Anthropogenic emissions of methane in the United States

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Objectives:

- This study combines comprehensive atmospheric methane observations, extensive spatial datasets, and a high-resolution atmospheric transport model to quantitatively estimate the spatial distribution of anthropogenic methane sources and the key source sectors in the United States over 2007-2008.
- Comprehensive observations were taken at the surface, from daily flask samples on telecommunications towers, and vertical profiles from aircraft.
- The study used the Stochastic Time-Inverted Lagrangian Transport model (STILT) to calculate the transport of CH_4 from emission points at the ground to measurement locations in the atmosphere, and also used a geostatistical inverse modeling (GIM) framework.
- The GIM framework uses footprints and concentration measurements, and optimizes CH_4 sources separately for each moth of 2007 and 2008 on a 1° × 1° latitude–longitude grid.
- Auxiliary spatial data (on population density and economic activity) and concurrent measurements of alkanes help attribute emissions to specific economic sectors.
- In aggregate the footprints used provide spatially resolved coverage of most of the continental U.S., except the southeast coastal region.

New Science:

- This study estimated a mean US anthropogenic CH_4 budget from 2007-2008 of 33.4 ± 1.4 TgC·y−1 or ~7–8% of the total global CH_4 source.
- Results show that the current inventories from the U.S. Environmental Protection Agency (EPA) and Emissions Database for Global Atmospheric Research (EDGAR) underestimate methane emissions nationally by a factor of about 1.5 and about 1.7 respectively.
- CH_4 emissions from Texas, Oklahoma and Kansas alone account for 24% of the US methane emissions or 3.7% of the total US greenhouse gas budget.
- Emissions due to ruminants and manure are up to twice the magnitude of existing inventories.
- The discrepancy in methane source estimates is particularly pronounced in the south-central U.S., where the study finds total emissions are about 2.7 times greater than in most inventories and account for 24 ± 3% of national emissions.
- The spatial patterns of the emission fluxes and observed methane–propane correlations indicate that fossil fuel extraction and refining are major contributors (45 ± 13%) in the south-central United States, suggesting regional methane emissions due to fossil fuel extraction and processing could be 4.9 ± 2.6 times larger than in EDGAR.

Significance:

- Methane is the second most important anthropogenic greenhouse gas, with approximately one third the total radiative forcing of carbon dioxide.
- A number of previous studies used top-down methods to constrain anthropogenic CH_4 sources from global to region scales over North America.
- The amount of anthropogenic CH_4 emissions in the U.S. and attributions by sector are controversial, with disparities between bottom-up and top-down studies.
- The disparities suggest a much greater uncertainty in emissions than often reported; independent estimates of current bottom-up inventories give error ranges from 50-100%

- Successful regulation of greenhouse gas emissions requires knowledge of current methane emission sources.
- Because the study finds that greenhouse gas emissions from agriculture and fossil fuel extraction and processing are likely a factor of two or greater than cited in existing studies, effective national and state greenhouse gas reductions strategies may be difficult to develop without appropriate estimates of methane emissions from these source sectors.
- Assessment of CH_4 sources to inform policy requires more accurate verified estimates for the United States.
- The results of this study cast doubts on the U.S. EPA's recent decision to downscale its estimate of national natural gas emissions by 25-30%.

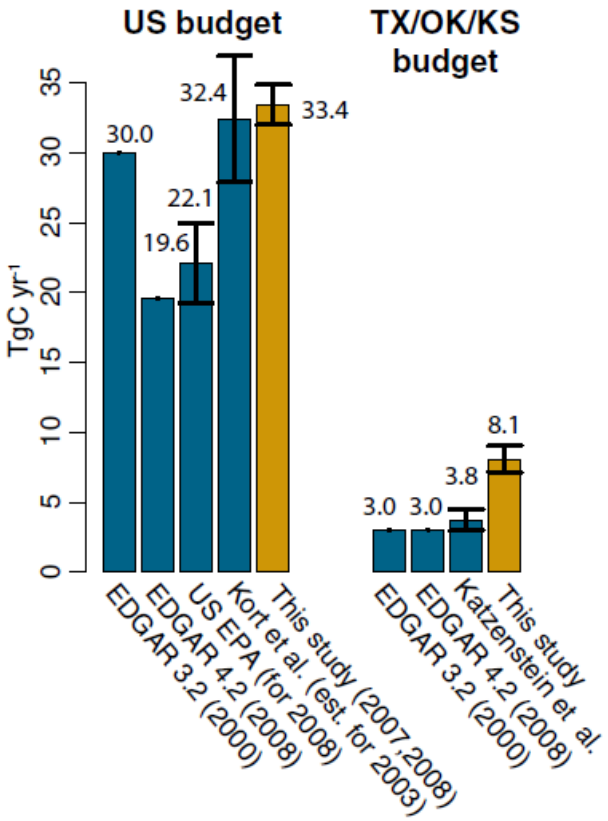

Figure 1. U.S. anthropogenic methane budgets from this study, from previous top-down estimates and from existing emissions inventories. The south-central United States includes Texas, Oklahoma, and Kansas. US EPA estimates only national, not regional, emissions budgets. Furthermore, national budget estimates from EDGAR, EPA and Kort et al. include Alaska and Hawaii whereas this study does not.

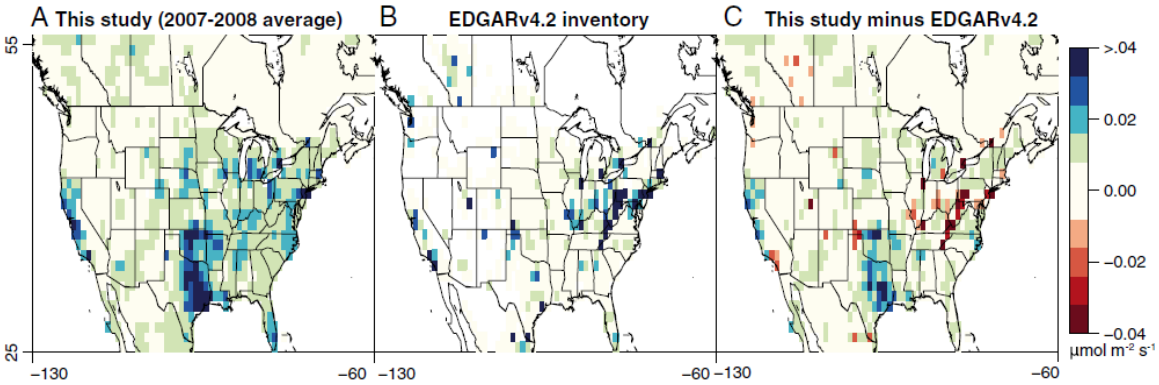

Figure 3. The 2-year averaged CH4 emissions estimated in this study (A) compared against the commonly used EDGAR 4.2 inventory (B and C). Emissions estimated in this study are greater than in EDGAR 4.2 especially near Texas and California.