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Interactive comment on "The global forest above-ground biomass pool for 2010 estimated from high-resolution satellite observations" *by* Maurizio Santoro et al.

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This comment is welcome because it sheds light on a feature of potential positive impact on global biomass estimation that could not be exploited to generate the dataset presented in this manuscript. Physically, the availability of a fully polarimetric dataset provides the most complete description of the forest structure seen by radar. Conversely, a dual-polarized acquisition misses part of the forest structure. The question, however, is which radar observable makes the difference.

In terms of radar backscatter, as used in this study, a fully polarimetric dataset is in our opinion of marginal benefit compared to a dual-polarimetric dataset. This is probably

the reason why fully polarimetric observations are usually ditched. Radar backscatter is a simple observable compared to more advanced observables that can be obtained from radar observations, e.g., through polarimetric, interferometric or tomographic processing. Nevertheless, these advanced observables are necessary for vegetation studies. The real potential of the fully polarimetric dataset is in the phase component of the signal because the phase captures the spatial variability of the vegetation structure more than the intensity. At L-band the scenario is, however, tricky because part of the vegetation is transparent, so the understanding of the signal is not straightforward.

Probably, the lack of a broad understanding of how the diversity of vegetation structure globally affects the polarimetric signal is the answer to the questions above. The global forest biomass retrieval presented in this study is based on evidence from an extensive literature (Santoro and Cartus, 2018) that assessed radar backscatter observations all over the world. This understanding is, in our opinion, still in its infancy for polarimetric observables. The lack of repeated observations at multiple locations is a reason for the slow development of large-scale thematic mapping based on polarimetric observations. Given the lack of knowledge, it is therefore premature to advocate satellite missions focusing on fully polarimetric observations. Of course, other variables affect the decision whether to select a DP over a FP mission (e.g., revisit times, bandwidth, frequency of observations) but this goes beyond the question posted in this comment on whether FP observations are of benefit to global forest biomass estimation.

Narrowing down our reply to this study, the availability of a global dataset of L-band FP data consisting of multiple acquisitions throughout one year would have been of enormous benefit to overcome what we see as two major weaknesses, i.e. the underestimation in forests with high AGB and the inability to capture small-scale variability of vegetation structure.

In our retrieval procedure, GSV (and thereof AGB) is predicted from observations of the radar backscatter, which combines horizontal properties of the canopy (density of trees, branches, foliage) and vertical properties (height) in a single measurement. The

limited capability of C- and L-band signals to penetrate dense canopies leads to weaker sensitivity of the backscatter to taller and denser forests. Resolving such forests with a closed canopy and different heights, i.e., different biomass levels, with backscatter observations implies considerable errors. In our study, several measures were implemented to reduce these errors (multi-temporal observations, spatially adaptive estimation of model parameters, simplifications in the retrieval models, etc.). Nonetheless, we could not overcome the inherent limitations of the observations, resulting in systematic retrieval errors

Again, the fact that the radar backscatter is an ensemble of horizontal and vertical properties of the vegetation is a limiting factor in ecologically diverse environments. Although we did not assess the global AGB dataset with respect to ecological zoning, we may assume that the dataset presents some systematic issues in regions where the radar observables could not resolve different vegetation structures. Resolving structures by polarimetric observations would be of substantial aid to improve biomass mapping.

In conclusion, although this manuscript does not discuss which satellite observations are most suited to estimate biomass globally, this comment provides some indications on the role of FP observations in future biomass mapping activities: 1. Foster studies on polarimetric observables at multiple sites; such studies should assess simultaneously the benefit of multi-temporal and multi-frequency observations 2. Undertake benchmark studies of FP vs. DP-based retrievals in forests prone to retrieval errors with the latter type of data (tropical rainforest, ecologically diverse environments) 3. Explore whether the polarimetric observables from global FP datasets (ALOS-1 and ALOS-2) present a diversity of values compared to the basic radar backscatter from DP observations

A solid knowledge of the FP observables would certainly foster discussion on the gain from implementing FP observations in future L-band SAR missions.

Reference

Santoro, M. and Cartus, O.: Research Pathways of Forest Above-Ground Biomass Estimation Based on SAR Backscatter and Interferometric SAR Observations, Remote Sensing, 10(4), 608, https://doi.org/10.3390/rs10040608, 2018.

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