Response to Reviewer 1

(Reviewer comments in blue, our response in bold black and quoted text in black italics)

This paper highlights the importance, but also the lack of knowledge around particulate organic carbon erosion from peatlands and the contribution this could make to CO2 emissions as these degrade. This is an interesting paper which will be of interest to a broad audience.

I am left wondering how the DOC pathway fits into this model of C loss and the relative importance of wasting, DOC and POC for C loss. Some discussion of how these are connected and an acknowledgement that POC is not the only fluvial C export would be helpful.

We agree that DOC is an important carbon loss pathway from peatlands and have now acknowledged this in the first paragraph as follows:

'*Peatlands are important sources of fluvial carbon including particulate organic carbon (POC), dissolved organic carbon (DOC) and dissolved gases (Billett et al., 2015; Rosset et al., 2022). Previous studies have suggested that the relative roles of these fluvial forms are typically ~15-40% of CO_2 equivalent net ecosystem exchange (Dinsmore et al., 2010; Roulet et al., 2007; Billett et al., 2010). However, POC flux is particularly high from peatlands where vegetation cover is partial (Evans et al., 2006) and in these systems POC can contribute > 80 % of the fluvial flux (Pawson et al., 2008) while a lack of vegetation will also be associated with a reduced terrestrial C uptake across the peatland and potentially to enhanced direct losses to the atmosphere. Given such large potential contributions to C losses, it is critical that more studies acknowledge the POC pathway in the carbon budget. Previous studies have suggested that both DOC and POC are metabolised to CO_2 in the fluvial system to some degree, with current best estimates between 50 – 90% conversion for POC and 80 -100% for DOC (Evans et al., 2013).* However, most studies focus on terrestrial gas fluxes or aquatic DOC fluxes. Hence, the various pathways for POC storage, transport or transformation to CO_2 are not well studied (Palmer et al., 2016).

L29 I would remove particularly as this makes it seem a UK focused issue which is then contradicted by the paragraph starting l45

We agree, we have replaced this text with the text above to comment more broadly on carbon losses from peatlands

L55/56 a reference for the calculation of emissions from POC should be included here

In response to RC2 on making our paper more generally applicable to all peatlands that are eroding, we included the IPCC 2013 Wetlands supplement equation on emissions from POC

L121 typo but -> by

We will apply this correction

L158 https://www.sciencedirect.com/science/article/pii/S0016706117317275 measures mass loss from litter bags in a UK peatland

We thank the reviewer for this reference and now refer to it, however, we note that this paper was a 60 day lab-based incubation of peat that will not undergo the variable temperature, moisture and physical disturbance that peat would during a multiannual study of decomposition in the field.

Table 1 – the title is very long and repeats much of the text in paragraph starting line 144, I would suggest putting more detail in the main text and shortening the table caption. If you wish to highlight this calculation, then perhaps convert it into a workflow figure.

We have integrated this long figure legend into the text around line 144 as follows:

'To evaluate potential direct CO_2 flux to the atmosphere from bare peat surfaces (termed 'wastage' (Evans et al., 2006)), we assumed no subsidence (while acknowledging this may cause overestimates of other losses) and applied emissions factors to SRR data compiled by Li et al. (2018). We calculated a median SRR of 18.9 mm yr^{-1} for UK eroding blanket bogs from 22 datasets that contributed to the review by Li et al. (2018) (Table 1). We then applied a best estimate of 35 % wastage rate (Evans et al., 2006), although this could vary between 5% (Pawson, 2008) and 80% (Francis, 1990), and UK average peat bulk density of 0.13 g cm^{-3} for peat soils between 30-100 cm and carbon content of 53% (extracted from UK soil Database (Frogbrook et al., 2009)) to estimate CO_2 loss from bare peat surfaces of 16.7 tCO_2 ha^{-1} yr^{-1}, assuming that all gaseous carbon losses from these exposed surfaces is CO_2 (Table 1).

We scaled the CO_2 flux per area bare peat to the catchment scale by assuming 15 % bare peat area combined with 85% of the catchment is 'Modified bog' which covers typical heather-dominated bogs and which currently carries an average CO_2 emission factor of 0.03 t CO_2 ha^{-1} yr^{-1} (Evans et al., 2022) The assumption of 15 % bare peat in eroding blanket bogs is based on the UK average bare peat cover in these systems (Evans et al., 2017). The composite CO_2 flux for the landscape from our estimate from bare peat (15% at 16.7 tCO_2 ha^{-1} yr^{-1}) and average net ecosystem exchange estimates for vegetated 'modified bog' (85% at 0.03 tCO_2e ha^{-1} yr^{-1}) results in an estimate of 2.5 tCO_2 ha^{-1} yr^{-1} for the landscape. This represents a potentially large flux of CO_2 from peat bogs to the atmosphere. Although these calculations are based on very limited data, this rough estimate is comparable to a recently published paper where authors measured net ecosystem exchange of 3.6 tCO_2 ha^{-1} yr^{-1} over an eroding blanket bog with approximately 15 % bare peat cover (Artz et al., 2022). Similarly, a former peat extraction site in Quebec with low vegetation coverage represented a large carbon source of between 5.8 and 8.7 t CO_2 ha^{-1} yr^{-1} (Rankin et al., 2018), indicating that bare peat could be a large direct source of CO_2.'

And shortened the table legend to read as follows:

'Table 1: Measured Surface retreat rate (SRR) and estimated direct CO_2 and POC losses from bare peat. Catchment scale net ecosystem exchange (NEE) of CO_2 and POC losses for an eroding bog based on an assumption of 15% bare peat cover compared to measured CO_2 NEE

(measured by Eddy Covariance (Artz et al., 2022) and POC losses (measured by sediment loss (Li et al., 2018)) at catchment scales.'

The details of how POC fluxes are estimated are still outlined in section 3 at Line 190

Concluding remarks – needs a statement between the two sentences linking POC erosion to CO2 emissions.

We agree with the reviewer and have added the text so the sentences are connected as follows:

'Depending on the extent of bare peat within a peatland, and the local slope and wind conditions, erosion can be the dominant pathway for carbon loss (Evans et al., 2006). Peat that is lost through erosion has potential to be degraded to CO_2 at various stages on its transit as POC. Due to the complex biophysical processes and interactions that cascade from peat erosion there is very high uncertainty around the emissions that occur as a result.'

References:

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