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Hydrology and Earth System Sciences Discussions

Interactive comment on "Estimation of forest structure metrics relevant to hydrologic modeling using coordinate transformation of airborne laser scanning data" *by* A. Varhola et al.

Anonymous Referee #3

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General comments:

The authors describe an approach for the derivation of various forest canopy metrics using airborne LiDAR data. They do so by emulating hemispherical photographs (HP) through a transformation of the LiDAR data from a given Cartesian world coordinate system to a local projected polar coordinate system. Additionally, a number of LiDAR metrics describing canopy architecture are derived on a plot level to allow for a comparison of both methods. Hemispherical photographs were used as ground truth and in regression analysis to test for significance of the derived metrics and for predic-

tion. The paper is well written in good English, the literature research seems extensive and the figures are sufficiently clear. The topic raises a number of scientifically highly interesting questions (mostly related to the complex scattering process of light in vegetation), some of which the authors try to answer in the discussion and conclusion. The approach is interesting because it describes a flexible method for the derivation of structure metrics from LiDAR data at arbitrary locations.

Overall I think the paper is significant and the topic is well suited for publishing in HESS.

Although not the goal (as the authors mentioned), I think the method could be easily applied to other types of forest and LiDAR data sets, as I see no special requirements of the method in this context that would suggest otherwise. Especially the application of full-waveform data (FWF) would open up new prospects for the approach. It would benefit from the generally higher amount of returns in vegetation and from the additional radiometric and geometric properties that can be derived from FWF (i.e. width of backscattered echo and backscatter cross section). The backscatter cross section could also be another solution for one of the approach's drawbacks: the more or less arbitrary size of the projected LiDAR echo. Wagner et al. (2006, 2008) describe the backscatter cross section as the effective area of collision of an object and the laser beam. Having FWF data at hand, this measure could be calculated and used for deriving the size of the echoes.

Another drawback I see lies in the differing viewing geometries of airborne LiDAR and HP. The authors mention this difference in the manuscript as an error source. I actually think that low to medium density LiDAR point clouds (as used in the study) do not offer enough detail to represent sub-canopy architecture (i.e. leaves and branches) directly, but more a rough abstraction of them (regardless of discrete or full-waveform LiDAR). For features like leaves and branches, I think one would need really high density LiDAR point clouds (e.g. >250 echoes / mˆ2, possibly from UAVs) or use terrestrial laser scanning data, as mentioned by the authors. This is critical because HP gives exactly that: a representation of sub-canopy strata.

Specific comments:

p. 5540.L3: even though the reader gets the meaning, the formulation "one-dimensional laser point" sounds odd to me. Maybe this can be rephrased.

p. 5541.L1-10: a long description on the optical distortions of hemispherical lenses is given, only to conclude with one sentence that circular representations for the LiDAR "spheres" are used because it is easier to plot them. So the description can be shortened. p. 5543.L9: "LD" in my opinion is related to both: structure and acquisition conditions (e.g. dense canopy architecture will influence LD).

p. 5543.L26: I think that vegetation echoes at small angles of incidence are also less likely because the footprint is bigger, thus the available energy for every scattering element is less and therefore often not enough to trigger a return pulse in the detector. I cannot really follow the argument with the longer path length.

p. 5550.L21: of the 3 given explanations I believe number 1 is the most reasonable. I would not expect too big structural changes in a larger number of plots within a period of 6 months, if there was not a storm or other acts of nature, desease, ...a.s.o. The positional inaccuracy should also not be too big of a problem (could easily be tested with higher accuracy GPS...e.g. longer GPS acquisition times).

p. 5554.L12: the authors state that their method avoids the need for a seperation of LiDAR points into ground and non-ground classes. This is not a generally difficult task, as a DTM is usually at hand. And in the paper a seperation in "canopy" and "sub-canopy" echoes is carried out, which is essentially the same.

Technical corrections:

p. 5540.L18: ...the diameter of each projected...

p. 5551.L2: ...needs to BE sufficient...

References:

W. Wagner, A Ulrich, V. Ducic, T. Melzer, N Studnicka: "Gaussian Decomposition and Calibration of a Novel Small-Footprint Full-Waveform Digitising Airborne Laser Scanner"; ISPRS Journal of Photogrammetry and Remote Sensing, 60 (2006), 2; 100 - 112.

W. Wagner, M. Hollaus, C. Briese, V. Ducic: "3D vegetation mapping using small-footprint full-waveform airborne laser scanners"; International Journal of Remote Sensing, 29 (2008), 5; 1433 - 1452.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 5531, 2012.