INSOLATION, MOISTURE BALANCE AND CLIMATE CHANGE ON THE SOUTH AMERICAN ALTIPLANO SINCE THE LAST GLACIAL MAXIMUM

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Our understanding of tropical South American climate since the last glacial maximum (LGM) and the associated climate forcing mechanisms is rapidly evolving. Paleoclimatologists and climate modelers increasingly rely on one another's research to advance new theories, strengthen existing arguments, and lay to rest old paradigms. Recently published paleorecords from southwestern Ecuador, inland and coastal Peru, and northern Chile have fueled the enthusiasm of the modeling community, and in turn, recent modeling efforts have encouraged field- and lab-based workers to build a more diverse, denser pattern of long, continuous, sensitive paleorecords from tropical-subtropical South America. The thick lacustrine sedimentary package preserved in the Lake Titicaca basin represents one of the longest, most complete paleoclimate archives from low-latitude South America. Geochemical, paleontological, and geochronological results from box-cores and piston cores collected from the deep, northern sub-basin indicate the lake has been a sensitive recorder of environmental change during the late Quaternary. The purpose of our presentation is to describe the construction and calibration of a bulk organic carbon isotope-based record of lake level from Lake Titicaca. We place the post-LGM lake-level record in the context of changing hydrologic conditions that occurred in the region, and we submit that regional shifts in hydrologic conditions are a direct consequence of insolation-induced and ENSO-forced changes in the greater tropical hydrologic system.

The Lake Titicaca drainage basin occupies the northernmost third of the South American Altiplano, a low-latitude (14ºS to 21ºS), high-elevation plateau of tectonic origin situated between the eastern and western cordillera of the central Andes. The Altiplano receives atmospheric moisture exclusively from the Amazon Basin. Consequently, changes in the level of Lake Titicaca are thought to reflect shifts in the larger-scale moisture flow that develops over the tropical Atlantic Ocean and propagates westward toward western South America.

Distinct stable isotopic and elemental compositions ($\delta^{13}C_{org}$, wt. $\%C_{org}$, C/N) of modern lacustrine organic matter recovered from core tops and modern organic endmembers (algae, aquatic macrophytes, terrestrial grasses) within and surrounding the lake serve to calibrate down-core changes in organic composition (**Figure 1**). Down-core $\delta^{13}C_{org}$ results reflect the dominance of either algal (deep water, lake highstand conditions) or littoral macrophytic (shallow water, lake lowstand conditions) material, and are therefore a proxy record of shoreline proximity. Viewed in the context of the modern organic calibration, down-core $\delta^{13}C_{org}$ results from overlapping piston/box-cores

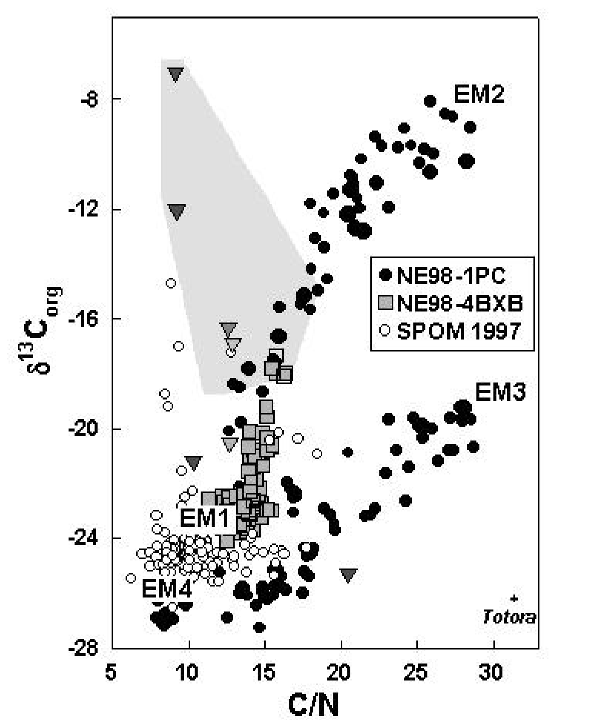

Figure 1: Plot of modern organic endmembers and down-core results. EM1-EM4 identify endmember compositions for modern/ancient organic material used in lake-level transfer functions.Upside down triangles refer to aquatic macrophyte compositions. Filtered lake water samples (surface particulate organic matter, SPOM) are also plotted. Shaded area identifies composition region for several aquatic macrophytes.

(NE98-1PC/ NE98-4BXB; water depth ~150 m) suggest that shoreline proximity to the core site has varied significantly since the LGM.

Changes in shoreline proximity to the core site represent changes in the level of Lake Titicaca. We use two transfer functions based on down-core $\delta^{13}C_{org}$, the modern lake level, and estimates of the mid-Holocene minimum and late Pleistocene maximum lake levels (**Figure 2**). Lake level was slightly higher than modern during much of the post-glacial (19,000 to 13,500 yr BP) and lake water was fresh under the associated outflow conditions. The Pleistocene/Holocene transition (13,000 to 7,800 yr BP) was a period of gradual regression, punctuated by minor trangressions. Following a brief highstand, mid-Holocene (7300 to 3600 yr BP) lake level dropped rapidly to an estimated 85 m below the modern level. The last 3600 years of the record is characterized by a higher lake level, indicating a shift toward positive moisture balance conditions. We submit that orbitally-induced changes in solar insolation, coupled with long term changes in El Niño-Southern Oscillation variability, are the most likely driving forces behind millennial-scale shifts in moisture balance of the Atlantic-Amazon-Altiplano hydrologic system.

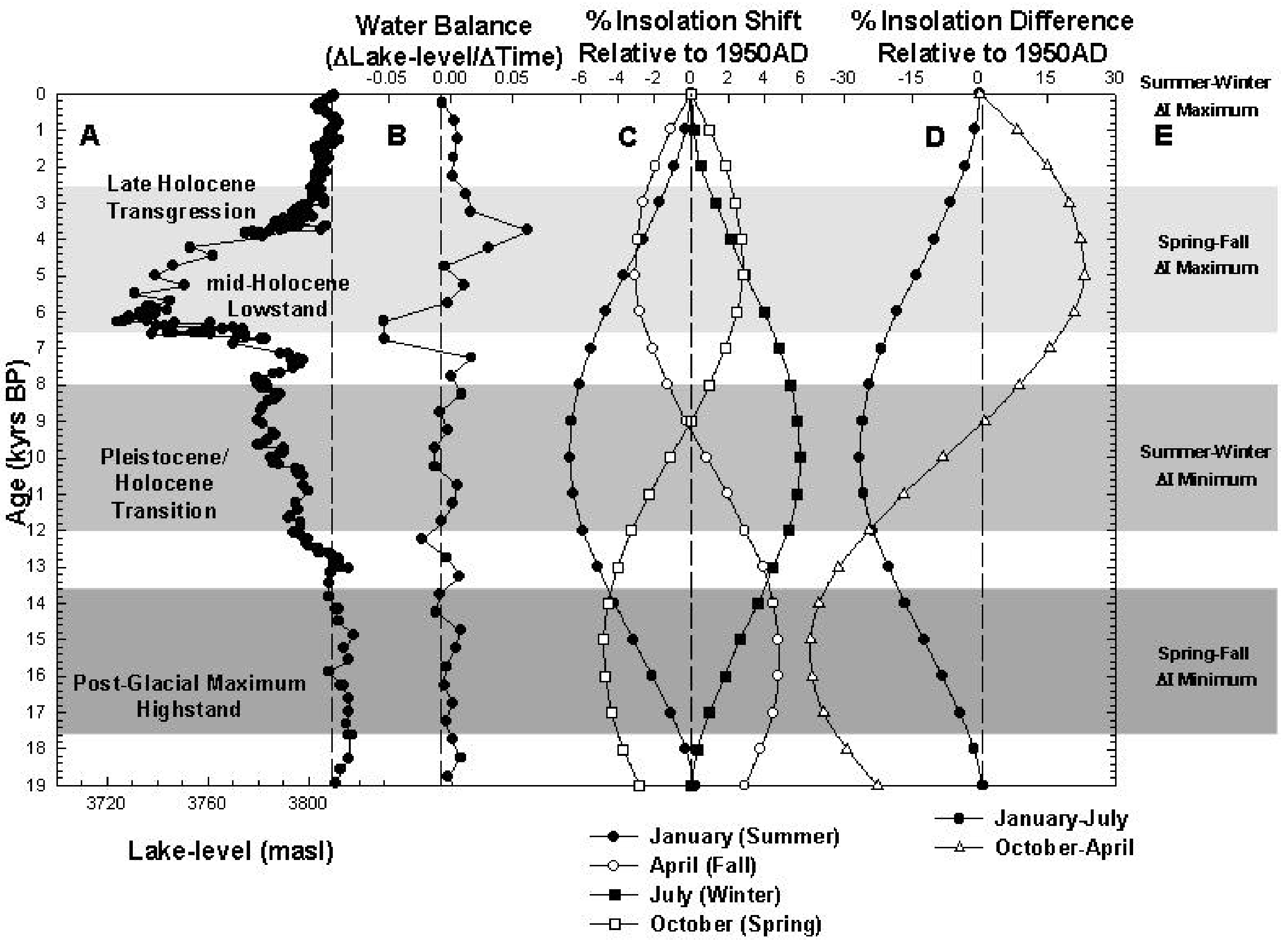

Figure 2: A) Past lake level curve derived from two carbon isotope transfer functions. B) Rate of lake level change with time. Points represent the average of all lake levels derived from sample analyses during each 500-yr time interval of record, starting from the top of the record. C) Shift in monthly insolation at 20°S expressed as a percent difference from the 1950 value. D) Shift in the difference between January-July (Summer-Winter) and October-April (Spring-Fall) insolation at 20°S, expressed as a percent difference from the 1950 value. E) Maxima/minima in seasonal insolation difference (ΔI).