Supplementary Material for:

Distributed summer air temperatures across mountain glaciers: climatic sensitivity and glacier size

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Contents:

S1. Air temperature inter-comparison.

We tested the contemporaneous differences in hourly air temperatures recorded at AWS_On (Parlung4 Glacier) and $T4_4$ T-Logger, that are <10 m of horizontal distance apart. We deem the measurements occupy a similar measurement space to be comparable for an estimate of uncertainty in the sensors, though cannot guarantee the measurement of same air parcel. We extract all hours of data for the two summers (12th July – 18th September) and compare the absolute differences between the naturally ventilated observations. Similarly we utilise the P90 hours (the warmest 10% of contemporaneous hours at the off-glacier AWS_Off (Table 1)) to test the differences. Figure S1 shows that the absolute hourly differences are typically below 1°C for all hour considered (mean differences = 0.46°C – red vertical line). For P90 hours, the mean absolute differences were 0.49°C, though with a distribution of differences that are slightly larger than for all hours. For P90 conditions, ~95% of the total differences are below 1°C (vertical green line in Figure S1). We employ this as a suitable estimate of uncertainty in the on-glacier temperature measurements in this study.

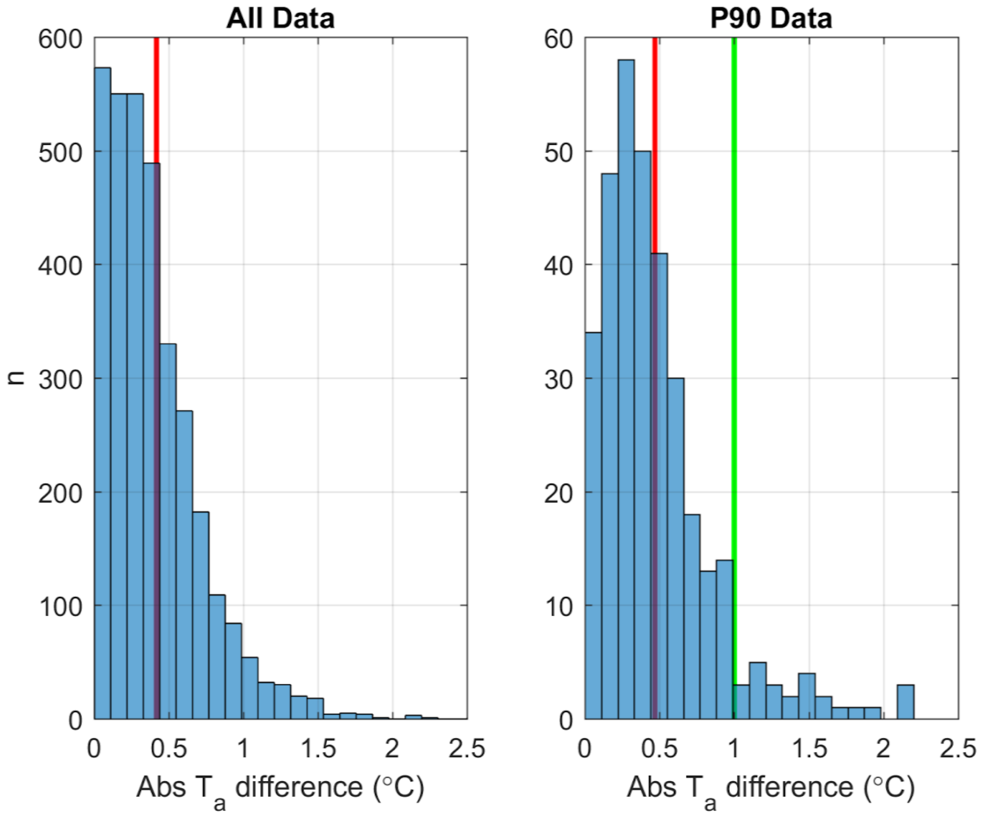

Figure S1: The absolute hourly differences in air temperature recorded at AWS_On and $T4_4$ on Parlung4 Glacier. The vertical red lines show the mean differences for all hours (left) and P90 hours (right). The vertical green line shows the 95 percentile at 1°C for the P90 differences.

S2. Off-glacier lapse rates

We utilised the hourly air temperature data at AWS_Off and T-loggers $T1_{94}$, $T2_{94}$ and $T1_{390}$ in order to construct a fixed-intercept lapse rate where AWS_Off is the reference 'forcing' station (e.g. the station from which air temperature must be distributed).
This is calculated where the best fit line is forced through the elevation (*z*)

$$y - y0 = \beta(z - z0) + \varepsilon \quad [1]$$

such that z0 and y0 is the point through which the regression line must pass (i.e., a linear regression without an intercept) to fit the model on a translated data set, and where y is the air temperature for each time step, β is the regression slope and ε is the original intercept value.
We compare this with a lapse rate that is calculated using a linear regression of all the aforementioned stations (Figure S2). This figure illustrates the inappropriate use of a standard linear regression equation to derive the lapse for multiple stations. Using a fixed intercept approach resulted in shallower lapse rates on average (smaller increases in air temperature with elevation – Figure S3). The mean fixed intercept (standard) lapse rate was -0.0051 (0.0053) °C m^{-1}.

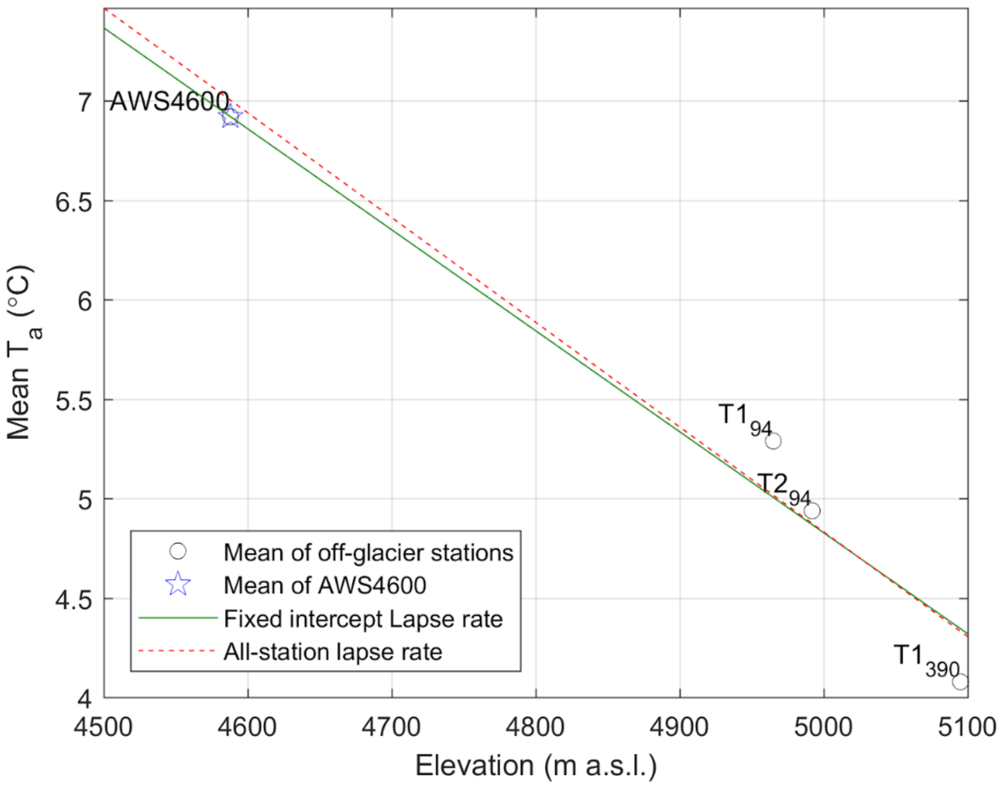

Figure S2: The mean off-glacier air temperatures for the whole measurement period compared to lapse rates derived following the fixed intercept and standard regression ('All station') approaches. AWS4600 is named AWS_Off in the main text.

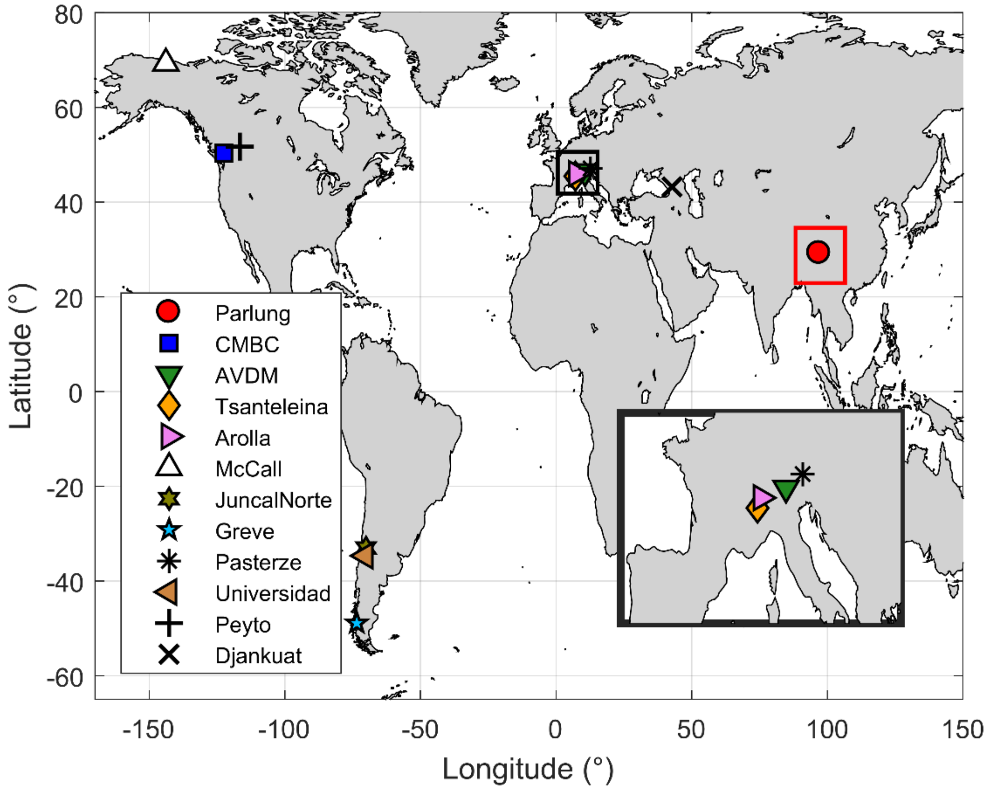

Figure S3: A map of the global datasets used in this study for comparison of climatic sensitivity. The red box is used to emphasize the location of this study and the black box and inset zoom on the European Alps for clarity.