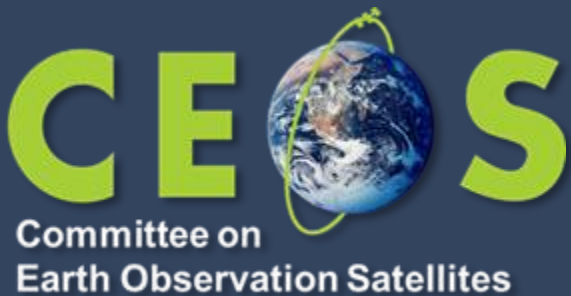


WGCV-52

Land Product Validation Subgroup



Michael Cosh
Agenda Item 4.4
WGCV-52, ESA/ESRIN, Italy
5th - 9th June 2023

Focus Areas



Focus Area

Biophysical

Fire/Burn Area

Phenology

Vegetation Index

Land Cover

Snow Cover

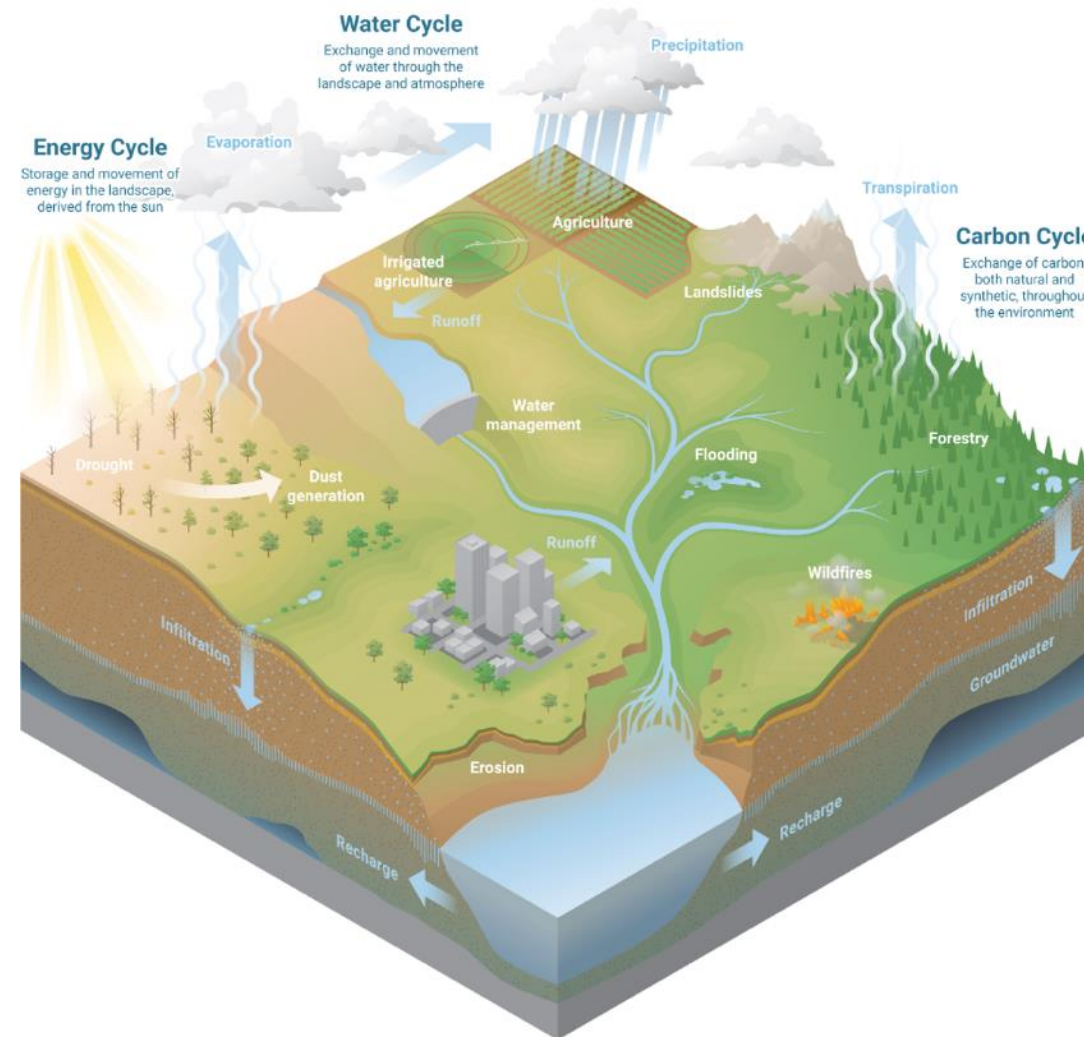
Surface Radiation

Soil Moisture

LST and Emissivity

Aboveground Biomass

10



Presenter Guidelines 2



	First Name	Last Name	Institution	Location	End of Term
Main	Michael	Cosh	USDA	USA	Apr 2025 (final)
Main	Fabrizio	Niro	ESA	Italy	Apr 2025(promotion to Chair)
Main	Jaime	Nickeson	GSFC	USA	never
Land Cover	Alexandra	Tyukavina	University of Maryland	USA	March 2024 (1st term)
Land Cover	Sophie	Bontemps	Université Catholique de Louvain	Belgium	Oct 2023 (2nd term)
Biophysical	Marie	Weiss	INRA	France	Sep 2023 (2nd term)
Biophysical	Sylvain	Leblanc	Natural Resources Canada	Canada	Sept 2023 (2nd term)
Biophysical	Luke	Brown	Salford	UK	Jan 2026 (1st term)
Fire/Burn Area	Louis	Giglio	University of Maryland	USA	Sep 2023 (1st term)
Fire/Burn Area	Bernardo	Mota	National Physical Lab	UK	Jan 2026 (1st term)
Surface Rad	Angela	Erb	Umass Boston	USA	Jan 2026 (1st term)
Surface Rad	Jorge	Sanchez-Zapero	EOLab	Spain	Jan 2026 (1st term)
Soil Moisture	John	Bolten	NASA GSFC	USA	Apr 2026 (2nd term)
Soil Moisture	Carsten	Montzka	Jülich Research Centre	Germany	Sept 2023 (2nd term)
LST	Glynn	Hulley	NASA/JPL	USA	July 2024 (2nd term)
LST	Lluis	Perrez Planells	Karlsruhe Institute of Technology	Germany	June 2026 (1st term)
Phenology	Joshua	Gray	North Carolina State University	USA	Jan 2025 (2nd term)
Phenology	Victor	Rodríguez-Galiano	University of Seville	Spain	Aug 2025 (2nd term)
Snow Cover	Juha	Lemmetyinen	Finnish Meteorological Institute	Finland	June 2026 (1st term)
Snow Cover	Carrie	Vuyovich	NASA GSFC	USA	Jan 2026 (1st term)
Veg Index	Tomoaki	Miura	University of Hawai'i	USA	Dec 2022 (2nd term)
Veg Index	Else	Swinnen	VITO	Belgium	Apr 2023 (2nd term)
Biomass	Kim	Calders	Univ. Ghent	Belgium	April 2026 (1st term)
Biomass	Neha	Hunka	UMD	USA	April 2026 (1st term)

LPV Validation Stage Status



Validation Stage - 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 Biomass
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 Burned Area LAI
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.	Vegetation Indices Albedo Soil Moisture LST & Emissivity Active Fire
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).	Land Cover

Focus Area Protocols Update



Focus Area	Protocol
Biophysical	LAI(2014)
Fire/Burn Area	Burned Area Targeting summer 2023 Active Fire next
Phenology	Targeting summer 2023
Vegetation Index	Targeting summer 2023 (60%)
Land Cover	Targeting summer 2023 (60%)
Snow Cover	
Surface Radiation	Albedo(2019) Global Downward Radiation Product Validation Best Practices (80%)
Soil Moisture	SM(2020)
LST and Emissivity	LST (2019)
Aboveground Biomass	AGWB(2021)

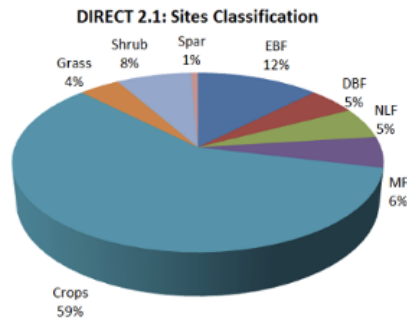
New campaigns and software development

- FRM4VEG (LAI, FAPAR, CCC) in cropland (Barrax, Sp) and forest (Wytham Woods, UK), July 2021
- P2S2 for the validation of S2 LAI/fAPAR (France & Belgium)
- Vertical LAI measurement over DNF & MF (China), Apr, Jun, & Sep, 2021

ESA FRM4Veg: Validation of S3 OLCI IG-FAPAR 300m with FRM data

- Validation and conformity testing was conducted using the FRM4veg dataset (2018, 2021), over Wytham (UK) and Barrax (Sp), with upscaled maps with uncertainties.

Updated CEOS DIRECT 2.1 database (new sites from Asia & FRM4VEG)



- **From 2000 to 2021**
- **176 sites (7 main biome types)**
- **280 LAI upscaled values (3km x 3km), 128 FAPAR, 122 FCOVER upscaled values**

Biophysical reference datasets in NE China croplands available (<https://doi.pangaea.de/10.1594/PANGAEA.939444>)
China is considering several newly recommended National Standards for the Validation of Remote Sensing Products.

Fire Disturbance

Validation Protocol Status

Discussed at the GOFC Fire Implementation Team meeting (June 2022)

- Solicited assistance with updating and writing the Burned Area and Active Fire protocols with participants from Canada (2), Europe (1), UK (2), and USA (7)

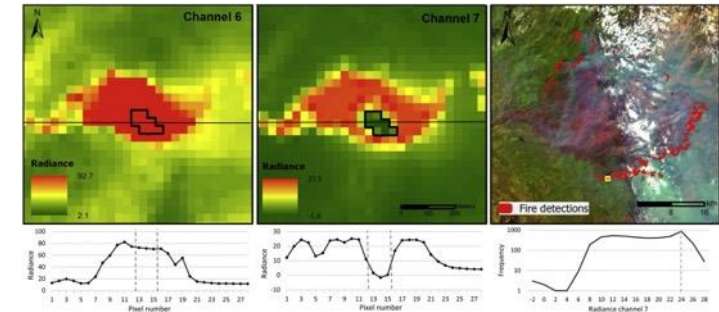
Planning a formalization of the incomplete Burned Area Validation protocol from 2010.

Active Fire

- Validation accomplished by contemporaneous product inter-comparison (moderate and coarse resolution) or prescribed fire programs (few locations, small fires)

FRP Validation challenges

- Limited availability of reference data
- Field campaigns - Logistically challenging/limited sample size



Burned Area Validation

Product intercomparison – need to address issues around different approaches to reference data

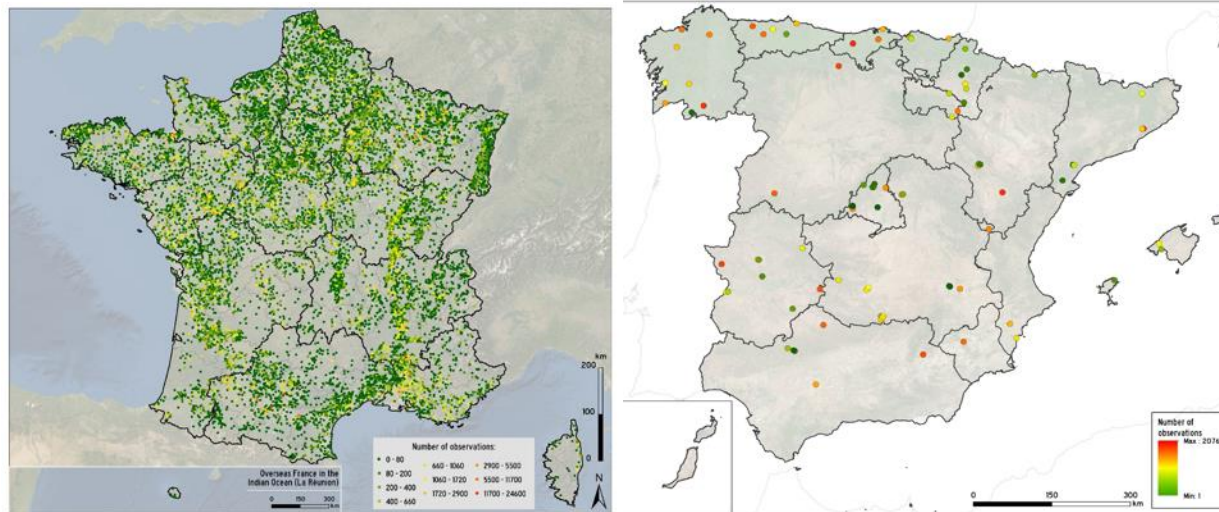
Recommended – Burned Area Reference Database (BARD) for both validation and product development

Progress on CEOS LPV LSP Protocol

- Most chapters now have leads, uneven but tangible progress across the chapters
- “Phenometrics” usually lack an ecological definition, making it more challenging to conduct true validation
- CEOS LPV protocol will document current best practices and definition and characterize self-consistency and errors resulting from choices in methodology

In situ Progress

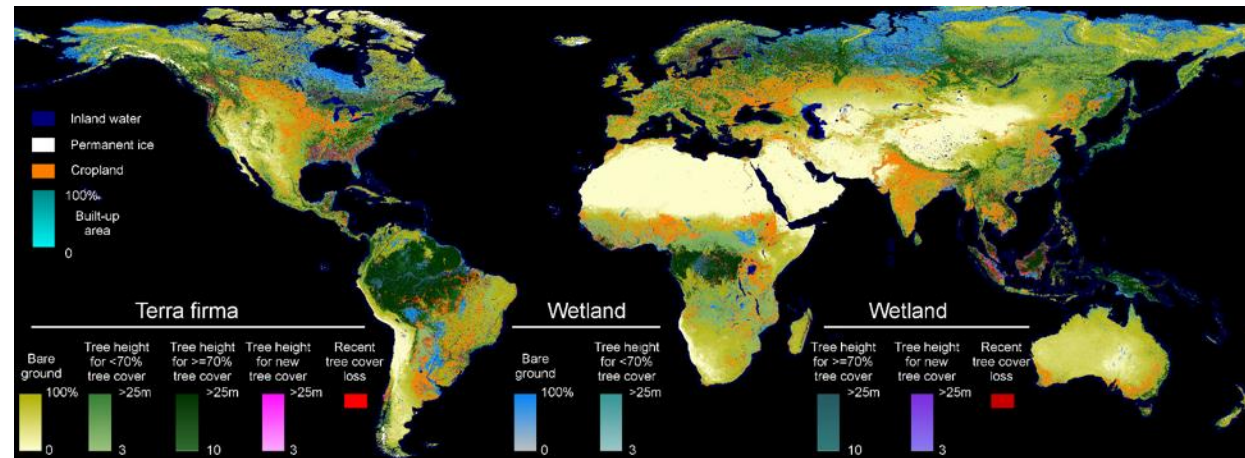
- “New” observational network in Spain managed by the Spanish Meteorological Agency (AEMET)
- “New” observational network in France managed by INRAE



Vegetation Indices

- Developed an outline for a Vegetation Indices Best Practice Protocol document. Recruited a small group of VI experts to review and finalize the outline.
- Held a kick-off meeting with the expert group to review the procedure, expectation, and timeline. Followed up with another meeting to review the comments and suggestions. Revised the outline and incorporated comments.
- Currently the leads are working on the first complete draft of the outline.

Updating the Land Cover Validation Good Practices protocol. This effort aims to update the 2006 Strahler, et al document and to also include Land Cover Change validation as well. First draft by summer 2023 followed by a technical workshop late 2023.



UMD GLAD Global Land Cover and Land Use, 2019 @30m
(<https://glad.umd.edu/dataset/global-land-cover-land-use-v1>)

Joint workshop between CEOS LPV and GEOGLAM on the validation of agricultural land cover products/essential agricultural variables planned for September 2023 at National Agricultural Library, Beltsville, MD.

ECV: GCOS IP 2022

NASA's SnowEx is a multi-year field experiment to study snow remote sensing challenges in different environments in preparation for future snow satellite missions. Four campaigns in different western U.S. snow regimes were conducted in the 2017 to 2023 time frame. Both airborne and ground-based measurements of snow water equivalent, snow depth, snow albedo and other snow properties were collected and are archived at the NSIDC: <https://nsidc.org/data/snowex>.


ESA's SnowPEX+ continues the intercomparison and validation project activities of SnowPEX, focusing on conventional and recently developed satellite-based snow products (2015-2020). SnowPEX continues to organize multiple International Satellite Snow Products Intercomparison and Validation Workshops. In addition, SnowPEX aims to contribute to advancing procedures for monitoring snow trends.

Snow International (SINTER) are scientists and engineers focused on seasonal snow and remote sensing, and provides opportunities to learn about techniques and methods to evaluate snow remote sensing data. See <https://nsidc.org/sinter/about-sinter>.

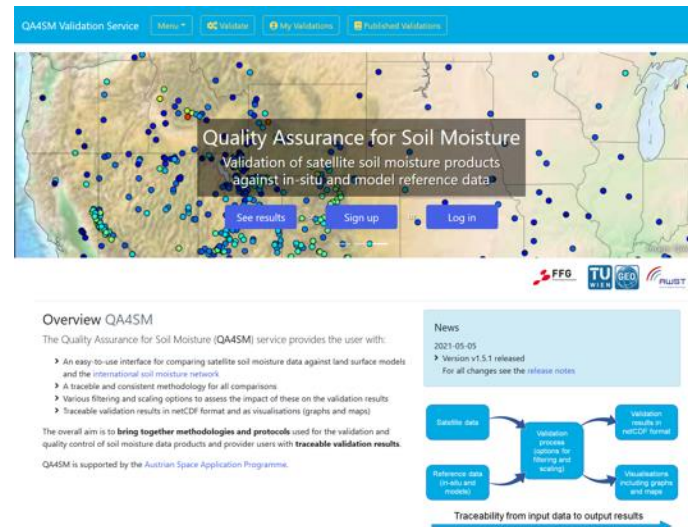
Snow Measurement field schools: For years, snow field measurement schools have been held in the US and Europe to teach proper snow measurement techniques and use of snow field instruments, led by the national science foundation (NSF) and the European geophysical union (EGU), respectively.

- The LPV Land Surface Albedo Best Practice Protocol (2019) is in place.
- Working with the Baseline Surface Radiation Network (BSRN) albedo working group
- Coordinating with scientists from China to share the *in situ* albedo measurements for albedo product evaluations.
- Coordinate BSRN *in situ* measurements for satellite albedo and downward radiation products validation.
- Surface Albedo Validation tool (SALVAL) published within the CEOS WGCV CAL/VAL portal (<https://calvalportal.ceos.org/web/guest/salval>)
- Focus area is currently preparing a global downward radiation best practices protocol document.

- The LPV Soil Moisture Best Practice Protocol (2020) is in place.
- ISMN has had challenges over the years, but now has a long-term maintenance commitment.



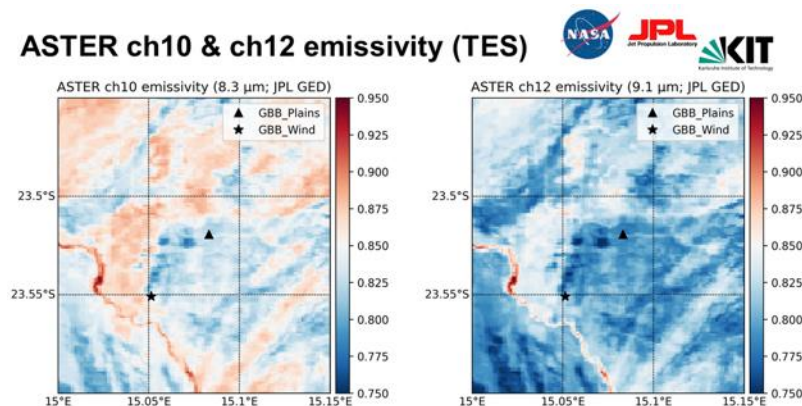
Screenshot of the International Soil Moisture Network (ISMN) website. The header includes "Welcome to the Data Hosting Facility of the International Soil Moisture Network" and navigation links like Home, News, Networks, Data, Forum, Tools, Participate, About Us, Terms and Conditions, FAQ, Publications, and Citation lists. A sidebar on the left lists "DATA ACCESS" options: ISMN Methodology, Metadata, Data availability, Additional datasets, Harmonization, Quality Flags, Flag overview, Flag methodology, ISMN data access, Data download, Download instructions, and Query download. The main content area is titled "Methodology" and contains a paragraph: "Within the ISMN, in situ soil moisture measurements (surface and sub-surface) are collected, harmonized in terms of units and sampling rates, advanced quality control is applied and the data is then stored in a database and made available online, where users can download it for free. Three additional metadata datasets are included for every station: Köppen-Geiger Climate Class, Harmonized World Soil Database and ESA's CCI Landcover." Below the text is a flowchart showing the data processing pipeline: "Additional Datasets" (Köppen-Geiger Climate Class, ESA CCI - Landcover, Harmonized World Soil Database) feed into "Metadata", which then feeds into "In situ Data". "In situ Data" feeds into "Data processing", which includes "Data harmonization" and "Quality control". The output of "Data processing" is stored in the "Database".



Screenshot of the QA4SM Validation Service website. The header includes "QA4SM Validation Service" and navigation links like Menu, Validate, My Validations, and Published Validations. The main content area features a map of the United States with numerous blue and green dots representing validation sites. A text box over the map reads "Quality Assurance for Soil Moisture" and "Validation of satellite soil moisture products against in-situ and model reference data". Below the map are buttons for "See results", "Sign up", and "Log in". Logos for FFG, TU Wien, GEO, and FLUWZ are visible. The "Overview QA4SM" section states: "The Quality Assurance for Soil Moisture (QA4SM) service provides the user with: An easy-to-use interface for comparing satellite soil moisture data against land surface models and the international soil moisture network; A traceable and consistent methodology for all comparisons; Various filtering and scaling options to assess the impact of these on the validation results; Traceable validation results in netCDF format and as visualisations (graphs and maps)." Below this is a "News" section dated 2021-09-09, mentioning "Version v1.5.1 released" and a link to "release notes". A flowchart at the bottom shows the process: "Satellite data" and "Reference data (in-situ and models)" feed into "Validation process (options for filtering and scaling)", which then leads to "Validation results in netCDF format" and "Visualisations (including graphs and maps)". A red arrow at the bottom indicates "Traceability from input data to output results".

- International Soil Moisture School – July 2022 UMass Amherst, NEON-Harvard Forest
- Soil Moisture Field School, August 2023, USDA, Beltsville MD, USA

- The LPV Land Surface Albedo Best Practice Protocol (2019) is in place.
- *In situ* LST from broadband hemispherical and narrowband directional radiances
- Performed instrument intercomparisons. Concluded that use of broadband hemispherical TIR sensors for LST validation, even over flat, homogenous surfaces (e.g. Namibian gravel plains) should be avoided.
- ECOSTRESS calibration update for collection 2 showing excellent results. Cold bias reduced from ~1K in collection 1 to near zero in collection 2.
- Landsat 8 collection 2 LST validation – found that the L8 surface temperature product has a consistent accuracy and precision of ~1 K across various land cover types and water.
- Participating in the Copernicus LST, Aerosol, and Water Vapor (LAW) project – product validation for Sentinel-3 LST products over KIT-Forest Site



Above Ground Biomass



Providing guidance for:

- Map producers, on how to estimate, propagate and report errors
- Map users, on how to interpret errors
- All, on how to collect reference data (field and airborne lidar), and use it to conduct independent product validation
- How to quantify biomass change (in progress)

Summary of:

- State of knowledge of biomass mapping
- Community identified research and tool development priorities
- Recommendations for protocol implementation

Biomass Product Harmonization Activity for the UNFCCC GST and Second Biomass retrieval and intercomparison exercise (BRIX2)

Both activities are utilizing the **Multi-Mission Algorithm and Analysis Platform (MAAP)**, developed by ESA and NASA, as open science activities.

- Following recommendations from CEOS LPV protocol
- Results in open source jupyter notebooks for validation
- Inform future development of missions / products



Committee on Earth Observation Satellites



Aboveground Woody Biomass Product Validation

Good Practices Protocol

Version 1.0 – 2021

Editors: Laura Duncanson, Mat Disney, John Armston, David Minor, Fernando Camacho, Jaime Nickeson



Review past actions/deliverables still open

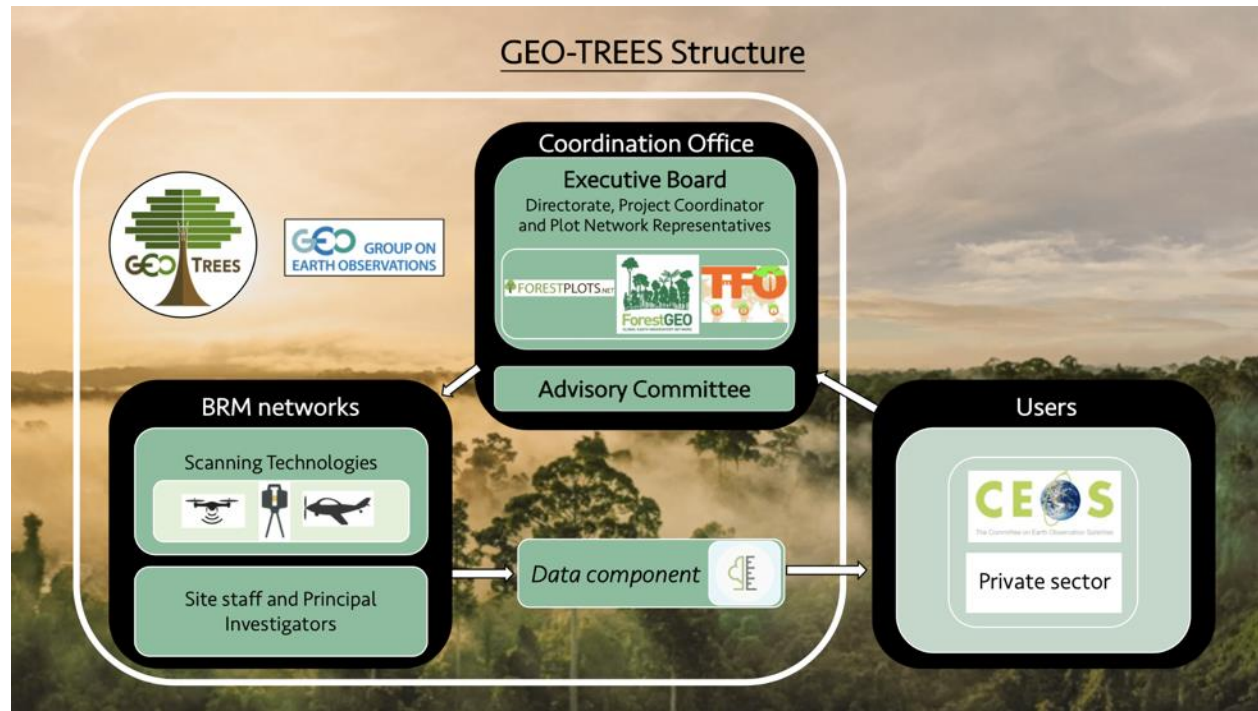
- Forest Biomass Reference Network (GEO-TREES) (CARB-21-03)
- Production of harmonised biomass products from CEOS Agency missions (CARB-22-01)
- Cal/Val and production of biomass products from CEOS Agency missions (CARB-17-05)
- Forest Biomass measurements for GFOI countries (CARB-19-04)

- ❖ Forest Biomass measurements for GFOI countries (CARB-19-04)
 - Moved to LSI-VC Forests & Biomass Subgroup

❖ Forest Biomass Reference Network (GEO-TREES) (CARB-21-03)

In Progress...The project office is up and running via funding from the French government. <https://geo-trees.org> and is actively soliciting funding, with various opportunities in the pipeline.

Nothing concrete as yet in terms of actual funding for data collection, but likely in the near future.



- ❖ Production of harmonised biomass products from CEOS Agency missions (CARB-22-01)
- Last update: For 2023 this activity will focus on intercomparison and validation of global biomass products from CEOS Agency missions.

- ❖ Cal/Val and production of biomass products from CEOS Agency missions (CARB-17-05)

Plot scale data is being coordinated through GEO-Trees. More data needs to be collected.



LPV Contributing Satellites Review



There is a need for a review on satellites which contribute to LPV development, not just in primary, but in ancillary datasets, both public and commercial

Challenges:

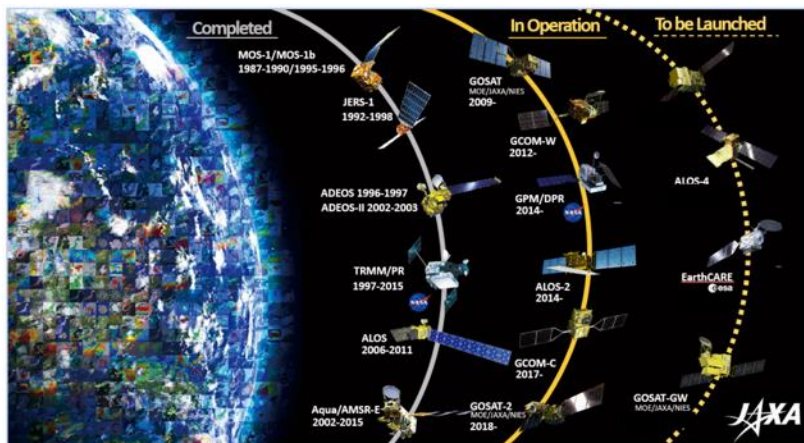
Moving Target: Aqua, Terra

Decommissioning cycles, GEDI, ECOSTRESS

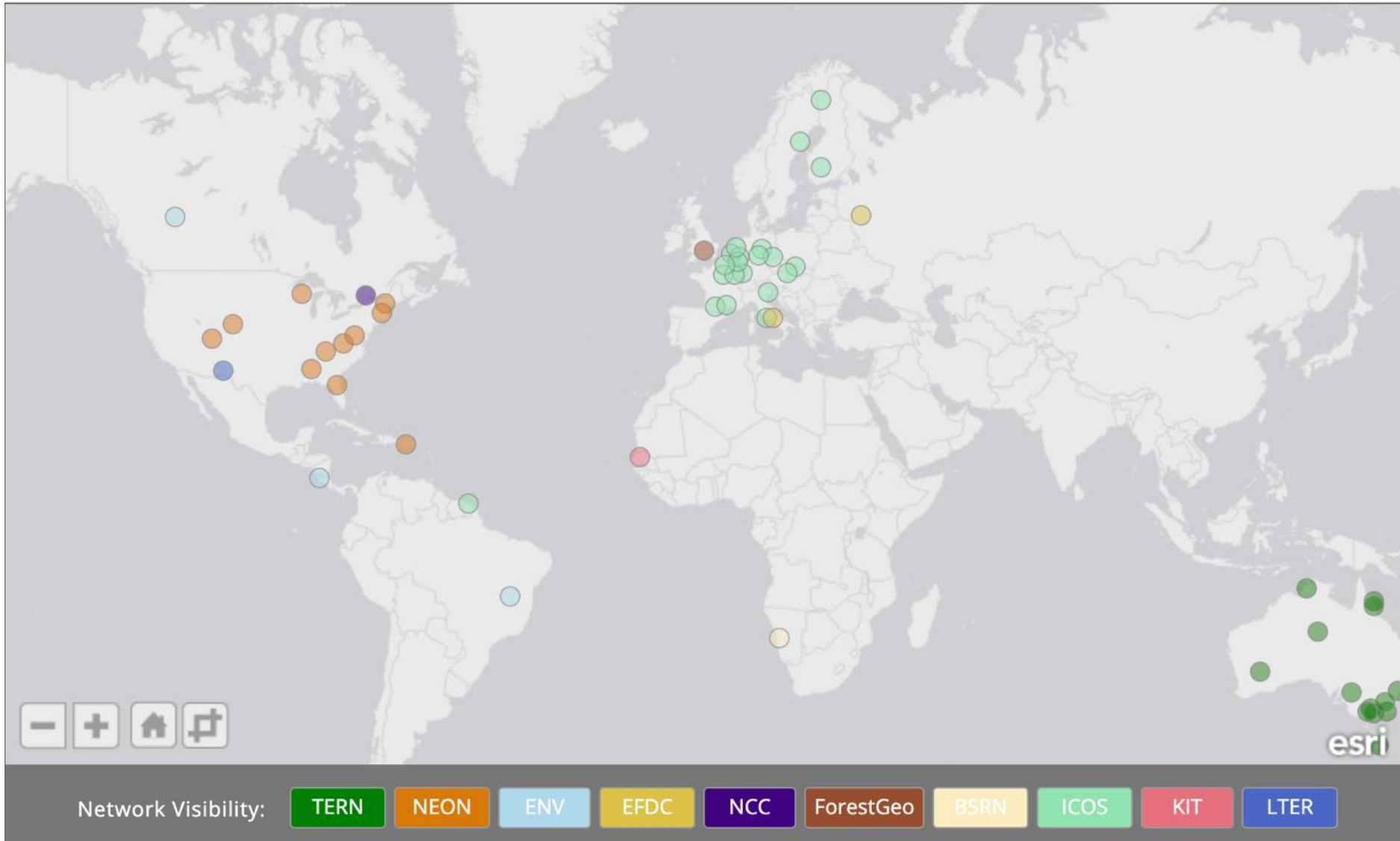
Commercial transparency

Interdependencies of products on multiple satellites

Constellations



Interaction with IVOS on Supersites



Diversity of Sites

Landscapes of Interest

Multiparameter

Economics

Many Cooks

Top of Atmosphere

Small number of well understood sites

High Accuracy



Wide Diversity of Sites for greater confidence

Troublesome atmosphere globally

Land surface is heterogeneous

Interpretation

Land Surface Temperature

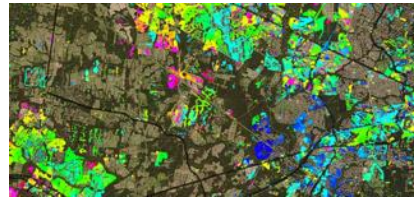
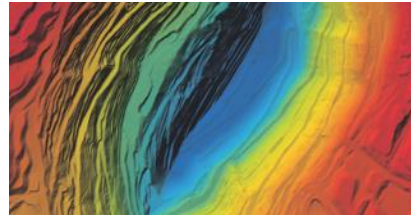
Commercial Satellite & Products



SOLUTIONS

- Agriculture
- Civil Government
- Defense & Intelligence
- Drought Response
- Science Programs
- Energy & Infrastructure
- Finance & Insurance
- Forestry & Land Use
- Mapping
- Maritime
- Sustainability
- Planet Federal
- Nonprofit Program

MAXAR



Earth's surface data sets

GNSS scatterometry and precise altimetry (GNSS-R):

Soil moisture

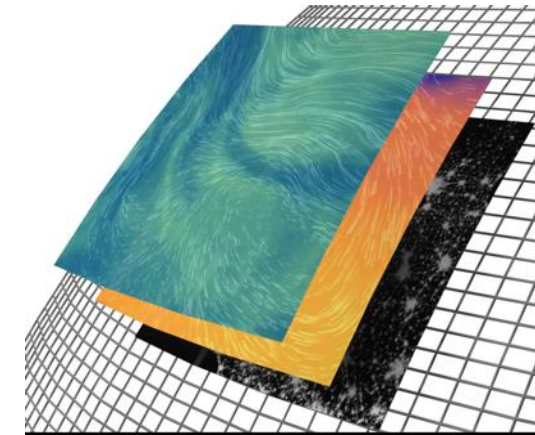
Sea ice classification & altimetry

Surface water mapping – river, wetlands, flooding (under development)

Ocean winds & waves (under development)

[Request data sample](#)

MUON SPACE



Google Earth Engine



A planetary-scale platform for Earth science data & analysis

Earth Engine provides a global catalog of satellite and sensor data, and a powerful suite of tools for analyzing and visualizing that data.

Climate and Weather

Surface Temperature:

Climate:

Atmospheric:

Weather:

Imagery

LandSat:

Sentinel:

MODIS:

High-Resolution Imagery:

Google Earth Engine Search places and datasets...

Scripts Docs Assets

Filter scripts... NEW

Owner (1)

- users/mhcosh/default
 - NAIP_test
 - New_Palm_Time_Series
 - New_Palm_Time_Series_051820
 - PALM_GROVE_Time_Series
 - Palm_Mite_0419_timeries
 - Sentinel_IKEA1
 - new_palm_578_series
 - palmgroves
- Writer (1)
 - users/kasparhurni/sharing
- Reader (2)
 - users/csadams/S4G_Public_Imagery
 - S4G_Ortho_Public_Collections
 - S4G_Ortho_Public_Download
 - Terra Bella Imagery for Fortaleza Brazil
 - users/gorelick/EE101-ZRH
- Archive
- Examples
 - Image
 - From Name

NAIP_test

```

Imports (7 entries)
var ikea: Polygon, 4 vertices
var lagoon1: Polygon, 4 vertices
var lagoon2: Polygon, 4 vertices
var lagoon3: Polygon, 4 vertices
var lake1: Polygon, 7 vertices
var heritage: Polygon, 7 vertices
var kingman: Polygon, 8 vertices

1
2
3 // Choose area of interest (AOI):
4 var aoi = ikea;
5
6 // Enter threshold value (percent) for minimum acceptable coverage of study area after cloud masking:
7 var pct_cov = 50;
8
9 // L5 L7 cloud mask function
10 var cloudMaskL57 = function(image) {
11   var qa = image.select('pixel_qa');
12   // If the cloud bit (5) is set and the cloud confidence (7) is high
13   // or the cloud shadow bit is set (3), then it's a bad pixel.
14   var cloud = qa.bitwiseAnd(1 << 5)
15     .and(qa.bitwiseAnd(1 << 7))
16     .or(qa.bitwiseAnd(1 << 3));
17   // Remove edge pixels that don't occur in all bands
18   var mask2 = image.mask().reduce(ee.Reducer.min());
19   return image.updateMask(cloud.not()).updateMask(mask2);
20 };
21
22
23
    
```

Inspector Console Tasks

GNDVI in palm grove

Red band reflectance in palm grove

Click a point on the chart to show the GNDVI image for that date.

Layers Map Satellite

- ❖ WGCV to consider potential for GPP/NPP land product Focus Area within LPV
- ❖ WGCV to consider potential for Evapotranspiration land product Focus Area within LPV
- ❖ Elevating Soil Moisture to Stage 4 with the release of FRM4SM

Potential for GPP/NP Focus Area

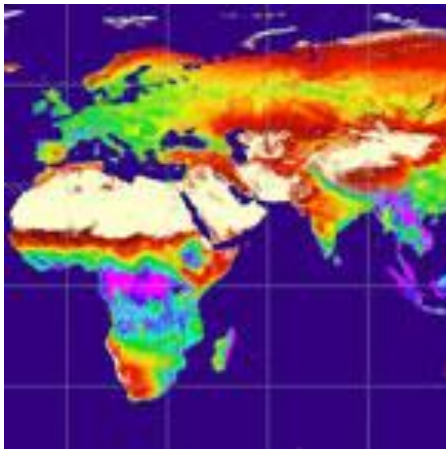


❖ WGCV to consider potential for GPP/NPP land product Focus Area within LPV

Does GPP/NPP land product have a home in LPV currently.

MODIS GPP/NPP uses FPAR, Land Cover, modelled products (LST), etc.

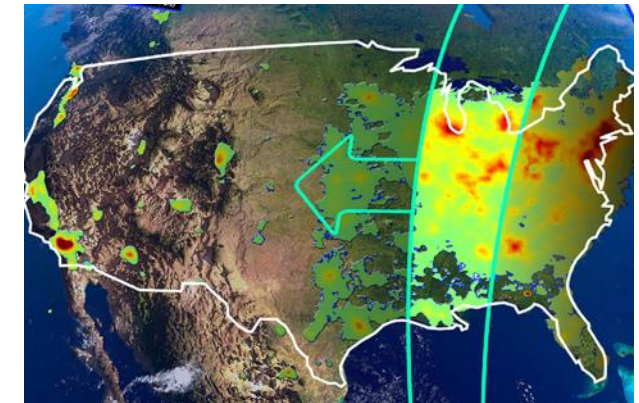
Are new missions coming online which will produce products not with LPV, specifically SIF



MODIS GPP/NPP



OCO2 and OCO3



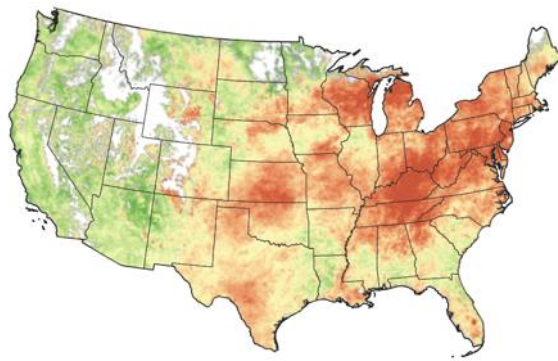
TEMPO

GPP/NPP - Gross Primary Production/Net Primary Production

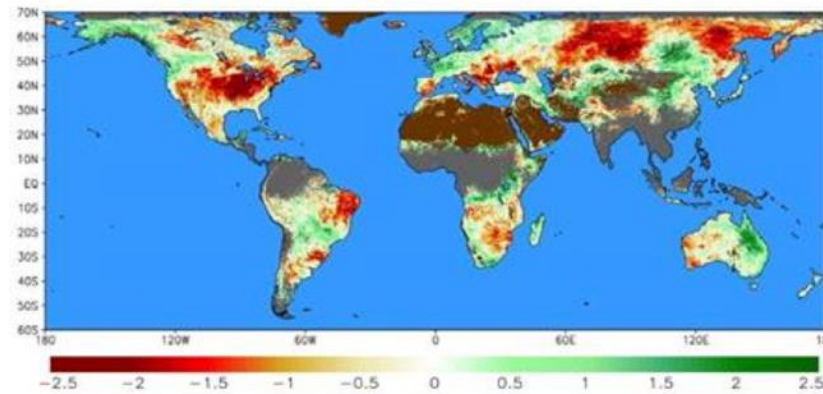
Potential for ET Focus Area



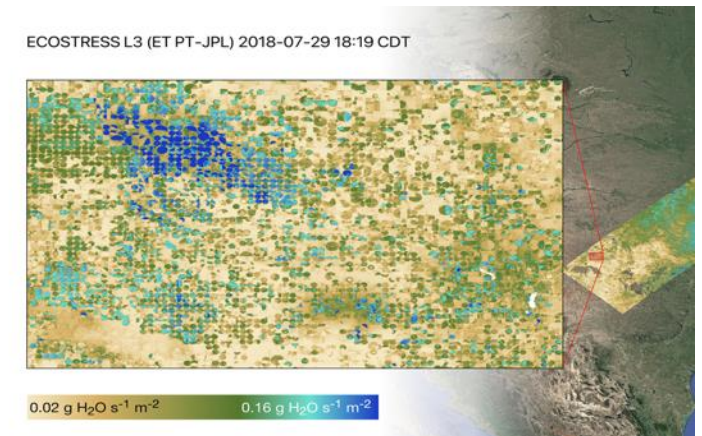
- ❖ WGCV to consider potential for Evapotranspiration land product Focus Area within LPV



Evaporative Stress Index



SERVIR Global ESI



ECOSTRESS

Elevating Soil Moisture to Stage 4



❖ Elevating Soil Moisture to Stage 4 with the release of FRM4SM



International Soil Moisture Network



Quality Assurance for Soil Moisture



Overview QA4SM

- The Quality Assurance for Soil Moisture (QA4SM) service provides the user with:
- An easy-to-use interface for comparing satellite soil moisture data against land surface models and the International Soil Moisture Network
 - A traceable and consistent methodology for all comparisons
 - Various filtering and scaling options to assess the impact of these on the validation results
 - Traceable validation results in netCDF format and as visualisations (graphs and maps)

The overall aim is to bring together methodologies and protocols used for the validation and quality control of soil moisture data products and provider users with traceable validation results. QA4SM was created thanks to support of the Austrian Space Application Programme. From 2021 on the application is also supported by the European Space Agency.

Share with us your opinion

If you think we could improve something or you see a missing functionality, please let us know using this [feedback form](#).
If you have any questions or you would like to share your opinion with us, please email us at [support\[at\]qa4sm.eu](mailto:support[at]qa4sm.eu).

News

2023-06-07

- Version v2.2.3 released!
For all changes see the [release notes](#)

FRM4SM

Fiducial Reference Measurements for Soil Moisture