Author's Response for All the Comments

Dear Topical Editor and Referees:

We are particularly grateful for your careful reading, and for giving us many constructive comments of this work!

According to the comments and suggestions, we have tried our best to improve the previous manuscript essd-2022-80 (SGD-SM 2.0: An Improved Seamless Global Daily Soil Moisture Long-term Dataset From 2002 to 2022). The modified words or sentences are marked as blue color in the revised manuscript. An item-by-item response follows.

Once again, we are particularly grateful for your careful reading and constructive comments. Thanks very much for your time.

Best regards,

Qiang Zhang and all co-authors

Response to the Comments of Topical Editor:

General comments:

Please, revise your manuscript by considering the suggestions provided by one of the Referees.

Response: We are particularly grateful to the editor and reviewers for these detailed suggestions! Based on the reviewers' comments, we have tried our best to revise the previous manuscript. An item-by-item response to each constructive comment follows.

Response to the Comments of Reviewer #3:

General comments:

Many improvements have been made to the manuscript. However, two important issues still need to be resolved.

Response: We are particularly grateful to the reviewer for his/her detailed suggestion! According to the comments, we have tried our best to improve the previous manuscript. An item-by-item response to each constructive comment follows.

Major comments:

Q1.1: ***First issue: In my first review, I indicated that some soil moisture values shown in Fig. 8 show extremely SM high values of more than 80 Vol.%. Such high values are very unlikely, as soil porosity in most soil is typically between 40-50 Vol.%.***

The authors responded:
"Actually, the SM values in this work are the volume ratio (unit: m3m-3, from 0% to 100%), rather than the mass ratio (kgm-3, usually 0% to 50%). This phenomenon is normal because of the unit via volume ratio, not measurement errors or SM overestimation by the CNN. (. . .) Overall, these outliers are few with small impact for SGD-SM 2.0. Therefore, we don't clean the data with an outlier detection method."

In fact, I was also referring to the volume ratio. Again, SM values above 80 Vol.% (i.e. above 0.8 m3m-3) are unrealistic. The authors also replied that there are only few outliers where

SM is above the porosity of the soil. However, this could be a bigger problem that definitely needs to be better addressed to prevent users from using unrealistic SM values for their analyses. I suggest that the authors identify outliers by comparing the SM data product with the porosity information from the global soil database SoilGrid (https://www.isric.org/explore/soilgrids). This would be an easy-to-implement outlier detection.

Response: Thanks for this comment. We also agree that SM values above 80 Vol.% (i.e. above 0.8 $m^3 \cdot m^{-3}$) are unrealistic. Nevertheless, one of the limitations for SGD-SM 2.0 is that the proposed reconstructing framework fully relies on the initial satellite-based SM information. Even if the original SM values are above 80 Vol.%, the proposed reconstructing framework still take them as the valid SM information for gap-filling. These retrieving errors (i.e. above 0.8 $m^3 \cdot m^{-3}$) in the initial satellite-based SM data are also inevitably transmitted into the SGD-SM 2.0 products. This limitation has been supplemented into the current discussion below:

"1) The errors of original AMSR-E/WindSat/AMSR2 products: The proposed SGD-SM product is generated based on original AMSR-E/WindSat/AMSR2 products. While these passive soil moisture products also exist errors (i.e. above 0.8 $m^3 \cdot m^{-3}$) , due to the satellite sensor imaging and soil moisture retrieval algorithm. As shown in Table 1, the R, RMSE, and MAE evaluation indexes of the original products are 0.679, 0.094, and 0.075, respectively. These errors are also inevitably transmitted into the generated SGD-SM 2.0 products. In other words, SGD-SM 2.0 absolutely trusts the initial satellite-based SM values without any hesitation."

In our future work (SGD-SM 3.0), we will introduce the outlier filtering strategy, to exclude these initial SM exception information (above 80 Vol.%). Identifying outliers by comparing the SM data product with the porosity information from the global soil database SoilGrid will also be utilized in SGD-SM 3.0.

Q1.2: ***Second issue: The authors now use data six stations from Bogena et al. (2022), but these are not part of ISMN database. The in-situ soil moisture data from ISMN used in this work are still treated anonymously. However, this practice is not in accordance with the General Terms and Conditions (https://ismn.geo.tuwien.ac.at/en/terms-and-conditions/), where it is written: "Whenever data distributed by the ISMN are being used for publication, the data's origin (i.e. the original data provider and the ISMN) must be acknowledged and referenced. A reference both to the ISMN AND to all networks providing data for the study in question shall be given." Therefore, the authors still have to add at table with basic information on the soil moisture data using, including the name of the site owners and/or monitoring networks.***

Response: Thanks for this suggestion. In this work, we select 124 stations from ISMN from 2002 to 2022 and match them with corresponding soil moisture product in SGD-SM 2.0. In other words, all the selected 124 in-situ sites (including COSMOS, SD-DEM, SMOS-CBR, SCAN, PBO-H2O, USCRN and OZNET networks) are employed to validate the accuracy of SGD-SM 2.0. for better scatter visualization, we chose partial in-situ soil moisture stations as examples. In addition, we have added acknowledgments and references of ISMN in the revised manuscript below:

Acknowledgments: We appreciatively acknowledge GES DISC and ISMN, for them releasing related products and in-situ sites.

References:

[1] International Soil Moisture Network (ISMN): https://ismn.geo.tuwien.ac.at/en/.

[2] Dorigo, W. A., Wagner, W., Hohensinn, R., Hahn, S., Paulik, C., Xaver, A., Gruber, A., Drusch, M., Mecklenburg, S., van Oevelen, P., Robock, A., and Jackson, T.: The International Soil Moisture Network: a data hosting facility for global in situ soil moisture measurements, Hydrol. Earth Syst. Sci., 15, 1675–1698, https://doi.org/10.5194/hess-15-1675-2011, 2011.

[3] Dorigo, W. A., Xaver, A., Vreugdenhil, M., Gruber, A., Hegyiová, A., Sanchis-Dufau, A. D., Zamojski, D., Cordes, C., Wagner, W., and Drusch, M.: Global automated quality control of in situ soil moisture data from the international soil moisture network, Vadose Zone J., 12, 1–21, https://doi.org/10.2136/vzj2012.0097, 2013.

[4] Dorigo, W., Himmelbauer, I., Aberer, D. et al.: The International Soil Moisture Network: serving Earth system science for over a decade, Hydrol. Earth Syst. Sci., 25, 5749–5804, https://doi.org/10.5194/hess-25-5749-2021, 2021.

Table 2. 124 selected soil moisture stations from ISMN from 2002 to 2022 for validating SGD-SM 2.0.

COSMOS-001	COSMOS-004	COSMOS-006	COSMOS-007	COSMOS-010	COSMOS-011
COSMOS-012	COSMOS-013	COSMOS-014	COSMOS-015	COSMOS-016	COSMOS-017
COSMOS-018	COSMOS-020	COSMOS-021	COSMOS-023	COSMOS-024	COSMOS-025
COSMOS-026	COSMOS-027	COSMOS-028	COSMOS-029	COSMOS-030	COSMOS-031
COSMOS-032	COSMOS-033	COSMOS-034	COSMOS-035	COSMOS-038	COSMOS-039
COSMOS-040	COSMOS-041	COSMOS-042	COSMOS-043	COSMOS-044	COSMOS-045
COSMOS-046	COSMOS-047	COSMOS-048	COSMOS-049	COSMOS-050	COSMOS-051
COSMOS-052	COSMOS-053	COSMOS-054	COSMOS-055	COSMOS-056	COSMOS-057
COSMOS-058	COSMOS-060	COSMOS-061	COSMOS-062	COSMOS-063	COSMOS-064
COSMOS-066	COSMOS-067	COSMOS-068	COSMOS-069	COSMOS-070	COSMOS-071
COSMOS-072	COSMOS-073	COSMOS-074	COSMOS-076	COSMOS-078	COSMOS-081
COSMOS-082	COSMOS-084	COSMOS-087	COSMOS-089	COSMOS-090	COSMOS-091
COSMOS-092	COSMOS-093	COSMOS-094	COSMOS-095	COSMOS-096	COSMOS-098
COSMOS-099	COSMOS-100	COSMOS-101	COSMOS-102	COSMOS-103	COSMOS-105
COSMOS-107	COSMOS-108	COSMOS-109	COSMOS-110	COSMOS-111	COSMOS-123
RSMN-15136	RSMN-15199	RSMN-15412	RSMN-15470	RSMN-15479	SD-DEM
SMOS-CBR	SMOS-LHS	SMOS-MTM	SMOS-SFL	SMOS-SVN	SMOS-PZN
SCAN-2014	SCAN-2046	SCAN-2055	SCAN-2087	SCAN-2179	SCAN-2181
PBO-076	PBO-094	PBO-250	PBO-472	PBO-474	PBO-482
PBO-498	PBO-508	PBO-525	PBO-569	PBO-742	PBO-811
USCRN-011	USCRN-020	OZNET-K1	OZNET-K2		

These 124 selected soil moisture stations from ISMN from 2002 to 2022 are shown in Table 2, for validating SGD-SM 2.0. Besides, we have also added a table with basic information on the in-situ soil moisture sites like Bogena et al. (2022). As listed in Table 3, it includes the name of the station, country, longitude/latitude, main land use, lattice water, and soil organic carbon. Due to the page limiting of this manuscript (it is too long to show the basic information of 124 selected sites. . .), we give representative in-situ sites (Taking partial sites as example, including COSMOS, SD-DEM, SMOS-CBR, SCAN, PBO, USCRN and OZNET networks) in Table 3 as follow:

Table 3. Basic information on the in-situ soil moisture sites (Taking partial sites as examples).

Station	Lon/Lat	Elevation (m)	main land use	lattice water	soil organic carbon
COSMOS-016	42.537, -72.171	316	Crop	4.50%	1.59%
COSMOS-055	0.282, 36.866	1824	Bush	6.10%	1.11%
COSMOS-082	48.141, 15.171	73	Grass	2.10%	1.93%
COSMOS-096	-14.159, 131.388	169	Silty Sand	2.30%	1.24%
COSMOS-101	-21.617, -47.632	563	Grass	1.70%	1.87%
COSMOS-123	31.369, 91.899	1201	Forest	4.40%	2.36%
SD-DEM	13.287, 30.479	864	Coarse Sand	1.30%	0.98%
SMOS-CBR	42.563, 13.798	52	Grass	3.40%	2.25%
SCAN-2014	38.173, -65.171	274	Crop	2.20%	1.97%
PBO-076	24.189, -81.343	156	Silty Sand	1.90%	1.14%
USCRN-011	20.507, -97.662	583	Grass	3.70%	1.98%
OZNET-K1	-21.683, 139.841	659	Scrub	3.60%	2.34%