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Reply on RC4

Luca Comegna et al.

Author comment on "The hysteretic response of a shallow pyroclastic deposit" by Luca Comegna et al., Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2020-362-AC5, 2021

OVERVIEW COMMENTS

Comment by Referee #4

The manuscript presents field measurements of rainfall, volumetric soil moisture content and soil suction. Hysteretic wetting and drying paths are shown in the data. The manuscript is reasonably well written, an interesting data set is presented and it describes an interesting phenomenon in the data (hysteretic wetting and drying paths). The data set is well referenced in the manuscript and it is accessible. At the data repository the data are clear and complete, including metadata.

The manuscript nicely analyses hysteretic wetting and drying paths in a data set of volumetric soil moisture content and soil suction. However, I am not sure whether this manuscript's objective fits the aims and scope of the ESSD journal. According to the aims and scope formulated for the ESSD journal, the ESSD journal aims at furthering the reuse of data. Articles may pertain to the planning, instrumentation and collection of data.

Interpretation is outside the scope of regular articles. Besides this point, improvements can be made to the description of the context and the methodology for analysing the hysteretic wetting/drying paths. These two points are reflected in the specific comments below: some comments are on more extensively describing the monitoring site and the data collection (specific comments 3, 4, 5, 6), whereas others are on the introduction, methodology and conclusion regarding the analysis of the wetting/drying paths (specific comments 1, 2, 7, 8, 9).

Reply by Authors

Dear Referee #4,

many thanks for your comments and suggestions, that give us the opportunity to clarify some aspects and that will be properly used to improve the quality of the manuscript.

Regarding the remarks about the contents of the paper and its ability to fit with the aim of ESSD, the Authors imagine that further reuse of data does not necessarily imply that no comment about them could be made by the presenters. By the way, such comments could work as a starting point for further analyses, which might even lead to a completely different perspective.

The replies to the specific comments are reported in the follow.

SPECIFIC COMMENTS

R1 - The introduction does contain a nice description of the hysteretic nature of main wetting/drying paths and scanning curves, and Figure 1 is very illustrative. It also introduces a laboratory experiment on these phenomena. However, the research gap leading to the manuscript's research objective could be better defined in the introduction. For example, is this the first manuscript in which the hysteretic nature of wetting/drying paths are shown in field measurements? Or if that is not the case, what is unique to this data set and study area?

A1– Even though often observed in laboratory experiments, the hydraulic hysteretic response of unsaturated soils is still often neglected at slope scale, being usually modelled by a single Soil Water Retention Curve. Such a choice is frequently due to unavailability of detailed field information. Most of the knowledge is in fact based on the results of laboratory investigations and/or of physical modelling. Such tests, although very useful, are unavoidably not able to take into account further aspects that that could make the actual hysteretic response of natural slopes quite different from what is observed in the lab such as the influence of different boundary conditions, the role of root water uptake or of the atmospheric evaporative demand, etc. The proposed manuscript is so aimed to give a contribution in this direction. We will stress such points in the modified version of the Introduction.

R2 - The topic of the manuscript does not seem well represented by the reference list. 17 out of the 34 items in the reference list are related to author(s) of the manuscript.

A2 – Unfortunately, the literature is not rich on this subject. The best examples known by the authors are however reported in the reference list. The mentioned Authors' papers report data from laboratory and field investigations, or of physical and mathematical modelling concerning the same investigated site. We believe that these references can be useful to the readers to get more information about properties and behaviour of the same soils, and to know concerned stability problems that often affect this kind of slopes (which is the main reason why the monitoring campaign was carried out). Anyway, we will check if some of the references can be removed without loss of information.

R3 - The manuscript presents data for January 2011 to January 2012. Has the data collection in this area not been continued after January 2012? It is stated that the data collection in this area started already in 2002, so it would be nice to also describe the data of 2002 to 2011 in this manuscript (as submitted to the ESSD journal). References to other data sets for this area would also be useful, such as meteorological measurements and discharge measurements, as this helps future reuse of the presented data set by other research groups.

A3 – As indicated at line 101, monitoring data from 2002 to 2009 regarded only rainfall and suction (these latter measured manually with coarse temporal resolution): the corresponding data are reported by Damiano et al. 2012.

The automatic monitoring station was installed at the end of 2009, but simultaneous information about soil moisture and suction at the same depth (necessary to highlight the hysteretic response) are available only since 2011. We understand that probably too emphasis is given to the previous monitoring activities, so that the reader expects these data to be discussed in the paper and to be made available in the open repository. We will modify the text between line 101 and 118, to avoid any misleading.

Due to maintenance and integration of the instrumentation, the automatic monitoring had to be stopped after January 2012 and it has been restarted only recently.

Regarding the meteorological data, the repository on Zenodo contains data about rainfall and temperature hourly values. Since November 2017 monitoring data at the same slope are again being collected, including more meteorological variables and also discharge measurements in nearby streams. Some of them are reported in Marino et al. (2020), which is acknowledged in the reference list, and is then accessible to the readers.

R4 - Line 62-64 and Figure 4: are these values the climatology values for rainfall, temperature and potential evapotranspiration? Over which period of years were these values calculated? Furthermore, are these values estimated for the monitoring site or based on measurements at a nearby meteorological station?

A4 - The monthly mean temperature data used for the estimation of PET are calculated with the 1979-1998 monthly temperature data from the meteorological station of Montesarchio, managed by the National Hydrologic Service, which was located some 4 km from the test site, approximately at the same elevation (560 m). Rainfall data used for the calculation of mean monthly rainfall are from the rain gauge of Cervinara, belonging to the meteorological alert network managed by the Regional Civil Protection, some 2 km far from the monitored slope. We will add information about the source of climatological data in the revised manuscript.

R5 - The monitoring site should be described in more detail. From Line 101-118, which describes the set-up of the monitoring site, it is not clear at which depth the Jet-fill tensiometers of 2002, the Jet-fill tensiometers of 2009 and the TDRs are installed. Could you make a schematic cross section of all the sensors (including types, such as 40 cm and 10 cm TDRs) and at which location and depth they were installed? Fig. 3b only shows a few sensors. Furthermore, what are other characteristics of the monitoring site? For example, is the location uphill or downhill and how does this affect the measurements? It would also be interesting to see photos of the monitoring site, showing i.a. the position of logger(s) and sensors, land cover and surroundings.

A5 – As anticipated in reply A3, monitoring data from 2002 to 2009 provided only rainfall and suction data: these have been already published by Damiano et al. 2012, and we will modify the text between line 101 and 118, so to make clear that present data are different. In fact, these concern only those automatically recorded by the couples of described instruments installed at very close depths, thus able to highlight the hysteretic soil response. Each TDR probe has been installed at a planar distance of 50 cm from the corresponding tensiometer. The four instruments are about 5 m far from the data logger.

As suggested, we will report such additional information through a sketch of the slope section adding some photos.

R6 - It is very good that the authors mention the sensitivity of the rain gauge and the calibration accuracy of the TDR. What is the uncertainty of the tensiometers? What is the brand and type of the rain gauge?

A6 – A specific table, reporting the main characteristics of the installed instruments, will be inserted (see the attached Supplement pdf file titled "Table_instruments").

R7 - Line 123-135 and Table 2, 3, 4: The methodology of fitting the Van Genuchten parameters was not described in sufficient detail. Were the measurement pairs from all nine experiments used? Which algorithm was used for the fitting? Was the fitting done specifically for this manuscript or was it done previously for another paper and did you re-use their result?

A7 – The three van Genuchten curves are featured by the same saturated and residual volumetric water contents ($\theta s = 0.75$; $\theta r = 0$), both assigned according to previous experimental results on undisturbed specimens (e.g. Damiano et al., 2012). As suggested by the simplified version of the van Genuchten equation, the parameter m has been related to parameter n by the equation $m = n-1/n$. Therefore, two are the remaining parameters to be fitted: α and n.

Regarding the assumed lowest boundary, the chosen α and n parameters (shown in Table 2) can provide the best fitting of all the experimental data located along the steepest part of each infiltration test. As shown by Figure 5, such points correspond to suction values smaller than 4 kPa.

Concerning the assumed upper boundaries, the α and n parameters have been chosen in order to provide the best fitting of the experimental points monitored during the time windows featured by the highest observed evapotranspiration effects, namely:

- at the depth z = 0.60 m, from May 8th (point B in Figure 8a) to July 18th (point D in Figure 8a)
- at the depth z = 1.00 m, from June 22nd(point C in Figure 8b) to July 18th (point D in Figure 8b)

All these information will be added in the text in the revised manuscript.

R8 - The last part of the conclusion is rather vaguely formulated. Do the results raise questions or do they allow to draw conclusion from the results on how we should set up reliable early warning systems? Please also check the last sentence of the conclusion (Line 354-355).

A8 – The results of this study should first of all highlight the limited reliability of early warning systems that use empirical threshold models exclusively based on the characteristics of precipitations (typically intensity and duration) without accounting for the prominent role played by the hydraulic properties and the initial state of the soil (that is also related to vegetation). Therefore, a reliable early warning system should be based on:

- a monitoring system able to provide real time updates about the weather-induced hydraulic paths;

- a forecasting model accounting for the soil water retention properties.

Both these aspects could be supported by the knowledge of the main drying and wetting curves that bound the water retention domain.

All these observations will be added in the revised Conclusions section. The sentence at lines 354-355 will be removed.

R9 - Section 2 is long and contains a variety of topics. Consider splitting it in a Section 2 ('Monitoring site') and a Section 3 ('Methodology'), or in subsections with headings that reveal what we can expect.

A9 - In order to facilitate the reading, we will shorten the current Section 2 ("Monitoring site") by inserting a "Data and methods" Section 3 (as suggested also by Reviewer #1) before "Results of field monitoring" (that will become Section 4).

R10 - In general the manuscript is well written, but the writing also needs some improvement. Consistency in terminology would increase the readability. For example, use one term for 'soil moisture content', 'soil moisture', 'volumetric water content' and 'θ' if you mean the same phenomenon. Next to that, if a symbol has been defined in the text, the symbol should be used from that point on and not interchanged with the term. Besides the technical corrections below, the manuscript would benefit from a check on the English writing.

A10 – We really appreciate you considered the manuscript as well written. We will follow your suggestion aimed at improving the consistency of terminology and at avoiding repeating the definition of variables instead of simply using the symbols. We will also check the English language of the entire manuscript.

TECHNICAL CORRECTIONS

R11 - The unit of soil moisture content values is missing throughout the manuscript.

A11 –Being the soil moisture content dimensionless, we will use the symbol [m^3/m^3].

R12 - Line 36: Define what 'TDR' stands for.

A12 – We will precise in the text that the acronym TDR stands for "Time Domain Reflectometer".

R13 - Figure 2: Define 'T' and 'TDR'.

A13 – We will define them in the caption of Figure 2.

R14 - Figure 3a: The topography of the study site is not clear from this figure. The figure also misses cartographic elements such as a north arrow and a scale (bar).

A14 – The updated version of Figure 3a will contain the location and geographic coordinates of the study site in the context of Italy, the North arrow and the scale too.

R15 - Figure 8 and Figure 10: I suggest to use different colours for the different time windows so that readers can distinguish them when they are (partly) overlapping. This especially applies to Figure 10.

A15 – The updated versions of Figure 8 and 10 will follow your suggestion.

R16 - Table 1: How were these properties determined or what is the source? Furthermore, the symbols used in the table must be defined in the caption or, if they are not used at other places in the manuscript, they could just be written out.

A16 – The soil properties, provided by Damiano et al. (2012), are the results of laboratory tests performed on several undisturbed and remoulded soil samples. We will precise such reference, indicating the symbols of the properties in the caption too.

R17 - Line 110: I do not understand what you want to say with "… after cold periods when low temperatures could freeze." It should also be specified what you 'check' for in those periods.

A17 – During the coldest periods, featured by temperature lower than 0°C, the de-aired water contained in the upper part of the hydraulic circuit of the tensiometers could freeze, thus affecting the correctness of the pressure transducer reading. If it occurred, we made note of that in order to give a correct interpretation of the corresponding registered data. Moreover, the expanded volume of ice could break either the pressure transducer or the plexiglass tensiometer tubes. If it occurred, they had to be fixed. These potential inconveniences will be mentioned in the text.

R18 - Line 126: Should 'the field porosity' be changed to 'a porosity'? At Line 96 you describe that the porosity at the monitoring site ranges between 50% and 75%, so this is not 'the field porosity'.

A18 –The model slope was formed with the Cervinara ashes, whose porosity ranges from 68 % to 75 %, as reported in Table 1. Therefore, we will precise in the text that it had

been reconstituted at the “maximum field porosity”.

Line 96 refers to the full range of field porosity, including also the pumices that, as reported in Table 1, present lower values (50-55 %).

R19 - Line 130: Should ‘steepest’ not be ‘steep’? I think you did not just fit to the steepest of the nine curves?

A19 – As previously explained in A7, the experimental points featured by a suction lower than 4 kPa have been fitted. Anyway, “steepest” will be replaced by “steep”.

R20 - Line 134-135: Does ‘possible reference lowest boundary’ refer back to the main wetting curve and lowest limits as explained in the introduction? If that is the case, please use the same terminology. The same is the case between ‘possible reference lowest boundary’ in Line 134-135 and ‘hypothesized lowest boundary’ in Fig. 5.

A20 – The “reference lowest boundary” coincides with the “main wetting curve” explained in the introduction. We used such less demanding expression because it has been derived by fitting a limited number of experimental points (those featured by suction lower than 4 kPa, as explained in A7). Anyway, in order to avoid confusion, we will refer in the text to the term “main wetting curve”.

R21 - Table 2, 3, 4,: Add to the captions that these Van Genuchten parameter values were fitted. For example, you could change ‘representative of’ to ‘fitted to’. Furthermore, the symbols should contain units or an indication of no unit (e.g. [-]).

A21 – We will insert the suggested modifications.

R22 - Line 142-143: “, typical of the Mediterranean climate, characterized by warm and dry summer.” can be removed. The climate the monitoring site has already been outlined in Section 2.

A22 – That sentence will be removed.

R23 - Line 145: What is the location of this local weather station? Could this be seen or shown in Fig. 3a?

A23 – These temperature data are provided at a hourly scale since 2002 by the Pietrastornina weather station, located at 495 m a.s.l. and 15 km from Cervinara, that is managed by the “Functional Centre for forecast, prevention and monitoring of risks and alerting for civil protection” of Campania Civil Protection Agency. We will add this information.

R24 - Line 144-145: If 'Tmin', 'Tmed' and 'Tmax' are not used at other locations in the manuscript, there is no need to define them in the text here. Furthermore, the symbol 'Tmed' is confusing. Could be changed to 'Tmean' or 'Tave'? Are 'minimum' and 'maximum' also 'daily minimum' and 'daily maximum' like the 'daily mean'?

A24 - Tmin, Tmed and Tmax (shown in Figure 6) refer to average monthly values of daily minimum, daily mean and daily maximum temperature. Such terms will be left just in Figure 6; in particular "Tmed" will be replaced by "Tmean".

R25 - Line 154-155: Could the potential evapotranspiration be estimated specifically for this year?

A25 - Unfortunately, we have no specific meteorological data available for the monitoring period at the monitoring site. A complete meteorological station has been installed at Cervinara in November 2017. You can find some recent data of potential evapotranspiration, estimated based on the acquired meteorological variables, in the cited reference Marino et al. (2020), so to have an idea of how current values can differ from the mean ones.

R26 - Line 155-157: Is this relevant for the analyses to come?

A26 –The reported information give an idea about the duration of the driest time window (essentially from May to October) that, as it will be shown in the following, is featured by the steepest paths in the water retention plane (Figures 8 and 10).

R27 - Line 182-185: The part "…, which departs from the gravitational -1 only during rainfall." is not clear to me. Besides, the sentence is too long (too many elements).

A27– We observed that in winter, when it does not rain, the vertical water potential gradient approaches "-1" (this happens when the vertical suction and/or water content profile tends to become constant), indicating that water (downward directed) flow is driven by gravity alone. Only during rainfall events the vertical water potential gradient departs from "-1" (this happens when the upper part of the soil profile becomes wetter owing to rain), indicating that capillarity favours the rapid rainwater infiltration.

The sentence will be simplified as follows: "This reflects a minor role of evapotranspiration during winter and early spring (when the vegetation is leafless). In this period, the soil profile is mainly drained downward by gravity, except during rainfall, when capillary gradient favours rapid infiltration".

R28 - Line 185-187: This sentence is not clear to me. What do you mean by "… the soil cover is being crossed by an intense downward flux …"?

A28 - What we mean is that when periods of intense and frequent precipitations (and very small evapotranspiration, as it happens in winter) are associated with (nearly) constant soil water content and suction, this implies that the infiltrating water passes through the

monitored soil layer without being retained (or being retained only in a little part). Hence, what we observe at -60 cm and at -100 cm is the result of a downward water flow crossing the layer. When we see increasing water content, the infiltration from above is exceeding the drainage towards below, while the opposite occurs when we see decreasing water content. We will expand this sentence in the revised manuscript to clarify this point.

R29 - Figure 8: Where does the hypothesized upper boundary come from?

A29 – As explained in reply A7, the hypothesized upper boundaries have been expressed through the van Genuchten equation (1) assigning saturated and residual volumetric water contents ($\theta s = 0.75$; $\theta r = 0$) as for the main wetting curve (as shown by Table 3 and 4). Assuming $m = (n-1)/n$, the remaining α and n parameters have been chosen in order to provide the best fitting of the experimental points monitored during the time windows featured by the highest evapotranspiration effects.

We will modify the comment to figure 8 adding this information.

R30 - Line 189-191: Could you also report the parameters of these curves?

A30 – The plotted curve is just a manual fit. We will remark that in the text.

R31 - Line 209-211: Change 'interpolated' to 'fitted'.

A31 – The term "interpolated" will be replaced by "fitted".

R32 - Caption Table 3, Caption Table 4 and Line 205-213: I think all the time windows should be BC? Please check if it is correct that there is also referred to BCD and CD here.

A32–From May, 8th (point B) to June, 6th (i.e. before June, 22nd, that is representative of point C), we observed that at the depth z = 1.0 m the experimental points are effectively again well fitted by the previous path AB. After that date, instead, the points are well fitted by the upper boundary at the depth z=1.0 m too.

We preferred to avoid inserting between B and C another letter (not necessary to understand the overall response) in order not to induce confusion.

R33 - Line 211-212: This is obvious; you already described that the paths are different.

A33 – Such redundant sentence will be eliminated.

R34 - Line 225-226: Change 'such a' to 'this'. Several similar occasions throughout the manuscript.

A34– The suggested modification will be reported there and elsewhere.

R35 - Line 226-227: Change 'is largely exceeding' to 'largely exceeds'. Add a comma after 'rainwater'. Remove 'owing to the action of plant roots' (you mean transpiration here, right?).

A35– The suggested modifications will be reported. Moreover, we confirm that "owing to the action of plant roots" refers to transpiration.

R36 - Line 228-231: Perhaps these two short paragraphs can be combined into one. No need to add tables with fitted Van Genuchten parameters here?

A36 –The two paragraphs will be combined into one. It's not necessary to add tables, because the described experimental points are fitted by the van Genuchten curves, whose parameters have been already reported in Tables 3 and 4.

R37 - Line 229: Is 'path BC' correct here?

A37–Yes, "path BC" is correct. Points B, C and D belong to the same curve BCD.

R38 - Line 255-256: What do you mean with "… did not accommodate the small evapotranspiration demand favouring an essentially downward flow …"?

A38 - When the leaves of deciduous trees fall, the vegetation enters a dormant phase, during which they need very little water. Hence, even a small atmospheric evapotranspiration demand (i.e. the small estimated PET of winter months) is likely larger than the amount of water actually extracted from the soil by the vegetation. This is what we mean when we write that "vegetation probably did not accommodate the small evapotranspiration demand". We will expand the sentence in the revised manuscript to clarify this point.

R39 - Line 266: Do you mean in the 48 hours before 5 December 2011?

A39 – Yes, we mean that. The sentence "a single precipitation of 98 mm over 48 hours causes an increase of the water content at both depths", will be replaced by "after a precipitation of 98 mm in 48 hours, an increase of the water content at both depths occurs".

R40 - Line 273-275: One paragraph?

A40 - The two paragraphs will be combined into one.

R41 - Line 278-285: One paragraph?

A41 - The two paragraphs will be combined into one.

R42 - Line 300: Could this sentence be added to the paragraph above or below? Add a comma before 'suggesting'.

A42 - The sentence will be added to the paragraph above. A comma will be added before "suggesting".

Please also note the supplement to this comment:
https://essd.copernicus.org/preprints/essd-2020-362/essd-2020-362-AC5-supplement.pdf