Geophysical Research Abstracts
Vol. 15, EGU2013-11050, 2013
EGU General Assembly 2013
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Sensitivity of the south-east African C_3/C_4 vegetation balance to climatic changes and atmospheric CO_2 during last 37 000 years - combining results from model simulations and paleodata

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Although both changes in climate (i.e. temperature, precipitation) and atmospheric CO_2 are important factors controlling the fraction of C_4 vegetation, little is known for their relative contribution in shaping the C_3/C_4 vegetation evolution in the past. A paleorecord based on stable carbon isotopes (δ^{13}C) of sedimentary leaf wax in the Zambezi catchment has demonstrated a shift from a C_4-dominated vegetation during the last glacial period to more C_3-dominated vegetation in the Holocene. At the large scale, such changes can be linked to an increase in atmospheric CO_2. However, the temporary decoupled evolution of atmospheric CO_2 and C_3/C_4 ratio, as seen in the paleorecord during the LGM and Heinrich 1 event, suggests that other factors such as precipitation and temperature may have also played an important role. In the present study we use the BIOME4 vegetation model to systematically estimate the sensitivity of the relative abundance of C_4 vegetation to changes in temperature, precipitation and CO_2. Our model results confirm that atmospheric CO_2 is the primary control on the C_3/C_4 vegetation evolution in southern tropical Africa. We also find that the sensitivity of the C_4 abundance to precipitation (δC4/δP) increases with both lower CO_2 and temperature. Furthermore, the sensitivity of the C_4 plant abundance to temperature (δC4/δT) increases with a decrease in CO_2. Consequently, the relative importance of climatic factors (such as temperature and precipitation) in controlling C_4 vegetation may vary under different background CO_2 concentrations. To better understand the individual factors shaping the C_3/C_4 vegetation evolution from the Zambezi catchment area, climate model simulations (Kiel Climate Model, PMIP models) are used to drive the BIOME4 model.