Soil gas flux factors in a hilly tropical forest

INTRODUCTION
Tropical rainforests are large sources of carbon dioxide (CO$_2$), nitrous oxide (N$_2$O), and methane (CH$_4$), which are known to be potent greenhouse gases (GHGs). Despite this, greenhouse gas flux in tropical rainforests is not well studied due to the difficulties of deploying and maintaining equipment. This gap in knowledge is a considerable issue since it is unknown how these big emitters and sinks of greenhouse gases currently function, making it difficult to try and estimate how climate change will influence these dynamics. Understanding the controls—typically soil temperature and moisture, but also other factors including slope and soil texture—on soil O$_2$ and GHG concentrations and fluxes across different landscapes will help us to better understand the potential changes that climate change may have in the future on GHG balances.

The big question is how will different land types be influenced or affected by climate change, and to what degree? The first step in answering these large questions is to understand what is currently going on in the system.

THE SILVER LAB’S OBJECTIVES
The experiment takes place in the Luquillo Experimental Forest (LEF), a tropical montane rainforest in northern Puerto Rico. Rainfall amounts in this area average 3500 mm to 5000 mm per year, making it a very wet place, and unsurprisingly the steep topography of the forest influences where all of this rainfall accumulates.

Dr. Whendee Silver’s team has set out to explore the hypothesis that slope, rather than soil texture or climate, is the most important predictor of soil O$_2$ concentration and GHG flux. Slope influences drainage properties in various topographies. This has a large influence on the redox potential of the soils on a ridge versus a valley; at a ridge you would expect to see very little standing water and oxic soils, and thus a high redox potential, whereas in the valleys you would expect to see standing water, little O$_2$, and high amounts of CH$_4$ gas being anaerobically produced and emitted (low redox potential).

WHERE EOSENSE COMES IN
To study these GHG flux dynamics, Dr. Silver and her team required continuous direct flux measurements at fine temporal scales. In order to acquire measurements in such detail, an eosAC autonomous closed chamber system and Picarro G2508 cavity ring down spectrometer gas analyzer were necessary. When asked about how it was decided that the Eosense system was the right system for their work, Dr. Silver is honest in her response, mentioning that initially they had wanted to build their own chambers.

The high temporal resolution data set that we have been able to acquire [with the eosAC/MX system] is flexible, robust and allows us to track changes in the system efficiently. It’s a very exciting tool to be able to work with.

Christine O’Connell (Post Doctoral Researcher, Silver Lab)
Not long after this decision, they realized that the true cost of doing this was much higher than expected and they began searching the market for existent instrumentation. What made Eosense the winner in Dr. Silver’s eyes were the eosAC’s form-factor and design, which minimize the probability of it catching on vegetation during sampling, as well as the fact that it is specifically designed to work with the Picarro G2508, one of the few gas analyzers that can measure all of the gas species of interest in their study.

At their LEF site, the Silver lab has erected a small shed which houses all of the equipment that cannot get wet including the Picarro G2508 and computer monitor, as well as their generator (Honda EU2000i). From the shed radiates a series of well-marked tubing leading towards the eosACs themselves, dispersed between 10 to 30 m away from one another. Each eosAC was pegged down using tent pegs to ensure that none tipped over on the steep slope. Every ten minutes the chambers would close and begin taking measurements.

The compatibility of the eosACs and eosMX with the Picarro G2508 allowed for smooth data collection and processing, making the whole process that much easier for the Silver lab.

**FINDINGS thus far**

Preliminary data suggest that Dr. Silver’s hypothesis of slope being an important dictator of greenhouse gas and O\textsubscript{2} fluxes appears to be on the right track. The field transect data show a pattern where high-levels of O\textsubscript{2} and N\textsubscript{2}O are seen on the ridges. Moving down the slope, N\textsubscript{2}O begins to show up as the dominant emitted gas mid-slope. Also, as predicted, the valleys were net sources of CH\textsubscript{4}, likely due to anaerobic production in water-laden soils. These findings would suggest that slope does play an important role in determining O\textsubscript{2} and GHG soil flux, although further studies are required to say this with any certainty.

**IT’S NOT OVER YET**

The field study in Luquillo will be expanding in the future. Dr. Silver’s team will be joining forces with another eosAC user to combine resources, totalling 21 eosACs, 2 eosMXs and 2 Picarro G2508s. The plan is to sample two different areas with similar topography but with two distinctly different textures (eg. fine versus coarse) in order to help disentangle the soil texture and slope controls on the total GHG fluxes. The findings from this will help to further our knowledge of tropical rainforest greenhouse gas dynamics, and filling in our current knowledge gaps.

1. Silver, W., Ruan, L., O’Connell, C., and Gutiérrez del Arroyo, O. The sensitivity of soil O\textsubscript{2} and redox biogeochemistry to landscape position and climate, AGU Fall Meeting, San Francisco, California (2015)