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Impacts of 1.5°C warming on high mountain systems: state of knowledge, challenges and the way forward

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Recently, both in science and policy, discussions have intensified about whether the 2°C 'guardrail' can really be considered a safety margin, i.e. natural and human systems would be reasonably safe when global warming can be limited to below 2°C with reference to preindustrial levels. Concerns about the 'safety' of the 2°C warming mounted especially with reference to highly vulnerable systems such as small islands, polar regions and high mountains where 2°C may imply crossing thresholds with major irreversible impacts. Several countries and organizations therefore called for a 1.5°C target, and it was one of the remarkable aspects of the Paris Climate Conference in December 2015 that 1.5°C was explicitly included in the Paris Agreement.
However, scientifically, little is known about the difference between 1.5°C and 2°C warming in terms of impacts on natural and human systems. This was also corroborated by the final report of the UNFCCC Structured Expert Dialogue (SED) which was based on the outcomes of the IPCC 5th Assessment Report and subsequent expert discussions.
Here we respond to this gap and challenge of understanding the differences of impacts as related to 1.5°C and 2°C above preindustrial levels. We concentrate on high mountains and impacts related to changes in the cryosphere because these systems are very sensitive to climatic changes (in particular to the key climate variables temperature and precipitation) and acknowledged as highly vulnerable areas.
We start with a systematic literature review and find that the mountain research community has addressed this issue only in a marginal way. We then develop a conceptual but evidence-based model how this challenge could be addressed: We suggest to first study the changes and corresponding impacts seen in high mountain systems since the Little Ice Age focusing on specified periods with 0.5°C global warming (corresponding regional warming, for instance in the Swiss Alps, in these periods was approximately 1°C). Corresponding periods of interest are ca. 1850 to 1950 and ca. 1980 to 2000. An important challenge is thereby different response characteristics (to climatic change) of different cryosphere, geomorphological, biospheric and landscape systems and related impacts.
We then study existing climate and impact projections for a number of cryosphere and high mountain systems, including glaciers, permafrost, runoff, lake formation and growth, slope stability, vegetation, sediment cascades and landscape changes focusing primarily on the Alps and complemented by available knowledge from the Himalayas and the Andes.
Our main conclusion is that the mountain research community urgently needs to pay more attention to the impacts which different warming targets and reference levels imply on highly vulnerable systems in high mountains and the related effects on downstream regions. This is also important in view of a likely upcoming IPCC Special Report on the impacts of 1.5°C warming, as based on a decision adopted at COP21 in Paris.