

Author Response Letter to Editor and Referees

A new drought monitoring network in the state of Brandenburg (Germany) using cosmic-ray neutron sensing

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EC/RC: *Editor/referee comment*, **AR:** *Author Response*, *Manuscript text*

Dear Dr Somogyvári, dear referees,

we would like to thank again both referees for the critical review, and the editor for the balanced decision on how to proceed with the manuscript. Following the editorial decision, we expanded our work to a research paper, and revised the manuscript accordingly.

Please find below our point-by-point replies. In our reply to the editor (section 1), we will summarize our overall revision approach, based on the outline we had already shared with the editor on February 13.

The point-by-point replies to the referees (sections 2 and 3) are partly different from our responses in the interactive discussion where we had put more emphasis on justifying the "Brief Communication" format. Instead, the responses in this letter focus more on how the actual revision of our manuscript relates to the referee comments. We are confident that we have, this way, addressed the referees' original concerns.

Thanks again for your feedback and your support of this process.

Kind regards,
Maik Heistermann
(on behalf of the author team)

1. Response to the editor

EC: *Thank you for your submission, and for answering the reviewer comments in detail. Both reviewers were very critical of multiple aspects of the submission, with the main criticism towards the Brief communication format, and whether it is the right solution for the contribution. I agree with the authors that formally the manuscript fits the BC format, and its scope also fits some of the BC criteria. However, the manuscript reads a lot like a technical note, with a lot of technical details and limited explanation, with a feeling that details had to be omitted to fit such format. Both reviewers are asking for further explanations regarding the methodology and the results - which is again pointing away from the BC format. Therefore as a BC I find it difficult to recommend the paper for further revisions. My recommendation to the authors would be instead to consider extending the manuscript to a research paper. This way, the revision could address the requested improvements from the reviewers, with special focus on the methodology, validation of the results and further details on the case study. A more detailed text would also allow for findings in the regional context, which would be relevant for the SI.*

AR: Based the editorial decision, we expanded our work to a research paper, and revised the manuscript accordingly. The following enumeration summarizes our overall revision approach, based on the outline we had already shared with the editor on February 13:

1. We extended the scope and the aims of the manuscript. The original (and still main) objective - to introduce the new CRNS-based soil moisture monitoring network in Brandenburg to the community, as a contribution for future research and applications - was supplemented by the following objectives: (1) to provide an evaluation of our procedure to estimate soil moisture from observed neutron counts, based on independent observations; (2) to evaluate the performance of our soil hydrological model, and on that basis, to demonstrate its potential to mitigate some of the inherent limitations of a sparse instrumental monitoring network (e.g., with regard to temporal and spatial coverage); (3) to discuss practical lessons learned from the establishment and operation of the network, as well as potential future applications.
2. On the basis of the extended scope, we added a new section 2 ("Data and methods") that combines parts of the original sections 2 and 3, and provides additional details on the the network design (section 2.1), the procedure to estimate soil moisture from neutron intensities and evaluate it by reference observations (section 2.2), as well as the set-up of the hydrological model and the metrics to evaluate its performance (section 2.3).
3. The original section 4 was comprehensively reworked into section 3 "Results and discussion" that now consists of three subsections which address the three additional objectives of our study (as outlined in item 1): the evaluation of the CRNS-based soil moisture estimation, the evaluation of the hydrological model performance, the discussion of how to extend the scope of soil moisture observations by hydrological modelling (by increasing spatial and temporal coverage, by enhancing information along the vertical dimension, by reconstructing water fluxes; all of which relating to the specific conditions in Brandenburg with regard to land use, soil, and distance to the groundwater table), and a discussion of practical lessons learned during the establishment and operation of the network.
4. We emphasize, in the new section 4 ("Conclusions and outlook") that the combination of model and data is only one way to make use of this observational network, and that our model application should be seen as a case study rather than any "final" analysis. In order to stimulate future applications in various related fields, and to allow for any interested parties to use the data according to their priorities, we

emphasize once more that the observational and the simulated data is displayed and shared on a public platform (see also section "Data availability") in order to invite and stimulate future collaboration.

5. Even with the aforementioned additions, we aimed to keep the manuscript concise and readable in order to reach a broader audience.
6. Based on the above items, we changed the title of the manuscript to "A new drought monitoring network in the state of Brandenburg (Germany) using cosmic-ray neutron sensing" (removing the "Brief Communication" element).

We hope that the revised manuscript meets your expectations and look forward to your feedback.

2. Responses to referee #1

RC: *The Authors present a very relevant and interesting initiative to establish an operational ground-based long-term soil moisture monitoring based on cosmic-ray neutron sensors (CRNS). Nine locations and around six months of data are presented. Comparisons with the soil moisture simulated by the agro-hydrological model SWAP are also reported. The manuscript reads well and clear. The preliminary results are meaningful and the discussion fair. Personally, I believe that the main contribution of this initiative is (L39) to bring together a consortium of research institutions and state agencies for establishing a long-term monitoring. And I would congratulate with the Authors for such an effort in moving CRNS research activities towards long term operational monitoring.*

AR: Thank you for sharing your positive views.

RC: *But back to the manuscript, it reads like an internal report of current status of the initiative and I'm not convinced that is worth a publication. I admit that this bold statement starts from the wish to read novelty in scientific papers and to not consider pure tech-transfer project innovative. In questioning my self-position, I made two actions. First, I look at the description of Brief communications, as it could have provided me with the right angle for judging the manuscript. The description is reported below. In addition, I looked at other published papers with similar vision (to my knowledge). Some of the papers are listed below (Benninga et al., 2018; Cosh et al., 2021). As for the Brief Communications, I leave to the Handling Editor to decide. Anyway, I highlight how the number of pages of the manuscript is way too much. Moreover, its scope might be (c) even if information and data do not seem to be properly disseminated.*

Brief communications are timely, peer-reviewed, and short (2–4 journal pages). These may be used to (a) report new developments, significant advances, and novel aspects of experimental and theoretical methods and techniques which are relevant for scientific investigations within the journal scope; (b) report/discuss significant matters of policy and perspective related to the science of the journal, including "personal" commentary; (c) disseminate information and data on topical events of significant scientific and/or social interest within the scope of the journal. Brief communications have a maximum of three figures and/or tables, maximum 20 references, and an abstract length not exceeding 100 words. The manuscript title must start with "Brief communication:".

AR: We thank the referee for the critical appraisal of the manuscript. Based on the referee comment and the editorial decision, we expanded the scope of the paper, as described in section 1. That way, the paper

became longer, but is not bound anymore to the limitations of the Brief Communication format. We believe that, with the new level of depth, we could also adequately demonstrate the relevance of this study for the NHESS special issue "Current and future water-related risks in the Berlin–Brandenburg region" (see https://nhesst.copernicus.org/articles/special_issue1295.html) to which our manuscript had been submitted. We are convinced that a new initiative on soil moisture monitoring *in Brandenburg* which is rooted in both research and public administration is worth being reported in such a context.

RC: *By looking at other published papers on similar topic (examples above), I have seen much more information in describing the issues and the effort, e.g., to establish such a network, to standardize the observations, to integrate the new data in current platforms, in defining accessibility to end users. Overall, while I'm currently not in favour of the publication of the present manuscript, by considering previous published papers, it might be considered if the Authors put much more effort and they succeed in improving the manuscript, e.g., by sharing their experiences in establishing, maintaining, and managing a fixed environmental sensor network that could be of utility to the community for avoiding mistakes and reproducing good practices.*

AR: Based on the referee comment, we feature, in the new section 2.1, information about the establishment of the network (namely the selection criteria for the monitoring sites), details on the standardization of neutron intensity observations in order to apply the soil moisture estimation (in section 2.2), and a discussion of practical lessons learned during the operation of the network (section 3.4).

RC: *Improving metadata (e.g., how was the calibration performed?), transparency (how data have been processed) and data accessibility (e.g., by API-type) should also justify the publication.*

AR: In sections 2.2 and 2.3 of the revised version of the manuscript, we put a stronger emphasis on providing the requested details regarding the estimation of soil moisture from neutron intensities and the set-up and evaluation of our soil hydrological model, as well as the evaluation of both. We also highlighted more clearly that we already provide an openly accessible directory to download both, raw observations *and* soil moisture products, including the required metadata. The directory can be accessed and viewed via a browser interface, and it also allows to obtain static https-links to each of the data files which can be directly used in any automatic data processing environment (which corresponds, in our view, to what the referee refers to as "API-type" access). As already done in the original preprint, we clearly state the availability of this directory in the section on "Data availability".

3. Responses to referee #2

RC: *In this Brief Communication, the authors present a new initiative in Germany to establish an operational, long-term soil moisture monitoring system based on cosmic-ray neutron sensors (CRNS) for the state of Brandenburg. In general, this is a very positive development, as CRNS has established itself as a new standard method for the continuous determination of soil moisture at the field scale and the widespread deployment of these sensors is very helpful and highly welcome both for environmental research and for the support of water management. In terms of content, this article presents the status of the project as well as a comparison of the measured soil moisture with simulations of the agrohydrological model SWAP. The manuscript is well written [...]*

AR: We thank the referee for the positive feedback on the relevance of our initiative and the readability of the manuscript which are, in our view, important aspects of the evaluation. In the revised version of the manuscript, we tried to maintain the aspect of readability in order to reach an audience beyond the CRNS community.

RC: [...] however, I have to agree with reviewer #1 that the paper reads more like a project report and does not fulfill the NHESS requirements for short communications, especially in terms of the length of the paper.

AR: We appreciate the critical appraisal. As already pointed out above, we expanded the scope of the paper, as described in section 1. That way, the paper became more detailed and extensive, but is not bound anymore to the limitation of the Brief Communication format. We believe that, in the revised version, we could adequately demonstrate the relevance of this study for the NHESS special issue "Current and future water-related risks in the Berlin–Brandenburg region" (see https://nhess.copernicus.org/articles/special_issue1295.html)

RC: Also, it may be beneficial to complete the installation and subsequently measure soil moisture over a longer period of time. Once this has been achieved, the authors could publish the results as a data paper.

AR: Our paper is not intended to serve as a replacement of a data paper, although we provide all means to access and use both the raw measurement data and the soil moisture products already at the current stage (see also response to referee 1, and the section on "Data availability" in the manuscript). We appreciate the suggestion that a longer time series could be published as a data publication in the future, but it should be noted that data publications refer to a closed set of data with a fixed DOI which is not what we intend in terms of a continuous long-term monitoring effort. Instead, as pointed out before, we put a stronger emphasis on the analysis of both observational and modelled data.

RC: Finally, we don't learn much from the case study and the context of the comparison of CRNS data with simulation is unclear (see also specific comment further below).

AR: We appreciate the critical appraisal of the case study. We have comprehensively revised the entire manuscript and put more emphasis on how and why CRNS-based soil moisture estimates should be put in context with a soil hydrological model (see also section 1 of this letter).

RC: L38: Why mention only national networks?

AR: In the light of the next referee comment (reg. 1. 44), we agree that the CRNS-based soil moisture monitoring network in the context of the ADAPTER project should be mentioned here, too. We added a corresponding sentence which refers to Ney et al. (2021).

RC: L44: Such an initiative is not unique in Germany, see e.g., Ney et al. (2021).

AR: According to our notion the focus of the ADAPTER project was exclusively on cropland while our initiative aims to cover forest and grassland sites, too. Furthermore, we consider the close involvement of various state agencies along the entire process as a distinct feature of our initiative. In order to avoid misunderstandings, we changed the sentence to

In a transdisciplinary effort, five institutions have combined their resources to establish a CRNS-based network for soil moisture and drought monitoring in Brandenburg [...].

RC: Figure 1: The small maps are hardly recognizable and the situation at the measuring stations is not readable. Also, this information is already available in table 1. Therefore, I suggest removing the small maps.

AR: We thank the referee for the suggestion. The motivation of the maps (including the smaller ones) was not to show the landscape attributes at the monitoring locations. This information is, as the referee correctly pointed out, provided in Tab. 1. The idea of the small maps was to give an impression of the overall spatial

distribution of important landscape attributes across Brandenburg. We think that this is relevant with regard to the issues of representativeness and regionalisation. In order to avoid the misunderstanding that the maps should show the attributes at the monitoring locations, we simply removed in the revised manuscript the location markers from the small maps.

RC: *L54-71: This sounds very much like an interim report.*

AR: We find it difficult to assess what this statement is supposed to imply. In any case, we find this part very relevant as it lists the selection criteria for the monitoring sites which was also information required by referee #1 (describe issues relevant for the establishment of the network). We hence prefer to keep that part mostly as is.

RC: *L116-119: It is not clear to me how this comparison is to be analyzed in this project. What are the consequences if there are discrepancies? Do you then not trust the measurement data, even though the model certainly may have a much higher uncertainty?*

AR: After the fundamental revision of the manuscript, the lines to which the referee referred to do not exist anymore. More importantly, we introduced a new section "Results and discussion" in which we more comprehensively address the comparison of model and observation, including a formal model evaluation by community-accepted metrics and a discussion of discrepancies, as well as a demonstration of how the model could be used to extend the scope of the instrumental monitoring. In section 3.4, we also highlight that the continuous comparison to the model results helped us to detect and fix sensor issues that might otherwise have remained hidden.

RC: *L126-129: Describing commitments should not be part of a scientific publication. It would make more sense to present the concrete implementation of a real-time data platform.*

AR: In the revised manuscript, these lines do not exist anymore in the previous form. As for the presentation of a real-time data platform, the amount and complexity of the provided data and products does not yet call for the design of real-time data platforms which would deserve a comprehensive documentation in the context of a journal article. We made a clear statement on data availability in the main text, and, more specifically, in the section on data availability. There, we provide the link to a website that includes a public directory to download both, raw observations *and* soil moisture products. You can access and view that directory via a browser interface, but you can also obtain static https-links to each of the data files which can be directly used in any automatic data processing environment. The directory also contains station metadata in a dedicated table.

RC: *L139-140: Formulations such as "some validity" and "some transferability" are too vague.*

AR: We agree. In a revised version of the manuscript, the model evaluation is carried out on a more formal basis, and the corresponding item on "upscaling and transferability" in the conclusions section was rephrased.

RC: *L142-145: This seems to be rather an alternative measurement approach instead of an upscaling approach for the presented CRNS network.*

AR: We agree that the description should be clarified in order to convey a better idea how the railborne CRNS roving could support the upscaling of soil moisture. In the revised version, we hence changed these lines as follows:

[...] an emerging perspective for future research is rail-borne CRNS roving: several locomotives of the Havelländische Eisenbahn AG have recently been equipped with CRNS sensors in order to monitor spatio-temporal soil moisture patterns along selected railway tracks (see Fig. 1). While those of our network locations which are close to these railway tracks (Tab. 1) could be used to verify the spatiotemporal integrity of the railborne data products, the latter could, in turn, be used to validate or train other model-based or data-driven upscaling approaches.

References

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