

Volcanoes and CO₂ and Global Temperatures

By Joseph D'Aleo, November 14, 2009

In a recent UK Telegraph piece, Dr. Ian Plimer, author of the best seller *Heaven and Earth* argues CO₂ is not causing global warming ([here](#)). The Telegraph title is correct but not one of the central themes that volcanoes are the primary source of CO₂ increases. They were in the early days of the planet one of the key sources of all gases, but now other natural and anthropogenic sources dominate

The Pinatubo eruption was estimated to have emitted only a modest 42 megatons CO₂ (Gerlach 1996), a small fraction of the total natural and anthropogenic annual emissions. Major volcanism causes global CO₂ level rise to actually decrease significantly for a year following. This can be seen after Agung in 1964, after El Chichon in 1982 and Pinatubo in 1992.

Alan Robock in “Introduction: Mount Pinatubo as a Test of Climate Feedback Mechanisms” (2003) showed a decrease in CO₂ rate after Pinatubo, El Chichon and Agung.

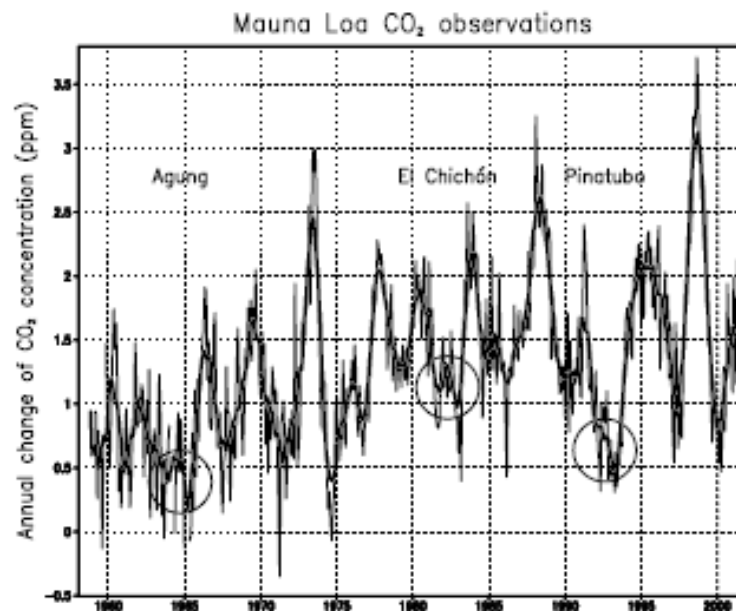


Figure 4. Annual rate of increase of CO₂ in the atmosphere. Data are from *Keeling and Whorf* [2002]. Thin line is monthly values and thick line is 9-month running mean. Minima following the largest volcanic eruptions of the period are indicated. Other interannual variations are partially due to El Niños, La Niñas, and emission variations.

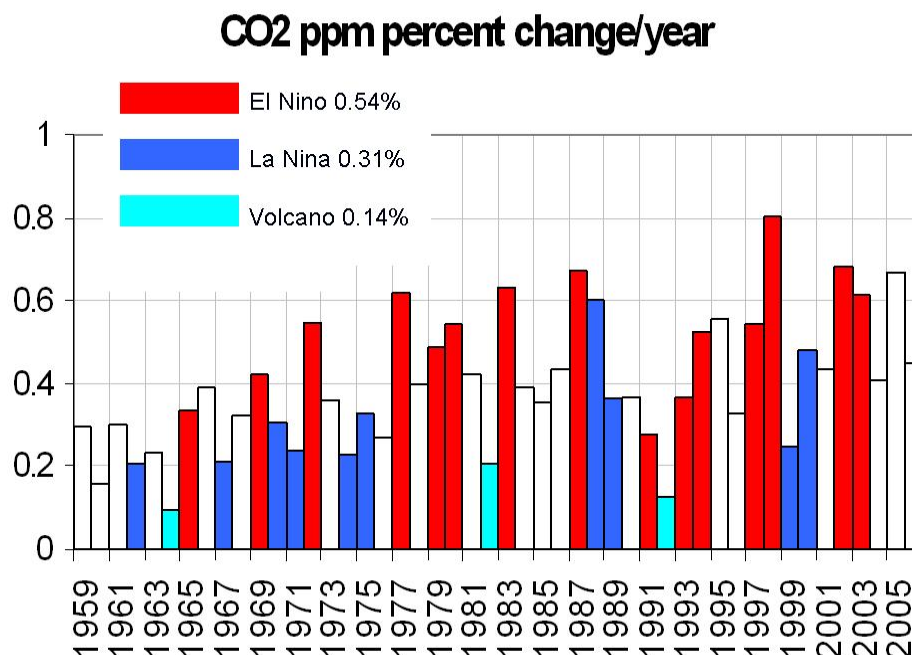
He noted “enhanced vegetation growth from more diffuse and less direct solar radiation took more carbon dioxide out of the atmosphere than normal, temporarily reducing the observed long-term increase in carbon dioxide.”

Angert et al.; (2004) looked at whether the “Enhanced CO₂ Sink Following the Mt. Pinatubo Eruption Driven by an Increase in Diffuse Radiation?” They noted in their abstract that “following the Mt. Pinatubo eruption in 1991, there was a sharp decrease in the atmospheric CO₂ growth rate. It is believed that this decrease was caused by an anomalous strong terrestrial sink (approx. 2PgC/yr) in the northern hemisphere. This strong sink is hard to explain, since the global low temperatures that followed the eruption (as a result of the injecting of volcanic aerosols to the stratosphere) were expected to reduce photosynthesis rate. There are currently two competing explanations for the enhanced sink. The first is that soil respiration rate declined more than photosynthesis rate, while the second suggests that the increase in the fraction of diffused radiation, as a result of the aerosol loading, caused an increase in photosynthesis.

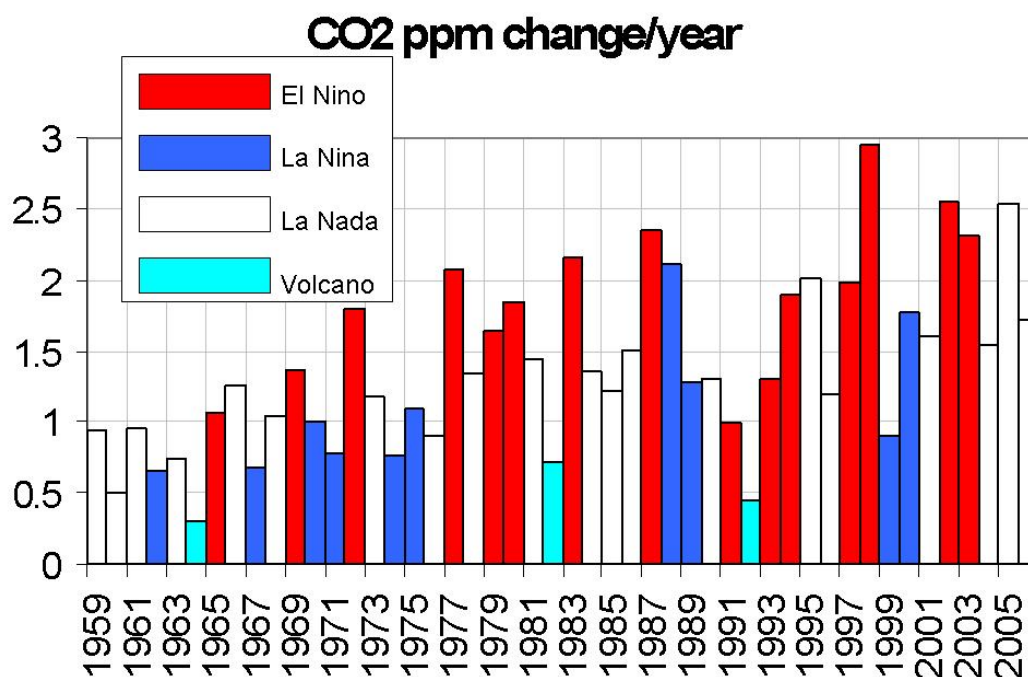
In their study they found that the enhanced sink cannot be explained by decreased respiration alone, and thus can be only explained by several land and ocean sink mechanisms acting in concert.”

THE OCEANS ROLE

By going further and separating the years by El Nino state and volcanism, we see the importance of the tropical ocean in the CO₂ increases. The primary source in the oceans comes from the tropical waters while the cold high latitude waters are sinks for CO₂. This is the well known fizz effect from carbonated beverage. When you open a cold beverage it has a lot of fizz (pumped in CO₂), let out to sit and warm on the counter and the gas escapes, eventually leaving the beverage flat. Whether a water body is a net absorber or emitter of CO₂ depends on Henry's Law. Equilibrium is established between the atmosphere and ocean rapidly when CO₂ levels change or when water and or air temperatures vary. We see that in both annual and interannual changes.



Above are changes in percent of ppm and below change in ppm directly.



On average the greatest increases occur in El Nino years, when the tropical oceans are warmest (averaging 1.80ppm/year or 0.54%), much lower rates in La Ninas (1.05ppm/year or 0.31%) and very low rates of increase (0.61ppm or 0.14%) in years of the three major volcanoes. This suggests the major role tropical OCEANS play in CO2 production.

It also suggests that long term changes in the ocean temperatures (the warming since the last little ice age) may be responsible for much of the increase in CO₂ observed just as it has in the past. Man after all is directly responsible for only 3-4% of the annual CO₂ production (and given the 0.038% trace gas content for CO₂, man's annual contribution represents just 0.0001% of the atmosphere).

And importantly the lifetime of CO₂ in the atmosphere contrary to Robock and the IPCC has been definitively shown to be the order of 5 to 6 years (Sundquist 1986, [Segalstad 1998](#)) not 100-200 years or as Solomon has speculated 1000 years.

| Effective atmospheric CO ₂ lifetime | | |
|--|------------------------|--|
| Authors [publication year] | Residence time (years) | |
| Based on natural carbon-14 | | |
| Craig [1957] | 7 +/- 3 | |
| Raveille & Suess [1957] | 7 | |
| Arnold & Anderson [1957] | 10 | |
| including living and dead biosphere (Siegenthaler, 1989) | 4-9 | |
| Craig [1958] | 7 +/- 5 | |
| Bolin & Eriksson [1959] | 5 | |
| Broecker [1963], recalcd. by Broecker & Peng [1974] | 8 | |
| Craig [1963] | 5-15 | |
| Keeling [1973b] | 7 | |
| Broecker [1974] | 9.2 | |
| Oeschger et al. [1975] | 6-9 | |
| Keeling [1979] | 7.53 | |
| Peng et al. [1979] | 7.6 (5.5-9.4) | |
| Siegenthaler et al. [1980] | 7.5 | |
| Lal & Suess [1983] | 3-25 | |
| Siegenthaler [1983] | 7.9-10.6 | |
| Kratz et al. [1983] | 6.7 | |
| Based on Suess Effect | | |
| Ferguson [1968] | 2 (1-8) | |
| Bacastow & Keeling [1973] | 6.3-7.0 | |
| Based on bomb carbon-14 | | |
| Blen & Suess [1967] | >10 | |
| Munnich & Roether [1967] | 5.4 | |
| Nydal [1968] | 5-10 | |
| Young & Fairhall [1968] | 4-6 | |
| Rafter & O'Brian [1970] | 12 | |
| Machta [1972] | 2 | |
| Broecker et al. [1980a] | 6.2-8.8 | |
| Stuiver [1980] | 6.8 | |
| Quay & Stuiver [1980] | 7.5 | |
| Delibrias [1980] | 6.0 | |
| Druffel & Suess [1983] | 12.5 | |
| Siegenthaler [1983] | 6.99-7.54 | |
| Based on radon-222 | | |
| Broecker & Peng [1974] | 8 | |
| Peng et al. [1979] | 7.8-13.2 | |
| Peng et al. [1983] | 8.4 | |
| Based on solubility data | | |
| Murray [1992] | 5.4 | |
| Based on carbon-13/carbon-12 mass balance | | |
| Segalstad [1992] | 5.4 | |

The effective lifetime for CO₂ in the atmosphere, can be determined by the help of radioactive, radiogenic, and stable isotopes.

All measurements with different methods show short effective lifetimes for atmospheric CO₂, only ca. **5 - 6 years.**

Sundquist (1985); Segalstad (1998)

[Segalstad](#) (1992; 1993; 1996) further concluded from 13-C/12-C isotope mass balance calculations, in accordance with the 14-C data, that at least 96% of the current atmospheric CO₂ is isotopically indistinguishable from non-fossil-fuel sources, i.e. natural marine and juvenile sources from the Earth's interior. Hence, for the atmospheric CO₂ budget, marine equilibration and degassing, and juvenile degassing from e.g. volcanic sources, must be much more important; and the sum of burning of fossil-fuel and biogenic releases (4%) much less important, than assumed (21% of atmospheric CO₂) by the authors of the IPCC model (Houghton et al., 1990).

Segalstad states the oceans are a virtually infinite buffer for CO₂ increases, absorbing more and more of whatever we add to the atmosphere.

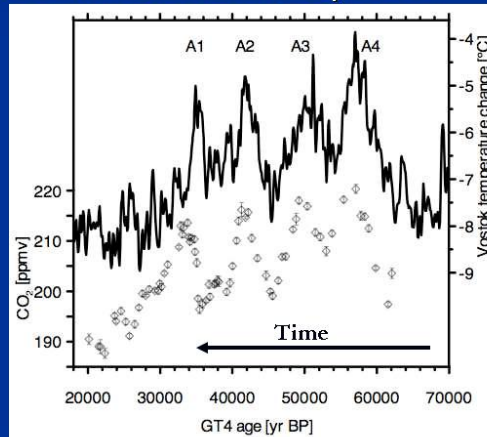
CO₂ LAGS NOT LEADS TEMPERATURE

Not less than 6 peer-reviewed ice core studies show that temperatures lead not follow the changes in carbon dioxide. Analysis of ice core data from Antarctica by Indermuhle et al. (2000) found that CO₂ lags behind the temperature by 1200±700 years.

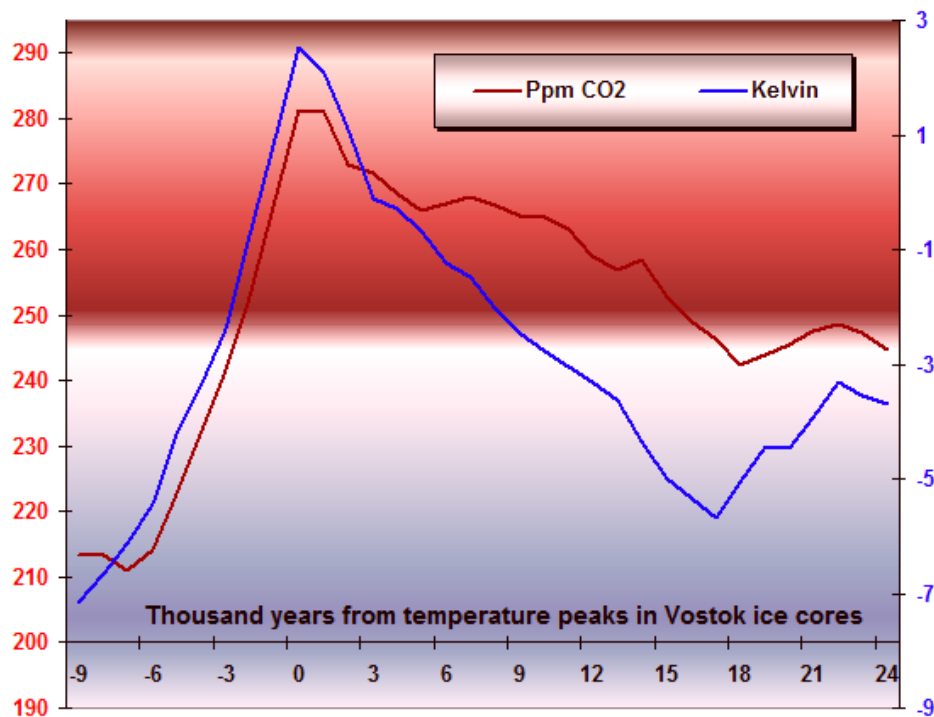
Lag or Lead?

- In any event not less than 6 peer-reviewed ice core studies show that temperatures lead not follow the changes in carbon dioxide by 1200 years or so

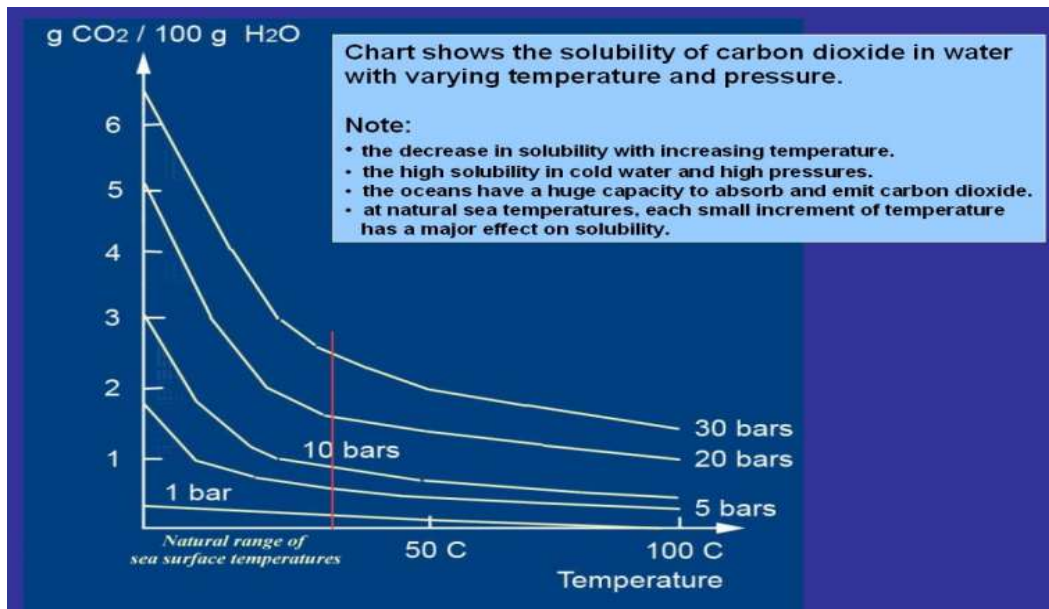
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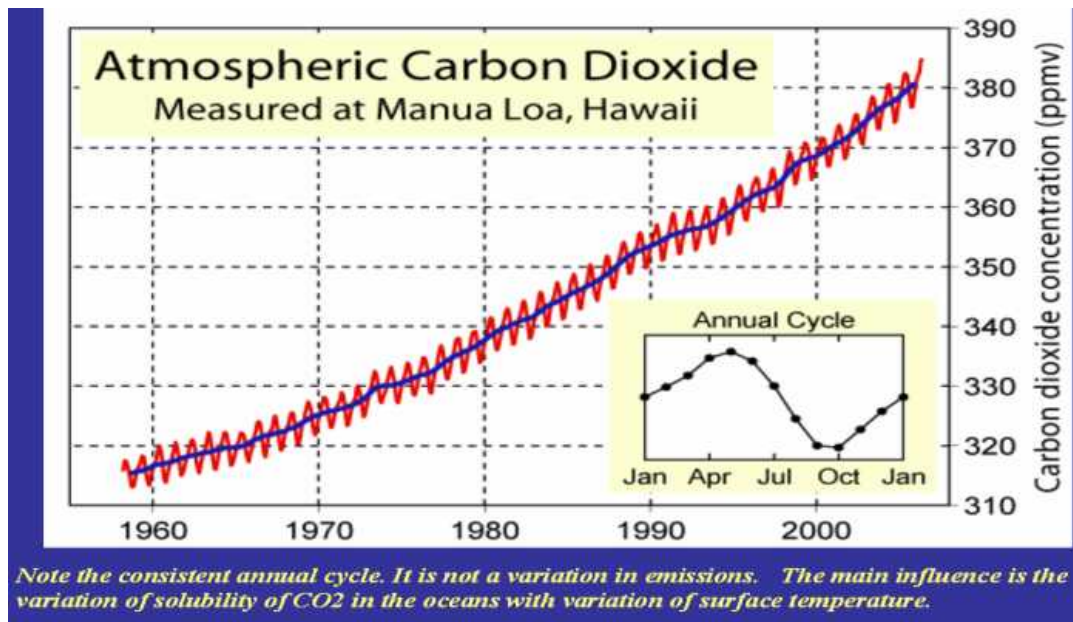
And [Frank Lanser](#), combining multiple cycles in the Vostok ice core shows this CO₂ lagging temperature relationship clearly.



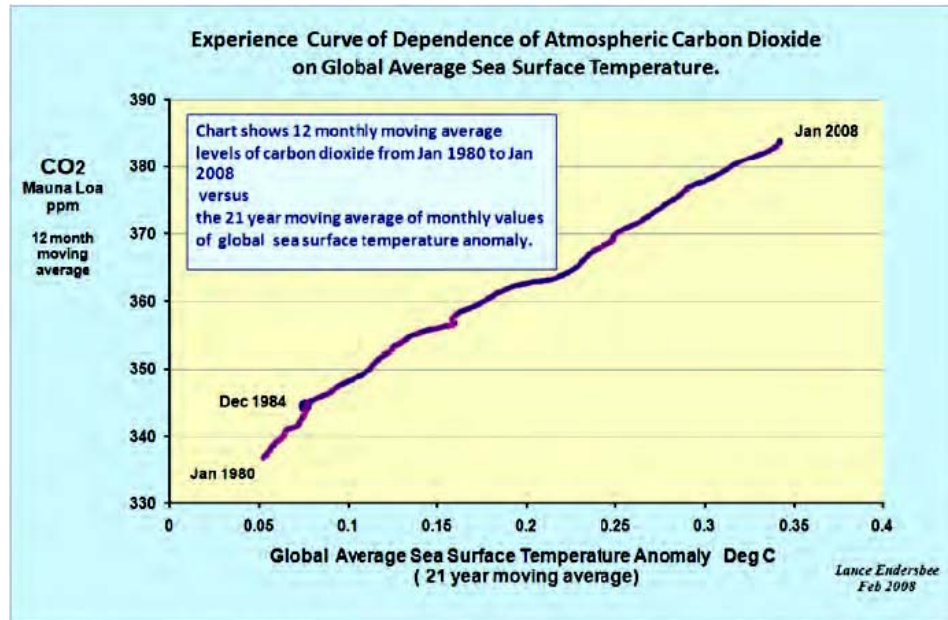
The late Lance Endersbee in this [2007 presentation](#) shows how temperature sensitive CO₂ absorption/emission is in the oceans especially under the high pressure.



He noted the annual cycle relates well to southern hemispheric ocean temperatures increasing during the southern summer and decreasing during the southern winter.

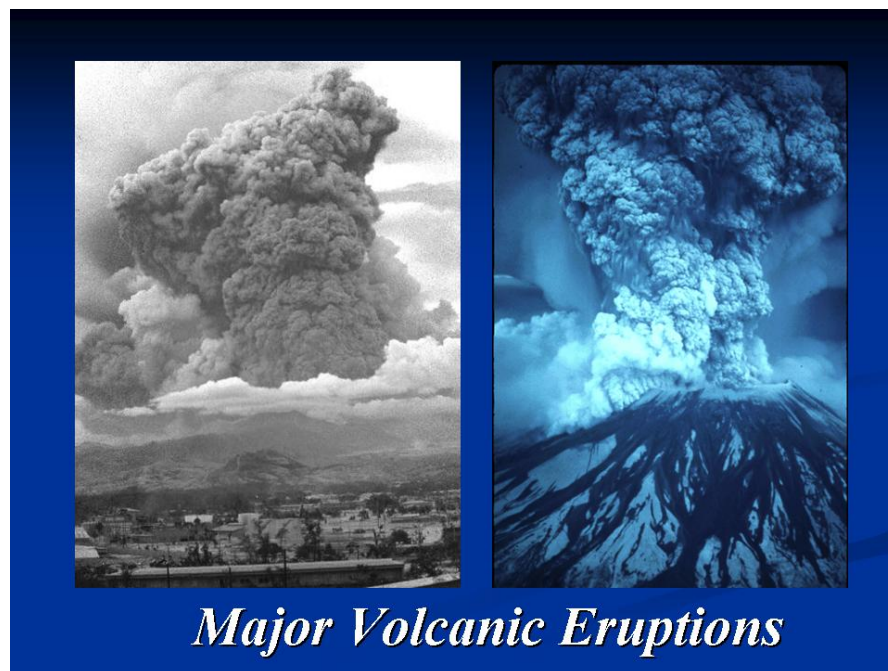


And that overall there is a very strong correlation with ocean temperatures and atmospheric CO₂.



He concluded: “The strong relation between atmospheric carbon dioxide levels and global average sea surface temperature levels is determined by the vast areas of the oceans and the solubility of CO₂ in sea water. It is a surface phenomenon. It is virtually a physical law. It cannot be changed by man.”

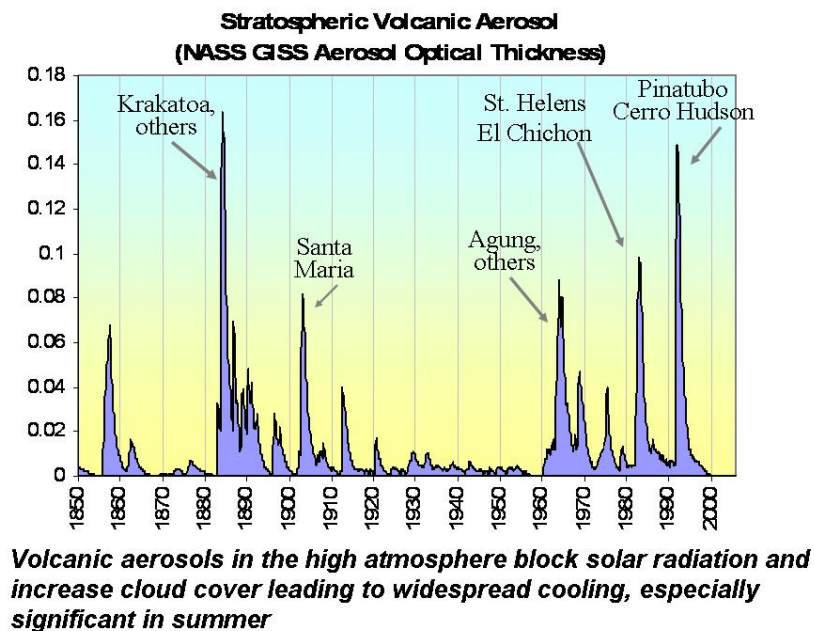
VOLCANIC ACTIVITY AND TEMPERATURES



Major volcanoes (those that reach well into the stratosphere) do have more effect on climate than CO₂ but the effects are temporary. It is not the ash but the sulfur dioxide which is quickly converted to sulfate aerosols that is responsible for reducing the

incoming solar radiation by backscattering it to space. Reductions of 7% were observed after Agung in the 1960s. For this reason, major eruptions of volcanoes cause global cooling. This is well established and non-controversial. The cooling is greatest in summer with a mixed picture in winter depending on whether the volcanoes are low or high latitudes. Tropical volcanoes lead to a stronger polar vortex and positive arctic oscillation in winter which mean less cold in Western Europe and eastern United States. High latitude volcanoes have a tendency for a negative arctic oscillation and colder temperature into mid-latitudes winter and summer (Oman and Robock 2006).

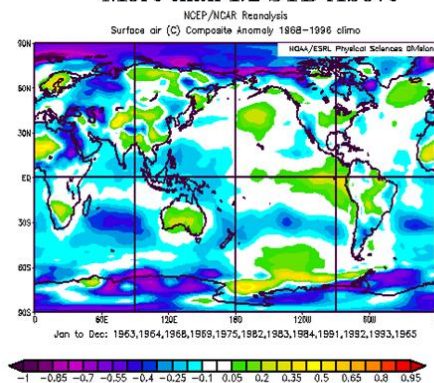
NASA (Sato) has compiled an historical data base of the stratospheric aerosol content. Note the tendency for clustering of major eruptions and also quiet periods. Note especially the very quiet period in the start of this decade.



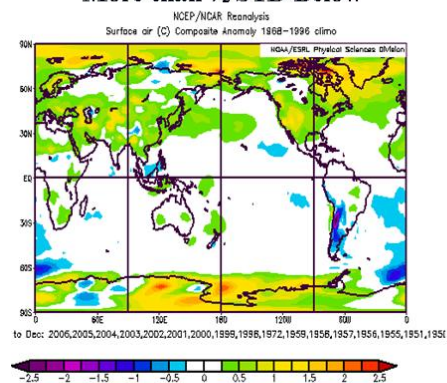
Taking her data base and compositing years with more than half standard deviation excess aerosols and years with more than one half standard deviations less than average aerosols leads to these annual temperature anomalies.

Years with more than 1/2 STD departures stratospheric aerosols

More than 1/2 STD Above



More than 1/2 STD Below



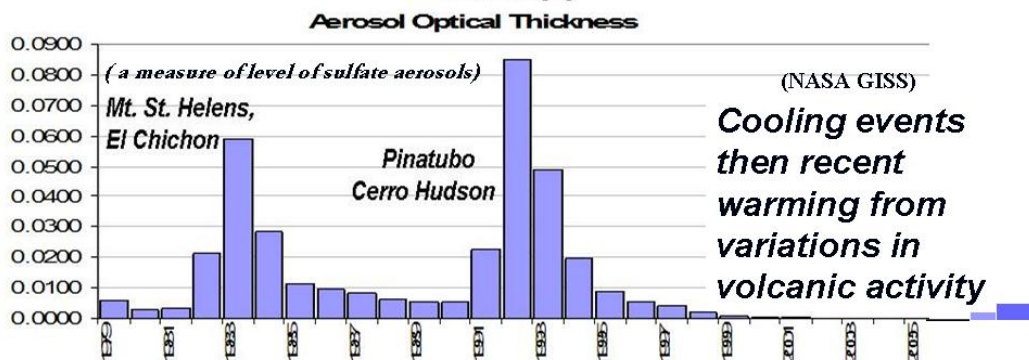
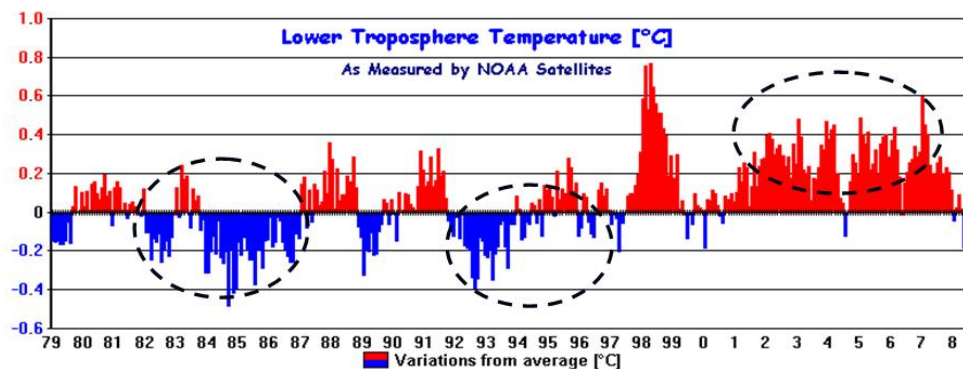
January to December Annual Temperature Anomalies

Data NASA GISS, CDC

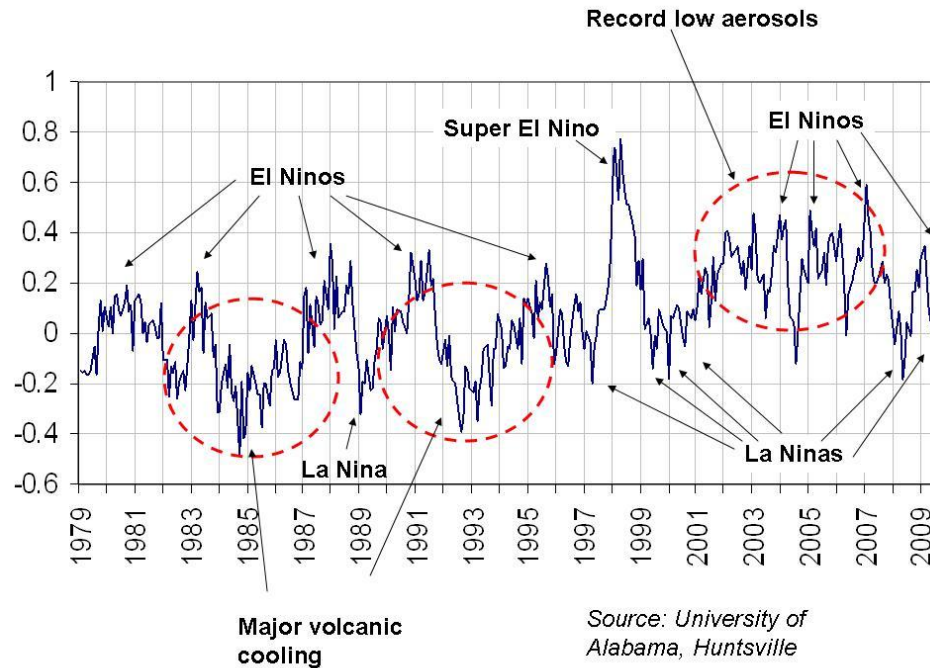
After major eruptions

During quiet periods

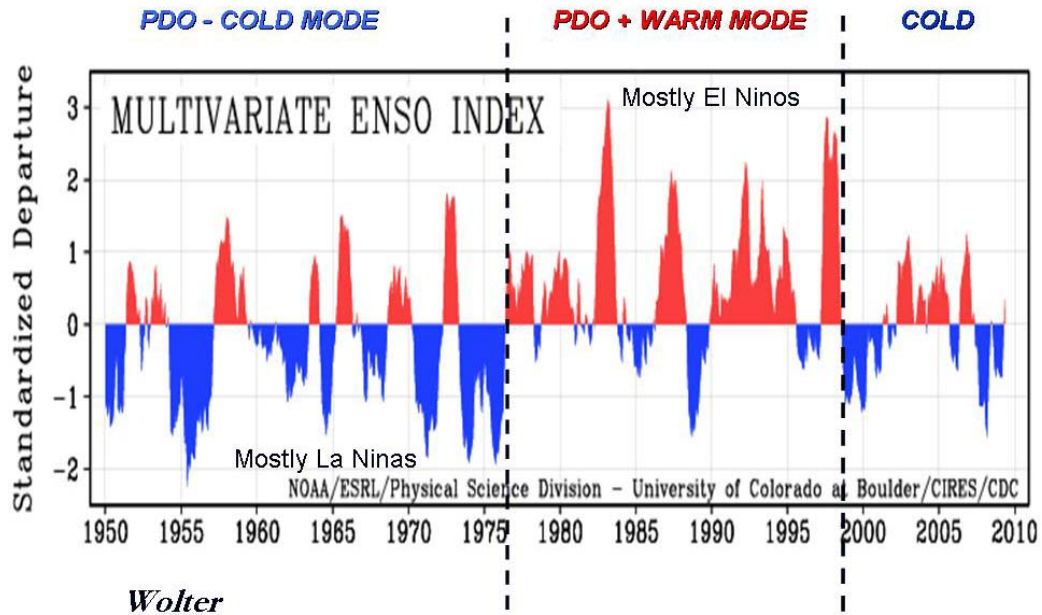
When superimposed on a graph with lower atmospheric temperatures (UAHMSU), we see the global cooling post major eruptions and warming during recent low aerosol years.



When you then combine it with El Nino and La Nina which lead to global and global warming respectively, you can explain virtually all the year to year changes since 1979.



When you consider that the PDO warm mode from 1979 to 1998 favored El Ninos 3 to 1 over La Ninas and the cold mode from 1947 to 1977 favored La Ninas over El Ninos and you explain the net trends.



PDO+AMO vs USHCN V2 Annual Temp

