Understanding the carbon balance of peatlands: A comment on Heinemeyer *et al*. (2025)

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SUMMARY

In this short communication, we respond to criticisms of our previous work relating to peatland carbon balance calculations that have been raised in the current volume of *Mires and Peat*.

KEY WORDS: aCAR, apparent carbon accumulation, DigiBog, net carbon accumulation, peat cores, peatland development models

INTRODUCTION

In an article recently published in *Mires and Peat*, Heinemeyer *et al*. (2025) have made two substantive criticisms of our previous publications Young *et al*. (2019) and Young *et al*. (2021). Heinemeyer *et al*. (2025) suggest that aspects of our work are "unjustified" and "misleading". Below, we summarise and respond to each criticism, showing that neither is correct. Since both criticisms relate to our understanding and representation of the peatland carbon balance, we also make recommendations on how peatland scientists should estimate past rates of peat and carbon (C) accumulation.

CRITICISM 1

Summary of Criticism 1

Young *et al*. (2019), which is based on a model simulation of ditch drainage, is used unfairly to discredit the studies of Heinemeyer *et al*. (2018) and Marrs *et al*. (2019) because neither of them was conducted on drained peatlands and because the model doesn't account for burning.

Actual wording of Criticism 1

Heinemeyer *et al*. (2025) say that "*the study of Young et al. (2019) is based on a model of unrealistic constant deep (50 cm) drainage and, as in Young et al. (2021), does not include any representation of controlled burning (charcoal). Both studies are, therefore, not directly applicable as a generic criticism to invalidate the peat core studies by Marrs et al. (2019) or Heinemeyer et al. (2018), which explicitly assess the impacts of heather burning and charcoal, respectively (as discussed in Ashby & Heinemeyer 2021).*"

Reply to Criticism 1

In Young *et al*. (2019) we used the DigiBog peatland model to simulate both an **undrained** and a **drained** peatland. We showed that our paper's main message - that near-surface measurements of the apparent carbon accumulation rate (aCAR) cannot be used to infer rates of net peatland C accumulation - applies to peatlands in both a natural and a drained state; i.e., it applies across the spectrum of peatland conditions. Nowhere in our paper do we say the drained version of the model applies specifically to the sites studied by Heinemeyer *et al*. (2018) and Marrs *et al*. (2019). However, we do note in our paper that the problems of using aCAR apply to studies carried out in any management setting, including the burn-managed peatlands considered by Heinemeyer *et al*. and Marrs *et al*.; that remains our position. In other words, we believe our findings are universal. That they are, indeed, universal is revealed via a simple proof in Young *et al*. (2021) where we show that aCAR is unable to represent net C accumulation. This is because the aCAR of a peat layer is based on an erroneous version of the balance equation that does not account for carbon losses in the peat profile below the layer during its formation or for carbon losses since it formed. These critical omissions are not accounted for in Heinemeyer *et al*. (2018) or Marrs *et al*. (2019).

CRITICISM 2

Summary of Criticism 2

Young *et al*. (2019) and Young *et al*. (2021) wrongly suggest that Heinemeyer *et al*. (2018) and Marrs *et al*. (2019) believe that measurements of near-surface accumulation of C in peatlands represent the overall, or net, C budget of the whole peatland or peat profile.

Actual wording of Criticism 2

Heinemeyer *et al*. (2025) state [text in square brackets added]: "*Moreover, neither study* [Heinemeyer *et al*. 2018, Marrs *et al.* 2019] *claims that their carbon accumulation rates represent a net carbon balance, which is specifically highlighted by Heinemeyer et al. (2018) together with a clarification that carbon accumulation rates near the peat surface are higher as they reflect largely undecomposed peat, which aligns with the findings presented within both of the Young et al. publications and thus invalidates their direct criticisms.*"

Reply to Criticism 2

We agree that we make this suggestion in our paper. We do so because that is exactly what is stated in both Heinemeyer *et al*. (2018) and Marrs *et al*. (2019).

Heinemeyer *et al*. (2018) note at the beginning of their paper [***bold*** emphasis added]:

> "*We assessed **peat carbon accumulation** over the last few hundred years in peat cores from three UK blanket bog sites under rotational grouse moor burn management. High resolution (0.5 cm) peat core analysis included dating based on spheroidal carbonaceous particles, determining fire frequency based on macro-charcoal counts and assessing peat properties such as carbon content and bulk density. All sites showed considerable **net carbon accumulation** during active grouse moor management periods.*"

Here they conflate 'net carbon accumulation' with 'peat carbon accumulation', the latter term being used throughout the rest of their paper.

Marrs *et al*. (2019) similarly use the terms 'net carbon accumulation' and 'net peat accumulation' when referring to their data. For example, at the end of the section "Peat can provide a recent historic record" they note the following [***bold*** emphasis added]:

> "*The measured peat accumulation rates are **net rates**, integrating the effects of damage to the peat and subsequent regrowth.*"

Perhaps more notably, they use the phrases "Net peat mass accumulation rates" and "Net carbon accumulation rates" in their Figure 3, which summarises their main findings.

RECOMMENDATIONS

The aim of Young *et al*. (2019) and Young *et al*. (2021) is to highlight the ongoing use in peatland science of the flawed and highly misleading approach to calculating past carbon accumulation rates from peat cores. We are not the first to raise the issue, which has been the subject of papers by Clymo (1984), Clymo *et al*. (1998) and Frolking *et al*. (2014). We recommend:

1. Peatland scientists should stop using aCAR to infer past carbon accumulation rates

The apparent Carbon Accumulation Rate (aCAR) calculated from peat cores cannot reliably indicate peatland carbon accumulation rates because it only measures carbon remaining in specific layers at the time of coring, not the true carbon balance when those layers formed.

aCAR systematically shows an artificial increase toward the surface of peat cores because recently-added plant material has decomposed much less than deeper, older peat. This often creates an illusion of accelerating carbon accumulation in recent decades when actual rates may be declining, stable, or even negative.

2. Reliable peatland carbon balance assessments require different approaches

To accurately assess peatland carbon dynamics over time, researchers should use peatland development models fitted to peat core data. Approaches that account for all carbon additions and losses across the entire peat profile should be used. Direct measurements of carbon fluxes are ideal when available (for example, Moore *et al*. 2011), but process-based models currently offer the most reliable way to reconstruct historical carbon accumulation patterns from peat cores (for an example, see Young *et al*. 2023).

AUTHOR CONTRIBUTIONS

AJB and DMY contributed equally to this work.

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