RC1: Referee #1

In their article **"Assessment of seasonal soil moisture forecasts over Central Mediterranean toward groundwater management"**, the authors investigate the performance of SEAS5 soil moisture predictions across various lead times compared to ERA5 reanalysis, employing several performance metrics. The evaluation spans the period 2001-2021, focusing on the Central Mediterranean region. The findings reveal promising forecast accuracy for specific regions and soil layers, particularly at a depth of 289 cm.

General comments

Overall, the manuscript is well structured and well written. The topic of this research – the analysis of seasonal forecasts - is an area of relevance and interest. However, I have a couple of general comments: (1) There is a need for more detailed explanations and discussions on the performance metrics utilized in the study. Referencing other studies that employ similar metrics would enhance the overall quality of the article. (2) To fully support the conclusions of this study, more case studies are needed. In their case study, the authors did not account for the antecedent moisture content, which is an important factor in understanding the dynamics of the studied phenomenon. I would greatly benefit the overall quality of this article to analyse additional events, e.g. to include case studies that examine wet/dry events occurring after a dry season versus after a wet season, to provide a more comprehensive analysis of the system's predictive ability to varying moisture conditions. Alternatively, comparing SEAS5 to additional soil moisture products such as SMAP, ESA-CCI, or in situ observations if available, would also support the conclusions of this research.

Dear referee,

we thank you for your efforts in reviewing our manuscript. In the following we will summarize how we will change the paper according to your request.

1) We will include new literature regarding SEAS5 performance (in the introduction), as we did for ERA5.

2) We will include detailed explanations and literature on the performance metrics utilized in our study. Moreover we will plot the ROC curve in different point of the studied domain.

3) We are studying in detail additional periods that we will include as case studies in the revised paper. In particular we will focus on the period 2014-2015 as example of a dry period which comes after a moist period, and compare it with the 2012-2013 which represents the opposite case.

4) After an examination of local sources of observations, we decided to not include other observational products in our study. The main reason is because the focus of the paper is on the deep soil moisture, while satellite products can observe up to 5 cm from the soil surface. Moreover in the considered study domain, there are few soil moisture observations from the International Soil Moisture Network, which are often maintained for short periods and they measure soil moisture only up to 45 cm. Therefore, regarding the evaluation of soil moisture below 5 cm depth and for an extensive period of 20 years, ERA5 reanalysis and water table observations are at the moment our best sources of observations.

Specific comments:

Introduction:

- This study is focussing particularly on SEAS5 performance. However, while ERA5 performance is stated and cited in the intro, the same is missing for SEAS5. Where do these forecast generally show best performance on a global scale? What are previous studies etc.

We will include new literature about SEAS5 performance in the new introduction

- What other climate services are available in general and specifically for this region? Are there already services available that are used by government/agriculture?

To the authors' knowledge, there are no climate services other than Copernicus, that provide seasonal forecasts of soil moisture for water resources management.

Methods:

- The metrics used here should be supported by more references and additional statements on their applicability, and interpretability.

This part of methods will be improved with more references and explanations.

- Why use the ROC metric and not plot the curve once?

We decide to focus in the spatial pattern of the ROC metric. However we will include the ROC curve in the revised paper.

- Are there no in situ observations of soil moisture available at all?

Please refer to point 4) in the answers to general comments.

Results:

- Overall, the results section is well structured. Some statements belong to the discussion or conclusion.

- It would be interesting to plot the performance of the whole ensemble of forecasts in one plot and comment on the spread.

We ask the referee for a clarification of the above comment. Is it about a specific figure/lines in the text? We will appreciate any specific suggestions or ideas on where to modify the results.

Conclusion:

- What is the relevance of this study, like development of real-time application for climate services as mentioned in Line 183 – 184. This is clearly stated in the title of but is not clear from the text. Mention again the relevance and goal of this study – drought risk, development for climate services. This is missing here.

We agree with the referee. We will modify the conclusion accordingly.

- In addition, the conclusion is missing an outlook. What is still missing for the development of climate services? What is the applicability of this study going forward? What is the applicability of this study going forward?

- Last comment needs more elaboration. This section should not be a summary of results but really dive into the limitations and outlook etc.

We agree with the referee. The conclusion will be more elaborated in the revised paper.

More specific and editorial comments are given below:

We thank the reviewer for all his comments. We will take care of all the specific comments below in the revised paper.

Line 8-10: Is this conclusion really supported by the results at hand? I suggest to soften or to analyse a larger variety of individual events to support this statement.

Line 15: Improvement in observations? Unclear! Do you mean in the availability of observations or do you mean in the quality of available data such as reanalysis (as you call reanalysis observations)? Please rephrase. This statement can be short in the abstract but needs to be supported by more elaborations in the conclusion. (see comments above on conclusion)

Line 21: I suggest reformulating "soil surface" to terrestrial surface or similar.

Line 23: I suggest removing "at the surface" form the sentence

Line 23 – 26: Unclear sentence structure, I suggest reformulating.

Line 27 – 30: Sentence unclear, please reformulate.

Line 32 – 34: Remove "the" after drive: "drives 90% of the inter-annual variability". Add more reference studies or soften the statement, e.g. "the variability of soil moisture simulations has been found to drive (…)"

Line 38 – 41: Shorten the sentence and use same tenses throughout the text. Suggestion: "In addition, Li et al. (2021) evaluated groundwater recharge estimations from different land surface models and found that the seasonal cycle of simulated groundwater storage (…)."

Line 47: Again, check for consistent usage of tenses. Which reanalysis products were compared?

Line 50 – 51: Please reformulate "regards (...)". For which product/land surface model?

Line 55: Which land surface model? I suggest removing this part (Line 54 – 57) as it is not really relevant to this study and makes the transition to the next paragraph a bit confusing/abrupt. (Alternatively, more elaborations are needed here to make the transition to next paragraph more comprehensive.)

Line 63: I suggest reformulating to something like: "(…) soil moisture is one of the most impactful land parameters and is crucial for the forecast skill. "

Line 68: I suggest reformulating: "This can be attributed to reduced variability (..). "

Line 75: This statement is false! Boas et al. looked at soil moisture predicted with LSM that was forced with atmospheric fields of SEAS. Please rephrase.

Line 87: "(…) to wet and dry events. "

Line 90: Accordingly, the paper is structures as follows. I suggest to shorten this whole paragraph substantially. This is not needed in this detail for a scientific manuscript.

Line 105: "Second, the complex orography of this region (…). "

Figure 1: Not the best choice of colormap. Please consider using a colormap that conforms to color blind standards.

Line 130 onwards: Why not use the bias adjusted version of ERA5?

Following suggestions from Referee #3 we will use also ERA5-LAND in the revised paper in order to validate the seasonal forecasts. Moreover we cannot find any bias adjusted version of ERA5 in the climate data store which contains the soil moisture at all soil levels (only surface soil moisture is usually available).

Line 137: Add reference citation for this statement.

Line 137 – 139: This belongs to methods section (is already mentioned there as well).

Line 152 – 153: "(…) with a mean water table depth below 10 m, (…)." Add reference citation.

Line 170 – 171, Equation is incomplete.

Line 183 – 184: Good statement but should be mentioned first in the introduction!

Line 200: I suggest reformulating this throughout the text: "1-month lead time"

Figure 2: Remove one "at " and missing parenthesis in Figure caption: Columns show the same statistics for the forecast values at different forecast lead times (1, 3 and 6 months).

Figure 4: "(..) over the whole domain (…)." I suggest adding the soil layer depth for all layers either to figure or caption.

Line 233: I suggest rephrasing to avoid confusion: "(…) and only for shorter lead times. "

Line 242 – 244: Belongs to discussion/conclusion.

Figures 5 and 6: I suggest changing "Lead 1" etc. to Lead time – 1 months for example, to be consistent with the other plots and text. There were substantial differences in performance for the different layers, why not show wet periods for all layers?

Figure 7: Legend and axis names/labels are missing.

Line 256: (..) as shown in Figure 7b.

Line 257 – 259: Belongs to discussion.

Line 267: tab missing after "(Figure 8d)".

Figure 8: Again, I recommend making adjustments to the figure caption, labels and titles, particularly ensuring consistency in lead time labels across all figures/captions and in the text.

Line 285: "nor".

Line 287 – 288: I suggest: "The seasonal model analysed in this study is (..)"

Line 294 – 295: Replace "this paper" with this research/this study or similar.

Line 298: regions

Line 299: "(…), even when considering only the deepest layer; "

Line 301: regions

Line 302: coefficients

Line 301 – 302: Which regions?

Line 304: forecasts

Line 305: regions

Line 305 - 307: This statement needs to be softened as this study did not really predict future events, e.g. to: "This indicates (…)".

Line 308 – 309: Which means? This section should not only include a summary of results but for each statement/bullet point a discussion/conclusion is needed.

Line 310 – 311: Same as above. Conclusion needed from this result.