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Modelling CO_2 and N_2O emissions from a tropical semi-arid parkland cultivated with groundnut and millet

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Agriculture contributes to climate changes through land use changes and greenhouse gas emissions. Models can provide crucial insights into the extent of this contribution; however, their effectiveness relies on proper evaluation within the application context. Moreover, crop models that can simulate greenhouse gas emissions have not been extensively tested for the semi-arid tropics. We calibrated and used the STICS soil-crop model to explore the skills of the model to reproduce observed variations in greenhouse gas emissions for a millet-groundnut rotation in an agro-silvo-pastoral parkland dominated by *Faidherbia albida* trees located in central Senegal. Model simulations were compared with observations of soil temperature, soil water content, N_2O and CO_2 emissions, aboveground and belowground biomass of millet and groundnut, collected between 2018 and 2022. CO_2 emissions were simulated with a two-step approach. Initially, STICS simulated crop leaf area index and biomass (aboveground and belowground), and soil heterotrophic respiration. These variables were then integrated into an independent autotrophic

respiration module, and summed with STICS simulated' heterotrophic respiration. In general, the STICS model tends to underestimate the observed minimum soil water content (wilting point) during the dry season and overestimate the observed soil water content after the wet season. However, the temporal dynamics of the soil temperature in the upper layer (0-30 cm) are generally well-represented by the model throughout the simulation period. Simulated N_2O emissions were generally consistent in terms of magnitude compared to on-site measurements, although the model currently does not account for N_2O absorption by the soil (i.e. negative fluxes). For instance, the simulated peak reached 0.041 kg N ha^{-1} d^{-1}, while the observed peak was 0.048 kg N ha^{-1} d^{-1}. The simulated average annual N_2O emissions for the period 2018 to 2022 amounted to 0.368 kg N ha^{-1} yr^{-1}. Simulated CO_2 emissions were also comparable to on-site measurements (2021: EF = 0.63, BIAS = -0.75 kg C ha^{-1} d^{-1}, and RMSE = 15.01 kg C ha^{-1} d^{-1}; 2022: EF = 0.56, BIAS = -3.25 kg C ha^{-1} d^{-1}, and RMSE = 5.01 kg C ha^{-1} d^{-1}). These results indicate that the STICS model can be used to explore the impact of land use and crop management changes on greenhouse gas emissions in a tropical semi-arid context.