Extreme Glacier Melt in the Central Tibetan Plateau during the Summer of 2022: Detection and Mechanisms

Fei Zhu[1,2], Meilin Zhu[3]*, Lu An[1,2]

[1]College of Surveying and Geo-Informatics, Tongji University, Shanghai, 200092, China.

[2]Center for Spatial Information Science and Sustainable Development, Tongji University, Shanghai, 200092, China.

[3]Center for the Pan-Third Pole Environment, Lanzhou University, Lanzhou 730000, China.

Corresponding author: Meilin Zhu* (zhuml@lzu.edu.cn)

Table S1. List of the model parameters, range of parameters used to estimate the uncertainties in melt during extreme heat events and mass balance on Sangqu Glacier at glacier scale.

parameter	Value	+/-	Uncertainty in melt (mm w.e.)
a_{snow}	0.94	0.03	0
a_{firn}	0.75	0.03	-13.8
a	-0.3	10%	0
b	0.48	10%	-75
$T_{snow/rain}$(°C)	5	10%	-6.1
P(%/100m)	1	10%	-0.4
C_b	0.004	10%	14.9
K	0.0045	10%	4.7

Table S2. List of the model parameters, range of parameters used to estimate the uncertainties in mass balance during 2019-2020 on Sangqu Glacier at glacier scale.

parameter	Value	+/-	Uncertainty in mass balance (mm w.e.)
a_{snow}	0.94	0.03	153.2
a_{firn}	0.75	0.03	66.4
a	-0.3	10%	0
b	0.48	10%	41.2
$T_{snow/rain}$(°C)	5	10%	15.1
P(%/100m)	1	10%	-0.7
C_b	0.004	10%	-28.9
K	0.0045	10%	-3.8

Table S3. List of the model parameters, range of parameters used to estimate the uncertainties in mass balance during 2020-2021 on Sangqu Glacier at glacier scale.

parameter	Value	+/-	Uncertainty in mass balance (mm w.e.)
a_{snow}	0.94	0.03	138
a_{firn}	0.75	0.03	98.4
a	-0.3	10%	0
b	0.48	10%	149.9
$T_{snow/rain}$(°C)	5	10%	0.3
P(%/100m)	1	10%	-0.9
C_b	0.004	10%	-47.7

K	0.0045	10%	9.5

Table S4. List of the model parameters, range of parameters used to estimate the uncertainties in mass balance during 2021-2022 on Sangqu Glacier at glacier scale.

parameter	Value	+/-	Uncertainty in mass balance (mm w.e.)
a_{snow}	0.94	0.03	220.8
a_{firn}	0.75	0.03	64.5
a	-0.3	10%	0
b	0.48	10%	107.5
$T_{snow/rain}$(°C)	5	10%	24.8
P(%/100m)	1	10%	1
C_b	0.004	10%	-60.6
K	0.0045	10%	-6.7

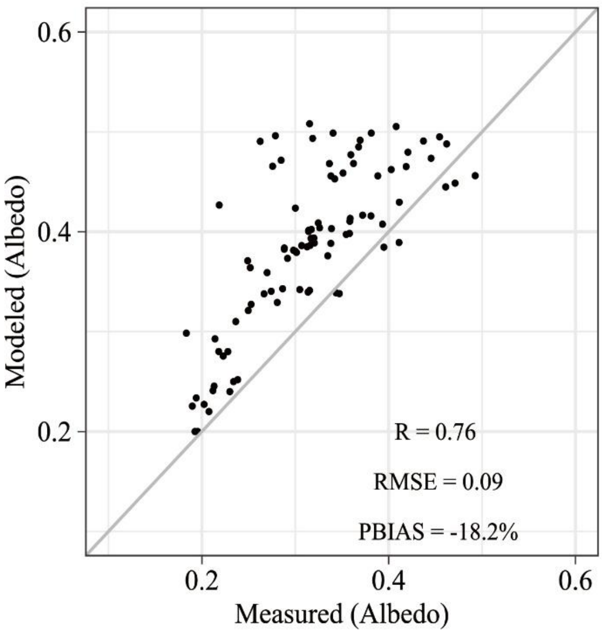

Figure S1. Comparison of albedo in weekly scale at the AWS sites on Sangqu Glacier.

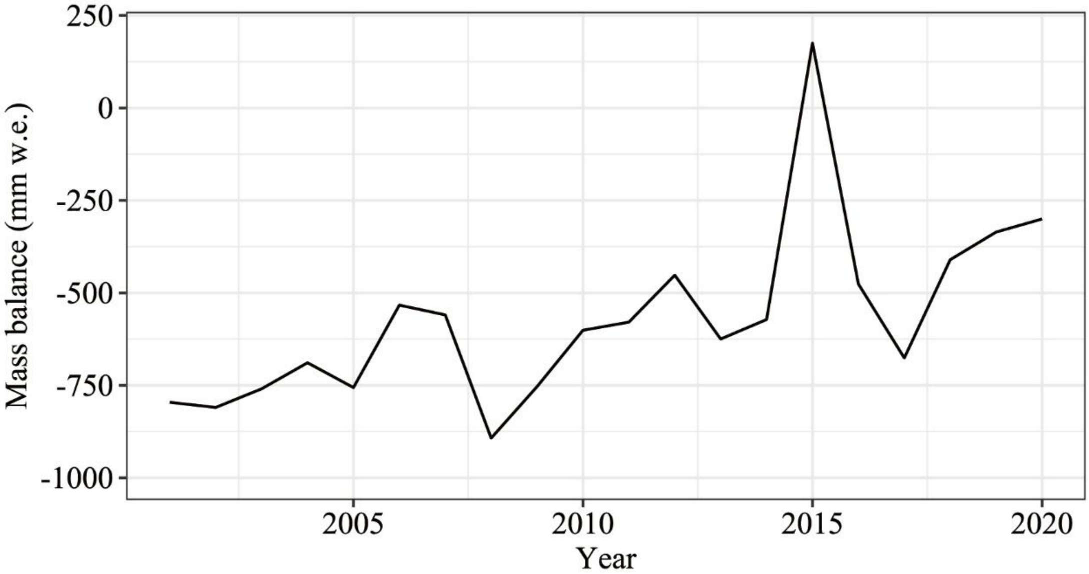

Figure S2. Annual mass balance time series of Sangqu Glacier from 2000 to 2019. The year 2020 represents the period 2019–2020, and similarly for the others. Date from Hugonnet et al.(2021)

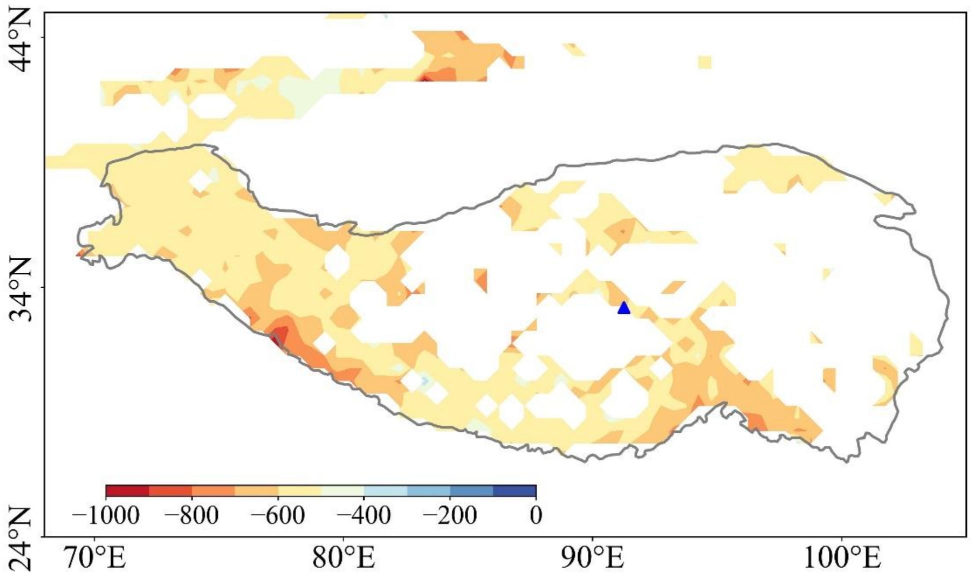

Figure S3. Abnormal mass balance of the Tibetan Plateau during 2021–2022 (relative to the 1975/1976–2020/2021 reference period). Date from glacier mass change gridded data from 1976 to present derived from the Fluctuations of Glaciers Database(https://cds.climate.copernicus.eu/datasets/derived-gridded-glacier-mass-change?tab=overview)

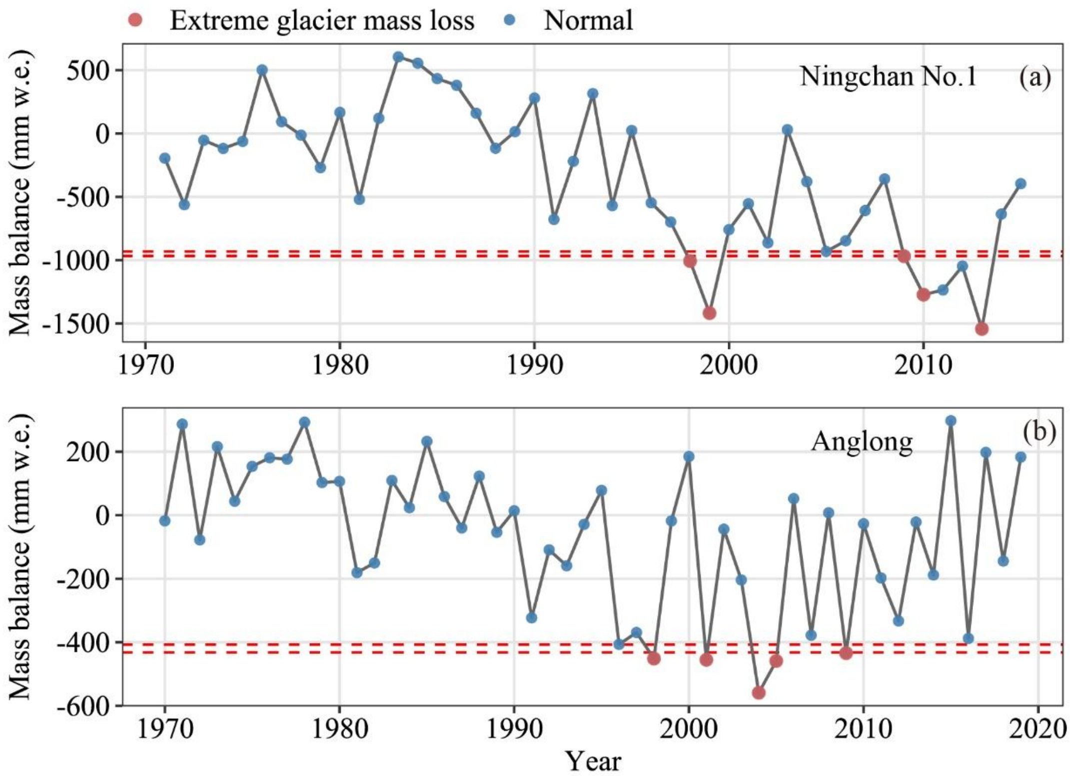

Figure. S4. Annual mass balance time series and extreme mass loss events for (a) Ningchan No.1 Glacier and (b) Anglong Glacier. The data were sourced from Zhu et al. (2022, 2023). The red dashed line represents the critical value of k .

References

Hugonnet R, McNabb R, Berthier E, et al (2021) Accelerated global glacier mass loss in the early twenty-first century. Nature 592:726–731. https://doi.org/10.1038/s41586-021-03436-z

Zhu, M., Yao, T., Thompson, L. G., Wang, S., Yang, W., & Zhao, H. (2022a). What induces the spatiotemporal variability of glacier mass balance across the Qilian Mountains. *Climate Dynamics*, *59*(11–12), 3555–3577. https://doi.org/10.1007/s00382-022-06283-4

Zhu, M., Thompson, L. G., Yao, T., Jin, S., Yang, W., Xiang, Y., & Zhao, H. (2023). Opposite mass balance variations between glaciers in western Tibet and the western Tien Shan. Global and Planetary Change, 220, 103997. https://doi.org/10.1016/j.gloplacha.2022.103997