RC: Reviewer Comment, AR: Author Response, ☐ New Manuscript text

Dear Referee,

We would like to thank you very much for your effort in reviewing our manuscript. Please find our responses to your comments below. On the one hand, we have compared the spatial distribution of soil texture from HWSD and SoilGrid datasets with the observations to show where these data differ significantly. On the other hand, we have evaluated both the SMAP_L3 and SMAP_L4 soil moisture products to represent the performance of remote sensing soil moisture products.

Kind regards,

Dr. Prof. Chansheng He

(on behalf of all the authors)

The comments of editor and reviewers are in black with bold text, the author's answers are indicated in blue color, as well as old text passages. New text passages are indicated in green color.

General Comments

The authors presented a valuable work by observing soil properties in Heihe Basin. The data set is well organized and presented, while its strength is also demonstrated by comparing it to other data sets. I think it should be accepted by ESSD.

AR: We appreciate your positive comments and suggestions.

Specific Comments

RC: **I just have several minor comments about it, such as: the authors can compare the spatial distribution of the observed soil texture against HWSD and SoilGRiD, to show**

where these data differ significantly.

AR: Thanks for your suggestions. We have compared the spatial distribution of the observed soil texture (sand and clay) with that of HWSD and SoilGrid datasets (Figure R1). We also calculated the spatial distribution of BIAS (and PBIAS) of soil texture for the HWSD and SoilGrid datasets (Figure R2).

Overall, the spatial distribution of sand and clay from observation is lower than that of HWSD and SoilGrid datasets (Figures R1 and R2). Specifically, results indicate that SoilGrid dataset overestimates clay and sand in almost the entire region, while HWSD underestimates clay and sand in some areas of the study area. However, there is no obvious spatial pattern for the bias (BIAS and PBIAS) of the clay and sand estimation from both the HWSD and SoilGrid datasets.

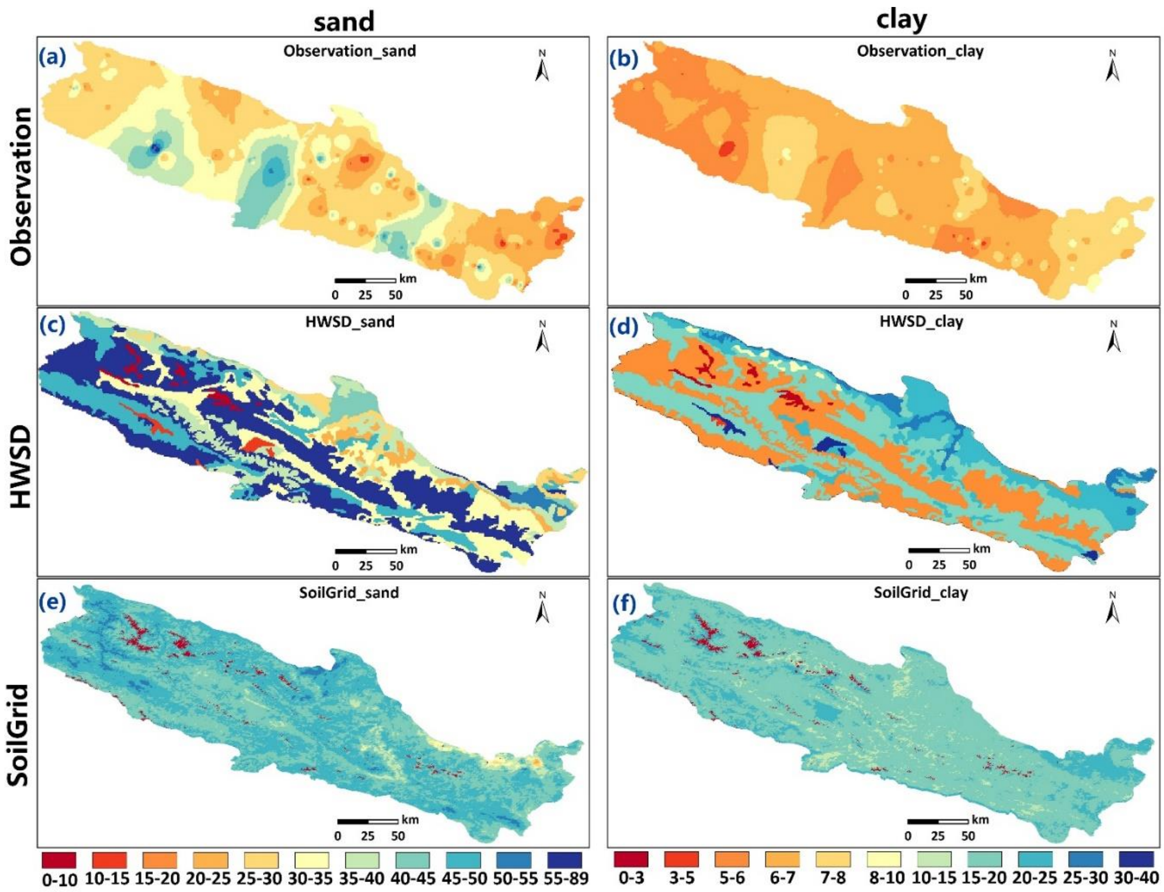

Figure R1. Comparison of the spatial distribution of the soil texture (sand and clay, with unit of %) between observation (a-b) with the HWSD dataset (c-d) and SoilGrid dataset (e-f).

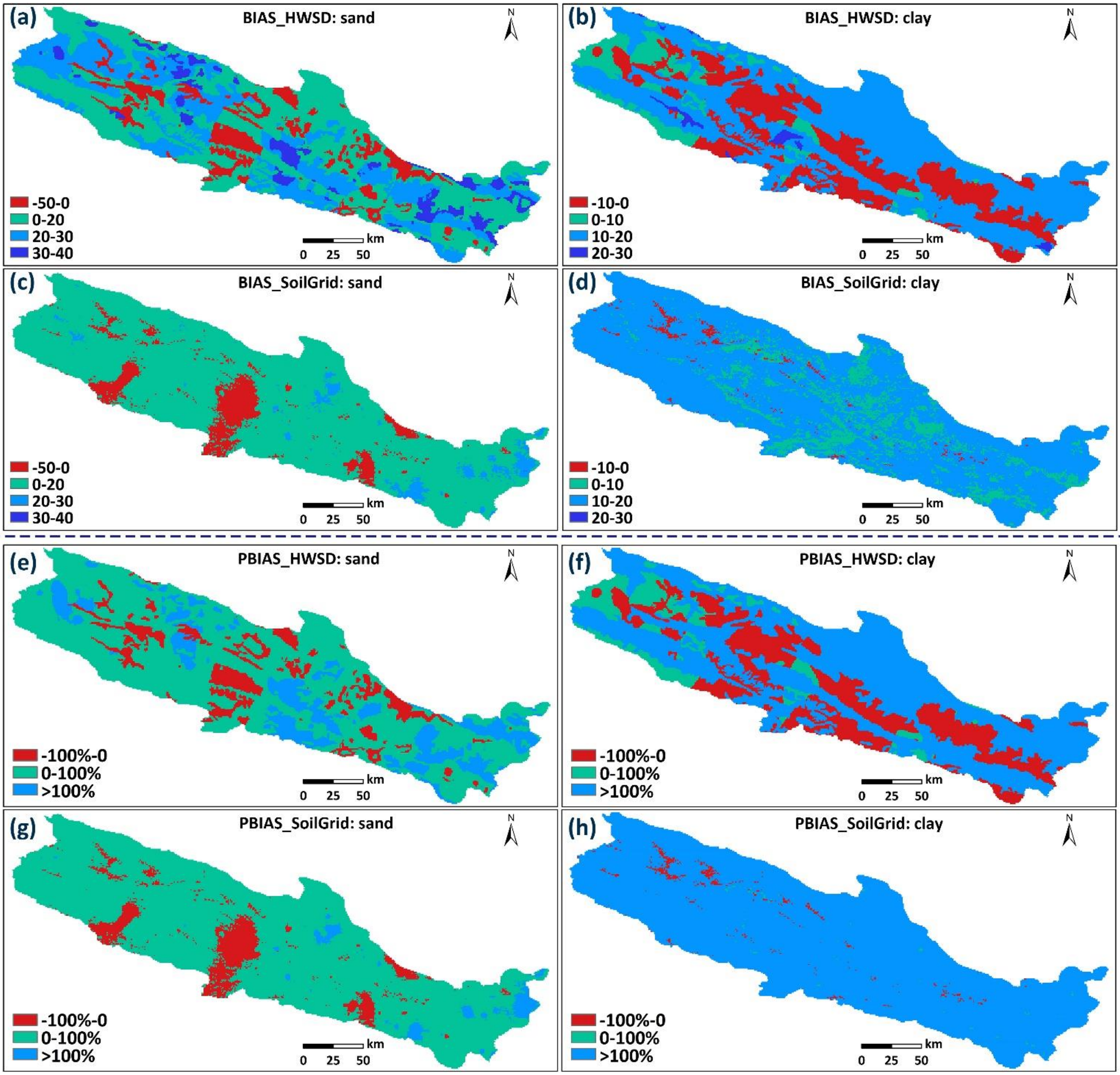

Figure R2. Spatial distribution of the BIAS (a-d) and PBIAS (e-h) for evaluating the spatial distribution of the errors of soil texture (sand and clay) of HWSD and SoilGrid datasets. The BIAS of sand and clay for HWSD (a-b) and SoilGrid (c-d); The PBIAS of sand and clay for HWSD (e-f) and SoilGrid (g-h).

RC: From my understanding, GLDAS does not assimilate land surface information, and then its soil moisture is not improved too much. In contrast, SMAP-L4 is an assimilation product. So, if it is possible, the authors are suggested using some purely-remote sensing product instead of SMAP-L4.

AR: Thank you for your suggestion. Yes, the SMAP_L4 product provides estimates of both surface and root zone SM products based on the assimilation of SMAP observations into the NASA Goddard Earth Observing System, Version 5 (GEOS-5) land data assimilation system (Reichle et al., 2017). The SMAP_L3 (Soil Moisture Active Passive Level-3) product provides a composite of daily estimates of global land surface conditions retrieved by the SMAP radiometer, which is a type of purely-remote sensing product (O'Neill et al., 2021). As we want to evaluate the SM product at both the surface and subsurface layers, we evaluated the SMAP_L4, ERA5-Land and GLDAS2.1_Noah SM products in this study.

Besides, in order to evaluate the performance of purely-remote sensing product, we also evaluated the SMAP_L3 SM product (SMAP Enhanced L3 Radiometer Global and Polar Grid Daily 9 km EASE-Grid Soil Moisture, Version 5, https://nsidc.org/data/SPL3SMP_E/versions/5, last accessed 11 May 2022) based on the in-situ surface SM observations (at 5 cm depth). Results are shown in Figure S8. Results show that the SMAP_L3 has a high R value (with the mean value of 0.54), but overestimates SM in the study area (with the mean Bias value of 0.055 cm^3/cm^3). Meanwhile, SMAP_L3 has the mean ubRMSE of 0.054 cm^3/cm^3, which is larger than the accuracy requirement of 0.04 cm^3/cm^3 (Chan et al., 2016). The overestimation of SM is different from our previous results in Tian et al. (2020), which found SMAP_L3 underestimated SM (with median Bias of -0.029 cm^3/cm^3 and ubRMSE of 0.037 cm^3/cm^3) during 2015-2016 in the study area. This may be because that SMAP_L3 Version 5, which was released in 2021, adopts the new baseline algorithm (Dual Channel Algorithm), which marks a departure from prior versions where the baseline algorithm was the Single Channel Algorithm-Vertical Polarization (O'Neill et al., 2021). Besides, our result is consistent with the results of Ahmad et al. (2022) at Maqu station, who found the overestimation of the original SMAP_L3 product, but the SMAP_L3 has good performance after the cumulative distribution function (CDF) correction. Further analysis of the improvement of the SMAP_L3 product is not in the scope of this study. The evaluation of the SMAP_L3 product has been added in the revised manuscript.

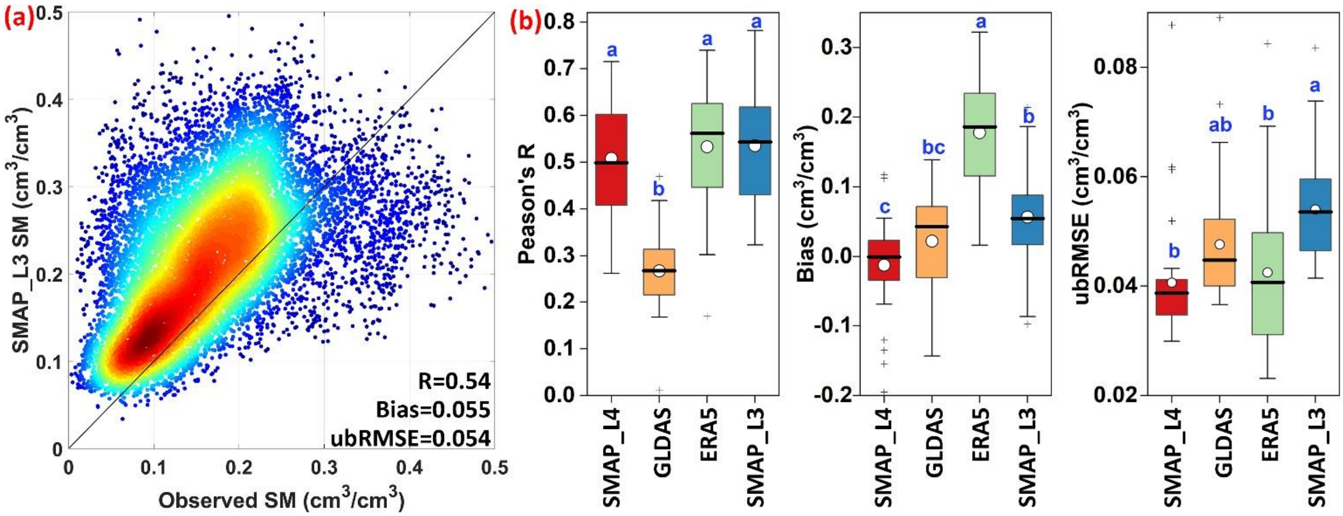

Figure S8. (a) Scatterplot comparing the surface SM from SMAP_L3 with the observation at daily scale. (b) Metrics of different surface SM products (SMAP_L4, GLDAS2.1_Noah, ERA5-Land and SMAP_L3). Different letters indicate the significant difference between different surface SM products.

☐ Additionally, besides the SMAP_L4 surface and profile SM product, SMAP_L3 surface SM (SMAP Enhanced L3 Radiometer Global and Polar Grid Daily 9 km EASE-Grid Soil Moisture, Version 5, https://nsidc.org/data/SPL3SMP_E/versions/5, last accessed 11 May 2022) was also evaluated to represent the remote sensing SM product. Results (Figure S8) indicate that both the SMAP (SMAP_L3 and SMAP_L4) and ERA5-Land SM products have significantly high R-value than the GLDAS-Noah product, while both the SMAP and GLDAS-Noah SM products have significantly lower Bias than ERA5-Land product. However, SMAP_L3 SM product has a high mean ubRMSE of 0.054 cm^3/cm^3, which is larger than the accuracy requirement of 0.04 cm^3/cm^3 (Chan et al., 2016). The large Bias and ubRMSE value of SMAP_L3 SM product may be caused by the new baseline algorithm (Dual Channel Algorithm) adopted by the SMAP_L3 Version 5 product (released in 2021), which marks a departure from prior versions where the baseline algorithm was the Single Channel Algorithm-Vertical Polarization (O'Neill et al., 2021). Further correction may be required for the SMAP_L3 Version 5 SM product in the study area (Ahmad et al., 2022).

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