CSQ-55 Summary

Question	Knowledge Advancement Objectives	Geophysical Observables	Measurement Requirements	Tools & Models	Policies / Benefits
What are local patterns of ecosystem structure and composition worldwide?	A) Quantifying three-dimensional vegetation structure at high resolution and at scales that also relate to ongoing on the ground ecological and forest monitoring networks	• Vegetation structure, height, cover, biomass • Fragmentation and connectivity • Related dynamics over time • Focus on related EBVs not covered by ECVs	• High resolution space-based LIDAR and RADAR measurements • Very high-resolution optical data • Quality ground reference networks (i.e. plot networks, GEOTREES) • Interoperability of different EO sensors and ground networks is important	• Various EO data analysis methods • Processing tools to allow for interoperability • Statistical and AI methods for integrating EO with innovative ground data	- UNCBD - IPBES - Nature-based solutions - Restoration efforts
	B) Characterizing ecosystem composition based on space-based imaging spectroscopy combined with ground reference data	• Species composition and biophysical/trait characteristics	• High-spectral-resolution / hyperspectral • Very high-resolution optical data • Innovative ground data (i.e. eDNA, sound sensors, citizen science)	• Various hyperspectral data analysis methods • AI for integrating EO with innovative ground data (i.e. eDNA, sound sensors, citizen science)	

CSQ-55 Narrative

What are local patterns of ecosystem structure and composition worldwide?

While ecosystems are undergoing rapid changes worldwide, a consistent, accurate and spatially detailed characterization of ecosystem structure and composition is largely lacking to date. Such information is essential to understand fundamental patterns of ecosystems and biodiversity and are needed to provide integrated information for guiding and assessing actions and policies aimed at managing and sustaining its many functions and benefits. In the recent assessment of EBV vs. remote sensing priorities (Skidmore et al., 2021), the variables focusing on the monitoring of ecosystem conditions (beyond just ecosystem extent) and structure (i.e. habitat structure, fragmentation etc.) have received a high score; considering that many of the top-ranking EBV's in that prioritization study are also covered by Essential Climate Variables (ECVs).

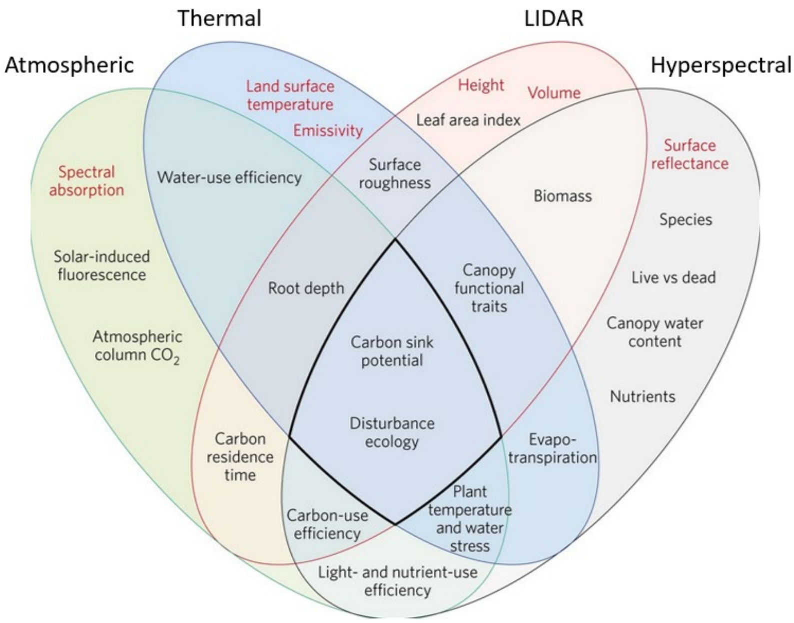

Fig. Synergy of different EO-based approaches for characterizing Ecosystems and Biodiversity (adapted from Stavros et al., 2017).

Advancing EO-based monitoring for such priority Essential Biodiversity Variables (EBVs) covering structure and composition can capitalize on new remote sensing opportunities. Only considering the synergy and interoperability of different novel EO-data streams allows for an increasingly comprehensive characterization of ecosystems and biodiversity (see figure above). Quantify the structure as key feature of many terrestrial ecosystems and forest, for example, can take advantage of various space-based mission either operation or forthcoming (GEDI/ICESAT-2, Sentinel-1, BIOMASS, ROSE-L …) that allow for much more detailed measurements of the three-dimensional structure at high resolution and at scales that also relate to ongoing on the ground ecological and forest monitoring networks. For characterizing ecosystem composition, the recent arrival of space-based imaging spectroscopy (ENMAP, PRISMA, EMITS, CHIME) provides new opportunities. EO-based in particular when combined with innovative ground data (i.e. eDNA, sound sensors, citizen science) to provide high resolution and accurate estimates of community composition.

These approaches should be leveraged for a new global effort for a characterizing both ecosystem structures and composition and its relationships at local and regional level. From an observation perspective, most opportunities exist for forests and vegetated ecosystems; but under-studied ecosystems (IPBES, 2019) such as freshwater systems, Arctic, marine/ocean, seabed, and wetlands should also be considered with priority.

From an observation perspective, using EO-system operating now or in the coming years provide a lot of additional new information that still needs to fully explored. One key challenge is interoperability. Different sensors and observational datasets will be useful (optical, hyperspectral, SAR, LIDAR etc.) and make sure they can be analyzed in conjunction and in consistent manner is to be ensured. The same is true for integrating with space-based on on-the ground monitoring. There is need for streamlining workflows from data collection to estimation and modeling across the different data streams and sources. High quality LIDAR/SAR observations are only available for recent years and will result in higher quality estimations. For long-term trends, the use of optical and SAR-based systems with a longer time series record is required.

In the longer term, a more precise and repeatable (i.e., revisiting the same areas every year) space-borne LIDAR system could be developed to track ecosystem structure increasingly through time.

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