Authors' response to Referee 2

This paper presents a dataset of ongoing in situ soil moisture measurements in a region in the eastern part of the Netherlands. The dataset covers the time period since 2009, 20 locations, and measurements at five different depths (in general). The paper presents also results from field campaigns that resulted in calibration functions for the soil moisture sensors.

Authors' response:
We would like to thank the referee for general positive feedback. In the text below, we provide our point-by-point response to the comments.

Most of the referee's suggestions have been implemented. Our response to the referee comments is structured as follows:

- The native referee comment is labelled and written in black.
- The authors response is written in blue
- Text from the manuscript is written with the Times New Roman font whereby the native text is in black and the changes are in red

R2GC1:
The paper is in general sound and I have only minor comments. However, a major concern is whether publication is warranted in a high impact journal like ESSD, for only 20 point soil moisture time series for a period of 13 years. Question is whether the dataset is unique enough for this journal. I have suggested "minor revision", but alternatively a recommendation could also be "rejection". I leave this decision to the editor.

Authors' response:
Our paper presents a unique dataset of in-situ soil moisture measurements in the Eastern part of the Netherlands. The uniqueness of this data set stems from its design as a network of fixed stations covering an area of 45 km by 40 km and measuring the soil moisture profile at nominal depths 5 cm, 10 cm, 20 cm, 40 cm and 80 cm for more than 10 years. Most of the current scientific articles reporting datasets based on in-situ measurements have generally a smaller temporal and spatial coverage in comparison to the presented work as will be further motivated in the following paragraph. Our paper also reports on complementary spatially distributed field measurements collected during campaigns organized in four different years, namely 2009, 2015, 2016 and 2017. Moreover, we have made an effort to describe in this paper an extensive collection of open third-party datasets (i.e. land cover/use, soil information, elevation, groundwater and meteorological observations) that can support the use of the Twente soil moisture and temperature datasets by other scientists and professional.

We have further investigated the suitability of our manuscript for the ESSD by searching in the title for the keyword 'soil moisture' and found 31 articles. From this collection of articles, we could identify at least eleven contributions of which the dataset relied on in-situ measurements. Those are listed below. The datasets reported in all articles cover a time span not significantly more 10 years and a similar spatial extent as the Twente region, with exception of Bogena et al. (2022) who report on an European network of cosmic ray probes. Three out of the eleven identified articles have a topic comparable to our manuscript, which are Benninga et al. (2018), Tetlock et al. (2019) and Zhang et al.

(2021). We have looked up the number of citations in Web of Science for those three articles and found that they are cited 18, 23 and 15 times, respectively. All three have been cited more than the journals impact factor. This leads us to the conclusion that the impact of the topic of our manuscript is at the appropriate level for the ESSD journal.

Acticles on in situ soil moisture measurement dataset:

1. Bam, E. K. P., Brannen, R., Budhathoki, S., Ireson, A. M., Spence, C., and van der Kamp, G.: Meteorological, soil moisture, surface water, and groundwater data from the St. Denis National Wildlife Area, Saskatchewan, Canada, Earth Syst. Sci. Data, 11, 553–563, https://doi.org/10.5194/essd-11-553-2019, 2019.

2. Benninga, H.-J. F., Carranza, C. D. U., Pezij, M., van Santen, P., van der Ploeg, M. J., Augustijn, D. C. M., and van der Velde, R.: The Raam regional soil moisture monitoring network in the Netherlands, Earth Syst. Sci. Data, 10, 61–79, https://doi.org/10.5194/essd-10-61-2018, 2018. (Web of Science citations: 18)

3. 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 Syst. Sci. Data, 14, 1125–1151, https://doi.org/10.5194/essd-14-1125-2022, 2022.

4. Fersch, B., Francke, T., Heistermann, M., Schrön, M., Döpper, V., Jakobi, J., Baroni, G., Blume, T., Bogena, H., Budach, C., Gränzig, T., Förster, M., Güntner, A., Hendricks Franssen, H.-J., Kasner, M., Köhli, M., Kleinschmit, B., Kunstmann, H., Patil, A., Rasche, D., Scheiffele, L., Schmidt, U., Szulc-Seyfried, S., Weimar, J., Zacharias, S., Zreda, M., Heber, B., Kiese, R., Mares, V., Mollenhauer, H., Völksch, I., and Oswald, S.: A dense network of cosmic-ray neutron sensors for soil moisture observation in a highly instrumented pre-Alpine headwater catchment in Germany, Earth Syst. Sci. Data, 12, 2289–2309, https://doi.org/10.5194/essd-12-2289-2020, 2020.

5. Godsey, S. E., Marks, D., Kormos, P. R., Seyfried, M. S., Enslin, C. L., Winstral, A. H., McNamara, J. P., and Link, T. E.: Eleven years of mountain weather, snow, soil moisture and streamflow data from the rain–snow transition zone – the Johnston Draw catchment, Reynolds Creek Experimental Watershed and Critical Zone Observatory, USA, Earth Syst. Sci. Data, 10, 1207–1216, https://doi.org/10.5194/essd-10-1207-2018, 2018.

6. Heistermann, M., Bogena, H., Francke, T., Güntner, A., Jakobi, J., Rasche, D., Schrön, M., Döpper, V., Fersch, B., Groh, J., Patil, A., Pütz, T., Reich, M., Zacharias, S., Zengerle, C., and Oswald, S.: Soil moisture observation in a forested headwater catchment: combining a dense cosmic-ray neutron sensor network with roving and hydrogravimetry at the TERENO site Wüstebach, Earth Syst. Sci. Data, 14, 2501–2519, https://doi.org/10.5194/essd-14-2501-2022, 2022.

7. Jackisch, C., Germer, K., Graeff, T., Andrä, I., Schulz, K., Schiedung, M., Haller-Jans, J., Schneider, J., Jaquemotte, J., Helmer, P., Lotz, L., Bauer, A., Hahn, I., Šanda, M., Kumpan, M., Dorner, J., de Rooij, G., Wessel-Bothe, S., Kottmann, L., Schittenhelm, S., and Durner, W.: Soil moisture and matric potential – an open field comparison of sensor systems, Earth Syst. Sci. Data, 12, 683–697, https://doi.org/10.5194/essd-12-683-2020, 2020.

8. Roche, J. W., Rice, R., Meng, X., Cayan, D. R., Dettinger, M. D., Alden, D., Patel, S. C., Mason, M. A., Conklin, M. H., and Bales, R. C.: Climate, snow, and soil moisture data set for the Tuolumne and Merced river watersheds, California, USA, Earth Syst. Sci. Data, 11, 101–110, https://doi.org/10.5194/essd-11-101-2019, 2019.

9. Schaffitel, A., Schuetz, T., and Weiler, M.: A distributed soil moisture, temperature and infiltrometer dataset for permeable pavements and green spaces, Earth Syst. Sci. Data, 12, 501–517, https://doi.org/10.5194/essd-12-501-2020, 2020.

10 Tetlock, E., Toth, B., Berg, A., Rowlandson, T., and Ambadan, J. T.: An 11-year (2007–2017) soil moisture and precipitation dataset from the Kenaston Network in the Brightwater Creek basin, Saskatchewan, Canada, Earth Syst. Sci. Data, 11, 787–796, https://doi.org/10.5194/essd-11-787-2019, 2019. (Web of Science citations: 23)

11. Zhang, P., Zheng, D., van der Velde, R., Wen, J., Zeng, Y., Wang, X., Wang, Z., Chen, J., and Su, Z.: Status of the Tibetan Plateau observatory (Tibet-Obs) and a 10-year (2009–2019) surface soil moisture dataset, Earth Syst. Sci. Data, 13, 3075–3102, https://doi.org/10.5194/essd-13-3075-2021, 2021. (Web of Science citations: 15)

R2SC1:
L28. Instead of Mecklenburg et al., 2016 an earlier citation should be included.

Authors' response:

The citation Mecklenburg et al. (2016) has been replace to a citation to Kerr et al. (2010)

Kerr, Y.H., Waldteufel, P., Wigneron, J.-P., Delwart, S., Cabot, F., Boutin, J., Escorihuela, M.-J., Font, J., Reul, N., Gruhier, C., Juglea, S. E., Drinkwater, M.R., Hahne, A., Martin-Neira, M., and Mecklenburg, S.: The SMOS mission: New tool for monitoring key elements of the global water cycle, P. IEEE, 98, 666-687, doi: 10.1109/JPROC.2010.2043032, 2010.

R2SC2:
L114. What does "forest" mean here? Fruit trees? Please specify.

Authors' response:
The forest in the study area are a mixture of coniferous and deciduous trees. Forest should in the context of the study area not fall under agriculture. Also based on the suggestion by Referee 1, forest and heath are removed from the sentence. The first sentence of the paragraph has been modified to include this information.

From the 2015 land use map from Statistics Netherlands can be deduced that 70.2 % of the land is used for agricultural activities, 13 % is mixed coniferous and deciduous forests, 11.3 % is built-up and the remaining 5.5 % is classified as water, recreational, dry and wet nature.

R2SC3:
L116. Probably harvested in September and October.

Authors' response:
Only in the recent dry years farmers started with the harvest maize in September. In the past it was not unusual that the harvest would be postponed to November because the maize cobs needed more time to mature. The text is modified as follows:

Maize is planted in the months April/May and harvested in the period from September to November depending on the vehicle bearing capacity of the land and growing conditions.

R2SC4:
L185. What has happened in case of sensor failure? What if sensors had to be replaced? Was the same sensor type used? Was there a check for inhomogeneity in the measurement time series?

Authors' response:
In the case of sensor failure the sensor was replaced by a similar METER group sensor, type EC-TM or 5TM. Prior to installation, every sensor was tested for its functionality using measurements of air and water.

The sensor-to-sensor variability was accounted for by the manufacturer's sensor calibration against known dielectric standards as we wrote on l192-194. The installed sensor type is included in the data quality flags as explained on l333-337. This issue with the internal calibration of a specific batch of the 5TM sensors has been dealt with as reported in l354-359.

The following sentence has been added to the first paragraph of section 3.2.

The functionality of the probes were tested using measurements of water and air prior to deployment and the installed probe types are documented as a quality flag within the datasets, see section 6.

R2SC5:
L296-L303. Can you explain why these RMSE´s are so large? What is the RMSE for the average soil moisture content of a complete field or area?

Authors' response:
The RMSE values are not specifically large for field campaigns during which soil moisture is measured in multiple fields and over the full dynamic range. The uncertainty levels are generally lower under controlled laboratory conditions or for a single prepared field because under those conditions soil sampling is more reliable due to the absence of natural variabilities in, for instance, soil clods and plant roots. This explanation is provided in the context of the conducted field campaigns around l300-303.
For comparison, Cosh et al. (2005) report on RMSEs varying from 0.027 up to 0.041 m^3 m^{-3} and from 0.040 m^3 m^{-3} up to 0.054 m^3 m^{-3} for field specific and soil specific calibrations, respectively, see copied table below. We obtain for the 2009 campaign the highest RMSE value of 0.048 m^3 m^{-3}. This field campaign had the lowest number of sampling days in combination with the largest number fields sampled, which may have led to a larger uncertainty. This explanation is given in l271-274 of the manuscript. We obtain for the 2015 field campaign a measurements uncertainty of 0.041 m^3 m^{-3} with the ThetaProbe and for the 2016/17 campaign an overall RMSE of 0.032 m^3 m^{-3} is achieved with the HydraProbe. So all-in-all the RMSEs are in line with the reported state-of-art.

Table 2
Summary statistics for the SMEX02 impedance probe calibration methods

Data set	Generalized calibration	Soil specific calibration	Field specific calibration
WC region			
R^2	0.698	0.698	0.787
Bias (m^3/m^3)	0.022	0.001	0.000
rmse (m^3/m^3)	0.061	0.049	0.041
IA region			
R^2	0.744	0.742	0.803
Bias (m^3/m^3)	0.009	−0.014	0.000
rmse (m^3/m^3)	0.053	0.054	0.040
Little Washita (LW)			
R^2	0.367	0.370	0.612
Bias (m^3/m^3)	−0.010	−0.006	0.001
rmse (m^3/m^3)	0.057	0.051	0.039
OS region			
R^2	0.713	0.722	0.844
Bias (m^3/m^3)	0.013	0.014	0.000
rmse (m^3/m^3)	0.039	0.040	0.027
ON region			
R^2	0.571	0.571	0.760
Bias (m^3/m^3)	0.003	0.007	−0.001
rmse (m^3/m^3)	0.048	0.040	0.028
Total			
R^2	0.716	0.716	0.821
Bias (m^3/m^3)	0.001	−0.006	0.000
rmse (m^3/m^3)	0.053	0.050	0.037

Table copied from Cosh et al. (2005)

Cosh, M.H., Jackson, T.J., Bindlish, R., Famiglietti, J.S., Ryu, D.: Calibration of an impedance probe for estimation of surface soil water content over large regions, Journal of Hydrology, 311, 49-58, doi:10.1016/j.jhydrol.2005.01.003, 2005.

R2SC6:
L335. iv) instead of v)

Authors' response:
done

R2SC7:
L343: Change to: "a readme document"

Authors' response:
We have changed this to 'the readme document accompanying the dataset'.

R2SC8:
L366. Do you compare here individual measurement points with measurements?

Authors' response:
These error metrics are based on the comparisons of the stations with the field average soil moisture obtained from the campaigns. This issue will be clarified in the new section on spatial representativeness that was suggested by referee 1.

R2SC9:
L375. "lower groundwater levels" instead of "low groundwater levels"?

Authors' response:
Done.

R2SC10:
L391. How doe you explain this? Could it be related to preferential flow in the unsaturated zone?

Authors' response:
It is possible that preferential flow is an explanation. Another more likely explanation is that the shallow groundwater table causes a naturally fast response of the surrounding hydrology, especially in winters. This leads to the fact that groundwater table fluctuations match relatively well with temporal variations in soil moisture measured at 5 cm and 10 cm measured. The moisture content measured at 40 and 80 cm is under those conditions less responsive to rain events because the surrounding soil is already saturated. The following three sentences are added.

This can likely to be attributed to the shallow groundwater table in the study area that causes a naturally fast hydrological response. The groundwater table fluctuations match especially in winters well with the variations in soil moisture measured at 5 cm and 10 cm. The moisture contents measured at 40 and 80 cm is under those conditions less responsive to rain events because the surrounding soil is already saturated.

R2SC11:
L394. Or opposite? In situ groundwater levels (whose availability is more abundant than soil moisture measurements) provide information on soil moisture content.

Authors' response:

Indeed, in the western world in-situ groundwater measurements often (readily) available and soil moisture measurements not. In the majority world, however, in-situ groundwater monitoring networks are seldomly in place, while societies have a great demand for them. The text is modified as follows,

Hence, there lies also an opportunity to further investigate the connection between the water content in the unsaturated zone and the groundwater table. This knowledge may be used to provide soil moisture estimates in regions where groundwater monitoring wells are abundant or groundwater information based on surface soil moisture observed from space in countries where groundwater monitoring networks are absent.

R2SC12:
L423. Typo: “third-party”.

Authors’ response:
done

R2SC13:
Figure 8. Please explain the numbers in the figure (why twice “1”, “2”, “3” etc.)

Authors’ response:
These numbers stand for the measurement locations within a unique field. We have decided to remove this figure based on the suggestion by referee 1 and because we find it in retrospect of little added value to the text.