The Chamoli-Disaster, 7^{th} of February 2021

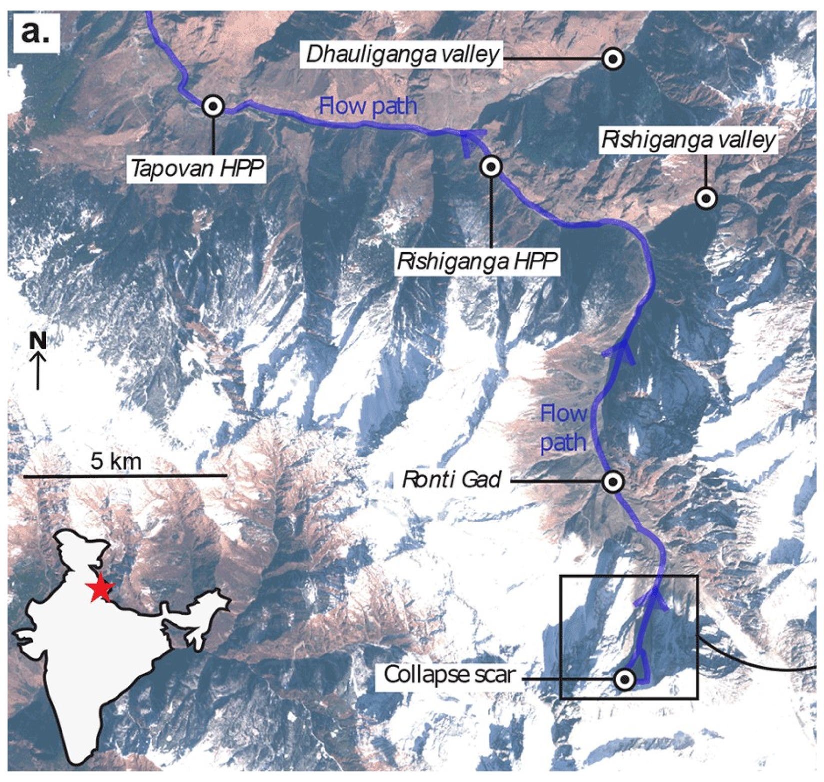
Tapio Werth 4324216

Institute for Physical Geography, Albert-Ludwigs-University Freiburg

Introduction

On the 7th of February in 2021 a north slope near the peak Ronti (6063m) collapse and caused a mass flow of rock & ice debris down the Rishiganga river valley, Chamoli, Uttarakhand, India. The collapsed area with a volumne of <27 mio.m^3 caused a massive avalanche, devastating the Ronti Gad, Rishiganga and Dhauliganga river valley, including severly damaging two hydropower plants and the death or missing of more than 200 people. The debris flow changed water flow and quality even in the Ganga river, ~160km downstream. Ice-mixture avalanches are the most devastating hazards in high mountain regions (HMR), due to high mobility and velocity. Climate change has an increasing impact in frequency and magnitude of avalanches. Since the scale of this landslide exceeded previous events, which led to a detailed analysis to improve future predictions [8, 7, 6, 2, 1].

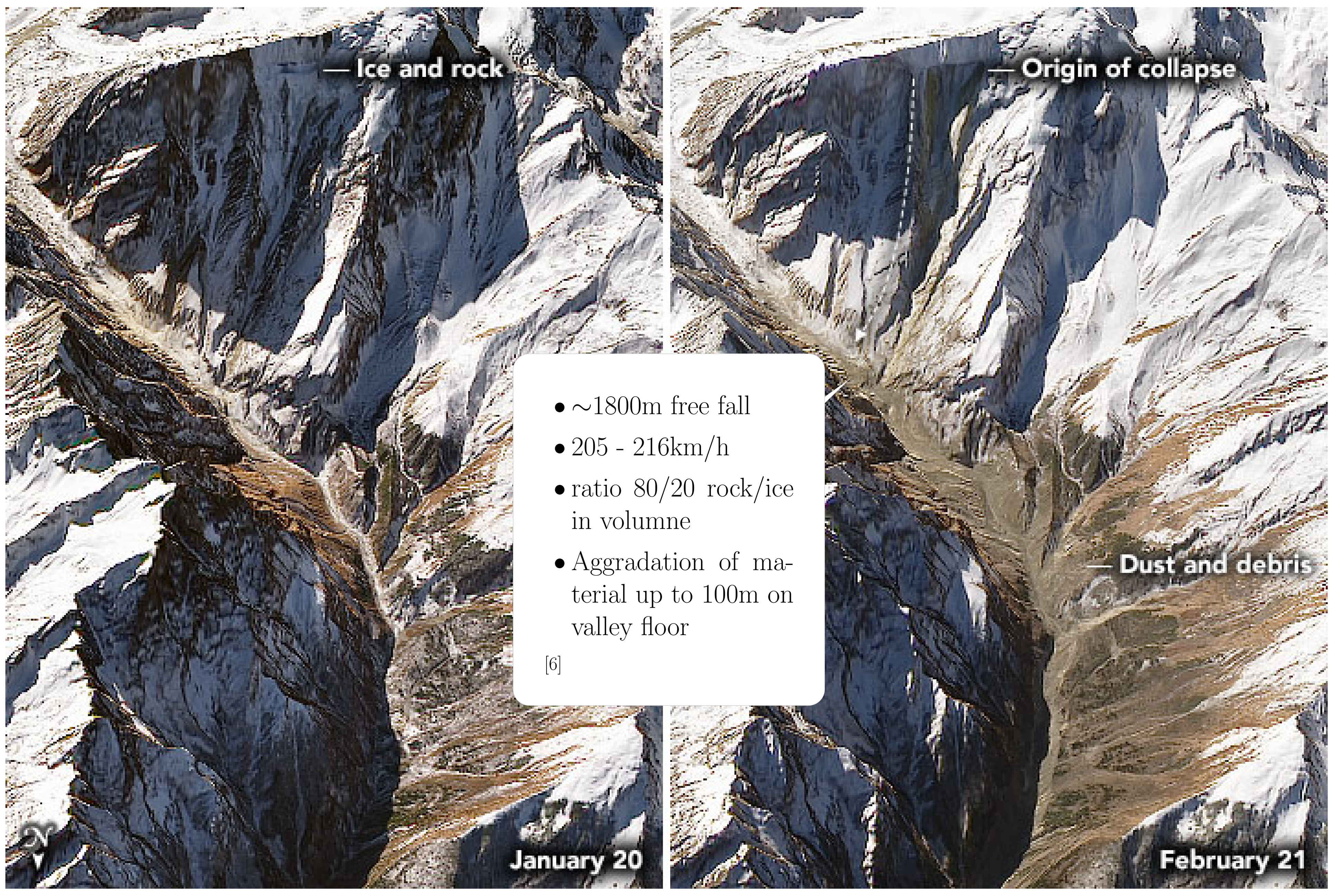
Location [7]



Climate

- Indian Summer Monsoon (ISM) influx
- 1770mm annual precipitation
- 54% of precipitation between June & August
- Mean annual average temperature is 2.1°C (1981-2020)
- Average air temperature **summer** 10.2 °C & **winter** -6.3 °C.
- MATA up to 2.26 °C in the last 40 days before collapse

Past & Prior [4]



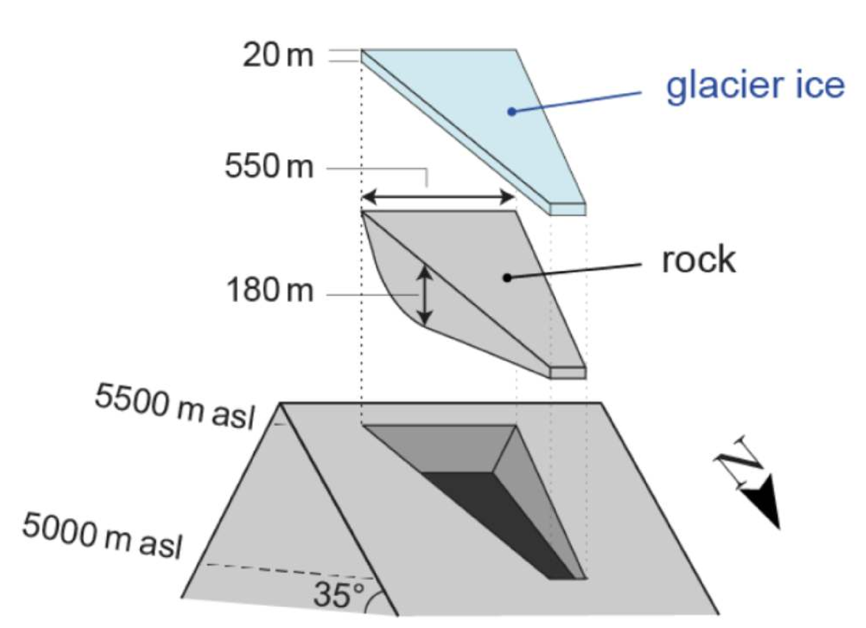
Hazard cascade

- **Summer 2017**: First signs of movement at the slope. Satellite images show a crack on top of the glacier with ~ 15m width.
- **Summer 2018**: Additional 10m down sliding of the area. Fracture reached up to 80m width into the glacier and bedrock [6].
- **Summer 2019** and **2020** significantly reduced expansion of the fracture.
- Over **autumn** and **winter** months, the glacier remained solid, without any changes. Although one should reckon this are the months with the highest likelihood for movements [6].
- **Fracture expanded** again in the last months leading up to the collapse.
- **23 earthquakes** occured during the 4 year progression of the fissure, with magnitudes of <5.2. But the observed fracture and the occurrence of the earthquakes differ in timesteps and therefore to consider separately as reasons of the collapse.
- On the **7^{th} of February 2021**, shy of 5am UTC the glacier area collapsed and descended ~ 1800m down into the Ronti Gad valley [8].
- The debris flow elevated the Rishinganga riverbed & valley ~1km downstream still up to 100m and traped people on site of the Rishiganga and Tapovan hydropower plants.
- The previously improved **water quality** from recent COVID-years changed severely with the rock & ice debris, which declined the water quality up to the junction of the Ganges river far down south [2].

Factors

The Himalayan High Mountain region (HMR) is a seismically active region, with frequent occurence of earthquakes, avalanches & landslides. Himalayan mountain range lies between the Tibetan plateau and Indian subcontinent, with a fracture-prone geology, glacial-shaped steep slopes or hanging glaciers. Significant increase in temparature occured throughout late January until mid February 2021. The mean air temperature anomaly (MATA) was up to 2.26 °C in the last days before the glacier burst, causing an abnormal winter melting event. Frictional heating melted the glacier ice, which accelerated the rock/ice avalanche even faster towards the valley and transformed it into a highly mobile and dynamic mass flow and caused the long distruptive force. Even 55km downstream signs of destruction and debris could be still observed. As a consequence, many research papers conclude this event to be a multi-factor triggered avalanche, respectively slope collapse, caused by a combination of a local MATA >2 °C, the long lasting decimation of the underlying bedrock structure, and neotectonic activity. The natural movement of hanging glacier bodies were foreclosed as driver behind the collapse. All papers tried to show ways to optimize the retrospective analysis of mountain hazards without local field observations [2, 3, 8, 6].

Collapsed area [6]



Prospects

- Field observations restricted due to dificult terrain, thus important work to implement field-based geotechnical monitoring.
- Different Remote sensing levels, numerical modelling and datasets are important measures contributing to a better understanding of multi-factorial hazard threats.
- Renewable energy from hydropower is an essential approach for India in effort to become climate neutral. To make critical infrastructures resilient to disasters, detailed knowledge of underlying causes of mountain hazards is crucial.
- It is of global interest to build a network of automatic weather stations to monitore large scale movements and changes in HMR, even in periphere regions.
- Better analysis of the local geological situation before planning critical infrastructure in disaster-prone regions can prevent human, ecological and economic loss.
- The Himalayan, as all HMR are highly sensitive for climate change and future events like this.

References

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