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Interactive comment on "A probabilistic approach to quantifying soil property change through time integration of energy and mass input" *by* Christopher Shepard et al.

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Response to Anonymous Reviewer #2

We thank the reviewer for their comments on the manuscript titled: "A probabilistic approach to quantifying soil property change through time integration of energy and mass input". Below we have detailed our response to the reviewer's comments, including how the manuscript was edited.

We disagree with a number of the assertions made by the reviewer. The objective of the presented work was to present the development of a probabilistic model of soil property change using time integrated energy and mass inputs. We added language

clarifying this hypothesis at lines 78-80 in the revised manuscript. We think the title is appropriate for the manuscript as written; the manuscript discusses modeling the change in soil properties using energy and mass inputs integrated with time or the age of the soil system, as such we did not change the manuscript title. Further, we did not attempt to model any soil forming process. The presented probabilistic approach is based upon the soil state factor model, which only considers the state of the soil forming environment to understand soil formation or soil structures (Jenny, 1941, 1961). Similarly, the effective energy and mass transfer model only quantifies the amount of potential heat and chemical energy added to the soil, it does not describe any soil forming processes (Rasmussen et al., 2005, 2011, 2015; Rasmussen and Tabor, 2007). This is clearly stated in lines 85-87 and 145-152 in the original manuscript. The model simply quantifies the net effect of all soil forming processes operating within the soil forming system. The revised manuscript has been edited to clarify this point at lines 154. Further, the discussion focused on the reasons for poor or acceptable model fits for the modeled soil properties, and discusses advantages and disadvantages to the probabilistic approach. Nowhere within the discussion do we claim that the presented approach models any soil forming process or soil formation. As was stated in lines 145-152 of the original manuscript, the model assumes all changes within the soil are due to pedogenic processes, this aligns with what is stated in the discussion in lines 345-348 in the original manuscript. EEMT and TPE quantify the amount of energy added to the soil system capable of doing pedogenic work, e.g. chemical weathering, which is most representative of clay formation.

The influence of climatic variability on the model results is discussed in length in lines 503-514 in the original manuscript. While palecolimatic reconstructions are available, such as the spatially explicit LGM paleoclimate reconstruction from the CIMP4 general circulation model, time resolved paleoclimatic reconstructions are still largely unavailable for many locations. We chose to use modern climate values as they represent the best available data. We did not discuss human or anthropogenic impacts on soil formation or evolution. We are exclusively focused on Quaternary soil formation. In this manuscript, we focused on clay formation, which occurs on a geologic timescale and does not readily change on human timescales. Additionally, the EEMT model is easily adaptable to accommodate human influences on the energy and mass inputs into soil, such as fertilizer inputs (Rasmussen et al., 2011).

We have added the age span and depth ranges to the revised manuscript at lines 179-180. Data on vegetation and stoniness were not available across all the sequences and were not included. Further, many of these data are included in Table S1, where all of the chronosequences are listed along with location, dating method, mean annual precipitation, mean annual temperature, parent material and geomorphic surface.

Based on the reviewer's suggestion we have added additional language about the EEMT model at lines 184-187 in the revised manuscript.

The reviewer added comments about the influence of primary minerals on the sand fraction, variability of weathering, and poor prediction with regards to soil formation on amphibolite. The influence of parent material and lithology is discussed at length in lines 403-424 and lines 467-479 in the original manuscript. Further, we did not claim that the model was insensitive to parent material; we discussed the role of parent material and differential weathering rates as a possible explanation for poor model fits and suggest including parent material within the model apparatus a possible correction. The model makes no assumptions about the parent material, in that parent material is not directly expressed within the probability distributions, all soils are considered equally and global values are used to parameterize the probability distributions. We have added language to the revised manuscript at lines 417-419 about the dominance of primary minerals in the sand and silt fractions and have revised lines 580-581 to reflect the role of initial conditions within the model.

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