Response to Anonymous Referee #1

The authors used LOVECLIM to explore global sea-level change due to melting of land ice combined with steric sea effects during the next 10,000 years. They adopted the scenarios following the Extended Concentration Pathways with no carbon dioxide emissions after 2300. They found that the change in global mean sea level ranges from 9.2 m to more than 37 m after 10,000 years. The Greenland ice sheet nearly disappears for all forcing scenarios while the Antarctic ice sheet contributes about 1.6 m and up to 27 m to sea level for the lowest and higher forcing scenario, respectively.This study investigates multi-millennial semi-equilibrated sea-level rise, which potentially contributes to our understanding of future sea level change beyond centurial timescales. Thereby, I would like to support publication after minor revisions.

Author's response: Thank you very much for the positive evaluation.

First, the authors may want to show the global maps of surface air temperature, surface winds and precipitation changes, especially over the Greenland and Antarctic ice sheet regions. Given the three-layer atmosphere model in LOVECLIM, how does LOVECLIM tackle surface air temperature and surface winds changes considering boundary layer processes? Also, how do precipitation changes affect mass balance of ice sheet and hence modulate the melting of ice sheet? How do surface wind changes drive the drifts of the Arctic and Antarctic sea ice and also drive the ocean circulation, like the Deacon Cell in the Southern Ocean?

Author's response: Given the numerous plots that we provided, we chose to add fields of surface air temperature change above the Greenland and Antarctic region in the supplementary information, since they are key in the long-term surface mass balance dominated melting of the ice sheets. We also added information on how the surface temperature and surface winds are computed in LOVECLIM in the model description section (section 2). Additionally, the positive degree day model (melt model) is explained in more detail and we explain how a change in precipitation affects the mass balance. We consider that the detailed discussion of the effect of surface winds on sea-ice drifts and Southern Ocean circulation is outside the scope of this study.

Besides, I am confused by the AMOC change in the simulations. Why does AMOC recover after a temporary almost shutdown, and even overshoot in the higher forcing scenarios? Is AMOC mono-stable in LOVECLIM?

Author's response: This is an interesting topic raised by the reviewer that we are now discussing in more detail (section 8). There is a large uncertainty whether the AMOC is mono-stable or bi-stable in climate models (GCM and EMIC's) and we gave more attention to the uncertainty that exists among climate models to simulate AMOC changes in response to freshwater fluxes.

"The AMOC in LOVECLIM exhibits a mono-stable behaviour with a recovery to the initial state as soon as the meltwater pulse halts. An EMIC intercomparison study

found that 7 models show a bi-stable regime and 4 others a monostable regime following a freshwater perturbation in the North Atlantic (Rahmstorf et al., 2005). A mono-stable regime of the AMOC is simulated in most GCM's where a freshwater pulse leads to a temporary reduction of the AMOC strength and a recovery when the freshwater pulse terminates (Liu et al., 2014). However, it is speculated that a mono-stable regime might be caused by a negative salinity bias in GCM's (Mecking et al., 2017) and that a bi-stable regime would explain the rapid climatic changes during the deglaciation better (Ganopolski and Rahmstorf, 2001). The equilibrium response of the ocean suggests that the AMOC strength will also increase in response to atmospheric warming, possibly due to a decrease in sea-ice area (Jansen et al., 2018). Several studies found that the AMOC was also stronger during the mid-Pliocene, in absence of freshwater feedbacks due to ice sheet melting (Chandan and Peltier, 2017; Chan and Abe-Ouchi, 2020). Our study supports the increase of the AMOC strength when the freshwater forcing halts."