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Surface area changes of Himalayan ponds as a proxy of hydrological climate-driven fluctuations

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The meteorological measurements at high-elevations of the Himalayan range are scarce due to the harsh conditions of these environments which limit the suitable maintenance of weather stations. As a consequence, the meager knowledge on how the climate is changed in the last decades at Himalayan high-elevations sets a serious limit upon the interpretation of relationships between causes and recent observed effects on the cryosphere. Although the glaciers masses reduction in Himalaya is currently sufficiently well described, how changes in climate drivers (precipitation and temperature) have influenced the melting and shrinkage processes are less clear. Consequently, the uncertainty related to the recent past amplifies when future forecasts are done, both for climate and impacts.
In this context, a substantial body of research has already demonstrated the high sensitivity of lakes and ponds to climate. Some climate-related signals are highly visible and easily measurable in lakes. For example, climate-driven fluctuations in lake surface area have been observed in many remote sites. On interior Tibetan Plateau the lake growth since the late 1990s is mainly attributed to increased regional precipitation and weakened evaporation. Differently, other authors attribute at the observed increases of lake surfaces at the enhanced glacier melting.
In our opinion these divergences found in literature are due to the type of glacial lakes considered in the study and in particular their relationship with glaciers. In general, in Himalaya three types of glacial lakes can be distinguished: (i) lakes that are not directly connected with glaciers, but that may have a glacier located in their basin (unconnected glacial lakes); (ii) supraglacial lakes, which develop on the surface of the glacier downstream; or (iii) proglacial lakes, which are moraine-dammed lakes that are in contact with the glacier front. Some of these lakes store large quantities of water and are susceptible to GLOFs (glacial lake outburst floods).
Whereas the lake surface areas variations of these lakes are strictly connected with the ablation processes and glacier velocities, variation related to unconnected glacial lakes are possibly influenced by only the resulting glacier melting. This difference with the other lake types makes unconnected glacial lakes potential indicators of changes of the main water balance components of high-elevated lake basins as: precipitation, glacier melting, and evapotranspiration.
An evaluable opportunity for a fine-scale investigation on climate-driven fluctuations in lake surface area is particularly evident on the south slopes of Mt. Everest (Nepal), which is one of the most heavily glacierized parts of Himalaya, at same time, the region that is most characterized by glacial lakes in the overall Hindu-Kush-Himalaya range, and in which a twenty years series of temperature and precipitation has been recently reconstructed for high-elevations (5000 m a.s.l.).
This contribution examines the surface area changes of unconnected glacial ponds, i.e. that are not directly connected with glaciers, on the south side of Mt. Everest in the last fifty years as part of an effort to evaluate if they can be considered potential indicators useful to detect how the climate is changed at high-elevations of the Himalayan range.