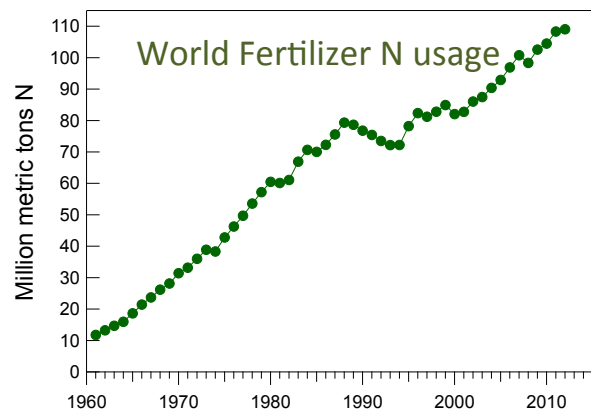


## Agriculture that feeds the world affects climate, air quality and stratospheric ozone

### Crop Fertilization



### Fertilizer made from synthesized Ammonia

**Ammonia:** emitted from fertilized fields,  
*leads to particle formation*

→ **Air quality and climate**

**Nitrous oxide:** emitted from fertilized fields  
*increase mostly from agricultural intensification*

→ **Climate and stratospheric ozone**

### Animal Husbandry



### Concentrated animal feeding operations

**Methane:** emitted from animal digestion and manure  
*emissions from ruminants ≈ fossil fuels*

→ **Climate**

**Ammonia:** emitted from animal waste

**CSD's response: develop techniques to quantify variable ammonia, nitrous oxide, methane emissions**

# Large uncertainties in agricultural emissions

Example: CSD's Calnex 2010 study, NOAA WP-3 aircraft flights over agriculture

Area-wide agricultural emission fluxes quantified and compared to inventories:

**Ammonia:** Large fluxes from dairies

**Underestimated by emission inventories**

*(Nowak et al., GRL, 2012)*

**Nitrous oxide:** Large fluxes from agriculture

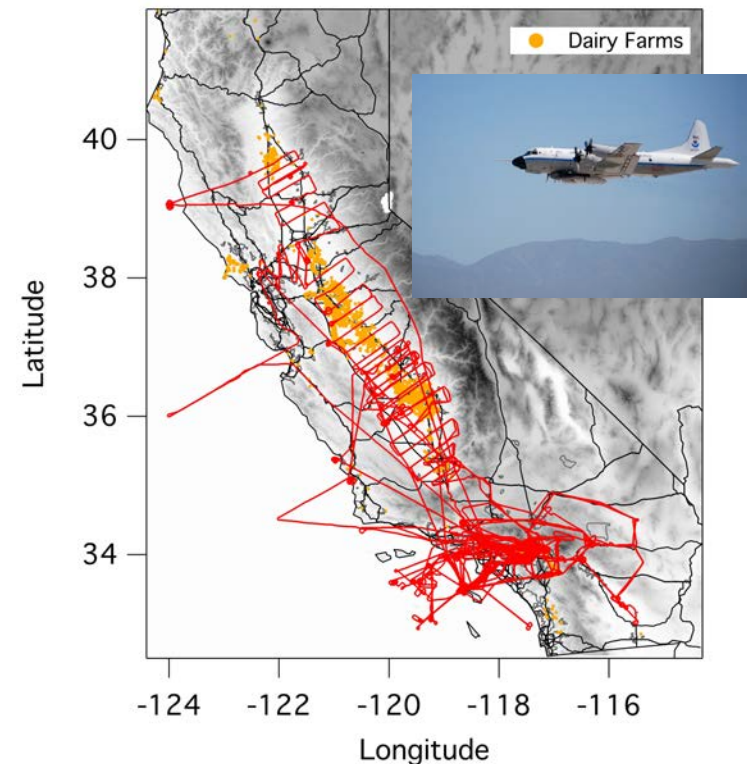
**Underestimated by emission inventories**

*(Xiang et al., JGR, 2013)*

**Methane:** Large fluxes from rice cultivation

**Underestimated by emission inventories**

*(Peischl et al., JGR, 2012)*



- Motivation: Accurate emission information required to predict AQ and climate change
- Findings: Observed fluxes typically 3x larger than inventories
- Response: Extend observations to capture temporal and spatial variability

# CSD's new mobile platform for extended observations

Instrumented ~~15-passenger~~ 2-passenger van to quantify agricultural emissions



## Versatile and powerful infrastructure

- Operate instruments for hours on battery power
- Seamless transition between power sources allows long duration, continuous measurement
- Easy to reconfigure for new instruments
- Detailed characterization of emission sources

## Current payload

(commercial and custom)

- nitrous oxide
- methane
- ammonia
- CO, CO<sub>2</sub>
- NO, NO<sub>2</sub>, NO<sub>y</sub>
- ozone
- bio-aerosol

# First results: Ammonia and methane from feedlots in NE Colorado

## Experiment:

Drive around several feedlots repeatedly

Diurnal variability

(in collaboration with Princeton U., Aerodyne)

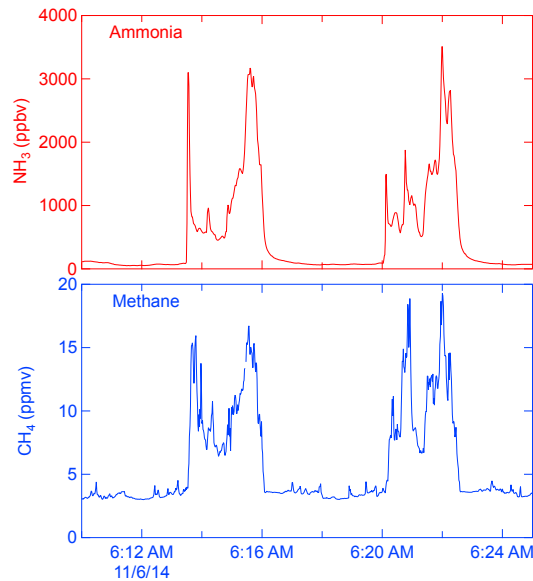
Seasonal variability



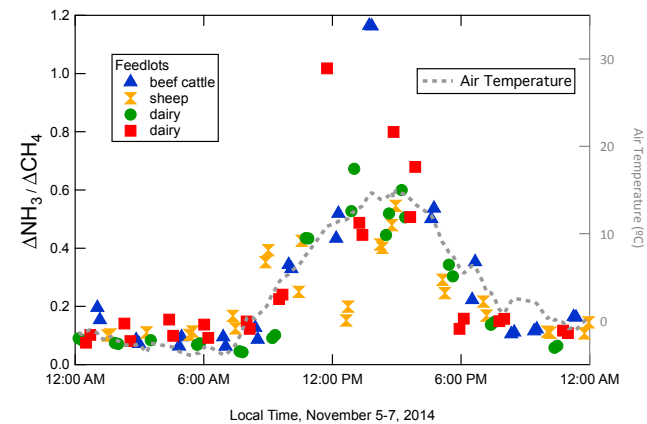
30,000 cattle



## Large (!) mixing ratios



## Use enhancement ratios to compare with inventories



- Critical to assess inventories and resolve discrepancies with observations
- Ammonia to methane emissions ratio vary with temperature and time of day

## Future directions for CSD's mobile van

- Quantify emissions flux to the atmosphere:
  - incorporate remote sensing or UAS to determine winds aloft and boundary layer height
  - vertical wind measurements, tracer release
- Partner with industry to identify practices that reduce emissions

**fertilizer lost to the atmosphere = \$ lost**
- Valuable platform for testing and deploying new instrumentation