

Using Aircraft for emissions verification

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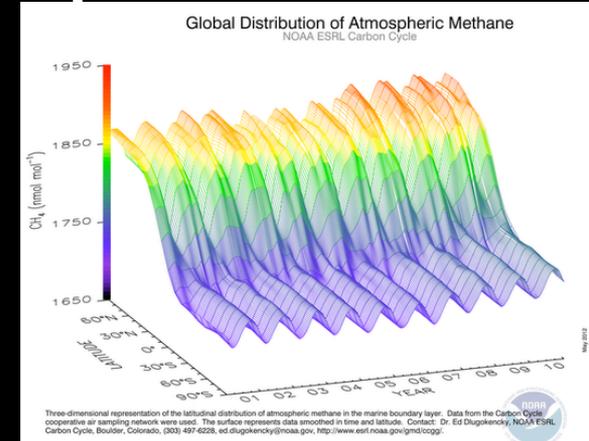
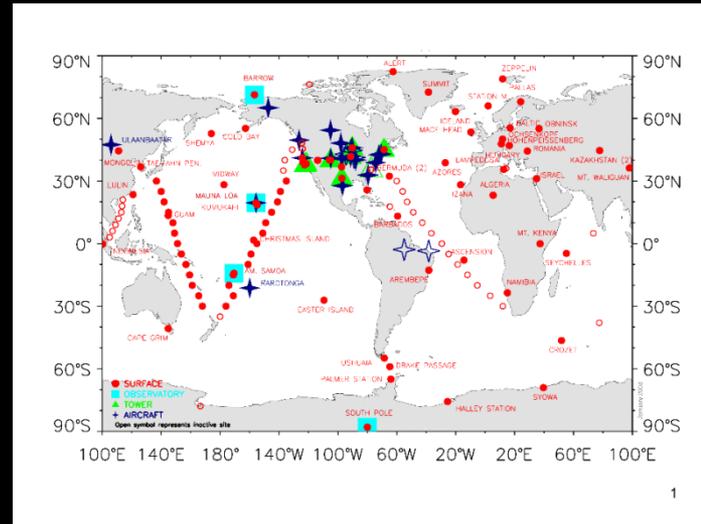
Scientific Aviation

Steve Conley

Carbon Cycle Group

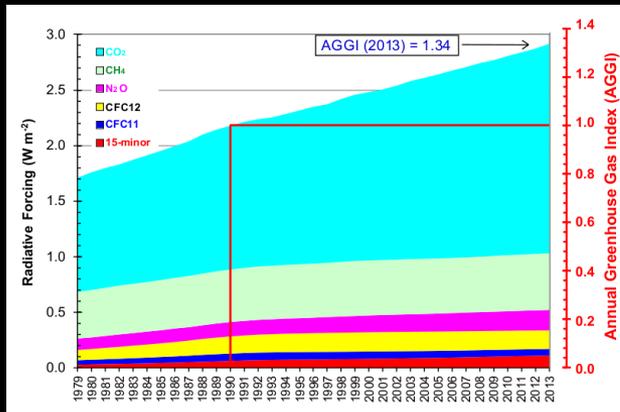
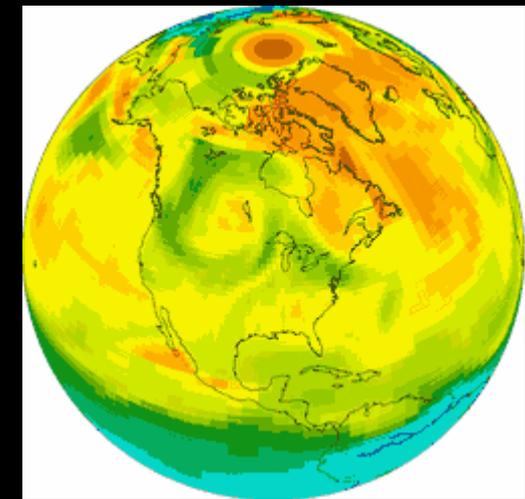


Cooperative network



Standards: CO₂, CH₄,
CO, N₂O, SF₆

Globalview



The primary goal of NOAA's Carbon Cycle Group is to monitor changes in Greenhouse Gases all over the world and to try to understand what is driving those changes.

Annual Greenhouse Gas Index

CarbonTracker – CO₂ and CH₄

Regional Studies of Greenhouse Gas

Problem:

- Most GHG emissions are aggregated at regional to local scales which means detection and verification techniques need to be developed for that scale.

Primary Goals:

- Develop and test techniques for measurement of regional greenhouse gas emission fluxes that can be scaled up to satellite observations.
- Comparison of top-down with bottom-up emission estimates.

Secondary Goals:

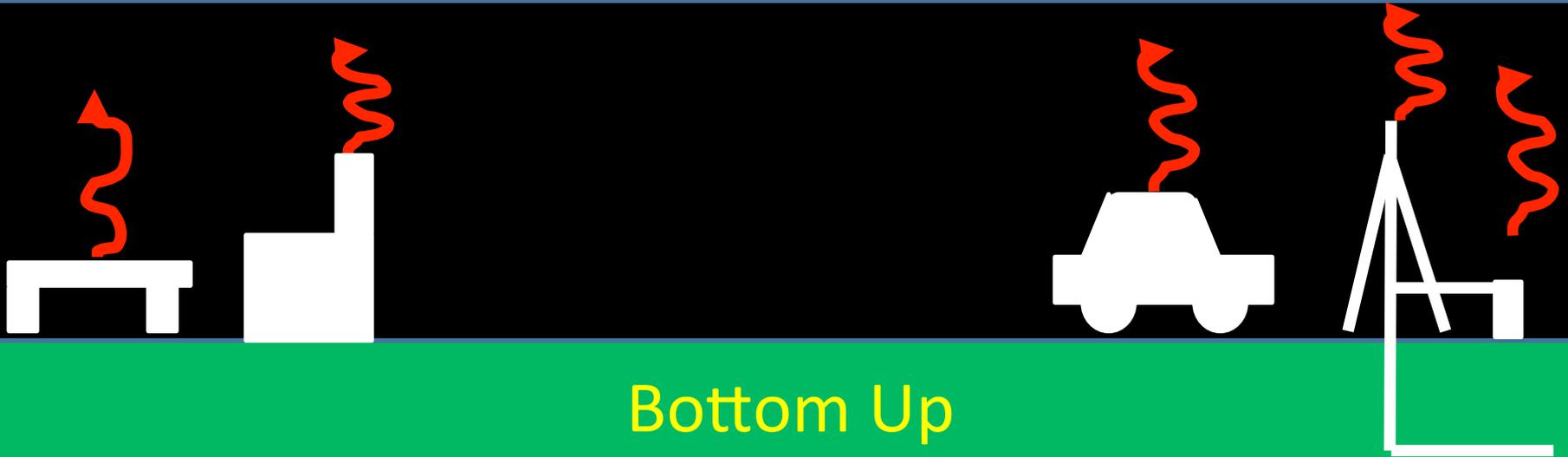
- Use emission ratios to quantify fluxes of other trace gases, e.g. CO, halocarbons, hydrocarbons
- Partition GHG flux into biological (natural) and fossil fuel components.
- Identify and characterize point sources distribution.

The simple picture

Top Down

Direct measurements of enhancements (ΔC)

Direct measurement of flux ($\langle w'c' \rangle$)



Bottom Up “INVENTORY”

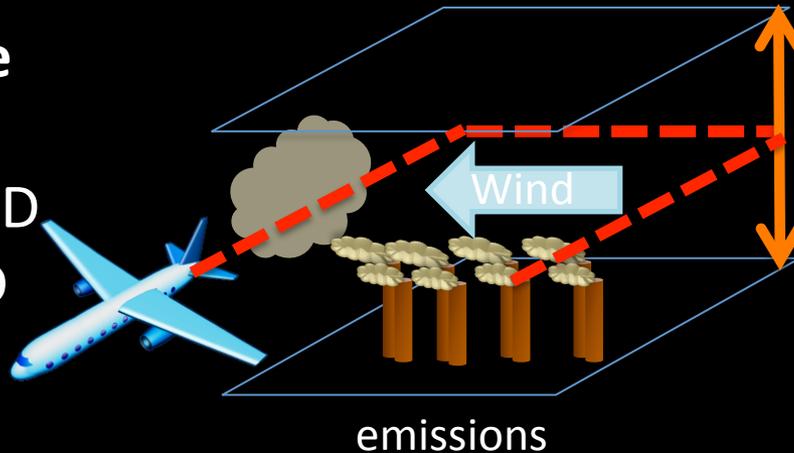
Process based estimate of emissions

Some processes can be well tracked based on economic data while other processes are not well tracked

Multi-scale/level approach

Mass Balance

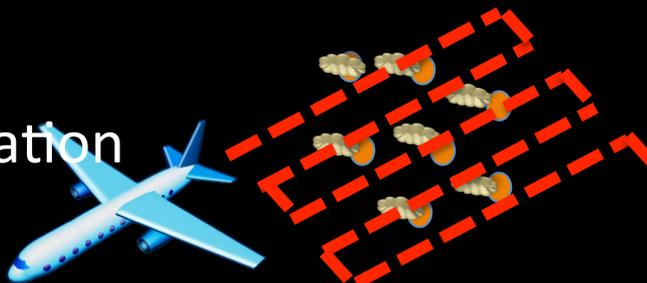
- Umich
- NOAA/GMD
- NOAA/CSD



Total basin emissions and large-scale source allocation

Point Source identification

- Scientific aviation
- NASA/JPL



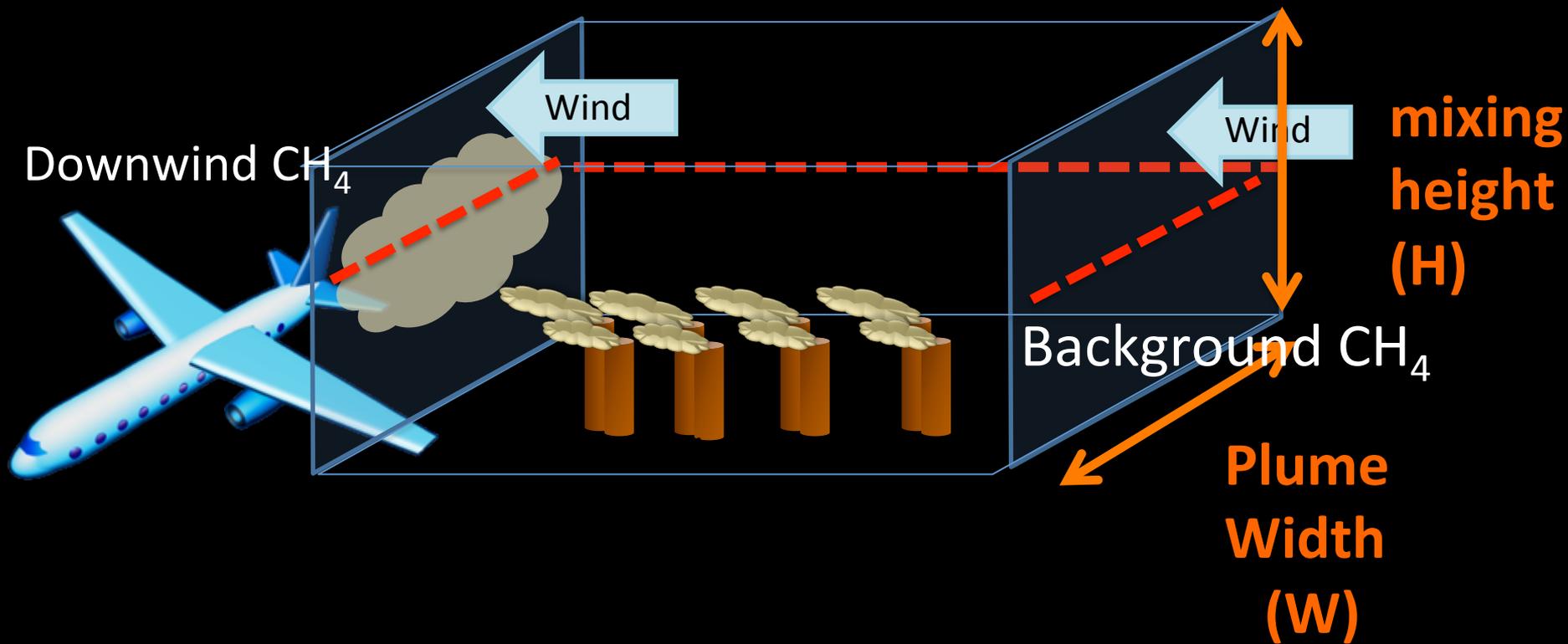
Large emitter site location and emissions quantification

- U of Colorado
- NOAA/GMD
- LANL



Process level emissions verification and emissions profile (e.g. $\text{CH}_4/\text{C}_2\text{H}_6$)

Aircraft Mass Balance Method

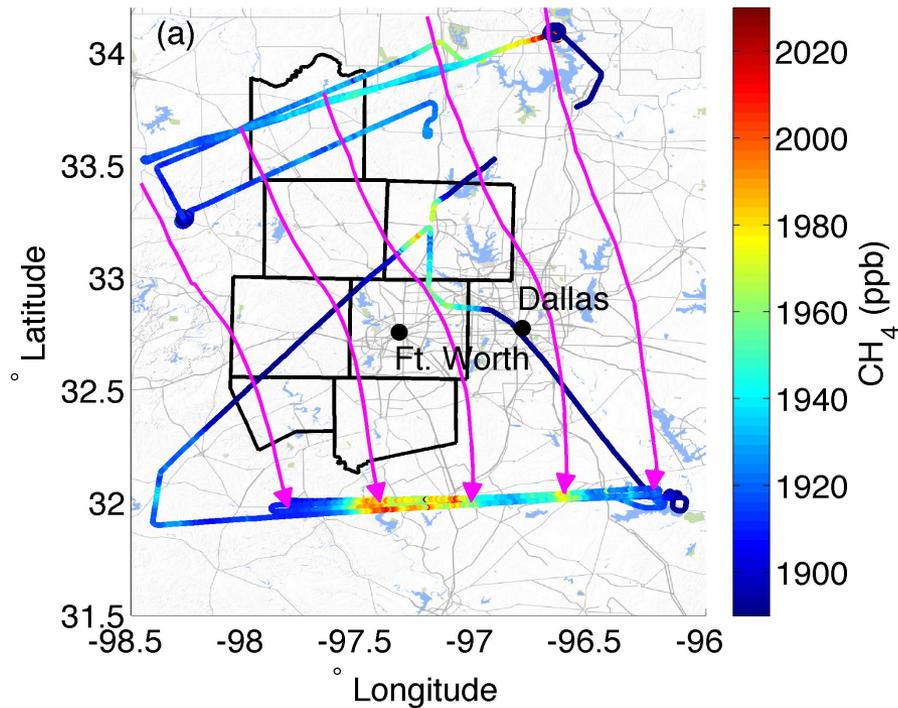


$$\text{CH}_4 \text{ emissions} = [\Delta\text{CH}_4] \times [\text{wind speed}] \times H \times W$$

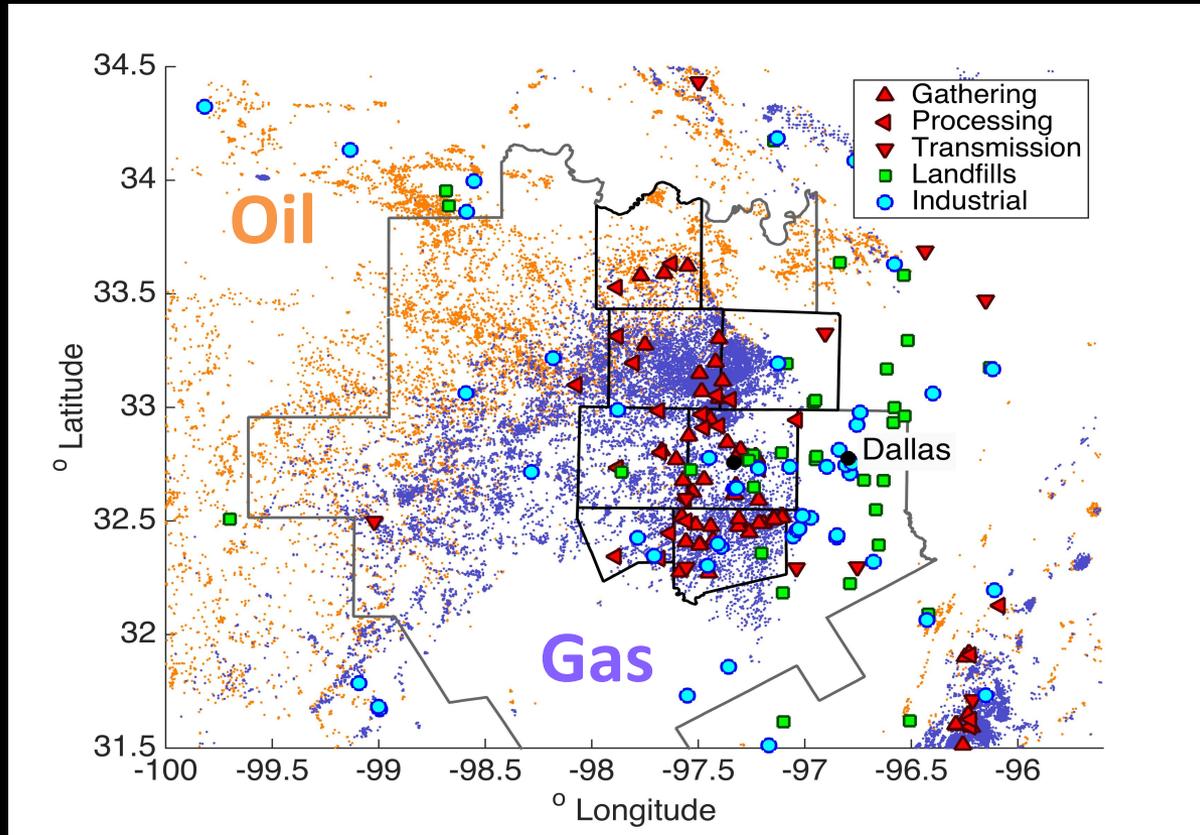


Background CH_4 - Downwind CH_4

Mass Balance example



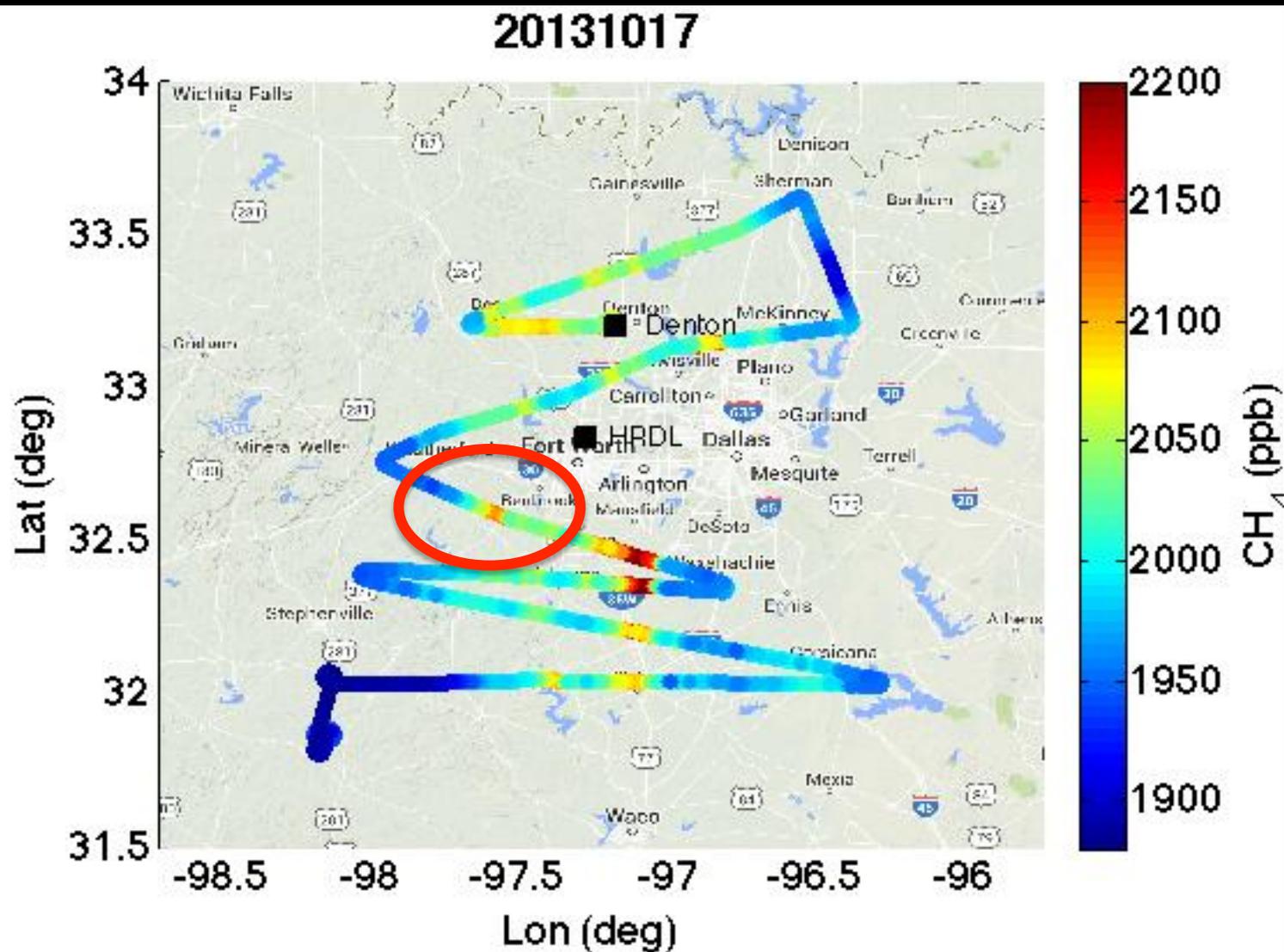
Scaling down



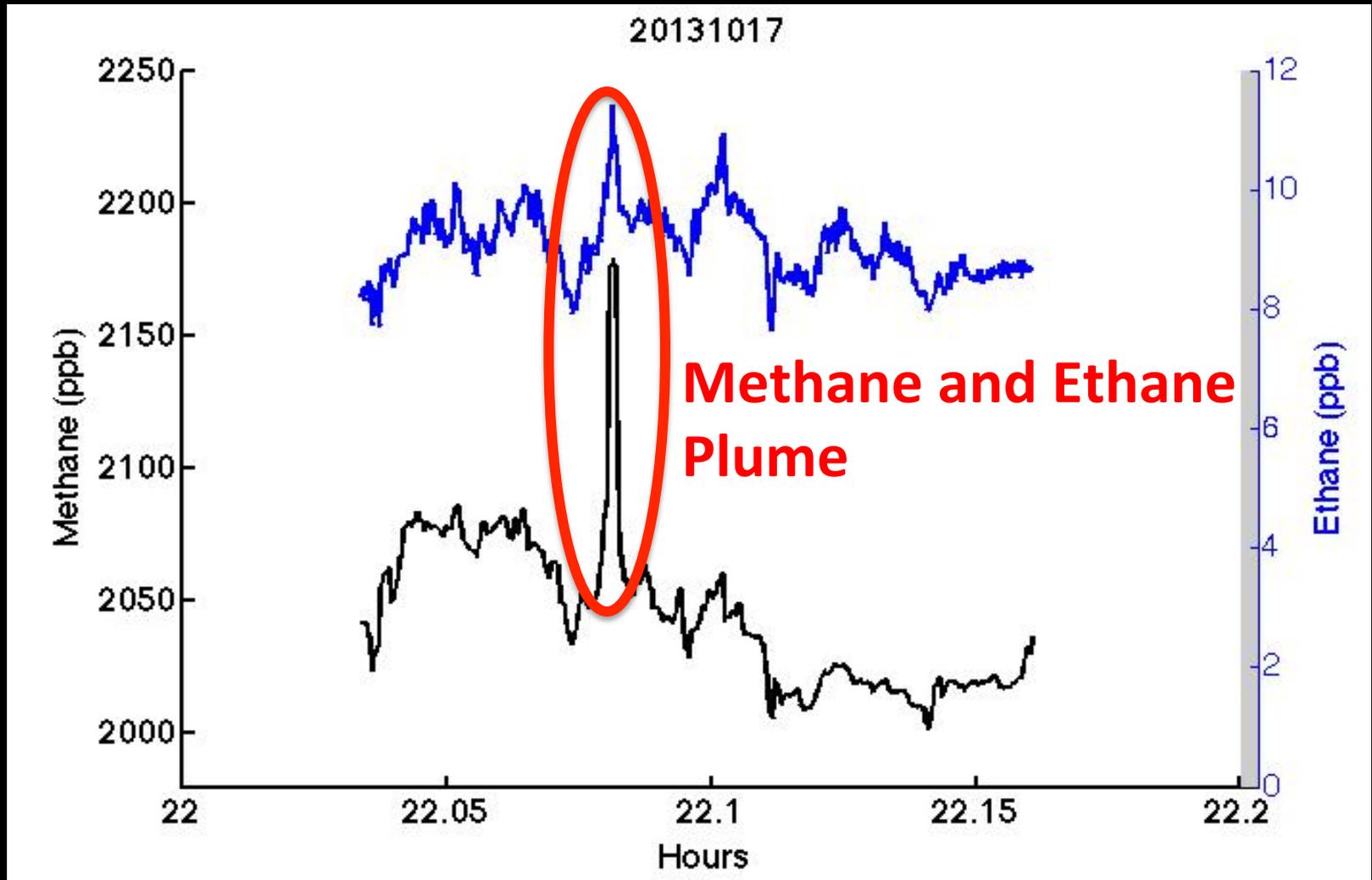
The Barnett Shale region has more than oil and gas wells. There were also landfills and some agricultural sources that need to be accounted for. Two approaches:

- 1) Point source identification to quantify role of large emitters
- 2) Use of tracers to attribute source of regional emissions

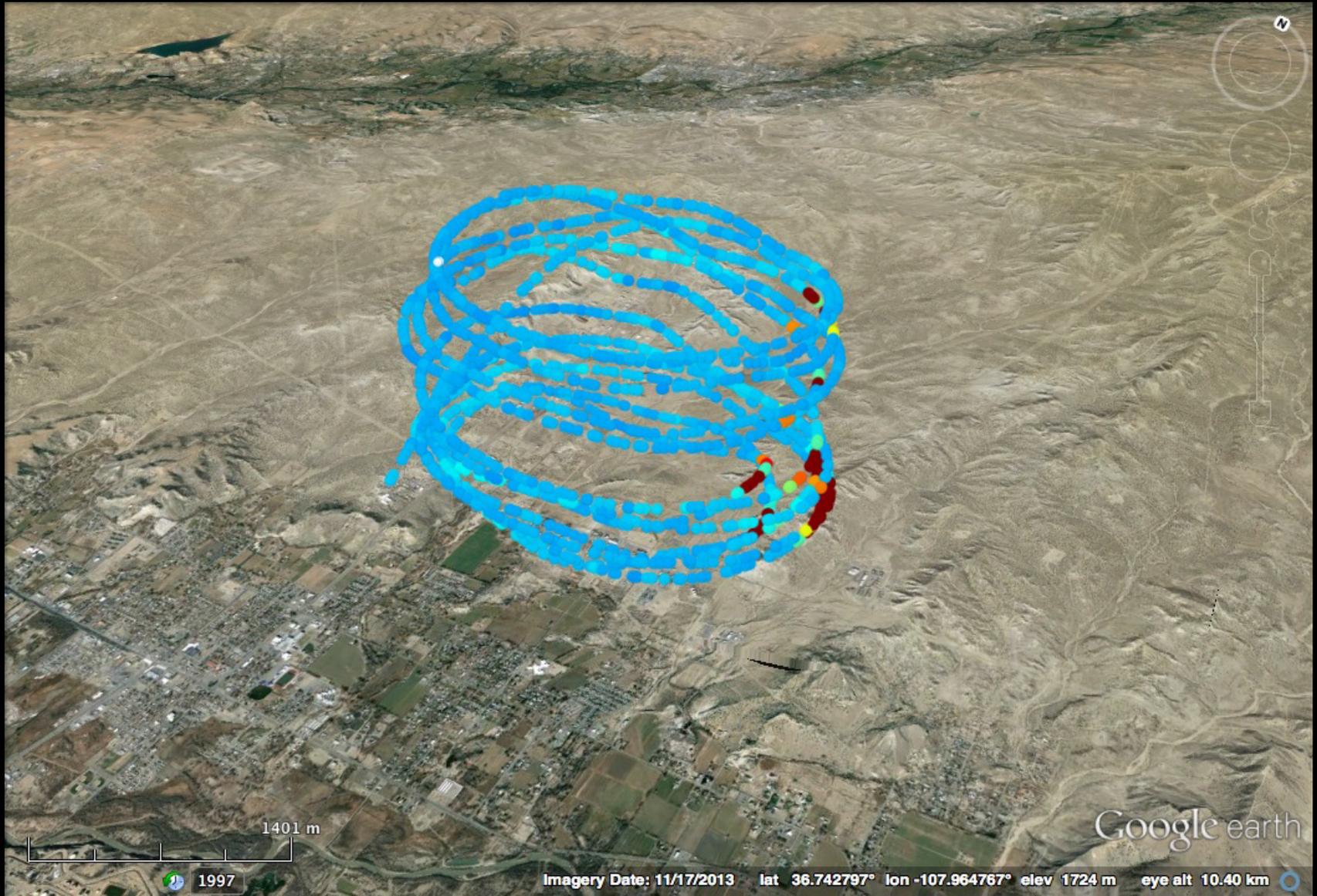
Point Source Identification



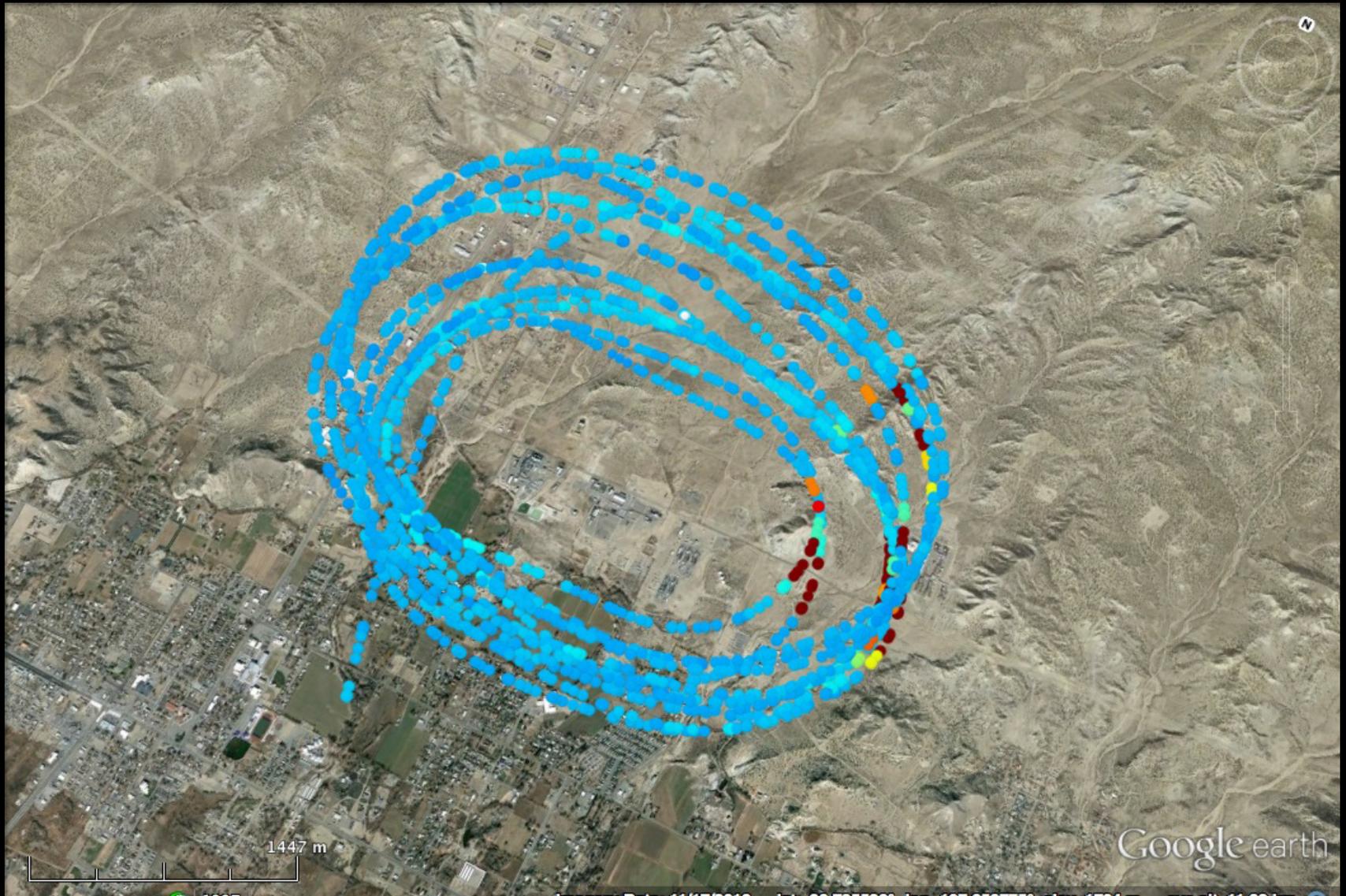
Point Source Identification



Point Source ID and Quantification



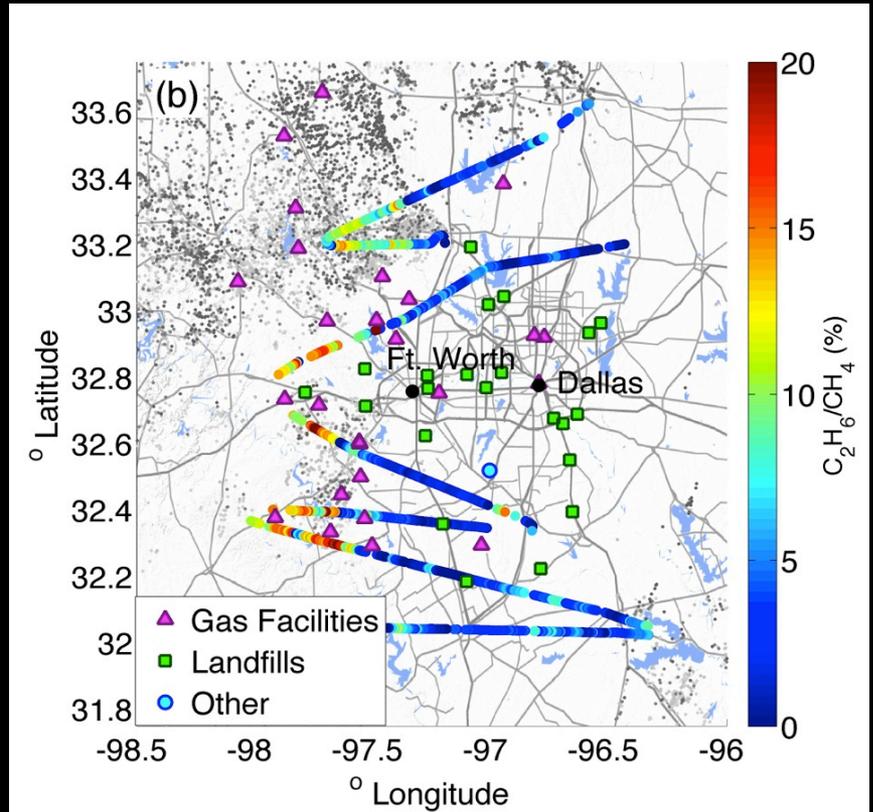
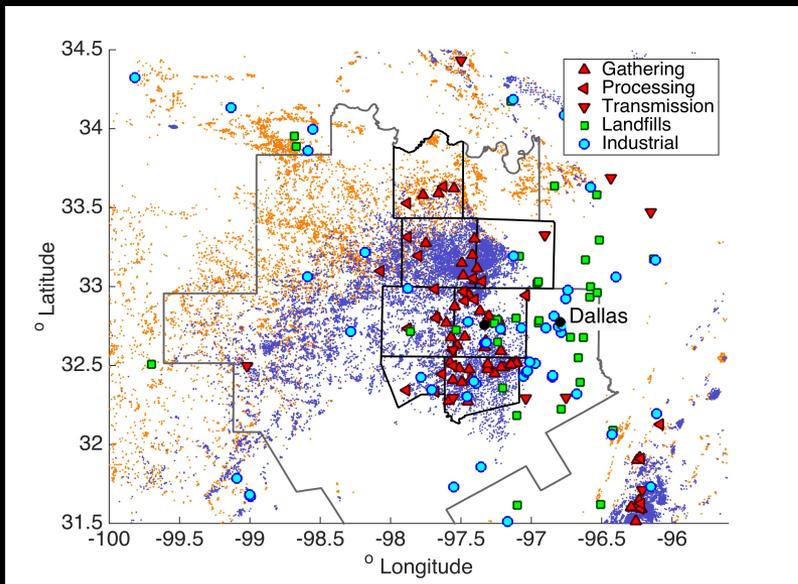
Point Source ID and Quantification



Point Source ID and Quantification



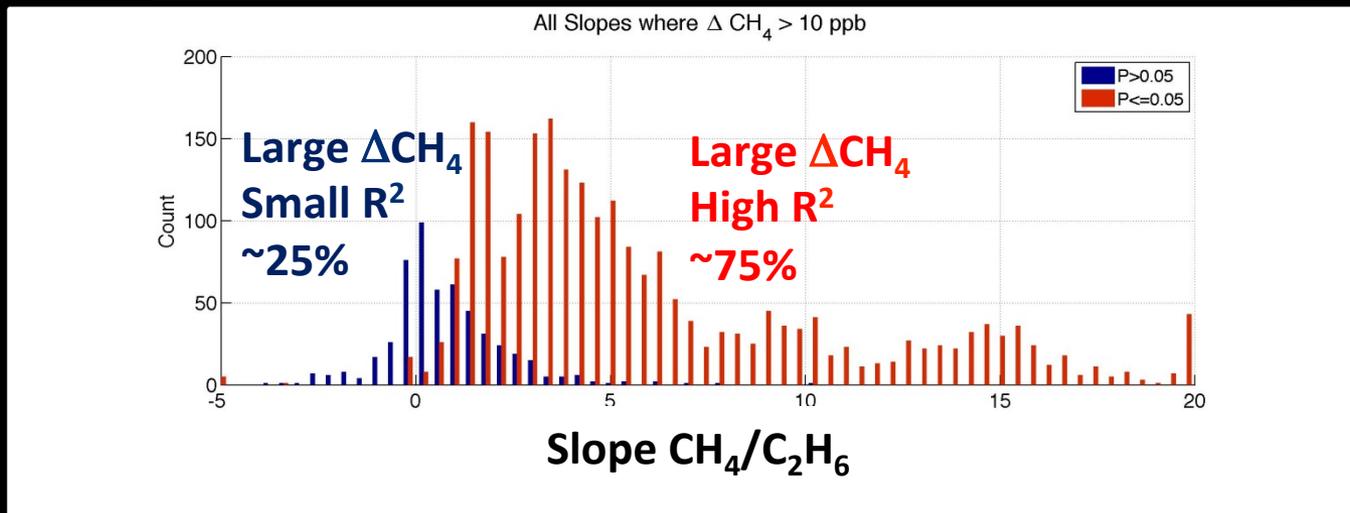
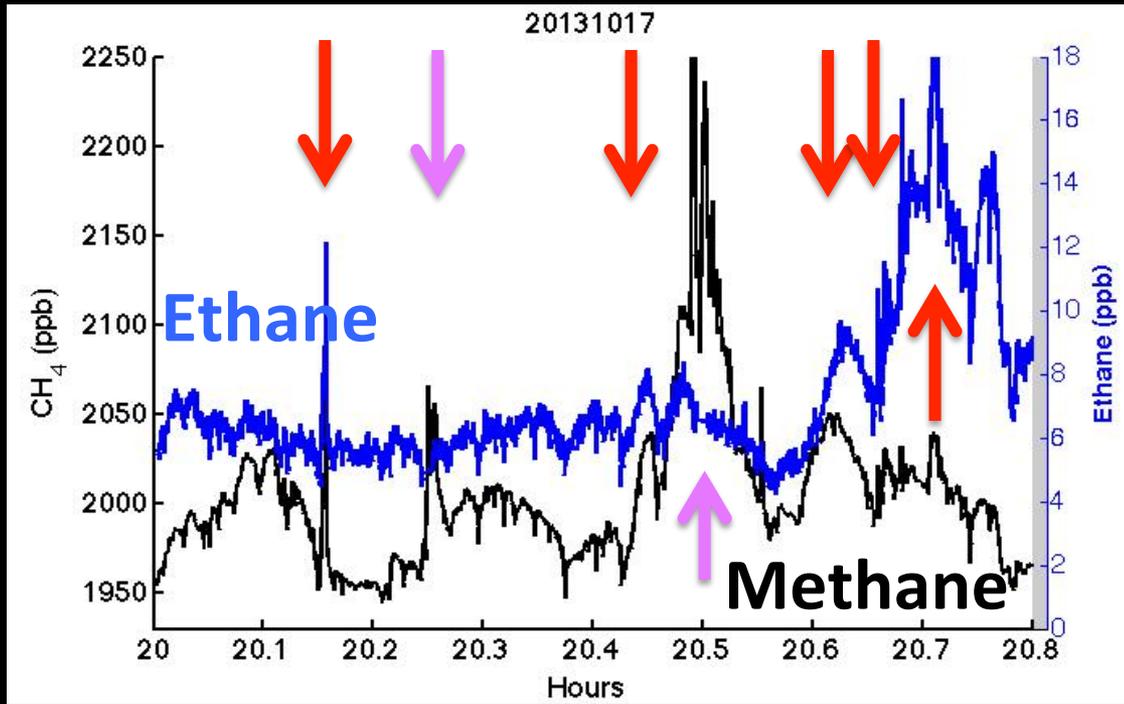
Attribution of emission



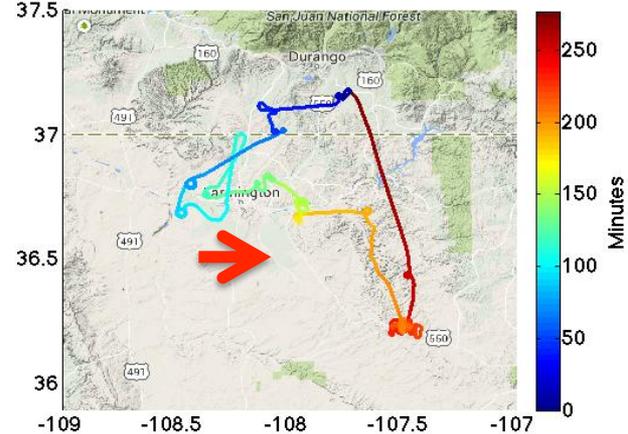
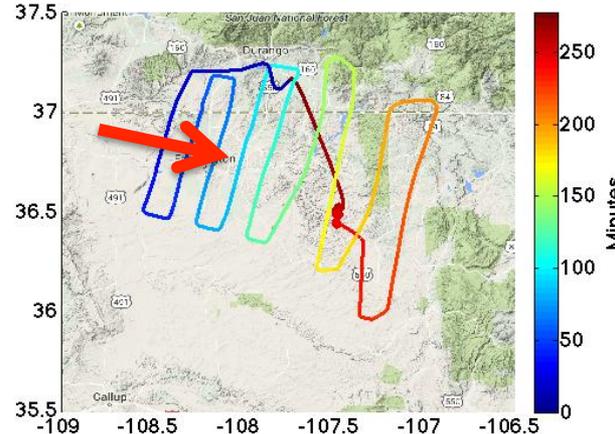
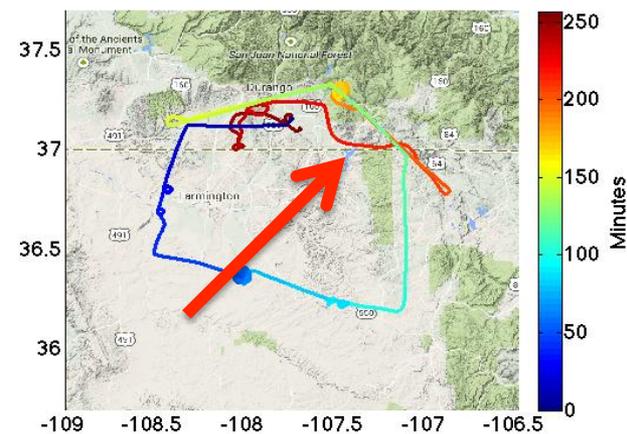
In the Barnett Shale region we used ethane and ^{13}C of CH_4 to separate oil and gas emitters from landfills and agricultural emissions.

Attribution of emission

Transect of ethane and methane in Barnett shows both fossil fuel and non fossil emitters



Examples of SJ Basin flights



Mass Balance

Attribution/Point
Source ID

Point Source
Quantification

Questions?