ABSTRACT: Large uncertainties remain surrounding vegetation and carbon responses in the Amazon forest to disturbance parameters including size, rates, spatial distribution, and return frequency. It has been long recognized that forest sample plots are embedded in larger landscapes consisting of varying disturbance regimes. Here, we studied the impacts of prolonged increased disturbance on a tropical forest and evaluated the steady-state mosaic of disturbance and succession across an old-growth Central Amazon forest. To help quantify the impacts of increased disturbances on the climate system, the accuracy of tree mortality in global land surface models (here the Community Land Model, CLM) warrants improvement. To address this issue, we parameterized, calibrated, and verified ZELIG-TROP, a dynamic vegetation gap model, to simulate a complex Central Amazon forest and improve disturbance-recovery processes in CLM. Under a high disturbance scenario (doubling background tree mortality annually) the dynamic vegetation model predicted that aboveground biomass and net primary productivity decreased by 41.9% and 8.4%, respectively, and turnover rates increased by 42.3%. In addition, there were a higher proportion of smaller stems (20.7%), and a decrease in larger stems, producing a decrease in annual coarse litter inputs (trunks and large branches >10 cm in diameter) by 7.1%. This reduction in coarse litter resulted in a carbon flux gain, which over the long term (>100 years) offset the total loss in standing live biomass. The largest discrepancies were that under a high disturbance, CLM did not capture the temporal variability in carbon flux with respect to disturbance, nor did CLM replicate the reduction in coarse litter over the long-term and gains in carbon flux. By integrating field plot data, remote sensing disturbance probability functions, and modeling approaches, results demonstrate that a steady state of patches of varying successional age occurs over a relatively large spatial scale. Additionally, as found here using a model-based analysis of fractional mortality across all gap sizes demonstrated that 9.1–16.9% of tree mortality was missing from plot-based approaches, underscoring the need to combine plot and remote-sensing methods for estimating net landscape carbon balance. This study highlighted important implications for detecting temporal trends on plots that sample a small fraction of the landscape. To maximize the detection of global change temporal trends for this Central Amazon site (e.g., driven by CO2 fertilization) plots larger than 10 ha would provide the greatest sensitivity. Lastly, in order to predict a more dynamic and accurately responsive carbon signal to disturbances in global climate modeling, the mechanistic and stochastic mortality algorithms used in ZELIG-TROP should replace the procedure used in CLM.