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The changes of Hailuogou Glacier in the southeastern Tibetan Plateau and the impacts on glacier dynamics from the mechanical ablation

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1. Introduction

Hailuogou (HLG) Glacier (Fig.1), a rapidly receding temperate land-terminating glacier in the **southeastern Tibetan Plateau**, has been observed to **lose mass partly through frontal mechanical ablation** (i.e., ice collapse).

The aim is to improve the **understanding of mechanical ablation** by achieving following three objectives:

- recent evolution of the **surface features** of HLG Glacier tongue
- **mechanical ablation** of the HLG Glacier terminus by using UAV
- the **contribution** of mechanical ablation to the mass balance

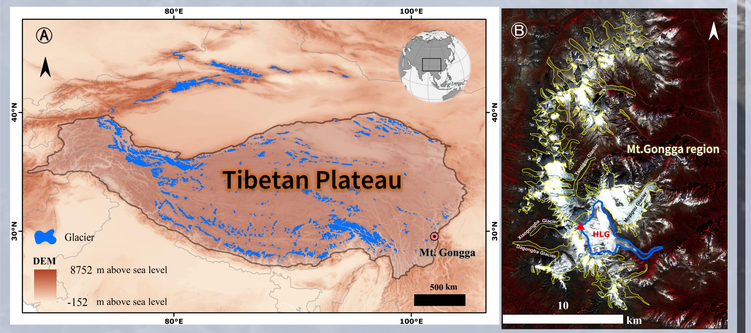


Figure 1.The extent of the Tibetan Plateau and the glaciers developed in Mt. Gongga.

HLG Glacier terminus experienced **thinning-retreating with extensive frontal ice collapsing-ablation** since 2017 (Fig.2)

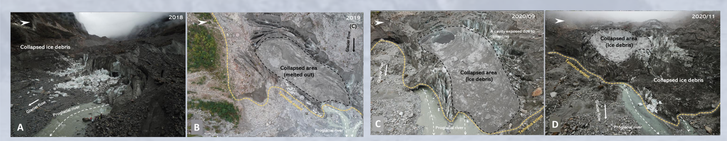


Figure 2.Traces of collapsing events at HLG Glacier terminus

References:

Xu, S., Fu, P*., Quincey, D., Feng, M., Marsh, S., & Liu, Q. (2022). UAV-based Geomorphological Evolution of the Terminus Area of the Hailuogou Glacier, Southeastern Tibetan Plateau between 2017 and 2020. **Geomorphology**.

Xu, S., Fu, P*., Quincey, D., Feng, M., Marsh, S., & Jia, T. (2022). Recent (2018-2021) glaciological, hydrological and geomorphological landscape changes of Hailuogou Glacier tongue, southeastern Tibetan Plateau. **Journal of Maps**.

2. Datasets and Methods

D1. Uncrewed Aerial Vehicles
- 2017-2021: 9 trips
- DJI Mavic Pro + Mavic Pro 2
- **2 collapse events captured**

D2. PlanetScope images
- 2009-2022
- Dove satellites (3.5 m)

D3. ASTER L1A images
- 3N+3B -> stereo images
- 2002-2021

M1. Structure from Motion with Multi-View Stereo (SfM-MVS) workflow

- *3-D surface reconstruction for producing ortho-mosaics/DSMs from UAV images*

Figure 3. Flight path, mapping extents, tie-points, and two UAVs

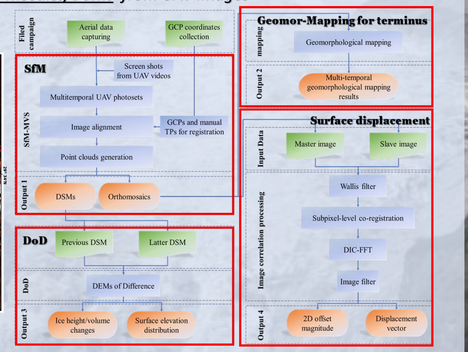


Figure 4. The SfM and 3-methods applied to ortho-mosaics/ DSMs

M2. Glacier outline extraction

- *Time-series of HLG Glacier outlines extracted from PlanetScope images, and more frontal collapse events*

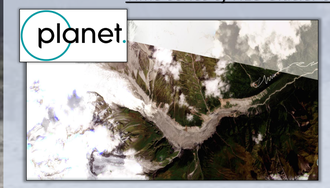


Figure 5. HLG Glacier tongue (PlanetScope)

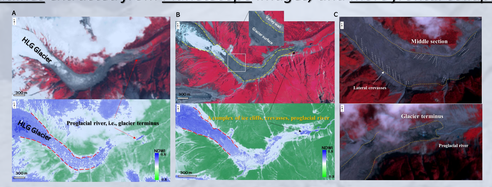


Figure 6. Auto/manual delineation of HLG Glacier extents

M3. DEMs derived from ASTER L1A stereo images (bands: 3N+3B)

Toolkit: NASA Ames Stereo Pipeline (ASP)

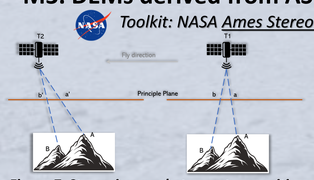
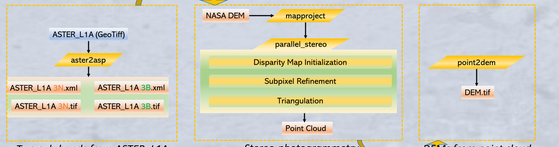


Figure 7. Stereo-images between two positions

Figure 8. NASA Ames Stereo Pipeline (ASP)



Two sub-bands from ASTER_L1A *Stereo-photogrammetry* *DEMs from point cloud*

3. Results

Figure 9. Surface evolution of HLG Glacier tongue

a. Changes of HLG Glacier tongue/terminus (Fig. 9)

- The frontal terminus retreated **132.1** m, whereas the collapsed terminus retreated **236.4** m, from 2017-2020.
- Ice loss from **a single collapse event** can exceed the **interannual** ablation level;
- ~ **28%** of ice loss is attributed to the **frontal collapsing** for the observed areas.

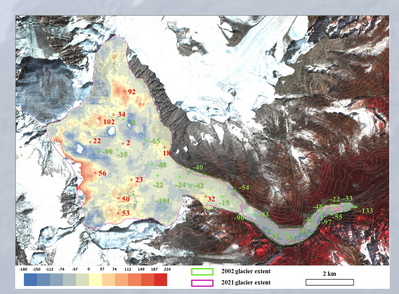


Figure 10. Elevation changes of HLG Glacier from 2002-2021

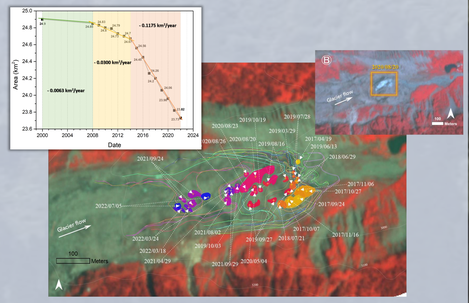


Figure 11. Terminus area changes and ice collapsed events

b. The contribution from mechanical ablation

- The annual mean ice mass change (2002-2021) is - 0.66 ± 0.05 m w.e. (**1.5 times** than that from 1968 to 2000)
- The contribution to the glacier mass balance that is attributed to **frontal ice collapse** is

0.49 to 1.12%

4. Key findings

- The glacier terminus was partly controlled by the **frontal ice collapse**
- Single collapsing event can exceed previous annual level.
- **Thinning-retreating with massive frontal mechanical ablation**
- The contribution to mass balance is limited, however it has probably changed the way of losing ice mass to some extent.

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