Dear Dr. Hueni,

We are grateful for your interest on this study and your constructive comments and suggestions concerning the hyperspectral measurements. Please find below your comments with our response and the related changes (highlighted in red) in the manuscript.

**(1) The third correction step related to the jumps in-between the VNIR and SWIR1 detector of the ASD spectroradiometer must be regarded as suboptimal. We have just recently provided physical evidence as to the reason for these effects, which can be attributed to instrument temperature and field of view effects. Hence, an additive correction as used here is introducing new radiometric errors while appearing optically more pleasing due to the removal of the obvious jump.**
**Details may be found in: Hueni, A. and Bialek, A. (2017). "Cause, Effect and Correction of Field Spectroradiometer Inter-channel Radiometric Steps." IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 10(4): 1542-1551.**

Answer:

Thank you for this hint. When we tried to apply the recommended jump correction algorithm, we recognized that the hyperspectral data were acquired as raw digital numbers (DNs) and reflectance factors only. Thus, the pre-processing algorithm was applied to DNs instead of radiance (contrary to the description in the first version of the manuscript). The acquired DNs differ from the corresponding radiance by a sampling interval dependent constant factor. Therefore, the applicability of the processing steps described in the manuscript and the resulting reflectance factors are not affected by the confusion. However, for the correction of the jump between the VNIS and SWIR1 detector (step 3), the algorithm of Hueni and Bialek (2017) cannot be applied, since radiances are required as input quantities.

The preprocessing steps will be retained and complemented according to your recommendation in comment (2.1). In addition, we will adjust the nomenclature of radiance and DN.

Changes in manuscript:

Page 8, line 20-21. Modified text: "Raw digital numbers (DNs) of the surface spectra and the related hemispheric-conical reflectance factors (Schaepman-Strub et al., 2006) were measured with a FieldSpec 3 spectroradiometer (FS3; Analytical Spectral Devices Inc.)."

Page 8, line 33-35. Modified text: "[…] (2) linear interpolation of the DNs acquired over the Spectralon before and after the target measurement runs to get an estimate of the white reference (WR) spectra at the time ($t$) of each target measurement (Milton et al., 2009)."

Page 8, line 35-37. Modified text: "Based on the estimated digital numbers of the white reference ($DN_{estWR}$), target digital numbers ($DN_{target}$) were converted into relative reflectance factors $r_{rel}$ applying Eq. (7) (Peddle et al., 2001):

$$r_{rel}(\lambda, t) = \frac{DN_{target}(\lambda, t)}{DN_{estWR}(\lambda, t)}$$

Page 8, line 40. Modified and added text: "$r_{rel\,VNIRcorr}(\lambda) = r_{rel\,VNIR}(\lambda) + r_{rel}(\lambda = 1001\,nm) - r_{rel}(\lambda = 1000\,nm)$ . \hfill (8)
Relative reflectance factors recorded in the SWIR1 domain were selected as reference level since the SWIR1 detector shows the smallest temperature related spectral drift (Hueni and Bialek, 2017);"

Page 15, line 22. Added reference: Hueni, A. and Bialek, A.: Cause, Effect, and Correction of Field Spectroradiometer Interchannel Radiometric Steps, IEEE J. Sel. Top. Appl., 40, 1542-1551, doi:10.1109/JSTARS.2016.2625043, 2017.

**(2.1) A further point that may be considered is the correction for the reflectance of the white reference panel.**

Answer:

The pre-processing chain will be expanded by a new step to transform relative reflectance factors into absolute reflectance factors. The new processing step will be inserted after step (3) "correction of the reflectance offset". Former step (4) "masking out of reflectance factors in wavelength ranges that were affected by water absorption and strong noise" becomes processing step (5).

Hyperspectral raw data will be processed again in accordance with the updated pre-processing chain. The new datasets will be forward to PANGAEA to replace the old datasets:

"Mean and standard deviation of hyperspectral surface reflectance acquired on the agricultural Gebesee test site (central Germany) in 2013" (doi: 10.1594/PANGAEA.874243)

and

"Mean and standard deviation of hyperspectral surface reflectance acquired on the agricultural Gebesee test site (central Germany) in 2014" (doi: 10.1594/PANGAEA.874245).

Changes in manuscript:

Page 9, line 1. Numbering of step (4) will be changed to (5).

Page 9, line 1. Added text: "[…] (4) transformation of $r_{rel}$ into absolute reflectance factors $r$ by multiplication with the reflectance of the Spectralon reference panel (Schaepman-Strub et al., 2006);"

Page 12, line 7. Modified text: "The absolute reflectance factors of winter wheat are generally lower and deviate by 0.076 and 0.071 on average from the reflectance factors of winter rape and potato, respectively."

Page 28, line 1. Modified Fig. 5e and Fig. 5f: In Fig. 5e, the relative reflectance factors were substituted by absolute reflectance factors. MTCI values were recalculated based on absolute reflectance factors and used to update Fig. 5f.

**(2.2.) In connection with that, a statement regarding the levelling of the Spectralon panel would also be important. We have shown that careful levelling is required to acquire more accurate absolute reflectance factors. See: Hueni, A., Damm, A., Kneubuehler, M., Schläpfer, D. and Schaepman, M. (2016). "Field and Airborne Spectroscopy Cross-Validation - Some Considerations." IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 10(3): 1117 - 1135.**

Answer:

Details on the measurement configuration for the acquisition of the reference spectra from the Spectralon reference panel will be added to the text.

Changes in manuscript:

Page 8, line 26-28. Adjusted and added text: "Readings were taken successively at all SSPs of an ESU accompanied by the acquisition of reference spectra immediately before and after the target measurements (Milton et al., 2009). The reference spectra were acquired from a Spectralon reference panel (SRT-99-050; Labsphere, Inc.) that was placed on a plane-parallel dimensionally stable packing foam (absolute reflectance factors $r < 0.045$ for $\lambda \in [350\,\text{nm} \mid 2500\,\text{nm}]$). During the measurements, the foam was held above the top of canopy, while its horizontal leveling was controlled with a spirit level (T type) placed at the edge of the foam. The comparison of the reference spectra recorded before and after the target measurements gives an indication for the stability of prevailing atmospheric conditions (ASD, 2005)."

**(3) Please update the nomenclature: the reflectance that is calculated from radiance measurements in this manner is actually a 'reflectance factor'.**
**For details see: Schaepman-Strub et al., 2006.**

<u>Answer:</u>

The nomenclature will be adjusted.

<u>Changes in manuscript:</u>

Page 1, line12. Modified text: "The database contains information on hyperspectral surface reflectance factors, the evolution of […]"

Page 2, line 6. Modified text: "Data acquisition was accompanied by hyperspectral measurements of surface reflectance factors."

Page 8, line 20. Modified text: "Raw digital numbers (DNs) of the surface spectra and the related hemispheric-conical reflectance factors (Schaepman-Strub et al., 2006) were measured with a FieldSpec 3 spectroradiometer (FS3; Analytical Spectral Devices Inc.)."

Page 8, line 35-37. Modified text: "Based on the estimated digital numbers of the white reference ($DN_{estWR}$), target digital numbers ($DN_{target}$) were converted into relative reflectance factors $r_{rel}$ applying Eq. (7) (Peddle et al., 2001):

$$r_{rel}(\lambda, t) = \frac{DN_{target}(\lambda, t)}{DN_{estWR}(\lambda, t)}$$

Page 8, line 38-40. Modified text: "[…] (3) correction of the reflectance factor offset occurring between the FS3 sensors VNIR (350–1000 nm) and SWIR1 (1001–1800 nm) by an adjustment of the relative reflectance factors in VNIR ($r_{rel\ VNIR}$) to the level of SWIR1 relative reflectance factors with Eq. (8):

$$r_{rel\ VNIRcorr}(\lambda) = r_{rel\ VNIR}(\lambda) + r_{rel}(\lambda = 1001\ nm) - r_{rel}(\lambda = 1000\ nm)\ .$$

Page 9, line 1. Modified text: "(5) masking out of reflectance factors in wavelength ranges that were affected by […]"

Page 11, line 29. Modified Caption: "5.3 Influence of vegetation parameters on hyperspectral reflectance factors and their variability between crop types"

Page 11, line 30-31. Modified text: "The simultaneous acquisition of in situ data and hyperspectral measurements permits the examination of relationships between plant physiological states and the surface reflectance factors that are expected to […]"

Page 11, line 35-36. Modified text: "Figure 5 shows nadir photos as well as mean values with 95 % confidence intervals of selected vegetation parameters and absolute reflectance factors $r$ […]"

Page 12, line 6. Modified text: "The corresponding absolute canopy reflectance factors (350 to 2400 nm; Fig. 5e) of winter rape and potato are rather similar […]"

Page 12, line 7-8. Modified text: "The absolute reflectance factors of winter wheat are generally lower and deviate by 0.076 and 0.071 on average from the absolute reflectance factors of winter rape and potato, respectively."

Page 12, line 19-20. Modified text: "PAI and LAD exert influence on the leaf area that interacts with solar radiation and, thus, the reflectance factors in the wavelength range from […]"

Page 12, line 20-21. Modified text: "Therefore, the combination of PAI and LAD might explain the lower absolute reflectance factors of winter wheat […] "

Page 12, line 25-26. Modified text: "In addition, these petals increase the reflectance factors between 500 and 2500 nm (Lilienthal and Schnug, 2005)."

Page 12, line 28-29. Modified text: "While the MTCI has been proven valuable for the determination of the *Chl a+b* from hyperspectral canopy reflectance factors under diverse phenological conditions […]"

Page 12, line 32-33. Modified text: "Interrelations between the absolute surface reflectance factors and vegetation parameters can be assessed for various crop types with differing canopy architectures."

Page 13, line 4-5. Modified text: "The uniqueness of the database is the high number of investigated vegetation parameters that influence the surface reflectance in the visible and infrared range […]"

Page 13, line 7-8. Modified text: "Data collection was accompanied by hyperspectral measurements of surface reflectance factors and […]"

Page 20, Table 3. Parameter name changed from "Hyperspectral reflectance" to "Absolute reflectance factor"

Page 28, Fig. 5e. Modified nomenclature of the ordinate: "Absolute reflectance factor"

Page 28, line 4. Modified figure caption: "Figure 5. Differences in parameter characteristics, illustrated for fractional vegetation cover ($FVC$), plant area index ($PAI_{LAI2200}$), leaf chlorophyll A and B content ($Chl_{a+b}$), averaged absolute canopy reflectance factors […]"