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What drives inter-annual variations in C flux and balance in a tropical rainforest of French Guiana?

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Amazon rainforests, a major contributor to the global carbon sink, is not on steady state and information about the long-term impact of climate change on carbon fluxes between this ecosystem and the atmosphere and the resulting balance is lacking. A thorough understanding of the forest responses to climate is indeed important to improve ecosystem process models and to reduce uncertainties in the contemporary carbon balance calculations for tropical forests. To address these issues, we examined the interannual variations in gross primary photosynthesis (GPP), ecosystem respiration (RE) and net ecosystem exchange (NEE) in a tropical rainforest in French Guiana and identified key climatic drivers influencing such changes across a 12-year long period (2004 – 2015).

The study period was characterized by strong differences in climate conditions, particularly in the intensity of the long dry and the long wet seasons. Fluctuations in annual average GPP vary from 9.27 $\pm$ 1.68 g C $m^{?2}$ $d^{?1}$ to 11.13 $\pm$ 2.21 g C $m^{?2}$ $d^{?1}$. RE is more varied than GPP having a difference of 2.53 C $m^{?2}$ $d^{?1}$ between the minimum (8.28 $\pm$ 0.85 g C $m^{?2}$ $d^{?1}$) and maximum (10.80 $\pm$ 1.67 g C $m^{?2}$ $d^{?1}$). GPP was always higher than RE annually and the forest remained a carbon sink in an annual basis although NEE has huge interannual variability, from -0.18 $\pm$ 1.64 g C $m^{?2}$ $d^{?1}$ to -1.62 $\pm$ 1.65 g C $m^{?2}$ $d^{?1}$.

Annually, the combination of global radiation (Rg), relative extractable water (REW) and soil temperature (Ts) explained 51% of the variations of GPP, 30% for RE, and 39% for NEE, but global radiation was always the best predictor variable. Seasonally, Rg was the major controlling factor for GPP (r^2 = 0.58; P <0.0001), RE (r^2 = 0.08; P<0.0001) and NEE (r^2 = 0.48; P<0.0001) during the wet season. During the dry season, variations in C fluxes and balance were poorly explained by climate factors. Yet, relative extractable water was the key driver of variations in RE (r^2 = 0.16; P < 0.0001) and NEE (r^2 = 0.10; P < 0.0001). Biotic factors such as plant area index, tree growth or litterfall did not contribute much to explain these variations. This study highlights the importance of taking into consideration the main drivers of C fluxes and balance for each seasonal type when integrating them in land atmosphere models. Detailed mechanisms on the impact of drought on photosynthesis and respiration must also be inferred in dynamic vegetation models.