Partitioning evaporation and transpiration in wet canopies

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Abstract

Our current understanding of fluxes from tropical rainforests is limited by insufficient data observations during wet canopy conditions. The aim of this project is to partition evaporation and transpiration under wet-to-dry canopy transitions within a montane forest in Costa Rica. Notably, this new Ameriflux site in a mature tropical rainforest has the highest mean annual precipitation of any in the network (4200 mm). The site is equipped with a 39-m canopy tower instrumented with two LI-COR 7200 eddy covariance systems (upper and lower canopy), a Campbell AP200 CO2/H20 profile system, five Decagon leaf wetness sensors, and additional micrometeorological sensors. In addition, 43 sapflow sensors in dominant, codominant, midstory, and suppressed understory trees provide estimates of stand transpiration. Total evapotranspiration (ET) was less than 10% of rainfall, which averaged 122 mm per week over a 21-week period of investigation (July 7 to Nov 30, 2014). The canopy was moderately to extremely wet 1/3 of the time, with more prolonged wetness near ground level. Only about ¼ of days could be considered "dry", having leaf wetness less than 10%. Preliminary estimates of ET from eddy covariance average 1.2 mm per day (up to 2.6 mm), while estimates of transpiration from sap flux averages only 0.65 mm per day (up to 1.6 mm), suggesting that evaporation comprises about half of ET in this system. By contrast, on dry days, the fraction of ET from transpiration was higher. This new site, which is strongly energy limited compared with most Ameriflux sites, has great potential to enhance our understanding of forest function under extreme wet conditions.

Objectives

To improve models for ET during wet conditions

At this stage of the project,

- Partition evaporation and transpiration under wet-to-dry canopy transitions
- Partition canopy T into three tree size categories (dominant, midstory, and suppressed)

Methods

Research Site: TAMU Soltis Center- San Isidro de Las Penas Blancas, Costa Rica: mature tropical forest stand surrounding a 40-m tower equipped with eddy covariance (LI-7200), AP200 profile system, and micrometeorological sensors at multiple heights. Ground measurements in 40x45 m area.

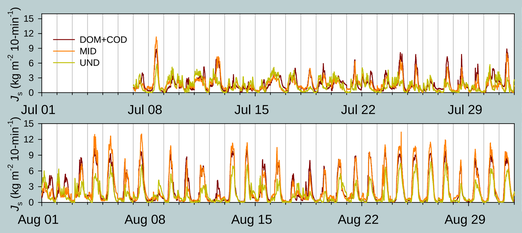
Trees: Measured 26 nearby trees ranging from DBH = 6 to 200+ cm; H= 6 to 40 m. Tree dominance classified by visual observations of canopy exposure and tree height → dominant (maximum exposure), co-dominant (80% exposure), midstory (50% exposure) and suppressed (under 30% to zero).

Measurements:
Sapflow (Js): 43 Granier (1985) heat dissipation sensors; Leaf Wetness: 5 sensors at heights of 5, 12, 24, 34, 40 m. VPD of upper canopy during daylight hours. Net Radiation above canopy during daylight hours.

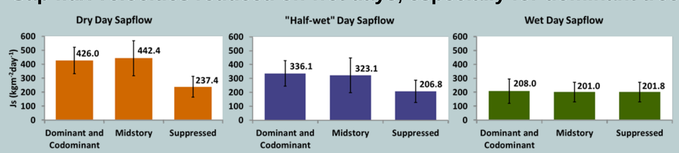
Day Wetness Classification: Study period was evenly divided into dry days (entire canopy <10% wetness), wet days (entire canopy >50% wetness), and "half-wet" days with dry upper canopy and wet lower canopy (N=37 days each).

Partitioning *within* the canopy

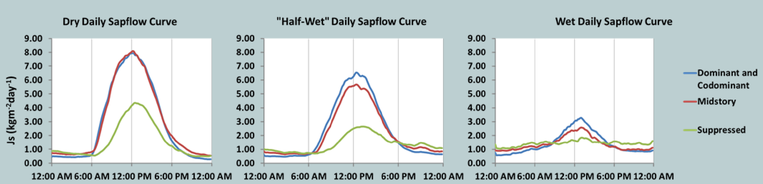
Sap flux velocities were restricted during a wet month (July, 900mm rain) and maximized during a dry month (August, 341mm rain).



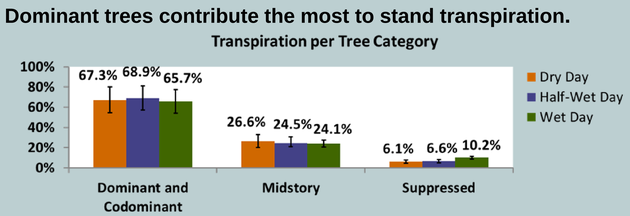
Sap flux velocities reduced on wet days, especially for dominant trees.



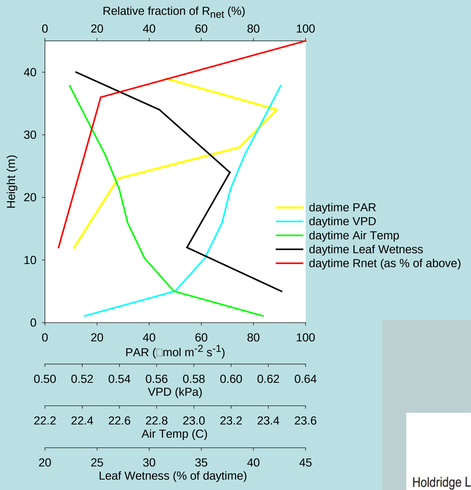
Daily trends similar for dominant and midstory trees, especially on dry days



Dominant trees contribute the most to stand transpiration.



STAND TRANSPIRATION (mm/day)				
Period	Dominant and Co-dominant	Midstory	Suppressed	TOTAL
ALL DAYS	0.439	0.163	0.045	0.648
DRY DAYS	0.572	0.226	0.051	0.849
WET DAYS	0.277	0.101	0.043	0.421
HALF-WET	0.441	0.157	0.042	0.640



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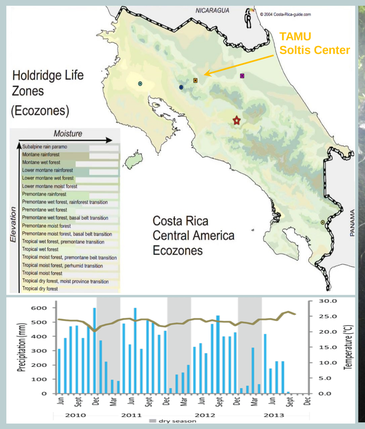
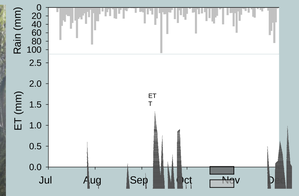
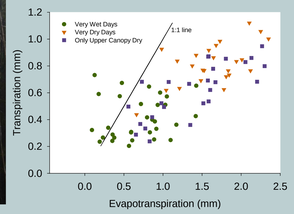
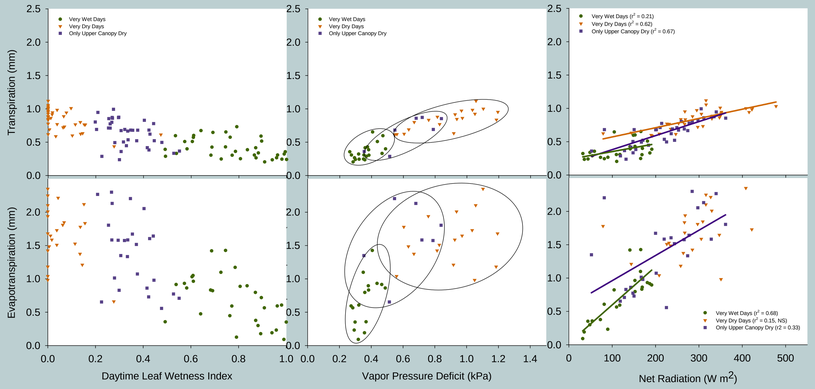
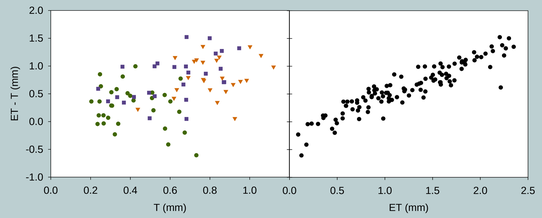
Take-home Message

This new Ameriflux site in a mature tropical rainforest has the highest mean annual precipitation of any in the network (4200 mm)

Because of frequent wet conditions
- ET is a small component of site water balance
- T amounts to only about half of total ET
- T is frequently reduced by wet leaves
- Dominant trees contribute even more to total site water use

Drivers
- Leaf wetness is a major driver of ET and T
- T responds better to VPD and R_{net} than ET
- Assuming ET-T=E, E is decoupled with T, but closely associated with ET

Partitioning Evapotranspiration