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Reliable Physics Demand Revision of the IPCC Global Warming Potentials

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Abstract:

The Global Warming Potentials (GWP) of the Intergovernmental Panel on Climate Change (IPCC) in Table 2.14 of the Fourth Assessment Report (AR4) show the increase in warming by methane (CH_4) and nitrous oxide (N_2O) is 21 and 310 times respectively that of CO_2. There has been wide acceptance of these values since publishing in 2007. Nevertheless, they are inaccurate. This study uses accurate methods to calculate the impacts of CO_2, CH_4, and N_2O on the warming of the atmosphere. For example, this quantitative analysis from reliable physics shows the contribution of CO_2 to warming at Amsterdam is 0.0083°C out of a difference of 26°C. The warming effect of CH_4 on the Earth's atmosphere is 0.408% of that of CO_2, and the warming by N_2O is 0.085% of that of CO_2. Thus, the warming effects of CO_2, CH_4, and N_2O are too small to measure. The invalidity of the methane and nitrous oxide values indicates the GWPs of the remaining approximately sixty chemicals in the Table 2.14 list are also invalid. A recommendation is that the IPCC consider revising or retracting the GWP values in Table 2.14.

1. INTRODUCTION

The purpose of this paper is to examine the Global Warming Potentials (GWPs) in Table 2.14 of the Fourth Assessment Report [1] of the Intergovernmental Panel on Climate Change (IPCC), Figure **1**.

The Global Warming Potentials (GWP) of methane and nitrous oxide calculated by the IPCC in Table 2.14 have profoundly affected the decisions made by elected officials worldwide. Nitrogen fertilizers have been restricted or banned in several countries because they emit a small amount of nitrous oxide. Nitrogen fertilizers are essential for the growth of plants, and nitrogen is often the limiting nutrient [2]. Restricting their use affects food production adversely and can cause food shortages. The IPCC claims that nitrous oxide has up to 310 times the warming effect of CO_2. This value is so significant that we must determine whether or not this value of 310 is valid.

A similar situation occurs with methane, which is claimed to have 21 times the warming effect of CO_2. Natural gas is virtually all methane transported widely by pipelines and pumping stations. The claim is that methane leaks from natural gas pipeline systems and processing are warming the Earth. Periodically, a scientist will quote Table 2.14 and raise the alarm about methane and the possibility of significant methane releases from the Arctic Tundra caused by the warming of the Earth [3].

The methodology of this study answers the question: "Of the temperature difference between two weather stations, how many degrees Celsius do CO_2, CH_4, and N_2O contribute?" Four weather stations—Pond Inlet, Amsterdam, Colorado Springs, and Princeton, NJ—were selected to provide the answers. The temperature and relative humidity are recorded within the same hour using AccuWeather on a smartphone. These values are input to a Humidair psychrometric program [4] to calculate enthalpy (heat content) and specific volume at each weather station. Humidair calculates enthalpy around 0^oC, i.e., enthalpy values below 0^oC are negative, and those above are positive.

2. THE NUMBER OF MOLECULES OF CO_2, CH_4 AND N_2O IN THE EARTH'S ATMOSPHERE

The temperature contribution by each gas is calculated using known and reliable technology, as shown in Table **1**. Pieter Tans and Kirk Thoning of the NOAA Global Monitoring Laboratory constructed Table **1** in September 2020. The carbon dioxide (CO_2) level at Mauna Loa at the time was 413 ppm. The mole fraction of CO_2 is 0.000413 moles per mole of dry air. In 3% wet air, the water vapor dilutes the CO_2 level from 413 to 400.6 ppm.

Table **2** is adapted from Table **1**, the table in Reference [5]. It shows the CO_2, CH_4, and N_2O molecules per million molecules of dry air in Column B in September 2023. The gas values in Column B are adjusted to CO_2 = 418.06 ppm from 413 ppm, so the total remains at one million molecules. The moles of each of the three gases per mole of dry air are in Column C. The grams of each per kg of dry air are in Column D. The method of Table **2** accurately separates the moles of each of the three gases per mole of dry air, and hence the warming effect of each gas.

The value for CO_2 in Line 5, Column B is the average measurement of CO_2 at Mauna Loa in September 2023 of 418.06 ppm [6]. The value for methane in line 9, Column B is the September 2023 value of 1927.38 ppb = 1.92738 parts per million (ppm) [7]. This value is comparable to the "2" in line 8, Column B, a rounded value. The September 2023 value for nitrous oxide in

Table 2.14. Lifetimes, radiative efficiencies and direct (except for CH_4) GWPs relative to CO_2. For ozone-depleting substances and their replacements, data are taken from IPCC/TEAP (2005) unless otherwise indicated.

Errata

Industrial Designation or Common Name (years)	Chemical Formula	Lifetime (years)	RadiativeEfficiency (W m^{-2} ppb^{-1})	Global Warming Potential for Given Time Horizon			
				SAR‡ (100-yr)	20-yr	100-yr	500-yr
Carbon dioxide	CO_2	See below[a]	[b]$1.4x10^{-5}$	1	1	1	1
Methane[c]	CH_4	12[c]	$3.7x10^{-4}$	21	72	25	7.6
Nitrous oxide	N_2O	114	$3.03x10^{-3}$	310	289	298	153

Figure 1: Table 2.14 from IPCC AR4.

Table 1: Mole Fraction in Dry Air of the Components of the Atmosphere from Reference [5] as of September 2020

	A Gas	B Dry air	C 3% wet air
1	Nitrogen	780,900	757,473
2	Oxygen	209,360	203,079
3	Water vapor	0	30,000
4	Argon	9300	9,021
5	Carbon dioxide	413	400.6
6	Neon	18	17.5
7	Helium	5	4.9
8	Methane	2	2
9	Krypton	1	1
10	Trace species (each less than 1)	1	1
11	Total	1,000,000	1,000,000 ppm

Table 2*:* Molecules per Million Molecules of Dry Air Adapted from Reference [5]

	A Gas	B Dry air	C Moles per mole of dry air	D Grams per kg of dry air
1	Nitrogen	780,896	-	-
2	Oxygen	209,359	-	-
3	Water vapor	0	-	-
4	Argon	9300	-	-
5	Carbon dioxide	418.06	0.00041806	0.630
6	Neon	18	-	-
7	Helium	5	-	-
8	Methane	2	-	-
9	Current level of Methane, CH_4	1.92738	0.000001927	0.001063
10	Krypton	1	-	-
11	Trace species (each less than 1)	1	-	-
12	Current Nitrous Oxide, N_2O	0.33678	0.00000033675	0.000511
13	Total	1,000,000	-	-

line 12, Column B is 336.78 parts per billion (ppb) or 0.33678 ppm [8]. Nitrous oxide is approximately one-third of the Trace species of one molecule in line 11.

3. CALCULATIONS FOR TABLE 2 COLUMN D

In Row 5, the grams of CO_2 per kilogram (kg) of dry air is (0.00041806 x 44 x (1000/29) = 0.630, where 44 and 29 are the molecular weights of CO_2 and air, respectively. In Row 9, the grams of CH_4 per kg of dry air are (0.000001927 x 16 x (1000/29)) = 0.001063, where 16 is the molecular weight of methane. Similarly, in Row 12, Column E, the grams of N_2O per kg of dry air are (0.00000033675 x 44 x (1000/29) = 0.000511, where 44 is the molecular weight of nitrous oxide.

There are 0.630/0.00106 = 594 grams of CO_2 per gram of methane. Thus, there are (594 x 44)/16) = 1634 molecules of CO_2 per methane molecule. Thus, because the molecular weights of CO_2 and N_2O are the same at 44, there are (0.630/0.000511) = 1235 molecules of CO_2 for each molecule of N_2O in the Earth's atmosphere. Thus, in September 2023, CO_2 molecules outnumber CH_4 molecules by 1634 and N_2O molecules by 1235.

Table 3: Grams of the Gases per Kg of Dry Air and their Contribution to Temperature from Pond Inlet, °C, are in Columns G. H and I

A Weather station	B Z12-15 Grams CO_2/kg dry air	C Al 12-15 Grams CH_4/kg dry air	D AR12-15 Grams N_2O/kg dry air	E AB 12 ΔT, °C	F AD12-15 Δ Enth, kJ	G AF12 -15 CO_2, °C	H AO12 -15 CH_4 °C	I AX12 -15 N_2O °C	J AZ12 -15 Total °C
Pond Inlet	0.630	0.001063	0.00511	-	-	-	-	-	-
Amsterdam	0.577	0.00967	0.00465	26	39	0.0083	0.000034	0.0000070	0.00833
Colorado Springs	0.471	0.00789	0.000379	21	27	0.0064	0.000026	0.0000055	0.00646
Princeton, NJ	0.583	0.00977	0.000470	22	26	0.0091	0.000037	0.0000078	0.00919

Table 4: The Increase in Temperature by CH_4 and N_2O is a Small Percentage of that of CO_2

A	B CO_2 Cell AF28	C Temperature Increase by CH_4 as % of CO_2 Cell AJ28	D Temperature Increase by N_2O as % of CO_2 Cell AL28
Amsterdam	100.0%	0.408%	0.085%
Colorado Springs	100.0%	0.408%	0.085%
Princeton, NJ	100.0%	0.408%	0.085%

Here is the reason from Reference [5] why the mole fraction is used: "Only the dry mole fraction reflects the addition and removal of a gas species because its mole fraction in dry air does not change when the air expands upon heating or ascending to a higher altitude where the pressure is lower."

4. MEASURING THE CONTRIBUTION OF CO_2, CH_4 AND N_2O TO TEMPERATURE IN THE EARTH'S ATMOSPHERE

It is essential to understand that the measured and recorded temperature is the sum of all the factors affecting Earth's temperature. These include warming caused by radiation from the Sun absorbed by CO_2, CH_4, N_2O, feedback, and other warming or cooling effects. These factors also apply to temperature differences. The recorded temperature is input to the Humidair psychrometric program, which includes these factors in the heat content (enthalpy) and specific volume.

The following method quantifies the contribution of carbon dioxide, methane, and nitrous oxide to the difference in temperature between three weather stations and Pond Inlet.

Table **3** is a summary of the Excel calculations. The file for the Excel calculations is: "Excel calculations for GWP Mar 102024.xlsx." From the Excel spreadsheet, Column H, the temperatures measured at Pond Inlet, Amsterdam, Colorado Springs, and Princeton on December 30, 2023, were -18°C, 8°C, 3°C, and 4°C, respectively. We set the recorded level of CO_2 at 418.06 at the location with the lowest of the four temperatures, i.e., at Pond Inlet. This is because the number of molecules of CO_2 per cubic meter falls as the temperature rises. The grams of CO_2 per kg of dry air in the Pond Inlet row of Table 3 are the same as in Column D of Table **2**. The temperature contributions of CO_2, CH_4, and N_2O to the difference in temperature in °C between Pond Inlet and the weather stations in Column A are in Columns G, H, and I. The total is in Column J. The upper lines in the titles of the columns are the locations in the Excel spreadsheet calculations.

Note that the average CO_2 for Table **2** was 418.06 in August 2023, and the level of CO_2 during the recording of the values for the Excel spreadsheet was 422.3 ppm. The difference of 4.24 ppm has no significant effect on the results of this study.

As shown in Table **4**, the temperature increase caused by CH_4 and N_2O is a small percentage of the temperature rise caused by CO_2.

The warming effect of CO_2 is too small to measure [9, 10]. Thus, the warming effects of CH_4 and N_2O are also too small. The data in IPCC Table 2.14, showing that

CH_4 has 21 times the warming effect of CO_2 and that N_2O has 310 times the warming effect of CO_2, are grossly incorrect.

5. VALIDITY OF THE REMAINING 60 CHEMICALS WITH GWPS

This study clearly shows the Global Warming Potentials (GWPs) for CH_4 and N_2O are incorrect, i.e., grossly overstated. The logical conclusion is that the GWPs for the remaining 60 chemicals in Table 2.14 are also wrong and grossly exaggerated.

6. SUMMARY AND CONCLUSIONS

This study provides evidence that the IPCC Global Warming Potentials are incorrect. It starts with the levels of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) measured as molecules per million molecules of dry air, which is the molar fraction. Then, quantitative results from reliable physics establish the enthalpy and specific volume at four weather stations. Chemistry determines the grams of each gas per kg of dry air. The increase in the temperature by current levels of methane (CH_4) and nitrous (N_2O) in the Earth's atmosphere is a small percentage of that of CO_2.

Conclusions 6.1, 6.2, and 6.3 answer, "Of the temperature difference between two weather stations, how many degrees Celsius do CO_2, CH_4, and N_2O contribute?"

6.1. In this study, the difference in temperature between Pond Inlet and Amsterdam is 26°C. The contribution of CO_2 to this difference is 0.0083°C, but this amount is too small to measure.

6.2. The contribution of CH_4 to the 26°C difference between Pond Inlet and Amsterdam is 0.0000338°C.This current level of methane in the atmosphere increases the temperature by 0.408% of that of CO_2. It does not have 21 times the warming of CO_2 as claimed by the IPCC.

6.3. N_2O's contribution to the 26°C difference between Pond Inlet and Amsterdam is 0.00000705°C. This is 0.085% of that of CO_2. It does not have 310 times the warming of CO_2, as claimed by the IPCC.

6.4. The total contribution of all three gases to the 26°C difference between Pond Inlet and Amsterdam is 0.00833°C. This is a typical result; this difference is too small to measure.

6.5. The warming of the Earth's atmosphere by CH_4 and N_2O is 0.408% and 0.085% respectively of that of CO_2.

6.6. The warming by CH_4 and N_2O is so tiny in the Earth's atmosphere that the IPCC estimates of warming by GWP over several years are irrelevant.

6.7. It is reasonable for the IPCC to consider revising or withdrawing Table 2.14 in the Fourth Assessment Report.

SUPPLEMENTAL MATERIALS

The supplemental materials can be downloaded from the journal website along with the article.

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