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What can be learned from the study of the hydrological evolution of the Ounianga lake region (NE Chad) over recent Holocene?

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A hydrological view to the Ounianga lake region (NE Chad) evolution during the recent Holocene period is proposed. It relies upon multidisciplinary inputs combining hydrological characterization and modeling, results from climate modeling and from the recent sedimentary core analysis by Kroepelin et al. 2008 from lake Yoa. The latter shows that 4 major phases in drying have been observed in this Saharan region over the Holocene, including, (1) disappearance of tropical and altitude pollen species by 4300 cal yr BP, (2) evolution of the lake from a freshwater habitat to the present day hyper-saline oasis (around 3900 cal yr BP), (3) establishment of today's terrestrial desert ecosystem as the result of continuous vegetation succession (5600 to 2700 cal yr BP), (4) evolution in regional wind regime with onsets of major dust mobilization at roughly 4300 cal yr BP and establishment of modern, near continuous northeasterly winds by 2700 cal yr BP.

The overall project strategy consists in studying the drying of the region and identifying the controlling parameters from a drastic climate change evolution, from humid (traces of tropical pollen types) to present day hyper arid environment. The interplay between climate change, vegetation, hydrological inputs from distant mountains and a regional aquifer makes this zone a complex and interesting system to study the impact of past climate changes.

In a first step of the hydrological study, analysis of the topography of the zone (ArcGis with SRTM data and radar images) shows that the water catchment area of lake Yoa is large (67000 km^2, including the Erdi plateaux and part of the Tibesti mountain range, ie 18600 km^2). A connection with the Tibesti mountains accounts for the altitude pollen source present in the core before 4300 cal yr BP. Globally, the lake is situated at a very favorable position that probably benefited from relatively large and perennial water inputs associated with distant recharge from the Tibesti massif and groundwater from the Nubian Sandstone Aquifer.

In a second step, a groundwater model (Cast3M code) is developed for the SW part of the Nubian Sandstone Aquifer to quantify the slow discharge to the lake from a humid period (African Humid Period, 5000 BP roughly) until now. It is forced by precipitation and evaporation issued from climate simulations. Resulting piezometric head fields are compared with present piezometric levels. Lake levels are simulated as resulting from groundwater inputs and routing of surface water for the precipitation time history considered. The reconstruction is confronted to the evolution of salinity issued from the analysis by Kroepelin et al. 2008.

Addressed herein are the issues of the level of confidence / uncertainty associated with the reconstruction of the drying phase, the identification of thresholds in the hydrological system influencing the change in the vegetation, the impact of future climate change on this system, lessons learned from the study of the paleo system.