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Impact of climate change on carbon and nitrogen cycling in a tropical ecosystem

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Abstract

Tropical montane rainforests growing on poorly developed soils are often nitrogen [N]- limited and therefore susceptible to N deposition and increased N release from mineralization. Temporal variability of total organic carbon [TOC] concentrations and their relationship with dissolved organic nitrogen [TOC/DON], electrical conductivity [EC] and pH in ecosystem solutions was analyzed along the water pathway through the forest, from precipitation [RF] through canopy runoff [TF], stem flow [SF], litter and organic layer leachate [LL] and soil mineral solutions at 0.15 and 0.30 m depth (SS15, SS30) to river outflow [ST] in a montane tropical forest from 1998 to 2013. Additionally, temporal variability, sources and transformations of dissolved organic matter (DOM) were assessed with the aid of stable C isotopes [$\delta^{13}C$]. Age of solutions was also determined with [$\Delta^{14}C$]. It was further explored whether stable N isotopes [$\delta^{15}N$] could provide information on N sources and transformations. Negative trends in TOC concentrations were found in most ecosystem solutions. The results suggest an accelerated degradation of particularly young DOM. Carbon isotopic values $\delta^{13}C$ decreased in the following order RF > TF > SF < LL due to increased leaching of isotopically light carbon compounds. Higher $\delta^{13}C$ values were found in SS15, SS30 and ST than aboveground solutions, suggesting that roots and root exudates are the main sources of DOM in the soil. The decrease in $\delta^{15}N$ values of total dissolved nitrogen [TDN] from rainfall to canopy runoff suggests that isotopically heavy N from rainfall was retained and in turn isotopically light N compounds including DON and nitrates (NO_3^-) were leached from the canopy. The higher $\delta^{15}N$ values of TDN in LL than in aboveground solutions suggest a contribution from isotopically heavy DON leached from organic horizons. The lower $\delta^{15}N$ value of soil mineral solution at 0.15 m depth than in organic layer leachate can be explained by retention of isotopically heavy DON and addition of isotopically light NO_3^- from mineralization and nitrification. Increasing $\delta^{15}N$ values in the order SS15 < SS30 < ST suggest gaseous N losses due to increasing denitrification. Therefore, stable isotopic ratios of carbon $\delta^{13}C$ and nitrogen $\delta^{15}N$ of dissolved organic matter provide an additional tool to assess the sources and cycling of DOM.

Keywords: Rainforests, Organic carbon, Stable isotopes, Mineralization.