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Climate variability and change in central Africa: An analysis of land surface-atmosphere interactions from idealised and realistic climate model experiments

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The importance of present-day and future land use change, and its impact on regional climate variability, is undeniable. This is especially true for environmentally and socio-economically vulnerable regions such as tropical central Africa, where the land plays a crucial role in maintaining livelihoods. The ecosystem of central Africa has been shown to be sensitive to climatic variability, however little is known about the role of land surface–atmosphere interactions on regional climate, in particular on rainfall and rainfall variability.

To date, very few studies have assessed the impact of present-day or future land cover change in central Africa. In this study a two-pronged approach is taken; firstly, the fundamental influence of the land surface on regional climate is investigated with basic idealised experiments using a general circulation model (GCM). Two idealised land cover scenarios are created and used to drive the model, one with a complete removal of vegetation and one with a complete afforestation throughout the region. Secondly the impact of future land cover change is investigated by forcing the GCM with realistic land cover scenarios. Based on those from the UNEP Millennium Ecosystem Assessment project, two land cover scenarios (representing future conditions) were produced and used to drive the model: i) Order From Strength (OFS), and ii) Techno Garden (TG). The model was used in atmosphere-only mode with prescribed present-day climatological sea surface temperatures, as well as present-day greenhouse gas emissions, to isolate the impact of the land surface on regional climate.

The results suggest that land surface-atmosphere interactions play a fundamental role in rainfall variability, with a complete removal of vegetation reducing rainfall by 11-55%. Conversely, in the idealized afforestation scenario, an increase of 17-41% in rainfall is shown. The future scenarios suggest a 2-12% decrease in rainfall in the OFS experiment, and mixed changes of both increases and decreases in the TG experiment. The physical mechanisms causing these rainfall changes, such as modifications to the jets and variations in temperature, humidity and moisture flux, are presented.