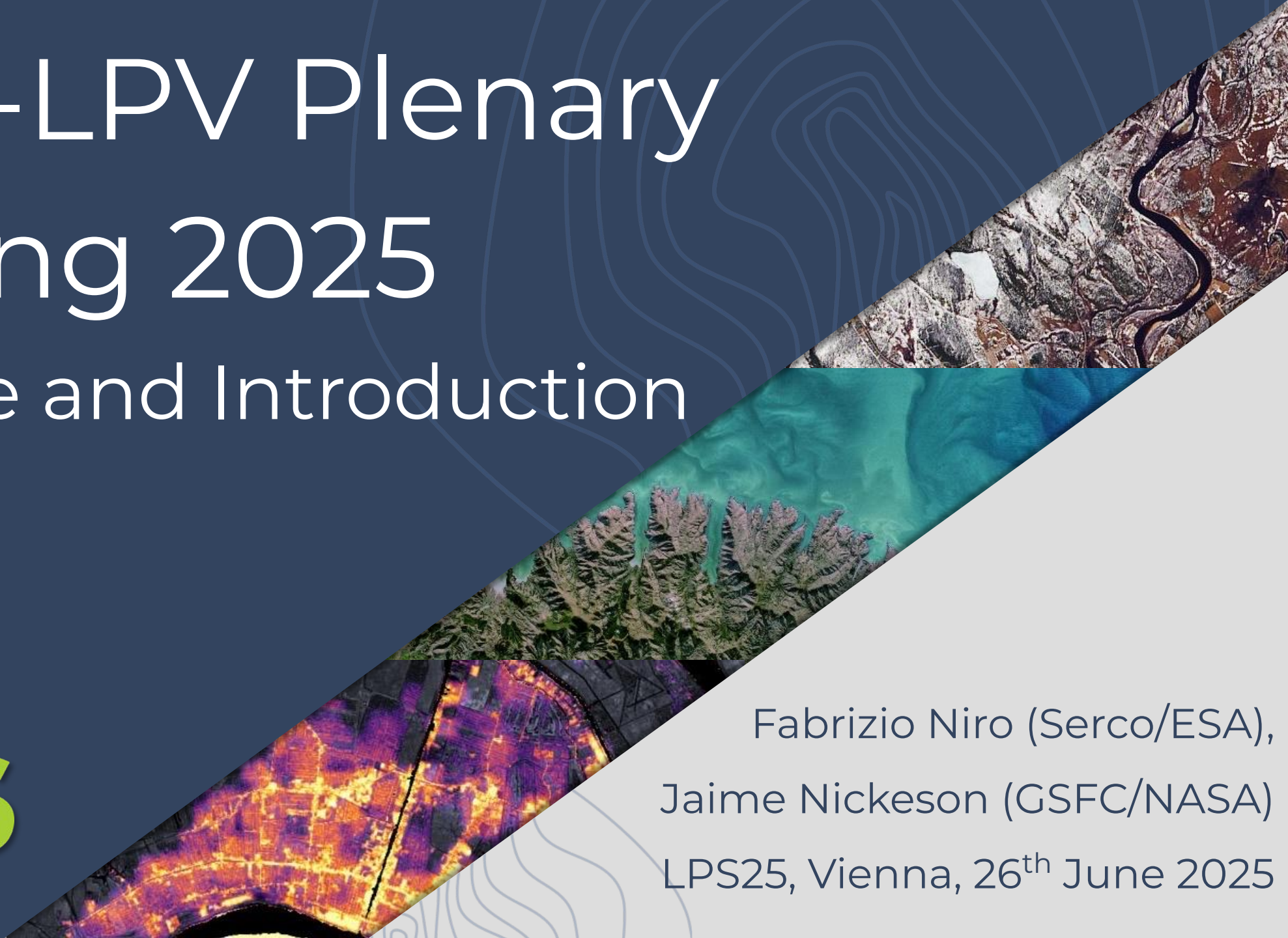
CEOS-LPV Plenary Meeting 2025

Welcome and Introduction



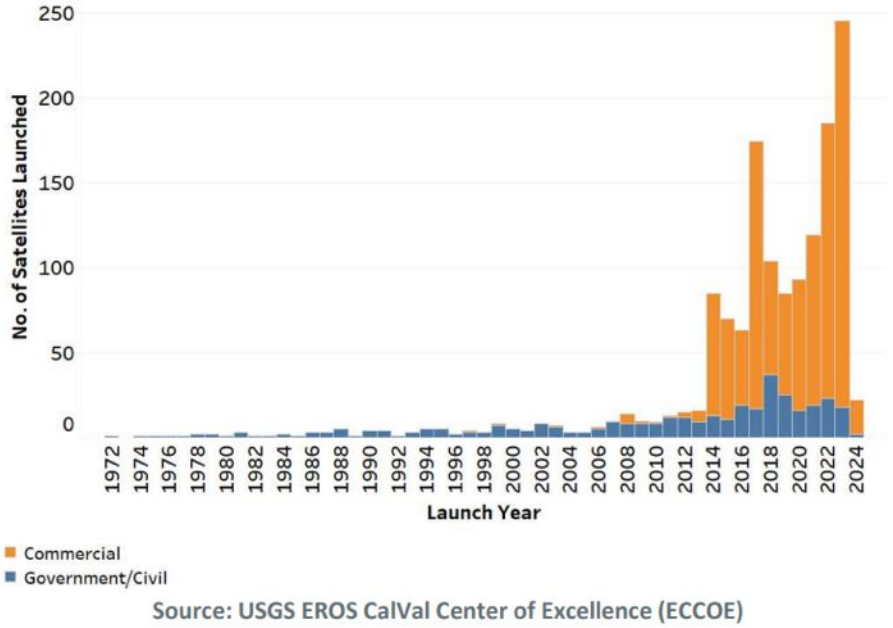
Fabrizio Niro (Serco/ESA),
Jaime Nickeson (GSFC/NASA)

LPS25, Vienna, 26th June 2025

CEOS
Committee on
Earth Observation Satellites

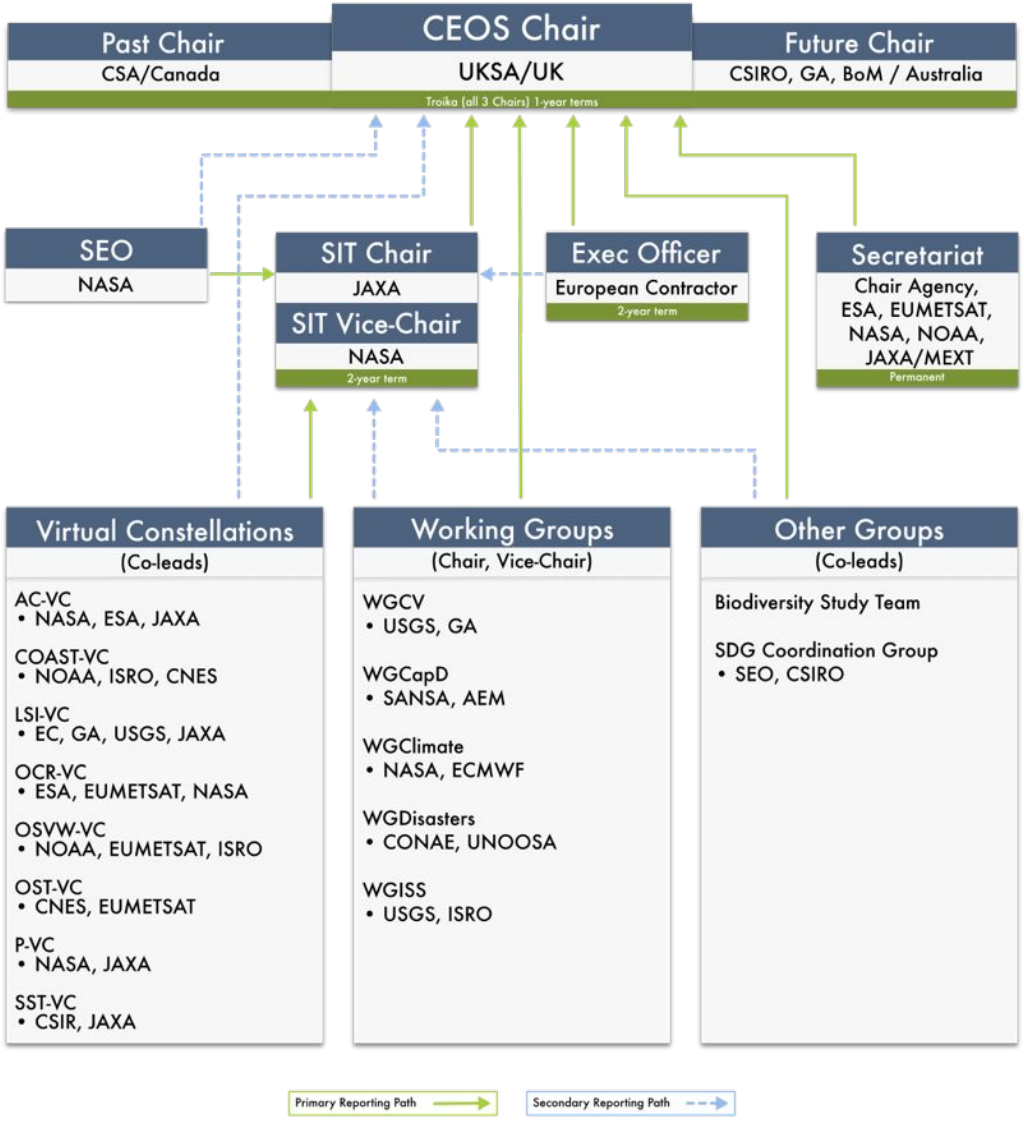
Context and Motivations

- The EO domain is undergoing dramatic **changes** with the **proliferation** of satellite missions, both from Institutional and Commercial entities, providing **ever improving** spatial, temporal and spectral coverage and resolution
- How to realise the full **potential** of such a wealth of EO data ?
- **Interoperability** and **consistency** across missions is crucial to enhance **comparability** and enable **synergistic** use of heterogeneous EO data



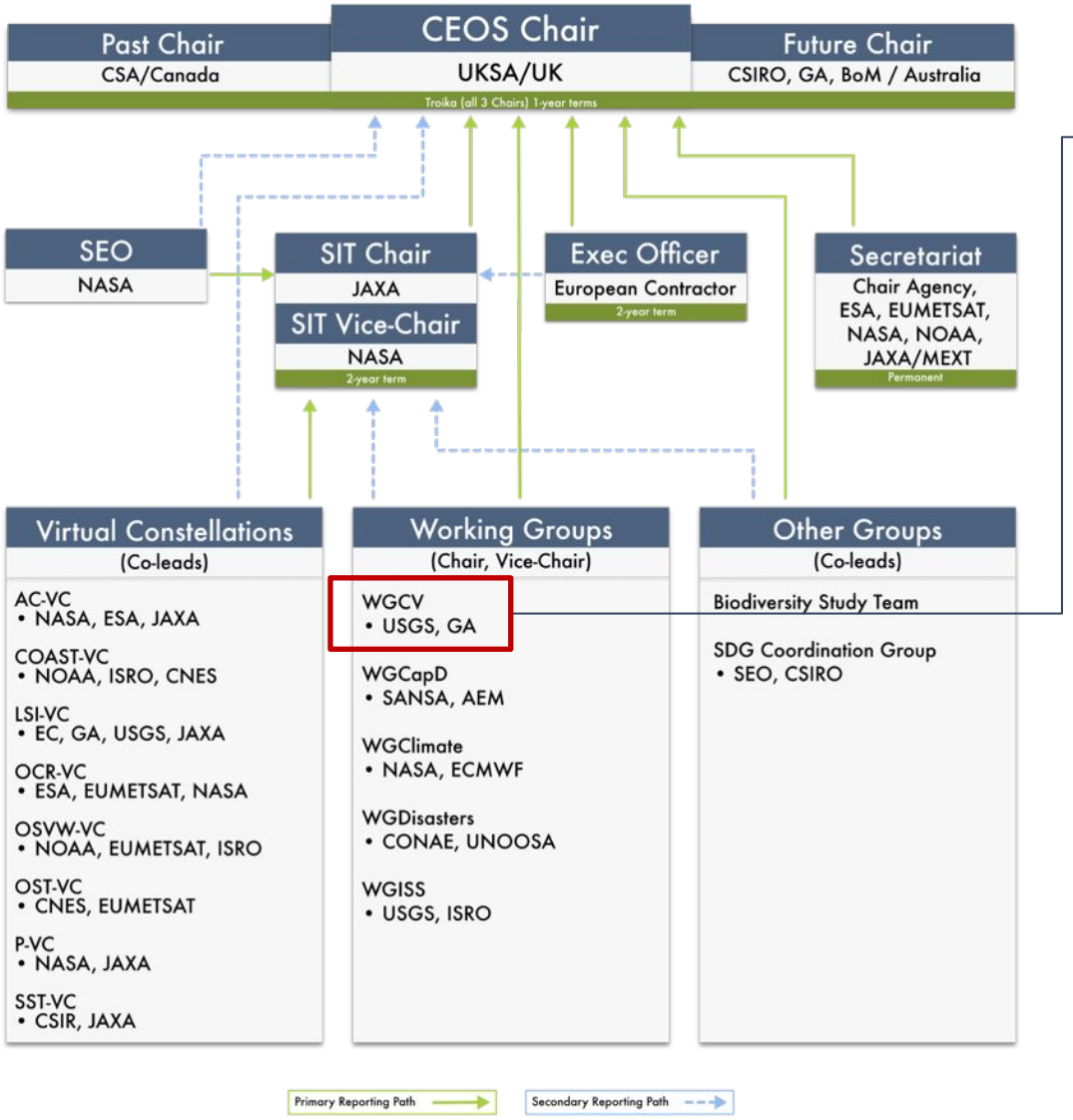
Commercial and government/civil satellites launched since 1972.

CEOS



- CEOS through its member organisations (60+ Agencies, ~200 satellites) is ensuring international **coordination** of several initiatives aiming at **improving quality**, **interoperability** and **consistency** of satellite EO systems and data products
- The overarching goal is to **optimise the benefits** of space-based Earth observation and inform decision making

CEOS-WGCV

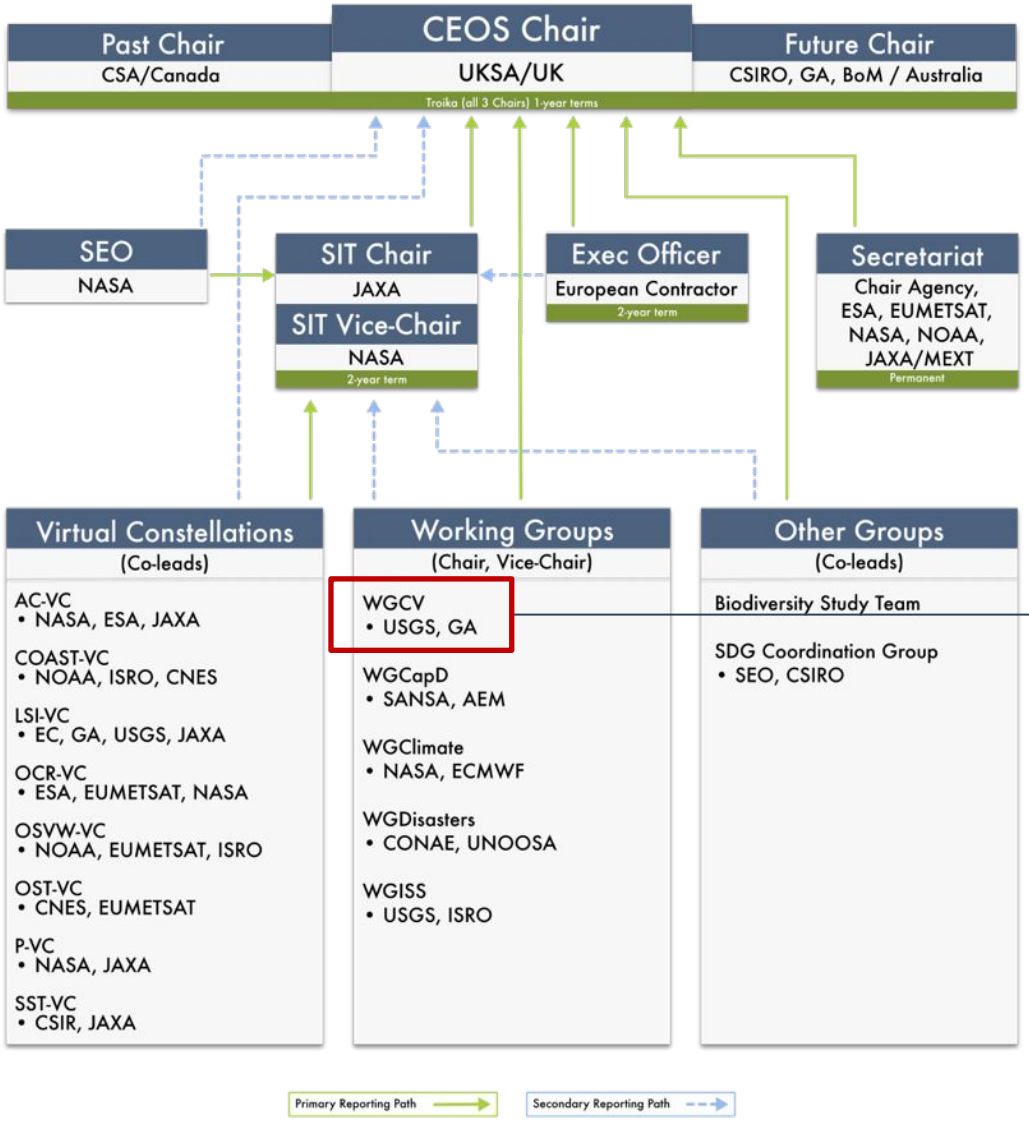


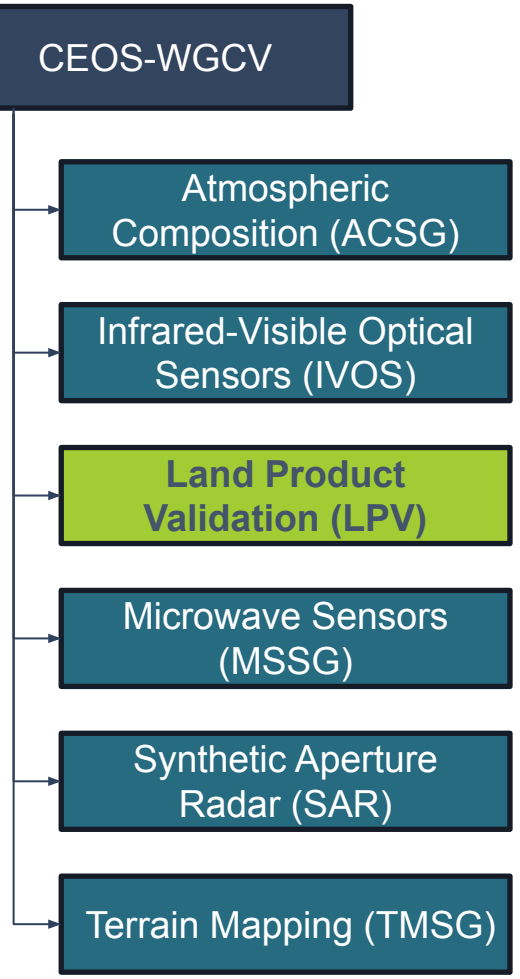
CEOS-WGCV

CEOS-WGCV has the primary focus on **data quality** and **Cal/Val**, with the following objectives :

- To ensure long-term confidence in the accuracy and quality of satellite-based EO data
- To provide a forum for the exchange of information about Ca/Val

LPV sub-group

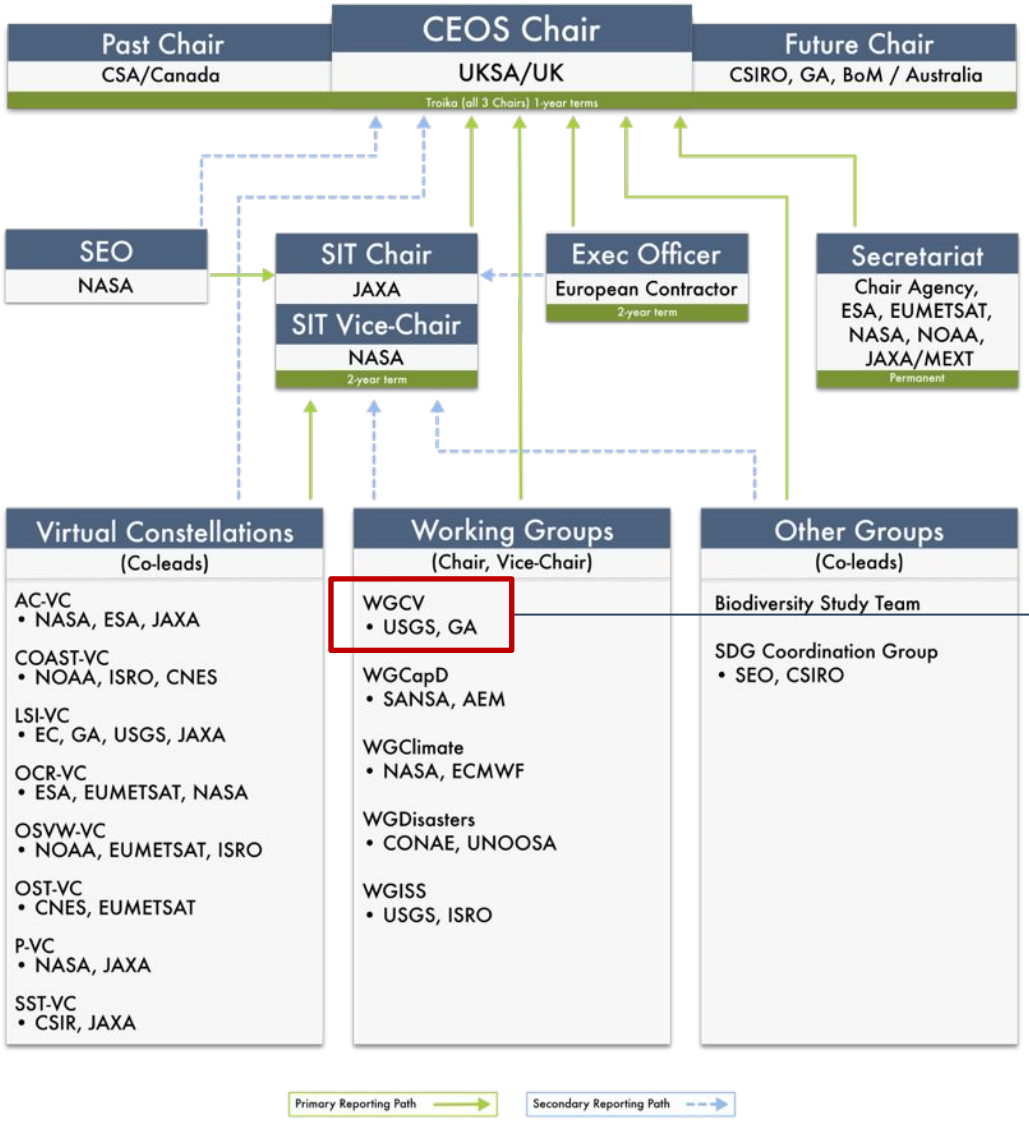


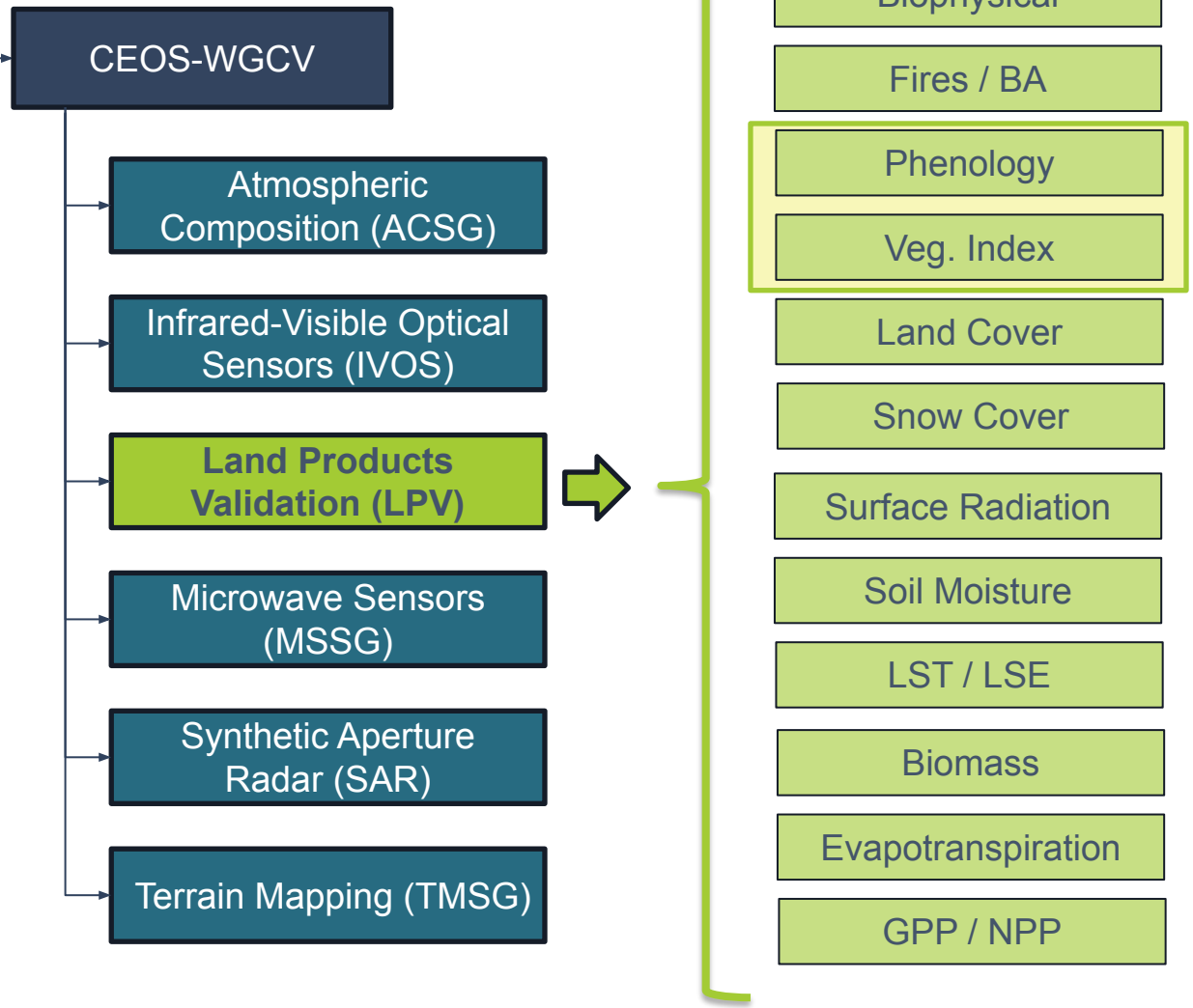


LPV sub-group focuses on terrestrial ECV/EBVs, and its **objectives** are :

- To foster and coordinate quantitative validation of satellite-derived global land products
- To increase quality and promote harmonisation of validation practices

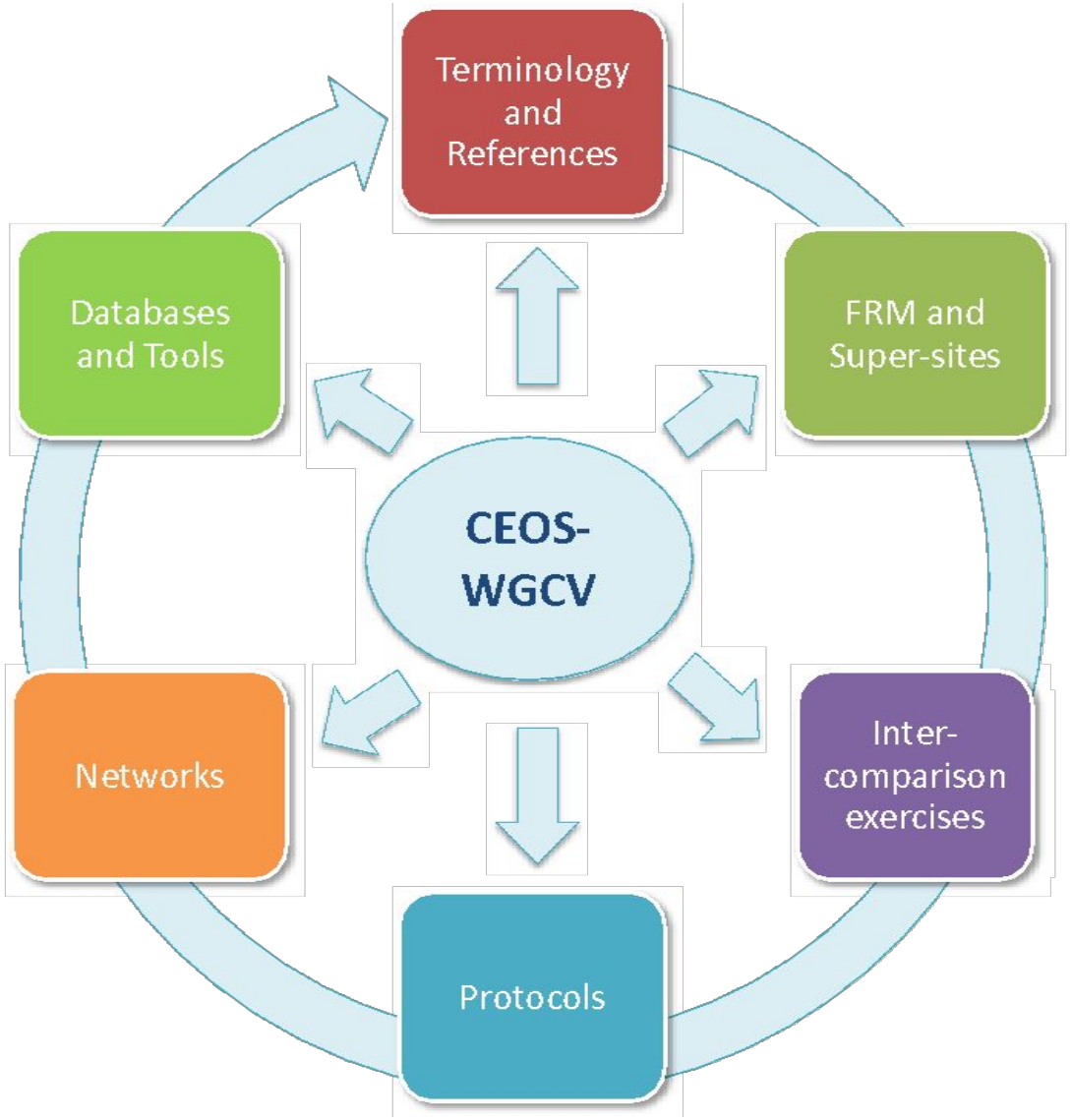
LPV internal structure





CEOS-WGCV coordination

- WGCV supports several initiatives aimed at **facilitating combined use** of EO data by providing :
  - Terminology and References
  - FRM and supersites
  - Inter-comparison exercises
  - Protocols
  - Networks
  - Databases and tools
- **LPV subgroup** is actively involved in most of these initiatives



Terminology and References

- Common Vocabulary
  - Dedicated WG on estabishing agreed **terminology** → **Review paper**
- **Surface Reflectance** (SR) Quality and Consistency
  - Dedicated group (including **LPV** members) aiming at enhanced consistency of SR products
  - Building on **CEOS-ARD** effort
  - Define the **measurand** and methods to enhance consistency: e.g., BRDF and topography correction, solar angle normalization

Lost in Translation: The Need for Common Vocabularies and an Interoperable Thesaurus in Earth Observation Sciences

P. A. Ströbl · E. R. Woolliams · K. Molch

Abstract

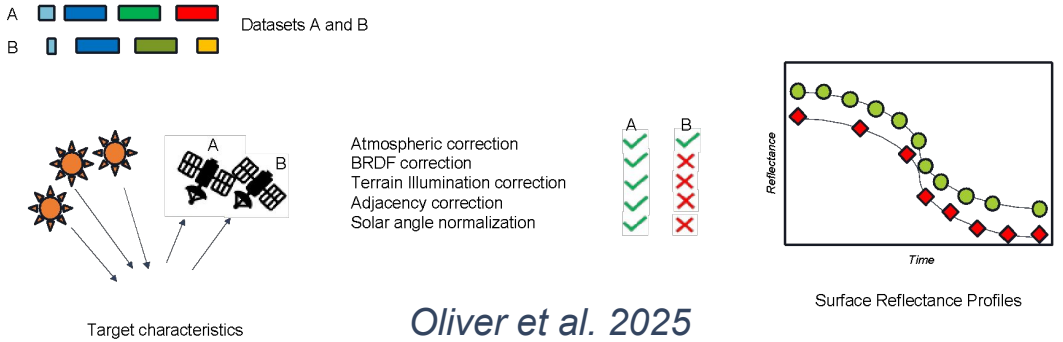
The Earth Observation sciences are highly multidisciplinary with long value chains from the development, characterisation and deployment of sensors, through data processing and modelling, to the information services provided to decision makers in, for example, governments, companies and non-governmental organisations. A prerequisite to any multidisciplinary collaboration is effective communication and many communities involved in the value chains have developed vocabularies or terminologies to define terms from a particular viewpoint or legacy. However, these vocabularies are often inconsistent, with circular definitions, contradictions and using technical terms that are not defined. Here, three case studies from Earth Observation disciplines are considered involving challenges in the definition and use of the terms 'observation', 'in-situ' and 'interoperable'. An approach is suggested for an initiative, starting in Earth Observation, to build a consistent thesaurus taking inspiration from the ISO 25964-2011 standard.

Plain Language Summary

A wide community of engineers, scientists and data quality experts engages in collecting, processing, analysing, and distributing data about the state of our planet and how its environment is changing. These people have various backgrounds and specialised jargons that assist in communicating with others in their own area, but confusion often results when different communities interact. These differences can limit interdisciplinary work. Here we discuss some of the problems with existing formal vocabularies and propose a project structure for developing a more consistent vocabulary for monitoring and understanding planet Earth.

Keywords Vocabulary · Thesaurus · Earth Observation · Observation · Interoperability

*Ströbl et al, 2024, ""**Lost in Translation: The Need for Common Vocabularies and an Interoperable Thesaurus in Earth Observation Sciences**", Surveys in Geophysics*



Oliver et al. 2025

Fiducial Reference Measurements

- A recent WGCV **document** and MDPI RS **paper** (***Goryl et al. 2023***) provides definition and process for endorsing specific measurements as FRMs
- Assess maturity and compliance of a Cal/Val measurement based on a set of community-agreed **CEOS-FRM quality criteria**.
- Self-assessment process by data provider based on **Maturity Matrix**, overall grading will be verified and endorsed at WGCV level
- WGCV members are conducting **pilot projects** : RadCalNet, ICOS, Pandora, Hypernets

remote sensing

MDPI

Communication

Fiducial Reference Measurements (FRMs): What Are They?

Philippe Goryl [1,*], Nigel Fox [2], Craig Donlon [3] and Paolo Castracane [4]

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* Correspondence: philippe.goryl@esa.int

Abstract: In recent years, the concept of a Fiducial Reference Measurement (FRM) has been developed to highlight the need for precise and well-characterised measurements tailored explicitly to the post-launch calibration and validation (Cal/Val) of Earth observation satellite missions. The confidence that stems from robust, unambiguous uncertainty assessment of space observations is fundamental to assessing the changes in the Earth system and climate model prediction and delivering the essential evidence-based input for policy makers and society striving to mitigate and adapt to climate change. The underlying concept of an FRM has long been a core element of a Cal/Val program, providing a 'trustable' reference against which performance can be anchored or assessed. The 'FRM' label was created to embody into such a reference a set of key criteria. These criteria included the establishment of documented evidence of uncertainty with respect to a community-agreed reference (ideally SI-traceable) and specific tailoring to the needs of a satellite mission. It therefore facilitates comparison and interoperability between products and missions in a cost-efficient manner. Committee on Earth Observation Satellites (CEOS) Working Group Cal/Val (WGCV) is now putting in place a framework to assess the maturity and compliance of a 'Cal/Val reference measurement' in terms of a set of community-agreed criteria which define it to be of CEOS-FRM quality. The assessment process is based on a maturity matrix that provides a visual assessment of the state of any FRM against each of a set of given criteria, making visible where it is mature and where evolution and effort are still needed. This paper provides the overarching definition of what constitutes an FRM and introduces the new CEOS-FRM assessment framework.

Keywords: earth observation; remote sensing; calibration; validation; fiducial reference measurements; CEOS

check for updates

Citation: Goryl, P.; Fox, N.; Donlon, C.; Castracane, P. Fiducial Reference Measurements (FRMs): What Are They? *Remote Sens.* **2023**, *15*, 5017. https://doi.org/10.3390/rs15205017

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1. Introduction

The need for post-launch calibration and validation (Cal/Val) of satellite sensors is well-established. For the primary level 1 observations, post-launch calibration against independent references external to the spacecraft ensures that unforeseen changes, and changes that cannot be corrected by any on-board calibration systems, are accounted for. Post-launch validation supports the accurate delivery of level 1 and higher-level products, confirming expected performance including processors and any retrieval algorithms. However, the cost, complexity and robustness of establishing mission-specific exercises have led to efforts by space agencies to improve coordination and generalisation of methods and infrastructure, through bodies like the Committee on Earth Observation Satellites (CEOS). This coordination not only reduces cost, but also leads to improved harmonisation and interoperability between sensors. Earth Observation data without proper calibration and uncertainty assessment has little value for most applications, because if the data cannot be trusted, no reliable information can be derived from them.

Remote Sens. **2023**, *15*, 5017. https://doi.org/10.3390/rs15205017 https://www.mdpi.com/journal/remotesensing

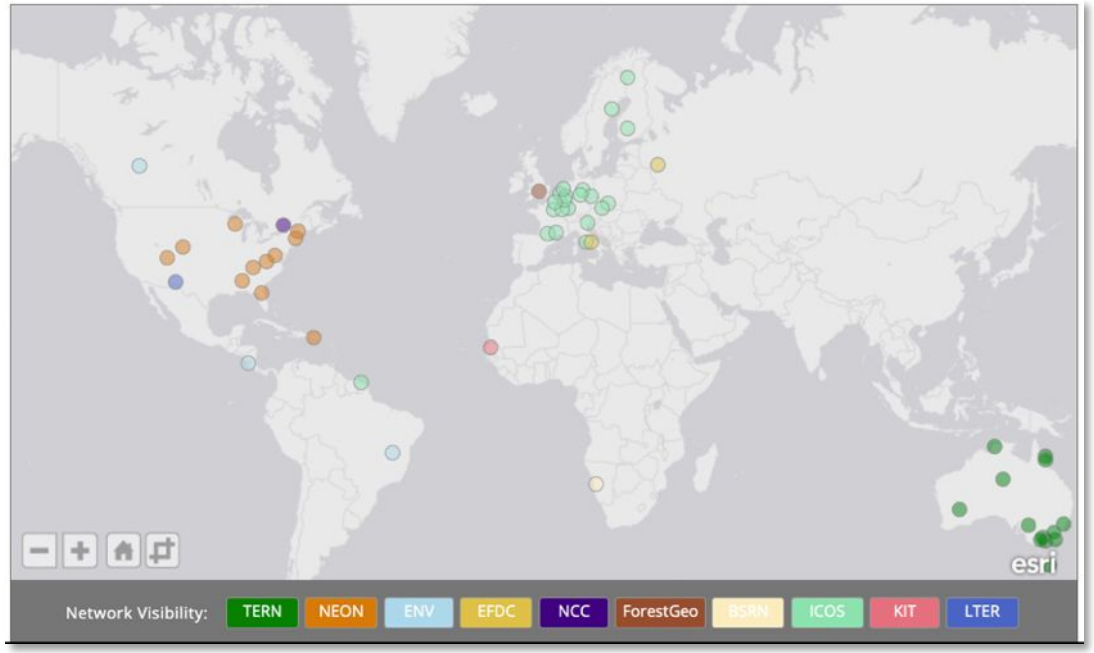
*Goryl et al, 2023, "**Fiducial reference measurements (FRMs): What are they?**", MDPI RS*

Self-Assessment					Independent Assessor
Nature of FRM	FRM Instrumentation	Operations/ Sampling	Data	Metrology	Verification
Descriptor	Instrument documentation	Automation level	Data completeness	Uncertainty characterisation	Guidelines adherence
Location/availability of FRM	Evidence of traceable calibration	Measurand sampling/representativeness	Availability and usability	Traceability Documentation	Utilization/ feedback
Range of instruments	Maintenance plan	ATBDs on processing: algorithms/software	Data Format	Comparison/calibration of FRM	Metrology verification
Complementary observations	Operator expertise	Guidelines on transformation to satellite pixel	Ancillary Data	Adequacy for intended class of instrument/measurand	Independent verification
FRM CLASSIFICATION					A B C D (to be selected)

Supersites

With the purpose of enhancing quality of Cal/Val reference data, **LPV** elaborated the concept of a **supersite**:

- Super characterized sites following **well-established protocols** useful for the validation of satellite land products (**at least 3**) and for Radiative Transfer Model (RTM) approaches
- Active, long-term **operations**, supported by appropriate funding
- Ideally supported by airborne **LiDAR** and **hyperspectral** acquisitions

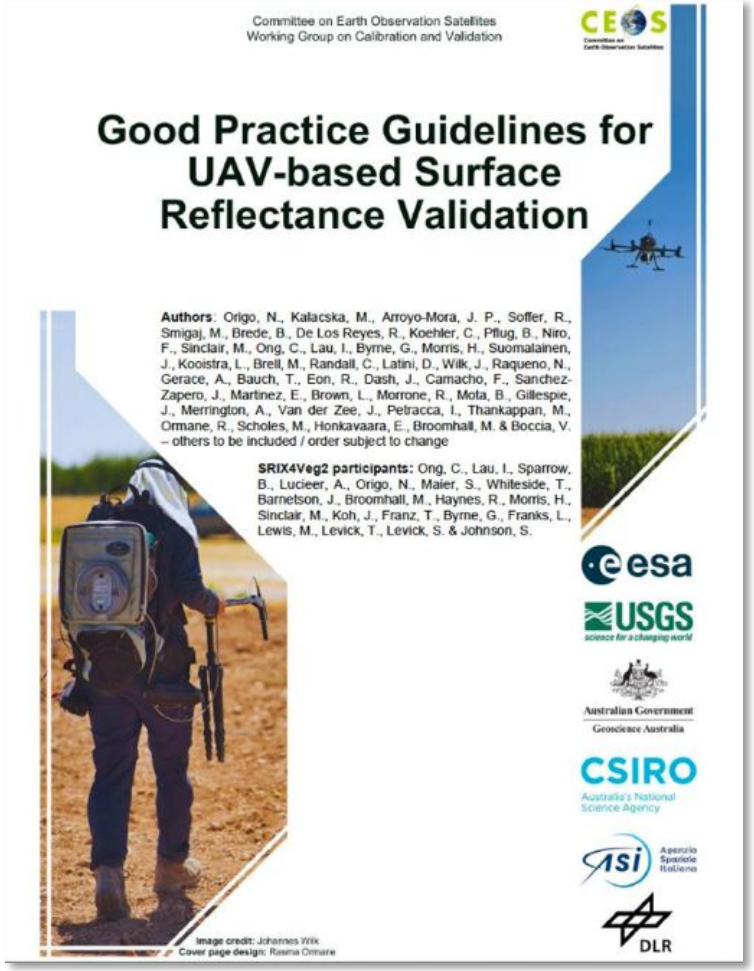


- Update on-going, see F. Camacho talk

Inter-comparison exercises

- **Goal**: Work towards enhanced harmonisation across algorithms and Cal/Val practices

	Description	Outcomes
ACIX	**Atmospheric Correction** scheme intercomparison	ACIX-I: ***Doxani et al. MDPI-RS, 2018*** ACIX-Aqua: ***Pahlevan et al. RSE 2021*** ACIX-II: ***Doxani et al. RSE 2023*** ACIX-III: to be submitted in 2025
CMIX	**Cloud Masking** scheme intercomparison	CMIX-I: ***Skakun et al. RSE 2022*** CMIX-II: draft being prepared
DEMIX	**DEM** intercomparison	***Strobl et. al. ISPRS 2021***
SRIX4Veg	Intercomparison of **Surface reflectance** for vegetation	***Origo et. al. 2025,*** CEOS-WGCV protocol, **joint IVOS - LPV effort**



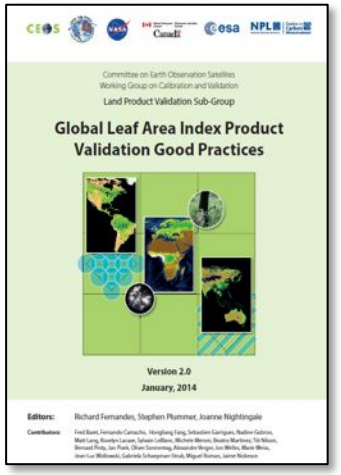
Protocols

- Most **visible** and **impactful** outcome of LPV highly recognised at CEOS level !
- LC protocol being finalised, to be endorsed at WGCV and CEOS level !
- LAI/fAPAR protocol being revised, have started effort with a review paper
- First draft of VI protocol being finalised

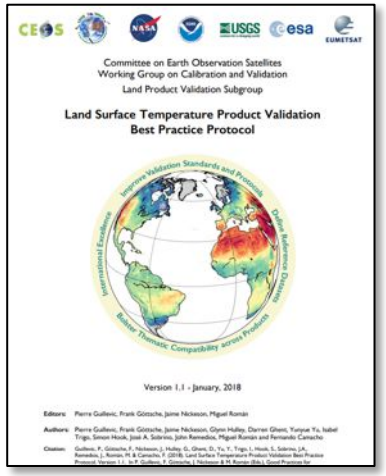
Summary - Annual Downloads

Year	AGB	SM	Albedo	LST	LAI*
2016					53
2017				17	58
2018				104	142
2019			126	79	95
2020		102	122	106	134
2021	445	126	90	81	129
2022	188	55	48	52	93
2023	239	77	60	79	104
2024	328	69	58	105	136
2025^	92	49	13	21	24
Totals	**1292**	**478**	**517**	**644**	**968**

*LAI missing stats from Aug2014 - Jun2016, ^thru May

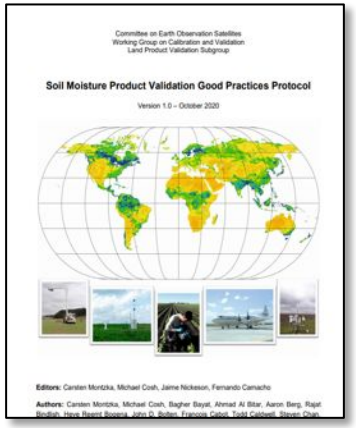


2014 - LAI



2018 - LST

2019 - Albedo



2020 - SM

2021 - AGB

2025 - LC

Networks

Calibration Networks	Description	Current Status
RadCalNet	Provides SI-traceable **TOA reflectances** for post-launch radiometric cal/val of optical sensors. **Led by WGCV-IVOS**	Fully operational, including 5 sites, currently considering expansion with additional sites https://www.radcalnet.org/
SARCalNet	Network of selected curated sites for **SAR cal/val**. **Led by WGCV-SAR**	Fully operational website and database publicly available: https://www.sarcalnet.org/
TIRCalNet	Dedicated to **TIR** optical sensors cal/val, mainly for TOA BT radiometric validation. **Led by WGCV-IVOS and LPV**	Coordinated by ESA and CNES in collaboration with NASA/JPL. Instrument specifications and algorithms being defined.

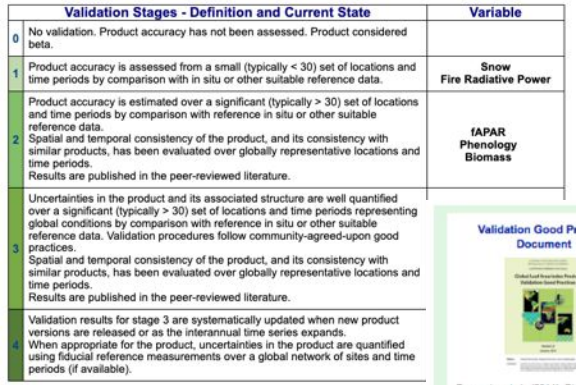
RadCalNet

Today 5 sites (+ 4 more in preparation)

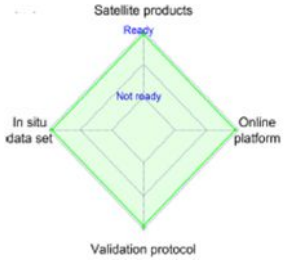
SAR Net Cal

Database and Tools

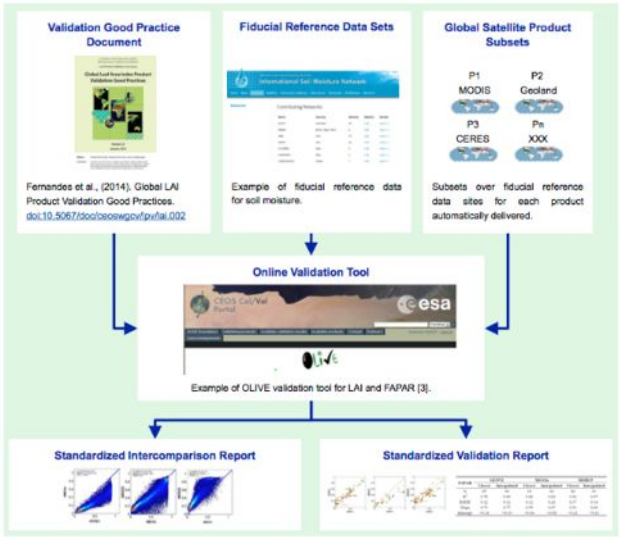
- LPV developed a validation **maturity** concept and a framework to ensure common approaches to the validation of terrestrial ECVs
- LPV framework basic **elements**:
  - Fiducial Reference Data
  - Validation Good Practices
  - Satellite products
  - Online validation tools
- Availability of an online validation tool (i.e., **operational validation**) is prerequisite to reach Stage “4”



	Validation Stages - Definition and Current State	Variable
0	No validation. Product accuracy has not been assessed. Product considered beta.	
1	Product accuracy is assessed from a small (typically < 30) set of locations and time periods by comparison with in situ or other suitable reference data.	Snow Fire Radiative Power
2	Product accuracy is estimated over a significant (typically > 30) set of locations and time periods by comparison with reference in situ or other suitable reference data. Spatial and temporal consistency of the product, and its consistency with similar products, has been evaluated over globally representative locations and time periods. Results are published in the peer-reviewed literature.	fAPAR Phenology Biomass
3	Uncertainties in the product and its associated structure are well quantified over a significant (typically > 30) set of locations and time periods representing global conditions by comparison with reference in situ or other suitable reference data. Validation procedures follow community-agreed-upon good practices. Spatial and temporal consistency of the product, and its consistency with similar products, has been evaluated over globally representative locations and time periods. Results are published in the peer-reviewed literature.	
4	Validation results for stage 3 are systematically updated when new product versions are released or as the interannual time series expands. When appropriate for the product, uncertainties in the product are quantified using fiducial reference measurements over a global network of sites and time periods (if available).	



Bayat et al. 2020



LPV communications

- Annual Newsletters (email)
- Quarterly telecons (Web)
- Yearly **tag up** meetings with each FA (VI/Phenology and ET already done)
- Up-to-date Web / list of products / key references
- Workshops or special sessions per variable (every 2-3 years)
- Plenary LPV meeting (every 1 or 2 years)

Meeting Objectives

- The main objective is to review status of LPV activities and elaborate an **LPV action plan** for the 2025-28 period.
- Specific objectives are:
  - Hear activity reports from CEOS LPV focus areas,
  - Discuss the status of good practices validation protocols,
  - Report on current validation and intercomparison activities,
  - Hear updates on fiducial reference data collection
  - Assess readiness towards upcoming satellite missions
  - Exchange information and promote synergies across focus areas

Agenda

- 15 min / slot including Q&A for each FA
- 15 min final slot for discussion and wrap up

Thursday 26th June 2025		
14:00	Start meeting	
	Introduction	
14:00 – 14:15	CEOS-LPV status and plans, updates on ESA Ca/Val projects	Fabrizio Niro (Serco/ESA), Jaime Nickeson (GSFC/NASA)
14:15 – 14:30	LPV Supersites update	Fernando Camacho (EOLab) – In person
	FA updates	
14:30 – 14:45	Land Cover	Sasha Tyukavina (UMD), Nandika Tsendbazar (WUR) – In person
14:45 – 15:00	Biophysical	Luke Brown (Salford University), Richard Fernandes (NRC) – In person
15:00 – 15:15	Fire	Bernardo Mota (NPL) – In person
15:15 – 15:30	Soil Moisture	Alexander Gruber (TUW) – In person
15:30 – 16:00	Coffee break	
16:00 – 16:15	Snow Cover	Juha Lemmetyinnen (FMI), Carrie Vuyovich (NASA) – Slides presented by FN
16:15 – 16:30	Above Ground Biomass	Kim Calders (U. Ghent), Neha Hunka (ESA/ESRIN) – Slides presented by FN
16:30 – 16:45	Land Surface Temperature	Lluis Perez Plannels (IMK) – In person
16:45 – 17:00	GPP/NPP	Alvaro Moreno (UV) – In person
17:00 – 17:15	Phenology	Victor Rodriguez Galiano (U. Seville) – In person
17:15 – 17:30	Surface Radiation	Jorge Sanchez Zapero (EOLab), Angela Erb (Leidos), Zhuosen Wang (NASA) – Remote
17:30 – 17:45	Evapotranspiration	Yun Yang (Cornell University) – Remote
17:45 – 18:00	Vegetation Indices	Simon Kraatz (USDA), Tomoaki Miura (U. Hawaii) – Remote
18:00 – 18:15	Wrap up and Closing remarks	F. Niro, J. Nickeson
18:15	End of Meeting	

Thank You!

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