Scientific highlights of the Glaciers_cci project: Year 2

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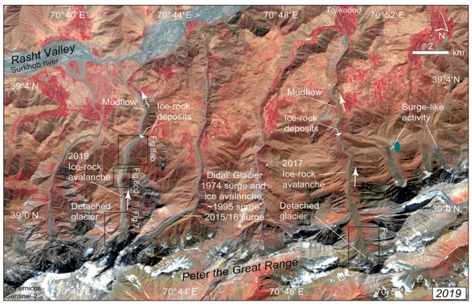
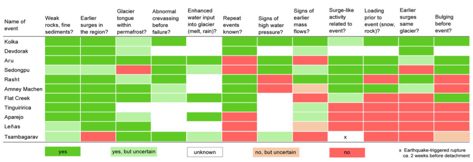
Glacier collapses around the world

- In this study we compiled a global overview of observed glacier collapses or detachments
- Such events only received attention after Kolkaglacier, a comparably small and flat glacier in the Caucasus left its bed in 2002, rushing down a valley with 250 km/h and killing more than 100 people
- This was considered a rare event that occurred under very special circumstances until two further glaciers in the Aru mountain range of Tibet also left their beds in 2016 within a period of 3 months
- The subsequent analysis of satellite image time series revealed several further detachments
- A removal of a glacier from flat bedrock is difficult and might be an end-member of dynamic behaviour
- An overview of the characteristics of these events revealed some commonalities but also differences



Locations of the 2017 and 2019 ice–rock avalanches in the Peter the Great Range, Tajikistan. Satellite image: Sentinel-2, 19 September 2019.

Publication:
Kääb, A., Jacquemart, M., Gilbert, A., Leinss, S., Girod, L., Huggel, C., Falaschi, D., Ugalde, F., Petrakov, D., Chernomorets, S., Dokukin, M., Paul, F., Gascoin, S., Berthier, E. and Kargel, J. (2021): Sudden large-volume detachments of low-angle mountain glaciers - more frequent than thought. The Cryosphere, 15, 1751–1785 .

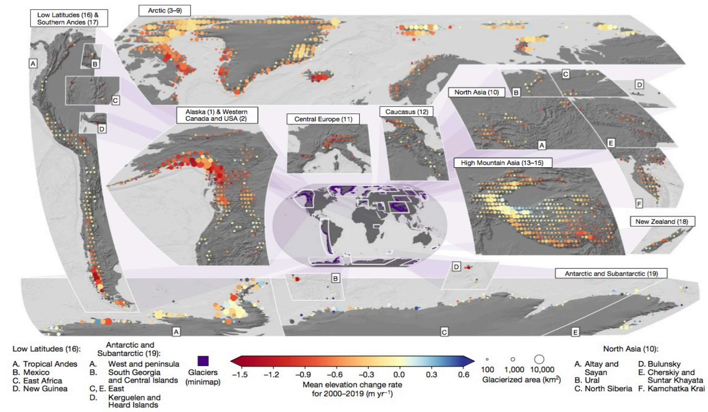


Possible indicators for and factors involved in low-angle glacier detachments. The columns and rows are roughly sorted according to increasing number of "no" entries towards the lower right

=> https://climate.esa.int/en/news-events/low-angle-mountain-glacier-detachments-more-frequent-than-thought
=> https://www.esa.int/Applications/Observing_the_Earth/Glacier_avalanches_more_common_than_thought

Global glacier mass balance from time-series of ASTER stereo images

- For the first time, the geodetic mass balance of nearly all 215,000 glaciers in the world was calculated
- The study used time-series of ASTER stereo images (440,000 scenes) & automated DEM processing
- The global overview revealed that glacier mass loss has further increased over the past 20 years
- Increasing mass loss despite shrinking glacier areas means glaciers are out of balance with climate
- They will continue shrinking in the future, even if global temperatures would not increase further



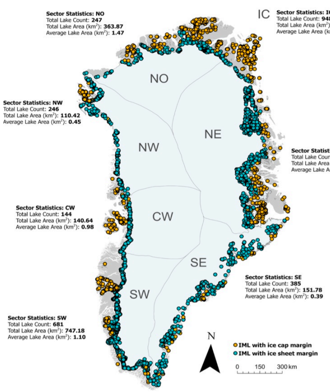
Glacier elevation change between 2000 and 2019 for various subregions. The mean change rate is aggregated for tiles of 1° x 1° below 60° latitude, 2° x 1° (60° to 74°) and 2° x 2° above 74°, giving similar areas of c. 10,000 km². Disks scale with glacierized area of each tile and are coloured according to the mean elevation change rate abd are shown on top of a world hillshade.

Publication:
Hugonnet, R., McNabb, R., Berthier, E., Menounos, B., Nuth, C., Girod, L., Farinotti, D., Huss, M., Dussaillant, I., Brun, F., Kääb, A. (2021): Accelerated global glacier mass loss in the early twenty-first century. Nature, 592, 726-731.

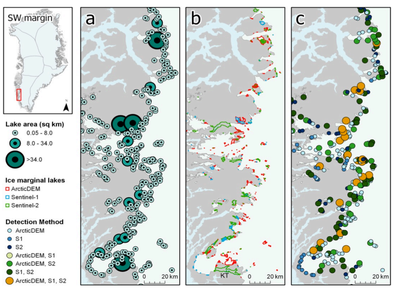
=> https://climate.esa.int/en/news-events/recent-acceleration-in-global-glacier-melt-study-warns

An inventory of ice marginal lakes in Greenland

- Due to the retreat of the Greenland Ice Sheet margin new ice-marginal lakes constantly form
- They hold back a part of the meltwater and can be a source of hazards (flooding)
- No detailed Greenland-wide overview of such lakes was available so far
- We used Sentinel-1 and 2 data as well as the Arctic DEM to automatically map and classify them
- 74% of the lakes were detected from one method, 22% from two and 4% from three methods
- 3347 ice marginal lakes >0.05 km² were identified covering an area of 2908 km²
- The number of lakes in a sub-reggion increased since 1985 from 387 to 678 (+75%)



Left: Overview of the 2017 ice marginal lake inventory of Greenland, where each defined point represents one unique ice marginal lake. Blue points denoting lakes sharing a margin with the ice sheet, points in ornage are ice marginal lakes adjacent to Greenland's ice caps and glaciers.

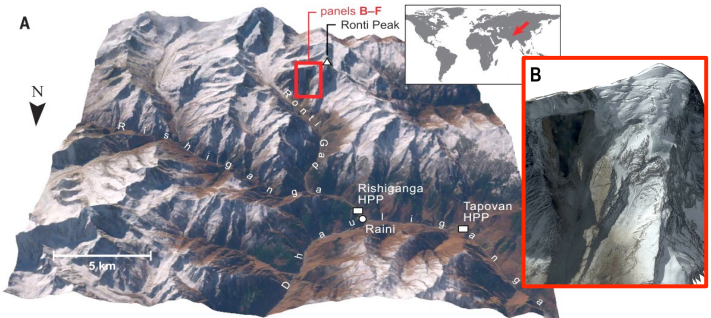


Right: Ice marginal lakes over a selected section of the SW ice sheet margin, with (a) lake area, (b) lake shape determined by each method, and (c) detection method. Ice, land and ocean are displayed in white, grey and light blue, respectively. The ice margin shown is a modified version of the MEaSUREs GIMP ice mask 33. The largest lake of this region (Kangaarssuup Tasersua) is labelled as KT in b.

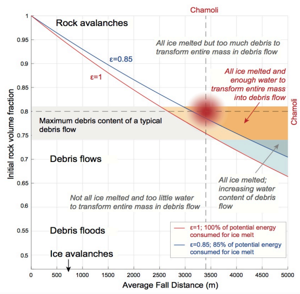
Publication:
How, P., A. Messerli, E. Mätzler, M. Santoro, A. Wiesmann, R. Caduff, K. Langley, M.H. Bojesen, F. Paul, A. Kääb and J.L. Carrivick (2021): Greenland-wide inventory of ice marginal lakes using a multi-method approach. Scientific Reports, 11, 4481.

The Chamoli disaster

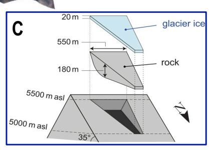
- On 7 Feb 2021 a large mass of rock and ice detached at an elevation of 5500 m below Ronti Peak in Uttarakhand, India, and formed a devastating debris flow that killed 200 people 25 km downstream
- A team of experts from all over the world came together and analysed a wide range of before/after satellite images and DEMs to decipher the reasons and time line of the event
- It was revealed that a mixture of 80% rock with 20% ice was ideal to melt all ice and transform the crushed rock into a deadly and far reaching debris flow, leveling up to 220 m above the valley floor.



(A) Region overview, (B) the scar in the mountain flank as seen by Pleiades on 9.2. 2021, (C) conceptual model of the rock/ice slab and scar



Publication:
Shugar, D.H. & 52 ohers (2021): A massive rock and ice avalanche caused the 2021 disaster at Chamoli, Indian Himalaya. Science, 373, 300-306.



https://www.esa.int/Applications/Observing_the_Earth/Satellites_reveal_cause_of_Chamoli_disaster

Rock volume fraction that would be able to melt all ice during fall as a function of average fall distance. The vertical dashed line at 3400 m represents the mean fall distance between the site of the initial detachment and the Rishiganga hydropower project. The vertical dashed line indicates the initial rock volume fraction of the detachment of about 0.8. The Chamoli rock and ice avalanche had a combination of rock-ice fraction and fall distance that enabled most ice to be melted and to transform into a debris flow (orange area).

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