Dear Reviewers and Editors,

We are very sorry for the late submission. This dataset was completed with the support of China's 13th Five-Year Key R&D Plan, and one of the goals of this project is to produce a set of soil moisture datasets with high spatial and temporal resolution in China. Validation and application analysis show that the accuracy of our dataset is reliable. Many users have used the dataset and it has been downloaded 1744 times (https://zenodo.org/record/4738556#.YJJcs8DiuUk). They gave a lot of good comments and a few users also put forward some suggestions to improve the data quality of local forest coverage areas. We have improved the data quality according to the user's suggestions, and now we have updated to the third version. At the same time, we also polished the English expression of the manuscript.

Thank you for your valuable comments on our manuscript. First, we would like to express our sincere appreciation for your professional and insightful remarks on our paper. The global soil moisture dataset is constantly being produced, especially in recent years, the frequency of updates is getting faster and faster. Each soil moisture dataset and method of producing soil moisture has its own advantages and disadvantages. Our soil moisture dataset is mainly concentrated in China. Two similar sensors mounted on different satellites are used to produce a set of soil moisture datasets that are continuous in time and space in China. For the missing part in the middle, a relatively reliable sensor was used to make up for it. In order to ensure the consistency of the time and depth of the observation data of the three instruments, we have made corrections through building reconstruction model. In particular, we took advantage of ground observation site data obtained from the National Meteorological Administration to make local improvements. In order to meet the needs of research such as agricultural drought monitoring, we downscaled the soil moisture products and obtained a higher resolution dataset.

Your comments are all valuable and have helped us to improve the quality of the dataset and paper. We have studied each comment and have made revisions that we hope will meet with approval. Please find our detailed responses below. Revisions to

the manuscript will be highlighted in blue in the revised manuscript file. Thanks again.

With our best regards,

Xiangjin Meng and co-authors

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Response to referees

Response to referee #1

 # Summary:

Soil moisture is an important indicator for a wide range of applications, especially those related to agriculture and the ecosystem. Measuring soil moisture is expensive with ground stations and difficult to cover the spatial variation of soil moisture. Satellite observation is able to cover a large area and has the potential for deriving soil moisture for a country or even the globe; however, the coarse resolution of the satellite-derived datasets limits wide use of these data, especially for soil moisture derived from passive microwave observations. The paper presents a soil moisture dataset for China with monthly and 0.05 degree resolutions, which could be helpful to many applications.

Response: We would like to thank you for reviewing our manuscript. Your comments and good suggestions are very important for us to improve the quality of manuscript and dataset. We have carefully addressed all the issues raised by you and the response is presented below. As you mentioned, soil moisture products are very important, so many countries and regions (especially the United States, the European Union, Japan, China, etc.) have been developing soil moisture products and are constantly updating their versions, especially in recent years, the frequency of updates is getting faster and faster. Traditional methods and new methods have been promoting the development of this product. Various methods have their own advantages and disadvantages, and the accuracy of different products is not consistent in different places.

In vegetation coverage areas, especially forest coverage areas, the accuracy of

different algorithms is somewhat different. The inconsistent consideration of vegetation in traditional physical algorithms leads to inconsistent soil moisture retrieval, while machine learning methods (such as deep learning algorithms) are difficult to obtain the corresponding large-scale ground truth values and the accuracy is also difficult to guarantee, so many people have been thinking of ways to improve retrieval accuracy of vegetation coverage area.

1. The paper claims that the 0.05-degree spatial resolution is a breakthrough for soil moisture; however, datasets with the same resolutions have been published for even the globe, for example:

(1) Chen, Y. Z, Feng, X. M., and Fu, B.: An improved global remote-sensing-based surface soil moisture (RSSSM) dataset covering 2003–2018. Earth Syst. Sci. Data, 13(1), 1–31. https://doi.org/10.5194/essd-13-1-2021, 2021.

(2) Jing, Wenlong, Pengyan Zhang, and Xiaodan Zhao. Reconstructing Monthly ECV Global Soil Moisture with an Improved Spatial Resolution. Water Resources Management, 32(7), 2523–37, 2018. https://doi.org/10.1007/s11269-018-1944-2, 2018.

(3) Zhang, Q., Yuan, Q., Li, J., Wang, Y., Sun, F., and Zhang, L.: Generating seamless global daily AMSR2 soil moisture (SGD-SM) long-term products for the years 2013–2019, Earth Syst. Sci. Data, 13, 1385–1401, https://doi.org/10.5194/essd-13-1385-2021, 2021.

(4) Kang, C.S., Zhao, T., Shi, J., Cosh, M.H., Chen, Y., Starks, P.J., Collins, C.H., Wu, S., Sun, R., and Zheng, J.: Global Soil Moisture Retrievals From the Chinese FY-3D Microwave Radiation Imager. IEEE Transactions on Geoscience and Remote Sensing. https://doi.org/10.1109/TGRS.2020.3019408, 2020.

Response: Thank you for your guidance. Although many people have done a lot of excellent work, the focus of different work is inconsistent and the work we did is different from other dataset in terms of time scale and spatial resolution, especially our focus on improving product accuracy in China with the aid of a large number

of ground station data, and the resolution is about 0.05-degree resolution covering 2002–2018. The resolution and time length of other datasets are introduced as follows.

(1) Chen et al. (2021) developed the global remote-sensing-based surface soil moisture dataset (RSSSM) **covering 2003–2018** through a neural network approach, and the accuracy is very high and **resolution is about 0.1-degree resolution**, **which has not been downscaled. This dataset can be publicly downloaded.**

(2) Jing et al. (2018) proposed a two-steps reconstruction approach for reconstructing satellite-based soil moisture products (ECV) at an improved spatial **0.05-degree resolution covering 2001–2012**. The reconstruction model implemented the Random Forests (RF) regression algorithm to simulate the relationships between soil moisture and environmental variables, and takes advantages of the high spatial resolution of optical remote sensing products, which is a good work. **This dataset cannot be publicly downloaded.**

(3) Zhang et al. (2021) develop a novel spatio-temporal partial convolutional neural network (CNN) for AMSR2 soil moisture product gap-filling, and the resolution is **about 0.25-degree resolution covering 2013–2019. This dataset can be publicly downloaded.**

(4) The research group of my supervisor Shi Jiancheng who is one of co-authors has improved the algorithm for FY 3D microwave data and also produced a global soil moisture product (Kang et al. 2020), and **the resolution is about 0.25-degree resolution covering 20017–2019. This dataset cannot be publicly downloaded.**

These works are very good, and do not contradict the work we have done, and their respective focuses are different. Our main point is to emphasize the consistency and downscaling of soil moisture obtained from three similar sensors mounted on different satellites, as well as their application in China. Different microwave bands have different penetration capabilities for different vegetation, and it is still limited to obtain soil moisture information under dense vegetation cover. Therefore, it is still difficult to guarantee the inversion accuracy of either traditional physical methods or machine learning methods in some regions. We mainly want to use ground observation sites to

further calibrate the soil moisture products in vegetation areas, especially forest-covered areas, to improve the accuracy of soil moisture products in China. We have introduced and revised our manuscript.

2. The paper needs to compare to the existing dataset to investigate the accuracy and improvements of this dataset over others, to provide a subjective review of the dataset accuracy for users. Meanwhile, recent studies have suggested advantage of down-scaling soil moisture using machine learning methods, for example:

Liu, Yangxiaoyue, Wenlong Jing, Qi Wang, and Xiaolin Xia."Generating High-Resolution Daily Soil Moisture by Using Spatial Downscaling Techniques: A Comparison of Six Machine Learning Algorithms." Advances in Water Resources 141 (July2020): 103601. https://doi.org/10.1016/j.advwatres.2020.103601.

Response: Thank you for your good suggestions. Some data is available for download, and some data is not available for download. We have mentioned it in the previous question. Our dataset differs from other data sets in observation time, resolution, and length of the data set, and we have tried made revisions and comparison.

Liu et al. (2020) have made a good comparison analysis which is a good work. Each method has its own advantages and disadvantages, and sometimes the accuracy of different algorithms in different areas is inconsistent. There are two main reasons. One is the data reason, and the other is the algorithm reason. At present, the resolution of most passive microwave data is very low, and they are basically mixed pixels. Most algorithms basically do not consider the problem of mixed pixels. Especially in vegetation coverage areas, it is difficult for us to completely eliminate the influence of vegetation and obtain high-precision ground soil moisture, and machine learning algorithms are no exception which is highly dependent on the accuracy of the training dataset. In areas covered by vegetation, we still need to further improve the accuracy of soil moisture products. We try our best to do more supplementary analysis on our data products. Thanks again.

3. The dataset was produced using aged algorithms with little methodology innovation by the authors, making it difficult to justify the value of this manuscript. Many of the sentences make little sense, and the writing needs improvement before publication.

Response: Thank you for your guidance, and we have tried our best to modify it. The main purpose of our work is to use AMSR-E, AMSR2, and SMOS soil moisture products to construct a long-term sequence of soil moisture products, eliminating the difference in observation time and depth of different products. In order to further meet the needs of agricultural drought and other research, we further downscaled and improved the data resolution by constructing a weight decomposition model using thermal infrared and visible light bands, which can ensure the stability of soil moisture product. In addition, in vegetation areas, especially forest coverage areas, we used site data to make corrections. Machine learning methods have certain advantages, but sometimes they are not stable enough. For example, when there is the influence of clouds and rainfall. Neural network is not a new method which has existed decades ago and has long been used in geophysical parameter inversion. Neural networks have their own advantages, but the disadvantage is that they depend on the accuracy of the training dataset. For large-scale pixels, it is difficult to obtain the corresponding ground truth values. The same is true for large-scale validation. In many cases, it is relative comparison.

We believe that by making the dataset public, and then application make it public in the paper, so that many users can use it in practice and point out that there are problems for data, which can help greatly improve the accuracy of dataset. Thanks gain.

4. It appears that the authors have been misusing terms in the paper, such as “verify”. Please replace it with “validation” or “evaluation”.

Response: Thank you for your guidance. We have made revisions.

5. The authors interpreted the changes of derived soil moisture in China, and explain the changes due to climate changes. I wonder if the authors have compared the results to climate datasets to justify these statements?

Response: Thanks for your guidance. Most of our analysis is similar to many related researches on climate change in China, but a few of them are inconsistent with some studies. Using different data sources and different research perspectives, it is normal to get a small number of different conclusions. This requires us to compare and analyze the reasons through different studies and even different disciplines in the future, so as to promote scientific progress. Controversy and differences are good things, which can make more people think about the reasons for the differences through public papers and data in ESSD, and thus discover more interesting knowledge. Most geophysical products (including NASA products) have been constantly updated and improved. We have been working hard to improve data accuracy, and we will continue to update the dataset version through user application feedback.

6. Line 80, please add a citation at the end of the sentence.

Response: Thank you for your guidance. We have made revisions.

7. Line 89, replace “verified” with “validated”.

Response: Thank you for your guidance. We have made revisions.

8. Line 103, why “most of the areas in China”? What happened to the rest of China?

Response: Thank you for your guidance. We have made revisions.

9. Line 136, replace “finite working life” with “limited lifespan”.

Response: Thank you for your guidance. We have made revisions.

10. Line 225, please clarify “different absolute values”.

Response: Thank you for your guidance. We have made revisions.

11. Line 227-228. Please clarify how the average was calculated from the one and half month's data.

Response: Thank you for your guidance. We have made revisions.

12. Line 378, what "consistent" is referring to? Similar trend or similar values?

Response: Thank you for your guidance. We have made revisions.

13. Line 386, I am not sure what "sensitive" refers to.

Response: Thank you for your guidance. We have made revisions.

14. Line 388, "most significant change" please clarify.

Response: Thank you for your guidance. We have made revisions.

15. Line 520, is there evidence to support the statement regarding the effects of urbanization?

Response: Thank you for your guidance. We have made revisions.

Anonymous Referee #2

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Soil moisture is very crucial in exploring the response of vegetation dynamics to the climate change in ecohydrological processes. Having professed my general enthusiasm for the topic and its importance, I have some concerns that require substantive effort, a large part should be recalculated and rewrote.

Response: Thank you for your valuable comments on our manuscript, which are very important and helped us to improve the quality of dataset and paper. **We have upgraded the dataset based on your comments and many users' feedback in the process of applying data, and it is currently updated to version 3 and has been downloaded 1716 times (https://zenodo.org/record/4738556#.YJJcs8DiuUk). We have** studied each comment and have made revisions. Please find our detailed responses below. Revisions to the manuscript will be highlighted in blue in the revised manuscript file. Thanks again.

The paper should be suitable for publication following the recommend major revisions below:

1. There are several similar studies on the reference. What are new findings on this study?

Response: In addition to providing a set of soil moisture data sets with high spatiotemporal resolution for agricultural drought monitoring and climate change models, we also analyzed the spatiotemporal changes in different regions. In the past 17 years, China's soil moisture has shown cyclical fluctuations and a downward trend, but the northwest has a slightly wet trend. Global warming drives the intensification of the water cycle, which is the fundamental reason for the warming and humidification of the climate in Northwest China. For the Northwest, water vapor mainly comes from the Arabian Sea and the Indian Ocean. As the Arctic warms, water vapor from the Arctic Ocean increases. Under the action of air currents, water vapor in the three places

concentrated in the northwest, and precipitation in the northwest increased rapidly, which leads to an increase in soil moisture. For more specific analysis, please refer to the manuscript.

2. Line 111-114: The authors should explain more about how to divide into these six regions (NEM, NCM, SCM, etc.) by climate and topography, and add these in Fig 1. What does the different color mean is Fig 1 (the patch not the points).

Response: We mainly divide regions based on topography (elevation), rainfall and other factors, so that we can better evaluate soil moisture changes and make corrections and assessments based on corresponding ground observation sites. Different color means different elevation information.

3. Eqs4: Why do you need to correct the surface temperature? Did these data already include the elevation effects?

Response: There are a lot of clouds in some mountainous areas in the south, and a few places have very few effective values of surface temperature. Only the bottom of the mountain has an observation station. In order to obtain a more reliable temperature at high altitudes, we can only use the valley ground observation site temperature, so the influence of elevation must be considered in the correction process.

4. Eqs8: These letters (i, j, a and b) seem to be four different pixels. Please explain clearly about how to get the new soil moisture data from the previous soil moisture and TVDI in different location.

Response: Thank you for your guidance. We have made revisions. Revisions to the manuscript will be highlighted in blue in the revised manuscript file.

5. Line 327-328: Can you explain why for this: 'the downscaled SM data underestimated the ground observations at all three temporal scales, especially the monthly scale.'

Response: Compared with thermal infrared remote sensing, passive microwave remote sensing has less influence on clouds and rainfall. Especially when there is rainfall, the accuracy error of passive microwave inversion of soil moisture is still relatively large. Therefore, when it is judged that there is rainfall and the error is relatively large, the inversion algorithm usually sets this inversion value to an invalid value (0). Some algorithms are filled by neighboring pixels. In addition, there is a gap between the data of two adjacent scenes, and some algorithms fill it with adjacent pixels. When there is rainfall, most of the soil moisture value reaches the maximum saturation value. The processing method of the inversion algorithm will lead to underestimation of soil moisture content during rainfall, which will lead to underestimation of soil moisture at all three temporal scales, especially the monthly scale. In view of this defect, we have performed optimized calculations to improve the accuracy as much as possible.

6. Lin 343: 'possibly attributable to ice and snow cover in winter' If it is true, why the RMSE in April was higher than that in November.

Response: In most areas, RMSE is relatively larger in winter. However, in some places, due to more rain and clouds in the spring, the error of the satellite inversion of soil moisture is relatively large, resulting in relatively large errors. In addition, it has something to do with the site location and measurement. Due to the low resolution of passive microwaves, there is a big difference between the representativeness of the site and the real pixels, which will also cause deviations in the validation process. We have already made more analysis and explanation in the manuscript.

7. There are five elements including station, vegetation types, R, SDV and RMSE in Fig 5. It is difficult for the reader to get information easily and it did not show the highlight (SM associated with higher vegetation is more variable) well.

Response: Thank you for your guidance, we have made revisions and gave a more detailed description.

8. Line 378-379: Would it be affected by the soil types either? The soil types could also

affect the soil moisture. Please include the effect of soil types in this part.

Response: Thank you for your guidance. The type of soil (surface type) has also a certain impact on the change of soil moisture, and we have made a supplementary explanation in the manuscript.

9. Fig6: I found large interannual variability along with the declined trend in each panel. Please explain the variability in the main text. Is it caused by low quality of the data or climate change?

Response: There may be many reasons, but the most important reason is global warming. The overall increase in temperature leads to an increase in evaporation, so that the overall soil moisture has a slight downward trend. The change trend of soil moisture is fluctuating, and the performance is different in different places. After considering the impact of rainfall, we re-corrected and re-analyzed the data in the manuscript.

10. Please mark the 'Changbai Mountains', 'Liaodong Peninsula', 'Sichuan Basin', etc. in relevant figures.

Response: Thank you. We have made revisions.

11. Fig8: why did the soil moisture increase in Northeast China in autumn?

Response: Global warming drives the intensification of the water cycle, which is the fundamental reason for the warming and humidification of the climate in Northwest China. For the Northwest, water vapor mainly comes from the Arabian Sea and the Indian Ocean. As the Arctic warms, water vapor from the Arctic Ocean increases. Under the action of air currents, water vapor in the three places concentrated in the northwest, and precipitation in the northwest increased rapidly, which leads to an increase in soil moisture.

12. The authors actually did 'results and discussion' in 'results' session. The 'Discussion and conclusions' part did not show much discussion. Please modify the

session name.

Response: Thank you for your guidance. We have made revisions.