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Climate sensitivity of Tibetan Plateau glaciers - past and future implications

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The Tibetan Plateau is one of the most extensively glaciated, non-Polar regions of the world, and its mountain glaciers are the primary source of melt water for several of the largest Asian rivers. During glacial cycles, Tibetan Plateau glaciers advanced and retreated multiple times, but remained restricted to the highest mountain areas as valley glaciers and ice caps. Because glacier extent is dominantly controlled by climate, the past extent of Tibetan glaciers provide information on regional climate. Here we present a study analyzing the past maximum extents of glaciers on the Tibetan Plateau with the output of a 3D glacier model, in an effort to quantify Tibetan Plateau climate. We have mapped present-day glaciers and glacial landforms deposited by formerly more extensive glaciers in eight mountain regions across the Tibetan Plateau, allowing us to define present-day and past maximum glacier outlines. Using a high-resolution (250 m) higher-order glacier model calibrated against present-day glacier extents, we have quantified the climate perturbations required to expand present-day glaciers to their past maximum extents. We find that a modest cooling of at most 6°C for a few thousand years is enough to attain past maximum extents, even with 25-75% precipitation reduction. This evidence for limited cooling indicates that the temperature of the Tibetan Plateau remained relatively stable over Quaternary glacial cycles. Given the significant sensitivity to temperature change, the expectation is perhaps that a future warmer climate might result in intense glacier reduction. We have tested this hypothesis and modeled the future glacier development for the three mountain regions with the largest present-day glacier cover using a projected warming of 2.8 to 6.2°C within 100 years (envelope limits from IPCC). These scenarios result in dramatic glacier reductions, including 24-100% ice volume loss after 100 years and 77-100% ice volume loss after 300 years.