Cornell University
College of Agriculture and Life Sciences

Accounting for methane in greenhouse gas inventories and assessments

Tompkins County Energy Task Force
December 6, 2018

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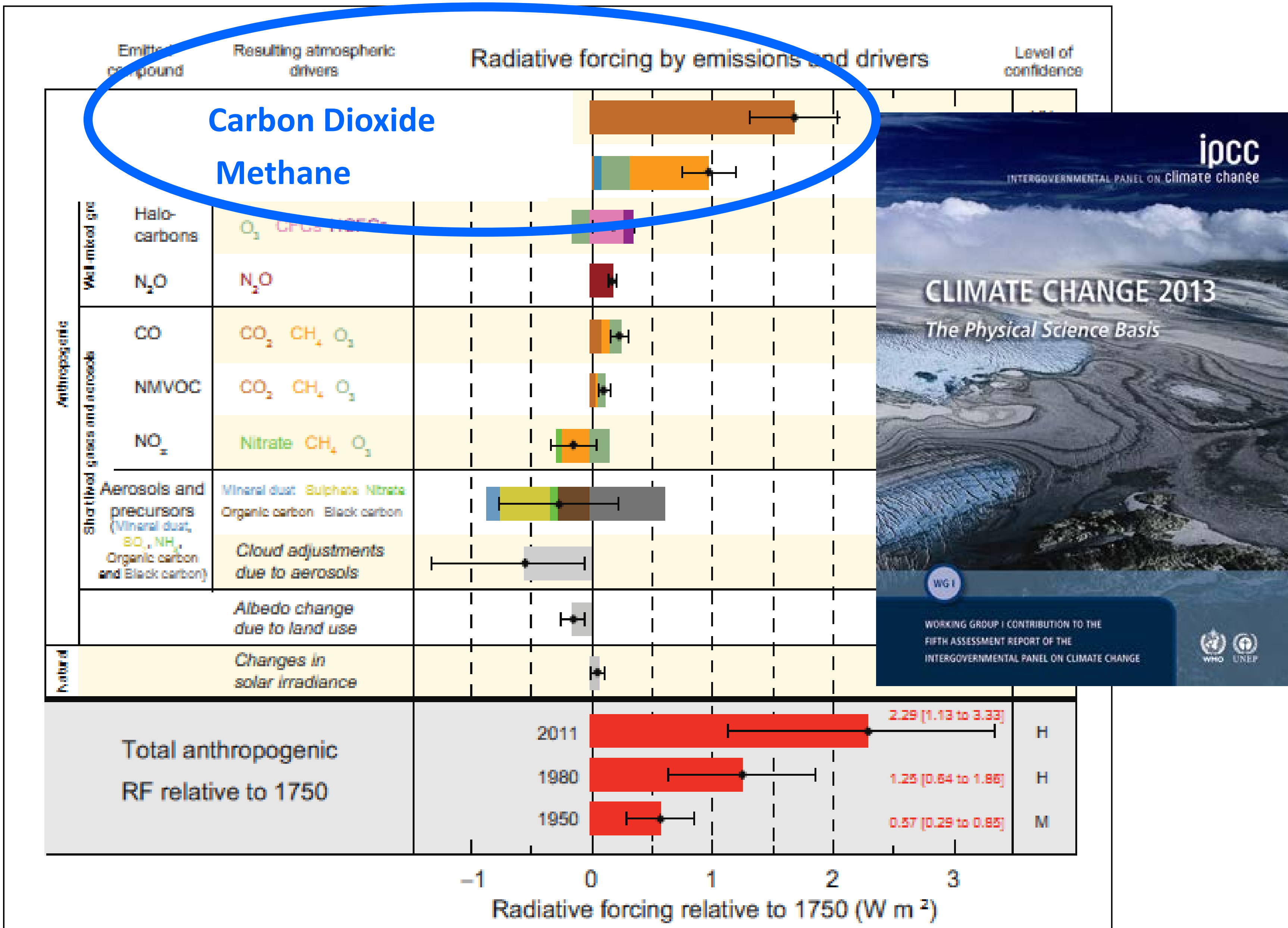
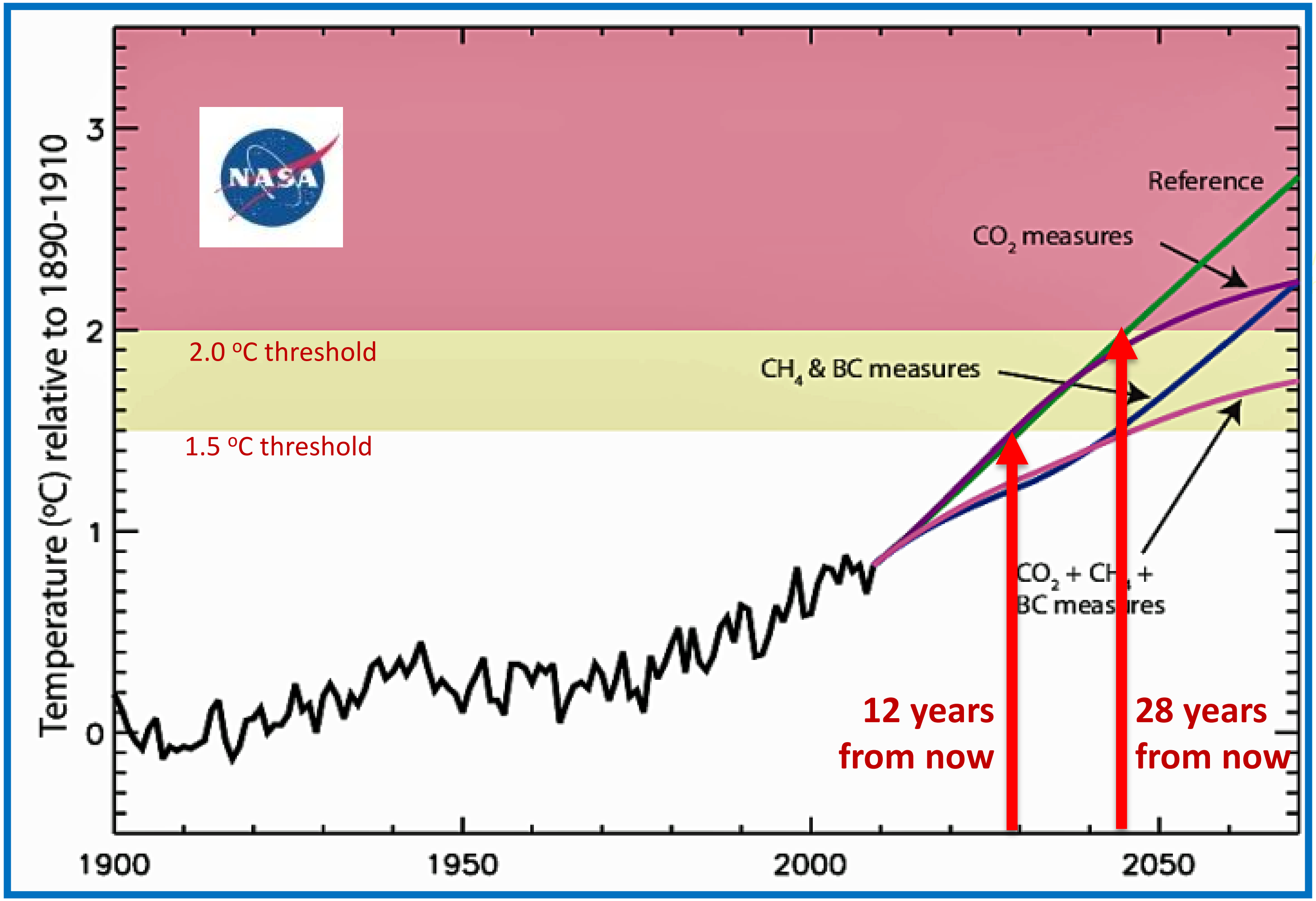

Carbon Dioxide
Methane
Radiative forcing by emissions and drivers
Resulting atmospheric drivers
Level of confidence
Halo-carbons
N_2O
N_2O
CO
CO_2 CH_4 O_3
NMVOC
CO_2 CH_4 O_3
NO_x
Nitrate CH_4 O_3
Aerosols and precursors
Mineral dust Sulphate Nitrate
Organic carbon Black carbon
Cloud adjustments due to aerosols
Albedo change due to land use
Changes in solar irradiance
Anthropogenic
Well-mixed greenhouse gases
Short lived gases and aerosols
Natural
Total anthropogenic RF relative to 1750
2011
1980
1950
2.29 [1.13 to 3.33]
1.25 [0.64 to 1.86]
0.57 [0.29 to 0.85]
H
H
M
−1
0
1
2
3
Radiative forcing relative to 1750 (W m⁻²)
ipcc
INTERGOVERNMENTAL PANEL ON climate change
CLIMATE CHANGE 2013
The Physical Science Basis
WG I
WORKING GROUP I CONTRIBUTION TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
WHO
UNEP

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

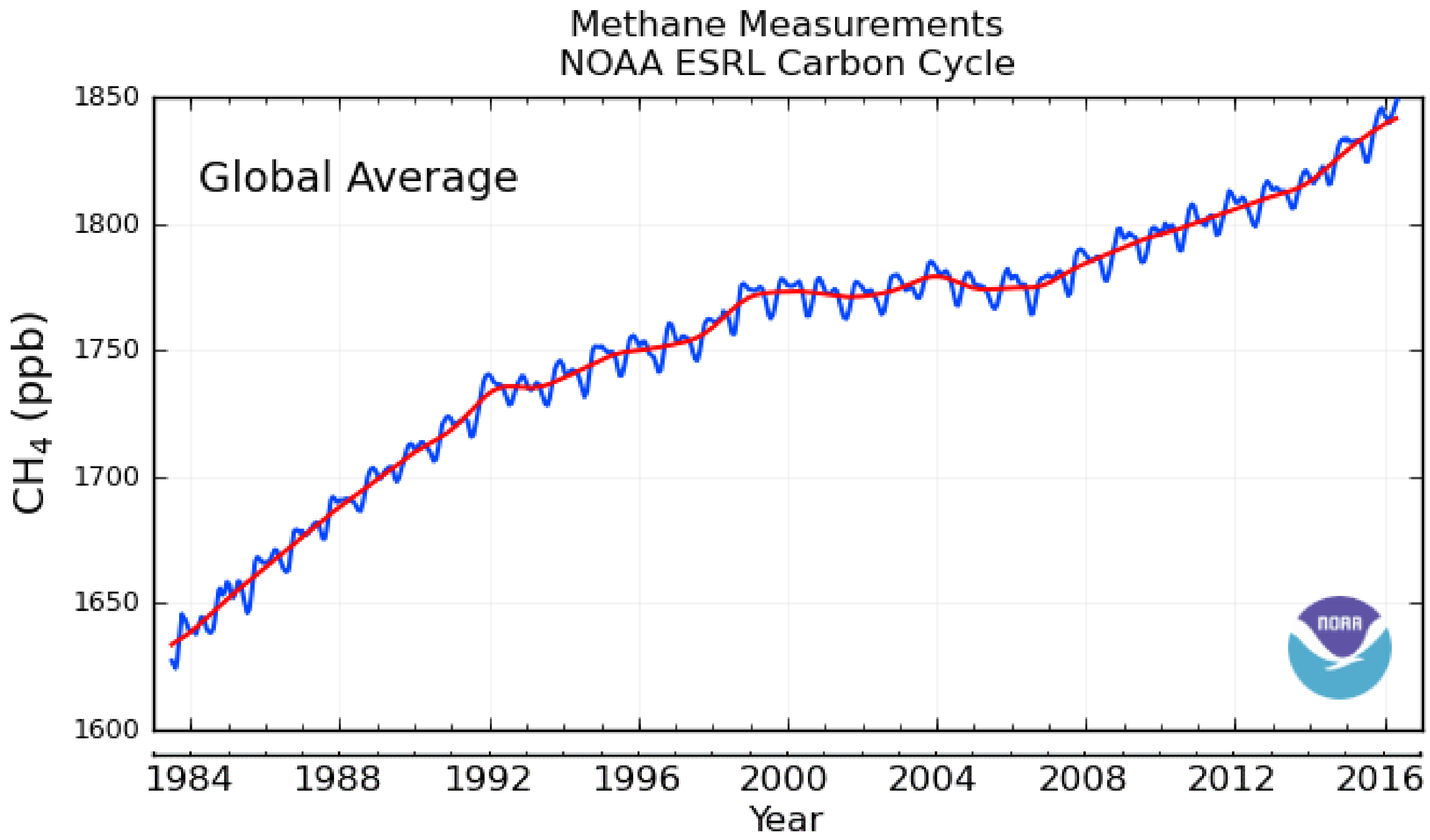
PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

- COP21 Paris Accord target: “well below 2 deg C”
- Clear recognition that warming beyond 1.5 deg C is dangerous

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



Shindell et al. 2012, *Science*



Rapid rise in atmospheric methane globally since 2008

http://www.esrl.noaa.gov/gmd/ccgg/gallery/figures/

Global methane sources (Tg/yr), as of 1990 - 2000

	1990 - 2000	2015 estimate
Total	**570**	**596**
Total natural	**220**	
Geological seeps	0	
Wetlands & lakes	220	
Total anthropogenic	**350**	**376**
Natural gas and oil	136	156
Coal	32	35
Animal agriculture	67	73
Rice	44	
Landfills & sewage	41	
Biomass burning	30	27

Begon et al. (2014), modified Oct 31, 2018 using data from Petrenko et al. (2017) and Howarth (in review)

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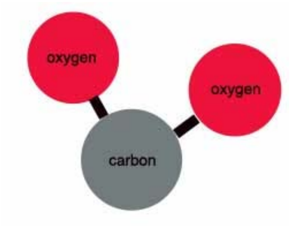
theguardian

US 'likely culprit' of global spike in methane emissions over last decade

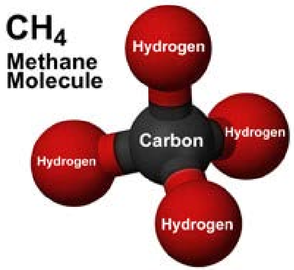
Harvard study shows 30% rise across the country since 2002 with peaks coinciding with shale oil and gas boom, reports Climate Central

Begon et al. (2014), modified Oct 31, 2018 using data from Petrenko et al. (2017) and Howarth (in review)

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 stays in atmosphere for only a decade or so;

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

How do we compare methane and carbon dioxide as greenhouse gases?

Global Warming Potential (GWP) is most used approach:

> **The integrated effect of radiative forcing of a greenhouse gas relative to carbon dioxide over a defined period of time.**

How methane emissions are included in traditional inventories & analyses:

1) Only methane emissions at site of combustion included (and those are low, based on EPA 1998; ie, ~ 0.02% of natural gas consumed);

2) Methane compared to CO2 using 100-yr “global warming potential” (and values used are based on out-of-date science, from IPCC 1996)

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__The alternative__: full life-cycle emissions of unburned methane included.

Consumers and communities take responsibility for these emissions, which would not occur if they were not using the natural gas.

In Tompkins County since 2011, all of our natural gas is shale gas from Pennsylvania. Full life-cycle emissions estimated as ~5.1%

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The alternative: use a 20-yr (or shorter) global warming potential, and up-to-date values (IPCC 2013).

100-yr GWP from IPCC 1996 = 21 (25 from IPCC 2008; 34 from IPCC 2013).

20-yr GWP from IPCC 2013 = 86 (instantaneous GWP = 105)

How methane emissions are included in traditional inventories & analyses:

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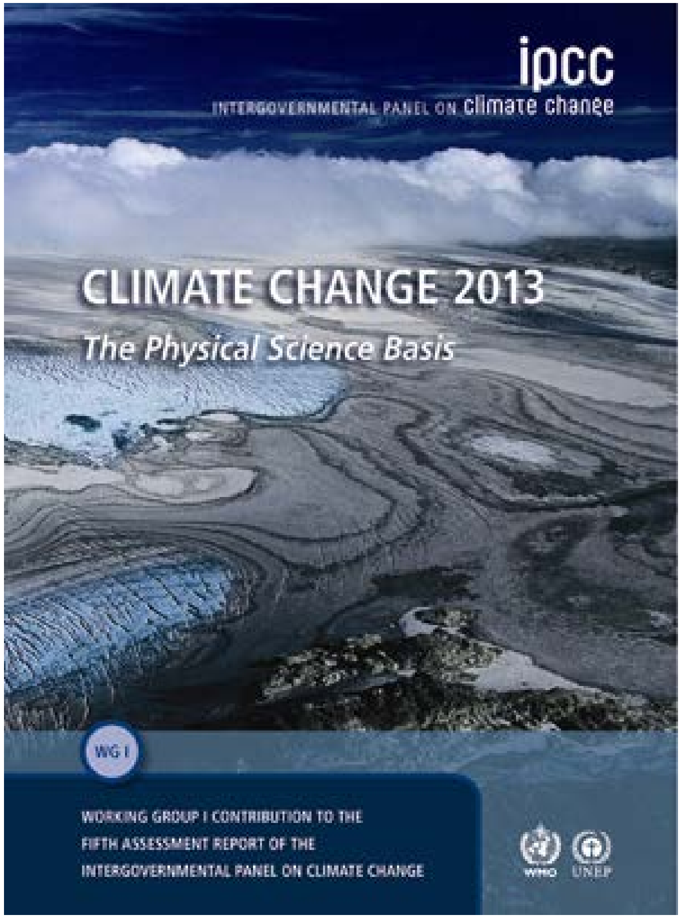
2) Methane compared to CO_2 using 100-yr "global warming potential" (and values used are based on out-of-date science, from IPCC 1996)

The alternative: using full life-cycle methane emissions for shale gas and 20-yr global warming potential increases significance of methane by **1,000-fold**



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.

But 20 year accounting underestimates long-term consequences of carbon dioxide.

Both methane and carbon dioxide are important, and both time frames are important, providing different insights to policy makers.

At COP23 in Bonn (Nov 2017), we called for the routine use of dual accounting: CO_2 alone, and CO_2 plus methane using full life-cycle emissions and 20-yr GWP.

https://unfccc.cloud.streamworld.de/webcast/put-climate-on-pause-coalition-launch

At COP23 in Bonn (Nov 2017), we called for the routine use of dual accounting: CO2 alone, and CO2 plus methane using full life-cycle emissions and 20-yr GWP.

This is precisely the approach used by both Cornell and Tompkins County in 2016, and mandated by Climate & Community Protection Act that passed NY State Assembly in June 2018.

https://unfccc.cloud.streamworld.de/webcast/put-climate-on-pause-coalition-launch

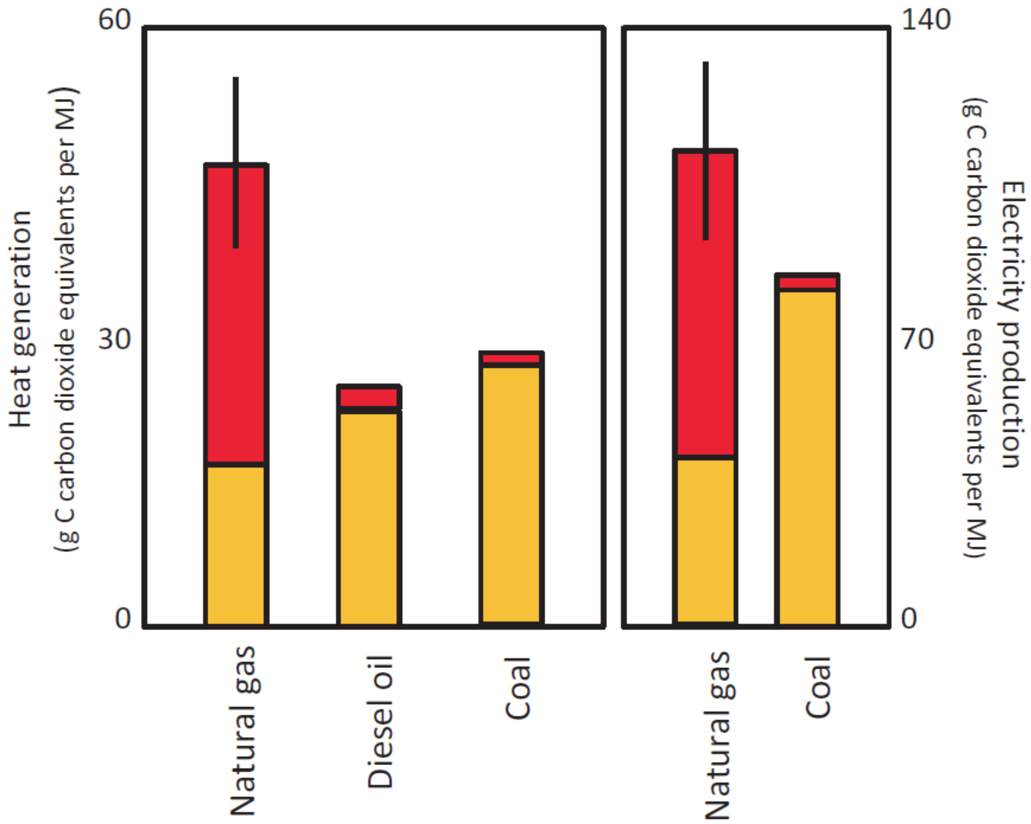


Figure 5. Comparison of the greenhouse gas footprint for using natural gas, diesel oil, and coal for generating primary heat (left) and for using natural gas and coal for generating electricity (right). Direct and indirect carbon dioxide emissions are shown in yellow and are from Howarth et al. [8], while methane emissions shown as g C of carbon dioxide equivalents using the 2013 IPCC 20-year GWP [34] are shown in red. Methane emissions for natural gas are the mean and range for the U.S. national average reported by Brandt and colleagues [29] in their supplemental materials. Methane emissions for diesel oil and for coal are from Howarth et al. [8] For the electricity production, average U.S. efficiencies of 41.8% for gas and 32.8% for coal are assumed [20].

Brandt et al. range is 3.6% to 7.1%, with mean of 5.35%
Most likely estimate for shale gas from Howarth (in review) = 5.1%

Howarth 2014

Cornell University

The science message from Paris and IPCC (2018): we need to move very aggressively away from fossil fuels.

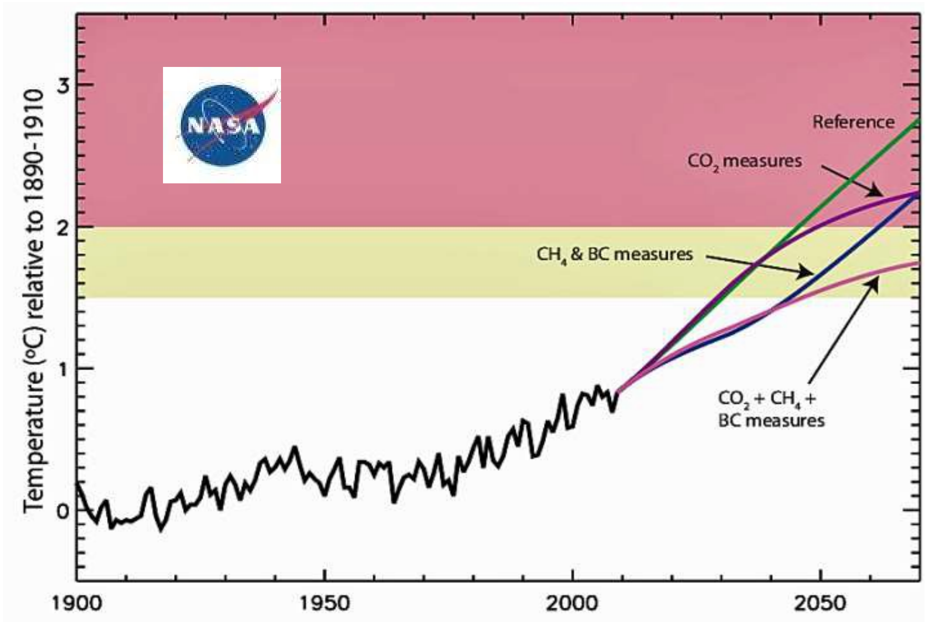
Without appropriate accounting for methane, our policies may inadvertently favor natural gas (shale gas), which is a climate disaster.

Funding:

Cornell University
Park Foundation

More info:

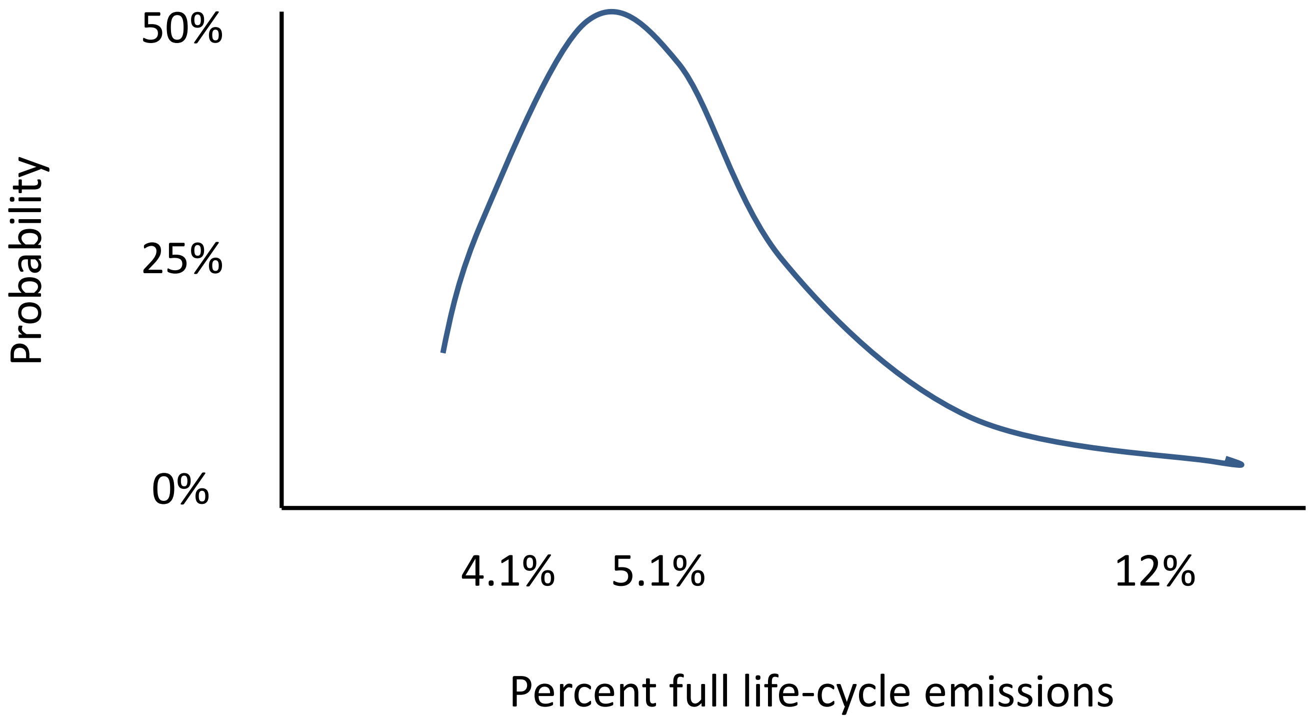
howarthlab.org

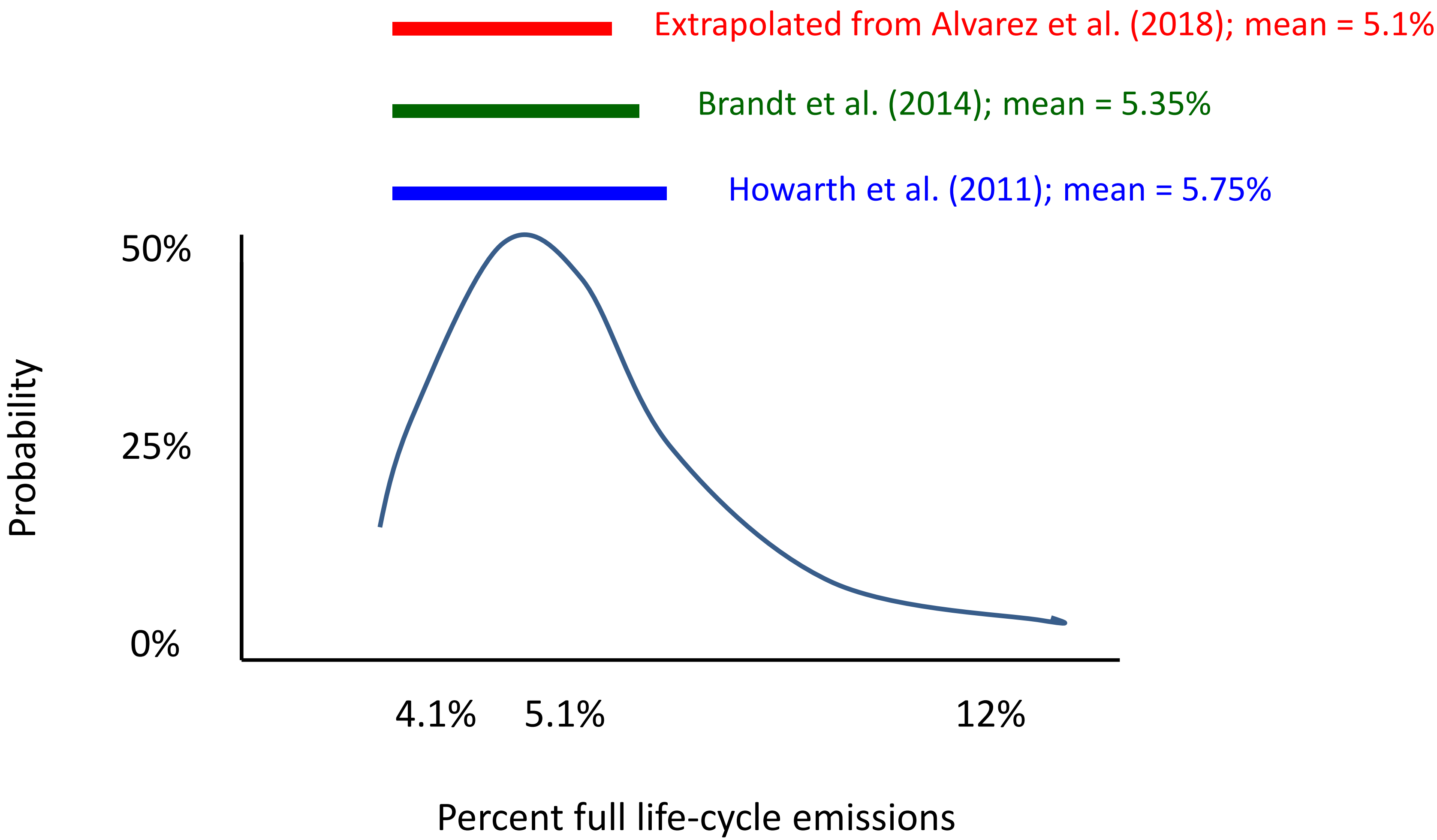


Shindell et al. 2012

Likely best estimate for methane emissions from US shale gas

(based on Howarth, in review)





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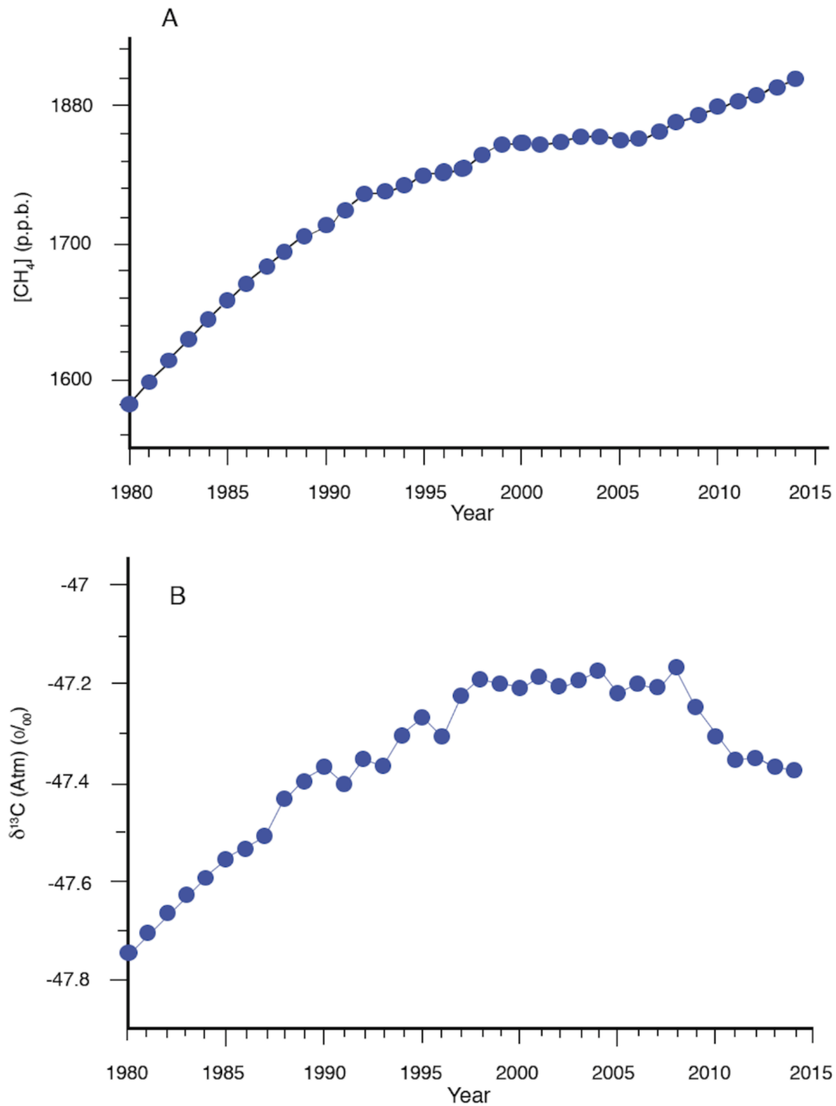
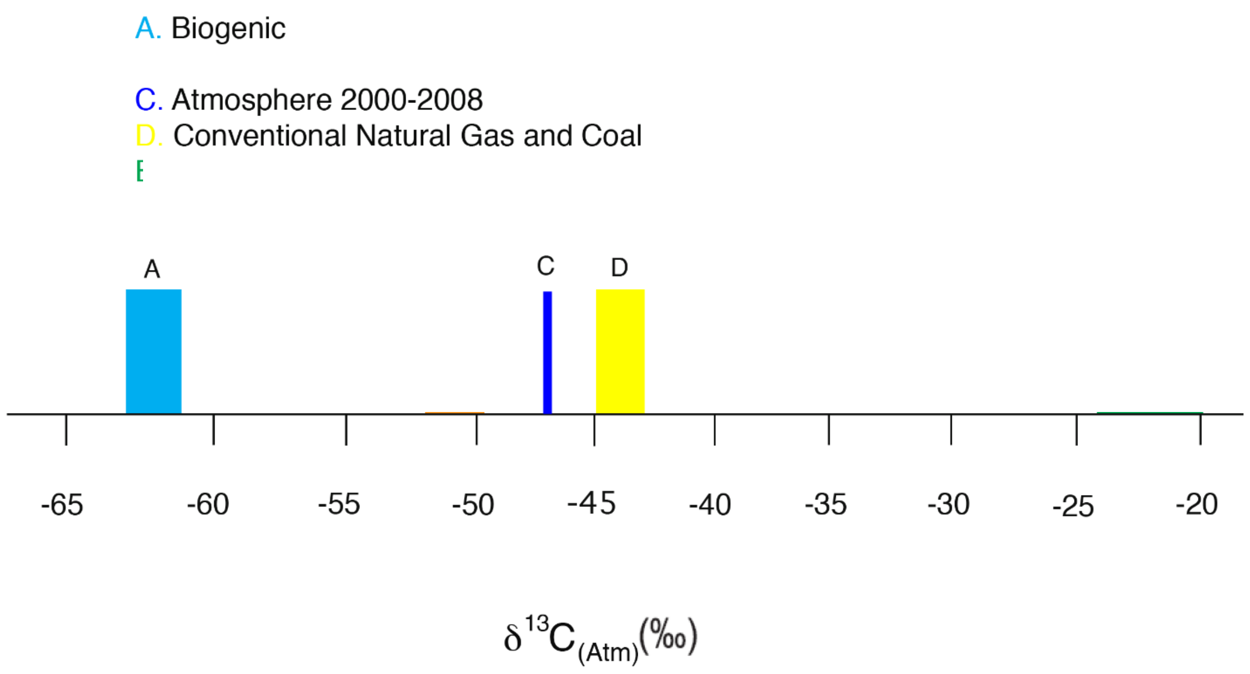
Global trend in atmospheric methane concentration (top) and 13C stable isotopic composition of that methane (bottom), 1980 to 2015



Howarth 2019, based on Schaefer 2016

Average atmospheric C13 composition of global methane (“C”) and major sources that could drive change over recent decades.



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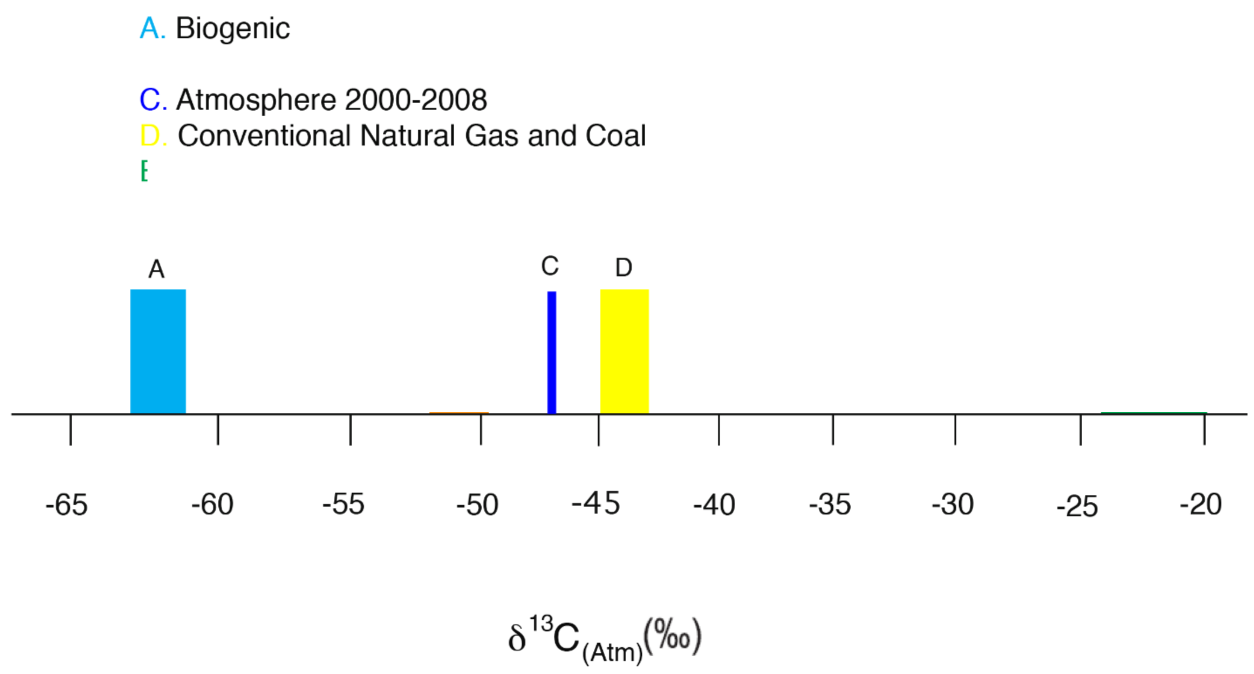

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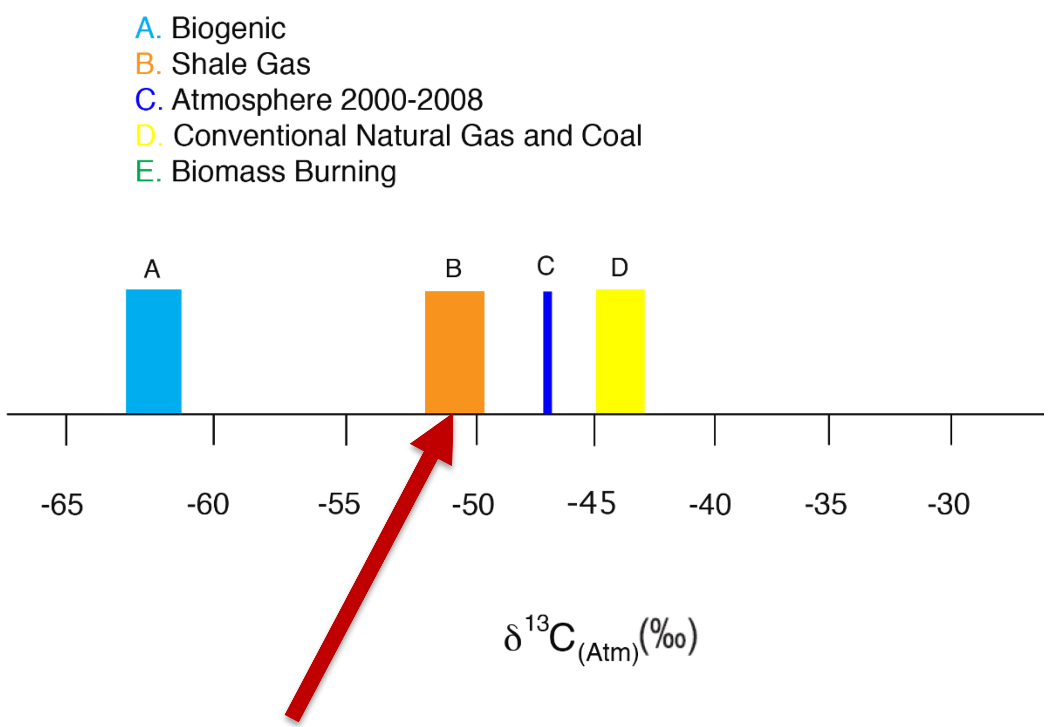

13C signal from shale gas is more negative (less 13C) than from conventional natural gas

Howarth 2019