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Vegetation-fire-climate interactions in sub-Saharan Africa: evaluating and comparing dynamic global vegetation models

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Tropical savannas cover about one third of the African land surface. At the wetter end of their distribution range, savannas transition into tropical forests, which cover about 10% of Africa. The dynamics of these biomes and their environmental limits are determined by a complex set of interactions between vegetation and environmental factors, such as climate (e.g. precipitation annual average and seasonality) and disturbances (e.g. fire, herbivory).
Fire has an important ecological role influencing the vegetation distribution of Africa, which is the continent with the highest fraction of burnt area. It is especially relevant for mesic savannas, where C4 grasses promote fires and maintain open canopies. In areas with similar climatic condition, fire has been suggested to play also an important role in maintaining savannas and forests as alternative stable states through a positive grass-fire feedback, which is reinforced by the different responses of the savanna and the forest tree types.
Dynamic Global Vegetation Models (DGVMs) are useful tools for simulating the distribution and structure of global vegetation in response to past, present and future climates. However, many of them display high uncertainty in predicting vegetation in tropical areas. This difficulty is often a consequence of the representation of the main ecological processes and feedbacks between biotic and abiotic factors.

The aim of this study is to evaluate and compare the outcomes of the two state-of-the–art DGVMs LPJ-GUESS and JSBACH, also currently used in two Earth System Models, and to assess which key ecological processes need to be included or improved within these models. To this end, we compare the relationships of tree and grass cover with precipitation and fire and the pattern of savannas and forests from remote-sensing data (from MODIS, TRMM, ESA CCI LC) and from models, and use the current ecological understanding of the mechanisms driving the savanna-forest transition. The two DGVMs are characterized by different spatial resolutions and a different complexity of the representation of vegetation. They can be run with simple and complex fire modules, permitting to highlight the changes resulting from the increase in complexity in the description of fire processes.
The comparison of the relationships between climate, vegetation and fire between DGVMs and observations allows to identify specific possible improvements in the model representations of tree-grass water competition, of vegetation-fire interaction, and of savanna and forest tree characteristics.