Resilience of tropical forests to cyclones: an individual-based model simulation approach

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Abstract

Tropical cyclones can have a major impact on tropical forests, and their intensity is believed to increase in the next decades. In addition, these forests have high level of biodiversity and endemism and are exposed to anthropogenic activities. However, a comprehensive understanding of the long-term effects of tropical cyclones on the structure and dynamics of tropical and subtropical forests has yet to emerge. Here, we coupled an individual-based forest dynamic model, TROLL, with a global climatic boundary condition, the CRU-NCEP re-analysis climate data. We applied this model to a subtropical forest of Taiwan, in a region with the highest frequency of cyclone visits in the world. We showed that the CRU-NCEP data represented reasonably well climatic forcing at the local level. We also compared extreme wind data derived from reanalysis dataset with best-track data (IBTrACS), which specifically track tropical cyclone path and intensity around the world. Baseline simulation results showed adequate fit between simulated and observed forest structure metrics (such as maximum height, tree density, and aboveground biomass.) Wind regimes were related to treefall probability using a bio-mechanic model, accounting for tree allometry, wood density and local neighborhood effect. As the intensity of extreme wind conditions increased, we observed a critical transition from a "forest" state to a "non-forest" state, suggesting a non-linear behavior of the system. A cross-site comparison was performed including sites from the Caribbean region, and showed that the model was also able to capture the dynamics of these forests. Future work should explore the vulnerability of forests to cyclonic events at global scale and under climate change scenarios.

Keywords: climate change, cyclone, forest, tree allometry, treefall

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