



Two Decades of Glacier Mass Balance in the Southern Andes

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1. Motivation

Accurately quantifying glacier mass change remains challenging, particularly in regions with complex topography and rapidly retreating glaciers. A major limitation of current glacier change studies is the **lack of high-resolution, regional-scale datasets capable of resolving spatial variability in glacier behaviour**. This study assesses glacier-level mass balances (GMB) for glaciers with contrasting morphologies on sub-decadal timescales. The results provide valuable constraints for glacier models and contribute to improving regional glacier mass-balance estimates.

2. Study Area and Data

- ASTER Digital Elevation Model – AST14DEM v004 [1]
- SRTM 1 Arc-Second Global (30 meters resolution) [2]
- Glacier outlines — Randolph Glacier Inventory (RGI) v7.0 [3]

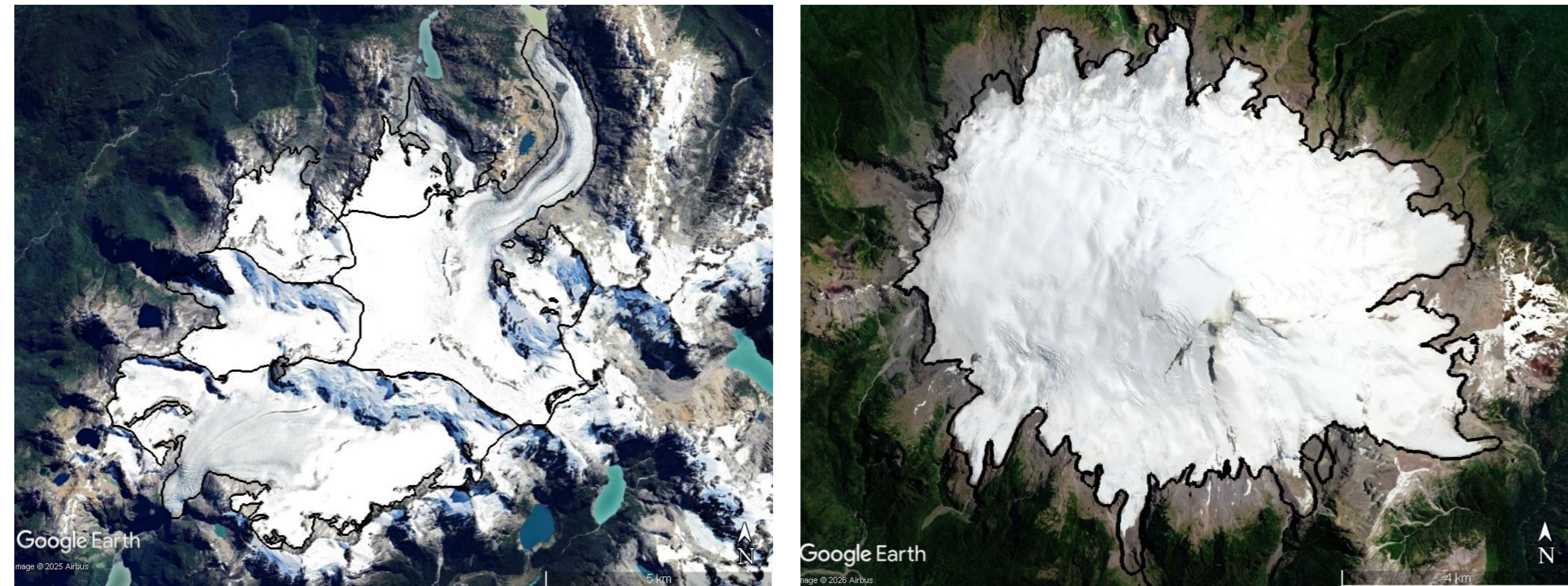
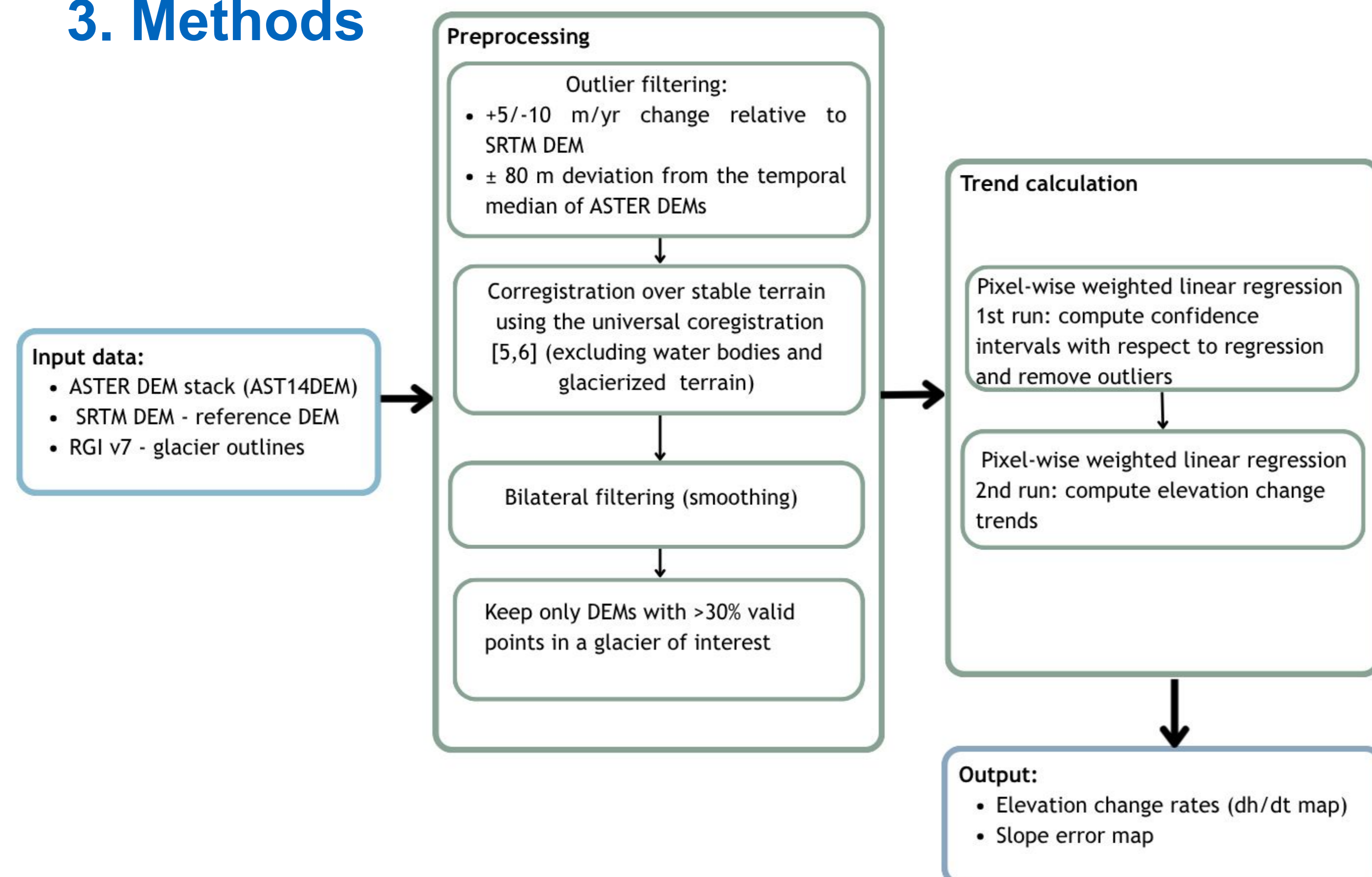


Figure 1. Test sites: Queulat Glacier Complex (102 km²) and Stratovulcano Melimoyu (55 km²) [4]

3. Methods



4. Results

4.1 Elevation change rates in sub-region of test glaciers

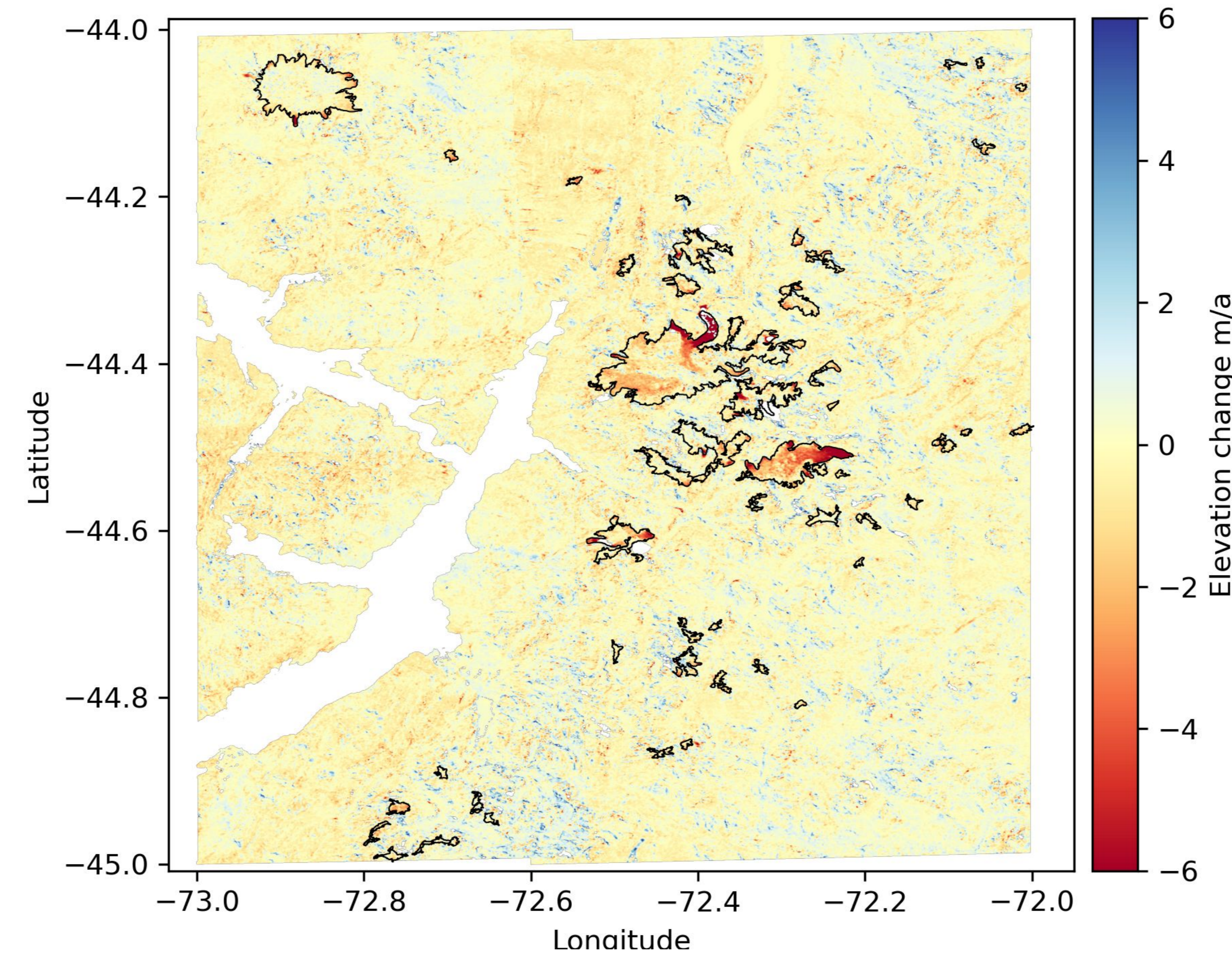


Figure 2. Elevation change (dh/dt) derived from DEM differencing.

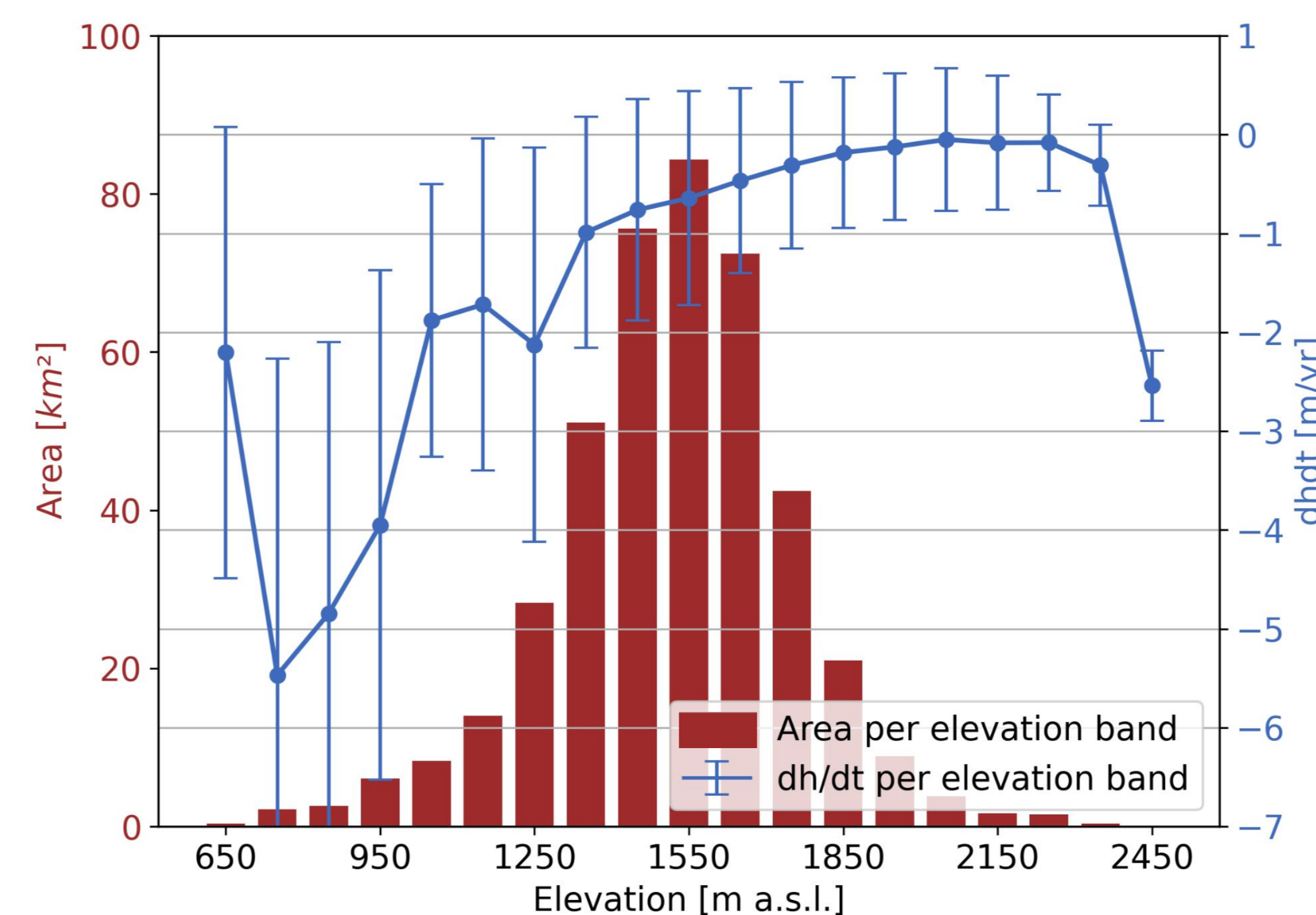


Figure 3. Elevation change (dh/dt) with respect to elevation bands.

- The sub-region shows a strong melt signal of up to -6 m yr^{-1} , dominated by a few large outlet glaciers.
- Hypsometry indicates pronounced mass loss at low elevations and near-stable conditions at higher elevations ($\sim 1900\text{--}2200 \text{ m a.s.l.}$).
- **GMB of sub-region = $-0.74 \pm 0.05 \text{ m w.e. yr}^{-1}$**

4.2 GMB across 5-10 year periods

Period	GMB of Queulat Glacier Complex [m w. e./yr]	GMB of Stratovulcano Melimoyu [m w. e./yr]
2000-2010	-0.38 ± 0.40	$+0.62 \pm 0.35$
2010-2015	-0.54 ± 0.08	$+0.26 \pm 0.24$
2015-2020	-0.51 ± 0.06	$+0.025 \pm 0.01$
2020-2026	-0.67 ± 0.05	-0.005 ± 0.005

- The glacier complex shows **consistently increasing melt** over time. By 2020–2026, its GMB is comparable to the GMB of the entire sub-region.
- In contrast, volcano-influenced glacier exhibits early accumulation followed by a recent transition to slightly negative mass balance.

4.3 How does melt change across elevation bands?

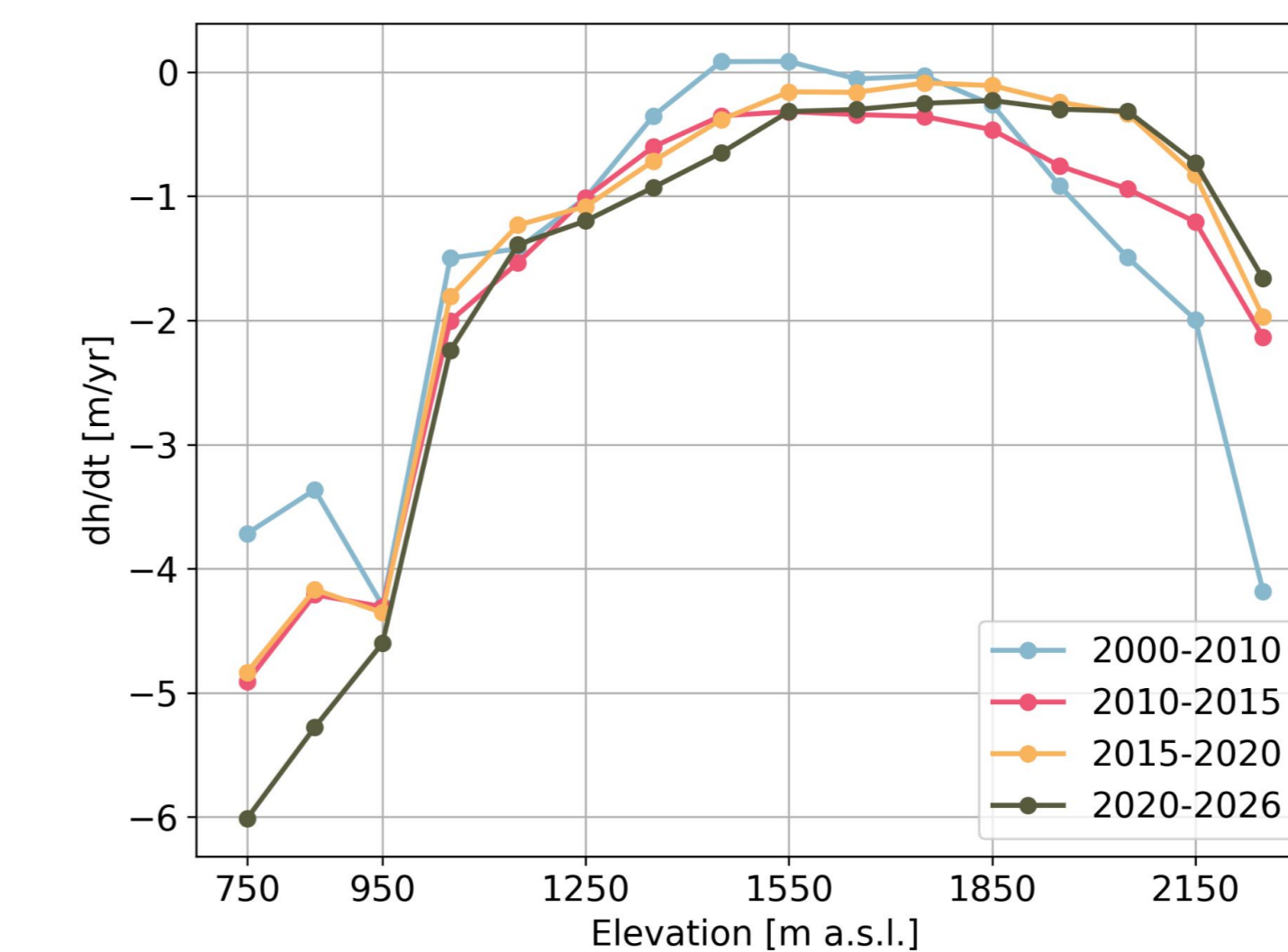


Figure 4. Elevation change (dh/dt) with respect to elevation bands for Queulat Glacier Complex.

- Increasing melt across all elevation bands.
- Significant acceleration in elevation lowering for lower, less stable altitudes until about 1000 m a.s.l.
- Equilibrium line altitude (ELA) shift.

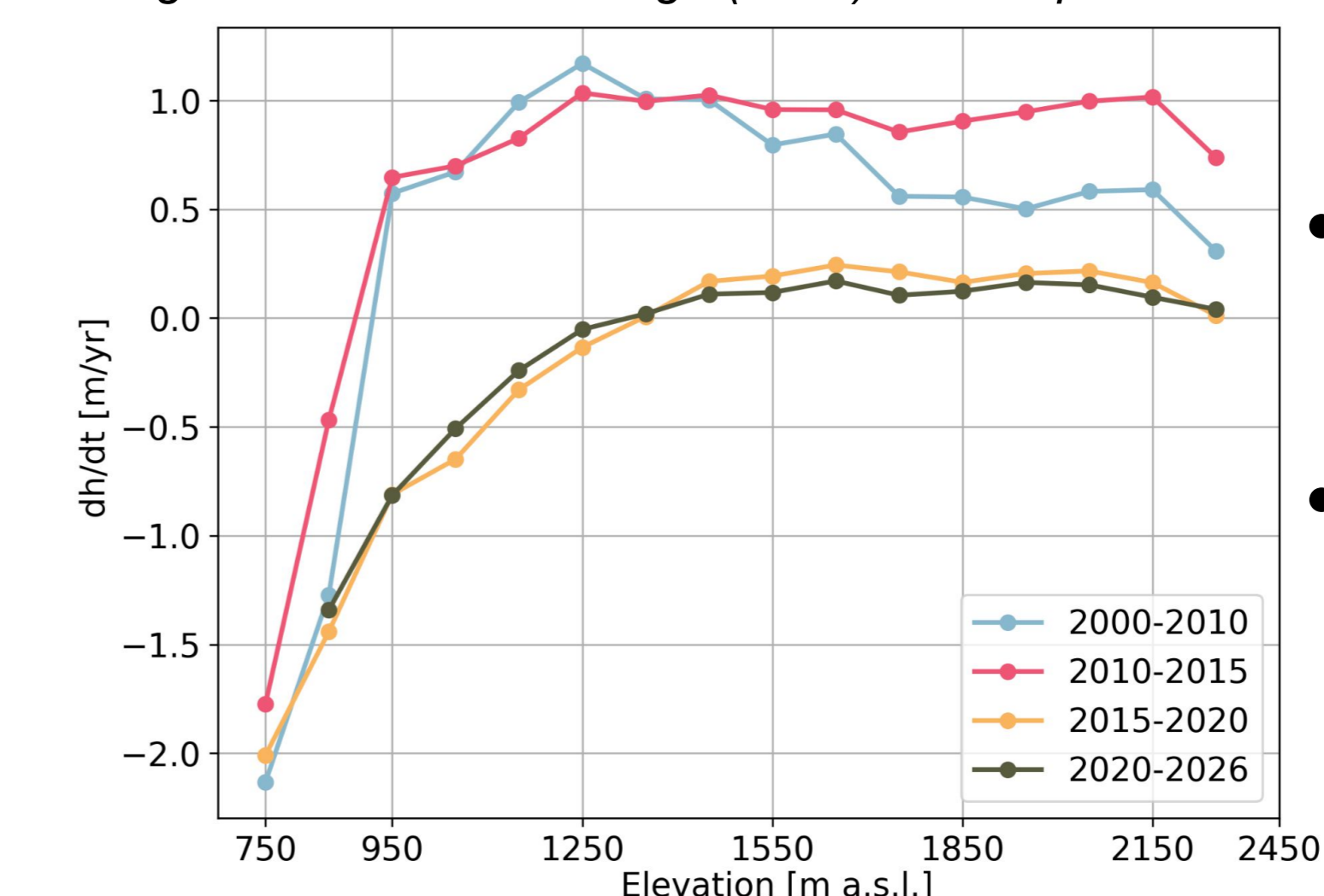


Figure 5. Elevation change (dh/dt) with respect to elevation bands for Stratovulcano Melimoyu.

- Volcanic topography produces different elevation thinning patterns, showing enhanced accumulation and reduced melt.
- Regional climate forcing affects both glaciers similarly at low elevations.

5. Conclusions

- Quelat Glacier Complex exhibits strong mass loss as well, showing acceleration of ice loss across all elevation bands but especially in lower altitudes.
- Stratovulcano Melimoyu glacier, influenced by volcanic topography and microclimate, has a near-neutral mass balance and contributes almost nothing to total mass loss. Nonetheless, this glacier experiences increasing elevation loss in lower altitudes as well.
- The contrast between the two glaciers highlights the impact of glacier type and local topography on melting patterns and total mass balance.

References

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