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Interactive comment on “The Hydropedograph Toolbox and its application” *by* C. B. Graham and H. S. Lin

A. Coppola (Referee)

antonio.coppola@unibas.it

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The authors propose a toolbox for analyzing soil moisture time series by various modules including statistical summary, soil water release curve, preferential flow occurrence, hydraulic redistribution, and the relationship between soil moisture and soil temperature. The toolbox would permit the exploration and visualization of key soil hydrological parameters and processes using multi-depth real-time soil moisture monitoring datasets. The authors use a hillslope transect case study for illustrating the topographic impacts on soil moisture dynamics, by quantifying the frequency of the occurrence of preferential flow, diel fluxes of water, and seasonal storage dynamics.

General comments Based on my reading of the manuscript, I suggest at least major re-

vision of the paper. The authors emphasise the value of their Hydropedograph Toolbox for a rapid, systematic, and consistent assessment of soil moisture time series, and the effectiveness of graphical visualizations in identifying various trends within a soil profile and between sites. To me, in its present configuration, the paper could be simply classified as (and it is organized as) an handbook for the toolbox, not more. What's more, the analysis provided by the various modules does not add any new information to those coming from a usual and basic exploratory analysis any researchers generally do when analyzing water content temporal series. It is my opinion that the paper does not give a real advancement to analyzing the information contained in soil moisture temporal series. According to their conclusions, the toolbox would facilitate the advancement of comparative hydrology and hydropedology. And yet, the modules in their toolbox do not use (seemingly) any important information about pedology, soil layering and its effects on the hydrological behavior (pedological effects do not coincide with topographical effects), the distribution and the role of texture, stones, fractures on water content measurements, and so on. In this sense, the analysis of the dataset used by the authors seems more based on the authors feeling rather than on real information content in the dataset. Especially preferential flow recognition seems quite subjective, sometimes unfounded and unexplainable from a physical point of view. Justifications to this may be found in the detailed remarks I will give below (especially from item 8 on). In the following, quoted sentences have been used for author's statements.

Detailed comments 1.) Page 3, lines 69-72. “In soil science, it is less clear what key graphical analyses of soil moisture time series are embraced by the community”. The authors themselves give the answer to this statement. “These analyses should be part of any initial investigation of soil moisture patterns and processes, especially when dealing with large datasets from sensor networks”. And in fact, in soil science and hydrology the exploratory (and graphical) analysis of the water content datasets is generally considered a basic investigation and is just considered a tool for understanding more complex processes (see Kachanosky and de Jong, 1985; Coppola et al., 2011b; among others). This is the main reason why it is uncommon finding such an initial investigation in the literature. 2.) Page 4, lines 119-121. “The most common visualization of soil moisture time series is a line plot of soil moisture vs. time for the duration of monitoring. While this plot is helpful in identifying precipitation events, relative wet and dry conditions, ..., it is often difficult to see finer patterns. Seeing finer patterns in a water content series only requires zooming on the time series in an excel graph, for example. Besides, it is not so infrequent finding 2D maps of water contents in the literature on soil science. 3.) Page 5, line 152. I would say S is a normalized water content. In the literature it is known as effective saturation. 4.) Page 6, line 158. See item 5 above. 5.) Page 6, lines 176-182. “Two operational definitions of preferential flow have appeared in the hydrological and soil science literatures. In the first, preferential flow results in soil moisture response with depth faster than that predicted by the Darcy’s law (Beven and Germann, 1982). In the second, preferential flow results in an out of sequence of soil moisture response to precipitation input within the same soil profile, which can result from either vertical flow bypassing the footprint of a soil moisture sensor. . ..”. They are not alternative definitions. The first is a theoretical one and accounts for a physical non-equilibrium condition which cannot be described by the Darcy’s law. The second one just describes the non-equilibrium implications from a monitoring perspective. The latter may be actually characterized by a sudden response of deeper sensors as compared to probes at the surface. This should be distinguished by the case of water content increases measured by deeper sensors and coming from “lateral flow from upslope area” which are expected to be much more gradual; 6.) Page 7, line 210. I would say “hydraulic redistribution by roots”, to distinguish it by the main hydraulic redistribution process controlled by soil water potentials. In any case, I do not think the water transfer at different depths by roots can be so easily detected by scattered sensors in the field; 7.) Pages 7-8, lines 221-241. My opinion is that there are much more robust tools for identifying correlation in time series of different variables (water content and any other driving variable, in the matter in question). Fourier’s analysis (and the related coherency analysis) would give much more information than a simple correlation coefficient. Nielsen et al. (1983), Kachanoski et al. (1985a), Coppola et al. (2011a) have given examples showing that a non-significant overall correlation may mask significant positive and negative correlations at different frequencies. In this sense, the analysis in the frequency domain may be a powerful tool for detecting and quantifying co-structures. Sophisticated state-space approaches also exist for evaluating spatial variability of field measured soil water status (Comegna et al., 2010, for example). A toolbox including such techniques could be much more helpful for soil scientist analysing water content space-time series, 8.) Page 9, Case Study section. A loamy-skeletal soil is considered to show the helpfulness of the toolbox. At lines 288-289 the authors says “matric potential has been monitored with the Campbell Scientific heat dissipation probes (accuracy and precision ± 1 kPa)”. Then (page 10, lines 309-313) they state “The ridge, midslope, and toeslope sites used in this case study currently do not have collocated matric potential data. To demonstrate the moisture release curve module of the toolbox, we analyzed soil moisture and collocated matric potential data from another site with the same soil type and vegetation as the ridge site”. It is quite ambiguous. Besides, no information are given on either the possible soil layering or the probable difference in the soil hydraulic behavior at different depths. Thus, the water retention curve showed in figure 5 is used for characterizing the whole soil profile. It is my opinion that this may well have induced some unclear statement about preferential flow detection (see items 10 and 11 below). Besides, measuring water content in skeletal soils should be done with caution, as stones may have a large impact on the measurements, depending on the sensors one is using (TDR probes, for example) (see Sauer and Logsdon, 2002; Baetens et al., 2009; Coppola et al., 2013, among others). How to manage the effects of stones on water content measurements in the field might well be an helpful information in any hydropedology toolbox; 9.) page 10-11, Summary Graphs section. I am sure all the analysis described by the authors here does not require any sophisticated toolbox; 10.) Page 11, Moisture Release Curves section, Table 1 and Figures 5-6. Firstly, my opinion is that pressure head data are too scattered for estimating a retention curve with acceptable significance. Actually, by looking at figure 6, it is quite arduous identifying graphically which parameter value corresponds to the lowest RMSE. This is especially true for the parameter alfa-vanGenuchten (aVG) and may be confirmed by crossing information coming from table 1 and figure 5. In the figure, there is a pressure head threshold at about -40 cm (the authors should explain why). The average value for aVG in table 1 is about 0.05 (corresponding to a pressure head of -20 cm). Thus, the graph does not include any data in the pressure head range containing information for estimating the parameter significantly. What's more, this is also the range of pressure heads-water contents containing the information near saturation, thus crucial for understanding (and detecting) preferential flow paths activation. Besides, by looking at the figure 5-6, my feeling is that any pedotransfer function now available in the literature would have estimated the curve with comparable uncertainty. May be data refer to different layers (from a hydrological, not necessarily pedological, point of view). In this case, they should have been either dealt with separately or alternatively analyzed with some scaling technique (again useful for the toolbox); 11.) Page 11-12, Preferential Flow section. At lines 394-396, the authors stated "Preferential flow was concentrated during the summer at the midslope site, while preferential flow events were more evenly distributed over the year at the toeslope and ridge sites (Fig. 7)". Firstly, by looking at the figure 7, it is quite strange seeing that the important out-of-sequence events correspond to drying periods (It would have been helpful for the reader seeing also rainfalls here). As it is quite arduous imaging preferential flow processes during intense drying (see the central band in the three graphs in the figure), my opinion is that the out of sequence events may well be explained by assuming that the different water content series at different depths just come from different retention curves crossing in that range of water contents. Of course, this can not be directly deduced by the toolbox graphs as they do non contain any information about soil layering in terms of hydraulic properties. However, it is useful remarking here that detecting preferential flow should be more based on pressure head dynamics rather than looking at water contents evolution, at least in the ambiguous cases, like that in question. Also, I would consider crucial, for a hydrogeological toolbox to be actually helpful, including

in the module on preferential flow information about fractures and any other preferential paths, their temporal dynamics (see Bronswijk, 1988; Greco, 2002; Coppola et al., 2012), repellency-fingering and so on; 12.) Page 16, lines 541-544. The toolbox provides a quantitative framework to quickly determine the timing, magnitude, and frequency of various soil moisture responses to precipitation events, including saturation events, dry-down periods, preferential flow occurrence, and diel signal frequency. See item 2. 13.) It is my opinion that all the remaining discussion about strengths and potentials of the Hydropedograph Toolbox are largely spoiled by the points discussed above.

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