Response to Reviewer #1 for bg-2016-449

"Author Responses are indented and in bold-text"

RC1 – Anonymous Referee #1

The following is a review of the manuscript "Attaining Whole-Ecosystem Warming Using Air and Deep Soil Heating Methods with an Elevated CO_2 Atmosphere." This manuscript details a newly developed air and soil warming study with elevated CO_2, located in the boreal forest of Northern Minnesota. The manuscript outlines the methods for achieving warming of soil and air, along with elevated CO2. Undoubtedly this will be the foundational methods paper cited in future research articles.

No response required.

Scientific significance: These types of large warming+CO2 studies are highly valuable to the understanding of future climate scenarios and modeling of ecosystem carbon fluxes. This manuscript not only focuses on a study design that emphasizes temperature response functions, but tests a temperature increase much higher than past boreal warming studies (+9 C), which sadly could be a realistic scenario that hasn't been thought possible in earlier boreal warming studies. This study has the potential to significantly improve the current understanding of how boreal systems respond to warming and elevated CO_2, especially in respects to carbon budgets.

We appreciate the supportive comments of Referee #1.

Scientific quality: The work that has gone into the outlined study is of high quality. The study design has been well thought out. The infrastructure to achieve the soil and air warming along with elevated CO_2 has been well tested and this manuscript illustrates the ability of the authors to achieve the goals of the study.

Thank you for recognizing our effort. We have indeed attempted to produce a system that allows a fair glimpse of plausible future environments.

Presentation quality: The manuscript is well written, easy to comprehend and illustrates two years of environmental manipulation. Below I pose a few questions along with a general comment for the authors and editor to consider. Overall, I believe this manuscript to be worthy of publication in Biogeosciences.

Thank you.

General comment: Hydrologic responses: An important component that I think is lacking in this manuscript are data relating to hydrologic changes due to the experimental manipulation. The hydrologic conditions drive this ecosystem, limiting decomposition and nutrient availability, while also suppressing soil carbon fluxes. The authors have chosen to allow soil drying (a viable future scenario) to occur with warming in this study. Lines 634-637 state that soil drying was correlated with plot temperatures, which is what readers would expect. However, readers will be interested to know the rate of change and magnitude to the water table with the various warming treatments. I would think a figure illustrating water table fluctuations and differentials between treatments would be very important. If the authors can provide data for the readers, it would be greatly appreciated.

Strong drivers for changes in hydrologic response are certainly apparent from the warming induced changes in atmospheric relative humidity (Table 4), and we agree that potential drying under warming climate scenarios is a key variable of interest related to both microbial and vegetation responses. We are monitoring surface drying with capacitance probes (see Supplemental Material section) and overall plot water status with central water table depth sensors (where the zero height is defined as the mean hollow height for the peatland plot.

During the initial years of air warming operations 2015 and 2016, rainfall occurred in an abundance and at a frequency that did not allowed sustained drying of the peatland for any treatment. Nevertheless, as noted by the reviewer, the enhanced drying potential with warming should be evident. This is most easily demonstrated in a cumulative manner through the accumulation of winter snow (Figure 11 showing less snow with warming). It is also evident in the dynamics of surface peat drying (on site observations), but is not as easily captured along the warming gradient by the capacitance sensors. A new figure showing mid-summer 2016 surface peat hollow moisture for contrasting the extremes of the warming treatments (control Plot 19 vs. the mean of hollow sensors in the +9 °C warmed plots 10 and 17) is provided below. Other plots fall between these values.

Two members of the SPRUCE team (Steven D. Sebestyen and Natalie A. Griffith) are also actively engaged in the detailed monitoring and interpretation of the water table levels and plot-scale quantification of outflow quantities and chemistries. The methods for collecting such “response” data have been summarized in the following 26-page archived description.

> **Sebestyen, S.D., and N.A. Griffiths. 2016. SPRUCE Enclosure Corral and Sump System: Description, Operation, and Calibration. Climate Change Science Institute, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, U.S.A. http://dx.doi.org/10.3334/CDIAC/spruce.030**

The current manuscript has been revised to include this reference and the text has been supplemented to suggest that such data will be forthcoming in another article dedicated to hydrologic changes induced by the SPRUCE treatments.

New Supplemental Figure

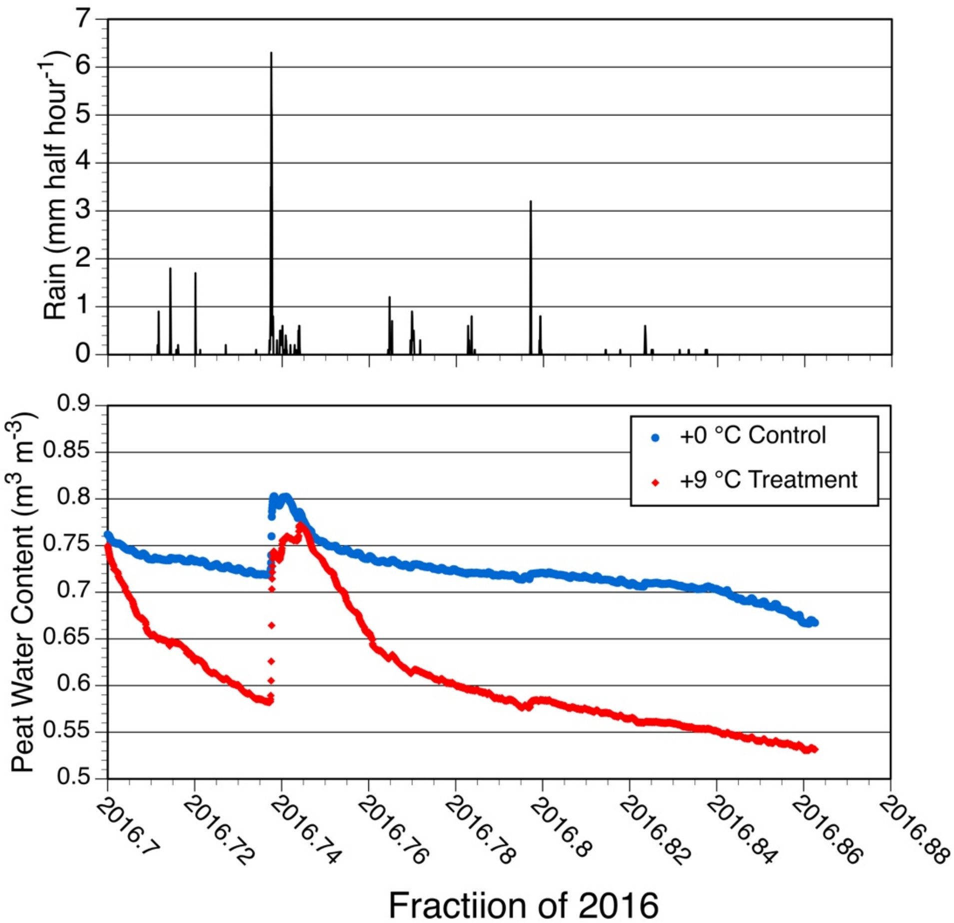

Figure S2. Graph of half-hour rainfall at + 6 m (upper graph) and surface peat water content averaged over 0 to -10 cm (lower graph) during a mid-summer dry period during 2016. Small precipitation events are intercepted by the canopy and peat *Sphagnum* surface and have limited effects on bulk water content observations.

<u>Specific comments:</u>

Lines 147-158: Could you state the number of trees per open top chamber/plot, maybe it is a range?

> **All saplings greater than 1 cm diameter at 1.3 m above the Sphagnum surface are defined as trees for the SPRUCE study. Within the interior boardwalk of each plot or enclosure the number of trees ranges from a minimum of 10 larger trees in Plot 10 to a maximum of 27 trees in Plot 20 for a mean number of trees per plot of between 18 and 19 whole trees. This information has been added to a modified description of site vegetation within Section 2.2.**

Line 183: Was the regeneration of the black spruce natural or artificial? Trees are 5-8 meters tall, but what is range in diameter? This will help readers better understand growth rates. I didn't see where the height of the chambers was mentioned. Please add this unless I missed it.

All regeneration following the strip cut events in 1969 AND 1974 occurred through natural vegetative processes or seeding events (3 to 4 successful events since 1969). Tree diameters at 1.3 m range from a plot mean minimums of 3.5 cm to plot mean maximum of 6.5 cm with a mean plot tree diameter of 5.2 ± 0.9 cm. The full range of dbh ranges from 1.2 to 11.1 cm. This information has also been added to a redrafted Section 2.2.

Figure 5 “Temperature profiles from -2m above through -2m below”: I have read this line a few times and I know what you are saying, but is the first -2m a typo? Did you mean to say 2m above the peat surface through -2 m below the peat surface? Something to look at.

The text was in error and has been corrected to state “2m above the peat surface through -2 m below the peat surface”.