

Cornell University



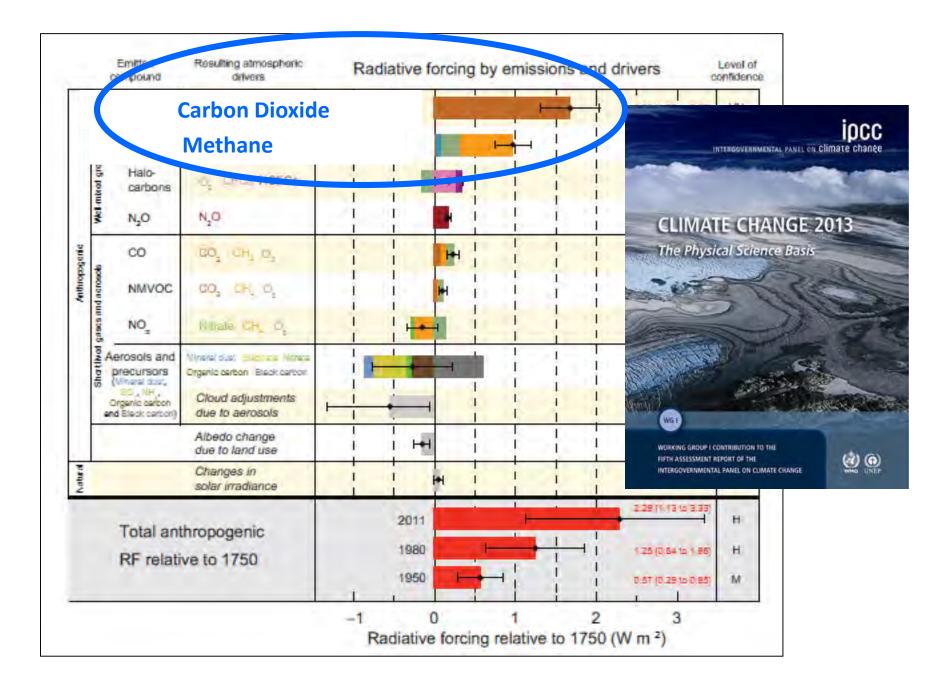
Methane's Role in Global Warming

Bob Howarth

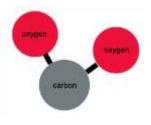
The David R. Atkinson Professor of Ecology & Environmental Biology

Cornell Cooperative Extension

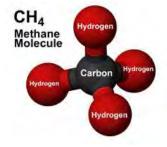
June 29, 2021



The two faces of carbon:



<u>Carbon dioxide (CO2)</u> – climate system responds slowly to changes, but current emissions will influence climate for 100s of years;



<u>Methane (CH4)</u> – much faster response by climate system, but methane has a half life in atmosphere of only 12 years;

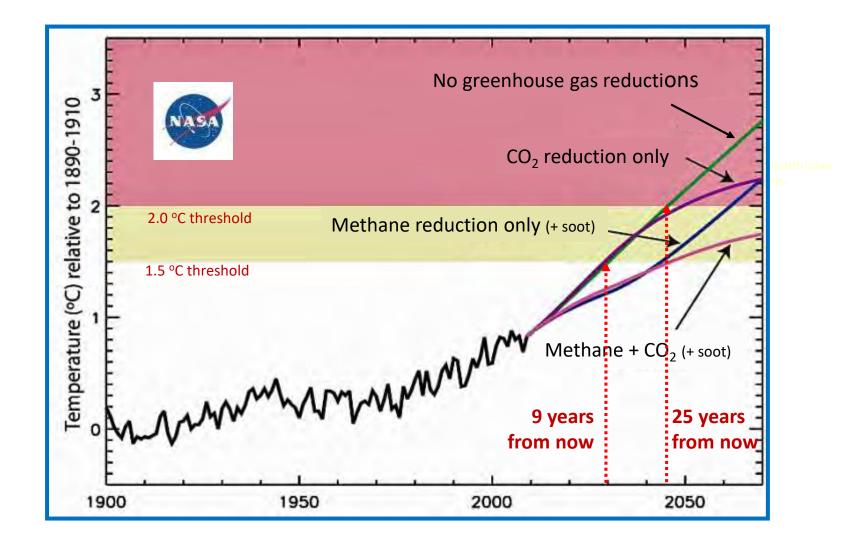
220 times more CO2 in atmosphere, but CH4 is 105 times more powerful as a greenhouse gas (by weight)

COP21: United Nations Conference of the Parties Le Bourget, Paris -- December 2015

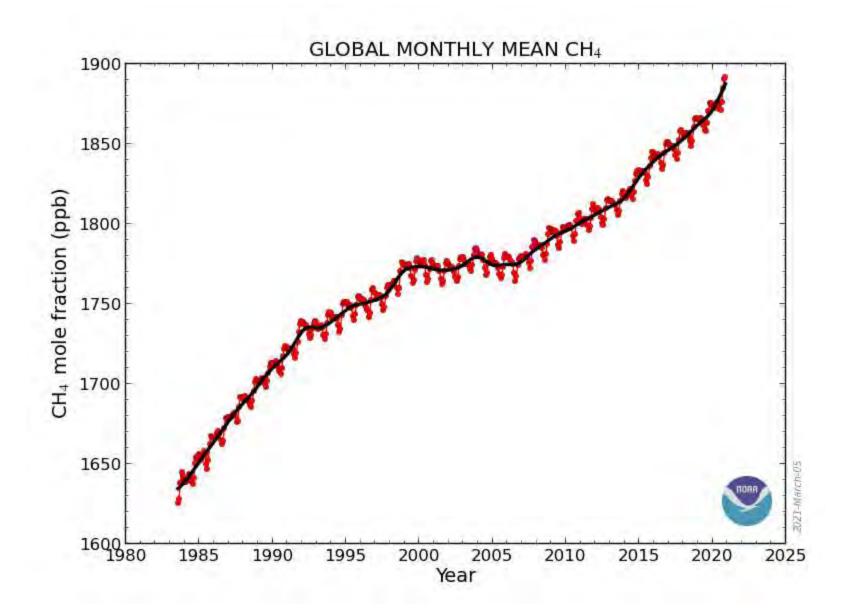


- COP21 Paris Accord target: "well below 2° C"
- Clear recognition that warming beyond 1.5° C is dangerous

 Methane reductions are critical; cannot reach COP21 target with CO₂ reductions alone



Shindell et al. 2012, Science



Global greenhouse gas emissions (2015):

CO₂ = 36 billion metric tons

CH₄ = 0.38 billion metric tons



CH₄ is 105-fold more potent as greenhouse gas at first and 86fold more on average over 20 years following the emission (IPCC 2013). **Global greenhouse gas emissions (2015):**

CO₂ = 36 billion metric tons

CH₄ = 0.38 billion metric tons



CH₄ is 105-fold more potent as greenhouse gas at first and 86fold more on average over 20 years following the emission (IPCC 2013).

Therefore, CH_4 emissions = 32 to 39 billion metric tons CO_2 -eq

Warming from CH₄ equals that of CO₂ for next 20 years!



GLOBAL METHANE ASSESSMENT Summary for Decision Makers

May 6, 2021

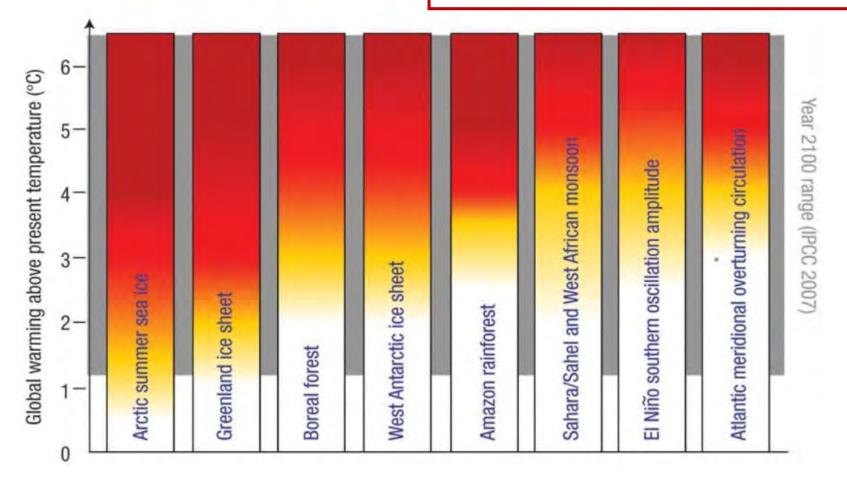


Reducing human-caused methane emissions is one of the most cost-effective strategies to rapidly reduce the rate of warming and contribute significantly to global efforts to limit temperature rise to 1.5°C. Available targeted methane measures, together with additional measures that contribute to priority development goals, can simultaneously reduce human-caused methane emissions by as much as 45 per cent, or 180 million tonnes a year (Mt/yr) by 2030. This will avoid nearly 0.3°C of global warming by the 2040s and complement all long-term climate change mitigation efforts. It would also, each year, prevent 255 000 premature deaths, 775 000 asthmarelated hospital visits, 73 billion hours of lost labour from extreme heat, and 26 million tonnes of crop losses globally (Figure ES1).

"Tipping Points"

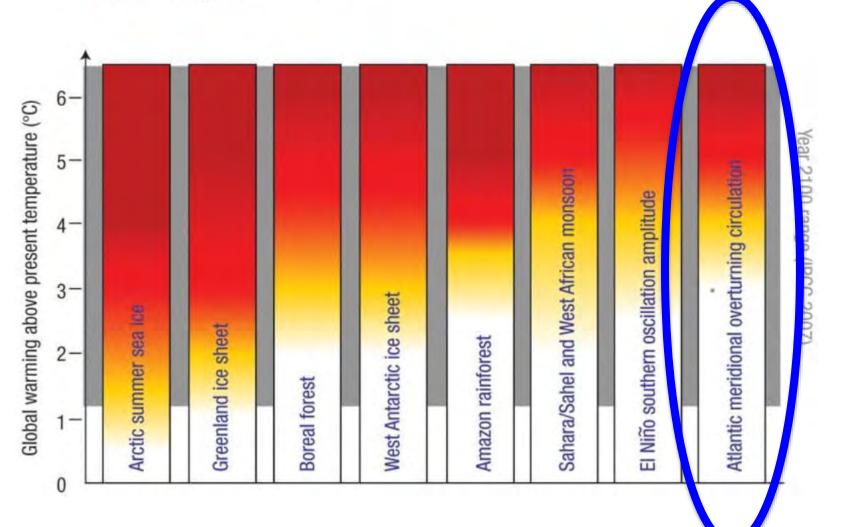
Uncertainty as to when tipping points will be hit, but increasing risk in yellow, high risk shown by red.

Best estimates as of 2007



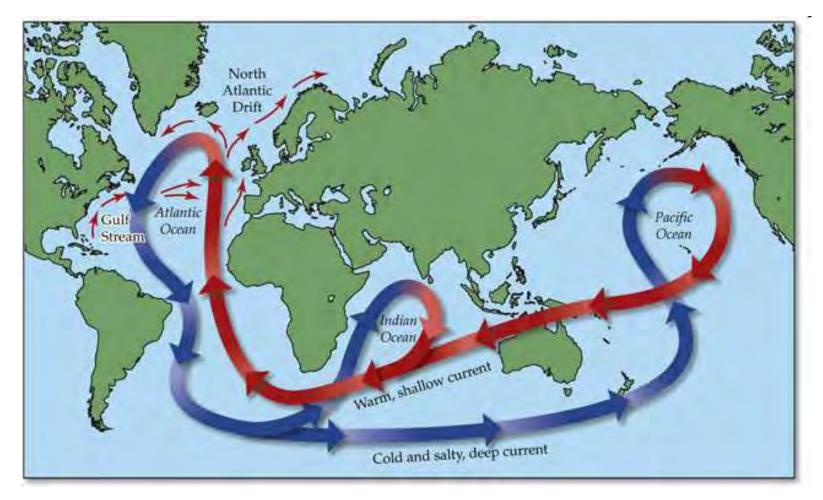
Also called the Great Ocean Conveyor Belt, and is probably much more sensitive to global warming than thought in 2007

"Tipping Points"



The great conveyor belt is slowing...

.... Caused by melting of Arctic ice and Greenland ice sheet, making North Atlantic very slightly less salty.



Caused in part by melting of Greenland and Arctic Ocean ice.

Consequences?

- -- greater weather extremes (cold, heat, floods, droughts, hurricane).
- -- faster build-up of CO₂ in the atmosphere?

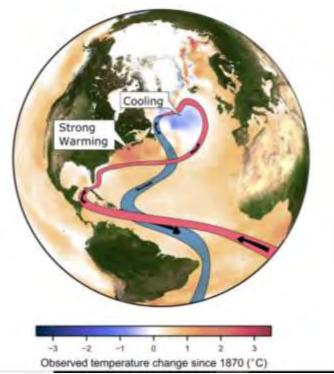
May become far worse.

Energy and Environment

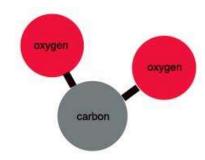
The oceans' circulation hasn't been this sluggish in 1,000 years. That's bad news.

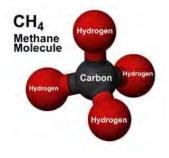
By Chris Mooney And II S Email the Mithor

April 11, 2018



How do we account for methane relative to CO₂ in terms of contribution to global warming, given the huge differences between the two gases?





Many approaches, but most commonly used in policy (and easiest to understand):

Global Warming Potential (GWP)

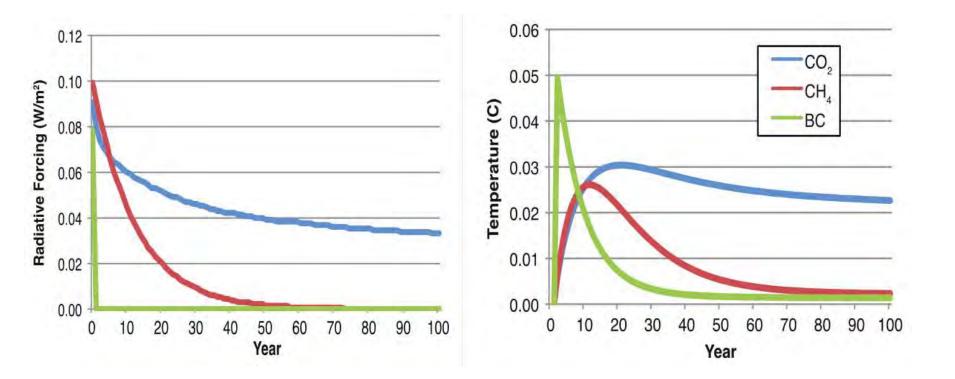
Ratio of radiative forcing caused by methane divided by radiative forcing caused by carbon dioxide following pulses of equal masses (weights) of the gases for a defined period of time into the future (20 years, 100 years, etc.).

Global Warming Potential (GWP) for methane:

	20 year	100 year
IPCC 1996	56	21
IPCC 2007	72	25
IPCC 2013	86	34

The changes over time in table reflect improved science, including indirect effects of methane on global warming

Comparison of Carbon Dioxide, Methane, and Black Carbon as Agents of Global Warming



Courtesy of Drew Shindell, Feb 2019

Global Warming Potential (GWP) for methane:



Most governments and almost all standard life-cycle assessments still use 21 or 25.



WORKING GROUP I CONTRIBUTION TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE IPCC (2013): "There is no scientific argument for selecting 100 years compared with other choices."

"The choice of time horizon depends on the relative weight assigned to the effects at different times." 100 year accounting time greatly discounts damage from methane over shorter time scales.

I and many others have argued for 20-year GWP, combined with separate accounting for carbon dioxide by itself.

Down Access

Energy Science & Engineering

PERSPECTIVE

A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas

Robert W Howarth

Instrument, in Sciency & Ecological participation, South Ecologic Total Ecological New York, 14857

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Foredday Informations

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WARNESS AMONG TELE TROUP OF MAIL TOLE MANAGER 72 April 2011.

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Abstract

In April 2011, we published the first per-prismed analyse of the greenhouse gis footprint (GHG) of shale get, concluding that the climate impact of shale ma must be some than that of other found harly each as coul and out because of methane annuminus. We noted the poor quainy of publicly available data to suppost our analysis and called for further research. that paper spanned a largeincrease in research and andysis, including several new makes that have better measured methane emissions from sidneral gas potents. Here, I certew this use reasonh in the context of our 2071 paper and the fifth nessament from the Intergovernmental Fund on Climate Change velocial in 2015. The best dataavailable now indicate that our estimates of mathans emission from both shalegas and conventional natural par same relatively without. Using these new, here stallable data and a Different lime period by comparing the warming portunial of outbane to cathon deoids, the conductor stands that both dails pay and conventional natural gas light a larger GBR3 than doi out for oil, for any penal-He use of natural gas and particularly for the primers uses of residential and commercial heating. The 70-year time period is appropriate because of the urgent need to reduce narrhane entitions over the coming 13-35 years.

KOURNAL OF INTEGRATIVE ENVIRONMENTAL SCIENCES https://doi.org/10.1083/1943815X.2020.1789666



OPEN ACCESS

Methane emissions from fossil fuels: exploring recent changes in greenhouse-gas reporting requirements for the State of New York

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ABSTRACT

In 2019, New York State passed aggressive new climate legislation to reduce greenhouse gas (GHG) emissions and fail out major changes for how emissions are reported. One change is the inclusion of emissions from outside of the boundaries of the State if they are associated with energy use within NY: the traditional inventory considered emissions only within the State. The new legislation also mandated that methane emissions be compared with carbon dioxide over a 20-year time frame rather than the 10K-year time frame previously used by NY and still used by virtually all other governments globally. This reflected the desire of NY's policymakers for a tool that evaluates emissions from the standpoint of energy consumption and that more heavily weighs the role of methane as an agent of warming over the next few decades. This paper compares emissions based on the new approach for GHG reporting with the

ARTICLE HISTORY

Received 12 September 2019 Accepted 5 June 2020

KEYWORDS

Greenhouse gas emissions, greenhouse gas footprint; CLCPA; methane emissions; climate and energy policy: global warming potential; GWP



Briefing by Robert Howarth for the White House Office of Science and Technology Policy May 27, 2016



Beginning in 2016, I worked with Assembly Person Englebright and others in NY Assembly in various versions of legislation leading to the 2019 Community Leadership & Community Protection Act (CLCPA).

The CLCPA mandates a 20-year GWP for methane.



New York **Climate Justice Climate Act Advisory Panels** Events Resources Climate Action Council Working Group **Climate Action Council** NEW YORK CLIMATE ACTION COUNCIL The New York State Climite Action Council (Council) is a 22-member committee that will Meetings and prepare a Scoping Plan to achieve the State's bold clean energy and climate agenda. Materials **Climate Action Council Members**

Co-Chairs

- Doceen Harra, Acting President and CEO, New York State Energy Research and Development Authority
- Basil Seggors, Commissioner, New York State Department of Environmental Conservation

State Agencies & Authorities

- Richard Ball, Commissioner, New York State Department of Agriculture and Markets
- Marie Therese Dominguez, Commosuover, New York State Department of Transportation
- Thomas Falcone, CEO, Long Island Power Authority
- Eric Gertler, Acting Commissioner and President & CEO-designate of Empire State Development
- Gil C. Dumicines. President and Ctuel Executive Officer, New York Power Authority
- Roberta Reardow, Commissioner New York State Department of Labor
- John B. Rhodes, Chair, New York State Public Service Commission
- Rossana Rosado, Secretary of State, New York State Department of State
- RuthAnne Visnaurikas, Commissioner and CEO, New York, State Howes and Community Renewal
- Howard A. Zucker, Continicationer, New York State Department of Heath

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- Jim Maketras, Characellar of the State University of New York
- Anne Reynolds, Executive Director Alliance for Clean Energy New York
- Raye Salter, Lead Policy Organizer, NY Reviews
- Paul Shepson, Dean, School of Maxime and Atmospheric Sciences at Story Brook University



What about GWP* ?

First introduced in a 2017 paper, already altered in a series of follow-up papers. Fairly complicated, and unlike GWP20 and GWP100, GWP* is not constant. It changes as emissions change.

Very popular in some agricultural circles, as some have suggested methane from animal agriculture is not a problem under this approach. I believe this is based on a mis-use of GWP*

What about GWP* ?

My take:

GWP* is defined in multiple and changing ways. Unlike GWP20 or GWP100, it is not a constant. It changes as emissions change.

Paradoxically, GWP* can be negative: this implies more methane is good for climate, which is nonsense.

I do not believe GWP* is likely to have long legs in policy world.

In any case, for greenhouse gas accounting in NY State, GWP20 is mandated by law (CLCPA of 2019).

Where does atmospheric methane come from?

Multiple sources, both natural and human-caused.

Total global flux estimate well constrained, since rate of destruction by photo-oxidation in atmosphere is well know.

Two major sources of methane:

- Methane formed in rock formations over geological time frame (fossil fuels)
- Methane formed by decomposition of organic matter by bacteria in absence of oxygen (wetlands, lake sediments, rice fields, sewage treatment plants, landfills, manure piles, animal guts)

ATMOSPHERIC METHANE

A 21st-century shift from fossil-fuel to biogenic methane emissions indicated by ¹³CH₄

Hunnen Schoeler," Sara E. Mikaioff Phetomer, Commita Voidt," Ketth R. Lamor, " Gerdon W. Braildord, Tony M. Brunley, "Edward J. Dissoluncky," Sylvia E. Michel,* John B. Miller,2 Ingeborg Levin,2 Dave C. Lowe,*) Ross J. Martin," Bruce H. Vaughn," James W. C. White"

Between 1999 and 2006, a plateau interrupted the otherwise continuous increase of atmospheric methane concentration [CH₈] since preindustrial times. Causes could be sink variability or a temporary reduction in industrial or climate sensitive sources. We reconstructed the global history of [CH_] and its stable carbon isotopes from ice cores. archived air, and a global network of monitoring stations. A box model analysis suggests that diminishing thermogenic amissions, probably from the fossil-fuel industry, and/or variations in the hydroxyl CH₄ sink caused the [CH₄] plateau. Thermogenic emissions did not resume to cause the renewed [CRa] rise after 2006, which contradicts emission inventories. Post-2006 source increases are predominantly biogenic, outside the Arctic, and arguably more consistent with agriculture than wetlands. If so, mitigating CH, emissions must be balanced with the need for food production.

tripled (CH.) diam preimitionial times (1-3). This contributes strongly to authorovernaclimate diarge through radiative Saving. n and impacts on atmospheric clomistry. particularly instruct consumption, tropospheric come emeration, and water capor formation. in the stratosphere (1). In a positive feedback to climate change, natural sources studt as CB, 79drates, tundin, and permatrost may increase (5).

uliroperate Th, emissives have almost | ICH, planess (Fig. 1) of 57 have been studied wittis inverse models (top-down) (#-34), as well its process modeling (0, 8, 17-20) and emission estimates (bottom-ig) (27-27). These approaches are efficier not emission-specific or anoertain to scaling and process representation (5). In contrast, the "C"C ratio in atmospheric CH, in "C and expressed in 5 notation relative to the Vienias Pee-Dee Belemnite sumdard) is controlled in the relative contributions from souger bypes with

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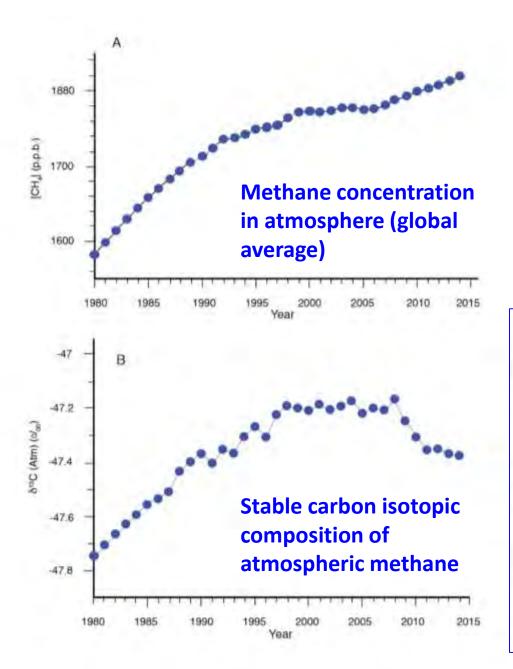
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High visibility paper published in March 2016 in *Science*: Increase in atmospheric methane since 2006 is most likely biogenic in large part, probably from cows.

Based largely on stable carbon isotopic composition (¹³C vs. ¹²C) in atmospheric methane.





Biogeosciences, (6, 3053-3046, 2019) InterestAnt.org/10.104/hg-16-3033-2010 In Autor(s) 2019, The work is distributed under the Creative Commons Auriduition 1111 January (Commons Auriduition 1111 January

Ideas and perspectives: is shale gas a major driver of recent increase in global atmospheric methane?

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Correspondence: Robert W. Howarth (howarth@cornell.nike)

Received: 10 April 2019 - Discussion stated: 23 April 2019 Revised: 31 July 2019 - Accepted: 12 July 2019 - Published: 14 August 2019 -

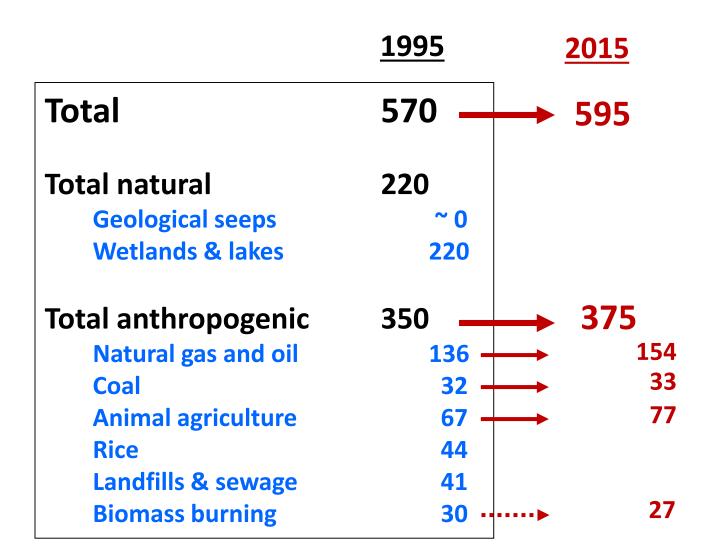
Abstract. Methane has been using rapidly to the atmospheric over the past decade, contributing to global climate change Unlike the loss 20th converse when the true in atmospheric methanic war accomposed by an emicroment in the beavter carries subtle isotope $({}^{13}C)$ of methane methane in its reart years have become more depleted in ${}^{13}C$. This depletion has been widely interpreted in anticating a primarily himgenic source for the meeta-of methane. Here we there that part of the change may instead be associated with emission from shale-gas and shale-oil divergement. Previous studies have not explicitly considered three logment, Previous studies have not explicitly considered the log scalar with one studies. Convention or Chunde Change (UNFCCC) COR21 target or locping the phaset well below 2°C above the pre-indominal banding (DEC 2016). Michana also contributes to the furmission of ground-local operative well large advants commuplencies for human health and agreed are Considering the efficient in which as climatic change. Should 1(2015) estimated that the social cost of methade is 40 in 100 times greater than that for carbon disorder USD 2700 per unit for methane compared in USD 27 per ton for carbon disorder when calculated with a 5% of coording table on D DB 000 per ton for methane compared in USD 27 per ton for carbon disorder when calculated with a 5% of coording table per ten for carbon disorder with a 14% discount calcu-

Atmospheric methane levels suse smallly during the tast

As it migrates through sandstone over geological time, some of the methane is oxidized, leading to fractionation The methane in conventional natural gas is Conventional gas enriched in ¹³C relative to the source methane in shale gas. CH Geological seal Sandstone CH4 Gas-rich shale

Howarth (2019)

Global methane sources (Tg per year)





The Methane Project at Cornell University

R. W. Howarth, based on Begon et al. (2014), modified 6/2/2019

Is methane from animal agriculture the same as from fossil fuels?

- When in atmosphere, methane is methane with same warming potential: 105 times that of CO₂
- When the methane is eventually oxidized to CO₂, that which came from fossil fuels is a new source of CO₂. The CO₂ for the agricultural source is not new.
- This difference is small (2.5%). When expressed as GWP-20, changes agricultural methane to 84 instead of 86 for fossil fuels.

Although fossil fuel emissions of methane far larger than those from animal agriculture, animal ag is important globally:

77 Tg/yr (20% of all human sources)

Animal agriculture in NY State contributes 0.23% of the global total.

This accounts for 1.2% of all greenhouse gas emissions in New York State. So relatively small, but still worth trying to reduce, and NY can help lead the way for other states and nations. Dairy farms and cattle operations produce methane in two ways:

- 1) Released from manure (~ 20% of total)
- Produced in the rumen and breathed or belched out (~80% of total) – Tom Overton will discuss in a moment.

Should NY promote anaerobic digestors to produce and use methane from manure?



Spruce Haven Farm, Union Springs, NY Doug Young & family, proprietors









Should NY promote anaerobic digestors to produce and use methane from manure?

Maybe..... but limited potential. At most could produce 370 million cubic meters (very optimistic assumptions).

This would replace 0.9% of current use of natural gas in NY State.

And could actually increase atmospheric methane emissions, if there were significant leakage from the digestors.

Manure management practices need to be improved, but is anaerobic digestion the best approach?



Tom Overton will now discuss methane from cows & cattle as influenced by feeds.

Funding:

Cornell University

Park Foundation

For more information: howarthlab.org