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Emerging trends in global forest above-ground biomass derived from a decadal time record of high-resolution satellite observations

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Characterization and quantification of terrestrial global carbon stocks increasingly integrates spaceborne remote sensing data. The wide range of multi-decadal time series of temporally consistent observations is key to understanding global processes related to terrestrial vegetation. As the organic mass stored in vegetation cannot be sensed, uncertainties in estimates of carbon stocks from remote sensing data can only be reduced by complementing multiple observations. This aspect is even more crucial given the weak sensitivity of the signals acquired by most systems in space to vegetation structural parameters. High-resolution observations, in addition, better allow natural events (e.g., fires) or processes (e.g., forest dieback) or human activities (e.g., shifting cultivation) to be identified, which in turn, improves understanding and explanations of vegetation carbon dynamics.

Time series of above-ground biomass (AGB, live) maps by the European Space Agency (ESA) Climate Change Initiative (CCI) Biomass for the years 2010, 2017, 2018 and 2020 were obtained from a combination of freely available high-resolution C- and L-band radar, laser and optical satellite observations. The pixel size of the maps was set at 100 m as a compromise between preserving spatial detail and reducing observational noise. The non-uniform temporal spacing of the mapping was selected to provide a first assessment of short- and long-term AGB dynamics.

Independent assessment based on *in situ* plots distributed across the major forest biomes and LiDAR-derived maps of AGB indicated a reliable representation of forest AGB levels globally. This first version of the CCI Biomass maps is therefore sufficiently reliable for identifying areas of changes that impact on the terrestrial carbon cycle. On the contrary, the presence of local biases and a 30-40% uncertainty relative to the estimated value do not allow for an estimate of AGB dynamics at the level of individual pixels. Such errors can be attributed to data quality or approximations in the models relating AGB to the remote sensing data.

Coupling biomass and land cover CCI data products revealed that, between 2010 and 2020, the terrestrial AGB pool in forests fluctuated between 550 Pg and 560 Pg while the global forest area increased by 1%. AGB changes were particularly evident in areas associated with persistent forest land, with areas such as western Canada and northeast Europe losing biomass whilst others (e.g., central and southeast Asia) experienced net gains. Differentiation between natural and plantation forests was not achieved and so the relative contribution of losses and gains associated with each was not able to be discerned. Conversion of forest to cropland and grassland resulted in a loss of

approximately 0.8 Pg of AGB whilst conversion of these non-forest landscapes to forest increased the global AGB pool by 0.2 Pg.

This presentation will review these emerging trends and give a perspective on the future suite of ESA CCI Biomass data products, which foresee a more regular temporal sampling, an extended time interval, and the inclusion of a wider range of recent satellite observations (e.g., by spaceborne LiDAR) and satellite data products with improved radiometric quality.

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