Forward Modelling and Optimization of Methane Emissions in the United States Gulf Using Aircraft Transects Across Frontal Boundaries

Zachary Barkley, Kenneth Davis, Sha Feng, Nikolay Balashov, Alan Fried, Joshua DiGangi

An ACT-America project funded by the NASA Earth Science Division
Observed Boundary Layer Methane (ppm)
Gridded EPA Inventory for 2012

Methane emissions (Mg a⁻¹ km⁻²)

Includes all methane emissions included in the National Greenhouse Gas Inventory.
40% of anthropogenic methane emissions in the US

Table 1. Anthropogenic CH$_4$ emissions by source for the area enclosed by 27N-45N, 110W-90W. Values come from the Gridded 2012 Methane Emissions Inventory

<table>
<thead>
<tr>
<th>Source</th>
<th>Emissions (Mg hr$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil and Gas</td>
<td>660</td>
</tr>
<tr>
<td>Animal Agriculture</td>
<td>436</td>
</tr>
<tr>
<td>Landfills</td>
<td>151</td>
</tr>
<tr>
<td>Other</td>
<td>149</td>
</tr>
<tr>
<td>Total</td>
<td>1396</td>
</tr>
</tbody>
</table>
Southerly winds begin

10/20/2017 00Z

2 days of steady state

10/21/2017 00Z

Plume converges at front

10/22/2017 00Z

XCH4 Enhancement (ppb)
Optimization of Methane Sources: Oct 18th, 2017

Oil and Gas

Animal Agriculture

Everything else

CH$_4$ Enhancement (ppm)
We’re really good at recreating the total methane plume

Figure 2. Observed vs. modelled CH₄ for each of the 7 flights using the optimized gas and animal ag emission rates for each flight.
...but not so great with knowing which source to attribute it to.
Major methane sources in the Gulf
Major ethane sources in the Gulf
Methane Enhancement (ppm)

Ethane Enhancement (ppb)
Figure 4. Observed vs. modelled $\text{C}_2\text{H}_6$ for each of the 7 flights using the optimized gas and animal ag emission rates for each flight.
Figure 5. Optimized EPA gas inventory multipliers and their 95% confidence intervals for each flight. Each color represents a different strategy used in the optimization. (blue) Both gas and animal ag inventories were optimized using CH$_4$ data. (red) Only gas inventories were optimized, keeping animal ag values constrained by their inventory data. (yellow) Gas inventories were optimized using C$_2$H$_6$ data. (purple?) Both gas and animal ag inventories were optimized using the joint CH$_4$-C$_2$H$_6$ technique.
Figure 5. Optimized EPA gas inventory multipliers and their 95% confidence intervals for each flight. Each color represents a different strategy used in the optimization. (blue) Both gas and animal ag inventories were optimized using \( \text{CH}_4 \) data. (red) Only gas inventories were optimized, keeping animal ag values constrained by their inventory data. (yellow) Gas inventories were optimized using \( \text{C}_2\text{H}_6 \) data. (purple?) Both gas and animal ag inventories were optimized using the joint \( \text{CH}_4-\text{C}_2\text{H}_6 \) technique.
Conclusions:

-Frontal weather events may be useful at quantifying emissions from various sources.

-There’s more methane in these frontal flights than is in the EPA’s gridded methane inventory.

-High ethane values indicate that the O&G sector is likely responsible for this discrepancy (factor of 2 increase). No evidence that animal agriculture deviates from inventory estimates.
Shameless ACT-America Plug
ACT-A observations sliced into 5 height sectors over 3 regions using 2 aircraft

Each pixel denotes data coverage at each height sectors (e.g. 0-2 km height) in hours