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Interactive comment on "Development of glacial lakes and evaluation of related outburst hazard at Adygine glacier complex, Northern Tien Shan" *by* Kristyna Falatkova et al.

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General

The authors describe interesting field and remote-sensing work in a mid-latitude Asian mountain range with continental-type climatic conditions, retreating polythermal glaciers, periglacial permafrost and multiple lake formation. Their integrative concept is admirable and continuation of the studies should be encouraged. In its present form, however, the submitted manuscript is not ready for publication but needs considerably more detailed/precise information, documentation and a corresponding discussion at the present state of knowledge and understanding, especially concerning the following

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aspects (see also the uploaded annotated Google Earth image):

Geomorphology: Carefully reading the landscape helps with assessing the most important conditions and processes. The region under investigation is permafrost and rock-glacier country with numerous small to large landforms reflecting viscous creep of ice-rich frozen material. The corresponding modern scientific literature should be consulted and mentioned in order to understand the phenomena and the corresponding environmental conditions. Adygine glacier, for instance, had been (Little Ice Age?) in contact with an active rock glacier, the high, steep and bright fronts of which show clear signs of advance (freshly exposed talus material). The glacier forefield now exposed through recent glacier retreat is predominantly a sediment bed and contains fluted (striated) moraine. The latter is an important indication of temperate bed conditions underneath the glacier.

Glacier-permafrost relations/interactions: With mean annual air temperatures being far below 0°C, the small surface ice bodies of the region are in close contact with periglacial permafrost and therefore most likely polythermal (glaciers) to cold (ice patches). Permafrost in the region can probably reach depths of many tens of metres or even more than hundred meters. Its ice content is likely to far exceed the pore space of the material (excess ice or ice super-saturation which enables viscous/cohesive long-term creep and strongly affects water circulation below ground). The polythermal structure in glaciers is correctly mentioned in the text but should be documented with measured data or should at least be discussed in comparison with, for instance, better-known polythermal glaciers in other parts of the Tien Shan, in Svalbard or in the Alps. Most likely, the ice of the ablation areas is cold and frozen to the bed at the ice margins, while the permeable firn area higher up on the slopes is temperate due to latent heat input by percolating melt water. This structure of englacial temperature would also explain the warm-based character of higher glacier parts and the formation of fluted/striated moraines under conditions of high (artesian?) water pressure at the warm-cold bed transition near the ice margin. An interesting question relates to the

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(ongoing?) formation of subglacial and proglacial permafrost with its influence on sediment permeability, groundwater, surface/subsurface runoff and lake hydrology. The mentioned geophysical soundings may provide information. They should be shown and discussed.

Geophysical soundings: Resistivity tomography usually enables to discriminate (a) between frozen/thawed materials, (b) between buried massive ("glacier") ice from wet firn metamorphosis (hundreds of Megohmmeters), buried ice-patch ice (few Megohmmeters) and massive subsurface segregation ice (tens of kiloohmmeters), (c) groundwater occurrence (hundreds of Ohmmeters) and dry sediments (kiloohmmeters). The corresponding sounding results should not only be mentioned but shown: what were the measured specific resistivity values and their distribution patterns at depth; how were the results interpreted and how do they compare with the many investigations in other cold mountain ranges? Where were the mentioned radio-echo soundings measured? What center frequency was used? With higher frequencies the temperate/cold interface in the ablation area may be detected but lower frequencies may be necessary to reach the bed in temperate, water-containing firn/ice. How does the glacier bed look like? Are there overdeepenings where future lakes may form, will the expansion of lake 3 continue and how large could this lake become? Numerical models exist to calculate glacier-bed topographies and corresponding glacier-bed overdeepenings. Corresponding studies have been carried out over large regions (Alps, Peru, Himalaya/Karakoram, etc.) and should be mentioned. The results of such model calculations could be compared to the results of the radio-echo soundings. Glacier-bed topography represents future surface topography and as such is an important basic information concerning future landscapes.

Future scenarios: What exactly is the relation of this part of the study to the primary subject of the paper (lakes, hazards)? Realistic scenarios can also be estimated using simple extrapolation techniques. Degree-day models are well established, empirical-pragmatic-useful rather than sophisticated approaches for calculating future glacier

scenarios. Why were point mass balances on the glacier measured parallel instead of perpendicular (elevation profile, mass balance gradient) to the ice margin? What is the reason for the strong inter-annual variability of mass balances calculated for the time period 2020-2030?

Hazard assessment: Of course local site investigation must complete overview studies by remote sensing – this has long been known and does not need to be recommended as a "new" approach. The authors should consult the GAPHAZ technical guidance document on hazard assessment concerning glaciers and permafrost in mountain regions (http://gaphaz.org/), the work of ICIMOD about dangerous lakes and also make themselves familiar with the extensive work on hazard assessments in connection with lakes in Peru by their university colleagues at Prague (Emmer, Vilímek, etc.).

Specific remarks

The English needs smoothing in places. Some specific remarks and suggestions can be found in the annotated pdf file (uploaded).

Please also note the supplement to this comment:
https://www.earth-surf-dynam-discuss.net/esurf-2018-21/esurf-2018-21-RC1-supplement.pdf

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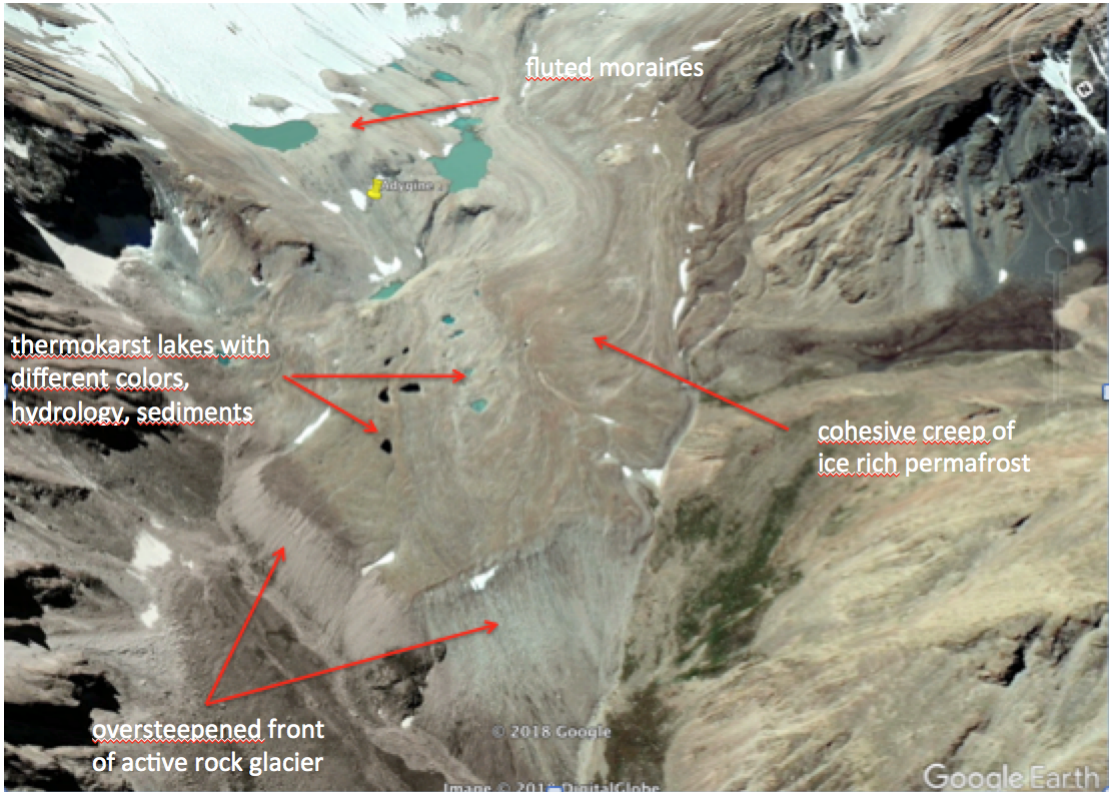

Fig. 1.

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