Climate records from ice cores in the Central Andes: Records of long and short term tropical teleconnections of temperature and precipitation.

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The results from the analyses of ice cores from the tropical Huascarán (9°06' S, 77°36' W, 6048 m a.s.l.), Quelccaya (13° 56' S, 70° 50' W, 5670 meters) and Sajama (18° 07' S, 68° 53' W, 6548 m a.s.l) ice caps willbe compared for the last 25 000 years. These records will be examined for patterns and sources of interannual, decadal and century-scale climaticvariability for a period and a region which has constituted a gap in our records of climate system. The comparison of climate model results with systematic regional, continental, hemispheric, and global-scale compilations of high-resolution paleoclimatic data is needed to fill this gap in our understanding and to develop more realistic climate models. Annual to decadal variations in visible dust layers, stable isotopes, microparticle concentrations, soluble chemistry, as well as cosmic nuclides allow us to look in detail at the environmental as well as chemical variations at these sites These climate and environmental histories will be examined both on short and long time scales and possible forcing mechanisms will be explored that might explain climate and environmental patterns found through-out the tropics. For example, the fact that the "little ice age" (about A.D. 1500 to 1900) stands out as a significant climatic event in all three of these sites confirms its large scale significance in the tropical Andes. Late Glacial Stage conditions at high elevations appear to have been cooler than today, although the magnitude of the inferred cooling differs with the particular proxy used (e.g. snowline depression, pollen, ice cores). Insoluble dust and anion concentrations in the ice cores reveal that LGS hydrological conditions in the tropics (9° S) were much drier than today, whereas the subtropics (18° S) LGS conditions were much wetter. Low nitrate concentrations in the LGS ice from both Huascarán and Sajama suggest that the Amazon Basin forest cover may been much less extensive. The conundrum surrounding the use of $d^{18}O$ as a palaeothermometer in the tropics, where temperatures exhibit little seasonal variation yet the ice-core records suggest that $d^{18}O$ records temperature variations on decadal to millennial time-scales. El Nino-Southern Oscillation (ENSO) events are marked in the Sajama and Quelccaya records by significant decreases in snow accumulation, and by $d^{18}O$ enrichment of snowfall at the Huascarán site. The ENSO phenomenon is now recognized as global event arising from large-scale interactions between the ocean and the atmosphere. This phenomenon as well as ENSO like phenomenon will be examined in each of these three tropical Andean ice cores, and teleconnections examined with recent ice core records of the south Asian monsoon.

Unfortunately, as a result of the recent warming all of the known tropical glaciers and ice caps in the Andes are retreating and soon will no longer continue to preserve viable paleoclimatic records. The Quelccaya ice cap is a graphic example of this threat. Although a stable isotopic paleoclimatic record was obtained from ice cores drilled in 1983, subsequent visits to the ice cap in 1991, 1995, and 2000 showed that melting was underway at the summit and the stable isotope record had been smoothed. The impact of

the recent warming can be seen not only the isotopic enrichment taking place in each of these three sites but also in the massive and accelerating retreat of the margins of glaciers in the tropical Andes and in fact in tropical glaciers through-out the world. The current retreat of these tropical Andean glaciers and the recent isotopic enrichment will be examined in the perspective of the last 25000 + years. The paper will examine the role of the tropical hydrological system and its response to regional and global forcing with special emphases on Milankovitch astronomic forcing both on recent and long term tropical climate variability.