

Interactive comment on “The amount and timing of precipitation control the magnitude, seasonality and sources (^{14}C) of ecosystem respiration in a polar semi-desert, NW Greenland” by M. Lupascu et al.

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Reviewer 1 General comments:

The manuscript examines effects of warming and precipitation changes on ecosystem respiration in the High Arctic. The research is conducted at a warming and irrigation experiment that mimics observed and projected climate changes for this region. The study measured CO_2 fluxes as well as $^{14}\text{CO}_2$ to identify the age of carbon that is being respired from this ecosystem. The methods, results and research focus are

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highly relevant, and the manuscript was well-organized and well-written. There are some gaps in the methods and results (e.g., statistics), but once these are filled, I feel this study will make an important contribution to understanding of permafrost carbon feedbacks to climate and, more generally, to controls over ecosystem respiration.

We would like to thank the reviewer for his support and the very constructive criticism of our work.

Specific comments: 1. Title & general: While results seem to show effects of both temperature and precipitation on Reco, the title and discussion seem to play down the temperature effect in lieu of a precipitation alone. I think the study is important because it examines Reco responses to soil moisture, which is not always considered in the context of Arctic climate change. But, the manuscript text downplays the temperature effect more than is warranted from the results. R: We agree with the reviewer in that both temperature and precipitation are critical drivers of arctic biogeochemistry. However, as stated by reviewer 1, because the response of “Reco to soil moisture is not always considered in the context of Arctic climate change”, we decided to draw more attention to the water effects, while still showing the temperature response.

2. Methods, page 2463-2464: Need to fill in detail on the experiment. At the very least, how many replicates did you have for each treatment? Plot distances? R: The paragraph has been amended with the requested information.

3. Methods, Climate trends, page 2464: Why use overlapping intervals? R: Regarding the choice of looking at the trend for overlapping periods, this approach is used by the IPCC AR4 to compare temperature trends over the past 25, 50 and 100 years and to show that global temperature trends have been increasing (Figure TS.6 http://www.ipcc.ch/publications_and_data/ar4/wg1/en/tssts-3-1-1.html).

4. Methods: The manuscript provides no information on statistical analysis! Please add this in. I was unable to review the appropriateness of statistics (when presented) in the results section. R: We are grateful to the reviewer for catching this oversight. An

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extra paragraph on the statistical analysis has been added.

5. Climate trends: R2? Can you include a figure (in the supplement) showing the trends? It would be a lot easier to see the change over time. R: Two figures showing the climate trends have been added to the supplement material.

6. Results: Include information on treatment effects on soil temperature and thaw depth, and warming effects on soil moisture. R: Information on the effect of the different treatments on soil temperature (new paragraph) and soil moisture has been included in the result section. Active layer depth estimates are based on soil pits dug in August during maximum thaw near the experimental area by us and for previous work (Sullivan et al., 2008, Horvath PhD thesis). Direct measurements of active layer depth inside the experimental plots were not performed to avoid destruction/disturbance of the 2.0×0.8 m² plots. Also, due to the high gravel content, the active layer depth cannot be reliably quantified from the surface, using e.g. tile probes commonly used in peatland studies. However, we were able to infer thaw depth during sampling of pore space CO₂, as no gas volume can be retrieved from frozen (or rarely during snowmelt, water-logged) soil. During the snowmelt, available data from gas wells tracks the soil thaw progression.

7. Results, page 2469, lines 8-9. The sentence discusses the treatments and refers to the figure, but the figure only shows control plot data. R: This sentence has been rephrased to clarify that only Control data is shown in Fig. 2. We decided to show Control data only in Fig. 2, because all treatments shows a similar interannual patterns of Reco and similar patterns of Reco in respect to changes in soil temperature and soil moisture. Due to the large number of treatments (5) and years (3), it would not be possible to convey our message in a clear way if we showed all available data. While Control data is shown in Fig. 2, the treatments are discussed in the text.

8. Results, page 2470, line 2: Here and throughout, there are several areas noted 'data not shown', but the data are relevant to this study. Can you please provide these data in a supplement. R: We thank the reviewer for proposing to show more data. All

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the "data not shown" is now provided as figures and table in the supplement material.

9. Results, pg 2470, lines 9-12: stats? P values? R: As suggested, we added statistical values to the paragraph.

10. Results, pg 2470, line 19: text states that pore space [CO₂] not affected by warming, but it looks like warm + precip is always the highest. This means that combined warming and precipitation are both important. Some stats here would also be useful. R: The warming treatments (+2 and +4°C) do not have a significant effect on soil pore space [CO₂], while irrigation treatments (W and +4°CxW) do. We consider the increase in [CO₂] in the +4°CxW plot mainly due to the water addition and not the warming. Statistics for the irrigation treatments-only, W, +4°C × W, have been added to the paragraph.

11. Results, pg 2470, line 21: text states that there is a bimodal pattern of [CO₂]. From the figure, I don't see this: There's no peak in 2010, a single early peak in 2011, and several peaks in 2012. R: The paragraph has been rephrased. Increases are discussed in response to snowmelt, temperature and precipitation events.

12. Results, page 2470, line 25: Is it just an irrigation effect, or is there a significant irrigation x warming? Please discuss these and all results in terms of statistical significance. R: As stated in point 10, the warming treatments do not have a statistically significant effect on soil pore space [CO₂], while the irrigation treatments do. We consider the increase in CO₂ concentration in the +4°CxW plot, mainly due to the water addition and not the temperature increase.

13. Results, page 2471, lines 16-19: What are these 14C values? Are these source values or your measured Reco mixed values? Why show separate values for each year for 'recently fixed C' and not for other sources? R: We clarify in this paragraph that the 14C data discussed as 'recently-fixed' is the 14C content of atmospheric CO₂ in the three measurement year. The 14C content of current year photosynthates and plant respiration is known from measurements of atmospheric CO₂. The 14C content of at-

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atmospheric CO₂ is declining over time due to mixing of the bomb-¹⁴C into the global C cycle and combustion of fossil fuels. The ¹⁴C content of all other contributing pools represent a mixture of compounds with a wide range of turnover times. In general, the ¹⁴C data of Reco presented represents a 'mean age'. We are only able to distinguish whether old or modern C dominates this signal.

14. Discussion, page 2472, line 20: change to "is strongly modulated by both SWC and temperature" R: Amended

15. Discussion, page 2472, line 22: "fluxes are positively correlated to snow". Three points/years, isn't really sufficient for a correlation, which wasn't presented in results. R: The sentence has been rephrased.

16. Discussion, general q.: In this system, what role, if any, does ground thaw play in seasonal/long-term variation in soil moisture? Do you have thaw depth data? If so, please present it. R: Unfortunately, as stated in point 6, we were unable to continuously measure thaw depth. We were able to infer thaw depth during sampling of pore space CO₂, as no gas volume can be retrieved from frozen (or rarely during snowmelt, water-logged) soil. The soils are rapidly draining by belowground sheet flow on the permafrost table. This can be seen in river runoff and DOC data (Welker, Csank, Czimczik et al. - manuscript in preparation). Data on ground ice content is not available.

17: Discussion, page 2473, line 2: "two distinct periods, a dry and a wet one". Those periods are only somewhat obvious in 2010. R: The reviewer is correct. This pattern is only clear in 2010 as stated on line 2.

18. Discussion, page 2476, line 17-18: I don't believe that you identified the C sources because you didn't partition Reco. Just refine the wording slightly. R: Amended

19. Table 1: Why not compare discrete (10-year) time intervals, rather than overlapping? R: See point 3

20. Table 3: Please note significance. Also, this is the first time I saw sample size. R:

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We thank the reviewer for pointing this out. More statistics have now been added to the result section along with the sample size in the method section.

21. Figures: I like the overall format of the figures, but it's really difficult to see the symbols and the text because they are so small. Consistency in symbol color/shape across figures would help. R: Color and shape are consistent within our figures with different colors representing the different years and different symbols for the treatment (where applicable). Font and symbol size have been increased for Fig. 3 as we agree they were too small. For the other figures we think the symbols have the right size (not too small, thus clear to see, but not too big to avoid overlapping).

22. Figure 2: Bottom panels for 2010 and 2011 show 2 sets of open square symbols and no open triangle. R: Reviewer 1 is correct. Starting the first year we had less 90 cm wells that have been slowly increased over the years. Thus, we did not have full coverage of all treatments at depth, especially in 2010.

Technical comments: 1. page 2460, line 8: change 'accompanying the warming' to 'accompanying warming' R: Amended

2. page 2460, line 12: change 'for the regional' to 'for regional' R: Amended

3. page 2460, line 17: change extend to extent; why 'and,or'? change to 'and' R: Amended

4. page 2462, question 2: Change to: 'How do simulated long-term increases in summer rainfall and temperature alter seasonal patterns of soil CO₂ and Reco fluxes?' R: Amended

5. page 2463, question 3: change and/or to and R: Amended

6. page 2463, line 6: change "This study is" to "This study was". Throughout the manuscript there are many places where verb tense should be changed from present to past. I have not noted them all here. R: While this might still be a little unusual, our manuscript is written in the present tense, because some of our co-authors insisted

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on this. We have revised the manuscript to keep the language tense as consistent as possible.

7. page 2474, line 2: change “cooperate” to “corroborate” R: Amended

8. page 2476, line 13: ‘low-Arctic’ or ‘sub-Arctic’? R: We thank the reviewer for spotting this. Denali NP is in the sub-Arctic aka Boreal.

9. Page 2478, line 15: change to: “These data further support” R: Amended

Please also note the supplement to this comment:

<http://www.biogeosciences-discuss.net/11/C2275/2014/bgd-11-C2275-2014-supplement.pdf>

Interactive comment on Biogeosciences Discuss., 11, 2457, 2014.