The Methane Misconceptions

A paper by Dr Wilson Flood

Summary

A doubling of the amount of methane in the atmosphere with its present composition would produce a warming equal to only about one thirtieth of the warming produced by a doubling of carbon dioxide.

At present rates of increase it would take about 360 years for atmospheric methane levels to double.

Molecule for molecule, methane is 7 times more effective at being a greenhouse gas than carbon dioxide.

Present changes in atmospheric methane levels pose no environmental risk whatsoever.

Introduction

Methane as a "powerfully climate wrecking" greenhouse gas features a lot in media articles about waste, farm animals, and peat bogs to name but three. For example, on the Met Office website, one of the links to their climate change section is titled "Belching Cows Contribute to Climate Change". This short paper shows, among other things, that they cannot contribute to global warming in any discernible way and that research into altering the diet of farm animals to reduce dietary methane is hugely wasteful of resources.

According to Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO)

http://www.cmar.csiro.au/e-print/open/gh_faq.htm

"A kilogram of methane released into the air today, for example, will lead to about 20 times more atmospheric warming over the next century than a kilogram of carbon dioxide."

The above statement is typical of what you will read in any article on anthropogenic global warming (AGW) that covers the topic of methane. The factor of 20 times for methane is termed its global warming potential (GWP).

The CSIRO webpage explains that GWP takes into account:

- the amount of radiation that the gas absorbs and the wavelength at which it absorbs
- the time that the gas stays in the atmosphere before reacting or being washed out by rainwater
- the current concentration of the gas in the atmosphere
- any indirect effects of the gas; for example, methane will produce ozone gas in the lower atmosphere and water vapour in the stratosphere.

The impression is thus created that a doubling of methane in the atmosphere will cause 20 times the warming caused by a doubling of carbon dioxide and that this could happen within a relatively short period of time. If we take a typical IPCC projection of a two centigrade degree (2C) rise for a doubling of carbon dioxide then the implication is that a doubling of methane would produce a rise of 40C and that even small increases in methane would be disastrous for life on this planet. It is easy to understand the concern about the warming that would result if large amounts of methane were released from the Siberian permafrost as has been widely discussed elsewhere. However, these are all based on a number of misconceptions related to methane which are described below.

The First Misconception

Doubling of atmospheric methane concentration will produce a massive rise in global temperature.

What mass of carbon dioxide is present in the atmosphere?

An estimate for the total volume of the Earth's atmosphere is

4.1×10^9 km^3 (converted to a pressure of 1 atm i.e. 10^5 pascals)

The concentration of carbon dioxide in the atmosphere at present is 390 ppmv (parts per million by volume), equivalent to 390×10^{-6} dm^3 of carbon dioxide per dm^3 of air.

The volume of carbon dioxide in the atmosphere (at 1 atm pressure) is therefore

$4.1 \times 10^9 \times 390 \times 10^{-6} \times 10^{12}$ dm^3 i.e. 1.6×10^{18} dm^3 (1km^3 = 10^{12}dm^3).

If we assume an overall temperature for the atmosphere of 273K, 1 dm^3 of carbon dioxide will have a measured mass of 1.96 g at a temperature of 273K and a pressure of 1 atm.

The mass of carbon dioxide in the atmosphere is therefore

$1.6 \times 10^{18} \times 1.96$ g = 3.14×10^{18} g

rounding to an approximation of 3×10^{12} tonnes i.e.

3000 gigatonnes or 3000 billion (10^9) tonnes.

What mass of methane is present in the atmosphere?

A calculation similar to that for carbon dioxide can be carried out for methane.

For methane the atmospheric concentration at present is 1.8 ppmv and 1 dm^3 of methane has a mass of 0.71 g.

The mass of methane in the atmosphere is given by the calculation

$4.1 \times 10^9 \times 1.8 \times 10^{-6} \times 10^{12} \times 0.71$ g = 5.24×10^{15} g

In other words, about 5 gigatonnes or 5 billion tonnes; much less than carbon dioxide, in fact a whopping 600 times less.

So, if the atmospheric concentrations of both carbon dioxide and methane were doubled over time the warming produced by the methane would not be 20 times that of carbon dioxide but roughly 20/600 i.e. one thirtieth of the warming produced by doubling carbon dioxide. If we take, as a hypothesis, the typical IPCC figure of a 2C rise for doubling carbon dioxide then doubling methane would produce a temperature rise of approximately 2/30C i.e. 0.07C.

A number of sample calculations are appended at the end of the paper showing projected temperature rises for different concentration increases in carbon dioxide and methane.

So the First Misconception to be corrected is:

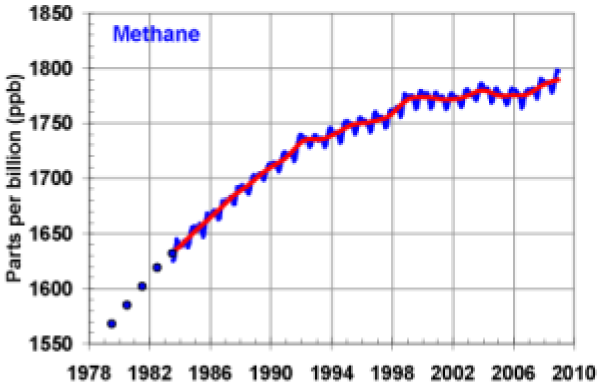
Doubling of atmospheric methane concentration will not produce a massive rise in global temperature. Although methane is an effective greenhouse gas (GHG) the total amount in the atmosphere is so small that a doubling would produce very little warming.

The Second Misconception

Methane levels are rising dramatically.

How quickly are atmospheric methane levels rising?

Levels of GHGs are monitored by the National Oceanic and Atmospheric Administration (NOAA) in the USA. The NOAA graph for methane is reproduced below:



Methane concentrations are given in ppbv (parts per billion by volume). The conversion is 1800 ppb = 1.8 ppm. It can be seen from the graph that atmospheric methane has increased in concentration by about 0.1 ppm in the period from 1988 to 2008. If we take this rate of increase as a benchmark then the doubling of atmospheric methane from the present value would take about 360 years. To put things into perspective, that is equal to the historical span from 1650 to the present day. It is therefore a moot point as to whether atmospheric methane levels represent one of humanity's more pressing concerns and whether scarce resources should be devoted to investigating them at this time.

Ruminant farm animals such as cows and sheep cause no increase *per se* in atmospheric carbon levels. They merely recycle atmospheric carbon and have no effect on global warming. Ruminants eat grass and convert it into meat and milk. They also produce carbon dioxide, and methane which in the course of about 12 years in the atmosphere is converted also into carbon dioxide. The meat and milk are consumed by people who metabolise some of it into carbon dioxide. The carbon dioxide is taken up by the growing grass and the process begins again. Over the long term, taking animal and human mortality into account, there is no net change in the carbon balance from these processes alone.

So the Second Misconception to be corrected is:

At present rates the atmospheric methane concentration would need 360 years to double. Methane levels are not rising rapidly and present no conceivable threat of any kind.

The/

The amount of methane in the atmosphere is increasing by a mere 14 million tonnes (0.014 gigatonnes) per annum . Only a small fraction of this will be due to farm animals and one is led to the conclusion that research into methane emissions from this latter source is wasteful of resources since the amount is insignificant when compared with the total mass of the atmosphere which is approximately 4.5 million gigatonnes.

The Third Misconception

Methane can warm the atmosphere 20 times more than carbon dioxide.

A little chemistry

When we compare the ability to warm the atmosphere of one greenhouse gas (GHG) with another we are dealing with behaviour of the gases at the molecular level. When a molecule of a GHG absorbs one quantum of energy, the energy of the molecule is raised to a higher energy state. This higher energy state is unstable and the quantum of energy is released after a short time. This process slows the release of energy from the atmosphere and causes the warming we call the greenhouse effect.

Atoms of different elements have different masses. Atomic mass is measured in a unit called the atomic mass unit. This allows chemists to work out the relative masses of molecules of different substances. The masses of atoms of four elements are shown below:

Hydrogen, H	= 1
Carbon, C	= 12
Nitrogen, N	= 14
Oxygen, O	= 16

Working out the mass of a gas molecule is accomplished simply on a “totting up” basis. So, for the gases concerning us:

Methane, CH_4	= 16
Carbon dioxide, CO_2	= 44

Since we are dealing with molecules, for a comparison of two gases to make any sense we must deal with equal numbers of molecules of the two gases. A way of doing this is by means of chemistry’s Avogadro’s Law which states that equal volumes of gases under the same conditions of temperature and pressure contain equal numbers of molecules. However, the mass of a gas molecule depends on the masses of the atoms that make up the molecule so equal volumes of gases will have different masses if the gas molecules are of different mass.

If a given volume of methane weighs 16 g, the equivalent volume of carbon dioxide would weigh 44 g, but both would contain the same number of molecules (we assume all comparisons are at the same temperature and pressure unless stated otherwise). Similarly, 16 tonnes of methane has the same number of methane molecules as 44 tonnes of carbon dioxide would have carbon dioxide molecules. Conversely, 1 kg of methane has 2.75 times the number of molecules as 1 kg of carbon dioxide.

So the Third Misconception to be corrected is:

A methane molecule does not have a warming ability that is 20 times that of a carbon dioxide molecule since the GWP is based on comparing equal masses. In one kilogram of methane there are 2.75 times the number of molecules that there are in one kilogram of carbon dioxide. Molecule for molecule, the warming ability of methane compared to carbon dioxide is 20/2.75 i.e. a more modest 7.3 times. This increased warming ability is mainly due to there being much less methane in the atmosphere in the first place coupled with the fact that absorption of energy diminishes logarithmically as concentration increases.

In Conclusion

Environmental NGOs, the mainstream media and public environmental agencies have generated considerable hysteria concerning the matter of "the dangerous greenhouse gas" methane being released from landfill sites or peat bogs, or being produced by farm animals. One consequence of this has been millions of hours spent by members of the public in sorting waste for recycling.

When one considers the facts it is difficult to see that there are any serious environmental issues with changes in atmospheric methane levels. One is drawn to a variety of possible conclusions: there is a woeful lack of knowledge of basic chemistry on the part of environmental agencies and NGOs; the available data is not known about or cannot be understood; or, more likely, desired ends (grants, publicity, public financial support, sales of publications, control) are not served by a consideration of facts and available data.

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APPENDIX – Sample Calculations

The calculations below are based on the Wigley formula for radiative forcing by carbon dioxide modified by Myrhe.

ΔF (W per sq m) = 5.35log(C/Co) where log is taken to be $\log_e$

Co is the initial concentration of carbon dioxide in ppm(v) and C is the changed concentration. The formula assumes no feedbacks.

IPCC have affirmed that the formula is valid from 250 ppm to 1000 ppm.

Forcing is converted to temperature changes in Kelvin (or centigrade degrees) by using the Stefan-Boltzmann Law which relates the radiative energy of a body (W per sq m) with its temperature (in Kelvin) ie

$E = \sigma T^4$ where σ is the Stefan-Boltzmann constant (5.6696 x 10^{-8} $Wm^{-2}K^{-4}$)

The temperature change is given by $T_2 – T_1 = (E_2\sigma^{-1})^{1/4} – (E_1\sigma^{-1})^{1/4}$ where $E_2 = E_1 + \Delta F$ and E_1 is assumed to be 390 Wm^{-2} given a mean global temperature of 288 K.
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1 Forcing from doubling carbon dioxide given atmospheric concentration of 390 ppm

5.35log(C/Co) = 5.35log2 = 5.35x0.693 = 3.71 W per sq m

equiv to a rise of **0.67 C** (0.6678 C) without feedbacks

2 Forcing from doubling of methane alone [1.8 ppm of methane equiv to 13.1 ppm carbon dioxide (1.8x7.3)]

5.35log(403.1/390) = 0.177 W per sq m

equiv to a rise of **0.032 C** without feedbacks

3 Forcing from doubling of methane and carbon dioxide

5.35log(793.1/390) = 5.35x.710 = 3.80 W per sq m

equiv to a rise of **0.68 C** without feedbacks i.e. contribution of methane is **0.01 C**

4 Forcing from 100 years of methane growth on its own given a doubling in 360 years (methane equiv to 13.1x100/360 = 3.6 ppm carbon dioxide)

5.35log(393.6/390) = 0.049 W

equiv to a rise of 0.**0085 C** without feedbacks

5 Forcing over 100 years assuming carbon dioxide doubles in 100 years and methane increases at present rate, doubling in 360 years

Forcing is 5.35log(783.6/390) = 3.73 W per sq m

equiv to a rise of **0.6719 C** without feedbacks

The warming produced by methane growth in 100 years accompanied by a doubling of carbon dioxide would be approximately **0.004 C** (0.6719 C – 0.6678 C from calc 1) without feedbacks. Even a feedback of 10x would cause a temperature rise of only 0.04 C.