Geophysical Research Abstracts
Vol. 12, EGU2010-11165, 2010
EGU General Assembly 2010

Sahara and Sahel vulnerability to climate changes, lessons from the past

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Since the Sahelian drought in the 1970s, climate variability in north tropical Africa has been the subject of intensive research focusing on the functioning of the Atlantic monsoon system as well as on past variations in rainfall from historical and natural archives. An "abrupt" climate change has been recorded off the Mauritanian coast at the end of the African Humid Period (AHP) 5500 years ago illustrating the onset of the modern climate regime [deMenocal et al., 2000]. At lake Yoa in NE Chad, [Kroepelin et al., 2008] report a "gradual" environmental change. Was this change abrupt or gradual, and amplified or not through vegetation change and feedbacks to the atmosphere is still the subject of debate.

Here, we compile paleohydrological and palynological data between 10 and 28°N in the Sahara and Sahel with the purpose of understanding the response of the hydrological system and the vegetation cover to rainfall fluctuations from the onset of the AHP.

Our data set is extracted from published studies. It is composed of 1651 dated samples from about 420 localities in the present day Sahara and Sahel. The occurrence of high and intermediate lake levels, fluvial terraces and wetlands as well as of dune edification are analysed with a 1000 yr period from 16 000 yrs BP to present. Clear trends are observed in the evolution of paleohydrological indicators versus time and latitude showing the progression of the centre of the distribution of humidity from south to north during the humid period and to the south after the AHP. The humidity maximum is observed with some temporal delay as compared to the June solar radiation maximum at 30°N. The reasons are investigated along the line of pure climate based processes and/or hydrological impacts. Further, the overall coherence among these signals is examined.

Using climate simulations for different key periods in the Holocene, we investigate the relative impact of the insolation forcing, of the remnant ice sheet in the early Holocene, and of possible freshwater inputs in the North Atlantic, on the position of the ITCZ in the Atlantic and over the African continent. Further, the coupling with large transitory lakes is also considered.

Considering local hydrological effects, two main features are analysed. First, some water inputs are related with distant water sources: main rivers of the region, Nile, Chari Logone, Niger are recharged in southern tropical zones and/or in mountainous regions. Second, groundwater outputs from aquifers correspond to long term transitory effects, where, in particular, the larger aquifers located in large sedimentary basin, provide groundwater inputs to valleys and topographic depressions at a multi millennium time scale.