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The critical precipitation threshold for the Amazon forest biomass in the LPJmL vegetation model

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The Amazon rainforest, one of the most important biomes in the world, and recognized as a potential tipping element in the Earth system, has received increasing attention in recent years. Theory and observations suggest that regional climate change from greenhouse gas emissions and deforestation may push the remaining forest toward a catastrophic tipping point.

Despite the urgency to assess the future fate of the Amazon, it remains unclear if state-of-the-art Dynamic Global Vegetation Models (DGVMs) can capture the highly nonlinear dynamics underlying such potentially abrupt dynamics and there is a noticeable scarcity of DGVM evaluations regarding their potential to predict forthcoming tipping points.

In our manuscript, we systematically investigate how the Amazon forest responds in idealized scenarios where precipitation is linearly decreased and subsequently increased between current levels and zero, using the state-of-the-art model LPJmL. We investigate whether large-scale abrupt changes and tipping points occur, and whether early warning signals as expected from theory can be detected.

Our results indicate a pronounced nonlinearity but reversible behavior between vegetation aboveground biomass (AGB) and mean annual precipitation (MAP) in the LPJmL simulations. In particular, there exists a threshold at a critical rainfall level below which there is a rapid decrease in forest biomass. The value of the threshold is determined by seasonality, evapotranspiration and the adaptive capacity of roots. Significant "early warning signs" can be detected before the transition.