Everyone is entitled to their own opinion but not their own facts

Tom Quirk

A presentation to The Lavoisier Group's 2007 Workshop

'Rehabilitating Carbon Dioxide'

held in Melbourne on 29-30 June 2007

7 June Presentation Lavoisier Meeting

Opinions and Facts

This presentation will be directed at the context in which various data sets are used to set the scene for the present and past climate.

1 Past Temperature Record

Figure 1 is the conventional presentation of the extensive ice core record.

Figure 1

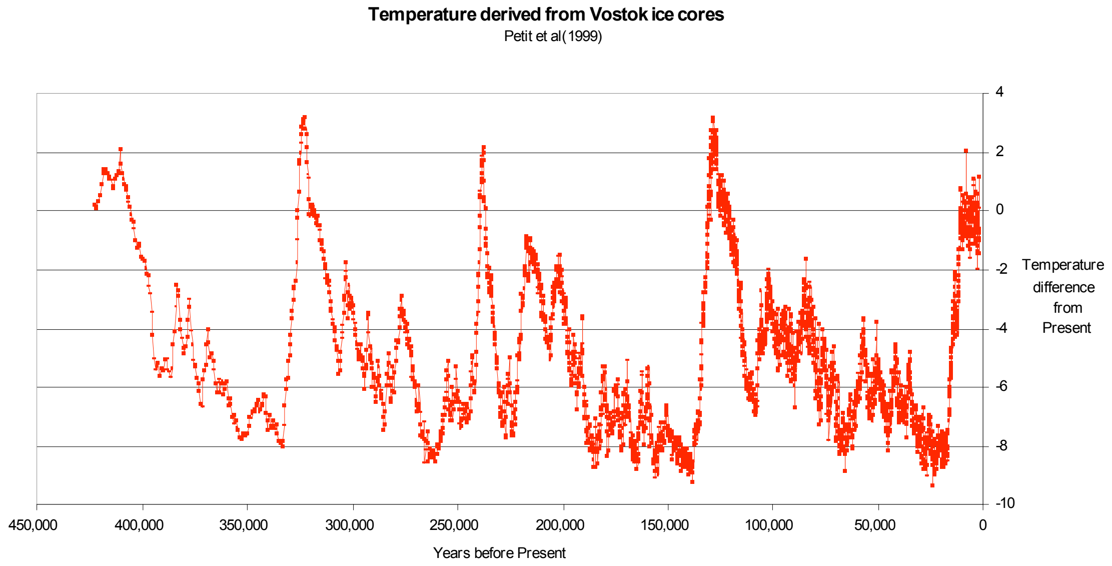
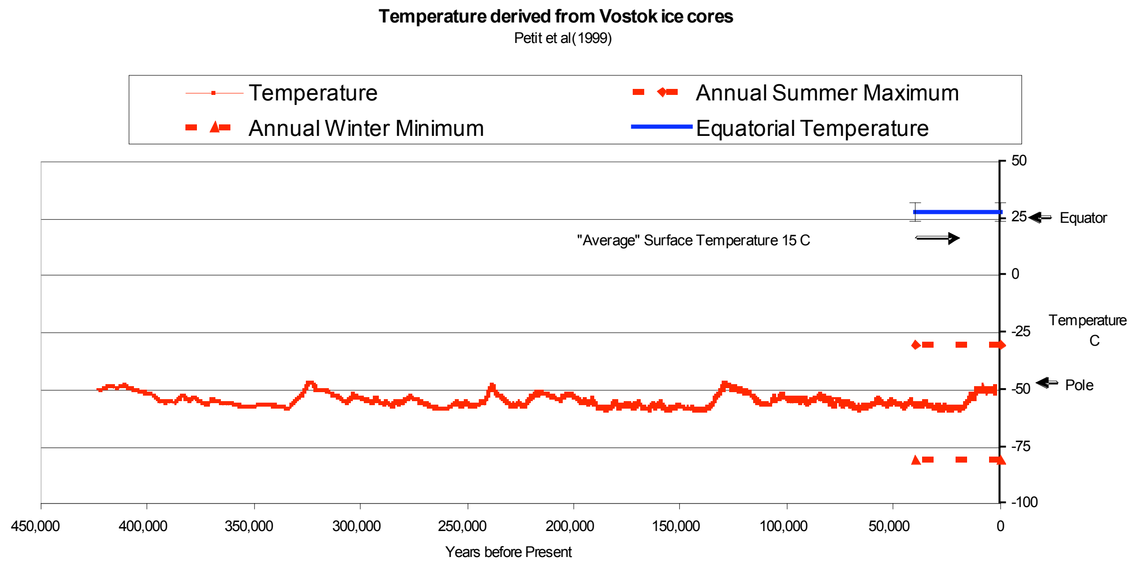


Figure 2 puts the ice core record in the context of present temperature variations from the Equator to the South Pole. Note the very large, 50 C variation at Vostok with a possible 4 C variation in the tropical oceans.

Figure 2



Figures 3 and 4 give a rough view of the global surface temperature distribution in summer and winter. Note that in the tropics there is little change in surface area for the high temperature bands. The tropical oceans are controlling and limiting temperature movements as a result of evaporation the Polar Regions have substantial change and particularly Antarctica shows extreme sensitivity moving from summer to winter.

Figure 3

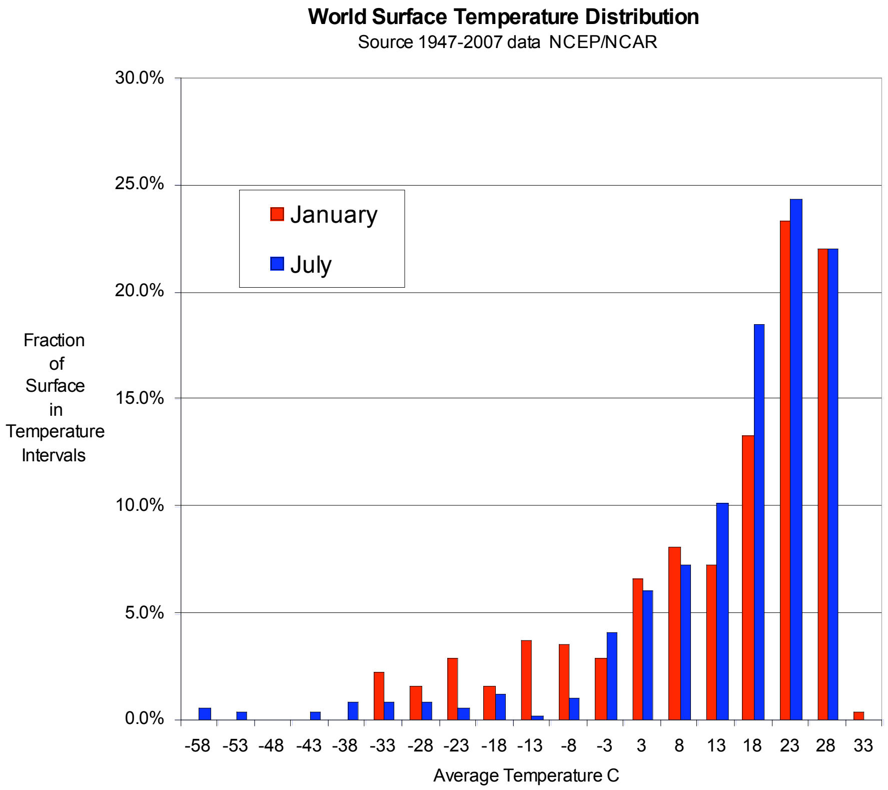
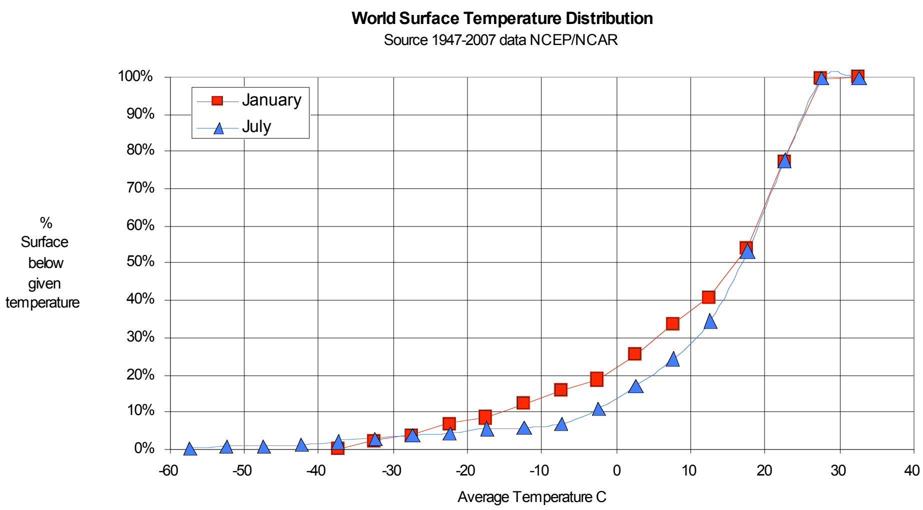


Figure 4

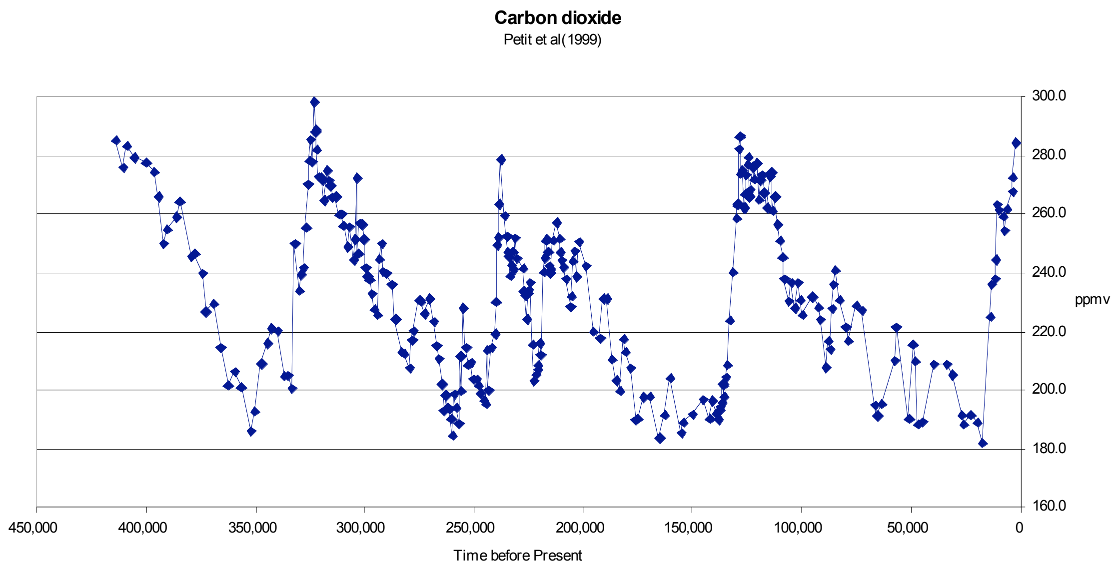


The interesting question is how the ice core record might indicate temperature changes nearer to the equator and the "average" global temperature. It is clear that the tropical temperature range is substantially damped.

2 Sampling CO2 in Ice Cores

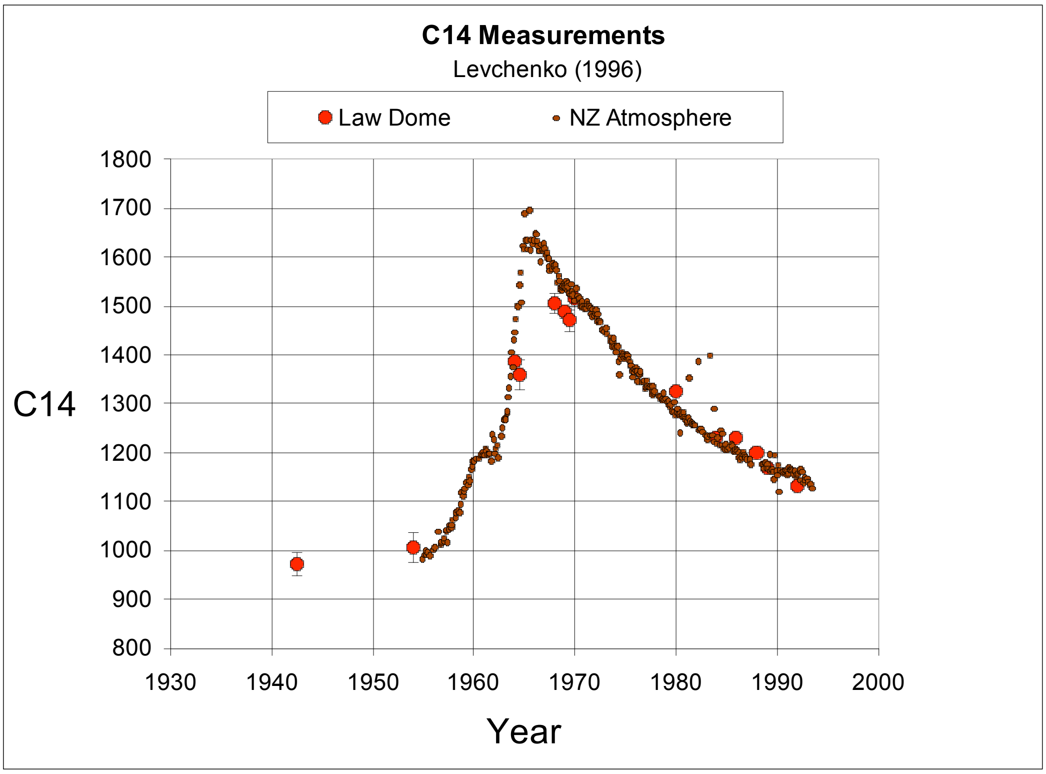
The statement is frequently made that, apart from the present, the level of CO2 in the atmosphere has not been above 300 ppm for the last 500,000 years. **Figure 5** shows the Vostok measurement of the level of CO2.

Figure 5



A comparison of ice core measurements and contemporary "in atmosphere" measurements is shown in **Figure 6**. This is a careful comparison of C14 sampled from CO2 in the atmosphere and at the Law Dome in Antarctica. The sampling explores the age resolution of CO2 measurements in an elegant manner.

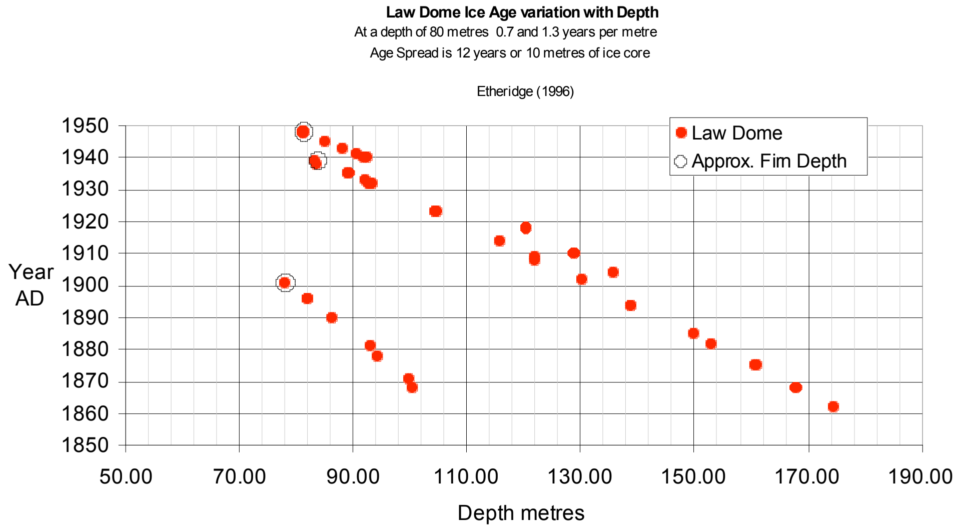
Figure 6



When snow falls it remains in a porous state for some time and air is able to diffuse through it. As the snow accumulates, the weight (pressure) compacts the snow finally sealing the spaces from the column above and then forming gas bubbles in the ice. The diffusing column is 70 to 100 metres deep. The partially compacted snow is referred to as Firn. The compacting process allows a mixing of the air over a period of years. By using the carbon pulse from weapons testing it has been possible to measure the effect of this compacting and sealing process for air sampling.

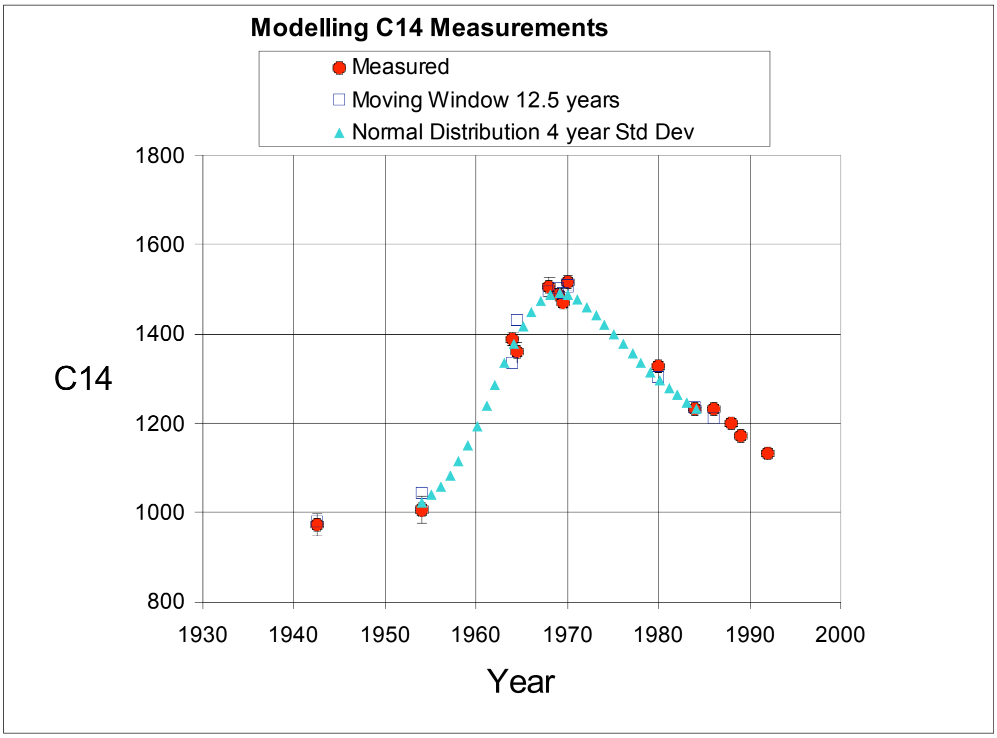
This resolution or extended sampling time reduces the carbon 14 peak by an absolute 10 percent compared to the atmospheric measurements

Figure 7



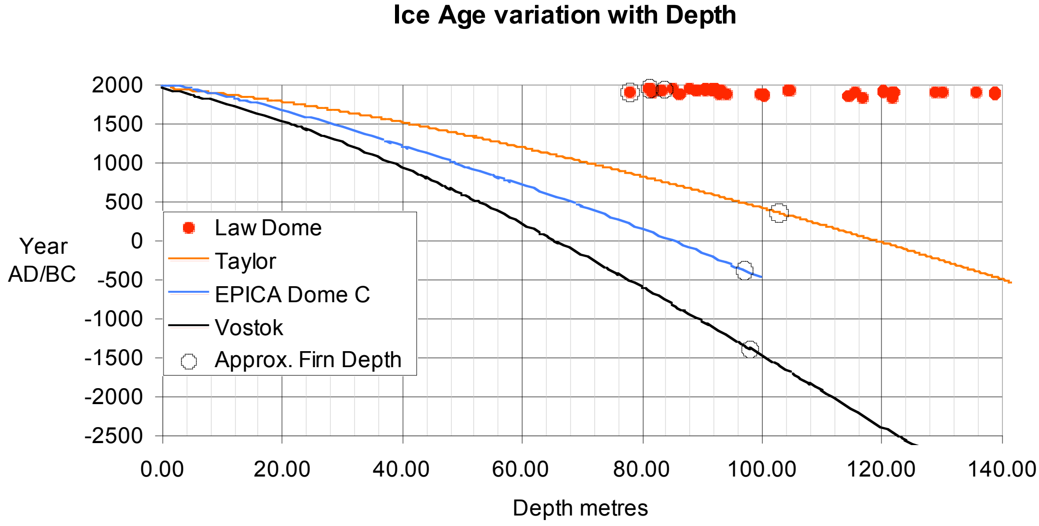
Ice accumulation at the Law Dome is 0.7 to 1.2 metres per year as recorded at a depth of 80 to 100 metres, **Figure 7**. As a result the diffusion process in the snow and firn averages out air sampling over a period of 12 years.

Figure 8



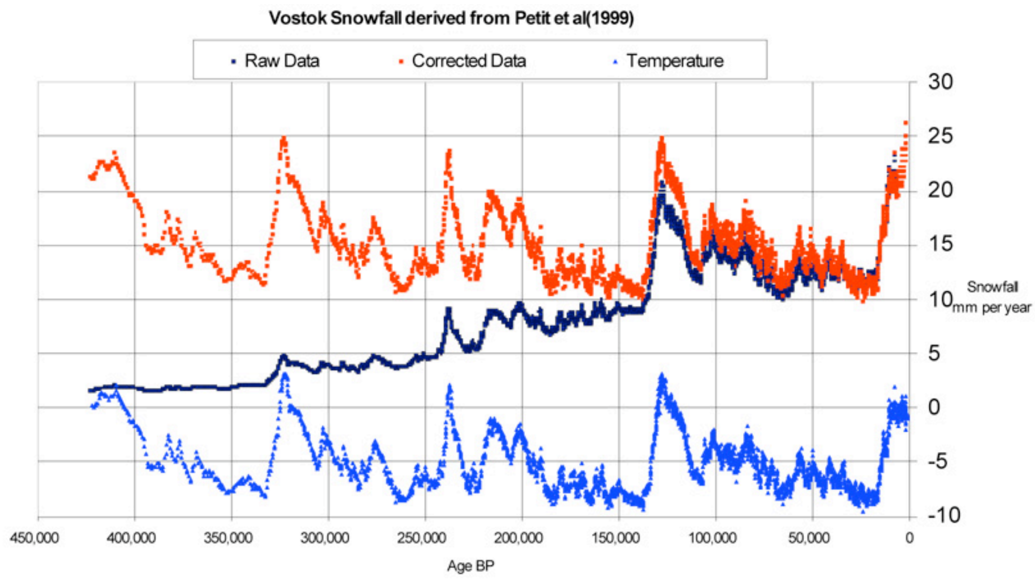
The result gives an indication of the age resolution in the Vostok and EPICA measurements The Vostok and EPICA cores show 0.01 to 0.02 metres accumulation per year, **Figures 9 and 10**. If the pressure column of Firn is the main control for the air sampling process then scaling the Law Dome results give an age resolution-averaging period of 100's to 1,000 years at EPICA and Vostok.

Figure 9



There is an additional correction to be applied for samples collected at depths where pressure has caused the ice to flow and the apparent snowfalls are reduced to mm per year. The apparent compression is shown in **Figure 10** with a correction**.** For a metre sample this may increase the sampling period by one to two hundreds of years.

Figure 10



The results of the ice core sampling resolution are illustrated below in **Figures 11 and 12**. **Figure 11** shows measurements from the Vostok ice cores while **Figure 12** shows the possible underlying values when unpacked with the measuring resolution.

Figure 11

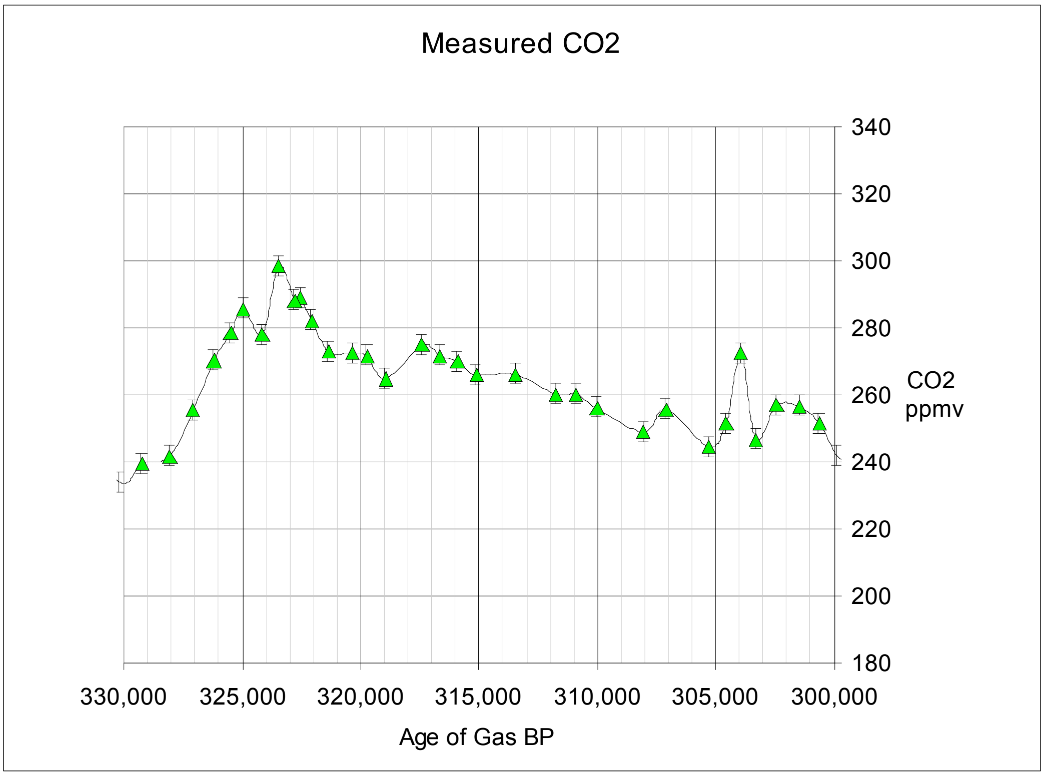
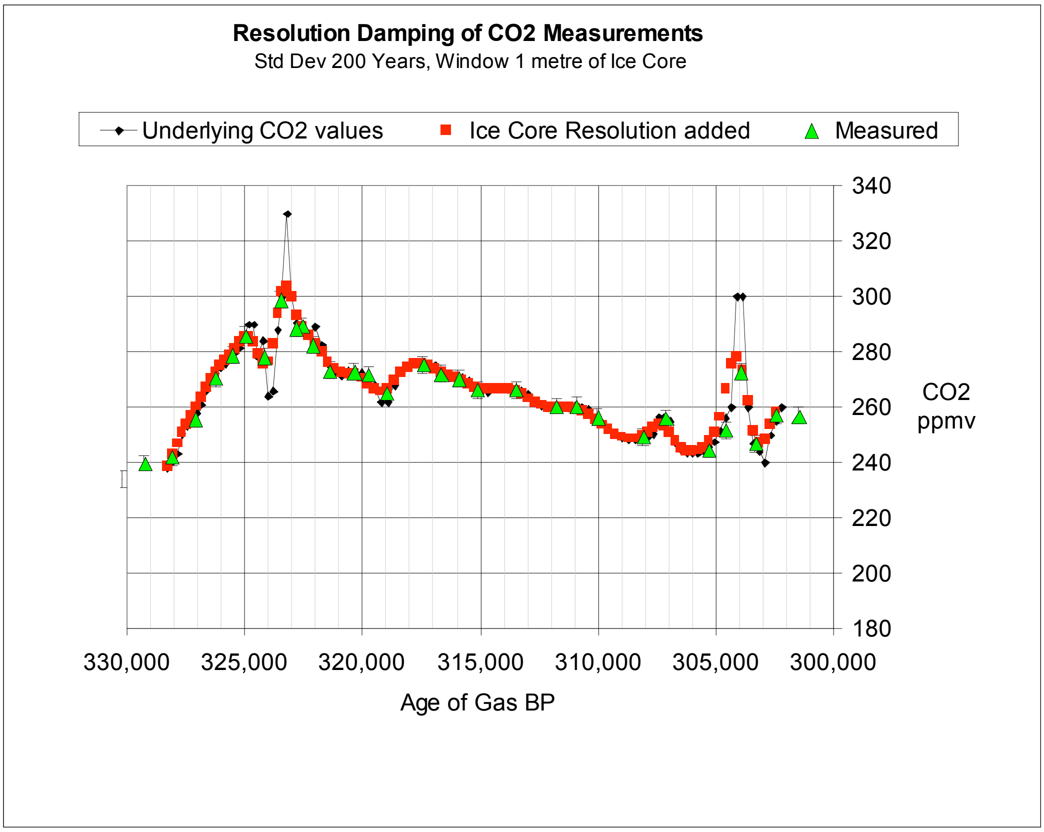


Figure 12



It is not possible to compare peaks and valleys in CO2 measurements from Vostok or EPICA with contemporary atmospheric time series. There is a mismatch in gas age resolution. Peaks are flattened and valleys are filled for ice core measurements.

Thus on our contemporary timescale it is not possible to say that the CO2 level has not been above 300 ppm for the last 500,000 years. The same comment applies to comparing the “rapid” run up of contemporary CO2 levels with the ice core records where “sharp” pulses of less than 100 years may well be smoothed away.

3 Sampling CO2 Elsewhere.

There have been a number of techniques used to get better measurement resolution than ice core data. The following are examples.

Figure 13

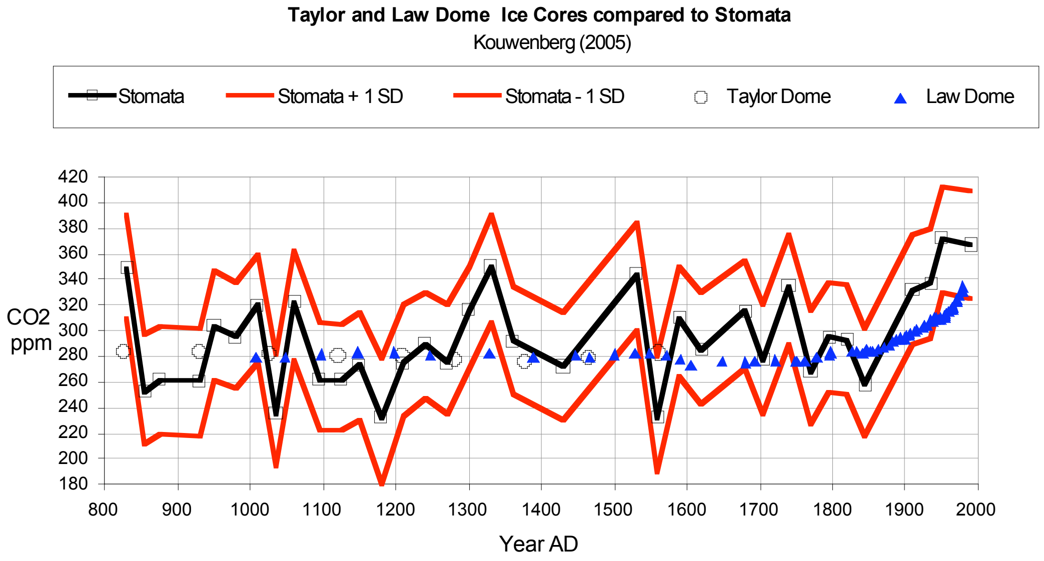


Figure 14

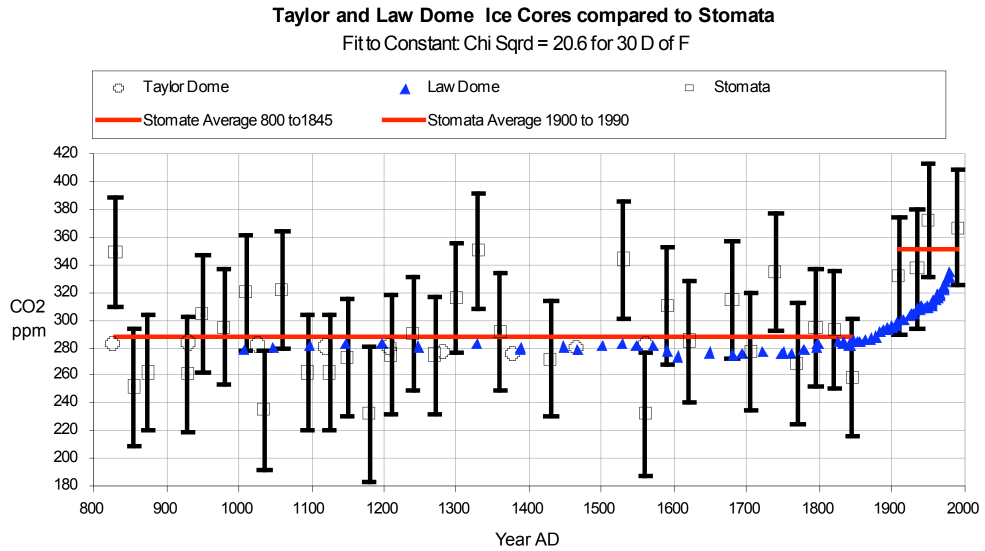


Figure13 shows CO2 measurement derived from leaf and needle stomata. The solid lines are as in the paper. **Figure 14** shows the minimalist position where a constant, a straight line, is sufficient to fit the data. There is no serious difference of ice core and stomata measurements.

Figures 15 and 16 below show a similar result where a constant is sufficient for a fit.

However it is often useful to see if correlations exist and a plot of semivariance in **Figures 17A and 17B** implies that there may be some significant variations in the data of **Figure 15**.

Figure 15

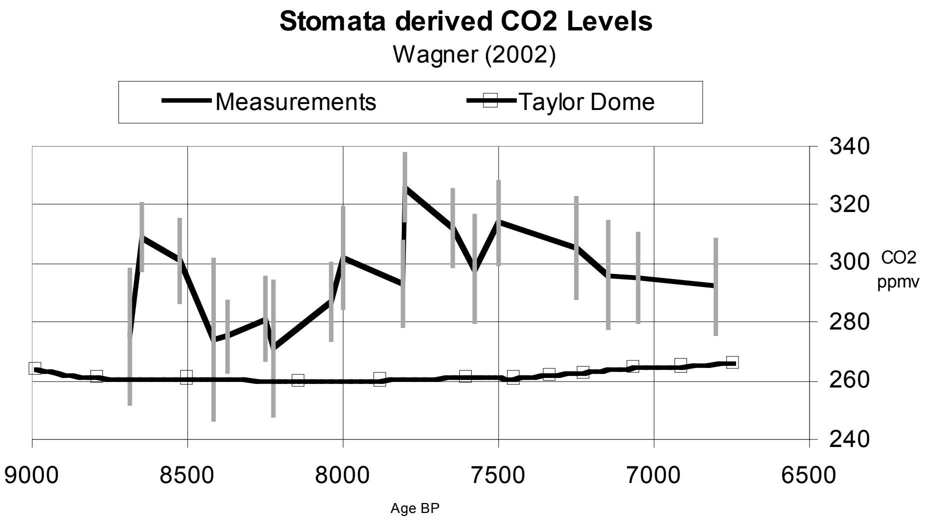


Figure 16

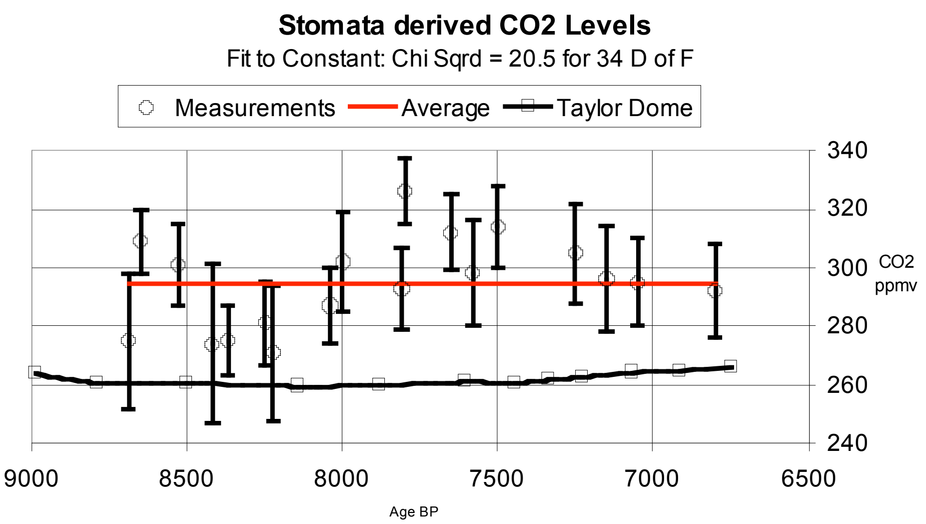
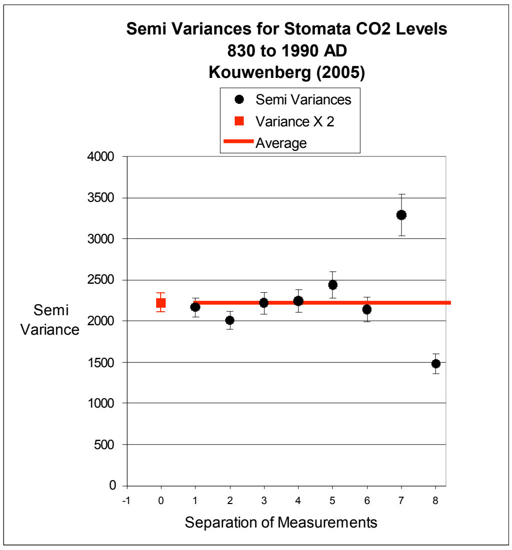
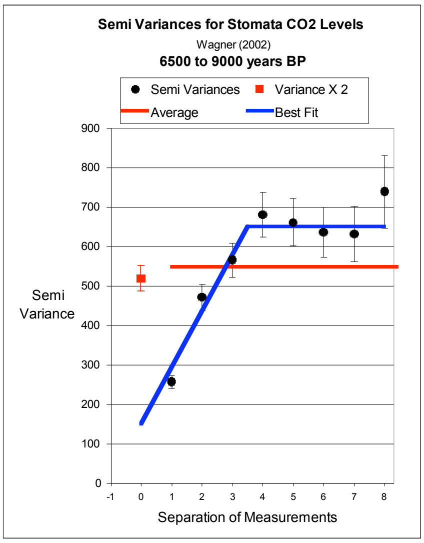


Figure 17A



17B



The conclusion of this section is that data needs to be critically assessed for its significance. This is apart from the systematic errors, which can be overwhelming.

4 Carbon 14 and Atmospheric Mixing

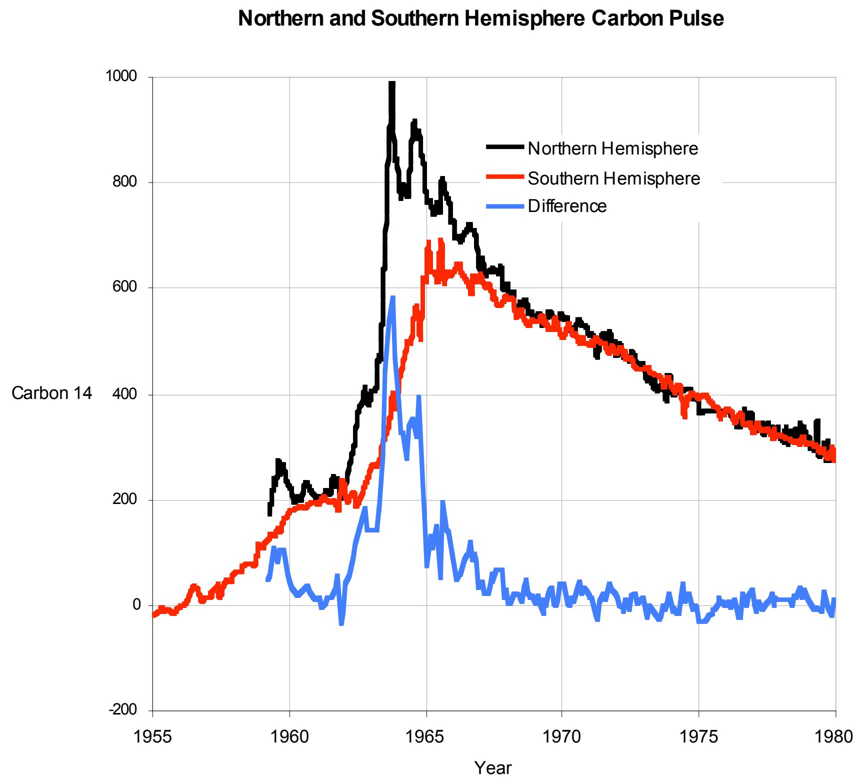
Neutrons produced in the upper atmosphere by cosmic rays from outer space change Nitrogen14 to Carbon14 by replacing a proton with a neutron. The carbon then reacts with oxygen to form CO2. This is a continual process independent of other sources of carbon in the atmosphere.

In the late 1950s, nuclear weapons testing in the atmosphere produced neutrons that changed N14 to C14. Atmospheric testing was stopped with the Partial Test Ban Treaty that came into force in October 1963.

The weapons tests nearly doubled the amount of C14 in the atmosphere. Thus in 1964, the atmospheric carbon dioxide had been radio-labelled and this has been of great value in tracing the path of carbon dioxide in the biosphere. C14 has a half-life of 5,700 years and decays back to N14.

Atmospheric measurements of carbon 14 have been made in the Northern and Southern Hemispheres. **Figure 18** shows these along with the difference between North and South. The difference diminished with time showing global mixing with a half-life of about one year. Also note the very large summer to winter variations of CO2 in the Northern Hemisphere that is of the order of 35 ppmv.

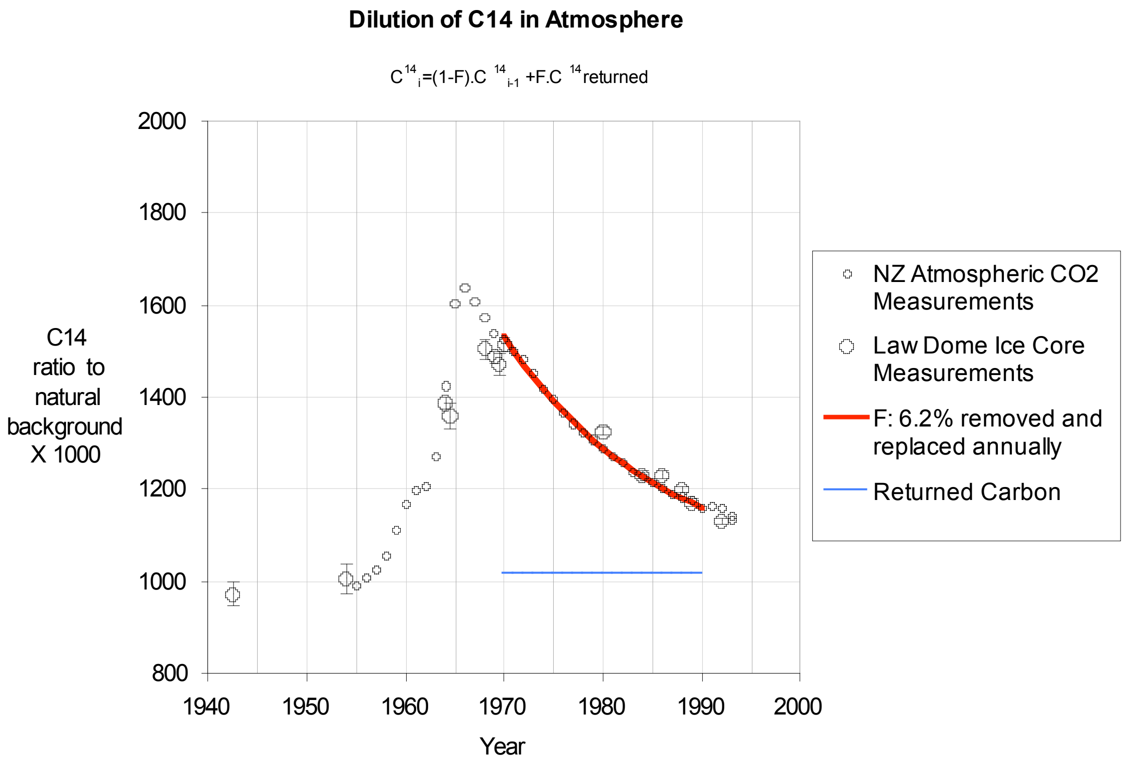
Figure 18



The dilution shown in the falling C14 measurements is not caused by fossil fuel derived carbon, which has no C14. Assuming all the extra CO2 since 1965 was derived from fossil fuel and remains in the atmosphere does not give sufficient dilution to explain the measurements.

The explanation must be with the general exchanges between sources and sinks for atmospheric CO2. This is a well understood position. However the fall in the C14 peak is driven by exchanges with sources of reduced C14. This is thought to be from the deep ocean where transport times of hundreds of years yield CO2 that predates the weapons created C14.

Figure 19



The fall in C14 is exponential (**Figure 19)** and this implies that the sources and sinks that contain different levels of C14 keep pace with the steady increase in the total CO2 in the atmosphere.

5 Conclusions

- The use of data derived from measurements is often location and context dependent. Presentations do not always make this clear.
- Ice Core measurements of CO2 sample over time scales of 100's to 1,000's of years. Detail is lost compared to contemporary measurements. Valleys are filled in and peaks are reduced. There is a mismatch of techniques.
- Data derived from alternative measure of atmospheric CO2 need to be carefully assessed
- Northern and Southern Hemisphere atmospheric mixing takes up to 5 years. Detail may be seen in one hemisphere but lost in the other hemisphere.
- Annual mixing shows continuous expansion of the capacity of sinks and sources for exchange of CO2. No evidence of constraints from C14 mixing**.**

T W Quirk
7 June 2007