Biogeosciences Discuss., 12, C6840–C6843, 2015
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Biogeosciences Discussions
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Interactive comment on "Nonlinear thermal and moisture dynamics of high Arctic wetland polygons following permafrost disturbance" *by* E. Godin et al.

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Received and published: 21 October 2015

We found the comments proposed by the Anonymous Referee #1 quite relevant and we think those suggestions will rise the quality of the manuscript. We are entirely willing to make changes and corrections to address the issues raised by the Referee.

Based on the Referee comments, we will discuss about the four main questions to improve our manuscript.

First question: thaw depth dynamics. Figure 7 focuses on the maximum thaw depth (y-axis) which depends on the sum of the degree day of thaw ($\sqrt{}$DDT). We have the data to present more details the length in days of the maxima and other relevant observations.

Referee #2 proposed that Figure 8 was not useful as is - we designed a figure to replace it - and we will find a way to properly represent the evolution of the 0 °C isotherm to discuss further about this aspect of the paper.

Second question: the issue of scale. We agree that this is quite important and should be further discussed in the paper. The parallel with the transition as in Cresto Aleina et al. (2013) proposed by the referee is quite interesting. In Cresto Aleina et al. (2013), the modelled process seem to occurs progressively, for instance when the water circulate through polygon rims or in interpolygon channels where there may be active thermal erosion between flowing water and the top of buried ice wedges. In their study, the center of wet polygons could experiment water drain toward lower adjacent interpolygon channels and following the topographic gradient. This is a process that occurs progressively and slowly over time. In our paper, the gully was formed rapidly, with channels about a dozen of meter in width and 2-3 meter deep. This erosion occurred just nearby some polygons that were until recently classified as wet. This gullying is breaking the steady state evolution of the polygon terrace by forcing changes to drainage networks and the capacity of each polygon to retain moisture. This drastic change affects: the polygons eroded by the gully and the polygons with a new drainage system due to stream rerouting following gullying.

At the landscape scale of the valley, intact polygons have similar active layer depth and moisture level. On the other hand, eroded polygon had dissimilar active layer depth and moisture level. This can be explained by different level (degree) of erosion that impacts differently the active layer and ground moisture. The affected eroded polygons landscape adjacent to the gully therefore tend to diverge, to differ, from the rest of the intact landscape.

The third question: the time scale. Gully development monitoring at the site is quite recent. The time lapse required to study if the eroding process is accelerating is short. Before the wide availability of precise imagery (ex: IKONOS, GeoEYE), the only references onsite were a few historical air photos of various quality (since 1958) with

BGD
12, C6840–C6843, 2015

gaps up to 25 years in length between surveys and satellite images providing insufficient details for this study (ex: Landsat, SPOT). We think we would require a longer monitoring lapse of the gullies evolution cross-analyzed against corresponding climate data to provide a solid answer to the question of erosion acceleration. Most precise or finer scale observations were therefore obtained in the last few years only; active layer depth, ground temperature and ground moisture of most features at the site were widely unavailable before the last few years. Sustained instrumentation and observation of the site in the future will provide very interesting evidences on the evolution of the gullies.

Most of the valley floor is featured by ice-wedges polygons. Most are intact, many progressively eroded (toward high-center polygons) and others were beached by several gullies during the last 60 years. By observing older stable gullies it is possible to project that the changes observed in our instrumented gully are likely to evolve toward the state of the older gullies, for instance a better overall drainage due to the presence of a long and wide channel, a loss of moisture in breached polygons and on the stabilized gully wall. Instead of a flat, continuous terrace, gullies fragment the terrace and affects stream circulation and water recharge potential. The terrace should be a dryer overall place than before gullies formed, with a more heterogeneous environment (dry and wet simultaneously), this being the new steady state. This is why we think it is important to not assume that all wet polygon terraces evolve uniformly and with a given direction, as gullies in such a terrace change ground conditions (active layer depth and moisture).

Nevertheless, gullies are formed following thermal erosion - and in our context the thermal erosion processes are a requirement for the rapid development of such large gullies - and further, positive feedbacks following the triggering can accelerate the erosion. Gullies change the hydrology and moisture; this should be taken into account in scenarios focusing on ground moisture and thermal evolution.

The fourth question: how our results influence the modelling of this type of landscape

BGD
12, C6840–C6843, 2015

and upscaling of fine-scale results at the landscape scale. Perreault et al (2015) in this issue analyzed at a larger scale ground moisture and plant distribution monitoring for stable and eroded polygons around the gullies. A few hundred polygons were studied in their paper, where we have a few with a particular focus on the polygon as a unit, which is reflected on the level of detail obtained locally, but comparatively lack on the upscaling capability. While taking into account these two scales and their respective reach, modelling the gullying of permafrost wetland is a project planned for future work.

Finally, the requests to clarify the terminology used in the paper (rephrasing, sentences optimization or rewording), such as presented in the list titled 'Minor comments' will be implemented as suggested.

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