Title: Disturbances drive stream greenhouse gas changes and increased heterogeneity at the reach-scale

Authors:

López Lloreda, Carla, Virginia Tech, carlalopez@vt.edu, ORCiD: 0000-0002-7983-1741

Barreto Vélez, Tatiana, Florida International University, tati.barreto.v@gmail.com, ORCiD: 0009-0002-4234-5333

Herreid, Allison M., USDA-ARS, allisonherreid@gmail.com, ORCiD: 0000-0002-5172-5605

Gutiérrez-Fonseca, Pablo E., University of Vermont, pabloe.gutierrezfonseca@gmail.com, ORCID: 0000-0003-0777-8889

Gómez, Jesús E., University of Puerto Rico-Mayagüez, jesus.gomez3@upr.edu, ORCID: 0009-0007-9276-8971

McDowell, William H., University of New Hampshire, billmcdowell@unh.edu, ORCiD: 0000-0002-8739-9047

Disturbances, such as droughts and hurricanes, can dramatically alter the structure and function of stream ecosystems. Large inputs of organic matter, riparian canopy opening and sustained impacts on hydrology following a disturbance can result in important changes in biogeochemical processes in small streams such as greenhouse gas (GHG) production.

To explore the impacts of disturbance on GHG dynamics, we conducted longitudinal measurements of dissolved carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) concentrations in two streams before and after a major hurricane. Subsequently, we have experimentally manipulated one of the streams through a stream flow reduction experiment (StreamFRE). We sampled nine pools across ~200m reaches in each stream before Hurricane María in 2017 and at intervals of 1, 4, 6, and 9 months post-hurricane. Experimental flow reduction was initiated three years post-hurricane, and we sampled during two experimental drying periods.

Before the hurricane, concentrations of the 3 gases were stable across the reach with an average of 67.3, 0.07, and 0.01uM for CO2, CH4 and N2O, respectively. Following the hurricane, CO_2 increased on average by 129% and N2O by 10%, while CH_4 decreased by 25%. Heterogeneity for CO_2 increased but N2O and CH_4 remained relatively stable across the two stream reaches. Specifically, CO_2 increased and continued increasing across our sampling periods and did not return to pre-hurricane concentrations during our sampling period. N2O increased post-hurricane and continued to increase until the 4-month mark and was back to

baseline at 7 months. On the other hand, CH_4 decreased and continued decreasing without returning to pre-hurricane concentrations during our study period.

Results from the flow reductions showed a more muted response of greenhouse gases during this experimental drought. During the flow reduction, the experimentally manipulated stream showed small differences in CO_2 concentrations, particularly near the diversion location (ie. higher upstream). CH_4 concentrations remained similar to pre-hurricane concentrations and N2O slightly increased.

Our findings suggest that disturbances can change greenhouse gas concentrations in streams and can also create heterogeneity and hotspots following disturbance. Our understanding of how disturbances change biogeochemistry will be crucial in a future with increased droughts and hurricanes. Moreover, the differences observed between the patterns resulting from natural disturbances and our experimental flow manipulation indicate that other factors may be influencing gas dynamics in small mountain streams.