Methane and Global Warming

"While all eyes were turned on Carbon Dioxide, almost by chance a few researchers discovered that other gasses emitted by human activities have a greenhouse effect strong enough to add to Global Warming."(1) This statement, made by Spencer Weart, author of the book Global Warming and his website, The Discovery of Global Warming perfectly illustrates our ignorance of the affect that methane has on our environment. Only as recently as the 1970's have researchers began to realize the true affect that other gases, including methane have on the advancement of global warming. So how does methane truly affect global warming?

Let us begin with the history. In 1859, after the discovery of the ice ages, researcher John Tyndall began to test several common gasses in his laboratory for their ability to block heat radiation. As his hope of finding non-transparent gases slowly dwindled, Tyndall thought to try coal-gas. Consisting of carbon monoxide mixed with a bit of the hydrocarbon methane and more complex gases, Tyndall found that for heat rays, this "gas was as opaque as a plank of wood."(1)

As studies of the affect of gases on the environment grew, little to no attention was paid to any gases other than water vapor and CO2. It was not until 1948 that methane was detected in the environment and thereafter, in 1960's and 1970's, largely out of curiosity, scientists cataloged a variety of sources for methane in the atmosphere. (1) Still, it was not thought that methane had any significance for climate change. In 1971, researchers studying climate stated, "To the best of our knowledge, most atmospheric CH_4 is produced [and destroyed] by microbiological activity in soil and swamps. For this reason and because CH_4 has no direct effects on the climate or the biosphere, it is considered to be of no importance for this report." (2)

While these were the beliefs of scientists in the late 18^{th} century, still we come to discover that atmospheric methane concentration is increasing by a drastic 1% per year due to human industrial

activities. This fact intrigued modern day scientists to study the effect of methane as a greenhouse gas. In fact, researchers concluded that methane is 20-30 times more efficient as a greenhouse gas than carbon dioxide, effectively trapping outgoing terrestrial radiation. (3) But where does methane come from? Methane is emitted from a variety of both human related (anthropogenic) and natural resources. Human related activities include fossil fuel production, animal husbandry, rice cultivation, biomass burning and agriculture residue burning.

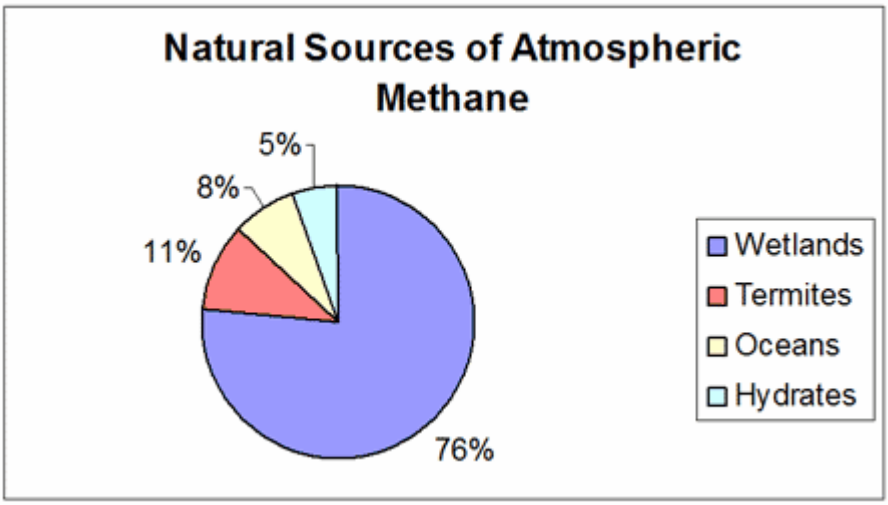
Table 1 U.S. Methane Emissions by Source ($TgCO_2$ Equivalents) Tg= teragrams

Source Category	1990	1997	1998	1999	2000	2001	2002	2003
Landfills	172.2	147.4	138.5	134.0	130.7	126.2	126.8	131.2
Natural Gas Systems	128.3	133.6	131.8	127.4	132.1	131.8	130.6	125.9
Enteric Fermentation	117.9	118.3	116.7	116.8	115.6	114.5	114.6	115.0
Coal Mining	81.9	62.6	62.8	58.9	56.2	55.6	52.4	53.8
Manure Management	31.2	36.4	38.8	38.8	38.1	38.9	39.3	39.1
Wastewater Treatment	24.8	31.7	32.6	33.6	34.3	34.7	35.8	36.8
Petroleum Systems	20.0	18.8	18.5	17.8	17.6	17.4	17.1	17.1
Rice Cultivation	7.1	7.5	7.9	8.3	7.5	7.6	6.8	6.9
Stationary Sources	7.8	7.4	6.9	7.1	7.3	6.7	6.4	6.7
Abandoned Coal Mines	6.1	8.1	7.2	7.3	7.7	6.9	6.4	6.4
Mobile Sources	4.8	4.0	3.9	3.6	3.4	3.1	2.9	2.7

Petrochemical Production	1.2	1.6	1.7	1.7	1.7	1.4	1.5	1.5
Iron and Steel	1.3	1.3	1.2	1.2	1.2	1.1	1.0	1.0
Agricultural Residue Burning	0.7	0.8	0.8	0.8	0.8	0.8	0.7	0.8
Total for U.S.	**605.3**	**579.5**	**569.3**	**557.3**	**554.2**	**546.7**	**542.3**	**544.9**

Source: US Emissions Inventory 2005: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003 (4)

Natural resources of methane include, wetlands, gas hydrates, permafrost, termites, oceans, fresh water bodies, non-wetland soil and other sources such as wild fires.



Source: Prepared from data contained in IPCC, 2001c (4)

While in the atmosphere, methane has been found in both the troposphere and the stratosphere. In addition to inducing climate warming on its own, this gas undergoes important chemical reactions in both spheres which lead to additional affects on climate warming. In the troposphere, there are strong interactions between methane and hydroxide, which produce ozone. Additionally, in the stratosphere, its reaction with the hydroxide produces water vapor. Both troposphere ozone and the stratospheric water vapor are green house gases, thereby bringing additional global warming.

Global warming potential (GWP) is the measure of how much a given mass of a given green house is estimated to contribute to global warming.

The GWP depends on the following factors:

- The absorption of infrared radiation by a given species
- The spectral location of its absorbing wavelengths
- The atmospheric lifetime of the species

Thus, a high GWP correlates with a large infrared absorption and a long atmospheric lifetime.

In comparison with other greenhouse gases, methane has more atoms. It is the simplest, stable hydrocarbon molecule its rovibrational spectroscopy is very complicated. This is mainly due to the high symmetry of the tetrahedral system which leads to the existence of much degeneracy and to its intricate vibration structure; it in fact has four fundamental vibration frequencies, three of them being degenerate oscillators. See table 2 below.

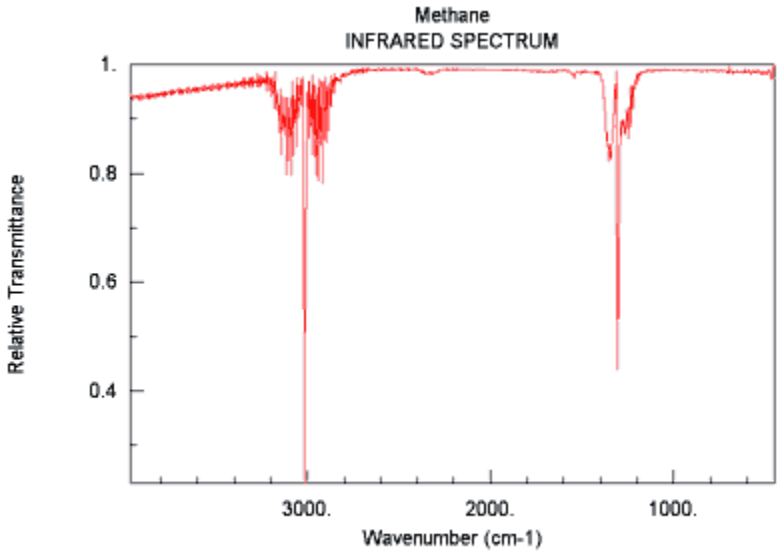
Table 2: The normal modes of methane

ν_1	ν_2	ν_3	ν_4
A_1	E	F_2	F_2
Stretching	Bending	Stretching	Bending
Raman	Raman	IR	IR
2916 cm^{-1}	1533 cm^{-1}	3019 cm^{-1}	1311 cm

Methane is a relatively potential green house with a high GWP of 25 over a 100 year period. This means that methane a methane emission will have 25 times the impact on temperature of a carbon dioxide emission of the same mass over the following 100 years. Methane has a net lifetime of 8.4 years

which means it has a large effect for a brief period, whereas carbon dioxide has a small effect for a long period (over 100 years)(6)

The Infrared spectrums lead to the vibration of methane molecule.



This image shows the spectrum of methane (CH_4), a naturally occurring gas that is used for cooking and heating.

When the red line is near the top of the graph it indicates that methane is transmitting energy at that wavelength. When there is a dip toward the bottom it is because energy at that wavelength is being absorbed and therefore not "seen".

(5)

Literature Cited

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