DEFINING POINTS

1) The Premise

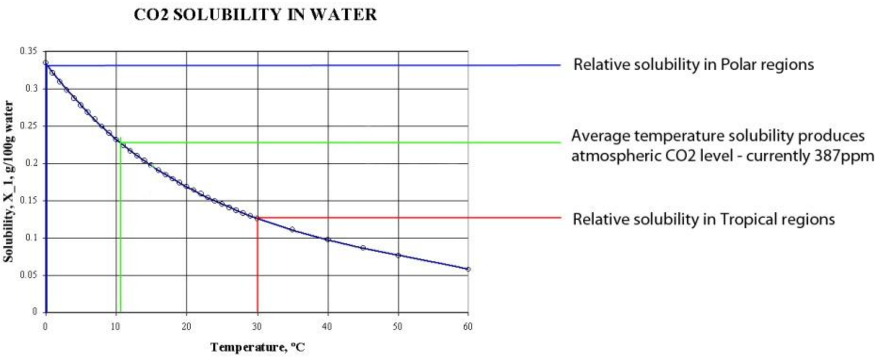
For an increase in global temperatures to be caused by man's CO_2 emissions these emissions must accumulate in the atmosphere. In other words, the atmospheric CO_2 levels are being controlled, or at least significantly influenced, by mans use of fossil fuels. The claim is that mans CO_2 emissions are entering the atmosphere and staying in the atmosphere, accumulating and trapping radiating heat, causing temperatures to rise.

2) The Physics

CO_2 can be dissolved into, or expelled out of, water. The physics gas laws that govern this process are Daltons Law of Partial Pressures, and Henry's Law - which relates to changes in the solubility of gases in solution in response to changes in temperature of the solution. CO_2 in the atmosphere will have a partial pressure that is equal to its proportion of the gas mix that makes up the atmosphere – currently around 400ppm (pressure 400uatm). A glass of water, left on a bench for a while, will absorb CO_2 until its partial pressure in the water is the same as the atmosphere and it is 'in balance'. The greater the difference in the partial pressures, the higher the rate of absorption, or expulsion. The partial pressure of water is raised when the water is heated, causing CO_2 to be expelled until the pressures balance again. Conversely, when the water is cooled the partial pressure is lowered, causing CO_2 to be absorbed until balance is achieved.

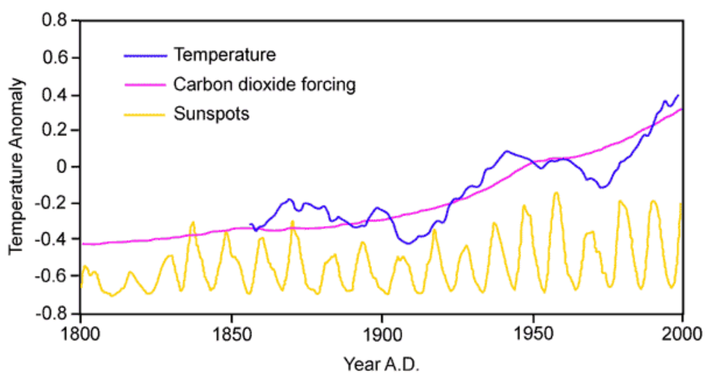
3) The Solubility Pump

The earth's oceans are not all the same temperature, unlike the glass of water referred to in 2 above, so the partial pressure balance is a dynamic mix averaging warm tropical waters with high partial pressures, and cold polar waters with low partial pressures. The result of this situation is huge volumes of CO_2 being absorbed into the polar regions and similar volumes being expelled in the tropical regions. This cycle is known as the solubility pump.

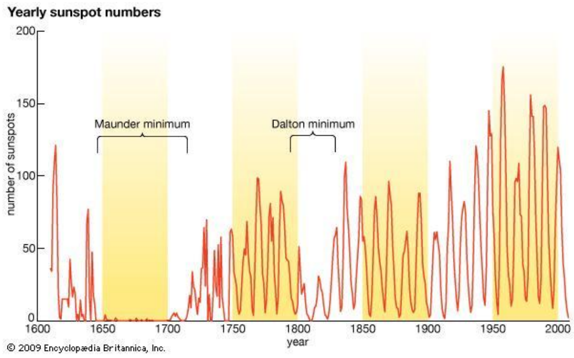


4) Rising CO_2 levels

If the temperature of the ocean were to increase it would release CO_2 into the atmosphere. This is Henry's Law – it must happen. The global surface temperatures have risen about 1°C since the beginning of the industrial revolution (about 1750). This will obviously result in a gradual increase in the temperature of the oceans. It would contravene the laws of physics if this did not cause the oceans to expel some of their dissolved CO_2 into the atmosphere as partial pressures increase.



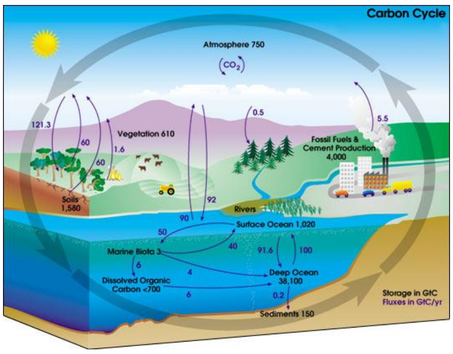
This is what we are seeing now, and is exactly what we should expect to see. During the ice ages the atmospheric CO_2 level drops to 180ppm. There seems to be an expectation that temperatures should be constant. There is no reason for such an expectation – they have never been constant. If they are not rising, they are falling.



Our planet experienced a mini ice-age during the 15th - 18th centuries, particularly during the late 17th century when, for some reason, there were virtually no sunspots, resulting in reduced radiation levels from the sun. At the end of an ice-age one would expect temperatures to increase - obviously. The ocean's temperature changes lag behind the land and atmosphere temperature changes, and the re-balancing of dissolved gases through the ocean profile takes centuries to correct. That this process is occurring during the time of the industrial revolution does not mean that the increase in atmospheric CO_2 is the result of fossil fuel burning. The increase is the result of Henry's Law causing an increase in the partial pressure of CO_2 dissolved in the oceans. Man's activities will have added a margin to the natural increase, but it represents a very small portion of the total CO_2 volume exchanged naturally between the atmosphere and the ocean during this time. Man's total CO_2 emissions to date will have increased the CO_2 concentration in the oceans by about half of one part per million. This is hardly going cause a significant increase in the partial pressure of the CO_2 in the oceans.

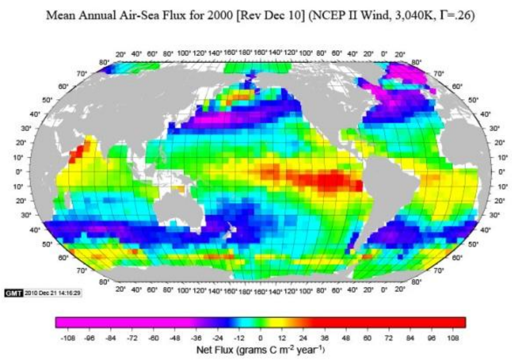
5) Carbon Flow Charts

The following carbon flow diagram, developed by NASA and presented by the IPCC, shows a central 2 way exchange of about 90Gt between the atmosphere and the ocean.



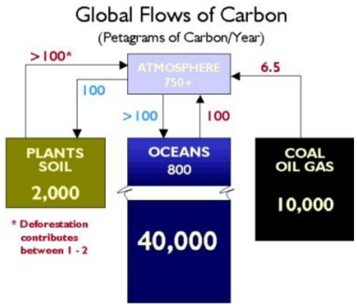
There are 3 issues to consider with regard to this diagram:

A) The central cycling volume of 90Gt. This volume is going into the ocean in the cool polar regions. The same volume is coming back out of the ocean in the hot tropical regions, and there is not much happening in the temperate regions in between. The 2 sides of this cycle are happening a long way apart from each other, but they are in balance, and temperature differences are the driving force.

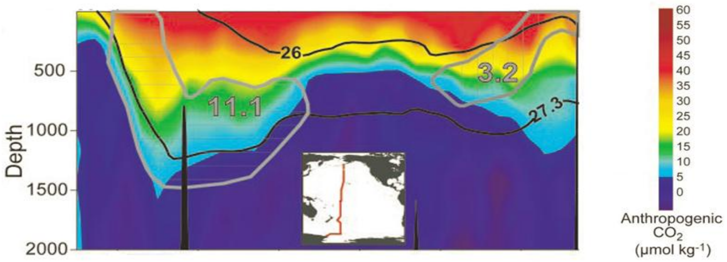


B) The volume of C in the atmosphere is currently nearly 800Gt. Atmospheric CO_2 levels are currently 400ppm, (roughly 2Gt of C equates to 1ppm of CO_2) but 50 years ago atmospheric CO_2 levels were only 320ppm – a total of 640Gt of C. If there was a central balancing volume of 90Gt both ways at 320ppm, and there is the same exchange now at 400ppm, then the partial pressure of the ocean must have been increasing – if it hadn't there would now be a huge imbalance between the partial pressures and exchanging volumes of CO_2. In the last 50 years there has been 4,500Gt of C absorbed into the ocean, and more importantly there has been 4,500Gt expelled from the ocean. It can only be expelled if the partial pressures allow it – in fact they force it. With this going on how can anyone claim that mans emissions are able to accumulate in the atmosphere? If the partial pressures allow this volume of CO_2 to be expelled from the ocean into the atmosphere it proves the exchange is balancing and self regulating. It is simply not possible to have mans CO_2 emissions accumulate in the atmosphere within this exchanging volume.

C) The flow charts we are presented with all show an upper ocean with about $1/40^{th}$ (2.5%) of the total ocean volume of dissolved CO_2 in it – as the average ocean depth is 3.8km this represents the top 90 meters. It is claimed that there is a very limited interaction between the upper and lower ocean and this is inhibiting the assimilation of CO_2 into the deep ocean, where the main storage potential of the ocean is.



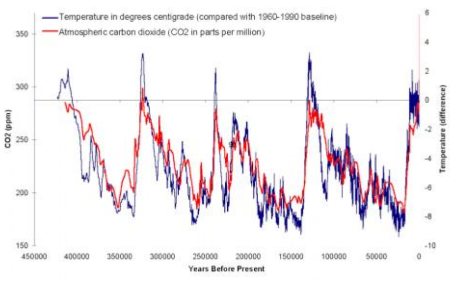
The problem with this model is that the upper ocean layer is defined by temperature, and the regions where such warm surface layers are theoretically 'trapped' on top of the main oceans are in the tropics. These are the regions that have temperatures that are above the ocean average temperature and so are expelling CO_2 into the atmosphere, not absorbing it. The cold waters that absorb the CO_2 would not be affected in this model. There is no evidence of a warm surface layer in the cold, wild waters of the Roaring Forties. This is the type of environment that is sucking CO_2 out of the atmosphere, as can be seen in the diagram 5A above. The Upper Ocean would be more accurately defined by the mesopelagic thermocline - about 25% of the ocean. The concentration of CO_2 through the ocean profile is fairly constant at 28ppm. Anyone with any practical knowledge of the sea will know it is ridiculous to state that there is no real interaction/mixing between the top 90 meters and the rest of the ocean below. It is interesting that all models have this error...



This chart shows the penetration of mans CO_2 emissions into the ocean on the line from Antarctica to Alaska. There is no evidence of a shallow, trapped, surface layer. The penetration into the central tropical area is much less than the cold areas, but this is exactly as would be expected, because the tropics are expelling CO_2, not absorbing it.

6) The History of CO_2 levels

Accurate records of atmospheric CO_2 started at Mauna Loa, Hawaii, in 1958. Prior to that, records are considered to be unreliable and are therefore generally disregarded in favour of ice core samples. The absence of records of atmospheric CO_2 levels above 320ppm is the foundation of the alarm at the current CO_2 level. The following graph is of the results from the Vostok ice core samples in Antarctica. The link between atmospheric CO_2 levels and temperature is obvious. The scientific reports confirm the graph traces – that temperature changes precede changes in CO_2 levels.



The problem with ice core samples is that the temperature and CO_2 records are formed in very different ways. Temperature is recorded using changing ratios of the oxygen isotope ^{18}O. Prevailing temperatures determine the amount of this isotope in the snow and this has produced detailed records with seasonal fluctuations. The process by which CO_2 is trapped in glacial ice is a slow one, and it is not until the snow is about 100 meters deep that it becomes a true 'time capsule'. By this time it has gone through a transitionary phase, called firn, of crystallisation where the snow is morphed and crushed down, resulting in the trapped CO_2 representing an average of a considerable time-frame. At the end of the firn stage it has become glacial ice. It is thought that each recorded point on the Vostok CO_2 graph represents more than 1,000 years, so the ice core records pick up short term temperature fluctuations, but not short term CO_2 fluctuations. This means that at any level in the ice the temperature and CO_2 records represent very different timeframes, and that any CO_2 level recorded represents an average level representing a period of maybe several thousand years, and is therefore highly smoothed and not showing the true peaks and troughs that will likely have occurred. The following is the first line from one of the raw data sheets from Vostok:

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Depth    Ice Age    Gas age    CO2 ppmv   mimimum    maximum
  m       years      years                 value      value
124.6      4050       1700      274.5      279.5      269.5
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In this context it is unrealistic to state that the current CO_2 levels have not been experienced during the last million years. Imagine if we made a similar recording of the last 1,000 years. We would have temperature fluctuations indicating the Mediaeval Warm Period and the Mini Ice Age of the 17th century, while our CO_2 records would average these significant fluctuations out to a single level. And this is exactly what has happened – using ice core samples the records for the last 1,000 years show a constant level of about 300ppm. We will probably never know, but it is extremely likely that we have had atmospheric levels fluctuating higher than we are currently experiencing. Also, drawing accurate conclusions about historic atmospheric CO_2 levels from the ice-core readings is, in reality, pushing science to the very edge of its ability. It is a bad scientific practice to be making direct comparisons between modern instantaneous atmospheric CO_2 readings and 100,000+ year old bubbles of trapped air from over 1km deep ice. The reality is that we simply do not have records to compare our current atmospheric CO_2 recordings with.

7) Pressure differences are the key

The mechanism driving the direction and volume of net CO_2 exchange is the difference between the average partial pressure of the atmosphere and the ocean. It is estimated that man is now emitting about 8Gt of C into the atmosphere annually, and it is claimed that about half of this volume is being absorbed by the oceans, with the balance remaining in the atmosphere. Research by Taro Takahashi has determined that the average partial pressure of the atmosphere is 8uatm higher than the average partial pressure of the oceans. It is this differential that drives 4Gt of C (equal to 50% of mans C emissions) from the atmosphere into the ocean. Mans C emissions can't possibly accumulate in the atmosphere within the naturally cycling volume of 90-100GT that exists between the oceans and the atmosphere, but they must however change the balance of this cycle. These emissions raise the partial pressure of CO_2 in the atmosphere, reducing (and essentially replacing) some of the CO_2 naturally expelled from the ocean. This results in there being a slight positive partial pressure of CO_2 in the atmosphere. The amount can be debated, but the principal is that if everything else was static, a pressure difference would establish that would drive man's CO_2 emissions into the ocean. If 16 microbars (uatm) of pressure was to be the pressure differential required to drive all mans CO_2 emissions from the atmosphere into the ocean, then the impact of mans emissions on the atmosphere would be that the CO_2 level is 16ppm higher than it would naturally be, regardless of whether the natural cycle is static, rising, or falling.

For the alarmist claim that atmospheric CO_2 levels could double to over 600ppm, the partial pressure of the ocean will need to increase to about 590ppm. If we consider the 1960 level of 320ppm (uatm) for both bodies as a starting point and split mans CO_2 emissions equally between the 2 bodies (on the premise that the ocean can only absorb 50% of man's emissions), then:

	ATMOSPHERE	OCEAN
Gt of C at 320uatm of CO_2	640	41,000
Gt of C at 600uatm (590uatm)	1,200	(41,540)
Equals increase as %	89%	1.3%

It can be seen that it is nonsense to predict that an (annual) addition of 4GT of C to each body will result in an equal increase in partial pressure in each body. The ocean has more than 60 times the volume of C that the atmosphere has (in 1960), so it is not going to increase lineally with the atmospheric increase in response to equal additions of CO_2. During the last ice age the concentration of CO_2 dissolved in the ocean was considerably higher than it is now (see 9B below) and yet the partial pressures of both bodies were in the region of 180uatm. The temperature of the ocean determines the partial pressure of the ocean, and this in turn determines the partial pressure of the atmosphere. If the atmospheric CO_2 levels were to rise to 600ppm it would not be as a result of mans CO_2 emissions, it would be because the temperature of the ocean had increased.

8) Man's Emissions within the Natural Cycle

It is claimed by the alarmist scientists that the oceans are only able to absorb about 50% of the CO_2 produced by man. The same scientists present the carbon cycle diagrams shown in 5 above. These clearly show that the oceans are absorbing 90+ GT of C per year. There is no explanation as to why the oceans can absorb 90GT, but not include man's 8GT. This doesn't make sense. These diagrams show the oceans are also expelling around 90GT of C. It is obvious that it is impossible to measure these volumes with any real accuracy due to the global variability of temperature, wind velocity, salinity, and seasonal sea ice cover. We can accurately measure atmospheric CO_2 levels, and we can get a pretty accurate estimate of fossil fuel emissions. Estimates for the other components vary considerably and it is obvious that the volumes of the components are rounded numbers that fit, and balance, the diagram. The numbers are not measurements, they are estimates. 'They' are effectively creating the right numbers to prove the desired result, and this is not how the principles of science are meant to be applied.

The oceans are warming as a result of a century of increasing temperatures, and this is increasing the partial pressure of the CO_2 in the ocean, and this means the partial pressure of the atmosphere needs to increase to remain in balance. This is achieved by a shift in the balance of the cycling CO_2 (solubility pump) that results in the volume of atmospheric CO_2 increasing. The increase is currently about 2ppm/year, which represents 4GT of C. This currently equals about half of man's emissions, the other half are being assimilated into the ocean, so the equation would be something like:

C entering Atmosphere			
Oceans expels	86GT	86	
Man's emissions	8GT	8	
Total			94
C leaving Atmosphere			
Ocean absorbs	90GT		90
Net Atmosphere increase	4GT		4

However, if the earth were in a cooling phase the atmospheric CO_2 level would be falling and this equation might look more like:

C entering Atmosphere			
Oceans expels	78GT	78	
Man's emissions	8GT	8	
Total			86
C leaving Atmosphere			
Ocean absorbs	90GT		90
Net Atmosphere decrease	4GT		-4

Because of the large storage capacity of the ocean, and the large cycling volume of CO_2, man's emissions will just be a component of the C entering the atmosphere, but will have a minimal impact on the overall balance between ocean and atmosphere. All the know fossil fuel deposits, dissolved into the oceans, would increase the CO_2 concentration of the ocean by about 1ppm.

9) Some Interesting Perspectives

A) Fossil Fuel Reserves

Oceans have 1.37 billion cubic Km water. = 1.4×10^{18} tons.
Man currently produces 7Gt C into the atmosphere per year. = 7×10^{9}
If man produces same level of C for 200 years = 1.4×10^{12}
This equals an increase of 1ppm of C over a 200 year period.
Equals an increase of 0.005ppm per year.

As we only have known fossil fuel reserves to last about 100-150 years it is hard to see this as a problem.

B) The Ocean's CO_2 History

Only 20,000 years ago we were in an ice-age. Ice sheets similar to Antarctica covered Russia, Canada, and Patagonia. This ice came from water vapour that had evaporated from the sea, resulting in the sea level falling 120 meters. The Dover - Calais ferry route was 60 meters above sea level. When the sea level drops 100 meters the concentration of CO_2 in the ocean will increase by 1/38th. Also the colder ocean water absorbs about 40% of the CO_2 out of the atmosphere. The accumulated result of these factors is an increase in dissolved CO_2 of nearly 1ppm in the ocean. This is more than all the known hydro-carbon fuel deposits and yet the partial pressure of both bodies was only 180uatm - and this was the situation 20,000 years ago.

C) The Capacity Of The Ocean To Absorb CO_2

There is 1.4×10^{18} tons of water on the planet. Water at 10°C can dissolve 0.23% of its weight in CO_2 at one atmosphere pressure. This produces a theoretical capacity for 3.22×10^{15} tons of CO_2 to be dissolved in the oceans. It is estimated that the ocean is currently storing about 41,000 Gt (41×10^{12}) of CO_2. This is just under 1.2% of the ocean's theoretical CO_2 capacity, excluding the effect of pressure at depth – which would increase it further.

D) Getting The Oceans And Atmosphere Into Perspective

If we consider a standard classroom globe, the UK will measure about 30mm and is actually about 1,000 km. This is a scale of 1mm equalling about 33km. The average depth of the ocean is 3.8km. This is 0.1mm on the globe - the equivalent of the thickness of a sheet of ordinary computer paper. Outer space is considered to start at an altitude of 100km. This is only 3mm above the globe surface, and satellites can orbit there. 75% of the air is within 11km of sea level – only 3 sheets of paper thick on the globe. The point being – these two bodies are very thin veneers that have a high level of contact and interaction.

E) Climate Models

Climate prediction models are being continuously updated as they are found to be making in-correct predictions. In 1998 the models stated that CO_2 levels were high and rising and that this would cause temperatures to continue to rise. They haven't, and it has recently been decided this is because of the high level of sulphur in coal burned in China. Until recently the model stated that deforestation was putting about 2Gt of C into the atmosphere annually. 'They' have now found that the world's forests have become more dense and calculate that this will likely have soaked up all the CO_2 released by deforestation in recent decades. The model didn't accommodate the well know fact that higher temperatures and raised CO_2 would promote vegetative growth. The reality of climate models is that they cannot even predict an up-coming season with any certainty. They are continuously being corrected/updated retrospectively when 'they' think they understand why it has not produced a correct prediction.

F) The Real Threat

It would be fantastic if man were, in fact, able to influence the climate significantly. The Vostok graph in 6 above clearly shows that earth is overdue for an ice-age. Using current technologies it is unlikely our planet will be able to grow enough food to feed the projected population of 9 billion during an ice-age climate. Imagine the pressure that will come to bear on those countries that will suffer as temperatures drop 10°C and continents become covered in great sheets of ice again. There are many issues worthy of collaborative policy on a worldwide scale, overpopulation, resource depletion, pollution, and anti biotics, being top of the list, but CO_2 is a long way down this list.

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