Cornell University

Shale Gas is a Bridge to Nowhere

Bob Howarth

The David R. Atkinson Professor of Ecology & Environmental Biology

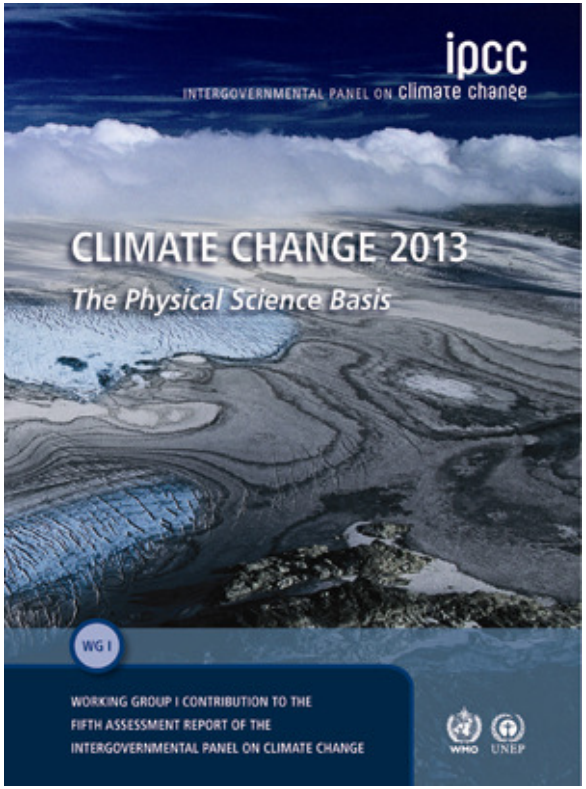
Cornell University

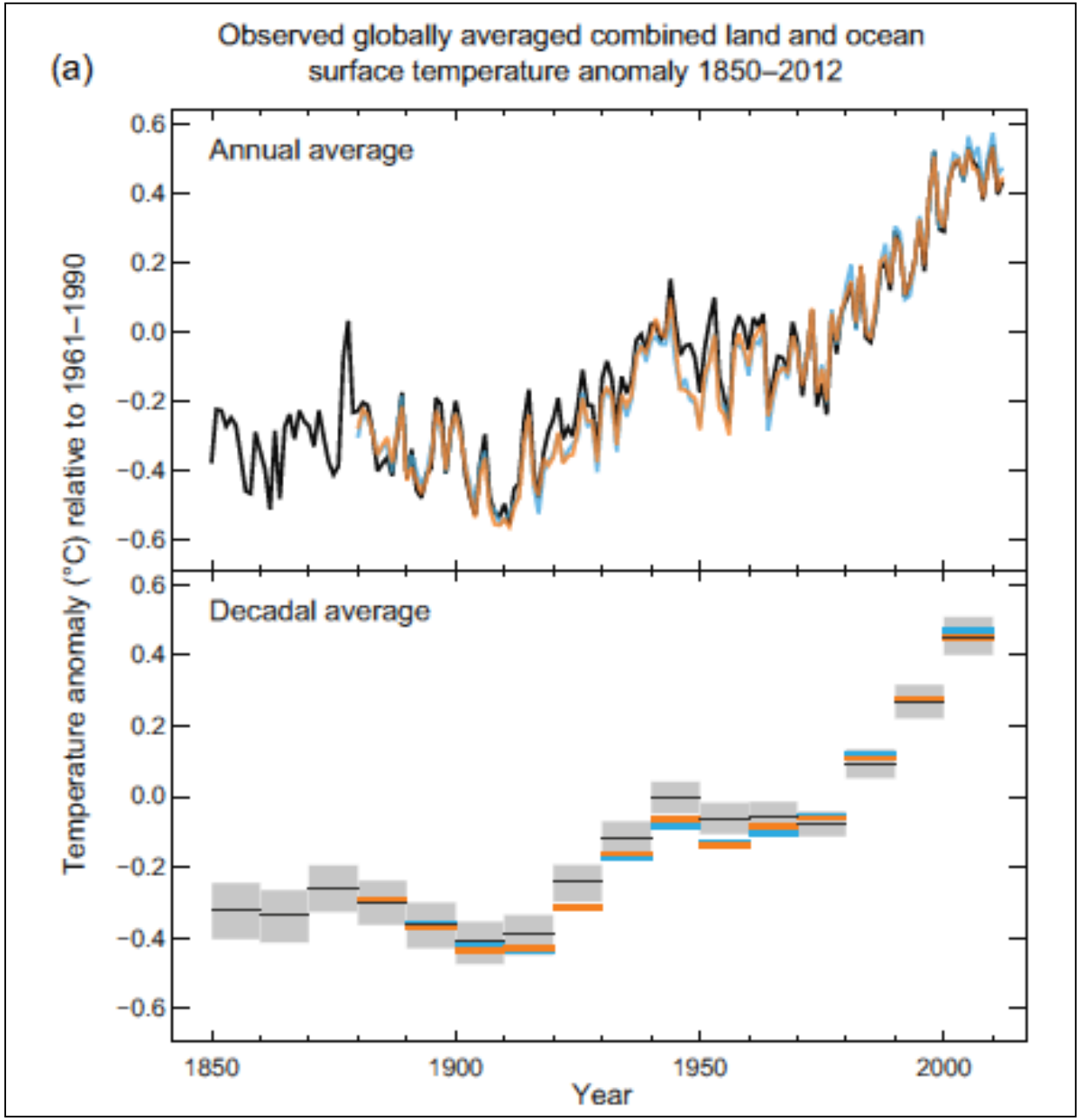
NC WARN Public Empowerment Forum

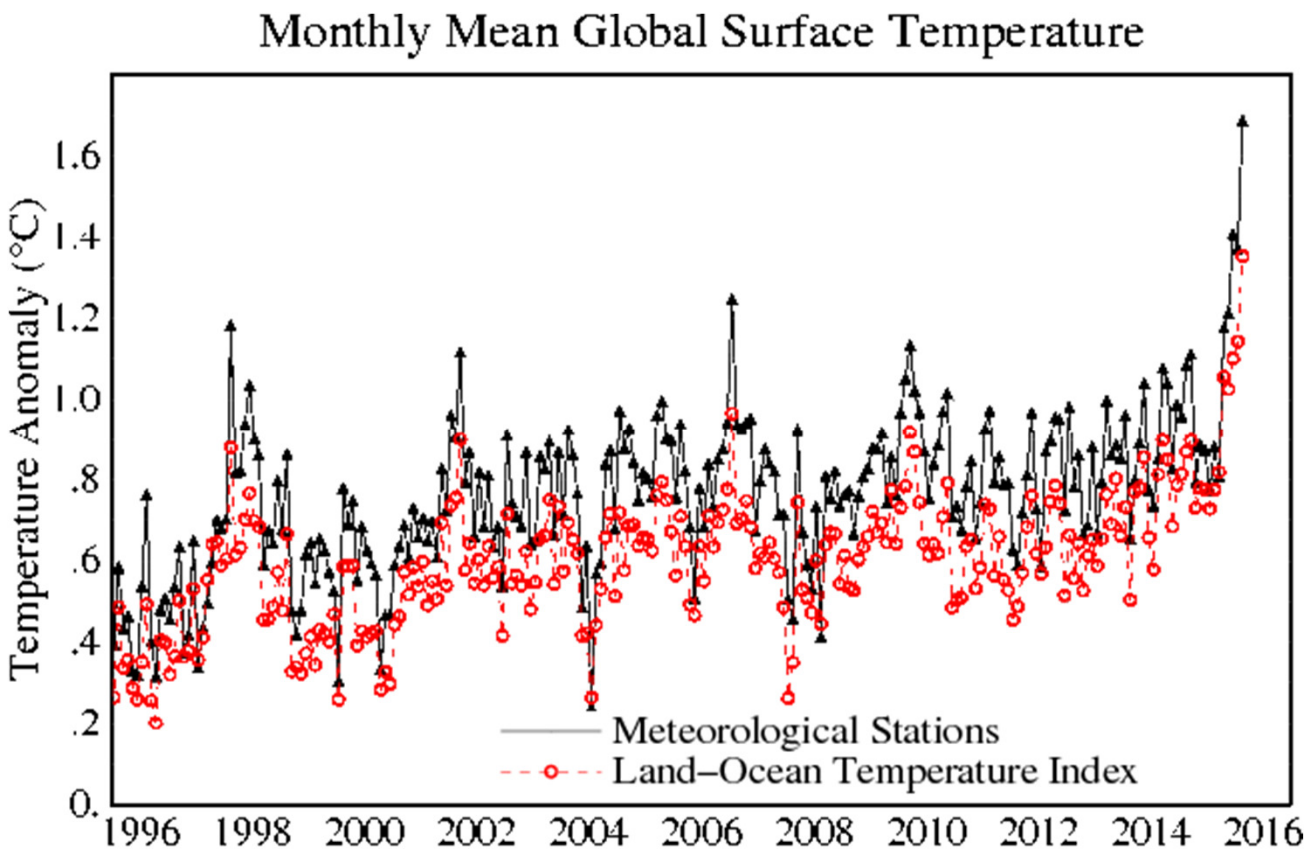
University of North Carolina Friday Center

Chapel Hill, NC

March 29, 2016


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
WMO
UNEP


(a)
Observed globally averaged combined land and ocean surface temperature anomaly 1850–2012
Annual average
Decadal average
Temperature anomaly (°C) relative to 1961–1990
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
1850
1900
1950
2000
Year



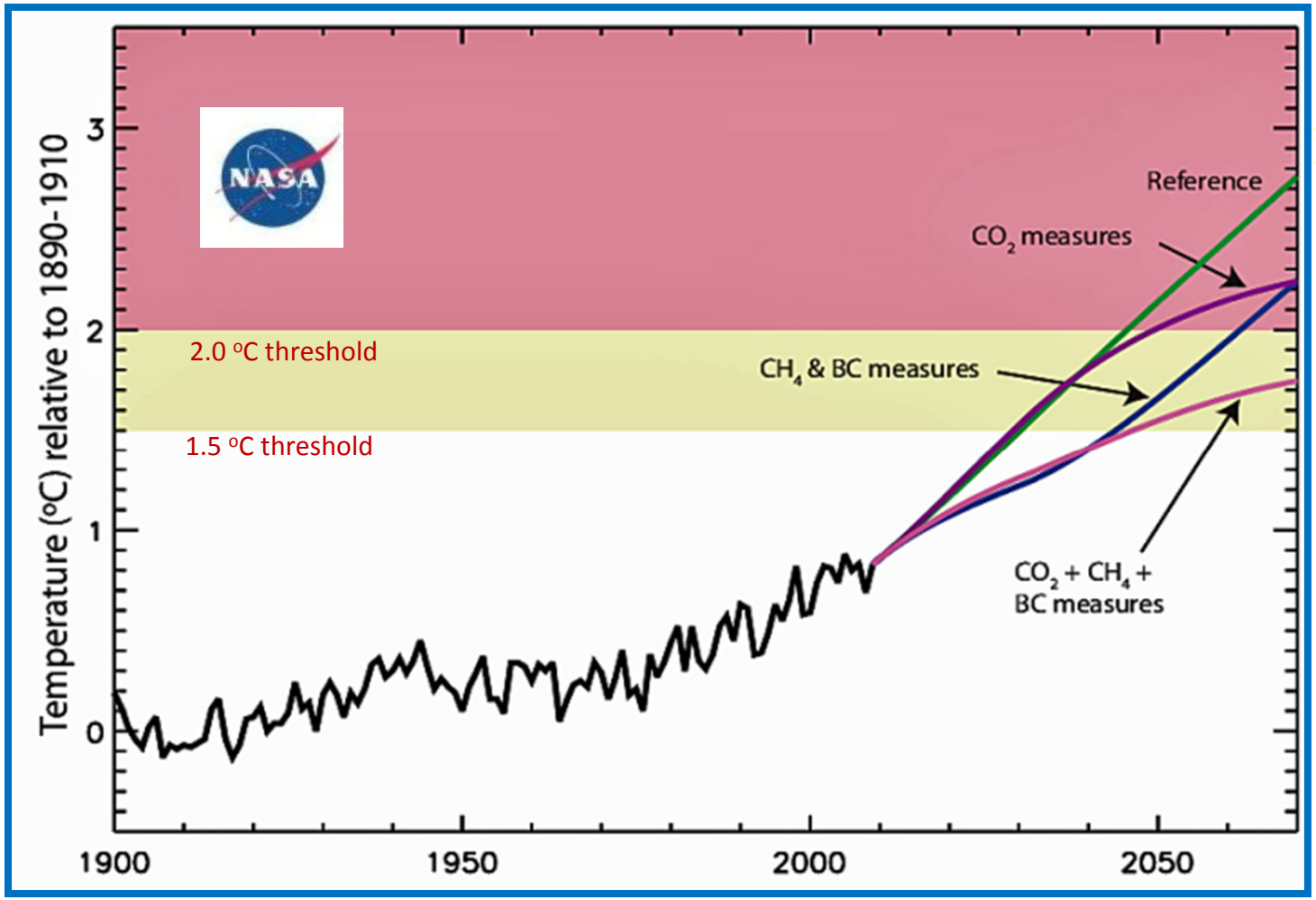
NASA Goddard Institute for Space Studies (downloaded March 13, 2015)

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

- COP21 Paris Accord target: “well below 2 deg C”
- Clear recognition that warming beyond 1.5 deg C is dangerous
- Carbon targets approved at COP21 will lead to 3.5 to 4 deg C
- To reach COP21 target will require the world to be largely free of fossil fuels by 2050 (and the US by 2035)
- Methane reductions are critical; cannot reach COP21 target with CO2 reductions alone

Increasing risk of dangerous tipping points at 1.5 degree C.

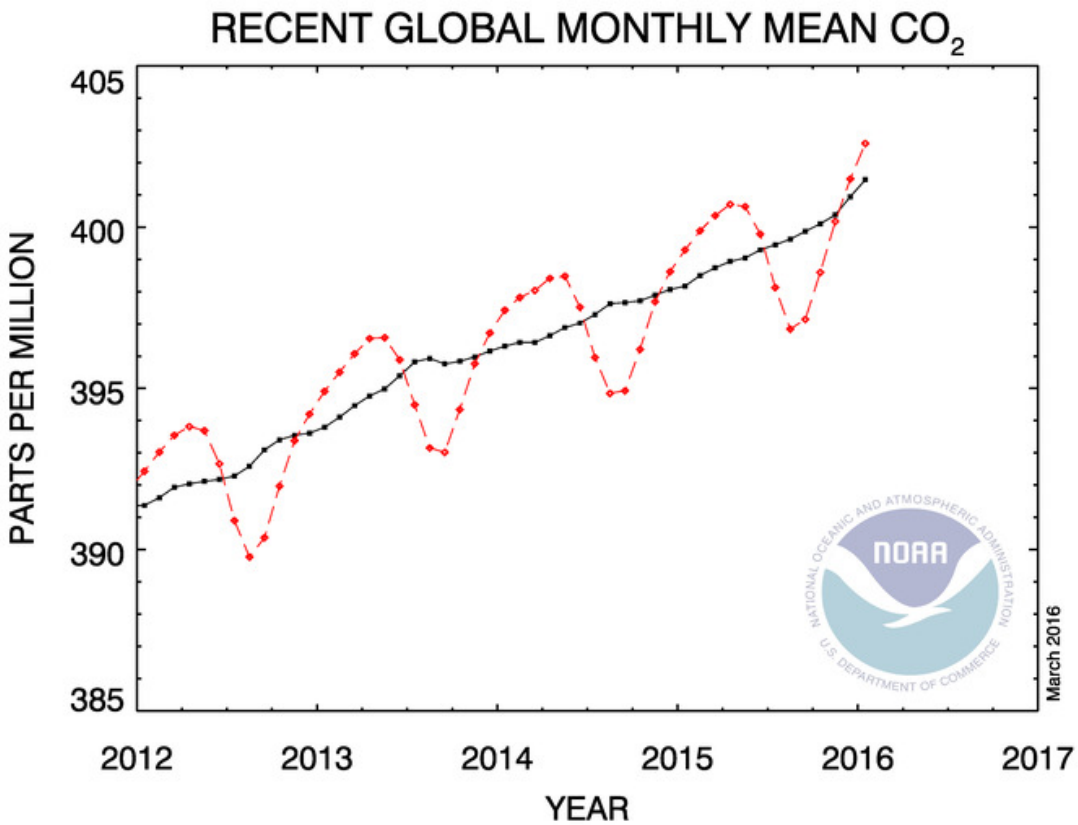
Only 12 to 15 years into the future at current emission rates.



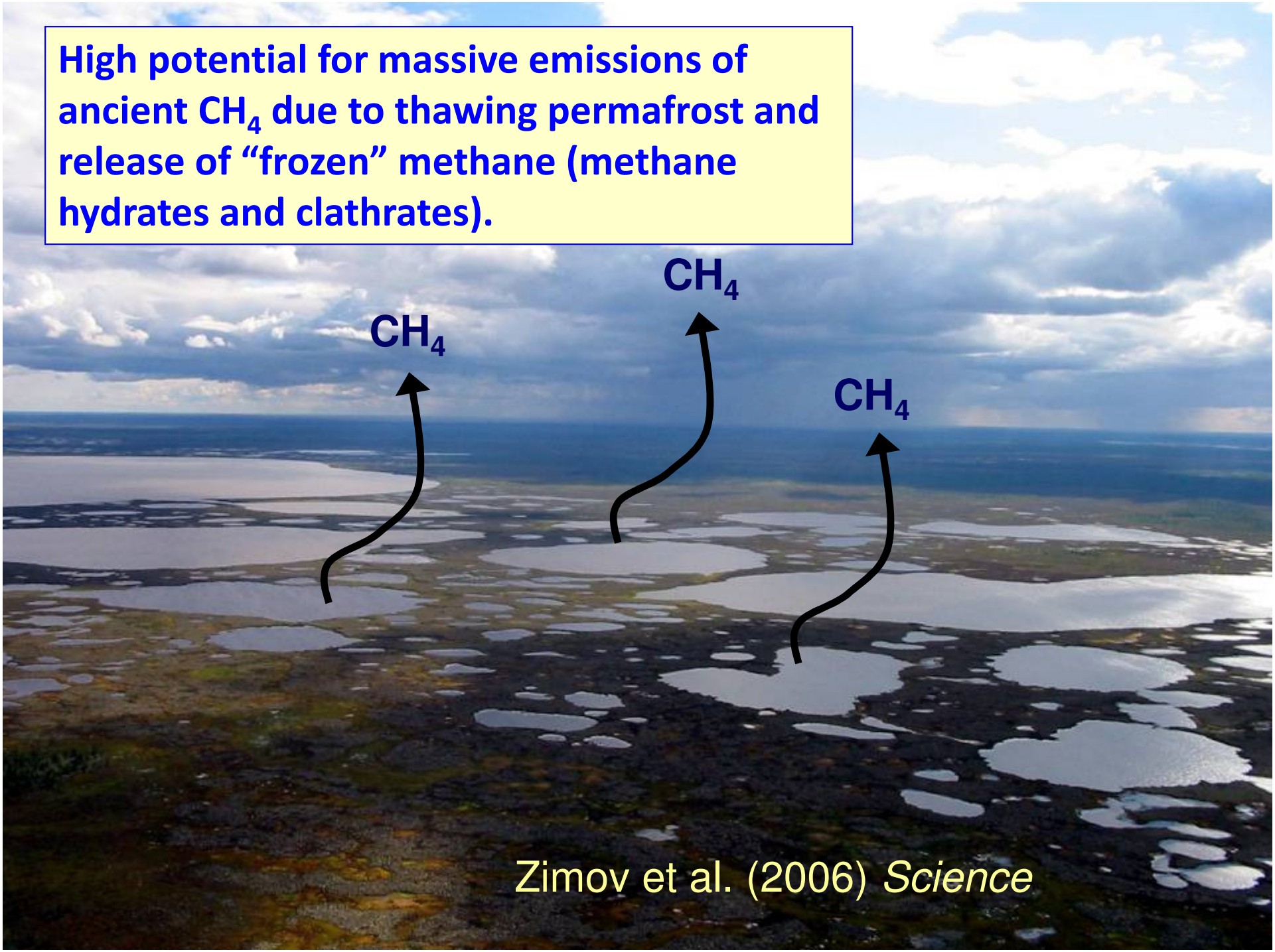
Shindell et al. 2012

Slowing of CO_2 uptake by oceans and forests?

CO_2 emissions have been stable for past few years, yet CO_2 concentration in atmosphere rose at fastest rate ever in 2015, reaching record high last month.



http://www.esrl.noaa.gov/gmd/ccgg/trends/global.html (downloaded March 13, 2016)

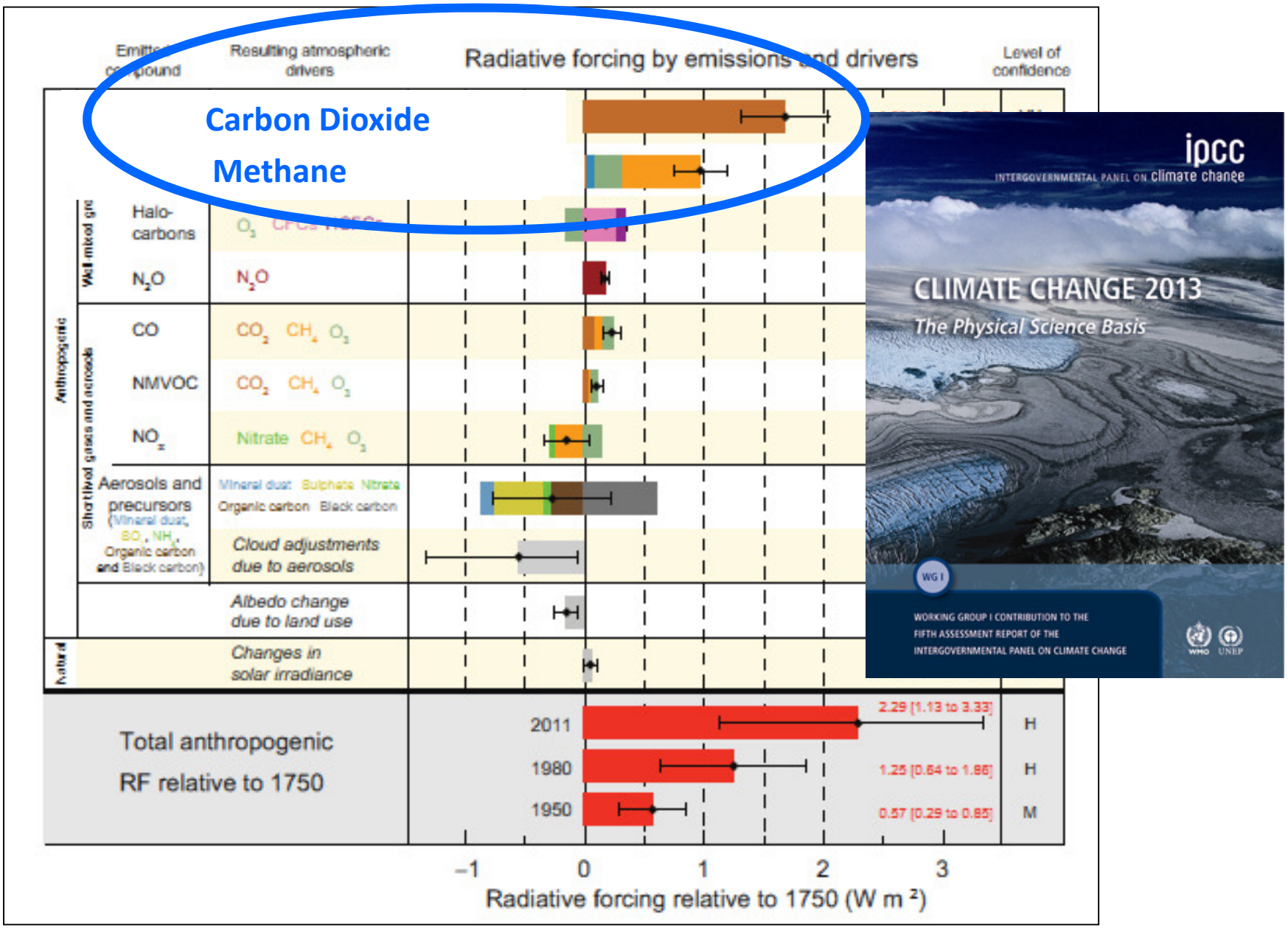

High potential for massive emissions of ancient CH_4 due to thawing permafrost and release of "frozen" methane (methane hydrates and clathrates).
CH_4
CH_4
CH_4
Zimov et al. (2006) *Science*

Is natural gas a "bridge fuel?"

For just the release of carbon dioxide during combustion…..

	g C of CO_2 MJ^{-1} of energy
Natural gas	15
Diesel oil	20
Coal	25

(Hayhoe et al. 2002)


Emitted compound
Resulting atmospheric drivers
Radiative forcing by emissions and drivers
Level of confidence
Carbon Dioxide
Methane
Halo-carbons
N_2O
CO
NMVOC
NO_x
Aerosols and precursors
(Mineral dust, SO2, NH3, Organic carbon and Black carbon)
Mineral dust Sulphate Nitrate
Organic carbon Black carbon
Cloud adjustments due to aerosols
Albedo change due to land use
Changes in solar irradiance
Anthropogenic
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)
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Climatic Change
DOI 10.1007/s10584-011-0061-5

LETTER

Methane and the greenhouse-gas footprint of natural gas from shale formations

A letter

Robert W. Howarth · Renee Santoro · Anthony Ingraffea

Received: 12 November 2010 / Accepted: 13 March 2011
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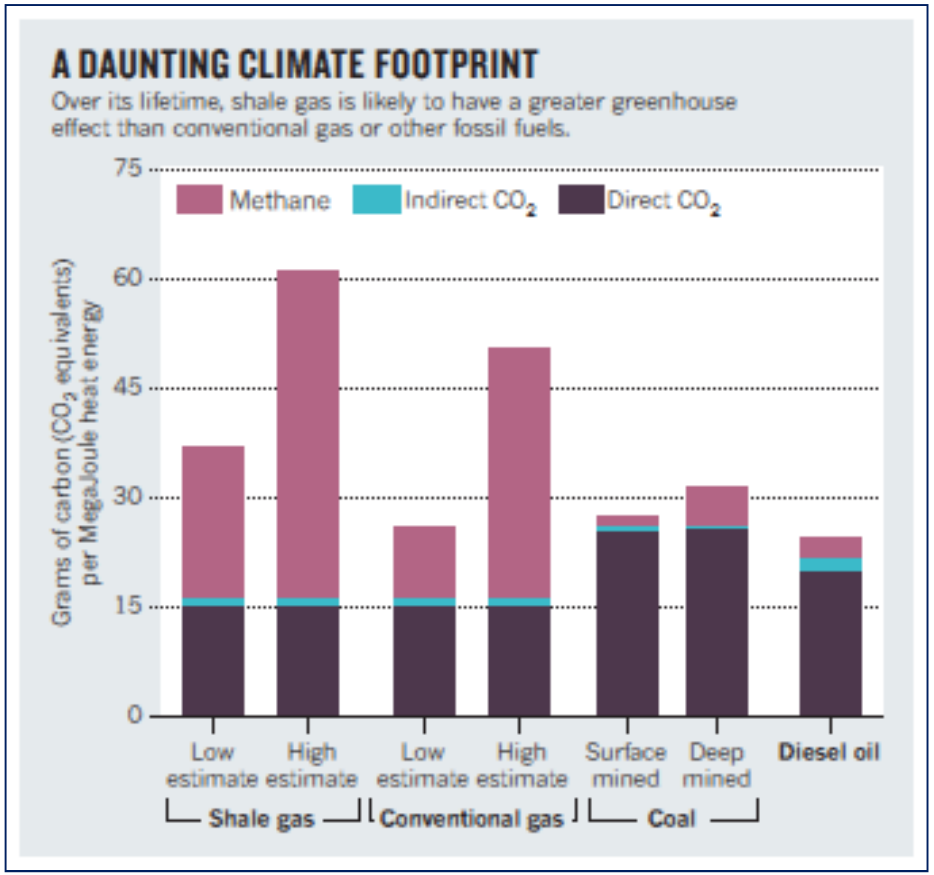
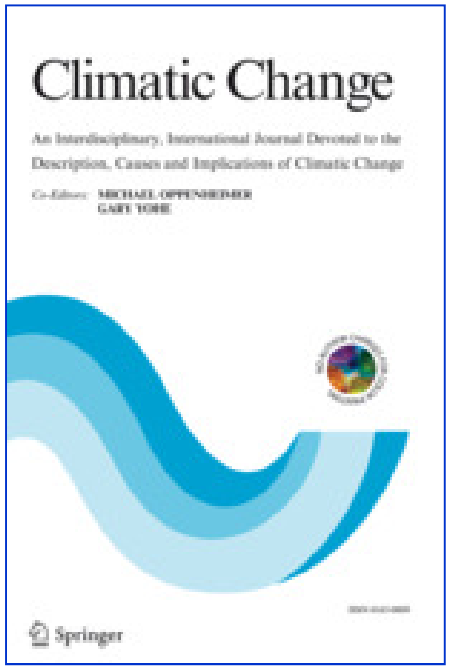
Abstract We evaluate the greenhouse gas footprint of natural gas obtained by high-volume hydraulic fracturing from shale formations, focusing on methane emissions. Natural gas is composed largely of methane, and 3.6% to 7.9% of the methane from shale-gas production escapes to the atmosphere in venting and leaks over the lifetime of a well. These methane emissions are at least 30% more than and perhaps more than twice as great as those from conventional gas. The higher emissions from





- **Natural gas is mostly methane**
- **Small leaks and emissions matter**
- **Shale gas emits more than conventional gas**

TIME Person of the Year

People who Mattered

Mark Ruffalo, Anthony Ingraffea, Robert Howarth
By Bryan Walsh Wednesday, Dec. 14, 2011

The biggest environmental issue of 2011 — at least in the U.S. — wasn't global warming. It was hydraulic fracturing, and these three men helped represent the determined opposition to what's more commonly known as fracking. Anthony Ingraffea is an engineer at Cornell University who is willing to go anywhere to talk to audiences about the geologic risks of fracking, raising questions about the threats that shale gas drilling could pose to water supplies. Robert Howarth is his colleague at Cornell, an ecologist who **produced one of the most controversial scientific studies of the year: a paper arguing that natural gas produced by fracking may actually have a bigger greenhouse gas footprint than coal. That study — strenuously opposed by the gas industry and many of Howarth's fellow scientists — undercut shale gas's major claim as a clean fuel**. And while he's best known for his laidback hipster performances in films like *The Kids Are All Right*, Mark Ruffalo emerged as a tireless, serious activist against fracking — especially in his home state of New York.

TIME Person of the Year

People who Mattered

Mark Ruffalo, Anthony Ingraffea, Robert Howarth
By Bryan Walsh Wednesday, Dec. 14, 2011

Other "People who Mattered" in 2011:

Newt Gingrich, Osama bin Laden, Joe Paterno, Adele, Mitt Romney, Muammar Gaddafi, Barack Obama, Bill McKibben, Herman Cain, Rupert Murdoch, Vladimir Putin, Benjamin Netanyahu…

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Methane and the greenhouse-gas footprint of natural gas from shale formations

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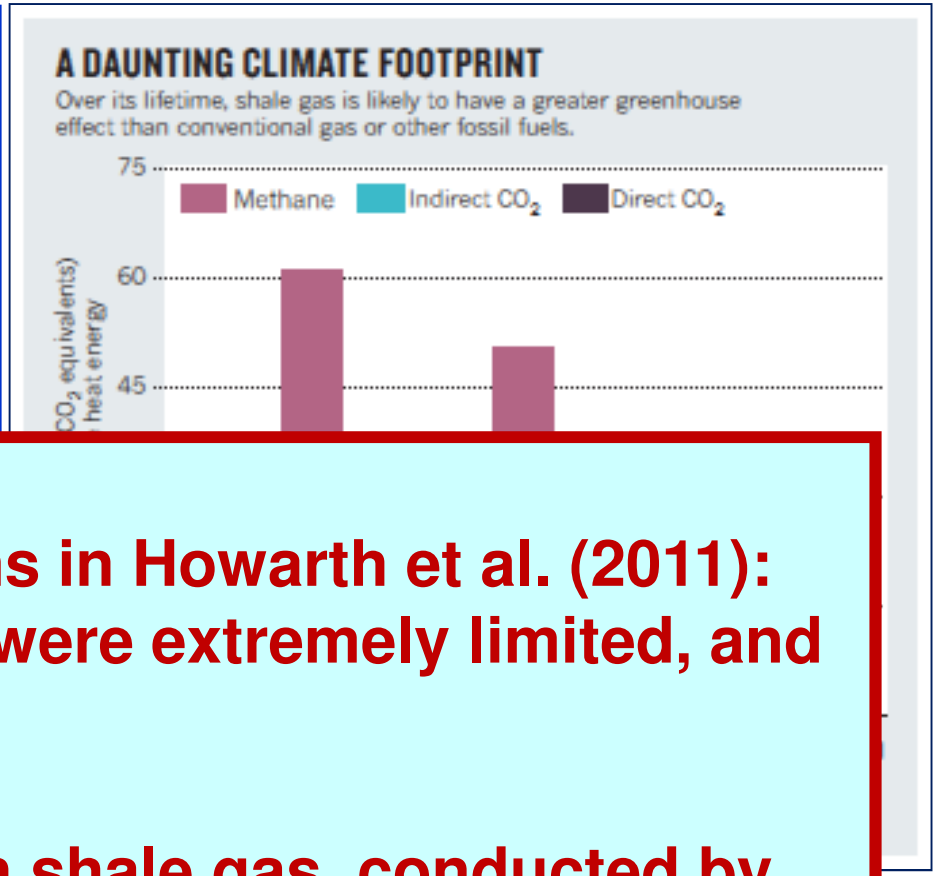


One of our major conclusions in Howarth et al. (2011): pertinent data for shale gas were extremely limited, and poorly documented.

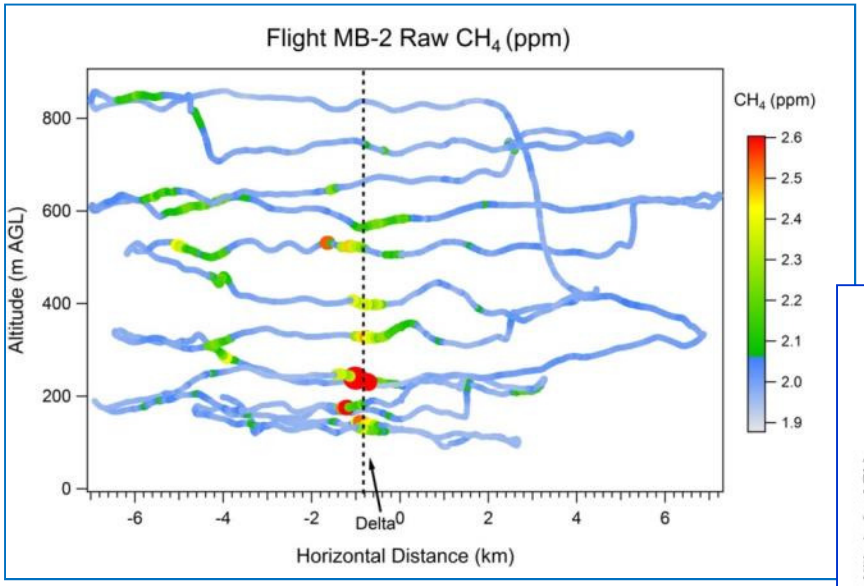
Great need for better data on shale gas, conducted by researchers free of industry control and influence.

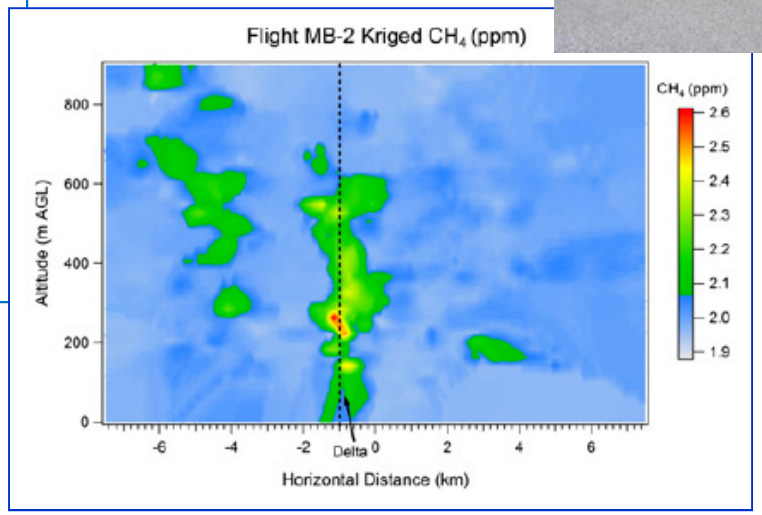
Proceedings of the National Academy of Sciences of the United States of America

Toward a better understanding and quantification of methane emissions from shale gas development

Dana R. Caulton[a,1], Paul B. Shepson[a,b], Renee L. Santoro[c], Jed P. Sparks[d], Robert W. Howarth[d], Anthony R. Ingraffea[c,e], Maria O. L. Cambaliza[a], Colm Sweeney[f,g], Anna Karion[f,g], Kenneth J. Davis[h], Brian H. Stirm[i], Stephen A. Montzka[f], and Ben R. Miller[f,g]

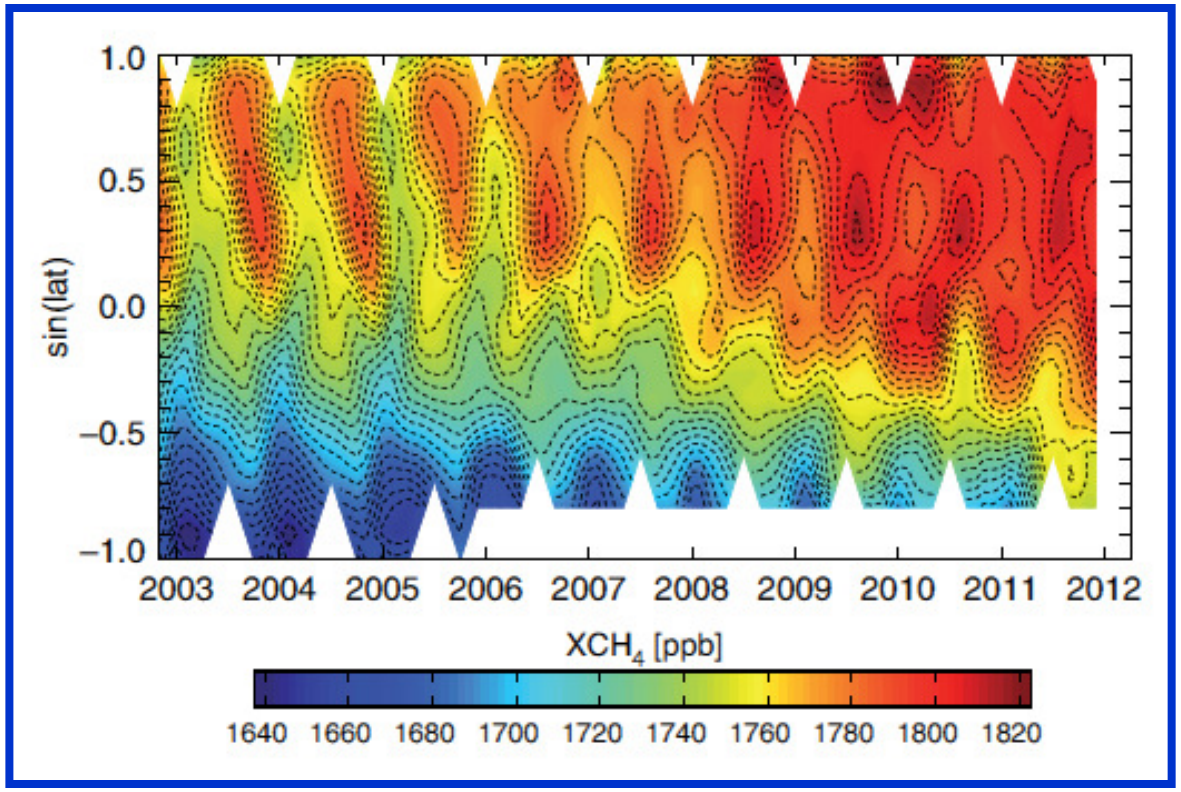
Departments of [a]Chemistry, [b]Earth, Atmospheric and Planetary Science, and [i]Aviation Technology, Purdue University, West Lafayette, IN 47907; [c]Physicians, Scientists and Engineers for Healthy Energy, Ithaca, NY 14851; Departments of [d]Ecology and Evolutionary Biology and [e]Civil and Environmental Engineering, Cornell University, Ithaca, NY 14853; [f]National Oceanic and Atmospheric Administration, Boulder, CO 80305; [g]Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO 80309; and [h]Department of Meteorology, The Pennsylvania State University, University Park, PA 16802





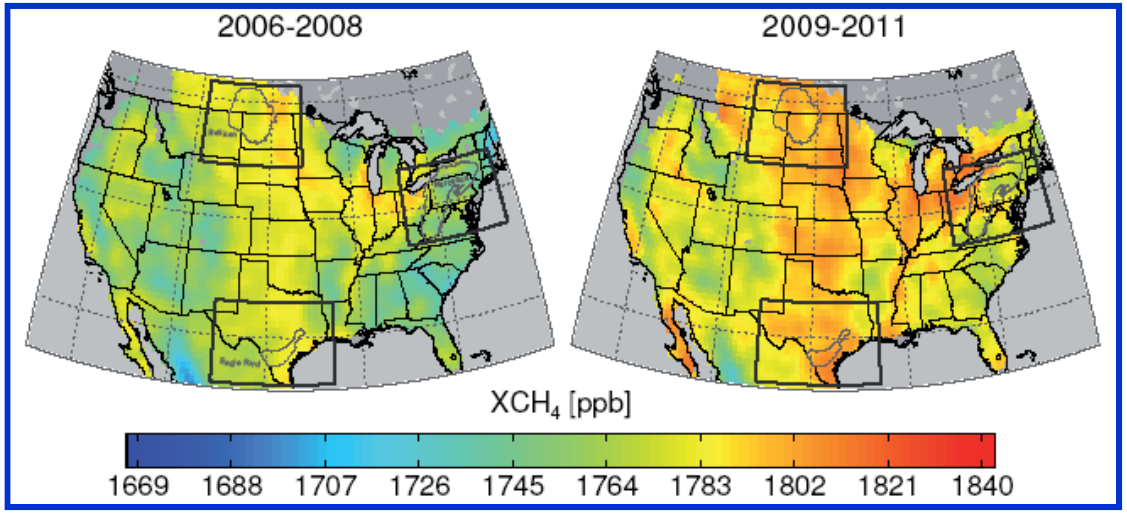
AGU PUBLICATIONS

Schneising et al. (2014) – "Remote sensing of fugitive methane emissions from oil and gas production in North American tight geologic formations." *Earth's Future* 2: 548-558

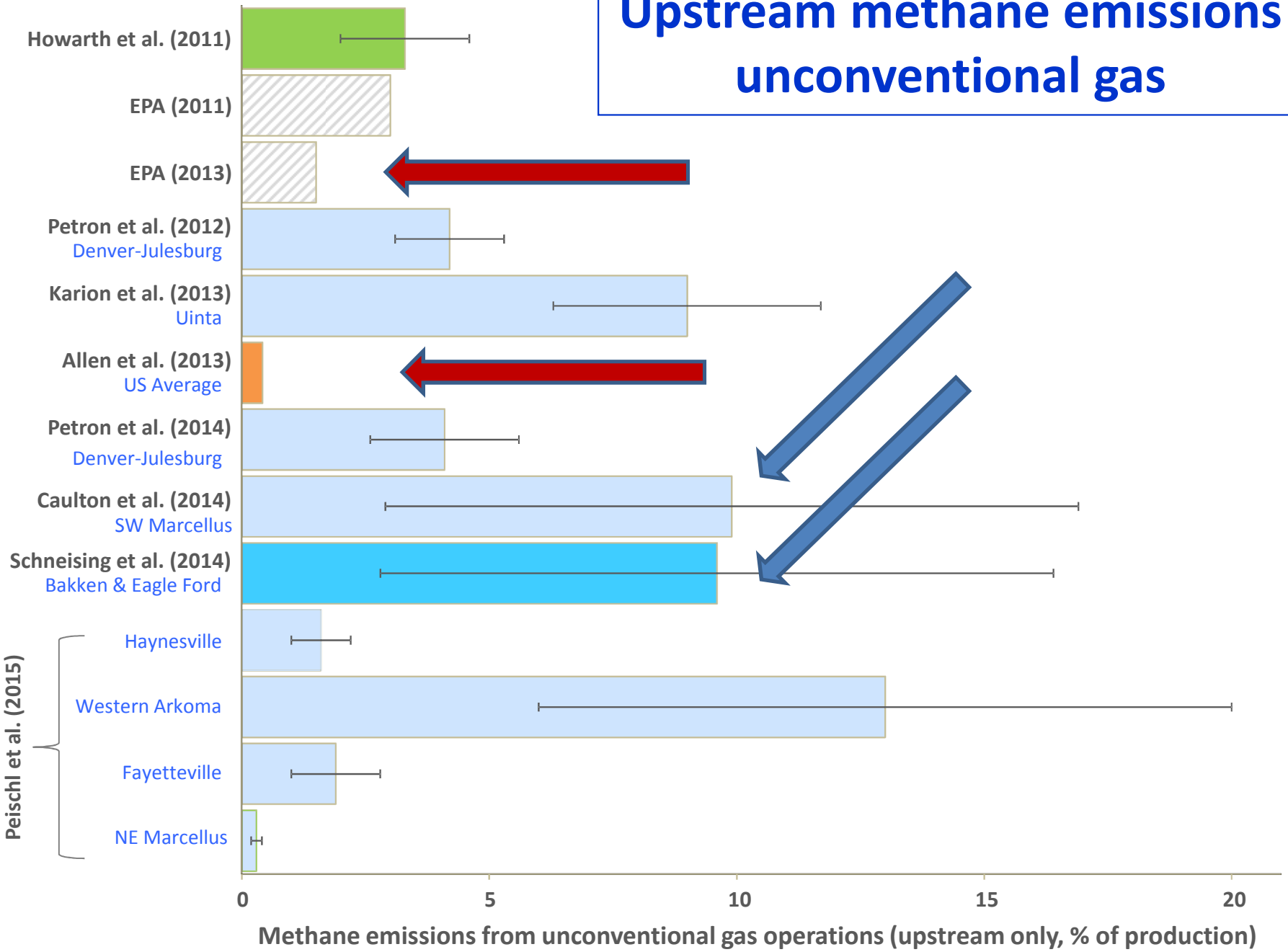


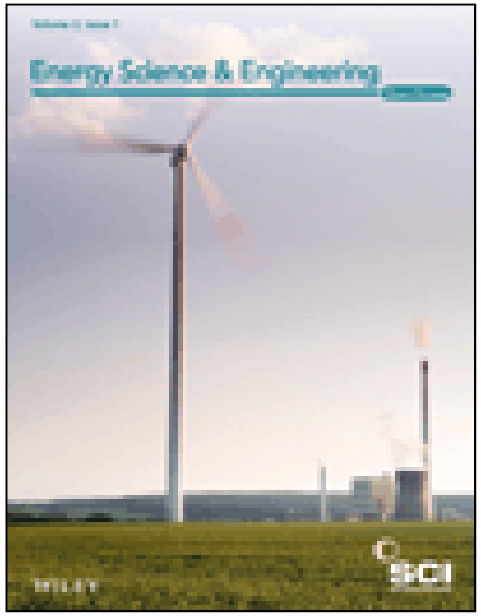
global

United States



Upstream methane emissions unconventional gas





Energy Science & Engineering

Open Access

RESEARCH ARTICLE

University of Texas study underestimates national methane emissions at natural gas production sites due to instrument sensor failure

Touché Howard

Indaco Air Quality Services, Inc., Durham, North Carolina

Keywords
Greenhouse gases, methane, natural gas

Correspondence
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E-mail: touche.howard@indacoaqs.com

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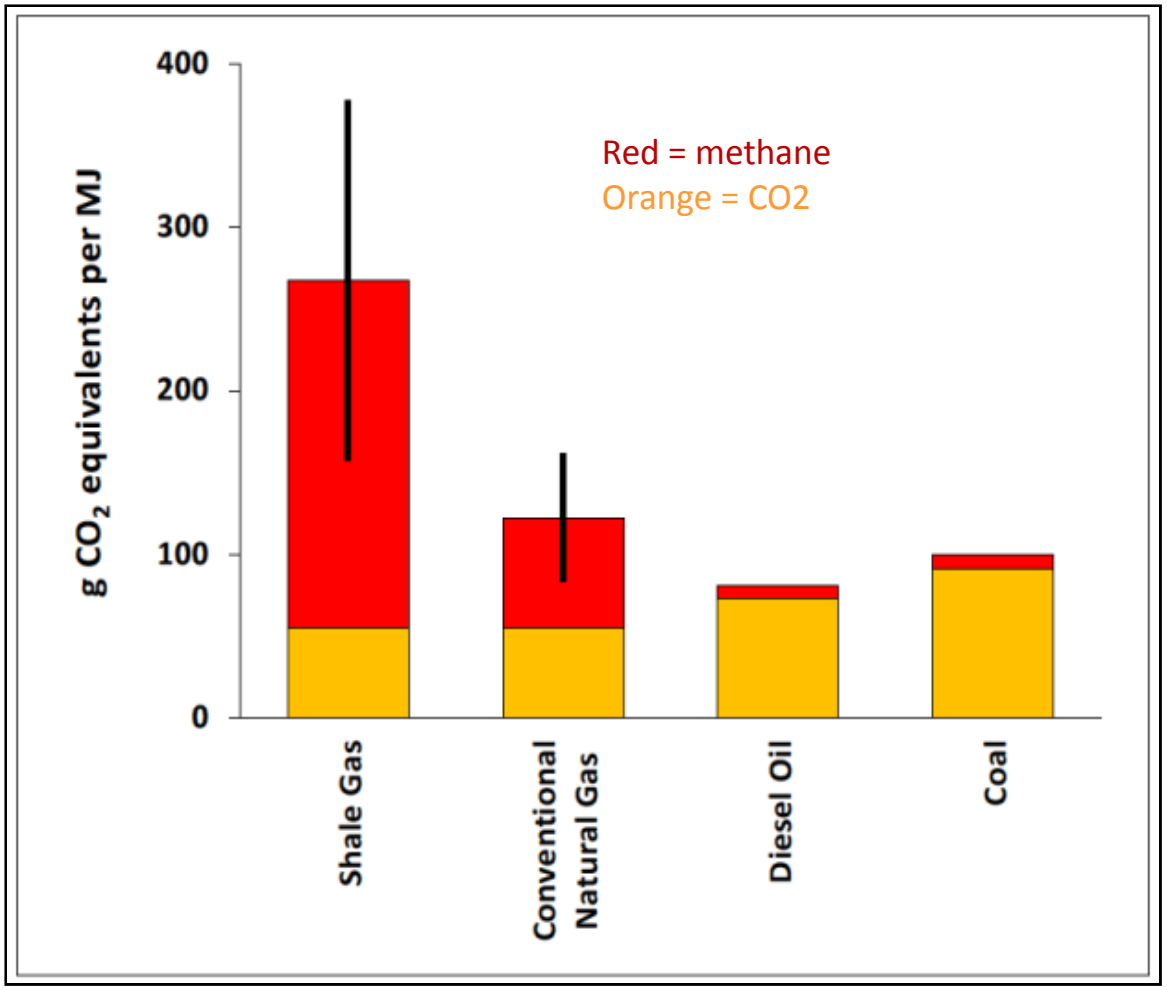
doi: 10.1002/ese3.81

Abstract

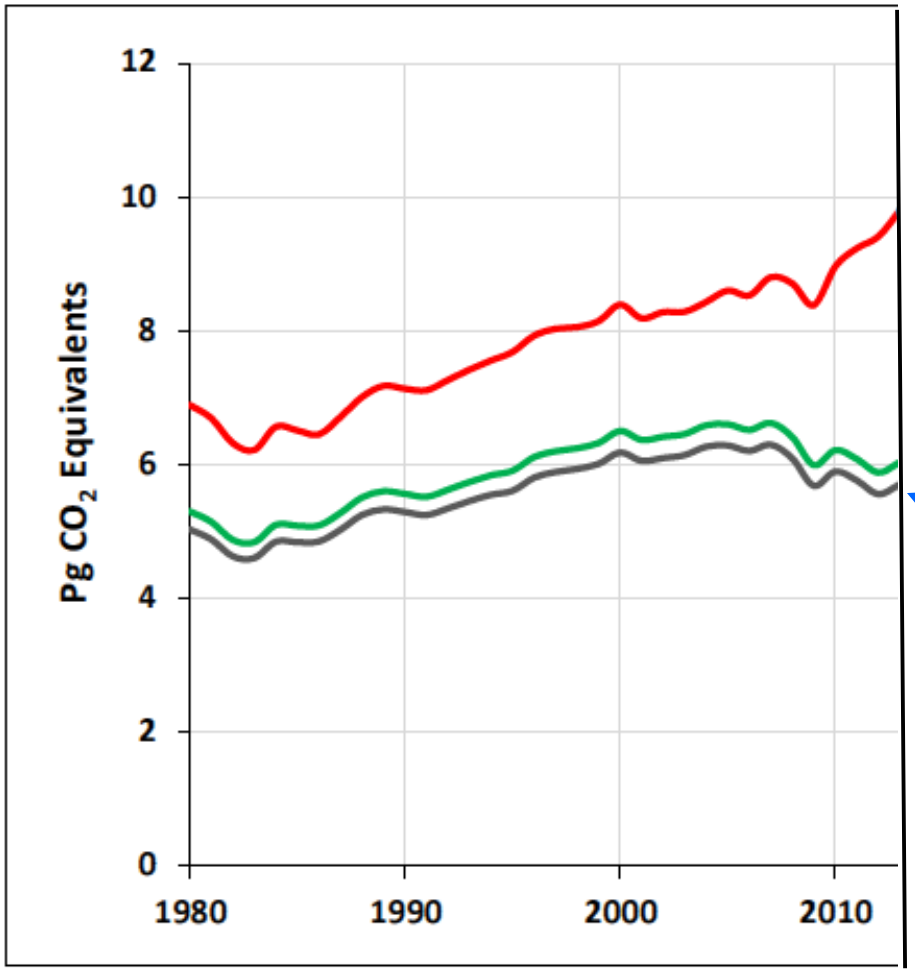
The University of Texas reported on a campaign to measure methane (CH_4) emissions from United States natural gas (NG) production sites as part of an improved national inventory. Unfortunately, their study appears to have systematically underestimated emissions. They used the Bacharach Hi-Flow® Sampler (BHFS) which in previous studies has been shown to exhibit sensor failures leading to underreporting of NG emissions. The data reported by the University of Texas study suggest their measurements exhibit this sensor failure, as shown by the paucity of high-emitting observations when the wellhead gas composition was less than 91% CH_4, where sensor failures are most likely; during follow-up testing, the BHFS used in that study indeed exhibited sensor failure consistent with under-reporting of these high emitters. Tracer ratio measurements made by the University of Texas at a subset of sites with low CH_4 content further indicate that the BHFS measurements at these sites were too low by factors of three to five. Over 98% of the CH_4 inventory calculated from their own data and 41% of their compiled national inventory may be affected by this measurement failure. Their data also indicate that this sensor failure could occur at NG compositions as high as 97% CH_4, possibly affecting other BHFS measurement programs throughout the entire NG supply chain, including at transmission sites where the BHFS is used to report greenhouse gas emissions to the United States Environmental Protection Agency Greenhouse Gas Reporting Program (USEPA GHGRP, U.S. 40 CFR Part 98, Subpart W). The presence of such an obvious problem in this high profile, landmark study highlights the need for increased quality assurance in all greenhouse gas measurement programs.

Greenhouse gas footprints, CO_2 plus methane (averaged for 20 years after emission)



Howarth 2015 *Energy Emissions & Control Technologies*

US Greenhouse Gas Emissions from Fossil Fuel Use, 1980 - 2014



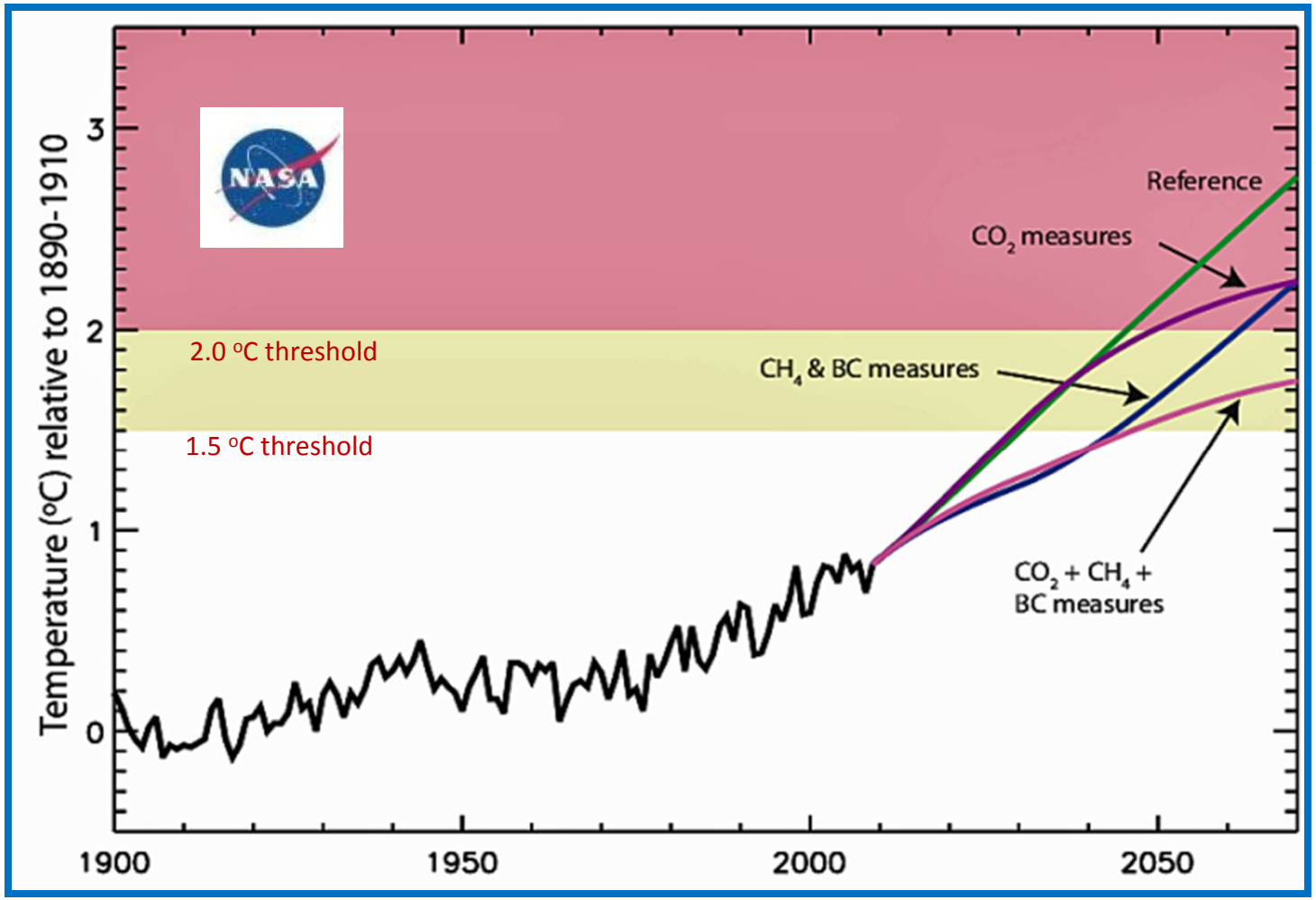
Total emissions (with best accounting for methane)

EPA estimate for total emissions

Just CO2

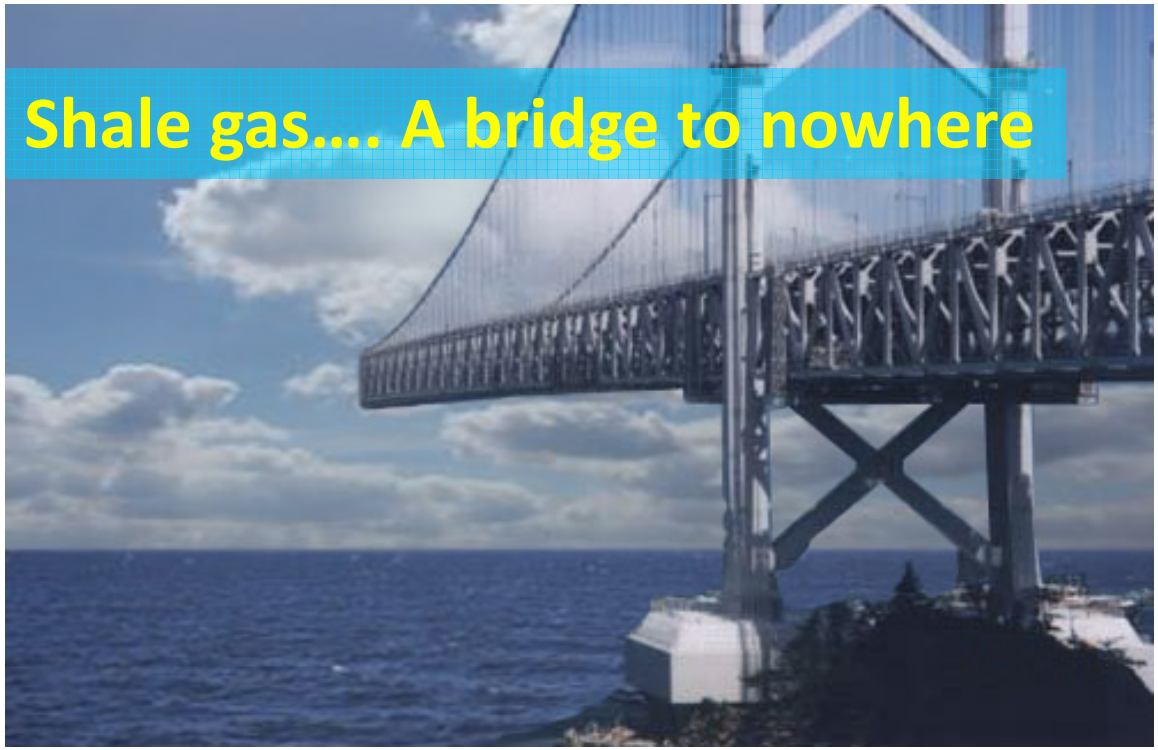
Howarth 2015 *Energy Emissions & Control Technologies*

Controlling methane is *Essential* to the solution!



Shindell et al. 2012

So what should our energy future be?



Powering New York State with Wind, Water, and the Sun to Address Global Warming, Air Pollution, & Energy Security

Energy Policy ▮ (▮▮▮▮) ▮▮▮–▮▮▮

Contents lists available at SciVerse ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Examining the feasibility of converting New York State's all-purpose energy infrastructure to one using wind, water, and sunlight

Mark Z. Jacobson[a,*], Robert W. Howarth[b], Mark A. Delucchi[c], Stan R. Scobie[d], Jannette M. Barth[e], Michael J. Dvorak[a], Megan Klevze[a], Hind Katkhuda[a], Brian Miranda[a], Navid A. Chowdhury[a], Rick Jones[a], Larson Plano[a], Anthony R. Ingraffea[f]

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[b] Department of Ecology and Evolutionary Biology, Cornell University Ithaca, NY 14853, USA
[c] Institute of Transportation Studies, U.C. Davis, Davis, CA 95616, USA
[d] PSE Healthy Energy, NY, USA
[e] Pepacton Institute LLC, USA
[f] School of Civil and Environmental Engineering, Cornell University, Ithaca, NY 14853, USA

HIGHLIGHTS

- New York State's all purpose energy can be derived from wind, water, and sunlight.
- The conversion reduces NYS end use power demand by ~37%.
- The plan creates more jobs than lost since most energy will be from in state.
- The plan creates long term energy price stability since fuel costs will be zero.
- The plan decreases air pollution deaths 4000/yr ($33 billion/yr or 3% of NYS GDP).

ARTICLE INFO

Article History:
Received 14 September 2012
Accepted 18 February 2013

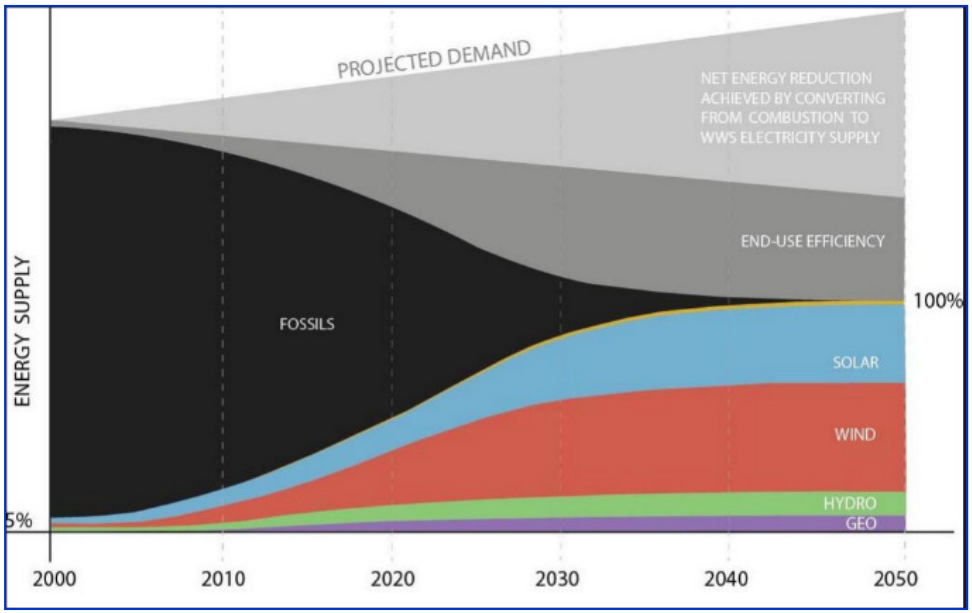
Keywords:

ABSTRACT

This study analyzes a plan to convert New York State's (NYS's) all purpose (for electricity, transportation, heating/cooling, and industry) energy infrastructure to one derived entirely from wind, water, and sunlight (WWS) generating electricity and electrolytic hydrogen. Under the plan, NYS's 2030 all purpose end use power would be provided by 10% onshore wind (4020 5 MW turbines), 40% offshore wind (12,700 5 MW turbines), 10% concentrated solar (387 100 MW plants), 10% solar PV

Our NY State "2030" Plan:

- Electrify transportation and heating – greater efficiencies lower total energy consumption.
- Generate all electricity from wind, solar, and water power.
- Rely on technologies that are commercially available today.
- Balance demand to production, modernize grid, increase electricity storage somewhat.



Prof. Mark Jacobson

Howarth-Marino home (1890's farm house) is 100% carbon neutral, with geothermal heating and renewable electricity.

Half of our driving is by electric car.

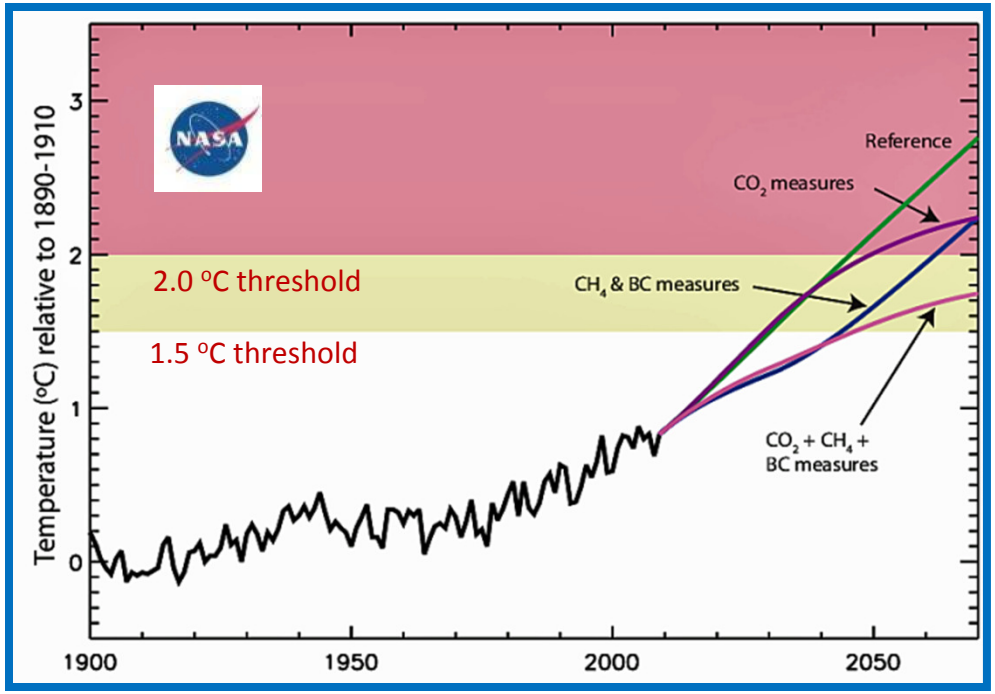
Cornell University

Funding:

Cornell University

Park Foundation

For more information:
howarthlab.org



PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

The science message from Paris: we need to move very aggressively away from fossil fuels.

We particularly need to get rid of natural gas.