FRM4Veg - Fiducial Reference Measurements for Vegetation: Status and way forward

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Why FRM?

**Current Challenges in Satellite Data Validation:**

- Lack of **multi-mission** & **long-term** strategy for **validation**.
- Lack of networks for validation of **land products**, to give continuity to the validation activities.
- Lack of international **standards** (with some exceptions: CEOS LPV “Global Leaf Area Index Product Validation Good Practices”).
- Product **uncertainties** not always assessed through a statistically representative set of locations and time periods.
- **Spatial representativeness** of the in situ measurements, and upscaling to satellite resolution.
- Need to **automate** individual measurements.

... and this is becoming more and more important because nowadays there are:

- Many satellite sensors
- Similar products
- Different algorithms used
- BUT limited validation data, and (often) without any traceability
What is a Fiducial Reference Measurement?

**FRM (Fiducial Reference Measurement):**

is the suite of independent ground measurements that provide independent validation results and satellite measurement uncertainty estimation, over the entire end-to-end duration of a satellite mission.

- Have documented evidence of metrological traceability to SI (or appropriate international community standard) including full uncertainty budget (instrumentation and usage);

- Consider all spatial/temporal/scaling issues;

- Be independent of any satellite geophysical retrieval process;

- Provide long-term sustainable mission validation information;

- Be carried out following community agreed good practice protocols (some of which still need to be written...!)

- Be a direct translation of QA4EO to in-situ data;

- Facilitate interoperability between sensors;

- Building on the existing capabilities.

FRM4Veg
for Land products
The FRM4Veg Team

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What is FRM4Veg?

FRM4VEG is an ESA-founded project aiming at applying the FRM concept to in-situ measurements of the several land products ESA distributes (surface reflectance, the fraction of absorbed photosynthetically active radiation (FAPAR), canopy chlorophyll content, etc.).

FRM4VEG is based on:

- Definition of methodology and protocols for validation;
- Provision of SI traceability;
- Estimation of full uncertainty budget;
- Building on existing capacity.

**CHIME**
2 FRM4Veg campaigns have been performed
What has been done so far?

- Experimental farm.
- Flat terrain.
- Generally clear skies.
- 2 hours driving from Valencia
FRM4Veg - What has been done so far?

- Semi-natural woodland (Oak, Ash, Beech, Hazel, Sycamore);
- Managed research forest with ~ 75 years of ecological monitoring;
- Canopy walkway, Flux tower
- A 3D model of the Wytham Woods site has been generated.
FRM4Veg - What has been done so far?

Instrument Calibration history and certificates

Validation Methodology Document

FRM Protocols and Procedures Document
- FRM4Veg campaign in summer 2021 in Wytham Woods (UK) in order to consolidate the methodology;

- SRIX4Veg (Surface Reflectance Inter-comparison eXercise for Vegetation) using drones with the international Surface Reflectance validation community in 2022, over an agricultural site in Europe;

- Consolidation of documentation, also together with the international community:
  - Validation Methodology document;
  - FRM4Veg Protocols and Procedures;
and their submission to CEOS WG LPV for endorsement.
SRIX4Veg – Surface Reflectance Inter-comparison eXercise for Vegetation
SRIX4Veg – Surface Reflectance Inter-comparison eXercise for Vegetation

SRIX4Veg represents a joint effort to ensure consensus on surface reflectance validation protocols using drones.

It has been endorsed by CEOS and is conducted in the framework of the ESA FRM4Veg project.

Objectives:
- Testing user-based differences in surface reflectance UAV-based measurements (including instrument and operator biases as well as measurement collection procedures);
- Helping design field measurement protocols and validation methodology that are clear and can be easily applied by all users;
- Ensuring international buy-in and consensus on the field measurement protocols and global SR validation methodology developed.

Requirements for participation:
UAV-mounted hyperspectral imagers capable of measuring 400 – 1000 nm contiguously; <= 10 nm spectral resolution.

https://frm4veg.org/srix4veg/

REGISTRATION now OPEN!
SRIX4Veg – Surface Reflectance Inter-comparison eXercise for Vegetation

REGISTRATION now OPEN!

https://frm4veg.org/srix4veg/

Contribute towards global community-agreed guidelines, protocols and procedures for UAV-based surface reflectance product validation.

The international validation community is invited.

Contribute towards global community-agreed guidelines, protocols and procedures for UAV-based surface reflectance product validation.
Next steps – after 2022

**ESA Long Term Vision for Satellite Data Validation...**

- Investment in one/two selected sites in Europe in order to **start to build a Network of Land Product Validation Supersites following the FRM4Veg Protocols and Procedures**, under coordination with CEOS WGCV LPV.

  What do we mean with Supersite?
  - Endorsed by CEOS WGCV LPV for the **validation of (at least 3) land satellite products** and for radiative transfer modelling approaches.
  - **Super characterized** (canopy structure and bio-geophysical variables) sites following well-established protocols.
  - **Active, long-term operations**, supported by appropriate funding and infrastructural capacity.

- Not relying only on dedicated campaigns BUT installing **permanent equipment** on selected sites (Supersites).

- Looking for potential **synergies** with international entities (e.g. Space Agencies, Research Institutes).
Plan for a European Optical Sensors Cal/Val Park
A new concept: Cal/Val Park

- Dedicated to VHR and HR optical missions;
- Open to both multi-spectral and hyperspectral missions;
- For both TOA radiance and reflectance and BOA reflectance;
- Open to be used by both the “institutional space” and the “commercial/new space”;
- Common “playground” to test and run new cal/val methodologies, instruments, and initiatives;
- Open to include temporary and long-term instrumentation and initiatives;
- Scalable (as far as possible) to accommodate new needs and new types of EO missions that may come in the next years;
- Building on already existing cal/val technologies AND new technologies and methods;
- Able to support the ever growing European and international EO industrial ecosystem;
- Multi-Agency joint effort;
- Synergetic approach not to duplicate efforts (and budgets).
A new concept: Cal/Val Park

- The “Cal/Val Park” idea is still in the definition phase.

- Discussions are on-going for a joint ESA-ASI effort (interest from other space agencies and institutions to be investigated).
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**Definition of requirements and design will also be based on the interests and needs of VHR satellites providers**

**HOW?**

- VH-RODA: first forum to gather needs
- Dedicated meetings and information exchange with commercial players as needed
Cal/Val Park: baseline requirements? (1/2)

- **MTF computation**
  - Edge targets?
  - Adjustable orientation?
  - Size?
  - Others?

- Quick visual assessment of the instrument **resolving power**
  - Periodic patterns?
  - Others?

- Absolute and multi-temporal geolocation assessment with a **common well-geolocalized Ground Control Point (GCP)**
Cal/Val Park: baseline requirements? (2/2)

- Installation of equipment for **radiometric performance assessment**:  
  - Aeronet site?  
  - RadCalNet site?  
  - Hypernets site?

- For both **multi-spectral** and **hyper-spectral** missions  
  - Spectrometer  
  - What else?

- Open for **temporary or long-term commercial cal/val services** and/or **new cal/val technologies** depending on satellite providers’ needs  
  - What are the needs?  
  - What should we include to make the Cal/Val Park really useful for VHR missions?

- Well maintained on the **long-term**, safe, with a storage facility and a meeting room
Cal/Val Park: open points

- Analysis and definition of requirements is on-going

- Actual needs from VHR commercial/new space satellite providers
  - Specific needs?
  - Different than HR missions from Agencies?
  - Specific or new cal/val technologies/services to be added in the Cal/Val Park?
  - Also thermal missions?
  - Etc.

- Commercial/New Space contribution to the Cal/Val Park
  - What’s the interest?
  - Shared investment?
  - Under-request service?
  - Other?

- Location still to be decided
  - Discussions on-going with ASI for a site in Italy
  - Main drivers: ✓ high probability of clear sky, ✓ big enough to include all the needed equipment, ✓ being scalable for new/developing needs, ✓ good accessibility, ✓ flat terrain

- Interest from other Space Agencies and Institutions at international level
Thank you!

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