Referee 2 – authors response

We would like to thank the referee for taking the time to read the manuscript and share their detailed and constructive comments. All their comments and suggestions have been addressed and have been thoroughly beneficial in improving the manuscript.

This work developed a new model INFERNO-peat. It has some improvements from the original INFERNO model in terms of estimations of burnt area, carbon emissions, etc, especially in northern high latitudes. The major comments are summarized as follows:

Thank you for your clear summary of the manuscript.

How did the model consider the effects of wind speed and ambient temperatures? I believe they play important roles in the ignition and spread of peat fires.

Ambient temperatures are considered as part of INFERNO in calculating PFT flammability. Therefore, whilst INFERNO-peat does not directly use ambient temperature, it is considered in how we calculate the number of peat fire ignitions. Wind speed, although plays a crucial role in the spread of fires, is not included in INFERNO-peat or INFERNO. This is because we do not model individual fire events, nor do we model the spread of fires, and instead try to capture the overall coarse scale patterns in burning, which is more of relevance to global climate/Earth system model applications. We refer to the original INFERNO paper for more information (Mangeon et al., 2016 doi:10.5194/gmd-9-2685-2016).

L55, ‘‘but can burn to as deep as 50cm’’. Some recent lab experiments showed it can burn at 100 cm depth (Qin et al. 2022)

Thank you for bringing this interesting study to my attention. L55 has now been adjusted to reflect what is being found in lab experiments.

L150, from Eq. 2, the combustibility of peat soil only depends on its moisture content. Even though the authors state MC plays dominate role, there are many studies emphasizing the significance of other factors like inorganic content (Frandsen 1997), ambient temperature, fuel density, etc.

Agreed, whilst soil moisture is often cited as the most important driver of peat fire ignition and spread, factors such as inorganic content and bulk density also play important roles. This is why we also use inorganic content and bulk density in equation 2. As stated in L156, we used fixed values for these variables from Frandsen (1997), due to a lack of datasets on these variables for the high latitudes. Additional factors appeared to not be as well studied and supported as the three used in this manuscript and therefore, were not included at this time to avoid adding additional sources of uncertainty. Future developments of INFERNO-peat could benefit from adding in additional variables.

Line 165, the unit is missing.

Thank you for spotting, the unit has now been added.

Line 180, the carbon emission calculation is too rough. I understand the authors try to calculate the total emitted carbon. But your cited works either use emission factors or carbon emission flux (7.1 kg C/m2). Assuming that all carbon (C) from the burned fuel (Eq. 5) is completely converted to emissions is far from realistic.

Agreed, as it stands the carbon emissions calculation likely results in an overestimation in the amount of carbon emissions. Initially we chose to use burn depth to determine the amount of carbon pool to burn, rather than a fixed carbon emissions flux to be able to capture the variations in peat fire emissions from fires that burn deep into the soil vs those that don't. However, upon receiving your comment, we decided to implement a fixed value for combustion completeness in the model. We tested multiple model runs using 4 different combustion completeness values based off the surrounding literature. A sensitivity analysis showed that 0.8 was the optimum value to use. A full explanation of this can be seen in the revised manuscript L191-197, and in the revised supplementary materials S2.

In Fig. 2a, it indicates peat becomes incombustible when MC =100%. But in Line 48, it states "However, fires can still be maintained at moisture contents as high as 160% (Rein, 2013; Hu et al., 2019b; Rein, 2015; Purnomo et al., 2020)". It is because the critical MC can change with other parameter (Frandsen 1997)

This is correct. So, whilst it is possible for peat to burn at 160% moisture content, this depends on other parameters such as inorganic content and bulk density of the soil. In Fig. 2a the combustibility of peat is calculated taking into account soil moisture but also using fixed values of inorganic content and bulk density, thereby altering the critical MC. Clarification on this point has been added into the revised manuscript (L48).

3, It seems INFERNO-peat can capture more fires in high latitudes but less fires in low latitudes (compared with GFED and fireCCILT11), especially in Eurasia area. Can the authors explain why?

In the lower latitude regions we have studied we do indeed see that INFERNO-peat doesn't capture much additional burning, especially in Eurasia. Simply, this is because there is not much peat in these areas (please see Supplementary Figure 3), therefore we would not expect that adding peat fires into the model would improve model performance in these specific areas. Furthermore, these areas in the model are largely dominated by C3 crops, suggesting that the underestimations seen in these regions are a result of INFERNO underestimating cropland burning. This is detailed in lines 236-241 in the manuscript.

5, 8, 9: The authors compare the average values over several years. However, providing subplots with the average values for each region on a yearly basis would be more compelling.

We chose to use these plots to allow for easy comparison between regions. However, the additional plots you have suggested may also be beneficial with aiding the readers understanding. Therefore, we decided to add these additional plots to the supplementary materials. Please see Figures S8, S9 and S10.