CEOS Product Validation Platform

Nigel Fox (NPL) reported *[slides]*:

- The CEOS Product Validation Platform (PVP) was developed in response to the new space community's request for a common method to demonstrate sensor performance. It aims to encourage CEOS Agencies to regularly collect and freely share L1 satellite imagery and metadata against common 'CEOS reference' sites. The PVP archives calibration information and includes three instrumented sites (Railroad Valley, Gobabeb, Lake Tahoe) and three natural PICS (Libya 1, Libya 4, Algeria 3), as well as spatial targets such as the King Fahd Causeway.
- Hosted on the UK EO Data Hub, the PVP provides open access to a radiometric comparison imagery database. Spectral response functions, while not necessarily public, are required for valid comparisons. A beta version of the Radiometric Validation Analytics Tool (RadVAL) is to be released soon.
- Next steps include interaction with commercial missions to encourage imagery delivery over reference sites, CEOS-PVP CID and RadVAL beta launch at ceos.org/pvp, refinement of the CEOS virtual reference concept, and populating the PVP with commercial and agency data.
- CEOS SIT-40 suggested the term 'Product Validation Platform' could serve as an umbrella for broader validation tools beyond optical, offering a unified access point rather than scattered individual sites.

WGCV-55-14	Subgroup Chairs and WGCV members to consider adding other product validation tools beyond the optical domain onto a common front page of the CEOS Product Validation Platform.	**WGCV-56**
WGCV-55-15	Satellite agencies including New Space of optical sensors to collect and provide imagery over sites identified in the CEOS Product Validation Platform.	**WGCV-56**

3.10 - The Future of CEOS Analysis Ready Data

Matt Steventon (CEOS-ARD Secretariat)* reported *[slides]*:

- For 2025, CEOS-ARD is focusing on gathering community feedback, expanding engagement beyond CEOS, and identifying priorities for future development. Since its inception in 2016, CEOS-ARD has defined Product Family Specifications (PFS) that set minimum processing standards to facilitate user uptake and improve interoperability, particularly for geophysical measurements. The initiative aims to provide benchmark requirements for data procurement, building user confidence while supporting both data providers and users.
- Nine PFS have been developed so far, covering Surface Reflectance, Surface Temperature, SAR, Aquatic Reflectance, and Nighttime Lights Surface Radiance. CEOS-ARD plans to modernise these documents to ensure scalability and consistency with evolving products and contributions. There is also an ongoing investigation into migrating these documents to a public GitHub framework to promote open access and collaborative discussion.
- The CEOS-ARD specifications have been powerful catalysts for products such as Landsat Collection 2. ISRO has been a significant contributor to CEOS-ARD, and has provided two datasets from RISAT-1A for normalised radar backscatter. Additional datasets are available at ceos.org/ard.
- Since 2016, rapid technological advances have driven a growing and evolving user base with increasing demands for interoperability. CEOS-ARD welcomes community input to help shape its future, specifically seeking feedback to refine definitions of analysis readiness, AI/ML readiness, CEOS-ARD's role in data procurement, data quality, fit for purpose, consistency and equivalence, interoperability, and community standards. Participants are invited to share their feedback at ceos.org/ard/survey.

Nitant shared an overview of WGISS:

- WGISS is one of the five working groups of CEOS, with interest groups for Data Preservation and Stewardship, Data Interoperability and Use, Data Discovery and Access, and Technology Exploration.
- WGISS best practices are shared online at https://ceos.org/ourwork/workinggroups/wgiss/. WGISS Jupyter notebooks, archival, STAC, etc. are available through the CEOS GitHub account. The WGISS Connected Data assets initiative serves as a single entry point for CEOS Agency data, through OpenSearch and STAC catalogues.

- Software preservation is important to maintain the maximum value of satellite data, including for re-analysis. WGISS is developing a white paper to assist data and software managers to ensure long term preservation of their data. A framework is being developed for authentication, authorisation, and federation processes, and a 'living' white paper has been developed on AI/ML, available on GitHub.
- A white paper on Digital Twins is being developed. More details can be read at https://ceos.org/ourwork/workinggroups/wgiss/.

3.11 - JAXA Agency Report

Kazuhisa Tanada (JAXA)* reported *[slides]*:

- JAXA is currently operating nine EO satellites focused on disaster response and land monitoring, including the EarthCARE and GPM satellites, as well as the ALOS and GOSAT series. In 2024, JAXA launched EarthCARE, for which it provides the Cloud Profiling Radar (CPR), the first W-band Doppler radar to observe the vertical structure and movement of clouds. ALOS-4 was launched in July 2024, and GOSAT-GW was launched on 29 June 2025, carrying GHG spectrometers and a microwave radiometer.
- The EarthCARE Level 1 dataset was released in January 2025, and was followed by the Level 2a and 2b synergy products in March.
- GOSAT-GW includes TANSO-3 and AMSR-3 instruments, providing enhanced GHG, solid precipitation, and water vapour data.
- The GCOM-C SGLI sensor is regularly calibrated against the moon via GIRO and features polarimetry at 670 nm and 865 nm for aerosol characterisation, sun glint reflectance, and TOA polarisation reflectance. The GOSAT programme began in 2009, continuing with GOSAT-2 in 2018 and now GOSAT-GW, which adds NO2 measurements as a proxy for CO2.
- The PMM mission (2028–2033) will carry the first satellite Ku-band radar.

3.12 - GHG Cal/Val and Networks

Jean-Christopher Lambert (BIRA-IASB), Hiroshi Suto (JAXA)* reported *[slides]*:

Hiroshi Suto reported:

- Since 2009, the GOSAT series have observed global GHG distributions. JAXA has collaborated with NASA AMES to conduct extensive Cal/Val activities, particularly in the US. These include field and airborne campaigns over desert sites in Nevada, where CO2 and CH4 columns and profiles, along with temperature data, are measured using instruments such as the EM27/SUN Fourier Transform Spectrometer (FTS) and the AJAX airborne instrument.
- The Railroad Valley site is a key location for these campaigns, hosting instruments that also measure Surface Reflectance (SR) inhomogeneity, bidirectional reflectance factor (BRF), atmospheric

parameters, and solar irradiance. These datasets are used in radiative transfer models to evaluate the accuracy of measured radiances from satellite sensors. Campaigns have leveraged coincident overpasses from GOSAT-1/2, OCO-2/3, and TROPOMI.

- The 2025 summer campaign successfully acquired ground and satellite data from these missions and assessed observations using common radiative transfer models.
- Efforts are ongoing to improve instruments for off-nadir signal analysis, with new match-up sites being prepared for TIR calibration. The JAXA VCAL website now hosts vicarious calibration data and sensor intercomparisons, notably for L2 XCO2 between OCO-2 and GOSAT.

Jean-Christopher Lambert reported on Cal/Val Networks:

- Three monitoring networks of Fourier Transform InfraRed spectrometers provide reference measurements for GHG satellites Cal/Val: the Network for the Detection of Atmospheric Composition Change - Fourier Transform InfraRed (NDACC-FTIR), the Total Carbon Column Observing Network (TCCON), and the Collaborative Carbon Column Observing Network (COCCON). The first two measure GHGs using high-resolution FTIRs and the third one using portable EM27/SUNs. Their respective status is presented regarding measurement capabilities, network deployment, retrieval software, calibration, and central processing. CEOS-FRM maturity assessments of TCCON and COCCON were published recently.
- NDACC-FTIR data is used in an automated validation channel for the operational validation of Sentinel-5P TROPOMI CH4 and CO products. TCCON and COCCON data are used in manual validation channels as their procurement is not automated yet.
- These networks, as well as AirCore balloon soundings, are mentioned in the CEOS GHG Roadmap Issue 2, which outlines Cal/Val capabilities and challenges. Annex C of the document includes a focus on tracking L2 validation capabilities, identifying evolving needs and addressing gaps in the ground-based L2 validation system, and on exploring a more operational framework for delivering its products to support evolving GHG mission needs.
- The joint IWGGMS-21 / AC-VC-21 / ACSG meeting in June 2025 explored evolving validation requirements, gaps, monitoring networks and campaigns, New Space and facility-scale missions, validation of emissions and fluxes, and steps towards an operational validation capacity.
- A new version of the COCCON software has been released, and reprocessing is underway.
- EUMETSAT has launched a Cal/Val support activity for the upcoming CO2M missions, developing TCCON and COCCON central processing facilities tailored to CO2M needs and identifying gaps in the validation networks.
- New low-resolution spectrometers are being deployed, with 163 currently checked at KIT in Germany. Additional stations are planned, particularly in urban emission regions including Tokyo, Kolkata, Bhopal, and Ahmedabad. All new stations are encouraged to follow COCCON standard procedures. Ongoing campaigns include ship-based observations using EM27/SUN and MAX-DOAS instruments.

- NIES and BIRA-IASB, in collaboration with IISER-Kolkata, IISER-Bhopal, and PRL, are deploying FTIR instruments in India to measure GHG columns using high and low resolution spectrometers.
- The CEOS SIT is working with the GHG-TT to engage the IMEO Use Case Working Group to establish a database of controlled release experiments data. The aim is to notify satellite operators in advance so they can plan satellite observations during these controlled release experiments.

Discussion

- Fabrizio Niro (ESA) asked whether the Railroad Valley site includes MODIS and VIIRS data. Hiroshi noted that MODIS datasets are normally used for BRDF correction. In the 2025 campaign, polarisation effects were also observed. Although MODIS products were used for comparison, a formal intercomparison has not yet been conducted but is planned in the coming months. Fabrizio noted past issues with ground-based BRDF measurements due to instrument stability and polarisation angles. He confirmed that updates were made to the ground instrument in 2025 to improve accuracy and stability.
- Regarding FTIR deployments in India, there was an inquiry about site selection criteria. Jean-Christopher noted that sites are selected on the basis of several criteria, including network requirements to capture a full range of GHG concentrations, but also logistics. Approximately 10-12 Indian sites were visited, with selections aimed at ensuring a longitudinal transect covering different emission types and monsoon regimes. Identical FTIR instruments will be deployed across all locations.

3.13 - GSICS-WGCV Interactions

Paolo Castracane (ESA) reported *[slides]*:

- The Global Space-based Inter-Calibration System (GSICS), initiated by WMO and CGMS, aims to ensure consistent calibration across sensors, satellites, and agencies for weather forecasting, climate modelling, and scientific research.
- The recent GSICS annual meeting took place from 17-23 March 2025 in Changchun, China. The agenda covered topics including calibration for space weather, VIS/NIR and lunar observations, IR, microwave, UVN-S, spectrometers, the GSICS Data Working Group, and the GSICS Research Working Group. It also included updates from CEOS WGCV, outcomes from the Pre-flight Calibration and Characterisation Workshop, and SITSat activities. Further details can be found here.
- GSICS provides a critical framework for satellite agencies to collaboratively develop community-agreed best practices, standard procedures, and tools. Over the past year, GSICS held 26 subgroup meetings in addition to the annual Executive Panel (EP) meeting in China.
- Examples of GSICS benefits include KMA's inter-calibration monitoring of GK2A with IASI/CRiS for IR and VIIRS for VIS-NIR, an approach now adopted by many agencies.

- The next GSICS annual meeting will be hosted by the National Research Council of Canada from 23-27 March 2026 in Ottawa. This event will invite commercial satellite providers alongside other potential users such as CEOS-CGMS WGClimate and CGMS Working Groups.
- Collaboration between WGCV and GSICS is continuously evolving and takes place at various levels, from Working Groups to the Executive Panel. Active areas of cooperation include methods, protocols, and joint workshops. New space topics are shared through workshops like VH-RODA and JACIE, as well as outreach platforms such as the Cal/Val Portal and the GSICS Newsletter.

Discussion

- Larry Flynn (NOAA) noted that the GSICS Wiki, a collaborative resource hosted by the University of Maryland, is currently being updated to improve its functionality and availability.

Appendix A: List of Participants

In person		**Virtual**	
Agency	**Full Name**	**Agency**	**Full Name**
Antaris Space	Alok Parashar	Azista	Bhargav Palsana
Azista	Abishekh Patil	Azista	Eeshan Beohar
Azista	Ashish Sachan	Azista	Tanishka Chauhan
Azista	Bharath Simba Reddy Pappula	CAS	Jieying He
Azista	Meenakshi Tomar	CAS	Xiaolong Dong
BIRA-IASB	Jean-Christopher Lambert	CAS	Zijin Zhang
ESA	Fabrizio Niro	CEOS Executive Officer	Steven Ramage
ESA	Paolo Castracane	CEOS-ARD Secretariat	Matthew Steventon
GA	Medhavy Thankappan	CMA	Sun Ling
GISTDA	Pawarin Kuha	CSA	Stephane Cote
GISTDA	Prayot Puangjaktha	CSIRO	Cindy Ong
ISRO	Girish Pujar	CSIRO	Ian Lau
ISRO/ADRIN	Archana Pragada	EC-JRC	Peter Strobl
ISRO/ADRIN	Nidhi Chubey	EUMETSAT	Mounir Lekouara
ISRO/NESAC	Pradesh Jena	GA	Josh Sixsmith
ISRO/NRSC	Hyndavi A.	ISRO/NRSC	Hari Priya
ISRO/NRSC	Jayasri Poludasu	ISRO/NRSC	Jayabharathi
ISRO/NRSC	Meena Kumari Gali	ISRO/NRSC	Kalyani

ISRO/NRSC	Murali Krishna	ISRO/NRSC	Nagalakshmi
ISRO/NRSC	Prakash Chauhan	ISRO/NRSC	Nagamani
ISRO/NRSC	Raghavender N	ISRO/NRSC	Sanjutha
ISRO/NRSC	Santhi Sree Basavaraju	ISRO/NRSC	Shilpa Prakash
ISRO/NRSC	Saritha P.K.	ISRO/NRSC	Tapas Martha
ISRO/NRSC	Shanmukha Rao D.	JAXA	Hiroshi Suto
ISRO/NRSC	Soma Sekhar Kopparthi	JAXA	Kazuhisa Tanada
ISRO/NRSC	Usha Sundari	JPL	Bruce Chapman
ISRO/SAC	Babu K.N.	MYSA	Adhwa Amir Tan
ISRO/SAC	Bhasakar Dubey	MYSA	Wayne Ng Su Wai
ISRO/SAC	Nilima Chaube	NOAA	Changyong Cao
ISRO/SAC	Nitant Dube	NOAA	Larry Flynn
KaleidEO Space Systems	Ankur Singhai	NOAA	Manik Bali
NPL	Nigel Fox	NOAA	Wenming Lin
SatSure Analytics Ltd	Divya Sharma	Pixxel	Mihir
SatSure Analytics Ltd	Rounak Goel	USGS	Cody Anderson
ISRO/IIRS	Shashi Kumar	USGS	Esad Micijevic

Appendix B: Decisions

Decision 01	WGCV endorsed the LPV Subgroup Land Cover Change assessment protocol, subject to incorporation of final feedback and a short WGCV review cycle, by October 2025.
Decision 02	WGCV endorsed Version 2 of the Roadmap towards an Assessment Framework for CEOS-Fiducial Reference Measurements (FRMs).
Decision 03	WGCV-56 will be held at USGS EROS in Sioux Falls, South Dakota, US, in April 2026.

Appendix C: Actions

WGCV-55-01	WGCV Subgroup chairs to communicate subgroup activities to Paolo to be shared on the Cal/Val Portal at https://calvalportal.ceos.org/wgcv.	**WGCV-56**
WGCV-55-02	Paolo Castracane to work with Nigel Fox to establish on the Cal/Val Portal an IVOS database on radiometric calibration capabilities.	**Q4 2025**
WGCV-55-03	Paolo Castracane to organise a second FRM Assessment Framework exercise to include PGN, FRM4DOAS, and RadCalNet, ACTRIS, ISMN.	**Q4 2025**
WGCV-55-04	WGCV to confirm the readiness of operationalisation and conduct a pre-launch review of the FRM Assessment Framework, and to define candidates for operational usage of the tool e.g. HYPERNETS.	**WGCV-56**
WGCV-55-05	Medhavy Thankappan to work with subgroup chairs to review the Terms of Reference from the RadCalNet CEOS WGCV review panel and identify suitable evaluators of the different types of submissions to the FRM Assessment Framework.	**Q3 2025**
WGCV-55-06	Cody to invite the GISTDA Cal/Val team to participate in TMSG GCPIX, in support of accessing more GCP information for THEOS geometric calibration.	**COMPLETE**
WGCV-55-07	Medhavy to clarify the submission and documentation requirements for CEOS-ARD self-assessment with the GISTDA team.	**Q2 2025**
WGCV-55-08	Paolo to work with the CEOS Communications Team to develop an FRM Assessment Framework logo and CEOS News article post.	**WGCV-56**
WGCV-55-09	Medhavy and Paolo to communicate with Bruce and Stephane that WGCV Membership should be notified when new SARCalNet site submissions are ready for approval. A step in the review and approval process for SARCalNet sites should include that WGCV membership is notified.	**Q3 2025**
WGCV-55-10	Fabrizio to share the updated LPV Subgroup Action Plan for 2025-28 with WGCV Members.	**Q4 2025**
WGCV-55-11	Fabrizio to finalise and share the updated list of LPV Supersites list with WGCV Members.	**WGCV-56**
WGCV-55-12	Pre-flight Calibration Workshop team (Nigel, Albrecht, Philippe, Paolo) to develop a good practice guidance document to summarise the workshop's outcomes and recommendations.	**Q1 2026**

WGCV-55-13	WGCV team to write a definition of improved 'data quality' in the context of CEOS-ARD, as input to a consultation paper for SIT TW / Plenary. The data quality piece will be a central theme, so we should have a clear definition of improved data quality. The writing team will consist of Medhavy, Cody, Nigel, Fabrizio, Paolo, Santhi Sree, and Hari Priya.	**August 2025**
WGCV-55-14	Subgroup Chairs and WGCV members to consider adding other product validation tools beyond the optical domain onto a common front page of the CEOS Product Validation Platform.	**WGCV-56**
WGCV-55-15	Satellite agencies including New Space of optical sensors to collect and provide imagery over sites identified in the CEOS Product Validation Platform.	**WGCV-56**
WGCV-55-16	Nigel and the RadCalNet team to prepare a note for information to CEOS Plenary 2025, noting the importance to CEOS Agencies and New Space of supporting the maintenance and development of long-term Cal/Val infrastructure e.g. RadCalNet. WGCV IVOS seeks to connect with CEOS WGCapD to support developments in smaller agencies in regions where such sites may exist.	**Q3 2025**
WGCV-55-17	Cody to respond to COAST-VC suggestions of the Interoperability Handbook, and to read the ISO standard 19157-3 to evaluate OGC's suggestion for quality measure registers.	**Q3 2025**