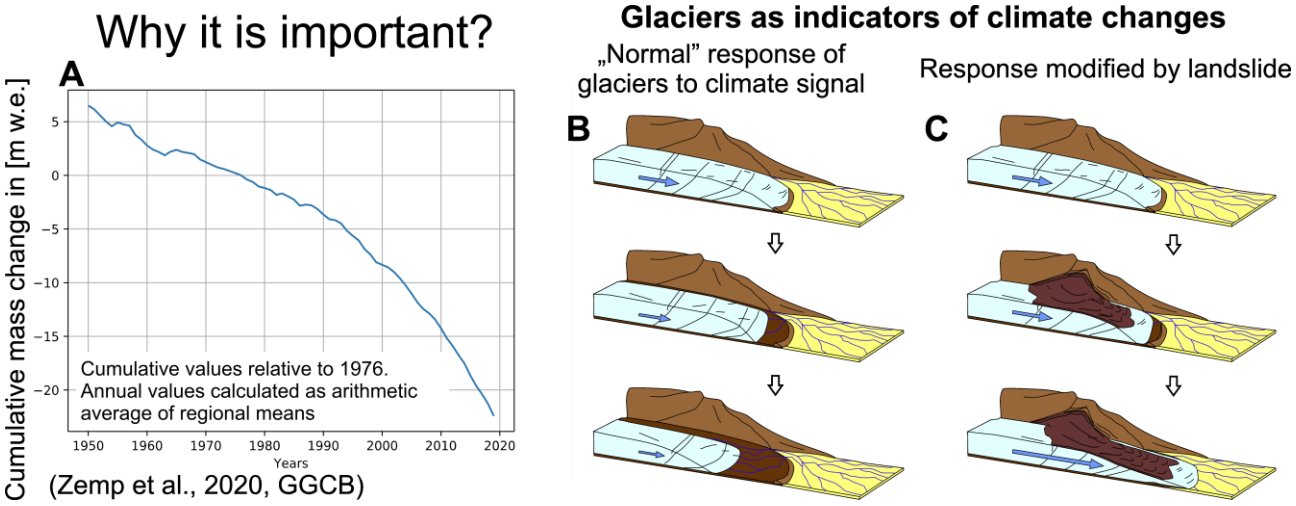
Global assessment of glacier-landslide interactions and associated geo-hazards

Rationale and motivation - Worldwide disappearing ice masses are iconic images often used to illustrate global climate warming. Glacier dynamics are commonly utilised as an indicator of climate changes; however, ice masses respond not only to changes in climate but also to non-climatic (e.g. landslides, tectonic) changes in local environments. For example, some glaciers might exhibit a sudden increase in velocity leading to rapid advances of their margins. Such glaciers represent non-climatic members of the glacial community. Therefore, their current or former extent should not be used to infer about climatic conditions. Catastrophic glacier instabilities can also threaten human life and infrastructure. Hence, knowledge about the non-climatic response of ice masses is crucial for: treating glaciers as markers of climate changes; using them as indicators of past climatic conditions; predicting hazards for local communities.



The problem is that the exact causes of glacier rapid instabilities are not fully recognised, and several theories of potential causes exist including large-scale debris loading (e.g. by landslides), hydrological changes, and thermal switching. Whereas the last two components are widely accepted, the relationships between landslide and glacier dynamics are still somewhat controversial. So far, only a limited number of observations have attempted to quantify the impact of landslides on glacier behaviour. Our knowledge about the effects of an increase in supraglacial debris load (both natural and artificial) on glacier dynamics is still limited. Therefore, it is crucial to provide more systematic and quantitative data on glacier-landslide interaction, especially in the context of future climate changes and increasing human activity in mountainous and polar areas. In this project, we are going to focus on glacier-landslide interactions and associated hazards by studying their distribution at global spatial-scale. We are going to look at how the landslides impact glacier dynamics by delivering a large quantity of debris onto their surface, which can be one of the potential causes for glacier instability.

Objectives - The main research problem which we are trying to solve is the role of landslide-induced changes in glacier extent in comparison to pure climatically-driven glacial changes. This project aims to systematically investigate and quantify the impacts of landslides on glacier dynamics based on examples representing different types of glacial landsystems. Main objectives of the project are to:

1) Investigate the global distribution of large landslides and rockfalls onto the glacier surface over the last 50 years – based on medium-resolution satellite imagery.
2) Quantify landslide-induced changes in ice velocity and mass balance for selected case study areas based on time-series of high-resolution satellite imagery and digital elevation models.
3) Recognise the main mechanisms of changes in landslide-affected glacial landsystems based on modelling, field surveys and drone for collection of detailed spatial data.

Methods and expected results - The proposed research includes multi-scale investigations (global-, catchment- and glacier-scale) of landslide-induced changes in glaciers' behaviour. The project uses a multidisciplinary approach that integrates multi-data remote sensing observations (medium- and high-resolution satellite imagery, UAV-based imagery), geomorphological and sedimentological surveys with numerical modelling of glacier behaviour in a broad spectrum of glacial landsystems. Thus, the project will increase knowledge about: (1) spatial scale and the number of glaciers affected by landslides; (2) the role of additional supraglacial debris loading on the glacier dynamics and their extents, and; (3) differences between climatic- vs non-climatic responses in glacial landsystems. The measurable effects of the project will be: (1) research framework integrating multi-data remote sensing approach to investigate the distribution and dynamics of landslide-induced glacier changes; (2) database of the global distribution of landslide phenomena onto glacier surfaces; (3) quantification of changes in velocity and volume for landslide-affected glaciers.