Climate change and mass movements in the NW Argentine Andes

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The chronology of multiple landslide deposits and related lake sediments in the eastern Argentine Cordillera suggests that major mass movements cluster in two time periods during the Quaternary; between 35,000 and 25,000 ^{14}C yr BP and after 5000 ^{14}C yr BP. The older cluster may correspond to the Minchin wet period (40,000 and 25,000 ^{14}C yr BP) identified in tropical and subtropical South America, suggesting a causal relation between enhanced landslide activity and climate change. The younger cluster predates the Titicaca wet period that began at about 3900 ^{14}C yr BP which also affected other regions in the Andes and the Amazon Basin. No landslide and associated lake sediments are documented during the Tauca wet period (between 16,000 and 8,000 ^{14}C yr BP). However, the two clusters correspond to periods where it assumed that the El Niño/Southern Oscillation (ENSO) and Tropical Atlantic Sea-Surface Temperature Dipole (TAD) was active. The analysis of the present-day precipitation patters in NW Argentina indicates significant spatial and temporal differences between the intra-Andean part of the study area and the Andean foreland. Whereas the TAD seems to consistently increase rainfall, the intensity of precipitation during the El Niño phase of the ENSO is reduced to only 25% of the mean-annual average in the intra-Andean basins, whereas the regions east of the Andeas receive more than 125%. Similar results, but with an opposite sign characterize La Niña events. The comparison of this pattern with paleo-precipitation data as inferred from varved lake sediments suggest that increased interannual climate variability and, therefore, increased fluctuations in rainfall and river discharge in narrow valleys may reduce landsliding thresholds.

Lake-balance modelling of the largest landslide-dammed lake in the Santa Maria Basin, NW Argentina reveals that a hypothetical present-day lake would stabilize around 70 m below the reconstructed 30,000 ^{14}C yr old paleolake. The volume of the water body would be one third of the corresponding paleolake volume. However, a 10 to 15% increase in mean-annual precipitation accompanied by a 3 to 4°C drop in temperature would result in a stable lake level at the reconstructed elevation. This result implies wetter and cooler conditions at 30,000 ^{14}C yr BP as compared to the present. The causal link between the potential causes of rainfall variability in this basin, the ENSO and TAD were parameterized using a new method of nonlinear time-series analysis, the quantitative analysis of cross recurrence plots. This methods seeks similarities in the dynamics of two diffferent systems, such as an ocean-atmospheric oscillation and local rainfall, by introducing measures of complexity. The analysis reveals similar influences of ENSO and TAD today and 30,000 ^{14}C yr in the Santa Maria Basin. This suggests that the same causes of precipitation variability were active during enhanced landsliding. However, there seems to be a

ity were active during enhanced landsliding. However, there seems to be a tendency towards a higher contrast between dry and rainy season as well as a longer duration of the rainy season. All this could help to explain enhanced landsliding in this region 30,000 ^{14}C yr BP.