Quantification of ice-breakup events and iceberg dynamics

in a highly dynamical proglacial lake in Austria (Pasterze Glacier)

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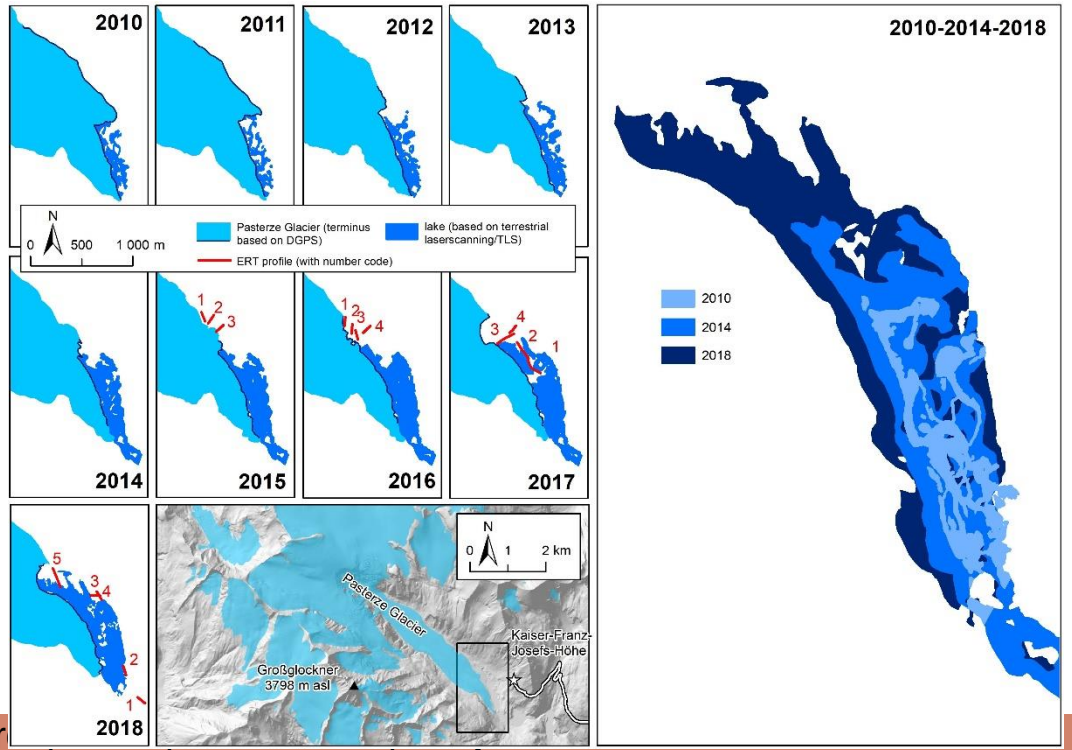
Introduction

- Glacier recession into glacier bed overdeepenings commonly cause the formation of highly dynamical proglacial lakes.
- Such a proglacial lake at the terminus area of Pasterze Glacier, Austria's largest glacier (approximately 16km²), sextupled during the last decade from 0.05 (2010) to 0.3km² (2019) as measured during multiannual ground-based differential global positioning surveys (DGPS) and terrestrial laser scanning (TLS) campaigns.



Evolution of the glacialproglacial area at Pasterze between 2010 and 2018 based on DGPS and TLS (taken from Kellerer-Pirklbauer et al. 2019)

Bathymetry

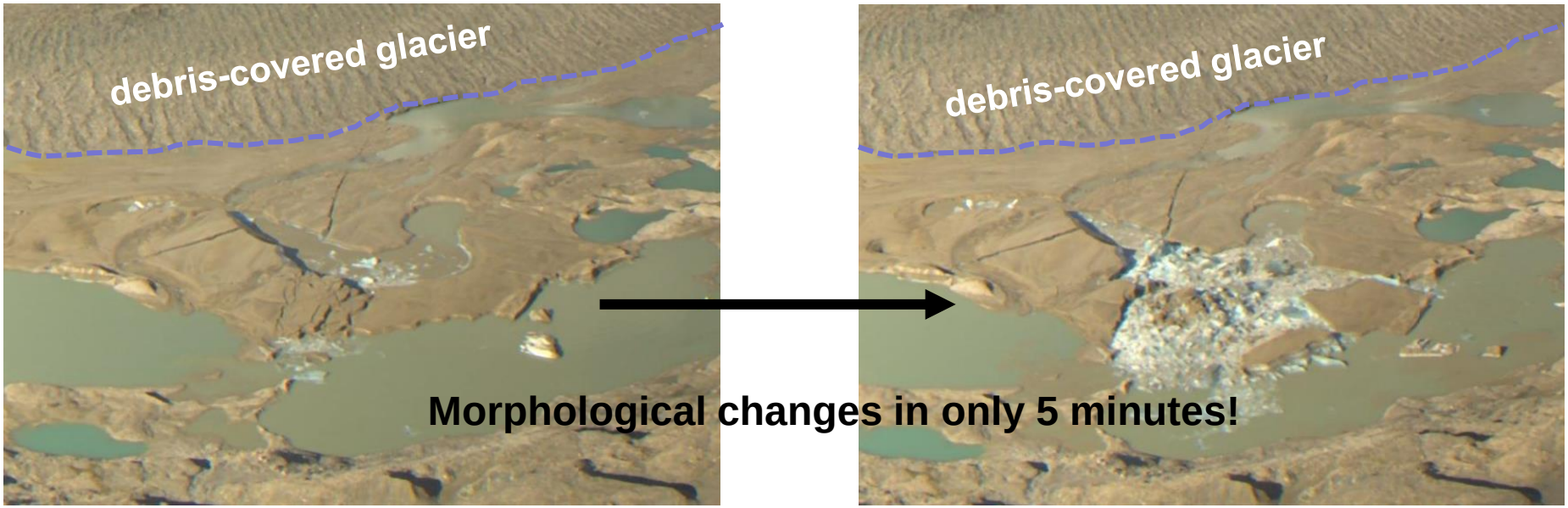
Sonar measurements in September 2019 based on 4276 individual data points (unevenly distributed over the lake) revealed:

- maximum lake depth of 48.2m
- several depressions at the lake bottom.
- mean lake depth of 13.4m
- water volume of 4 million m^3.

(photos by authors)

Ice-breakup events

- Five large-scale and rapid ice-breakup and ice-floating events were observed during the period September 2016 to October 2018 based on webcam images with a temporal resolution of (mostly) 5 minutes.
- Furthermore, three medium-sized and five smaller ice-cracking events or collapses as well as three iceberg-tiltings were observed.



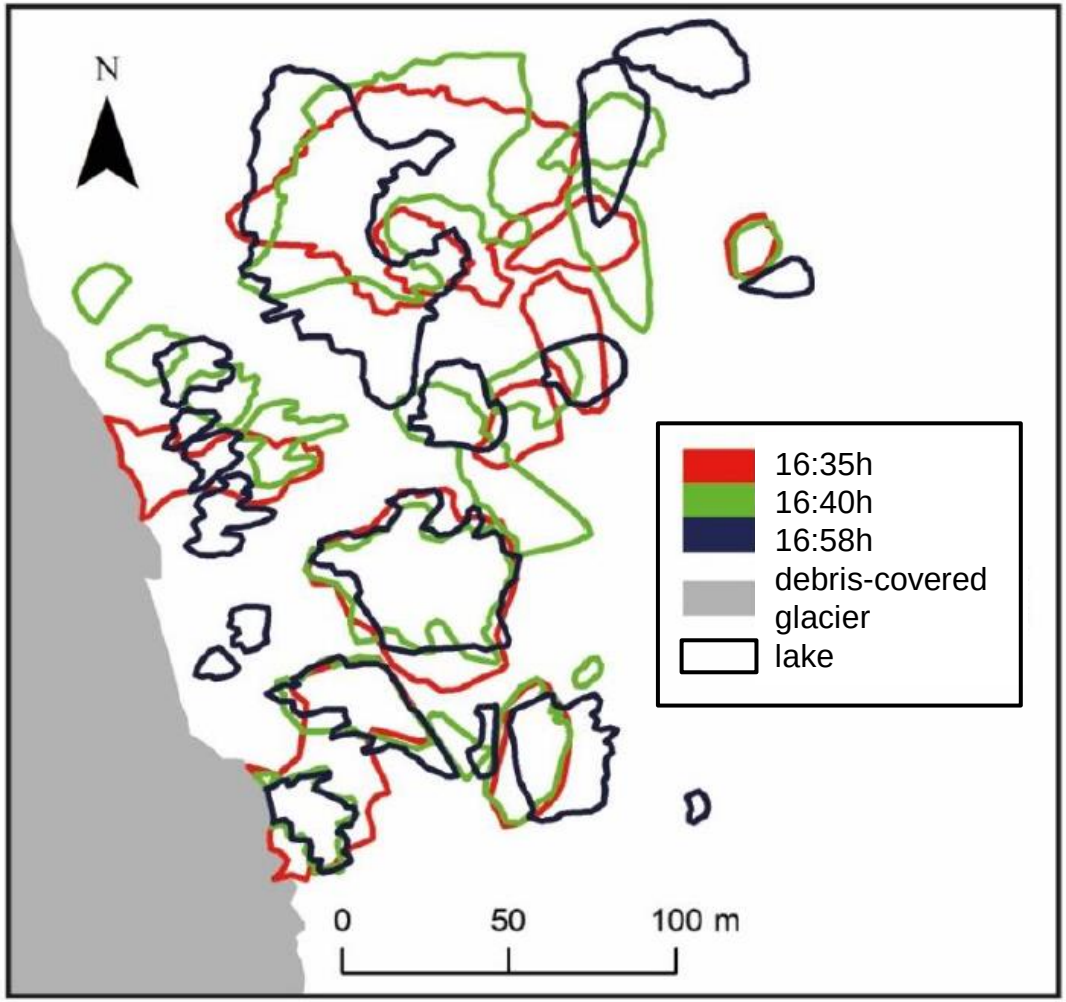
(photos by GROHAG)

Processes

- The icebergs at the proglacial lake of Pasterze Glacier probably formed by disintegration of glacier ice at the lake bottom or at the near-shore surface influenced by high water pressure along fractures.
- The breakup events demonstrate that the originally presumed pure “proglacial lake” seems to be (at least during the period of observation) to some extent a “supraglacial lake” covering glacier ice, which steadily disintegrates forming icebergs.
- The first analytical approach using the EMT (Environmental Motion Tracking) software and webcam images yields meaningful results if icebergs do not modify substantially their geomorphological appearance during the event.
- The second analytical approach using Erdas and ArcGIS for orthorectification of the webcam images provides data on of surface extent and structure data as well as location of the icebergs at different times during for instance the ice-breakup events (*example next page*).

Processes

- During breakup events, such ice masses show signs of tilting, sudden disintegration and formation of icebergs, which steadily melt accompanied by further tilting events at the lake surface.



Iceberg formation and dynamics during a 23-minute period at 09.08.2018 as revealed by webcam-data analysis

Outlook

- No major ice-floating event was observed during the ablation period 2019.
- The aerial extent of icebergs in the proglacial lake decreased substantially in 2019.
- We conclude that the process of lake-bottom ice disintegration has widely ceased and that the glacier ice at the lake bottom has mostly vanished.

Distribution of icebergs at the Pasterze Lake in mid-September 2019 (photo by authors)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