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Quantifying recent lake level changes in Patagonia (Argentina and Chile): Back to the future?

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Lake levels in hydrologically closed-basins are very sensitive to climatically and/or anthropogenically triggered environmental changes. Their record through time can provide valuable information to forecast changes that can have substantial economical and societal impact.

Increasing precipitation in eastern Patagonia (Argentina) have been documented following years with strong El Niño (cold) events using historical and meteorological data. Quantifying changes in modern lake levels allow determining the impact of rainfall variations while contributing to anticipate the evolution of lacustrine systems over the next decades with expected fluctuations in ENSO frequencies. Laguna Carrilaufquen Grande is located in the intermontane Maquinchao Basin, Argentina. Its dimension fluctuates greatly, from 20 to 55 km^2 water surface area and an average water depth of 3 m. Several well-preserved gravelly beach ridges witness rainfall variations that can be compared to meteorological data and satellite images covering the last ~50 years. Our results show that in 2016 lake level was the lowest of the past 44 years whereas the maximum lake level was recorded in 1985 (+11.8 m above the current lake level) in a position 1.6 km to the east of the present shoreline. A five-years moving average rainfall record of the area was calculated smoothing the extreme annual events and correlated to the determined lake level fluctuations. The annual variation of lake levels was up to 1.2 m (e.g. 2014) whereas decadal variations related to humid-arid periods for the interval 2002 to 2016 were up to 9.4 m. These data are consistent with those from other monitored lakes and, thus, our approach opens up new perspectives to understand the historical water level fluctuations of lakes with non-available monitoring data.

Laguna de los Cisnes in the Chilean section of the island of Tierra del Fuego, is a closed-lake presently divided into two sections of 2.2 and 11.9 km^2, respectively. These two water bodies were united in the past forming a single larger lake. The lake level was ca. 4 m higher than today as shown by clear shorelines and the outcropping of large Ca-rich microbialites. Historical data, aerial photographs and satellite images indicate that the most recent changes in lake level are the result of a massive decrease of water input during the last half of the 20^{th} century triggered by an

indiscriminate use of the incoming water for agricultural purposes. The spectacular outcropping of living and fossil microbialites is not only interesting from a scientific point of view but has also initiated the development of the site as a local touristic attraction. However, if the use of the incoming water for agriculture in the catchment remains unregulated the lake water level might drop dangerously and eventually the lake might fully desiccate.

These two examples illustrate how recent changes in lake level can be used to anticipate the near future of lakes. They show that ongoing climate changes along with the growing demand of natural resources have already started to impact lacustrine systems and this is likely to increase in the decades to come.