Five-decade glacier mass balance observations in the Indian Himalaya

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Importance of the Himalayan Cryosphere

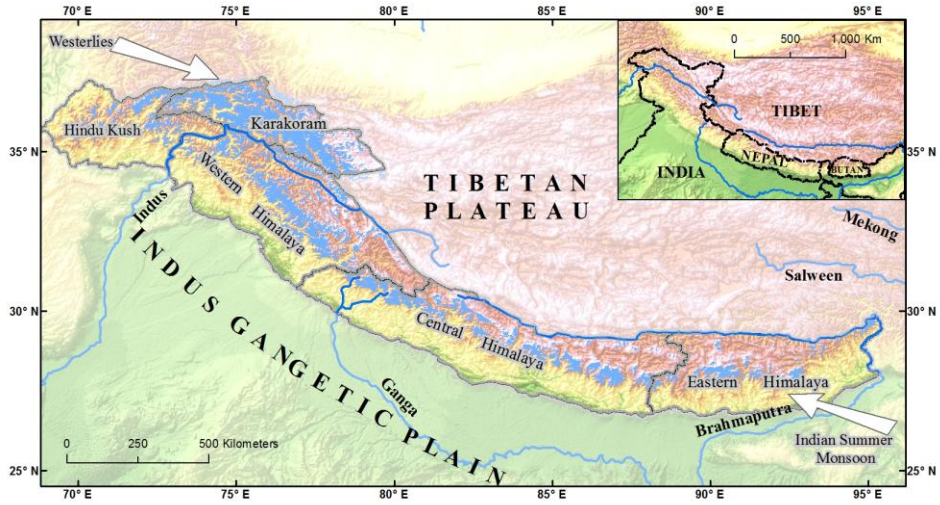
Vital water resources.

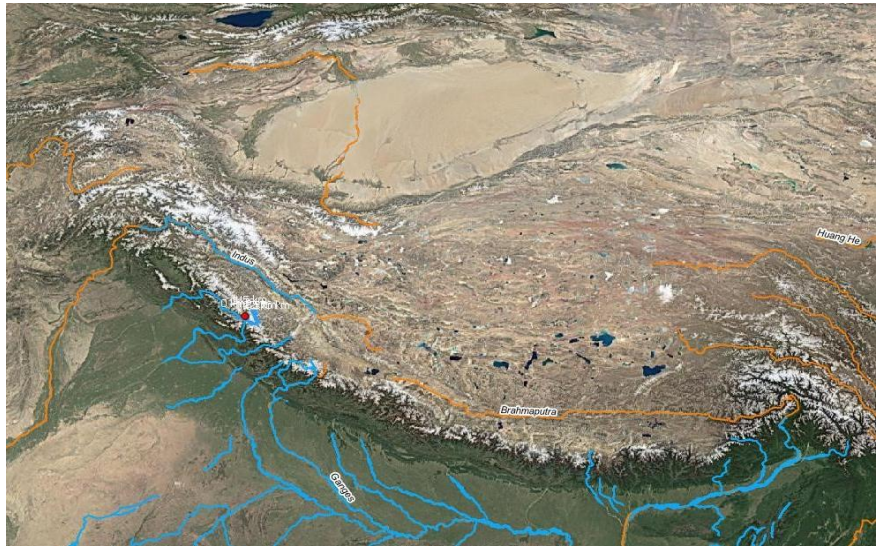
Impact on river systems and ecosystems.

Indicator of global climate change.

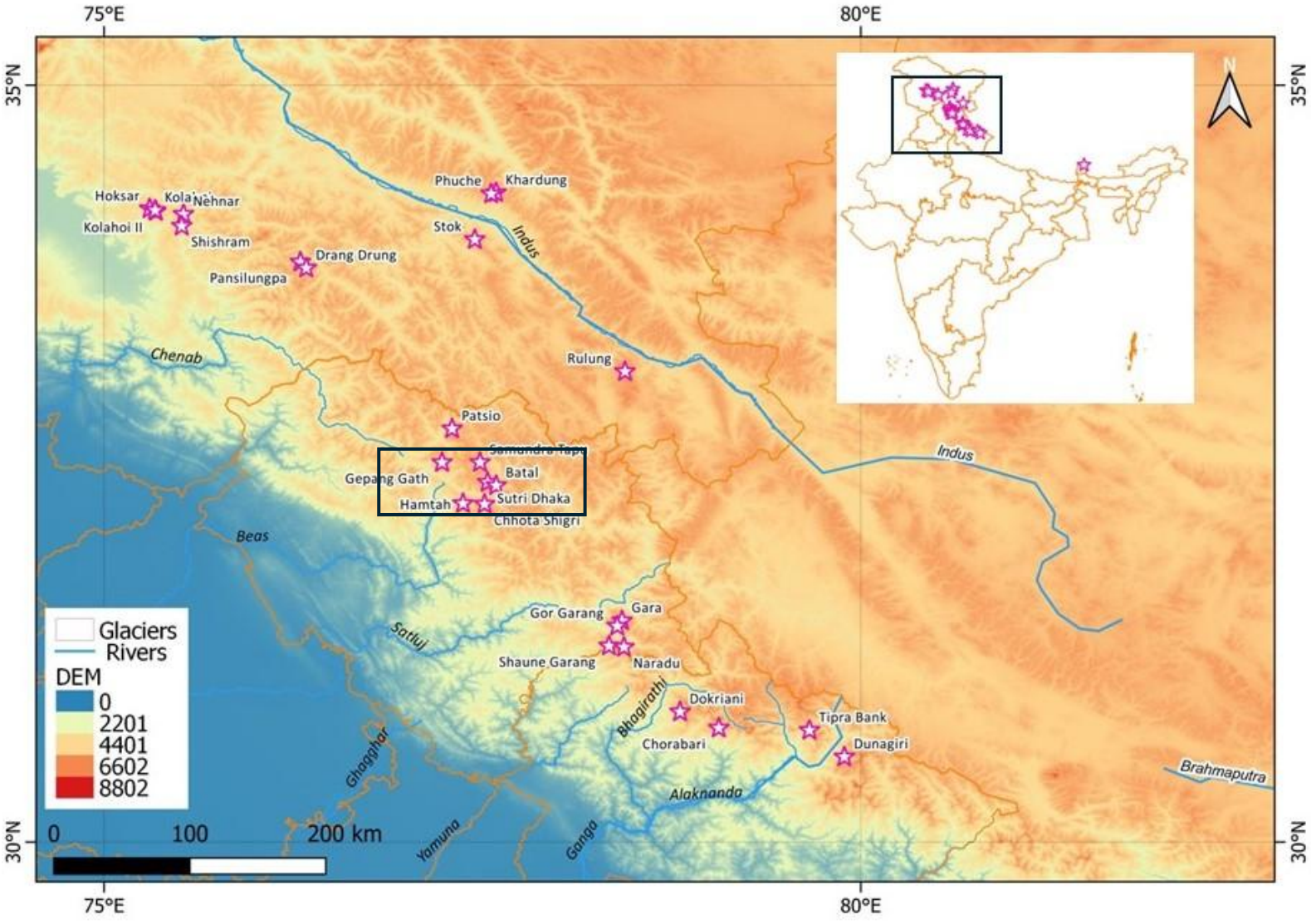
Monitoring glacier mass balance and ice volume changes.

Understanding cryosphere-climate interactions.



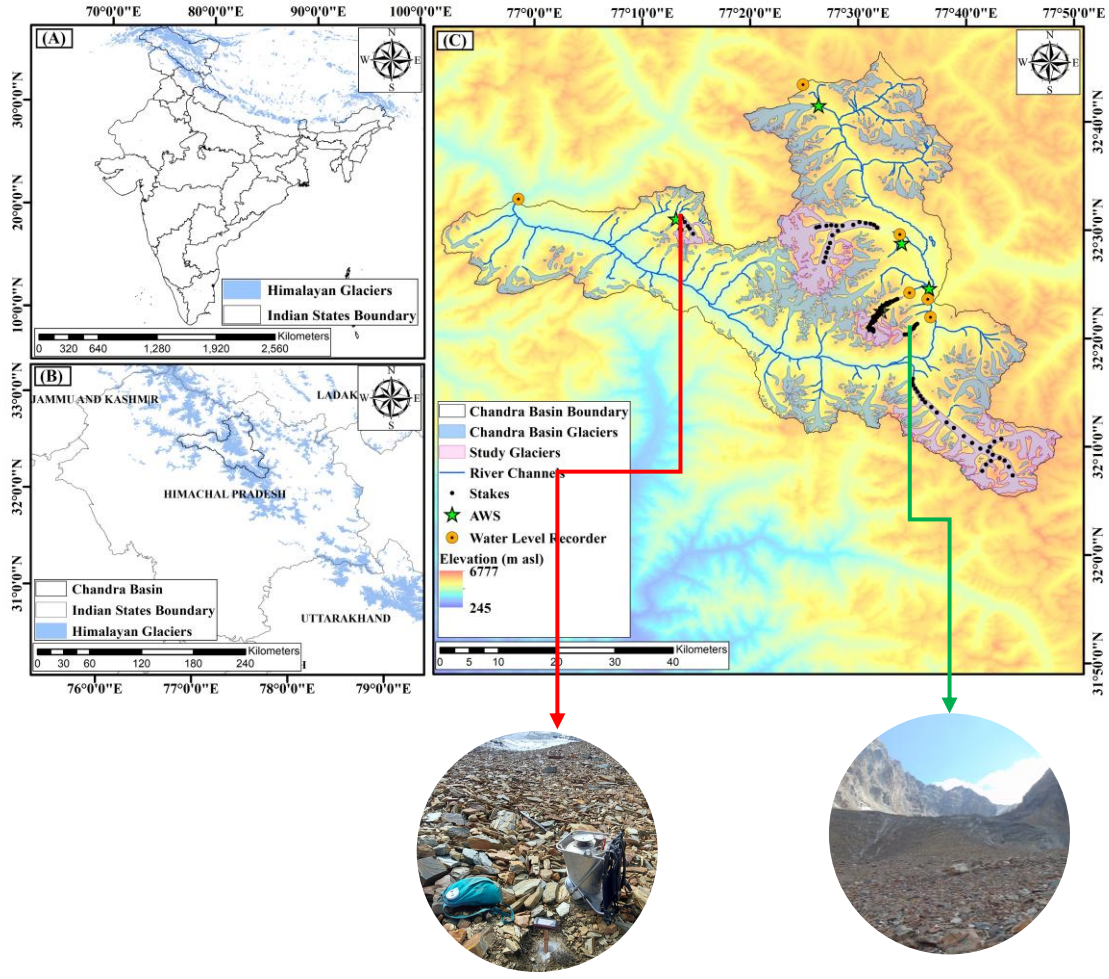


Glacier mass balance observations



Clean and debris-covered glaciers

Mass balance
Hydrological balance
Meteorological observations
Glacier dynamics



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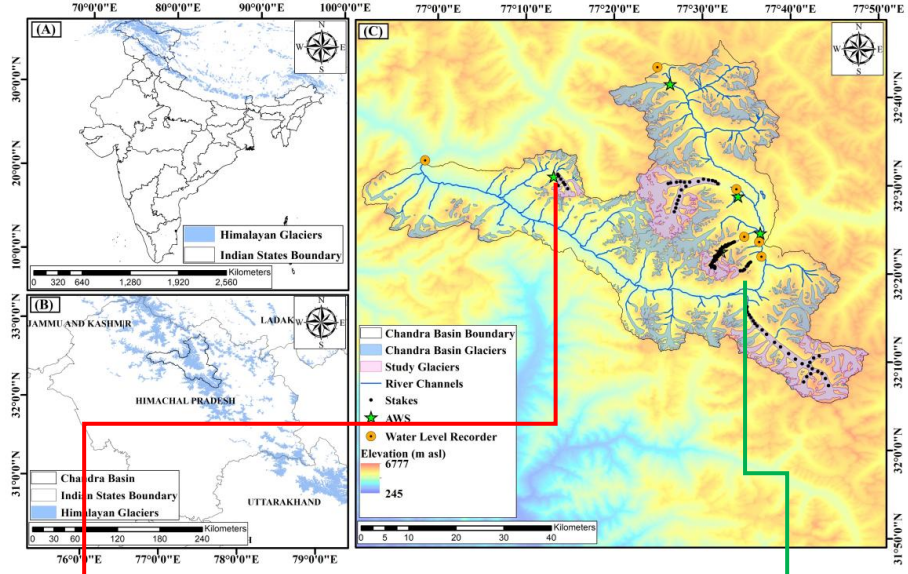
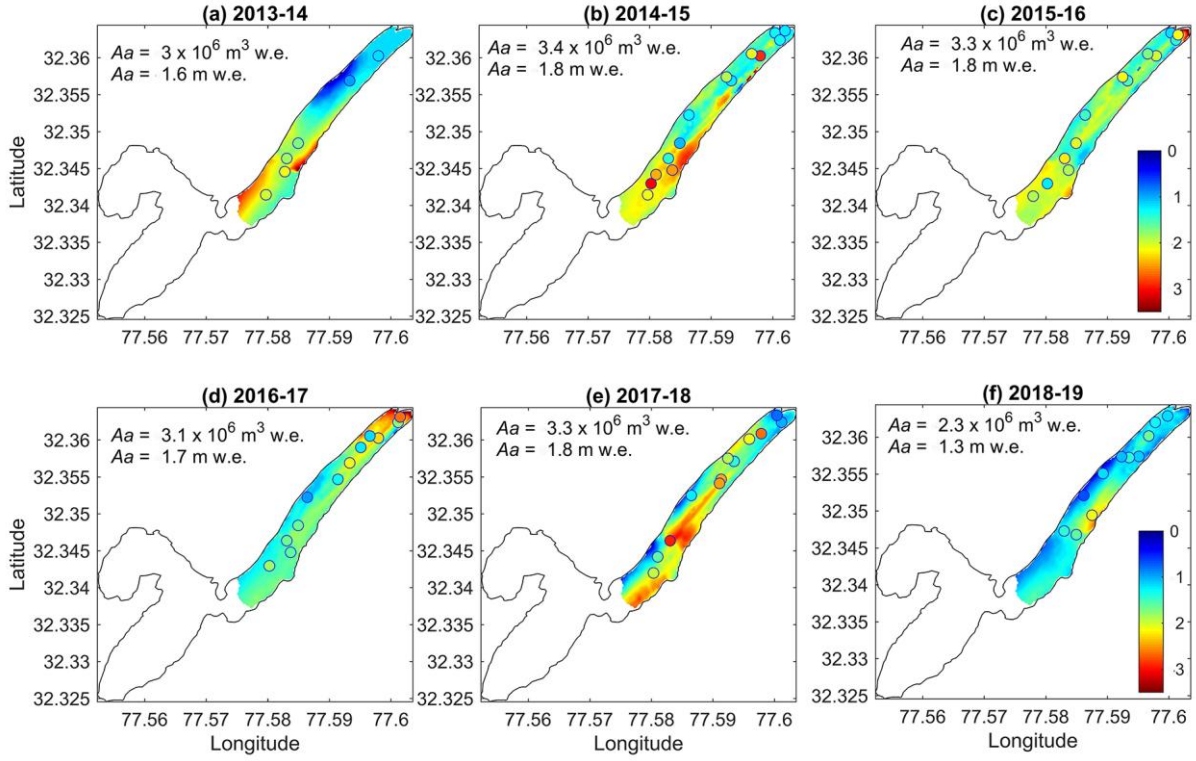


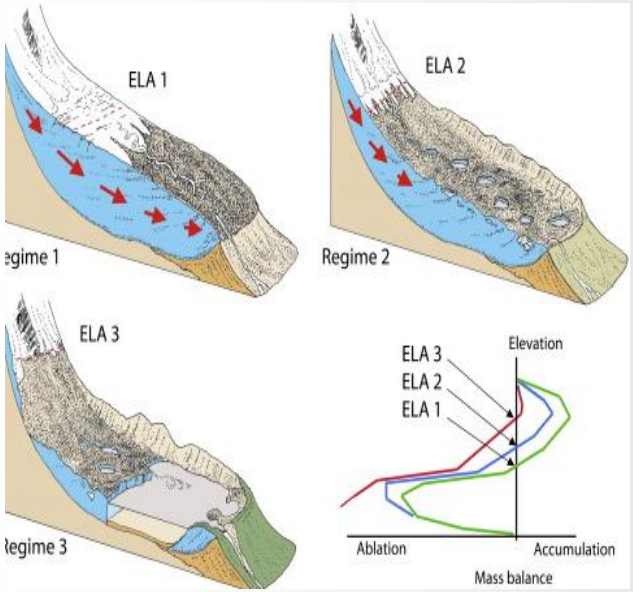
Batal Glacier

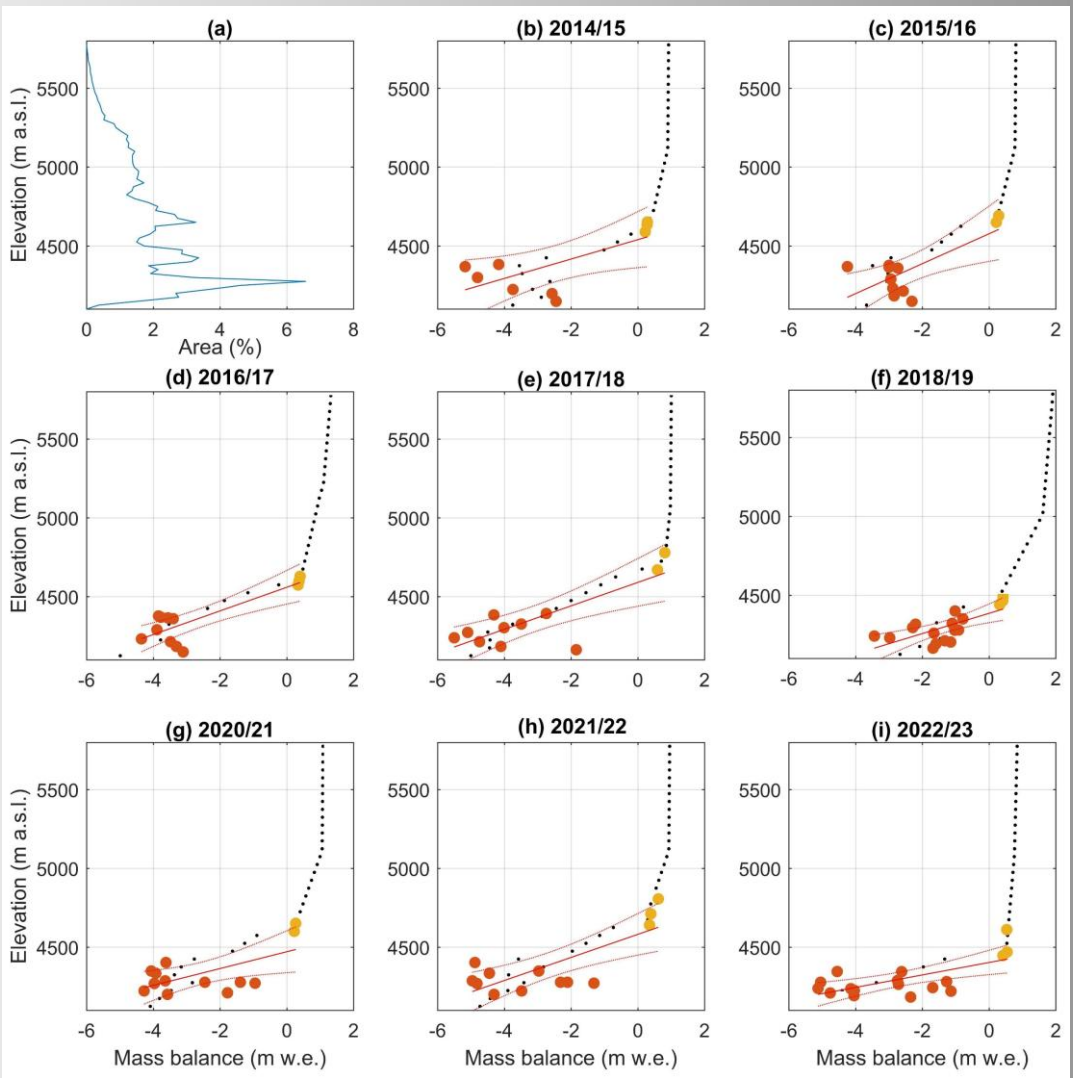
- ~80% reduction in ablation rate was found with the effects of debris varied from 2 to 72 cm.



Pratap et al., 2023 (Jo Geomorphology)

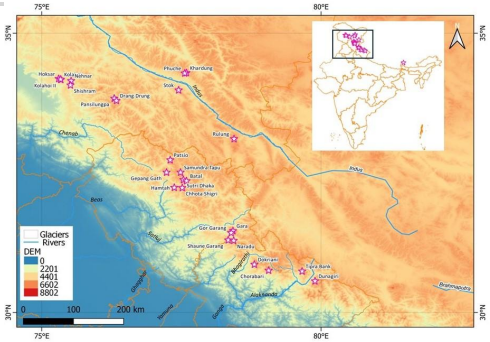
Gepang Gath Glacier

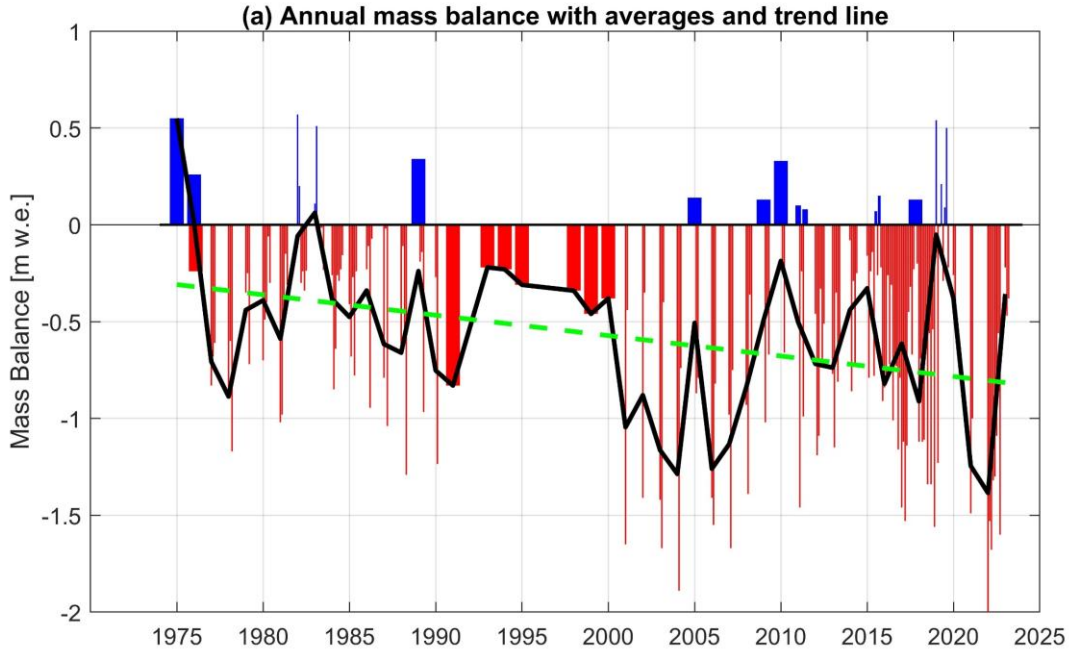


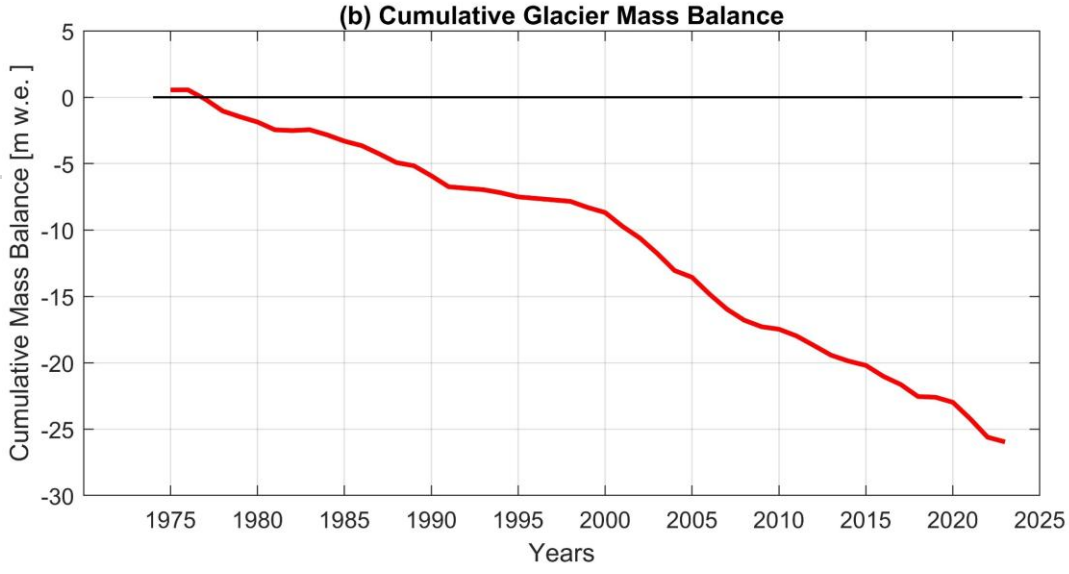


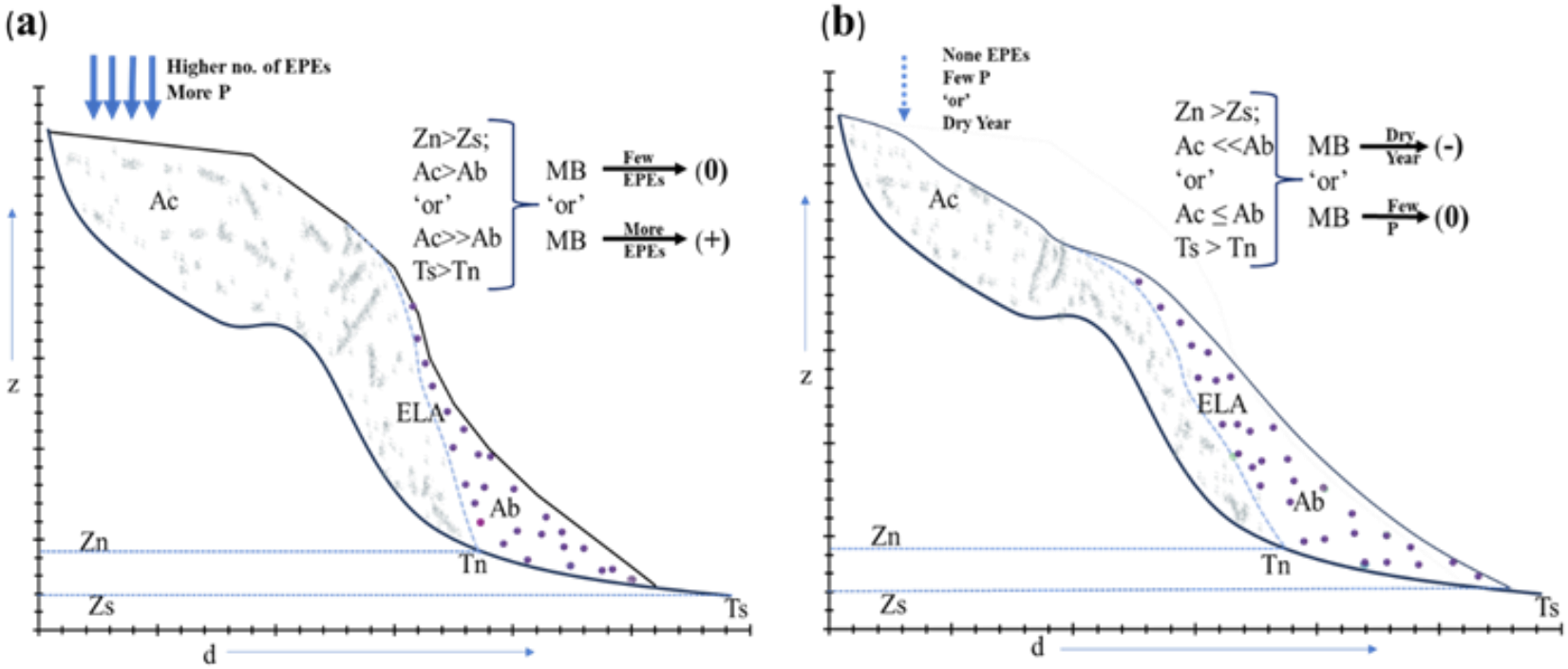
Pratap et al., 2025 (Jo Glaciology)

Current state of the Himalayan glaciers



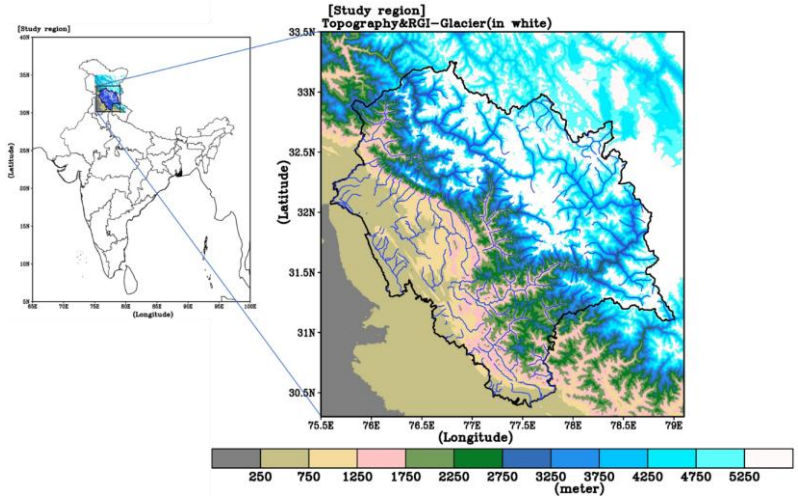


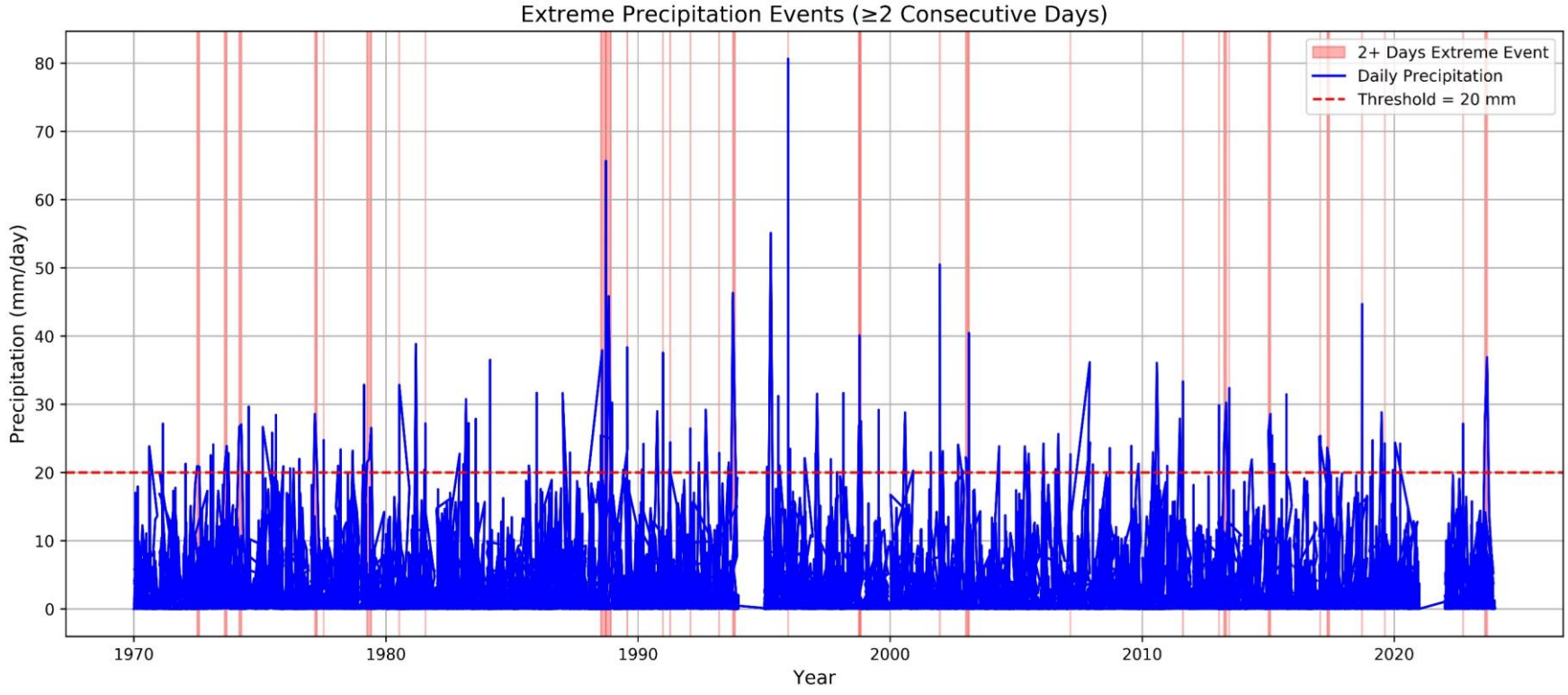


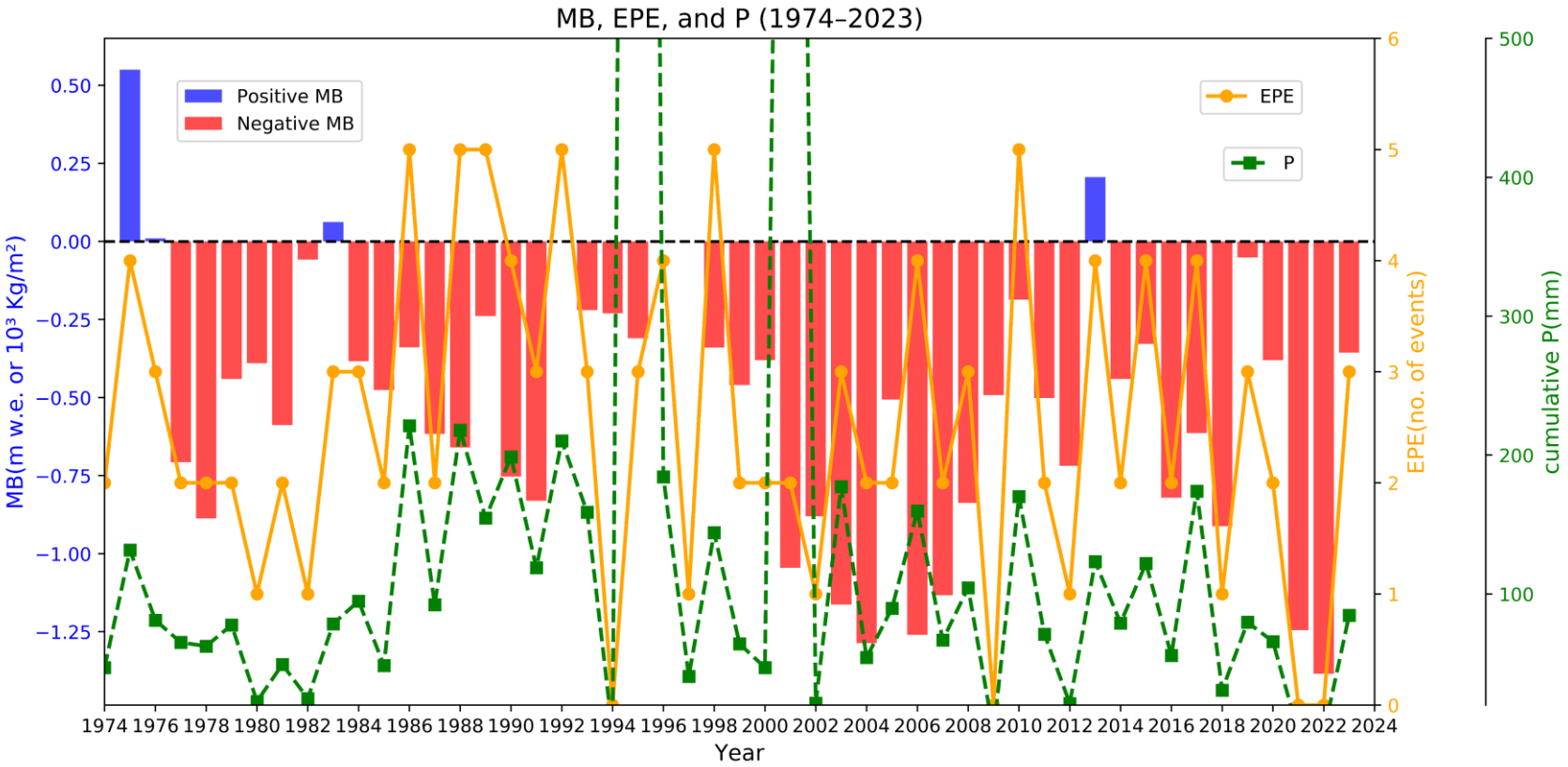


Correlation between EPEs and MB fluctuations

Figure shows substantial extreme precipitations corresponding to the negative temperature extreme.







Trends of Mass Balance and Extreme Precipitation Events

Conclusion

Over the past five decades, an accelerated mass loss of Himalayan glaciers has been observed.

EPEs activity are associated with relatively positive MB, indicating that extreme events can temporarily offset glacier loss through enhanced accumulation.

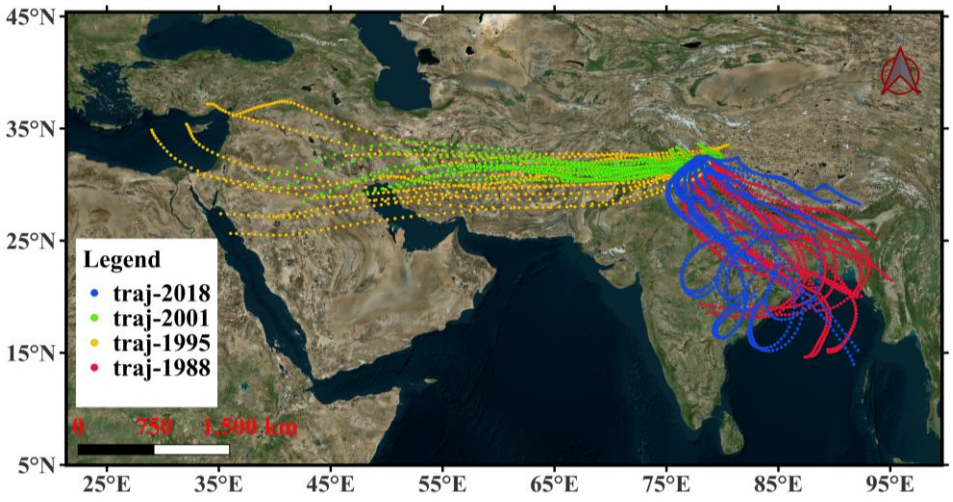
The source dynamics of EPEs such as the role of (WDs), (ISM) and mixed ISM+WD influences is yet to confirm.

Thank You

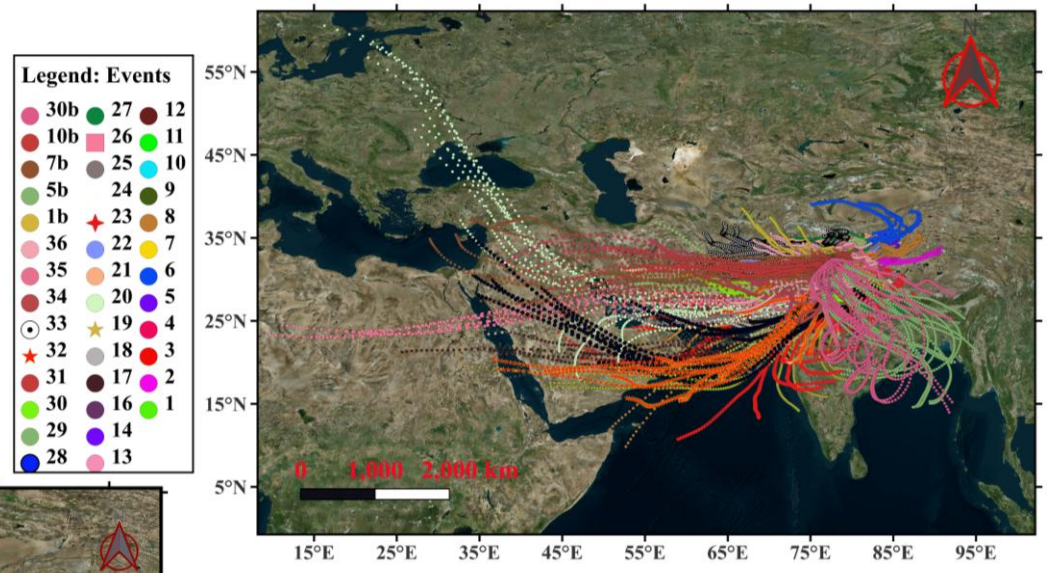
The backward trajectory corresponds to extreme precipitation events.

T_n=41 (total observed extreme events)
ISM_n=10 (Events controlled by ISM)
(i.e., **24.39%**);

$(WD+NAO+AMOC)_n$=31 (Events controlled by WD+NAO+ AMOC)
(i.e., **75.61%**)



The four captured *severe* extreme precipitation events' backward trajectory.



The Forty-one (41) captured extreme precipitation events' backward trajectory.

- Modeled trajectories potentially related to meteorological phenomena.
- These (phenomena) include atmospheric circulation patterns, extreme weather events (e.g., North Atlantic Oscillation NAO); Atlantic Meridional Overturning Circulation (AMOC), WDs, cyclogenesis, and monsoon depressions), hydrometeorological pathways (e.g., moisture transport to feed the extreme events).

GLOBAL GLACIER STATE

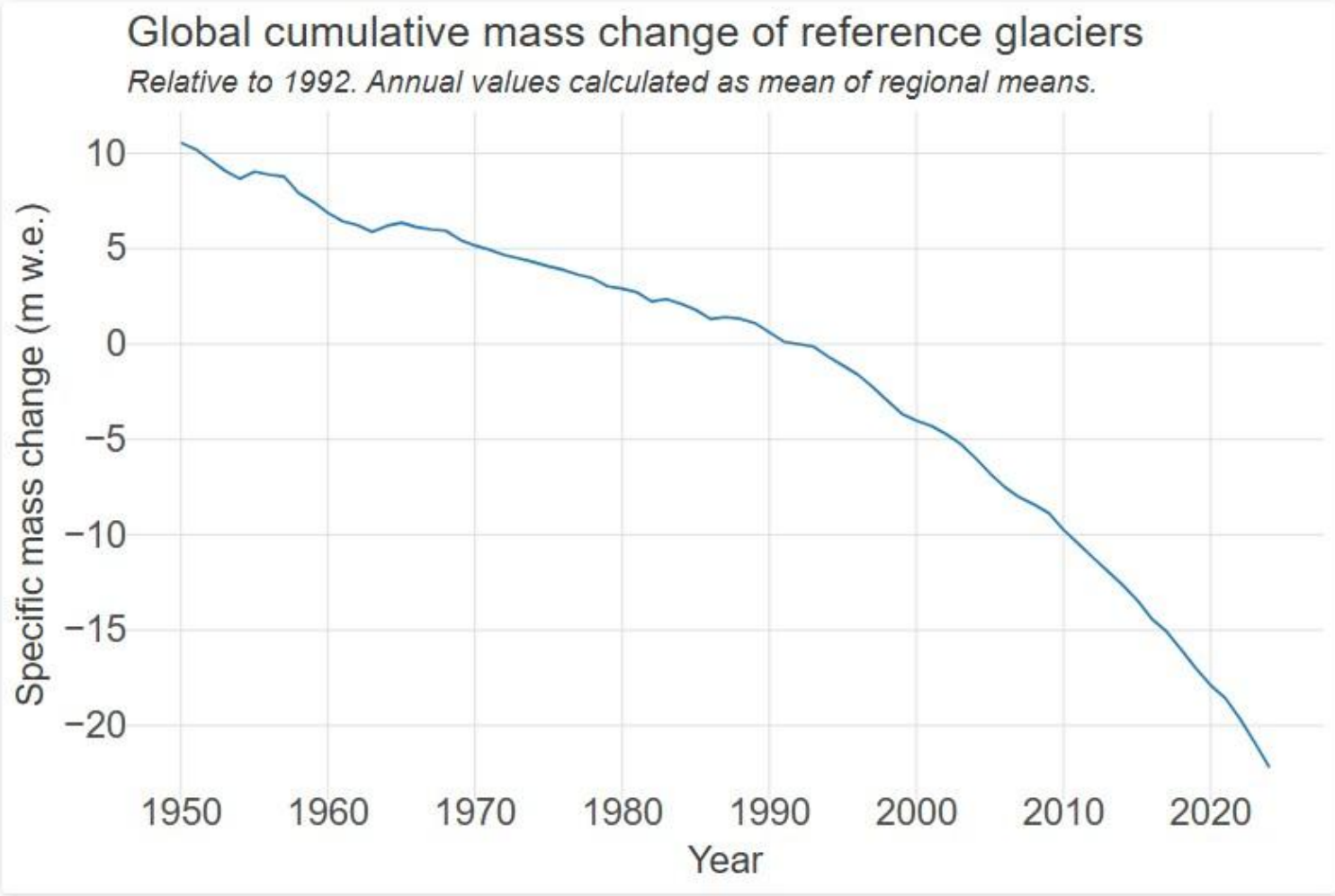


Figure 2: Cumulative mass change of reference glaciers. Cumulative values relative to 1992 are given on the y-axis in the unit meter water equivalent (m w.e.).

Source: WGMS