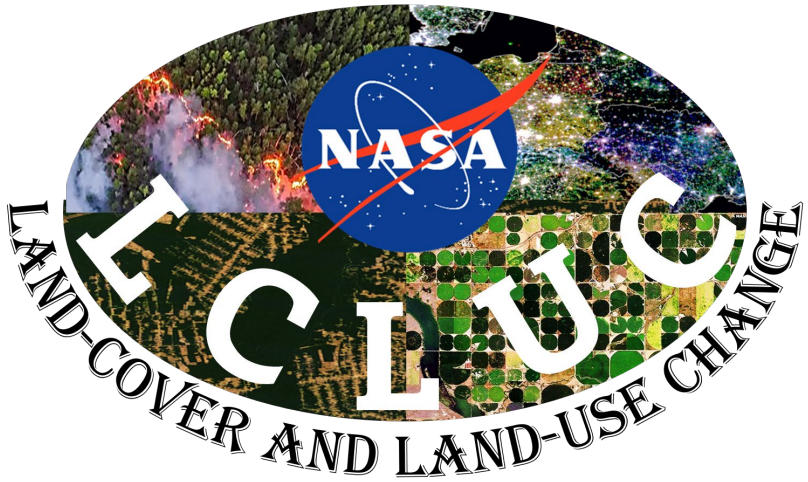
Committee on Earth Observation Satellites (CEOS)
Working Group on Calibration and Validation (WGCV)
Land Product Validation (LPV) subgroup
Land Cover (LC) focus area activities



CEOS LPV LC focus area co-leads:
Sophie Bontemps (UC Louvain, Belgium)
Alexandra (Sasha) Tyukavina (U. Maryland, USA)

NASA LCLUC Program Science Team Meeting
April 2-4, 2024

Committee on Earth Observation Satellites

CEOS is an international organization including 34 national space agencies as regular members (as of 2024)

CEOS focuses on validated requirements levied by external organizations (government agencies, commercial interests, etc.), works closely with other satellite coordinating bodies (e.g. the Coordination Group for Meteorological Satellites and Group on Earth Observations/Global Earth Observation System of Systems), and continues its role as the primary forum for international coordination of space-based Earth Observations.

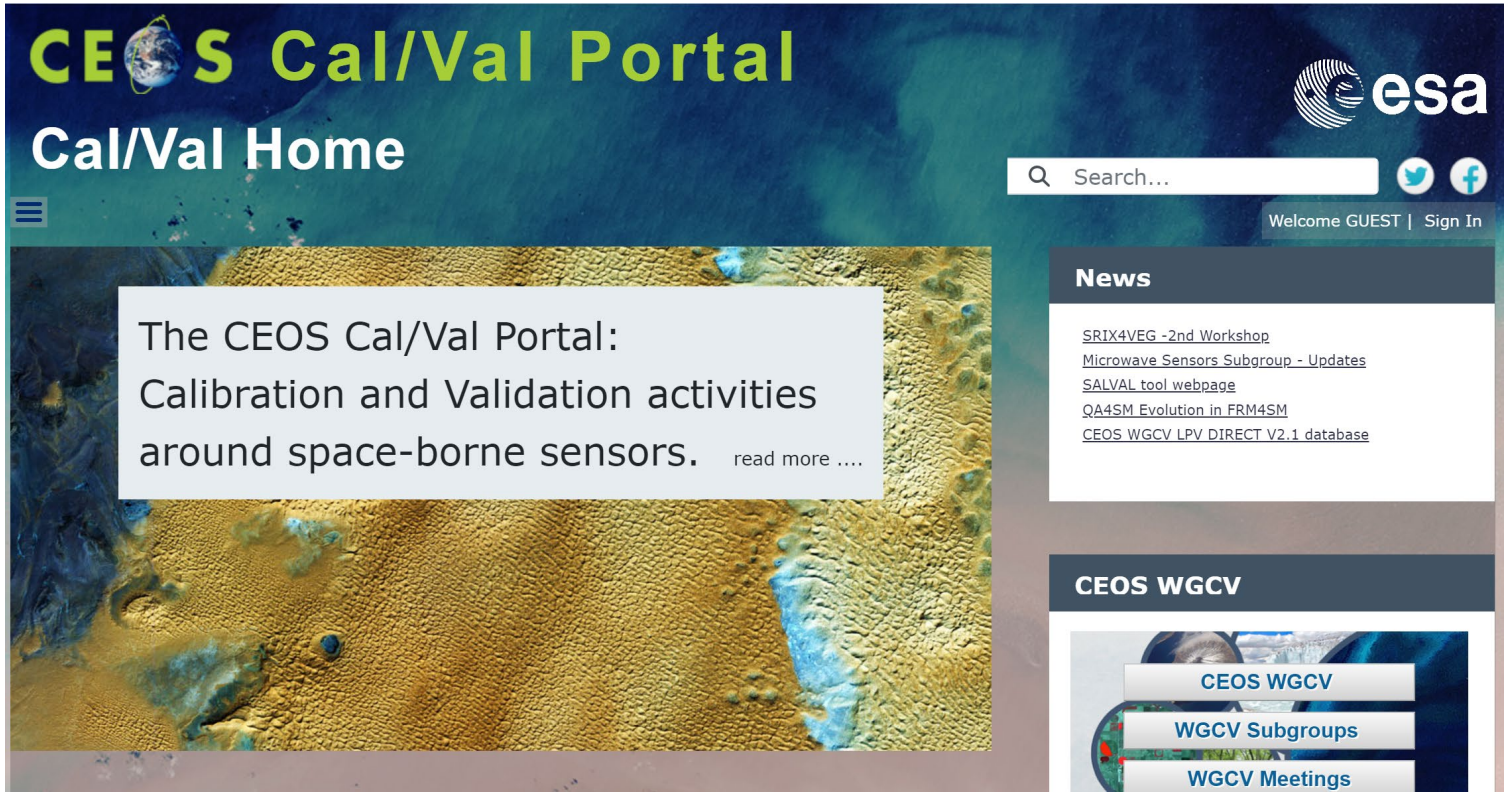
Working groups within CEOS

- WGCapD: The Working Group on Capacity Building & Data Democracy
- WGClimate: The CEOS/CGMS Working Group on Climate
- WGCV: The Working Group on Calibration & Validation
- WGDisasters: The Working Group on Disasters
- WGISS: The Working Group on Information Systems & Services

Working Group on Calibration & Validation

Subgroups within WGCV

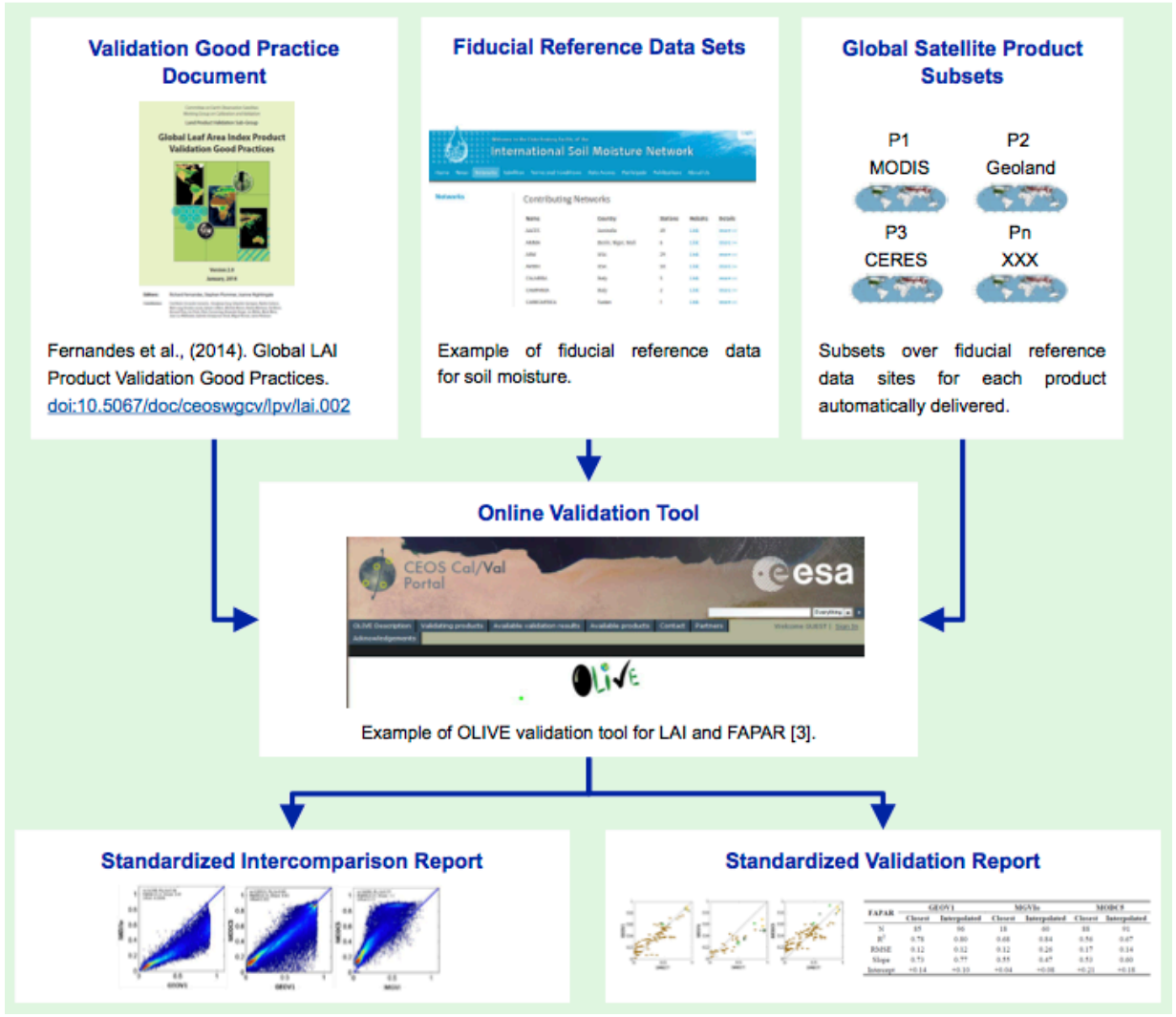
- Atmospheric Composition (ACSG)
- Infrared Visible Optical Sensors (IVOS)
- Land Product Validation (LPV)
- Microwave Sensors (MSSG)
- Synthetic Aperture Radar (SAR)
- Terrain Mapping (TMSG)



Focus Areas of LPV WG

10

Focus Area
Biophysical
Fire/Burn Area
Phenology
Vegetation Index
Land Cover
Snow Cover
Surface Radiation
Soil Moisture
LST and Emissivity
Aboveground Biomass

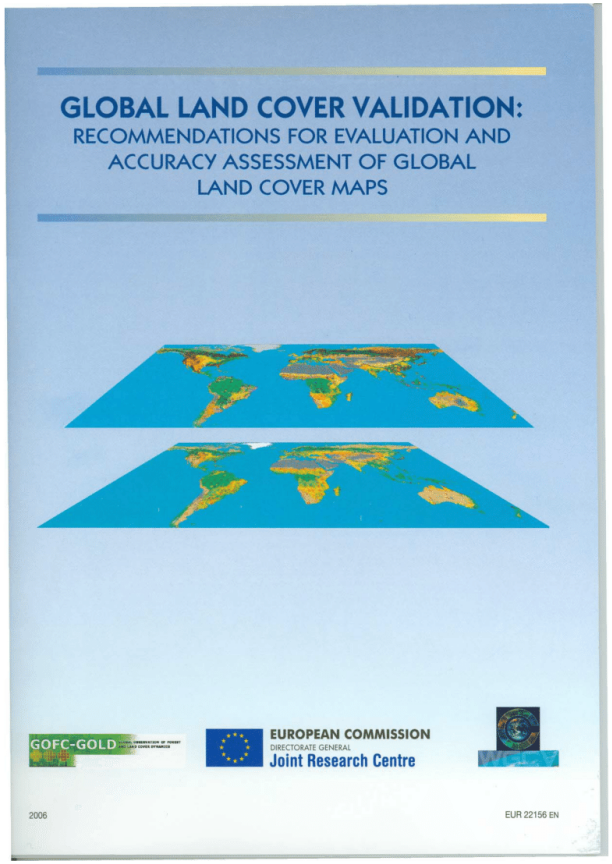


Land cover validation guidelines update

Goal – to update Strahler et al. (2006) guidelines to reflect:

- new literature on land cover map validation published in the last ~20 yrs;
- existing and new sources of reference data (previous guidelines were published in the pre-free Landsat and Sentinel era);
- examples of existing global- and continental-scale validation efforts.

+ to emphasize recommendation from Strahler et al. (2006) that map accuracy assessment should be taken seriously, planned ahead, and significant resources (**at least 30% of the budget**) need to be allocated towards validation (the latter is important to be communicated to research funders!)



Strahler, A., Boschetti, L., Foody, G., Friedl, M., Hansen, M., Herold, M., Mayaux, P., Morisette, J., Stehman, S., Woodcock, C. (2006) Global land cover validation: Recommendations for evaluation and accuracy assessment of global land cover maps. European Communities, Luxembourg 51, no. 4,1-60.

Land cover validation guidelines update

Status: finalizing the edits of the version 0.1 of the updated guidelines, expected to be sent out to community review in Spring 2024 (version 1.0 – after review)

Working group: 34 people from 17 institutions from 9 countries

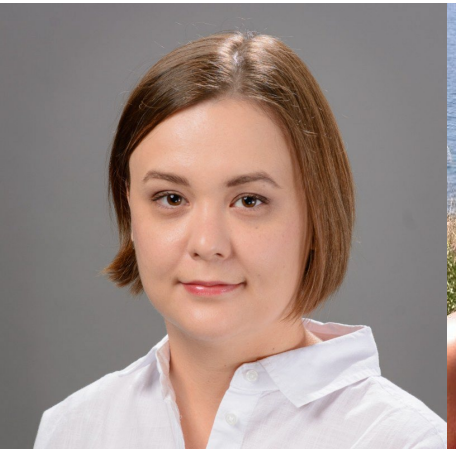
Editors:

Alexandra (Sasha) Tyukavina
U. Maryland, USA

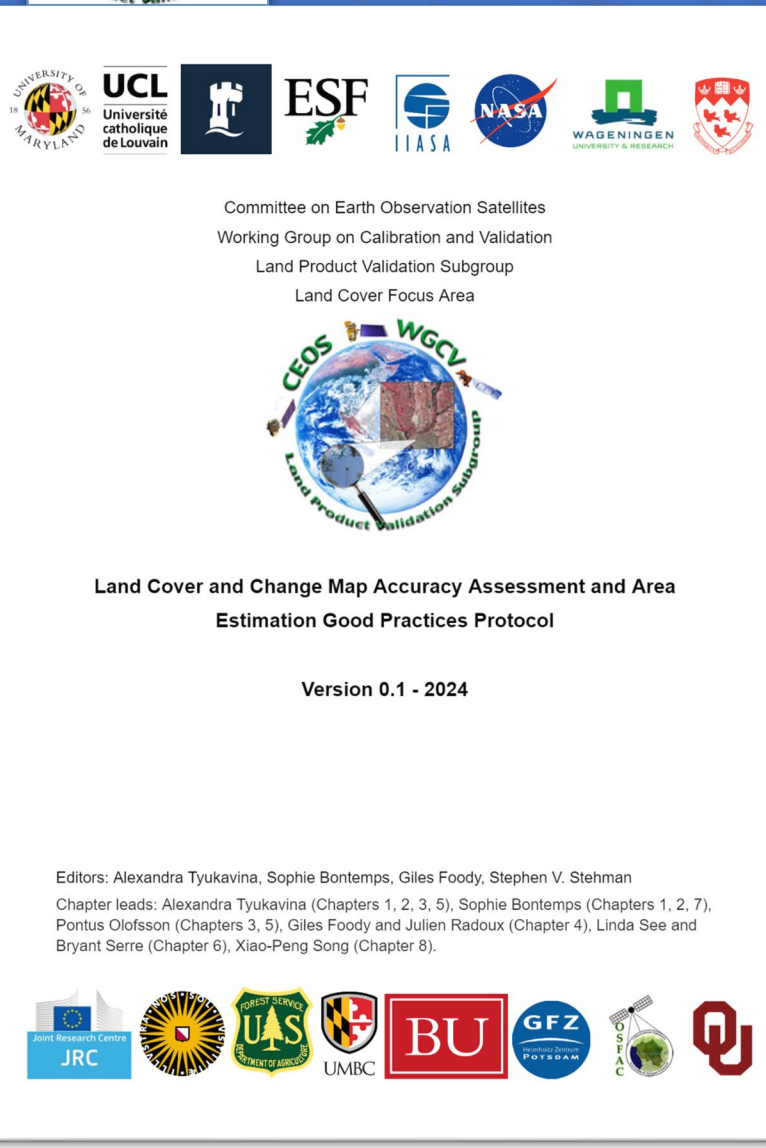
Sophie Bontemps
UC Louvain, Belgium

Giles Foody
U. of Nottingham, UK

Stephen Stehman
SUNY ESF, USA




CEOS LPV Land Cover Focus Area Co-leads



Accuracy assessment in land cover studies

"From 1994 to 2008 approximately 40% of all land cover articles also had 'accuracy' as a keyword and this percent increased to about 50% for the past decade, 2009–2018, providing some evidence that ***accuracy has become more prominently emphasized in land cover studies***." Stehman & Foody, 2019

But,

- Accuracy assessment methods are very much an area of ongoing research

and

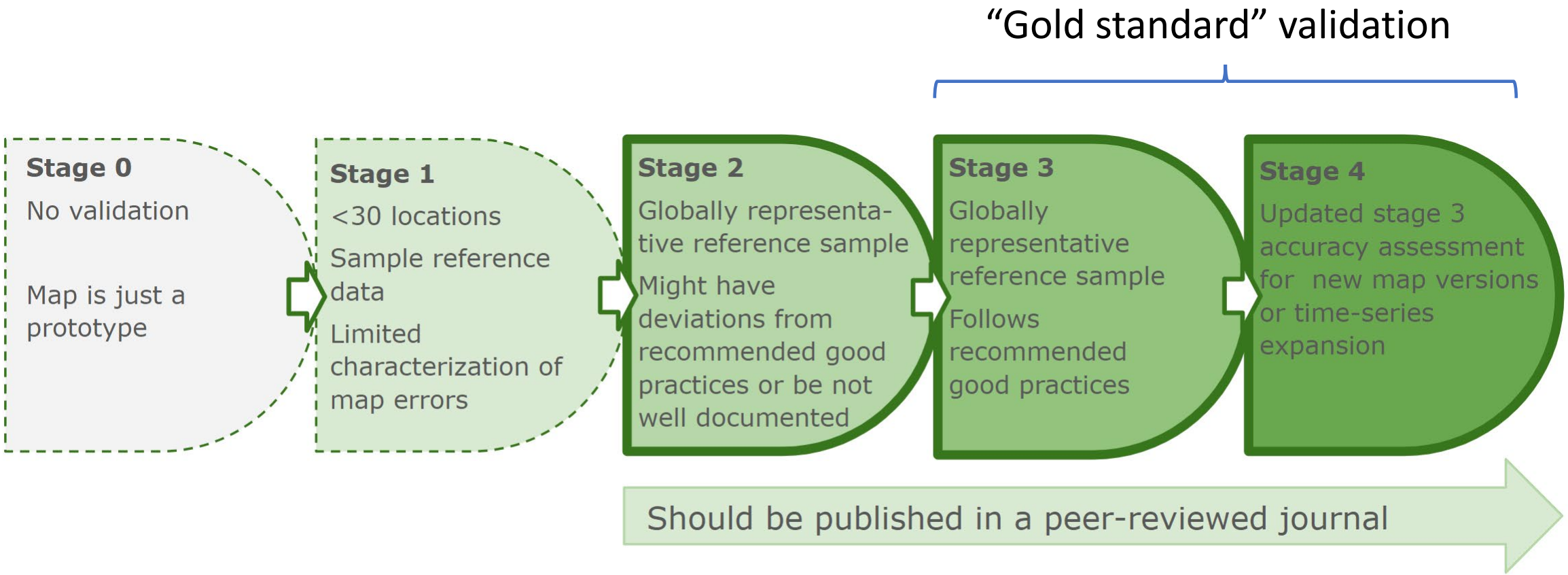
- Even if map accuracy is reported, accuracy assessment is often superficial, methodology not well described, reference data are not shared, etc.

Table 1. Publications in *Remote Sensing of Environment* (*RSE*) in five-year intervals resulting from two *Scopus* searches, one for 'land cover' and another for 'land cover' AND 'accuracy' in titles, keywords, and abstracts (searches conducted 25 January 2019).

Time Interval	Total #*RSE*	Land Cover (% of All)	Accuracy AND Land Cover (% of Land Cover)
1969–1973	64	0 (0)	0
1974–1978	128	0 (0)	0
1979–1983	206	9 (4)	1 (11)
1984–1988	307	6 (2)	3 (50)
1989–1993	434	7 (2)	2 (29)
1994–1998	565	55 (10)	22 (40)
1999–2003	755	117 (15)	45 (38)
2004–2008	1263	185 (15)	72 (39)
2009–2013	1503	227 (15)	110 (48)
2014–2018	2187	286 (13)	149 (52)
Total	7412	892 (12)	404 (45)

From Stehman, S. V., & Foody, G. M. (2019). Key issues in rigorous accuracy assessment of land cover products. Remote Sensing of Environment, 231, 111199.

LPV Validation Stages



State of validation of global multi-class land cover maps

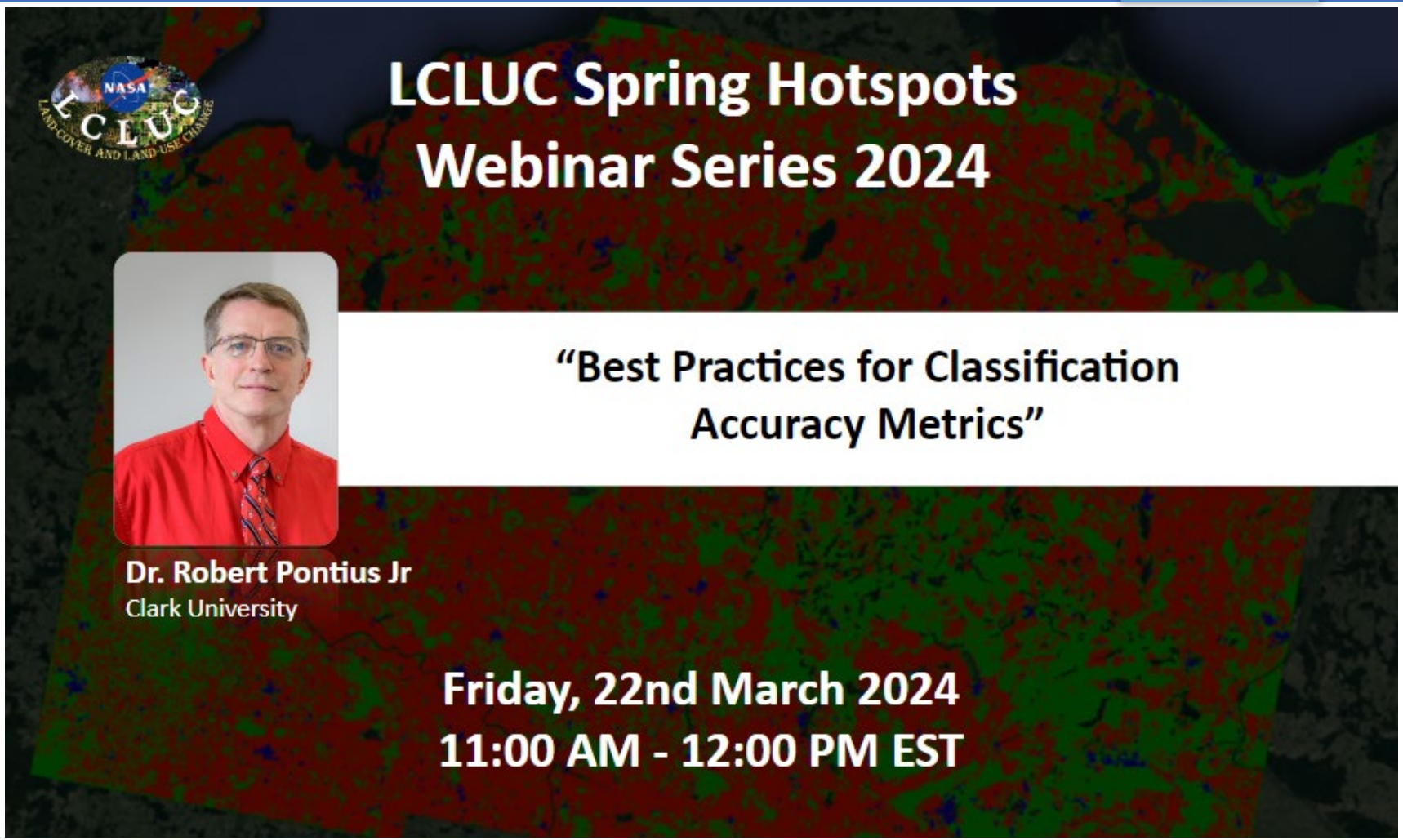
- ✓ Most generalized multi-class legend land cover maps including cropland as a class **are validated**;
- ✓ Validation data (reference sample labels) is mostly not published, validation is rarely updated, and validation methodology descriptions often need improvement (more details) -> increased confidence in validation and reproducibility

Sensor/ satellite	*Land cover map*	*Resolution (m)*	*Temporal Frequency and Range*	*Link to data*	*Link to documentation/publication*	*Validated (Yes/No)*	*Validation methodology well described (Yes/No)*	*Validation data available (Yes/No)*	*Validation updated (Yes/No)*	*Validation stage*
MODIS	MCD12Q1 Land Cover Type	500	Yearly, 2001-2021	USGS	User guide Validation status	Partially	Yes Olofsson et al., 2012; Stehman et al., 2012	No	No	Stage 2
MERIS	ESA CCI Land Cover	300	Yearly, 1992-2015	ESA	User guide	Yes	Yes Link to description GlobCover 2009 validation dataset	No	No	Stage 3
PROBA-V	Copernicus GLS-LC100	100	Yearly, 2015-2019	Copernicus	User manual	Yes	Yes Validation report	No	Yes Tsendbazar et al., 2021	Stage 4
Landsat	UMD GLAD Global Land Cover and Land Use Change	30	Bi-decadal change, 2000-2020	UMD GLAD	Potapov et al., 2022b	Yes	Yes	Partially: Cropland, Surface water	Partially, only forest extent (initial validation Potapov et al., 2019)	Stage 3, Forest extent Stage 4
Landsat	UMD GLAD Global Land Cover and Land Use	30	One year, 2019	UMD GLAD	Hansen et al., 2022	Yes	Yes	Yes Link	No	Stage 3
Landsat	GLC-FCS30	30	One year, 2015	Liu et al., 2020	Zhang et al., 2021	Yes	Yes	Yes Link	No	Stage 3
Landsat	FROM-GLC30	30	Intermittent, 2010, 2015, 2017	Pengcheng Laboratory, 2015 and 2017	Gong et al., 2013	Yes	Yes	No	No	Stage 3

Sensor/ satellite	*Land cover map*	*Resolution (m)*	*Temporal Frequency and Range*	*Link to data*	*Link to documentation/publication*	*Validated (Yes/No)*	*Validation methodology well described (Yes/No)*	*Validation data available (Yes/No)*	*Validation updated (Yes/No)*	*Validation stage*
Landsat, HJ-1	Globeland30	30	Intermittent, 2000, 2010 2020	Globeland30	Chen et al., 2015	Yes	No, Missing sample interpretation protocol description	No	No	Stage2/3
Sentinel-2	FROM-GLC10	10	One year, 2017	Pengcheng Laboratory	Gong et al., 2019	Yes	Not clear which validation dataset used, no details except Overall Accuracy number	Perhaps this dataset	No	Stage 2
Sentinel-2	ESRI Land Cover	10	Yearly, 2017-2022	ESRI	Data description Karra et al., 2021	Yes	No, lacking sampling design and sample interpretation protocol details	No	No	Stage 2
Sentinel-1, Sentinel-2	WorldCover (ESA)	10	Yearly, 2020, 2021	ESA	User manual v100 (2020) and v200 (2021)	Yes	Yes Validation report v100 (2020) Validation report v200 (2021)	No	Yes Tsendbazar et al., 2021	Stage 4
Sentinel-2	Dynamic World	10	Near Real Time, 2017-Present	Dynamic World	Brown et al., 2022	Yes	Response design described in detail, sampling design and analysis not clear	Yes, Brown et al., 2021	No	Stage 2/3

Global land cover maps with generalized multi-class legends with spatial resolution of 500m and finer, which map land cover for at least one year after 2013

Accuracy assessment in land cover studies



Webinar recording available at the LCLUC website: https://lcluc.umd.edu/sites/default/files/Pontius-Webinar.mp4

CEOS & GEOGLAM joint cropland validation workshop

- 12-14 September 2023, National Agricultural Library, Beltsville, MD;
- Co-hosted by CEOS LPV and GEOGLAM;
- Funding from NASA LCLUC and Applied Sciences programs;
- 47 participants from 9 countries (USA, Belgium, Canada, UK, Netherlands, France, Italy, Germany, Austria);
- 10 presentations sharing cropland validation and area estimation experience;
- 4 discussion topics (Cropland typology, sampling design, response design, quality metrics): keynote presentations and breakout group discussions followed by report backs; notes taken.

Outcomes and next steps:

- Formulated minimum requirements/critical components for cropland validation (not inventing the wheel, but rather communicating the basics to the cropland community).
- Agreed on the publication structure (community guidelines/good practices for cropland and crop type validation).
- **Peer-reviewed publication, Sophie Bontemps – lead author**, everyone is invited to contribute (please email Sophie at Sophie.Bontemps@uclouvain.be)
- Tentative timeline for submission to the journal – **Summer/Fall 2024**.
- Summary of this publication will be included in the general LC validation guidelines.
- Useful take-homes for the general LC validation guidelines, e.g. need to include the section on the key validation requirements early on, more clarity on spatial accuracy/uncertainty assessment, etc.
- We had a chance to talk to the LC validation guidelines contributors face-to-face!

Thank you for your attention!

If you want to serve as a **reviewer** of the LC validation guidelines, please contact me at **atyukav@umd.edu**