

State of the Art in Earth Observations: the golden age?

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Section 1.4 Remote Sensing and Geoinformatics

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Growing demand: Recent EU policies requiring Earth Observation

Stimulates varying sustainable land management, land use and resource use practices

Earth Observation becoming essential for policy making, compliance monitoring

Agricultural foci:

- Precision Resource Management
- Stress/Pest Control & Phenology Monitoring
- Yield Prediction
- Compliance Assessment
- Carbon/MRV

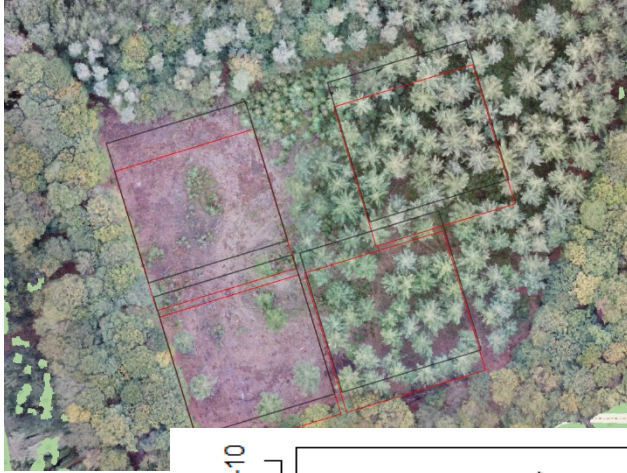
 Agriculture	• Common Agricultural Policy 2023-27 (Reg. (EU) 2021/2115-2117): 02/12/2021 (CAP initiated 1962) • Farm-to-Fork Strategy (COM(2020) 381): 20/05/2020 — superseded 2025 • Vision for Agriculture and Food (COM(2025) 75): 19/02/2025
 Forestry	• Stepping Up EU Action to Protect and Restore Forests (COM(2019) 352): 23/07/2019 • EU Forest Strategy for 2030 (COM(2021) 572): 16/07/2021 • Regulation on Deforestation-free Products (EUDR) (Reg. (EU) 2023/1115): 31/05/2023
 Climate change mitigation/adaptation	• EU strategy on adaptation to climate change (COM(2021) 82): 24/02/2021 • European Climate Law (Reg. (EU) 2021/1119): 30/06/2021 • Communication on Sustainable Carbon Cycles (COM(2021) 800): 15/12/2021 • General Union Environment Action Programme to 2030 (8th EAP) (Dec. (EU) 2022/591): 06/04/2022 • 2023 EU Regulation on Land, Land Use Change and Forestry (LULUCF) (Reg. (EU) 2023/839): 19/04/2023 • Carbon Removals and Carbon Farming Regulation (CRCF) (Reg. (EU) 2024/3012): 27/11/2024
 Soils	• EU Soil Strategy for 2030 (COM(2021) 699): 17/11/2021 • Soil Monitoring Law (COM(2023) 416) (proposed): 05/07/2023
 Biodiversity	• EU Biodiversity Strategy for 2030 (COM(2020) 380): 20/05/2020 • Nature Restoration Regulation (Reg. (EU) 2024/1991): 24/06/2024
 Inland Water/Marine waters and pollution	• Water Framework Directive (Dir. 2000/60/EC): initially adopted in 2000 • Proposal for a Directive amending the Water Framework Directive, the Groundwater Directive and the Environmental Quality Standards Directive (COM(2022) 540): 26/10/2022
 Air quality	• Zero Pollution Action Plan (COM(2021) 400): 12/05/2021
 Raw materials	• Critical Raw Materials Resilience (COM(2020) 474): 03/09/2020

Source: Berger et al., (2025): Evolving Earth observations for recent EU environmental policies, LUP, <https://doi.org/10.1016/j.landusepol.2025.107749>

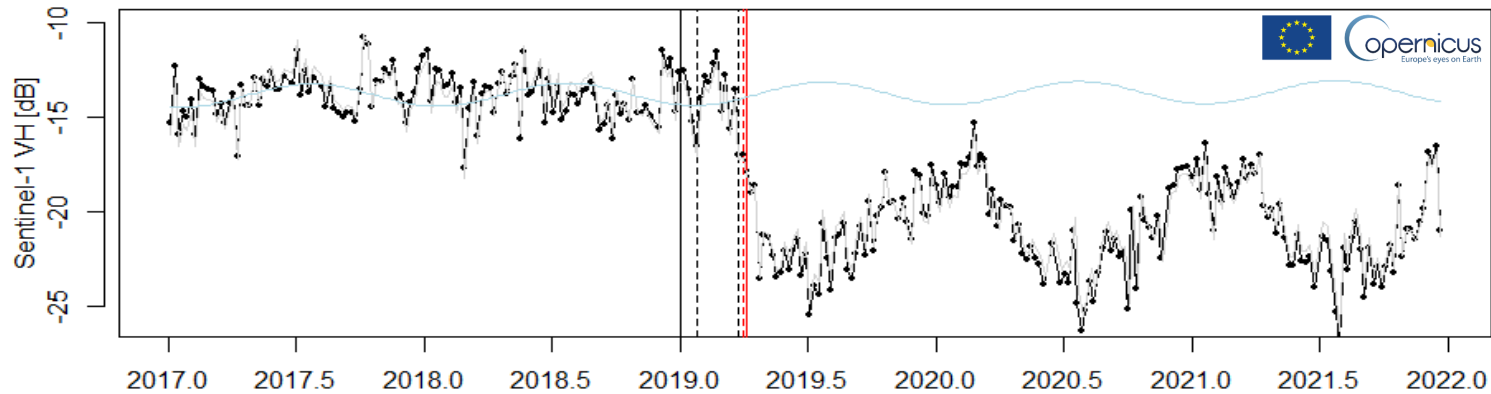
More technological opportunities to track critical dynamics from above

Remote sensing technology	In plain language: what it sees	Typical agricultural uses	What it misses or struggles with	Satellite data examples with Free/Public Access	Examples of Commercial/Paid
Optical	Reflected visible and infrared sun-light	Crop type, growing cycle, vegetation condition / management, yield proxies	Clouds, smoke, limited night use	Landsat, Sentinel-2 (10+ m)	PlanetScope (daily, 1-4 m), SkySat (tasked, sub-1m), others
SAR/RADAR	Surface structure and moisture response using microwave signals	Soil moisture proxies, flooding, crop type & structure, all-weather monitoring	Harder to interpret/more expertise needed; affected by geometry and surface conditions	Sentinel-1, NISAR, (ROSE-L 2029) – (10+ m)	ICEYE, Capella Space, RADARSAT-2
Thermal	Surface temperature / emitted radiation from land	Crop water stress, evapotranspiration / irrigation	Atmospheric effects; requires careful calibration	Landsat TIRS, ECOSTRESS, (LSTM 2029)	FLIR drone/airborne sensors, Hydrosat
Hyperspectral	Very detailed spectral signatures and land surface material properties	Crop traits, stress, biochemical properties (chlorophyll, nitrogen), soil characteristics (i.e. carbon)	Larger, complex data volumes, specialist analysis, ground calibration / validation	EnMAP, PRISMA, (CHIME 2029) – (30 m)	Tanager (Planet), Pixxel, Hypspx (i.e. drone)
LiDAR	Three-dimensional structure and height	Biomass, canopy structure, terrain	Coverage constrains repeated monitoring, current sensors with limited use for agriculture	GEDI, ICESAT-2 (spaceborne, gap-filled coverage only)	RIEGL (drone/airborne), Velodyne/Ouster (drone/airborne)

More frequent and near-real time monitoring



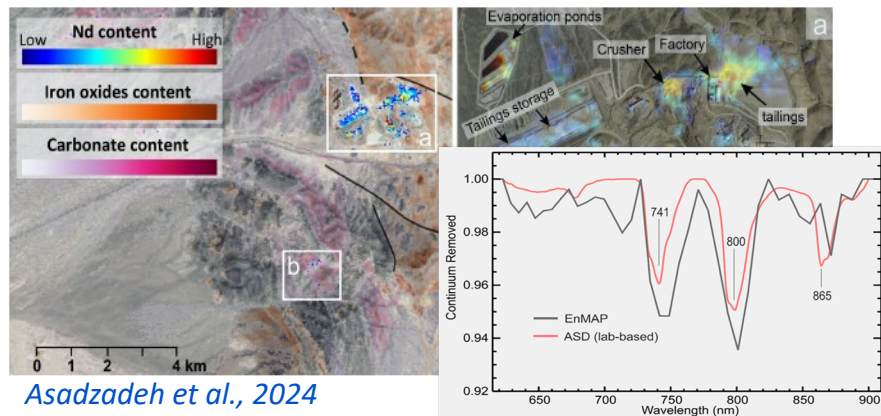
- Importance of dense global time series data (i.e. Sentinel 1: $\sim 10 \times 10$ m, 2-5 days repeat)
- Rapid detection of changes and tracking of land use, agricultural developments and management



Moving hyperspectral to add detail – ENMAP > CHIME

Article | [Open access](#) | Published: 05 September 2024

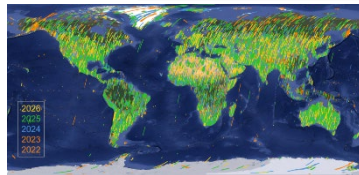
Detecting rare earth elements using EnMAP hyperspectral satellite data: a case study from Mountain Pass, California



Asadzadeh et al., 2024

www.enmap.org

Global archive
since 2022



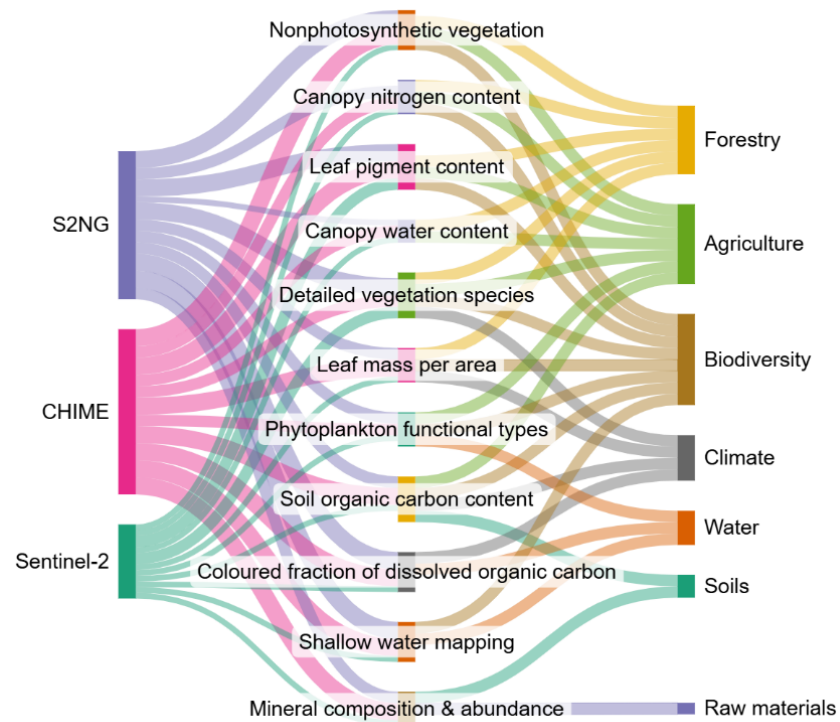
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Advancing optical earth observation for EU policies: needs, opportunities, recommendations

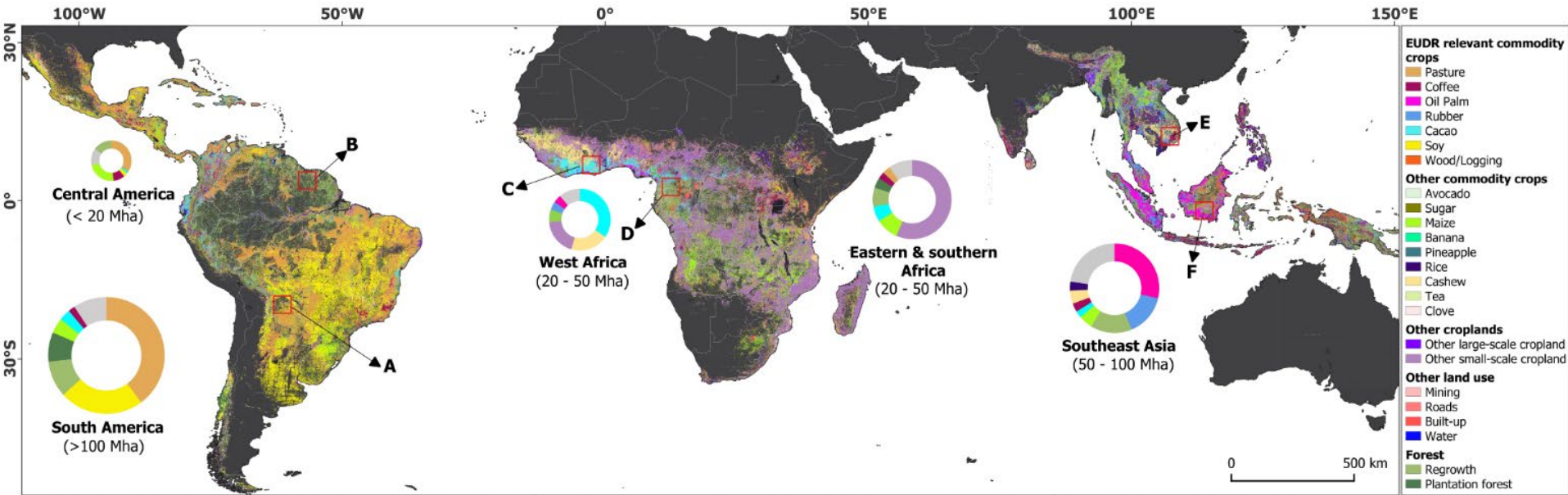
Review | [Open access](#) | Published: 11 February 2026

Volume 38, article number 52, (2026) [Cite this article](#)

<https://doi.org/10.1186/s12302-026-01346-3>



Tracking the diversity of agricultural crop types and commodities



Typical agriculture monitoring:

- Larger area: crop area and type
- Regional/local: crop condition, soil moisture/ irrigation, biomass and yield proxies

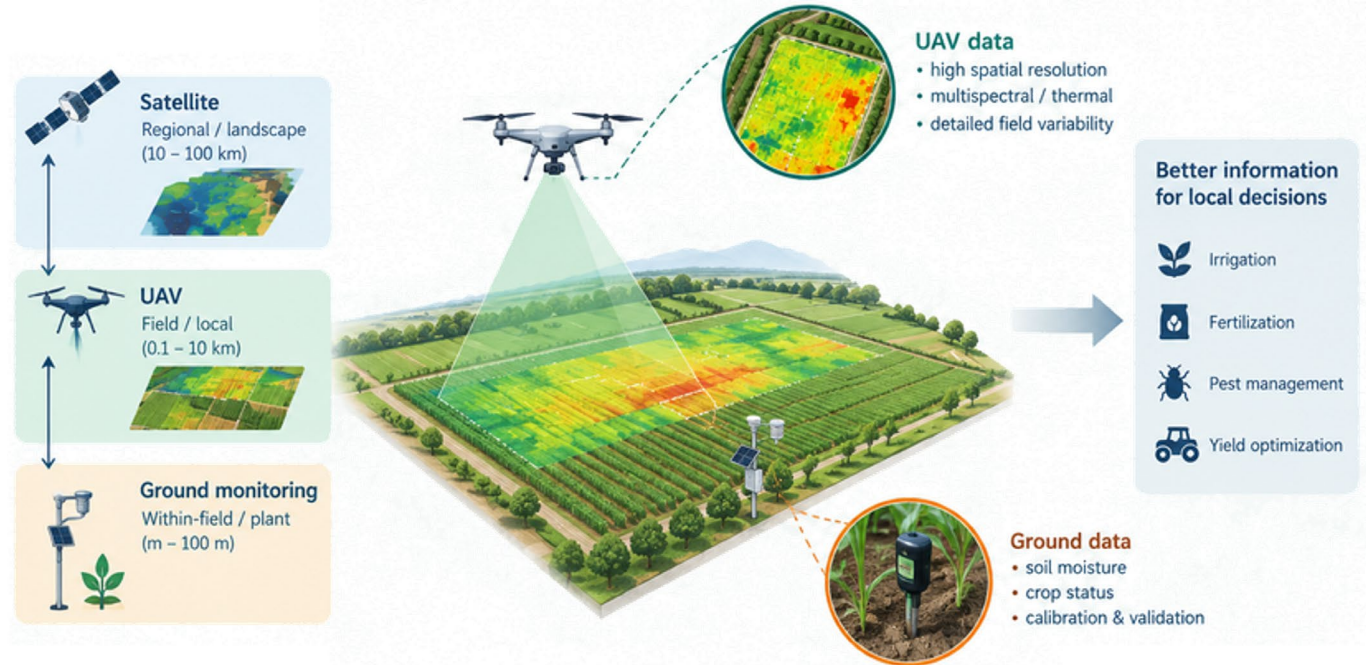
Source: Masolele et al., WUR (paper in review)

Africa data: Masolele et al., (2024). Mapping the diversity of land use following deforestation across

Africa. Nature Scientific Reports. <https://doi.org/10.1038/s41598-024-52138-9>

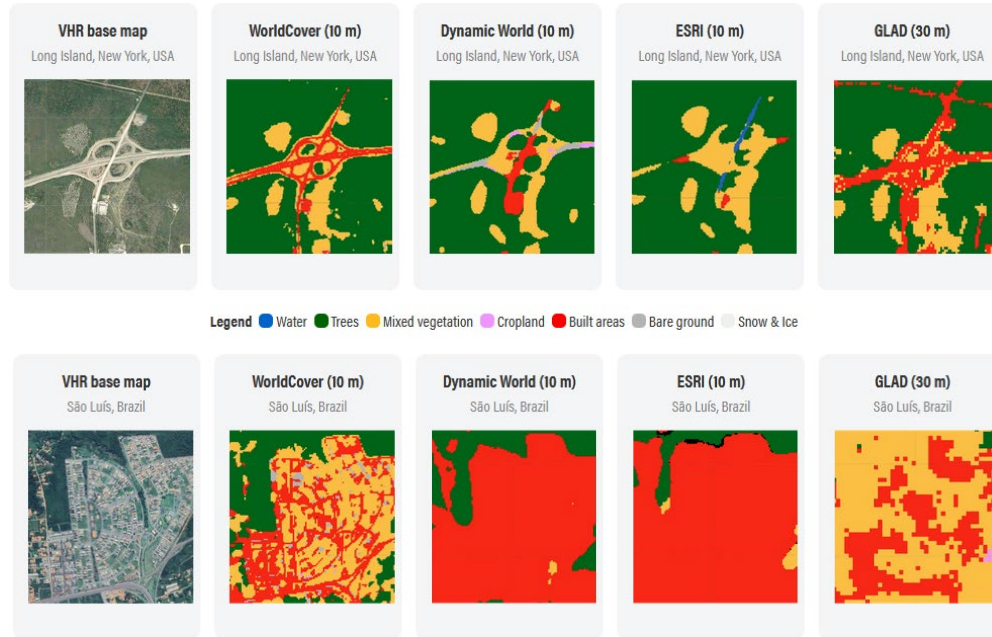
<https://robertnag82.users.earthengine.app/view/pantropicalandusefollowingdeforestation>

Going local: integration with near-sensing

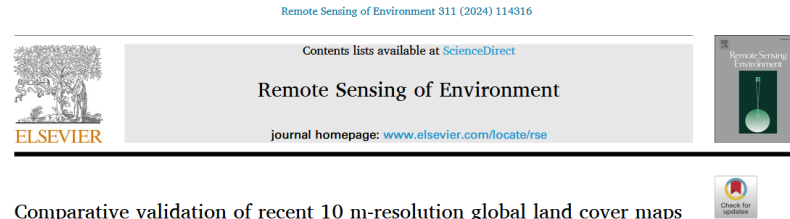


- Novel sensing systems (drones, in-situ)
- Each observation stream has advantages & limitations
- Local calibration, tuning and delivery

Turning data into information – right, wrong, different?



10m global land cover datasets comparative validation recently published in [scientific paper](#) and [user-oriented blog](#)



Comparative validation of recent 10 m-resolution global land cover maps

Panpan Xu^a, Nandin-Erdene Tsendbazar^{a,*}, Martin Herold^{a,b}, Sytze de Bruin^a, Myke Koopmans^a, Tanya Birch^c, Sarah Carter^d, Steffen Fritz^e, Myroslava Lesiv^e, Elise Mazur^d, Amy Pickens^f, Peter Potapov^f, Fred Stolle^d, Alexandra Tyukavina^f, Ruben Van De Kerchove^g, Daniele Zanaga^h

<https://doi.org/10.1016/j.rse.2024.114316>

WRI: <https://landcarbonlab.org/insights/global-land-cover-maps-accuracy-applications/>

Final reflections

- **Golden Age** for Earth Observations:
 - Increasing and diversifying demands (policy, services and science)
 - Key developments in sensor technologies (i.e. hyperspectral, near-real time)
 - More efficient approaches to turn data into information; incl. for agricultural purposes underpinning more efficient use of water, fertilizers, energy etc.
- **Mind the gap:** Earth observation technological advancements vs. user uptake
- **Decisions vs. uncertainties:** access, errors, privacy, ownership

GFZ Helmholtz Centre for Geosciences

Thank you

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