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The climate responses of tropical and boreal ecosystems with an improved land surface model (JULES)

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The Joint UK Land Environment Simulator (JULES) is the land surface of the next generation UK Earth System Model (UKESM1). Recently, JULES was updated with new plant functional types and physiology based on a global plant trait database. These developments improved the simulation of terrestrial gross and net primary productivity on local and global scales, and enabled a more realistic representation of the global distribution of vegetation.

In this study, we explore the present-day distribution of ecosystems and their vulnerability to climate change in JULES with these improvements, focusing on tropical and boreal ecosystems. Changes to these ecosystems will have implications for biogeophysical and biogeochemical feedbacks to climate change and need to be understood. First, we examine the simulated and observed rainforest-savannah boundary, which is strongly related to annual precipitation and the maximum climatological water deficit. Second, we assess the length of growing season and biomass stored in boreal ecosystems, where 20th century warming has likely extended the growing season. In each case, we first evaluate the ability of JULES to capture observed climate-vegetation relationships and trends. Finally, we run JULES to 2100 using climate data from 3 models and 2 RCP scenarios, and examine potential 21st century changes to these ecosystems. For example, do the tropical forests shrink in response to changes in tropical rainfall seasonality? And, how does the composition of boreal ecosystems change in response to climate warming? Given the potential for climate feedbacks and the inherent value in these ecosystems, it is essential to assess their responses to a range of climate change scenarios.