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Summary slides of L2 Validation part 1 & part 2

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Level 2 Validation – Part 1+2 Summary



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8 talks addressing

- Vegetation (land and water) monitoring with Sentinel 2
- Fiducial Reference Measurements for Vegetation monitoring
- Quality Control of Land Products benefitting from Machine Learning methods
- Water processing: future ESA aquatic reflectances product and processor, validation with in-situ network

Key findings and messages

- Literature study, PRISMA methodology, 1700 (1261 left after screening) papers analysed.
- Top 3 subjects: Phenology & growth monitoring; biomass, Carbon & GHG; stress and health monitoring
- New indices could be derived thanks to S2; multi-sensor integration required in the future
- The ICOS Integrated Carbon Observatory includes a global network of measurements supporting GHG, and methods have been developed to calculate land vegetation parameters (LAI and fAPAR).
- FRM4VEG is a key project supporting the validation of key European satellites and vegetation biophysical variables: surface reflectance (SR), fraction of absorbed PAR (fAPAR) and canopy chlorophyll content (CCC). It provides protocols, assessment of ICOS stations, and is currently assessing the feasibility of BRDF retrievals.



Key findings and messages (cont.)

- Use of AI in EO Quality control: Currently, AI is not largely used in the satellite EO data QC ecosystem, but it has great potential. The exploitation of the parallax due to the detector layout on S2 MSI for automated QC was demonstrated. Further, a general method for outlier detection using different NN models demonstrates the power. However, more research is required to raise such methods to an operational level
- Near-coastal lakes remote sensing signal analysis was performed in terms of contributions by bottom, water column, glint, and adjacency effect, using a set of new TOA reflectance-based indices without usage of SWIR bands.
- FRM4Drones-AQUA paves the way for Fiducial Reference Measurements for UAV-Based Aquatic Reflectance. Importance of generating transects of lakes to better assess adjacency perturbation of signal (~10 km). Two workshops were set to organise the common practices of this UAV-based validation community for water applications.
- HYPERNETS network is slowly expanding with 12 water and 7 land sites; a new site in South Korea, coming soon another one in Australia that would help to support the validation of new space hyper- and multispectral sensors. Adjacency effect need to be better characterised for each site as well as adjacency effect from clouds.
- Sentinel-2 Aquatic Reflectance Layer Processor (Sen2Water) will be available through a SNAP plugin with SNAP13 (October 2025). Preliminary validation showed good performance. Independent validation would be required to check, including how single aquatic reflectance processor compare with each other.



Recommendations

- Need for validation data was expressed by various participants, including radiometric measurements as well as vegetation products. HYPERNET provides excellent radiometric measurements. Future operations of HYPERNETS should be ensured and complemented with higher land vegetation products.
- ICOS network should be taken (better) into account as in-situ reference data source. ICOS mentions the possibility to discuss new products, adaptation of the protocols and new measurements if needed and critical. A feasibility and sustainability analysis is needed but if added they become standard and ensured long term.
- Recommendations from FRM4VEG
 - Surface reflectance: Further validation of additional Sentinel-2 scenes, encompassing a broad spectrum of DDV levels and vegetation types, is essential to rigorously test the underlying assumptions of the back-up algorithm.
 - Focus on the synergy between permanent and autonomous surface reflectance infrastructure and UAV-based hyperspectral.
 - Vegetation parameters: Review current mission requirements and set more realistic requirements at least for the threshold level both absolute (for very low values) and relative terms,
 - Setting procedures to undertake conformity testing at the decametric and the hectometric scales by directly comparing with spatially representative FRMs to avoid the two-stage validation approach uncertainties
 - A BRDF corrected Level 2 product should be considered. Inversion of the BRDF correction should be possible.



Recommendations (cont.)

- Recommendations from FRM4Drones
 - Inland/coastal aquatic reflectance (e.g., S2) needs distinct Cal/Val approaches vs. ocean colour where drones are involved
 - Clear consensus on the need for standardized calibration and processing protocols for drones
 - FRM4Drones will continue working towards these goals but probably will require follow-up actions.
- Adjacency effect should get more attention in the future. (few) algorithms are available and should be re-evaluated. New approaches may be investigated. WATERHYPERNETS and Drones can provide suitable reference data.
- The upgrade of the ESA L2A product with the aquatic reflectance requires proper validation in the OPT-MPC, supported by independent validation from S2VT
 - S2VT: Independent deep scientific analysis of match-ups, campaigns, time-series etc., Intercomparison of single processors (C2RCC, Acolite, Polymer) and alternatives processors
 - OPT-MPC: Maintain sen2water code including close collaboration with algorithm developers, continuous validation with publicly available reference data (Aeronet-OC, WATERHYPERNETS), intercomparison with other satellite products