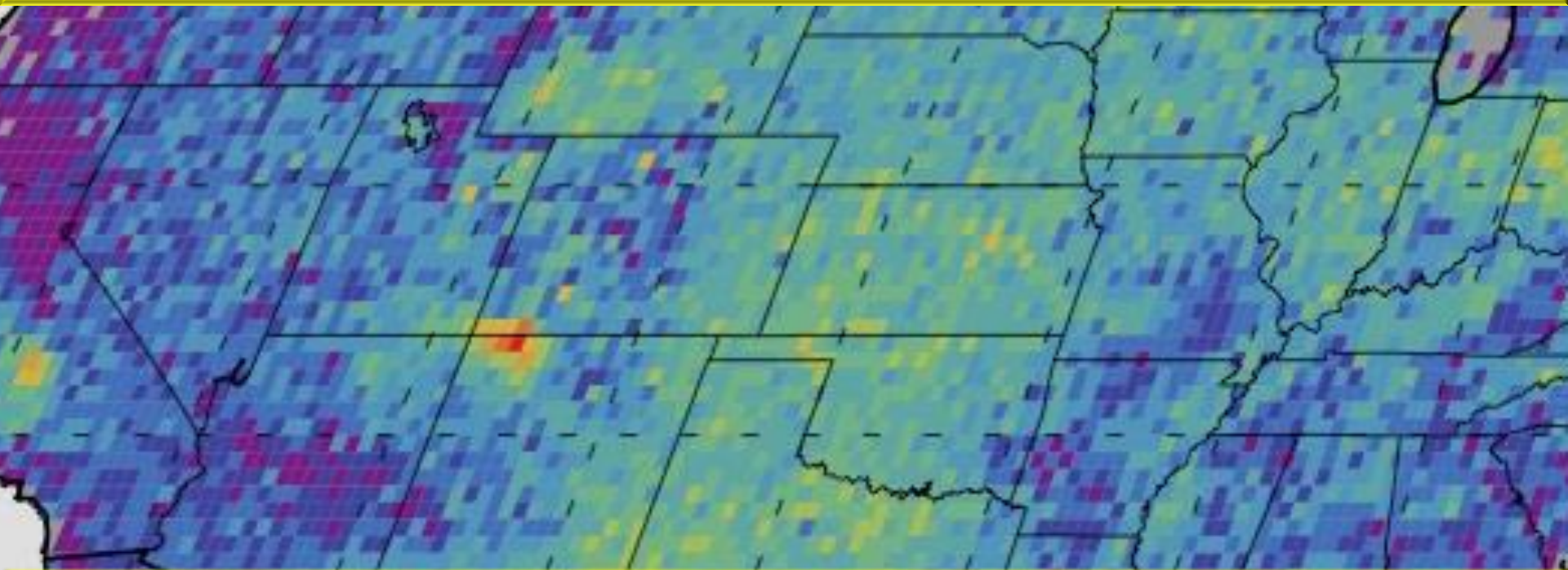


New Mexico's Atmospheric Methane

A story of Madness and Mystery



Bob Endlich

bendlich@msn.com

18 June 2016

Cruces Atmospheric Sciences Forum

Acknowledgements

Dave Tofsted for helping puzzle through the Kort et. al. publication,
AGU Research Letter:

Four corners: The largest US methane anomaly viewed from space

Mike Wallace: For comments, especially noting that the anomaly does not appear
in the Permian Basin of West Texas and Southeast New Mexico

Bernie McCune for graphics, information from the Bulletin, and helpful comments as
I was trying to assemble thoughts on the Methane Mystery.

Others in the group who helped, thank you.

A Story of Methane Madness and Mystery

Background Information on Methane
Space-based Measurements

Airborne and Surface Measurements

San Juan Basin Background Information

Recent publications raising alarm on Atmospheric
Methane in New Mexico's 4-Corners Region

Methane Madness in New Mexico

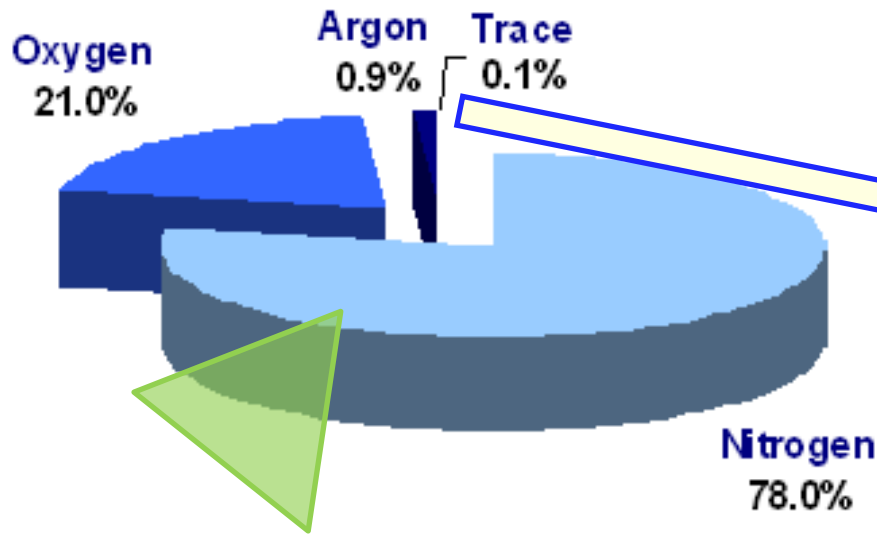
Methane Mystery still not resolved

Background Information on Methane

Concentrations of Atmospheric Gases

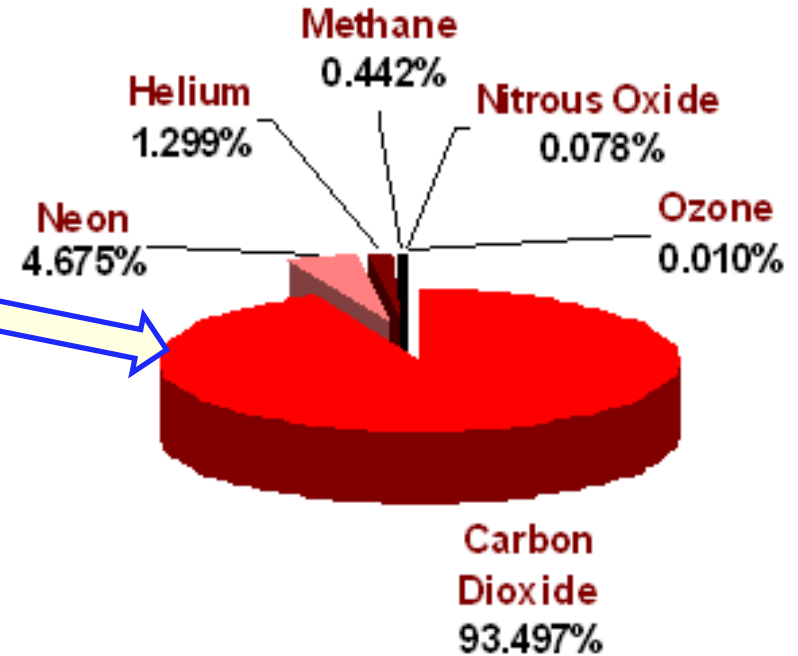
<https://climate.ncsu.edu/edu/k12/.AtmComposition>

Atmospheric Composition



Water Vapor

Trace Gases



Water Vapor is highly variable; often 4% in Summer (Monsoon)

Water Vapor is the source of most “weather:” clouds, rain, snow, hail, fog...

At 4%, Water Vapor is 40,000 parts per million

Carbon Dioxide is now 400 parts/million, <400,000 parts per Billion>, or 0.04%

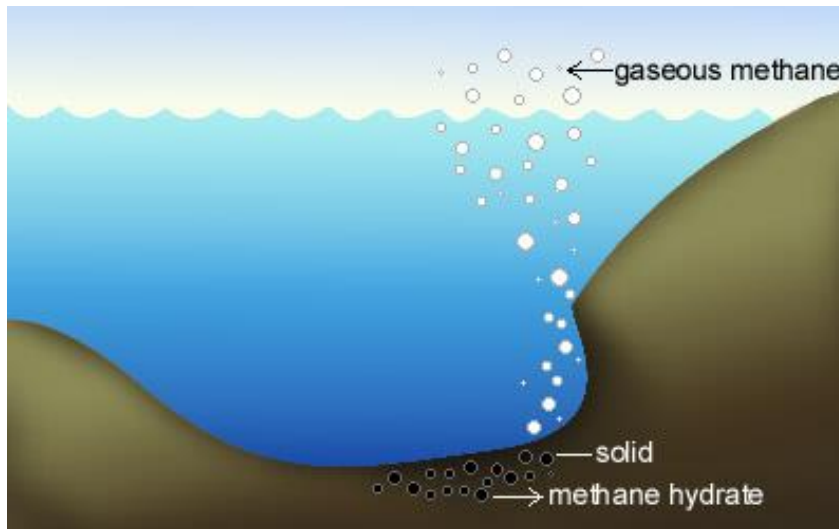
Methane is now 1834 Parts Per Billion,

Marsh gas

From Wikipedia, the free encyclopedia

Marsh gas, **swamp gas** and **bog gas** are common names for **biogas** which forms in **wetlands**, whose principal component is **methane**, produced naturally within some geographical **marshes**, **swamps**, and **bogs**.

The surface of marshes, swamps and bogs is initially **porous** vegetation that **rots** to form a **crust** that prevents **oxygen** from reaching the organic material trapped below. That is the condition that allows **anaerobic digestion** and **fermentation** of any **plant** or **animal** material which incidentally also produces methane.



Facts About Methane:

Chemical Formula: CH₄

Also known as Marsh Gas, Natural Gas

Described by Benjamin Franklin as “flammable air”

Isolated by Allesandro Volta, Lake Maggiore, Italy-Switzerland

Colorless and odorless at room conditions.

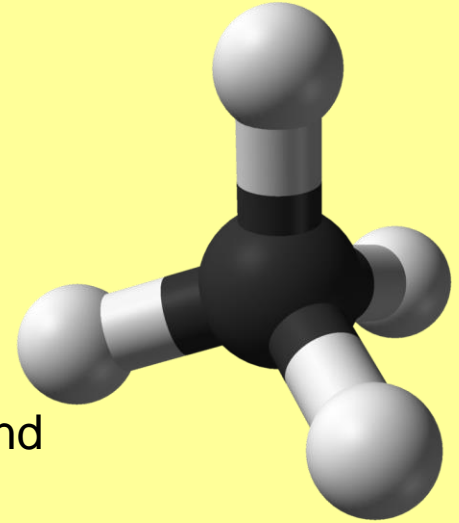
Not toxic, but explosive at concentrations of 4.4% – 17%

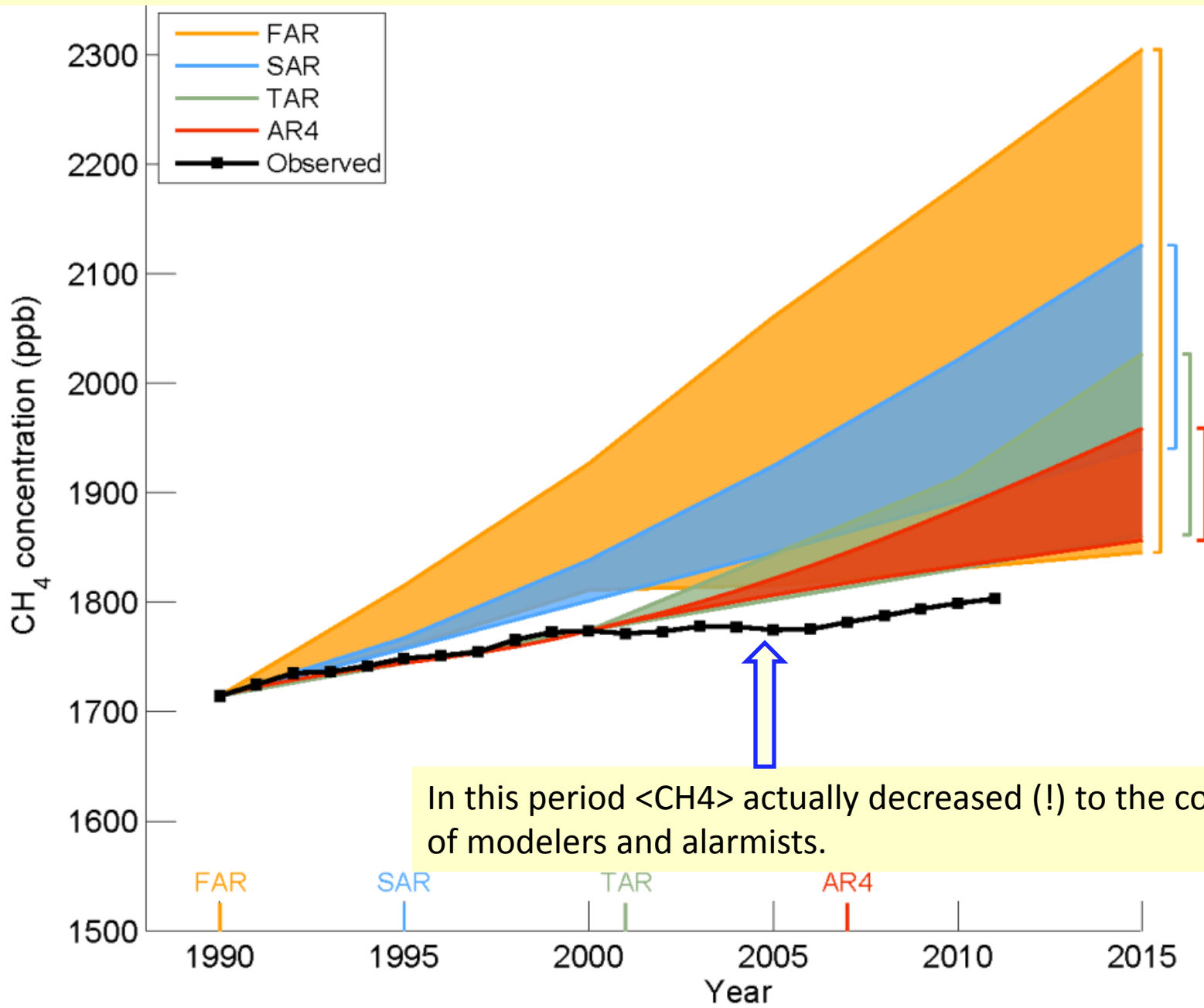
Old-time miners used Canary in the Coal Mine—Canaries fainted as Oxygen displaced

Nominal Atmospheric Concentration now on order of 1834 Parts Per Billion

Found in the sea bed, landfills, swamps, lake bottoms, below ground, especially in coal seams and organic shales.

Methane is important for [electrical generation](#) by burning it as a fuel in a [gas turbine](#) or [steam generator](#).





In this period <CH₄> actually decreased (!) to the consternation of modelers and alarmists.

WUWT

Watts Up With That?

The world's most viewed site on global warming and climate change

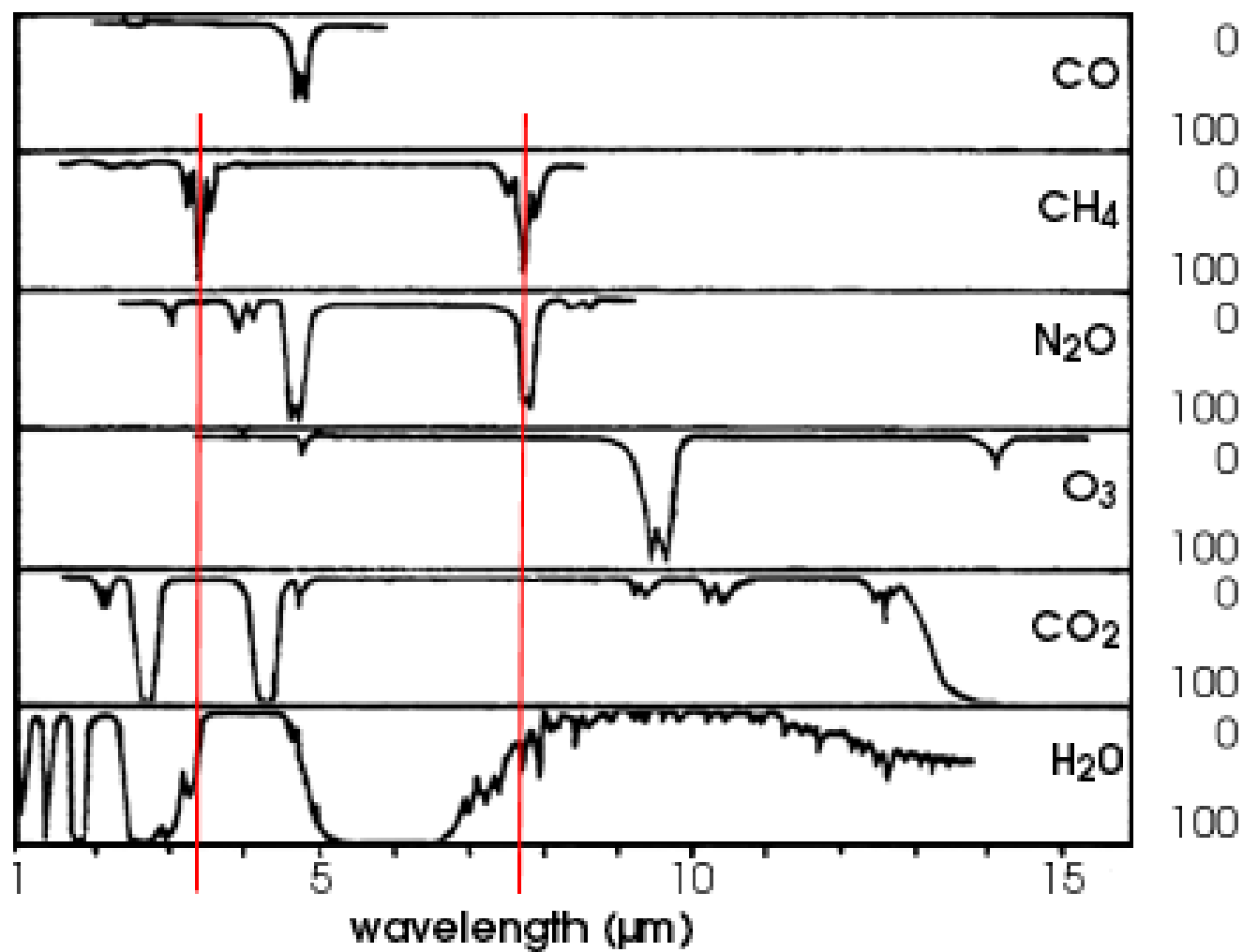
[Home](#) [About](#) [Climate FAIL Files](#) [Climategate](#) [Reference Pages](#) [Submit story](#) [Test](#) [Tips &](#)

Methane: The Irrelevant Greenhouse Gas

Anthony Watts / April 11, 2014

Water vapor has already absorbed the very same infrared radiation that Methane might have absorbed.

Guest essay by Dr. Tom Sheahen



The absorption percentage of radiation of gases found in Earth's atmosphere

Information about Methane:

“methanotropic bacteria oxidize methane in aerobic zones of soils

amount of methane removed ...equivalent to...total world production of methane

Methane sinks ... in operation over a wide range of soil types from tundra, to boreal forests, to temperate forests, to grasslands, to arable lands, to tropical forests, even to deserts.”

<Prinn et al, (1992)>

concentrations of methane...leveled off... actually started to decrease.

“It is questionable whether human activities can cause methane concentrations to increase greatly in the future.”

< Kahlil et al (2007)>

Climate Change Reconsidered, Craig Idso and S. Fred Singer,
2009 Report of Nongovernmental Panel on Climate Change, (NIPCC)
Chicago, IL, June, 2009, Feedback and Radiative Forcing, Chapter 2.6, Methane:

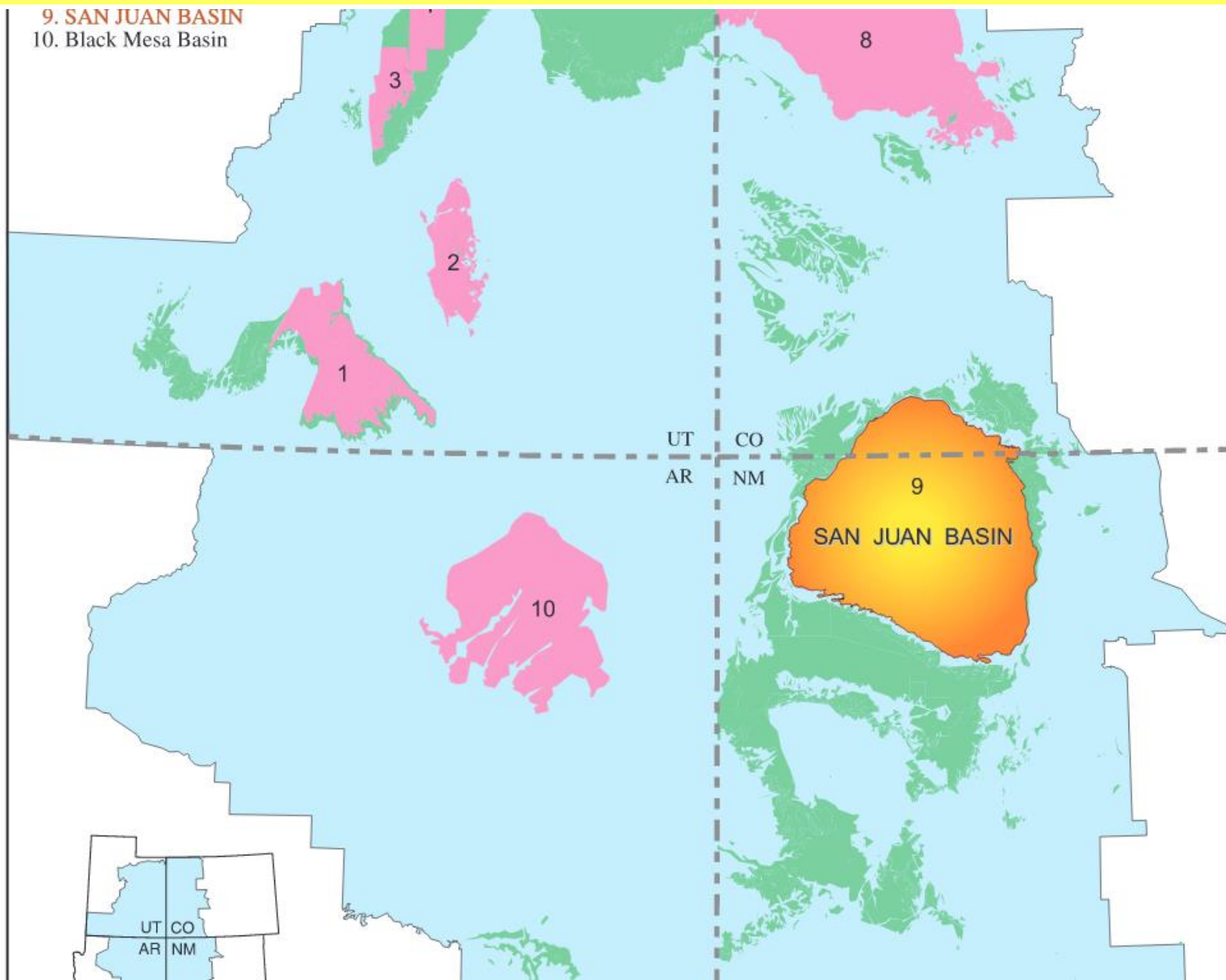
Background Information on the San Juan Basin

Surrounded by Monsters!



Map with location of the San Juan Basin of New Mexico and Colorado

http://pubs.usgs.gov/pp/p1625b/Reports/Chapters/Chapter_Q.pdf



The Four Corners is part of the San Juan Basin

7,500 square miles

“the most productive coalbed methane basin in North America,”
according to the EPA.

About 60,000 wells are scattered across the area.

PBS Questions:

How are such massive amounts of methane getting released into the air?

Is it coming from natural sources, like the exposed coal seam jutting above the earth's surface in parts of the San Juan Basin?

Is it coming from open mine shafts or leaking equipment that belongs oil and gas companies?

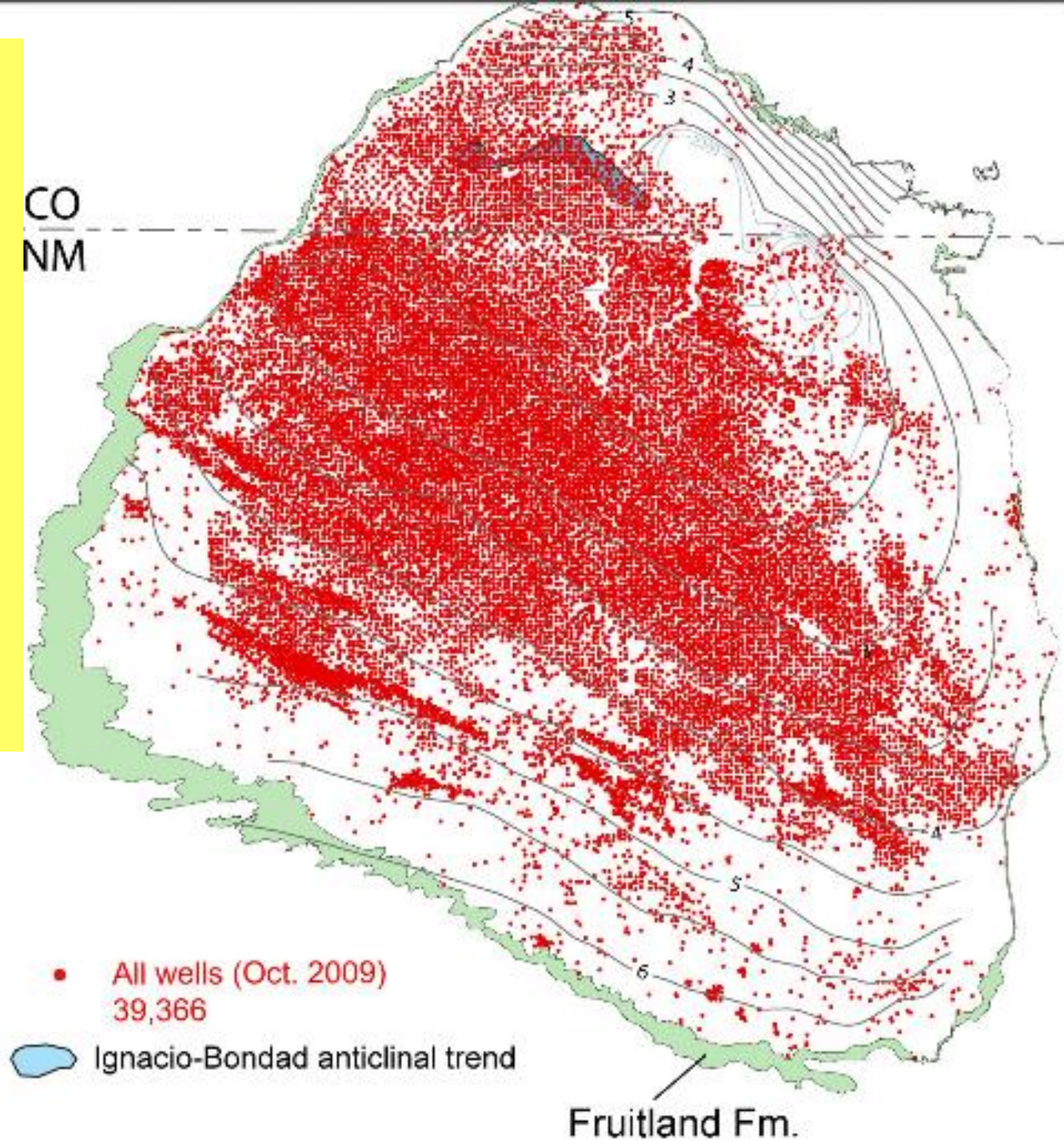
Is it a combination of these factors, or none of these factors?

<http://www.pbs.org/newshour/updates/huge-methane-hotspot-american-southwest/>

The San Juan Basin contains a huge number of wells

http://www.searchanddiscovery.com/pdfz/documents/2010/10254fassett/ndx_fassett.pdf.html

Note Well:
the **Fruitland Formation**, a huge source of coal bed methane, in green.



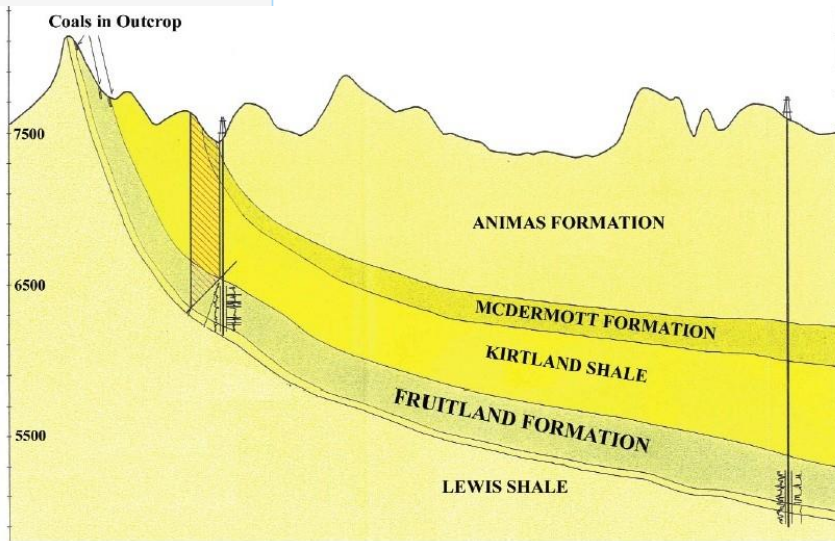


WIKIPEDIA
The Free Encyclopedia

Article [Talk](#)

Fruitland Formation

From Wikipedia, the free encyclopedia



Fruitland formation
Stratigraphic range: **Campanian**,^[1]

75.5–74.5 Ma

PreЄЄOSDCTJKPcN

Type	Geological formation
Sub-units	Fossil Forrest Member, Ne-nah-ne-zad Member
Underlies	Kirtland Formation
Overlies	Pictured Cliffs Sandstone

Location

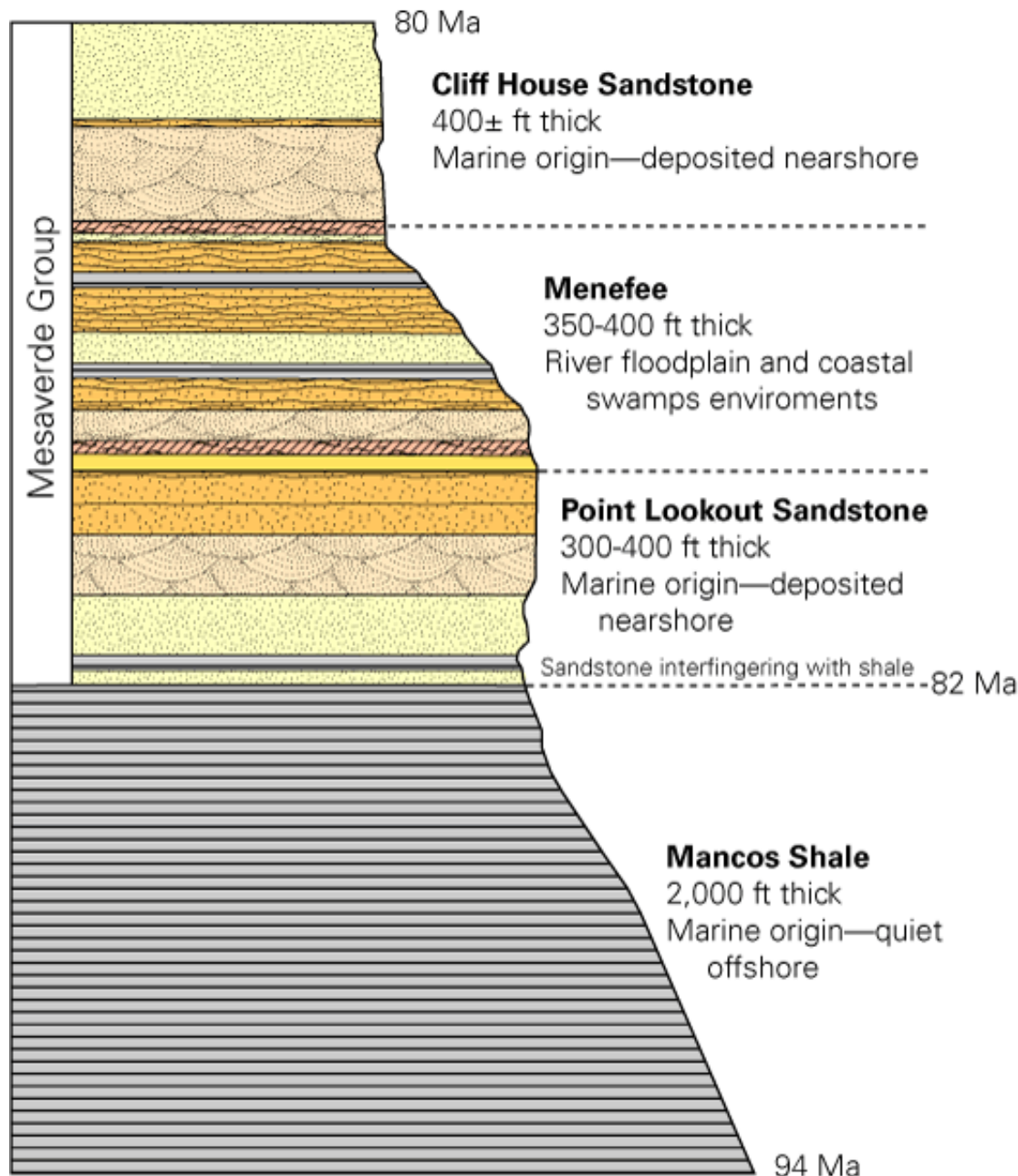
Region	 New Mexico  Colorado
Country	 USA

The Fruitland Formation contains beds of [bituminous coal](#) that are mined in places along the outcrop.

Since the 1980s, the coal beds of the Fruitland Formation have yielded large quantities of [coalbed methane](#).

The productive area for [coalbed methane](#) straddles the [Colorado-New Mexico](#) state line, and is one of the most productive areas for coalbed methane in the [United States](#).

Formations of Mesa Verde National Park



Mancos Shale Formation

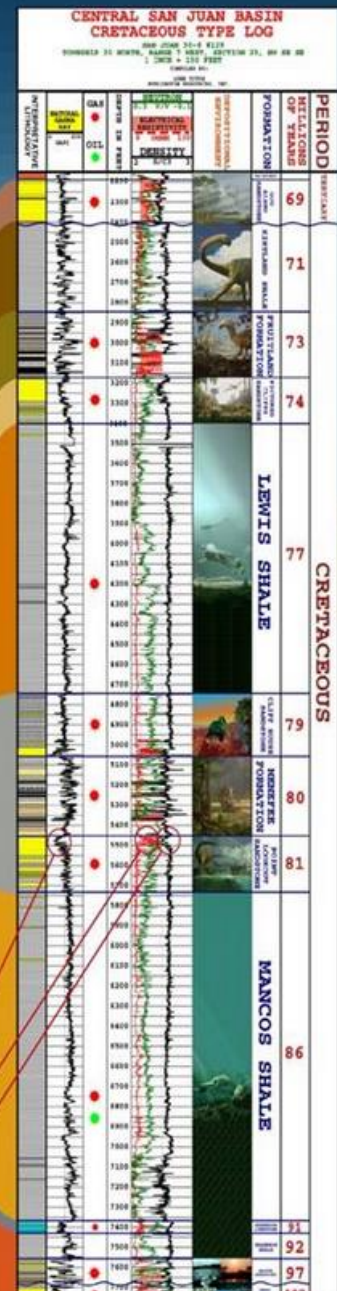
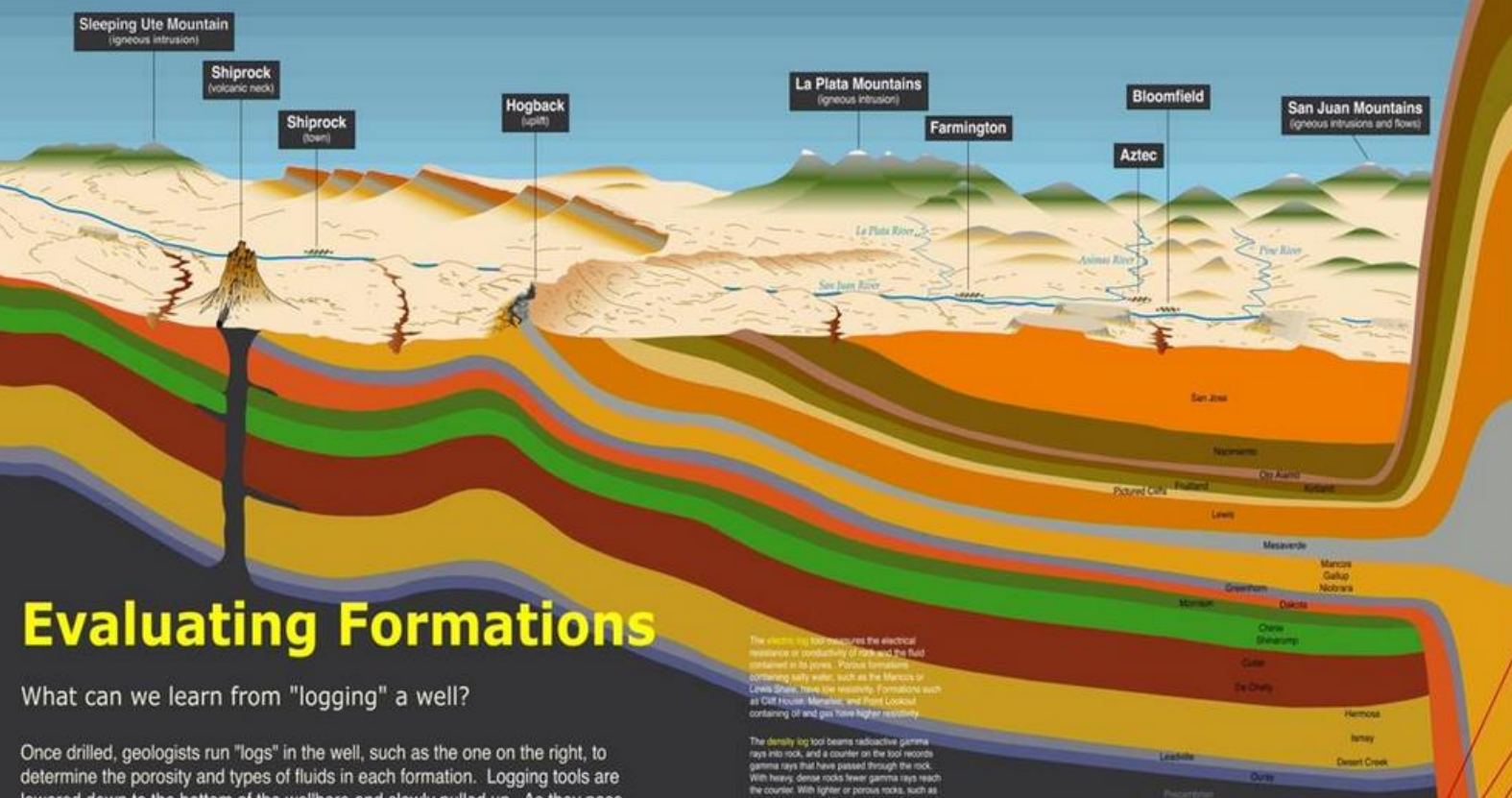
Stratigraphic range: Late Cretaceous



Mancos Shale badlands in Capitol Reef National Park, southern Utah.

Type	Geologic formation
Underlies	Mesaverde Formation
Overlies	Dakota Group
Location	
Region	Arizona, Colorado, New Mexico, Utah, Wyoming
Country	United States
Type section	
Named for	Mancos, Colorado

Geologic Cross Section of the San Juan Basin



Evaluating Formations

What can we learn from "logging" a well?

Once drilled, geologists run "logs" in the well, such as the one on the right, to determine the porosity and types of fluids in each formation. Logging tools are lowered down to the bottom of the wellbore and slowly pulled up. As they pass the different formations, they are able to measure and record different properties such as: electrical conductivity, density, and radioactivity. Logs are graphs that look like an electrocardiogram (EKG); however, they measure elements that give us clues to the presence of hydrocarbons.

The electric log (EL) measures the electrical resistance or conductivity of the rock and the fluid contained in its pores. Porous formations containing salty water, such as the Mancos or Lewis Shale, have low resistivity. Formations such as Cliff House, Mancos, and Point Lookout containing oil and gas have higher resistivity.

The density log tool beams radioactive gamma rays into rock, and a counter on the tool records gamma rays that have passed through the rock. With heavy, dense rocks fewer gamma rays reach the counter. With lighter or porous rocks, such as sandstone, coal, and limestone reservoirs, more gamma rays return to the counter. In the Pictured Cliffs Sandstone, the density porosity is about 18-24%. In other words, 18-24% of the rock is made up of holes like a sponge that may contain gas or oil.

The gamma ray log tool measures natural gamma ray radiation emitted by the potassium, uranium and thorium constituents of rock. Shale, with a high concentration of these elements, releases many gamma rays resulting in high log values. Sandstones, coals and limestones release fewer gamma rays and have lower log values.

PAY ZONE

How do we know where hydrocarbons are located?

- Low gamma ray indicates a sandstone instead of a shale.
- High resistivity indicates the pores in the rock contain hydrocarbons.
- Diluted of salt water.
- Low density indicates more porous sandstone instead of dense shale.

Oil is almost always accompanied by natural gas, and it's often not cost-effective for an oil company to build infrastructure to capture the natural gas released during the drilling.

So most of the natural gas, along with other unwanted byproducts, is burned off, "flaring," that releases pollutants like benzene and volatile organic compounds into the atmosphere.

... High Country News



An oil well flaring off Highway 550. Credit: Laura Paskus



An oil well flaring off Highway 550. Credit: Laura Paskus

“The wells I own piped the methane to a natural gas pipeline for four days in the 1980s.

We received a hundred dollars a day for the gas from our portion of our wells and then the Feds said we couldn't put our state natural gas into a Federal pipeline.

We have had to burn it for thirty years.

Now they say we must not burn it, but we still can't put it into a Federal pipeline.

The only alternative is to cap the wells. They are east of Roswell, NM.

They are at 2000 ft and have a fifty years approximate lifetime...”

“... Doesn't matter the methane reasons, the intent is to cap the wells.”

...MICHAEL SWICKARD

Space-based Measurements

Envisat, ESA's Environmental Satellite

Polar Orbit: 490 miles, 101 min period

Launched 2002, lost contact 2012

16 Ft Long 18,102# 703# fuel
4669# Instrument Payload
3560 Watts of Power (Solar)

Design Life: 5 years

9 Instruments, including:

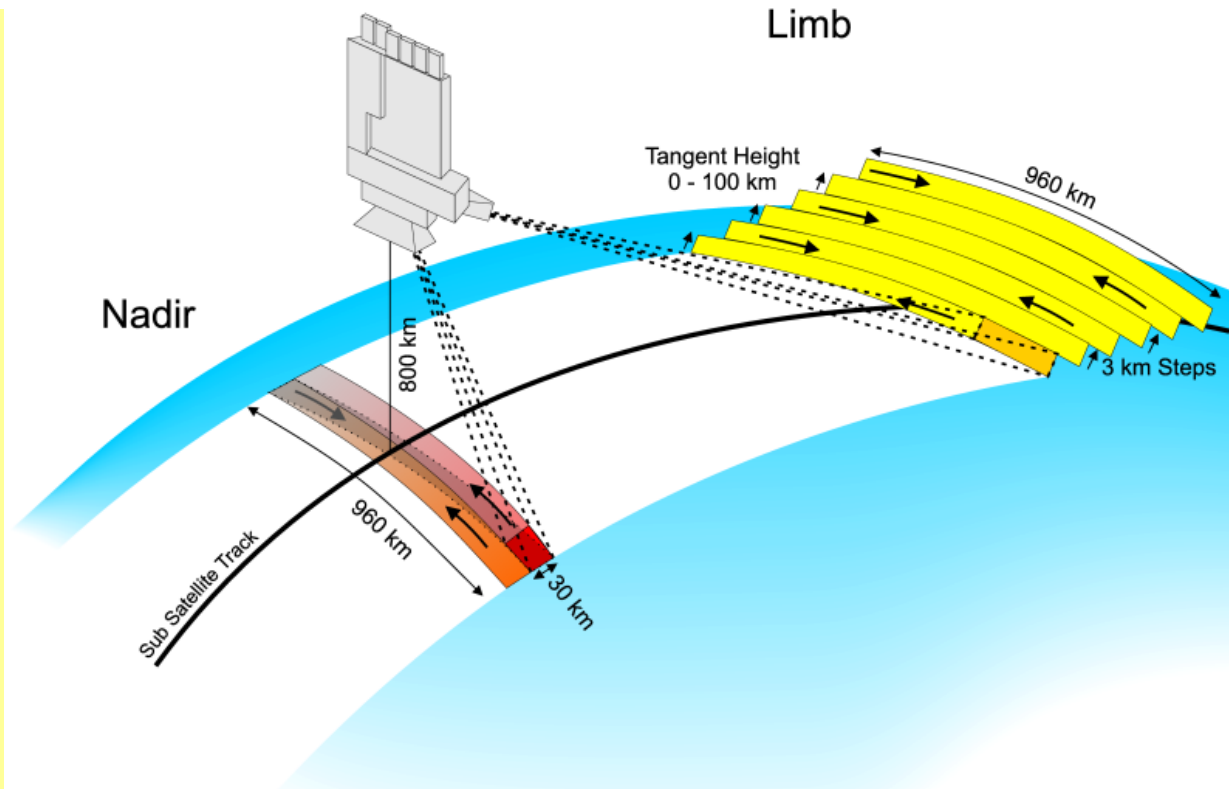
RA-2 Radar Altimeter 2
(Sea Level Data)

SCIAMACHY
(SCanning Imaging Absorption
spectroMeter for Atmospheric
CHartographY)



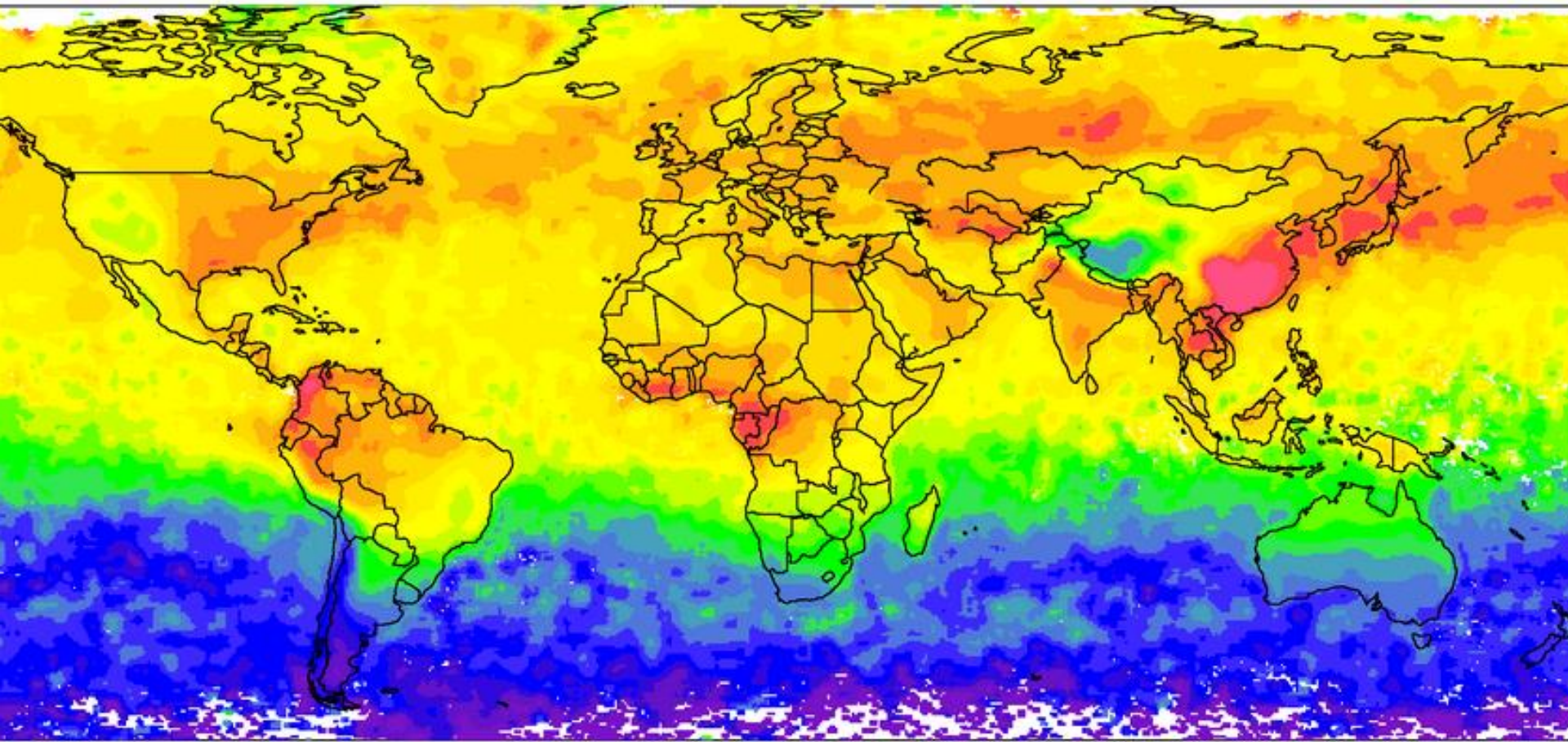
SCIAMACHY

A satellite spectrometer designed to measure sunlight, transmitted, reflected and scattered by the earth's atmosphere or surface in the ultraviolet, visible and near infrared wavelength region (240 nm - 2380 nm) at moderate spectral resolution (0.2 nm - 1.5 nm).^[1]



<https://en.wikipedia.org/wiki/SCIAMACHY>

Methane SCIAMACHY/ENVISAT



CH₄ column averaged mixing ratio [ppb]



1703

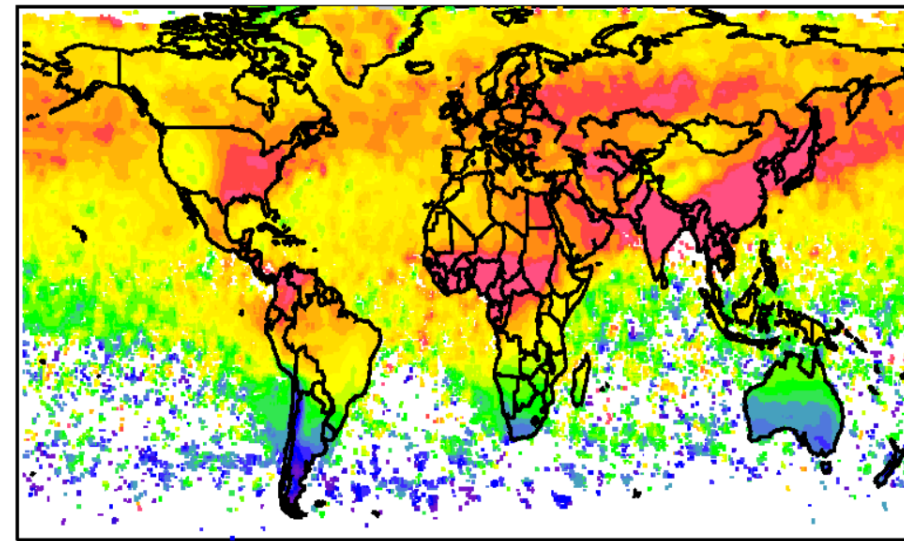
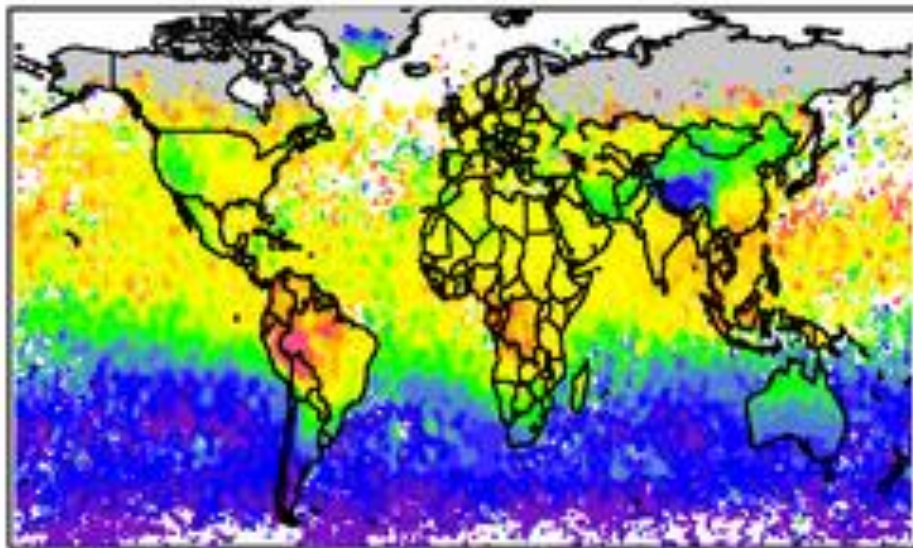
1738

1773

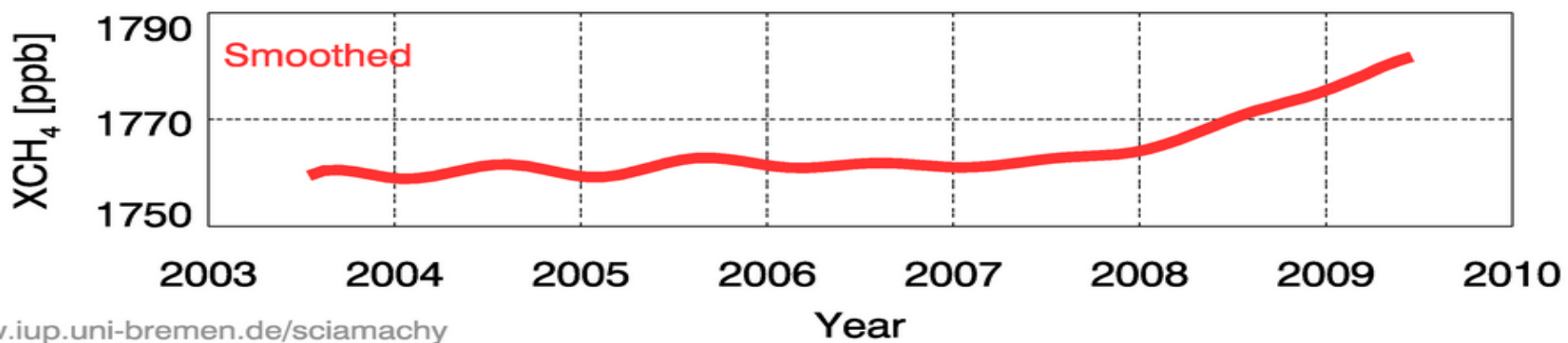
1808

Jan-Mar

Jul-Sep

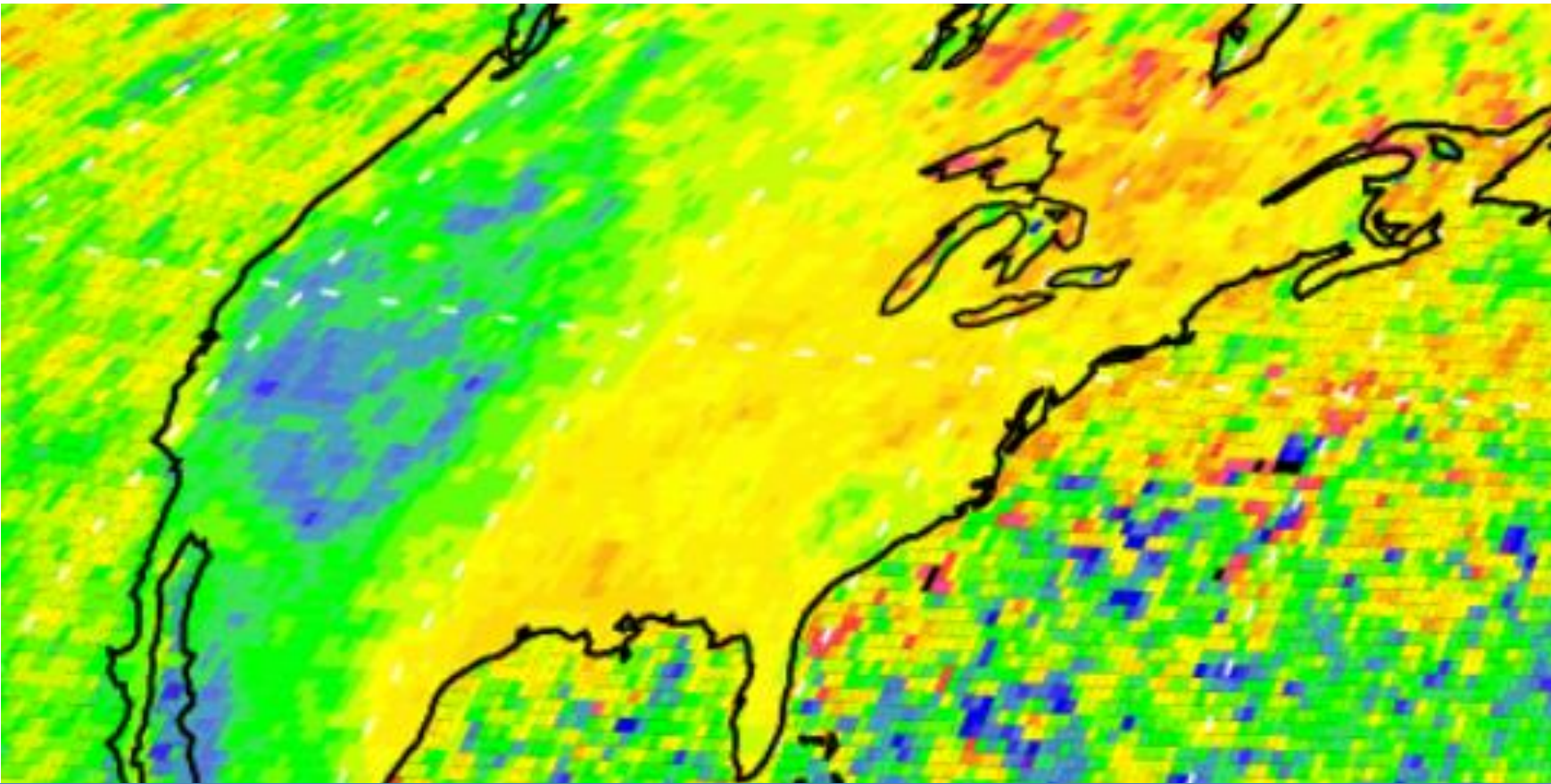


CH₄ column averaged mixing ratio [ppb]



“The San Juan Basin is peppered with oil and gas infrastructure and clouded in the highest concentrations of methane in the country.”

http://www.iup.uni-bremen.de/sciamachy/NIR_NADIR_WFM_DOAS/xch4_v1_2003-2005.png



CH₄ column-averaged mole fraction [ppb]



Airborne Measurements

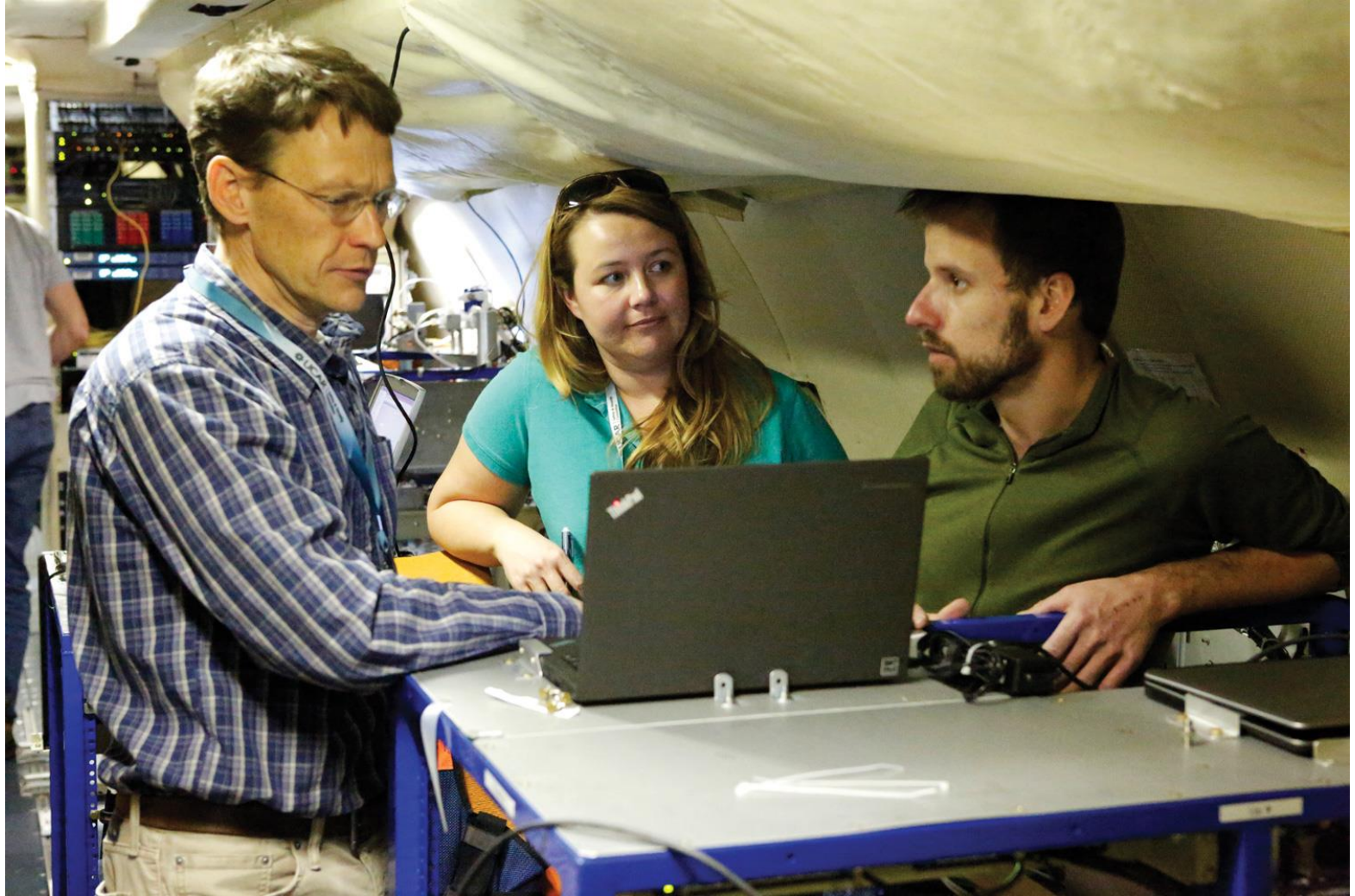


THE TEAM — Personnel from NASA's Jet Propulsion Laboratory, NOAA, University of Michigan, University of Colorado, Scientific Aviation and Twin Otter International assemble on the tarmac of the Durango-La Plata County Airport prior to their study of methane levels in the Four Corners region. Photo by Shaun Stanley

Posted 15 June 2015



Seth Chazanoff of NASA's Jet Propulsion Laboratory conducts final checks on a Hyperspectral Thermal Emission Spectrometer mounted within an aircraft used to study methane gas emissions in the Four Corners area. Photo by Shaun Stanley



The four-engine turbo-prop plane, built for hurricane research and surveillance, costs \$5,000 an hour to operate, and today's flight will last seven hours. The inside of the plane is crammed with people and machinery.

Scientists stare at monitors hooked up to air sensors outside the plane.

<https://www.hcn.org/issues/47.15/in-the-southwests-four-corners-methane-has-a-dark-side/tracking-energys-fugitive-emissions-from-above/view>

Posted 15 June 2015



TRACKING METHANE — *A plane that contains equipment to detect methane levels flies above natural gas production facilities in the San Juan Basin area of New Mexico.*
Photo by Shaun Stanley

Surface Measurements

Current Ground Campaign

Gaby Petron, Eryka Thorley,
Jonathan Kofler and many
colleagues

Bruce Vaughn, Ingrid
Mielke-Maday, Owen
Sherwood



NOAA Global Monitoring Division
CU Cooperative Institute for Research in Environmental Sciences
CU Institute For Arctic and Alpine Research

A silver van rolls slowly down a narrow road on the edge of the small town of Bayfield, Colorado ... with its darkly tinted windows and Government plates, the van has an ominous appearance, not helped by the long, fishing-pole-like appendage, accessorized with wires and tubes, that extends from its top.



<https://www.hcn.org/issues/47.15/in-the-southwests-four-corners-methane-has-a-dark-side>

The NOAA Mobile Lab



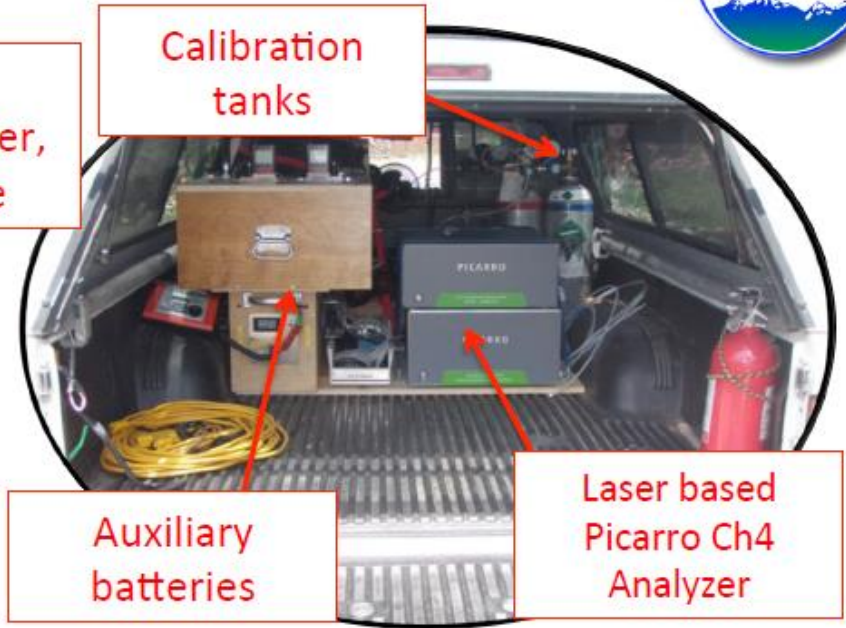
- GPS, winds, temperature, RH
- In-situ methane, CO₂, CO, water vapor, ozone
- Discrete air samples in flasks analyzed in NOAA and INSTAAR labs



The INSTAAR Mobile Methane Lab



GPS,
Anemometer,
Air Intake



Calibration
tanks

Auxiliary
batteries

Laser based
Picarro Ch4
Analyzer

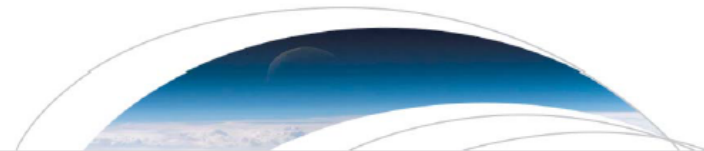


Methane



NASA CAMERA — Andrew Thorpe of NASA's Jet Propulsion Laboratory powers up a thermal camera imaging system next to a storage tank believed to be leaking methane at a natural gas facility near Aztec, New Mexico. Photo by Shaun Stanley

Recent Publications Raising Alarm about Atmospheric Methane in New Mexico



Geophysical Research Letters

RESEARCH LETTER

10.1002/2014GL061503

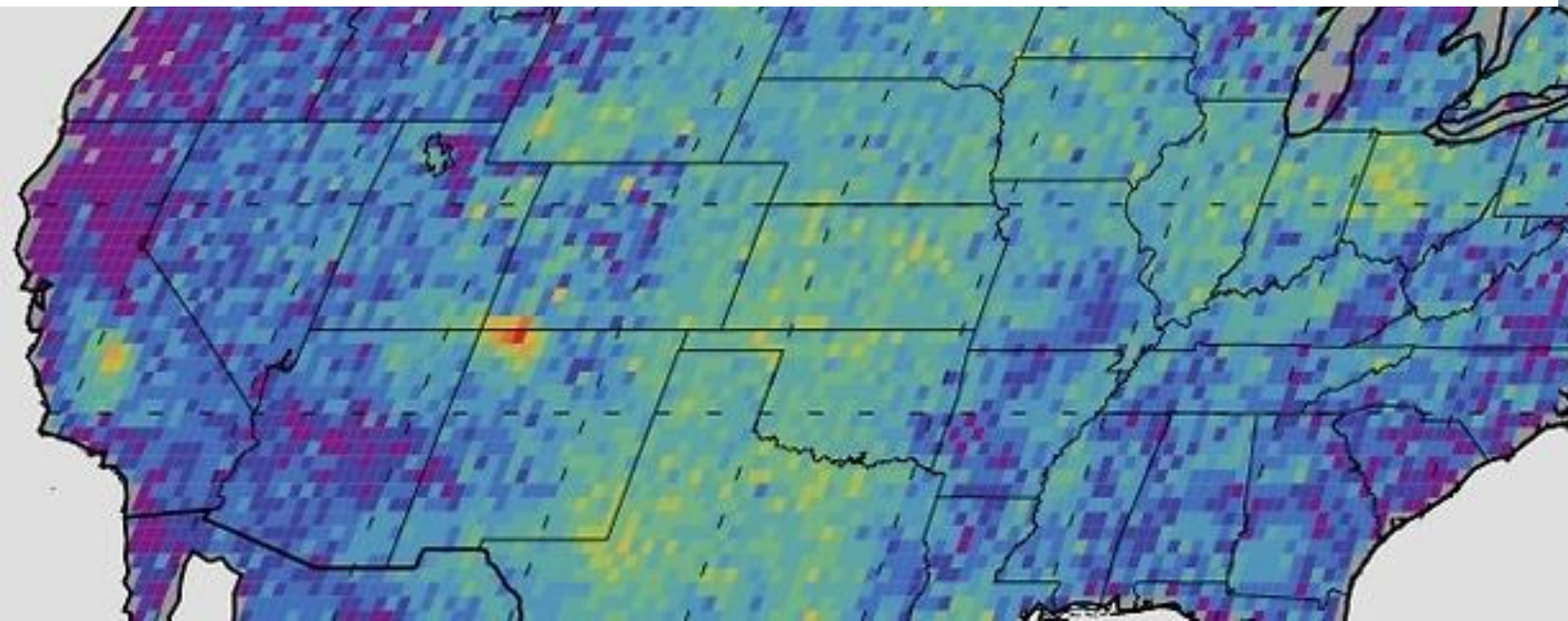
Key Points:

- Four Corners exhibits largest CH₄ anomaly seen from space
- Emissions of >0.5 Tg CH₄/yr have persisted since 2003
- Space- and ground-based CH₄ identify missing emissions from fossil fuel extraction

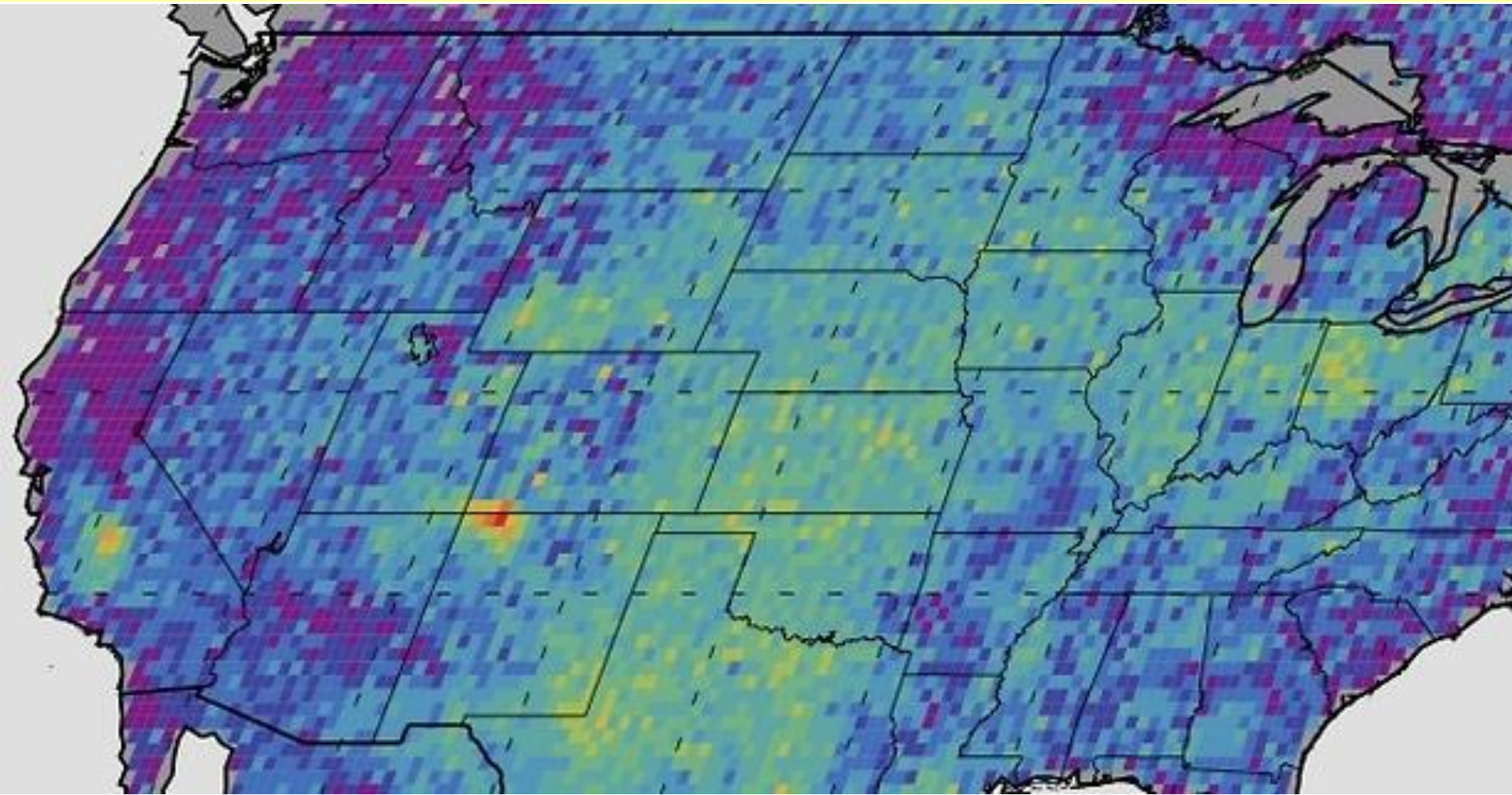
Four corners: The largest US methane anomaly viewed from space

Eric A. Kort¹, Christian Frankenberg², Keeley R. Costigan³, Rodica Lindenmaier^{3,4}, Manvendra K. Dubey³, and Debra Wunch⁵

¹Atmospheric, Oceanic and Space Sciences, University of Michigan, Ann Arbor, Michigan, USA, ²Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA, ³Earth and Environmental Sciences, Los Alamos National Lab, Los Alamos, New Mexico, USA, ⁴Now at Pacific Northwest National Laboratory, Atmospheric Chemistry and Global Change Division, Richland, Washington, USA, ⁵Department of Earth Science and Engineering, California Institute of Technology,



Satellite Data Shows U.S. Methane 'Hot Spot' Bigger than Expected



<https://www.nasa.gov/press/2014/october/satellite-data-shows-us-methane-hot-spot-bigger-than-expected/>

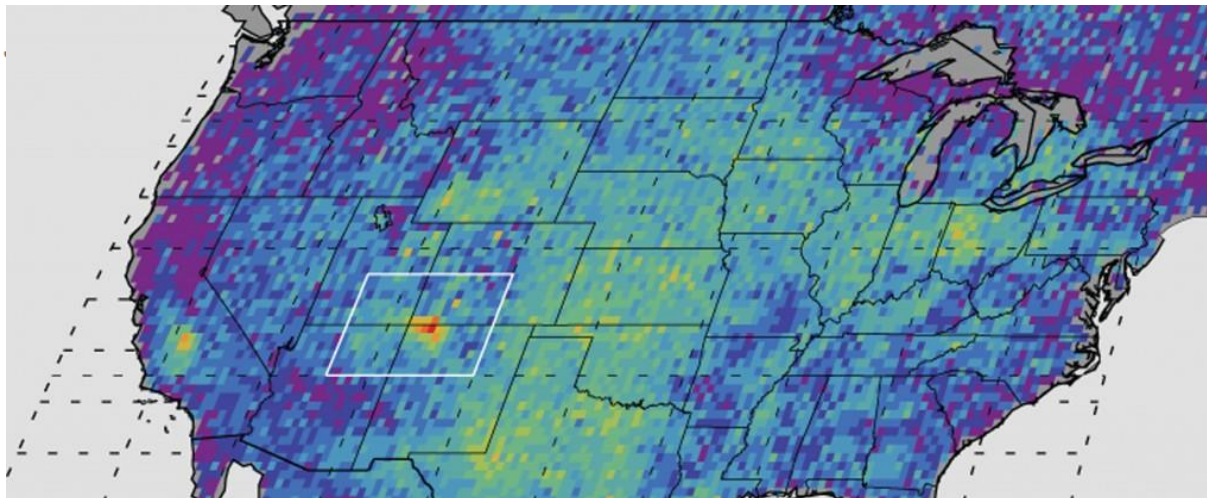
Satellite Data Shows U.S. Methane 'Hot Spot' Bigger than Expected

One small “hot spot” in the U.S. Southwest is responsible for producing the largest concentration of the greenhouse gas methane seen over the United States – more than triple the standard ground-based estimate -- according to a new study of satellite data by scientists at NASA and the University of Michigan.

Methane is very efficient at trapping heat in the atmosphere and, like carbon dioxide, it contributes to global warming. The hot spot, near the Four Corners intersection of Arizona, Colorado, New Mexico and Utah, covers only about 2,500 square miles (6,500 square kilometers), or half the size of Connecticut.

Why is there a huge methane hotspot in the American Southwest?

BY LAURA SANTHANAM



This image shows methane hotspot, highlighted in red, in the Four Corners area. This map shows how much methane emissions varied from average background concentrations from 2003-2009 .

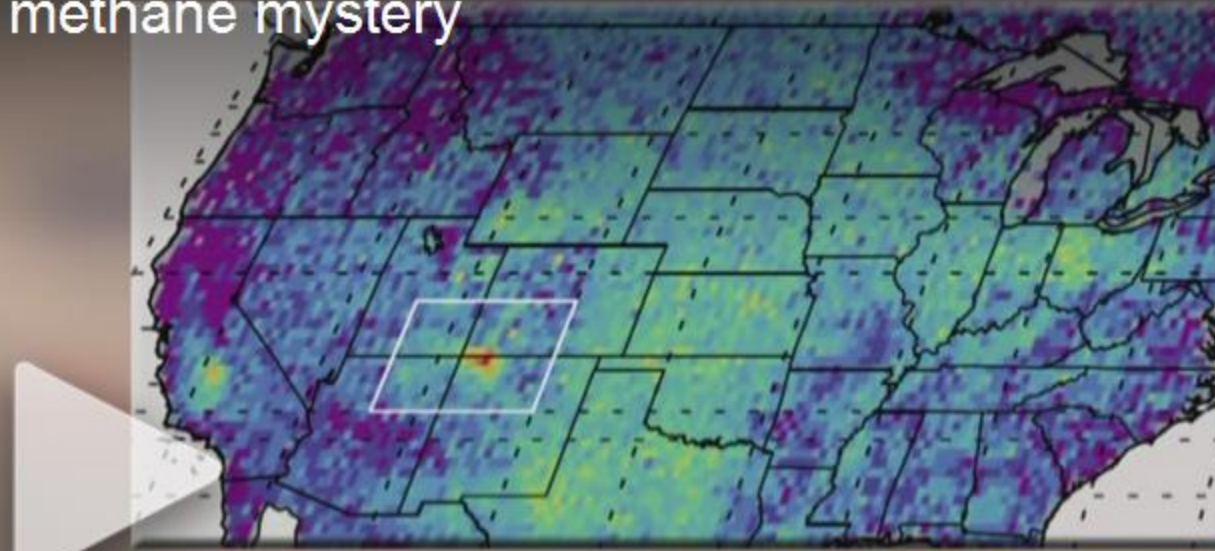
(dark colors are lower than average; lighter colors are higher.)

(AP Photo/NASA, JPL-Caltech, University of Michigan)

But billowing above the rust-colored earth is the country's largest concentration of methane, according to satellite data.

That's because this spot where Utah, Colorado, Arizona and New Mexico meet is also home to one of the nation's most productive natural gas fields and coalbed methane basins

Scientists descend on New Mexico to solve methane mystery



COURTESY:
American Geophysical Union

FARMINGTON, N.M. (KRQE) – It's a scientific mystery:
Why is there a giant plume of methane hovering over the
Four Corners region?

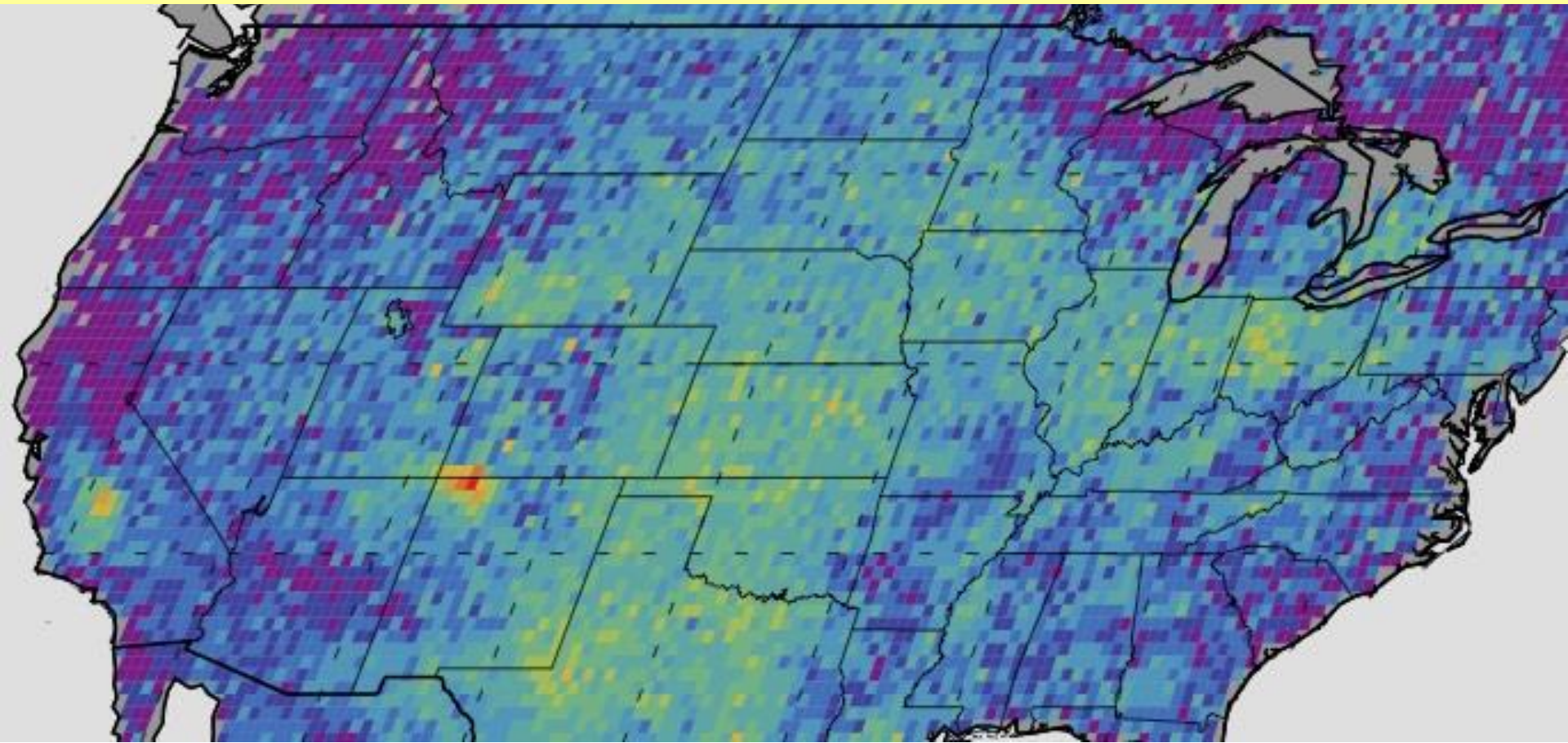
<http://krqe.com/2015/04/08/scientists-descend-on-new-mexico-to-solve-methane-plume-mystery/>



“Images picked up by a European satellite, published last year, show the nation’s largest plume of methane is hanging over the San Juan Basin.

Methane is a potent greenhouse gas that contributes to global warming.”

<http://wattsupwiththat.com/2014/10/11/the-methane-hotspot-identified-in-the-four-corners-area-of-the-u-s-southwest-can-be-fixed-with-some-preventative-maintenance/>



The Four Corners area (red) is the major U.S. hot spot for methane emissions in this map showing how much emissions varied from average background concentrations from 2003-2009 (dark colors are lower than average; lighter colors are higher).
Image Credit: NASA/JPL-Caltech/University of Michigan

<http://www.daily-times.com/story/news/local/four-corners/2015/12/27/scientists-study-methane-hot-spot-sources/77462312/>



Eric Kort speaks to attendees at a Four Corners Public Science Forum on Methane at San Juan College on April 17. (Photo: Daily Times file photo)

The Methane Madness in New Mexico

Ignorance of Las Cruces writers is on display almost daily in the Sun-News:

<http://www.lcsun-news.com/story/opinion/2016/02/11/letters-editor-feb/80233402/>

“Methane leaks threaten residents of New Mexico” -- Vi-Ann Beadle

- “The recent methane leak in California is proof methane is toxic...”
- “The San Juan Basin is peppered with oil and gas infrastructure and clouded in the highest concentrations of methane in the country.”
- “Climate change will make New Mexico even hotter and drier.”

“The recent methane leak in California is proof methane is toxic...”

ATSDR

<http://www.atsdr.cdc.gov/#>

Agency for Toxic Substances and Disease Registry



MENU

ATSDR A-Z



SEARCH

Agency for Toxic Substances and Disease Registry

The Agency for Toxic Substances and Disease Registry (ATSDR), based in Atlanta, Georgia, is a federal public health agency of the U.S. Department of Health and Human Services. ATSDR serves the public by



Methane is **not** toxic.

“Methane gas is relatively non-toxic; it does not have an OSHA PEL Standard.

Its health effects are associated with being a simple asphyxiant, displacing oxygen in the lungs.”

<http://aetinc.biz/newsletters/2010-insights/october-2010>

Methane is not listed in the CDC Agency for Toxic Substances for Disease Registry.

Methane leaks a threat to global community --- Kennan Newton

<http://www.lcsun-news.com/story/opinion/2016/02/14/letters-editor-feb/80264780/>

“...the San Juan Basin, has over 4,000 wells. The wells leak methane and so the basin has the nation’s largest methane hotspot.

<methane leaks> “...are a global threat to us all.”

New EPA methane rules are good for New Mexico... Jan Thompson, Las Cruces

<http://www.lcsun-news.com/story/opinion/2016/05/29/letters-editor-may/84992212/>

On May 12, the Environmental Protection Agency finalized new safeguards on methane pollution from the oil and gas industry. The rules increase New Mexico's revenue and put people back to work.

Similar standards have already been implemented in Colorado, with backing from industry.

Some in New Mexico, though, have been too stuck in old thinking to see the facts.

...The largest methane "hot spot" in the country looms above the Four Corners area, and communities across the state are at higher risk for respiratory illness, cancer, birth complications due to unregulated oil and gas extraction.

Let's work together to implement strong, comprehensive safeguards on methane pollution.

Welcome federal rules to curb methane gas Dan Lorimier, Williamsburg

<http://www.lcsun-news.com/story/opinion/2016/05/26/letters-editor-may/84981542/>

The Environmental Protection Agency has just finalized the first ever national standards on methane pollution from the oil and gas industry. We should all welcome this federal rulemaking to curb emissions of this toxic gas, as our fellow New Mexicans in the Four Corners region are left concerned and exasperated by the methane hot-spot looming above their homes.

<Dan Lorimier is an activist for the Sierra Club>

He clearly does not know that methane is not toxic.

Elected officials call for reduction of methane pollution

Miyagishima, Garrett join 66 mayors, commissioners in signing letter

By **Camilla Fiebelman**
For the Bulletin

In April, Santa Fe Mayor Javier Gonzales joined 68 mayors and county commissioners, seven from New Mexico (two from Las Cruces) in sending a letter to President Barack Obama and Environmental Protection Agency (EPA) Administrator, Gina McCarthy, urging them to take action on dangerous methane pollution from new and existing oil and gas industry sources. This group of leaders from 13 different states and the District of Columbia has united to protect their constituents from methane pollution's devastating impact on public health and the accelerated effects of climate change.

Mayor Gonzales said, "For our children's health, for our economy, and for

our environment, it is important that we all work to ensure that we are venting less methane into New Mexico's air. That's why I support the EPA's proposed rule."

In the letter Mayor Gonzales joined his colleagues from around the country in writing, "One in three Americans live in a county with oil and gas development, and as the leaders of America's cities and counties, we write today to support the Environmental Protection Agency's effort to reduce methane emissions from new and modified sources in the oil and gas sector. We also urge the agency to swiftly move forward with a rule to rein in emissions from existing sources of oil and gas methane pollution. Doing so will protect our constituents from unhealthy air pollution associated with the meth-

ane and toxic chemicals emitted from oil and gas infrastructure and equipment, and protect us from the consequences of climate change that our cities and counties face on a daily basis."

The mayors highlighted the efficacy of state level collaboration, specifically in Colorado, as proof that curbing methane pollution from oil and gas development can happen without harming state economies.

The mayors summed up their support for action from the EPA on dangerous methane pollution by noting that "strong standards are needed to keep our air clean and our constituents healthy."

A copy of the mayors' letter and more information about the dangers of methane pollution on our environment and our communities can be found at www.methanefacts.com.

methanefacts.com.

Local New Mexico elected officials have also signed a letter in support of BLM methane rules which complements EPA methane rules:

Mayor Javier M. Gonzales, Santa Fe, NM

Mayor Ken Miyagishima, Las Cruces, NM

County Commissioner Billy G. Garrett, Doña Ana County, NM

County Commissioner Alex M. Naranjo, Chair, Rio Arriba County, NM

County Commissioner Kathleen Hollan, Santa Fe County, NM

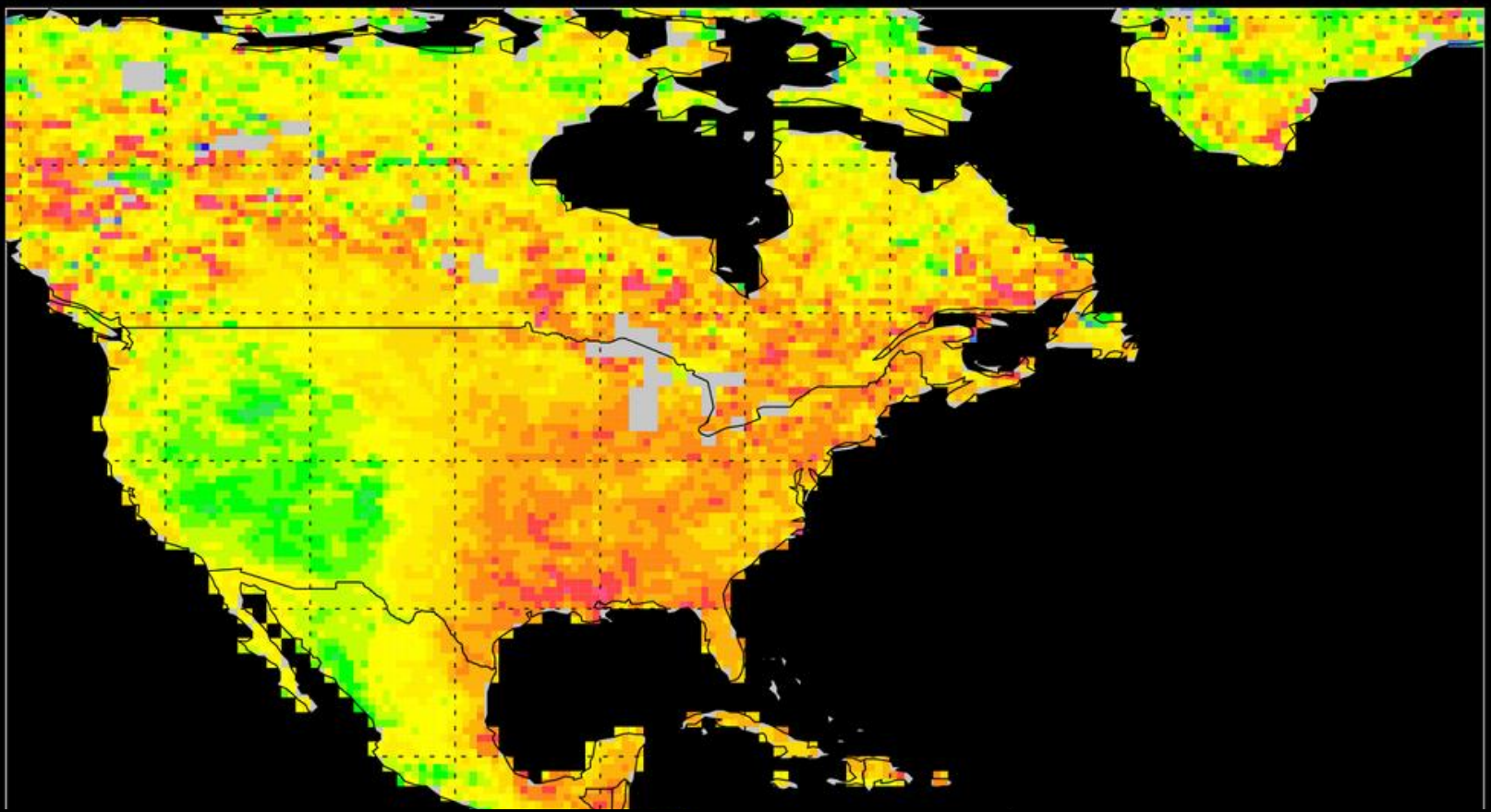
County Commissioner Miguel Chavez Santa Fe County, NM

County Commissioner Debbie O'Malley, Bernalillo County, NM

City Commissioner Katee McClure, Aztec, NM

“The San Juan Basin is peppered with oil and gas infrastructure and clouded in the highest concentrations of methane in the country.”

Methane SCIAMACHY 2003



http://www.iup.unibremen.de/sciamachy/NIR_NADIR_WFM_DOAS/scia_ch4_2003_usa.png

Methane column-averaged mole fraction [ppb]



The Methane Mystery in New Mexico

The AGU Geophysical Letter is difficult to understand and replicate; no equations.

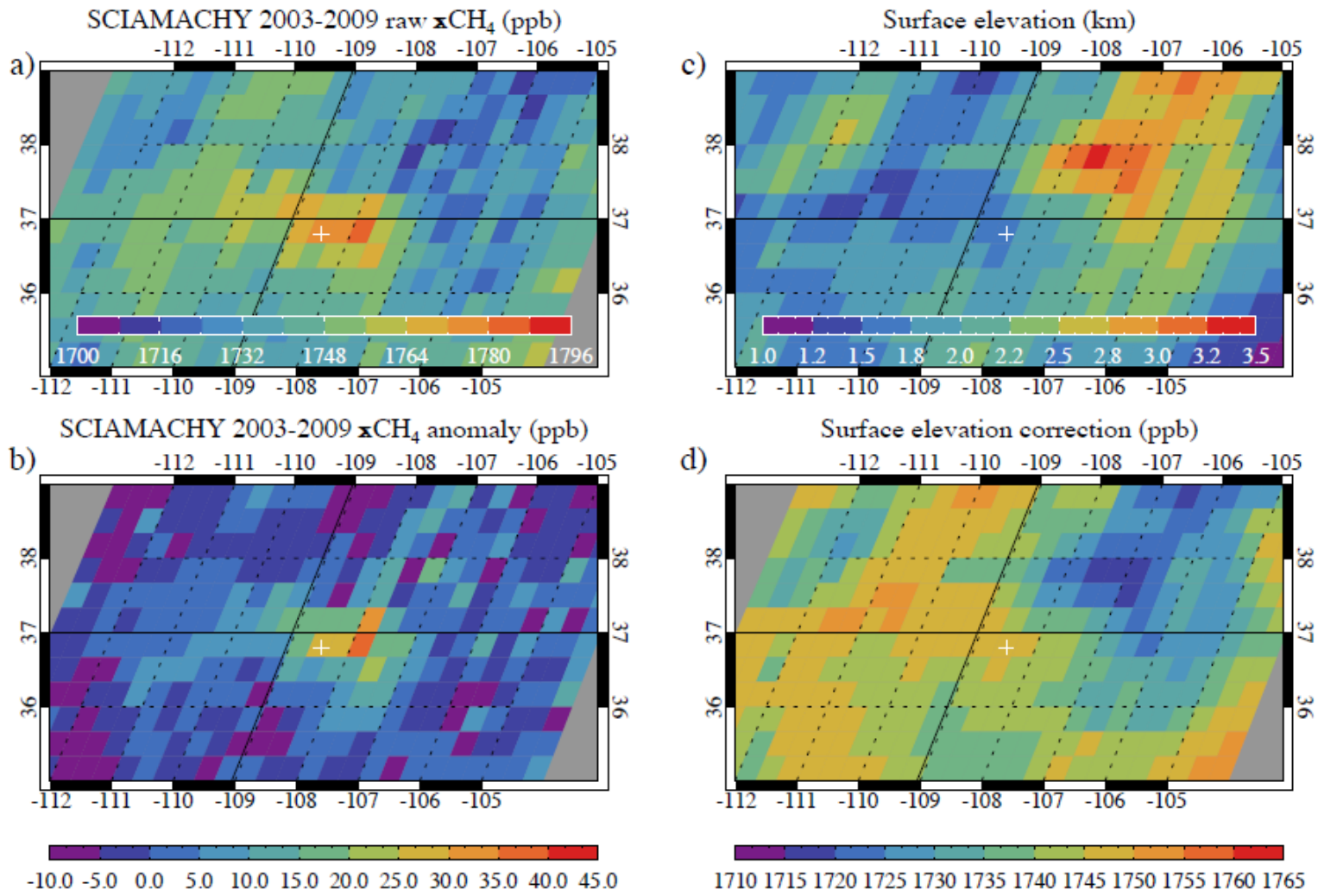
Added back in normal stratospheric loss of methane
Hot Spot graphic sensationalizes the data
The anomaly did not get worse over time.

Why are the authors so silent?

Why are the media not curious?

What is the source of the Methane?

Results of the surface elevation correction. b, lower left, the prominent graphic associated with the article



Supplementary Figure 1: Effect of surface altitude correction on SCIAMACHY data. a) Original gridded SCIAMACHY XCH_4 data; b) altitude corrected XCH_4 anomaly; c) Gridded surface elevation; d): altitude correction (as subtracted from the raw SCIAMACHY data).

<http://www.daily-times.com/story/news/local/four-corners/2015/12/27/scientists-study-methane-hot-spot-sources/77462312/>

SEQUENCE OF EVENTS:

Late 2014: Kort et al published Geophysical Research Letter on the Methane Hot Spot

April, 2015: NASA, NOAA, U Mich, U Colorado campaign
Twin Otters, Mobile Ground Stations

December, 2015: Working Group at American Geophysical Union annual meeting, San Francisco, no papers released.

Spokeswoman for CIRES, University of Colorado at Boulder:

Study in April, 2015 will produce a final report on atmospheric methane sources in the Four Corners region “early next year.”

Report will be announced at an event yet to be scheduled in Durango, Colo.

No Data Reports, No Interim Reports, No Press Releases of results,

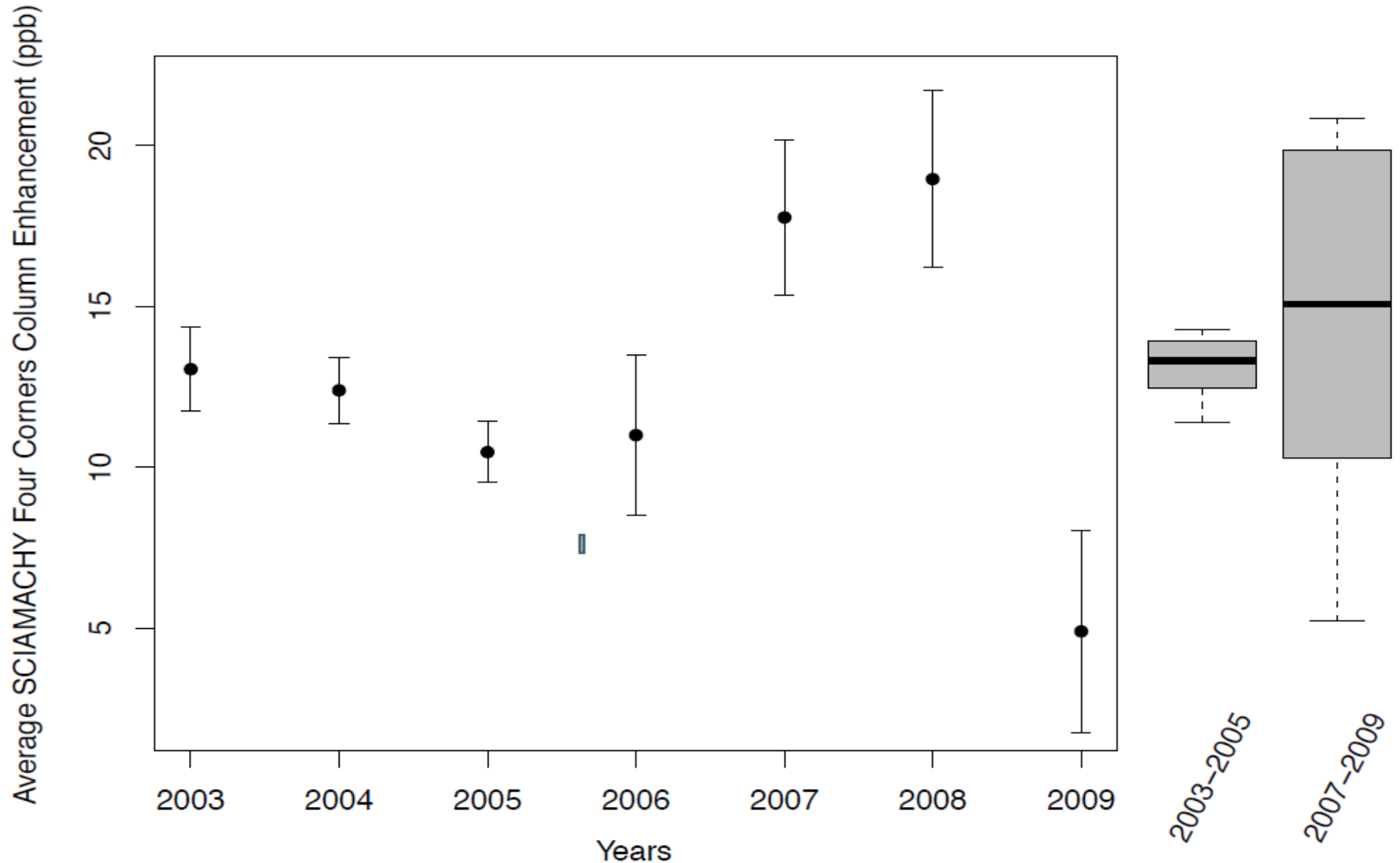
Supplementary Information

Methods Summary:

SCIAMACHY XCH₄ retrievals [Frankenberg et al., 2011] have been gridded at 1/3 degree resolution for the long-term averages as shown in Figure 1.

Small-scale elevation features can have an impact on XCH₄ as they affect the fractional contribution of the depleted stratosphere (hence generally lower XCH₄ over mountains).

The anomaly maps were created by fitting a 3rd order polynomial through the surface elevation – XCH₄ dependence in the region of interest and subtracting this fit from the original XCH₄ dataset (detailed below “Surface topography impact on SCIAMACHY”). WRF-Chem output was converted into XCH₄ and gridded at 1/3 degree as well.

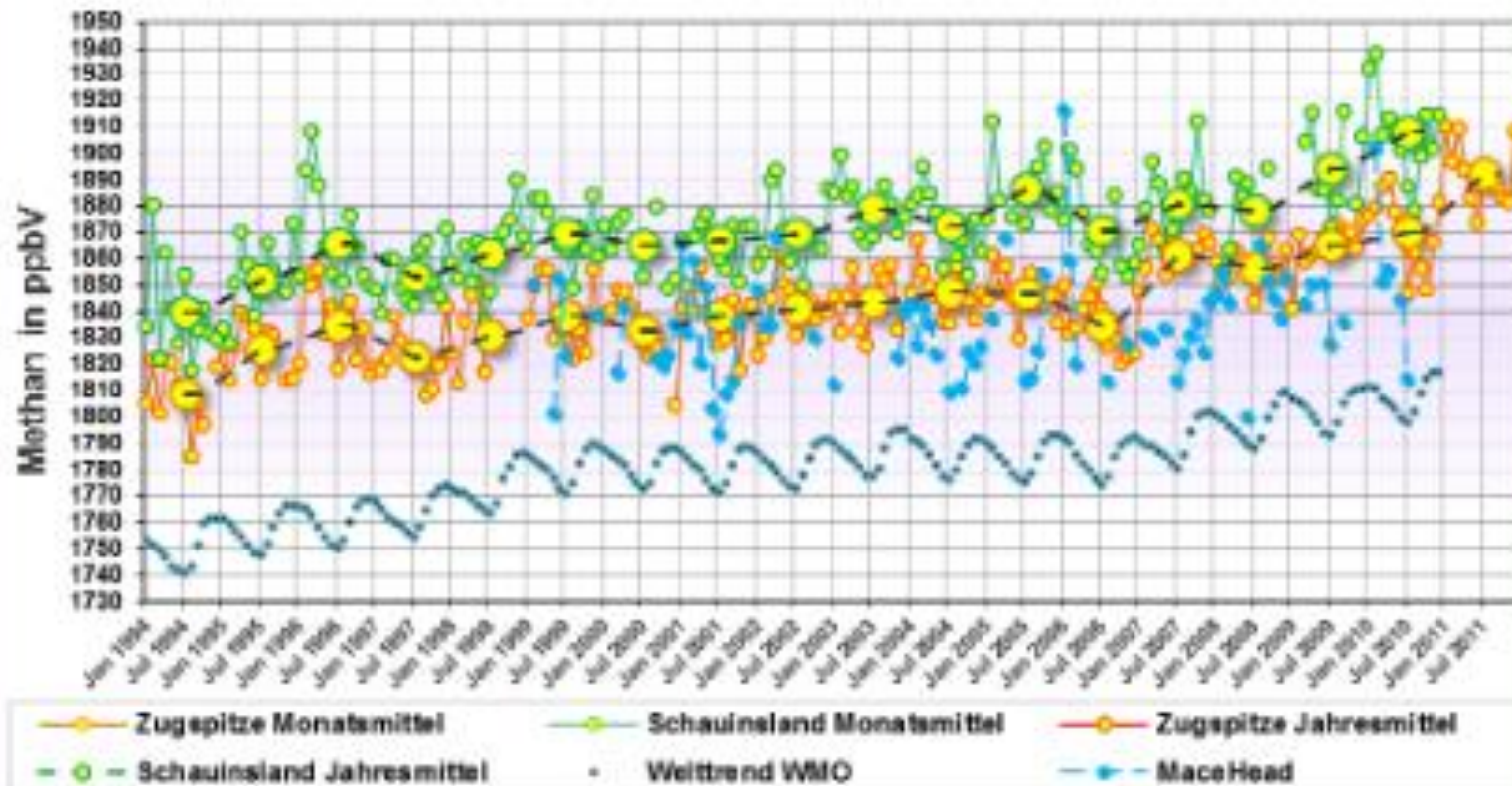


Supplementary Figure 3: Average annual Four Corners SCIAMACHY enhancement. The average enhancement in each calendar year for the Four Corners region is shown, with error bars indicating 1σ . On the right the box and whiskers plot shows the median enhancements and 1st and 3rd quartiles for each time period. Notice we see no statistically significant change between time periods.



<https://www.wmo.int/pages/prog/arep/gaw/documents/GAW-2013-poster-Ries.pdf>

Methan 1994 - 2011, Zugspitze, Schauinsland, MaceHead, Welt



Methane Trend, 1957-2011, Schauinsland, Zugspitze, Mauna Loa, World, monthly averages.

Rough order of Magnitude Computation vs. Time Series

Global Mean in 2003: 1850 Parts Per Billion

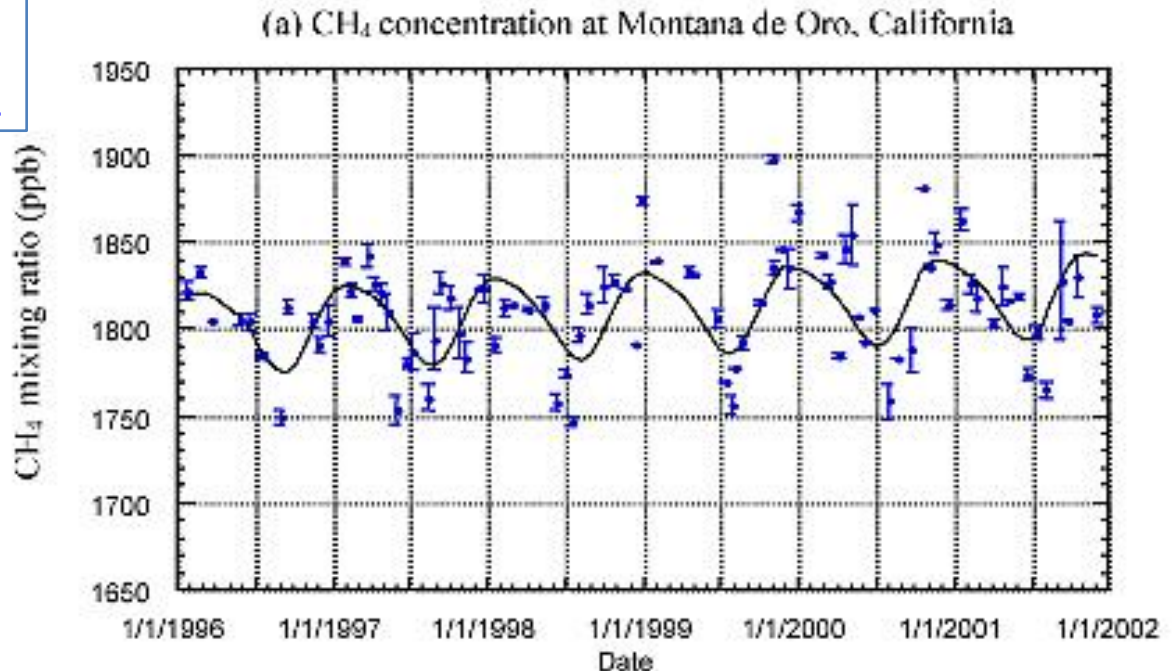
Kort enhancement noted in 2003: 14 PPB

Total Enhancement as a ratio: 14/1850

Anomaly appears to be on the order of <1% or 0.76%

Annual wave is ~50 PPB or +/- 25/1850; +/- 1.3%

<http://cdiac.ornl.gov/epubs/db/db1022/graphs/figure1.html>



In February, I sent this to the Principal Investigator, Dr Eric Kort, U Michigan

From: Bob Endlich [bendlich@msn.com]
To: eakort@umich.edu
Cc: 'Bob Endlich'
Subject: Questions about the methane hot spot in New Mexico

Sent: Sun 2/21/2016 8:46

Message | PDF_New data sets from OCO-2_31_Oct_2015.pdf (3 MB)

Hello Eric,

I am a mostly retired meteorologist with a bachelor's in Geology from Rutgers, 1962, and an MS in Meteorology from Penn State, 1969.

Anyhow, I have not seen any information on the data from the twin otters and ground stations involved in last spring's campaign over the San Juan Basin.

Eric, my questions are:

Why do I not find charts similar to topmost chart in the charts posted from the SCIAMACHY instrument on Envisat over at U Bremen? As a side note, the topmost chart shows none of the Methane sources from the swamps of Louisiana, and the wetlands of NC, VA, PA, NJ, NY, and Ontario. OTOH, there is/was no concentration scale for the topmost graphic which I found in several locations (as said previously, these are popular literature pieces, not from journals....)

Are there any drafts or preprints or data reports from the Twin Otter or ground station instruments?

Follow-up email to the Principal Investigator, Dr Eric Kort, University of Michigan

From: Bob Endlich [bendlich@msn.com]
To: 'Bob Endlich'; eakort@umich.edu
Cc:
Subject: Could you reply? I'm speaking on 1 March 2016 -- Questions about the methane hot spot in New Mexico

Sent: Fri 2/26/2016 9:12 A

Eric,

I'm speaking on this to a civic group on 1 March, and would like your input before that date.

Below I spoke about my field work on the Mancos. During that work Al Hirsch, the PhD student and I found horizons in the Mancos where there was a distinct organic gas odor to the samples we gathered. I'm pretty sure Al put that in his field notes, but that was in 1961.

Have the studies so far shown natural leakage from the exposures of the Mancos Shale?

Bob

ROBERT W. ENDLICH
5010 Noche Bella Loop
Las Cruces, NM 88011
H: 575-522-9083 C: 575-635-3889

Email sent to Gabrielle Petron of NOAA, the Ground Measurements Campaign Lead

From: Bob Endlich [bendlich@msn.com]
To: 'gabrielle.petron@noaa.gov'
Cc: 'Bob Endlich'
Subject: Request for data report on Methane Campaign in Northwest NM

Sent: Thu 6/9/2016 11:03

Hello Gabrielle,

I am a meteorologist interested in the air and ground measurements campaign in northwest New Mexico.

In my undergraduate years I was a geology major and was a student assistant for Al Hirsch in 1961 when we gathered samples of the Mancos Shale in Colorado and New Mexico; some of the samples had a distinct hydrocarbon smell.

I was a Weather Officer in the Air Force and operated aerosol particle counters for ground and C-130 dust particle size distribution characterizations in New Mexico and Europe, and have some appreciation for these types of measurements.

After the 2014 publication by Kort, et al on the "methane hot spot" in New Mexico, you participated in the subsequent ground campaign of 2015. I have not heard of the results of that campaign. The source of the methane anomaly might be from coal, the Fruitland Formation, the Mancos, the numerous gas wells of the San Juan Basin, or the Oil and Gas industry itself, which is why the air and ground campaign measurements are so important in the resolution of the source of this puzzling emission.

Do you have or can you point me in the direction of at least a Data Report or draft of such that is the result of this campaign?

Thanks for any information you might have on this.

Bob

ROBERT W. ENDLICH
5010 Noche Bella Loop
Las Cruces, NM 88011
H: 575-522-9083 C: 575-635-3889

Thoughts up to now:

All of this flap over a <1% anomaly?

When swamplands of Louisiana and Georgia have over a 2% anomaly over huge areas?

No anomaly is noted in the Permian Basin of Texas and New Mexico

From 2003 to 2016 the global mean has increased from 1740 to 1834, or 5%.

There was no increase in <Methane> over the Four Corners during the ENVISAT years; therefore, no fracking signature.

What if the hot spot is natural, not a result of anthropogenic sources?

Final mystery:

What is the source of the enhanced methane signature?

<http://www.daily-times.com/story/money/industries/oil-gas/2016/05/12/geologist-coal-outcrops-cause-methane-hot-spot/84291088/>

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Geologist: Coal outcrops cause methane hot spot

James Fenton, jfenton@daily-times.com 8:17 p.m. MDT May 12, 2016



*LT Environmental Senior Geologist Ashley Ager gives a presentation on Thursday on the subject of "Contributing factors to the Four Corners Methane Hot Spot and Converting Fugitive Methane Gas Emissions into Viable Resource." at McGee Park Convention Center in Farmington.
(Photo: Jon Austria/The Daily Times)*

<http://www.daily-times.com/story/money/industries/oil-gas/2016/05/12/geologist-coal-outcrops-cause-methane-hot-spot/84291088/>

Geologist: Coal outcrops cause methane hot spot

James Fenton, jfenton@daily-times.com 8:17 p.m. MDT May 12, 2016

FARMINGTON — A major reason why a concentration of atmospheric methane the size of Delaware was recorded over the Four Corners area may turn out to be a matter of geology — not the oil and gas industry.

That was the consensus — and the hope — of many oil and gas representatives in the room during a presentation by Durango, Colo.-based geologist Ashley Ager on the final day of the [Four Corners Oil and Gas Conference](#) at McGee Park, Thursday.

CONTRIBUTING FACTORS TO THE FOUR CORNERS METHANE HOT SPOT AND
CONVERTING FUGITIVE METHANE GAS EMISSIONS INTO A VIABLE RESOURCE

From the Abstract:

One contributor to the hot spot is the fugitive methane gas emissions from near-surface and surface coal bed outcrops in the San Juan Basin.

Historically the seepage has resulted in explosion hazards, methane in water wells, distressed vegetation, and greenhouse gas emissions.

Gas surveys along the 23-mile long Fruitland Formation outcrop located on the northern rim of the San Juan Basin have identified the most active areas of methane gas seepage.

In a rural area of La Plata County, methane has historically been observed bubbling into a creek.