Review report for: "Assessment of the Effect of Soil Amendments and A Three Phase Soil Water Retention Model"

The authors investigated the effect of soil amendments on the soil's capacity to retain water. A control sand is amended with two clays (A and B) and a conditioning water retainer. Water retention is then characterized at low suctions using an evaporation-based HYPROP-2 device and at much higher suctions using a climatic chamber. The experimental data are subsequently fitted to the standard van Genuchten model and a three-phase soil water retention model, which accounts for water retention by both capillarity and sorption onto solid surfaces. The presented data and related modeling could provide relevant insights into the effects of amendments on water retention in soils.

The paper is well-organized and well-written, with clean figures, though there are some typos, a few grammatical issues, and a few unclear sentences. However, I found the paper's layout somewhat complex with its seven sections. I would have preferred a more conventional structure, including an introduction, a theory section, materials and methods, experimental results, modeling, and conclusions.

Response:

Thanks for the positive comment. We will adopt the reviewer's suggestion to restructure the layout of the paper.

Additionally, some references to figures and equations are incorrect both in the text and in the figures. Moreover, the figure layout could be improved, and some figures could be combined to facilitate comparison between scenarios (see my suggestion to combine Figures 8 and 9). Finally, the citation references and bibliography need to be checked and standardized. All my suggestions are included in the annotated PDF file.

Response:

Many thanks for the reviewer's insightful comments, constructive suggestions, and the elaborated annotations in the PDF file. We apologize for our careless attention on these errors, mistakes and inaccuracies when did the final proof reading. We will seriously address all the highlighted problems in the follow-on revision.

In its current form, this study cannot be published, and major corrections and amendments are required to avoid rejection. I suggest that the authors address the following points, which I consider crucial:

- The title could be revised to more accurately reflect the findings of this study. The modeling tool (the three-phase model) is as significant as the main goal of the investigation (the study of soil amendments). I would suggest titling the paper

'Assessment of the Effect of Soil Amendments Using a Three-Phase Soil Water Retention Model.' However, if the model is the central focus of the paper, then the paper's layout should be adjusted accordingly and the paper rewritten.

Response:

We will adopt the suggested title, and will restructure the layout and revise the paper thoroughly.

- Clarification is needed regarding the use of the conditioning solution in this study and its intended applications. It is unclear whether the authors used the solution as a conditioner before investigating its effects on water retention in the treated soils or if they studied the retention of the conditioning solution itself (whose chemical and physical properties may differ from those of water). The two objectives—(i) understanding the beneficial effects of a conditioning solution on water retention and (ii) understanding the retention of the conditioning solution—are complementary but distinct, and they require different experimental plans and protocols.

Response:

We studied the retention of the conditioning solution itself and compare it with the retention of pure water. Yes, the conditioning solution has different chemical and physical properties from the pure water. In the paper, on the existing condition and available results, we can only produce a qualitatively analysis and discussion, on which it is concluded that the conditioning solution has enhanced the surface tension of itself and the interfacial binding force at the surface of soil particles. Referring to the comments, we will further effectively clarify this in follow-on revision.

- The chemical aspects should be discussed in more detail. Very little information is provided about the chemical processes and aspects related to the experiments. There is no justification for the tested concentrations nor any information on the composition of the conditioning liquid (which may be protected by a patent). I suggest adding a paragraph to explain the processes behind the chemical effects of the conditioning solution and their consequences on physical processes. The introduction should include more details on the chemical processes that enhance water retention. Other questions arise: How long do the beneficial effects last? What are the application protocols for the solution (e.g., mixing with the soil, adding to dry soil or at a specific water content, resting time before use)? How can the duration of the beneficial effects be optimized for long-term applications? More information about the chemical composition of the solution and insights into the effects of each compound would be beneficial.

Response:

We will conduct extra research to add more information about this from other published research work or open available resources. We ever asked the partner, who provided the water retainer product for the test, to input some basic technical information regarding the product, even in general, however, they did not response.

- Modeling: I had some difficulties understanding the novelty of the proposed approach. After reading the references provided, I came to understand that the main novelty might lie in the expression and implementation of the last term of Eq. (9), which relates to water sorption onto the particle surface, as well as the introduction of the term "exp(Y*C_{WR})" to account for the effect of the conditioning solution. I also concur with the first reviewer regarding the estimation of model parameters and the lack of clarity in the inversion strategy. With nine parameters, there is a significant risk of over-parametrization, which should be discussed in the revised paper. Additionally, some parameters cannot be distinguished from each other, such as the term lumped in the product "exp(Y*C_{WR}) * λ." This issue is not addressed when discussing the fit of the new model, and the values of the optimized \gamma are not discussed at all.

Response:

The novel works on the modelling of this manuscript include: 1). the proposed three-phase pore water retention model, which hasn't been officially published through peer view process; 2). the Eq. (9), the application of the three-phase WRC model used to assess the Water Retainer effect. The proposed WRC model adopts a novel approach to understand and represent the unsaturated soil water retention mechanisms based on classical interfacial physicochemical theory. The modelling has demonstrated their performance on the representation for a wide range of soil water retention curve from fully saturated to nearly fully dry. On the physical and mathematical derivation (there were detailed information from the concept to procedure in previous publications), all the parameters have their respective physical meaning. In this paper, we used the physicochemical WRC model to represent the effect of the water retainer effect in revised form by introducing an extra term and parameters. We acknowledge both reviewers' comment on the number of parameters involved. However, it is due to the descriptive approach for underlying physical mechanisms, the work in this direction has further research significance and implication. At the current stage of the progressive research activity, we tried to provide a qualitative discussion to link the parametric values with the underlying physics. For more profound investigation and quantitative clarification, there is the need of more experiments on wide soil types of varied composition nature, and particularly fundamental study into material science, such as the interfacial energy characteristics of water on absorbents. However, such works required further research elaboration and resources, which were beyond of this study. We appreciate the chance to have the open discussion on our work, hoping the reported work can receive wider interest and opens new research activities on the topic and in wider relevant areas.

- I suggest considering that the main parameters are estimated with C_{WR} = 0 for the sand alone and the sand amended with the two types of clay, and then, the parameter Y is optimized based on the experimental data obtained with various WR concentrations. As it stands, the proposed model is challenging to use and offers little insight into the understanding of the system. I fully agree with the first reviewer on this point.

Response:

Thanks for the technical suggestion. We will investigate this in follow-on revision.

- Lastly, the authors come from a community that also works on concrete and anthropogenic materials. It is valuable that scientists from these communities address scientific questions posed by soil physicists with agricultural applications. Such exchanges between scientific communities are highly beneficial. I also agree with the first reviewer regarding the fact that soils in the environment are typically much more wetted than concrete in buildings. Consequently, the effects at low suction are likely more significant than those at very high suction. The authors should discuss this point in the introduction.

Response:

The evaluated water retainer product aims to prevent the soil pore water evaporation when exposed to atmospheric conditions. The water retainer is spread on the surface of cultivated field plots as doing irrigation. Thereafter cultivated plots are directly exposed to atmospheric humidity conditions. The Fig. 1 below shows the surveyed atmospheric Relative Humidity profile across Europe. Fig. 2 is the anomalies of atmospheric condition across Europe. Under the relatively low RH conditions, at the ground surface, soil pore water is subjected to a very high suction (in term of the Kelvin equation for the relation between the suction and RH) to evaporate fast, so has a low moisture content accordingly. Using the water retainer product can reduce the surface water evaporation under high suction to help reduce the water loss in deeper ground. We will produce a 1D hydrological simulation in follow-on revision to demonstrate the effect of water retainer on deep ground water.

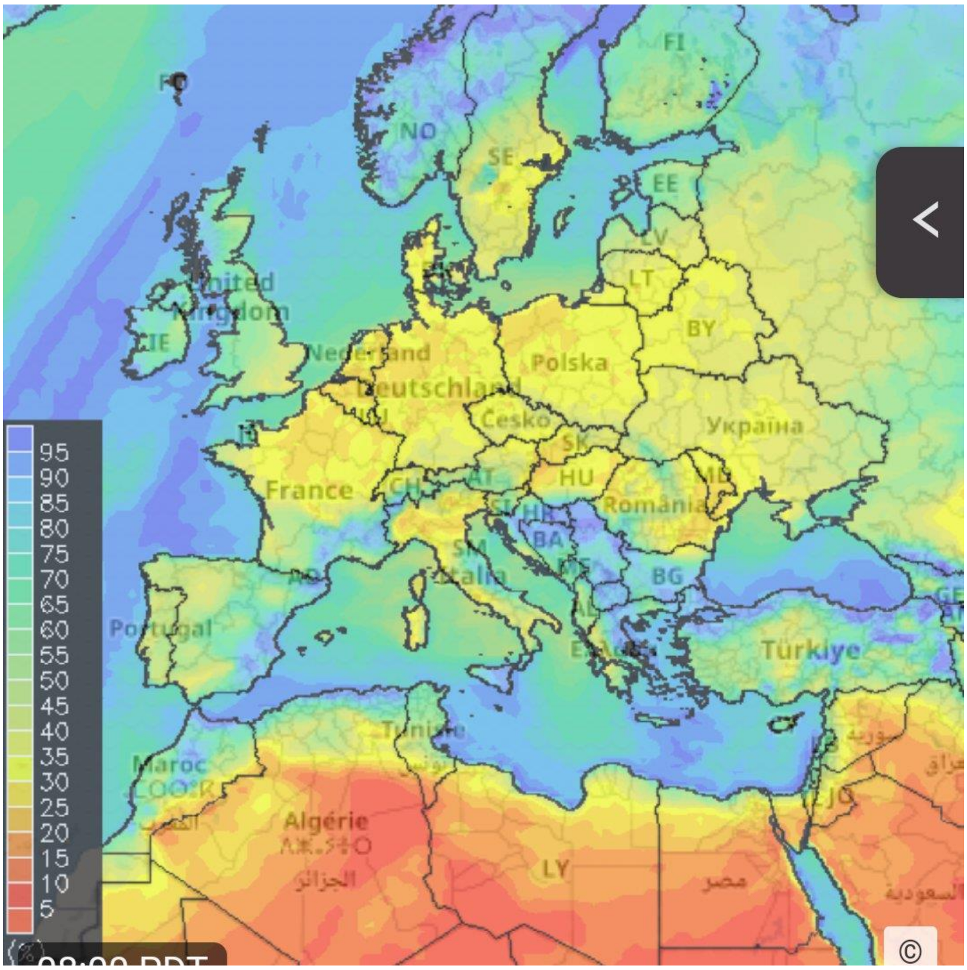

Fig. 1. Europe relative humidity maps

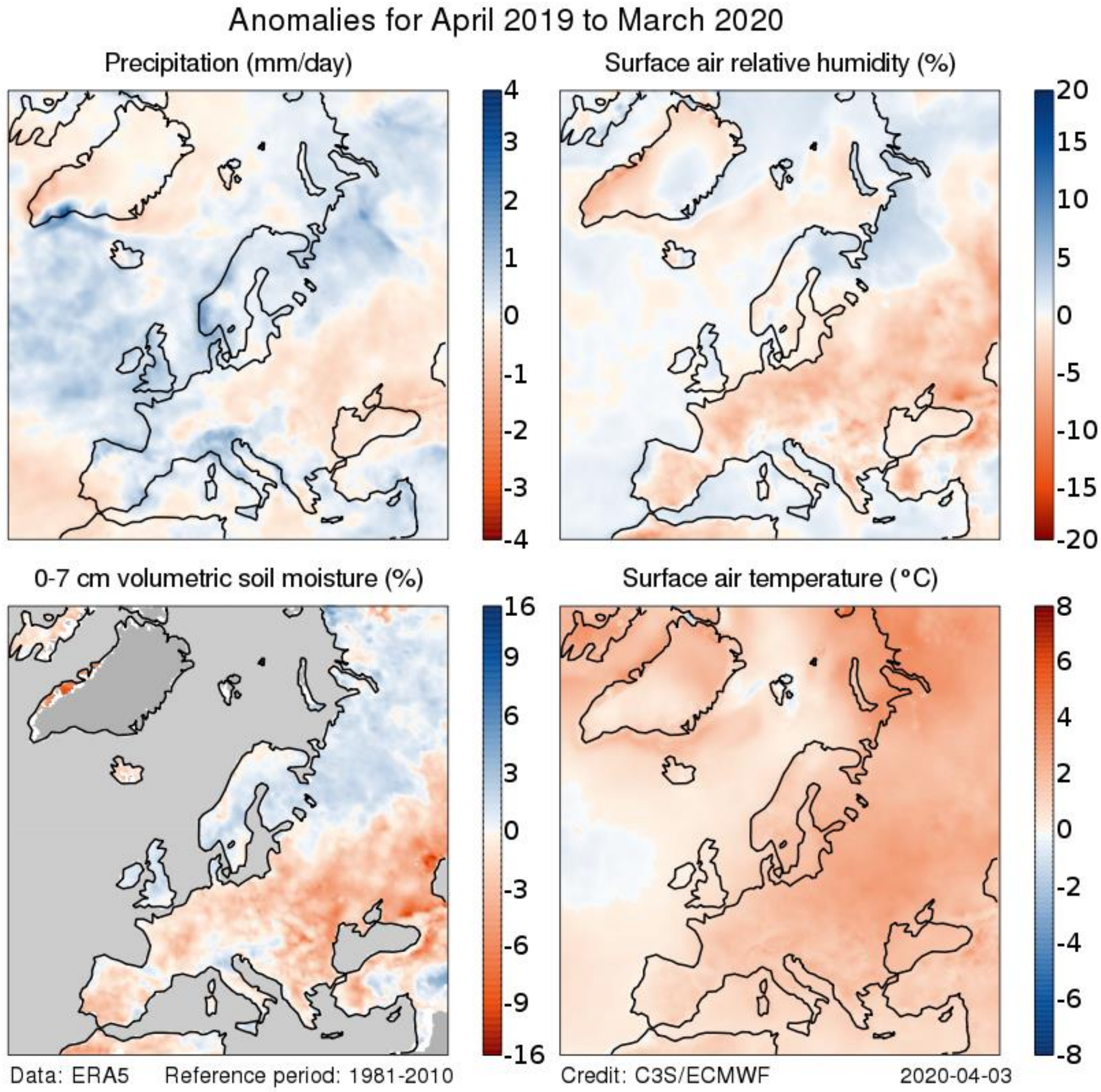

Fig. 2. The anomaly of RH and soil water content in Europe

I hope that this assessment, along with the related remarks and suggestions, will help the authors improve their manuscript and present their findings more effectively.

Response:

we highly appreciate the reviewer's insightful expertise on the topic. The critical and constructive comments are very helpful. Some key points highlighted in the feedback were what we either ignored with less consideration or neglected considering the length of the paper. We will thoroughly revise the current paper to address all these comments and reflect all the feedback in the next revision. We will do all the best to enhance the quality of the work.