

Review of Douglas et al., 2021, Organic carbon burial by river meandering partially offsets bank-erosion carbon fluxes in a discontinuous permafrost floodplain. Submitted to *Earth Surface Dynamics*.

Summary

This manuscript explores the effect of riverbank erosion on the fate of permafrost organic carbon, specifically examining the balance between removal of OC from permafrost cutbanks and deposition of OC onto point bars in the Koyukuk River, Alaska. The key question being asked is whether OC mobilized from ancient permafrost deposits is oxidized to CO₂ within river systems or is it quickly re-deposited and buried in floodplains. This study is timely because the effects of climate change on the arctic carbon sink cannot yet be predicted, and studies like this will enable us to predict changes in permafrost carbon stocks as river channel migration rates accelerate in the future. This is a relevant scientific question within the scope of *ESurf*.

The authors quantified OC stocks and used a 1-D mass-balance model to quantify net fluxes of OC from cutbanks, to point bars, and to downstream transport. The estimation of carbon stocks and the balance of OC fluxes in the river system appear robust, however, the estimation of OC produced by floodplain vegetation needs to be revisited. The authors should also revisit the biospheric fraction modern values calculated for individual samples. These issues do not appear to affect the overall message of the manuscript, which is that biospheric OC production on point bars is sufficient to offset any OC lost to downstream transport or OC oxidation in the floodplain. However, there are flaws in their calculations that need to be corrected.

Overall, I think this is a nice study that will be of interest to readers of *ESurf*. However, details regarding some measurements and calculations need to be revised before this manuscript can be accepted. Therefore, I support publication after the authors address the concerns detailed below.

Detailed comments

L15: change *radiocarbon abundance* to *radiocarbon activity*

What is the timescale over which sediment is deposited onto the point bar?

What is the role of petrogenic OC? Is it possible that petrogenic OC gets preferentially deposited on point bars because it is associated with the denser mineral fraction, while aged biospheric organic matter is transported downstream due to its lower density?

L85: This equation for fraction modern is incorrect. See Jordan Hemingway's review for reporting the correct equation. Equation 1 in Reimer et al. (2004) is the full equation. Other useful references for fraction modern reporting are: Stuiver and Polach, 1977; Donahue et al., 1990.

I also recommend rephrasing "low fractions of modern radiocarbon" to "low radiocarbon activity"

L87: "...low Fm values inherited..."

L91: Avoid saying “low or high Fm carbon.” Alternatively, I would recommend saying “organic carbon with low Fm values”, or “radiocarbon depleted OC”.

L104: TOC “concentrations” and Fm “values.” Fm is not a measurement, but a value calculated from measurements of ^{14}C and ^{12}C .

L107: In the parentheses, do you mean to say OC_{petro} and OC_{bio} , rather than $\text{TOC}_{\text{petro}}$ and TOC_{bio} ?

L108: TOC “concentrations”

L110: Figure 4d does not exist.

L110: Constant f_{petro} or $\text{TOC}_{\text{petro}}$? Make sure the appropriate terms are used throughout the text.

L127: Briefly define what you mean by *in situ*.

L134: Why choose the oldest woody debris as the end-member? The permafrost OC is a mixture of organic matter varying in ^{14}C activity, and as such should be represented by a mean value for ancient permafrost OC samples/woody debris samples. By using the oldest-value as the end-member, the mixing model will result in overestimated proportions of $\text{OC}_{\text{bio, is}}$.

L157: 12.4 m? Need units here.

Section 3.1 Field sampling methods – it’s not clear why the paragraphs are broken up like this. I would combine the ADCP depth with the channel migration rate calculations and move the digging/coring sampling method immediately after the categorization of permafrost vs. non-permafrost.

L167: SIPRE “corer”

L170-180: Were the samples not ground to a fine powder prior to EA and EA-IRMS analyses? I worry that the samples were not thoroughly homogenized prior to analysis. This is particularly important for permafrost cutbank samples that contain both mineral-associated OC and particulate plant debris.

Additionally, TOC and TN concentrations would be measured on the elemental analyzer, and stable carbon and nitrogen isotopes would be measured on the EA coupled to the IRMS. Please clarify that both concentrations and isotopic compositions were measured and on which instruments.

I also suggest moving the details about the measurement calibration standards to the supplement, but it is also fine if you leave it in.

L187: It seems confusing that you had TOC concentrations and stable isotope values measured at two different labs. Please add a sentence before L170 that briefly describes why samples were acid-treated using two different methods and then measured at two different facilities. Were the duplicate EA and EA-IRMS analyses performed on all samples? Additionally, please explain why you used the LANL TOC concentrations for the TOC_{meas} values.

L196: What was the percent concentration of Calgon solution?

L197: Were samples split twice? L191 says samples were split using a riffle splitter.

L199-200: Is it necessary to say that sand card grain size approximations were made? If you only use the laser diffraction particle size data, then the non-quantitative field observations seem irrelevant.

L217: TOC “content” or “concentrations”

Figure 4: Using the term “organics” is somewhat misleading on the plots. I suggest changing to “organic horizon.” It would also be helpful if the shaded regions were labeled with blue text, red text, etc. for the material they represent.

L222: yielded lower “Fm values”

L225: to calculate the “proportions” or the “radiocarbon activity” of petrogenic and biospheric end-members?

Why must there only be two end-members? From my perspective, there is a petrogenic end-member, a permafrost-derived aged biospheric end-member, and a modern biospheric end-member. Because you sampled permafrost OC from cutbanks and soil organic horizon OC, you should be able to sufficiently characterize these three end-members.

L229-230: Supplemental figure S4 contains field photos. I think you want to reference Fig. S5. I’m confused about the exclusion of >-20 per mil because all the $\delta^{13}\text{C}$ values on those plots are < -23 per mil – did you exclude the elevated $\delta^{13}\text{C}$ samples from Figures S5 and S6 as well? And it looks like the samples with higher TOC content do not have elevated $\delta^{13}\text{C}$ values, so I don’t think incomplete carbonate removal is a concern. However, it is interesting that the NOSAMS $\delta^{13}\text{C}$ values were often significantly higher than the LANL $\delta^{13}\text{C}$ values. I worry that because the radiocarbon measurements were made on the same aliquots as these elevated $\delta^{13}\text{C}$ measurements, then the radiocarbon activities would also be influenced by any remaining carbonate.

L229: Fig. 4c

L252: If f_{petro} varies across samples, but you are still using the regression to calculate F_{mbio} for individual samples, you will end up calculating similar F_{mbio} values for all samples. You would need a different end-member mixing model approach to calculate f_{bio} for individual samples.

L280: It might be helpful to write out the assumption that $M_{\text{H}_2\text{O}} + M_{\text{dry}} = 1$.

L340: How do these OC fluxes compare with the OC flux exported by the river? A more thorough mass-balance would account for the sediment flux in the river and determine how much is deposited onto point bars over the $\sim 80\text{m}$ reach studied. Although, it may not be necessary if the main point is that modern biospheric production and soil development on point bars is the primary mechanism of balancing OC stocks between cutbanks and point bars.

L354: need space between *being* and *present*

L380: I think the authors need to re-calculate the percentages of *in situ* biospheric OC in the samples. It seems highly unlikely that cutbanks have $\sim 72\%$ of sediment OC produced *in situ*

given what we know about permafrost carbon stocks. I think this can be corrected by using a permafrost OC cutbank end-member with a higher mean Fm value.

L382: Some oxidation of modern, labile OC? Or rather, oxidation of labile ancient permafrost-derived OC?

L414: “biospheric OC *production*?”

L455: TOC content and Fm values

L459: ~~that~~

L460: The authors should reconsider the calculations of Fm_{bio} for individual samples and not make a comparison across grain sizes using those estimated values.

Figures

Figure 1: Is it true that channel width has been remaining constant over the last few decades? Based on Figure S2, it appears that there is a minor shift to increased channel widths, and I wonder if mean values would be better suited to characterize this measurement. Mean values would only be appropriate if the channel width is measured continuously along the study reach.

Figure 4c: Should the blue squares be blue circles?

Figure S1: I recommend using different colors or shapes to distinguish between core, bank, and pit samples, like that used in Figure 2.

References Cited

Donahue, D. J., Linick, T. W., & Jull, A. T. (1990). Isotope-ratio and background corrections for accelerator mass spectrometry radiocarbon measurements. *Radiocarbon*, 32(2), 135-142.

Reimer, P. J., Brown, T. A., & Reimer, R. W. (2004). Discussion: reporting and calibration of post-bomb ¹⁴C data. *Radiocarbon*, 46(3), 1299-1304.

Stuiver, M., & Polach, H. A. (1977). Discussion reporting of ¹⁴C data. *Radiocarbon*, 19(3), 355-363.