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Chemical evidences of the effects of global change in high elevation lakes in Central Himalaya, Nepal

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It is well known that the lakes integrate the pressure of their surrounding terrestrial environment and the climatic variability. Both the water column and sediments are capable to accumulate signals of global change, such as warming of the deep layers or mutation of diverse biological records (e.g., fossil diatoms) and the nutrient loads variability affecting the trophic state.
Typically, the biological responses to climate change have been studied in several types of lakes, while documented changes in water chemistry are much rare.
A long term study of 20 high altitude lakes located in central southern Himalaya (Mt Everest) conducted since the 90s has highlighted a general change in the chemical composition of the lake water: a substantial rise in the ionic content was observed, particularly pronounced in the case of sulphate. In a couple of these lakes, monitored on an annual basis, the sulphate concentrations increased over 4-fold.
A change in the composition of atmospheric wet deposition, as well as a possible influence of decrease in seasonal snow cover duration, which could have exposed larger basin surfaces to alteration processes, were excluded. The chemical changes proved to be mainly related to the sulphide oxidation processes occurring in the bedrocks or the hydrographic basins. In particular, the oxidation processes, considered as the main factor causing the sulphate increase, occurred in subglacial environments characterized by higher glacier velocities causing higher glacier shrinkage. Associated to this mechanism, the exposure of fresh mineral surfaces to the atmosphere may have contributed also to increases in the alkalinity of lakes. Weakened monsoon of the past two decades may have partially contributed to the solute enrichment of the lakes through runoff waters.
The almost synchronous response of the lakes studied, which differs in terms of the presence of glaciers in their basins, highlights the fact that the increasing ionic content of lake water cannot be associated to local situations. These lakes can be witnesses of the effects of the reduction in glacial cover as a response to climate warming.