Comment Part 2/2: Spatial patterns and interpolation

Anonymous Referee #2

Referee comment on "Spatio-temporal soil moisture retrieval at the catchment scale using a dense network of cosmic-ray neutron sensors" by Maik Heistermann et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-25-RC3, 2021

(continued)

1. GENERAL COMMENTS

The ideas of designing a dense network and devising a constrained model to study soil moisture variability with multiple CRNS are innovative. As pointed out by the authors, this study was limited by making various assumptions and decisions' arbitrariness. This study still made valuable contributions to applications of CRNS. The selection of the model and its parameters requires some more clarification. This paper can also be improved by considering issues on footprint and resolution.

2. SPECIFIC COMMENTS

2.4 Models

Line 88 References for the concept of geophysical inversion are needed.

Line 329 There are three parameters for a variogram model, nugget, sill, and range. The paper only emphasized the range but did not mention the other two. Please specify the parameter selections.

Line 297 The Kriging ranges for soil moisture and bulk density are quite different. Please justify this selection.

2.5 Footprint, model parameters, and scaling

One of the unique features of CRNS is its large footprint, which could directly influence data visualization, model selection, and interpolation. The grid size for the interpolation process is 10 m * 10 m (Line 311), which is much smaller than the footprint. This implies that the modeling is not just an interpolation but also involves a downscaling process for the CRNS measurements. It is of great interest in terms of the CRNS studies. However, it also requires more clarification and cautiousness. For example, is it reasonable to use observed soil moisture, $\theta(N^{obs})$, to do Ordinary Kriging with a resolution much smaller than its footprint? Does it implicitly assume that observed soil moisture values are also

representative at a smaller scale?

The design of the forward operator and the optimization argument is innovative since it provides a way of downscaling CRNS measurement to almost any arbitrary scale/resolution, which may be only limited by computational capacity.

The design of the dense network made the footprints of CRNS largely overlapped, which provides extra information about soil moisture spatial patterns. This may also make it logically possible and reasonable to do the downscaling and to improve the interpolation. Can the overlaps be used for results validation?

3. TECHNICAL COMMENTS

Line 262 Eq. 1

Recommendation: replace comma with semicolon, i.e. theta(N_i; N_0)

To my understanding, N_i is a variable, and N_0 is a parameter in Eq. 1.

Line 350 delete extra "suitable"

Line 622 reliably -> reliability