Evolution Of Geodetic Mass Balance Over The Largest Lake-terminating Glacier In The Tibetan Plateau Based On Multi-source High-resolution Satellite Data

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Abstract

This work focuses on relatively accurate evaluating the penetration depths of both C-band and X-band radar for glacier areas of the south-eastern Tibet Plateau and further estimate multi-temporal glacier mass balance for the largest lake-terminating glacier in the TP based on the geodetic method. Our results demonstrate that there are either an underestimation of 60% or an overestimation of 202% for the previous C-band penetration corrections. We also found that the rate of mass loss of Yanong Glacier has doubled since 2000, and the interannual mass change has shown a highly volatile and accelerating trend.

Introduction

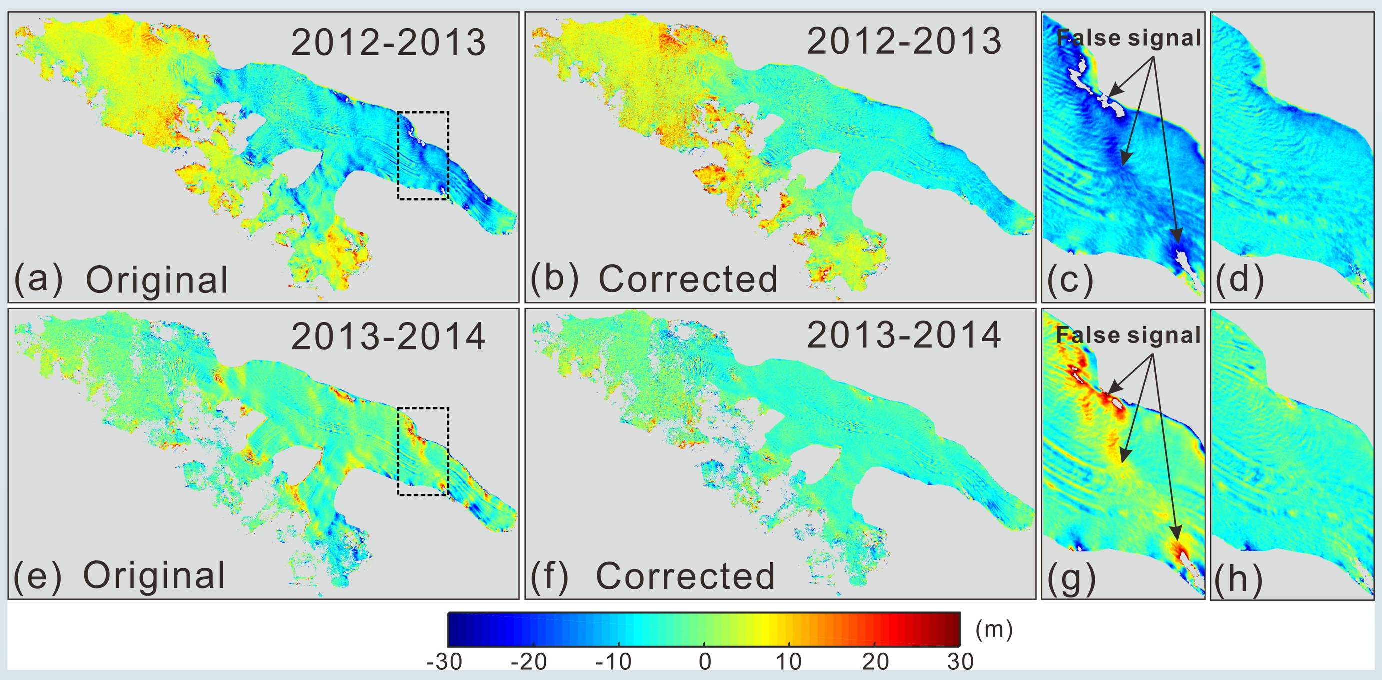
- The lake-terminating glaciers experienced the most rapid mass loss, but their evolution remains unclear.
- Time-series monitoring of glacier mass change is essential to facilitate understanding of this rapid thinning mechanism, but the unknown radar penetration depth limits relevant studies.

Objectives

- Evaluating the penetration depths of C-band and X-band radar in the glacierized areas of the southeastern Tibet Plateau.
- Unraveling the evolution of mass balance of the lake-terminating glacier.

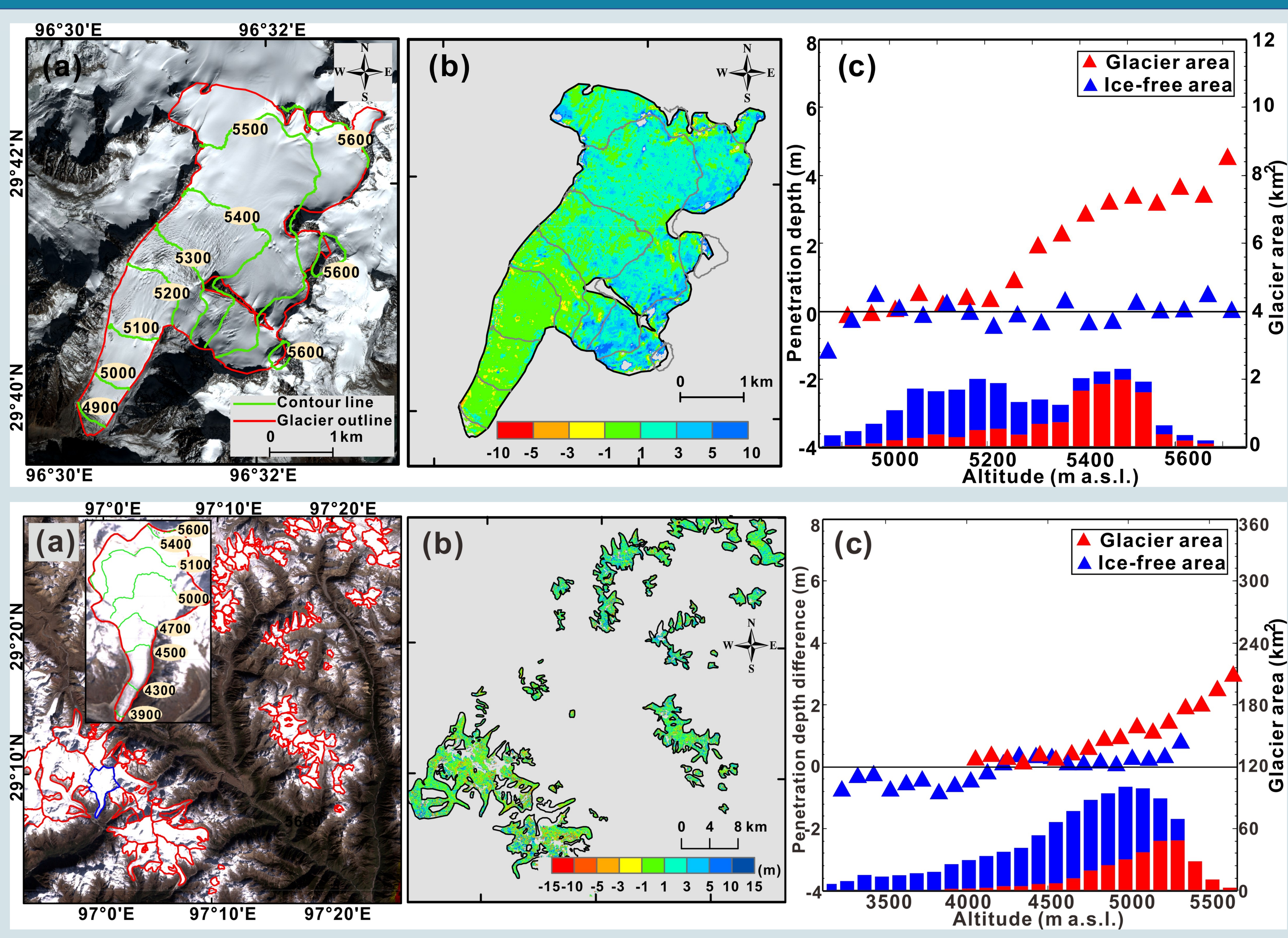
Methods

- We used Pléiades stereo data and TanDEM-X bistatic data with an acquisition time of 4 days to estimate the X-band penetration depth in winter of 2013, and further calculated the C-band penetration depth.
- We used KH-9, SRTM DEM, SPOT-7 and multi-orbit TanDEM-X data estimate the multi-decadal and inter-annual glacier mass balance.



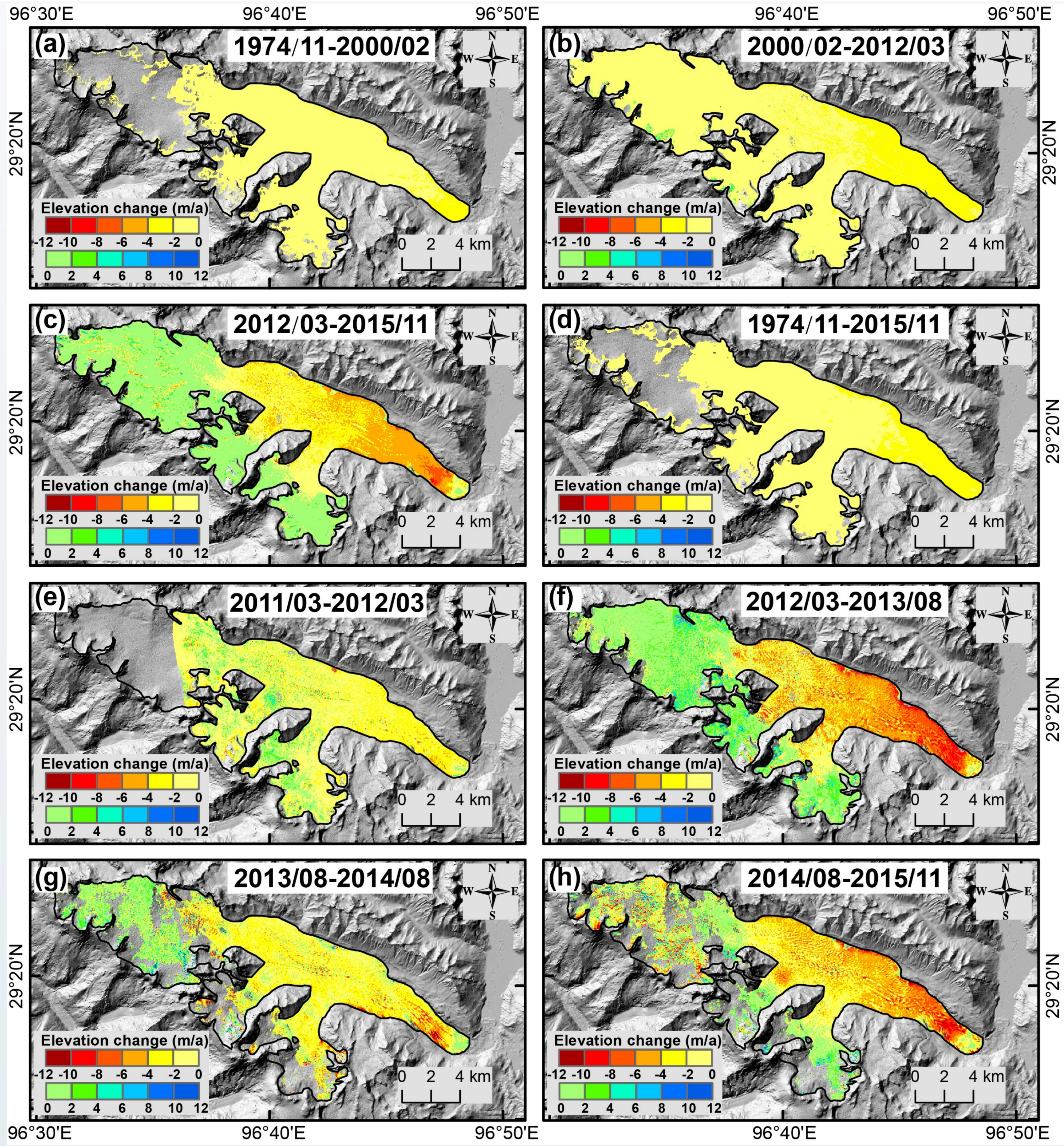
Left: The performance of the correction of the geomatic positioning error for TanDEM-X DEM based on a simple strategy we proposed in this work.

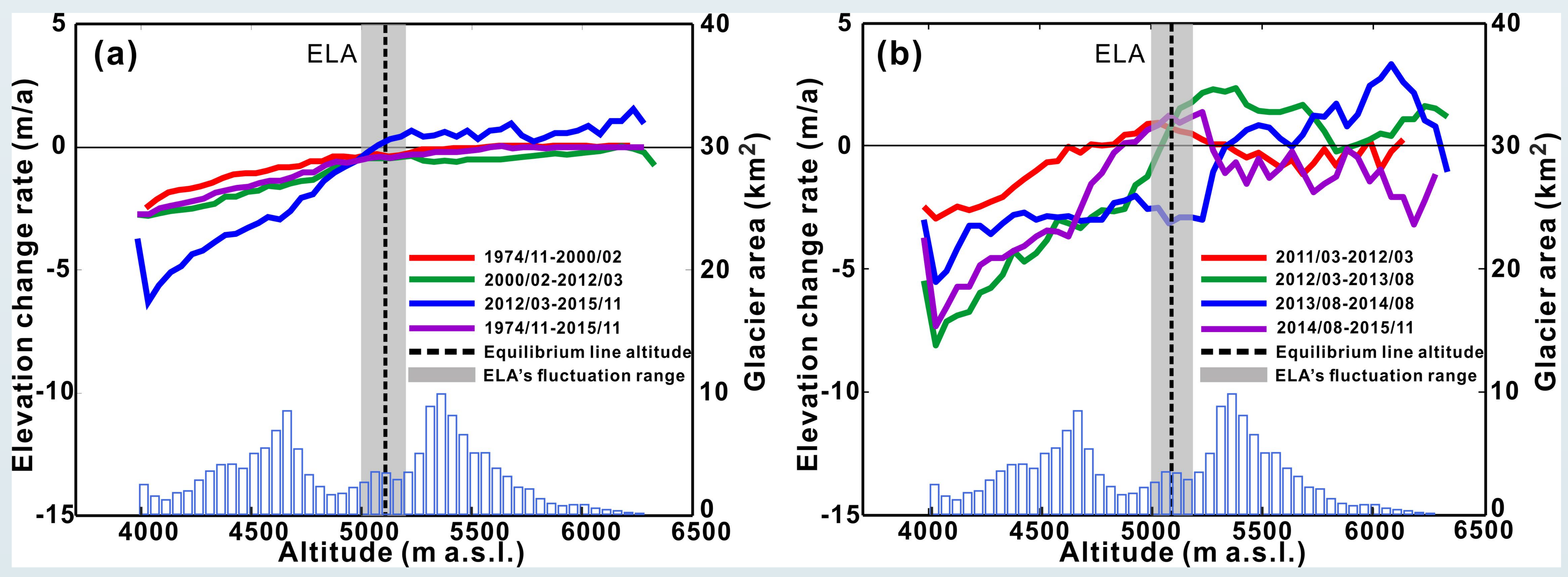
Results



Above: (a) Pleiades true-color image. (b) Penetration depth map for the X-band radar in the glacier area. (c) The relationship between the X-band penetration depth and altitude. The average penetration depths of the X-band radar are 3.19 ± 0.89 m and 0.96 ± 0.10 m for snow-covered and bare ice areas, respectively.

Below: Penetration depth difference between C-band and X-band radar. The average penetration depths of C-band radar are 1.47 ± 0.23 m and 1.20 ± 0.25 m for snow-covered and bare ice areas, respectively.

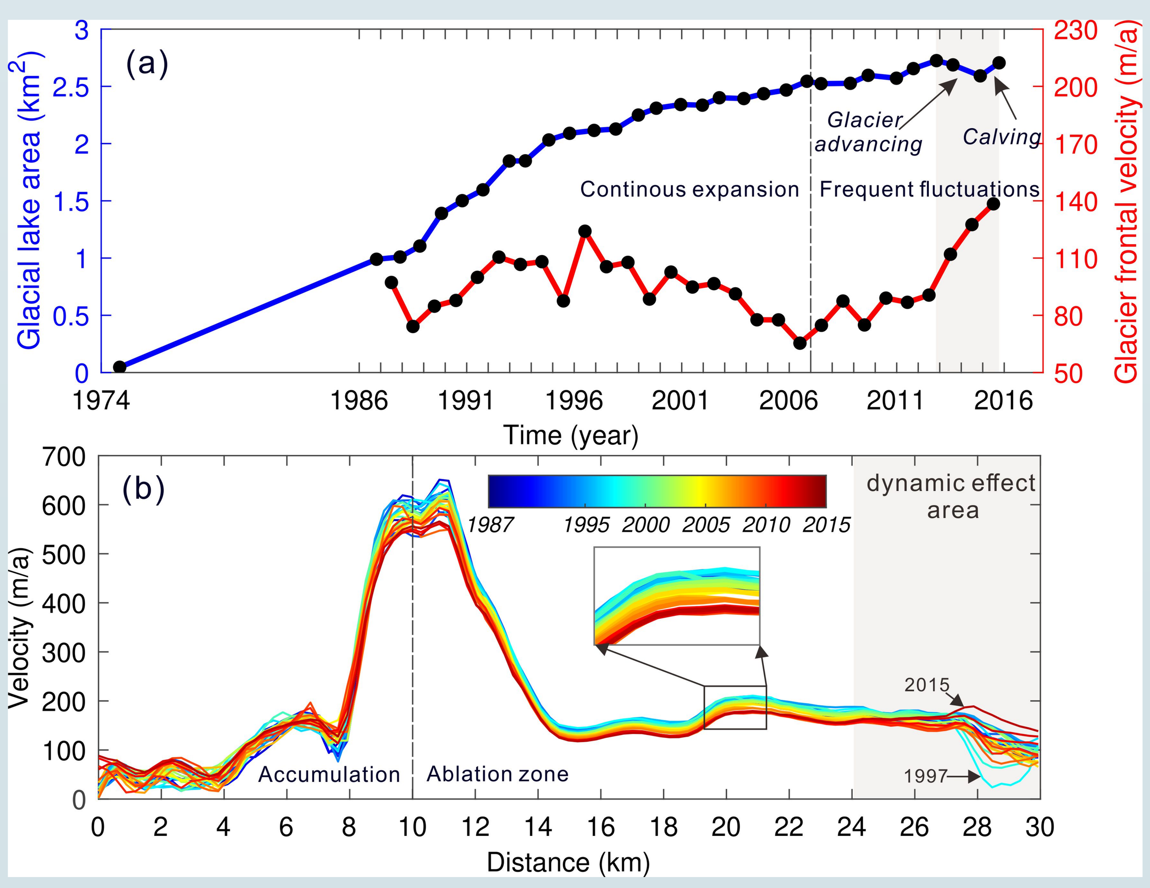




Above: Glacier thickness change for different periods.

Below: The rate of glacier thickness change as a function of altitude for the multi-decadal timescale (a) and for the inter-annual timescale (b). The ELA represents the equilibrium-line altitude.

Discussions



Left: (a) The time-series change of the proglacial lake area and the evolution of the glacier velocity at the midpoint of the terminus of the Yanong Glacier from 1974 to 2015.

(b) The changes in glacier velocity along the central flowline of the Yanong Glacier .

Conclusions

- The long-term accelerated mass loss of the Yanong Glacier has mainly been driven by climate change.
- The contribution of dynamic thinning to the overall mass loss has been limited (only acting on the front area of the glacier).
- Subglacial/englacial melting, to some extent, accounts for the acceleration of mass loss at the inter-annual timescale.

Major references

- Benn, D.I., Warren, C.R., Mottram, R.H., 2007. Calving processes and the dynamics of calving glaciers. Earth Sci. Rev. 82 (3–4), 143–179.
- King, O., Bhattacharya, A., Bhambri, R., Bolch, T., 2019. Glacial lakes exacerbate Himalayan glacier mass loss. Sci. Rep. 9 (1), 1–9.