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Climatic controls and climate proxy potential of Lewis Glacier, Mt Kenya

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Glaciers in the tropics can provide information about regional climate, its dynamics, and its evolution over decadal and centennial time scales, if their interaction with the atmosphere is understood, and their changes are documented or reconstructed. The glaciers on Mount Kenya capture a climate signal from the mid troposphere at about 5 km a.s.l., where our knowledge of climate change is scarce and controversial.
We use in-situ meteorological and glaciological observations to optimize and validate a physically-based, process-orientated energy and mass balance model to quantify the exchange processes between the glacier surface and the atmosphere above and to explore the sensitivity of energy and mass exchanges to changing climatic conditions. Currently the glacier loses mass due to the imbalance between insufficient accumulation and enhanced melt, because radiative energy gains cannot be compensated by turbulent energy sinks. Exchanging model input data with synthetic climate scenarios, which were sampled from the meteorological measurements and account for coupled climatic variable perturbations, reveal that the current mass balance is most sensitive to changes in atmospheric moisture (via its impact on solid precipitation, cloudiness and surface albedo). Scenarios with lower air temperatures are drier and associated with lower accumulation and increased net radiation due to reduced cloudiness and albedo. Hence, similar to the glaciers of nearby Kilimanjaro, the recession of Lewis Glacier is not because of increased air temperatures, but because of decreased atmospheric moisture.
If the climate scenarios currently producing positive mass balances are applied to Lewis Glacier's late 19th century maximum extent (L19), negative mass balances are the result, meaning that the conditions required sustaining the glacier in its L19 extent are not reflected in today's climate observations. Alternatively, a balanced mass budget for the L19 extent can be explained by changing model parameters that imply a distinctly different coupling between the glacier's local surface-air layer and its surrounding boundary layer, a consequence of the vast deglaciation of the glacier catchment. This result underlines the difficulty of deriving paleoclimates for larger glacier extents on the basis of modern measurements of small glaciers.