Quantifying the contribution of plants and soils to CH$_4$ fluxes and net seasonal N$_2$O emissions in an agricultural wetland

Jennifer Morris, Lucas Silva, Rongzhong Ye, William R. Horwath, Department of Land, Air, and Water Resources, University of California-Davis
The Delta

- Tidal marsh drained for agriculture in 1800’s

http://www.sitesatlas.com/Flash/USCan/static/CAOF.htm
The Delta

- Tidal marsh drained for agriculture in 1800’s
- Supplies water for 25 million people, supports $2 billion agriculture industry, and crucial wildlife habitat

http://www.sitesatlas.com/Flash/USCan/static/CAOF.htm
http://users.humboldt.edu/ogayle/hist383/DebateBay-DeltaEcosystem.html
The Delta

- Tidal marsh drained for agriculture in 1800’s
- Supplies water for 25 million people, supports $2 billion agriculture industry, and crucial wildlife habitat
- Soil subsidence of organic soils caused by drainage and agricultural use has resulted in health, safety, environmental, and economic concerns
Rice as a solution?

- Flooded conditions mimic Delta formation
- Potential to reverse or mitigate soil subsidence
- Wildlife habitat

- Anaerobic conditions favorable for methane emission
- Methane contributes to global climate change
Questions

What is the net contribution of living rice plants to CH$_4$ emission and subsurface carbon pools?

How does nitrogen management affect carbon cycling in the Delta rice system?
Pulse Labeling Experiment

Stable Isotope Label
• 99.9 atom% $^{13}$CO$_2$
• Two events- each lasting 14 days

Measurements
• CH$_4$, N$_2$O emissions
• Pore water (0-10 cm depth): DIC, DOC, porewater CH$_4$ ($p$CH$_4$)

N Treatments
• Three treatment rates: 0, 80, and 160 kg N/ha
Expected response to label over time

δ\textsuperscript{13}C (‰)

Days after label event

DIC

emitted CH\textsubscript{4}
dissolved CH\textsubscript{4}

Background CH\textsubscript{4} δ\textsuperscript{13}C
Actual response: Emitted CH$_4$
**CH₄ source**

The diagram shows the distribution of CH₄ sources over different treatment levels and events. The percentages for plant-derived CH₄ are 10.8% and 14.2% for events 1 and 2, respectively. The soil-derived CH₄ percentages are also presented, with an overall trend indicating higher contributions in some treatment levels.
Dissolved C pools source

<table>
<thead>
<tr>
<th>Event</th>
<th>Treatment (kg N/ha)</th>
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<tbody>
<tr>
<td>1</td>
<td>11.7%</td>
</tr>
<tr>
<td>2</td>
<td>48.2%</td>
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<tr>
<td></td>
<td>23.2%</td>
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<tr>
<td></td>
<td>38.7%</td>
</tr>
<tr>
<td>3</td>
<td>2.0%</td>
</tr>
<tr>
<td>4</td>
<td>3.9%</td>
</tr>
<tr>
<td></td>
<td>16.8%</td>
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<tr>
<td></td>
<td>36.1%</td>
</tr>
<tr>
<td></td>
<td>38.7%</td>
</tr>
</tbody>
</table>

- **DOC**: 2.0%, 3.9%
- **DIC**: 23.2%, 16.8%, 36.1%, 38.7%
- **pCH₄**: 11.7%, 48.2%
Emitted CH$_4$ and pCH$_4$

Recent plant contribution
pCH$_4$: 11.7%  CH$_4$: 10.8%

pCH$_4$: 48.2%  CH$_4$: 14.2%
Average CH$_4$ emissions

![Bar chart showing CH$_4$ emissions for different treatments (kg N/ha)].

- Event 1
- Event 2
Average $\text{N}_2\text{O}$ emissions

![Graph showing $\text{N}_2\text{O}$ emissions across different N treatments (0 N, 80 N, 160 N) and events (Event 1, Event 2). The graph indicates the average emissions in mg N m$^{-2}$ day$^{-1}$, with error bars representing variability.]
Yield and harvest index response

Harvest index = yield/aboveground biomass
Conclusions

- CH$_4$ emissions averaged 73.5 mg C m$^{-2}$ day$^{-1}$ with recent plant photosynthates contributing around 12.6%
- We saw N$_2$O consumption, with average uptake of -0.199 mg N m$^{-2}$ day$^{-1}$
- There was no response to N rates on CH$_4$, N$_2$O, or plant contributions (except DIC, event 1)
- Yield and harvest index declined at highest N rate
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Thank you. Questions?