

Response to Reviewer 1

GENERAL COMMENTS

I found this paper to be very interesting and generally well written. I think the subject matter will be increasing importance to the global CRNS community as we strive to make our datasets available and useful to the global research community. Your approach should prompt networks (existing and evolving) to think about the types of data and metadata that they would need to contribute to help harmonization.

We thank the reviewer for their very positive comments. The crspy tool has been developed to help further disseminate the Cosmic-ray Neutron Sensor (CRNS) technology by providing valuable datasets for the global research community.

I really like the ideas and concept presented. Those who run CRNS networks will acknowledge that their processing is not up to date but will also point out that changing a database can be a big undertaking. I think it may be worth mentioning this as a discussion point and stating that a central approach to processing might be quite valuable. It's not hard to imagine a system where networks might collect the raw data and metadata but then use crspy (or similar) as an internal processing tool to deliver the final product through their website. This is taking the product further than the intention of this paper, but it will get readers thinking. If new corrections or procedures are developed, then all that changes is a new crspy procedure calculation.

We agree with the point raised by the reviewer that it is not so easy to change already established databases. Hence, we have developed crspy as a "post-processing" tool (i.e., raw data collection is still carried out by site PIs and networks individually). We presented the initial application utilising freely available raw data already provided by many CRNS networks.

The crspy tool can in theory provide the initial steps in developing a more centralized processing point, as described by the reviewer. However, such future version is somewhat out of the scope of this manuscript as it would require a stronger engagement by the CRNS community. This version, however, takes the first steps in providing an open-source tool in the pursuit of harmonization of CRNS datasets.

The approach of bringing in other data sets like ERA-5 and soils data to help with corrections is a great approach. Many countries are improving the spatial and temporal data sets of climate and soil properties so being able to choose a specific dataset set could be a further development for the future—again it would be good to have some brief discussion around this. This type of thing would not necessarily be for the authors to handle but a network may choose to contribute code to achieve this. This does get away from the harmonization idea, but it does open up the options further.

Related to the previous point, in terms of processing, I think you could propose two potential paths, 1) crns researcher level -the user steps through and chose the correction/datasets to apply at each step which keeps it flexible, 2) CRNS output user -global best practice which can be used for global or standardised comparisons

This is an interesting point. The use of ERA-5 land was motivated by two reasons: (1) to establish a uniform base product that can be applied on any CRNS site, and (2) to allow us to process global CRNS sites regardless of their national network affiliation. Developing an

open source allows users to implement their own routines to include alternative data sets as needed. We will discuss this opportunity in the update manuscript.

The two proposed paths are attractive, and we would suggest that currently `crspy`'s focus is on being a research level tool that allows data harmonization to begin comparing sites as a global network. We agree that having a global best practice option would be of great benefit, however this will require input and discussion from numerous groups and researchers. If a common best practice for CRNS data processing is decided by the community in the future, `crspy` can include this as its default process.

You say `crspy` can process using the most current methods –I think the issue may become keeping track of what is the “most current” method. If there is a globally accepted best approach that is going to require some discussion and agreement between network representatives. The CRNS community stands to benefit from this type of approach but some consensus on when and how to implement ‘best practice’ will be needed. The continued update of `crspy` will also need to be supported. This is an important point to make.

As above, we agree with the points made here and hope that future discussion and collaboration within the CRNS community can lead to an established ‘best practice’. Our aim is to continue updating `crspy` in the future to keep pace with advancements. In that sense, future developments of `crspy` can be interpreted, by analogy, as following similar steps when hydrological or land surface models incorporate new parameterizations due to new knowledge available from the community. `crspy`'s list of functions and subroutines have been designed to account for future updates which can be replaced or updated easily.

It would be good to see some discussion on what the future potential/ direction might be. `Crspy` requires a lot of user setup, package installation and folder structuring that might be beyond data users (i.e. not CRNS researchers). I had a quick go at getting `crspy` to run in Python a couple of months ago and ran into a couple of hurdles that stopped me proceeding through lack of time. I have limited exposure to Python having trained in R so I think most of the issues come back to my experience. That being said there could be room for some discussion around the potential for lowering the bar to entry by utilising a webpage interface. I have seen some nice Python Dash or R Shiny applications which really make these types of things a breeze.

We first thank the reviewer for trying `crspy` and already giving us some user-specific feedback. This is very important for us to provide a clean and easy-to-use tool to the community. We welcome the reviewer's suggestion of adding more discussion on the future direction with `crspy`. Indeed, the set-up process may not be fully suitable for entry level users. We aim to collect feedback from users in order to understand how we can improve `crspy` in future versions, although currently we would consider it a research level tool. One particular issue we have encountered when developing `crspy` is the wide range of formatting styles of data from the different networks (i.e., column orders, column titles etc). This ultimately means additional work for the user to prepare the data environment initially. Standardisation of data structure could be an option in the future, such as is currently done in the Fluxnet community but would require the national networks to define and adhere to such standard.

In summary a nice piece of work.

We once again thank the reviewer for their very positive feedback. We will also deal with more specific comments raised by the reviewer (not included in this response) in the revised version of the manuscript.