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P3_3 Fizzy Ocean!

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Abstract

This paper investigates the effect of the increasing levels of carbon dioxide (CO_2) in the atmosphere, and it's absorption into the oceans. We look at the temperature dependence of the solubility of CO_2 and whether the increasing levels absorbed would reach a similar amount to soda water, which would then turn the oceans fizzy. Our result shows that current increases in CO_2 are not sufficient to create a high enough atmospheric pressure to cause the ocean surface to become fizzy.

Introduction

Current trends in rising CO_2 are of great concern in regards to of the greenhouse effect on the Earth's environment. However most of the CO_2 is actually found in the oceans, which is the biggest sink of atmospheric CO_2. Here we investigate the solubility of CO_2 within the ocean.

Theory

The solubility of a gas into water is described by Henry's law is given by [1],

$$p = H_T C \quad (1)$$

Where p is the partial pressure, H_T is Henry's constant, and C is the concentration of the diluted CO_2. Partial pressure is the pressure a gas would have if it alone occupied the total volume, which in our case is dependent on the concentration of CO_2 in the atmosphere. The partial pressure of each atmospheric gas, sums to 1 atmospheric pressure. Henry's constant is dependent on the solute (substance being dissolved), the solvent and the temperature.

It is important to note that the above relation is true for constant temperature. H_T can also be dependent on temperature and its value can be approximated using equation [2],

$$\frac{H_i(T_1)}{H_i(T_0)} = \exp\left[\left(\frac{\Delta H_{sol}}{R}\right)\left(\frac{1}{T_1} - \frac{1}{T_0}\right)\right] \quad (2)$$

Where ΔH_{sol} , is the enthalpy of solution for CO_2, R is the gas constant. $H_i(T_0)$ and $H_i(T_1)$ are the Henry's constants at temperature T_0 and T_1 respectively.

Sea surface temperatures (SST) are lower at higher latitudes and increase near mid latitudes.

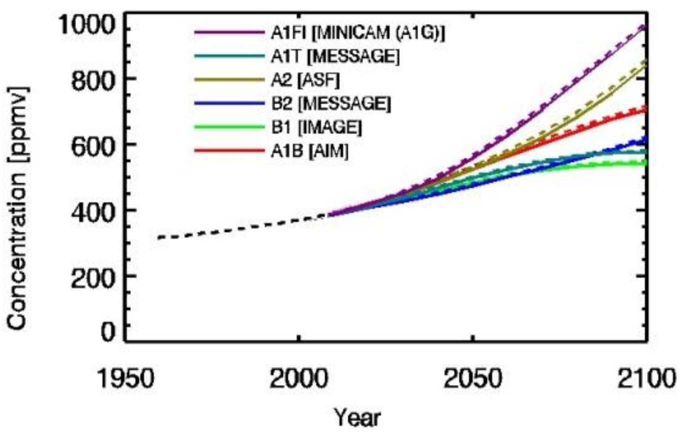

Figure 1: Prediction of increasing CO_2 trends in future years using climate models [4].

Here we have used data from December 2013 global SST in the calculation for Henry's constant. The value of SST ranges between -4˚C to 32˚C for the data chosen [3].Prediction of values of the CO_2 levels in the future years, are approximated in Figure 1 which displays the trends from the year 1950 to 2100. The model providing the maximum level of CO_2 in the year 2100 (purple line) was used for calculating the result shown in Figure 3.

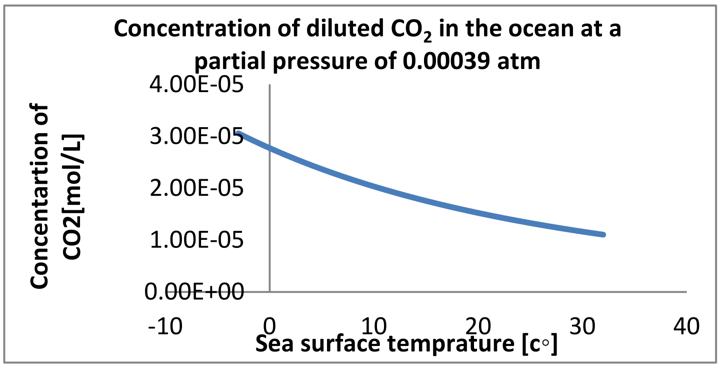

Figure 2: Shows relationship between concentration of CO_2 and SST. Currently CO_2 concentration in the atmosphere is 390 ppm [5], which gives partial pressure of 0.00039 atm.

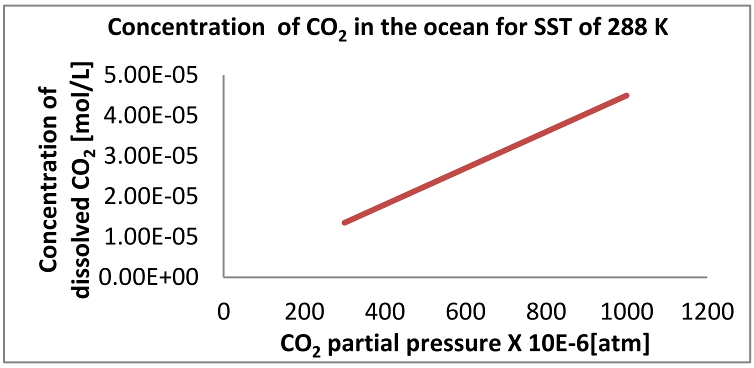

Figure 3 (right): Shows relationship between the concentration of CO_2 in the ocean and the increase in CO_2 from the year 1950 to 2100.

Discussion

We calculated Henry's constant, which gives the solubility of CO_2, for the range of global SST using equation 2. $\frac{\Delta H_{sol}}{R}$ is taken as 2400K [1] and a reference Henry's constant of 29.41 L.atm/mol for a temperature of 298K [1], was used to calculate changing values of Henry's constant at different temperatures. Using these values, the concentration of diluted CO_2 is calculated.

Figure 2 displays the results and shows that for higher SST (at mid latitudes), solubility would be lower than at lower SST (at the poles), which proves that solubility varies globally.

Figure 3 shows a linear increase in the concentration of dissolved CO_2 over time due to increase in CO_2 partial pressure only. CO_2 dilution depends on both SST and partial pressure. So by keeping SST constant in our investigation, we can focus on the effects of partial pressure. Here we have used average SST of 288 K.

Figure 1 shows the predicted concentration levels of CO_2 from 1950 till 2100. These values were used to convert the increasing concentrations to partial pressure used in Figure 3. Results show with increasing years the concentration of CO_2 is also increasing which causes a greater concentration to be absorbed by the sea.

We also compared the soluble CO_2 concentration with the concentration found in soda water. From this we can see whether the increasing trends of CO_2 in the ocean could ever reach a concentration similar to that found in soda water, which is 0.14mol/L [6]. Using the predicted data for the year 2100, our calculations for the amount of CO_2 dissolved in the ocean is $5.5\text{x}10^{-5}$mol/L. This value is far too small; hence it is unrealistic to assume that the oceans will become fizzy.

Conclusion

The results demonstrate that the absorption of CO_2 into the oceans is highly dependent on temperature (so varies globally) and also the amount of CO_2 which, as current trends show is increasing. In terms of comparison to carbonated water (soda water), taking into account current increases in CO_2 would still not be enough create a high enough pressure to cause the ocean surface to become fizzy. However our results are a simplified look into the chemical processes that are occurring. We have looked only at the direct absorption of CO_2 from the atmosphere; however there are other mechanisms which introduce CO_2 into the ocean.

References

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