**RC2: Referee #2**

Review comments for "Assessment of seasonal soil moisture forecast over central Mediterranean toward groundwater management" by Silvestri et al.

The authors have evaluated SEAS5 soil moisture forecast skills in the Mediterranean region. They found that the deepest soil layer (289 cm) has more skill than the upper soil layers. Hence, the authors conclude that deep soil layer forecast can be potentially valuable for groundwater management regionally.

The authors present a comprehensive review of the relevant literature. The manuscript is well written, and the figure quality is generally good. A novel contribution of this study is the skill in the deepest soil layer forecast. For these reasons, I liked the manuscript, which should eventually be publishable. I recommend the following revisions for the manuscript.

Dear referee,

We would like to thank you for your valuable input. We will try to address your comments as follows.

- Please show the sensitivity of your findings for the reanalysis data selected, which is highly dependent on the selected model (Kumar et al. 2019). Authors may consider alternative data sources, e.g., GLEAMv3 (Martens et al. 2017) and MERRA2 (Gelaro et al. 2017).

Related to the above point, I am somewhat supervised in seeing a lower skill in the upper layer soil moisture anomalies even at shorter lead times, e.g., 1 and 3 months (Figure 2). The root zone (0-1m) has a memory time scale ranging from 2-4 months; I was expecting a higher skill at the shorter lead times.

Additionally, it is unclear if the Authors used ERA5-Land soil moisture data for observations. There are clear differences between ERA5 and ERA5-Land soil moisture data, especially for deeper soil layers (Muñoz-Sabater et al. 2021).

We will definitely use ERA5-Land soil moisture data for observations and we will compare the results with ERA5. However, we decide not to use alternative reanalysis datasets and to maintain a coherence between the soil model used in the seasonal forecasting system and the one used for the production of the reanalysis observation datasets (ERA5 H-TESSEL land surface model) . The comparison of performances between different reanalysis datasets has been done previously [1] for a part of the domain under consideration and ERA5 resulted the best performing dataset in such region. The comparison of different soil models and how they perform in different seasonal forecasting system, or how the findings of this paper depends on the utilized soil model, will be investigated in future work and will be included in the conclusion section.

[1] Cerlini, P. B., Silvestri, L., Meniconi, S., & Brunone, B. (2023). Performance of three reanalyses in simulating the water table elevation in different shallow unconfined aquifers in Central Italy. *Meteorological Applications*, 30(2), e2118. https://doi.org/10.1002/met.2118

- Process level understanding – please discuss biophysical reasons behind more skillful deeper layer soil moisture prediction in SEAS5. The authors may consider showing the memory time scale in each soil layer for the reanalysis of data and comparing the memory-based predictions with SEAS5 predictions.

We thank referee #2 for his/her useful suggestion. We would like to perform such comparison and we will include the memory time scale in each soil layer, as already done in past works [1], by using a cross-correlation function. However we ask if she/he could indicate us some reference literature or reference method to follow in order to perform and implement a memory-based prediction.

Cerlini, P. B., L. Silvestri, S. Meniconi, and B. Brunone, 2021: Simulation of the Water Table Elevation in Shallow Unconfined Aquifers by means of the ERA5 Soil Moisture Dataset: The Umbria Region Case Study. Earth Interact., 25, 15–32, https://doi.org/10.1175/EI-D-20-0011.1.

- Figure 7 needs a thorough revision – the legend text is missing. X-axis labels are missing. Also, I would suggest two groundwater well data separate in (a) and (b), and they can be compared with the corresponding reanalysis data.

We think that this maybe an error of the printer since all the labels of Figure 7 are visible in the pdf on the screen. Anyway, we will ensure that the figure will be printed correctly and we will follow the suggestion of separating the well data in two figures.

Detailed comments:

Title: ‘toward’ -> ‘for’

The title will be changed accordingly

Line 5: ERA5 reanalysis -> Is this ERA5 or ERA5-Land?

In the original paper it was ERA5, but we will use ERA5-Land in the revised version, as requested by the referee

Line 6-7: ‘good performance in the … deepest layer’ -> why?

Thanks to the referee suggestion about the memory time scale and to the suggestions of referee #3 about investigating the monthly soil moisture variations, we will try to answer this question and we will include results in the abstract.

Line 165 to 170: SSMA -> Eq1.  -> Add parentheses in the numerator.

This will be corrected

A related comment is that forecast biases (drifts) are a function of the lead time and forecast initialization months (Kumar et al. 2014); it is unclear how you have incorporated these effects in the anomaly calculation. In particular, if you look at Fig. 9 (c), the forecast anomaly does not match the corresponding reanalysis data, even at the start of the forecast! Is it the effect of forecast drifts? If so, this can be easily removed using lead month and forecast initialization month-dependent climatology (Kumar et al. 2014).

We thank the reviewer suggestion. We will try to introduce a bias-adjustment method which consider lead month and month-dependent climatology and we will analyze how this improve the forecast bias in the revised paper.

We will apply all the below suggestions in the revised version of the paper.

Line 204: ‘this can be reconducted…’ -> what does ‘reconducted’ refer to. Please consider simplifying this sentence.

Line 205: ‘temporal oscillation’ -> ‘temporal variability’

Figure 1 and other figures, too: please consider using a color-blind-friendly color scheme. For example, I can not clearly distinguish between red and green colors. Additionally, in Figure 1, RMSE < 0.25 looks similar to the color ranging between 0.75 and 1.25.

Figure 2b,c, and f-> why there are stipplings on the Gary color areas; I am assuming they are statistically insignificant correlations.

Figure 2l,m,n -> why darker red areas ( ACC > 0.7) are not stippled, but the yellow area (0.2<ACC<0.4) are stippled.

Thank you.

References:


- Gelaro, R., and Coauthors, 2017: The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2). *J Climate*, **30,** 5419-5454.
- Kumar, S., P. A. Dirmeyer, and J. Kinter, 2014: Usefulness of ensemble forecasts from NCEP Climate Forecast System in sub-seasonal to intra-annual forecasting. *Geophysical Research Letters*, **41,** 3586-3593.
- Kumar, S., M. Newman, Y. Wang, and B. Livneh, 2019: Potential reemergence of seasonal soil moisture anomalies in North America. *J Climate*, **32,** 2707-2734.
- Martens, B., and Coauthors, 2017: GLEAM v3: satellite-based land evaporation and root-zone soil moisture. *Geosci Model Dev*, **10,** 1903-1925.
- Muñoz-Sabater, J., and Coauthors, 2021: ERA5-Land: A state-of-the-art global reanalysis dataset for land applications. *Earth System Science Data*, **13,** 4349-4383.