A large increase in U.S. methane emissions over the past decade inferred from satellite data and surface observations

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Objectives:

- The global burden of atmospheric methane rose by 1-2% a^{-1} in the 1970s and 1980s, stabilized in the 1990s, and has been rising again since the mid-2000s, and there has been much speculation as to the cause of recent trends.
- To better understand contribution of the U.S. methane emissions to the global burden, the authors of this letter reviewed and compared satellite retrievals and surface observations of atmospheric methane, reviewed inverse studies, and studied trends in GOSAT satellite data over the continental United States (CONUS).
- Bottom-up methods of methane emissions calculations reviewed include Greenhouse Gas Inventory of the U.S. Environmental Protection Agency (US EPA 2014), the EDGARv4.2FT2010 global inventory (European Commission 2013), and the Wetland CH4 Intercomparison of Models Project (2013).
- The inverse methods reviewed were studies based on Scanning Imaging Absorption Spectrometer for Atmospheric Chartography (SCIAMACHY) satellite data for July–August 2004 (Wecht et al. [2014]), NOAA Global Greenhouse Gas Reference Network in situ observations for 2007–2008 from ground stations and aircraft (Miller et al. [2013]), and Greenhouse Gases Observing Satellite (GOSAT) data for June 2009 to December 2011 (Turner et al. [2015]).
- The authors also reviewed long-term trends in surface observations from the DOE/Atmospheric Radiation Measurement (ARM) Southern Great Plain (SGP) site in central Oklahoma, Tudor Hill Atmospheric Observatory in Bermuda, and NOAA Mauna Loa Observatory in Hawaii.
- The authors orographically corrected GOSAT satellite data to find the methane enhancement over the continental U.S. (CONUS) and tracked the trends from 2010 – 2014.

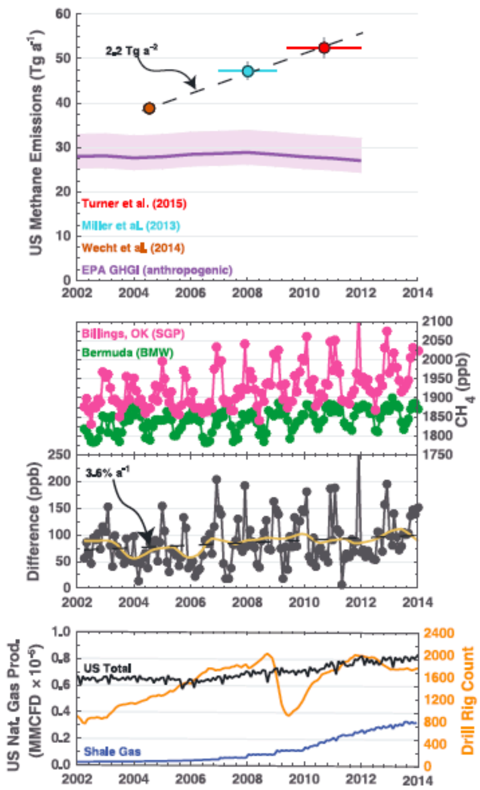
New Science:

- Long-term surface observations and satellite retrievals of atmospheric methane, interpreted directly and using inverse methods, point to an increase of more than 30% in U.S. methane emissions from 2002-2014.
- The trend is largest in the central part of the country, but it cannot be readily attributed to any specific source type.
- This large increase in U.S. methane emissions could account for 30–60% of the global growth of atmospheric methane seen in the past decade.

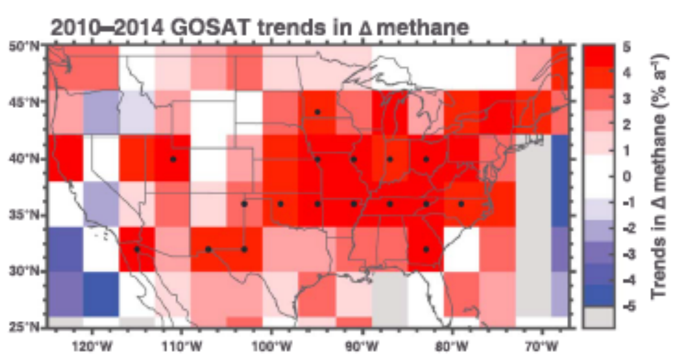
Significance:

- Methane is the second most important anthropogenic greenhouse gas, with a radiative forcing of 0.97 W m^{-2} since preindustrial times on an emission basis, as compared to 1.68 W m^{-2} for CO2.
- The global burden of atmospheric methane has been increasing over the past decade, but the causes are not well understood.
- Major anthropogenic sources of atmospheric methane include oil and gas systems, livestock (enteric fermentation and manure management), coal mining, and waste (landfills and wastewater).

- Wetlands are the dominant natural source of methane.
- Oxidation by the hydroxyl radical (OH) is the main sink of methane, imposing an atmospheric lifetime of about 10 years.
- Because the results of this study suggest that U.S. anthropogenic methane emissions could account for up to 30–60% of the global increase, understanding the sources and drivers of this increase is important for understanding and management of this portion of the global methane burden.
- Future studies designed to increase understanding of the U.S. anthropogenic methane emissions, particularly from the livestock and oil and gas sectors, are needed.



The 2002–2014 trends in U.S. methane emissions, atmospheric mixing ratios, and gas production rates. (top) The total contiguous U.S. (CONUS) methane emissions from three recent inverse studies [Miller et al., 2013; Wecht et al., 2014; Turner et al., 2015] with horizontal bars indicating the temporal averaging periods and vertical bars indicating reported uncertainties. U.S. EPA anthropogenic emission estimates from the Greenhouse Gas Inventory for 2002–2012 are also shown, with shading indicating reported uncertainties [US EPA, 2014]. (middle) The monthly atmospheric methane mixing ratios measured in surface air by the U.S. DOE at the Southern Great Plains site [SGP; Biraud et al., 2013] near Billings, Oklahoma (36.62∘N, 97.48∘W) and the NOAA/ESRL site (BMW) [NOAA ESRL, 2015] at Bermuda (32.27∘N, 64.87∘W), along with the corresponding SGP-BMW difference (black), a deseasonalized difference (gold line), and the ordinary least squares trend expressed as the percent change from 2004 (dashed black line). (bottom) The trend in CONUS oil and gas production and drilling activity as measured by active rig counts [US EIA, 2015] (number of active rigs at a given time). Oil and gas production data are from the U.S. Energy Information Administration.



The 2010–2014 trend in U.S. methane enhancements as seen from GOSAT. The methane enhancement (Δ methane) is defined as the difference in the tropospheric column mixing ratio relative to the oceanic background measured in the glint mode over the North Pacific (176–128∘W, 25–43∘N) and normalized with the 2010 Δ methane. Trends are computed on a 4∘× 4∘ grid. Statistically significant trends ($p < 0.01$) are indicated by a dot.

Predicted total carbon under (A) current climate and (B) future climate; (C) the carbon difference between the current and future; and (D) the percent change in carbon distribution.