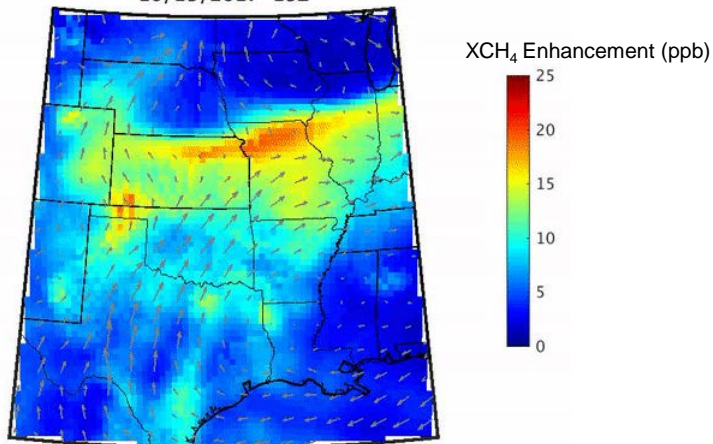


Forward Modelling and Optimization of Methane Emissions in the United States Gulf Using Aircraft Transects Across Frontal Boundaries

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

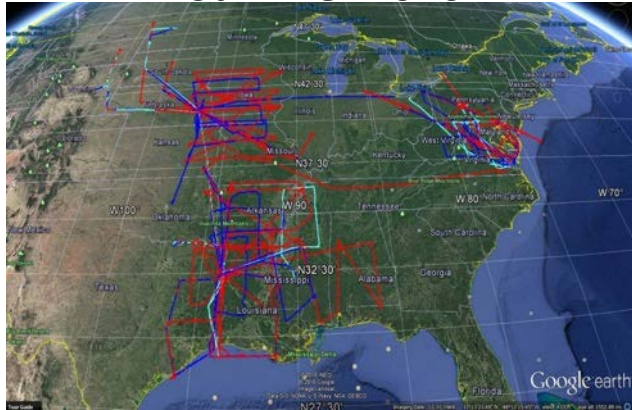
10/19/2017 15Z



An ACT-America project funded by the NASA Earth Science Division

Shameless ACT-America Plug

Summer 2016



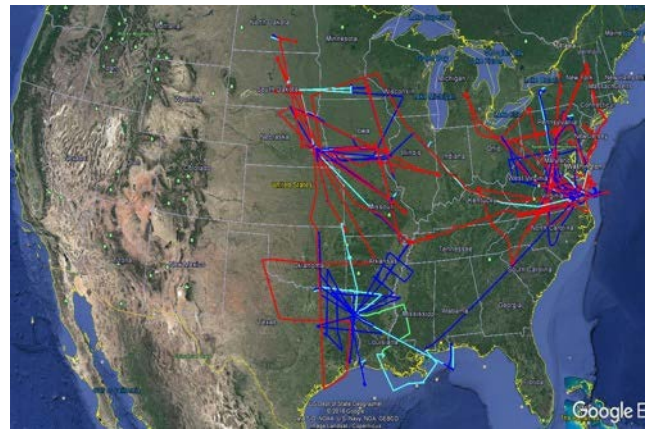
Winter 2017



Fall 2017

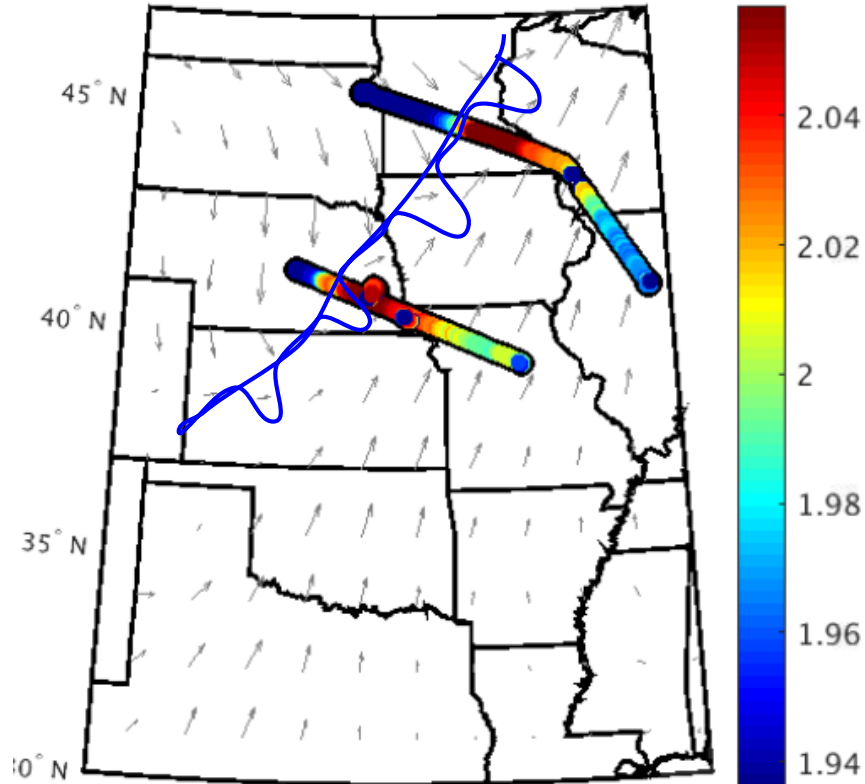


Spring 2018

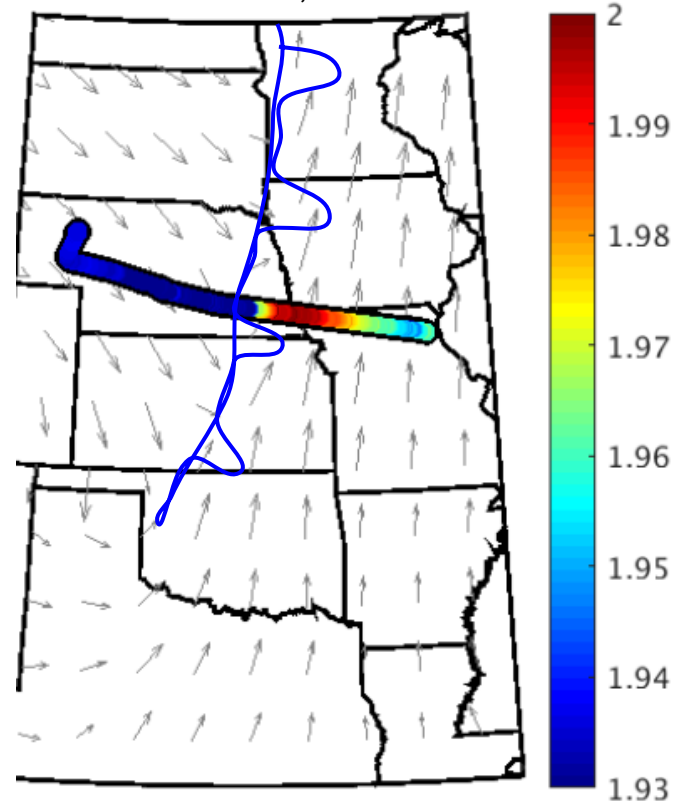


Observed Boundary Layer Methane (ppm)

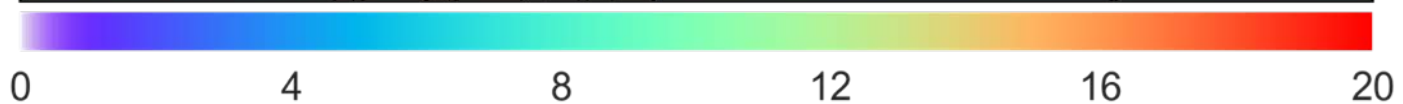
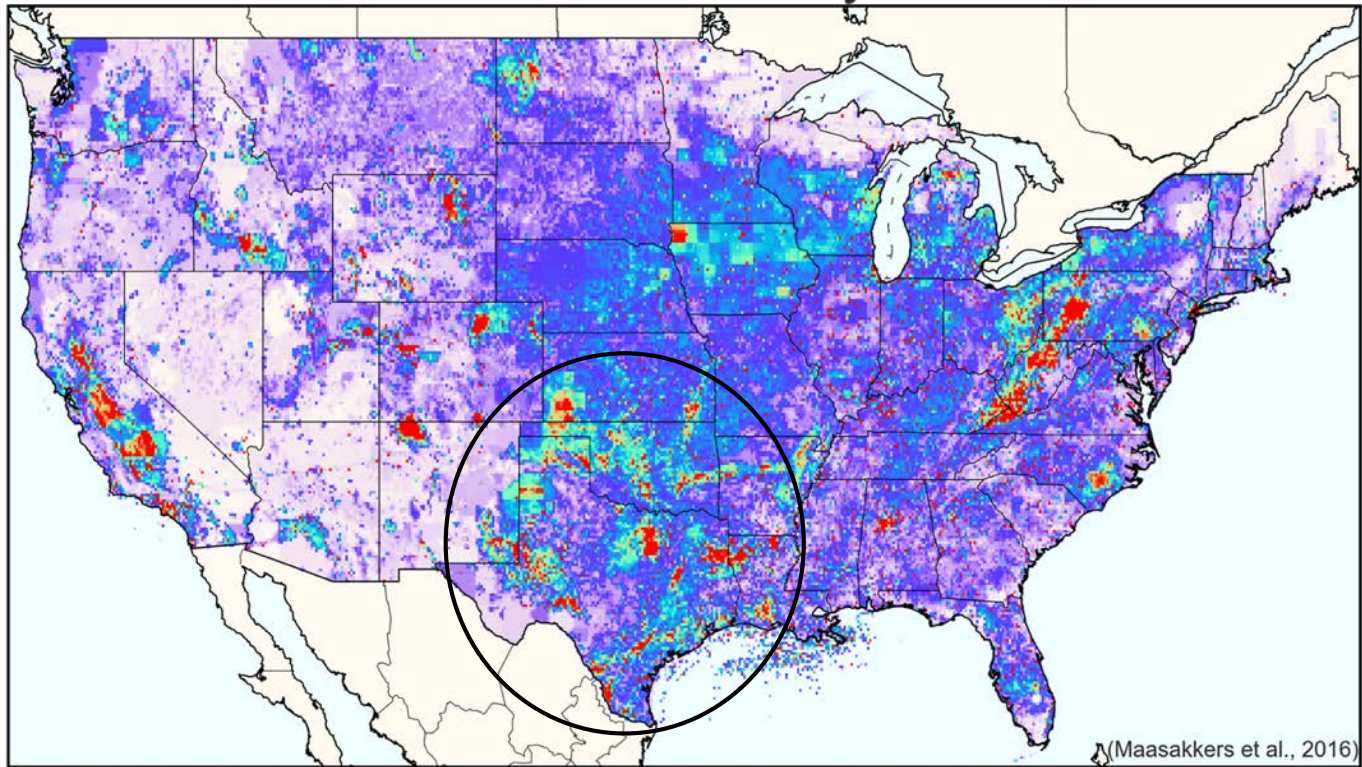
Oct 18, 2017



Oct 21, 2017



Gridded EPA Inventory for 2012



Methane emissions ($\text{Mg a}^{-1} \text{ km}^{-2}$)

Includes all methane emissions included in the National Greenhouse Gas Inventory.

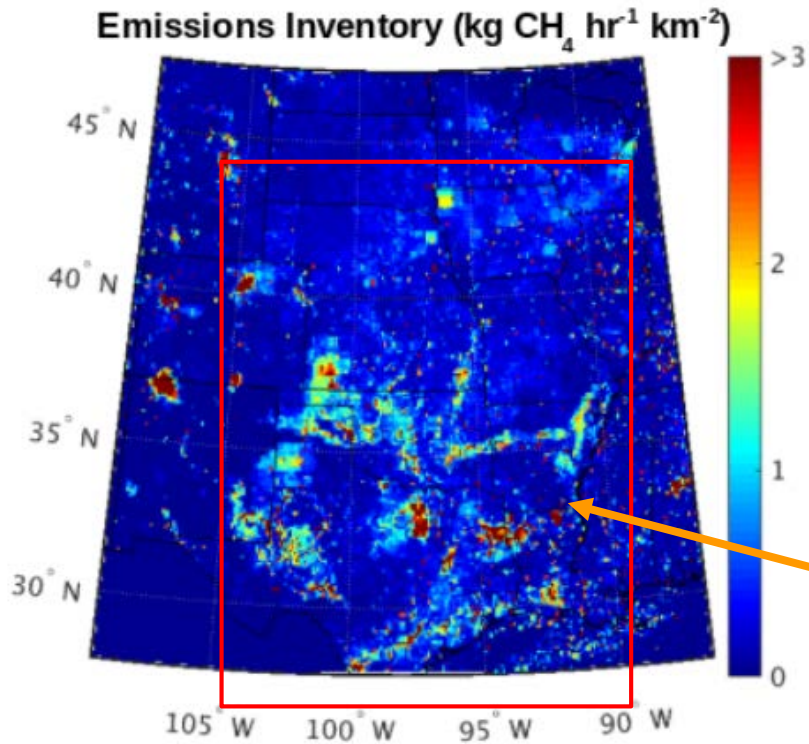


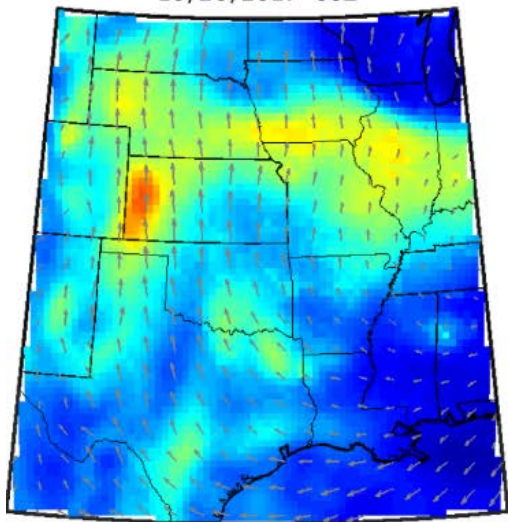
Table 1. Anthropogenic CH_4 emissions by source for the area enclosed by 27N-45N, 110W-90W. Values comes from the Gridded 2012 Methane Emissions Inventory

Source	Emissions (Mg hr^{-1})
Oil and Gas	660
Animal Agriculture	436
Landfills	151
Other	149
Total	1396

40% of anthropogenic methane emissions in the US

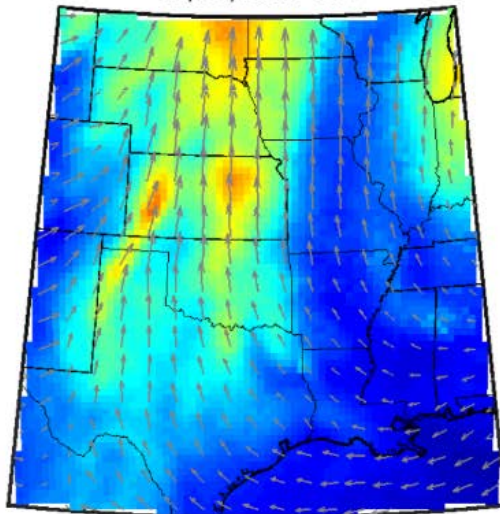
Southerly winds begin

10/20/2017 00Z



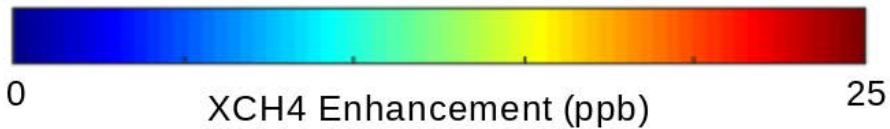
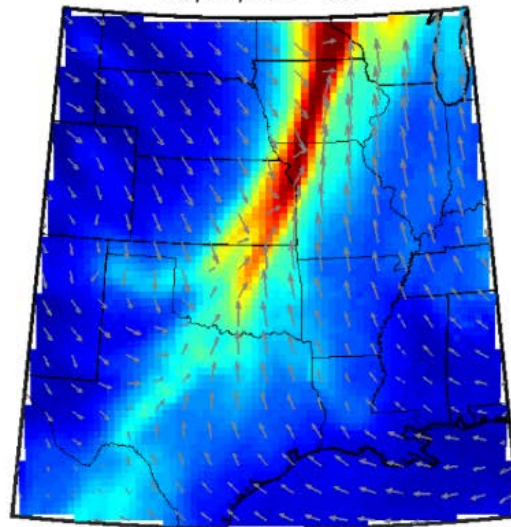
2 days of steady state

10/21/2017 00Z

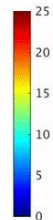
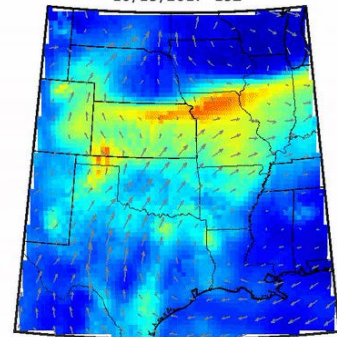


Plume converges at front

10/22/2017 00Z

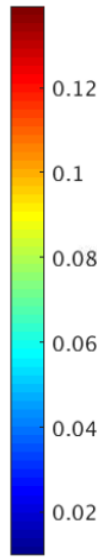
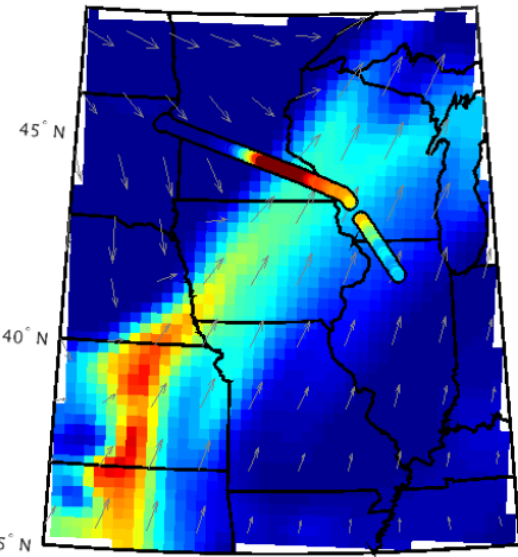


10/19/2017 15Z

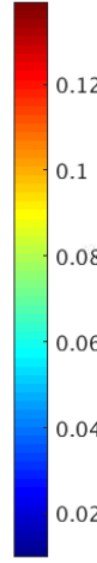
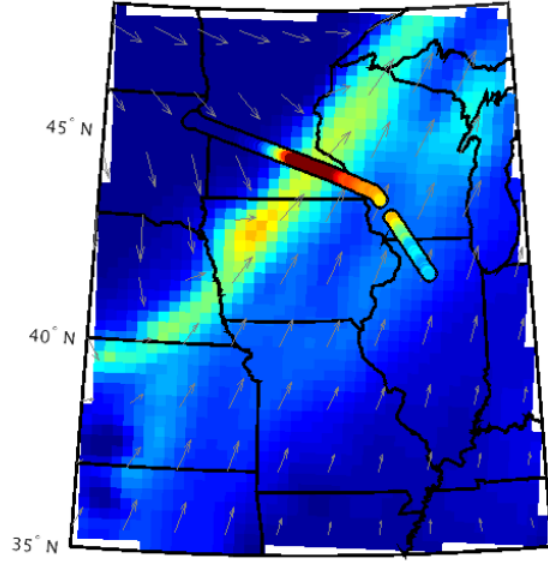


Optimization of Methane Sources: Oct 18th, 2017

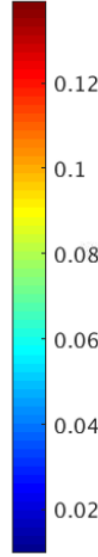
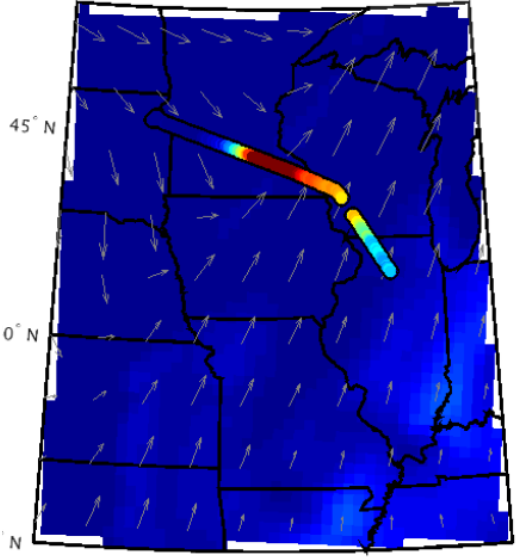
Oil and Gas



Animal Agriculture



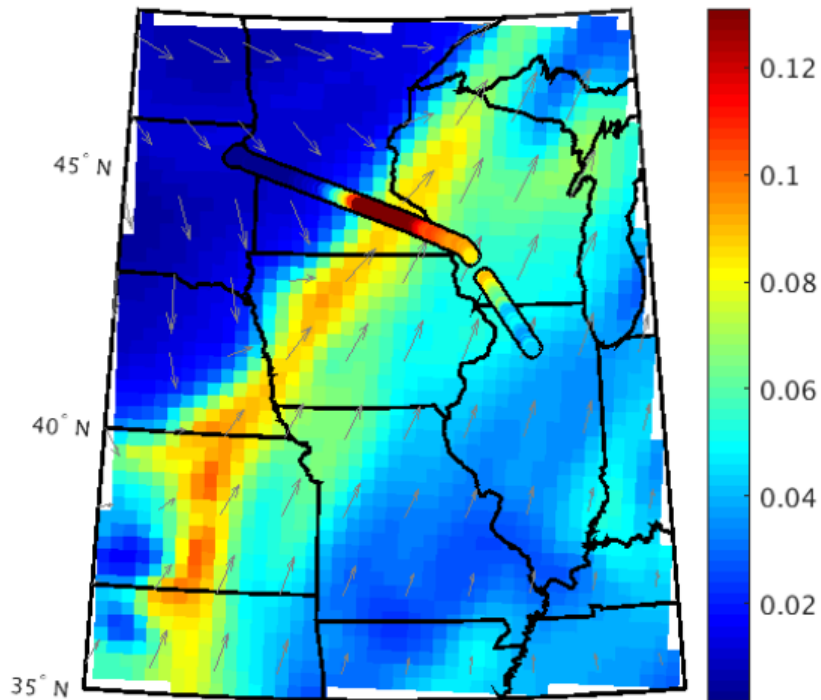
Everything else



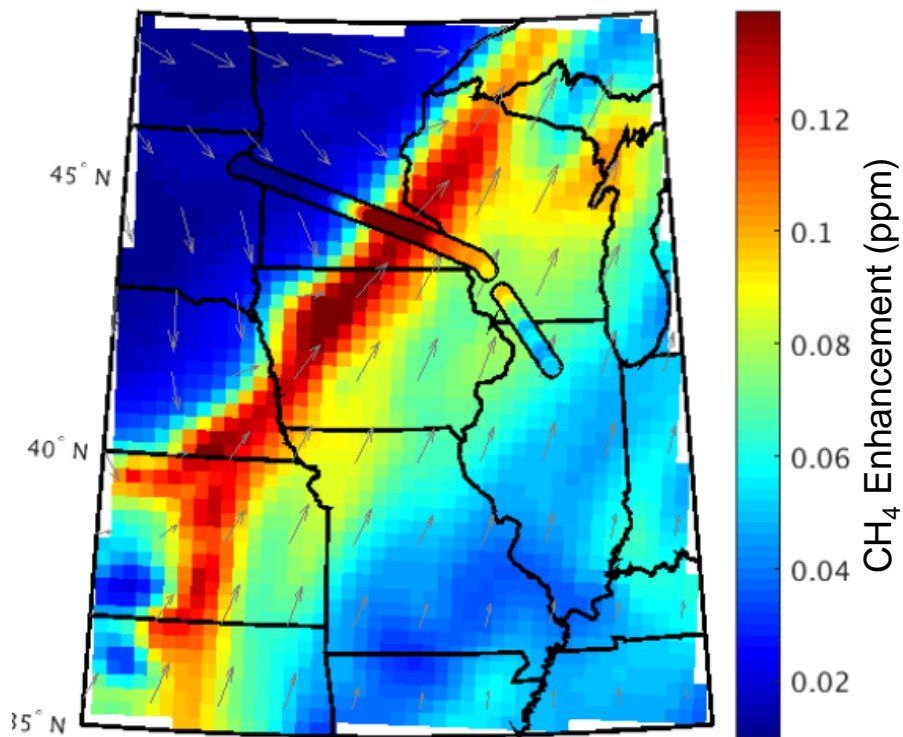
CH₄ Enhancement (ppm)

Optimization of Methane Sources: Oct 18th

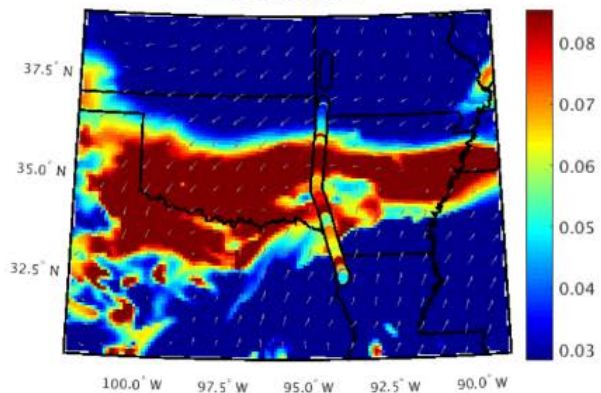
Oct 18, 2017
Original



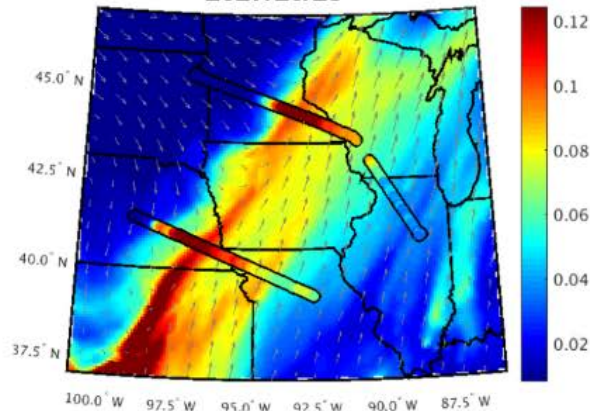
Oct 18, 2017
Optimized



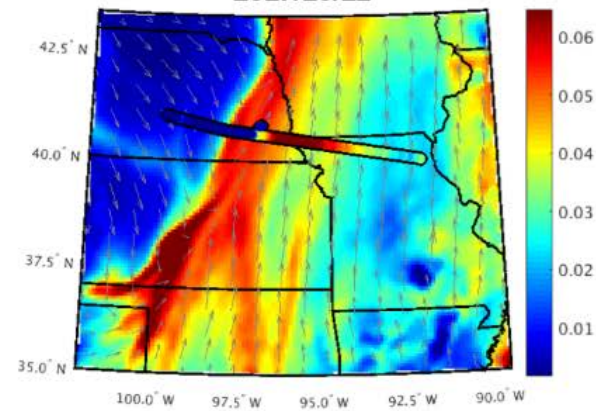
2017/02/01



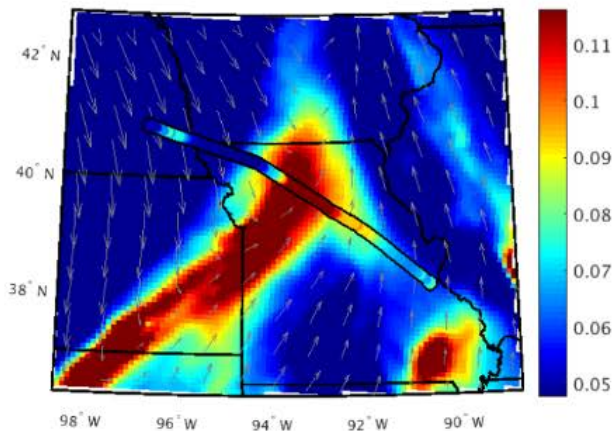
2017/10/18



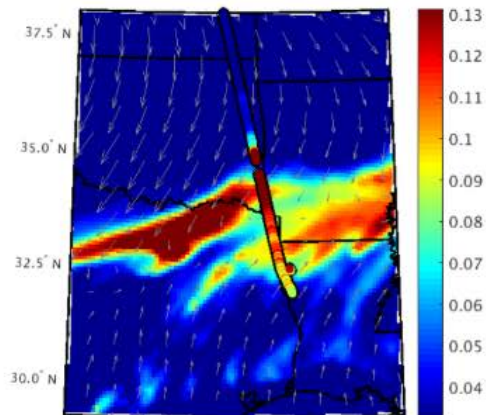
2017/10/21



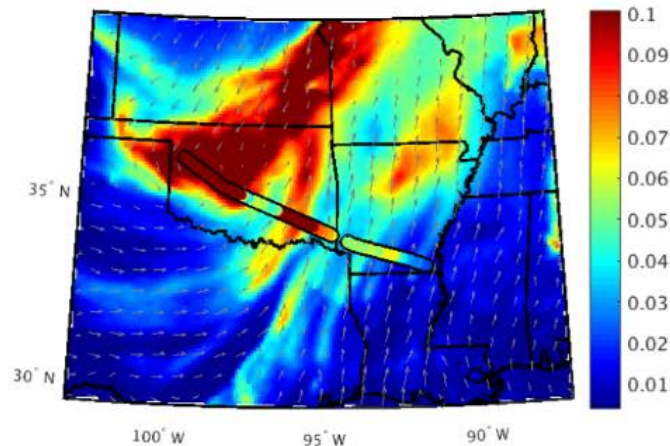
2017/10/26



2017/10/30



2017/11/02



We're really good at recreating the total methane plume

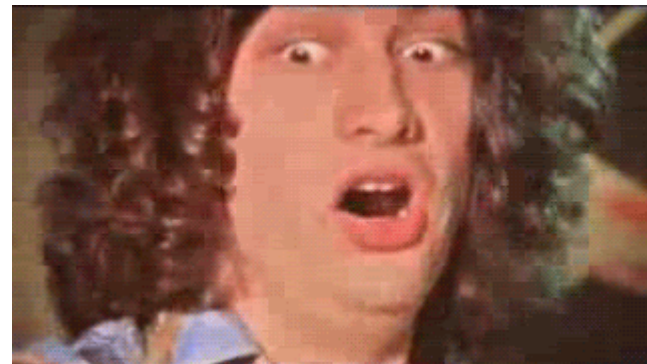
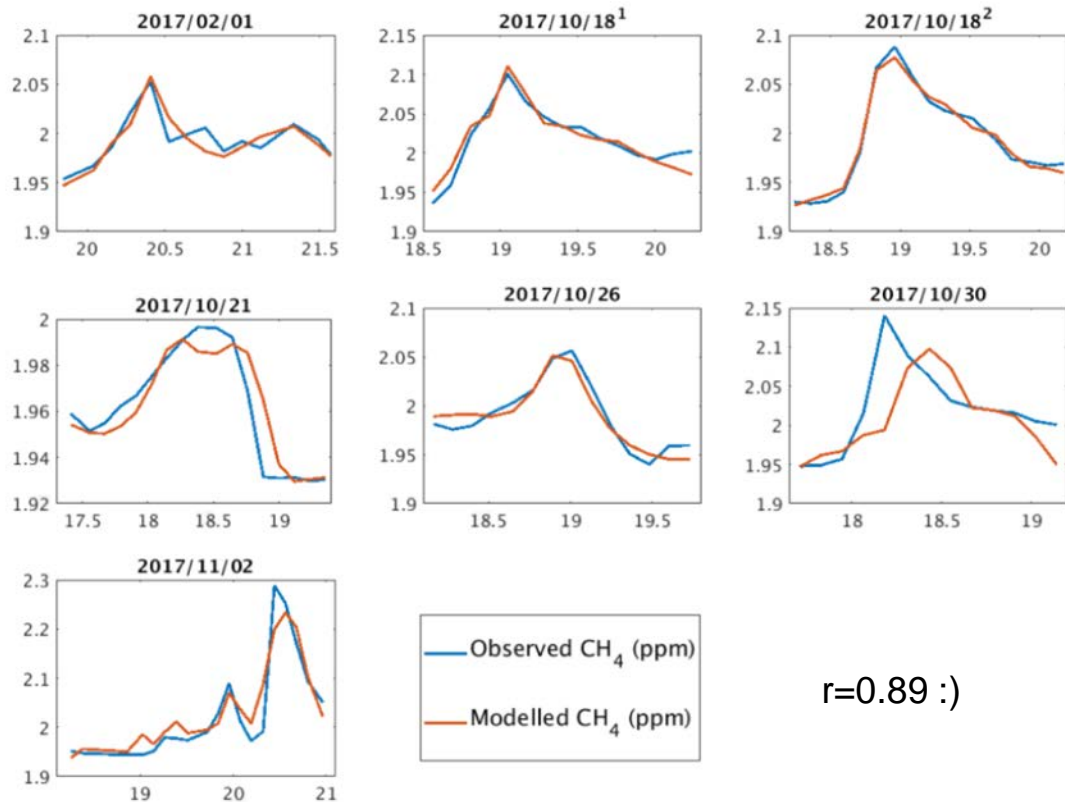
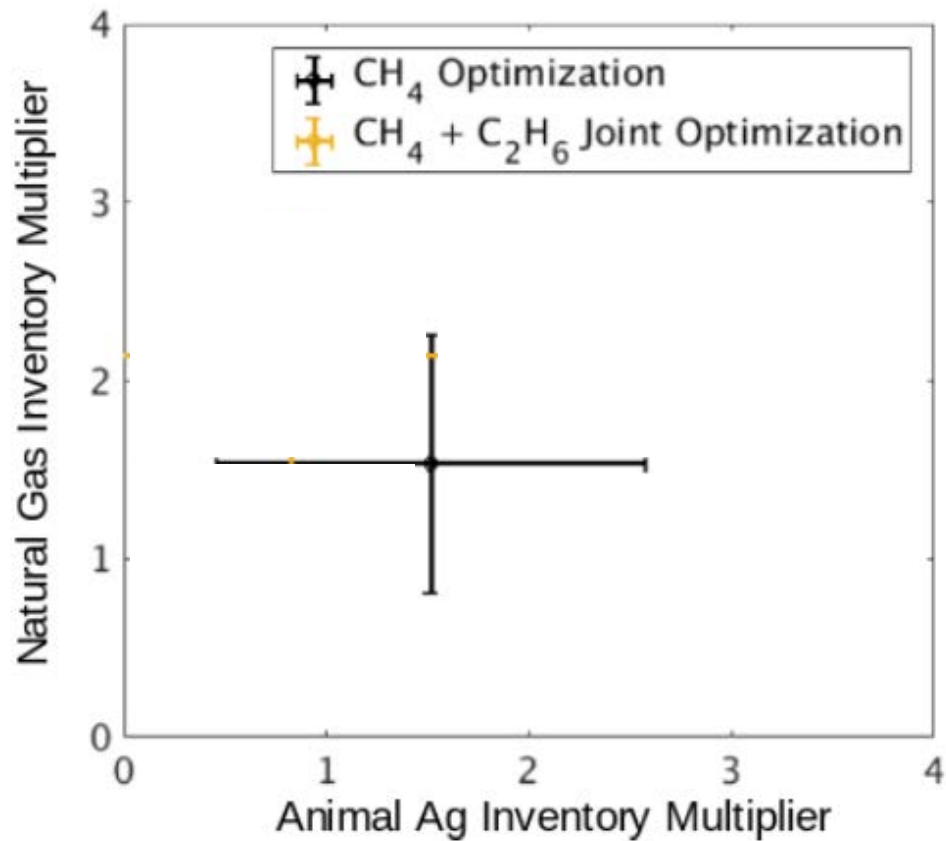


Figure 2. Observed vs. modelled CH₄ for each of the 7 flights using the optimized gas and animal ag emission rates for each flight.



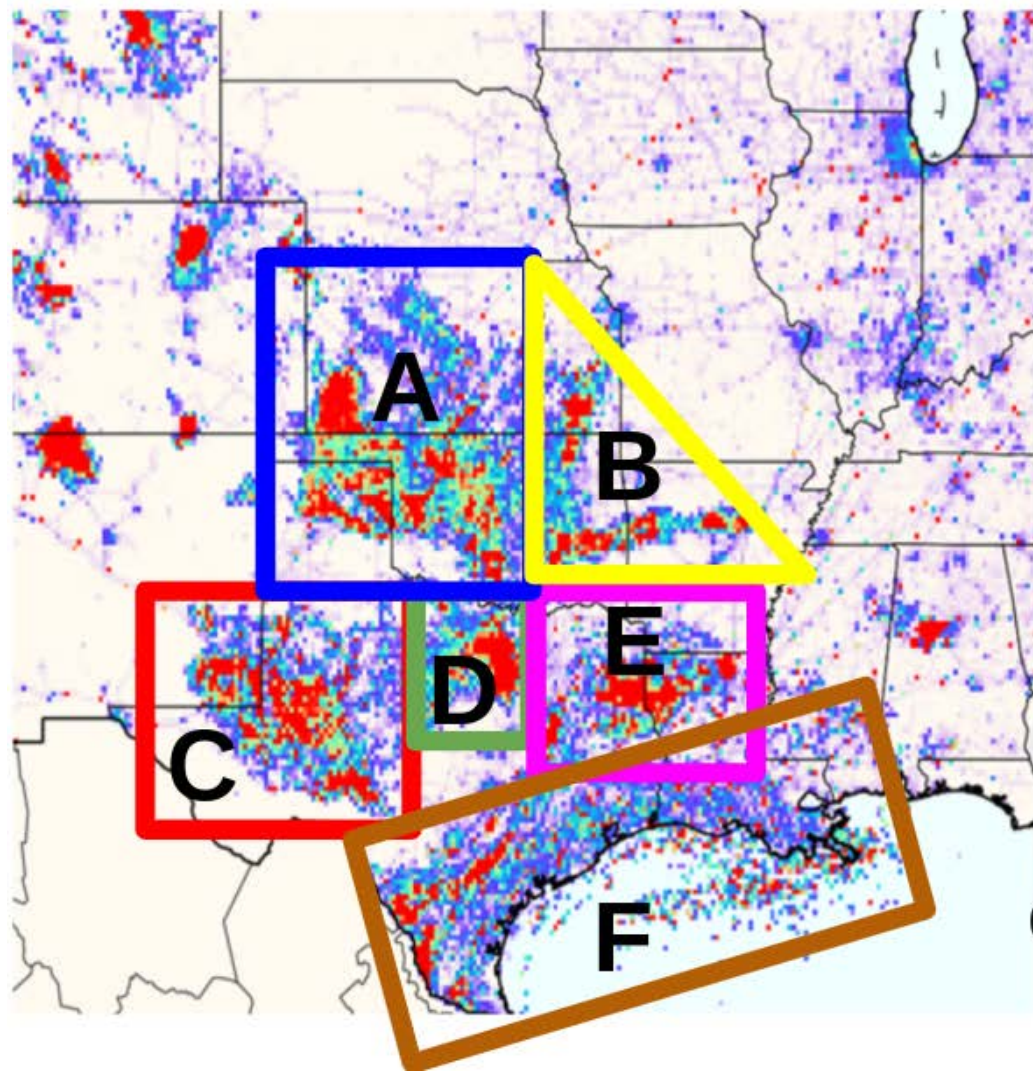
...but not so great with knowing which source to attribute it to.

Major methane sources in the Gulf

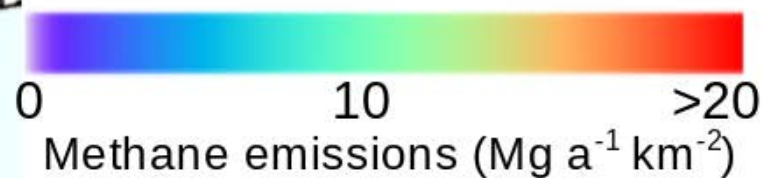


Major ethane sources in the Gulf



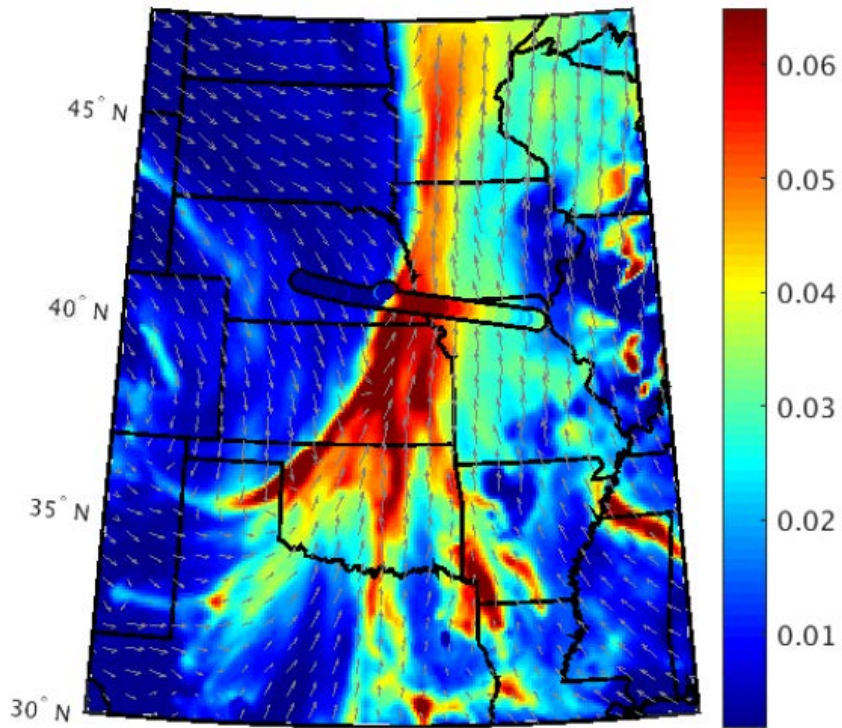


ID	Basin	C_2H_6/CH_4
A	Anadarko	0.080
B	Woodford	0.070
C	Permian	0.125
D	Ft. Worth	0.067
E	East Texas	0.040
F	Gulf	0.051

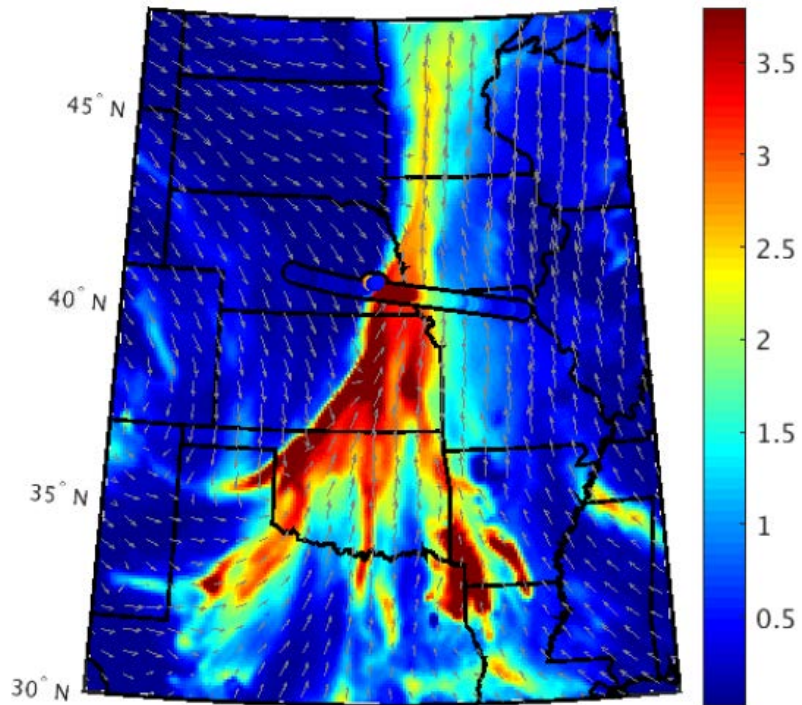


10/21/2017

Methane Enhancement (ppm)



Ethane Enhancement (ppb)



Ethane Optimization

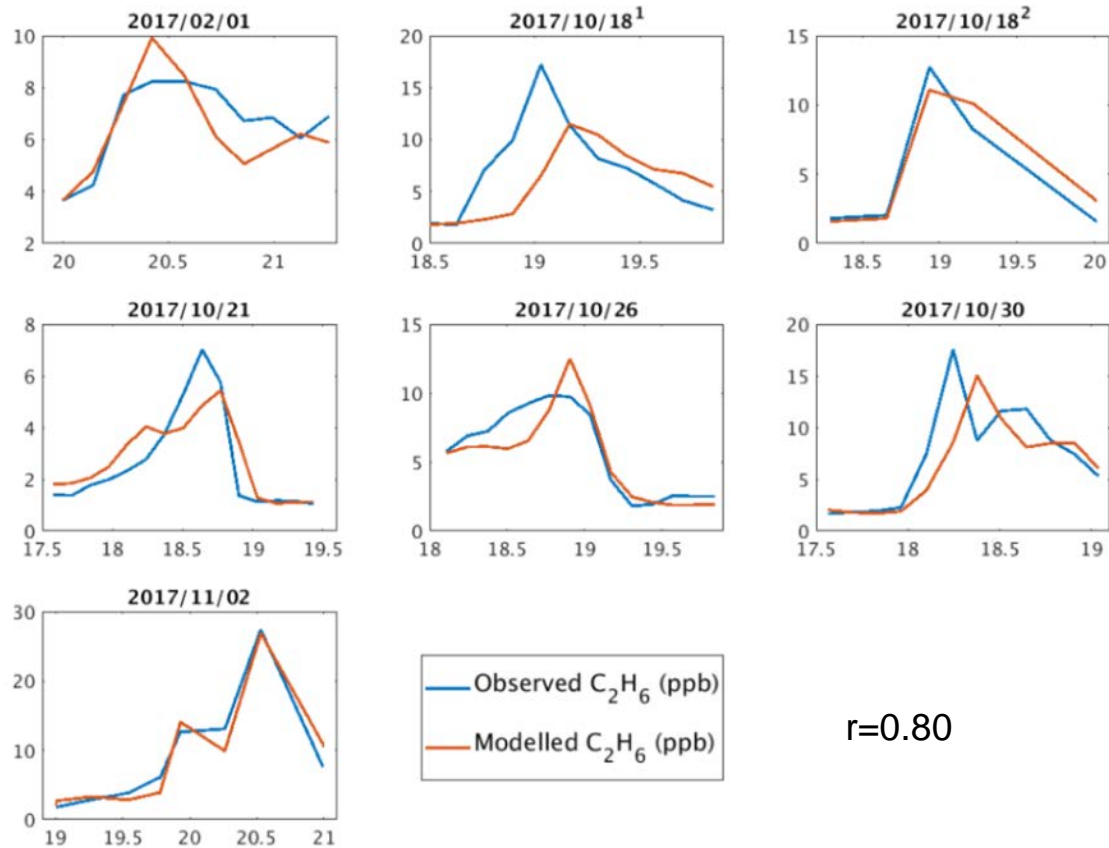


Figure 4. Observed vs. modelled C₂H₆ for each of the 7 flights using the optimized gas and animal ag emission rates for each flight.

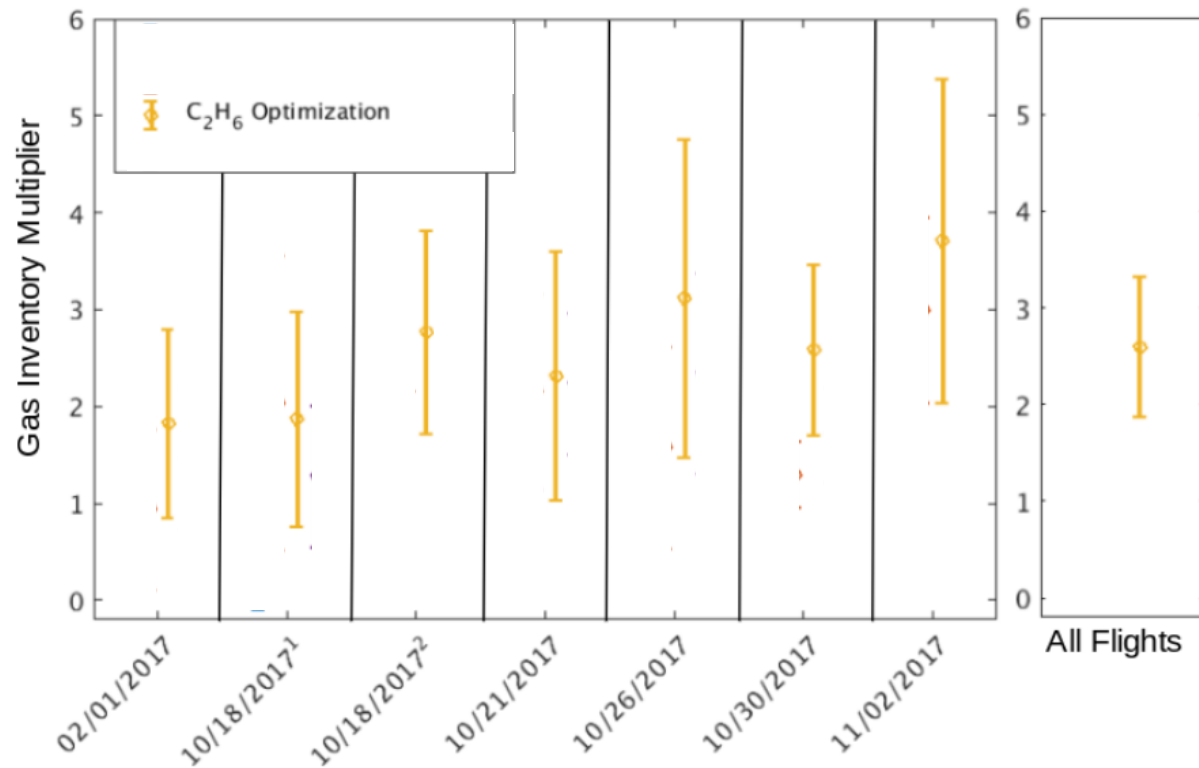
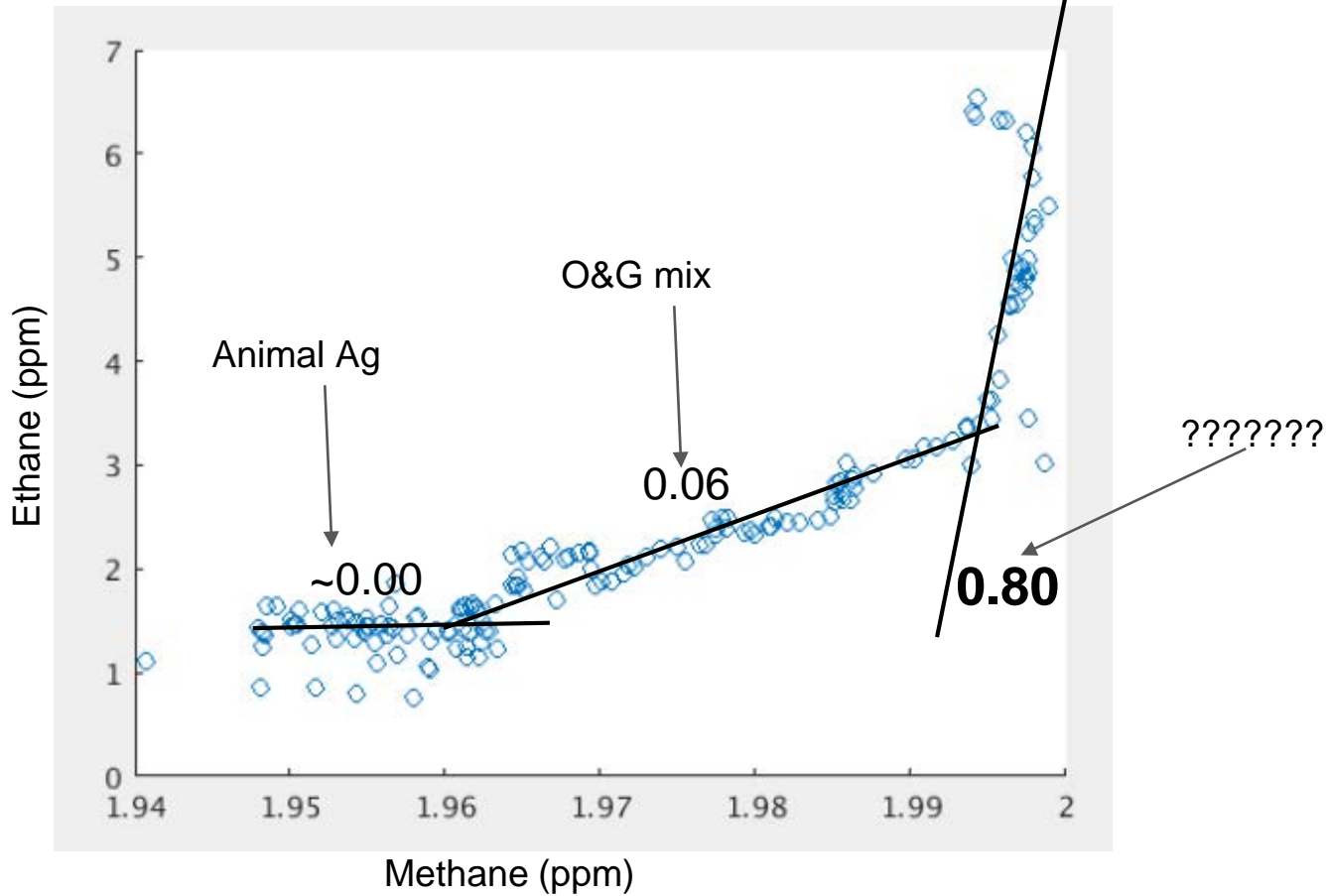


Figure 5. Optimized EPA gas inventory multipliers and their 95% confidence intervals for each flight. Each color represents a different strategy used in the optimization. (blue) Both gas and animal ag inventories were optimized using CH₄ data. (red) Only gas inventories were optimized, keeping animal ag values constrained by their inventory data. (yellow) Gas inventories were optimized using C₂H₆ data. (purple?) Both gas and animal ag inventories were optimized using the joint CH₄-C₂H₆ technique.

10/21/2017



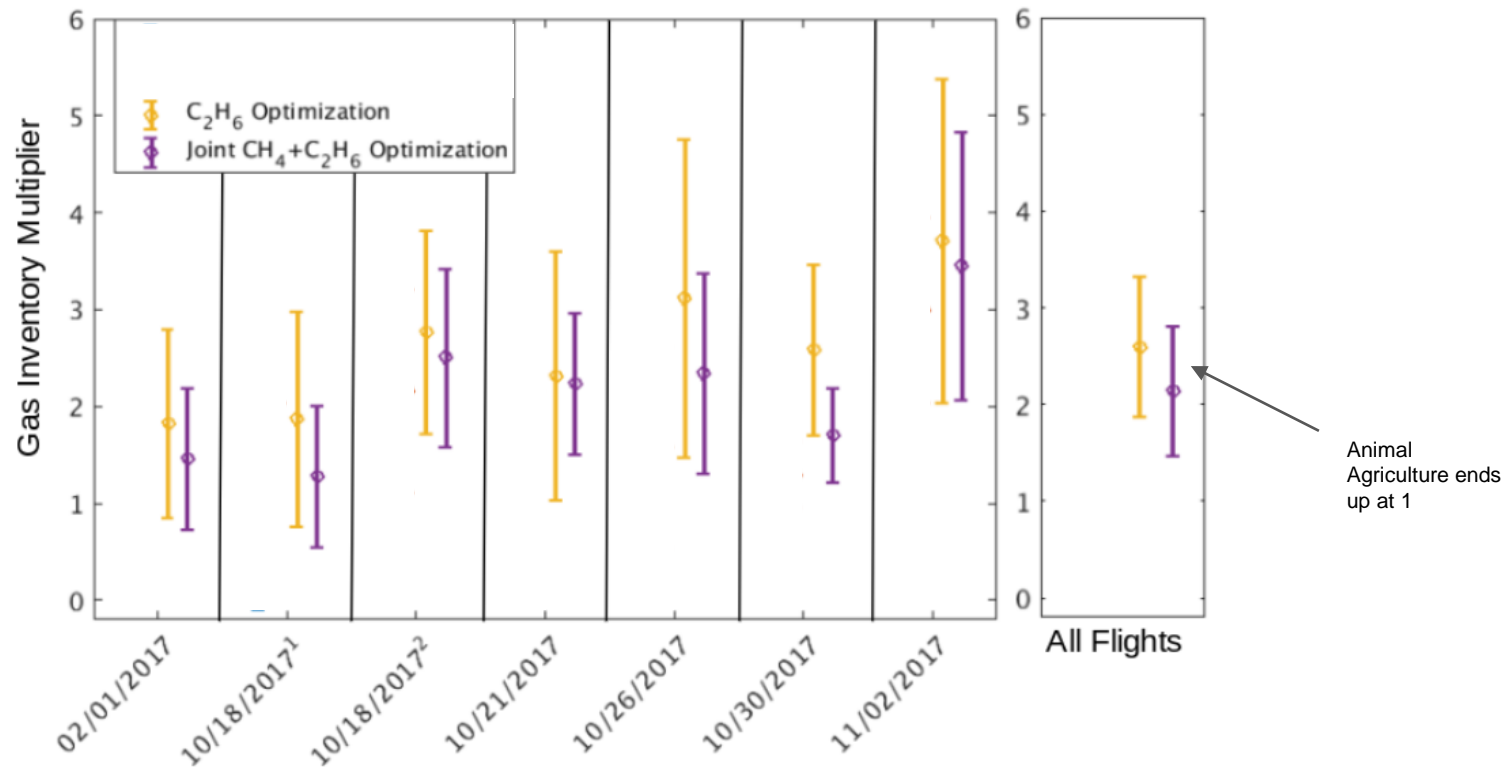


Figure 5. Optimized EPA gas inventory multipliers and their 95% confidence intervals for each flight. Each color represents a different strategy used in the optimization. (blue) Both gas and animal ag inventories were optimized using CH₄ data. (red) Only gas inventories were optimized, keeping animal ag values constrained by their inventory data. (yellow) Gas inventories were optimized using C₂H₆ data. (purple?) Both gas and animal ag inventories were optimized using the joint CH₄-C₂H₆ technique.

Conclusions:

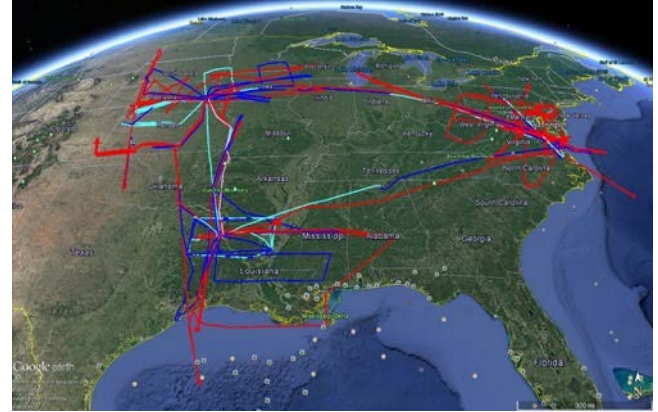
- Frontal weather events may be useful at quantifying emissions from various sources.
- There's more methane in these frontal flights than is in the EPA's gridded methane inventory.
- High ethane values indicate that the O&G sector is likely responsible for this discrepancy (factor of 2 increase). No evidence that animal agriculture deviates from inventory estimates.

Shameless ACT-America Plug

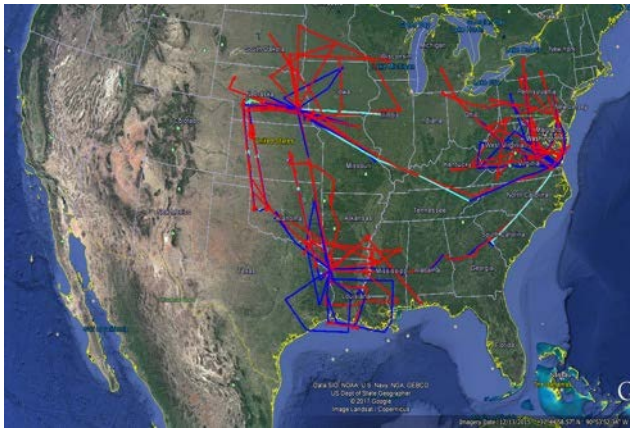
Summer 2016



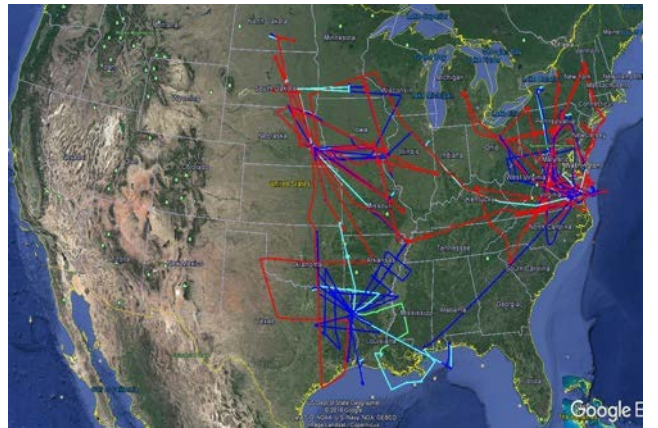
Winter 2017



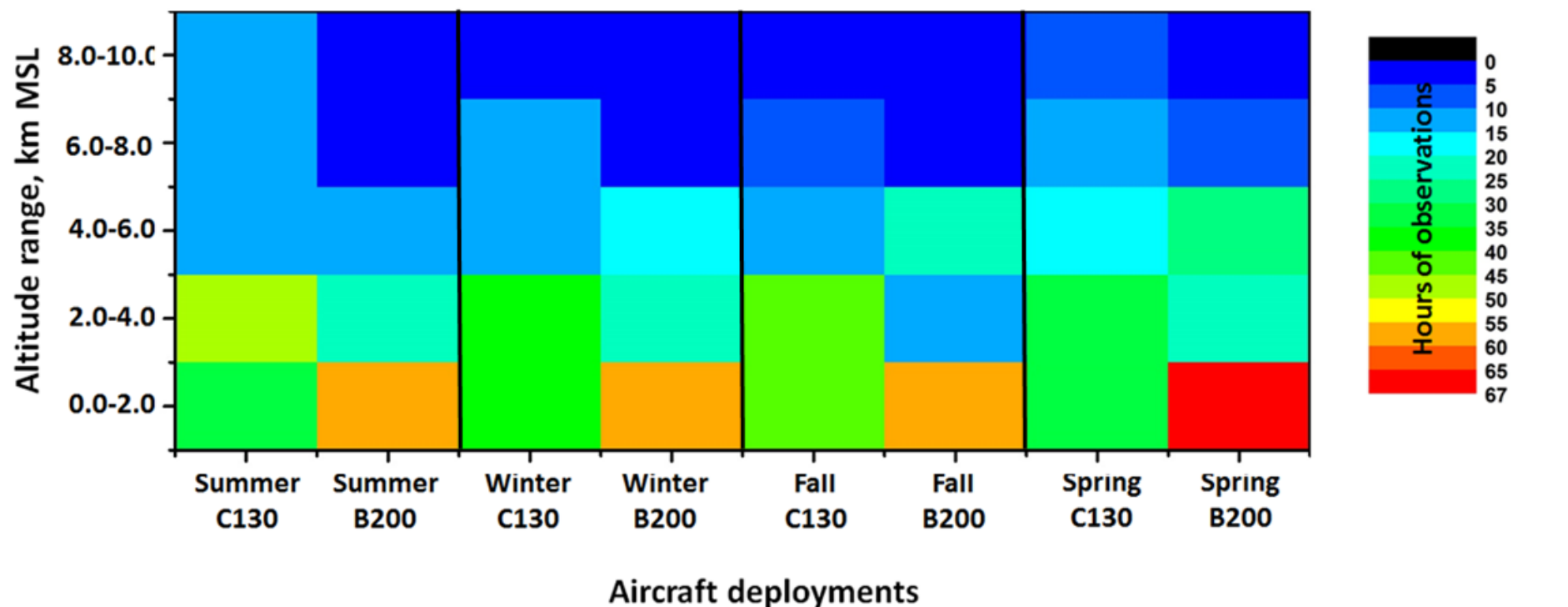
Fall 2017



Spring 2018



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