Greenhouse gas dynamics along a forested piedmont stream

1. INTRODUCTION

Greenhouse gas emissions are important and significant in headwater streams. They may account for a large portion of landscape carbon budgets (Crawford 2013). They have been demonstrated to be largest in headwater streams worldwide, with most supersaturated (Li et al 2021).

They can come from all of these places. They are consumed or lost in these ways.

Some studies suggest a strong internal processing control, others indicate most evasion is from groundwater sources.

The ecology of GHG: why does this matter energetically and to organisms?

This difference in important to stream biogeochemical cycling. Higher in stream contributions may be an indicator of anaerobic metabolism, which has important consequences for linked elemental cycles. Understanding this difference will also allow us to predict the behavior over time. Shifting groundwater inputs and water tables may be a consequence of climate change, which would be of central importance in a stream where emissions are primarily linked to groundwater flowpaths. Hypoxia is becoming more widespread and streams are becoming warmer, which will be important for instream processing rates and for the balance between aerobic and anaerobic pathways.

We measured greenhouse gas concentration and stream aerobic respiration and primary productivity longitudinally from the end of the fall respiration peak until the spring primary productivity window. We use these data to characterize the patterns and magnitudes of greenhouse gas fluxes from New Hope Creek and examine a set of potential predictor variables to describe these patterns. We also use mass balance calculations between sites in this reach to understand the spatial dynamics of groundwater inputs and exchange and the relative magnitude of aerobic and anaerobic respiration.

Questions and hypotheses:

1. What are the patterns and magnitudes of greenhouse gas concentrations and evasion rates in NHC? What variables are good predictors of these concentrations?
   1. High concentrations will be associated with high respiration and organic matter
   2. Methane will be best predicted by CO2
   3. Temperature, discharge and metabolism will be the main predictors
2. What is the relative importance of instream processing vs inputs to GHG evasion?
   1. Respiration will account for a large part of excess CO2
   2. Excess CO2, after accounting for aerobic resp and gw inputs, will be related to other indicators of anaerobic metabolism (NH4:NO3, CH4:CO2)

2. METHODS

**2.1 Site Description**

**2.2 Data**

**Sensor deployment**

* DO, temp, conductivity, level
* CO2

**Hydrology**

* Rating curve
* Flow accumulation model (upslope area GW contribution)
* Corroboration with a) water chemistry (?), b) flow measurements
* Stream upwelling zones with stream concavity

**Water Chemistry**

* NO3, DOC, ions

**2.3 Metabolism**

* Data Processing
* StreamMetabolizer
* Estimation of K

**2.4 Gas**

**Gas sampling**

* Gas chambers : 24 hr deployments

Diel cycles @ NHC

* Headspace gas concentrations

**Gas Flux**

* Flux calculations using saturation and K600
* Scaling to a reach

**2.5 Analyses**

* Multiple Regression:
  + Temperature, discharge, metabolism, NO3, DOC -> concentration and fluxes of ghgs
    - *CO2 will increase with temperature, ER, and DOC and decrease with Q and GPP*
    - *CH4 will increase with T, ER, and CO2 and decrease with Q, GPP, DO*
    - *N2O will increase with T, NO3, will decrease with DO*
    - *All fluxes will increase with K and by extension Q*
* Mass balance
  + Fout = Fin + Finstream – Fevasion + Fgwinputs
  + Calculated between each sample site. Compared to Data.
  + Systematic variation with a) sample site b) concavity c) water residence time
    - *Some sites will systematically be hotspots of ghg*
    - *Anaerobic processes will be important. This will be indicated by excess CO2 not correlated with GW and not explained by aerobic met, especially when paired with anaerobic indicators and DOC consumption in excess of aerobic metabolism*
    - *GW exchange will be more important than gw inputs. Could be suggested if higher water residence times mean higher met and CO2 production. Or when excess CO2 is present w/o gw inputs.* 
      * *This could be analyzed at the NHC site. When does C:O relationship deviate? Is it discharge or temperature dependent?*
* Metrics
  + Excess CO2 (above respiration)/GW inflow volume vs indicators of anaerobic met: NH4/NO3, CH4/CO2, upwelling zones
  + DOC consumption in excess of metabolism
* Excess CO2 vs excess O2 slope at NHC
  + Flat slope indicates external source of CO2 or anaerobic metabolism.
  + Does slope vary seasonally?
  + Is slope flatter when stream is gaining (highQ) or losing?
    - *Flat slope while gaining => groundwater*
    - *Flat slope while losing => anaerobic met?*
  1. **Statistics and accounting for uncertainty**
* MCMC sampling for uncertainty.

RESULTS

DISCUSSION