Geophysical Research Abstracts
Vol. 20, EGU2018-17132-5, 2018
EGU General Assembly 2018

A novel approach to mapping functional diversity from space

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The rampant decline of global biodiversity over the last decades has become a major threat to the ecosystems on which humans depend. Large-scale monitoring tools are needed to get a grip on the current global biodiversity crisis. A full understanding of the biodiversity dynamics is required to develop and evaluate measures aiming at reverting further decline. Ongoing advancements in satellite remote sensing have raised expectations for comprehensive global monitoring of biodiversity. Specifically, functional diversity - the diversity in traits within vegetation communities - might be assessed from space with high potential for studying the diversity, productivity and stability of ecosystems. Until now, concrete observational proof using satellite remote sensing is still lacking. Here we present a first physical approach of mapping functional diversity from space.

In this study, we mapped plant traits and functional diversity metrics over a large spatial scale in Sabah, Malaysia using satellite imagery from Sentinel-2. The area presents an important biodiversity hotspot that is under increasing pressure of forest degradation and land use change driven by oil-palm and timber plantations. The approach first requires mapping of remote sensing derived plant functional traits, which include three traits; Leaf Water Content (LCW), Chlorophyll a-b (CAB) and Leaf Area Index (LAI), as retrieved through a neural network trained on radiative transfer models and the canopy reflectances. Based on these trait maps, functional diversity is mapped by three different metrics; functional richness, divergence and evenness.

The results indicate that the diversity in plant functional trait combinations are profoundly larger in intact forests than in oil-palm plantations and other land use types. Specifically, across the LCW-CAB dimension, diversity in plant trait combinations based on convex hull estimation, is found to be almost twice as large for intact forests as compared to oil-palm plantations. The functional diversity maps show that the remote sensing techniques are capable to detect that functional diversity patterns over a large areas providing novel possibilities for global biodiversity monitoring and opportunities to start managing the global biodiversity crisis. By linking the generated trait maps and derived functional diversity to land use data on intact forests, logged forests, cropland and oil-palm plantations, the research illustrates how satellite remote sensing derived functional diversity metrics can provide crucial understanding in land use - biodiversity dynamics. Ways forward for satellite-derived functional diversity monitoring will need to include temporal dynamics, incorporate more traits, spatial gap filling and reduce uncertainties through data assimilation of satellite archives and ancillary ecological data.