General Comment:

If I understand it correctly, the authors first use TOPMODEL to simulate wetland extent, then wetland areas with peat thickness>=30 cm are defined as peatland. However, the distinction of wetlands and peatlands in the paper are fuzzy. For example, in SI Figure2, it compares wetland abundance with peatland maps, an evaluation of simulated wetland area is missing. The paper sometimes confuses wetlands and peatlands in the main text.

Author's response: We've added the explanation to Section 2.2.3:

"Notably, the extent of pan-Arctic peatlands is used as an approximation of pan-Arctic wetlands because the northern peatland extent is estimated to be 2.9-3.3 Mkm^2, with an average of 3.05 Mkm^2 (Xu et al., 2018; Hugelius et al., 2020; Melton et al., 2022); while the northern wetland extent is estimated to be 3.2 Mkm^2 (Olefeldt et al. 2021), indicating northern wetlands are dominated by northern peatlands. In addition, the peatland coverage from Xu et al. (2018) and Hugelius et al.(2020) both include the shallow peats (<30cm), which is classified as wetlands rather than peatlands in this study."

Is peatland resilience considered in the model? Lowering of water table and enhanced decomposition can lead to compaction of surface peat, with a lower hydraulic conductivity, it helps maintain soil moisture and slow down decomposition.

Author's response: This effect is not considered in PTEM.

It is hard to read the manuscript due to too many abbreviations, and too many procedures to make the start of new simulations consistent with the Holocene simulation.

Author's response: We've divided the workflow into two parts and simplified each part. To help understanding, we also added a SI Figure 1 to explain the way we estimate wetland extent dynamics. In addition, we deleted the abbreviations for the uncommonly used terms in the paper (e.g., CRU, ALD, FAO), and added Table1 at the beginning of the method section for abbreviations and their full names.

Specific Comments:

L53-54: peatland extent in Qiu et al., 2020, Müller and Joos, 2021 are not fixed. Both studies dynamically simulated peatland area in the future.

Author's response: We've deleted these two citations here.

L62-63: Incomplete sentence, when peat thickness is ?

Author's response: We've rephrased this sentence to 'and the theoretically maximum run-on corresponding with 0 cm peat thickness'.

Eq.9: Why moss has been excluded from the calculation of evapotranspiration? Is it because the FAO algorithm and Penman-Monteith model are not applicable to moss? Anyway, moss shouldn't be neglected not only because of their high abundance in peatland, but also because of the special characteristics of moss: due to the lack of stomata, moss cannot control the water loss to the atmosphere.

Author's response: For one reason, we haven't seen works applying FAO algorithm to moss. For the other reason, evapotranspiration in PTEM is calculated as how much water is extracted from the soil, so the non-vascular plants does not fit into this category. Since the top hydrology layer in PTEM is a moss layer, the evapotranspiration from moss layer is better represented by the soil evaporation from the top hydrology layer. We find a mistake in the original text saying E_soil is the evaporation from bare soil – actually, E_soil is the evaporation from the top hydrology layer (moss). We've corrected this.

L254-255: If the 50-year running mean WTD for a bin is shallower than 25cm for only one time during the whole 1990-2300 timeseries, then this bin is "potential peatlands"? Would be informative if you could add a figure to show the frequency distribution of long-term WTD of all bins/grid cells.

Author's response: That's correct. Two SI figures (6&7) were added to the appendix on the average water table depth of the simulated bins. These two figures are cited in result Section 3.1.

L302: higher than what? Should be "increasing temperature and precipitation"?

Author's response: We've changed 'higher' to 'increasing'.

L310: stable throughout 1990-2300? the increase in temperature obviously slows down after 2200

Author's response: We've rephrased the sentence to '…is stable during 1990-2300, and slows down after 2200'

SI Figure9: Even at present-day, 1990-2000, pan-Arctic peatlands are dominated by woody PFTs? Is it realistic? A validation of simulated vegetation composition is missing in this manuscript.

Author's response: Yes, the fraction of woody plants could be overestimated. One explanation is the 'potential peatlands are included, where the WTD is usually lower than the existing peatlands and is more suitable for woody plants'. We've added this to Discussion section 4.2, and cited a previous PTEM simulation when PFT is only considered for the existing peatlands. In this previous simulation (Zhao el al. 2022 (b)), the fraction of herbaceous plants is much higher than presented in this study (SI Figure 10 & 16 in Zhao el al. 2022 (b)).

L358: In Figure4 3(a), CO2 emission (net ecosystem exchange, NEE?) are positive over 1990-2300 for both bcc-csm1-1 and IPSL-CM5A-LR, that means pan-Arctic peatlands are C sources during 1990-2100 under bcc-csm1-1 RCP 2.6, isn't it?

Author's response: The CO_2 emissions are the amount of CO_2 released by soil heterotrophic respiration. We've clarified this in the caption by adding 'CO_2 emissions from soil heterotrophic respiration'. Whether peatlands are C sinks or sources are determined by the trend of the top panel (C stocks).

L446-447: I couldn't find Table 2 in the manuscript.

Author's response: Table2 was added (now Table 5).

L487-488: Isn't WTD a more direct driver for peatland area change? Why high decomposition rate result in peatland area shrinks?

Author's response: Peatland here is defined as area with peat over 30cm. Under high decomposition, the peat thickness decreases, and peat area over 30cm also decreases. We've clarified this process by saying '…due to the shrinkage of the area with over 30cm peat thickness under high decomposition rate'.