Response to Referee Comment on "Exploring hydrological similarity during soil moisture recession periods using time dependent variograms"

by Mälicke et al.

November 2018

Response

Dear Referee,

Thanks for your helpful comment on our work. Your comment is highly appreciated.

We will revise section 3.3 in terms of comprehensibility. Technical terms referring to to the clustering method will be checked and explained.

We will improve the description of the study site and the corresponding map (manuscript, Figure 1). Additionally, we might include more locations into our analysis, please refer to our response to Referee #1 in this context.

As suggested by the referee, we tested different common clustering algorithms and ran the clustering on the actual data. The resulting comparison presented below and how we justify the selection of *MeanShift* will be added to the manuscript's method section. Note that a variogram is viewed as a coordinate tuple in $\mathbb{R}^6$ and therefore cannot be plotted easily. We rather visualized the classification result of four different clustering algorithms (Figure 1). This shows that *MeanShift* and *KMeans* result in the same classification. The main downside of *KMeans* is that the number of clusters has to be predefined, which makes it unsuitable for the study. *DBSCAN* is, like *MeanShift*, a density based algorithm. It failed to find more than one cluster in all investigated cases, most likely because our variograms are of rather high dimensionality ($\mathbb{R}^6$) compared to the sample size of 92 (variograms). *Affinity Propagation* sounded promising as it is based on the idea of finding the set of n most representative instances within the sample. The *Affinity Propagation* is mainly controlled by the *damping factor*, which influences the calculation of similarity between two instances. Like the bandwidth parameter for *MeanShift*, different *damping factors* can result in just one or as many clusters as sample size. However, we preferred the
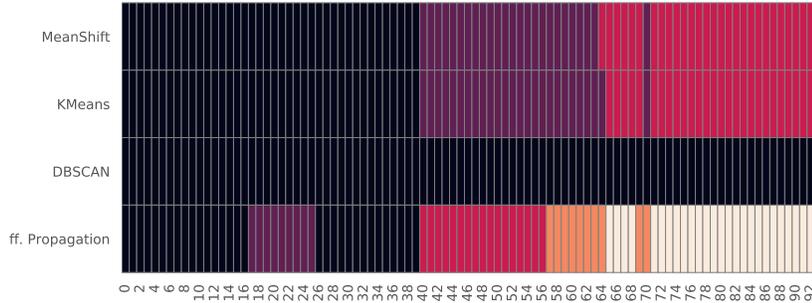
Figure 1: Clustering result for the 30cm variograms presented in the manuscript using four different algorithms: *MeanShift*, *KMeans*, *DBSCAN* and *Affinity Propagation*. The time lag of the moving window is shown on the x-axis and the cluster membership of each variogram is indicated by the color. Same color means same classified cluster.

MeanShift as the bandwidth is directly linked to the Euclidean distance between two coordinates (variograms) in the sample and could therefore be inferred from the variogram distribution. The *damping factor*, on the other hand, seems more like a dimensionless calibration factor tweaking the results and therefore it would be way more complicated to select an overall justifiable value.

Regarding the physical connection of the manuscript's Figure 5, we will consider adding either a rainfall or throughfall time series to the manuscript. This could be done in Figure 4, as it would align with the soil moisture observations and their ranks over time. Including a rainfall time series per sensor, as suggested in the minor comments, will not be possible, as rainfall was not observed at this high spatial resolution (note that some sensors are only a few meters apart). From our understanding the sudden changes in Figure 5 are either due to rain- /throughfall or a change to terrestrial controls dominating the described spatial structure. The presented sensor locations share similar vegetation and soil characteristics, therefore investigating their influence does not seem to be promising for the scope of the current study. A soil map of the current study site would locate them all in the same soil unit. However, as more locations might be included into the revised study, this is an important and interesting aspect for discussion and will be considered.

While we cannot discuss 2015 and 2016 in as much detail as 2013, we will add a brief methodological assessment covering these two years to the revised manuscript.

Concerning the other minor comments:

- *p.5 l.9:* The sequence of the equations will be revised.

- *p.6 l.5:* The sentence will be reworded to be grammatically correct.

- *p.7 l.1-5:* The whole section 3.1 will be revised, as more sensors will be included into the study. Special attention will be given to the marked paragraph.

- *p.8 l.20:* We mean similar in terms of variogram shape. This will be clarified.

- *p.8 l: 25-30:* This paragraph will be revised and, as indicated above, technical terms will be defined.

- *p.12, caption of Figure 4:* As described above, a rainfall time series per sensor is not possible, but rainfall data will be added to the study.

We would like to thank the referee for these helpful comments and will improve our manuscript by connecting our results better to other physical observations in the field, along with a substantially improved and clarified description of the clustering method.