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**Review of doctoral thesis**

Thesis title: Dynamics of glacial lakes and hydrological conditions of a glacio-morainic complex (Adygine, northern Tien Shan)

Author: Kristýna Falátková

The thesis deals with hydrological conditions in a proglacial environment, focusing on the development of glacial lakes and the assessment of their susceptibility to outburst. This work has been prepared as cumulative thesis and comprises a collection of papers published in or submitted to scientific peer-review journals. The thesis of Kristýna Falátková consists of four papers, from which 1 paper was published in high-impact journal, two papers were published in well-known journals and 1 more paper is under consideration in Hydrological Sciences Journal. Three papers have already gone through critical review process.

Structure of the thesis is as follows: introduction, chapter with scientific background, chapter presenting applied methods and materials, author's contribution statement. Afterwards, four papers mentioned above are presented. The thesis ends with conclusions and discussion section and reference list.

**Introduction.** Receding glaciers lead to rapid change of proglacial environment including formation of new lakes and expansion of existing lakes as well as change of their outburst probability and hazard. This situation is typical for Tian Shan (Wang et al., 2013; Zheng et al., 2019). The thesis summarized “big data” obtained during research Department of Physical Geography and Geocology of Charles University (since 2004) and added some novelty which was not described in Introduction. The aim of the thesis was to investigate the proglacial lakes dynamics and water flow from glacier to a stream. Five objectives are clearly formulated.

**Scientific background.** Chapter 2 consists on four sub-chapters where author describes main aspects related to glacier lakes evolution, outburst susceptibility and meltwater transfer. Factors of formation and development of glacier lakes are clearly described but I am a bit wondering why landslide dammed lakes are included in table 1. Some regional papers (Daiyrov et al., 2018; Narama et al., 2018) are not cited despite important findings related with non-stationary or short-lived lakes are presented there. Glacier lake stability and outburst hazard have been analyzed using state-of-the-art papers. Glacial hydrological regime is linked to regime or balance of glacier lakes, but this relation might be not tight. Hydrological regime (or balance) of glacier lakes is interesting topic with numerous gaps and it should be highlighted more. Lake level fluctuations depend not just on water inflow but on situation inside englacial tunnels, especially for case of non-stationary lakes prevailing at Kyrgyz Range (see Table 1 of the thesis). There are some papers on lake level fluctuations for glacier- and moraine dammed lakes, but just two are cited. Glacier meltwater passage and runoff changes in future sub-chapter provides relevant information.

Chapter 2 provides high-quality review of existing publications about current situation in the area of scientific research. Typically aim of such review is identification of research gaps and clear statement on how these gaps could be filled in after thesis will be completed. Objectives are in good connection with the background, but description of research gaps is missing. Thus it is not clear how significant are research objectives both regionally and globally.

**Applied methods and data.** This chapter starts from description of the study site. I am not sure that this description is part of methods or data. Anyway description of the site is good as well as justification of selection the site for detailed research. There are some problems with terminology, at least with common definitions used in most of Europe and Russia. Surprisingly rock glacier below lake No.1 calls “large morainic landform with buried ice”. Of course, in case of Tian Shan rock glaciers frequently formed from terminal moraines, but at this stage it is rock glacier and it should be specified in the thesis. Tarns are mountain lakes formed in cwms or cirques. Thermokarst lakes are not tarns!

Description of the site followed by methods used to assess formation and development of lakes. State-of-the-art techniques of field research and data processing have been used by the author both for lake area and bathymetry. The same has been done to assess hydrology of the site. Probably conductometer in combination with hydraulic propeller might gave more precise results comparatively to solo hydraulic propeller. Lake outburst hazard has been assessed using well-known approaches. Detailed geophysical data from Adygine site provide a possibility for detailed assessment and high-quality forecast for future.

**Author's contribution** in published and submitted papers varies from 60% to 100%, which is really high value.

Findings of the thesis are presented in four papers.

The first one, Falátková, K. (2016), *AUC Geographica*, 51(2), 145-154 is focused on temporal analysis of GLOFs in high-mountain regions of Asia and assessment of their causes. Author collected and analyzed all published data on GLOF events. According to the dataset, the highest frequency of GLOF events has been observed in 1956-1985, then decreased with splash in 2001-2005. It is very significant finding which contradicted with existing mainstream (increase of GLOFs due to glacier recession and climate warming) but has been confirmed by latter studies both at global (Harrison et al., 2018) and regional (Veh et al., 2019; Zaginaev et al., 2019) levels. Author distinguishes bursts of ice- and moraine-dammed lakes which is also important.

The second paper, Falátková, K. et al. (2019), *Earth Surf. Dynam.*, 7, 301-320 received status “published” since March, 18, but surprisingly indicated in the thesis like “in press”. The paper is focused on development of proglacial lakes at Adygine ice-debris complex, assessment and forecast of their outburst probability. According to direct observations one of the lakes rapidly expands whereas two others are in quasistable conditions. Formation and expansion of the lake is explained by glacier recession which is a main reason for lake area enlargement in Tian Shan. Cryospheric change caused by climate warming will lead to increase of outburst susceptibility for two lakes in coming decades. The paper provides high-quality case study with significant conclusions, both locally and regionally.

The third paper, Falátková, K. et al. (2014), *Geografie*, 119(4), 320-341 investigates hydrological regime of the lake Adygine. Basing on direct measurements from 2007-2012 authors identify specific drivers of lake level fluctuations. They confirm that lake level increases with delay after beginning of glacier melt. Intra-annual lake level fluctuations are significant and may exceed 3 m. Daily fluctuations are also clear and mainly depends on snow and ice melt. Inflow discharge is closely related with thawing and liquid precipitation and fluctuation span depends on weather conditions. Water balance of the lake has been estimated in details. The study suggests that

regime of the lake Adygine is typical for proglacial lakes, data to support this opinion is provided in the paper.

The fourth paper, Falátková, K. et al. (2019), Hydrological sciences Journal, in review, analyses hydrological and isotopic characterisation of proglacial lakes and their connectivity basing on data from Adygine area. It is important topic considering potential chain reactions in case of the upper lake burst. There are at least two major findings in the manuscript. Basing on dye tracer authors report that water flow speed in transition zone between glacier and stream was quite fast. Just very small part of water (0.03%) routed efficiently, almost all water delayed in moraine complex. Authors concluded that moraine complex is expected to retain the considerable volume of water. This conclusion is very important because explains catastrophic consequences caused by outbursts of relatively small lakes in Tian Shan.

**Conclusion and discussion.** In this section author summarizes individual findings. Conclusions are based on data collected by the author, clearly written and show significant progress in glacier lake studies. This progress was not highlighted and mentioned in the thesis. Unfortunately, discussion is almost missed. Limitations of obtained results are briefly explained, but discussion should show all author's results as a single whole and tighten author's findings with relevant papers.

**Overall evaluation.** Doctoral thesis of Ms. Falátková definitely contributes to glacier lakes research in Kyrgyzstan as well as in High Mountain Asia. Quality of papers presented in the thesis of Kristýna Falátková is very high, author's contribution is significant. I also note impressive amount of field research carried out using state-of-the-art techniques and equipment. Data processing, analysis and generalization were performed at high level. All conclusions are supported by instrumental data. Individual objectives are fully achieved. Ms. Falátková demonstrates all necessary skills to continue academic career and further add value to research related with glacier lakes and surroundings. Despite comments raised with regard to some terminology, discussion and background I estimate the thesis very positively.

I recommend acceptance of Kristýna Falátková's thesis submitted in a fulfillment of the requirements for a Ph.D. degree.

Dr. Dmitry Petrakov

May 31, 2019