Response to reviewer comment 1:

Specific comments

Pg1, L43: In addition to increased temperature, the projected increases in high latitude precipitation could also accelerate the release of permafrost carbon (e.g., Chang et al., 2019; Grant et al., 2017).

- We thank the reviewer for the suggested references. These new references will be added in the revised manuscript.

Pg1, L46-47: Can you give a quantitative description about the release of greenhouse gases (e.g., in terms of g CO2-eq/m2)? How about Knoblauch et al. (2018) that found strong CH4 production under anoxic conditions?

- We will add the following section in the revised manuscript version:

"However, for a future model estimate, Knoblauch et al (2018) predicts twice as much permafrost carbon release in anoxic conditions (241±138 g CO2 kgC-1) compared to oxic conditions (113±58 g CO2 kgC-1) by 2100.".

Pg2, L1-3: There are many other "detailed processes representations" that can alter high latitude CH4 emissions in addition to surface wetland coverage. For example, the representations of permafrost thaw stage, surface topography, vegetation and microbial community compositions (e.g., Grant et al., 2017; Malhotra & Roulet, 2015; McCalley et al., 2014; Olefeldt et al., 2013).

- We thank the reviewer for these suggestions. We agree to include more detailed processes that influence the high latitude CH4 emissions in the revised version. The following section will be added in the revised manuscript:

"Besides surface wetland conditions, models should also properly estimate permafrost thaw stage (Malhotra & Roulet, 2015), changing surface topography (Olefeldt et al., 2013), and surface vegetation and microbial conditions (Grant et al., 2017) in order to improve estimations of surface CH4 emissions."

Pg7 Fig. 3: It might be a good idea to include the simulated soil temperature map here to (1) confirm it aligns reasonably with the simulated ground subsidence; (2) give a sense of how much warming leads to this amount of ground subsidence. Also, if the blue regions (subsidence<0.1m) are close to 0 degree C, wouldn't it suggest a potentially strong ground subsidence with the projected warming after 2010?

- We thank the reviewer for this suggestion and we want to emphasize that the scope of our current work is the connection between subsidence and surface water since the relation between subsidence and soil temperature/moisture was thoroughly discussed in the previous work: Lee et al. 2014. So for the sake of keeping the manuscript concise, we would like to refer to Lee et al. (2014) for the soil temperature diagnostics.

- The blue regions with subsidence <0.1m, the reviewer mention here, can indeed indicate a strong subsidence in the future where the soil temperatures are close to 0. We would like to emphasize that this is one of the motivations to use our new parameterization for future simulations and investigate the subsidence under warming scenarios.

Pg8, Fig.4: The spatially averaged sigma-micro between the two sets of runs are very similar. Can you include the variability along with the mean values? It appears that the model is extremely sensitive to a parameter (sigma-micro) that exhibits limited temporal variability. How do the author propose to find realistic sigma-micro values for contemporary and future simulations? Once the parameterization proposed in this study is applied to ESMs, it will trigger significant changes in surface hydrology and thereby biogeochemical feedbacks resulting from sigma-micro selection along (not including the parameterization uncertainty).

- We understand the reviewer's concern about the strength of microsigma parameter in our model. The variability of spatially averaged microsigma in Exice experiment is quite small indeed (variance: 2.8e-8, standard dev.:1.6e-4), so for the figure it doesn't make sense to add these in the manuscript. With the current knowledge, there is no perfect way to optimize the microsigma parameter for each gridbox in global simulations, this is why we tried to estimate micro-sigma by coupling to other well-known physical processes like excess ice melt. Since there is no global dataset to directly compare with our model results, one should be cautious interpreting our model's contemporary and future estimates. One avenue to constrain our parameterization will be to use the terrestrial greenhouse gas fluxes, once we use the biogeochemistry coupled to our parameterization, and this is for the next step in our work.