

Interactive comment on “Delayed responses of an Arctic ecosystem to an extremely dry summer: impacts on net ecosystem exchange and vegetation functioning” by D. Zona et al.

Anonymous Referee #1

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The authors compare growing season eddy covariance CO₂ exchange (GPP, Reco, and NEE) between two years in Alaskan arctic wet sedge; one ‘normal’ year and one ‘extreme’ weather year (experiencing summer drought and warming). They also measure net Sphagnum CO₂ exchange (NSE) and discuss the impact of drought and warming on moss vs vascular plants – and the ability of the ecosystem to adjust to such extreme weather events. This is an interesting and timely topic, and in general I find the manuscript well-written. Please find comments and concerns below.

First, I’m unsure if a 2 degree Celsius warmer growing season (relative to the long-term temperature mean) is really considered an ‘extreme weather event’? Compare this with the temperature amplitude (and shorter duration) of the extreme warming events investigated by e.g. Stef Bokhorst and colleagues in Abisko, N Sweden. A 2 degree warmer growing season is more or less equivalent to the ITEX open-top chamber warming methodology – and the authors could include and discuss such references in more detail in this manuscript.

Second, I would like to see weather data (as presented in figs 1 and 2) from 2008, and in particular I would like to see water table and thaw depth data from 2006 and 2008. Such data could be put in the supplementary info (if data exist). Regarding CO₂ data: Why not analyse multiple years (e.g. including 2005, 2008 and 2009) instead of just 2006 and 2007 (table 2)? This would convince your readers that 2007 really was an ‘extreme’ year – and how it affected CO₂ exchange in 2008. Also, why is incomplete CO₂ data presented from 2008 and 2009 (only cumulative net CO₂ uptake is presented in the text)? How CO₂ exchange responded, i.e. all CO₂ compartments, in 2008 would seem to be a pretty big part of the story here. Likewise, 2009 data showing how the CO₂ compartments were ‘back to normal’ would also seem to be a big part of the story. Adding these years would significantly improve the manuscript.

Third, the authors conveniently side-step discussing the impact a lowered water table and deepened soil thaw layer may have on the soil microbial community, affecting soil respiration and decomposition rates – which in-turn would change nutrient availability for the vegetation. As the authors seem to want to discuss their findings at the ‘ecosystem’ level, which I encourage, they should include the soil environment in their discussion. I would have liked to see data on soil nutrient pools and/or nutrient fluxes between the years in question, thus getting a more detailed view of the impact of the drought and warming on the whole ecosystem. However, I acknowledge that this would have been a much greater undertaking. At the very least, warming induced changes in soil respiration should be discussed in the paper. See e.g. Dorrepaal et al. 2009, Nature, for details on how warming may affect CO₂ efflux in a subarctic peatland.

The results section is unusually long with lots of text. In comparison, the discussion section is quite short. I would suggest, shortening the results section text, and expanding

ing on my concerns above in the discussion.

There are too many figures, e.g. figures 4 and 5 could be put in supplementary info.

I am not fully convinced of the novelty of the hypotheses, and the authors should address this concern and make changes to the introduction accordingly. Convince the reader that the study and its findings are novel. Additionally, the hypotheses are not mentioned at all in the discussion.

Please find comments/edits to the text below. I hope they may be of use for the authors.

19191 Lines 1: What do you mean by “mode of action”? Please rephrase. Line 9: Here, you call your study site an “arctic tundra ecosystem”, which may be true but that could be anything from polar desert to fen ecosystems. Please be specific - throughout the manuscript text. Line 16: Insert ‘warm and dry’ after ‘extremely’. Line 21: Consider changing ‘uptake’ to ‘sink’.

19192 Lines 1: Insert ‘in’ after ‘increases’. Line 9: What does this relate to; ‘Drought and extreme temperatures are the most important extreme events to understand’? More important than what? Consider rephrasing to: ‘Extreme weather events such as drought and (extreme) warming are hugely important to understand. . . .’ Line 16 and throughout the manuscript text: Why not call it ‘warming’ instead of ‘temperature increase’? Line 25: Change to ‘and/or drying’ Line 27: Warming also increases deep peatland soil carbon release to the atmosphere, Dorrepaal et al. 2009, Nature.

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Line 3: Either be more specific than just saying ‘arctic tundra’ - or at least add ‘ecosystems’ after ‘arctic tundra’. Line 5: Insert ‘regime’ after ‘precipitation’ Line 14: Specify what kind of tundra ecosystem. Line 14: From reading the introduction, I’m not convinced of the novelty in hypothesis (i). Line 16: How is hypothesis (ii) really different from (i)? Line 16 and throughout the manuscript text: Always call it ‘net C uptake’, be consistent. Line 19: Specify that you are comparing upland NEE to plot-scale moss

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measurements

19194 Line 13: From what I can gather you only used CO₂ data from one tower. Delete the first sentence of this paragraph, and start it with ‘Three EC towers. . . .’ Line 18: ‘Increased’ not ‘increase’. Line 20: The Zona et al. 2009 reference is not apparent in the references which only list Zona et al. 2011 and 2012.

19195 Line 6: delete ‘in’ before ‘Lasslop’. Line 19: “experienced’ not ‘experience’.

19196 Line 7: why 2-4 cm and not just 4 cm every time? I would be concerned that differences in soil moisture could be attributed to e.g. comparing moisture from a larger moss biomass at one date to moisture from a smaller moss biomass. This would be similar for the NSE measurements – but here you always used 2 cm, avoiding the issue. Line 8: ‘date’ not ‘dates’, insert comma after ‘date’, delete ‘and’ after comma, insert comma after ‘cans’ Line 9: Consider removing the sentence starting with ‘Sphagnum water content. . . .’ Line 11: So you removed 8 moss samples per plot? If so, add ‘In each of’ before ‘three different plots’. Also, this is the first time said plots are mentioned in the text and I would like to see more info on these; e.g. specify plot size, average distance between plots, and average distance between samples inside each plot.

19197 Line 2: What biomass samples? Line 9: add ‘and’ before ‘LAI’.

19198: Line 12: What is ‘VPD’? It hasn’t been stated yet.

19199 Line 19: Be specific, what kind of arctic tundra ecosystem?

19201 Line: 18: Delete ‘may’.

19202 Lines 4-6: Allow me to be blunt and ask ‘so what?’ – Instead of starting the discussion by saying that you found drought to affect GPP and Reco as also found in other studies, I would start with the most novel finding of this study, enticing the reader to read on.

Figure 3: Is it realistic that NSE would equal Reco on 12-30 June in 2007?

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