Reply to reviewer 2

We would like to thank the reviewer for valuable suggestions and comments. After the paper has been revised, we will reply to each of these with page number and line indications. **P** refers to the page number and **L** refers to the line number. For example, **P3L65-70**, refers to page 3, lines 65-70.

Reviewer 1		
No	**Comment**	**Reply**
1	I thank the authors for their response, which have addressed some of my minor concerns. However, my main concerns were not adequately addressed. I therefore restate these comments below and hope that the reviewers will find the time to address these in a future revision.	We thank the reviewer for the comments. Although we do not fully agree with all the points raised, we appreciate the opportunity to reflect on them. In our responses below, we aim to provide constructive clarifications and propose intermediate solutions that address the reviewer's concerns while preserving the core objectives of the manuscript.
2	My concerns about the usability of these results persist, as the authors do not show evidence that ISIMIP is providing reliable results. Benchmarking the used climate model data against observations is not difficult and but very important in the context to discuss the reliability of the shown results. (see my comment 10)	We acknowledge the concern regarding the reliability of ISIMIP outputs compared to observations. However, we would like to clarify that the primary objective of this study is not to evaluate ISIMIP models, but to use them as input data for assessing the impacts of droughts and heatwaves. This is the main reason why we did not include a dedicated ISIMIP model validation in our manuscript.

Nonetheless, we agree that we should provide information regarding the ISIMIP model evaluations.

The ISIMIP models have been extensively used in recent years to study the impacts of climate change on the hydrological cycle and water resources (E.g., Eisner et al., 2017; Vetter et al., 2017; Mishra et al., 2017; Wang et al., 2017; Gelfan et al., 2017). More specifically, it has been applied to study the extreme events, such as droughts, floods, and heatwaves (Samaniego et al., 2017; Pechlivanidis et al., 2017; Tabari et al., 2021; Messori et al., 2025), suggesting its robustness for such applications.

Several studies have investigated uncertainties within the ISIMIP models and have concluded that most of the variability stems from the climate models rather than the hydrological models (Samaniego et al., 2017; Vetter et al., 2017; Hattermann et al., 2018). Furthermore, uncertainties tend to be higher in dry basins than in wet basins (Samaniego et al., 2017; Pechlivanidis et al., 2017). We added this information in the revised version. |

			We also included a comparison between drought and heatwave analysis derived from ISIMIP models and ERA5 Land. The results show that the simulated number of drought events from ISIMIP models aligns closely with ERA5 Land, with a median difference of only 7% (Figure 1a below). For heatwaves, ISIMIP models slightly underestimate their frequency compared to ERA5 Land, with 75 percentile of events reaching 75 in ERA5 land and 59 in ISIMIP models (Figure 1b). These findings support previous studies, which report higher uncertainty from the climate models than the hydrological model. In addition, the bias corrected ISIMIP datasets used in our study show lower uncertainty compared to ERA5 Land (see also point 3). We incorporated this explanation into the revised method section and added Figure 1 to the appendix (**P4L98-108**).
3		I'm also not satisfied with the authors response to my question regarding the increasing the resolution by a regridding the data. To be convinced that this is useful approach, I would like to see the differences between results based on the original low-res grid and the artificially increased high res. results. Of course stakeholders are interested in high res data, but if this data consists of artefacts then sticking with more reliable low res data is the way to go (original comment 7).	We regret that our previous response regarding the regridding of data did not fully satisfy the reviewer and we will clarify in more detail below.

The main reason we chose to conduct our analysis using high resolution data is directly related to the bias correction process applied. The regridding was done to facilitate an easy bias-correction of the ISIMIP soil moisture data with ERA5-Land data, and should not be regarded as an attempt to downscale the ISIMIP data. The ISIMIP soil moisture data were first resampled to match the ERA5-Land resolution, and subsequently bias-corrected using ERA5-Land soil moisture data as the observational reference (**P3L84-87**). This step was essential to ensure that the model outputs better reflect real-world conditions.

It is important to note that the uncorrected ISIMIP soil moisture values were lower than ERA5 Land, largely due to differences in model structures, soil layering, and depth representations (see Figure 2 below). After bias correction, the modeled soil moisture data show a much closer agreement with ERA5 Land data.

A comparison using the original low resolution data would not yield a meaningful evaluation, since only the high resolution data underwent bias correction. Given these points, we believe that working with bias corrected high resolution data was more appropriate and scientifically sound |

			approach for our analysis. We are confident that these data better represent the observed soil moisture conditions that the original ISIMIP outputs and thus are more suitable for the objectives of our study.
4	I can only repeat my initial comment that the term 'cascading' should not be used for 'sequential' events. In their response to my initial comment 4 and 6 the author use sequential to explain what they mean with cascading. I would therefore urge the authors to change 'cascading' to 'sequential' throughout the manuscript.		The feedback from the reviewer is accepted. We thus revised the word cascading into consecutive throughout the manuscript.
5	Figure 6 then does not show an impact but a frequency (my original comment 15). Please change the Figure label accordingly.		We changed the figure Y axis accordingly.
6	Original comment 16, my apologies for the mix up I meant l. 367 'This study is pioneering in predicting future drought and heatwave characteristics, both in isolation and as CnC events, including their impacts.' Compound Drought heat events are one of the most thoroughly studied compound event types. While I do not want to downplay the ambitions of the researchers 'pioneering' seems a bit much here.		We changed the sentence into "This study contributes to an insight into predicting future drought and heatwave characteristics, both in isolation and as CnC events, including their impacts" (**P18L417-418**).

References

Eisner, S., Flörke, M., Chamorro, A., Daggupati, P., Donnelly, C., Huang, J., Hundecha, Y., Koch, H., Kalugin, A., Krylenko, I., Mishra, V., Piniewski, M., Samaniego, L., Seidou, O., Wallner, M., and Krysanova, V.: An ensemble analysis of climate change impacts on streamflow seasonality across 11 large river basins, Clim. Change, 141, 401–417, https://doi.org/10.1007/s10584-016-1844-5, 2017.

Gelfan, A., Gustafsson, D., Motovilov, Y., Arheimer, B., Kalugin, A., Krylenko, I., and Lavrenov, A.: Climate change impact on the water regime of two great Arctic rivers: modeling and uncertainty issues, Clim. Change, 141, 499–515, https://doi.org/10.1007/s10584-016-1710-5, 2017.

Hattermann, F. F., Vetter, T., Breuer, L., Su, B., Daggupati, P., Donnelly, C., Fekete, B., Flörke, F., Gosling, S. N., Hoffmann, P., Liersch, S., Masaki, Y., Motovilov, Y., Müller, C., Samaniego, L., Stacke, T., Wada, Y., Yang, T., and Krysnaova, V.: Sources of uncertainty in hydrological climate impact assessment: a cross-scale study, Environ. Res. Lett., 13, 015006, https://doi.org/10.1088/1748-9326/aa9938, 2018.

Messori, G., Muheki, D., Batibeniz, F., Bevacqua, E., Suarez-Gutierrez, L., and Thiery, W.: Global mapping of concurrent hazards and impacts associated with climate extremes under climate change, Earth's Future, 13, e2025EF006325, https://doi.org/10.1029/2025EF006325, 2025.

Mishra, V., Kumar, R., Shah, H. L., Samaniego, L., Eisner, S., and Yang, T.: Multimodel assessment of sensitivity and uncertainty of evapotranspiration and a proxy for available

water resources under climate change, Clim. Change, 141, 451–465, https://doi.org/10.1007/s10584-016-1886-8, 2017.

Pechlivanidis, I. G., Arheimer, B., Donnelly, C., Hundecha, Y., Huang, S., Aich, V., Samaniego, L., Eisner, S., and Shi, P.: Analysis of hydrological extremes at different hydro-climatic regimes under present and future conditions, Clim. Change, 141, 467–481, https://doi.org/10.1007/s10584-016-1723-0, 2017.

Samaniego, L., Kumar, R., Breuer, L., Chamorro, A., Flörke, M., Pechlivanidis, I. G., Schäfer, D., Shah, H., Vetter, T., Wortmann, M., and Zeng, X.: Propagation of forcing and model uncertainties on to hydrological drought characteristics in a multi-model century-long experiment in large river basins, Clim. Change, 141, 435–449, https://doi.org/10.1007/s10584-016-1778-y, 2017.

Tabari, H., Hosseinzadehtalaei, P., Thiery, W., and Willems, P.: Amplified drought and flood risk under future socioeconomic and climatic change. Earth's Future, 9, e2021EF002295, https://doi.org/10.1029/2021EF002295, 2021.

Vetter, T., Reinhardt, J., Flörke, M., van Griensven, A., Hattermann, F., Huang, S., Koch, H., Pechlivanidis, I. G., Plötner, S., Seidou, O., Su, B., Vervoort, R. W., and Krysanova, V.: Evaluation of sources of uncertainty in projected hydrological changes under climate change in 12 large-scale river basins, Clim. Change, 141, 419–433, https://doi.org/10.1007/s10584-016-1794-y, 2017.

Wang, X., Yang, T., Wortmann, M., Shi, P., Hattermann, F., Lobanova, A., and Aich, V.: Analysis of multi-dimensional hydrological alterations under climate change for four major river basins in different climate zones, Clim. Change, 141, 483–498, https://doi.org/10.1007/s10584-016-1843-6, 2017.
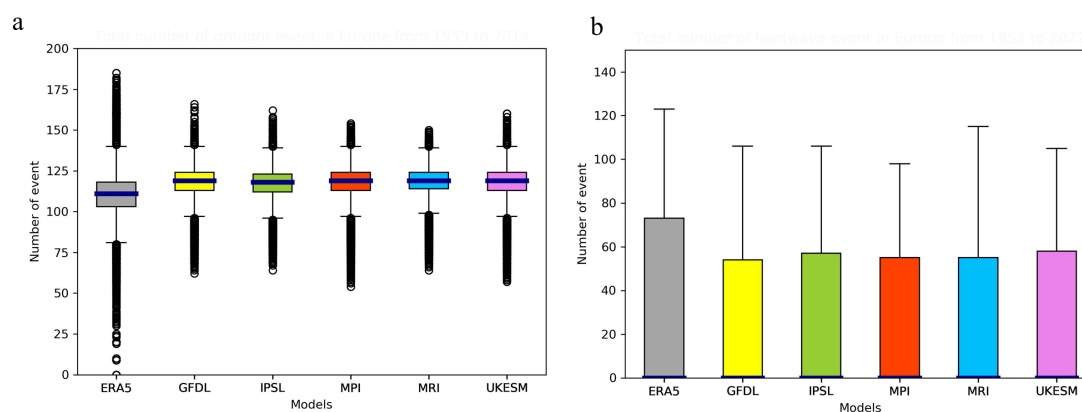
Figure 1. a) Comparison of total number of drought events between ERA5 Land and ISIMIP models across Europe from 1953 to 2014 and b) Comparison of total number of heatwave events between ERA5 Land and ISIMIP models across Europe from 1953 to 2022.
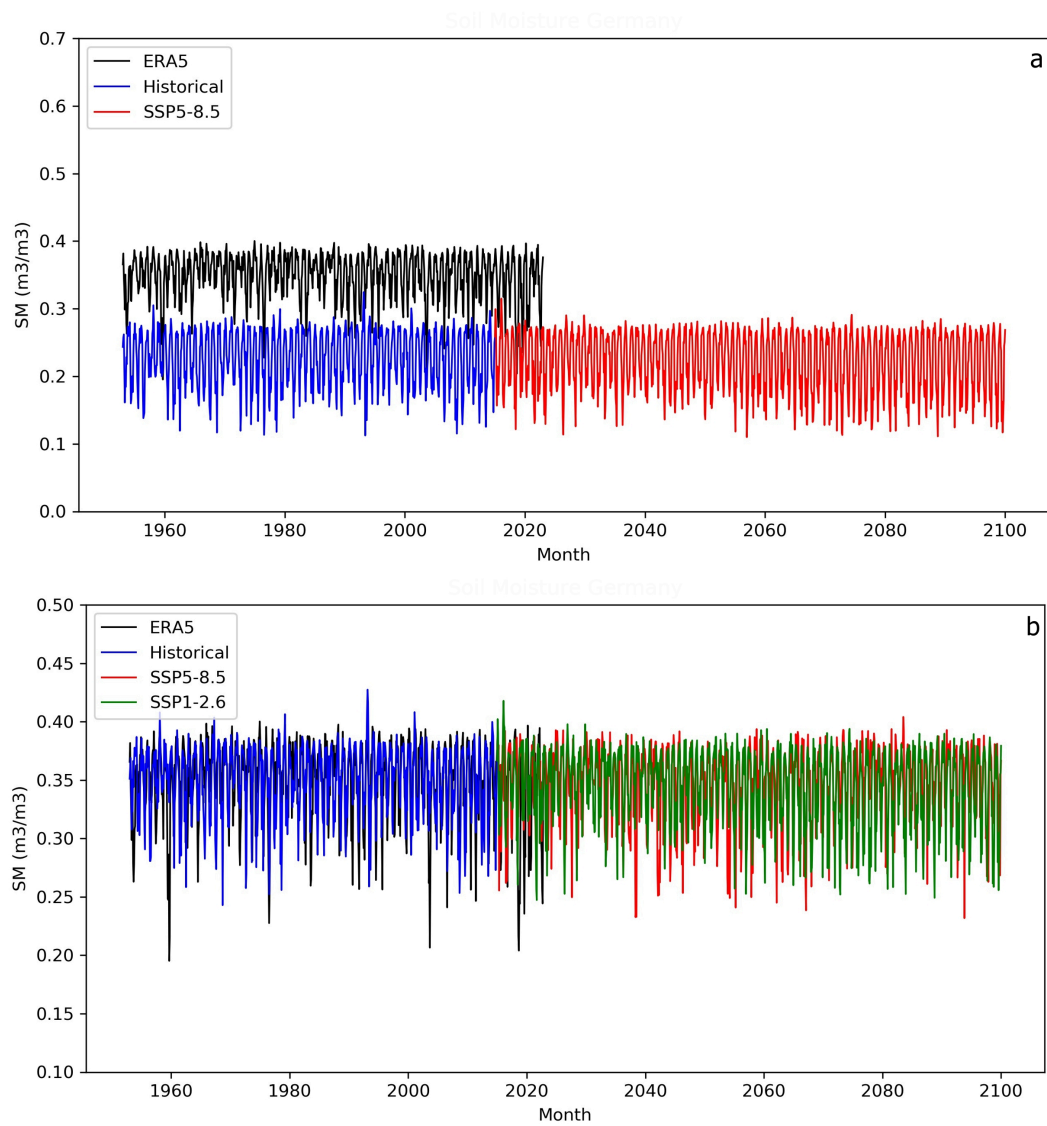
Figure 2. Comparison ISIMIP modeled soil moisture data with ERA5 Land without (a) and with bias correction (b).