CHARACTERIZING INFLUENCES OF PULSE-DISTURBANCE EVENTS ON BIOGENIC GAS DYNAMICS IN EVERGLADES PEAT SOILS

Matthew Sirianni¹; Xavier Comas¹; Barclay Shoemaker²; Frank Anderson³

¹Department of Geosciences, Florida Atlantic University, Boca Raton, FL
²U.S. Geological Survey, Davie, FL
³Land IQ, Sacramento, CA
Introduction

1. Wetlands are important component in regulating global climate.

2. Source or sink for methane (CH$_4$) and carbon dioxide (CO$_2$).

3. Largest contributor to natural CH$_4$ emissions, and account for $\sim$25% of global CH$_4$ emissions.

4. Majority of CH$_4$ coming from tropical and subtropical wetlands.

5. Skunk apes are not currently quantified in the carbon budget...
Introduction: Previous Subtropical Wetland Studies

(1) **Spatial** Scale of Measurement: Biogenic Gas Production

Wright, W., and X. Comas (2016). Ranging between 0.02 to 0.47 g CH4/m²/d depending on site location.

(2) **Temporal** Scale of Measurement: Biogenic Gas Flux


- **Daily** ~250 mL/m²/d
- **Hourly** ~2500 mL/m²/d
**Introduction: Traditional Methodologies**

- **Ecosystem Scale (100s m)**
  - Continuously measured area integrated flux
  - 30 min flux average
  - May overlook ebullition

- **Plot Scale (10s m)**
  - Portable/low cost
  - Better at defining flux variability due to environmental conditions and plant communities.
  - Often filtered to remove ebullition

---

**Eddy Covariance**

- CH₄ Analyzer
- Soni Anemometer
- CO₂/H₂O Analyzer

**Static Flux Chambers**

- Syringe
- Three-way valves
- Rubber tube
- Top box
- Fans
- Sensor
- Digital thermometer
- Base box
- Seal groove

*Figure and analysis adapted from Tang et al., 2018*
Introduction: Gas Trap Methodology

- This study employs eddy covariance techniques with a gas trap methodology.

- Segment of millimeter graduated clear PVC pipe with an inverted funnel and cut-off sampling valve attached on opposite ends.

- Funnel is fixed approximately 20-30 cm above the soil surface where gas bubbles will enter and travel upward being stored in the millimeter graduated PVC chamber.

- Progressive displacement of the water by gas bubbles in clear PVC is captured by time-lapse cameras programmed to capture images every half hour.

*Specifically targets ebullition
What is the proper **spatial** and **temporal scale** for measuring biogenic gas emissions from peat soils?
Methodology: Experimental Design

1: Identify existing vegetation communities.

Q: How do soil CH$_4$ emissions from different vegetation communities compare to the overall flux observed by the EC tower?

2: Install platforms
3: Data collection
4: Data analysis
Study Area: Regional Maps

- US 41
- Loop Rd.
- Cypress Swamp
- Dwarf Cypress
Study Area: Soils

Dwarf Cypress

Field Sample

After Furnace

Physical Properties

<table>
<thead>
<tr>
<th>Porosity</th>
<th>0.73</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Density (g/cm³)</td>
<td>0.36</td>
</tr>
<tr>
<td>Organic Matter %</td>
<td>24</td>
</tr>
</tbody>
</table>

CaCO₃ rich
High periphyton presence

Cypress Swamp

Field Sample

After Furnace

Physical Properties

<table>
<thead>
<tr>
<th>Porosity</th>
<th>0.83</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Density (g/cm³)</td>
<td>0.23</td>
</tr>
<tr>
<td>Organic Matter %</td>
<td>51</td>
</tr>
</tbody>
</table>

Cypress litter derived
No visible periphyton
### Study Area: Vegetation maps

**Legend**
- Marl Prairie
- Cypress
- Swamp Forest
- Road
- EC Tower
- Platforms

Modified from Welch and Madden (1999) and Duever (2004)

### Dwarf Cypress

<table>
<thead>
<tr>
<th>Vegetation Type</th>
<th>Area (m²)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marl Prairie</td>
<td>317,120</td>
<td>63</td>
</tr>
<tr>
<td>Cypress</td>
<td>160,391</td>
<td>32</td>
</tr>
<tr>
<td>Road</td>
<td>24,976</td>
<td>5</td>
</tr>
<tr>
<td><strong>Footprint Total</strong></td>
<td><strong>502,487</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

### Cypress Swamp

<table>
<thead>
<tr>
<th>Vegetation Type</th>
<th>Area (m²)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cypress</td>
<td>1,370,295</td>
<td>68</td>
</tr>
<tr>
<td>Swamp Forest</td>
<td>622,825</td>
<td>31</td>
</tr>
<tr>
<td>Road</td>
<td>17,165</td>
<td>1</td>
</tr>
<tr>
<td><strong>Footprint Total</strong></td>
<td><strong>2,010,285</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Results: Big Cypress CH$_4$ – Site Comparison

Dwarf Cypress

- *Higher* CH$_4$ accumulation (i.e. released)
- *Regular* ebullition events
- *Larger* ebullition events

Cypress Swamp

- *No EC CH$_4$ analyzer at site*
- *Lower* CH$_4$ accumulation (i.e. released)
- *Sporadic* ebullition
- *Smaller* ebullition events
Results: Big Cypress CH$_4$ – Scale Comparison

Results from gas traps and time lapse cameras help to demonstrate how assessing CH$_4$ flux at different spatial and temporal scales yields different flux estimates.
Results: Dwarf Cypress – CH$_4$ Flux by Vegetation Type

**CH$_4$ flux from Marl Prairie > Cypress**

**Possible Explanations?**

1. Periphyton mats may provide readily fermented compounds for methanogenesis (Bachoon, 1990).
2. CH$_4$ production partially stimulated by buffering effect of carbonates (Le Mer and Roger, 2001).
3. CH$_4$ oxidation rates in peat soils > CH$_4$ oxidation rates in marl soils (King et al., 1990; Happell and Chanton, 1993).
Results: Dwarf Cypress – Upscaling Gas Trap Fluxes

\[ F_T = f_{MP} F_{MP} + f_C F_C \]
**Results:** Dwarf Cypress – Up-Scaled Gas Trap Flux

**Summary Statistics**

<table>
<thead>
<tr>
<th>Vegetation</th>
<th>n</th>
<th>EC</th>
<th>GT</th>
<th>X</th>
<th>r</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marl Prairie</td>
<td>9</td>
<td>42.6</td>
<td>105.9</td>
<td>3.6</td>
<td>0.74</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Cypress</td>
<td>9</td>
<td>42.6</td>
<td>24.1</td>
<td>0.9</td>
<td>0.55</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Scaled</td>
<td>9</td>
<td>42.6</td>
<td>74.4</td>
<td>2.5</td>
<td>0.73</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Rapid ebullition? 1:1 Ratio
Conclusions:

1. EC tower may not properly represent ecosystem variability within their footprint, and may also be missing rapid ebullition events.

2. Gas traps and time lapse cameras can reveal CH$_4$ flux heterogeneities between vegetation communities otherwise masked by eddy covariance.

3. Complementary eddy covariance and gas trap measurements supports enhanced characterization of CH$_4$ flux heterogeneities across vegetation communities in subtropical wetlands.
Thank You!

Acknowledgements:
This work has been partially supported by NOAA (GC11-337), DOE (TES-10959421), USGS (Cooperative Agreement: Carbon Dynamics of the Greater Everglades), and the FAU CES Walter & Lalita Janke Foundation Innovations in Sustainability Science Research Fund. Thank you to all who participated in field data collection.