

Greenhouse gases – a more realistic view

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The contributions of water vapour (H₂O), carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) to the warming of the atmosphere are reviewed. Water vapour and clouds are responsible for 90% or more of the greenhouse gas (GHG) effect. CO₂ has a finite influence. However, contrary to the common assertions, the contribution of methane and N₂O to world's total emissions is negligible. We therefore conclude that expensive attempts to reduce human emissions can have negligible effects only on regional and world temperature.

Therefore, the generally accepted effects of CH₄ and N₂O as infrared-absorbing GHGs, causing about 50% of the total New Zealand emissions, must therefore be urgently reassessed, and to a lesser extent the quantitative role of CO₂. It is suggested therefore that CH₄ and N₂O be removed from New Zealand's Greenhouse Gas Inventory, and that the supporting case for such treatment be prepared for negotiation with our international partners towards eventual withdrawal from the Paris 2015 agreement.

Introduction

The rotating planet earth is warmed by incoming sunlight in the daytime and cooled by outgoing infrared radiation at night.

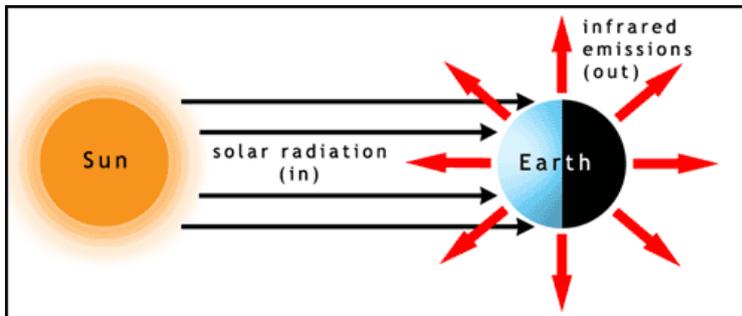


Figure 1A : Incoming solar radiation (energy) in and infrared emissions out.

The planet never actually reaches equilibrium. The real atmosphere contains a varying percentage of water vapour, (dry air is an idealised concept found only in the laboratory). The principal atmospheric gases N₂ and O₂ have no role in cooling.

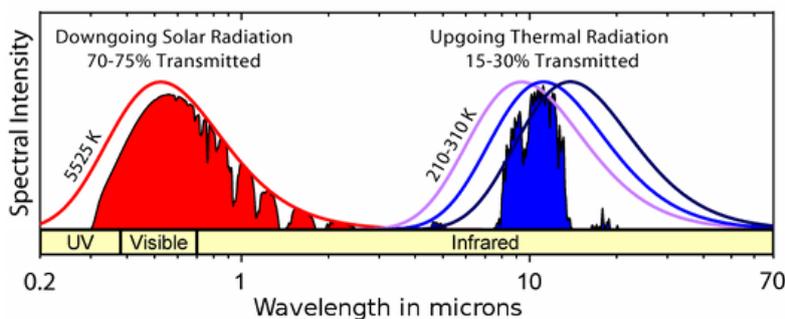


Figure 1B : Incoming solar radiation (energy) at 0.2 to 3 microns, and outgoing thermal radiation at 3 to 70 microns

The blackbody curves shown in the figure are displaced in wavelength (shifted horizontally) depending on temperature. Molecules radiating from different altitudes will do so at corresponding temperatures.

The cooling process involves multiple steps: heat from the surface is radiated back, absorbed by the various GHGs (mainly water vapour), and transported upward by the convection of moist air to the upper troposphere, where clouds form. Throughout this journey from the surface molecular collisions, emission and re-absorption of radiation continues. The 'greenhouse effect' is attributed to gases that absorb and emit solar electromagnetic energy in a particular part of the electro-magnetic spectrum – ultraviolet (UV), visible, infrared light.

The final cooling step (emission to space) takes place via infrared radiation leaving the upper troposphere and stratosphere.

The downcoming radiation from the sun is in the UV and visible light part of the spectrum (0.1 to 1.2 microns wavelength), and here there is some interception of energy by clouds and a little by water vapour. There is virtually no effect of the GHGs, CO₂, CH₄, and N₂O at the wavelength of the incoming radiation (heat) from the sun.

All of the upgoing thermal radiation is in the 3 to 70 micron range of the spectrum, where the GHGs have some effect in absorbing the up-radiated heat from the earth's surface. This will be discussed in greater detail later.

Computer models attempt to account for all these mechanisms, and make future predictions about planetary conditions, especially temperature.

GHGs and their contribution to global warming (aka climate change and more recently 'climate disruption') are of national interest in view of the 2015 Paris Climate Agreement, and the commitments New Zealand has made to reduce emissions of these gases in the future. In addition to the known GHGs, ozone is recognised for its protective effect against UV radiation from space and will not be discussed further. CH₄ and N₂O make up almost half of New Zealand's assessed GHG emissions, but are insignificant in comparison with CO₂.

Mistakenly, water vapour is not included in any assessments of GHG effects by the International Panel on Climate Change (IPCC), a crucial omission. The IPCC concentrates mainly on anthropogenic (human) emissions, and ignores natural contributions of the GHGs from the planet and the ubiquitous water vapour, both of which also must be included in any sensible consideration of the effects on world temperature.

The potential effectiveness of GHGs in influencing temperature depends essentially on five factors:

1. The capability of individual molecules to absorb or radiate heat.
2. Their relative concentration in the atmosphere.
3. Whether each can actually absorb effectively (as heat is radiated to and from the earth) depends on both the location of their spectral bands and the energy distribution of the earth's outgoing radiation.
4. Competition for absorption by and between other gases.
5. Phase change of water, evaporation, condensation and precipitation.

These factors will be discussed in turn.

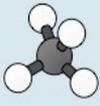
Capability of individual molecules

In the 1860s, John Tyndall demonstrated that some atmospheric and other gases absorbed heat from black body radiation. He reported that CH₄ and N₂O both absorbed about four times as much heat as carbonic acid, the original name for CO₂. While his observations were not truly quantitative, this estimated value is many times less than indicated by the adopted Global Warming Potential (GWP) figures from the Intergovernmental Panel on Climate Change (IPCC) – see values in Table 1.

GWP is a calculated ratio that the IPCC uses to estimate how much heat a GHG absorbs in the atmosphere (IPCC AR5, pp.210-216). It compares the amount of heat trapped by a very small amount of the gas in question to the same additional very small amount of the comparator gas, CO₂ in this instance. This value for ‘radiative forcing’ is supposed to estimate the relative capability of a GHG molecule to have an effect on warming in comparison with one molecule of CO₂. GWP is a concept promulgated by the IPCC and is accepted (by governments) as the basis for the calculation of their country GHG inventories. More of that later.

The individual molecules of CO₂, H₂O and N₂O are similar in structure. Their relative concentrations in the atmosphere are in Table 1: CO₂ is now 410 ppm.

Table 1: Atmospheric parameters of GHGs

	Water	Carbon Dioxide	Methane	Nitrous Oxide
				
Atmospheric Concentration	0.01–4%*	385 ppm	1797 ppb	322 ppb
Rate of Increase	n/a	1.5 ppm/yr	7.0 ppb/yr	0.8 ppb/yr
Atmospheric Lifetime	Very short 1–5 days	Variable 5–200 yr	12 yr	120 yr
Global Warming Potential (GWP)	n/a†	1	21	310

* The amount of water vapor in the air varies according to temperature and density of air (usually ~1–3% of troposphere)

† Water vapor levels vary strongly according to region, so rates of change and warming potential cannot be assessed

The GWP values are from the 2007 IPCC AR4 report. In 2013, the IPCC adjusted the GWP for CH₄ up to 28, and for N₂O downwards to 265. Effectively these values are almost certainly wrong, because of the faulty conceptual approach embedded in the very definition of GWP. Recent reports also emphasise that the treatment of reputedly long-lived gases such as CO₂ in the same way as short-lived gases (such as CH₄, 12 years) is not environmentally credible (Allen et al., 2018). This same approach must also be considered for N₂O because the half life of this gas in the atmosphere is about half that for CO₂. Allen et al’s (2018) approach if adopted will probably reduce CH₄’s assessed effect by three-quarters, or New Zealand’s

calculated emissions by about 30%. Quite evidently, the ‘official’ GWP numbers asserted by the IPCC are unreliable and controversial.

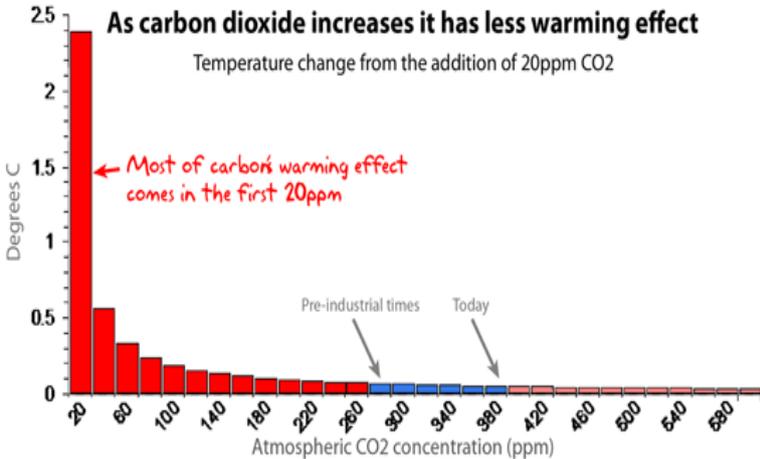
Recent calculations (Happer & van Wijngaarden, unpublished data) clearly show that the absorptive capability of individual molecules of the GHGs is not as widely different as the GWP values might suggest (Table 2). **Table 2: Calculated heat absorptive capability of individual GHG molecules, relative to CO₂ with a concentration change of zero to one ppb, at the tropopause (11 km) or the top of the atmosphere**

Capability to absorb heat in comparison with CO₂ = 1

Gas	Top of atmosphere	Tropopause
CO ₂	1	1
CH ₄	0.19	0.22
N ₂ O	0.54	0.66
H ₂ O	0.084	0.14

Table 2 shows that the capability of the individual molecules to absorb heat (radiative forcing) is of the same order of magnitude. This seems reasonable since the molecular structure of the four molecules is not enormously different. Also, the absorptive value differences between the molecules is very similar to what Tyndall found in the 1860s.

This refutes the popular notion and the IPCC’s claim that CH₄ and N₂O are much more powerful GHGs than CO₂. The reason for this is that the assumed radiative forcing for CO₂ is much more strongly saturated than the other gases (Figure 2).



* Assumes a climate sensitivity of 0.15°C/W/m2 following Lindzen and Choi, 2009

Figure 2: Increasing levels of CO₂ cause less and less warming effect. Source: Adapted from Lindzen & Choi (2009), this relationship is the basis of the MODTRAN atmospheric model, University of Chicago

Because of this saturation additional CO₂ above 400 ppm has a miniscule effect on warming in comparison with the very low unsaturated concentrations for N₂O and CH₄. However, the comparative effects of CH₄ and N₂O on warming are derived with no cognisance of any competitive effects of water vapour throughout the atmosphere, or the fact that there is very

little energy transfer from the earth at the frequency at which these trace gases might have an effect. More of this later.

Relative concentration of GHGs in the atmosphere

Omitting water vapour, the major gas components of a ‘dry’ atmosphere are nitrogen (N), oxygen (O) and argon (Ar), at 78.1%, 20.9% and 0.92% by volume, respectively, all of which do not absorb heat. This leaves 0.1% by volume for the remaining gases. CO₂ at 400 ppm is the largest of the trace gases. CH₄ and N₂O are very small, just traces in effect, 1.7 and 0.3 ppm, respectively (Table 1).

But the real atmosphere is not dry. Water vapour is widely variable: a very low percentage at the poles, but up to 4% in the tropics. For the purposes of comparisons and discussion in this article, we have assumed it is 1.5% or 15,000 ppm. Of course, any amount of atmospheric water vapour will proportionately reduce the percentage of all the other gases.

Further the amount of anthropogenic CO₂ (human induced) produced each year is less than 5% of the total CO₂ entering the atmosphere. Now, how are these gases supposed to cause all of the warming the world has experienced since the Little Ice Age (LIA)? In the teaching and scientific literature the estimates vary. The estimates in Figure 3 below suffice for the discussion. CO₂ is generally regarded as causing about 60% of the warming from GHGs, CH₄ 15%, and N₂O about 5%. Clearly the ‘agricultural gases’, although at very minor concentrations in the atmosphere, are estimated as being major causes of the total warming effect on the world from GHGs.

A common representation of the effect of the relative effects of the GHGs is in Figure 3, which ‘conveniently’ eliminates the dominant effect of water vapour.

Relative Contribution to the Anthropogenic Greenhouse Effect

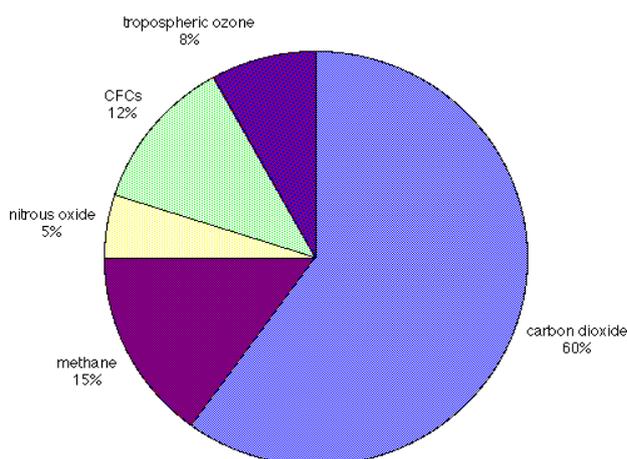


Figure 3: Putative global warming effects of selected GHGs. Source: http://eesc.columbia.edu/courses/ees/slides/climate/g_effect.gif

The 2013 IPCC Report, AR5 (Physical Science Basis, Chapter 8, p.666) states: ‘Water vapour is the primary GHG in the earth’s atmosphere. The contribution of water vapour to the natural greenhouse effect relative to that of CO₂ depends on the accounting method, but can be considered to be approximately two to three times greater. Further, the IPCC’s 1992 report

indicates that water vapour accounts for 55% of natural GHGs and that clouds account for a further 17% (Figure 4).

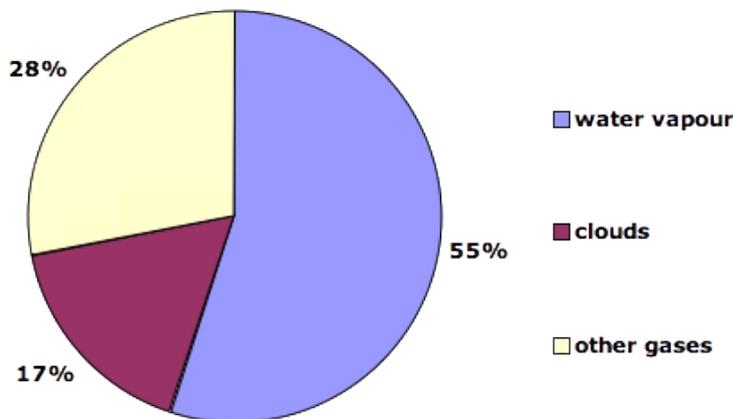


Figure 4: Breakdown of the 'natural' greenhouse effect by contributing gas. As halocarbons are industrial gases they are not represented here. Source: IPCC Report (1992)

Many scientific assessments consider that the total effect of water vapour is more like 90%, much more than the 72% suggested by the IPCC. Even at a value of 72% for water vapour, the proportion of the GHG effect on the world temperature, which international governments are ambitiously seeking to diminish through the reduction of the GHGs going into the atmosphere, is far less than conveyed in communications to the general public through official channels or the media.

Of all the CO₂ going into the atmosphere each year, 5% or less is anthropogenic, in comparison with CH₄, about 40% of which is from natural sources, and similarly estimates of naturally occurring N₂O are about 60%. It is frequently claimed that without the anthropogenic contribution of CO₂ the amount of natural CO₂ being released into the atmosphere would equal the amount of CO₂ being absorbed each year by the biosphere, and mankind is blamed for the absence of the balance.

Governments rely heavily on the IPCC's reports and claims about GHGs causing or threatening to cause dangerous warming. As shown above, however, the IPCC's reports fail to provide the complete picture, especially about water vapour. The IPCC relies on General Circulation Models (GCMs) to predict future temperatures, and when run with and without GHGs, to estimate mankind's contribution to warming. Because water vapour added to the atmosphere is present there for only a few days, it is not incorporated into the models. Instead, the assumptions in the GCMs are that water vapour operates as a 'positive feedback', which amplifies the effects of the GHGs by two to three times.

This indicates an assumption that H₂O does not operate in a direct way as do other GHG molecules in the atmosphere. This contention is made in spite of the fact that water vapour molecules are always present. All of the GHG molecules are well mixed throughout the atmosphere, albeit with water vapour at differing percentages (i.e. humidity). In this situation, all GHG molecules absorb, lose and re-absorb photons of energy. Thus, some radiant heat from the earth's surface is reflected back.

There is no logic for the removal of water vapour molecules from consideration in the dynamic situation where all of the GHGs participate in exchanging photons of energy radiating outward from earth. This is particularly relevant in a situation where there is such a high concentration of water vapour in comparison with the other GHGs. As noted previously, many scientific assessments specify that water vapour is the most important GHG, and responsible for 80% to 90% of the greenhouse effect. The IPCC dismisses any possible role of variations in solar output, such as the solar wind interacting with the earth’s magnetic field or variations in sunspot activity.

Temperature

The fact is that the world’s temperature is not increasing at anything like the rate projected from the GCMs of the IPCC. The ‘feedback’ from water vapour amplifying the actual temperature effect of CO₂ by two to three times, as expected in the IPCC models, is not evident at least for the last two decades. Clearly the climate models are running hot, which is shown in Figure 5.

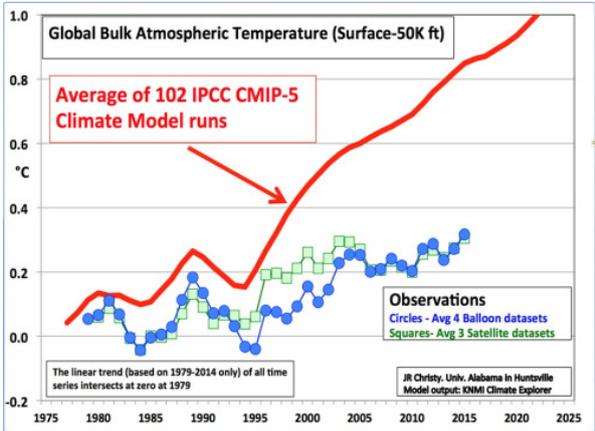


Figure 5: Climate models predicted temperature compared to actual. Source: Christy et al. (2016)

The data are lower stratosphere measurements from satellites (blue) and radiosondes on balloons (green). These are the most accurate temperature data available, covering most of the world (including the oceans) not suffering from the Urban Heat Island (UHI) effects from poor siting of climate stations in urban areas, or allowances for the heat build up, particularly at night from asphalt, shelter and other heat stores. Adjustments of past surface temperature records have also often resulted in apparent amplification of recent warming.

There has been no significant increase in the world’s temperature in the last couple of decades, the well-known and accepted ‘pause’. Over this short time there has been about one-third of all human GHG emissions ever, and the concentration of atmospheric CO₂ has increased more than 10%. Apart from some variation up and down, the mean temperature has not shifted much, certainly not at the rate suggested by the IPCC models. This is good evidence that CO₂ is not the main driver of the world’s temperature and/or does not have a major effect on the world’s temperature.

Heat absorption activity range of GHGs over the total electromagnetic spectrum

The ability of the GHGs to absorb and emit radiation has been investigated extensively. In the daytime incoming radiation from the sun spans wavelengths from 0.2 to 3 microns. CO₂ has a small absorption band centred at 2.8 microns, which can absorb some incoming radiation. At this same wavelength water vapour is 100% saturated, so its 15,000 ppm versus 400 ppm substantially diminishes any minor effect CO₂ might have on incoming heat. We conclude therefore that there is little effective absorption of incoming radiation by CO₂. Far more important is that the central stratosphere (~50 km) is warmer than the tropopause because of ozone-absorbing UV energy.

Water vapour does have two significant absorption peaks and some smaller ones in the 0.2 to 3 micron range of the spectrum which will be responsible for some absorption of incoming radiation. The outgoing radiation of heat from the earth is in the 4 to 70 micron range of the electro-magnetic spectrum (peaking around 15 microns) as shown in Figures 6A and 6B. Absorption bands for CO₂, CH₄ and N₂O are indicated. The water vapour bands are dominant. Note that CO₂ does not compete with CH₄ and N₂O for heat radiated back from the earth, at any specific wavelength, only water vapour. Their roles are completely independent of each other.

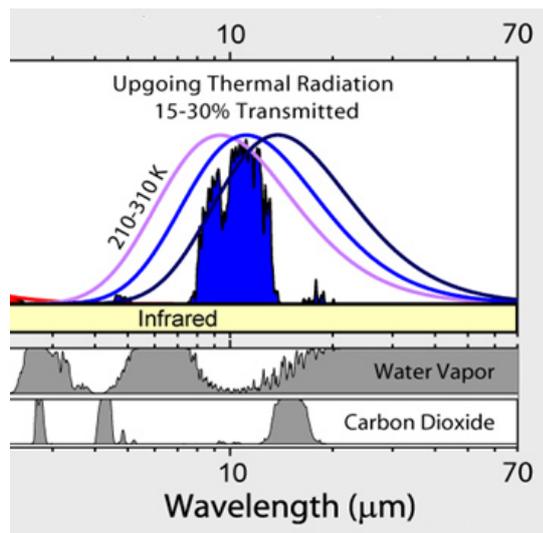


Figure 6A: Absorption peak for CO₂ for outgoing radiation from the world's surface in comparison with water vapour in the 2 to 70 micron range of the spectrum

One very important point that stands out in Figures 6A and 6B is that water vapour absorbs over a very broad region of the spectrum. In contrast, CH₄ and N₂O absorb only in narrow bands. This means that H₂O captures much, much more of the radiant energy.

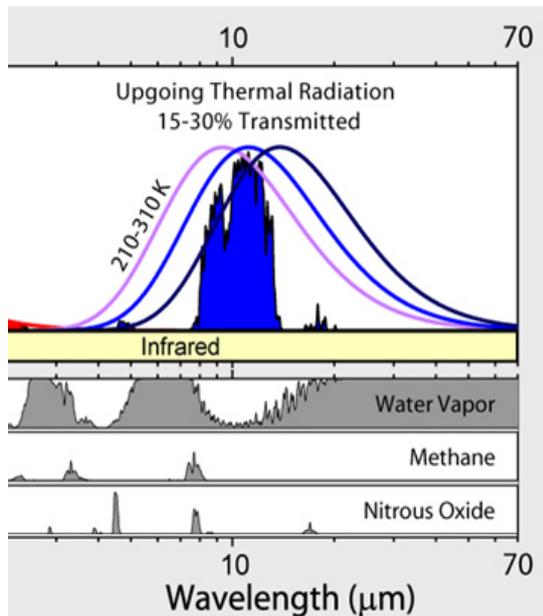


Figure 6B: Absorption peaks for CH₄ and N₂O for outgoing radiation from the world's surface in comparison with water vapour in the 2 to 70 micron range of the spectrum

CO₂ has three main bands of infrared absorption: 1.8 to 2 microns, 4 to 5 microns and 12 to 18 microns. At the position of the first two bands where CO₂ is able to absorb there is hardly any energy being radiated by the earth anyway, and thus CO₂ is not effective as a GHG in those bands. The 12 to 18 micron band is the main place where CO₂ absorbs outgoing radiation. Absorption and emission from this band of CO₂ remains a major factor even up into the high stratosphere – above 50 km.

For CH₄ and N₂O, Figure 5B shows narrow absorption peaks in the 7 to 8 micron range; these are their only relevant bands. At the other minor absorption peaks for these gases there is very little energy emitted by earth into that spectral region.

In this discussion 15,000 ppm is taken for the atmospheric concentration of water vapour. This is 38 times the concentration of CO₂, and a much bigger concentration difference in comparison with those of CH₄ and N₂O. We know the individual capability of the GHG molecules is of the same order of magnitude (Table 2). We also know the projected warming is not happening, and that the GWP metrics presently used by the IPCC to classify the various GHGs as to their respective effects on warming are defective. The suggested treatment of a new way for CH₄ to get an environmentally credible metric (Allen et al., 2018) is a case in point.

Further, Sheahan (2018) has pointed out the mathematical illogicality of using the slope of a saturated gas (CO₂) as the divisor of the numerator (the top number in a fraction). If any number is divided by another number (the divisor), which is close to zero, then the quotient (the result) becomes a large number itself. This is the simple situation in the calculation of the GWP. A normal numerator (the number related to the absorption by CH₄ or N₂O) is divided by the very low number, the slope of the CO₂ absorption curve. This ridiculous situation produces a huge quotient (purported value for GWP).

CH₄ and N₂O at their tiny concentrations in the atmosphere absorb radiated heat at the earth's surface and in the troposphere – in small, narrow bands. While this happens, water vapour (a GHG of similar absorptive capacity) is at concentrations thousands of ppm higher than these GHGs. The sequence of absorption, collisions (with N₂O and O₂), emissions and more collisions combines to carry energy away, and that process is dominated by H₂O and CO₂. That mechanism completely truncates the effectiveness of CH₄ and N₂O as GHGs.

Further, Ollila (2014) suggested that the present assessment of the effectiveness of the various GHGs was badly flawed, referring to an analysis from the Harvard-Smithsonian Centre for Astrophysics (2014), which noted that the total contributions of GHGs up to 120 km in altitude were H₂O 82.2%, CO₂ 11%, O₃ 5.2%, CH₄ 0.8% and N₂O 0.8%. This assessment agrees with many other estimates in the scientific literature that suggest that water vapour is the main GHG, and 82% being higher than the IPCC's estimate of 72% mentioned above. Clearly, the main GHG is water vapour and there is not a great deal that can be done about the control of this gas.

Other energy transfer mechanisms that must be examined simultaneously

There is an important factor that is often overlooked with one of these GHGs, namely water, which has the additional ability to change phase (evaporate, condense, and precipitate) which the others cannot. These properties also act to provide cooling mechanisms for the earth.

If the planet heats up for any reason, the oceans (which are 70.9% of the earth's surface) will heat up slightly, water will evaporate, and the atmosphere will increase in humidity. Then convection carries the moist air to the cooler upper troposphere, where water changes phase back again, deposits its heat at high altitudes and forms clouds. More clouds reflect heat back to the earth. Further, in the daytime clouds will reflect back or absorb about 30% of the incoming sunlight. This is a built-in cooling effect, a 'negative' feedback. Again, this casts doubt on the IPCC contention that water vapour provides strong positive feedback that amplifies the warming effect of CO₂.

Increasing the concentration of CO₂ in the atmosphere is not such a potential warming problem for the world as frequently promoted in the scientific literature, by governments and the media. Clearly water vapour is the dominant GHG. CO₂ becomes less and less effective (at a logarithmic rate) as its atmospheric concentration increases. Thus, there is limited opportunity for additional CO₂ to cause heating, as previously illustrated in Figure 2.

There is agreement that increasing CO₂ in the atmosphere causes some warming; the relevant discussion is about how much? There is also general agreement that doubling the CO₂ levels in the atmosphere from 'pre-industrial' levels of about 280 ppm might increase global temperatures by up to 1°C. Just how much of the temperature rise is due to expected warming as the earth comes out of the Little Ice Age (LIA), i.e. natural variation and how much is due to an increase in CO₂ levels is impossible to determine.

High altitude absorption

The observed temperature and GHG concentration data are pertinent close to the earth's surface and through much of the troposphere where water is the dominant GHG. At higher altitudes water is largely frozen out and the dominant absorber becomes CO₂. At higher stratospheric altitudes water vapour is in the few ppm range, with CO₂ and CH₄ still at their

lower tropospheric values. In the lower stratosphere the oxidation of CH₄ to H₂O and CO₂ begins to occur. Consequently, CH₄ always remains less than half the concentration of water vapour.

In the stratosphere the ambient temperature is below minus 30°C, and so the energy peak of outgoing radiation has shifted further out into the infrared, leaving even less energy in the 7 micron zone. Again, CH₄ has no significant role as an absorber of infrared energy. Ultimately, the cooling of the planet takes place from the stratosphere and upper troposphere as gases emit radiation into space.

CO₂ participates in this process, but CH₄ does not. CO₂ does not compete with CH₄ or N₂O to absorb radiation from the earth; CO₂ absorbs at different frequencies. Nevertheless, the effect of water vapour in the atmosphere overwhelms the role of CO₂; H₂O is known to provide about 33°C worth of greenhouse effect warming (IPCC, AR4 & AR5). That suggests that reducing atmospheric CO₂ by reducing human emissions has little potential to reduce temperature, much less to control climate. Presently, anthropogenic CO₂ is less than 5% of all the CO₂ going into the atmosphere, and as the temperature increases (as it has in the last millennium) the ocean will heat up and 'outgas' CO₂. Of course, this will also contribute to the atmospheric concentration.

Benefits of CO₂

There is a huge scientific literature about the benefits of additional CO₂ in the atmosphere; it is in fact the gas of life. The fact that many refer to this gas and the increasing levels in the atmosphere, even the adding any of it to the atmosphere, however small, as 'carbon pollution' is illustrative of a misinformed general public.

Already the increase in atmospheric CO₂ from 280 to 400+ ppm from 1850 to 2018 is responsible for probably more than a 15% increase in plant growth, and the "greening of the earth" is well recognised. Adding additional CO₂ to the atmosphere will increase crop, pasture and forest growth. In fact a doubling of the level of CO₂ in the atmosphere would most likely result in about 30% increase in plant growth, a result which would be a terrific boon towards food production for an increasing world population.

Are the present IPCC Estimates of GWP for the various GHGs realistic?

It is clear that the warming effect of CH₄ and N₂O is limited due to their molecular structure, their concentration in the atmosphere, and the minor amount of energy falling within their very narrow absorption bands. They are ineffective GHGs.

There are four serious discrepancies regarding our present political assessment of the effectiveness of CH₄ and N₂O as GHGs:

1. The not dissimilar molecular structure to CO₂ and H₂O, N₂O and CH₄ result in their individual capability to absorb radiating heat from the earth of a similar order of magnitude.
2. There are very tiny amounts of CH₄ and N₂O in the atmosphere.
3. The earth emits very little energy in the energy band where both CH₄ and N₂O can absorb radiation.

4. The absorption bands of CH₄ and N₂O are narrow and small, thus these molecules are unable to materially contribute to the dominant role of water vapour in the heat transfer process.

These factors drive the potential impact of these gases down to vanishingly small values. Based on the information presented we conclude that the GWP value of 25 (and rising) for CH₄, and between 265 and 310 for N₂O, is incorrect. Such an error, if followed through to financial commitment according to the United Nations Framework Convention on Climate Change (UNFCCC) and the 2015 Paris Agreement will have very serious negative effects on the New Zealand economy, not to mention all other countries. All of this would be promulgated with a barely discernible effect on temperature or climate. Thus, the generally accepted GHG effects of CH₄ and N₂O, almost 50% of the total New Zealand emissions, must be seriously questioned, and to a lesser extent the quantitative role of CO₂. Water vapour is the dominant GHG.

We assert therefore that the GWP values of both CH₄ and N₂O are vastly overstated by the IPCC, and therefore by member governments of the UNFCCC. Consequently, it is suggested that these gases be removed from New Zealand's Greenhouse Gas Inventory, and that the supporting case for such treatment be prepared for negotiation with our international partners.

Further, there is a much bigger prize at stake. CO₂ has such a small part to play in global warming/climate change, with no more than 30% of the total greenhouse (heating of the earth) effect, and the effects of CH₄ and N₂O are trivial. This means that there is an urgent need to stop all this expensive concentration on 'climate change' and be rid of the naivety of assuming that human beings can control and/or stabilise the climate.

Acknowledgements

The authors thank Will Happer, Professor of Physics at Princeton University in the USA, and William van Wijngaarden, Professor of Physics of York University in Canada, for allowing us to present their unpublished data in Table 2, and for their ongoing expertise and patience in improving our understanding and application of atmospheric physics during the preparation of this article.

Further reading

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For those who wish to read further on the topic of global warming we recommend a small (and free) book available on Google, *Why Scientists Disagree About Global Warming: The NIPCC Report on the Consensus* (2nd Edn).

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