Interactive Discussion: Author Response to Referee #2

The Potsdam Soil Moisture Observatory: High-coverage reference observations at kilometer scale

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

Dear Madam or Sir,

thank you very much for your referee report and for the time and effort you invested in reviewing our manuscript. We also appreciate your positive assessment of the dataset and your constructive suggestions to improve the structure, clarity, and documentation of the paper. We sincerely apologize for the linguistic and structural shortcomings in the previous version.

Please find below our point-by-point responses. We plan to address all your comments in the revised version of the manuscript.

Thank you again for your valuable feedback and for supporting the improvement of our work.

Kind regards,
Peter Martin Grosse (on behalf of the author team)

RC: ***The Introduction should conclude with a concise summary of the paper's structure and the data presented in this data paper.***

AR: We will add a respective summary to the end of the introduction.

RC: ***L59: There are more papers on signal correction that could be mentioned here, e.g. Baatz et al. (2015) introduced a biomass correction for CRNS, Davies et al. (2022) tested optimal temporal filtering methods for CRNS.***

AR: We will add additional references here.

RC: ***L62: Brogi et al. (2022) is not about biomass estimation using CRNS. I believe you meant Brogi et al. (2025).***

AR: Will be corrected.

RC: ***L63: Here you could also cite Bogena et al. (2020).***

AR: We will add the indicated reference.

RC: ***L65–67: This sentence is unnecessary and could be removed.***

AR: Sentence will be removed.

RC: ***L75: "three such data sets".***

AR: Will be corrected.

RC: ***L123: A separate "Highlights" chapter does not appear necessary. Consider integrating its content into the Introduction as part of the motivation.***

AR: Will be implemented.

RC: ***L125: This statement is difficult to understand without referring to Figure 2.***

AR: Will be rephrased.

RC: ***L137: Refer to Fig. 2.***

AR: Will be implemented.

RC: ***L157: Methods and results are mixed in this chapter, which is inappropriate for a scientific publication. Please restructure the manuscript to clearly separate them. You may refer to Heistermann et al. (2022) as a good example, where the methods are presented first, followed by two separate chapters describing the data provided with the paper and exemplary results from the data analysis.***

AR: We thank the reviewer for this constructive comment on the manuscript structure. In the revised version, we will clearly distinguish between the Methods and Results sections to ensure a more coherent and scientifically appropriate organization. The revised structure will follow the example of Heistermann et al. (2022), with the methods presented first, followed by separate sections describing the datasets accompanying the paper and representative results from the data analysis.

RC: ***L182–185: Since all CRNS stations are located in close proximity, it would be more appropriate to use meteorological data from the reference station for corrections of all CRNS stations. This approach ensures that corrections are applied consistently, increasing data consistency. Moreover, reference data are generally more accurate than the lower-quality sensor data used at the CRNS stations.***

AR: Our reference station (ID11) is also a CRNS station equipped with the same type of sensor as the others, not a calibrated meteorological station. Using data from this single station for all corrections would not reliably represent potential spatial variations across the site, especially for humidity. Therefore, each CRNS station was equipped with its own external sensors to account for microclimate conditions (e.g., proximity to the Wublitz water body (ID2) or location within a poplar stand (ID4)). This approach ensures that footprint-specific conditions are properly captured.

RC: ***L184–188: In agricultural fields, such as those in this study, biomass changes constantly over the years, which can significantly influence CRNS signals depending on the type of vegetation (e.g., Jakobi et al., 2022). Therefore, the calibration will not implicitly account for this effect. Please discuss this aspect.***

AR: We will add discussion on this aspect.

RC: ***L208: The chapter on Bonner sphere measurements feels somewhat isolated. It is also rather long and distracts from the main focus of the paper, i.e., soil moisture data. Therefore, this chapter should be shortened and better integrated into the manuscript.***

AR: Will be shortened and better introduced.

RC: ***L399: The section on stable water isotopes in soil and groundwater appears off-topic for a paper focused on soil moisture. Given that only three campaigns may not provide sufficient accuracy to infer groundwater recharge, and the paper already covers a wide range of topics, consider removing this part.***

AR: We agree that the collected isotope data alone may not suffice to infer groundwater recharge. However, we'd like to point out that their conjunctive use with the other data sets may open additional options for seepage water-related analyses. Thus, we would like to retain this section and data despite their limitation.

RC: ***L514–521: Unfortunately, this example demonstrates that the dataset's value for remote sensing validation is quite limited, as only a few grids of the RS product are actually covered by the CRNS data, with most sensors clustered within a single grid. Therefore, I suggest removing this part.***

AR: Many thanks for the comment, which helps us to clarify this point.

The Potsdam network differs from other CRNS sites (e.g., Bogena et al. (2022)) due to its uniquely high station density within a single 1-km² area.

A recent study comparing COSMOS data in Germany with 15 widely used satellite soil moisture products Schmidt et al. (2024) showed that even a 1-km satellite resolution does not resolve the spatial scale mismatch: one single CRNS footprint covers <10% of a 1-km grid cell, and individual pixels often include land-cover types outside the CRNS support area (see Fig. 7 in Schmidt et al. (2024)).

Figure 8 demonstrates that the dense configuration at PoSMO significantly improves the spatial representativeness of CRNS measurements within a 1-km pixel and thus supports more robust CRNS–remote sensing comparisons. Moreover, within this specific site we provide an actual measurement representative of the 1-km pixel, and the locations of CRNS stations in the surrounding pixels could potentially allow extending the spatial coverage to approximately 3.4 km² (see Figures 1 and 8). We therefore consider this site a valuable extension to the existing CRNS reference infrastructure.

RC: ***Data archive: I downloaded some of the data (e.g., CRNS, profile, muon) to check whether the files are well documented and complete. The README file provides a good overview of the data and the units of the values. However, there is no description of the file formats. In addition, the CRNS data are split across two separate files, which is confusing. The same issue applies to the SWC profile data.***

AR: We will add the description of the file formats to the README file. We deliberately decided to separate CRNS-counts from CRNS-soil moisture (and profile-based permittivity records from converted soil moisture series) because we are convinced that each of the latter provides the most convenient entry point for users interested in the use of the SM-data, while the former offers more methodological improvements for re-processing the raw data. We do not expect typical use cases to use both (raw and processed data) thus we preferred to keep the respective file smaller with single variables each. In case you refer to the difference between CRNS data and the long-term observations, we acknowledge, this might be confusing. We will rename the parts of the data set and describe in the manuscript as well as the README more clearly the difference between the data. While the stationary CRNS contains all data from the PoSMO since 2023, a subset of CRNS sensors as well as soil moisture profiles provide continuous data since 2019, which we think is valuable to present as a separate data set.

RC: ***Figure 1 only shows locations of CRNS stations (not shallow SWC and SWC profile stations).***

AR: The shallow SWC and profile sensors are all located in close proximity of the stations and would not be discernible at the map. We will add this explanation to the figure caption.

RC: ***Figure 5: The graph on the right is not easily readable and should be enlarged. The image on the left does not add much value.***

AR: Image will be removed, graph enlarged.

References

Bogena, H. R., Schrön, M., Jakobi, J., Ney, P., Zacharias, S., Andreasen, M., Baatz, R., Boorman, D., Duygu, M. B., Eguibar-Galán, M. A., Fersch, B., Franke, T., Geris, J., González Sanchis, M., Kerr, Y., Korf, T., Mengistu, Z., Mialon, A., Nasta, P., Nitychoruk, J., Pisinaras, V., Rasche, D., Rosolem, R., Said, H., Schattan, P., Zreda, M., Achleitner, S., Albentosa-Hernández, E., Akyürek, Z., Blume, T., del Campo, A., Canone, D., Dimitrova-Petrova, K., Evans, J. G., Ferraris, S., Frances, F., Gisolo, D., Güntner, A., Herrmann, F., Iwema, J., Jensen, K. H., Kunstmann, H., Lidón, A., Looms, M. C., Oswald, S., Panagopoulos, A., Patil, A., Power, D., Rebmann, C., Romano, N., Scheiffele, L., Seneviratne, S., Weltin, G., and Vereecken, H.: COSMOS-Europe: a European network of cosmic-ray neutron soil moisture sensors, Earth System Science Data, 14, 1125–1151, 10.5194/essd-2025-54610.5194/essd-14-1125-2022, 2022.

Schmidt, T., Schrön, M., Li, Z., Francke, T., Zacharias, S., Hildebrandt, A., and Peng, J.: Comprehensive quality assessment of satellite- and model-based soil moisture products against the COSMOS network in Germany, Remote Sens. Environ., 301, 113 930, 10.5194/essd-2025-54610.1016/j.rse.2023.113930, 2024.