Tropical Wetlands as a Dominant Driver of Long-Term Atmospheric Methane Changes

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Introduction

- Atmospheric methane CH$_4$ is a greenhouse gas with direct and indirect effects on climate
- Methane has radiative forcing of 0.5 W/m$^2$ which is second only to CO$_2$ (RF= 1.91 W/m$^2$)
- Global Warming Potential (GWP$_{100}$) for CH$_4$=28
  - GWP is climate impact of equal masses of emissions of CH$_4$ and CO$_2$ integrated over 100 years
Introduction

- CH$_4$ is important to atmospheric chemistry since it affects the oxidizing capacity of the atmosphere and results in increased tropospheric ozone and stratospheric water vapor (RF $\sim$0.3 W/m$^2$)
- OH radicals in troposphere destroy CH$_4$ and other reduced long-lived GHG
Process that Emit Methane

- 3 main processes:
  - Thermogenic
  - Pyrogenic
  - Microbial

- Produce and consume methane
- Rate of production is T dependent
- Methanogens: anaerobic methane producing microbes belonging to kingdom archaea
• Methanotrophs: methane consuming microbes
  - Archaeal methanotrophs: must be in symbiotic relationship with a bacteria which consumes sulfates; anaerobic
  - Bacterial methanotrophs: independent; aerobic
Atmosphere 1984 + 2970 ± 45
(average atmospheric increase: 17 ± 9 (Tg CH₄ yr⁻¹))

Units
Fluxes: (Tg CH₄ yr⁻¹)
Stocks: (Tg CH₄)
<table>
<thead>
<tr>
<th></th>
<th>Top-down</th>
<th>Bottom-up</th>
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</thead>
<tbody>
<tr>
<td><strong>Natural</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural</td>
<td>218</td>
<td>347</td>
</tr>
<tr>
<td>Wetlands</td>
<td>175</td>
<td>217</td>
</tr>
<tr>
<td>Other</td>
<td>43</td>
<td>130</td>
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<tr>
<td><strong>Anthropogenic</strong></td>
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<tr>
<td>Agriculture + Waste</td>
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<td>200</td>
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<tr>
<td>Biomass Burning</td>
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<td>35</td>
</tr>
<tr>
<td>Fossil Fuels</td>
<td>96</td>
<td>96</td>
</tr>
<tr>
<td><strong>Total Emissions</strong></td>
<td>553</td>
<td>678</td>
</tr>
<tr>
<td><strong>Sinks</strong></td>
<td>550</td>
<td>632</td>
</tr>
<tr>
<td><strong>Imbalance</strong></td>
<td>3</td>
<td>46</td>
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</tbody>
</table>
Weekly methane at Barrow, AK. The red symbols show retained values. The blue and green symbols show flagged values. A map of GMD air sampling sites is inset.

\[ [\text{CH}_4](t) = [\text{CH}_4]_\text{ss} - ([\text{CH}_4]_\text{ss} - [\text{CH}_4]_0) e^{-t/\tau} \]

Lifetime ≈ 9.4 yr

Role of Wetlands
Conclusions

• Tropical wetlands were important in paleoclimate

• Believe wetlands also a main driver of methane changes in the last decade

• In many tropical countries, few resources are spent on data relevant to understanding large scale methane changes
  - Human activities impact streamflow
  - Testing for memory effects was limited by insufficient data and technical complications

• Limited understanding of production of methane from archaeal methanogens and oxidation by methanotrophs
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Sources


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