Optimal Crown Temperature of Basal Stem CO₂ Efflux in Canopy Dominant Trees in the Central Amazon

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Stem respiration is estimated to represent 20-30% of autotrophic respiration, but its response to environmental drivers like temperature remains unclear. Although respiration sources and CO₂ transport in the transpiration stream are known to increase with temperature, their combined influence on diurnal stem CO₂ efflux (Eₛ) in the tropics remain poorly understood.

In this study, we show that basal Eₛ (1.3 m) from three canopy dominant trees in a mature tropical ecosystem in the central Amazon is tightly correlated with crown temperature (27-31 m) over fast (5 min), medium (hourly), and diurnal time scales. Transient variations in daytime crown temperatures caused by the passing of clouds overhead were accompanied by rapid variations in basal Eₛ.

Elevated crown temperatures during the daytime were accompanied by high sap velocities and reduced basal Eₛ. In contrast, during the night and rainy conditions, crown temperatures and sap velocities reached minimum values while basal Eₛ reached maximum values.

The results show that Eₛ was depressed when crown temperatures exceed 24-28.5°C, potentially reflecting an optimum crown temperature where stem CO₂ sources reach a maximum relative to stem CO₂ sinks (e.g. transport in the transpiration stream). We suggest this optimal temperature may be useful as a new benchmark for land models that mechanistically link autotrophic respiration and transpiration. In contrast to current global models, which predict higher Eₛ with temperature, our results imply that warmer conditions lead to reduced Eₛ and increased transport in the transpiration stream, potentially enhancing internal CO₂ re-assimilation and consequently carbon use efficiency and photo-protection during climate warming.