The Cryosphere Discuss., 6, C2229–C2233, 2012
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The Cryosphere Discussions

Interactive comment on "The influence of climate and hydrological variables on opposite anomaly in active layer thickness between Eurasian and North American watersheds" *by* H. Park et al.

Anonymous Referee #1

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General comments

This study modeled permafrost active-layer thickness (ALT) in the terrestrial Arctic region over 1948-2006 using a process-based model. It is found that the warming air temperature is not simply expressed to the increase in ALT in recent two decades. Most Eurasian regions experienced deepening in ALT with climate warming. On the contrary, the Mackenzie and Yukon basins showed decreases in ALT after the 1990 although air temperature was increasing during this period. By analyzing the variations in snow depth and soil moisture conditions, the authors found that the thinner snow depth and drier soil moisture probably offset the warming effects on ALT in the Mackenzie

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and Yukon basins. Previously, the lack of a clear deepening trend in measured ALT in Mackenzie basin was considered mainly due to thawing of ground ice, and that in some areas in Alaska is due to reduction in snow depth. This study provides some new insights into the behaviour of ALT in Mackenzie and Yukon basins in the context of the entire arctic region. This paper also reported the tempospatial variations in ALT, snow depth and soil moisture and their relations over the entire terrestrial arctic region at half degree latitude/longitude resolution. Both the hydrological effects on ALT and the tempospatial information are interesting and worthy to be published.

The model has been validated and published, and the authors also compared the results with available observations. The figures are well prepared and the writing is clear. I agree that snow depth and soil moisture are important for ALT, some words and statements seem a little bit exaggerated. The claimed effects of soil moisture **in pre-thaw season** on ALT are not convincing and need to be clarified or revised (See specific comments below).

Specific comments

Some words and statements used about the effects of hydrology seem exaggerated. For example, Lines 8-9 in abstract "Time series of ALT in Eurasian watersheds showed generally increasing trends, while ALT in North American watersheds showed **decreases.** An **opposition** of ALT variations . . . ". For the entire period (1948-2006), ALT in Mackenzie and Yukon basins also increased although not so large. The difference occurred only after 1990. Lines 19-23 in abstract, these statements are too speculative and general, and seem exaggerated. Snow and soil moisture conditions will affect ALT in addition to air temperature, whether their effects can **over-ride** the effects of air temperature depends on many conditions, including the rates and seasonality of the changes in air temperature, snow conditions and soil moisture, and the time period considered. In addition, snow and soil moisture also related to air temperature. Following are some specific points which may complicate these conclusions.

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1) In your analysis, you used the period 1991 to 2006. The annual thaw index (ATI) is very low in 1991, which promote the increasing trend in ATI. If you start the period several years earlier or later, the trend will be weaker or even declining. Observations from 1998-2005 in Mackenzie Basin show ALT generally have positive responses to ATI at all the eight observation sites (Smith et al., PPP, 20: 201-220, 2009).

2) Observed ALT in 1998 was significantly deeper than in other years and it is due to the unusually warm year (Smith et al., PPP, 20: 201-220, 2009; Smith et al., 2001: *The response of active-layer and permafrost temperatures to the warming during 1998 in the Mackenzie Delta, Northwest Territories and at Canadian Forces Station Alert and Baker Lake, Nunavut*. Geological Survey of Canada Current Research 2001-E5, 8p). Early snow melt can promote deeper ALT as well. Your modeled ALT in 1998 was not very deep and the snow depth in Jan-March was very shallow. The under-estimation of ALT in this extreme year could affect your statistics.

3) You claim that the pre-thaw season soil moisture also affect ALT (Line 12-13, P 2556, and other places). The linkage is not clear in your analysis. The soil moisture you used for analysis is from June to August. Figures 6b and 7e show consistent positive responses of ALT to soil moisture. As you said, low soil moisture reduces thermal conductivity while high precipitation may cool the soil as well (P2556). For your conclusion, you need to separate the effects of summer precipitation and the pre-thaw season condition on soil moisture. Clarify or revise it.

In Figure 6, I feel the response of ALT to soil moisture is as consistent as to annual thawing index. Is this related to your definition of soil moisture used for analysis? Please check. I am doubtful of such a strong correlation. Adding some explanation or supporting observations would be useful.

Minor corrections

Line 10, P. 2540. Delete the comma after accumulation.

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Line18-19 “under the present-day climate” is not needed.

Line 2, P 2546. Delete “wind speed”? It seems no wind speed in this dataset according to the following sentences.

Line 22. The initialization assuming no snow and no soil carbon. Is there no snow on the first day or the entire beginning years? If so, the modeled soil temperature will be under-estimated. The model simulated the accumulation of soil C in 420 years? If so, how good is the modeled soil C distribution? Does soil C change during 1948-2006?

Section 3.1.2 and 3.1.3. The modeled soil temperature has a low bias of 2.1C, especially for the Russian climate stations. The observed ALT at these climate stations seem no systematic difference although they are scattered, and the model overestimated ALT for most of the CALM sites and the sites in Mackenzie basin.

Lines 25-27, P2547. This sentence is repeating the previous one.

Line 1, P 2549. Climates, delete ‘s’.

Line 3, P 2549. “transfer” probably should be “received”.

Line 12, P2549: “for” to “from”.

Line 14, P 2549. What is the unit of the soil moisture? You used mm in Figure 4. According to this definition, increasing ALT will directly add more liquid water as soil moisture.

Line 22, P 2549. “in the Manitoba region”. It seems not in Manitoba. Probably should say “in some southern permafrost regions in Canada”.

Line 25, P2549. Delete the first “century”.

Line 8, P 2550. “Mean and time series of ALT..” Revise to “Time series of mean ALT . . . ”

Line 20, P 2551: “not” should be “not only”?

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Line 9, P2552. 20mm should be 20cm?

Line 8, p2553. “ones” should “that”

Figure 8 and the discussions are complicated and somewhat repeat Figure 7. probably not needed.

Discussion section. The changes of precipitation and its impacts on soil moisture are very important, probably should be described in the results section.

Line 14-15, P 2558. Too general and not related to the paper.

Figure 6. checking the units in the caption. Indicating the duration for calculating the linear regressions.

Figure 7c. “SD” should be “SND”

Interactive comment on The Cryosphere Discuss., 6, 2537, 2012.