Spatiotemporal Assessments of Greenhouse Gas Concentration and Flux in Headwater Tropical Streams

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Conclusion: CO_2 Evasion from Tropical Headwater Streams to the Atmosphere is Highly Variable and Mediated by Discharge, In-Stream Metabolism, and Slope

Long thought to be a carbon sink, the Páramo region of the Andes may be a significant carbon source (Carrillo et al. 2019 AFM). We evaluated the spatiotemporal dynamics of CO_2 concentration and flux in a high-elevation stream. We measured 15-min dissolved CO_2, O_2, and discharge, across a wetland-stream transition, characteristic of tropical, alpine environments.

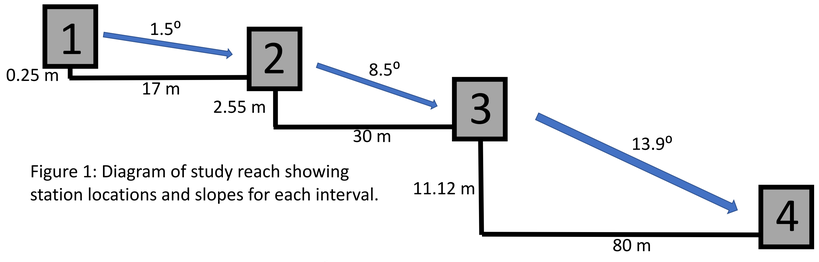


Figure 1: Diagram of study reach showing station locations and slopes for each interval.

$$f = \frac{\Delta ppm}{A} * .0018 * \frac{10^6}{44.01} * Q + (\mathrm{R} - \mathrm{P})$$

f : aquatic CO_2 flux [µmol $m^{-2}s^{-1}$]
Δppm: CO_2 change [ppm] between stream locations,
A: Stream surface area between stream locations [m^2]
Q: Discharge [m^3s^{-1}]
R: In-stream respiration [µmol$m^{-2}s^{-1}$]
P: Gross Primary Production [µmol$m^{-2}s^{-1}$]

The Páramo

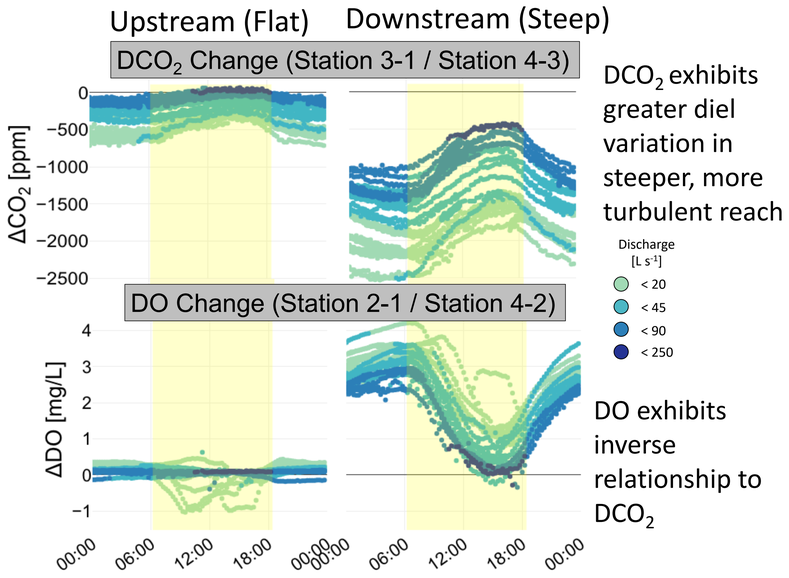
- High altitude, tropical grassland and wetland ecosystems connected by well-defined stream channels
- Annual rainfall ranges from 1450mm to 4000mm. Since 2012, rainfall has occurred on 84% of days of the year.
- Mean daily temperature is 5^0 C.
- We instrumented a 250-m reach, which serves as the main outlet to a 2.3-ha wetland and multiple additional wetlands further upstream.

Station	1	2	3	4
Level	X	X	X	X
DO	X	X		X
CO_2	X	X	X	X
EC	X	X		X

Sensors:
4 Vaisala GM-220 DCO_2 sensors
3 HOBO Dissolved Oxygen
3 HOBO Electrical Conductivity
2 Solinst Water level loggers
1 Eosense eosFD Chamber

Check out these plots and more, interactively!

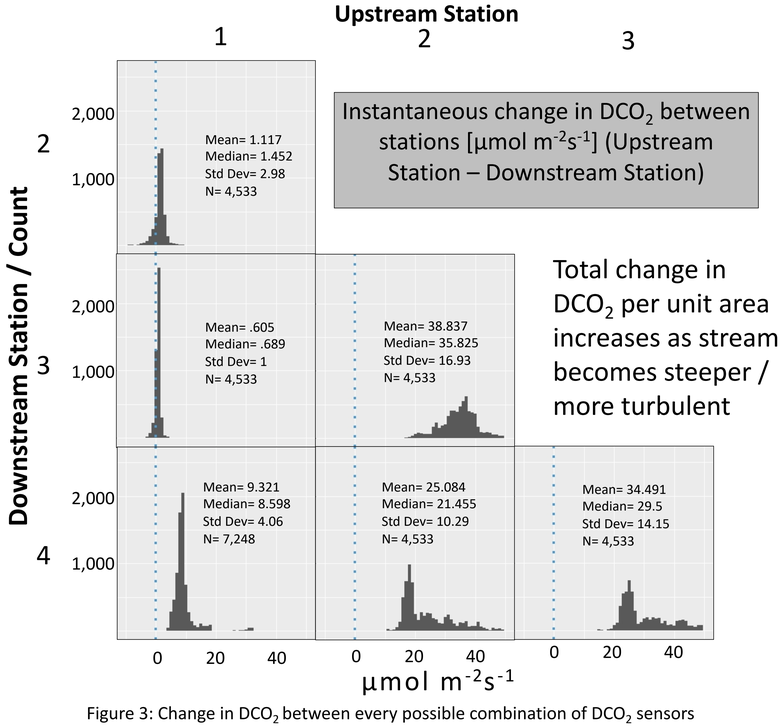
CO_2/O_2 variability along a single stream



DCO_2 exhibits greater diel variation in steeper, more turbulent reach

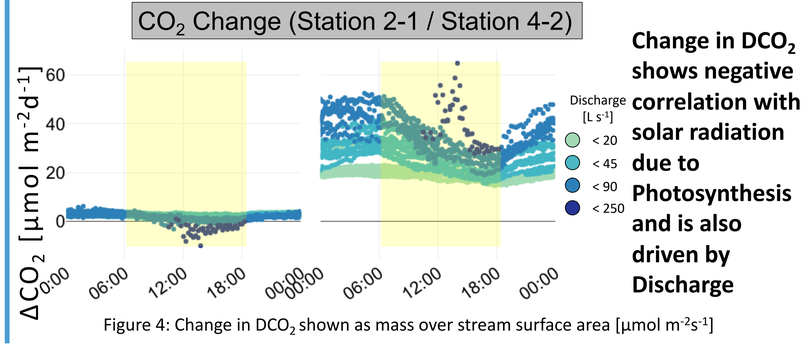
DO exhibits inverse relationship to DCO_2

Figure 2: CO_2 and DO show inverse relationships indicating the presence of metabolic processes in the stream. Greater daily variation is exhibited in the downstream (steeper) portion of the stream.



Total change in DCO_2 per unit area increases as stream becomes steeper / more turbulent

Figure 3: Change in DCO_2 between every possible combination of DCO_2 sensors



Change in DCO_2 shows negative correlation with solar radiation due to Photosynthesis and is also driven by Discharge

Figure 4: Change in DCO_2 shown as mass over stream surface area [µmol $m^{-2}s^{-1}$]

CO_2 Change → CO_2 Evasion

Stream Metabolism

- We estimated Respiration (ER) & Gross Primary Productivity (GPP) using the stream Metabolizer R package from USGS (Appling et al., 2016)
- CO_2 evasion from the stream to the atmosphere is estimated as the change in CO_2 after accounting for respiration and gross primary productivitv.

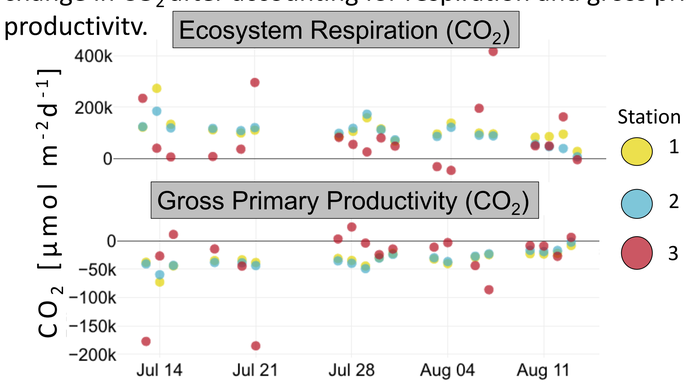


Figure 5: Daily estimates for ER and GPP (photosynthesis) from USGS streamMetabolizer R package for each station with DO

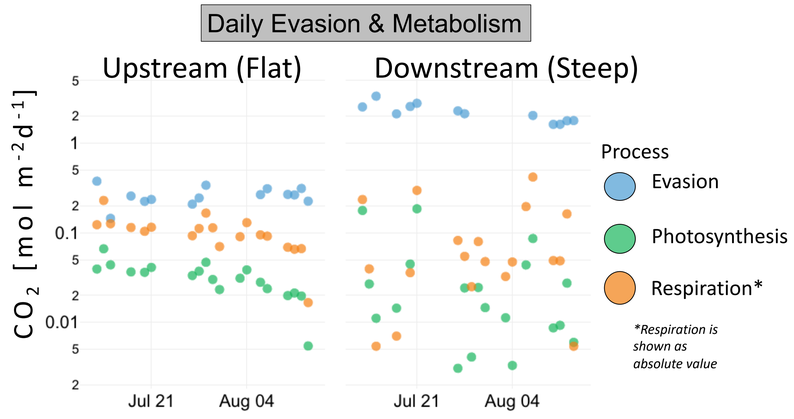
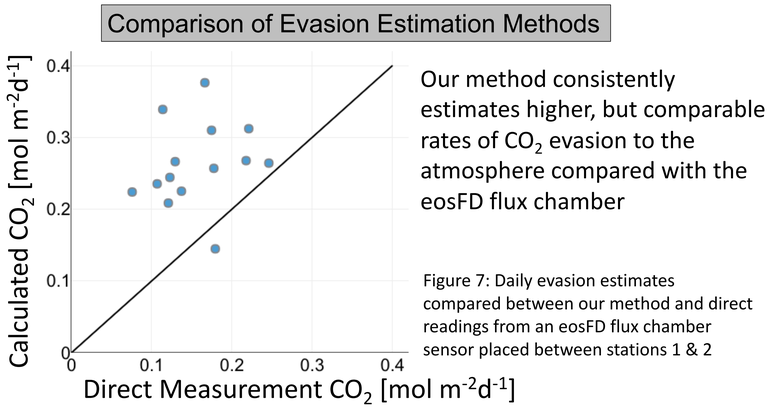


Figure 6: Daily estimates for respiration and photosynthesis and evasion, calculated separately for upstream and downstream sections



Our method consistently estimates higher, but comparable rates of CO_2 evasion to the atmosphere compared with the eosFD flux chamber

Figure 7: Daily evasion estimates compared between our method and direct readings from an eosFD flux chamber sensor placed between stations 1 & 2

Daily Evasion ranged from .1447 to .3761 mol $m^{-2}d^{-1}$ in the flatter, less turbulent reach and from 1.618 to 3.339 mol $m^{-2}d^{-1}$ in the steeper, more turbulent reach, equating to between 6.4 and 147 g $CO_2m^{-2}d^{-1}$.

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