Supplementary Material

Manifestations and mechanisms of the Karakoram glacier Anomaly

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S1 Brief history of the idea of a Karakoram Anomaly

Early reports on Karakoram glaciers stem from European exploration journeys during the mid-19th and the early 20th century [1, 2, 3, 4]. With respect to possible, anomalous behaviour, signs of rapid, partly cyclic [5] glacier advance were of particular interest. In an overview from the 1930s [6], this behaviour was attributed to "accidental changes", and was thought to be directly responsible for the high number of river-floods caused by the outburst of glacier-dammed lakes. Today, some of these "accidental changes" are recognized to be *glacier surges*. A first inventory of Karakoram surges was presented in the late 1960s [7].

The difference in behaviour of Karakoram glaciers when compared to the rest of High Mountain Asia or to more intensively studied regions in Europe and North America, was addressed by individual studies between the late 1970s and early 1990s [8, 9, 10, 11]. It was around the latter decade, however, that interest in the Karakoram gained momentum [12], with several studies focusing on surge-type glaciers [13, 14, 15, 16, 17, 18]. By the mid-2000s, enough evidence had accumulated to prompt Hewitt [19] to propose the existence of a "Karakoram Anomaly": he highlighted how the central Karakoram *"does emerge as the largest of those very few areas where glaciers are growing today, most probably due to the great elevations, relief, and distinctive climatic regimes involved"*. The latter interpretation rested upon reports analysing regional climatic trends [20], which seemed to indicate the possibility that the glaciers of the region were gaining mass.

The idea of the Karakoram having a positive glacier mass budget was intriguing, but was also met with scepticism [21, 22]. For one, it was in stark contrast to the widespread glacier mass loss observed for the Himalaya [23] and other nearby regions [24]; for another, it was in contradiction with the only glaciological mass balance measurements available for the region [25]. The quest gained additional attention after the publication of the Intergovernmental Panel on Climate Change's Fourth Assessment Report in 2007 [26]. The report, in fact, included the unfortunate and erroneous [27, 28] claim that *"the likelihood of [glaciers in the Himalayas] disappearing by the year 2035 and perhaps sooner is very high"*. This sparked a suite of new studies, often fostered by the advances in remote sensing capabilities [29, 30], which confirmed the Karakoram being a region with slightly positive glacier balances [31] resulting in glacier expansion [32] and thickening [33]. In the same wake, also the region's many surge-type glaciers gained attention [34, 35, 36, 37, 38], with indications for a noticeable increase in surging activity after the year 1990 [39].

The most recent studies [40, 41, 42, 43] largely confirm that, albeit small in magnitude, a slight glacier mass gain has occurred in the Karakoram during the past two decades. Compared to worldwide glacier changes, this seems the strongest argument for a "Karakoram Anomaly" at present.

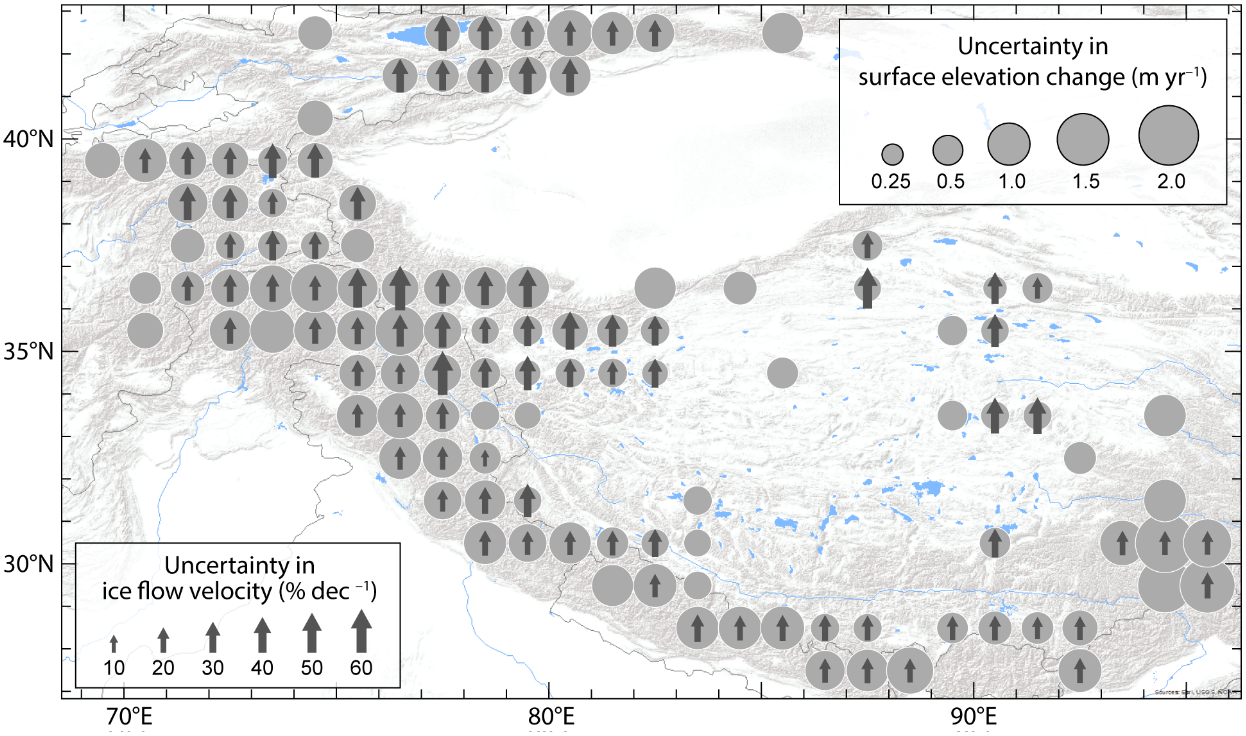

Figure S1: **Uncertainties in trends of glacier surface elevation changes and ice-flow velocities.** Circles show the 2σ-uncertainty of the glacier surface elevation change rates by Brun et al. [44] (colors of the circles in Fig. 2 of the main article), and arrows show the 2σ-uncertainty of the ice flow velocity trends by Dehecq et al. [45] (arrows in Fig. 2 of the main article). Basemap source: Esri, USGS, NOAA.

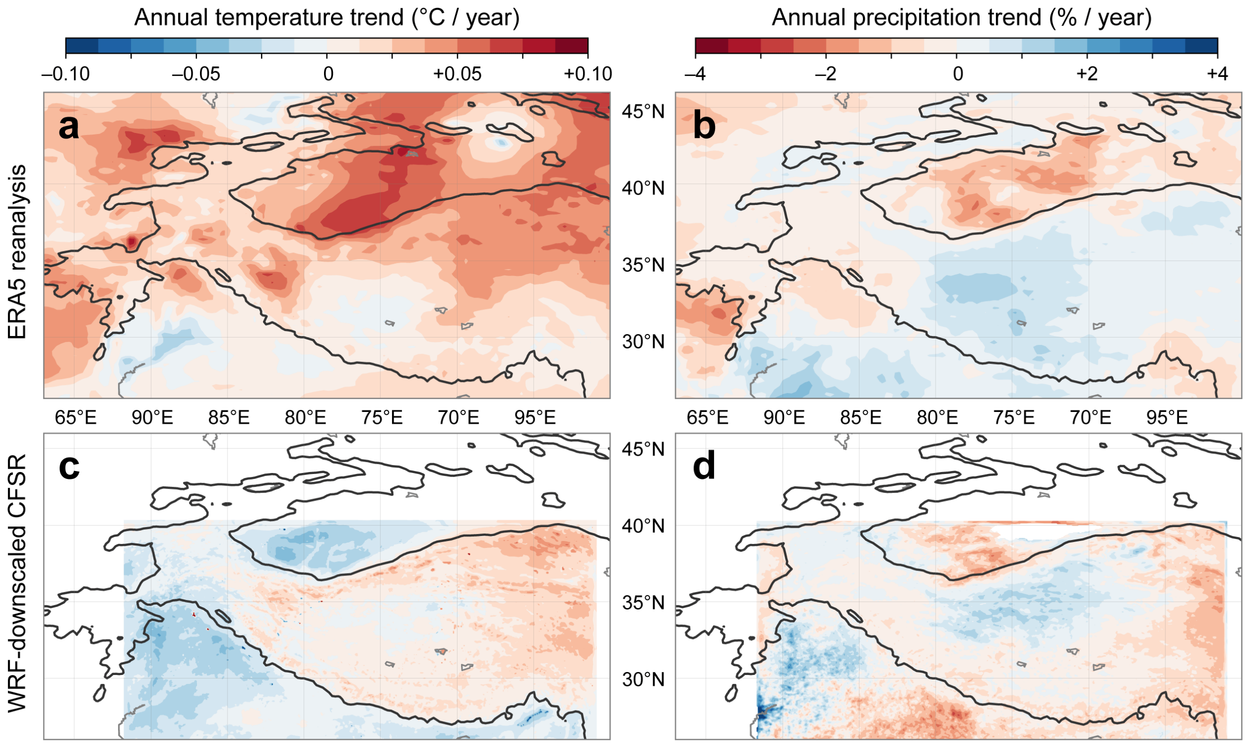

Figure S2: **Comparison of climatic trends from different datasets**. 1979-2014 trends in April-to-March temperatures (left column, **a**, **c**) and precipitation (right column, **b**, **d**) are compared for two dataset. The top row (**a**, **b**) refers to the ERA5 climate reanalysis [46]; the bottom row (**c**, **d**) to the Climate Forecast System Reanalysis (CFSR) downscaled by using the Weather Research and Forecasting (WRF) model (Norris et al. [47]). Spatial resolution is 31 km for ERA5 and 6 km for the WRF-downscaled CFSR. Note that the WRF-downscaled CFSR dataset does not cover the whole domain (white areas). A 2,000 m contour line (black) is provided for orientation.

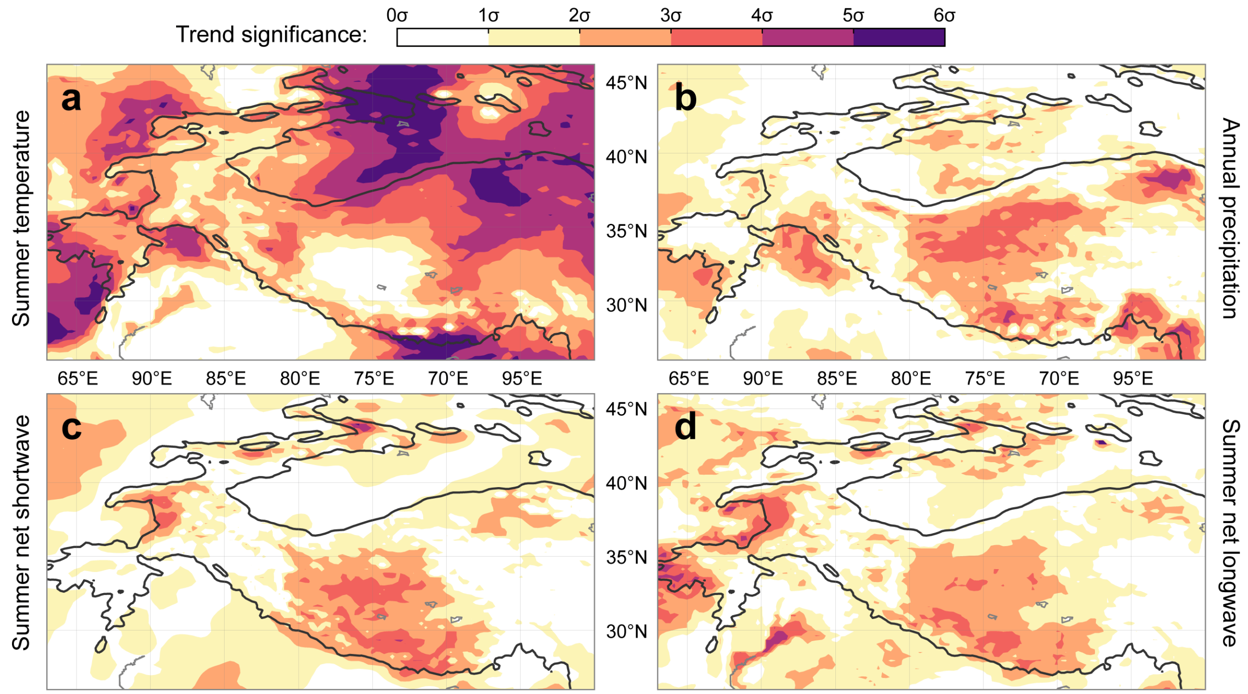

Figure S3: **Significance of climatic trends.** Panels show the significance of 1980-2018 trends in (**a**) summer (JJA) temperature, (**b**) annual precipitation, (**c**) summer net shortwave radiation, and (**d**) summer net longwave radiation (cf. Fig. 3 in the main article). Significance levels are expressed in units of standard deviations (σ) from the mean, and are obtained from two-sided p-values of a Wald test. The Wald test was performed using the Python package *SciPy* [48]. A 2,000 m contour line (black) is provided for orientation.

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