Major comments have been addressed in the review. I think the paper therefore requires minor revisions. Please see below my general and specific comments.

GENERAL COMMENTS
I would like to again, add as a cautionary note, that comparing “raw” and “gapfilled” values and exploring their difference is not related to the merit of the gap-fill, due to the complex missingness pattern of the soil moisture data. I would discuss this more prominently in Section 4.1 and Section 4.5. The differences between “raw” and “gap filled” are however very interesting, and likely related to the pattern of missing values that is underlying. I find this very interesting to discuss and would encourage you to write a bit more about it in those Sections. In the abstract and the introduction you cite satellite coverage and radio-frequency interference as a mechanism for the missing values in ESA CCI SM. Note however that according to Dorigo et al, 2017, those are not the only one and quite possibly not the major contributors to missing data. In this citation, they also note that snow-covered pixels are removed since the water in the snow is measured by the satellite, not the soil moisture, in these situations. Furthermore, regions with high vegetation cover are set to missing in post processing, since there the signal cannot penetrate through the vegetation and reports, respectively, only the water stored in the above-ground vegetation. I haven’t looked into how those two missingness mechanisms play a role in your study area, but it could be that the snow-cover problem is responsible for many missing values in winter (e.g. Fig 5a) and the overall wetter gap-filled values in high latitude regions in Figure 13 and Figure 5b,c for winter. Or, it could be due to vegetation cover. It might be interesting to investigate, for example by plotting Figure 13 separately for each month, to see where the “wet” signal in the gapfill is coming from and which missingness mechanism it can be explained by, if any.

Unfortunately, I still can’t wrap my head around the applied variable correction. I understand now that this is applied to the ERA SM data before using it for the gap-filling. I agree that a bias is very likely to exist between ESA SM and ERA SM and needs to be corrected before using traditional machine learning methods. But I don’t yet understand what the difference between Equations (3) is and standardised anomalies. When I inspect the equations, I understand that the result is the mean of the ESA SM plus the anomalies of the ERA SM, scaled with the ratio of their standard deviations. To me, this is an equal procedure as using standardised anomalies for both ERA SM and ESA SM. However, both is fine, so no need to change the variable correction. However, also note that for the Random Forest method, scaled/standardised variables are not necessary, since the scale of a feature (input variable) does not depend on its importance after training. (E.g see https://datascience.stackexchange.com/questions/62031/normalize-standardize-in-a-random-forest https://stackoverflow.com/questions/8961586/do-i-need-to-normalize-or-scale-data-for-randomforest-r-package; I could not find a literature source for this unfortunately but it derives logically from the RF function). So you might do additional work here that is, after all, not necessary, if I understood everything correctly.

As far as I understood, the training period of the Random Forest, described in Section 3.2.1, is on the years 2003-2008, and therefore overlaps with the Long term extension, described in Section 4.5., that runs from 2005-2015. Since using the same data for training and predicting with a Random Forest likely leads to overestimation on the merit of the Random Forest, I suggest adding a cautionary

note to that effect in the text.

SPECIFIC COMMENTS
L12 and L58+59: radio-frequency interference is mentioned as a major reason for gaps in the ESA CCI SM data. However, many values in the ESA CCI SM are also missing because of snow cover, frozen soil, or dense vegetation (Dorigo et al, 2017). Since those mechanisms are relevant for the interpretation of the results (see general comments above), I think they should be included here.

L29: missing comma “soil moisture (SM),”

L39 optionally add Dorigo et al, 2021

L84: sentence a bit unclear. Is “compared” meant instead of “focused”?

L65: Bessenbacher et al, 2022 useful citation here

L65, L197, L357, L523: “strong capacity/capability” leads in my opinion to convoluted sentences and is not very clear. Try to not use as much.

L67: no brackets needed around citation

L95: missing space character before Zhang et al

L128ff: add in brackets behind (i), (ii), (iii) where they can be found in Fig. 2. Example: “(i) use a regression (…) bias between them (Fig2 Part 1 red text);”

L186: possible typo “MODSI”

L207: remove “reliable”

L207: presented -> present

L240: if available, it would be really interesting to know what the computational efficiency of the presented gap-filling algorithm was, i.e. how long it roughly ran on how many CPUs / which machine. If possible, would be nice to include this information!

L246: missing space character before citation

L259: is 2003-2008 the training window or the cross-validation window for the RF parameters? Or both? Please clarify

L262: remove “best”

L291: Do you perhaps mean Eq (1)?

L314: is suppose to -> can

Figure5: optional suggestion: put Figure S3 here and move Figure5 (b, d) into S3.

Makes more sense to me, but just optional.

L375-376: severe contamination in winter season is likely related to snow cover in ESA CCI SM, list as reason

L279ff: You state that in the warm season, more missing pixels are reconstructed than in the cold season. You argue this is because surface coupling is larger in summer. This might be true, but how does the algorithm know this? I thought it only leaves gaps unfilled when there are not sufficient neighbouring points available to run the Random Forest. How does this related to the strength of the surface coupling? Please clarify.

L382: Yes they tend to produce "bias", however, this is not a problem itself. If the pixels are missing not at random, I would expect bias between "raw" and "gap filled", because the gap filled data might e.g. fill especially pixels under dense vegetation, which are systematically wetter than pixels with less dense vegetation. Therefore, this "bias" is not a bad thing, I would be worried if there wasn't any.

L410: consider moving this part of 4.2 into a separate (sub)section.

L412: "better" compared to what? As R2 and RMSE are not comparable, because of different units.

L419: unnecessary space character after bracket

L426: "some grids" unclear. Some regions?

L522: add year 2009 to the table for easy comparison

L525ff: Add that the gap-filled product is drier overall than the "raw" is consistent with the findings in Figure 5.

L527: "overestimated": since we don't know the ground truth of missing values, I would not use words like "overestimated"

L531: important finding: trends could be overestimated in satellite SM due to missingness.

L535f: How does missing values in AOD and missing values in albedo compare to missing values in SM? Since the missing values mechanisms (below clouds) are different from soil moisture (vegetation, snow, interference), why would we expect the effect of gap-filling to be similarly, e.g. reducing trends? This might be related to the next sentence in the text, but unfortunately I don't understand this sentence. Please clarify.

L549: Unfortunately I don't understand Figure S7. Is that like Figure14, but disaggregated into trends and seasonal cycle? Then, trends are barely visible and cannot be compared like this.

L554: "Overall…" unclear statement, please clarify.

Figure14a,b: These values are hard to compare. Idea: combine a and b into 1 plot and mark “raw” and “gap-filled” with different colours. Same for S7

REFERENCES

Dorigo et al, 2017: ESA CCI Soil Moisture for improved Earth system understanding: State-of-the art and future directions. Remote Sensing of Environment. Volume 203, Pages 185-215, https://doi.org/10.1016/j.rse.2017.07.001

Dorigo et al, 2021: The International Soil Moisture Network: serving Earth system science for over a decade. Hydrol. Earth Syst. Sci. 10.5194/hess-25-5749-2021

Bessenbacher et al, 2022: CLIMFILL v0.9: A Framework for Intelligently Gap filling Earth Observations, GMD, https://doi.org/10.5194/gmd-15-4569-2022