Note to both reviewers and the editor

Please find in the following our replies to the referee comments in blue. To increase the usefulness of the presented SwissSMEX data, we have extended the time series of all products with the years 2024 and 2025. Note that for this temporal extension, the ESA CCI PASSIVE near real time equivalent product from the Copernicus Climate Change Service (C3S SM PASSIVE) is used (Dorigo et al., 2025), which is based on the same (passive) input data and v9 algorithm as the product considered in the original manuscript. The corresponding product description has been adjusted.

2.2.2 C3S satellite soil moisture

The Copernicus Climate Change Service (C3S) provides up-to-date global satellite surface soil moisture data through the CDS every 10 days (C3S SM; Dorigo et al., 2025). The algorithm for v202505 is the same one as in version 9 of the European Space Agency Climate Change Initiative (ESA CCI) soil moisture products (Dorigo et al., 2024; Dorigo et al., 2017; Gruber et al., 2019). The PASSIVE product (representative at ~2–5 cm depth) is purely satellite (radiometer)-based and therefore preferred for our study over COMBINED, which may adopt certain model features (Dorigo et al., 2017). The C3S SM PASSIVE data were gap-filled using a stand-alone 3D-interpolation framework, independent of ancillary variables (Preimesberger et al., 2025). Root-zone soil moisture was derived by extrapolating gap-filled surface estimates to deeper soil layers using an exponential filter (Wagner et al., 1999; Albergel et al., 2008), calibrated for four layers with a large number of in situ time series (Pasik et al., 2023): layer 1 at 0–10 cm; layer 2 at 10–40 cm; layer 3 at 40–100 cm; and layer 4 at 100–200 cm. This data is also being used in the Copernicus European State of the Climate Reports (C3S and WMO, 2025) and available on a 0.25° x 0.25° latitude–longitude grid with daily temporal resolution. The closest grid cells for each station location (see Table 1) were used for comparison with SwissSMEX, and we restrict the usage of C3S SM PASSIVE to data from 1991 onwards due to larger data gaps prior to this date in the non-gap-filled product, and the thereby caused high uncertainties associated with the interpolated values (Preimesberger et al., 2025).

The IWC in the 0–0.5 m soil layer has been calculated based on VWC of the soil layers 1–3:

$$IWC_{0-0.5\mathrm{m}}\ (\text{in mm}) = (VWC_{0-10\mathrm{cm}} \cdot 0.1\ \mathrm{m} + VWC_{10-40\mathrm{cm}} \cdot 0.3\ \mathrm{m} + VWC_{40-100\mathrm{cm}} \cdot 0.1\ \mathrm{m}) \cdot 1000 \tag{5}$$

The assumption is that the $VWC_{40\text{-}100\mathrm{cm}}$ is representative for the 10 cm between 40 and 50 cm soil depth.

We note that the inclusion of 2024 and 2025 has moderated the trend magnitudes compared to the previously considered 2010–2023 period, and some previously marginally significant trends from SwissSMEX are no longer significant over 2010–2025. This is consistent with the paper's overall finding that the current record length is not yet sufficient for robust trend estimation.

We would also like to point out that there was an error in the original Abstract, which stated twelve grassland stations instead of ten on the Swiss Plateau.

Reference

Dorigo, W., Preimesberger, W., Lems, J., Frederikse, T., Dostalova, A.: Soil moisture gridded data from 1978 to present, v202505. Copernicus Climate Change Service (C3S) Climate Data Store (CDS), (Accessed on 2025-12-01), url: https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-soil-moisture?tab=overview, 10.24381/cds.d7782f18, 2025.

Replies to RC1: Heye Bogena, 16 Dec 2025

This paper presents 15 years of curated in situ soil moisture time series from the SwissSMEX network and demonstrates how data from 12 grassland stations, providing volumetric soil water content at multiple depths and integrated values down to 50 cm, can be used to analyze drying trends in soil water content. The data set is of broad interest given the increasing occurrence of drought in many regions worldwide under global climate change and fits well within the scope of ESSD. The presented data product will be valuable to the scientific community working on global change and water scarcity issues in alpine regions. It would be great to also include the data in the International Soil Moisture Network (Dorigo et al., 2021).

Unfortunately, the manuscript exhibits several substantial shortcomings with respect to its methods, content, overall structure, and clarity of writing, which need to be addressed in detail (see specific comments below). I have suggested improvements to the text in some places. However, the entire text should be revised by a native speaker. When revising the manuscript, authors should bear in mind that ESSD focuses on the data set rather than on the interpretation of the data.

We would like to thank Heye Bogena for his valuable and constructive feedback.

We agree that the manuscript includes an application of the presented in situ data and related interpretations. This is intended to demonstrate the ‘validity and applicability’ of the data, in line with the recommendation in Sect. 3.5 of the ESSD editorial by Carlson and Oda (2018) to demonstrate validity through comparison to ‘prior or alternate products’. We have reframed the text to make this validation purpose of the analysis of summer soil moisture changes and the comparison with the alternative ERA5-Land and C3S SM PASSIVE products clearer. We present this in section “3 Application of SwissSMEX for investigating summer soil moisture anomalies and trends” (instead of the general Results section) to more clearly highlight the intention of the analysis of the summer soil moisture trends.

General comments:

The Abstract is overly long and not suitable for ESSD. It should be 150–200 words and focus on the dataset rather than scientific interpretation, describing the data type, size, and spatial and temporal coverage, explaining how the data were collected, briefly outlining quality-control procedures, and clearly indicating where the dataset is available (e.g., repository or DOI).

We have shortened the Abstract and focus more on the presented dataset rather than on the interpretation of the changes in summer soil moisture. The latter is presented as a use case of the data, which also includes the comparison to the alternate reanalysis and remote sensing data. We have also indicated where the dataset is available for download.

The Introduction section is too long and includes discussion, which is inappropriate for ESSD. It should instead concisely provide context and justify the dataset by highlighting gaps in existing data, clearly state the dataset’s purpose, scope, key variables, and coverage, and emphasize its value.

We have also shortened the Introduction, particularly by condensing the more detailed context in the first paragraph. However, we believe it is important to provide some background information on the uncertainties of reanalysis-based soil moisture, given that it is a widely used data source due to the scarcity of in situ soil moisture measurements.

The Conclusion section should be shortened and focus on the dataset rather than scientific interpretations, emphasizing its main contributions, unique features or improvements over existing datasets, and briefly noting potential applications.

Similarly to the Abstract, we have shortened the Conclusion section (which has been renamed to "Summary and conclusion"). We focus more on the dataset and present the analysis of the temporal changes in soil moisture as demonstration of the utility of the in situ data.

The manuscript does not provide sufficient references and details for the statistical methods used. Even well-known methods such as the Mann-Kendall trend test should be properly cited and the implementation described (e.g., software/library and version). For example: "The Mann-Kendall test (Mann, 1945; Kendall, 1975) detects monotonic changes over time and is robust to non-normally distributed data. Calculations were performed using the Python library pyMannKendall (vX.Y.Z) at $\alpha = 0.05$, with missing values handled according to the library's default options."

More details and references on the methods and code libraries used have been included as appropriate (see below).

A map showing the locations of the measurement stations should be included, along with a table summarizing key soil properties, such as soil type and texture.

A map with the locations of the stations has been included in the manuscript (new Fig. 1, see Replies to RC2 below), and Table 1 has been extended with a column "Soil texture". For further information on soil properties, we explicitly refer to Mittelbach (2011, Appendix B therein).

Table 1 Overview of the ten SwissSMEX stations on the Swiss Plateau (see also Fig. 1). For more detailed information on soil properties, we refer to Mittelbach (2011, Appendix B therein). The crosses indicate the different station combinations used to calculate the Swiss Plateau median summer and summer-half-year soil moisture anomalies (see Sect. 2.3), and "Missing years" indicates the absence of these anomalies for specific years.

Station	Full name	Coordinates (lat, lon)	Soil texture	Best coverage[1]	S22	S22 + best coverage	Missing years	
							JJA	AMJJAS
BAS	Basel	47.54, 7.58	silt loam		X	X	2014–2022	2014–2022
BER	Bern	46.99, 7.46	loam	X	X	X	2011	none
CHM	Chamau	47.21, 8.41	sandy loam	X		X	2021	none
CHN	Changins	46.40, 6.23	loam		X	X	2010, 2017, 2018, 2020	2010, 2017, 2018
PAY	Payerne	46.81, 6.94	loam				2021, 2022	2021, 2022
PLA	Plaffeien	46.75, 7.27	sandy loam	X		X	none	none
REC	Reckenholz	47.43, 8.52	loam	X	X	X	2021, 2024	2021, 2024
RHB	Rietholzbach	47.38, 8.99	loam				2014, 2015	2014, 2015
TAE	Tänikon	47.48, 8.90	loam	X		X	2023–2025	2023–2025
WYN	Wynau	47.26, 7.79	silt loam				2010–2012, 2014, 2015, 2021, 2022	2010–2012, 2014, 2021, 2022

Specific comments:

L10: “curated time series of in-situ”

“timeseries” has been changed to “time series” throughout the manuscript. “in situ”, however, should not be hyphenated according to the journal guidelines.

L16: “vertically integrated” or “root-zone soil moisture”

Has been changed to “vertically integrated” in cases when the integration depth is not explicitly mentioned.

L16: “the robustness of recent drying trends”

This sentence has been deleted.

L44-59: This section reads more like a discussion and is not directly related to the data presented; it should be rewritten in a more concise way.

As mentioned above (general comments), we have condensed the more detailed context in this paragraph.

L45: Is the increase in evapotranspiration significant?

Yes, the increase in evapotranspiration is significant. We have added this and the reference to Scherrer et al. (2022).

L53: “soil moisture”

“moisture limitation” has been changed to “soil moisture limitation”.

L117: Please explain the trapezoidal method.

The following explanation and equation, as well as references for the R-packages have been added.

The degradation of sensor availability is particularly relevant for deriving the 0–0.5 m depth integrated soil water content (IWC, in mm). This integration is performed using the trapezoidal method (e.g. Hupet et al., 2004) and relies on the simultaneous availability of VWC measurements from sensors at multiple depths. The trapezoidal integration approximates the integral by assuming a linear variation between the measurements at the individual depths and was computed using the R-function trapz from the caTools package (Tuszynski, 2021; version 1.18.2). Historically, the integration was performed based on the n VWC measurements (VWC_i) at depths z_i of 0.05, 0.10, 0.30 and 0.50 m (Mittelbach and Seneviratne, 2012), plus an additional value of VWC at the surface, which is set equal to the measurement at 0.05 m depth (see Eq. 1). These depths were originally fully equipped with 10HS sensors, whereas TDR sensors were predominantly installed at 10 and 80 cm depth (Mittelbach et al., 2011; see also Figs. 2 and 3). Over time, at some stations, already existing TDR sensors were incorporated into the integration to replace defective 10HS sensors (e.g. station Changins in Fig. 5), or the number of sensors (i.e. depths) included in the integration had to be reduced while ensuring the representativeness of the remaining sensor data (e.g. station Chamau in Fig. 4). This set of sensors used for the historical IWC time series is referred to as the original sensor configuration (IWC_{orig}, see also Table S1).

$$IWC_{\mathrm{orig}}\ (\text{in mm}) = \left(VWC_{0.05\mathrm{m}} \cdot 0.05\ \mathrm{m} + \sum_{i=1}^{n-1} \frac{VWC_{i+1} + VWC_i}{2} \cdot (z_{i+1} - z_i) \right) \cdot 1000 \qquad (1)$$

L115-143: This section on data processing is very confusing. The processing steps are not clearly presented, and information on data processing, e.g. sensor calibration and data correction, is missing. It needs to be rewritten in a clearer and more concise manner, with the focus on how the data was processed.

This section has been revised. The description of the historical measurement setup and processing of VWC (Sect. 2.1.1) and the calculation of IWC based on these VWC measurements (Sect. 2.1.2) are more clearly separated now. We have added information on the original sensor calibration (by referring to Mittelbach et al., 2011, Mittelbach et al., 2012) and on the data quality control of the VWC measurements. To clarify the processing steps, we have further included the formulas for the trapezoidal integration of the VWC measurements to calculate IWC (see above), and for the scaling of the IWC time series (see Replies to RC2 below).

The standard instrumentation of SwissSMEX, initiated in 2008, consisted of low-cost capacitance soil moisture sensors (Decagon 10HS) at all measurement depths of 5, 10, 30, 50, 80, and 120 cm, and of TDR soil moisture sensors (IMKO TRIME-PICO) at 10 and 80 cm depth (Mittelbach, 2011). Both sensor types provide volumetric water content (VWC, in Vol.% or $m^3\ m^{-3}$). In the follow-up project SwissSMEX-*Veg*, selected stations were additionally equipped with TDR sensors at 5, 30 and 50 cm depth in 2010. Ten SwissSMEX grassland sites on the Swiss Plateau are still operational (Fig. 1, Table 1). The installed low-cost 10HS sensors are prone to higher measurement errors when only the factory calibration is used (e.g., Domínguez-Niño et al., 2019; Mittelbach et al., 2012). Therefore, site-specific exponential calibration functions were derived from the parallel 10HS and TDR measurements and applied to the raw 10HS readings. These site-specific calibrations allow to reduce the absolute error to about 2 Vol.% for most 10HS measurements, including under dry and moist soil conditions, and extend the effective measurement range of the sensors to up to 50 Vol.% (Mittelbach et al., 2011).

L164: “0–0.5 m (merged)” should be removed, as this information is unnecessary; the acronym IWC is self-explanatory.

“0–0.5 m (merged)” has been removed where appropriate.

L165: Please clarify how this percentage was determined. Was a statistical analysis performed to derive it, or was it determined in another way?

We consciously selected a fraction of up to 35 % missing days in the calculation of seasonal anomalies, representing a compromise between the resulting availability of stations for the summer drying analysis (see Table 1) and ensuring a reasonable annual data coverage. We have clarified that this 35% threshold has been chosen pragmatically and that it is relevant to the calculation of the yearly summer and summer-half-year values in the text. We have also pointed out that certain use cases might warrant stricter data availability thresholds.

of the VWC sensor readings. We deliberately allow up to 35 % missing days when calculating the mean anomalies for each summer and summer half-year, respectively. This choice represents a compromise between the number of stations available for the summer drying analysis (see Table 1) and ensuring reasonable annual data coverage. We also note that certain use cases might warrant stricter data availability thresholds.

L184-186: This section should be moved to Chapter 2.1.2. In addition, the weighting function should be presented as a numbered equation. Note that the weights in the equation should not have units of length, otherwise the unit of IWC would be mm·m rather than mm. Combining several measurement depths into a single layer (e.g., 7–28 cm) causes measurements at 5 cm depth to be weighted more heavily. It would be preferable to weigh each measurement depth individually when calculating IWC.

While Sect. 2.1.2 describes the data processing of the SwissSMEX in situ data, this paragraph (originally L184-186) describes the processing of the ERA5-Land gridded data (originally Sect. 2.2). As such, the layers are given by the ERA5-Land reanalysis product (which is based on a land surface model) and are not related to the in situ measurements. Since VWC is given in m^3 m^{-3}, its multiplication with the layer depth yields an IWC unit of m (or mm when multiplied by 1000). To more clearly separate the comparison datasets from the presented SwissSMEX data (Sect. 2.1), we have restructured Sect. 2 and present the ERA5-Land and the C3S SM PASSIVE products under a separate Chapter “2.2 Comparison datasets”.

As proposed, the weighting functions have been included as numbered equations.

L186: This is a strong assumption and should be tested using periods for which deeper soil moisture measurements are available.

As mentioned above, this paragraph describes the processing of the ERA5-Land gridded data. The assumption is related to the available layers of the ERA5-Land land surface model and thus cannot be directly tested with deeper soil moisture measurements (which are also less abundantly available). Since we focus on the temporal dynamics of the anomalies, which are dampened in these deeper soil layers, this assumption for the gridded product appears justified.

L188–193: Since these data are not part of the dataset provided with this submission, this section is too excessive and should be reduced to a single sentence.

We have restructured Chapter 2 and now present the ERA5-Land and the C3S SM PASSIVE products under a separate Chapter “2.2 Comparison datasets” to make this distinction from the in situ data clearer. We have also shortened the description of the remote sensing product so that it is more balanced with the description of the ERA5-Land.

L199: “in-situ time series”

As mentioned above, “timeseries” has been changed to “time series” throughout the manuscript, while “in situ” should not be hyphenated according to the journal guidelines.

L201: "available on a 0.25° × 0.25° latitude–longitude grid with daily temporal resolution."

Thank you for the suggestion, we have changed this text accordingly.

L211: “Figure 3 presents the individual soil moisture anomaly time series of the summer IWC at SwissSMEX stations (2010–2024) for each station combination (Table 1), along with the respective median anomalies.”

Thank you for the suggestion, this has been changed accordingly.

L214–215: The median anomalies appear to exhibit different trends. Please add trend lines to make these differences more clearly visible.

We have added the overall trend lines based on the respective medians in Fig. 6 for visualisation. The corresponding Theil-Sen trends based on the various station combinations are presented in Table 2.

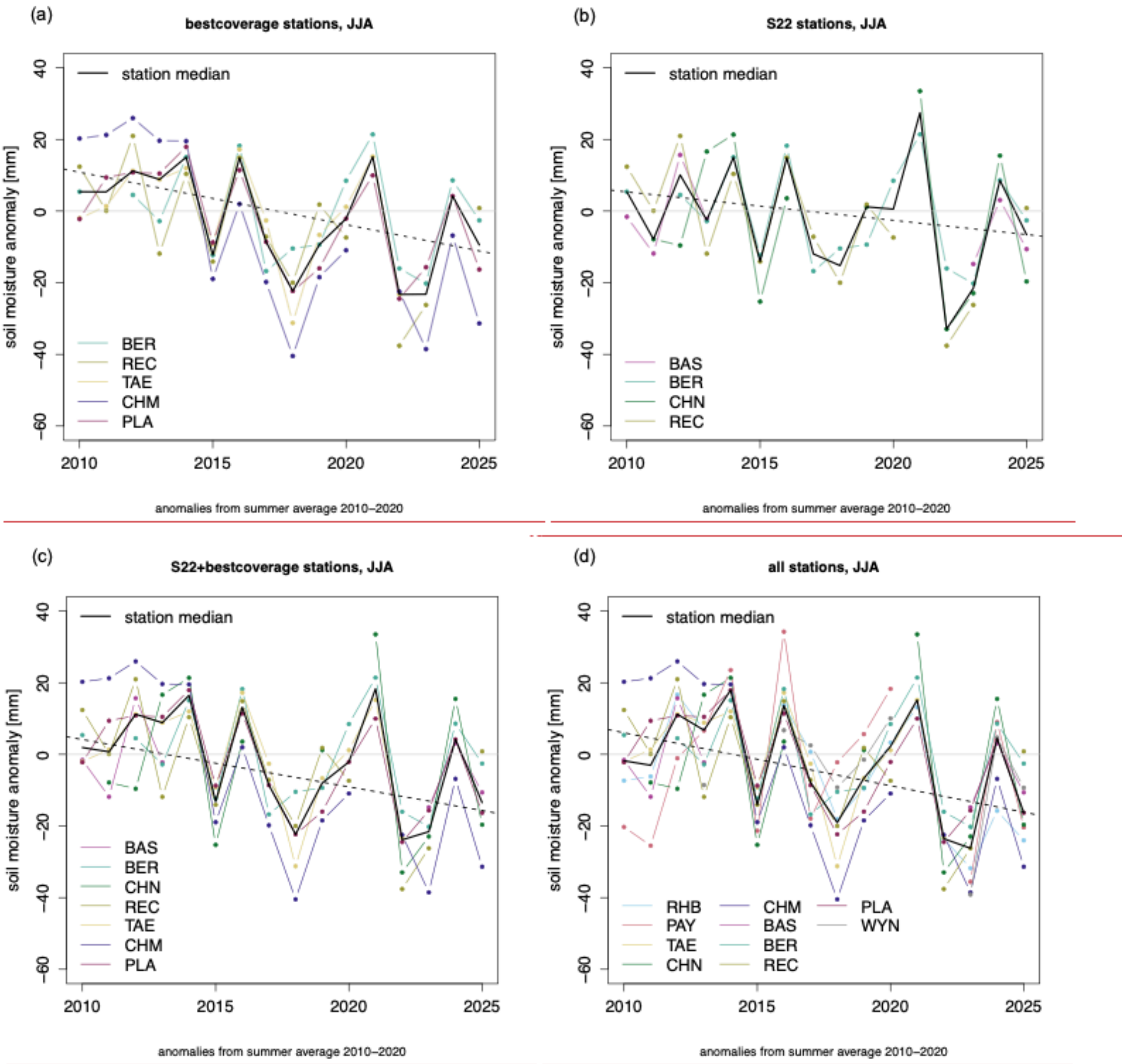

Figure 6 Soil moisture anomaly time series of summer IWC of different SwissSMEX station combinations (see Sect. 2.3, Table 1) and respective station medians. (a) Stations with best temporal coverage, (b) station selection as in S22, (c) S22 and best coverage stations combined, (d) all Swiss Plateau stations. Anomalies are expressed as the absolute deviations from the summer mean over 2010–2020. The straight lines show the Theil-Sen trend slopes for the period 2010–2025 based on the respective station median time series (solid lines indicate a significant trend with $p < 0.05$; dashed lines indicate a non-significant trend).

L234: Please explain "Theil-Sen trend"

We have added an explanation of the Theil-Sen trend slope and as well as the Mann-Kendall trend test (Sect. 2.3).

The robust Theil-Sen trend estimator (Theil, 1950; Sen, 1968) is used to compute trends, while the non-parametric Mann-Kendall trend test is used to determine trend significance (Mann, 1945; Kendall, 1975). These allow to detect monotonic changes over time and are robust to non-normally distributed data. Statistical significance is indicated by a p-value of less than 0.05. The R-functions sens.slope and mk.test from the trend package (Pohlert, 2020; version 1.1.4) are used for the calculation. The trends are calculated based on the median time series of the respective station combinations.

L284-285: "ERA5-Land and ESA CCI PASSIVE also show good agreement in the long-term monthly variations of Swiss Plateau soil moisture since 1991…"

This sentence has been shortened accordingly. Note that these are not monthly data, but summer and summer-half-year aggregated values.

L295–299: This summary section does not fit in the Discussion and should be removed.

Thank you for the suggestion. We have integrated the explanation of the Mann-Kendall calculation in the Data and methods section (see above, Section 2.3). The discussion of the temporal robustness of the trend has been moved to Appendix B and updated to reflect the extended analysis period (including updated significance thresholds for the starting-year analysis), since we focus on the 2010–2025 period in the main part of the manuscript now. This is also done to strengthen the validation purpose of the comparative analysis of SwissSMEX with the ERA5-Land and C3S SM PASSIVE products.

L329–330: Domínguez-Niño et al. (2019) found no evidence of decreasing sensitivity of the 10HS sensors in detailed laboratory experiments with different soil materials. However, using only the factory calibration led to much higher measurement errors compared to sensor- and soil-specific calibrations, which could falsely suggest a decrease in sensitivity. This important clarification should be included here.

Thank you for pointing us to this additional evaluation of the 10HS sensors, which we have included in the paper (Sect. 2.1.1). Accordingly, we have removed the original statement about decreasing measurement sensitivity at high VWC and reframed the discussion around the higher measurement errors associated with using only the factory calibration. Indeed, also the analyses of Mittelbach et al. (2011) and Mittelbach et al. (2012) show that using site-specific calibration of the 10HS sensors (as implemented in the SwissSMEX network) improves their accuracy and increases their measurement range. We have clarified this in the in situ data processing section (Sect. 2.1.1).

and 50 cm depth in 2010. Ten SwissSMEX grassland sites on the Swiss Plateau are still operational (Fig. 1, Table 1). The installed low-cost 10HS sensors are prone to higher measurement errors when only the factory calibration is used (e.g., Domínguez-Niño et al., 2019; Mittelbach et al., 2012). Therefore, site-specific exponential calibration functions were derived from the parallel 10HS and TDR measurements and applied to the raw 10HS readings. These site-specific calibrations allow to reduce the absolute error to about 2 Vol.% for most 10HS measurements, including under dry and moist soil conditions, and extend the effective measurement range of the sensors to up to 50 Vol.% (Mittelbach et al., 2011).

L341-342: "We present a curated and comprehensive set of in situ soil moisture time series from the SwissSMEX stations on the Swiss Plateau."

This sentence has been changed accordingly.

Figure 1: This figure only shows snapshots of data availability. A time series diagram illustrating the availability of measurements over time would be more informative (see, for example, Fig. 2 in Bogena et al., 2022).

Thank you for this input. We now present the data availability of the TDR and capacitance sensors in two time series diagrams in the revised manuscript (see new Figs. 2 and 3).

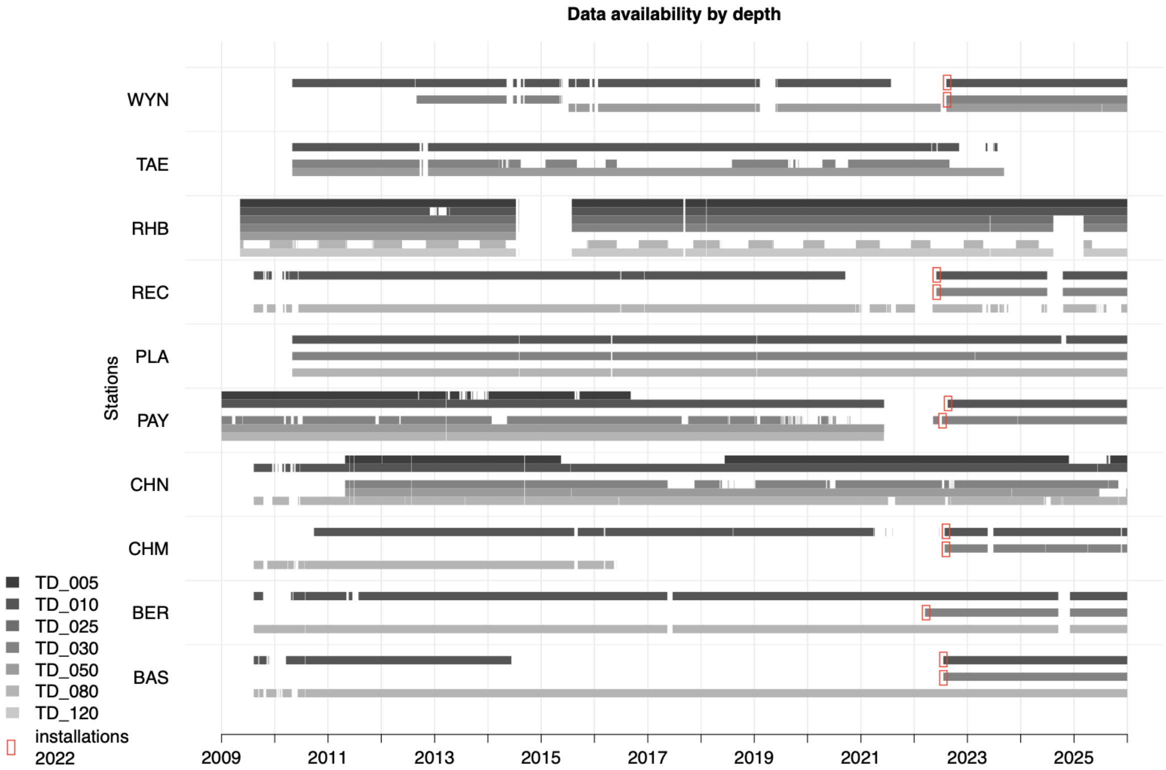

Figure 2 Time series diagram of the IMKO TRIME-PICO TDR (TD) sensor availability at the SwissSMEX grassland stations on the Swiss Plateau. Abbreviations for station names are given in Table 1; numbers alongside the sensor type indicate the installation depth in cm. This is a condensed view that combines all redundant sensor profiles. Note that station RHB includes an additional sensor at 25 cm depth, and that the sensors at the other depths are partly shifted by 5 cm in this profile. For simplicity, the sensors installed at depths of 15 cm, 35 cm, and 55 cm are shown as TD_010, TD_030, and TD_050, respectively. The TDR installations in 2022 are highlighted by red rectangles.

Figure 2 does not effectively present the data. The many overlaid lines make it difficult to distinguish individual series, and the thick black line is superfluous, as it merely duplicates other datasets. I suggest presenting the data in two additional subplots. In addition, the legend could also be placed outside the plot area so that the data range does not have to be unnecessarily restricted. Finally, similar plots should be provided for the remaining stations in the supplement.

Thank you for the suggestion. In the revised plot (new Figs. 4 and 5), we have separated the VWC and the IWC curves into two panels (see example of CHM below). Please note that, to ensure comparability, the y-axes are kept consistent between stations. We have also included the corresponding plots for the other stations in the supplement.

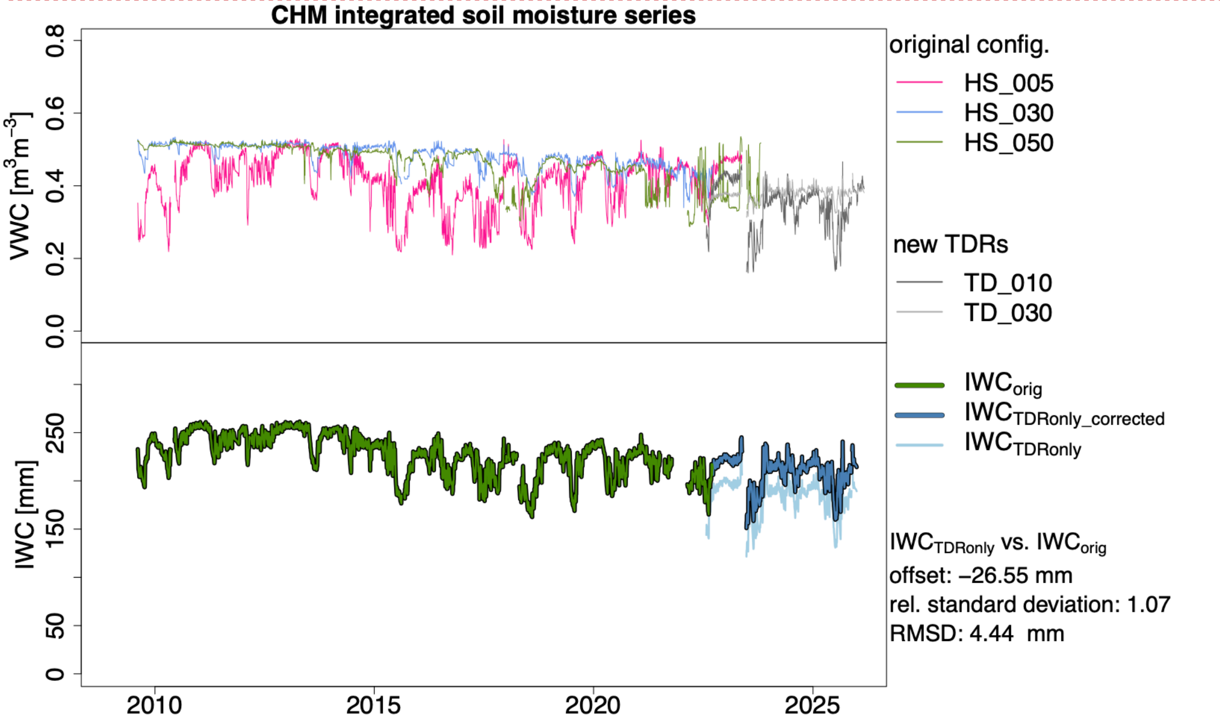

Figure 4 Daily time series of volumetric water content (VWC, in m^3 m^{-3}) and vertically integrated soil water content (IWC, in mm) at the station Chamau (CHM), where IWC_{orig} could be extended to the present. (Top) VWC from the 10HS sensors contributing to IWC_{orig}, based on the original sensor configuration (see also Table S1), and from the two new TDRs installed in 2022 that are used to calculate $IWC_{TDRonly}$. (Bottom) IWC_{orig} and the 10 and 30 cm TDR-only based $IWC_{TDRonly}$ and $IWC_{TDRonly\_corrected}$ (see Eq. 3a,b). The original offset of $IWC_{TDRonly}$ is also noted, as well as its relative standard deviation and RMSD compared with IWC_{orig} (all metrics are based on the overlapping hourly time steps). See Figs. S1–S4 for similar plots for the other stations.

Figure 4: The numbers inside the circular areas are not all easily readable and should be made clearer.

We have changed the colours of the numbers to make them better readable, with lighter grey for the correlation plot and black/white for the RMSD plot (revised Fig. 7, see Replies to RC2 below).

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Replies to RC2: Matthias Zink, 09 Jan 2026

The manuscript and data are fitting to the scope of ESSD. They are about an observational dataset of soil moisture data in Switzerland. The authors present in situ data from volumetric soil moisture that are used to estimate the integrated soil water content. They further validate their data and results of a trend analysis with model data (ERA5 Land) and a remote sensing product (ESA CCI).

The manuscript would benefit from a streamlining of the storyline. Currently the manuscript is divided into a results, discussion and conclusion section. The discussion section includes in major parts results and isn't discussing the results from the results section with exception of a few points. The presented results can be discussed more in depth to support the analyses that have been presented in the results section. Further some figure captions are repeated in the text which elongates the paper unnecessary. The conclusion section is mainly a summary rather than a conclusion section and would benefit from some overhauling.

I also suggest to show some of the maths used for calculating for example IWC and correction/homoginization of the IWC time series.

The manuscript will be well placed in ESSD after some work into streamlining the storyline. It highlights important points like the difficulties of funding and maintaining long-term observational networks and their benefit for climate impact assessment studies. It showcases ideas how to deal with short time series and ways of bringing observations from various instruments together.

We would like to thank Matthias Zink for the positive feedback and the valuable comments.

Following the RC1 comments, we have reframed the manuscript to make the validation purpose of the analysis of summer soil moisture changes and the comparison with the alternative ERA5-Land and C3S SM PASSIVE products clearer. This included a shortening and streamlining of the whole text.

As proposed, we have included the formulas for the scaling of the IWC time series (see below), and for the trapezoidal integration of the VWC measurements to calculate IWC in the revised manuscript (Eq. 1–3).

Specific Comments:

Can you please add a map of the locations of the stations and add the footprint of the ERA and ESA CCI data.

We have added such a map in a revised version of the manuscript (new Fig. 1).

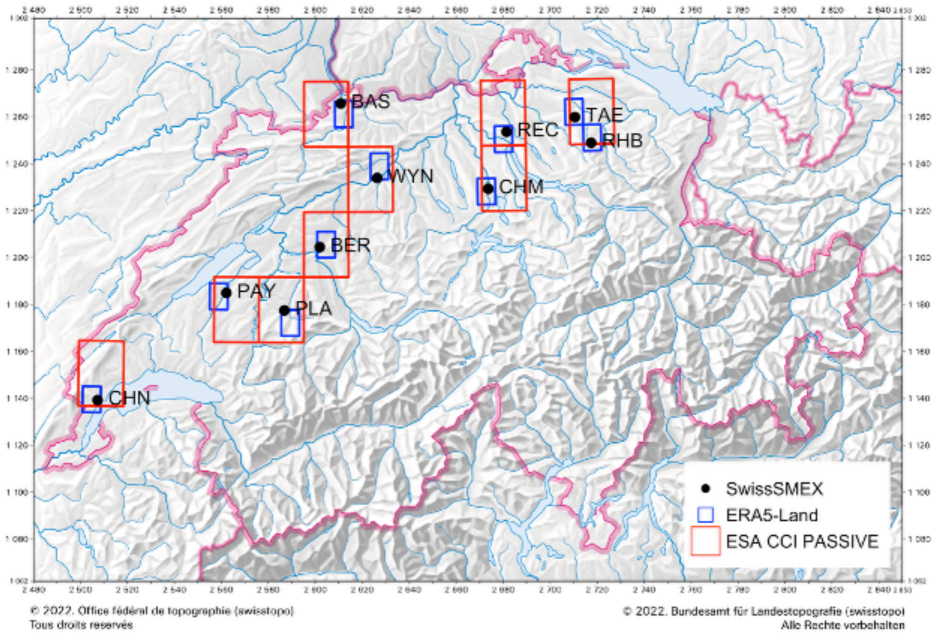

Figure 1 Locations of the SwissSMEX stations on the Swiss Plateau, as well as of the nearest ERA5-Land and C3S SM PASSIVE grid cells (see Sect. 2.2). Please refer to Table 1 for station abbreviations.

L140-144 Can you please elaborate on the scaling one time series with the other using mean and standard deviation. Ideally add the formula.

The scaling is applied to correct the original offset and variability difference of the 10 and 30 cm TDR-only IWC towards the IWC based on the original configuration. This correction assures that the TDR-only IWC data distribution matches that of the original configuration (in terms of mean and standard deviation). We have added this in the revised manuscript.

The historical hourly IWC time series (IWC_{orig}) and the 10 and 30 cm TDR-only based series ($IWC_{TDRonly}$) are then merged by correcting the mean offset and difference in standard deviation of the latter with respect to the former to account for the difference in the representative depth (Eq. 3a,b).

$$IWC_{\mathrm{TDRonly\_corrected}} = \left(IWC_{\mathrm{TDRonly}} - \overline{IWC_{\mathrm{TDRonly}}}\right) / relsd + \overline{IWC_{\mathrm{orig}}} \quad (3a)$$

$$relsd = \mathrm{sd}\left(IWC_{\mathrm{TDRonly}}\right) / \mathrm{sd}\left(IWC_{\mathrm{orig}}\right) \quad (3b)$$

The overbar denotes the temporal average, sd the standard deviation, and relsd the ratio of the standard deviations. The offset and relative standard deviation between the two series are calculated from the overlapping hourly time steps (except for BAS and WYN, where there is no overlap and all time steps are therefore used to calculate the scaling parameters). This correction assures that the data distribution of $IWC_{TDRonly\_corrected}$ matches that of IWC_{orig} (in terms of mean and standard deviation). Merging IWC_{orig} and $IWC_{TDRonly\_corrected}$ substantially increases recent station coverage with IWC. In some cases, historical

Figure 2: Panel a) is hard to read. It might be useful to move the IWC up to have a better view on the VWC.

Thank you for the suggestion. We have separated VWC and IWC into two panels in the revised plot (new Figs. 4 and 5, see Replies to RC1 above).

Figure 2: The figure caption is quite hard to understand.

The separation of VWC and IWC into two panels has implied a revision and rephrasing of the figure caption (see above). Also, we now use the variables names as introduced in Eq. 1–3 for IWC in the figure legend, which also simplified the description.

Figure 4 Daily time series of volumetric water content (VWC, in $m^3 m^{-3}$) and vertically integrated soil water content (IWC, in mm) at the station Chamau (CHM), where IWC_{orig} could be extended to the present. (Top) VWC from the 10HS sensors contributing to IWC_{orig}, based on the original sensor configuration (see also Table S1), and from the two new TDRs installed in 2022 that are used to calculate $IWC_{TDRonly}$. (Bottom) IWC_{orig} and the 10 and 30 cm TDR-only based $IWC_{TDRonly}$ and $IWC_{TDRonly,corrected}$ (see Eq. 3a,b). The original offset of $IWC_{TDRonly}$ is also noted, as well as its relative standard deviation and RMSD compared with IWC_{orig} (all metrics are based on the overlapping hourly time steps). See Figs. S1–S4 for similar plots for the other stations.

L186: assumption VWC28-100cm

This sentence has been changed to: “The assumption is that the $VWC_{28\text{-}100cm}$ is representative for the 22 cm between 28 and 50 cm soil depth.”

Can you please elaborate on the meaning of Figure 4? What is the take home message of the pairwise correlations?

The meaning and take home message of the original Fig. 4 (now Fig. 7) is twofold:

1. For SwissSMEX (values within the red rectangle), the figure shows that the median time series of IWC based on the different station combinations all agree on a consistent temporal evolution, given the high pairwise correlations and comparably low RMSDs. Thus the median evolution of IWC on the Swiss Plateau is mostly independent of the set of stations used. This was presented on L230-232 originally and has been extended regarding its meaning.
2. For ERA5-Land and C3S SM, the figure shows the agreement of these gridded products with the in situ data (and among each other). This is again shown for the different station combinations for completeness. These pairwise comparisons show that the independent gridded products agree well with the in situ data for the set of best coverage stations. For the other station combinations, the agreements in the medians is also mostly good. This was presented on L251-263 originally. Note that the agreement of the C3S SM time series based on the S22 set of stations improved when considering the extended period up to 2025. All correlations are now significant.

To improve the readability of Fig.4 (revised Fig. 7), we have rearranged the pairs of product/station combinations by moving “ERA5-Land bestcoverage”, “C3S SM bestcoverage” and “SwissSMEX bestcoverage” next to each other. This makes it easier to guide the reader through the different comparisons and ensures that the statistics for the best coverage-based pairs of products are not distributed throughout the matrix anymore.

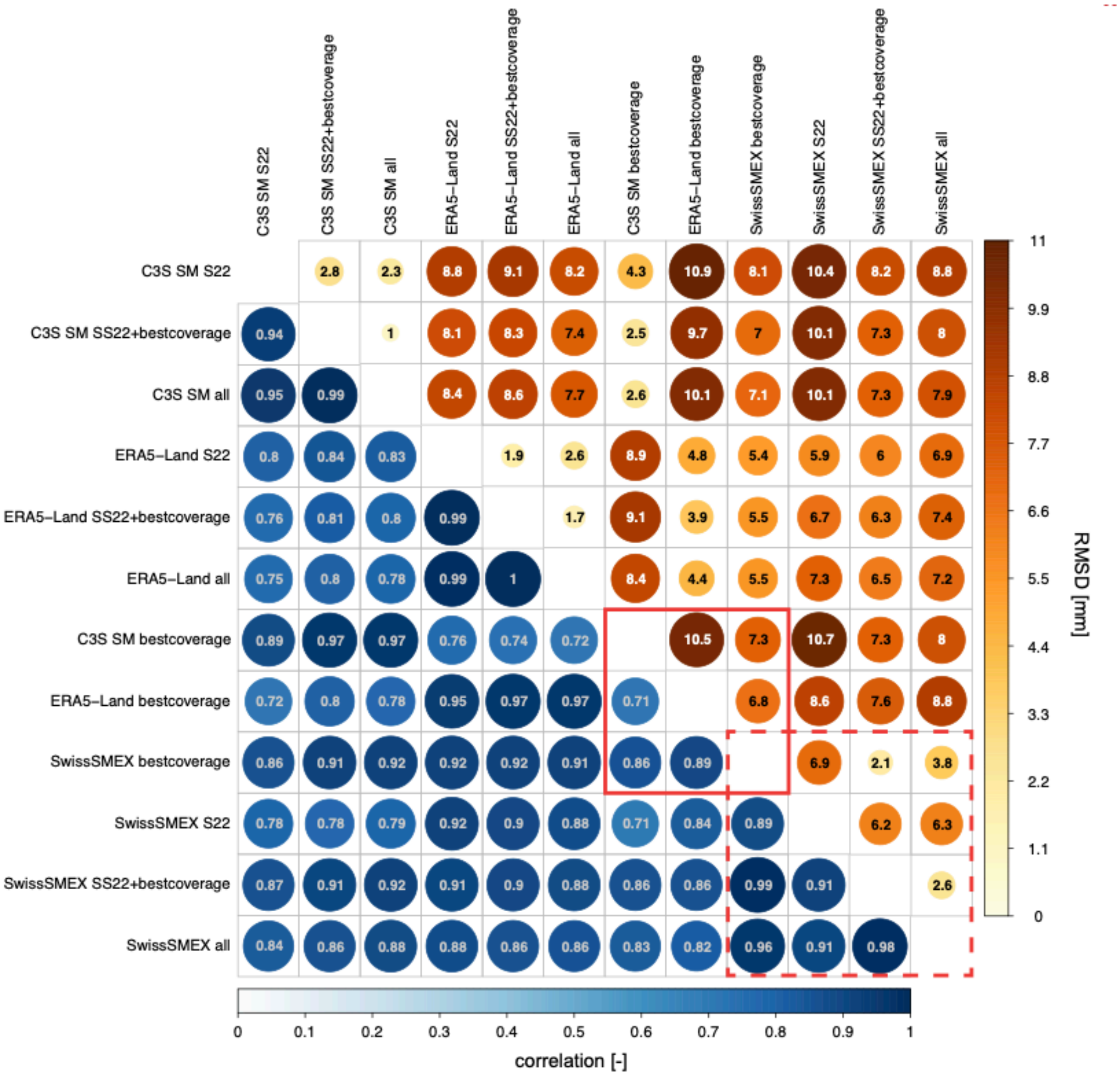

Figure 7 Pearson correlation and RMSD matrices from the pairwise comparison of SwissSMEX, ERA5-Land and C3S SM PASSIVE soil moisture, considering the different station combinations for the Swiss Plateau median time series of summer soil moisture anomalies (expressed as the absolute deviations from the 2010–2020 summer mean). Values are calculated for the common period 2010–2025. All correlations are significant ($p < 0.05$). The red dashed rectangle highlights the comparison of the different station combinations based on SwissSMEX, while the red solid rectangle highlights the comparison of the gridded products and SwissSMEX based on the best coverage station combination. See Fig. S5 for the corresponding summer-half-year correlations and RMSDs.

L237 for the trends calculated between -0.1 % year-1 and -1.2 % year-1 it would be useful to discuss the accuracy of the measurement devices. This enables the reader to assess the relevancy of the detected trends.

Note that the trends in % year^{-1} refer to percentage anomalies of the vertically integrated soil water content (IWC), not to volumetric water content (VWC) as directly measured by the sensors. These anomalies are expressed relative to the average summer IWC and thus cannot be directly related to sensor uncertainties. We have clarified this in the revised manuscript (Sect. 2.3).

relative to the 2010–2020 mean, respectively). Note that these percentage values should not be confused with the Vol.% units of the VWC sensor readings. We deliberately allow up to 35 % missing days when calculating the mean anomalies for each

Figure 5: Can you please increase the font size of the labels and caption? I am not sure if the figure needs to start in 1980. I would suggest zooming in to 2010-2025.

Thank you for the suggestion. As proposed, we zoom in this plot to 2010–2025, when we have coverage with the SwissSMEX data (see new Fig. 8 below). This also strengthens the validation purpose of this comparative analysis with the ERA5-Land and C3S SM PASSIVE products. The 1980–2025 evolution is shown in the Appendix A to provide the long-term context. Given this change in the temporal focus, we have also moved the analysis of the robustness of the trend to Appendix B.

We have also increased the font sizes of these figures.

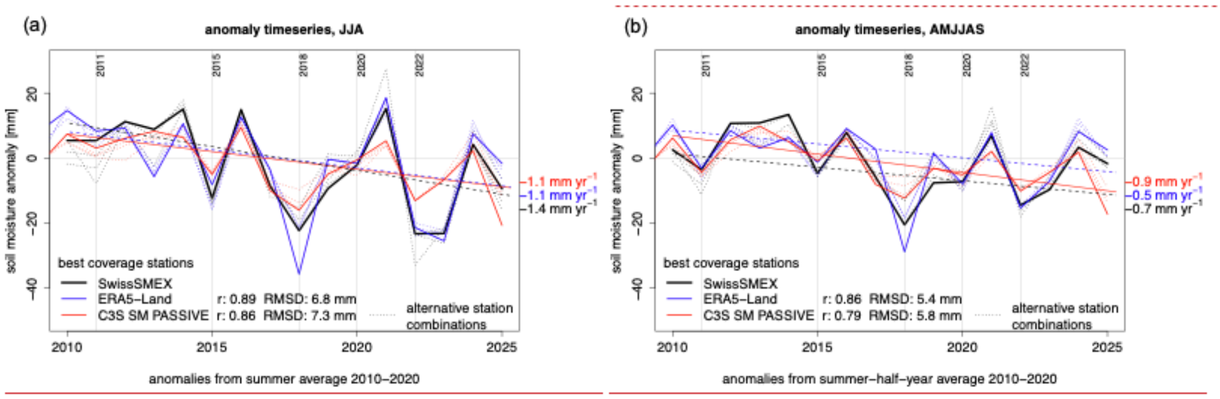

Figure 8 Evolution of (a) summer and (b) summer-half-year soil moisture anomalies based on SwissSMEX, ERA5-Land and C3S SM PASSIVE. Anomalies are expressed as absolute deviations from the summer or summer-half-year mean IWC over the period 2010–2020, respectively (see Fig. S6 for corresponding anomalies as percentage deviations from this mean). Shown are the median time series based on the best coverage stations (solid lines), as well as the ones based on the alternative station combinations presented in Section 2.3 (dotted lines). For the gridded products, the nearest grid cells to the stations are considered as the basis for the median. Straight lines show the Theil-Sen trend slopes for the period 2010–2025 (based on the best coverage stations time series), which are also indicated to the right of the plots (solid lines indicate a significant trend with $p < 0.05$; dashed lines indicate a non-significant trend). Also noted are the Pearson correlation r and RMSD of the gridded products with respect to SwissSMEX, and known drought summers are indicated by vertical lines.

Data:

Thanks for including metadata like the soil texture and land cover into the data repository. This is very helpful.

Can you please provide the SiteInfo_SwissSMEX.pdf as ASCII file. This makes it machine readable and hence easier to work with.

We have added the corresponding information in an ASCII text file in the data directory.

It would be useful to get a lookup table for the nomenclature in the header columns. I know; it can be worked out from the file headers. I would appreciate a dedicated lookup table though.

Thank you for the suggestion. We have included a lookup table in the data directory as proposed.