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Response to the Reviewers

Original reviewer comments are in italics, **authors' response is in bold**.

Referee #1:

SUMMARY:
A recommendation: moderate revision
Using observed SM data collected from 40 locations and in 4 different measurement methods in Germany, the authors evaluate the performance of second generation operational German Drought Monitor in simulating soil moisture (SM). Two major research questions within this paper have been adequately addressed and can be summarized as follows: 1. how well the GDM capture the SM dynamics; 2. will GDM with higher spatial resolution produce SM estimates with higher quality compared with the GDM of former edition. Through the research, it was found that 1. SM dynamics simulations could be moderately improved; 2. higher resolution drought information at the one-kilometer scale can be met.
This research is a report of the improvement in the model performance which is evaluated in the perspective of comparisons between the model simulations and the observations. The article conforms to the journal-specific instructions and is relevant to HESS. The work is appropriate to be published in this journal after some revisions. In the following part, I will state the major arguments in detail..

Authors' response #1: We thank the Reviewer for an overall positive assessments of our work. We paid detailed attention to all comments and have addressed all of them below accordingly.

The comparison between the observations and the model simulations are mainly indicated in the form of Spearman rank correlation coefficient. Nevertheless, the results of the comparison are in fact not so ideal in the perspective of solely the Spearman correlation coefficient, not to mention that significance values have been neglected when the observations and model results are compared. For example, when the observations from all the sites are included, the coefficients are normally lower. In addition, p-value has only been mentioned when both versions of the mHM and observations are compared (table 2). No mentioning of significance values also makes the comparison results not so validated. The significance value should be mentioned in the research to make results more reliable

Authors' response #2: Thank you for this comment. We agree with the reviewer that the significance value is the essential information. Therefore we will add the significance values into Figure 4 (see exemplary Figure R1 below) and Figure 5 by indicating locations with p-values < 0.05 and positive correlations.

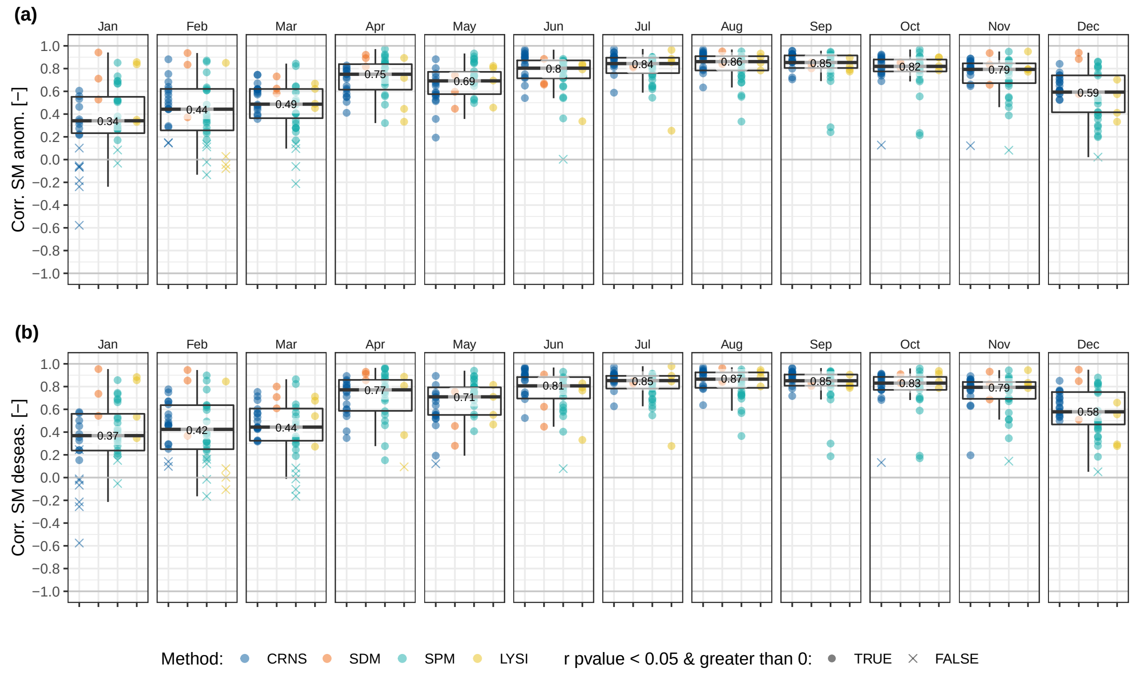

Figure R1: Same as Figure 4 in the main manuscript, but including information of correlation significance (p-value < 0.05) and positive correlation.

In addition, the analyses are focused on the explanations for the correlation coefficients, few further knowledge regarding the inner uncertainty within the models such as misrepresentations or no involvement of certain natural factors are included to be accounted for the discrepancy between the observations and model results. In this way, the detailed explanations in the conclusion and discussion part of this paper are needed to clarify the differences between observations and model results.
The four kinds of observations seem not to be standardized. In this way, some values of correlation coefficient which concern a specific observation technique, are not guaranteed to be valid in indicating the performance of GDM in simulating SM dynamics. A standardization method should be carried out to ensure a consistent comparison between observations and model simulations.

Authors' response #3: We thank the reviewer for the suggestions and agree that aspects regarding soil moisture measurements need to be considered carefully. Since there are differences between available soil moisture measurement techniques and to the spatial simulation scale, the approach of this paper was to include various measurement techniques in the model evaluation. Therefore, we believe that it is one of the strengths of the manuscript to show the comparison of mHM simulations to not only one type, but different soil moisture measurement techniques. As a consequence, differences that result from the measurement techniques are considered and discussed thoroughly in the manuscript.
The differences can be related e.g. to the site conditions, type of measurement devices and spatial or vertical scales that are represented. We were not completely sure to which of these differences the reviewer refers. Therefore, we aim to point out in the following how we addressed them in the main manuscript and how to improve it.
The SM sites are not homogeneously distributed over site conditions (e.g.

lysimeters are placed in grasslands). In general, it could be shown that the model performances doe not systematically depend on site conditions that could result from different measurement techniques (see also answer #4). We suggest to move the Figure A2 to the section 3.1 to give it a more central focus.
Regarding the measurement devices, the single profile measurements (SPM), spatially distributed measurements (SDM) and lysimeters (LYSI) use either Time or Frequence Domain Reflectrometry (TDR, FDR) sensors that do not expect differences in measurement quality. Cosmic Ray Neutron Sensing (CRNS) use a different measurements technique but were validated by spatially distributed measurements using TDR and FDR sensors (lines 200-204). As well, due to methodological reasons days with snow were discarded from analyses for CRNS as further explained in the method section in lines 200-204 and possible implications in lines 304-307.
The measurements represent different horizontal spatial scales, with the area represented being smallest for SPM and LYSI (≈ point scale), while SDM (resp. the corresponding mean) and CRNS represent much larger areas at 0.1 km^2 (see lines 275-276). It was shown that SDM shows slightly better correlations to the simulations that support the closer scale match to the simulations (see e.g. 342-345). Those measurements are however still rare (see line 67) and since the paper focuses on SM dynamics the value of including SPM and LYSI measurements increases substantially. Additionally, CRNS data was excluded from the comparison in depth 25 - 60 cm due to its varying vertical penetration depth that does not allow a consistent depth-wise evaluation (see lines 325-236).

In order to facilitate a better standardization, not only the differences in the methods of the observations, the observation sites' conditions should be considered in explaining the research results, such as the landuse, elevation, precipitation of different sites.

Authors' response #4: We acknowledge the reviewers recommendations. In the main manuscript it is mentioned that the German-wide available information (soil maps, land use) is considered (lines 263-265). No available site-specific information is used in setting-up the hydrological model, e.g. precipitation is taken from daily available, interpolated DWD-observations and existing observations in the locations of soil moisture measurements are neglected. Hence, a different model setup would be required to meet the proposed standardization.
Correlations against sites´ conditions (landuse as reported at the site, elevation and average precipitation from model) are plotted in the appendix of the main manuscript Figure A2 (see also Figure R2). As stated in the results section lines 285-286 “there is no general tendency for lower correlations at forest sites compared to crop and grassland sites (see Fig. A2)“. Crop sites show slightly lower correlations than grassland sites, which is expected since anthropogenic activities (e.g., crop rotation) are not represented in mHM. Also, correlations show no clear tendency across the range of elevation and precipitation regimes.

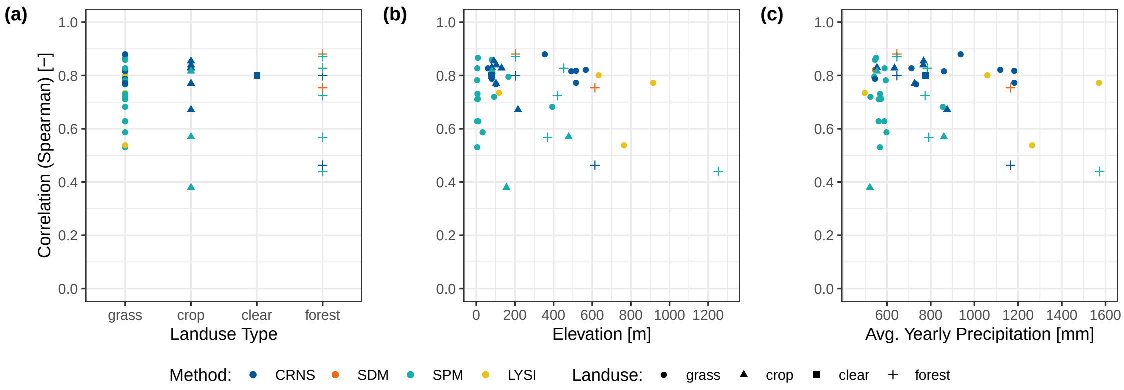

Figure R2: Same as Figure A2 in preprint manuscript.

Additionally, the change of the landuse dataset and geology dataset in the two versions of the models has not been verified to have a positive effect on the simulation of soil moisture as the improvement in the second version of the model is not so evident (especially in spring and summer the change of Spearman rank correlation coefficient is negative). Further clarification for the effects of the model setting is needed in this research or in the future studies to be conducted by the authors' team.

Authors' response #5: The increase of model resolution in the second version of the drought monitor was motivated both by the release of a new German-wide soil map [1] and increased user need to higher resolution simulations as extensively described in the main manuscript. This resulted in $\approx 1.2 \times 1.2\,\mathrm{km}^2$ model resolution in the GDM-v2-2021 setup as a compromise between scientific/model perspective (limited by data availability and process representation) and stakeholder/user perspective (see conclusion lines 438-441). Changes in landuse data and geology data (also the change of projection to WGS-84) in the new drought monitor version (GDM-v2-2021) on the other hand were driven by current efforts increasing the applicability and comparability of mHM to regions other than Germany and outside Europe. See also reviewer response #8 regarding the applicability of mHM outside of Germany. We acknowledge the critical remarks related with these changes but will point out in the following that the geology and landcover dataset changes have minor implications for SM drought simulations compared to the change in soil dataset. Currently, mHM takes relatively raw landuse classes. Species specific landcover is currently not accounted for. The difference in the resolution of GLOBCOVER and CORINE landuse dataset are in sub grid scale that influences the subgrid variability (GLOBCOVER resolution: 300 meters, CORINE $<$ 100 m). Differences between the land cover datasets reduce if the land cover data is aggregated to the spatial resolution of the model. For example, at the spatial resolution of 1.2km, over 85 % of the grid cells both datasets agree on the dominant landcover. This shows that differences stem from differences at high spatial resolution and do not have a large impact on the simulation. We will include these aspects in the main manuscript to point out the limitations of the study. We propose to add the following sentence in the main manuscript in line 147: "The changes in landuse and geology dataset can influence the simu-

lations, yet play a minor role for the soil moisture simulations compared to the change in the soil dataset because changes of landuse data are in subgrid scale (resolution GLOBCOVER 300m, CORINE <100m) and no direct feedback of from saturated "groundwater" storage to soil moisture storage is implemented in mHM."

Moreover, the limited length of observed soil moisture data (< 10 years for most locations) causes some uncertainty in the comparison between observations and model results in the whole. More observations are needed to facilitate a more reliable model evaluation using the observation datasets as the existing observations within this paper are only validated in representing some regions of the Germany.

Authors' response #6: We compiled an unprecedented sample of soil moisture observations for hydrological model evaluation in Germany from different state-of-the-art measurement techniques and monitoring networks (FLUXNET and TERENO). We acknowledge the limitations of the length of observational data. In order to investigate the consequences of different time series lengths, Figure R3 shows correlation against length of time series. No trend of deteriorating correlations with length of time series can be detected. We agree on the need to further broaden the observational database for future comparisons of model simulations to observations.

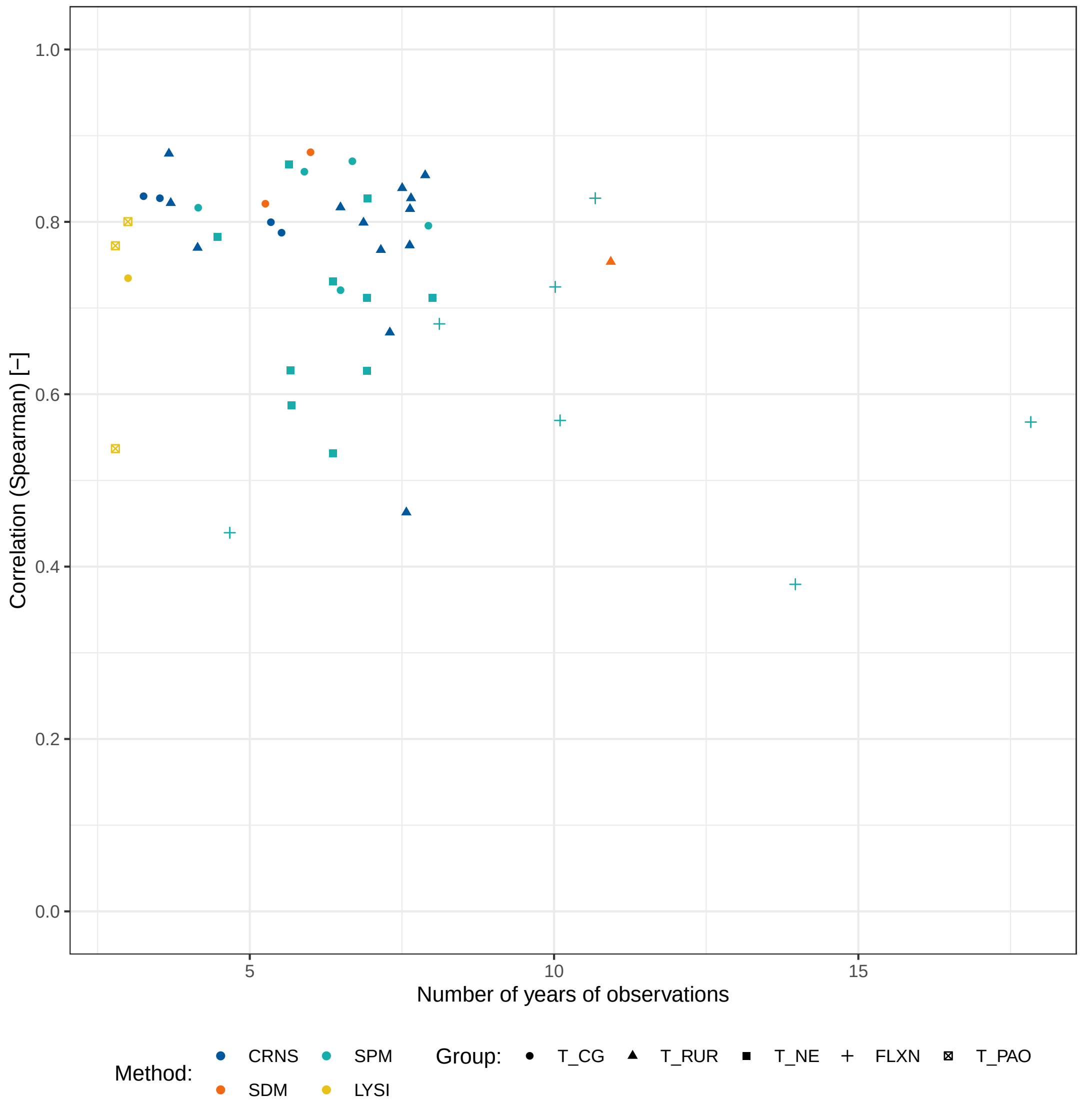

Figure R3: Correlations for the soil moisture observations against simulations (GDM-v2-2021 setup, 0-25cm depth) dependent of number of years of observations.

The authors can try making better simulations of the water cycle including soil moisture, ground water, and precipitation, while a higher-quality observational soil moisture dataset is applied in the future study. Other methods to indicate the correlations between the observations and model results can be used and also other indices apart from SMI can be utilized in indicating the severity of soil moisture drought.

Authors' response #7: Thank you for your comment. We will include the recommendation in future studies.

Last but not least, it would be better to have some discussions on the applicability of the model to other regions other than Germany. Are there some future plans on extending the regional applicability of the model? Besides, some discussions on what can we learn from a small-scale modelling to improve large-scale modelling can be stated.

Authors' response #8: The applicability of the model to multiple scales and locations is a core element of mHM. The multiscale parameter regionalization (MPR) framework that is unique feature in mHM and now

available as a standalone tool yields seamless model parameters at multiple scales and locations in an effective manner [13]. The effectiveness of MPR to transfer model parameters to scales and locations other than those used during calibration was demonstrated first in [10, 3]. The mHM was applied and evaluated in different climatological regions e.g. Europe [14, 7], West Africa [2], India [9] and US [4, 8]. [7] extensively evaluated mHM fluxes in Europe against evapotranspiration, soil moisture, runoff and total water storage (GRACE). [9] recently implemented a drought monitoring tool for South Asia based on mHM simulations and SMI. Global mHM simulations are currently conducted and evaluated within ULSYSSES project `https://www.ufz.de/index.php?en=47367`.

Some specific revisions regarding some parts of the manuscript are listed as follows:
1. The abstract is complete and correctly summarize the content of the paper, but it may need to be reduced a little to be more concise.

Authors' response #9: We double checked that the abstract length meets the requirements of the journal. We could not identify potential for reducing the length without removing important information.

2. The process of parameter calibration and optimization needs to be in more detail to facilitate a reproducibility in the future study.

Authors' response #10: To improve reproducibility we suggest to extend the description of the calibration procedure with the following tables and suggest to put them in the supplements of the main manuscript.

- **Table 1 showing the results of the 201 basins from the final selected parameter set.**
- **Table 2 showing the 200 sets of random multi-basin draws.**

3. Some of the conclusions are overstated. The explanation should be in more detail regarding these issues.
(1) Figure 3 shows the time series of both the observations and model simulations. It seems that the coefficient is much higher than those when all the sites were selected. How the sites are selected may need to be mentioned if there are other sites that contain both Cosmic Ray Neutron Sensing (CRNS) and Spatially Distributed Measurements (SDM).

Authors' response #11: The sites have been selected because of the available time series length for different measurement methods. We propose to add relevant information regarding the selection to the manuscript by extending the caption of Figure 3 with the following sentence: "The Hordorf site also contains both CRNS and SDM measurements, but with much shorter time series length. For visualization the stations with longer time series were selected."

(2) There is lower agreement between observations and simulations in winter.

Authors' response #12: This is shown and discussed against other studies extensively in lines 289-302 of the main manuscript. The reasons lie in

the variable importance of hydrological processes in different seasons.

(3) There is improvement of second version of the model in representing the upper soil but stagnation in representing the whole soil.

Authors' response #13: We are not sure if we understand this comment correctly. Direct comparison of observed and simulated soil moisture is only possible for the upper soil due to observational data availability. For the total soil column, a comparison of drought intensities was performed showing similar results for both GDM versions. Assessing an improvement in soil moisture simulations between the GDM versions for the total soil column based on SM observations is not possible in the underlying study design.

(4) The values of the Spearman rank correlation coefficient are not high enough to conclude a definite improvement of the first version of the mHM (Table 2).

Authors' response #14: We clearly support this comment, but did not conclude a definite improvement. See line 397 in manuscript: „However, the overall improvements were relatively small, partly because the lower resolution model setup (4x4km grid cells) was already capturing the observed SM dynamics well."

4. In general, the authors have given proper credit to related work and clearly indicate their own original contribution. The references are appropriate to the research, but it would be better if some more papers are referenced especially those in which multibasin model calibrations and the SMI were applied.

Authors' response #15: We have extended references with previous works focusing on the multi-basin calibrations, such as [5, 8, 6]. SMI was applied a.o. in [11, 12].

The suggestions regarding some minor flaws and typos are described as follows:
Page 5, line 125: delete the ".However".
Page 5, line 131: delete the "," between "1.23" and "km".
Page 6, line 138: move "that were used in the analysis" before "are located".
Page 9, line 212, 213: remove "as"
Page 9, line 212, 213: add "," before "including", "the estimating", and "is hampered".
Page 11, line 270: remove "," after the "both".
Figure 3: add (a) to (l) for each sub panel to facilitate a better reference to the figures in the text when making the explanations.
Page 22: change the subtitle to "Conclusions and Discussions".
Page 23, line 436: remove "that".
Page 23, line 438: change "constitute" to "conclude".
The research is sound and fundamental. Some language edits could be good for improving the paper's quality.

Authors' response #16: We agree to the suggestions and will change accordingly.

References

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Appendix

Table 1: Calibration results of the final selected best mHM parameter set for the 201 basins in Germany. Daily and monthly NSE and KGE metrics are shown as well as their three components r (correlation), alpha (bias) and beta (variability). The best calibration parameter set was selected based on the median of daily KGE over all 201 catchments. The IDs are GRDC

num	ID	nse mon	kge mon	r mon	alpha mon	beta mon	nse day	kge day	r day	alpha day	beta day
1	6337200	0.938	0.942	0.972	1.050	1.010	0.795	0.816	0.924	1.167	1.010
2	6335304	0.925	0.847	0.979	1.139	1.060	0.836	0.786	0.950	1.200	1.061
3	6337515	0.931	0.913	0.971	1.080	1.019	0.790	0.780	0.931	1.208	1.019
4	6335240	0.936	0.900	0.975	1.090	1.035	0.825	0.819	0.937	1.166	1.035
5	6337517	0.923	0.896	0.970	1.091	1.039	0.801	0.785	0.935	1.201	1.039
6	6337518	0.932	0.933	0.970	1.056	1.019	0.831	0.831	0.938	1.156	1.020
7	6335302	0.925	0.857	0.977	1.130	1.055	0.783	0.787	0.926	1.192	1.056
8	6337100	0.937	0.951	0.971	1.039	1.004	0.822	0.845	0.930	1.139	1.004
9	6337514	0.936	0.922	0.973	1.073	1.004	0.805	0.823	0.927	1.161	1.004
10	6337516	0.953	0.951	0.978	1.044	0.996	0.850	0.875	0.938	1.109	0.996
11	6337250	0.900	0.883	0.961	1.100	1.047	0.647	0.741	0.878	1.224	1.048
12	6335500	0.942	0.919	0.978	1.046	0.937	0.768	0.832	0.906	1.125	0.937
13	6337519	0.957	0.963	0.980	1.025	0.981	0.845	0.885	0.933	1.092	0.981
14	6335301	0.952	0.927	0.981	1.054	0.955	0.791	0.846	0.914	1.120	0.955
15	6335600	0.949	0.917	0.979	1.078	1.018	0.908	0.932	0.958	1.049	1.019
16	6337400	0.957	0.972	0.979	0.996	0.983	0.847	0.909	0.929	1.054	0.983
17	6335303	0.947	0.895	0.982	1.093	0.954	0.767	0.824	0.908	1.143	0.954
18	6338140	0.977	0.964	0.989	0.978	0.973	0.923	0.933	0.961	0.953	0.972
19	6338100	0.969	0.927	0.988	0.958	0.942	0.914	0.906	0.958	0.939	0.942
20	6335601	0.931	0.911	0.973	1.064	1.056	0.891	0.895	0.954	1.076	1.056
21	6337501	0.870	0.787	0.966	1.195	1.078	0.735	0.745	0.916	1.228	1.078
22	6335530	0.762	0.635	0.962	1.362	0.976	0.558	0.588	0.899	1.399	0.975
23	6337510	0.877	0.919	0.942	1.014	1.054	0.614	0.751	0.856	1.195	1.055
24	6337507	0.934	0.922	0.972	1.069	1.023	0.768	0.863	0.897	1.087	1.023
25	6340200	0.757	0.809	0.910	1.143	1.089	0.144	0.482	0.785	1.462	1.090
26	6337513	0.935	0.966	0.968	1.010	1.004	0.788	0.853	0.911	1.118	1.004
27	6337509	0.885	0.912	0.948	1.012	1.070	0.675	0.757	0.884	1.201	1.071
28	6337511	0.933	0.939	0.970	1.025	1.047	0.766	0.813	0.911	1.158	1.047
29	6338110	0.957	0.866	0.987	0.881	0.940	0.888	0.822	0.951	0.840	0.940
30	6337502	0.921	0.867	0.979	1.015	0.870	0.795	0.826	0.921	1.085	0.870
31	6337512	0.939	0.958	0.969	0.977	1.016	0.764	0.856	0.897	1.099	1.017
32	6335800	0.929	0.802	0.982	0.819	0.923	0.771	0.791	0.881	0.846	0.924
33	6335083	0.852	0.759	0.973	1.087	1.223	0.824	0.749	0.945	1.100	1.224
34	6335030	0.950	0.900	0.983	1.017	1.097	0.851	0.874	0.933	1.047	1.096
35	6342502	0.676	0.728	0.927	1.163	1.205	0.138	0.468	0.798	1.448	1.206
36	6335115	0.948	0.902	0.977	0.941	1.075	0.855	0.797	0.932	0.825	1.076
37	6335602	0.911	0.870	0.964	0.897	0.929	0.893	0.891	0.948	0.935	0.930
38	6338130	0.905	0.735	0.988	0.770	0.869	0.825	0.683	0.944	0.717	0.869
39	6335350	0.964	0.899	0.986	0.902	0.982	0.865	0.803	0.938	0.814	0.982
40	6340700	0.818	0.847	0.928	1.127	0.956	0.737	0.794	0.903	1.176	0.958
41	6337506	0.967	0.969	0.983	0.975	0.992	0.807	0.852	0.899	0.892	0.992
42	6338160	0.943	0.859	0.984	1.135	0.965	0.879	0.852	0.956	1.137	0.964
43	6337500	0.851	0.825	0.929	0.861	1.080	0.722	0.809	0.854	0.907	1.080
44	6338120	0.900	0.774	0.972	0.800	0.900	0.763	0.652	0.906	0.681	0.899
45	6335045	0.981	0.949	0.992	0.958	1.027	0.873	0.871	0.936	0.892	1.027
46	6335116	0.962	0.952	0.982	0.978	1.038	0.873	0.838	0.939	0.855	1.038
47	6342970	0.691	0.755	0.888	0.966	1.215	0.460	0.660	0.804	1.174	1.216
48	6337508	0.974	0.965	0.987	0.969	0.988	0.843	0.866	0.919	0.894	0.988
49	6342521	0.817	0.833	0.934	1.098	1.118	0.292	0.557	0.803	1.378	1.119
50	6338161	0.969	0.928	0.989	1.046	0.946	0.925	0.931	0.966	1.025	0.946
51	6335081	0.907	0.940	0.956	1.029	0.973	0.696	0.761	0.894	1.212	0.973
52	6335031	0.849	0.755	0.970	1.094	1.225	0.788	0.724	0.934	1.146	1.225
53	6335290	0.937	0.825	0.982	0.838	0.936	0.824	0.713	0.931	0.729	0.936
54	6335681	0.946	0.943	0.975	1.000	1.051	0.844	0.905	0.922	0.985	1.052
55	6335351	0.960	0.910	0.983	0.913	0.982	0.871	0.803	0.942	0.813	0.981
56	6335520	0.775	0.789	0.923	1.151	1.125	0.726	0.782	0.894	1.142	1.126
57	6342130	0.915	0.796	0.973	0.803	0.955	0.757	0.730	0.878	0.764	0.956
58	6338150	0.953	0.948	0.978	0.972	0.962	0.839	0.813	0.921	0.835	0.962
59	6335660	0.854	0.788	0.964	1.165	1.128	0.722	0.684	0.928	1.279	1.129
60	6335046	0.968	0.901	0.988	0.906	0.969	0.850	0.822	0.926	0.842	0.969
61	6337505	0.641	0.817	0.837	1.082	0.989	0.031	0.564	0.603	1.179	0.989
62	6340050	-0.892	-0.287	0.949	2.286	0.979	-0.440	-0.008	0.892	2.002	0.977
63	6341500	0.459	0.587	0.918	0.863	0.619	0.413	0.581	0.856	0.903	0.619
64	6342520	0.880	0.863	0.941	0.882	0.963	0.468	0.742	0.752	1.062	0.963
65	6340365	0.701	0.808	0.885	1.107	0.891	0.563	0.761	0.815	1.104	0.891

66	6337050	0.945	0.880	0.982	1.106	1.055	0.905	0.876	0.964	1.105	1.055
67	6337504	0.936	0.800	0.985	0.801	0.999	0.829	0.776	0.920	0.791	0.999
68	6337610	0.940	0.914	0.971	0.920	0.993	0.772	0.884	0.891	1.037	0.993
69	6335160	0.862	0.760	0.976	1.141	1.193	0.828	0.751	0.949	1.147	1.194
70	6335082	0.698	0.721	0.922	1.193	1.186	0.315	0.465	0.866	1.483	1.186
71	6337550	0.909	0.817	0.967	0.854	0.894	0.806	0.710	0.919	0.742	0.894
72	6335521	0.883	0.864	0.942	0.878	1.019	0.802	0.801	0.899	0.830	1.021
73	6337601	0.949	0.940	0.977	0.988	0.946	0.887	0.874	0.944	0.900	0.946
74	6342522	0.881	0.813	0.953	0.877	1.133	0.623	0.756	0.806	0.935	1.134
75	6337060	0.879	0.857	0.961	0.983	0.864	0.789	0.778	0.904	0.854	0.863
76	6335125	0.922	0.893	0.967	0.940	1.082	0.867	0.886	0.934	0.958	1.083
77	6342110	0.512	0.440	0.946	1.556	1.038	0.315	0.344	0.922	1.650	1.038
78	6335310	0.961	0.942	0.983	1.041	1.038	0.751	0.861	0.887	1.072	1.038
79	6340320	0.850	0.914	0.925	0.978	1.035	0.508	0.725	0.811	1.197	1.036
80	6337570	0.932	0.912	0.972	1.078	0.972	0.837	0.914	0.919	1.002	0.972
81	6335048	0.967	0.891	0.991	1.093	1.056	0.886	0.918	0.946	1.027	1.055
82	6335460	0.918	0.952	0.961	1.021	1.018	0.856	0.880	0.926	0.908	1.019
83	6342980	0.920	0.840	0.968	0.846	0.970	0.832	0.883	0.913	0.928	0.971
84	6357020	-0.979	0.370	0.837	0.894	0.401	-0.841	0.364	0.795	0.951	0.400
85	6335291	0.916	0.785	0.976	0.792	0.951	0.824	0.724	0.928	0.738	0.951
86	6342670	0.653	0.655	0.943	1.286	1.185	0.632	0.747	0.828	0.989	1.185
87	6336930	0.971	0.970	0.986	1.012	1.023	0.908	0.935	0.953	0.961	1.023
88	6335540	0.911	0.793	0.971	0.799	1.038	0.828	0.811	0.914	0.837	1.038
89	6335670	0.726	0.620	0.969	1.265	1.271	0.557	0.504	0.922	1.408	1.271
90	6335695	0.920	0.879	0.963	0.887	1.020	0.873	0.871	0.935	0.891	1.021
91	6335076	0.965	0.934	0.985	0.988	1.063	0.859	0.847	0.929	0.880	1.063
92	6335360	0.967	0.875	0.990	0.876	1.013	0.890	0.836	0.949	0.844	1.013
93	6335450	0.906	0.858	0.957	0.868	0.968	0.844	0.841	0.921	0.866	0.969
94	6340810	-1.298	0.423	0.717	1.038	0.499	-0.560	0.436	0.744	0.978	0.498
95	6340070	0.410	0.367	0.963	1.590	1.227	0.372	0.368	0.940	1.587	1.227
96	6338250	0.896	0.880	0.956	0.937	0.908	0.788	0.757	0.899	0.800	0.907
97	6335510	0.054	0.385	0.830	1.525	1.273	-0.368	0.140	0.824	1.796	1.273
98	6335690	0.937	0.895	0.979	1.076	1.069	0.802	0.807	0.898	0.851	1.068
99	6337530	0.967	0.911	0.986	0.918	0.967	0.864	0.817	0.936	0.832	0.967
100	6337560	0.783	0.795	0.888	0.842	0.932	0.672	0.684	0.824	0.746	0.932
101	6335675	0.905	0.893	0.964	1.063	1.078	0.702	0.715	0.843	0.776	1.079
102	6342120	-0.134	0.066	0.942	1.929	1.073	0.273	0.420	0.872	1.560	1.074
103	6337520	0.930	0.809	0.979	0.814	0.963	0.803	0.789	0.900	0.818	0.962
104	6338800	0.927	0.945	0.966	1.023	0.964	0.882	0.929	0.941	0.984	0.964
105	6335710	0.929	0.917	0.969	0.968	1.070	0.822	0.887	0.912	0.991	1.070
106	6335603	0.919	0.820	0.971	0.827	0.959	0.783	0.697	0.906	0.714	0.960
107	6342070	0.497	0.756	0.763	1.054	1.020	-0.000	0.519	0.679	1.357	1.021
108	6335032	0.927	0.942	0.966	1.043	1.019	0.727	0.839	0.882	1.108	1.019
109	6337410	0.924	0.872	0.969	0.903	0.921	0.780	0.710	0.900	0.740	0.921
110	6335650	0.702	0.712	0.919	1.263	1.087	0.620	0.711	0.876	1.245	1.088
111	6340218	-2.784	-0.761	0.922	2.755	0.878	-1.504	-0.268	0.824	2.250	0.877
112	6342640	0.532	0.507	0.924	1.485	1.047	0.472	0.722	0.790	1.176	1.047
113	6342100	0.337	0.445	0.887	1.541	0.953	0.524	0.654	0.858	1.312	0.954
114	6342655	-0.166	0.287	0.893	1.651	1.272	0.423	0.611	0.815	1.207	1.272
115	6335167	0.329	0.362	0.969	1.560	1.304	0.397	0.417	0.923	1.492	1.303
116	6340220	0.369	0.507	0.776	1.042	1.437	0.339	0.480	0.765	1.151	1.438
117	6335075	0.784	0.739	0.940	1.254	0.986	0.632	0.793	0.847	1.139	0.984
118	6340335	-3.081	-0.289	0.340	1.755	1.811	-2.381	-0.162	0.168	1.638	1.501
119	6335810	0.938	0.873	0.975	0.898	1.071	0.786	0.734	0.898	0.765	1.071
120	6335565	0.834	0.782	0.931	0.832	1.120	0.736	0.655	0.880	0.700	1.120
121	6338163	0.917	0.889	0.970	1.081	0.930	0.819	0.888	0.914	1.019	0.930
122	6337340	0.899	0.929	0.951	0.982	1.048	0.699	0.805	0.879	1.144	1.048
123	6340210	0.921	0.957	0.962	1.017	1.011	0.839	0.850	0.917	0.876	1.010
124	6337541	0.891	0.940	0.945	0.988	0.977	0.814	0.903	0.910	1.030	0.977
125	6335117	0.766	0.759	0.914	0.912	0.793	0.713	0.697	0.867	0.824	0.793
126	6342675	0.612	0.667	0.919	1.271	1.175	0.588	0.670	0.779	0.828	1.175
127	6340350	0.716	0.674	0.935	1.141	1.287	0.624	0.667	0.862	1.095	1.288
128	6335190	-1.020	-0.127	0.839	2.103	1.164	-1.454	-0.252	0.810	2.227	1.162
129	6342230	0.082	0.439	0.934	1.417	1.369	0.021	0.252	0.896	1.642	1.370
130	6337310	0.914	0.844	0.966	0.888	1.103	0.852	0.812	0.929	0.860	1.103
131	6340315	0.889	0.826	0.959	0.986	1.168	0.782	0.800	0.903	1.044	1.169
132	6335621	-1.611	-0.208	-0.203	1.075	1.090	-1.398	-0.084	-0.075	1.107	1.088
133	6340440	0.879	0.861	0.959	1.085	0.898	0.768	0.813	0.882	0.897	0.897
134	6340360	0.764	0.644	0.911	0.658	1.042	0.672	0.617	0.841	0.654	1.044
135	6340366	0.868	0.838	0.946	0.892	0.893	0.647	0.612	0.822	0.672	0.892
136	6337542	0.845	0.826	0.941	0.912	0.862	0.808	0.835	0.913	0.973	0.862
137	6335470	0.663	0.641	0.950	1.323	1.150	0.694	0.712	0.914	1.230	1.151
138	6336510	0.881	0.743	0.982	1.107	1.233	0.821	0.754	0.923	0.983	1.233
139	6342105	0.513	0.484	0.929	1.509	1.043	0.622	0.643	0.904	1.341	1.043
140	6335465	0.871	0.868	0.945	0.915	1.084	0.819	0.851	0.908	0.919	1.084
141	6335697	0.918	0.895	0.963	0.940	1.077	0.675	0.628	0.839	0.673	1.077

142	6335610	-0.386	0.281	0.732	1.655	1.128	-0.707	0.063	0.777	1.897	1.158
143	6342060	0.812	0.825	0.905	0.863	1.052	0.624	0.808	0.815	1.011	1.052
144	6335010	0.938	0.886	0.972	0.894	0.969	0.867	0.823	0.937	0.838	0.969
145	6337350	0.903	0.856	0.955	0.864	0.982	0.585	0.794	0.811	1.079	0.983
146	6340330	0.766	0.771	0.923	0.894	0.812	0.714	0.716	0.870	0.831	0.812
147	6340225	-1.133	-0.213	0.853	2.203	0.938	-1.085	-0.126	0.796	2.107	1.014
148	6337600	0.923	0.902	0.969	0.985	0.909	0.824	0.825	0.912	0.881	0.908
149	6335651	0.537	0.628	0.882	1.344	0.924	0.442	0.663	0.813	1.270	0.924
150	6335640	-0.024	0.255	0.921	1.649	1.357	0.275	0.353	0.892	1.529	1.357
151	6337320	0.920	0.945	0.960	0.975	0.972	0.842	0.905	0.927	1.053	0.972
152	6342820	0.930	0.916	0.971	1.069	1.038	0.811	0.878	0.902	0.937	1.038
153	6340400	0.694	0.765	0.895	1.186	0.902	0.583	0.718	0.773	0.865	0.902
154	6335730	0.905	0.911	0.957	0.976	1.074	0.701	0.796	0.881	1.148	1.074
155	6335820	0.771	0.696	0.960	1.230	1.194	0.692	0.678	0.910	1.240	1.195
156	6342081	0.044	0.399	0.916	1.326	1.498	0.392	0.444	0.859	1.199	1.499
157	6335175	0.028	0.199	0.934	1.770	1.210	0.042	0.246	0.899	1.717	1.209
158	6335035	0.814	0.812	0.905	0.838	0.994	0.403	0.509	0.636	0.670	0.995
159	6338260	-0.863	-0.249	0.935	2.247	0.961	-0.379	0.195	0.783	1.774	0.959
160	6335676	0.857	0.843	0.952	1.047	1.141	0.627	0.641	0.800	0.738	1.142
161	6335700	-3.456	-0.483	0.862	1.887	2.181	-1.554	-0.472	0.749	1.839	2.183
162	6335680	0.889	0.753	0.966	0.756	0.990	0.790	0.715	0.906	0.731	0.991
163	6357510	0.700	0.765	0.864	0.885	0.847	0.480	0.488	0.709	0.607	0.847
164	6335830	-0.740	-0.046	0.836	2.033	1.034	-0.839	-0.063	0.819	2.047	1.032
165	6335550	0.441	0.612	0.845	0.777	0.723	0.333	0.632	0.777	1.095	0.724
166	6340340	0.747	0.604	0.915	0.616	0.954	0.632	0.510	0.860	0.532	0.955
167	6335620	0.900	0.838	0.962	1.016	1.157	0.841	0.807	0.921	0.922	1.157
168	6342810	0.418	0.575	0.906	1.142	1.389	-0.102	0.331	0.776	1.496	1.390
169	6337330	0.891	0.857	0.948	0.870	0.972	0.823	0.853	0.908	0.889	0.972
170	6342525	0.774	0.762	0.938	1.134	1.187	0.738	0.776	0.890	1.056	1.187
171	6335635	0.917	0.931	0.958	0.945	0.998	0.674	0.655	0.832	0.698	0.999
172	6335720	0.896	0.831	0.955	0.848	1.058	0.789	0.856	0.890	0.926	1.057
173	6342660	0.797	0.874	0.910	1.088	1.007	0.716	0.786	0.846	0.851	1.008
174	6335696	0.854	0.832	0.928	0.848	0.993	0.738	0.870	0.872	1.021	0.994
175	6335155	-1.910	-0.279	0.896	2.177	1.490	-3.707	-0.717	0.729	2.623	1.490
176	6335671	0.834	0.795	0.949	1.138	1.143	0.417	0.562	0.849	1.386	1.143
177	6342050	0.380	0.425	0.834	0.581	0.643	0.432	0.369	0.769	0.534	0.643
178	6342125	0.229	0.381	0.931	1.580	1.205	0.588	0.724	0.822	1.047	1.206
179	6342571	-0.162	0.491	0.574	1.256	1.107	-0.455	0.347	0.615	1.517	1.106
180	6335560	0.691	0.746	0.887	0.955	1.222	0.703	0.703	0.855	0.868	1.223
181	6335665	0.767	0.818	0.925	0.932	0.848	0.593	0.690	0.788	0.833	0.849
182	6335725	0.881	0.839	0.944	0.851	1.026	0.801	0.817	0.896	0.852	1.026
183	6337590	0.799	0.625	0.961	0.811	1.321	0.800	0.618	0.921	0.811	1.322
184	6335677	0.884	0.784	0.955	0.792	0.964	0.649	0.579	0.836	0.614	0.964
185	6342960	0.863	0.862	0.946	1.127	0.989	0.706	0.852	0.852	0.994	0.990
186	6335485	-0.041	0.306	0.891	1.595	1.339	0.038	0.372	0.800	1.489	1.339
187	6335156	0.812	0.740	0.952	1.145	1.211	0.765	0.766	0.896	1.002	1.210
188	6335735	0.921	0.851	0.975	0.923	1.125	0.810	0.787	0.906	0.857	1.126
189	6337503	0.557	0.767	0.815	1.136	0.962	-0.284	0.447	0.563	1.338	0.961
190	6343537	0.569	0.685	0.918	1.199	1.230	0.546	0.629	0.863	1.257	1.230
191	6335165	-0.127	0.194	0.934	1.729	1.337	0.007	0.289	0.866	1.612	1.337
192	6340216	-0.755	0.075	0.927	1.632	1.672	-0.028	0.242	0.828	1.309	1.671
193	6337580	0.910	0.865	0.958	0.873	0.985	0.807	0.784	0.904	0.807	0.985
194	6335570	0.818	0.853	0.912	0.903	0.933	0.742	0.853	0.871	0.979	0.932
195	6342945	0.635	0.805	0.849	1.027	1.120	0.570	0.764	0.799	1.032	1.120
196	6343120	0.547	0.633	0.887	1.027	1.348	0.511	0.578	0.834	1.174	1.347
197	6343520	0.722	0.817	0.902	1.059	1.143	0.638	0.777	0.834	1.044	1.142
198	6342540	-0.031	0.439	0.818	1.352	1.397	0.306	0.504	0.755	1.169	1.397
199	6342940	-7.264	-1.095	0.607	3.034	1.311	-15.740	-2.599	0.661	4.569	1.311
200	6337300	0.900	0.831	0.964	0.903	1.134	0.846	0.799	0.930	0.870	1.136
201	6342947	0.778	0.845	0.904	0.981	1.120	0.679	0.748	0.828	0.861	1.121

Table 2: 200 sets of random multi-basin draws used for multi-basin calibrations.

basin 1	basin 2	basin 3	basin 4	basin 5	basin 6	
N01	6336930	6338140	6337502	6340360	6335725	6335116
N02	6335083	6342070	6338800	6335510	6337505	6335303
N03	6335602	6335310	6338161	6335450	6335676	6342081
N04	6338130	6337580	6337410	6335720	6335075	6335650
N05	6335710	6340220	6335610	6335650	6342525	6335190
N06	6335650	6336510	6338140	6341500	6335800	6335830
N07	6335660	6340315	6335460	6335665	6340335	6335730
N08	6342571	6337501	6335700	6340216	6335820	6335800
N09	6335603	6335602	6337518	6335470	6337517	6338800
N10	6337509	6337503	6335450	6335697	6335696	6357510

N11	6335560	6337509	6335830	6338250	6342970	6338100
N12	6335710	6340218	6335351	6337310	6335010	6335290
N13	6337502	6335697	6335167	6335570	6337250	6342130
N14	6337310	6337100	6335696	6337500	6336930	6335620
N15	6335175	6335565	6337310	6335155	6337500	6337504
N16	6342820	6335621	6337510	6337550	6335117	6335620
N17	6340366	6335360	6342105	6335160	6342120	6337512
N18	6337510	6335310	6335510	6335155	6338140	6338161
N19	6337508	6342081	6335156	6335696	6335725	6335570
N20	6335117	6337520	6335032	6338800	6335075	6335301
N21	6337502	6335032	6342980	6337550	6337511	6342070
N22	6337514	6338160	6357510	6337500	6340350	6335125
N23	6337518	6337513	6342060	6338110	6337503	6338161
N24	6340350	6338250	6340335	6335810	6335116	6342960
N25	6342120	6335302	6340320	6335031	6335600	6338130
N26	6335820	6340810	6335603	6335465	6337610	6335031
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