“Assessment of seasonal soil moisture forecasts over Central Mediterranean” by Silvestri et al. submitted to Hydrology and Earth System Sciences

Replies to Editor and Referees

EDITOR (Nunzio Romano)

Dear Authors,
The revised version of your article has been reviewed by the previous three reviewers, who expressed appreciation for the changes made, even agreeing with some of the somewhat more critical comments. As a reviewer also pointed out, perhaps due to the less experience of some of the group members, it was not always easy to identify the changes made. This was partly due to some lack of clarity regarding which line number was being referred to (whether that of the original article or the revised one).
In general, your revised version was rated favorably for its scientific significance and quality, as well as for the way in which the various elements of the study have been presented.
However, some modifications are still required. The paper is thus released under minor revisions allowing for some additional comments and suggestions received by the reviewers.
I look forward to receiving a new revised version together with the point-by-point replies to the additional comments and suggestions received so far. Should you disagree with a reviewer's comment, please explain why clearly.

Dear Editor,

We thank the Editor for the attention he paid to our paper. We feel the need to apologize for the imprecise reply to the Reviewer’s request. Then in the present reply we indicate line numbers for each change (see also tracked-changed version attached). As shown below, in the revised version, we try to address all the requests by Reviewer 1 and 2. In the re-revised version we also added the citation of a paper (Saraceni et al. 2024) accepted in the meantime to corroborate the effectiveness of the use of reanalysis data for water resource management.

REFEREE 1:

The authors have addressed most of the specific and minor comments raised in the previous review. They have provided additional details regarding the products used and the performance metrics, incorporated information on antecedent moisture content, and introduced several new figures. These revisions have enhanced the overall quality of the manuscript.

We thank Referee 1 for the attention he/she paid to our paper.

A few minor comments for the authors:
• Please consider using color maps that conform to the standards for color blindness etc.

Reply: In the re-revised version we changed the color maps of Figures 10, 11 and 13, as the other figures passed the test executed by one of the authors who is color blind.

• Most figures lack details regarding the soil layer depths; this information should be included either within the figures or their captions.

Reply: In the re-revised version we add more details of layer depth in all the figure captions.

REFEREE 2:

I have carefully reviewed the authors' responses to my earlier comments, which I find to be generally satisfactory. The inclusion of ERA5-Land data and the added memory analysis (Fig. 3) have enriched the manuscript, making it more comprehensive. Additionally, the expanded discussion section provides valuable insights.

Reply: We thank Referee 2 for the attention he/she paid to our paper.

Below, I outline three comments that the authors may wish to consider incorporating into the final version of the manuscript:

1. **Memory-Based Prediction Model Reference**: In one of their responses, the authors requested a reference for the memory-based prediction model. The signal component in such a model can be represented as follows:

   $S(t + \tau) = S(t) * \rho(\tau)$

   Here, $S(t + \tau)$ represents the predicted soil moisture anomaly at a lead time of τ, $S(t)$ is the initial condition soil moisture anomaly, and ρ(τ) is the autocorrelation value at lag time τ. The authors might consider calculating the autocorrelation values using ERA5- Land data and using initial condition anomalies derived from the SEAS5 system to generate a memory-based forecast. For example:
   - If for January 2010, S(t)=1.5
   - And the 6-month lag autocorrelation from ERA5-Land data is 0.60
   - Then the memory-based prediction at 6-month lead time, i.e., for June 2010 is 1.5·* 0.6=0.9

   For reference, the authors might consult Supplementary Fig. 3 in Esit et al. (2021).

   Reply: We agree with Referee 2 for the relevance of the memory-based prediction model. However, the exploration of the performance of this approach and its comparison with the one used in this paper merits a detailed analysis and it will be considered in future research. In the re-revised version, we add the following sentence in the Discussion to point out this need:

   Lines 472-475: "The second path is to analyze in more detail the behavior of the autocorrelation function of soil moisture anomalies across different soil layers. This to evaluate the role of the seasonal cycle and the reemergence of soil moisture as hypothesized by Kumar et al. (2019). Then, this would allow us to compare the seasonal forecast performance with those obtained by memory-prediction models, following the approach proposed by Esit et al. (2021).

2. **Clarification of Ground-Well Data Comparison (Figure 14)**: It appears that one of my earlier comments was not fully addressed, possibly due to a misunderstanding. Specifically, my comment referred to "two ground-well data separate in (a) and (b)." The updated Figure 14 does not reflect this separation. To clarify:

- In plot (a), could the authors compare ground water well data at Umbria with the corresponding ERA5-Land reanalysis?
- Similarly, in plot (b), could the authors compare ground water well data at Veneto with the corresponding ERA5-Land reanalysis?

This modification would provide a clearer, location-specific analysis, improving the interpretability of the results.

Reply: Done.

3. **Rebound in Autocorrelation (Figure 3):** Based on the new Figure 3, I notice an interesting feature in the autocorrelation structure: after an initial decay (as expected), the autocorrelation shows a rebound, reaching a secondary statistically significant maximum at a lag of approximately 300–350 days. This phenomenon merits further exploration.
   - Is this rebound indicative of a seasonal cycle, or could it signify the reemergence of soil moisture anomalies, as hypothesized by Kumar et al. (2019)?
   - A brief discussion of this aspect in the manuscript would be valuable for readers.

   Furthermore, given the observed rebound in autocorrelation, the authors might consider exploring the feasibility of longer lead-time forecasts (e.g., a 12-month lead forecast), which could be highly impactful for applications.

   Reply: We thank Reviewer for the precious suggestion. To address his/her request we explore the obtained results with respect to the autocorrelation behavior in all the grid points. As the results do not indicate a unique behavior in all the grid points, we decided to address such behavior in the continuation of our research, as outlined at the end of the discussion (Lines 472-475). Moreover, we added the following lines to the re-revised version:

   Lines 226-230: "A further interesting feature is pointed out by the autocorrelation structure. Precisely, after an initial decay (as expected), the autocorrelation shows a rebound with a secondary statistically significant maximum at a lag of approximately 300-350 days. Such rebound could be indicative either of the seasonal cycle or of the reemergence of soil moisture anomalies as hypothesized by Kumar et al. 2019. However, this behavior is not representative of all regions and then merits further explorations in future research."

References

Esit, M., Kumar, S., Pandey, A., Lawrence, D. M., Rangwala, I., & Yeager, S. (2021). Seasonal to multi-year soil moisture drought forecasting. npj Climate and Atmospheric Science, 4(1), 16.

Kumar, S., Newman, M., Wang, Y., & Livneh, B. (2019). Potential reemergence of seasonal soil moisture anomalies in North America. Journal of Climate, 32(10), 2707-2734.

REFEREE 3:

Accepted as is (no comments)

Reply: We thank Referee 3 for the attention he/she paid to our paper.