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Climate and CO_2 effects on the vegetation of southern tropical Africa over the last 37,000 years

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The savannah vegetation of southern tropical Africa is characterized by co-dominance of C4 grasslands and C3 woodlands. Long-term variations in the tropical savannah vegetation in arid and semi-arid climates are commonly considered to be primarily sensitive to precipitation and atmospheric CO_2 concentrations.

In our study we propose that also temperature changes should be considered when assessing the effect of a changing climate on tropical Savannahs. We combine BIOME4 vegetation simulations with climate simulations and climate reconstructions to understand vegetation changes in southern tropical Africa of the last 37,000 years. Precipitaion and vegetation reconstructions stem from the same marine sediment core near the Zambezi River mouth, temperatures were reconstructed from lake sediments within the Zambezi catchment. Our simulations demonstrate that temperature changes can reconcile a seemingly inconsistent evolution in precipitation, atmospheric CO_2 and vegetation change.

We focus on two periods for which the vegetation reconstructions cannot be explained alone by precipitation changes and changes of atmosphere CO_2:
(i) For the Holocene, we force BIOME4 simulations with reconstructed atmospheric CO_2 concentrations, and spatial and seasonal climate patterns from the early- and mid-Holocene (9 and 6 ka BP) simulations with a global climate model.
(ii) For the glacial period, we analyze idealized experiments based upon reconstructed temperature, precipitation and CO_2 at 31, 28 and 21 ka BP.

Our study shows that both Holocene and glacial simulations of vegetation cover exhibit good agreement with reconstructed C4:C3 ratios when temperature changes are taken into account. Adapting and refining this approach might permit to constrain continental temperature reconstructions or to evaluate the sensitivity of vegetation models to long term climate variations.