hess-2022-121 – Author's response to Anonymous Referee 2

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Referee comments are written in blue italics; author's responses are written in normal font; and proposed changes are highlighted in green font.

In this study, the authors used passive microwave satellites observations of vegetation optical depth (VOD) to estimate leaf moisture content (LFMC) at the global scale. VOD is a relatively new vegetation product compared with classic optical vegetation indicators, and the exploration of its application should be encouraged. However, I found it is a bit difficult to follow. The authors need to address the issues elaborated below during the revision.

We thank the referee for the review of our manuscript.

Based on the description of the current manuscript, I think the logic order is (1) establishing the relationship between Ku-VOD and site measurements of LFMC using the models (A, B, C and D), (2) applying these regional relationship to the globe to derive VOD-based LFMC, and (3) comparing with existing satellite-based LFMC (i.e. MODIS-LFMC) at the global scale (rather than only Australia and Europe) to illustrate their similarities and differences. Otherwise, the analysis is incomplete.

Prior to our study, only the study from Fan et al. (2018) investigated the correlations between VOD and LFMC (for sites in France) and no study investigated the correlation or relationships between VOD and LFMC at continental scales or for different ecosystems. Based on this prior knowledge, we decided to start our analysis with a correlation analysis between multi-frequency VOD and LFMC from the Globe-LFMC and the MODIS-LFMC data. Already in this analysis, the use of the MODIS-LFMC data is needed to investigate how differences in spatial scale between site measurements and of the VOD affect the correlations. Second, we tested the different model structures to estimate LFMC from Ku-VOD (step #2 of the referee). Third, we applied the relationships to the globe (step #3 of the referee). In the third step, we evaluated the model against the site measurements using spatial cross-validation. We did not compare the VOD-based LFMC with MODIS-LFMC because of several reasons that we explain in the following.

In our view, the spatial cross-validation is a stronger test of the global VOD-based LFMC dataset because it makes direct use of the site measurements and does not rely on the radiative-transfer models used in the MODIS-LFMC dataset. The VOD-based LFMC uses monthly LAI from MODIS as input, which is derived from the same spectral bands like MODIS-LFMC and hence both LFMC datasets are not independent of each other and a high correlation can be expected and occurs indeed (Figure AC2 1). The spatial patterns of correlation between VOD2LFMC and MODIS-LFMC show similar regions where already Ku-VOD had high and low correlations with MODIS-LFMC, respectively (cf. Figure 1 c and d of the main text). The correlation between VOD2LFMC and MODIS-LFMC is higher than between Ku-VOD and MODIS-LFMC in many regions, which is likely due to the use of the MODIS-LAI in VOD2LFMC. The low correlation in parts of northern Europe and the Alps (Figure AC2 1 b) was already present in the correlation between MODIS-LFMC and Ku-VOD and hence this comparison provides no insight if the estimated dynamics in LFMC are wrong because of the used VOD data or because of the MODIS-LFMC. In contrary, the spatial cross-validation against site data revealed that the VOD2LFMC estimates perform worse in needle-leaved forests, which could indeed partly explain the low correlations in parts of northern Europe. In summary, the correlation between VOD2LFMC and MODIS-LFMC demonstrates in many regions (and in most fire-prone regions) a good comparability of the two datasets but the comparison is not a valid independent evaluation because both datasets make use of MODIS spectral observations.

We propose to include those results in the appendix or in supplementary material for the interested reader.

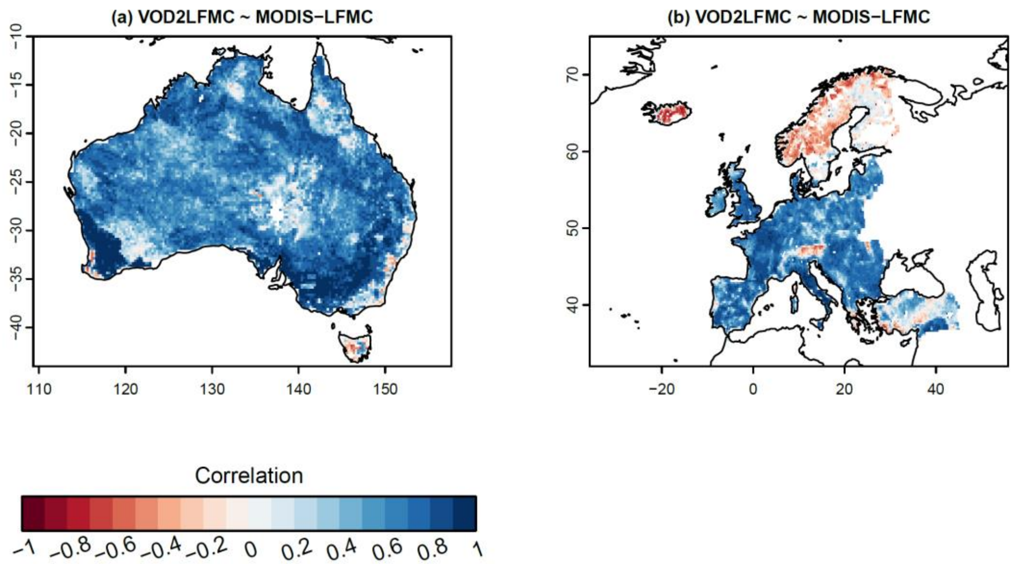

Figure AC2 1: Pearson correlation between VOD-based LFMC and MODIS-LFMC for Australia and Europe for the time period February 2000 to July 2017.

Model B uses both Ku-VOD and LAI as the input. The authors need to show whether the relationship between Ku-VOD and LAI is consistent over different countries/continents, on top of what has been presented in Figure 3A. That is, a map showing *the correlation between Ku-VOD and LAI on a pixel-by-pixel basis would further illustrate the possible uncertainties of the new LFMC developed in this study.*

The used Ku-VOD product has been previously intensively compared against MODIS LAI (Moesinger et al., 2020). For example, Figure AC2 2 shows that Ku-VOD is positively correlated with MODIS LAI in most parts of the world. Differences occur in tropical forests (e.g. Amazon), wetland regions (e.g. northern Canada, Pantanal), or deserts (e.g. parts of the Sahara). Moesinger et al. (2020) provide also a discussion of those results.

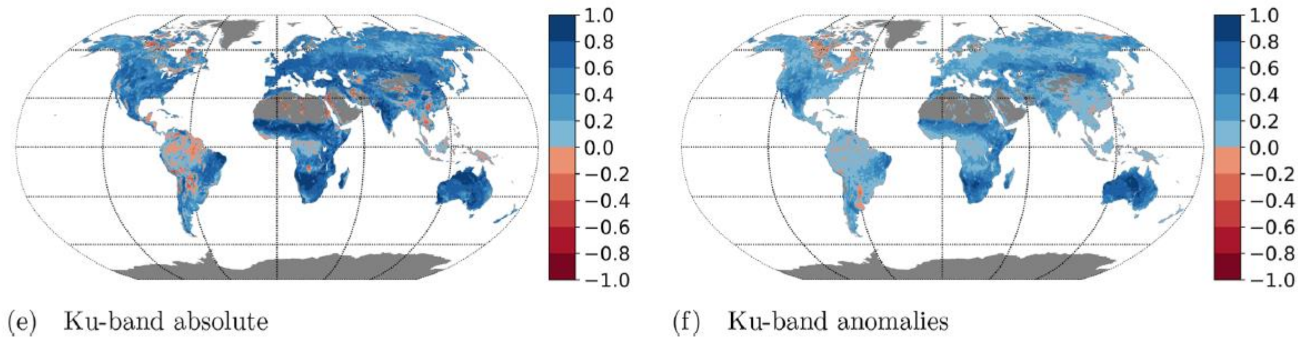

Figure AC2 2: Spearman correlation between the VODCA Ku-VOD product and MODIS LAI. The figure is taken from Moesinger et al. (2020).

When I read the abstract, my understanding/expectation is that the authors will generate daily VOD-based LFMC, and we will get LFMC updated every day with only 1 day delay. However, the LFMC generated in this study uses daily VOD and monthly LAI as the input, which means that we have to wait until the end of the month to get daily LFMC for the past month. At that time, we will already get MODIS-LFMC for the past month with a higher spatial resolution. In that case, what are the advantages of the 0.25 degree VOD-LAI-based LFMC if we cannot get near-real-time update more frequently than MODIS-LFMC?

The abstract does not mention that we would be generating a near-real time LFMC dataset. We generate a daily LFMC dataset for past conditions, whereby the daily information originates from the Ku-VOD data. Indeed, the coarser resolution of the VOD-based dataset is a disadvantage in comparison to MODIS-LFMC. However, cloud cover or other atmospheric distortions frequently affect retrievals of land surface variables from optical instruments such as MODIS, which causes frequent data gaps in the derived variables. Hence, the VOD-based LFMC dataset can complement LFMC retrievals from optical sensors by providing a higher temporal frequency.

The aim of this study was to investigate the VOD-LFMC relationship and to develop and test a model approach to estimate LFMC globally. The advantage of this methodology is the long time span of VOD data (e.g. Ku-VOD starting in 1987), which potentially allows to produce long-term estimates of LFMC in future studies. Such long time series of LFMC can facilitate climatological studies on the variability and LFMC and the potential effects on fire.

We propose to improve the description of those advantages in the discussion of the paper.

Minor comments:

Line 145: "primarily" should be "primary".

We will change this.

The authors mentioned in line 149-150 that China has 229 sites in the Globe-LFMC database. However, these site measurements were not used in this study. Why?

The Globe-LFMC database contains 229 sites in China, however, each site has only one LFMC measurement. VOD retrievals were not available for those days of these measurements. In future developments of our approach, we propose to use VOD retrievals from previous days or possibly filling of small temporal gaps to increase the availability of site measurements for model calibration.

We will improve the description of the Globe-LFMC database in section 2.2 and the discussion in section 3.5.

Why did the authors use Spearman rank correlation in line 199, but Pearson correlation in line 295.

We used Spearman correlation for the comparison between VOD and LFMC because we did not a priori assume that the relationship between both variables is linear. We used Pearson correlation for the comparison between different LFMC measurements and satellite-derived LFMC estimates as these variables should be ideally linear related.

Figure 2. These dots can be plotted using different colours for different countries/continents, i.e. Australia, Europe and USA. It will help the audience understand whether the relationship between LFMC and VOD varies over different countries/continents.

The figure is provided coloured by continents/regions in Figure AC2 1. The figure indicates that the slopes do not vary strongly between continents but the offset varies. This offset is, however, not caused by the continent but by the type of vegetation that were sampled at the sites (Figure AC2 4).

We are open to the suggestion of the referee to replace Figure 2 of the manuscript with Figure AC2 4.

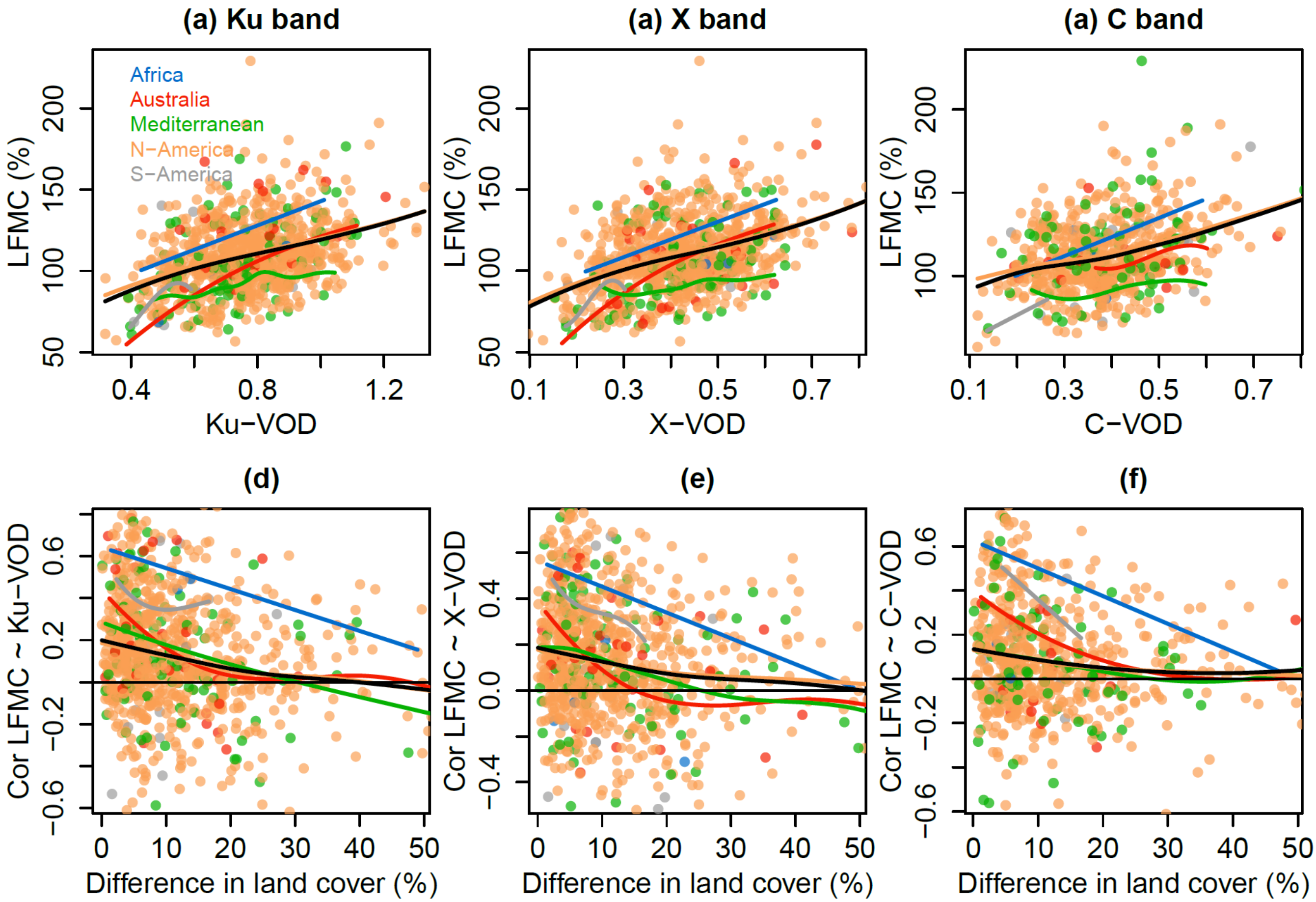

Figure AC2 3: Global scatterplots and correlation of LFMC from the Globe-LFMC database against Ku-, X- and C-VOD, coloured by continent. The black line is the global relationship across all data points. Africa includes LFMC data from Senegal and South Africa. The Mediterranean includes data from France, Spain and Tunisia. N-America and S-America include data from the USA and Argentina, respectively.

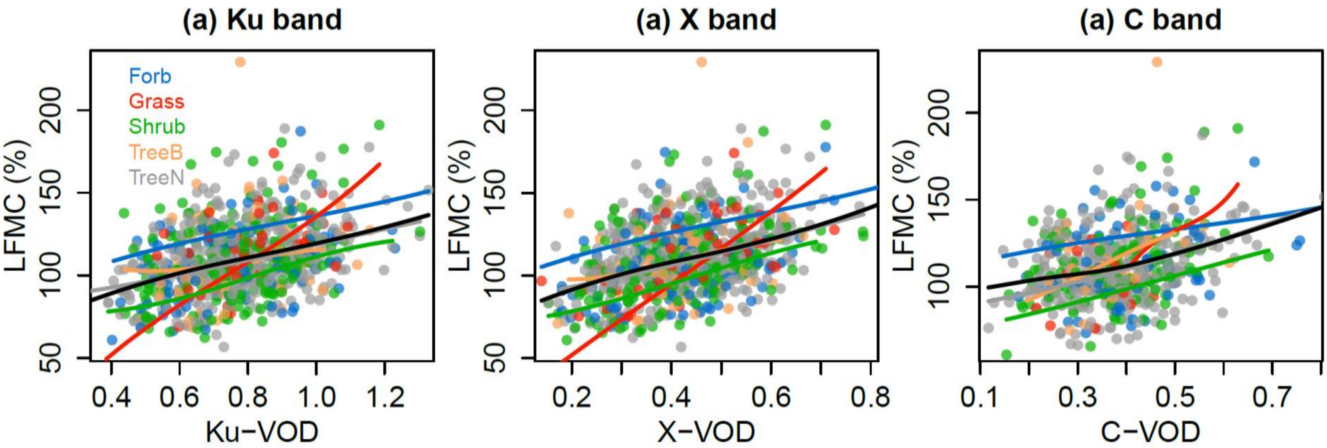

Figure AC2 4: Global scatterplots of LFMC from the Globe-LFMC database against Ku-, X- and C-VOD, coloured by vegetation growth form.

References

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