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Interactive comment on "Comparative validation of UAV based sensors for the use in vegetation monitoring" *by* S. von Bueren et al.

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General comments Overall the authors present an interesting study comparing four imaging and non-imaging spectral instruments integrated in small multi-rotor UAVs for vegetation monitoring. The overall scope of the paper should be of interest to the UAV remote sensing community. The paper has the potential to make an important contribution providing practical advice on UAV sensor configurations for different spectral sampling requirements. However, in its present form there are several key issues that should be addressed:

1. From the introduction it is not entirely clear what the specific aim of this paper was and how it builds onto previous work. Burkart et al. (2014) previously presented the UAV STS system and described the spectral performance of this system. Nijland et

al. (2014, link provided below) presented in great detail how consumer-grade cameras can be utilised for spectral imaging (and where they fall short). There are other UAV papers that deal specifically with the TetraCam mini-MCA. This papers seems to combine these sensors and approaches in a single study within the context of pasture management. However, the authors should be more specific about the research niche of this paper. Can you be more explicit about the innovation and contribution of this study? How does it build onto previous studies?

2. One of the key issues in this study is the difference in spatial scale and field of view of the different sensors. When comparing spectral performance, the spatial footprint and area sampled should be identical. The fact that there are major spectral differences between the ASD ground spectra, TetraCam imaging spectra, and STS UAV-based point spectra does not surprise me. I would expect these differences to be caused by the differences in footprint (area measured/imaged) and BDRF effects. One of the key contributions of this paper could be to quantify and test these effects.

3. Another key issue is the inaccurate positioning and sensor pointing ability of the UAV systems. This relates to my point about footprint above. If the uncertainty in the waypoint position is 5 – 10 m (typical for navigation-grade GPS) in addition to uncertainty in the pitch, roll, and yaw of the sensor (caused by multi-rotor movement and inaccuracies in the gimbal) there is potentially a very large difference in the area being sampled. Repetitive and overlapping sampling over homogenous sites might reduce this effect, however, this needs to be described in more detail in the paper.

4. This study in carried out in the context of pasture management. It would be nice to see some practical applications of how point-based and image-based spectral information might be used in the context of pasture management. There is no need to go into derivation of standard vegetation indices, but it would be good to illustrate the power of high spectral resolution vs high spatial resolution sensors in the context of remote sensing products (biophysical and biochemical derivatives) for pasture management. This is another area where the paper falls short, but where it could make a

significant contribution. In the discussion and conclusion the paper could suggest how the systems could be used in practice and what the advantages and disadvantages of each of the sensors are (rather than it just being a comparison of standard vegetation signatures).

5. I was wondering if the ASD HandHeld2 was calibrated. The device is used to measure on-ground reference spectra, but can it be trusted as a 'reference' instrument?

6. Overall, the writing style is good and it is easy to follow. The quality of the figures is good as well.

7. This paper has the potential to make a great contribution to the UAV remote sensing literature, but I feel slightly more detail and consideration to some of the points outlined above is required.

Specific comments: -The second half of the abstract seems too generic about the main findings. More specific information about the results could be included.

-P.3 l.25: I recommend adding some information on the type of remote sensing products that are required on a dairy farm. What are the typical spectral derivatives that could benefit pasture management? Is it important to get information on biomass, nutrients, and other specific biophysical and biochemical characteristics, or is a simple NDVI sufficient for estimation of overall grass density?

-P.4 l15: 'remote sensing data' is very generic. What type of remote sensing data is required for precision agriculture applications and pasture management specifically?

-P.4 l23: I recommend replacing table 3 with a graph showing the spectral response function of the MCA filters. If these are 'standard' Andover filters this should be straightforward as the spectral response functions are provided on the Andover website. This would give a good visual indication of band width (FWHM), wavelength position, and transmission.

-P.5 l6: Perhaps come up with a name for the custom designed STS, e.g. STS UAV.

Also, please specify what customisations were employed. How is this STS different from the standard OO STS?

-P.5 l9: How was the "high spectral accuracy" verified? Is this statement based on the instrument specifications or was it cross-calibrated with the ASD? If so, how did the sensors compare on the ground?

-P.5 l15: Was the FOV of the STS spectrometer and the RGB camera the same?

-P. 5 l25: Important to mention here that the spectral response of this camera is also based on the Bayer pattern and that there is significant overlap between the three bands. A good reference is Nijland et al. (2014) Monitoring plant condition and phenology using infrared sensitive consumer grade digital cameras (downloadable from http://www.geo.uzh.ch/microsite/rsl-documents/research/publications/peer-reviewed-articles/Nijland2014_AFM-1460242176/Nijland2014_AFM.pdf)

-P. 6 l15: Was georeferencing done with a navigation-grade GPS (5-10 m accuracy) or a more accurate geodetic RTK GPS?

-P.7 l12: Were the aperture and shutter speed settings fixed on the Sony RGB camera? This seems important if the image pixel values were used for spectral measurements. Also, were images recorded in the RAW format?

-P.7 l13: It would be good to show the spectral signatures of these tarpaulins. Isn't it common practice to use spectrally 'flat' reference targets at different reflectance intensities for empirical line correction rather than coloured targets?

-P.8 l1 and Fig.3: please explain how the six MCA bands were spatially aligned.

-P.11 l9-16: Could you explain the value in looking at the correlations between cameras/sensors? It might be clearer just to compare each sensor to a reference, e.g. ASD.

-P.12 l15-20: I would expect that such a large difference in footprint of the spectrometers would result in large differences in the measured spectra.

-P. 13 l22-29 (and section 2.2): I recommend to only briefly list the UAV system and not compare the two platforms. The focus of the paper is on the sensors, not on the platforms. There are probably more suitable commercial platforms available now (and the market is changing rapidly). From an academic perspective it is best to focus on the sensors in this paper and I recommend reducing the comparison between platforms.

-P.14 l11-13: The overly positive start of the conclusions contradicts the more critical/negative experience just outlined in the last paragraph of the discussion.

Technical corrections -Please see annotations in PDF of manuscript

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/11/C885/2014/bgd-11-C885-2014-supplement.pdf

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