Agricultural Gas and Aerosol Experiment (AGGAE)

Scientific background and overarching questions

- Agriculture is a major industrial sector in the US and Canada
- Agricultural sources of greenhouse gases are dominant for key species: N_2O, CH_4; important for CO_2.
- Soil sources of NO_x are potential crucial for understanding HO_x and O_3 chemistry in North America.
- Agriculture produces large quantities of CO, aldehydes, NH_3, CCN.

What are the magnitudes of these sources?

How are they distributed, in time and space?

How do they impact atmospheric chemistry & global greenhouse gases?

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Programmatic and Societal Interest

- The North American Carbon Program (NACP) is has agriculture as a major focus.
- Agricultural emissions will be a major issue for any future efforts to regulate greenhouse gases.
- Aircraft observations over North America will fulfill major validation objectives for CO_2 (OCO, GOSAT) and CH_4 (GOSAT).
- Separating the influence of urban and rural emissions is a major problem for continental and regional scale atmospheric chemistry.
- Atmospheric chemical species are transported rapidly to the upper troposphere by deep convection in the Great Plains. This could be especially important for CO, aldehydes, NH_3, CCN.

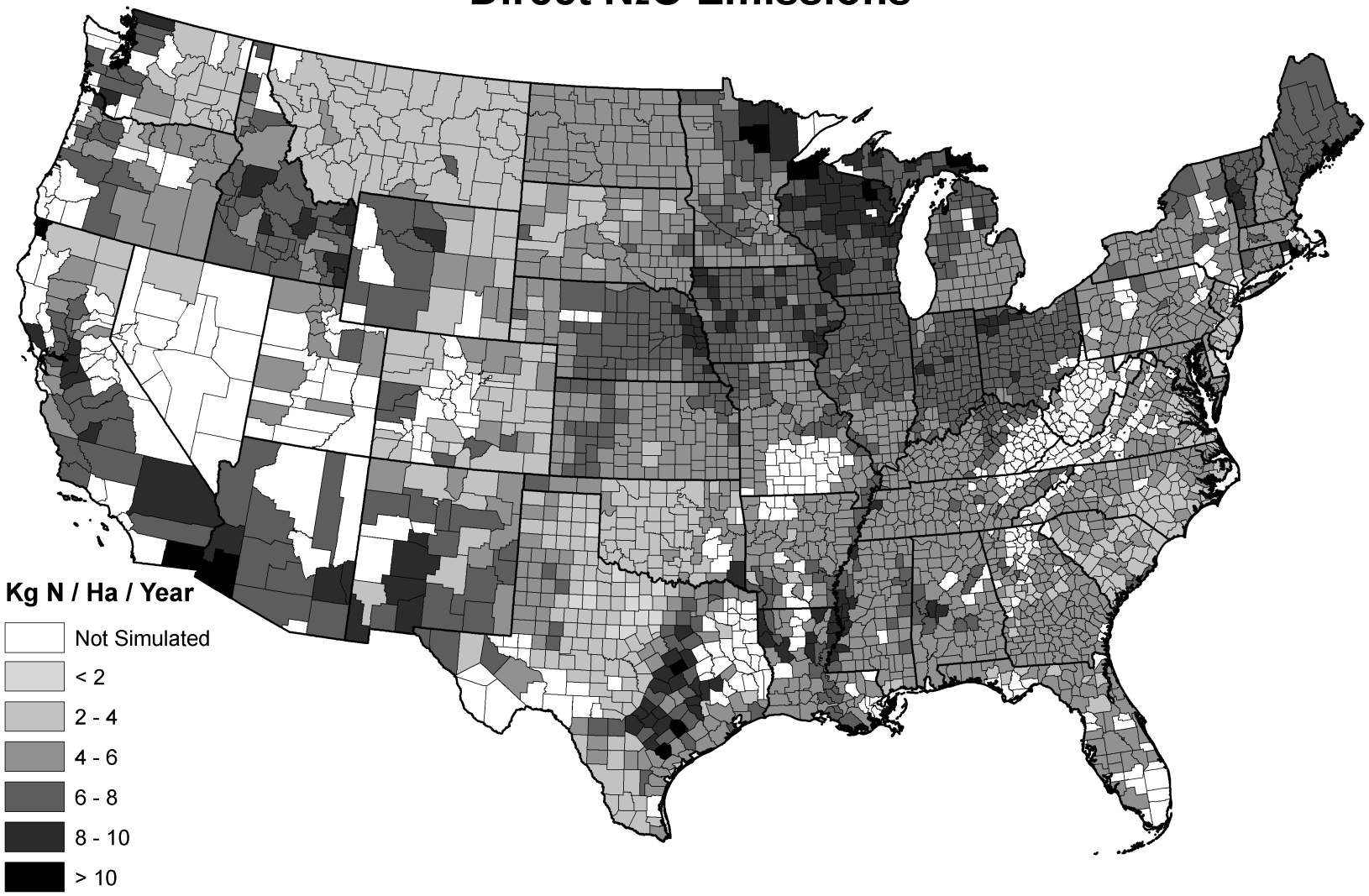
PRESENT-DAY GLOBAL BUDGET OF ATMOSPHERIC N_2O

SOURCES (Tg N yr^{-1})	18 (7 – 37)
Natural	10 (5 – 16)
Ocean	3 (1 - 5)
Tropical soils	4 (3 – 6)
Temperate soils	2 (1 – 4)
Anthropogenic	8 (2 – 21)
Agricultural soils	4 (1 – 15)
Livestock	2 (1 – 3)
Industrial	1 (1 – 2)
SINK (Tg N yr^{-1}) Photolysis and oxidation in stratosphere	12 (9 – 16)
ACCUMULATION (Tg N yr^{-1})	4 (3 – 5)

IPCC [2001]

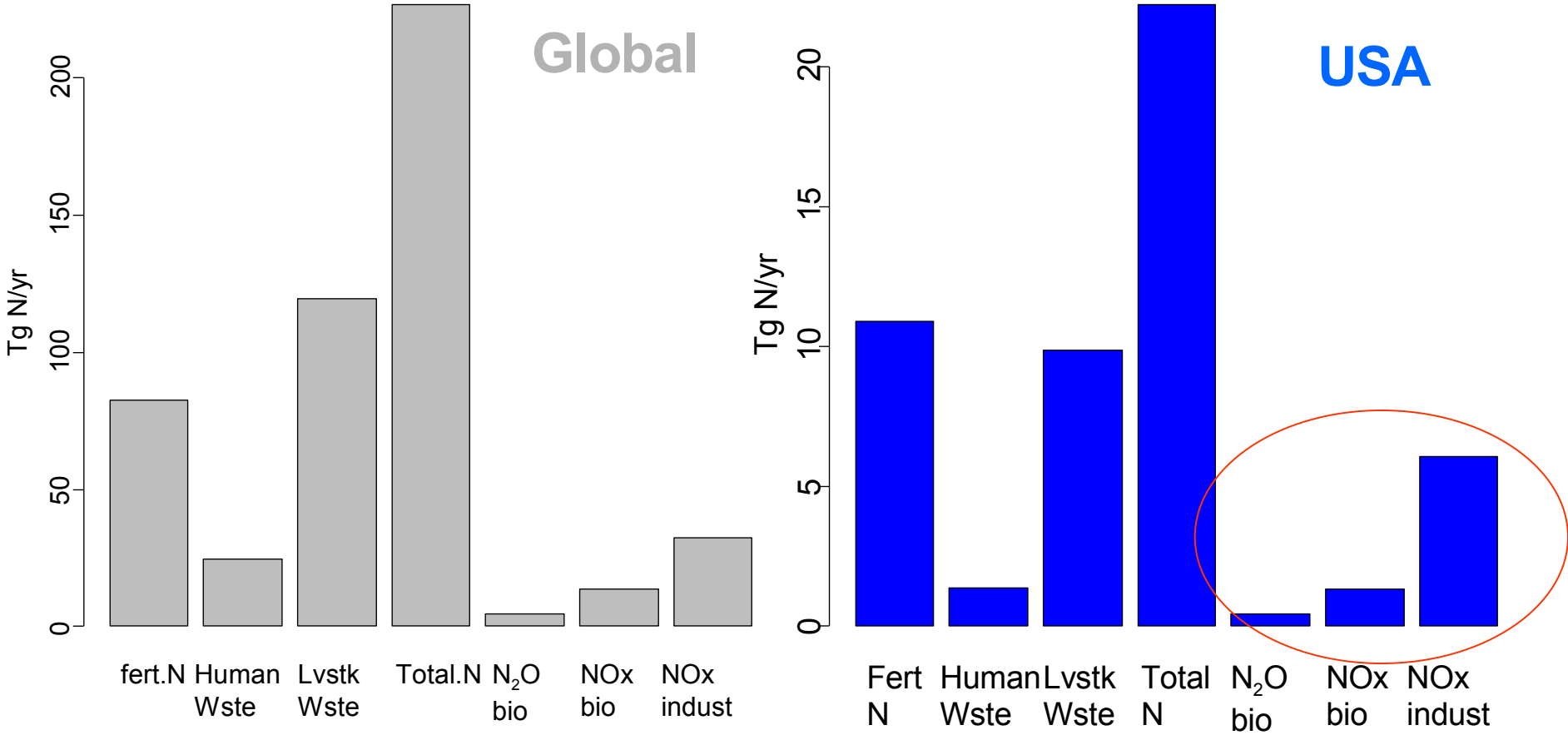
Although a closed budget can be constructed, uncertainties in sources are large!
(N_2O atm mass = 5.13 10^{18} kg x 3.1 10^{-7} x28/29 = 1535 Tg)

Major Crops
Direct N_2O Emissions



S. Del Grosso, S. Ogle and B. Parton, in review

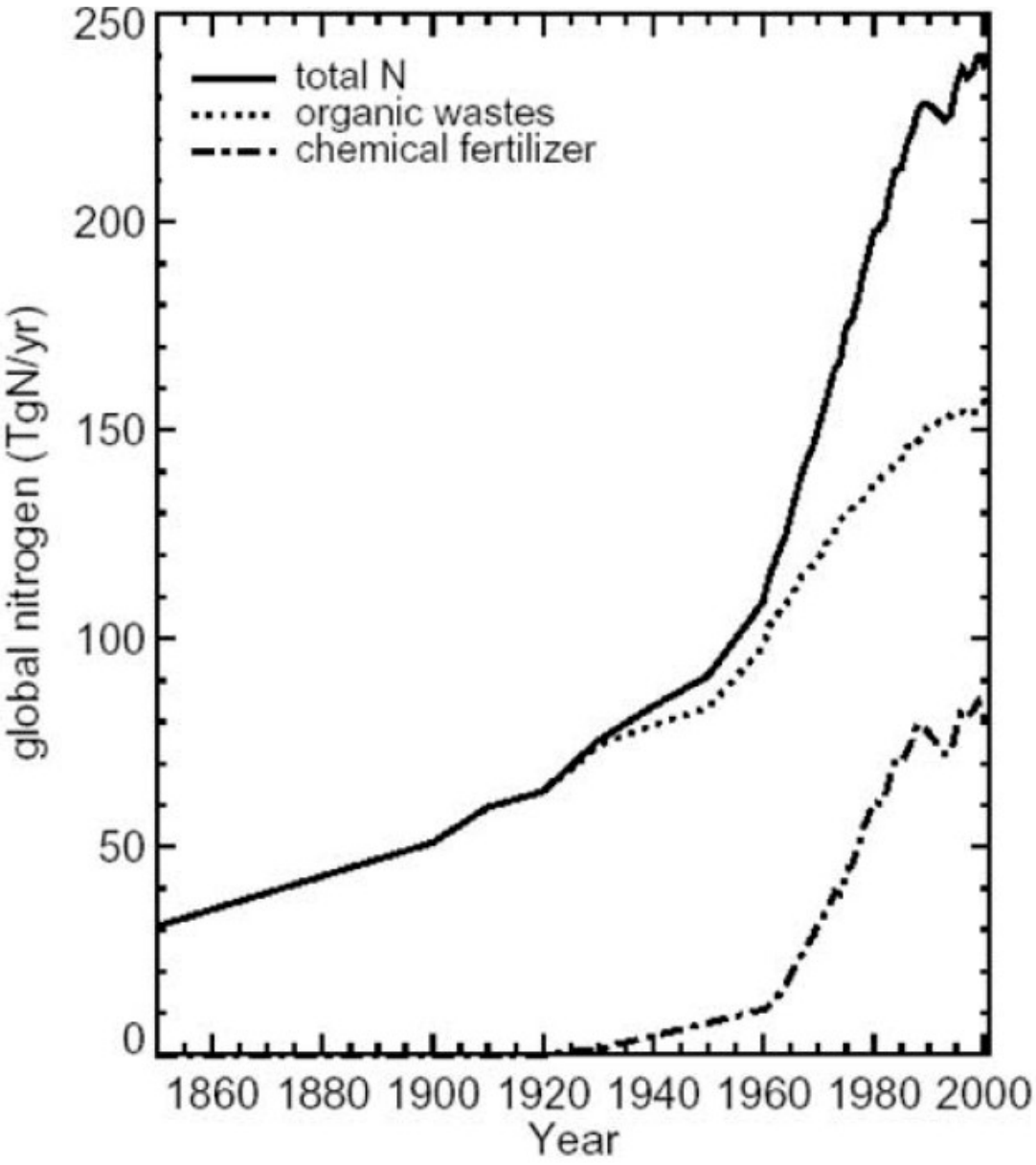
Total ~ 0.6 TgN/yr, 15% of global total



Source: McElroy and Wang, 2006

Agricultural sources are believed to dominate sources of anthropogenic N_2O and to account for ~25% of NO_x emissions…emerging in otherwise low-pollution areas.

Agricultural uses of N are growing rapidly, and agricultural sources of NO_x and N_2O will grow commensurately

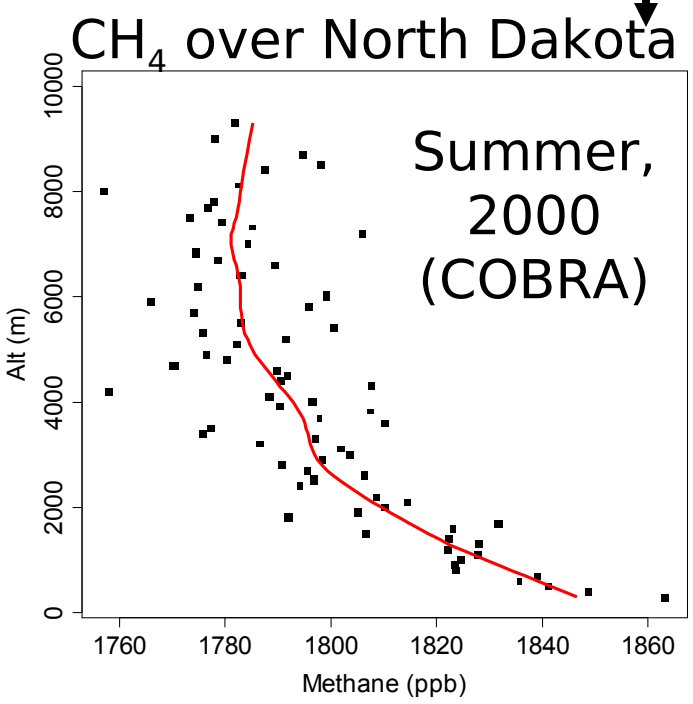


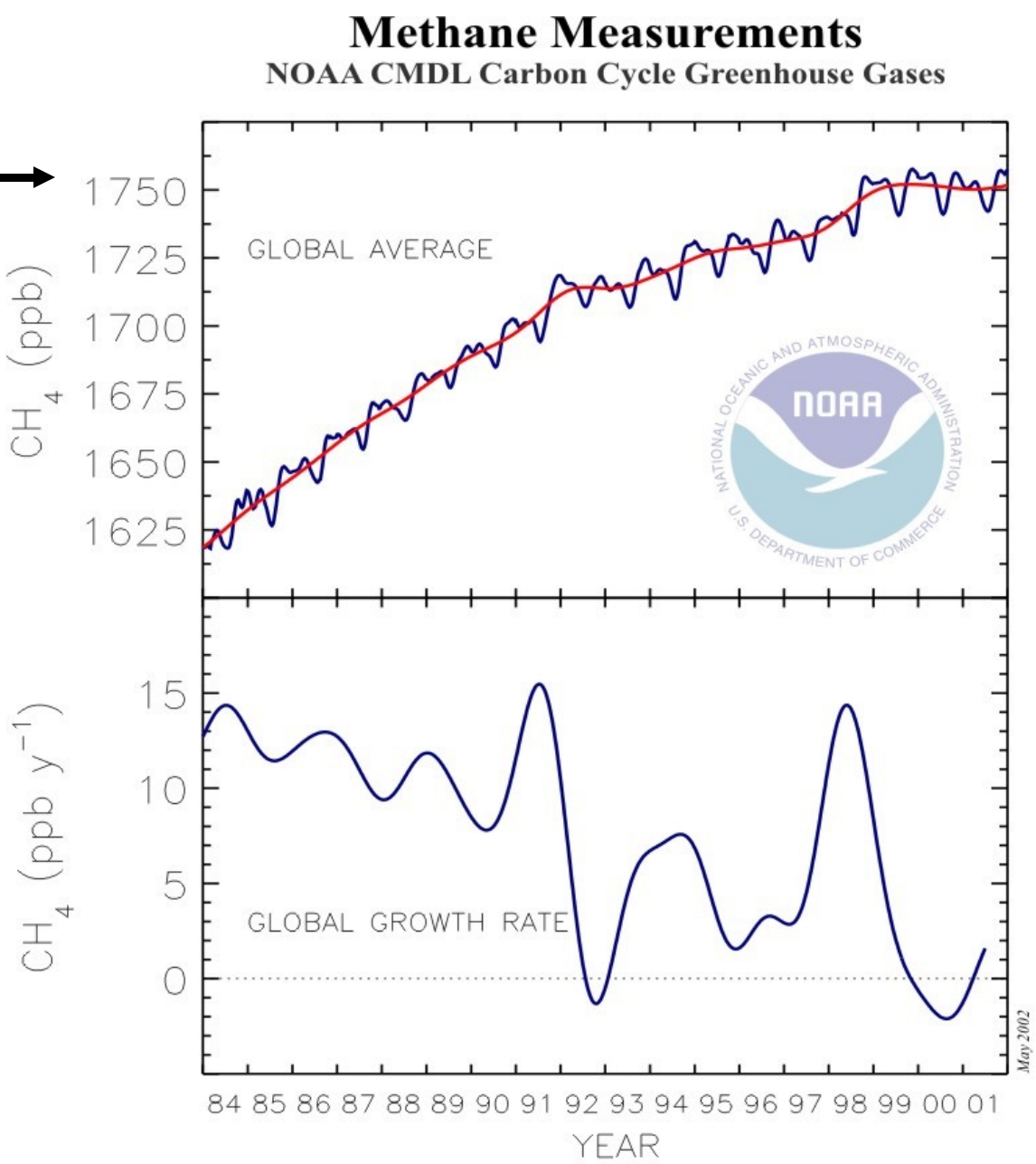
Source: McElroy and Wang, 2006

Growth of CH_4 slowed dramatically after 1991.

Will increases resume?

The vertical gradient over the Midwest is comparable to the gradient in the Amazon.

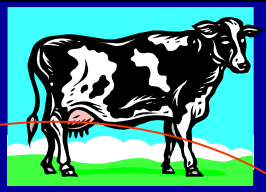


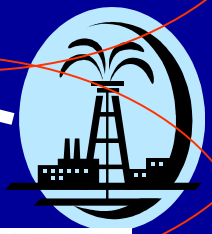


Top: Global average atmospheric methane mixing ratios (blue line) determined using measurements from the NOAA CMDL cooperative air sampling network. The red line represents the long-term trend. Bottom: Global average growth rate for methane. Principal investigator: Dr. Ed Dlugokencky, NOAA CMDL Carbon Cycle Greenhouse Gases, Boulder, Colorado, (303) 497-6228 (edlugokencky@cmdl.noaa.gov, http://www.cmdl.noaa.gov/ccgg).

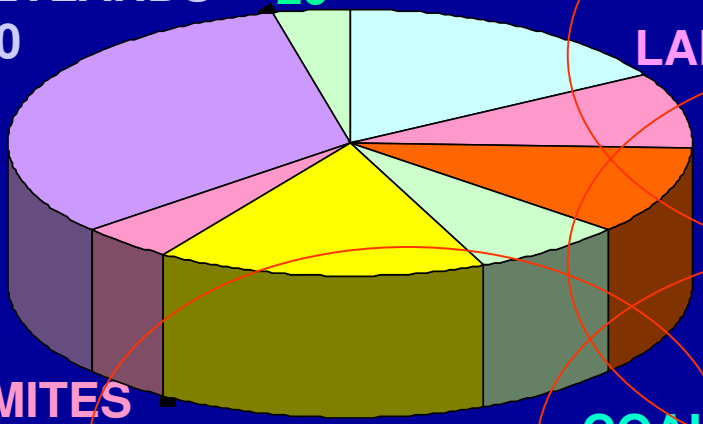
SOURCES OF ATMOSPHERIC METHANE

Diffuse human-caused sources account for 365 in a total of 550 (70%). Agriculture accounts for 175 (30%)





GLOBAL METHANE SOURCES (Tg CH_4 yr^{-1})



WETLANDS
180

BIOMASS BURNING
20

ANIMALS
90

LANDFILLS
50

GAS
60

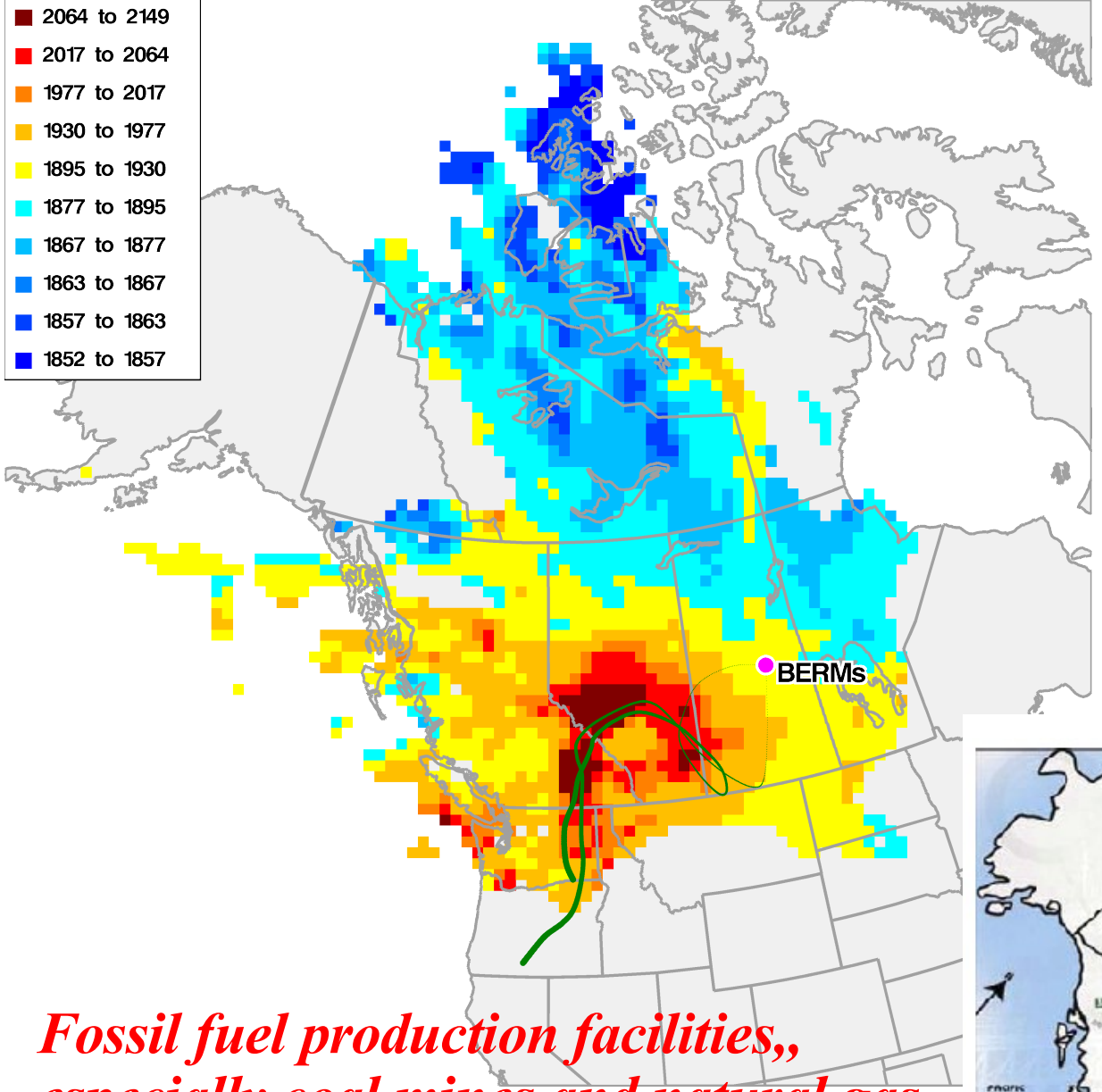
COAL
40

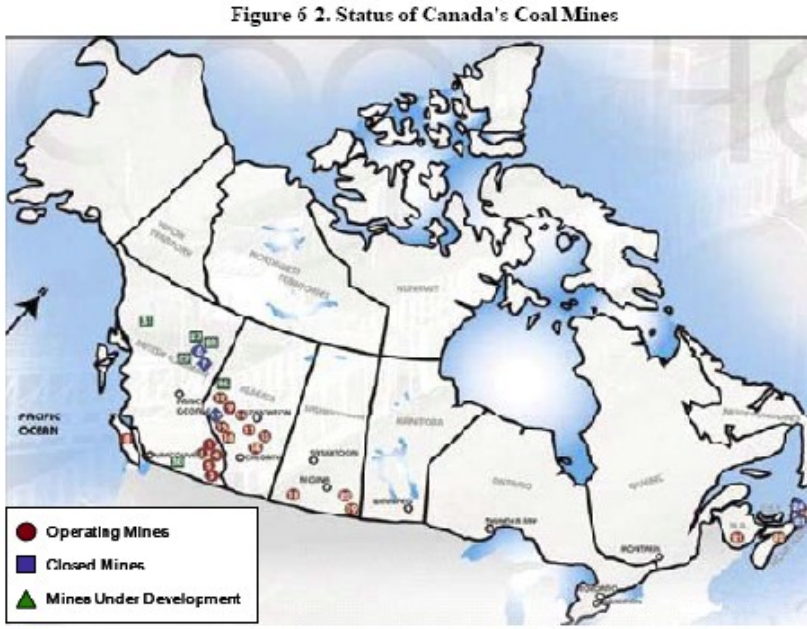
RICE
85

TERMITES
25

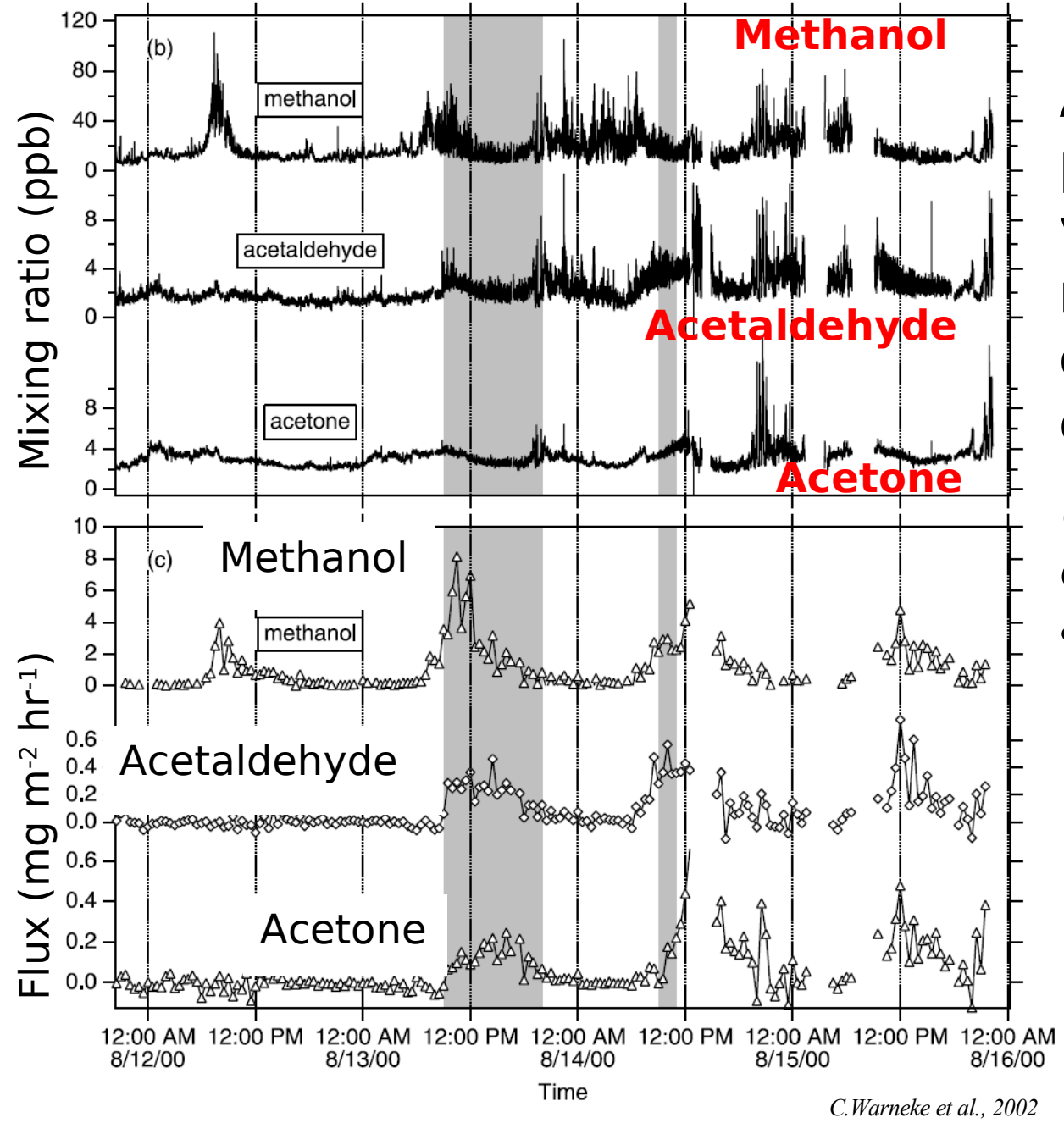
Boundary-layer CH_4 concentrations inferred from air data at monitoring stations in Canada

Slide courtesy D. Worthy, unpublished, 2007





Fossil fuel production facilities,, especially coal mines and natural gas wells, may play a much larger role for CH_4 than generally believed.



C.Warneke et al., 2002

Agriculture also produces a wide variety of highly reactive hydrocarbons, often in large quantities.

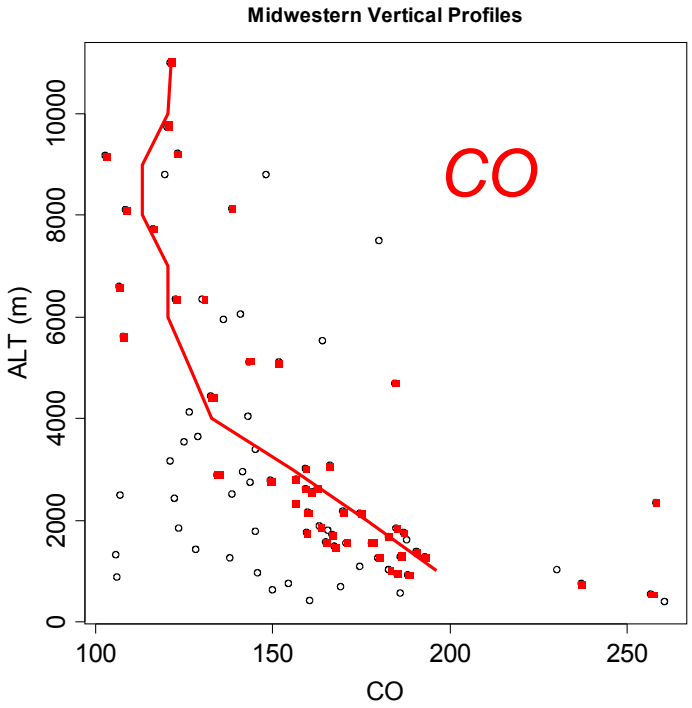
Concentrations and fluxes of oxygenated HCs over an alfalfa field in Colorado.

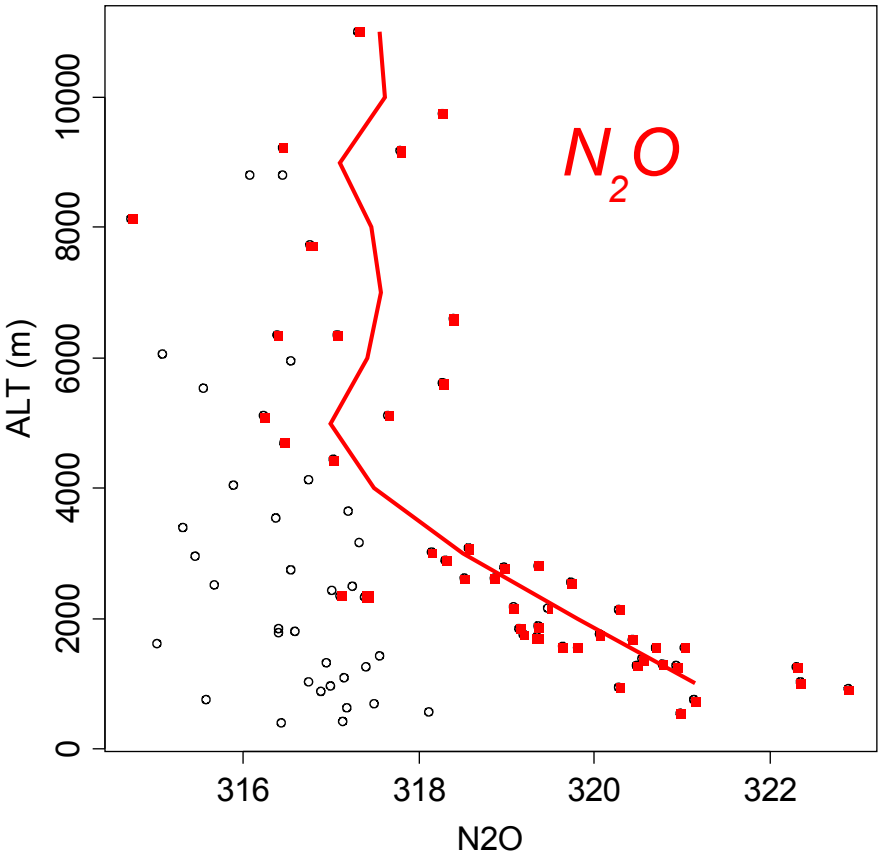
e 2. Results of the field experiment conducted near Fort Morgan, Colorado:
. (b) the volatile organic compound (VOC) mixing ratios determined from the grab samples, and (c) the eddy
fluxes of VOCs. The hatched areas indicate when the field was cut.

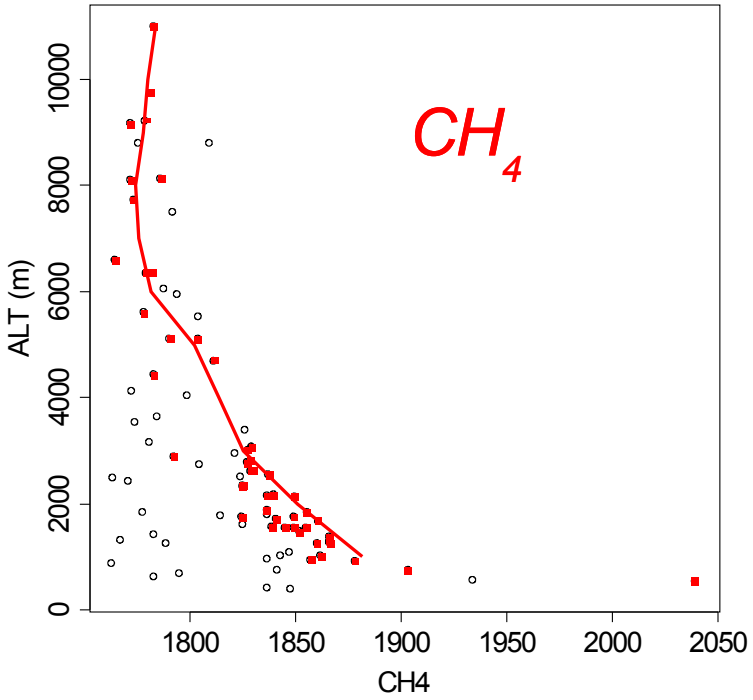
Can inputs of important species from the agricultural heartland be detected in the atmosphere?

COBRA-2003 surveyed the northern US and central Canada for CO_2 , CO, CH_4, CFCs, etc.

Map shows the first of two "racetrack" patterns flown over the US in 2003 using the UND-Citation II

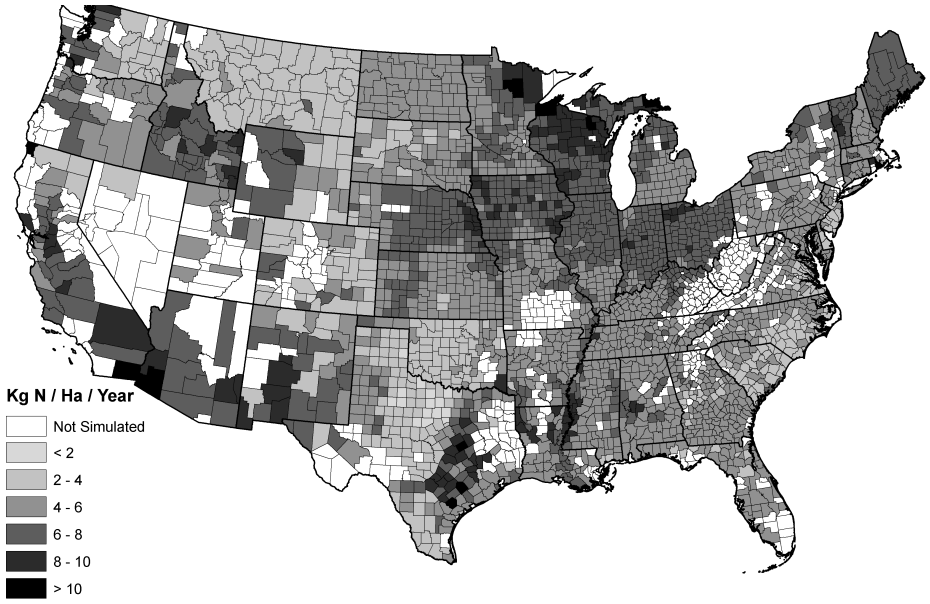




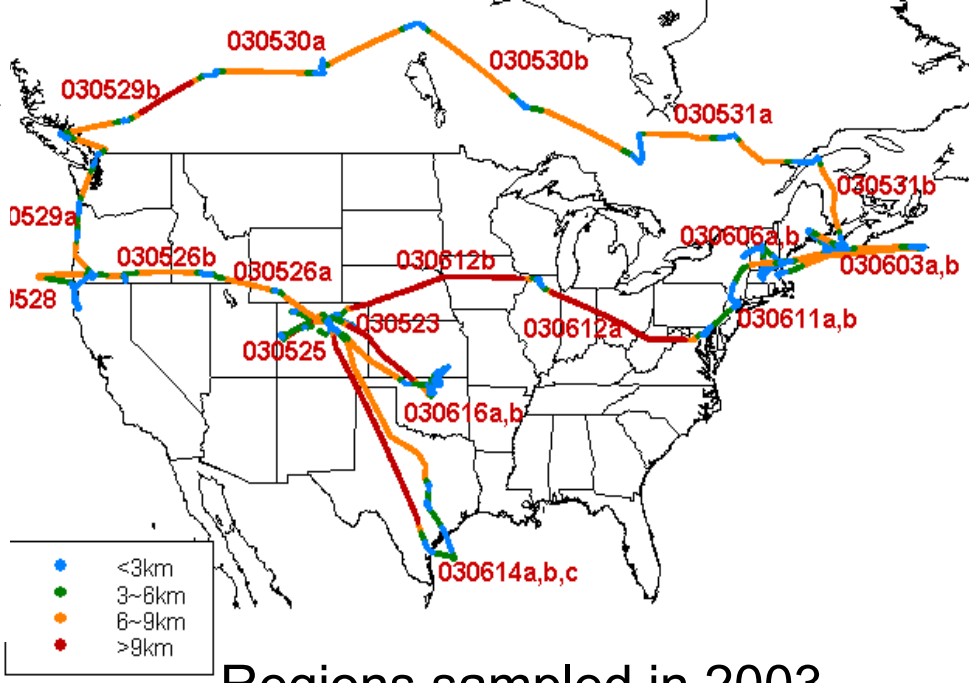


Vertical profiles of CO, CH_4, and N_2O in the midwest of the US in 2003 ("COBRA-2003").

Red points denote profiles with elevated N_2O in the PBL.

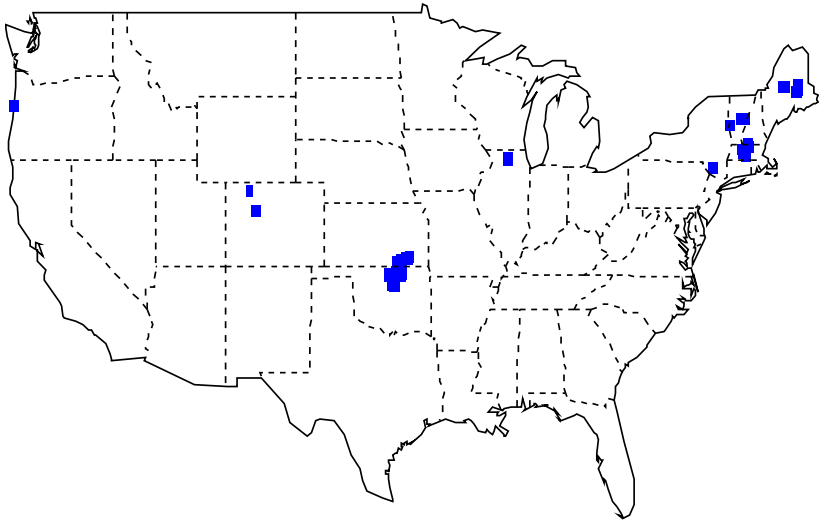


Regions with high agricultural fluxes of N_2O and NO_x



Regions sampled in 2003, "COBRA"

The sparse data from COBRA-2003 indicate that agricultural production of N2O and other gases leaves a strong imprint on the atmosphere.



Regions with High N_2O in the PBL in 2003

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Summary

- Important scientific, remote sensing, and societal issues attach to the sources of greenhouse gases and reactive species from industrialized agriculture.
- A typical complement of DC-8 sensors is ideal for studying this question (tracers, reactive species, NOx, HOx.), if possible complemented with small aircraft.
- AGGAE could piggyback on any, or many, DC-8 experiments by adding flights at the start or end of a mission, since the DC-8 is based in or near the area of interest.
- AGGAE would be an ideal complement to NASA studies in the NACP, and to OCO validation.