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Beta effect of eCO_2 can cause as much rainfall decrease as large-scale deforestation in the Amazon

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Amazon region's climate is particularly sensitive to surface processes and properties such as heat fluxes and vegetation coverage. Rainfall is a key expression of such land surface-atmosphere interactions in the region due to its strong dependence on forest transpiration. While a large number of past studies have shown the impacts of large-scale deforestation on annual rainfall, studies on the isolated effects of elevated atmospheric CO_2 concentration (eCO_2) on plant physiology (i.e. the β effect), for example on canopy transpiration and rainfall, are scarcer. Here we make a systematic comparison of the plant physiological effects of eCO_2 and deforestation on Amazon rainfall. We use the CPTEC-Brazilian Atmospheric Model (BAM) with dynamic vegetation under a $1.5xCO_2$ and a 100% substitution of the forest by pasture grassland, with all other conditions held similar between the two scenarios. We find that both scenarios result in equivalent average annual rainfall reductions (Physiology: -252 mm,-12%; Deforestation: -292 mm, -13%) that are well above observed Amazon rainfall interannual variability of 5.1%. Rainfall decrease in the two scenarios are caused by a reduction of approximately 20% of canopy transpiration, but for different reasons: eCO_2-driven reduction of stomatal conductance in the Physiology run; decreased leaf area index of pasture (-66%) and its dry-season lower surface vegetation coverage in the Deforestation run. Walker circulation is strengthened in the two scenarios (with enhanced convection over the Andes and a weak subsidence branch over east Amazon) but, again, through different mechanisms: enhanced west winds from the Pacific and reduced easterlies entering the basin in Physiology, and strongly increased easterlies in Deforestation. Although our results for the Deforestation scenario are in agreement with previous observational and modelling studies, the lack of direct field-based ecosystem-level experimental evidence on the effect of eCO_2 in moisture fluxes of tropical forests confers a substantial level of uncertainty to this and any other projections on the physiological effect of eCO_2 on Amazon rainfall. Furthermore, our results denote the incurred responsibilities of both Amazonian and non- Amazonian countries to mitigate potential future climatic change and its impacts in the region driven either by local deforestation (to be tackled by Amazonian countries) or global CO_2 emissions (to be handled by all countries).