



IEAGHG Information Paper: 2016-IP6; A new debate on Increases in Methane Emissions and Terrestrial Carbon Uptake

Recently several new studies have been published that have studied the emission increases particularly of methane and nitrous oxide.

A recent article in the journal *Nature* published by Scientists from the Carnegie Mellon's Department of Global Ecology has studied the net balance of the three most important greenhouse gases—carbon dioxide, methane, and nitrous oxide¹. The study has covered for every region of the Earth's landmass. The study found that that human-induced emissions of methane and nitrous oxide from ecosystems overwhelmingly surpass the ability of the land to soak up carbon dioxide emissions, which makes the terrestrial biosphere a contributor to climate change. These results are regarded as surprising and revise the current understanding of how human activity contributes to global warming.

Co-author Anna Michalak is quoted as saying "*Typically we think of land as a net 'sink' of carbon dioxide. But we found that the sign of the human-induced impact is reversed if we also take into account methane and nitrous oxide.*"

The study considered the biogenic fluxes² of the three greenhouse gases on land that were caused by human activities over the last three decades and subtracted out emissions that existed "naturally" during pre-industrial times. Historically, such fluxes included methane emissions from wetlands and nitrous oxide emissions from soil. However the study shows that human activity has both changed the magnitude of these existing fluxes and also added new categories of biogenic fluxes from sewage, cattle, and fertilizer use. Note: the study did not include non-biogenic gas emissions from activities like fossil fuel burning or natural gas production.

The results showed that the human impact on biogenic methane and nitrous oxide emissions far outweighed the human impact on the terrestrial uptake of carbon dioxide. The conclusion drawn is that humans have caused the terrestrial biosphere to further contribute to warming. The even starker conclusion is that the terrestrial biosphere, as a consequence of human action, is now a net contributor to climate change. The authors claim that this latter conclusion is different to conventional thinking based on previous studies, which had focused only on carbon dioxide and had emphasized the climate change mitigating effect of human impacts on terrestrial carbon uptake.

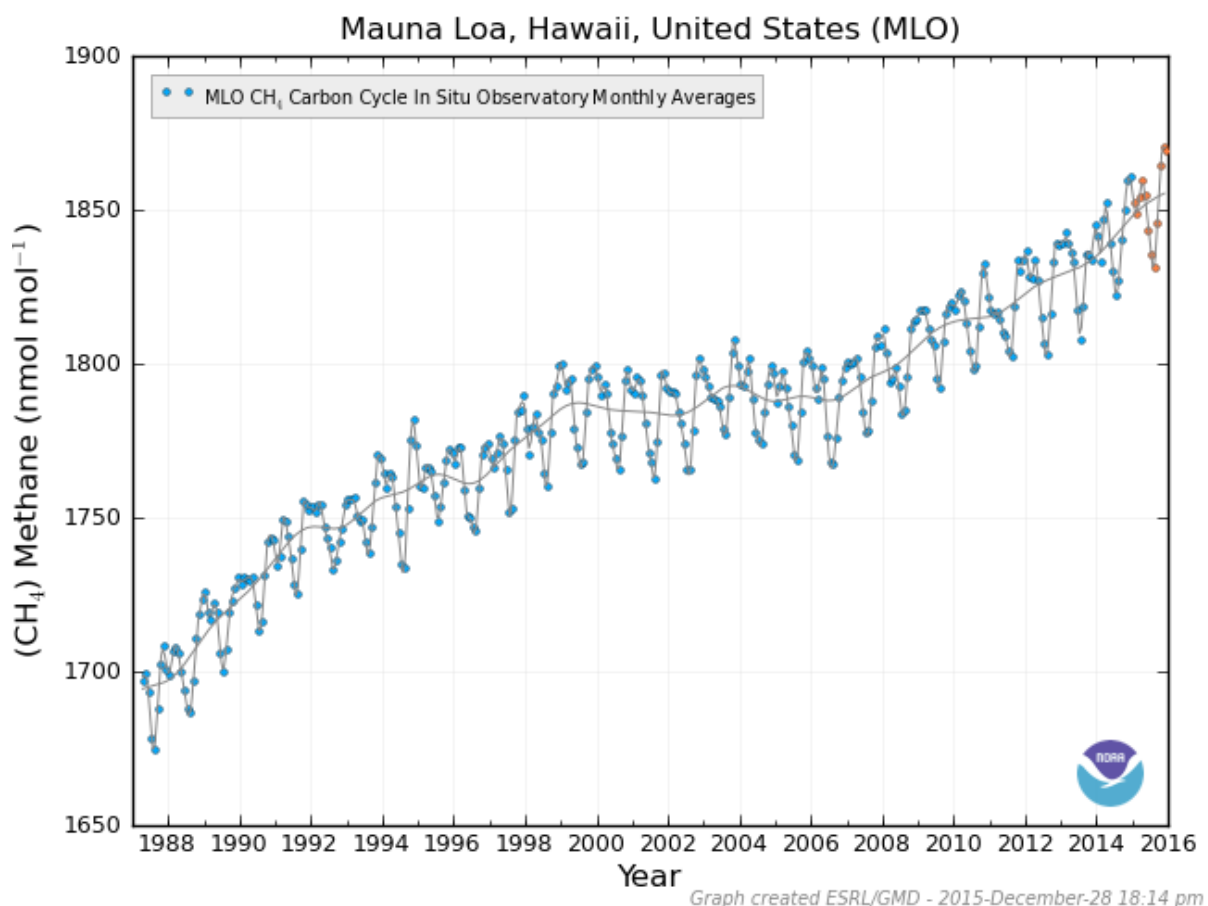
The scientists also found that greenhouse gas emissions vary considerably by region. The human-induced emissions of the gases in Southern Asia, including China and India, had a larger net warming effect compared to other areas. Southern Asia contains some 90% of the world's rice fields and more than 60% of the world's nitrogen fertilizer use. Thus, methane emissions in this region are largely from rice cultivation and livestock, while man-made fertilizers are a major source of nitrous oxide.

In a second study recently published in the journal *Science*³ there is support for the first study's conclusion on the impact of agricultural growth on methane emissions in Asia. The study has looked at why methane levels in the atmosphere started rising in 2007 after holding steady for nearly a decade, see graph below.

¹ The terrestrial biosphere as a net source of greenhouse gases to the atmosphere, *Nature*, DOI: 10.1038/nature16946, see <http://phys.org/news/2016-03-greenhouse-gas-bookkeeping.html>

² Biogenic sources include gas emissions from plants, animals, microbes, etc.,

³ 21st century shift from fossil-fuel to biogenic methane emissions indicated by ¹³CH₄ *Science* 10 Mar 2016 DOI: 10.1126/science.aad2705, see <http://science.sciencemag.org/content/early/2016/03/09/science.aad2705>



Source: <http://www.esrl.noaa.gov/gmd/obop/mlo/programs/esrl/methane/methane.html>

This study undertaken by atmospheric scientists at the National Institute of Water and Atmospheric Research in Wellington, New Zealand focused on the unique isotopic signatures of methane from different sources. Methane from natural gas leaks in oil and gas production, for example, has a different signature from methane generated by bacteria in a cow's stomach or similar methane-producing bacteria found in rice paddies or other wetlands. The different signatures are based on the ratio of carbon-12 to carbon-13, two forms of carbon that are in methane. This ratio varies from source to source, allowing researchers to make inferences about the origins of the gas. The authors conclude that if you see changes in the carbon-12 to carbon-13 ratio of methane in the atmosphere, you can draw conclusions about how different methane sources change over time. The study also drew on previously published research based on satellite data that suggested the region including India, China and Southeast Asia was the source of increased emissions. The combined information led the researchers to conclude that the additional emissions were from agriculture, not from oil and gas or melting permafrost. Their conclusion is that the rise in methane concentration in the atmosphere reflects the growth of agriculture as a direct result of Asia's booming population. Specifically that rice paddies in Southeast Asia and livestock in India and China are probably the major source the global increase in methane emissions observed.

It must be noted that that the results have been challenged, in particular others suggest the fracking-driven U.S. oil and gas boom is more likely to be the cause. Scientists at Harvard looked at satellite data and surface observations and suggested that U.S. methane emissions could account for 30 to 60



percent of the global growth of atmospheric methane over the past decade⁴. This work did not attempt to pinpoint the source of the emissions but suggests that leaks from the oil and gas industry may be the cause. The study notes that other researchers have recently observed increases in atmospheric concentrations of ethane. Ethane is a component of natural gas. The conclusion is that if both methane and ethane are rising, natural gas production is likely the source.

Researchers from Stockholm University publishing in *Nature Geoscience* also suggest the global methane increase *"is mostly a northern hemisphere problem, most likely due to leaks from natural gas wells, and distribution systems, which is a relatively easy to solve problem"*. However they go on to suggest that whilst not the cause of the increase since 2007 the release of methane from northern lakes and ponds needs to be taken seriously. These waters they suggest are significant, contemporary sources because they cover large parts of the landscape. They consider that they are also likely to emit even more methane in the future, because with global warming, particularly at high northern latitudes, longer ice-free seasons in combination with permafrost thaw is likely to fuel methane release from lakes, potentially causing their emissions to increase 20-50 percent before the end of this century. Such a change they postulate would likely generate a positive feedback on future warming, causing emissions to increase even further.

The one point that all the studies agree on is that global methane emissions have started to increase since 2007. However, it would appear that there are two opposing scientific views as to source of the increase in methane emissions post 2007; Asian agriculture and/or US oil and gas production. At present it seems that further research is needed to quantify if which is the most significant contributor then mitigation steps can be put in place.

However, it is fair to say that the increase in US methane emissions has been recognised and the need to mitigate these emissions acted upon. A recent joint communique by President Obama of the USA and President Trudeau of Canada agreeing to reduce methane emissions from oil and gas by as much as 45 percent from 2012 levels by 2025. The USA has already put in place regulatory efforts to limit emissions at existing oil and gas infrastructure.

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⁴ A large increase in U.S. methane emissions over the past decade inferred from satellite data and surface observations, *Geophysical Research Letters*, Research Letter 10.1002/2016GL067987, see http://acmg.seas.harvard.edu/publications/2016/Turner_GRL_2016_Methane.pdf