Nitrous oxide (N_2O) emissions estimated with the Carbon Tracker Lagrange North American regional inversion framework

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Nitrous Oxide (N_2O)

- Natural, long-lived GHG increasing at about 0.3%/yr in the atmosphere
- Responsible for 6% of anthropogenic radiative forcing (GWP ~ 300)
- Produced mainly by microbial cycling of nitrogen at Earth's surface and destroyed photochemically in the stratosphere

Motivations

1) Characterize North American N_2O emissions.

2) Examine role of agriculture.

Carbon Tracker Lagrange

Regional inverse modeling framework

- Jan-Dec 2012, 24-hour time step
- North America 1°x1° (10°-80°N, 170°-50°W)
- Ground and aircraft data from NOAA GGGRN (n =7,281)
- **H** matrix from STILT particle back trajectories

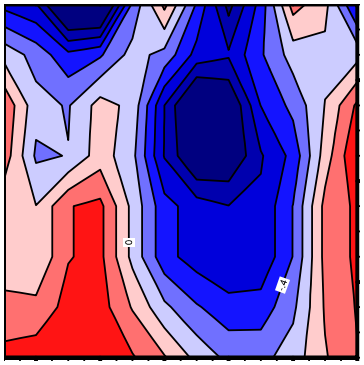
$$L_s = 0.5*(\mathbf{z}-\mathbf{Hs})^T \mathbf{R}^{-1}(\mathbf{z}-\mathbf{H}s) + 0.5(\mathbf{s}-\mathbf{s_p})^T \mathbf{Q}^{-1}(\mathbf{s}-\mathbf{s_p})$$

$\mathbf{s_p}$ = prior fluxes. Solve for optimal flux vector **s**
z = vector of **observations – background**

NOAA Empirical Background Product

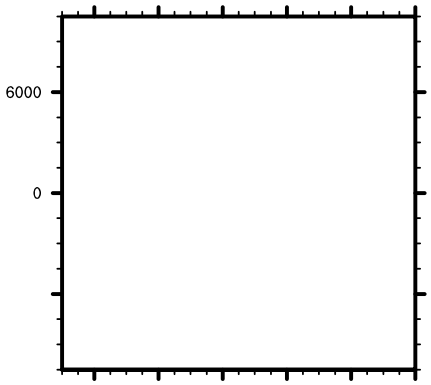
(Arlyn Andrews et al.)

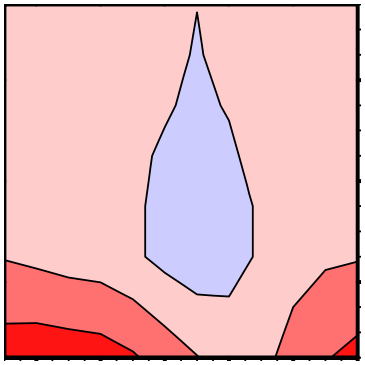
75°-85°N



65°-75°N

55°-65°N





45°-55°N

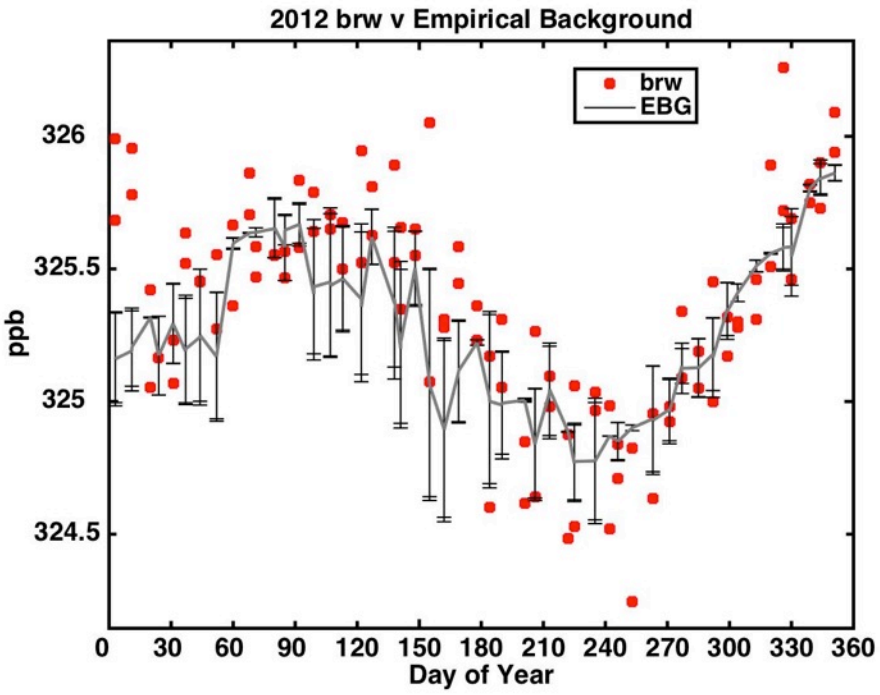
35°-45°N

25°-35°N

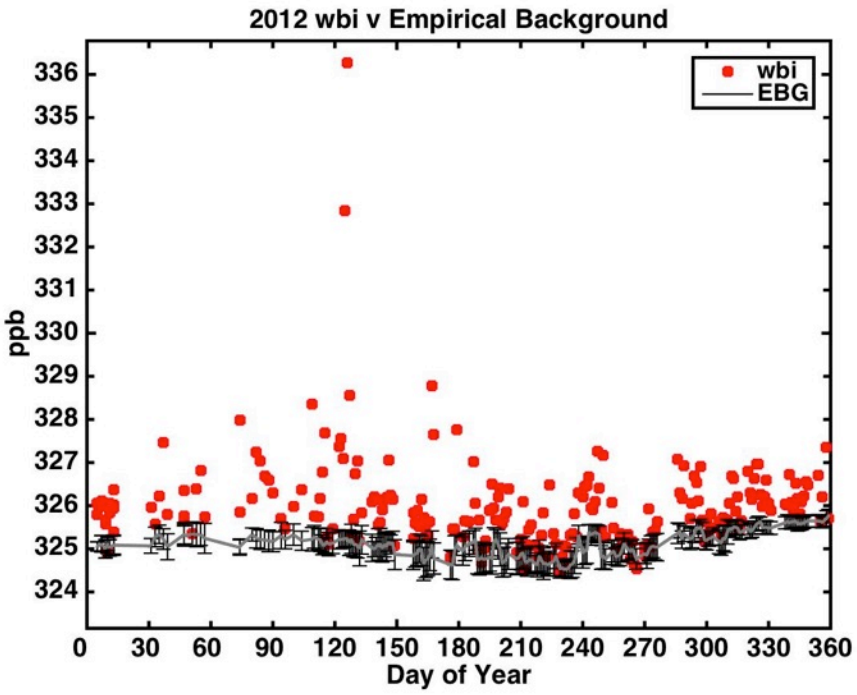
Anomalies after subtracting MLO data

NOAA data compared to Empirical Background

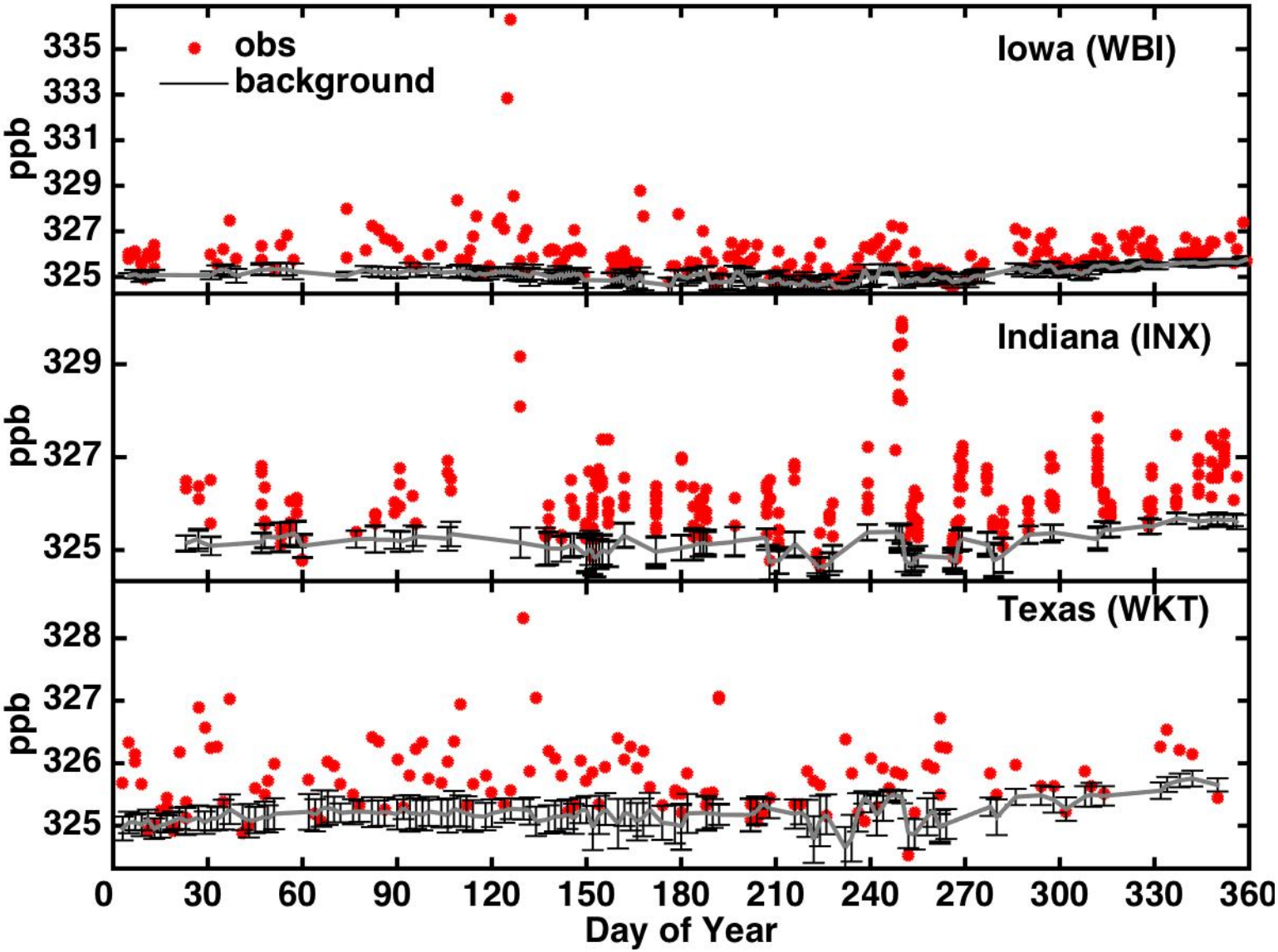
Alaska



Iowa

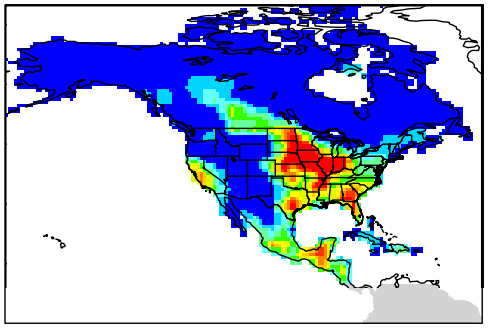


Large Excursions above Background



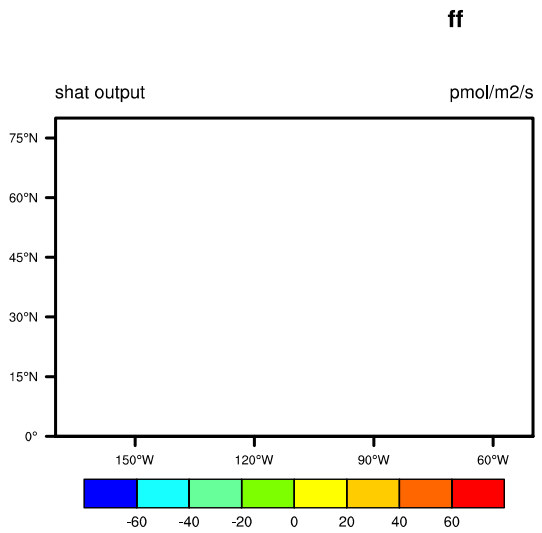
Posterior Annual Mean Results: 3 different priors

Saikawa Global Inversion

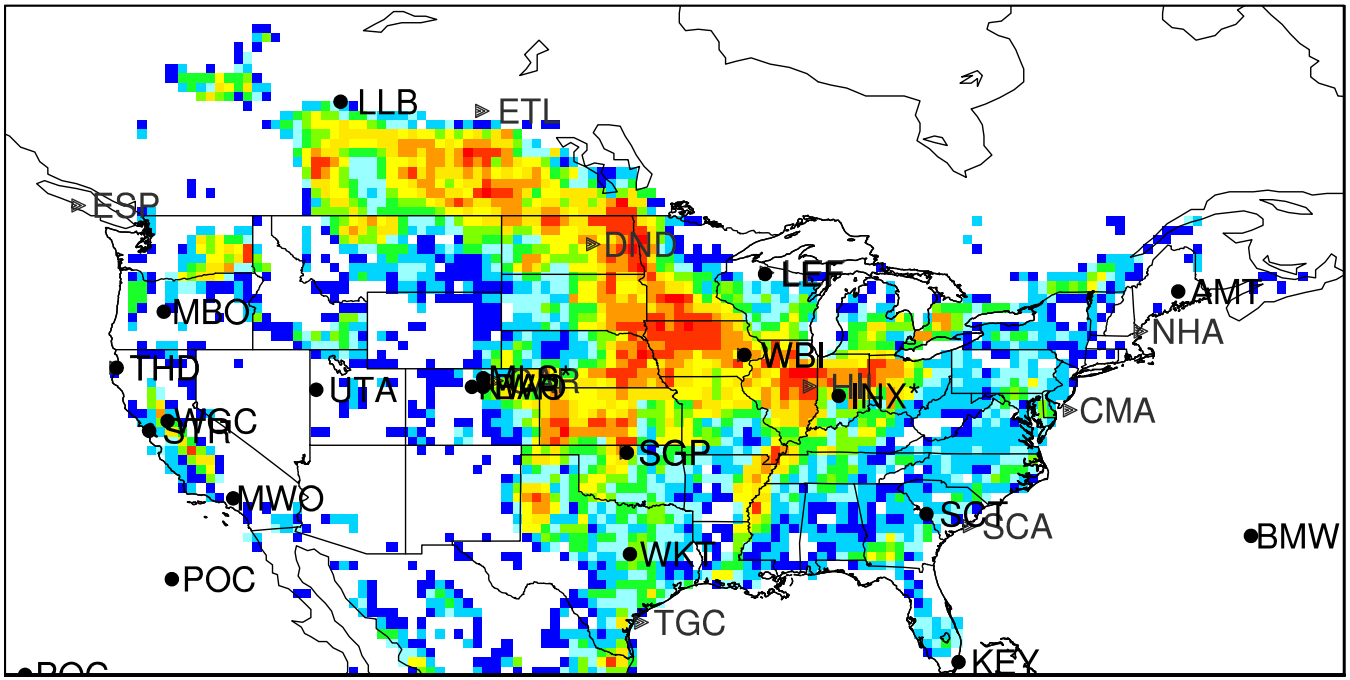


10% of N Fertilizer

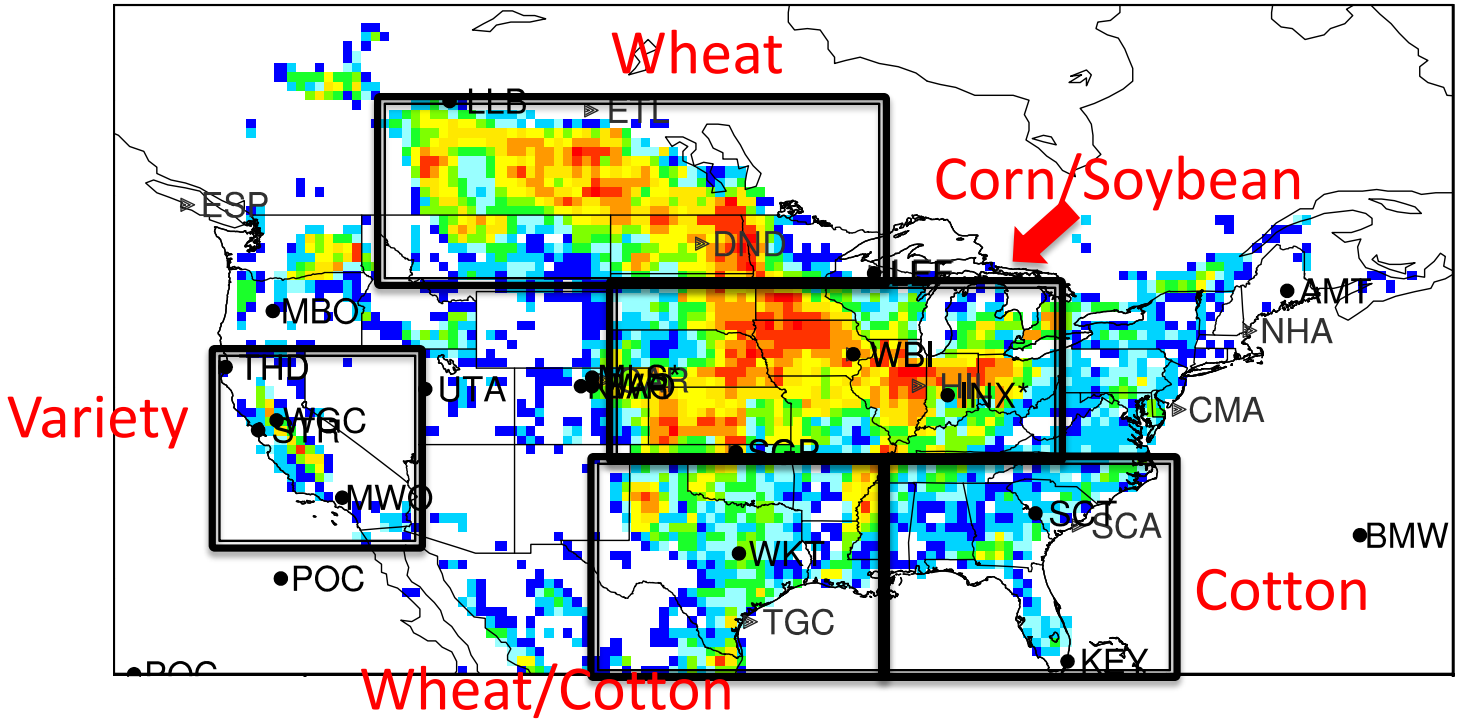
Flat Prior



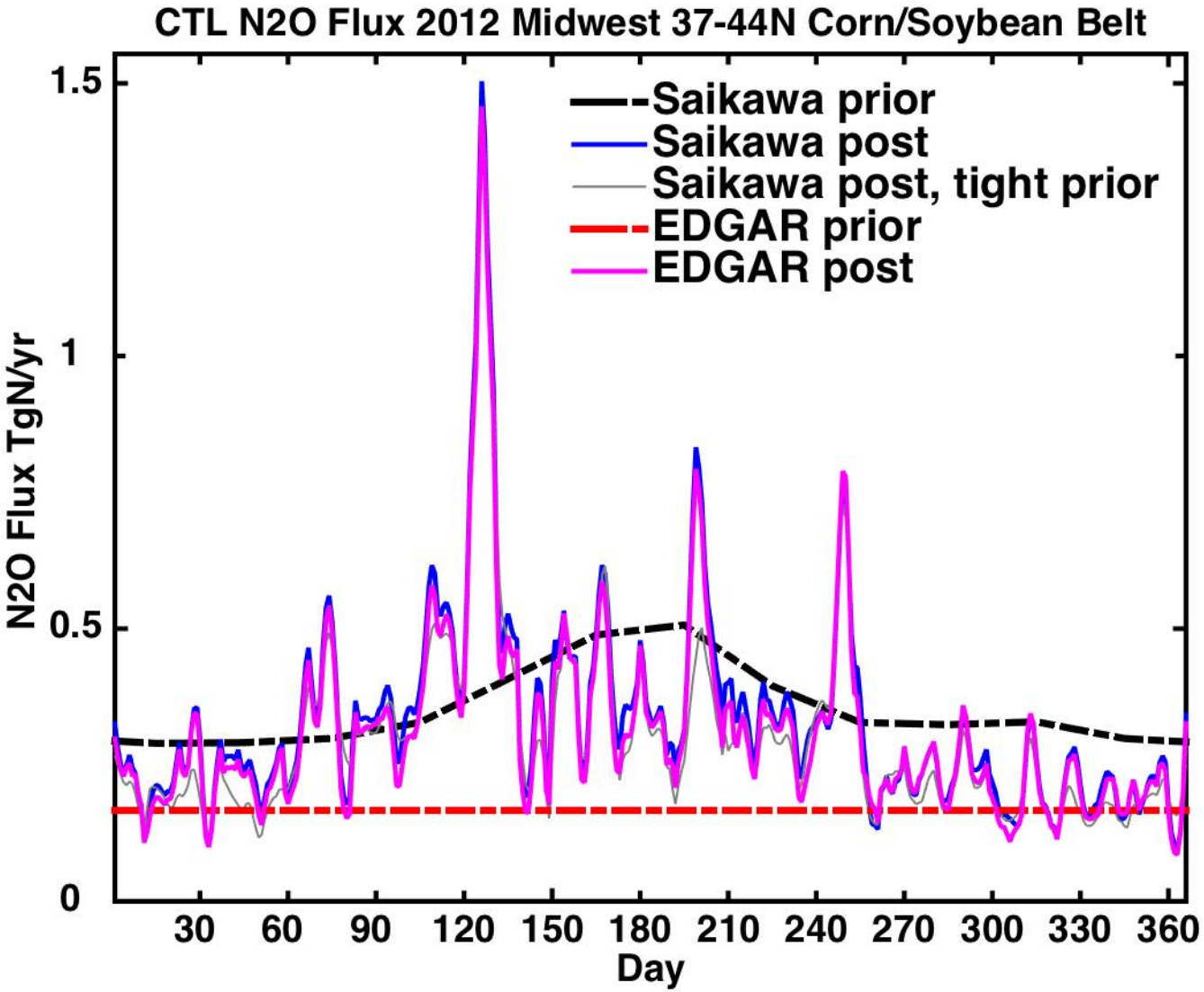
Crop Area


LLB
ETL
ESP
DND
LEF
AMT
MBO
NHA
THD
WBI
UTA
INX*
CMA
SGP
MWO
SCT
SCA
BMW
WKL
POC
TGC
KEY

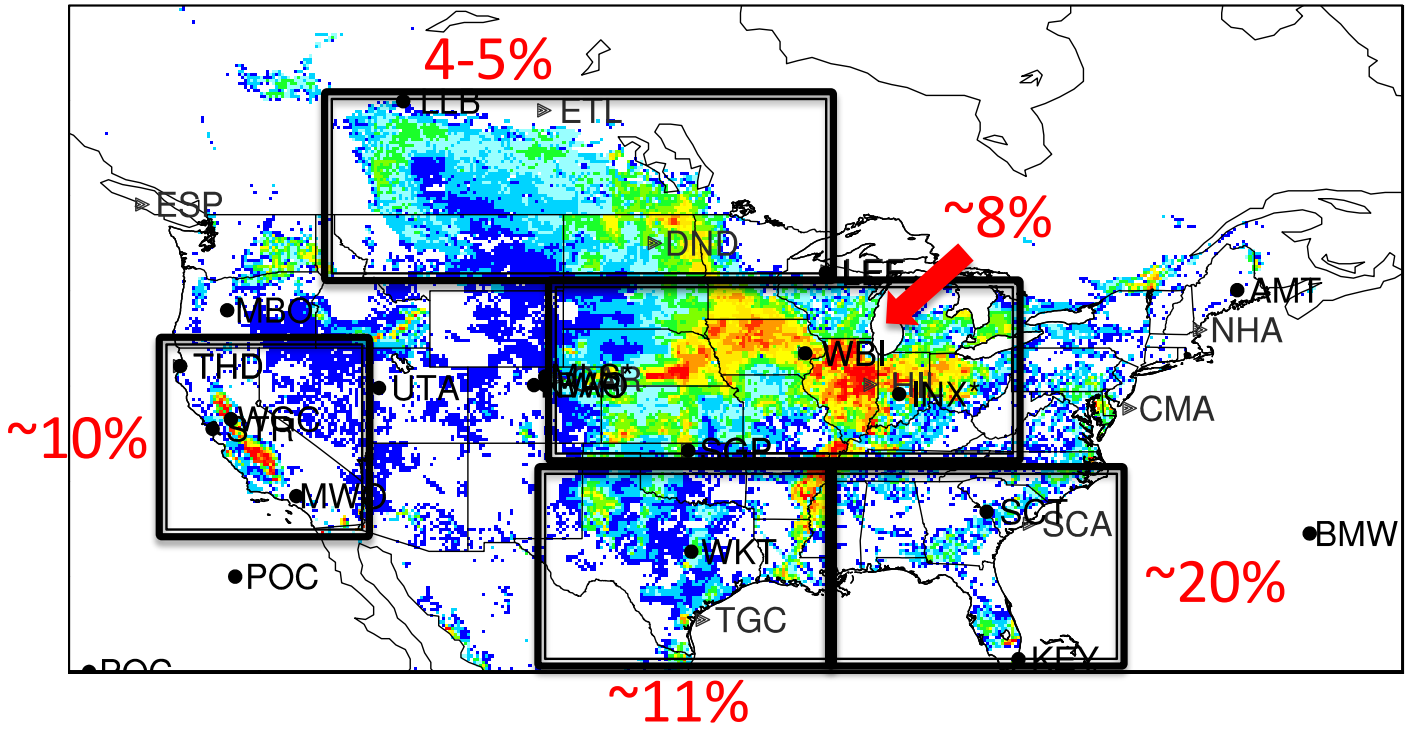
Crop Area


Wheat
Corn/Soybean
Variety
Cotton
Wheat/Cotton
LLB
ETL
ESP
DND
MBO
AMT
NHA
THD
UTA
WBI
INX
CMA
SYR
MWO
SCT
SCA
BMW
WKT
POC
TGC
KFY

Maximum N_2O Flux in Springtime

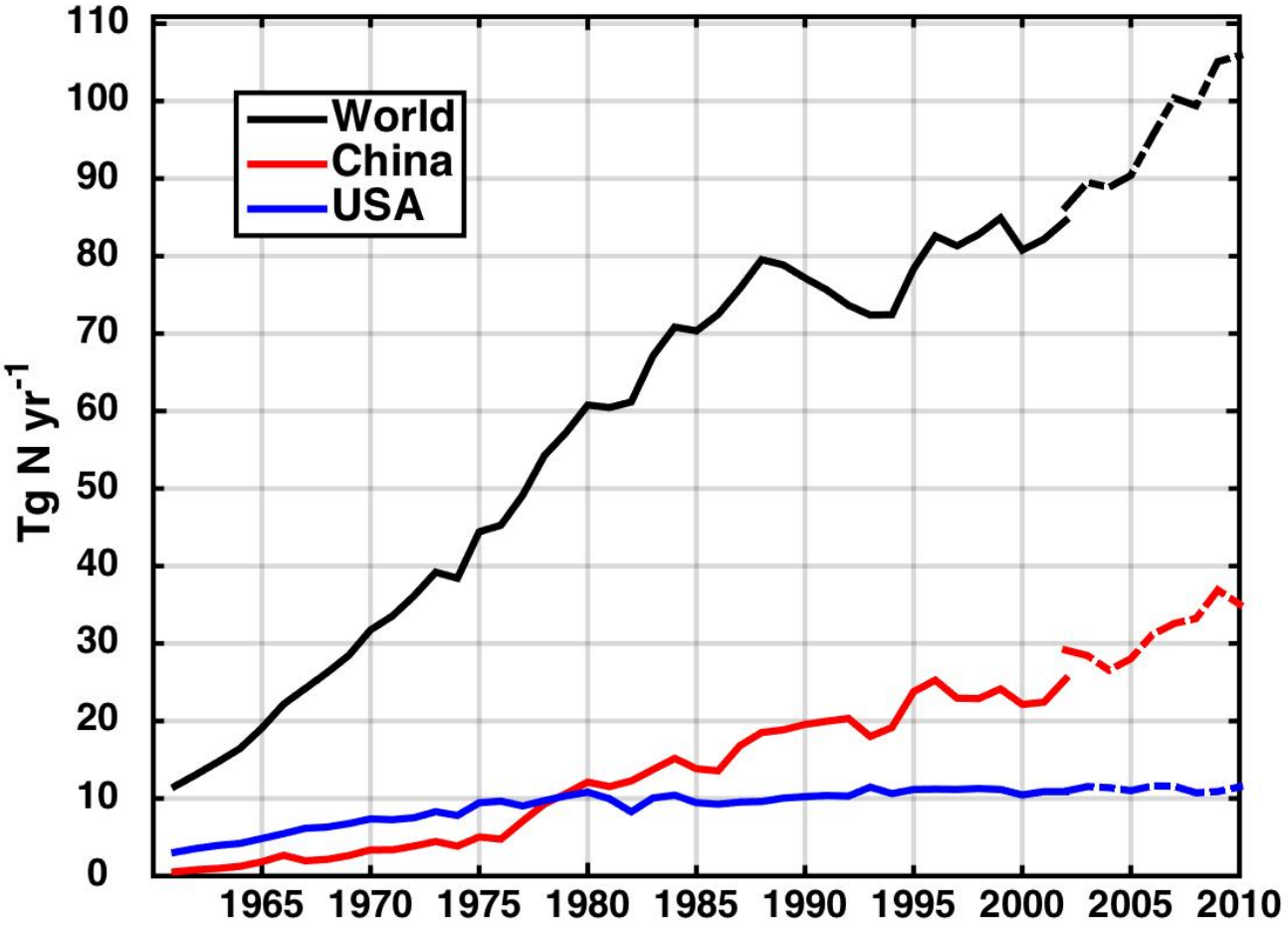


If N_2O all came from N Fertilizer, what would the emission fraction be?



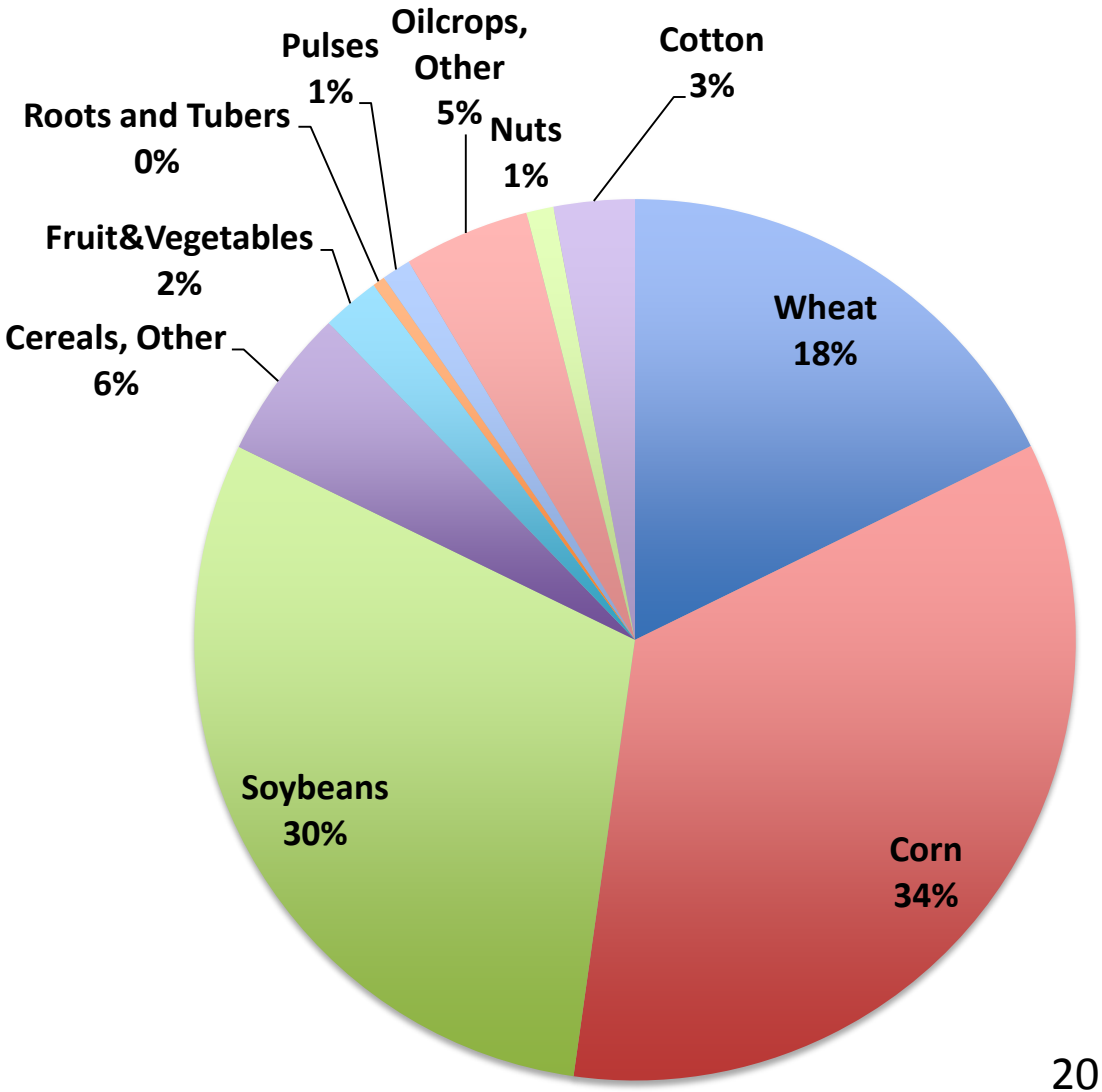
Fertilizer Map from University of Wisconsin

N Fertilizer Consumption



Data from FAOSTAT

United States Crop Area

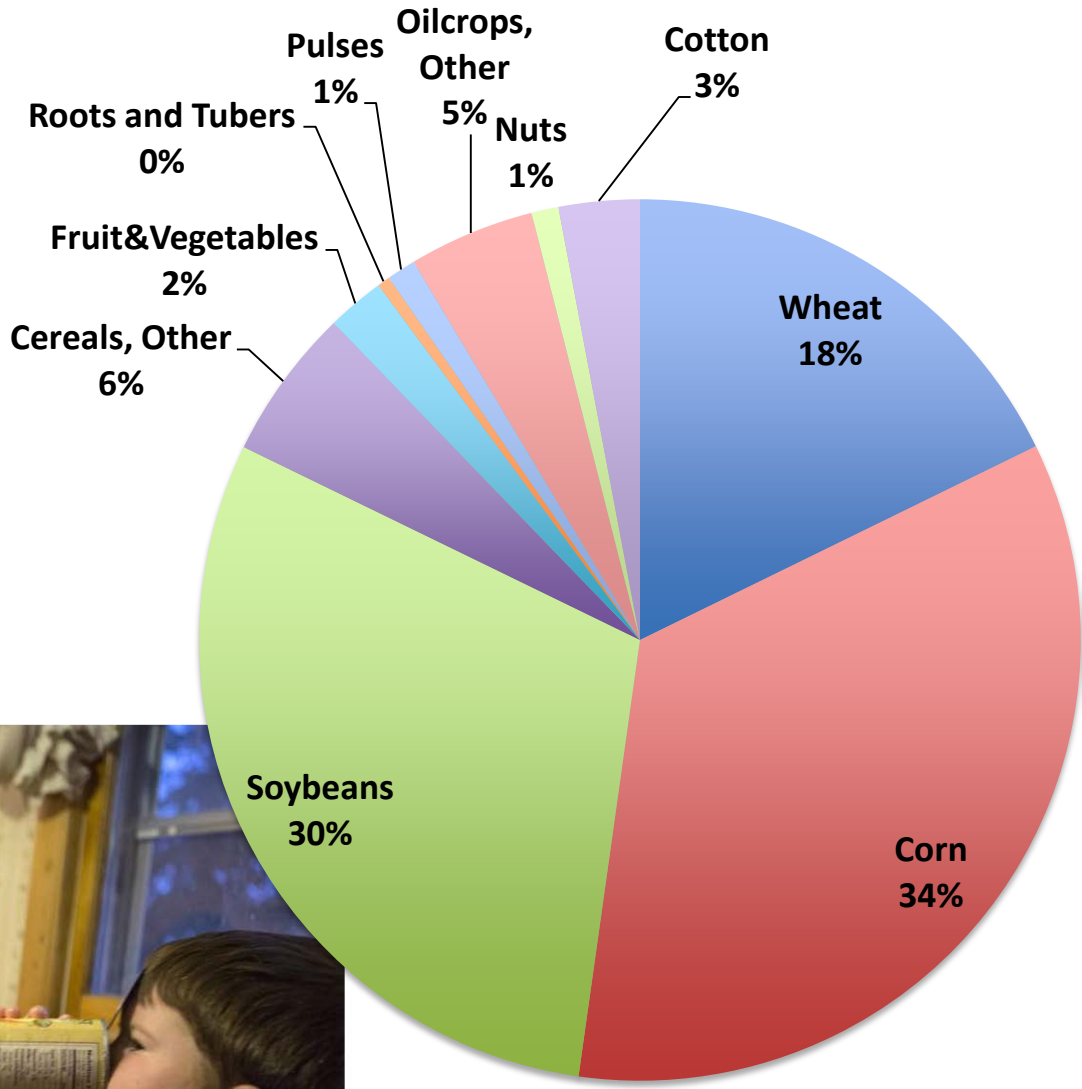


2013 data from FAOSTAT

The New Face of Hunger

National Geographic, Aug 2014

"It is a cruel irony that people in rural Iowa can be malnourished amid forests of cornstalks running to the horizon. Iowa dirt is some of the richest in the nation …"



Conclusions

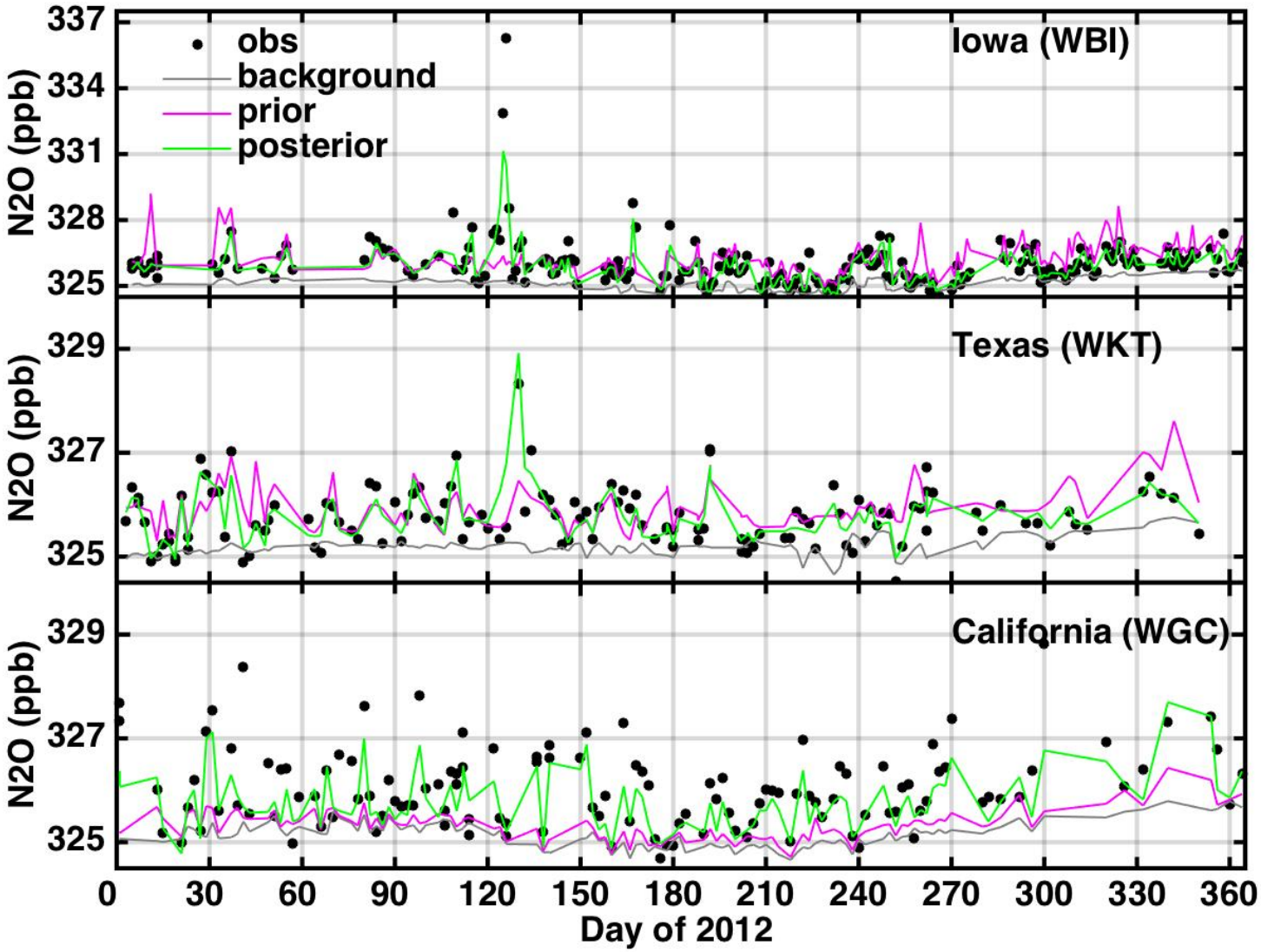
1. North American N_2O emissions, according to CTL inversion, are 1.4 ± 0.3 Tg N/yr.

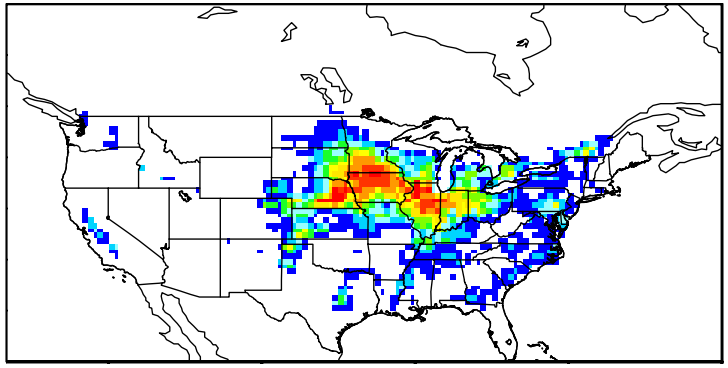
2. More than half of these emissions come from the Central U.S. (105°-80°W), with about 0.35 ± 0.03 Tg N/yr from the corn/soybean belt.

Anthropogenic N_2O source is relatively well constrained by observed growth rate and the known stratospheric sink

	Global Anthropogenic N_2O source Tg N/yr
Box Model (top-down)	~ 6
EDGAR (bottom up inventory)	7

Prior vs. posterior fit to observations at individual sites





Percent of land area in crop

Percent

60°N
55°N
50°N
45°N
40°N
35°N
30°N
25°N

W
105°W
90°W
75°W
60°W

5
10
15
20
25
30
35
40
45