The authors would like to thank the Anonymous Referee 2 for his/her valuable comments and suggestions to strengthen the analysis presented in our manuscript. The comments and suggestions have been taken into account in the revised manuscript, as follows (original referee's comments in bold):

General comments: This study applied the ecosys model to predict soil thaw dynamics, NEE, and CH4 fluxes across a permafrost thaw gradient encompassing palsa, bog, and fen at a subarctic peatland. The authors also investigated impacts of potential climate bias on the simulated active layer depth (ALD), NEE, and CH4 fluxes. My major concern is that this manuscript is lacking of clearness for methods and explanation/discussion for some results. While the authors cited a lot of ecosys related references, it is not clear how this model simulate ALD, water table, NEE, and CH4 fluxes (i.e. lacking of the model structure/principle/processes related to these variables) and how the authors set different parameters for palsa, bog, and fen to simulate these variables for different land types (i.e. lacking of description for setting of some parameters; please check specific points). I therefore suggest adding these contents. In addition, I noticed some indigestible results, but did not find explanations/discussions related to these results (check specific comments). I suggest adding explanations/discussions for these results.

The authors thank the reviewer for the valuable comments, which we believe have improved the manuscript substantially. We have included a qualitative summary of the *ecosys* model to improve our model structure description. We have included the list of parameters we used for our simulation to improve our parameter description. We have included the necessary explanations and discussions requested by the reviewer to improve the clarity of our manuscript.

Specific comments:

Line 151: ALD should be defined at the first place of 'active layer depth'.

We have now defined ALD as 'active layer depth' at the first place of its presence (Line 108).

Line 151: For clarity, I suggest changing '35 cm' to '35 cm below the peat surface'.

We have applied the wording suggested by the reviewer to improve clarity (Line 160).

Lines 240 to 241: Did you mean that you used the climate data from 1901 to 2010 for model initialization? If so, which year's results were used for analysis?

The climate data from 1901 to 2001 were used for model initialization (i.e., spinup) and those from 2002 to 2010 were used for analysis. We have clarified this approach in the revised Methods section (Lines 254-255)

Line 268: How about the values for bog?

Rydén et al. (1980) did not specify the differences between bog and fen, so we applied the same soil bulk density values for the upper part of the bog and fen sites. We have included a table (Supplemental Material Table 1) to specify some of the key model parameters used in our simulation.

Lines 264 to 274: How about the vegetation parameters for these three land types?

Vegetation parameters at the three peatland types were assigned by the observed plant species (section 2.1; Figure 1). The palsa, bog, and fen sites were composed by 4 (shrubs, mosses, sedges, and lichens), 2 (mosses and sedges), and 1 (sedges) plant functional types, respectively.

Lines 296 to 298: In this sentence, did you want to say inter-annual variability of GSWP3 temperature is smaller in summer. If so, I suggest adding information of the inter-annual variability, in addition to information of underestimation.

The inter-annual variability information has been added to this sentence (Lines 314-316).

Lines 336 to 337: This is not accurate; I noticed some points of net CO2 emission during summer from the figure 4.

The sentence has been revised to account for the CO_2 emission events during summer (Line 355).

Line 345: What is the meaning of 'different subsites' in this and other places? Different chambers for a peatland type?

'Different subsites' was used to indicate different automated chambers for a given peatland type. We have annotated the definition of subsites to improve the clarity of our manuscript (Lines 189 and 363).

Lines 351 to 356: I noticed consistent over-predictions of net CO2 uptake for bog. Could you please provide some explanations?

The authors agree with the reviewer that the simulated net CO_2 uptake, indicated as negative NEE, were sometimes greater than the measured values during summer. The over-predictions of net CO_2 uptake for the bog could be due to overestimated plant biomass or overestimated CO_2 uptake rate per biomass. However, we currently don't have data to examine the actual cause of overestimated net CO_2 uptake for the bog since the CO_2 flux derived from automated chambers only represents the aggregated results of all controlling factors. An additional dataset of plant biomass (for mosses and sedges at individual automated chamber locations) is needed to examine the cause of overestimated net CO_2 uptake for bog.

Lines 372 to 375: It is not clear for me how the authors simulated different water table for different land types without considering lateral water transport. Was the simulated different WT driven by different ET among the types since they had the same rainfall? In addition, why this is 'a particular issue' for bog considering that fen receives a large amount of water from a lack (Line 153)?

The WTD in *ecosys* is calculated at the end of each time step as the depth to the top of the saturated zone below which air-filled porosity is zero. Changes in the simulated water table (WT) were driven by dynamical interactions among precipitation, ET, vertical water transport, and lateral water transport. An external WT was prescribed in our simulations, and that WT interacts with our one-dimensional gridcell. However, the one-dimensional simulation cannot account for lateral water transport among landscape features within a system. For example, no additional water could be transported from the neighboring grids to lift local WT, and no excessive water could be transported to the neighboring grids to deepen local WT. We believe that such processes could be important in determining local WT, but those effects could not be represented in our one-dimensional column simulation. Although both bog and fen WTs were affected by the limitations of our one-dimensional column simulation, it could be more of a concern for bog because the measured WT variability is stronger in bog than those in fen.

Line 390: The 'weaker CH4 emission variability measured across subsites' is confusing.

This sentence was meant to indicate that the variability of CH_4 emissions measured across subsites (automated chambers) within a given peatland type was weaker than CO_2 variability, so increased temporal resolution (helpful for reducing variability across subsites) did not improve our evaluation of CH_4 emissions. This sentence has been revised to improve its clarity (Lines 408-410).

Line 399: I cannot catch this sentence. The model can produce hourly/daily results,

so it is easily to calculate seasonal cumulative NEE directly using the simulations. Why you calculate it based on the seasonality identified in another paper?

We calculated seasonal cumulative NEE directly using our simulation results, but with the green and snow seasonality instead of the quarterly seasonality. We chose to apply the green and snow seasonality identified in Bäckstrand et al. (2010) to help facilitate the inter-comparison of carbon budgets estimated in the Stordalen Mire, and to better capture the actual seasonality recorded at the study site.

Lines 427 to 429: Could you please explain why the simulated ALDs at palsa and fen under cold and wet conditions are shallower than that under cold conditions? This seems not consistent with the comparisons between wet and control.

The simulated ALDs in BIASED-WET were deeper than those in CTRL because the increased snowpack depth keeps the soil warmer with lower soil ice content during winter. A similar snowpack warming mechanism was found in the comparisons between BIASED-COLD and BIASED-COLD&BIASED-WET (i.e., soil ice content was lower with the additional snowpack from the wet biases); however, summertime soil heating in some of the simulation years was not strong enough to thaw the soil ice between 20-40 cm completely with the cold biases. The presence of ice in the middle of the soil column in the BIASED-COLD&BIASED-WET run thus reduces the simulated ALD in some of the simulation years and results in shallower mean ALD as compared to the BIASED-COLD run. These descriptions have now been added to the revised manuscript (Lines 449-452).

Lines 451 to 452: Why the fen showed weak CO2 emissions under cold and wet conditions and net CO2 uptake under cold conditions, due to reduced NPP and/or increased soil respiration under wetter conditions? I cannot understand the large impacts of wet on CO2 emissions at fen given that WT is close to or above ground surface for this site (Figure 5).

The vegetation structure and function simulated in *ecosys* dynamically respond to changes in environmental conditions. The amount of sedges simulated in the fen becomes lower under colder/wetter environment (BIASED-COLD/ BIASED-WET vs. CTRL), which slightly weakens the simulated CO_2 uptake strength (Figure 9a). When cold and wet biases are coupled together, simulated CO_2 uptake in the fen was substantially reduced in the BIASED-COLD&BIASED-WET run due to increased oxygen stress. Therefore, the simulated GPP/NPP is significantly reduced in the BIASED-COLD&BIASED-WET run, which shifts the fen toward a weak source of CO_2 emissions

(Figure 9a). These descriptions have now been added to the revised manuscript (Lines 474-475).

Lines 483 to 487: Could you explain the simulated negative impacts of wet on CH4 emissions at bog and fen; in particular for the cold and wet scenario, why the CH4 emissions was simulated close to zero?

As described above, the presence of wet biases (BIASED-COLD and BIASED-COLD&BIASED-WET) reduces oxygen exchange, which reduces heterotrophic respiration, microbial biomass, and the amount of CH_4 production. The reduction of sedges under wetter environment (BIASED-COLD and BIASED-COLD&BIASED-WET) weakens aerenchyma transport, which also limits CH_4 emissions. When cold and wet biases are coupled together, both of these effects (reduced CH_4 production and weaker aerenchyma transport) strongly inhibit CH_4 emissions and greatly reduce the simulated CH_4 exchanges in the bog and fen sites. These descriptions have now been added to the revised manuscript (Lines 509-512).