Hydrological evidence of Late Quaternary changes in the Hadley circulation and monsoon rainfall in Africa

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Climates of tropical Africa, the largest land mass of the tropics, exhibit a broadly zonal pattern which reflects primarily the Hadley circulation, with northern and southern subtropical deserts, and two belts of monsoonal climates bracketing a humid equatorial zone. The seasonal distribution of precipitation is governed by the seasonal migration of the ITCZ. There are two monsoon systems, the West African and the East African monsoons. The Atlantic Ocean is the major source of moisture on the continent. The air flows from the Atlantic and Indian Oceans converge along the "Congo Air Boundary".

Here, evidence for changes in atmospheric circulation and extreme ITCZ positions over tropical Africa is primarily derived from new and recently published hydrological records.

During the Last Glacial Maximum, generally dry conditions have prevailed in the tropics of both hemispheres. Enhanced northern trade winds generated high dust flux from the Sahara-Sahel into the Atlantic Ocean. Dry conditions in the southern tropics are documented by new lake records from southeast Africa (L. Malawi, L. Rukwa, L. Massoko), and marine core records off Namibia (Shi et al., 2001; EPSL 187, 311-). In Southeast Africa, the "South African monsoon" brought very little moisture because its northern trade wind flow traversed continental areas of that were drier than today. In Southwest Africa, reduced Congo Air flow was associated with enhanced southeast trade winds contributing to strong upwelling and reduced SSTs (Shi et al., 2001). A noble gas temperature and isotope record in southwest Africa suggests that the westerly winds on the southwestern seabord of the continent extended northward than today, at least to 25°S (Stute & Talma, 1998; IAEA SM349/53, 307-).

Once the glacial boundary conditions decayed, generally wet climate established in the northern tropics while the southern tropics were relatively dry during the early Holocene, as expected from orbital forcing. The most dramatic paleoclimatic changes have been the early Holocene wetting of the Sahara-Sahel and lake level rises in East Africa North of 10°S. The northern fringe of the paleo-Sahel reached about 22°N in West Africa. The very low stable isotope values of groundwaters in northern Mali and northern Niger are attributed to convective showers generated by squall lines that develop along the ITCZ. This implies that the ITCZ moved at least 500 km more northward than today during the boreal summer. In Southern East Africa, a recent multi-proxy record from Lake Malawi (Johnson et al., 2002, Science 296, 113-) suggests that post-glacial periods with more frequent northeasterly winds in the region coincided with droughts in North Africa and with cold events in the Northern Hemisphere (e.g., the Younger Dryas). This may result from a more southward excursion of the ITCZ, or its longer stay at its southern terminus during austral summer.