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RESPONSE

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Validating assumptions in calculating carbon dioxide removal by enhanced rock weathering in Kantola et al., 2023

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Reershemius and Suhrhoff (2023) have identified some concerns with Kantola et al. (2023). We wish to point out that Reershemius and Suhrhoff find no fault with the derivation in the paper (equations 3–6), which are factually true by inspection. Reershemius and Suhrhoff are focused in their letter on implementation details that, in their words, "do not necessarily detract" from the study's final outcomes. In fact, these same authors arrive at more or less an identical result in their own unpublished work for the identical experimental plots. This should not be surprising, because their work takes a substantially similar approach to estimating mass fluxes of cations in the soil using immobile trace elements to constrain mineral application rates. Far from being "unusable without significant alterations," we will show that the issues they identify lack merit. Nonetheless, the authors of this response appreciate the constructive engagement on this exciting scientific frontier, and we appreciate the convictions of Reershemius and Suhrhoff for clear data transparency.

1 | GEO-TRACER METHODS TO DETECT BASALT ADDITION TO SOILS

Reershemius and Suhrhoff are arguing that a mass balance approach should be taken to constrain elemental budgets in the soil layer, that is to use $mass_{basalt}$ and $mass_{soil}$ and not simply the concentrations $[REE]_{basalt}$ and $[REE]_{soil}$. We do not disagree: Our paper plainly states in the paragraph following equation 3: "The calculated slope difference (kg rock kg^{-1} soil) was converted to kg rock m^{-3} units by using estimates of the soil bulk density. [...] The total sampling depth of 30 cm was used to ultimately convert the rock application rate units to kg rock m^{-2} units." Reershemius and Suhrhoff can find a worked example making use of these parameters in the appendix 2 spreadsheet, tab "Full Analysis—Basalt," cells AF24:33.

2 | CONSERVATIVE CONSIDERATION OF THE CONTROL DATA TRENDS

Reershemius and Suhrhoff are arguing that the untreated plots should be interpreted as a background or baseline signal, and that this signal should be added back into the treated plots. Because the untreated plots show losses of elements, subtracting this negative baseline would have the effect of increasing the estimated rate of carbon removal. We do not share this interpretation. First, the untreated plot is not a ceteris paribus comparison with the treated plot, because the dissolution of the mineral changes the pH of the soil,

This article is a Response to the publication by Kantola et al., https://doi.org/10.1111/gcb.16903 and the Letter by Reershemius and Suhrhoff, https://doi.org/10.1111/gcb.17025

and the change in pH has a known and clear impact on elemental fluxes. Stated differently: The untreated control is more acidic and is fully expected to have greater leaching than an identical soil with higher pH. Second, these experiments are carried out in a social context in which lower carbon intensity for farms is a desired outcome; it has value. Subtracting this negative baseline would have the effect of increasing the estimated carbon removal, thus enhancing the claims. Thus, in addition to the mechanistic rationale, it is more conservative from a carbon accounting perspective to not subtract the non-equivalent baseline.

3 | CLARITY IN GEO-TRACER CHOICE AND SOIL DEPTH SELECTION

Reershemius and Suhrhoff are arguing that the choice of immobile tracers is subjective. However, Reershemius and Suhrhoff themselves (their figure 1a) show that selection of HREE versus all REEs only changes the slope of ΔREE_{soil} versus rock REE_{rock} from 0.0409 to 0.0401, a slope difference of just 2%. The synthetic results in figure 1c,d make use of the untreated plots as a baseline to which they add modeled rock dust for dissolution. As discussed above, these untreated plots are not a proxy for the treated plots but for the addition of the rock: They are a distinct geochemical system, with different boundary conditions, and the addition of the rock changes the boundary conditions in meaningful ways, including pH, and cation exchange dynamics. These plots are perhaps interesting to illustrate how a toy model differs from reality, but they are not useful as an alternate reality to the empirical evidence that was actually presented.

AUTHOR CONTRIBUTIONS

Adam Wolf: Conceptualization; formal analysis; methodology. **Elliot Chang:** Conceptualization; formal analysis; methodology. **Ilsa B. Kantola:** Conceptualization; formal analysis; methodology. **Elena Blanc-Betes:** Conceptualization; formal analysis; methodology. **Michael D. Masters:** Conceptualization; formal analysis; methodology. **Alison Marklein:** Conceptualization; formal analysis; methodology. **Caitlin E. Moore:** Conceptualization; formal analysis; methodology. **Carl J. Bernacchi:** Conceptualization; formal analysis; methodology. **Evan H. DeLucia:** Conceptualization; formal analysis; methodology.

CONFLICT OF INTEREST STATEMENT

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DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed for the current article.

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