Committee on Earth Observation Satellites

Working Group on Calibration and Validation

Land Product Validation (LPV) Subgroup Report

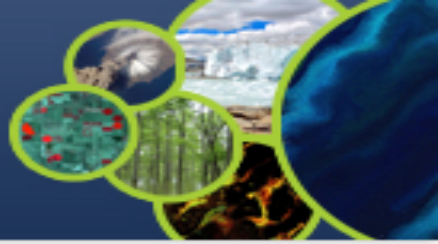
Chair: Fernando Camacho (EOLAB / U. Valencia)

Vice-Chair: Michael Cosh (USDA)

Secretariat: Jaime Nickeson (SSAI/NASA Goddard)

& Focus Area leads

LPV Subgroup Objectives



1. **To foster and coordinate quantitative validation of global land products** derived from remotely sensed data, in a traceable way, and to relay results to users.

2. To **increase the quality and efficiency of global satellite product validation** by developing and promoting **international standards and protocols** for:
    - Field sampling
    - Scaling techniques
    - Accuracy report and use
    - Data and information exchange

3. To **improve quality of ground references** used for product validation
    - Field campaigns for fiducial references
    - Identification of sites and supersites for validation

4. To **provide feedback to international structures** for:
    - Requirements on product accuracy and quality assurance
    - Terrestrial ECV measurement standards

LPV Focus Areas and Co-leaders

Michael Cosh
(USDA) Vice Chair

We FINALLY have a full complement in our WG for the first time in a over 2 years.

Snow Cover*, Sea Ice	Thomas Nagler (ENVEO, Austria)		Chris Crawford (USGS)
Surface Radiation (Reflectance, BRDF, Albedo*)	Zhuosen Wang (NASA GSFC)		Dominique Carrer (Meteo-France)
Land Cover and Land Use Change*	Pontus Olofsson (Boston University)		Sophie Bontemps (University of Louvain)
Biophysical variables (FAPAR*, Leaf Area Index*)	Sylvain Leblanc (Natural Resources Canada)	Marie Weiss (INRA)	Hongliang Fang (Chinese Academy of Science)
Fire* (Active Fire, Burned Area)	Luigi Boschetti (University of Idaho)	Gareth Roberts (U. Southampton, UK)	Louis Giglio (University of Meryland)
Land Surface Temperature* (LST and Emissivity)	Glynn Hulley (NASA JPL)		Frank Goettsche (KIT, Germany)
Soil Moisture*	John Bolten (NASA GSFC)		Carsten Montzka (Jülich Research Centre)
Land Surface Phenology	Joshua Gray (University of Montana)		Victor Rodriguez-Galiano (Universidad de Sevilla)
Vegetation Index	Tomoaki Miura (University of Hawaii)		Else Swinnen (VITO)
Above Ground Biomass*	Laura Duncanson (GSFC)	John Armston (UMD/UQ, Australia)	Mat Disney (U. College London, UK)

*Essential Climate Variable (ECV) as defined by GCOS
Co-lead: sitting, recent, vacant, ex-officio

LPV Focus Areas and Co-leaders

Ian Grant – *In memory*

Dr. Ian Grant
Bureau of Meteorology
Australia

Dr. Ian Grant passed away peacefully on 30 November 2019 surrounding by his family and friends.

He served as co-lead of the Surface Radiation focus area group during the last two years.

He contributed to the Albedo validation protocol, and during the last year lead the development of the Downwelling Radiation Validation Protocol - A conference paper in the Solar World Congress 2019 was accepted and is now available in our wiki.

The CEOS LPV group will miss him and acknowledge his significant contributions while with us!

LPV Validation Hierarchy

	Validation Stage - Definition and Current State
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.
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.
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 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 inter-annual 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).

Recently updated (19-LPV-01):

Two main criteria were added:

Stage 3 –

Validation procedures follow **community agreed-upon protocols**

Stage 4 –

Uncertainties quantified using ***Fiducial Reference Measurements*** over global network

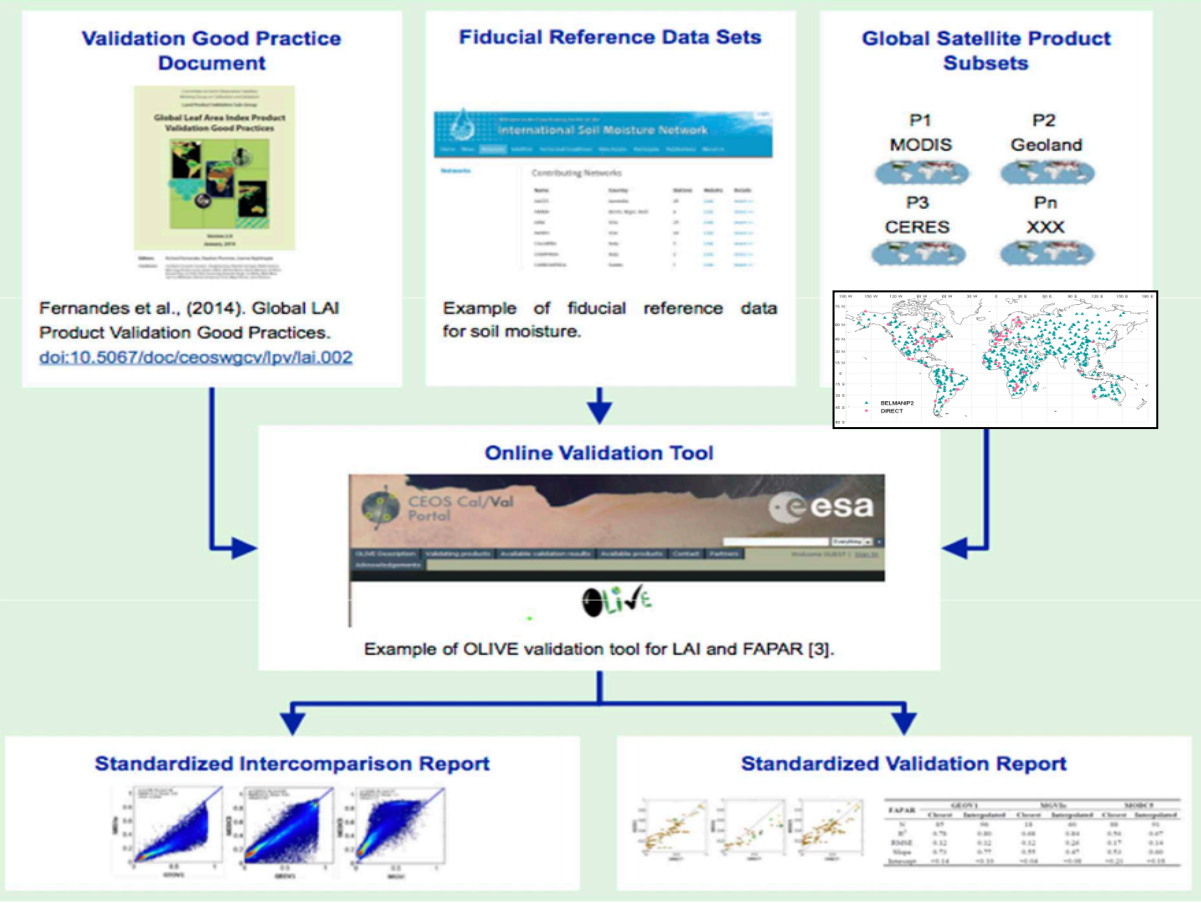
Operational Validation Capacity

LPV Validation Framework

Lead Agency: NASA

Lead Agencies: Various

Lead Agencies: USGS/NOAA



Towards Operational Validation Systems for Global Satellite-Derived Terrestrial Essential Climate Variables

Bagher Bayat[a]*, Fernando Camacho[b], Jaime Nickeson[c], Michael Cosh[d], John Bolten[c], Harry Vereecken[a], Carsten Montzka[a]

[a] Institute of Bio- and Geosciences: Agrosphere (IBG-3), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany; E-Mail: b.bayat@fz-juelich.de, h.vereecken@fz-juelich.de, c.montzka@fz-juelich.de
[b] Earth Observation Laboratory (EOLAB), Parc Cientific University of Valencia, C/ Catedràtic Agustín Escardino, 9, 46980 Paterna, Valencia, Spain; Email: fernando.camacho@eolab.es
[c] NASA Goddard Space Flight Center, 20771 Greenbelt, Maryland, USA; Email: jaime.nickeson@nasa.gov, john.bolten@nasa.gov
[d] USDA-ARS Hydrology and Remote Sensing Laboratory, 20705 Beltsville, Maryland, USA; Email: Michael.Cosh@usda.gov

*Author to whom correspondence should be addressed; E-Mail: b.bayat@fz-juelich.de

Abstract:
Essential Climate Variables in the terrestrial domain, called terrestrial ECVs, are key sources of information for both application-oriented and scientific research. A large number of global

Submitted to International Journal of Applied Earth Observation and Geoinformation ***(revision completed)***

Operational Validation Capacity

Towards Operational Validation Systems for Global Satellite-Derived Terrestrial Essential Climate Variables

Bagher Bayat[a]*, Fernando Camacho[b], Jaime Nickeson[c], Michael Cosh[d], John Bolten[c], Harry Vereecken[a], Carsten Montzka[a]

Terrestrial ECV	Data record		CEOS LPV document		online validation tool	Overall readiness (%)
	EO	in situ	good practice (protocol)	Reference to CEOS LPV document		
LAI	✓	✓	✓	**(Fernandes et al., 2014)**	✓	**100**
fAPAR	✓	✓	×	×	✓	75
LST	✓	✓	✓	(Guillevic et al., 2018)	×	75
ET	✓	✓	×	×	×	50
SM	✓	✓	✓	**In preparation, based on (Gruber et al., 2020)**	✓	**100**
Albedo	✓	✓	✓	**(Wang et al., 2019)**	**In preparation**	**75**
GPP	✓	✓	×	×	×	50
LC	✓	✓	✓	**(Strahler et al., 2006)**	✓	**100**

LPV Strategy (2019-2022): 1st year Progress

LPV Strategy agreed in Milan 2019 : https://lpvs.gsfc.nasa.gov/LPV_Meetings/LPV_plenary2019.html

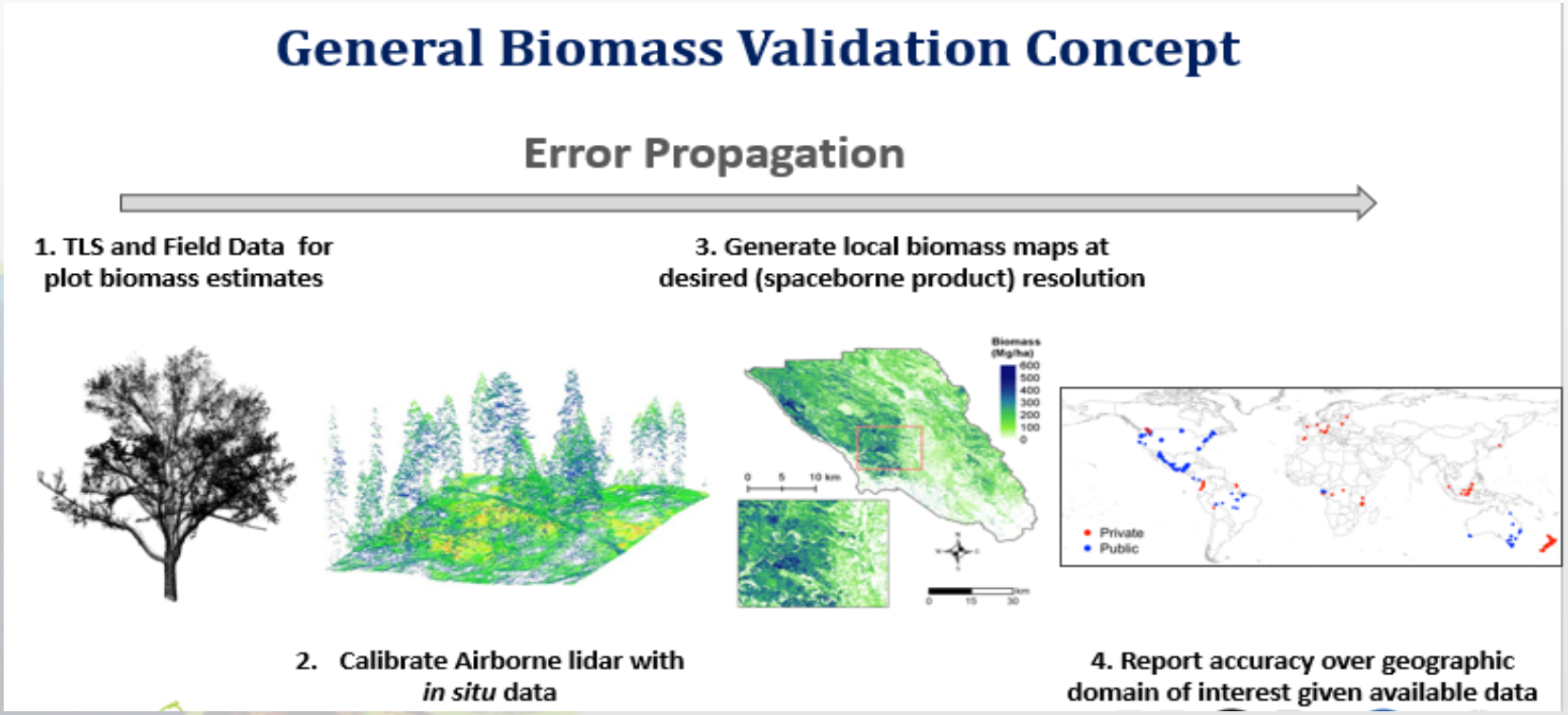
- Continuous Development of Good Practices
- Improving ground references: data, sites, uncertainties
- Promoting validation and intercomparison exercises
- Improving LPV communication

CEOS CARB-16:Cal/Val and production of biomass products from CEOS missions

Continuous Development of Good Practices

Coordinated cal/val between GEDI, ICESat-2, NISAR, BIOMASS and JAXA missions ongoing

CV- 19: Biomass validation protocol



Protocol in final editing stages before review.

On track to have it in fall.

CARB-16:Cal/Val and production of biomass products from CEOS missions

Continuous Development of Good Practices

Improving ground references: data, sites, uncertainties

Supersites and Biomass Validation Workshop – WGCV LPV- Event Dates: March 2nd - 6th, 2020 - CSIRO, Canberra, Australia

As part of the CEOS "carbon and biomass" strategic action to promote the adoption of the biomass protocol, CSIRO hosted the Supersite and Biomass Validation Workshop:

Space Agencies (ISRO, JAXA) and ecosystem networks (TERN, ICOS, eLTER) contributing for potential extension of biomass reference sites to fill gaps in tropics and Asia

It was also discussed the strategy to present biomass validation needs to CEOS Principals :

Biomass team **working on a 'business case'** for presentation to the SIT in October **on implementation of the biomass protocol through new coordinated field measurements** funded by CEOS member

Soil Moisture Validation Protocol (19-LPV-16)

Continuous Development of Good Practices

Soil Moisture Product Validation protocol V1.0 almost ready for review

Review published in RSE, Gruber et al 2020:

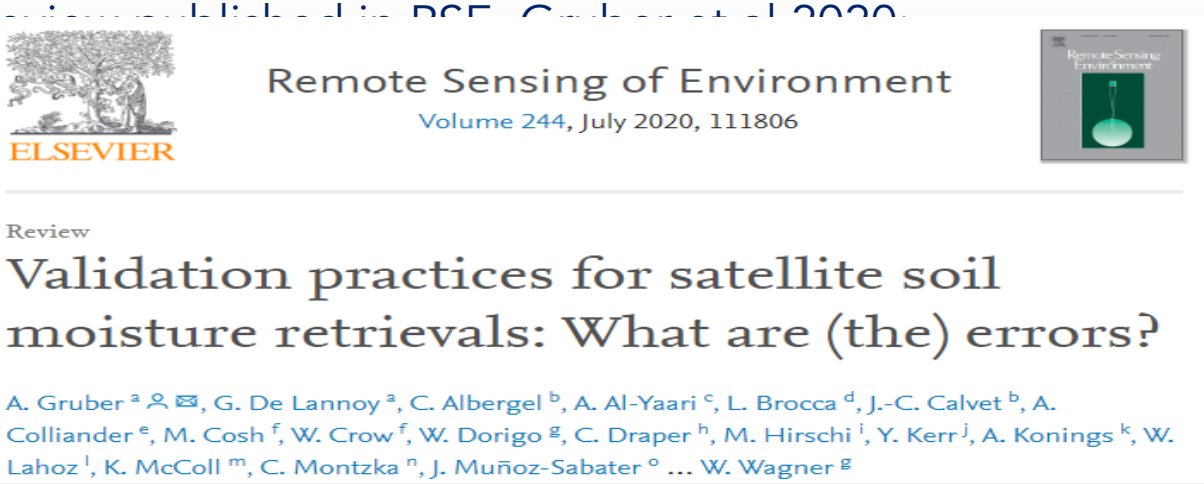
Soil Moisture Product Validation

Best Practice Protocol

Version 1.0

Editors: Carsten Montzka, Michael Cosh, Jaime Nickeson, Fernando Camacho

Authors: Montzka, Carsten, Michael Cosh, Bagher Bayat, Ahmad Al Bitar, Aaron Berg, Rajat Bindlish, Heye Reemt Bogena, John D. Bolton, Francois Cabot, Todd Caldwell, Steven Chan, Andreas Colliander, Wade Crow, Narendra Das, Gabrielle De Lannoy, Wouter Dorigo, Steven R. Evett, Alexander Gruber, Sebastian Hahn, Thomas Jagdhuber, Scott Jones, Yann Kerr, Seungbum Kim, Christian Koyama, Mehmed Kurum, Ernesto Lopez-Baeza, Francesco Mattia, Kaighin A. McColl, Susanne Mecklenburg, Binayak Mohanty, Peggy O'Neill, Dani Or, Thierry Pellarin, George P. Petropoulos, Maria Piles, Rolf H. Reichle, Nemesio Rodriguez-Fernandez, Christoph Rüdiger, Tracy Scanlon, Robert C. Schwartz, Daniel Spengler, Prashant Srivastava, Swati Suman, Robin van der Schalie, Wolfgang Wagner, Urs Wegmüller, Fernando Camacho and Jaime Nickeson



ELSEVIER

Remote Sensing of Environment

Volume 244, July 2020, 111806

Review

Validation practices for satellite soil moisture retrievals: What are (the) errors?

A. Gruber [a], G. De Lannoy [a], C. Albergel [b], A. Al-Yaari [c], L. Brocca [d], J.-C. Calvet [b], A. Colliander [e], M. Cosh [f], W. Crow [f], W. Dorigo [g], C. Draper [h], M. Hirschi [i], Y. Kerr [j], A. Konings [k], W. Lahoz [l], K. McColl [m], C. Montzka [n], J. Muñoz-Sabater [o] ... W. Wagner [g]

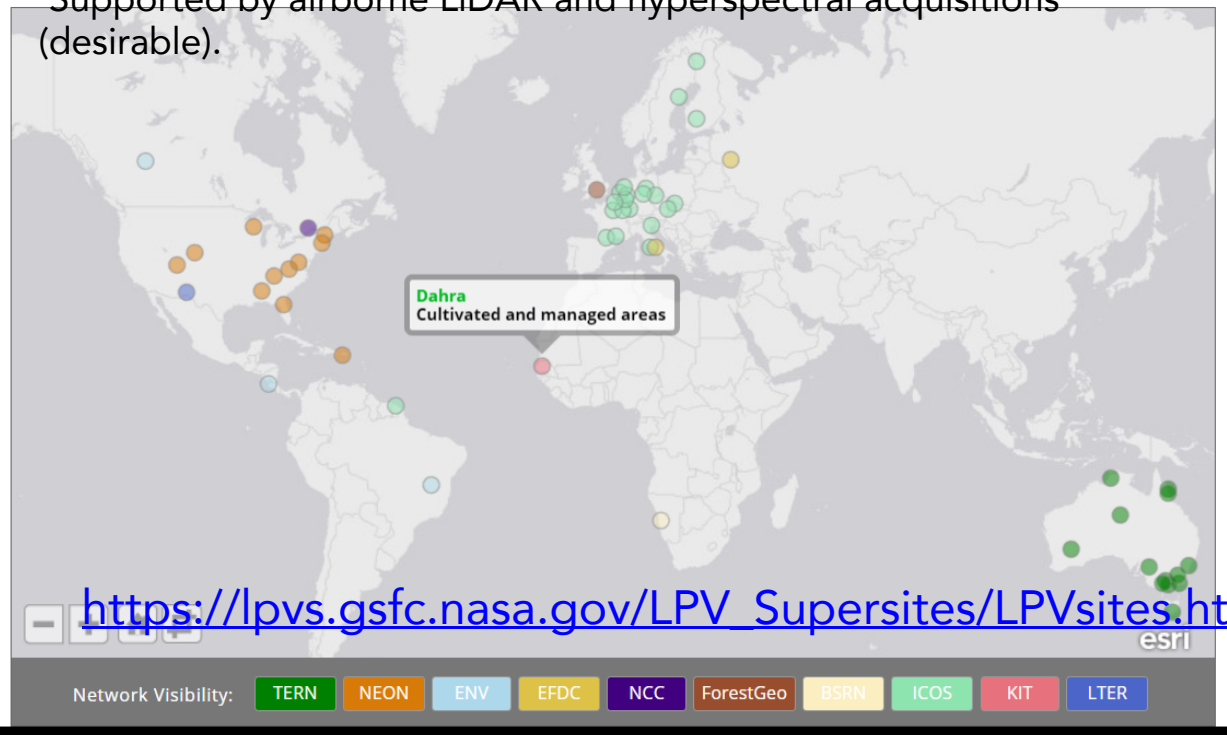
4 main validation components identified:
(1) low level data validation; (2) ground-based validation of soil moisture; (3) satellite product intercomparison; and (4) time series comparisons.

Full validation capacity of Soil Moisture Products, with community-agree-upon protocols, references (ISMN) and online validation tools (QA4SM)

CEOS LPV Supersites

Improving ground references: data, sites, uncertai nties

- **Super characterized** (canopy structure and bio-geophysical variables) **site** following well- established protocols **useful for the validation of satellite land products (at least 3)** and for radiative transfer modeling approaches.
- Active, long-term operations, supported by appropriate funding
- Supported by airborne LiDAR and hyperspectral acquisitions (desirable).



https://lpvs.gsfc.nasa.gov/LPV_Supersites/LPVsites.html

TERN, ICOS, eLTER willing to adapt their protocols to fit better validation needs

Collaborative actions between networks (GBOV and TERN) to deploy new instrumentation in AUS Supersites

FOR CEOS AGENCIES

In you are maintaining product validation site useful to validate LAND products, please contact me: Fernando.Camacho@eolab.es

We need to expand the spatial coverage of our supersite network (Asia, Africa and South America not represented)

CEOS LPV Supersites

Improving ground references: data, sites, uncertainties

Tower- sites in Borela region for satellite product validation

NordSpec network

NordSpec: a network of multispectral measurement sites

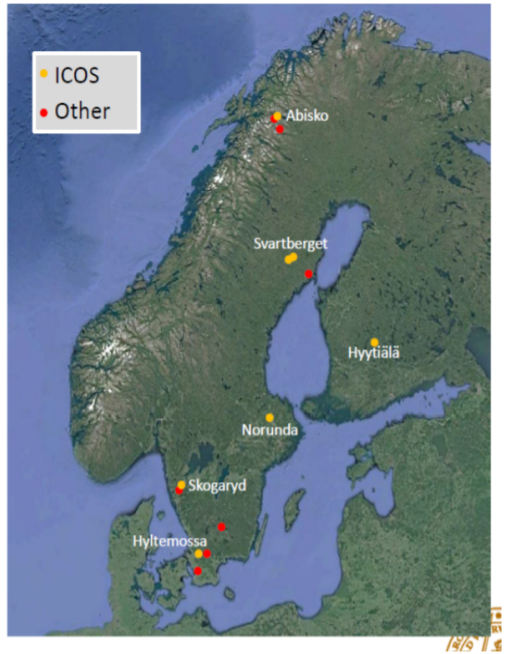
Collaborators:

- **ICOS Sweden + Finland**
- **SITES** (Swedish Infrastructure for Ecosystem Science)

For satellite data validation and improved process knowledge

http://nordspec.nateko.lu.se

Eklundh et al. 2011, *Sensors*, 11, 7678-7709.



Long term support

- Long term support
- Open data policy
- SR, NDVI, FAPAR, phenology + ICOS (LAI, ABG)

Contact:

- Lars Eklund, University of Lund

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Svartberget forest

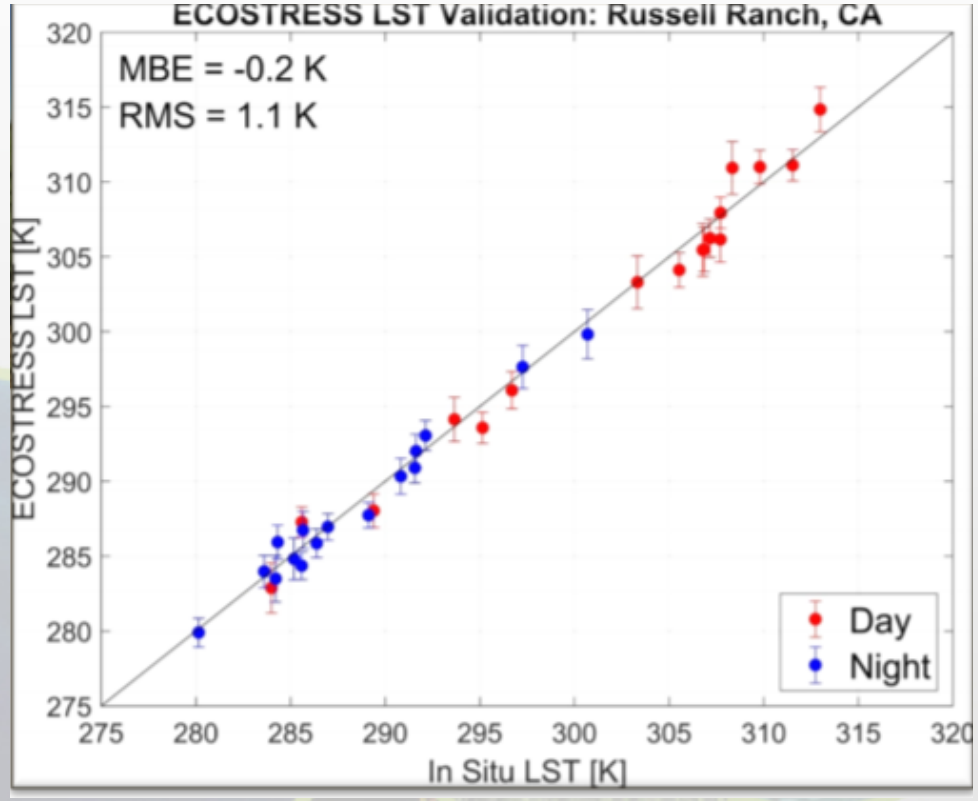
- Lat 64°N
- Boreal coniferous forest
- Multispectral sensor at 80 m, footprint ca 1700 m^2
- Homogenous area ca 40 ha
- 150 m ICOS mast

Norunda forest

- Lat 60°N
- Hemi-boreal coniferous forest
- Will be clearcut 2021
- Multispectral sensor at 68 m, footprint ca 700 m^2
- Homogenous area ca 100 ha
- 150 m ICOS mast

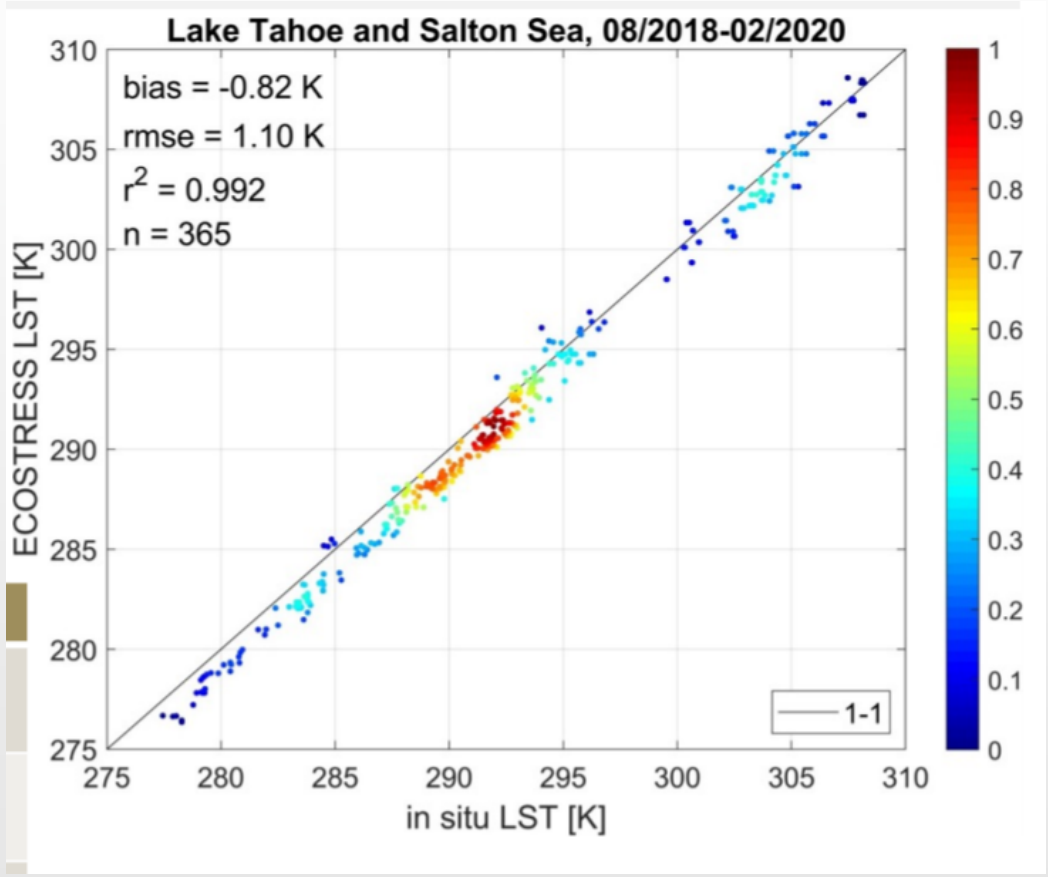
ECOSTRESS LST validation

Promoting validation and intercomparison exercises



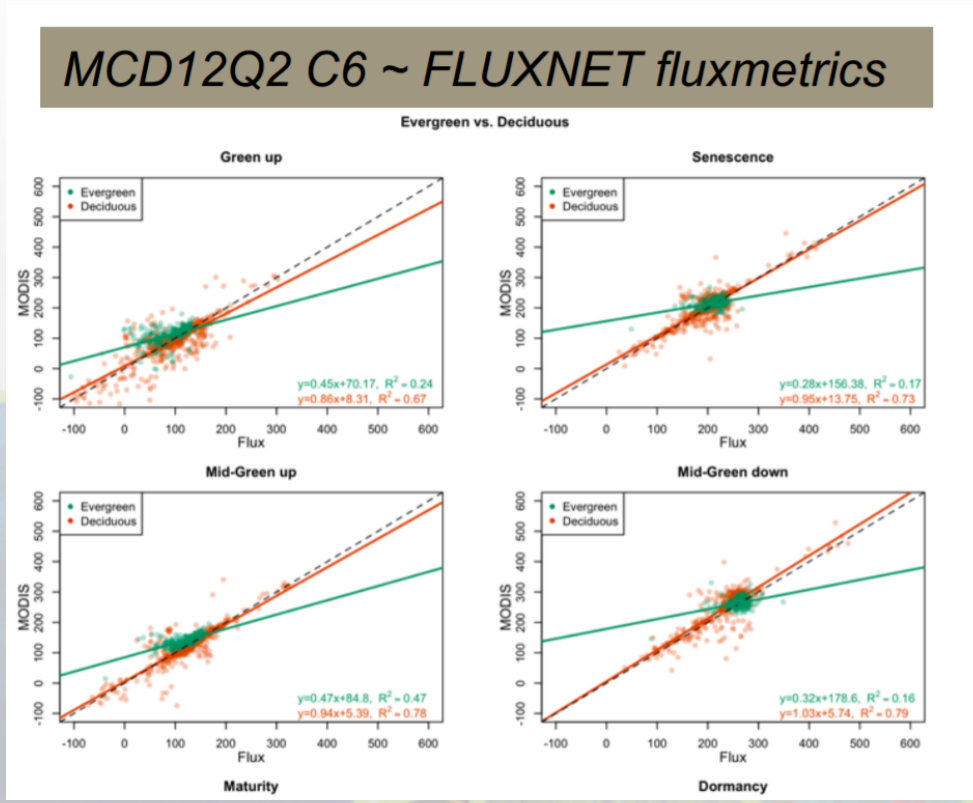
https://russellranch.jpl.nasa.gov/

Inherent cold bias in ECOSTRESS LST being addressed



Phenology validation

Promoting validation and intercomparison exercises



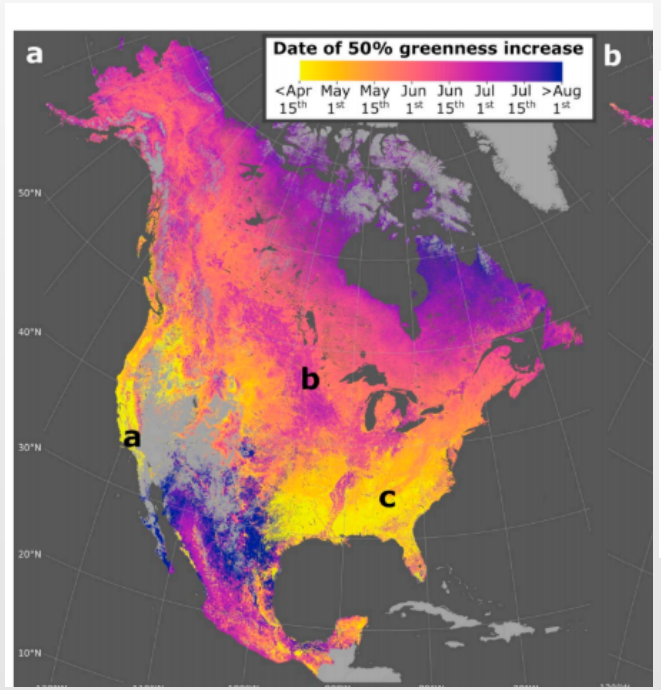
Contents lists available at ScienceDirect

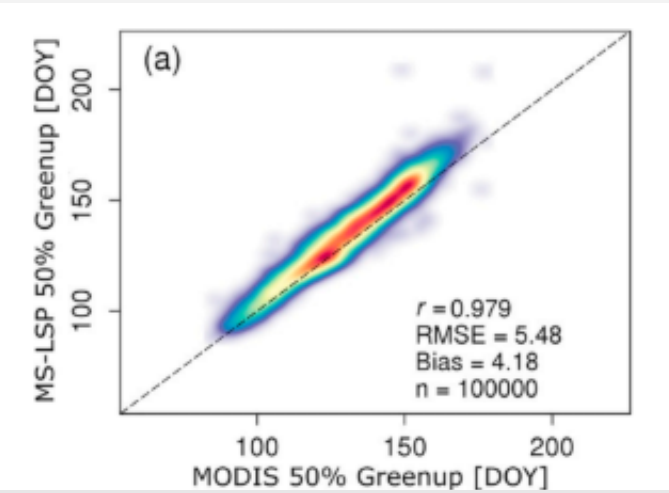
Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

Continental-scale land surface phenology from harmonized Landsat 8 and Sentinel-2 imagery

Douglas K. Bolton[a,*], Josh M. Gray[b], Eli K. Melaas[c], Minkyu Moon[a], Lars Eklundh[d], Mark A. Friedl[a]





Albedo validation

Promoting validation and intercomparison exercises

remote sensing

MDPI

Article

Evaluation of Two Global Land Surface Albedo Datasets Distributed by the Copernicus Climate Change Service and the EUMETSAT LSA-SAF

Gabriel Lellouch [1], Dominique Carrer [1,*], Chloé Vincent [1], Mickael Pardé [1], Sandra C. Frietas [2] and Isabel F. Trigo [2]

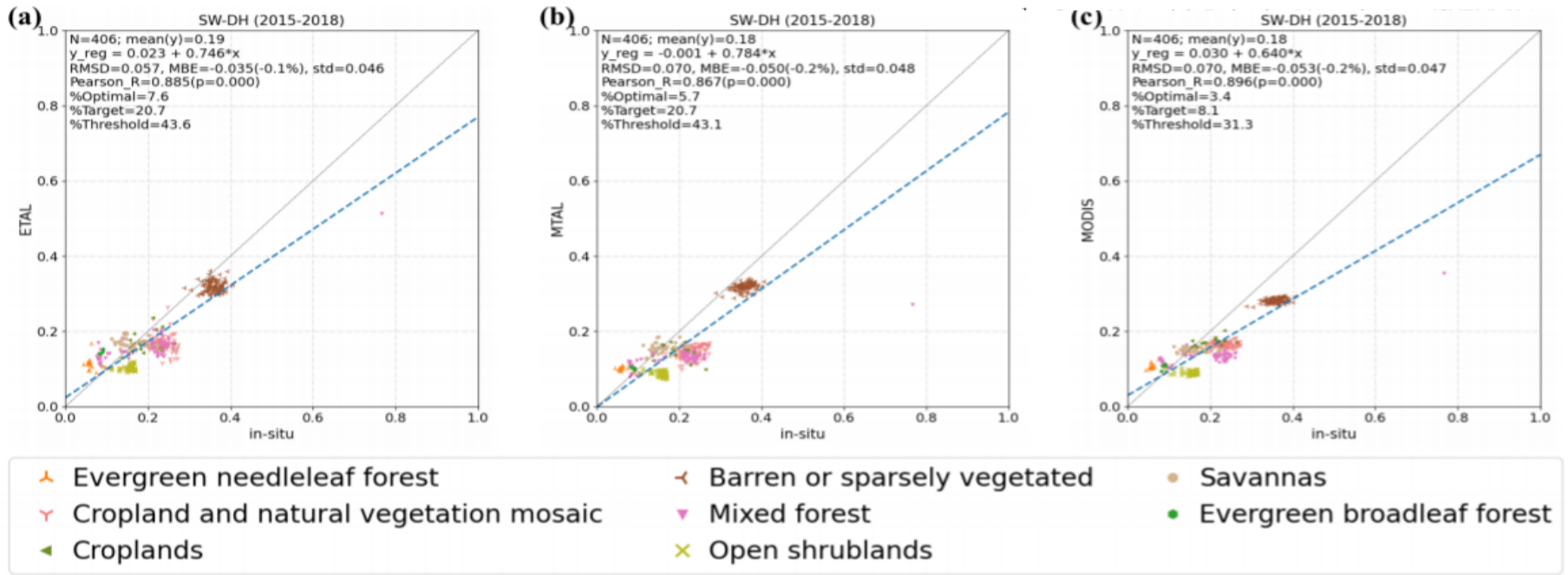


Figure 7. Accuracy assessment of (**a**) ETAL, (**b**) MTAL-R/NRT and (**c**) MODIS surface albedo satellite products versus ground measurements coming from GBOV, AMMA and BSRN stations during the 1 January 2015–31 December 2018 period. Only those dates that provided concomitant data for all three

Surface Reflectance measurements Intercomparison eXercise for vegetation (**SRIX4Veg**)

Promoting validation and intercomparison exercis
es

CEOS Work Plan 20-22: CV-20-01

- **Surface Reflectance** measurements **inter-comparison exercise for vegetation** (**SRIX4Veg**) represents a joint effort (ESA, GA, NPL, CSIRO, USGS) **to test user-based differences in surface reflectance fiducial reference measurements** used for validation**, and to ensure consensus on field protocols and global SR validation protocols.**

- It is a continuation of CV-17 on continental SR validation, **including the use of drones and extending to other biomes (vegetation targets),** conducted in the framework of the ESA FRM4Veg.

- These objectives shall be achieved inviting the scientific community to a **round-robin inter-comparison exercise** and **two international workshops** to discuss first the design of the SRIX4Veg exercise and then the main outcomes and next steps.

- Start of this activity postponed till 2021 for COVID-19.

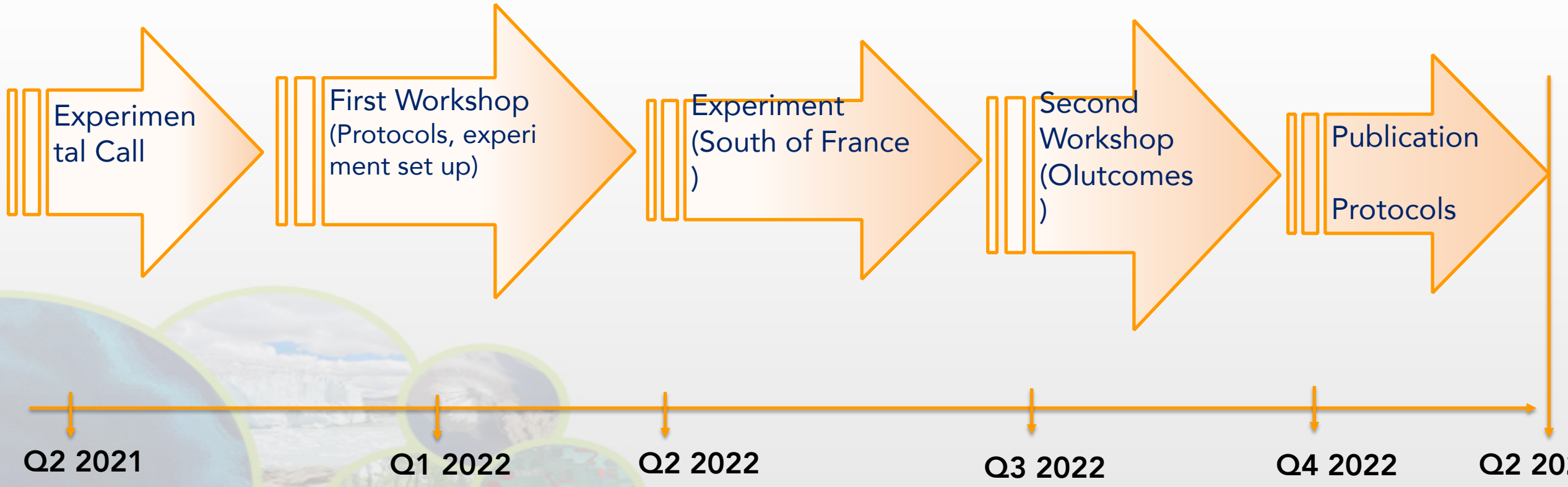
Surface Reflectance measurements Intercomparison eXercise for vegetation (**SRIX4Veg**)

Objectives:

- **Testing user-based differences in surface reflectance 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; and
- **Ensuring international buy-in and consensus on** the field measurement **protocols and global SR validation methodology** developed.
- Publish SRIX4Veg inter-comparison results.
- Develop global SR validation protocols (field radiometry, drones, others).

Surface Reflectance measurements Intercomparison eXercise for vegetation (**SRIX4Veg**)

Preliminary Schedule: 2021 – 2023



Biomass Intercomparison Exercise 2 (BRIX-2)

Promoting validation and intercomparison exercises

CEOS Work Plan 20-22: CV-20-02

- BRIX-2 represents a new CEOS task to **intercompare algorithms** specifically **for biomass mapping** using current and future spaceborne missions. It will be coordinated by ESA and NASA

- These objectives shall be achieved by making available **standardised test cases** (based on airborne campaign and spaceborne simulated data), inviting the scientific community to **develop and apply retrieval algorithms** based on this test case, and finally **compare and evaluate the performance** of submitted results.

- For the purpose of an objective algorithm evaluation, the exercise will be based on the **ESA-NASA M**ulti-mission **A**lgorithm and **A**nalysis **P**latform **(MAAP)**

BRIX-2 for an increased understanding of strengths of the next generation of active remote sensing datasets, with a focus toward algorithm fusion.

Biomass Intercomparison Exercise 2 (BRIX-2)

Objectives:

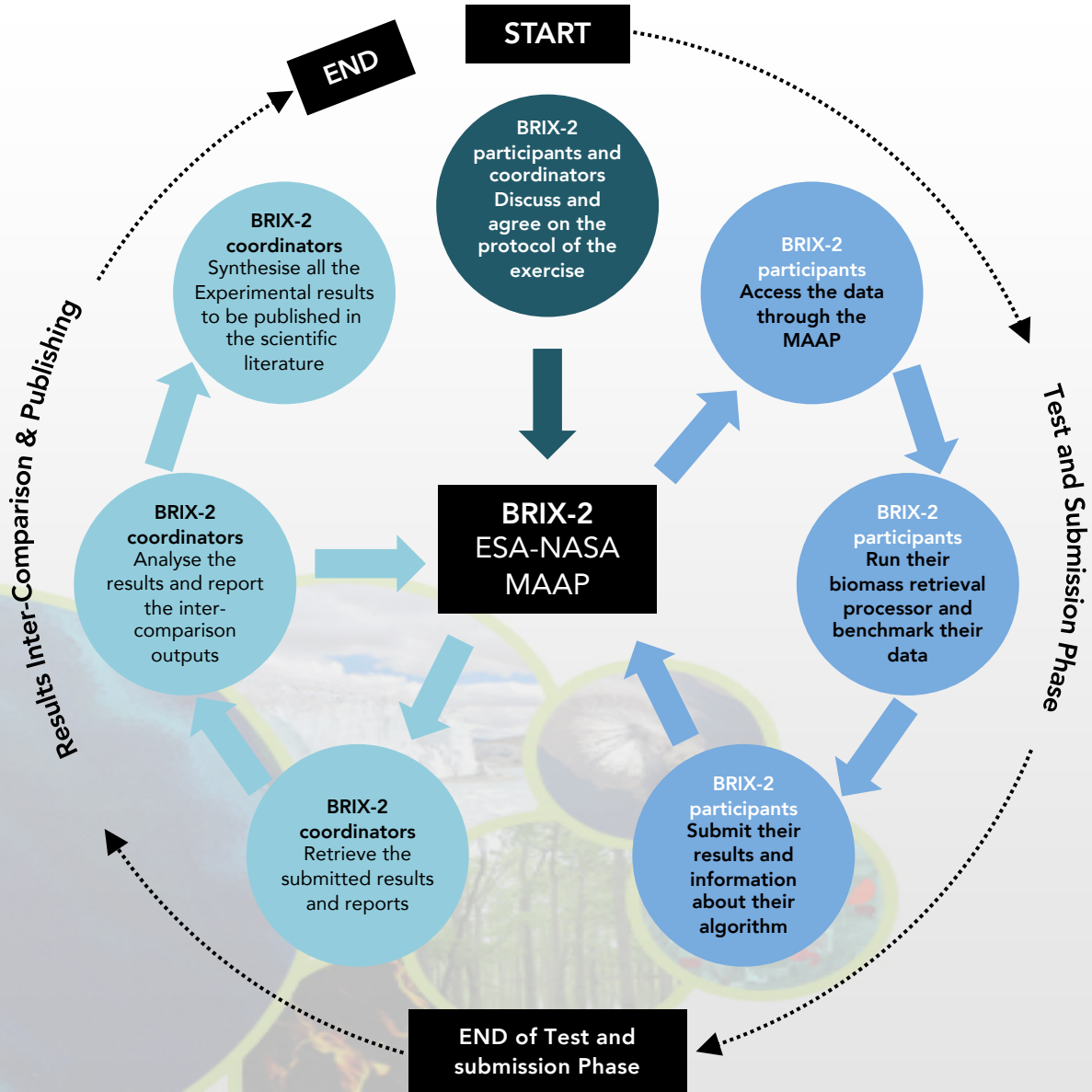
1. Provide an **objective, standardized comparison and assessment** of biomass retrieval algorithms developed for the **BIOMASS, NISAR and GEDI** missions, and fusion of these mission datasets.

2. Establish a forum to **involve scientists** in the development of retrievals that **have so far not been part of the biomass** community.

3. The **adoption of CEOS LPV validation protocol** to compare biomass estimates to **reference datasets** (e.g. field plots or airborne lidar biomass maps).

4. **Collect inputs** from the biomass user and scientific community on data formats and characteristics towards the generation of **Analysis Ready Data**.

Biomass Intercomparison Exercise 2 (BRIX-2)



Schedule: 2020-2021

- Experiment call (September 2020)
- Registration Deadline (November-December 2020)
- **First Workshop** (end of January 2021 in Europe)
- Results Submission Deadline (May 2021)
- Results Evaluation Report (September 2021)
- **Second workshop** (October-November 2021 in the US)

The evaluation will be done by ESA/NASA

The results should easily be adapted for publication

Remote sensing and in-situ data

- **Develop a biomass retrieval** based on the data that has been acquired during the **ESA-NASA AfriSAR campaign** for the La Lopé, Mondah and Rabi sites.

•Datasets from the MAAP that will be used:

- **P-band** fully polarimetric interferometric SAR images and related additional information (incidence angles, DEM, etc.)
- **L-band** fully polarimetric interferometric SAR images and related additional information (incidence angles, DEM, etc.)
- **ICESat-2** global photon counting lidar data, **GEDI** global data, **LVIS** L1-L4 data and derived biomass maps, discrete return lidar biomass maps and discrete return lidar DEM.

- The retrieval will be evaluated over the three sites with existing forest plot data and lidar estimates of **biomass and forest height**.

LPV Communication

Improving LPV communication

In addition to our annual newsletters, and our Plenary meeting (every 1-2 years), we are since this month distributing our bi-monthly telecons with the updates of each Focus Area:

This will allow to our stakeholders to keep updated with the progress of the Land Product Validation subgroup.

Website and list of products and references are keep updated. Thanks to Jaime Nickenson and our focus area co-leads.

CEOS LPV 5-Year Roadmap

Mission

Coordinate quantitative validation of satellite-derived land products in a traceable way

Increase the quality and efficiency of global satellite product validation by developing good practices and

	2018	2019	2020	2021	>2022
Operational Validation Framework					
Operational Validation in Services					(Lead : EC Copernicus)
LST & Albedo protocols					
Soil Moisture, Active Fire, Burned Area, VI, Phenology Protocols					
CEOS Carbon Actions					
Biomass Protocol					(Lead : NASA)
snowpex protocols for Snow					
snowpex 2					(Lead : ESA)
WGCV ACIX	(Lead: ESA)				
BRIX-2					(Lead: ESA/NASA)
WGCV ACIX- 2 , Cloud Masking IX					
SRIX 4Veg					(Lead: ESA/GA)
Field Data (TERN, neon, ICOS integrated carbon observation system, JECAM, fiducial reference measurements for vegetation)					
Definition of LPV Supersites , carbon supersites, supporting FRM campaigns, new supersites					

New Missions

ICESat-2 · ECOSTRESS · GEDI · NI-SAR · Biomass

Sustained Missions

Terra/Aqua/S-NPP · sentinel-2a/b · Landsat 8 · sentinel-3b · Morning · Landsat 9 · sentinel-3c · JPSS-1 · Afternoon · JPSS-2 · EPS-SG

Vision

Land products **algorithms are iteratively improved** based on validation results.

Reliable uncertainty information is only determined through **community agreed good practices for validation using fiducial measurements** or other suitable references

Committee on Earth Observation Satellites

Thank you for your attention !

https://lpvs.gsfc.nasa.gov/