

Interactive comment on “Technical Note: Hyperspectral lidar time series of pine canopy physiological parameters” by T. Hakala et al.

Anonymous Referee #1

Received and published: 17 December 2014

This is an interesting paper with significant novelty in testing a range of spectral indices derived from multispectral laser scanning. The study is very small in scale and includes only very limited sampling, but does provide an initial demonstration of the potential of this technology for plant physiological measurements. In this context it does represent a significant and original contribution to the literature. It is likely to be of significant interest to both the plant physiology and remote sensing scientific communities. However, it could be improved by English language editing, clarification of the methodology and a more thorough discussion of results as outlined below.

Specific comments: 1) The title of the paper refers to ‘physiological parameters’ but the study only really considers the single parameter of chlorophyll content. I think the title could be more specific and therefore more fitting to the study. The lidar system would

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also be better described as multispectral as it measures at only 8 discrete wavelengths.

2) Page 15022, lines 5–8: A single panel of 99% reflectance is used to normalise the lidar intensities. This will account for range influences, but is a single reflectance panel sufficient? Is the detector response linear? Is the laser output intensity constant? Given the focus of the paper is on the intensity data the normalization method is of considerable relevance.

3) Page 15022, lines 18 – 24: Only a very small number of needles are sampled at each time period. The majority of the results discussed rely on the Chlorophyll content of just 2 needles from 2 branches (i.e. 4 needles in total) at each time period. This limitation is acknowledged by the authors, but does reduce conclusiveness of the study somewhat. Whilst little can be done retrospectively to remedy this, the sample size should be made clear upfront in the methods not just later on in the discussion (i.e. the number of needles per sample needs to be included here in all cases).

4) Page 15023–15024: A range of indices are tested, benefitting from the multiple wavelengths of the lidar. This is a novel and interesting aspect, representing an advance on previous attempts to retrieve physiological parameters from single / dual-wavelength systems. However, a little more discussion of these indices would be useful in terms of the extent to which using different wavelengths (those of the lidar) to those for which they were designed might influence results and their sensitivity to structural changes and multiple scattering. With this system, needles will be significantly smaller than the footprint so these factors as well as physiological parameters could have significant influence (and structural changes might influence results based on a time series).

5) Page 15024, line 14 (and fig. 2 caption): There is reference here to the branch parts ‘drying out’. It is unclear where the physiological measurements to demonstrate the shoots are drying are and which spectral index would show water loss (rather than other physiological / structural changes). Only NDVI is plotted. Can it be demonstrated the NDVI changes are due to loss of moisture content?

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6)Conclusions: I find the conclusions reached rather broad. The paper demonstrates, based on a quite limited sample, that Chlorophyll content (not all 'physiological parameters') can be estimated from a multispectral lidar system and that changes over time can be detected. It less clearly shows the extent to which spatial variation can be mapped as only a limited needle sample from a small number of branches was taken. It would be useful to see a more thorough discussion of the findings and the potential challenges of applying such systems (e.g the role of multiple scattering, how to determine if a point is a needle rather than woody material, influence of structural change on physiological parameter estimates). At least an acknowledgement of such issues should be included. Re. the 'further work', what specifically would be needed that hasn't already been examined in the hyperspectral remote sensing / leaf optical properties modelling literature? Are there reasons the indices likely to work with lidar might be different to those for passive optical systems?

7)Figure 3: While there is some relationship shown for mean values in Fig. 3 bottom row, it would be useful to know if there was any statistically significant differences in laboratory and lidar measurements for each branch (and the tree) between dates. The spectral changes look rather limited and the indices quite variable (top row graphs) compared to the laboratory measurements.

Technical corrections:

There are a number of grammar errors in the paper. It would benefit from detailed language editing.

Page 15025, lines 16-19: This is unclear. Rephrase this. What is meant by 'the weight of the year 0 and 2 laboratory measurements'?

Interactive comment on Biogeosciences Discuss., 11, 15019, 2014.