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Major Portion of the Increased Atmospheric Concentration of Carbon Dioxide Emitted by the Oceans

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Abstract: This paper continues the application of Henry's Law to climate change. The basic ideas have been covered in our previous paper. We separately calculated the concentrations of carbon dioxide in the atmosphere as a function of time emitted by the oceans and human contribution. We know that the sum of those two concentrations was equal to the observed one. Note that the carbon dioxide emitted by the oceans depends only on the temperature. We can verify our theory by calculating the global temperature using only the observed atmospheric carbon dioxide emitted by the oceans, which is convincing evidence of Henry's Law. In this paper, we will present additional evidence using the measured abundance of $^{13}CO_2$ in the atmosphere starting from the 18^{th} century. We will also show that the concentrations of N_2O and SF_6 follow Henry's Law and that human contributions are insignificant. Note that these concentrations can be used as a thermometer to measure global temperature. However, as a thermometer, CO_2 is better due to its higher concentration in the atmosphere.

Keywords: Climate Change, Henry's Law, $\delta^{13}C$

1. Introduction

At equilibrium, the concentration of any gas depends on the temperature. Thus, concentrations can be used as a global thermometer as shown in our previous paper [1]. The main problem is a big release of the gas directly into the atmosphere, because we must estimate the portion that stays in the atmosphere. Usually, the majority of this released gas, p_r, dissolves in the oceans. Note that we will use the word 'release' instead of 'emission' in cases where gases go directly into the atmosphere not emitted by water. Thus, we will use the term human release not human emission. In addition, all the chemical reactions in the atmosphere and in the oceans can make the application of Henry's Law more difficult. Figure 1 from our previous paper presents partly experimental CO_2 curves p_e and p_h, emitted by the oceans and the portion of the human release remaining in the atmosphere, respectively. The curve p_e also gives the observed temperature change. This is the first experimental evidence of our theory concerning Henry's Law. The source of CO_2 in the atmosphere can be studied measuring the abundance of ^{13}C in air samples. The measurements are available in the unit $\delta^{13}C$.

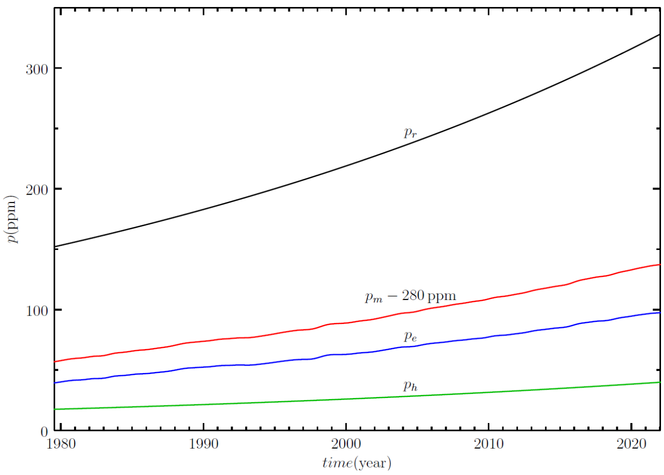

Figure 1. Human CO_2 release p_r (black), measured $p_m - 280$ ppm (red), CO_2 emitted by water p_e (blue) and human CO_2 contribution to the atmosphere p_h (green). [1]

The curves p_e and p_h explain the observed $\delta^{13}C$

measurements very well. This will be the second experimental proof of our theory. In principle, all gases must obey Henry's Law. Thus, as new examples, we look at N_2O and SF_6 in the atmosphere. We will find that increases in those gases are merely due to the temperature increasing and human influences are small.

2. Explanation of Per-mil (δ^{13}C) Measurements in the Atmosphere

Per-mil (per-mille, promille...) values define as follows:

$$\delta^{13}\mathrm{C} = \left(\frac{(^{13}\mathrm{C}/^{12}\mathrm{C})_{\mathrm{sample}}}{(^{13}\mathrm{C}/^{12}\mathrm{C})_{\mathrm{standard}}} - 1 \right) \times 1000, \tag{1}$$

where the standard $^{13}\mathrm{C}/^{12}\mathrm{C}$ is 0.0112372. The per-mil value gives the abundance ratio of carbon dioxide isotopes $^{13}CO_2$ and $^{12}CO_2$ compared with the standard ratio. Using the curves p_m, p_e and p_h shown in Figure 1, we can calculate the per-mil-curve as follows:

$$\delta^{13}\mathrm{C} = \frac{-6.5‰ \cdot 280\ \mathrm{ppm} - 26‰ p_h - \delta^{13}\mathrm{C}_{\mathrm{ocean}} p_e}{p_m} \tag{2}$$

The first term in the above equation is a constant per-mil -6.5 ‰ and concentration 280 ppm before 1750, as shown in Figure 2. The next term is the contribution of burning fossil fuel, which has an average per-mil value of approximately -26‰. The last term is an effect of carbon dioxide emitted by the oceans. The per-mil value $\delta^{13}\mathrm{C}_{\mathrm{ocean}}$ of the emitted CO_2 is little smaller than -6.5‰, because in the oceans, the dissolution of the major part of human release p_r decreases the abundance of ^{13}C, see for example [2].

Note that p_r has the per-mil value -26‰. The per-mil value of the oceans $\delta^{13}\mathrm{C}_{\mathrm{ocean}}$ has been derived by fitting Equation (2) with the observed per-mil values δ^{13}C, assuming a linear decrease in $\delta^{13}\mathrm{C}_{\mathrm{ocean}}$, see Figure 3. According to the fit, per-mil values of $\delta^{13}\mathrm{C}_{\mathrm{ocean}}$ changed from 7.1‰ to 7.8‰ in the time interval between 1980 and 2020. We also fit Equation (2) with exponential decay in $\delta^{13}\mathrm{C}_{\mathrm{ocean}}$. However, the difference between the linear and exponential fits was negligible.

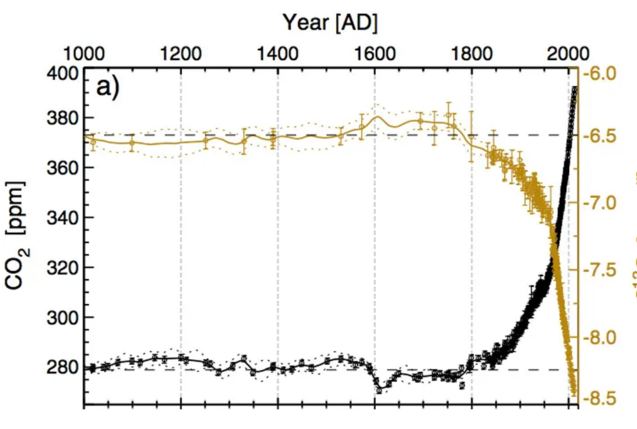

Figure 2. CO_2 concentration (black circles) and the δ^{13}C (brown circles) [15]

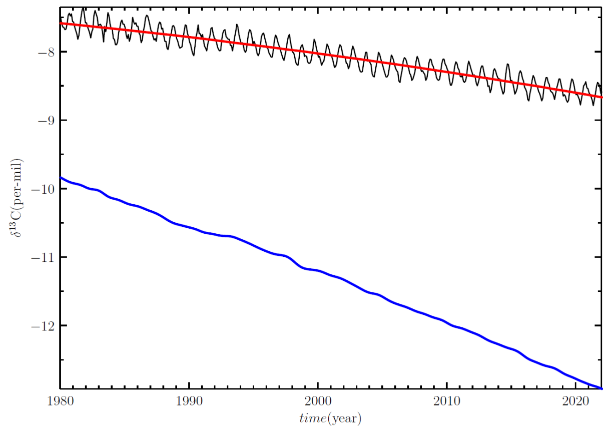

Figure 3. Observed per-mil values [16] (black), Equation (2) fitted to the observed values (red) and per-mil values calculated assuming total increase of CO_2 in the atmosphere ($p_e + p_h$) is anthropogenic (blue).

The total CO_2 concentration, p_m, measured in Mauna Loa is given by:

$$p_m = 280\ \mathrm{ppm} + p_h + p_e \tag{3}$$

Equations (2) and (3) include both p_e and p_h, so we can solve these values using the observed δ^{13}C and p_m values also in equations (2) and (3). If we define, according to the fit, $\delta^{13}\mathrm{C}_{\mathrm{ocean}} = -7.06$ ‰ $- 0.0177$ ‰/yr $(t - t_0)$, where $t_0 = 1980$ yr, $\delta^{13}\mathrm{C}_{\mathrm{fossil}} = -26$ ‰, $\delta^{13}\mathrm{C}_0 = -6.5$ ‰ and $p_0 = 280$ ppm, we get:

$$p_e = \frac{p_m(\delta^{13}\mathrm{C}_{\mathrm{fossil}} - \delta^{13}\mathrm{C}) - p_0(\delta^{13}\mathrm{C}_{\mathrm{fossil}} - \delta^{13}\mathrm{C}_0)}{\delta^{13}\mathrm{C}_{\mathrm{fossil}} - \delta^{13}\mathrm{C}_{\mathrm{ocean}}} \tag{4}$$

and

$$p_h = p_m - p_0 - p_e. \tag{5}$$

Next we compare these curves with those in Figure 1. First the measured δ^{13}C is smoothed out using Fourier filtering, see Figure 4. It is now possible to compare the curves p_e and p_h derived using Henry's Law [1] with those derived using the measured δ^{13}C, see Figure 5. In 2020, the values of p_e and p_h were 95 ppm and 37 ppm, respectively. Note that all the information of Henry's Law is in the per-mil values.

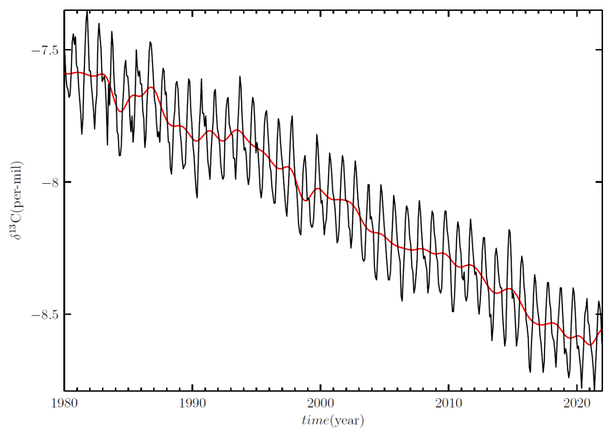

Figure 4. The observed per-mil curve δ^{13}C between 1980 and 2022 in Mauna Loa (black) [16], and a Fourier smoothed [3,4] red curve, which does not show seasonal variations.

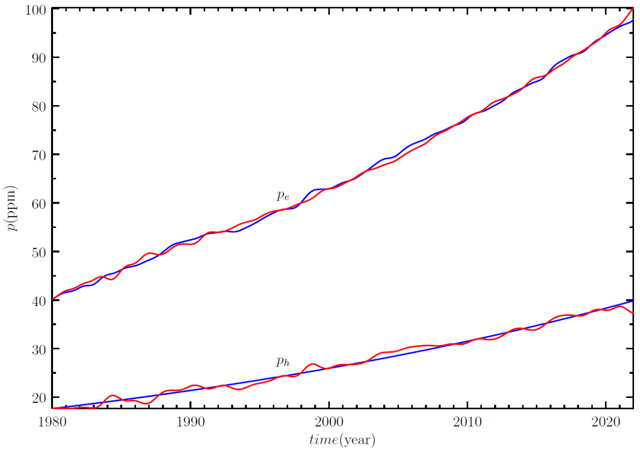

Figure 5. CO_2 emitted by ocean p_e (upper curves) and human CO_2 contribution to the atmosphere p_h (lower curves). The blue curves are derived using Henry's law and the red curves, Eqs. (4) and (6), using per-mil data with Eqs. (2) and (3).

In Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) [5] (p. 467), referring to paper [6] by Joos et al., it is stated that in 2011 "about half of the emissions remained in the atmosphere 240 PgC ± 10 PgC since 1750". In this statement, emission means human release, or our p_r. This statement means 112.5 ppm CO_2 and is close to the sum of $p_e + p_h$ in 2011, see also Ollila [7]. This implies that the total increase of CO_2 should be anthropogenic. This is simple to test by replacing $\delta^{13}C_{\text{ocean}}$ with -26 ‰ in Equation (2). Figure 3 shows the result compared with the measured per-mil curve. As can be seen, the per-mil value was -12.1 ‰ in 2011, compared with the measured value of -8.32 ‰. It is clear that the IPCC case is not realistic and no explanation has been provided for these conflicting values. Figure 5 thus proves, experimentally, that human contribution is surprisingly small.

3. Discussion

In our previous paper [1] we introduced a global thermometer using CO_2 emitted from the oceans, p_e, because p_e depends on the temperature. However, in this case, we have to calculate p_h in order to get p_e from Equation (3). The human contribution in the atmosphere is approximately given by:

$$p_h = \tau \frac{dp_r}{dt}, \tag{6}$$

where p_r is the total human release into the atmosphere and τ is the response time of Henry's Law. The derivative of p_r is now large enough that p_h is significant, see Figure 1. In principle all gases in the atmosphere can work a global thermometer because gases must obey Henry's Law and its temperature dependence. In Figure 6, the measured concentrations of CO_2, N_2O and SF_6 in the atmosphere are shown. The scales of concentrations have been adjusted so that the curves overlap and as a result, they are remarkably similar. This behaviour is real because the same temperature change ΔT controls the abundance. If we apply Equation (7) from paper [1]:

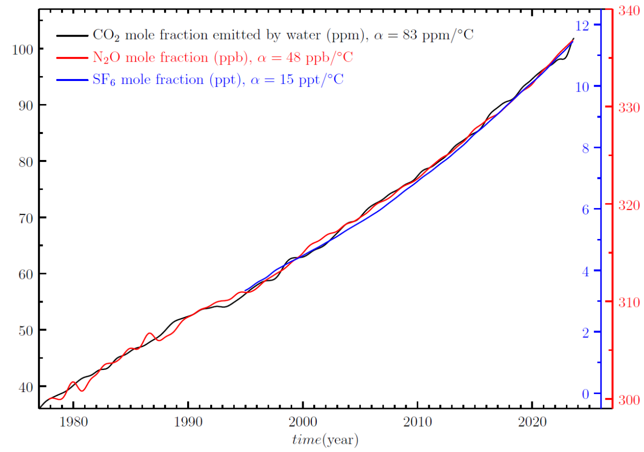

Figure 6. Measured concentrations of CO_2 (black), N_2O (red) and SF_6 (blue) [17]. The scale of each curve adjusted so the curves overlap each other's so good as possible.

$$\Delta T = \frac{1}{\alpha}\left(p_e + \tau \frac{dp_e}{dt}\right), \tag{7}$$

where α is the emissions strength of a given gas in Henry's Law. We can then get the total change of the temperature between 1980 and 2020 calculated from CO_2 and N_2O. The results are 0.78°C and 0.79°C, respectively. Note that in the case of N_2O other sources like human release are small. In other words, the derivatives of other releases, using Equation (6), are so small that they cannot be seen in the figures.

It is useful to note that solving p_e and p_h from Equations (2) and (3) is a simple task. We do not need to know the human release p_r, the emission strength α, response time τ, or temperature. The information about these parameters is in per-mil values.

4. Conclusion

Our main results [1, 8-14] concerning climate change can be summarized by the following: the total temperature increase from 1750 to 2020 was about 1.3°C, which consists of roughly 1.2°C due to the decrease of clouds or relative humidity [8, 9, 12, 13] and 0.1°C of greenhouse gases due to p_e and p_h. The human contribution was about 0.03°C due to p_h. Our climate sensitivity [8-12] for CO_2 is 0.24°C, which is about one order of magnitude smaller than the value given by IPCC. Our climate sensitivity has been theoretically derived, and it has proved robust in at least five different experimental methods [8-12]. On the other hand, IPCC value is based only on theoretical circulation models without any experimental verification [13].

We have shown that the increase of CO_2 levels is not the cause of global warming but a consequence. Future research should look for other causes of global warming than increasing CO_2 levels. The most promising line of research is to focus on the causes of the variation of cloudiness or relative humidity.

Abbreviations

IPCC Intergovernmental Panel on Climate Change
AR5 Fifth Assessment Report

Conflicts of Interest

No conflict of interest for this article.

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