General comments

Overall, I enjoyed reading this review and synthesis paper very much; it is well written and includes an amazing review of literature. The text is about 60 pages long and thus it is sometimes hard for the reader to keep the focus. Thus, the authors might consider re organizing, for example merging and distilling the content of some of the sections. For example, section 4 seems to be a mixture of literature review and synthesis and is partly repetitive to section 1-3.

Overall, I recommend strengthening the synthesis part; what are the new insights and challenges? Furthermore, this paper should also synthesize some of the new results that are provided by the various papers in this unique THAW special issue.

Some specific recommendations are provided below.

Specific comments, with focus on sections 1& 2

Abstract

-The Arctic is a water-rich region, with freshwater systems covering 16 % of the northern permafrost landscape.

Where does this number come from? Later in the paper, several numbers are given.

-… lentic and lotic systems

I suggest supplying short explanations for these words (in brackets).

Introduction

-The Arctic is extremely rich in water. Lakes, reservoirs, rivers, and various types of wetlands, floodplains, bogs, fens and mires, on average occupy 16 % of the landscape underlain by permafrost (Fig. 1; Global Lakes and Wetlands Database; Lehner and Döll, 2004).

These numbers refer to lake sizes larger than lakes larger than 10^5 m^2. It is important to note that (i) smaller water bodies are not considered and (ii) that these water bodies are especially hot spots for greenhouse gas emissions (Abnizova et al. 2012; Repo et al., 2007&2009).

-In this review we provide an overview of the effects of permafrost thaw on aquatic ecosystems and their potential feedbacks to climate, with a consideration of all aquatic ecosystems located within the permafrost zones defined by Brown et al. (1998; Fig. 1).

I suggest to focus more on the synthesis. What are the new insights that have come out by recent literature, including the recent THAW special issue papers? Did new challenges arise or have some even been "resolved"?

-Thermokarst lake processes , which include lake formation, expansion and drainage, are the most abundant (10–50 % of permafrost-impacted landscapes; Jorgenson et al., 2006; Kokelj and Jorgenson, 2013)… and are particularly emphasized in this review..

Please give an explanation why. Other permafrost related features (for example, ponds) have been identified as hot spots of greenhouse gas emissions.

Figure 4: The figure needs revisions. Why are palsas included, but not other permafrost related ground features? Why is there solar radiation in the winter time? Spring solar radiation can warm thermokarst lakes under the ice during spring.

Furthermore, summer thermal stratification occurs in shallow ponds/lakes (< 2 m) and in deeper (> 4 m) lakes (THAW special issue; Boike et al. 2015).

Section 2.1

-..thermokarst lakes

Please give a definition of thermokarst lakes. It might be important to note that water body maps are based on (optical) surface classification (such as Lehner and Döll, 2004) and they do not provide information on the type and/or genesis of the lake (for example thermokarst or glacial lake).

-They encompass a wide range of physical characteristics, which in turn contribute to the large variations in their biogeochemical properties. In this section, we focus on the effects of thermokarst on the physical and optical limnology of ponds and lakes (Fig. 4).

The biogeochemical properties of lakes and ponds are very different in their characteristics. An important example for an important difference in the physical limnology, shallower ponds and their sediments freeze completely during the winter, while deeper lakes remain unfrozen. Summer stratification is depending on lake depth. Figure 4 thus does not give a complete overview of the physical processes in (deeper) thermokarst lakes and (shallower) ponds.

-Thermokarst lakes vary greatly in surface area, from ponds that are only a few meters across (Bouchard et al., 2011; Breton et al., 2009) to lakes that are several kilometers in their maximum dimension (Arp et al., 2011; Pelletier, 2005; Pokrovsky et al., 2011). In some thermokarst-impacted landscapes, ponds and lakes cover up to 30% of land surface area (Hinkel et al., 2005; Côté and Burn, 2002)…

While thermokarst lakes dominate in total water surface area, Muster et al. (2015) show for three Arctic sites (Canadian High Arctic, Northern Russia and Alaska) that ponds represented over 95% of the total water body number. This might be an important point considering them as “hotspots” in the permafrost landscapes (Repo et al. 2007&2009, Abnizova et al. 2012; Laurion et al. 2010).

Overall, the numbers on ponds on lake coverage are likely to be (much) higher. For example, the inclusion of subpixel-scale water bodies increases the water surface area of the total land area in the Lena Delta from 13 to 20% (Muster et al. 2012).

-In summary, thermokarst lakes and ponds occur in wide varieties (Fig. 2) depending on, for example, their formation process, surface area, and depth; from here on we collectively refer to all of these waterbodies as thermokarst lakes.

I strongly suggest differentiating between thermokarst lakes and ponds, due to distinct differences in their physical and biological properties. In the following text, the term “ponds” is still used using varying definitions: page 10752: “thermokarst ponds” are smaller in size and freezing to bottom in winter; page 10756 “ trough ponds” are very shallow systems (< 1 m); page 10752: “thermokarst ponds” are smaller in size and freeze to bottom in winter. Lakes and ponds should be defined clearly and used throughout the text.

-Depending on their CDOM and particle content, the surface waters of thermokarst lakes may strongly absorb solar radiation, and this gives rise to pronounced surface warming of the more colored lakes. In combination with the cooling of their bottom waters by the permafrost beneath, this means that thermokarst lakes can have pronounced vertical thermal and density gradients and may be strongly stratified in the summer despite their shallow depths (Fig. 4; Sepulveda-Jáuregui et al., 2015). Strong thermalstratification during summer has been reported in many thermokarst lakes, for example even in waters less than 2m deep in northern Québec (Laurion et al., 2010; Deshpande et al., 2015). Similarly, in a north–south transect in Alaska, the lakes on yedoma-like permafrost were typically stratified in summer despite their shallow depths, with less than 0.1mgO2 L1 at the bottom of the water column. On the other hand, lakes in non-yedoma permafrost or non-permafrost catchments tended to be less stratified and had well-oxygenated bottom waters (Sepulveda-Jáuregui et al., 2015). In other thermokarst lakes, little or no stratification has been observed during

summer (Burn, 2003; Hinkel et al., 2012; Pokrovsky et al., 2013), possibly as a result of greater wind exposure, increased convective mixing or less near-surface heating…

In general, the entire section “Physical and optical limnology” would benefit from further organization and structure. One important point here is that the thermal regime and stratification is mostly determined by lake morphometry (depth), and the discussion could be organized along this theme.

The paper by Sepulveda-Jáuregui et al., (2015) shows stratification only for deeper lakes (> 6 m) which is in agreement with Boike et al. (2015; THAW special issue). However, shallower thermokarst lakes (4-2 m depth) experience strong stratified events only during short periods. In contrast, shallow lakes/ponds (< 2 m) experience strong stratification (Langer et al. 2011). Shallower lakes may be strongly stratified in the summer not *despite* (as cited in the text), but *because of* their shallow depths.

Is the discussion between the importance of Yedoma and non Yedoma lakes simply caused by differences in their respective lake depths?

-The combination of high rates of bacterial metabolism, small lake volumes and prolonged ice cover means that permafrost thaw lakes can experience full water column anoxia for much of the year,…

This statement is only valid for deeper thermokarst lakes.

-..in striking contrast to deeper, less productive lakes in the Arctic such as Toolik Lake, Alaska, and Char Lake, Canada (Deshpande et al., 2015).

These lakes are not thermokarst lakes. Can the comparison still hold?

-Presently, there are major gaps in our understanding of the physical and hydrological dynamics of thermokarst lakes, including measurements of heat transfer from the..

After the THAW issue papers, which gaps still remain and which have been resolved? Any new challenges?

Section 2.2 ..transfer of material to land

In general, what is the role of the specific hydrology on carbon fluxes, for example differences between low and high gradient watersheds, importance of water balance components (snow and/or rain dominated), varying active layer depths and subsequent groundwater flow? For example, at polygonal tundra sites at the site of Abnizova et al. (2012) in North Siberia, the runoff of the low gradient polygonal tundra site (comprised of lakes and ponds) is very small, only about 10% of the total water budget. This is several orders of magnitude smaller when compared to larger rivers (for example, the Lena River with an annual discharge of about 16 800 m^3 s^1). Consequently the export of DOC via runoff is low in this watershed, but the CO_2 emission from these ponds is very high (Abnizova et al. 2012).

The importance of the “hydrologic connectivity” as another physical determining parameter determining DOC is mentioned in the text and has also been introduced for a high Arctic Canadian site (Abnizova et al., 2014).

References (in addition to the papers from the THAW special issue)

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