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Biogeosciences Discussions

Interactive comment on "Remote sensing of plant trait responses to field-based plant-soil feedback using UAV-based optical sensors" *by* Bob van der Meij et al.

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Anonymous Referee #1 Received and published: 12 December 2016

The paper is well written and logically structured. A plant-soil feedback experiment inducing variation in the growth of Avena sativa (oat) is used for the development of a model predicting plant height biomass, N-content and chlorophyll content. The models (for each plant characteristic) were build using hyperspectral and DSM information derived from a UAV flight. The model was built from a calibration dataset and validated on a validation dataset derived from the same population. Only one UAV flight was executed around the time of maturation of the plants as mentioned by the authors. The model building is well described as is the effect on predicted values and the subsequent

statistical analysis (Fig. 6). Reply: We thank the referee for these positive comments on our manuscript.

In the title 'field-based plant soil feedback' is mentioned but no real biological interpretation related to the preceding crop is given. This experiment was used to assess variability in plant characteristics as such I would omit this in the title and put 'Avena sativa' instead. Reply: In our study we tested the variability in plant traits of A. sativa in response to the legacies of the preceding crops. Therefore we prefer to retain the title and will provide a more extensive biological interpretation in the discussion part of our manuscript. The plant-soil feedbacks are generated via nutrient mineralisation/immobilisation which supports/constrains plant growth and these are linked to different organic matter inputs resulting from the cover crop treatments. Also the build-up of plant growth suppressing organisms can suppress plant height, biomass and nitrogen content, these effects however are more patchy/less homogeneous than plant-soil feedbacks generated via nutrient cycling.

The model building is well described. Future improvements could be using a different flight, derived from a subsequent day, as a validation data set or use a bootstrapping method to find the best combinations of indexes or even use machine learning techniques based on the wavelengths. Reply: We agree that further improvements of our model building are possible and should be explored. We will provide these in the discussion by including the paragraph 4.4 Future improvements, these will include using data of several flights to improve temporal resolution, data analysis via bootstrapping and machine learning, and more accurately aligning field sample locations with UAV spectrometer data from which data is further processed, and improving the spatial sampling to also capture within plot variation. We will also include extra references: Capolupo, A. et al. (2015) Estimating Plant Traits of Grasslands from UAV-Acquired Hyperspectral Images: A Comparison of Statistical Approaches. ISPRS Int. J. Geo-Inf., 4: 2792-2820. Souza, A.A. et al. (2010) Relationships between Hyperion-derived vegetation indices, biophysical parameters, and elevation data in a Brazilian savannah environment. Remote Sensing Letters, 1: 55-64. Singh, A. et al. (2016) Machine Learning for High-Throughput Stress Phenotyping in Plants. Trends in Plant Science, 21: 110-124. von Bueren, S. et al. (2014) Comparative validation of UAV based sensors for the use in vegetation monitoring. Biogeosciences Discussions, 11: 3837-3864.

It is to be expected that there is a lot of redundancy to be found between the tested NDVI indices. Other combination of indices will perform as good or almost as good this could be discussed. Reply: We included the range of different NDVI indices because these have all been reported in literature and tested for one or two plant traits, whereas we wanted to explore how well these indices performed across a wider range of plant traits. We agree that redundancy between the indices can be expected but as it was not a priory clear which ones would produce the best results for our range of plant traits we decided to test the available indices as well as new combinations of two spectral bands in SR, SD and NDV indices. We will include in our discussion (section 4.2 Plant traits and physiological stage) that we tested a range of indices because the best fitting index was not a priory known and may differ depending on plant physiological stage. Some minor issues are: - describe the RTK-GPS used: type, company, country Reply: Included

- describe how plant height was measured e.g. from soil level to the tallest stretched leaf or. . . Reply: Indeed from soil level to the top of the plant, we include this now in material and methods.

- p7l36: the sentence is unclear, probably a word is missing Reply: We rephrase the sentence into '. . .although indices yielding comparatively high coefficients of determination in relation to a distinct trait were generally found to also be rather strongly correlated to multiple of the other studied traits'.

- p9l30: 'biophysical and biochemical oat plant constituents'. I would replace 'constituents' by 'characteristics' Reply: Replaced as suggested.

- p9l34: F-values are reported except for N content, why? Reply: The data of the

in situ measured N content did not meet the assumptions for using parametric tests (variances were unequal also after data transformation). Hence we performed non-parametric tests which do not yield an F-value, we report the $\chi 2$ value instead.

- p9l35: the authors report that 'similar results' were found related to the F-values. If you compare the F-values, differences can be found resulting in a better post-hoc differentiation of the treatments. This is the case e.g. for fresh biomass: 4.93 vs. 24.58 or for Chl content: 11.10 versus 26.91. This should be more discussed. Reply: We do not explicitly compare F-values as such, we do compare whether or not the differences between the plant legacy treatments can be picked-up and whether the same treatment levels are being discriminated using the in situ measured data on the one hand and the remote sensed and modelled data on the other hand. We rephrased this part of the results to make clear what we mean: 'Similar results were found when using the predicted plant trait values from the remote sensing data to test the soil legacy effects: we found significant effects of plant legacies on oat plant height (F6,21= 18.05, p< 0.001), fresh biomass (F6,21= 24.58, p< 0.001), leaf chlorophyll content (F6,21= 26.91, p< 0.001) and N content (F6,21= 11.87, p< 0.001) (Fig. 6e-h).'

-p10l27: '2008; ' – '; ' can be removed Reply: We removed the ;

- Fig. 3: a colour legend of plant height should be added. Reply: We now included a colour legend for the figure showing plant height.

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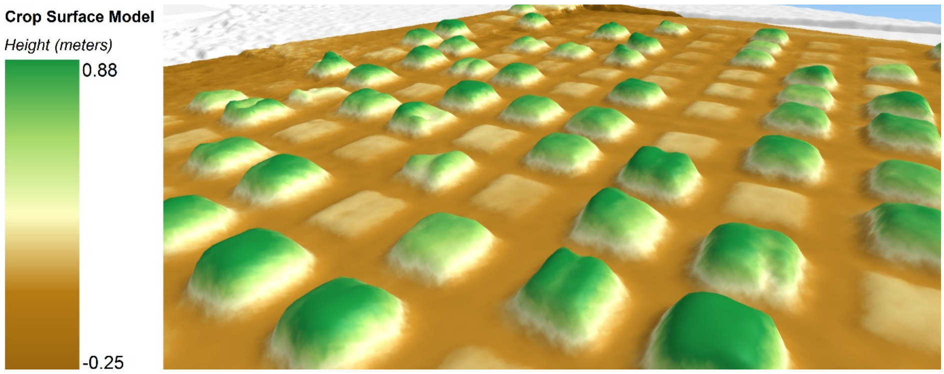

Fig. 1. New figure oat hight