Interactive comment on "Beneath the arctic greening: Will soils lose or gain carbon or perhaps a little of both?" *by* Jennifer W. Harden et al.

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Response to Anonymous Referee #3 General Comments 1. The authors do not provide any data on the parent material except for the fact that it is "loess deposits originating from [: : :] the Matinuska and Knik glaciers (Inceptisols), glacial to post-glacial outwash along the Missouri River and distal loess sources in Nebraska (Mollisols)". The source of the parent material for the Gelisol is not even mentioned at all. Please provide additional information on the soil profiles investigated:

(a) where are the profiles located? How far are profiles from each of the three soil types investigated apart from each other? I suggest adding a map of all soil profiles investigated.

In the "Section 2.1 Study Sites," we discuss the location of sites and provide GPS coordinates for each sampling locations, and we also refer to citations of original studies that generated these soil samples.

(b) What about the mineralogical composition of the parent material of each soil profile? What is the texture? Are Fe-/ Al- oxides or hydroxides present? Are carbonates present? All these parameters strongly influence soil C concentrations, amounts of mineral-associated and particulate C as well as C stability in soil. Please give additional information in your table if available. If not available, these factors should at least be clearly taken account of and be discussed!

All of our data are carbonate free and indeed there was no evidence for carbonate in these soils (pH acidic to neutral; no white precipitates). Textures are mostly silt loams but some silts and silt clay loams are present (see Suppl Table ST1) –there are no obvious correlations in texture-%C. We don't have consistent oxide data although such data may be added eventually to the repository at International Soil Radiocarbon Database.

(c) How sure are the authors about the exact development of their soils, i.e. how sure is the assumption that a Gelisol under Alaskan Black Spruce forest will develop to a Mollisol under a grassland ecosystem? Is it possible that other vegetations/ecosystems would develop (e.g. mixed or deciduous forests) and what would that mean in terms of the C distribution and stability in the soil?

"How sure?" Not at all. It would be fun to run an exercise based on probability functions for ecosystem types /soil types in various soil temperature space. If however there indeed are new grass-dominated ecosystems in a drastically warmer arctic, it is conceivable that Mollisols will form underneath them and that their roots will colonize deep, unfrozen substrate.

2. The conclusions drawn from the data are a bit too far stretched or let's say formulated too general. E.g. p. 2, l. 8-10 "Thawing from Gelisol to Inceptisol in loess parent

materials from present to year 2100 resulted in small net gains to soil C, reflecting: : :"
or the sentence thereafter (p. 2, l. 10-12 "Greater warming and shifts from Inceptisol to
Mollisol analogous to predicted warming from circa 2100 to 2300 resulted in net losses
from both occluded and mineral associated C" – the authors did not observe / measure
C gains or losses during soil development, they only PREDICT these upon ASSUMED
/ PREDICTED soil development during global warming. Therefore, you only ASSUME
that this happens. Please phrase your conclusions more carefully.

We made a number of edits to the Abstract and Discussion sections to better character-
ize our "exercise" so that it is not misinterpreted. Examples include: "The comparison
and postulated transition.." "alludes to"; "comparisons among. . .states" . "Model output
based on these comparisons suggests that. . ." are indicated by this comparison"

Specific Comments

1. p. 2, l. 1: The authors write that all profiles developed on similar geologic substrate,
i.e. "wind-blown loess deposits". However, on p.5, l. 5-6 they write that Mollisols were
formed on "loess deposits originated from glacial to post-glacial outwash along the
Missouri River and distal loess sources: : :" –

We omitted the text about "similar geologic substrates" and simply state that all profiles
developed from "wind-blown loess deposits."

2. p. 4 "2.1 Study sites": Information on how many profiles per soil type were collected
are missing. One can draw the information from the tables, but this is cumbersome
– please add here Further, it looks to me that the number of profiles collected differs
between soil types (4 profiles for Gelisols, 3 profiles for Mollisols and 14 for Inceptisols
– is that correct?) – how was this taken into account statistically / in modelling?

We added text in parentheses here to note the number of profiles per soil type. Sample
size did not impact depth fits, as Equation (1) was fit to each individual profile. Modeling
output was based on only one soil profile of fractionated soil per soil type.

3. P. 7, l. 18-23: Please provide a bit more information on the density fractionation: (a) what density agent was used? In case it was sodium polytungstate or another salt (b) how did the authors get rid of salt remaining in the sample? Washing?

We added several sentences here to clarify the methods for density fractionation.

4. p. 8, l. 14: different font

We corrected the font in this section.

5. p.9, l.8: I suggest writing "The C concentration (C%) decreased with: : :" instead of "C percent decreased with: : :"

We edited the text here following this recommendation.

6. p. 9, l. 9: change Molliols to Mollisols

We corrected the spelling of "Mollisols" in this sentence.

7. p. 9, l. 8-10: "Parameters of Z* are deeper for Gelisols and Inceptisols than for Mollisols , whereas Zmin parameters are shallower for Gelisols and Inceptisols than Mollisols." First, what exactly does this mean? A deeper Zmin means that the lowest C concentration was reached in a deeper soil depth? What exactly means a "deeper parameter of Z*"? Second, if I read Table 1 correctly, Z* for Gelisols range from 14.8 to 33.8, Z* for Inceptisols range from 9.8 to 64.3 and Z* for Mollisols range from 35.5 to 56.6. So I would not underline that "parameters for Z* are deeper for Gelisols and Inceptisols than Mollisols"? The same holds true for Zmin: : : Or did I get something wrong here?

We revised the text in this section as follows: "C concentration (C%) of bulk soil declines exponentially with depth, as captured by the depth parameters for Eq. 1 (Table 1). Values for Z* indicate an e-folding depth and are shallower for Gelisols (mean 24) and Inceptisols (27) than for Mollisols (43), whereas values for Zmin indicate the biotic zone and are deepest for Mollisols (120 compared to 57, 66 for Gelisol and Inceptisols).

Cdeep values are greatest for Gelisols (mean 1.1%C), followed by Inceptisols (0.9%) and Mollisols (0.1%). " 8. p. 13, l. 17: Manuscripts in preparation, i.e. non-accepted, should not be cited.

We omitted this citation from the text.

9. p. 14, l. 21: write "C" instead of carbon - p. 14, l. 22: delete one dot after ": : :spruce.."

We changed the text to "C' instead of "carbon" throughout the manuscript. We also deleted the extra period as indicated by the reviewer.

10. p. 14, l. 23: =0.87 instead of .87 - p. 15, l.23: write "C" instead of carbon - p. 15, l. 26-28: "our space-for-time approach integrates changes in vegetation, climate, and mineral factors to provide: : :" What mineral factors are integrated? Where is the data for that?

We corrected the text here, including writing the value as "0.87" and changing "carbon" to "C" throughout the manuscript.

11. Table 1: (A) I would change the order of the soil types from "Gelisol – Mollisol Inceptisol" to the order of the assumed soil development, i.e. "Gelisol – Inceptisol – Mollisol" (B) I had to search for the meaning of each parameter in the Material and Methods section and this is cumbersome. Please add a short explanation of all parameters listed in Table 1 either in the header or as a footnote (e.g. Cs – surface C, Cmin – minimum C etc.) (C) Additionally, I did not even find an explanation for all of the parameters: What are the adjusted parameters (Zadj, Z*adj, Zmin_adj?) – what did you do to adjust them? This information needs to be added in the Materials and Methods section. (D) Please add units for the parameters given

We changed the order of the profile types in Table 1. We also added a footnote with definitions for all parameters and units for each parameter. We specifically not that the "adjusted" parameters are adjusted for organic horizon thickness.

12. Table 2: Please add a column with the soil type here as you did in table 1

We revised Table 2 to include a "Soil type" column.

13. Table S1: Profile HCCN2/3 starts at 24 cm soil depth? What happened to the upper 23 cm?

The upper 23 cm is the O horizon (following O'Donnell et al. 2011).

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