NPL

fiducial reference measurements for vegetation

frm4veg

Joanne Nightingale, Jadu Dash, Fernando Camacho

Niall Origo, Rosalinda Morrone, Luke Brown, Vicente García-Santos

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Overview

- FRM's: What and Why
- Satellite Land Product Validation: Challenges
- FRM4Veg – past, present & future

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Satellite Product Validation

Current widely accepted definition (CEOS):

Validation is the process of assessing, by independent means, the quality of the data products derived from system

Validation Definition

- As satellite-derived data and products are increasingly driving the information and knowledge required for decision making, **quantitative assessment** of the quality of these data will become even more critical

Amsterdam Declarations Partnership

Towards deforestation-free sustainable commodities

?

?

"the process of assessing the uncertainty of satellite sensor derived products by analytical comparison to independent reference data, which is presumed to represent the target or true value of an attribute"

?

?

?

ESA FRMs

Within the ESA FRM programme, validation is being addressed through **conformity testing** using data and methods which are accompanied by an uncertainty budget demonstrating SI (or appropriate international community standards) traceability and adherence to international good practices

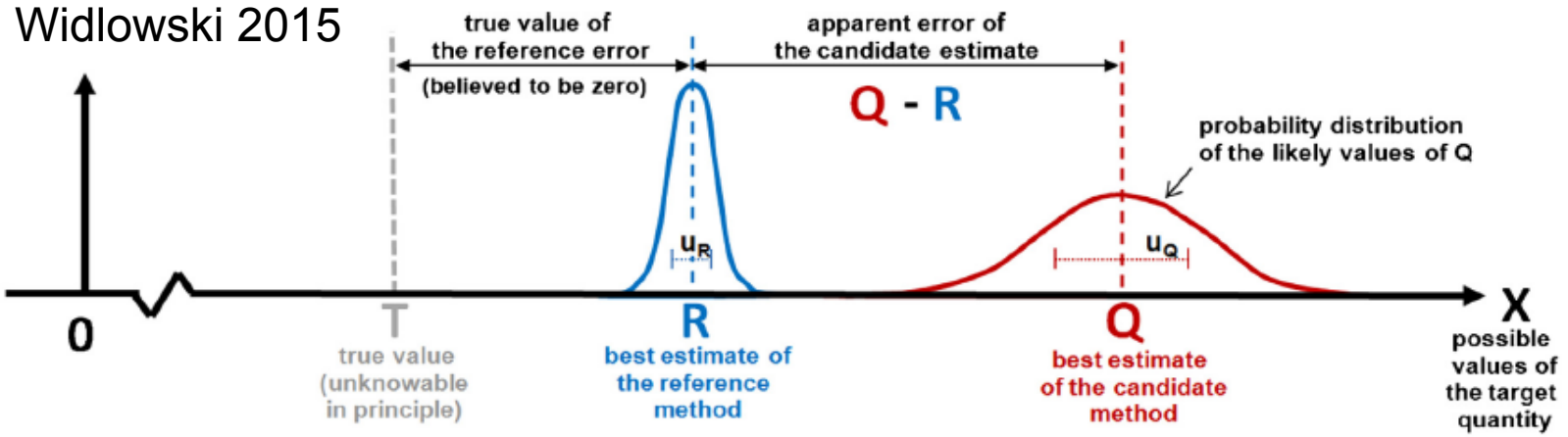
- Have documented SI traceability (or conform to appropriate international community standards), utilising instruments that have been characterised using metrological standards, both pre-deployment and evaluated regularly post-deployment
- Be independent from the satellite geophysical retrieval process
- Be accompanied by an uncertainty budget for all instruments, derived measurements and validation methods
- Adhere to community-agreed, published and openly-available measurement protocols/ procedures and management practices (most still need to be established and written!)
- Be accessible to other researchers allowing independent verification of processing systems

Conformity Testing

The process that determines whether the estimated target quantity (i.e. the satellite estimate) falls within the range of tolerable values (i.e. the reference estimate), or not.

- The conformity of a data product can only be established with respect to permissible deviations from an agreed reference
- The requirements or criteria for conformance must be specified in the standard or specification
- Ideally the reference should be SI traceable (or community agreed) and the uncertainty of the reference will be smaller than that of the candidate item

Widlowski 2015



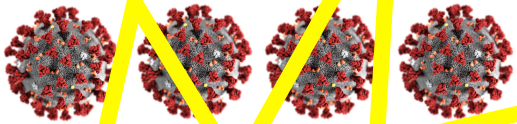
FRM4VEG

FRM4Veg is focused on establishing the protocols required for traceable in-situ measurements of **vegetation-related parameters** (surface reflectance, FAPAR, LAI, CCC) to support Sentinel-2,-3 and PROBA-V, + *new*, product validation

Phase 1

March '18 – March '1

- 2 Field Campaigns, Wytham Woods UK, Las Tiesas, Barrax, Spain
- Initial protocols and validation methodology

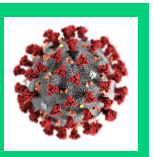


CCN

Oct-Dec '20

- Update website
- Write overview paper
- Initial plan for ESA permanent sites

Phase 2



Feb '21 – Feb '23

- 1 Field campaign
- SRIX4Veg
- Evolve protocols and validation methodology
- Plan for ESA permanent sites

Land Product Validation + Data

- Common approaches involve comparison with independent **in situ**, **aircraft** and **satellite sensor** data of "known or better quality"

Land Product Validation community faces many challenges

Challenges

Satellite Data

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1. Satellite data

- Many data products created with independent or multiple sources of EO data using different retrieval algorithms and assumptions
- Sensor characteristics for different mission goals
- Access to mission / pixel quality / uncertainty requirements

ECV	# Products
LAI	33
fAPAR	30
Soil Moisture	62
LST & Emissivity	45
Albedo	33

Field Sites

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2. Lack of long-term monitoring sites suitable for satellite product validation activities

Review of Ground Measurement Networks for Validation of Satellite-Derived Land Surface Parameters

- Goal of the network
- Network extent
- Permanent Infrastructure
- Campaign data collected
- Protocols & Procedures
- Network maintenance investment

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24 Networks reviewed

1. Ecological Research (TERN, NEON)
2. Carbon Monitoring Networks (FLUXNET, ICOS)
3. Forest Census Networks (ForestPLOTS, FAO)
4. Surface Radiation Networks (SurfRAD, BSRN)
5. Phenology Networks (PEN, EnviroNET)
6. Individual Parameter Measurement Networks (ISMN, KIT)

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Review of Ground Measurement Networks for Validation of Satellite-Derived Land Surface Parameters
VERSION 1.0

National Physical Laboratory
University of Southampton
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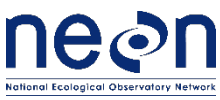
26 November 2020

This document was produced as part of the ESA-funded project "Fiducial Reference Measurements for Vegetation Phase 2 (FRM4VEG 2)" under ESA contract number: 4000129823/20/I-NS

Field Sites



- The networks commonly used are not primarily designed for, or focussed on, the specific measurement challenges of the satellite data
  - Each network has a core set of measurements particular to the research questions to be addressed and the science priorities of the funding bodies supporting them.
  - Many have implemented standard measurement procedures to ensure consistency across their field sites, however, these often differ between networks.

Other sites may not be considered due to:

- Access (terrain, political, remoteness)
- Costs associated with deployment and maintenance of instrumentation, campaign revisits

ield measurements

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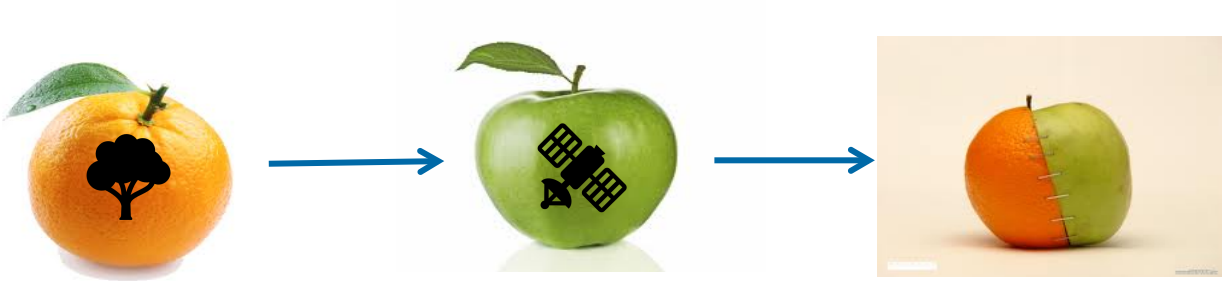
3. Disparity between satellite algorithm representation and ground-measured target quantities



4. Consistency of measurements of the same parameter taken at individual sites by different teams cannot be guaranteed

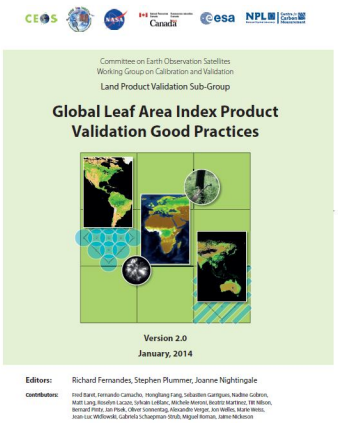
- Spatial sampling and measurement equipment may differ
- Operator and post-processing errors are not typically quantified
- Existing “sites” / in situ campaigns are ah hoc

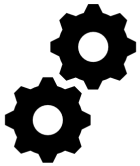
5. Inadequate attention to measurement uncertainties

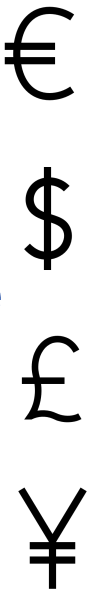
Protocols

6. The protracted compilation of internationally agreed protocols to ensure consistency in field measurements and validation methodologies

- They need to be internationally agreed
- They are not funded and all contributions are in-kin







7. Under-investment in coordinated cal/val infrastructure and methods

— First budget to be cut → “leveraging”

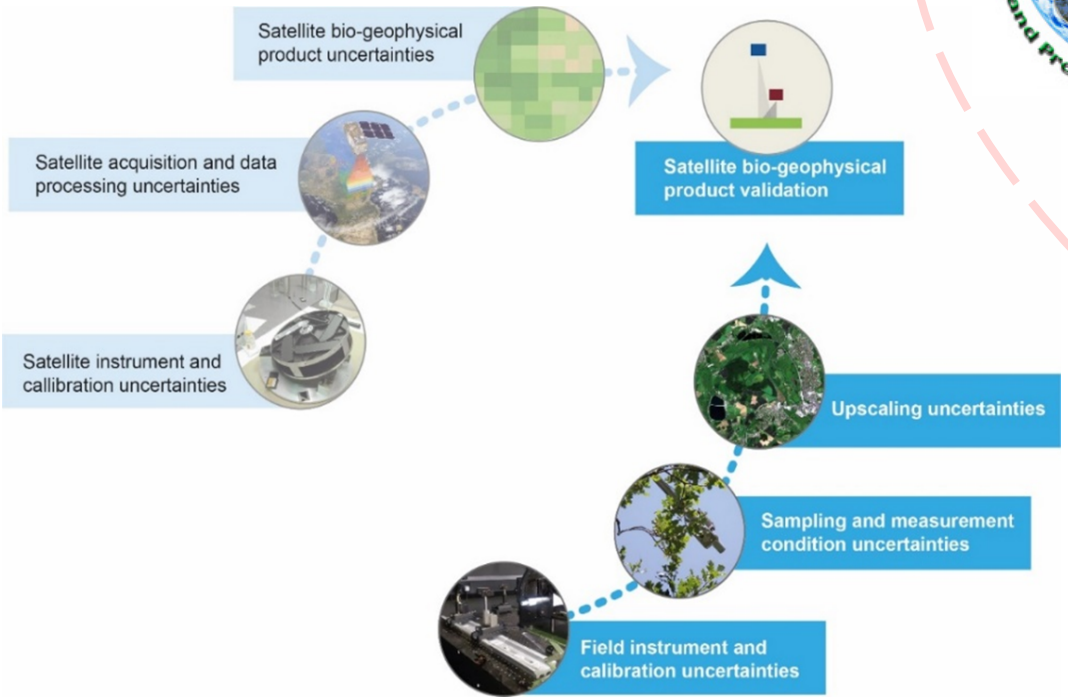
Satellite LPV Networks

- GBOV, Hypernets and NORDSPEC
  - Majority of sites belong to the existing networks
  - Additional infrastructure being added (fAPAR networks, FLOX sensors) or instrumentation still in R&D phase

- It is possible to use existing network sites for satellite LPV, and network managers are keen to engage!
- However this requires:
  - Thorough assessment of the individual sites + current and required infrastructure
  - Engage and maintain strong links with site PI's
  - Willingness of networks to adopt new measurement protocols? Allowing permanent infrastructure on already "full" towers etc?
  - Regular revisits? Or local staff to help with maintenance?
  - Investment to support this process

Ideal Validation Scenario - FRM

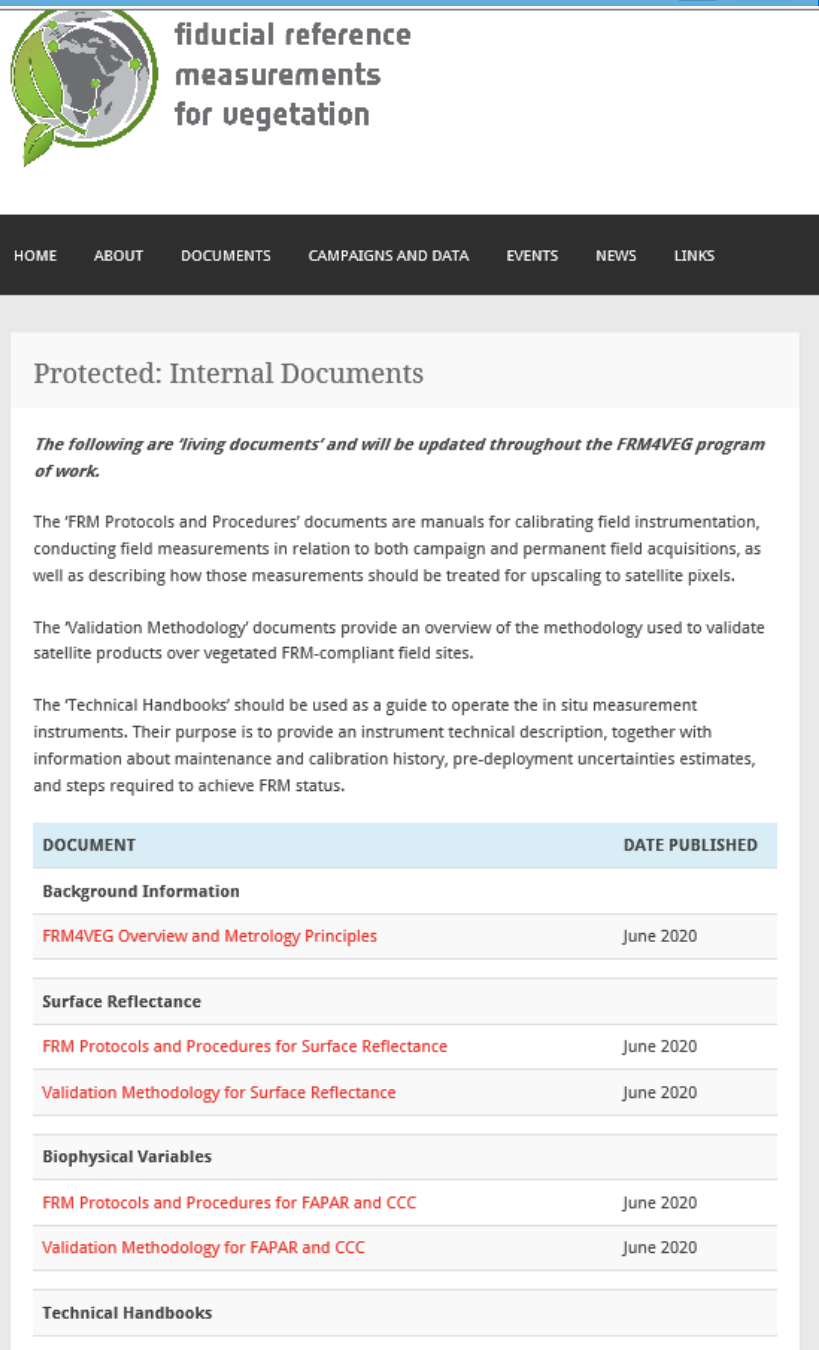
- End – to – End Traceability
  - (how the product was produced and how the product was validated)
- Uncertainty characterisation and propagation
  - (sources and extent of error)
- Fully documented with use case examples



FRM4Veg Phase 2

- ***FRM Protocols and Procedures (FPP)***
  - Manuals for calibrating field instrumentation, conducting field measurements in relation to both campaign and permanent field acquisitions, as well as describing how those measurements should be treated for upscaling to represent satellite pixels. The FPP documents are accompanied by supporting instrument ***Technical handbooks***

- ***FRM Validation Methodology (VM)***
  - Overview of methodology for validating Copernicus land surface reflectance, LAI, fAPAR and CCC data products over vegetated FRM-compliant field sites



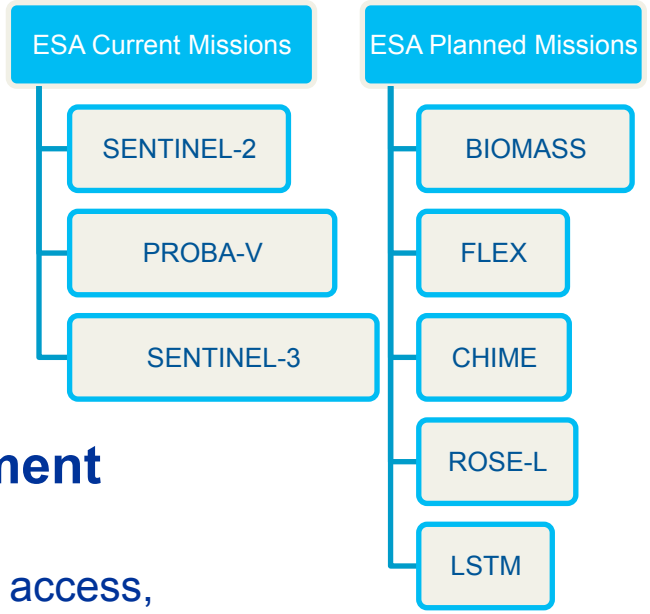
FRM4Veg Phase 2

- ***Surface Reflectance Inter-Comparison eXercise for Vegetation – SRIX4Veg***
  - Endorsed by CEOS WGCV to encourage international participation will enable practical implementation of and test for user-based differences in the interpretation of the FRM4Veg FPP-SR.
  - Workshops held pre- and post the exercise.
  - FPP documents updated based on outcomes.

- Planned for Summer 2022

FRM4Veg Phase 2

- ***ESA LPV Supersites Roadmap***
  - Scope the requirements for both **campaign** and **permanently equipped** sites for validation of satellite derived land surface parameters that shall be considered to become part of the network of CEOS WGCV LPV supersites
  - ***Initial*** work started on this in the CCN ->



1. **Network Review Document** ✓
2. **Missions & Sensor Characteristics Review** ✓
3. **FRM Sites – Campaign & Permanent Deployment Considerations**
   - Parameters, spatial, temporal, canopy height, weather, access, management, legal, costs etc
4. **Parameter Measurement Table**

Parameter	Key Measurements	Campaign Instrumentation	Pro/ Con	Permanent Installations	Pro/ Con	Approx cost (€)	Additional Considerations

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Thank you

frm4veg.org/