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

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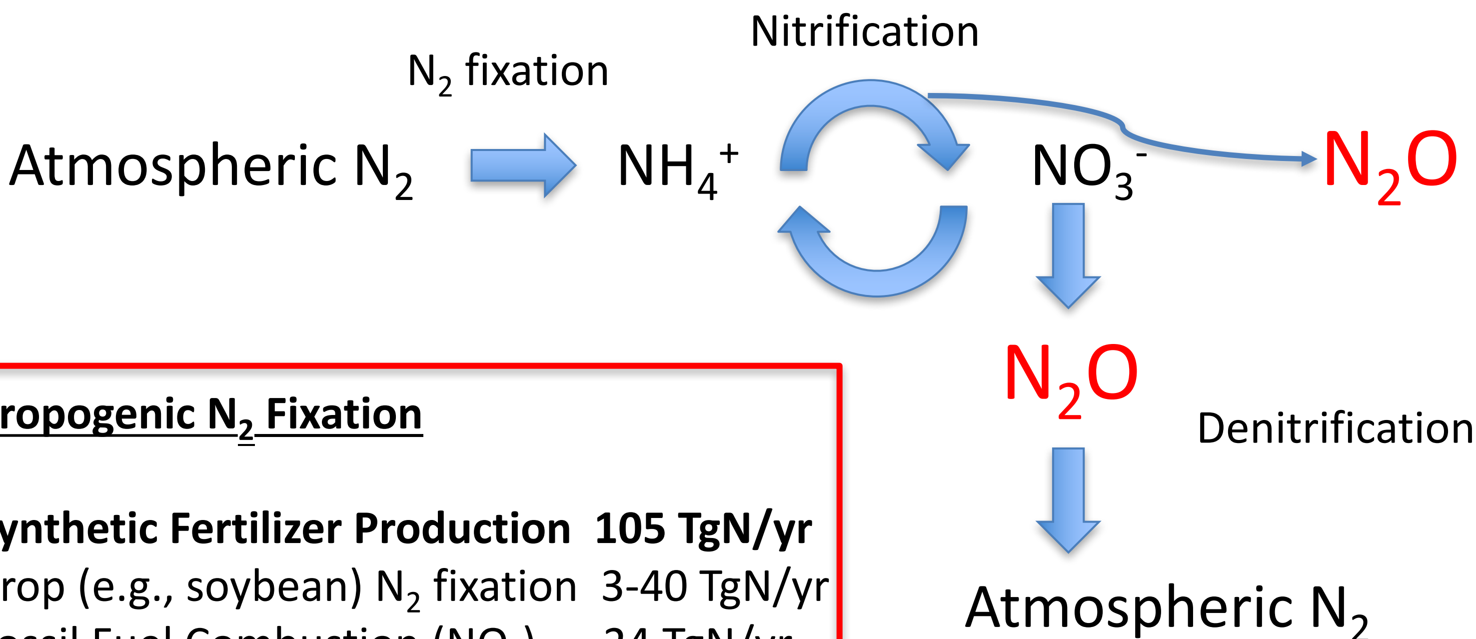
Nitrous Oxide (N_2O)

Natural, long-lived GHG produced mainly by microbes, responsible for 6% of anthropogenic greenhouse forcing.



<u>Anthropogenic N_2 Fixation</u>

1. **Synthetic Fertilizer Production 105 TgN/yr**
2. Crop (e.g., soybean) N_2 fixation 3-40 TgN/yr
3. Fossil Fuel Combustion (NO_x) 24 TgN/yr

Carbon vs. N_2O Tradeoffs

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Offsetting the radiative benefit of ocean iron fertilization by enhancing N_2O emissions

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[1] Ocean iron fertilization is being considered as a strategy for mitigating the buildup of anthropogenic CO_2 in the atmosphere. Assessment of this strategy requires

1991]. One pathway is linked to the oxidation of ammonium to nitrate (nitrification), where it appears that about 1 ammonium molecule in 1000 is converted to N_2O [*Cohen and*

Carbon benefits of anthropogenic reactive nitrogen offset by nitrous oxide emissions

Sönke Zaehle[1]*, Philippe Ciais[2], Andrew D. Friend[3] and Vincent Prieur[2]

Additions of reactive nitrogen to terrestrial ecosystems—primarily through fertilizer application and atmospheric deposition—have more than doubled since 1860 owing to

We perform a set of model simulations aimed at isolating global and regional effects of anthropogenic Nr addition due to fertilizer applications and atmospheric deposition from those due

N_2O release from agro-biofuel production negates global warming reduction by replacing fossil fuels

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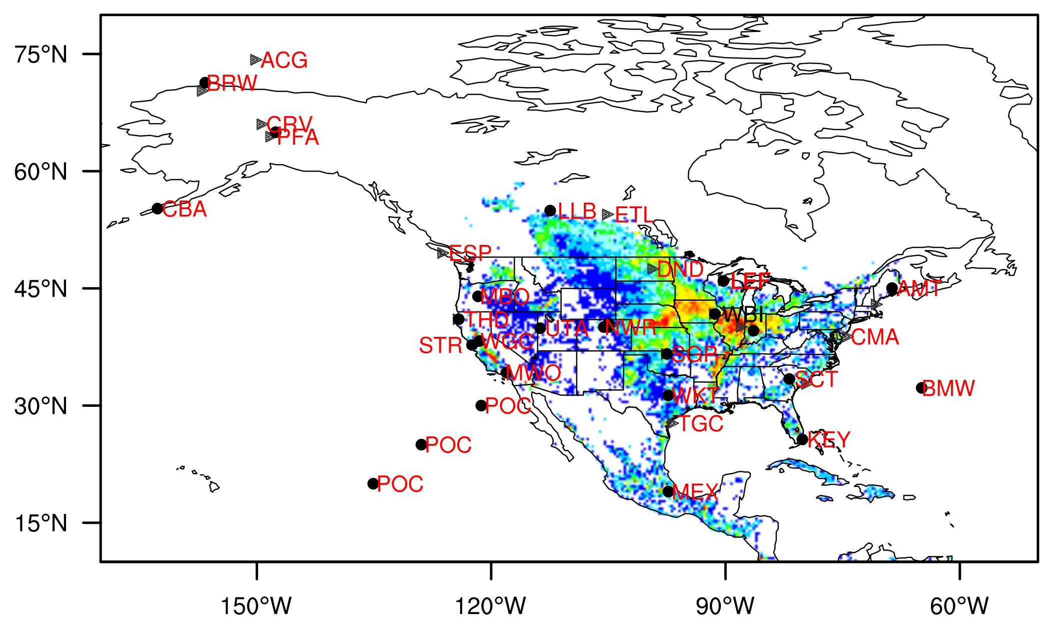
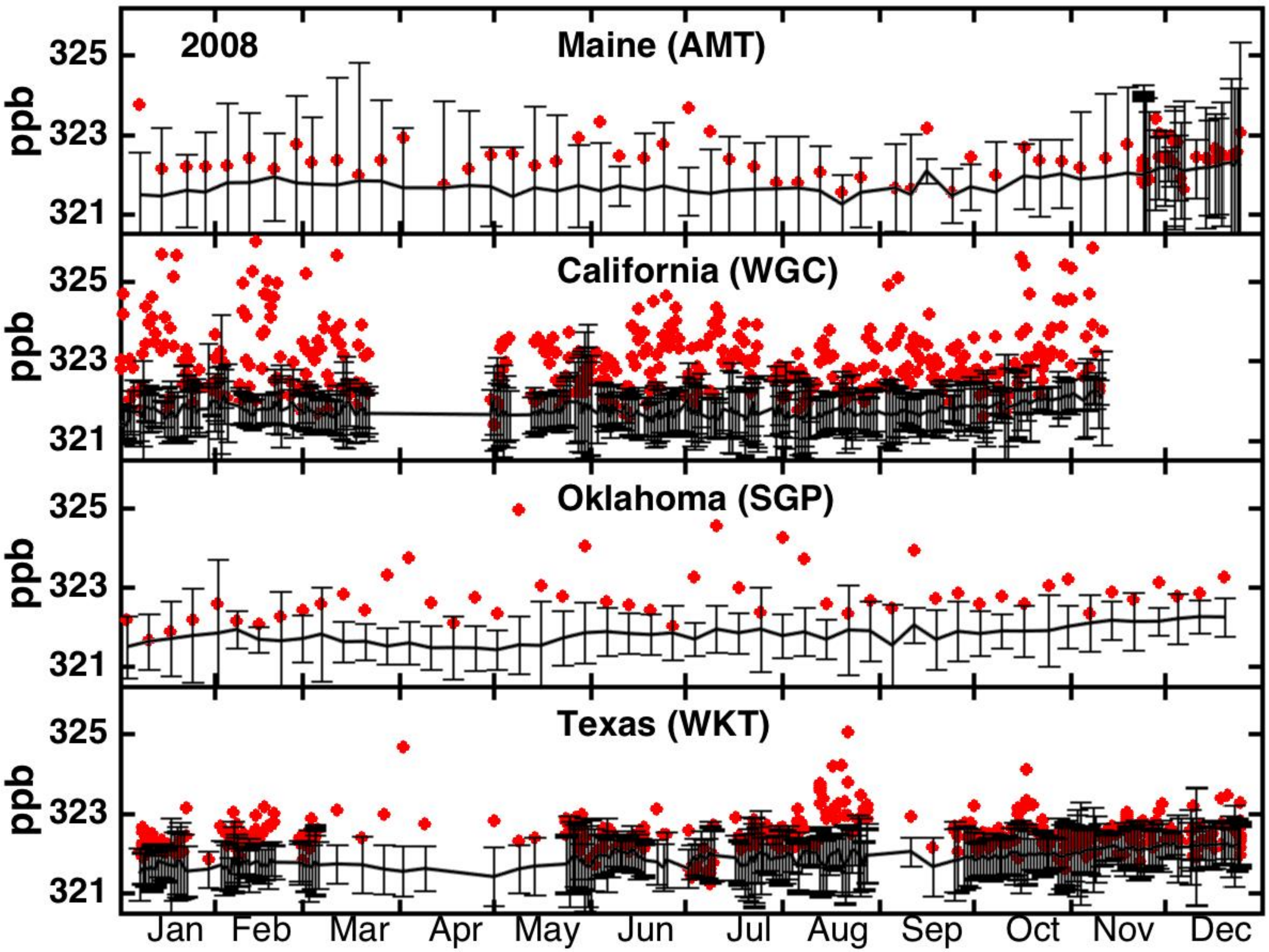
Carbon Tracker Lagrange
Regional inverse modeling framework

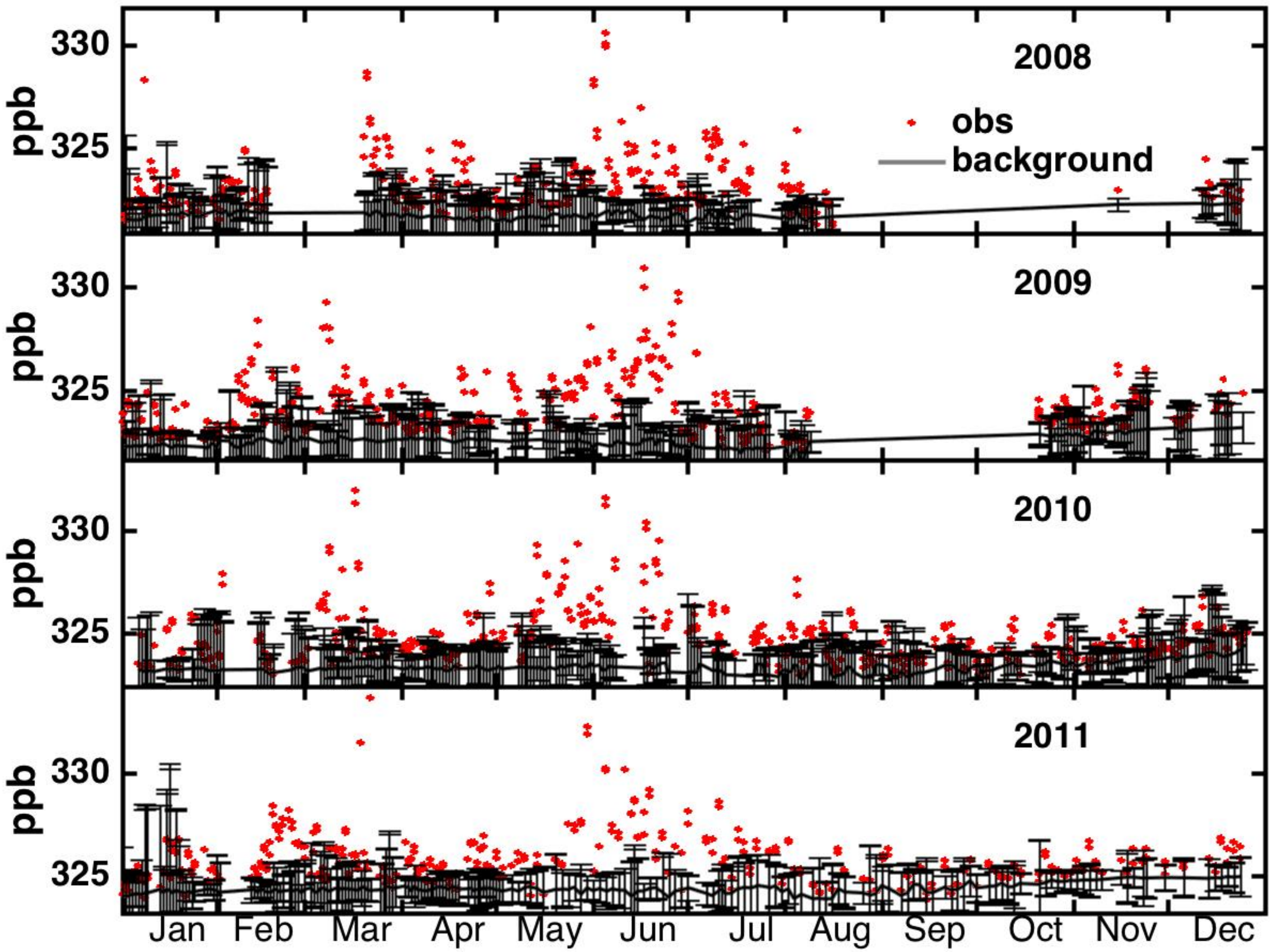
- Jan 2007-Aug 2014, daily time step,
- North America 1°x1° spatial resolution
- **H** matrix from STILT particle back trajectories
- Solve $L_s = 0.5*(\mathbf{z}-\mathbf{Hs})^T \mathbf{R}^{-1}(\mathbf{z}-\mathbf{H}s) + 0.5(\mathbf{s}-\mathbf{s_p})^T \mathbf{Q}^{-1}(\mathbf{s}-\mathbf{s_p})$
- Ground and aircraft data from NOAA GGGRN



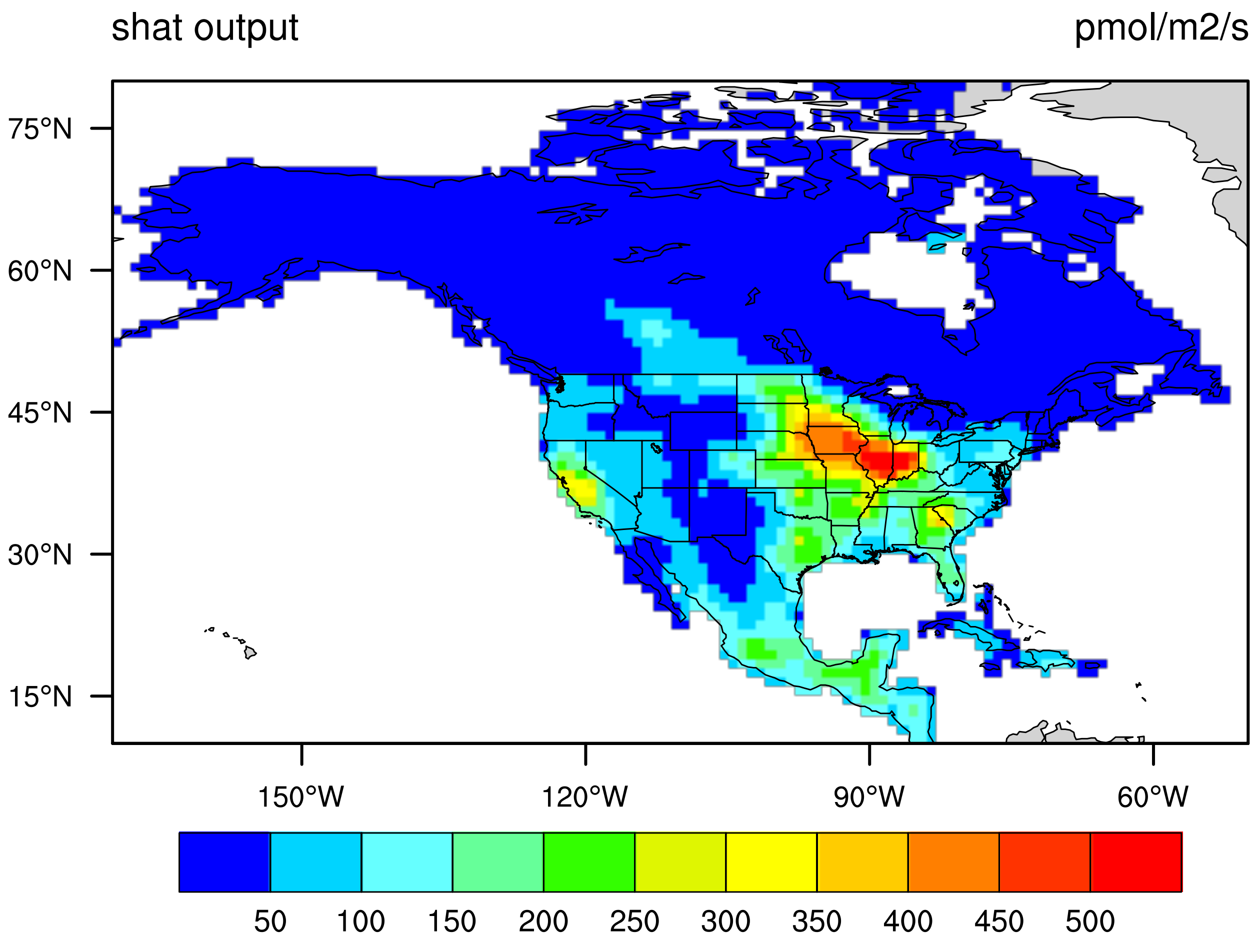
NOAA data compared to Empirical Background



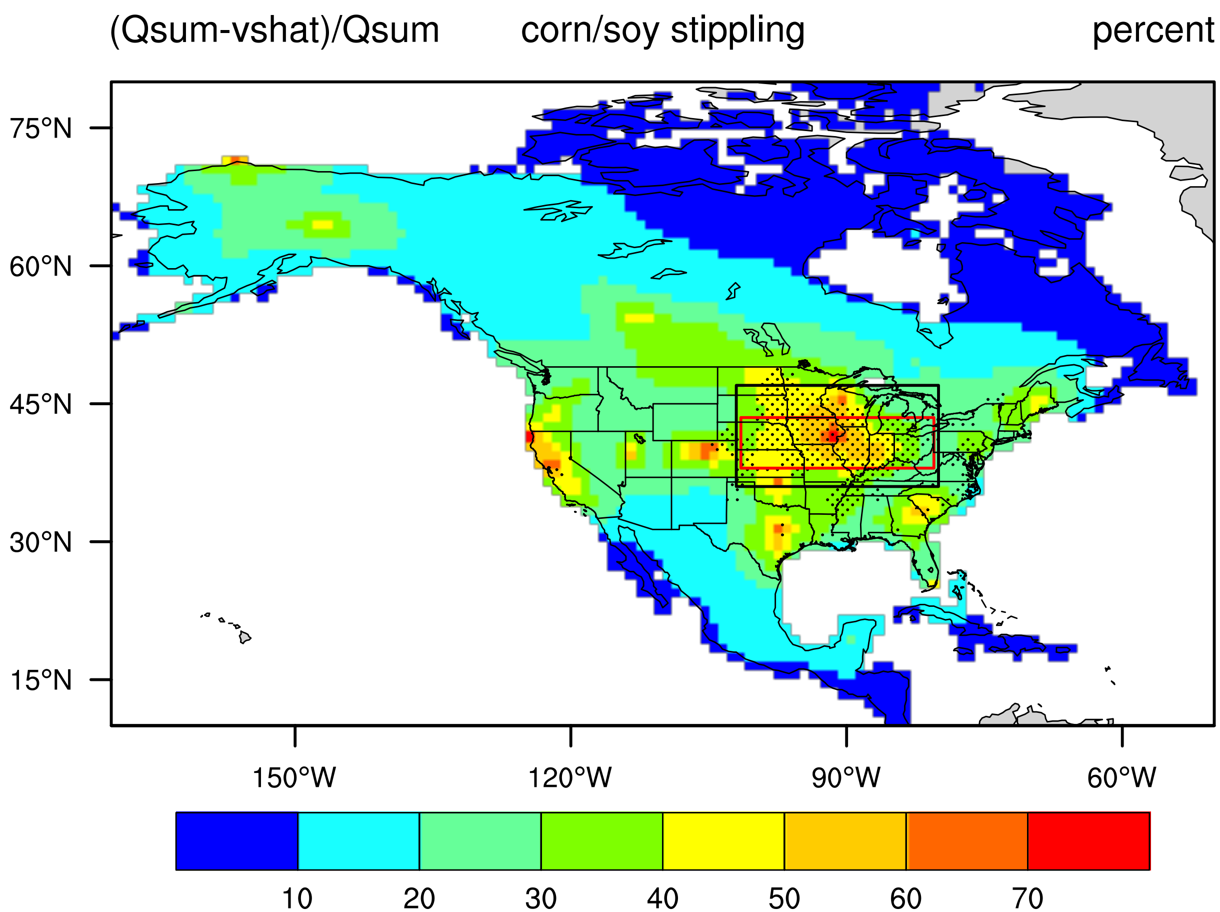
Dual spring maxima in excursions above background at WBI (Iowa)



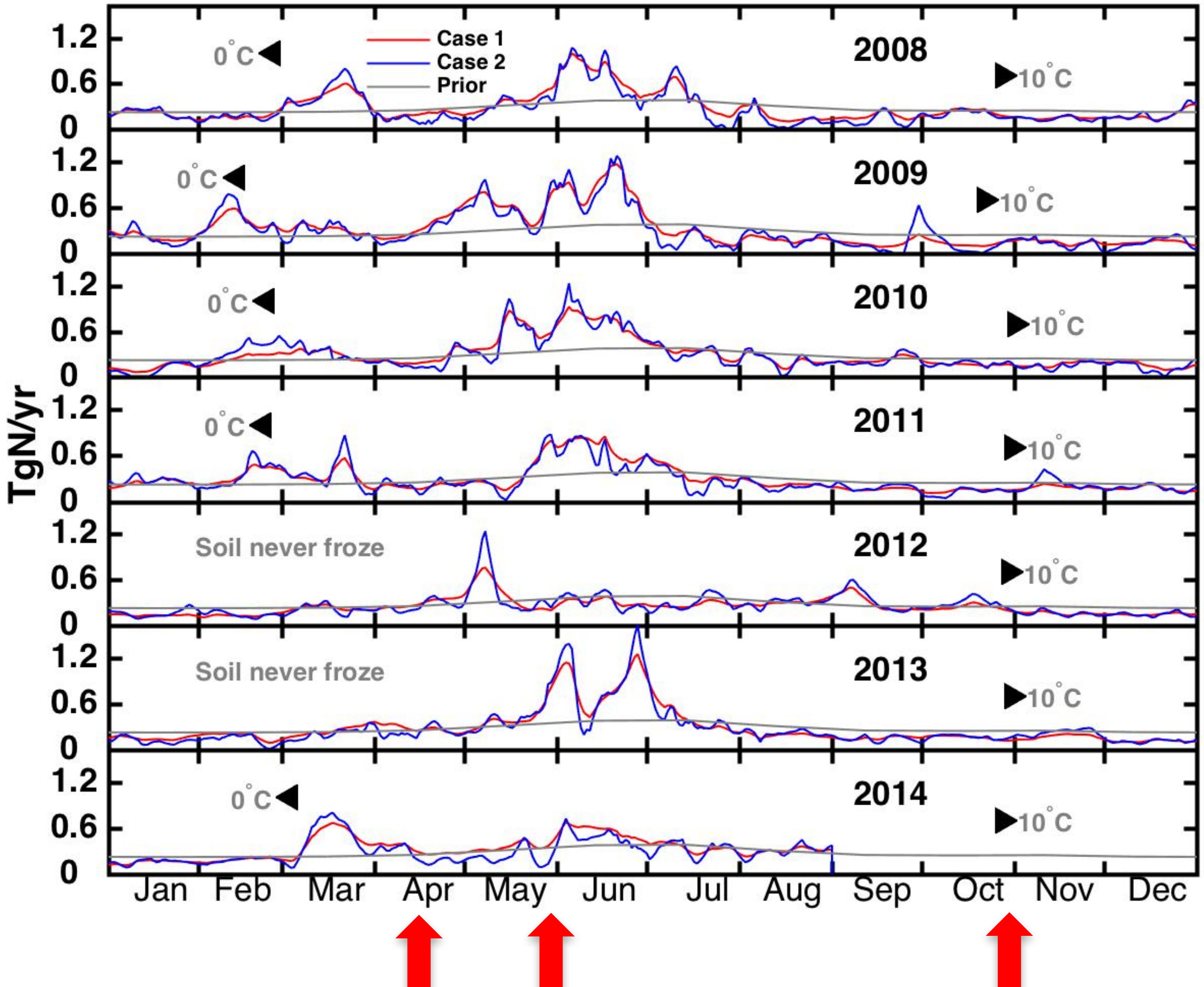
Annual Mean Posterior Flux (2008-2013)



Uncertainty reduction greatest in Midwestern corn/soybean belt



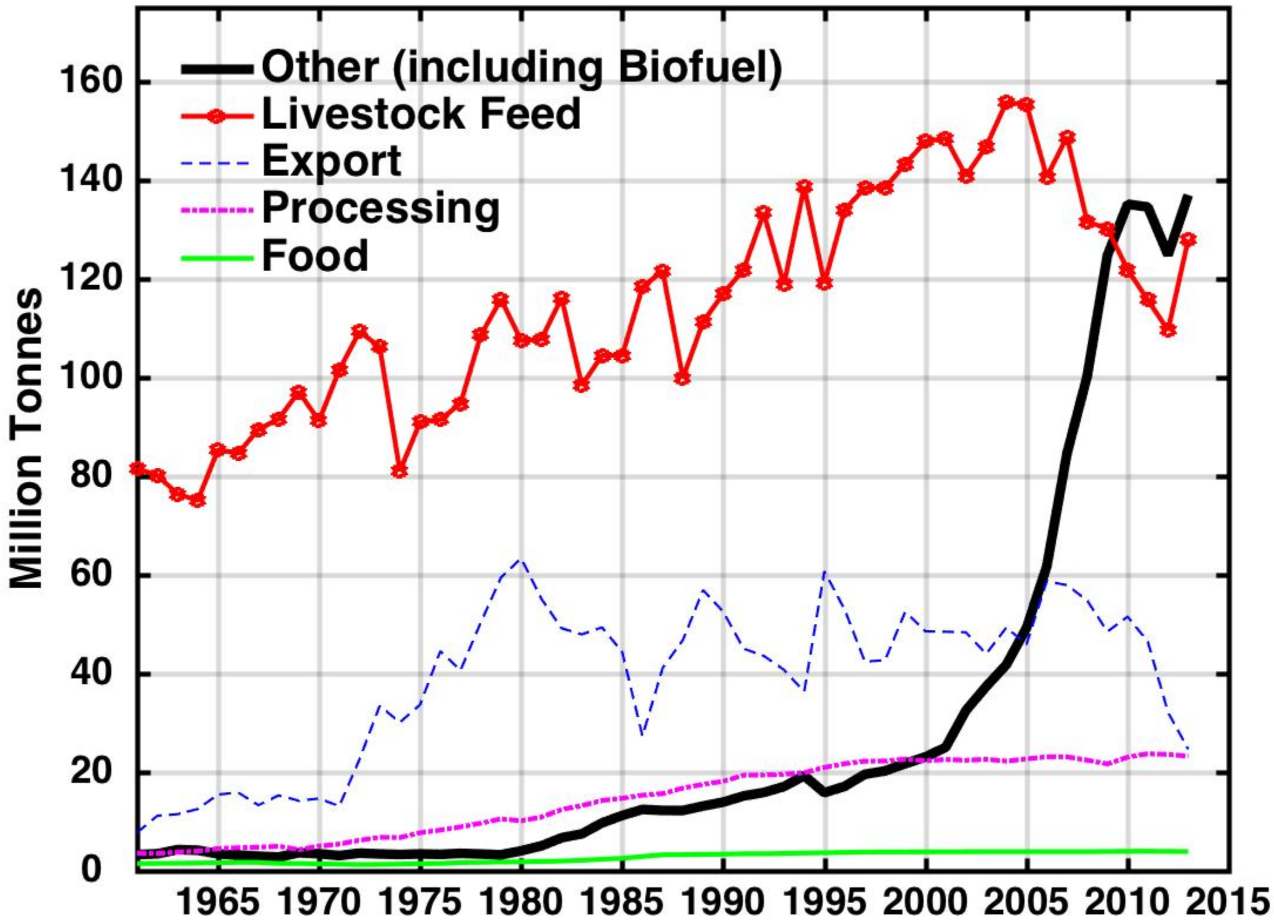
Seasonal and interannual variability in posterior N_2O flux from Midwest corn/soybean belt (38-43°N)



N fertilizer applications Pre-plant Sidedress Fall NH_3/manure

Changing use of United States Corn Crop

about 40% of total production is classified as "other" than food



Data from FAOSTAT

Fossil CO_2 emissions avoided due to biofuel vs. N_2O produced (2008-2013)

130 Tg/yr "other" Corn * 0.44gC/g biomass*0.37 gC in fuel/gC in biomass

~ 0.02 Pg C/yr fossil CO_2 avoided

300 million barrels/yr EtOH* 1 Mg EtOH/8 barrels*24 gC/46 gEtOH

(0.43 Tg N_2O-N -0.08‡)*300 mol CO_2,eq/mol CO_2 (GWP)* 12g C/28 g N

‡EDGAR industrial/energy source

total corn/soybean N_2O emissions = 0.045 Pg $CO_{2,eq}$

Attribute up to 40% of this to "other" corn

biofuel-related N_2O emissions ~ 0.02 Pg $CO_{2,eq}$

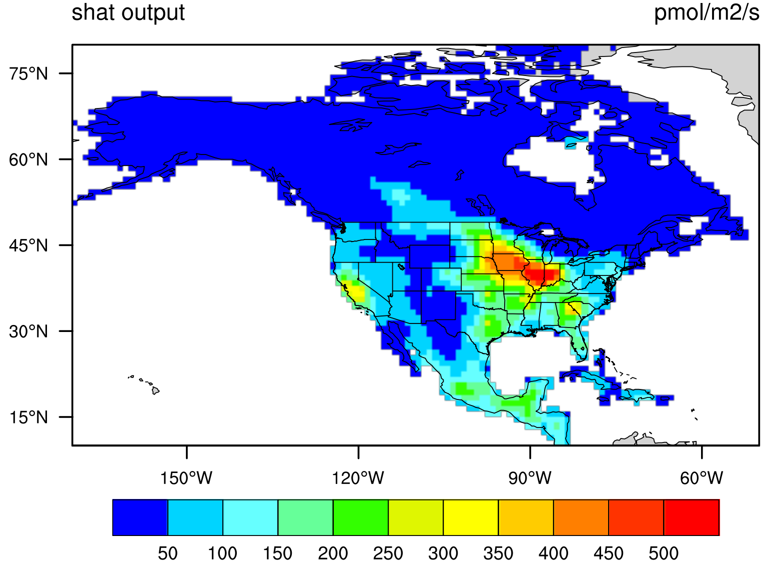
Conclusions

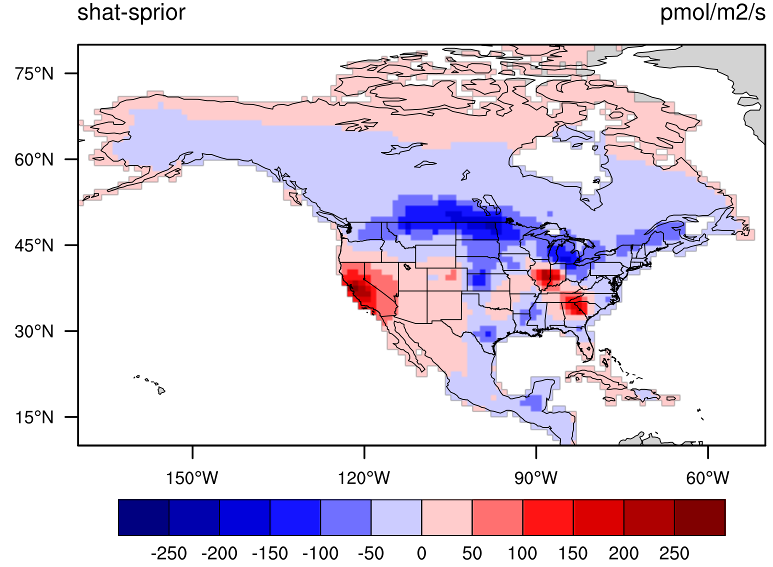
1. North American N_2O emissions = 1.5 ± 0.2 Tg N/yr with hotspot (~25% of total) in Midwestern corn/soybean belt.

2. Variability in N_2O emissions from corn/soybean belt is influenced by both N fertilizer inputs and climate.

3. Growing corn for biofuel may not lead to a net reduction in greenhouse gas emissions.

Annual Mean Posterior N_2O Flux





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ARTICLES

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Globally important nitrous oxide emissions from croplands induced by freeze–thaw cycles

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Seasonal freezing induces large thaw emissions of nitrous oxide, a trace gas that contributes to stratospheric ozone destruction and atmospheric warming. Cropland soils are by far the largest anthropogenic source of nitrous oxide. However, the global contribution of seasonal freezing to nitrous oxide emissions from croplands is poorly quantified, mostly due to the lack of year-round measurements and difficulty in capturing short-lived pulses of nitrous oxide with traditional measurement methods. Here we present measurements collected with half-hourly resolution at two contrasting cropland sites in Ontario and Manitoba, Canada, over 14 and 9 years, respectively. We find that the magnitude of freeze–thaw-induced nitrous oxide emissions is related to the number of days with soil temperatures below 0 °C, and we validate these findings with emissions data from 11 additional sites from cold climates around the globe. Based on an estimate of cropland area experiencing seasonal freezing, reanalysis model estimates of soil temperature, and the relationship between cumulative soil freezing days and emissions that we derived from the cropland sites, we estimate that seasonally frozen cropland contributes 1.07 ± 0.59 Tg of nitrogen as nitrous oxide annually. We conclude that neglecting freeze–thaw emissions would lead to an underestimation of global agricultural nitrous oxide emissions by 17 to 28%.