Earth Surface Dynamics Discussions

Earth Surf. Dynam. Discuss., referee comment RC1
https://doi.org/10.5194/esurf-2021-68-RC1, 2022

Comment on esurf-2021-68

Elchin Jafarov (Referee)

Referee comment on "Probabilistic estimation of depth-resolved profiles of soil thermal diffusivity from temperature time series" by Carlotta Brunetti et al., Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2021-68-RC1, 2022

The manuscript describes an interesting and timely study that applies the Bayesian method to the measured at multiple depth temperature time-series to estimate/recover thermal diffusivity. The method and implementation are sound. My main concerns:

- The choice of the model. The thermal model worked well for the examples shown in this study (i.e. when we are dealing with temperatures above 0°C). However, it was shown in many studies that applying the classical thermal equation described in this study does not capture the full temperature dynamics in permafrost-affected soil (Romanovksy et al., 2000). The effect of the unfrozen water is an essential factor that needs to be accounted for.
- How the Bayesian approach used in this study is different from the variational approach when the gradient is explicitly/implicitly calculated to find the next iteration?
- Please extend the discussion on estimating thermal diffusivities at or near 0oC and estimating thermal diffusivities during time periods when the gradient sign changes from positive to negative.
- In Section 3.4. it was not clear how the optimal number of sensors had to be selected. In the Discussion, the authors mentioned the effect of low gradients between temperature time-series makes it hard to estimate diffusivity. This finding is also consistent with studies by Jafarov et al., (2014; 2020). What is the best way to proceed in the case of a low gradient? Is it better to exclude those chunks of data from the method? How can this method be used at the design stage to build temperature probes that could capture optimal temperatures signals (i.e. no low gradient signals)?

Minor concerns:

Consider simplifying the title and removing “and uncertainty quantification” because, in the end, you recovered diffusivity from temperatures not from UQ. Consider including UQ into the search words for the paper.

L121-122 It was mentioned that diffusivity depends on soil moisture. It is not clear how water content is accounted for in the eqn. 2.

L421-422 The moving-time window. Jafarov et al., (2014) found that 30 days moving average filter worked the best when applied to changing over time snow thermal conductivity. Will 30 days average window here? If not, why?

In conclusion, include the caveats about the model (does not account for soil moisture), the method (will it fail with low gradient data), and how choosing different moving average windows will affect the estimated diffusivity.