



# Mobile Measurements of Air Pollutants and Greenhouse Gases in the Front Range of Colorado



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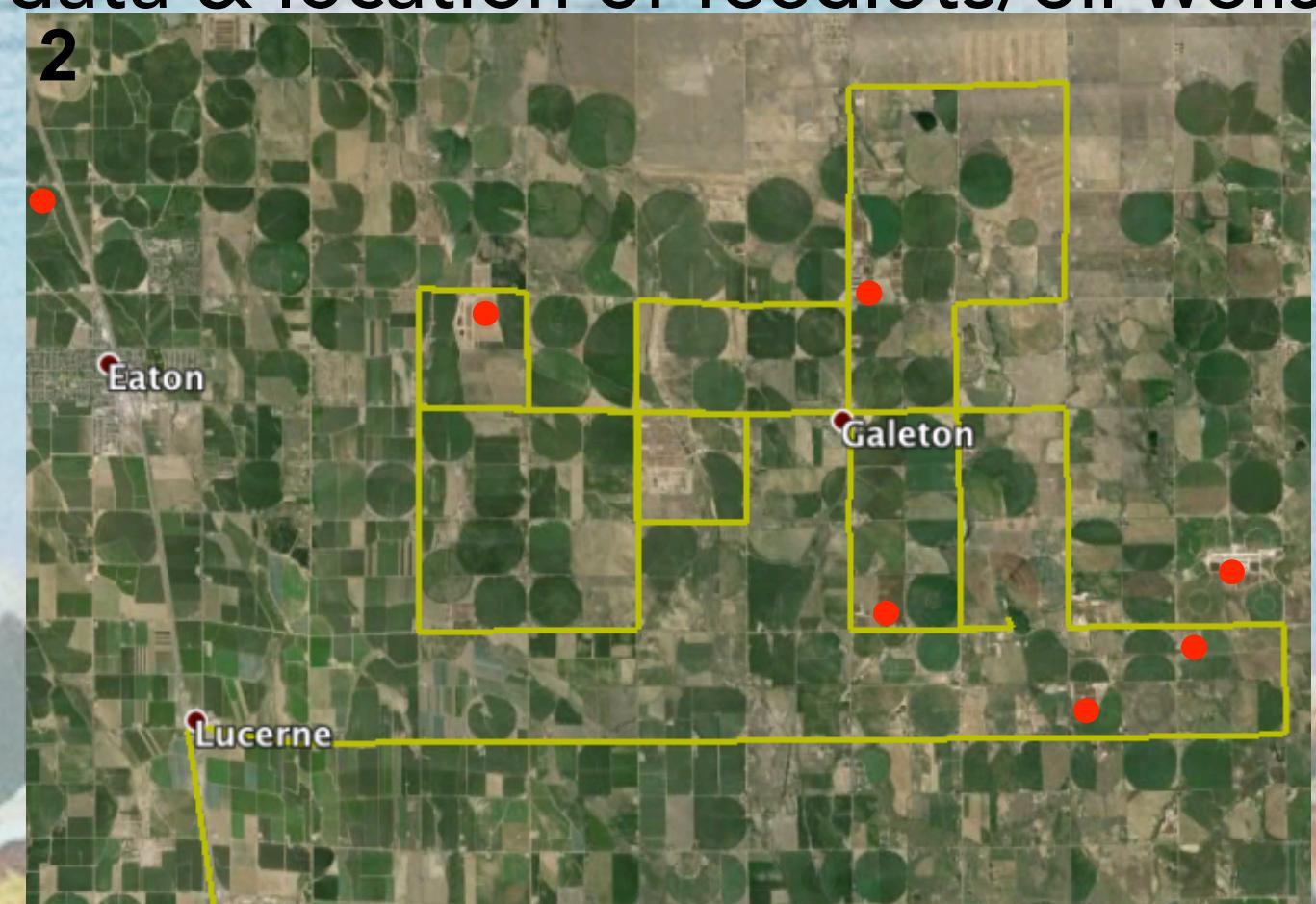
## 1. Motivation

- Atmospheric ammonia ( $\text{NH}_3$ ) is a gas-phase precursor to fine particulate matter, which is harmful to both the environment and human health [1]
- Methane ( $\text{CH}_4$ ) is a potent greenhouse gas with 23 times the warming potential of carbon dioxide over a hundred-year cycle [2]
- We deployed mobile sensors to quantify methane & ammonia emissions from animal feedlots, fracking wells and composting operations in northeast Colorado
- Field campaign in collaboration with NASA's DISCOVER-AQ campaign
- How do our ammonia measurements compare to the accepted global value?



## 2. Methods

- PAC-MAN (Princeton Atmospheric Chemistry Mobile Acquisition Node)
  - 3 Quantum Cascade Laser (QCL) sensors (ammonia, methane, nitrous oxide)
  - 1 carbon dioxide/water vapor sensor
  - Air temp., relative humidity, and wind speed/direction measurements also taken
- Planned daily driving routes according to NASA/NOAA weather data & location of feedlots/oil wells

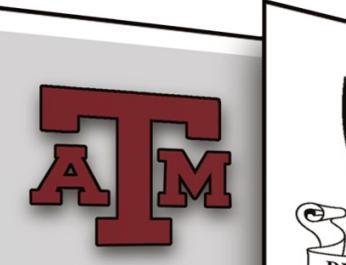


### References:

- [1] Pinder, RW, AB Gilliland, RL Dennis. Environmental impact of atmospheric  $\text{NH}_3$  emissions under present and future conditions in the eastern United States . Geophy. Res. Lett. 35: 25, 2008.  
 [2] McDermitt, D. et al., "A new low-power, open-path instrument for measuring methane flux by eddy covariance" Applied Physics B, 102, 391-405, (2011).  
 [3] Data source: <http://www.springfieldcolorado.com/map.html>  
 [4] 2013 Intergovernmental Panel on Climate Change (IPCC) Report

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## 3. Results

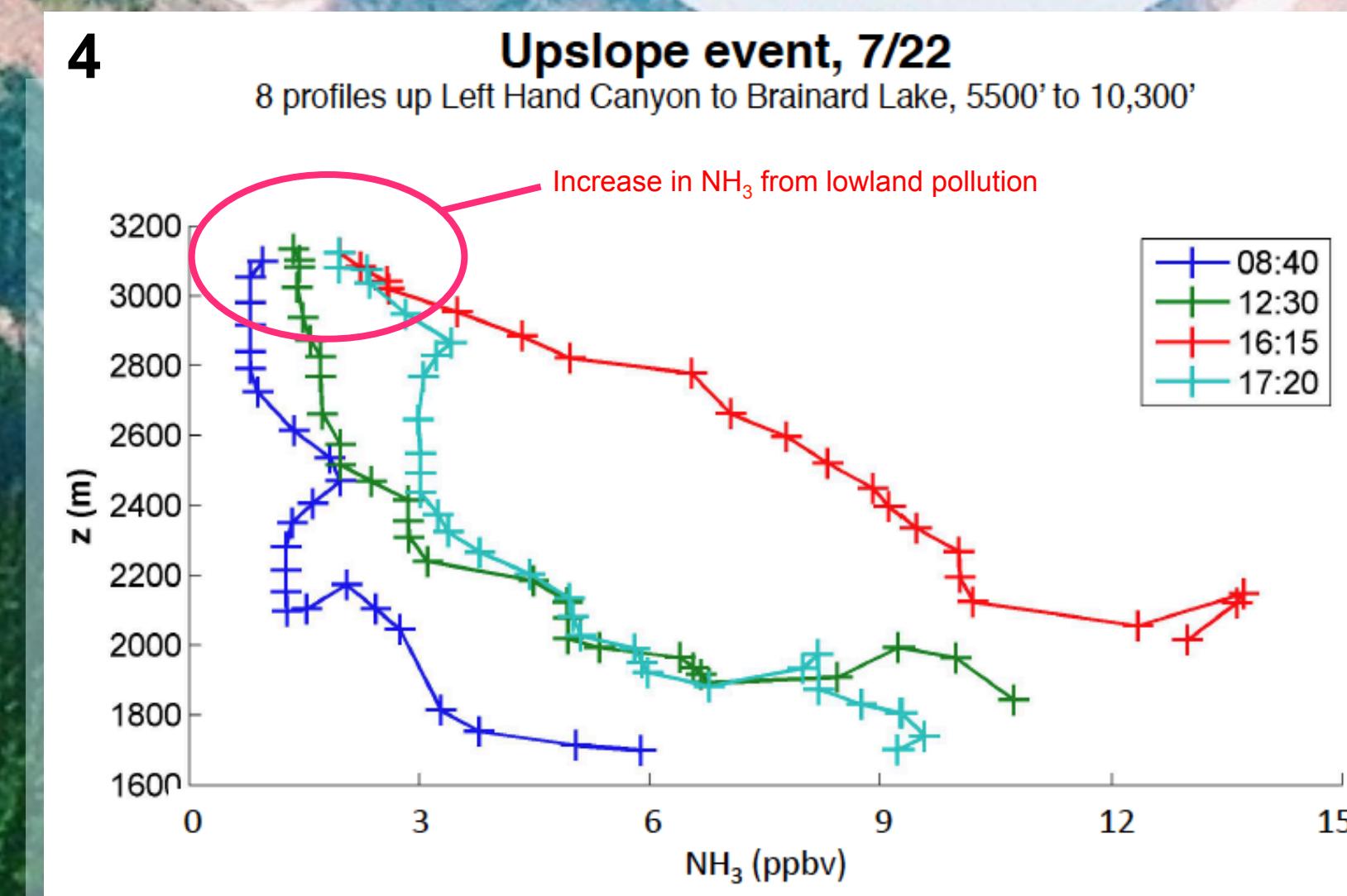


Fig. 4 (top left): Ammonia measurements taken at increasing elevation to Brainard Lake, CO ( $\approx 3100\text{m}$ )

Fig. 5 (top right): Change in ammonia/change in methane emission ratios for individual feedlots ( $N$ =# of passes by individual feedlot)

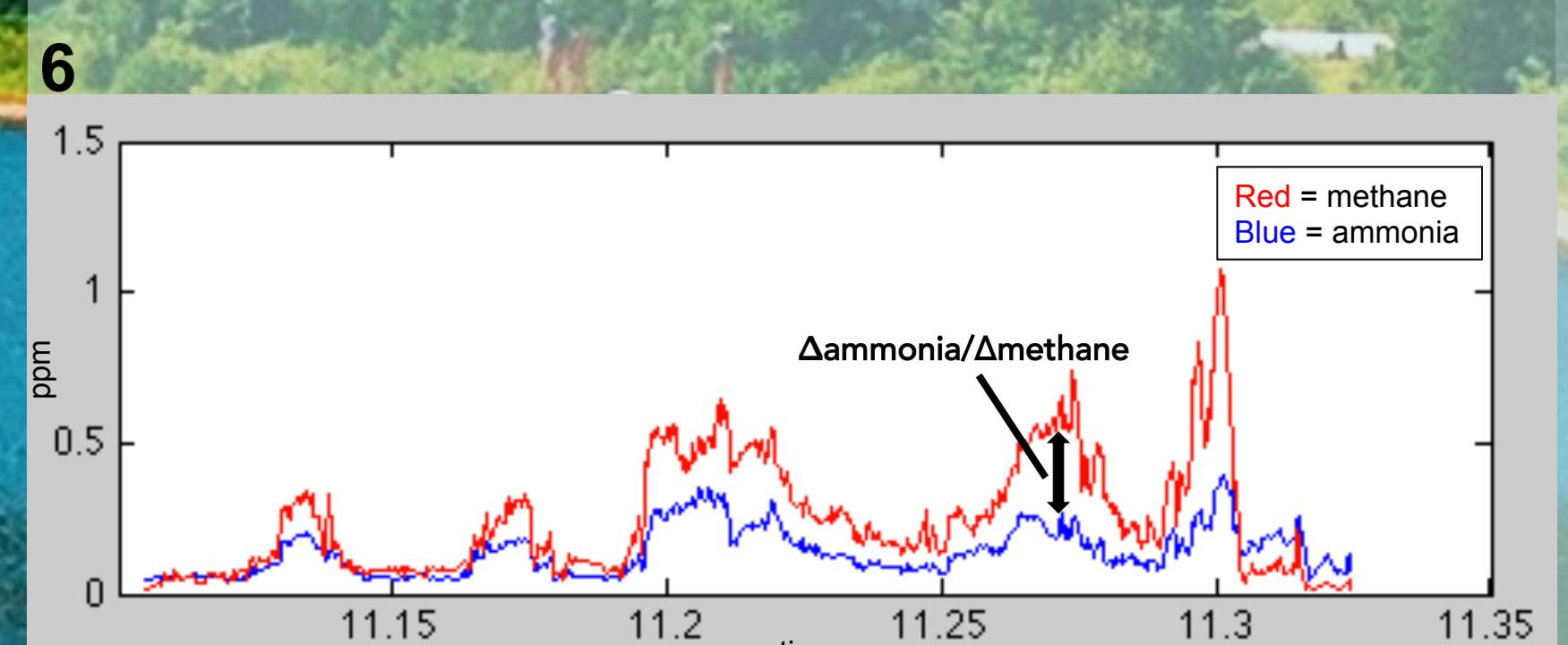
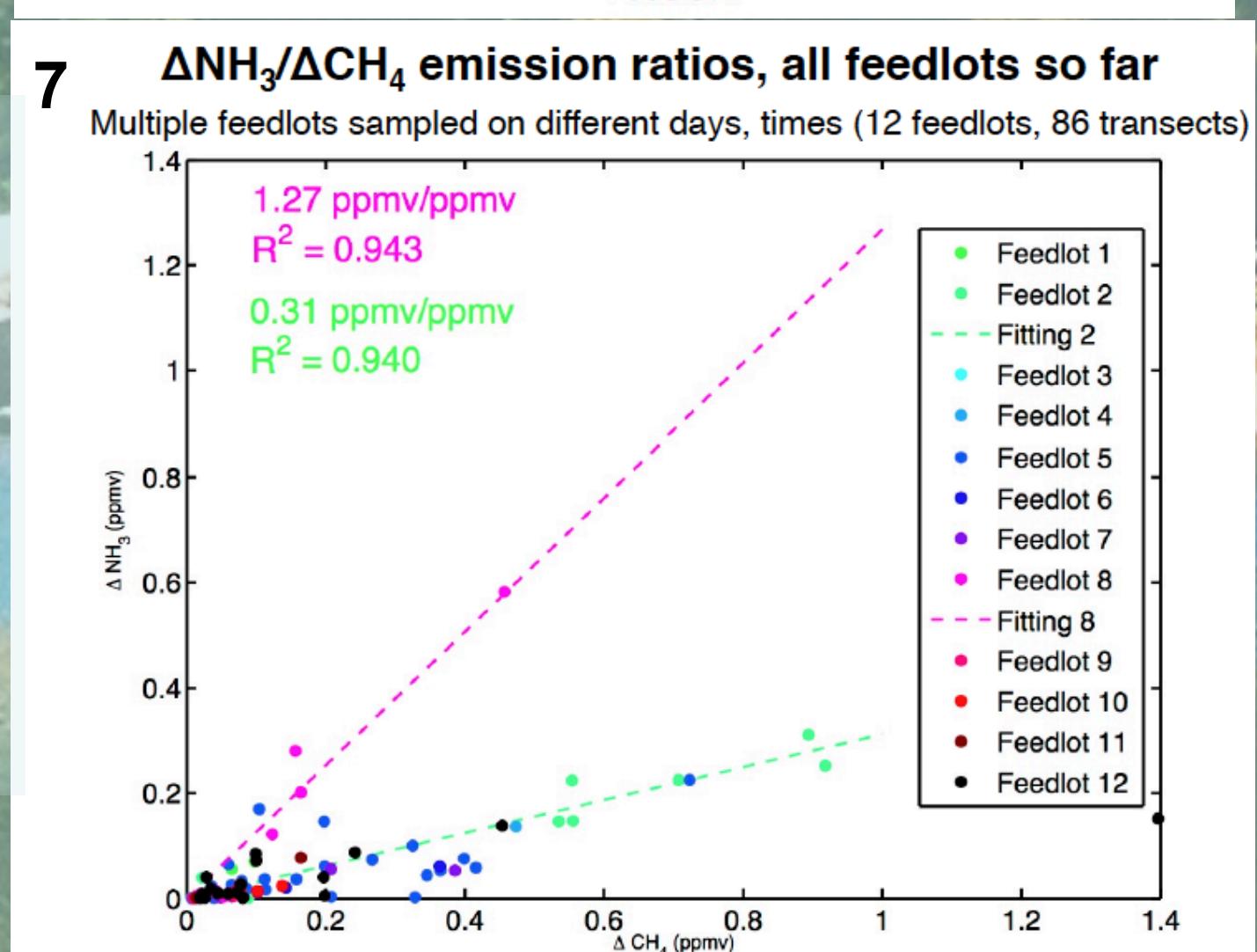
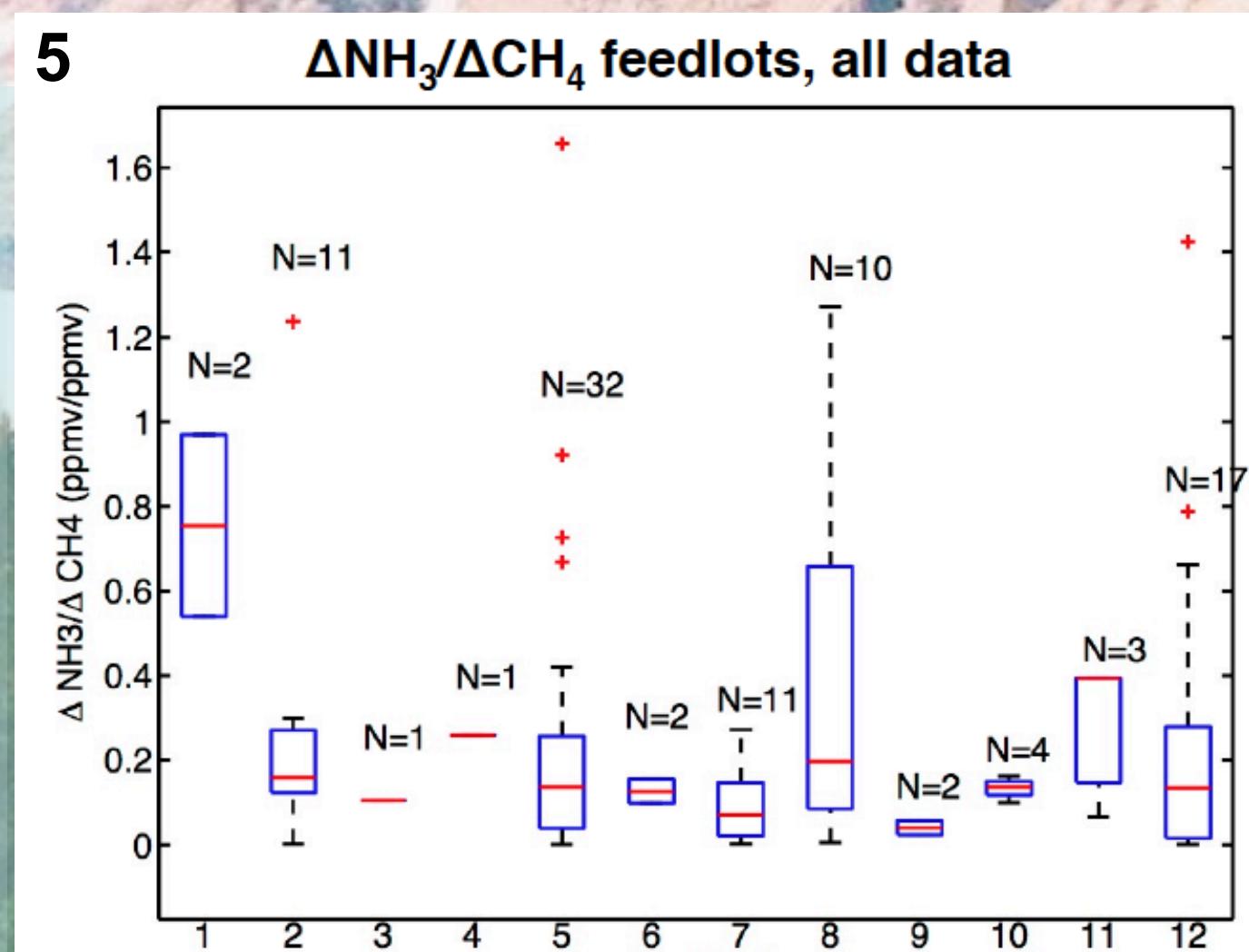


Fig. 6 (bottom left): How emissions ratios were calculated

Fig. 7 (bottom right): Change in ammonia/change in methane emission ratios for all feedlots tested thus far in the field study



- (Fig. 4)- We measured transport of pollution up a mountain (polluted air at lower elevations transported to pristine air at upper elevations, all the way to near continental divide); (Fig. 5)- We sampled individual feedlots several times each to measure variability, since feedlots are sources of both  $\text{NH}_3$  and  $\text{CH}_4$ ; (Fig. 6)- Method of calculating emissions ratios; (Fig. 7)- We found that even though there is variability among feedlots (Fig. 5), the  $\Delta$ ammonia/ $\Delta$ methane emissions ratios remain internally consistent for individual feedlots

## 4. Conclusions/Future Work

- 7/22 upslope event suggests ammonia steadily decreases upslope, but steadily increases from morning to late afternoon as pollution from cars and agriculture moves upslope
- Median  $\Delta$ ammonia/ $\Delta$ methane emissions ratio (from all data) =  $0.14 \text{ ppmv}/\text{ppmv} \pm 0.04$ , which is consistent with findings from 2013 DISCOVER-AQ California field campaign
  - Suggests this work can be translated to all US feedlots
  - In the future, we should obtain more data on individual feedlots (for example, feedlots #3 and 4) as well as more data at different times of the day
- Based on the emissions ratio, we calculated a total of  $\approx 28.8 \text{ TgNH}_3/\text{yr}$  released globally from feedlots alone; IPCC calculated  $30.4 \text{Tg}/\text{yr}$  from total agriculture (our value is higher for just feedlots) [4]- Discrepancy exists