Geophysical Research Abstracts
Vol. 21, EGU2019-8392, 2019
EGU General Assembly 2019

Between Deserts and Lakes: Determining the pace and magnitude of environmental changes in southern Ethiopia

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The Kenyan and Ethiopian rifts in eastern Africa are known for their diverse landscape, ranging from arid and semi-arid savannahs to high and lush mountainous regions, where anatomically modern humans were present since ∼195 ka BP. Lacustrine sediments and paleo-shorelines indicate water availability fluctuated dramatically during this period from deep fresh water lakes, to shallow highly alkaline lakes, to completely desiccated lakes. To investigate the role lakes have played through time as readily available water sources to humans, an enhanced knowledge of the pace as well as the magnitude of these changes near key paleo-anthropological sites in eastern Africa is essential. Hydro-balance models are used to calculate paleo-precipitation rates and the potential pace of lake level changes. Such models, which were successfully applied to numerous lake basins in Kenya, could prove similarly useful for investigating paleo-lake basins in Ethiopia. However, these models did not consider changes in hydrological connectivity during humid periods, which may have led to an overestimation of paleo-precipitation rates. Here we present a comprehensive hydro-balance modelling approach that simulates multiple rift lakes from the southern Ethiopian Rift (Abaya, Chamo, Chew Bahir) simultaneously, considering their temporal hydrological connectivity. During the high stand at the peak of the African Humid Period (AHP, 15-5- ka), the lakes were hydrologically linked and display cascade-like behavior, flowing southwards from Abaya to Chamo to Chew Bahir and finally spilling over into Lake Turkana. We further used the Surface Energy Balance Algorithm for Land (SEBAL) to calculate the evaporation of Lake Chew Bashir's catchments and used the energy balance to determine possible paleo-evaporation conditions due to shifts in precipitation patterns. The results suggest an increase in the long-term precipitation trend of 20.6% to 28.6% throughout the whole Southern Ethiopian Rift is necessary to fill Lake Chew Bahir to its overflow level. Furthermore, it was demonstrated that Lake Chew Bahir was highly dependent on the water supply from the upper lakes Abaya and Chamo and dries out within ∼30 years if the hydrological connection is cut off and the precipitation amount decreases to present day conditions. Several of such rapid lake level fluctuations, from a freshwater to a saline lake, might have occurred during the termination of the AHP, when humid conditions were less stable due to a change in precessional cycle. Fast changes in fresh water availability requires high adaptability for humans living in the area and might have caused strong migration pressure towards more favorable regions such as the Ethiopian Highlands within single generations or even less.