2023 Sun-Climate Symposium

Solar Forced Ocean Warming and Cooling through the Common Era and its Effect on Carbon Dioxide

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Abstract

Common Era climate changed often. Cold Dark Ages between the Roman and Medieval warm eras, and the colder Little Ice Age (LIA) afterward defined pre-industrial climate before modern warming. Volcanic aerosols were credited with climate cooling along with the Maunder Minimum, the 17th century low solar activity. LIA recovery has been attributed to atmospheric carbon dioxide increases via man-made emissions. New methods using historical reconstructions and CO_2 data challenge this view. The exact measured temperature change in the 30-year average global HadSST3 representing climate change, of 0.47°C from 1890-2010 was calculated by comparing the estimated average total solar irradiance (TSI) of consecutive 109-year periods of sunspot averages using the Hansen Planetary Temperature Equation - a modified Stefan-Boltzmann Equation incorporating albedo, and a simple sunspot-TSI model convolved with the v2 sunspot number (SN), indicating greenhouse gas forcing was inconsequential. The method was used with sunspot reconstructions then compared to millennial ocean and Law Dome and Mauna Loa CO_2 evolution. The Roman Warm Era enjoyed 440 years with the 110-year average SN above the 95 sunspot decadal ocean warming threshold, ending with the Dark Ages from 180 years below this threshold, then the Medieval Warm Era above the threshold for 230 years, followed by the LIA, 650 years below the threshold with a 1495 minimum. Climate rebounded from the increasing return to higher solar activity into the 1700's to the early 1800's solar Dalton Minimum cooling, a century later followed by the Modern Maximum sun-warming period. Law Dome CO_2 reached a minimum in 1611 at the depths of the LIA. By 1934, a year before the Modern Maximum, CO_2 sinks and sources equaled, then sun-ocean warming above the threshold warmed the ocean, changing its solubility to outgas more CO_2 than it sank, making emissions also naturally accumulate in the atmosphere.

Introduction

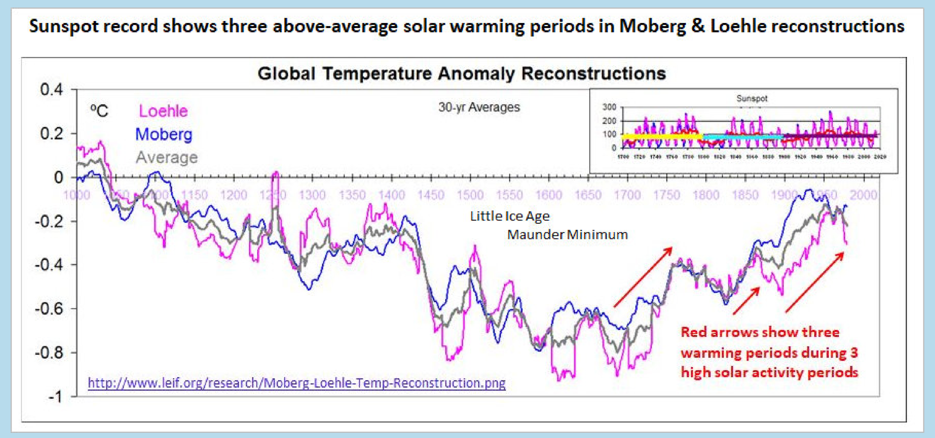
The Climate.gov website made two common claims re: CO_2.

1. "Each year, human activities release more carbon dioxide into the atmosphere than natural processes can remove, causing the amount of carbon dioxide in the atmosphere to increase."
2. "Carbon cycle experts estimate that natural "sinks"—processes that remove carbon from the atmosphere—on land and in the ocean absorbed the equivalent of about half of the carbon dioxide we emitted each year in the 2011-2020 decade."

Those claims and the assumption that there was a carbon dioxide equilibrium in the mid-1800s ended by human activities are examined using temperature and CO_2 reconstructions, and sunspot activity is compared to both.

Moberg etal (Nature 2005), and Loehle (E&E 2007), and later Marcott etal (Science 2013), then McGregor etal (Nature GeoScience 2015) observed a cooling trend from 1 to 1800 CE and ocean cooling from 801 to 1800 CE from various proxies.

Figure 1. Moberg & Loehle Reconstructions & Sunspots



Prohaska etal (Nature 2023) found an abrupt change in the Pacific tropical mean-state climate near the Phillipines around 1630 to 1900 CE lead to increasingly El Niño conditions.

Carbon dioxide and ocean outgassing are examined with the man-made emissions history to determine the full extent and relative contribution of both to the recent measured Mauna Loa atmospheric CO_2 levels, and the role solar forcing has had on both temperatures and CO_2. The 9kYr Multi-Messenger sunspot reconstruction is used to compare timing/level of forcing changes relative to ocean climate and Law Dome CO_2.

Discussion

Typical sun-climate calculations result in ~0.1°C forcing over a solar cycle, which results from assuming the important aspect is exclusively the instantaneous atmospheric radiative forcing.

Here the warming effect of TSI on the ocean is calculated using the 109-year average sunspot number by comparing the influence on the 30-year SST over two consecutive 109-year periods. The 109-year average period was determined first using cross-correlation analysis, as Fig.2 indicates a robust statistical relationship between the two at r=.95 and R2=0.91.

The exact measured 30-year HadSST3 average temperature was computed using the Hansen Equation, ie, a modified Stefan-Boltzmann equation that includes albedo, and the PMOD TSI-SN least-squares error polynomial model. This physical result confirms the robust statistical relationship.

Figure 2. Hansen Planetary Temperature Equation, SST & SN

Stefan-Boltzmann Equation Confirms Total Solar Climate Forcing

The *exact temperature rise* of 0.47°C of the 30-year average HadSST3, for 1890-2010 representing the climate, between **A** & **B** in the second panel, was calculated using v2 SN and my v2 SN-PMOD TSI empirical model, $TSI = -2(10^{-5})SN^2 + .0091SN + 1360.4$, and the Stefan-Boltzmann equation.

For the 109 year average ending in 1999 (2010 minus the 11 year lag), the sun emitted **9.2W** more than the 109 years average ending in 1890. Adding in the 11 years during the lag ending in 2010 for a full 120 years of sunspot activity, the sun emitted 10.2 W/m² more TSI than pre -1891.

$$T = \sqrt[4]{\frac{S(1-A)}{4\varepsilon\sigma}}$$

ε	0.98
σ	5.67E-08
A	0.3
S= TSI	

Period	109ya SN	TSI, W/m²	T, K
1999	88.7	1361.0498	255.8695
1890	74.3	1360.9657	255.8656
	difference	*0.084*	*3.95E-03*
# years	109	9.2 W	+0.43 °C
+11y lag	109ya SN	TSI, W/m²	T, K
2010	88.9	1361.0509	255.8695
1890	74.3	1360.9657	255.8656
	difference	*0.085*	*3.95E-03*
# years	120	10.2 W	+0.47 °C

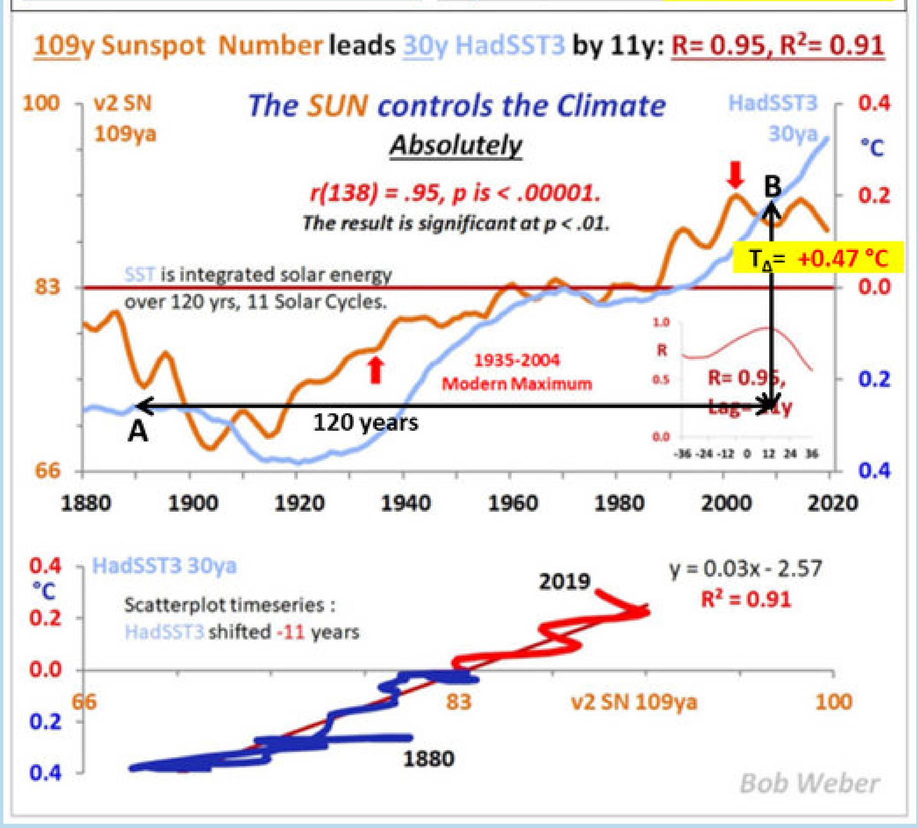
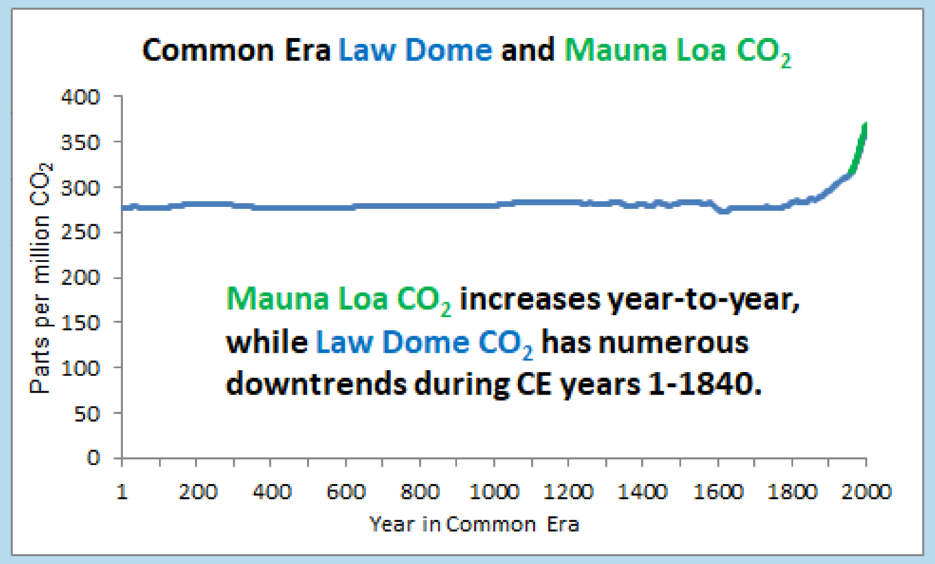


Figure 2 established that solar activity caused global warming, and the GHG *carbon dioxide was not involved*.

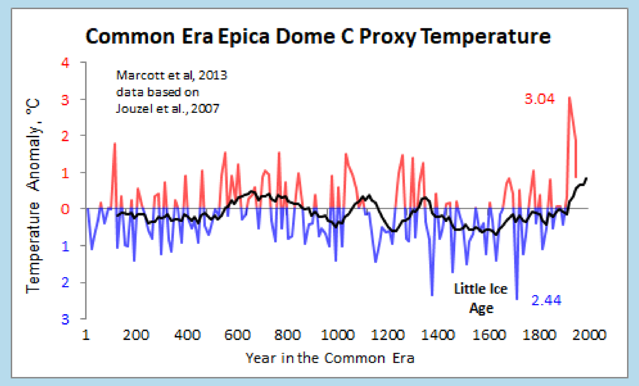
Figure 3. Law Dome CO_2 had downturns Mauna Loa CO_2 didn't



The assumption of an long-term equilibrium CO_2 state in the mid-1800s appears solid at first glance, but a deeper look into the otherwise very flat Common Era Law Dome CO_2 yields new insights into actual CO_2 outgassing dynamics that are generally neglected or unknown within climate science today.

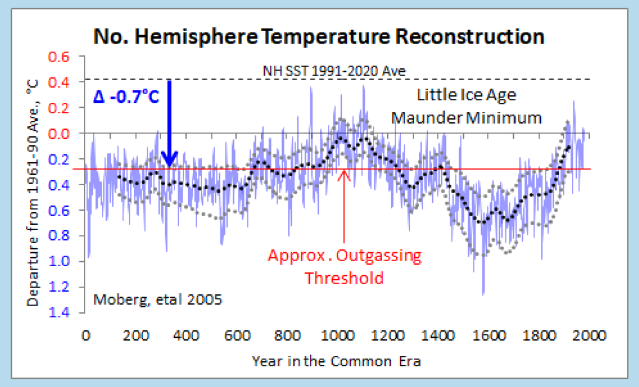
For instance the Law Dome CO_2 had 192 years of negative net annual CO_2, 1180 years of zero net CO_2 change versus 274 yrs of positive net change, for 83% of years without a positive net annual CO_2. **All** Mauna Loa CO_2 annual net fluxes ***are positive***.

Figure 4. Little Ice Age is low spot in Common Era Temperature



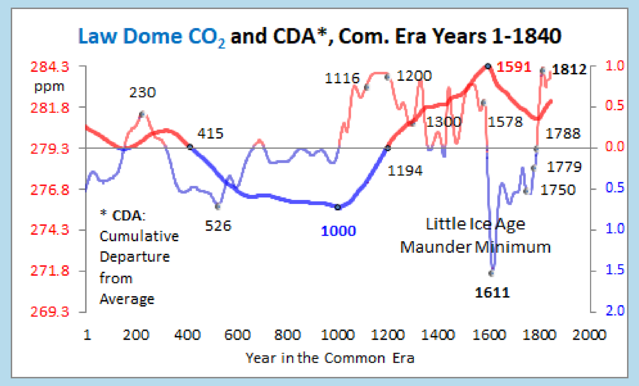
The Antarctica Epica Dome C temperature reconstruction from Jouzel etal (2007) indicates a temperature drop into the 1600s, then increasing after the 1800s. The Epica Dome C is about 1000 km inland from Law Dome, Antarctica. Jouzel 2007 Epica Dome C temperature variation is similar to the temperature changes in the Moberg etal (2005).

Figure 5. Moberg N. Hemisphere Temperature Reconstruction



Common Era NH temperatures in Moberg etal have similar evolution to the latter reconstructions, including the amount of scale variation (scale smaller than the other plots), with 600 years of decline from the year 1000 to around the year 1600, the depths of the Little Ice Age.

Figure 6. Law Dome CO_2 varies with CE Temperature Evolution

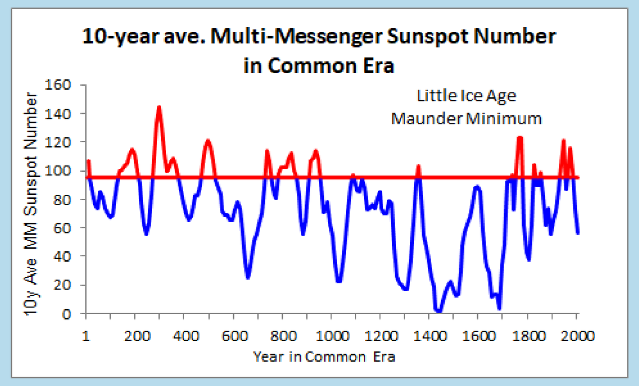


Correspondence between the NH reconstructions and Law Dome CO_2 suggests a highly dependent relationship. The entire range from CE years 1-1840 of 15 ppm for the net annual Law Dome CO_2 is within the same range as Mauna Loa CO_2 annual rising and falling phases shown in Figure 10.

CE CO_2 positive-going excursions during the Roman Warm Period, the Medieval Warm Period and the 1800s were offset by negative-going periods during the Dark Ages, the Little Ice Age, and the Maunder Minimum.

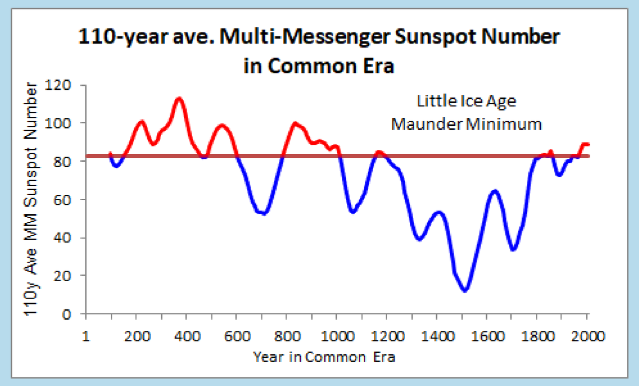
The approximately 12 ppm change from the year 1200 to the low annual net flux in 1611 and then the return back up to large positive net flows by the year 1800 are unheard of in the modern instrumental era. Two explanations are either less CO_2 was produced by the climate during the downturns or suddenly large CO_2 sinks appeared for hundreds of years then disappeared again, which then quickly reversed roles to cause the large positive-going Law Dome CO_2 periods, or both.

Figure 7. Multi-Messenger Sunspots are Low in Common Era



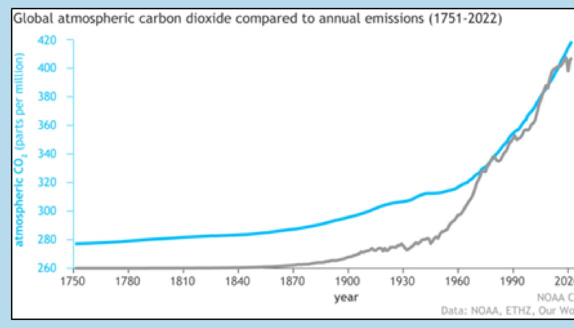
The Wu etal (A&A 2018) multi-proxy reconstruction of solar activity and Svalgaard (2019) Multi-Messenger Sunspot Number from the previous 9400 years was plotted for the Common Era, when most of the time during the CE, the 10-year SN average was below the decadal warming threshold.

Figure 8. Moberg & Loehle Reconstructions & Sunspots



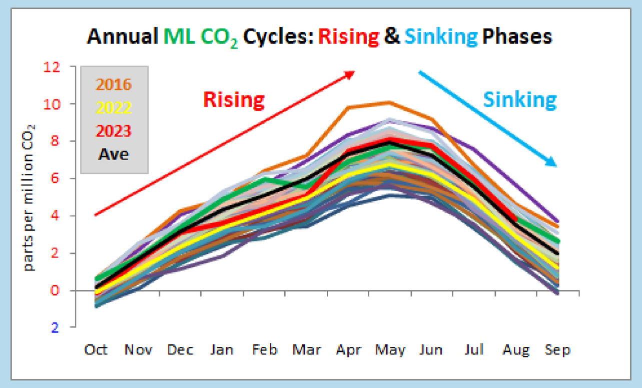
Utilizing the 109y average (Figure 2) rounded to a 110 year average of the M-M sunspot reconstruction, the Little Ice Age stands out as the most severely negative impact on the climate of the long-term duration of low solar activity.

Figure 9. Climate.gov inadvertant CO_2 misinformation



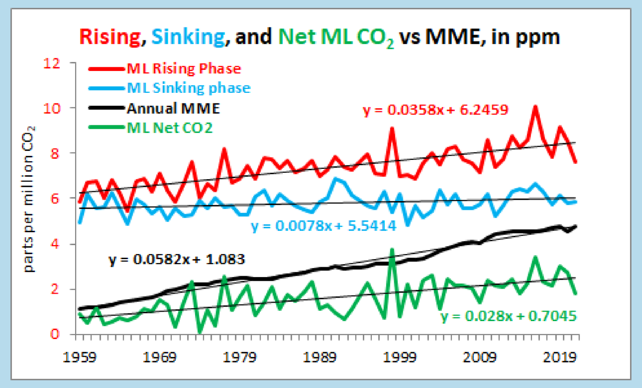
The misleading US government image (Figure 9) misrepresents the reality. From Figure 12, when converted into gigatons and on the same scale, the relationship between man-made emissions and measured Law Dome and Mauna Loa CO_2 is put into perspective: MME is ***quite small***.

Figure 10. Deconstruction of Mauna Loa into two phases



The annual rising & sinking phases of Mauna Loa CO_2 are determined by finding the net CO_2 changes from the previous year December values, for each year.

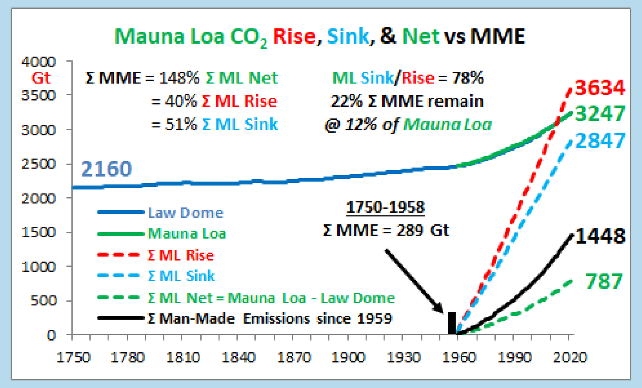
Figure 11. Annual relative contributions of ML phases & MME



A timeseries was made for both deconstructed ML CO_2 phases as seen in Figure 11.

MME appear to be greater than the net annual ML flux, however this view doesn't take into account that the Mauna Loa sinking phase is proportionately 78% of the rising phase (Fig. 12). If 78% of well-mixed MME are also sunk, then the net annual MME must be about 22% of the Figure 11 values, a much smaller portion of the net annual Mauna Loa fluxes.

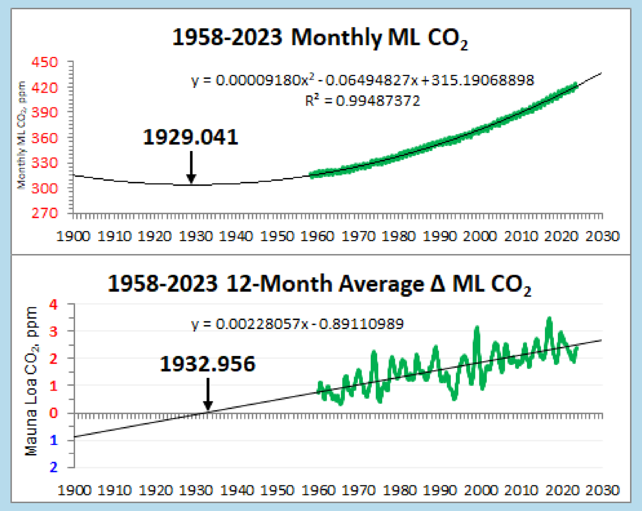
Figure 12. Sums of ML Rising/Sinking Phases vs Sum of MME



The fact is that now only 12% of atmospheric CO_2 at Mauna Loa is from MME (2021).

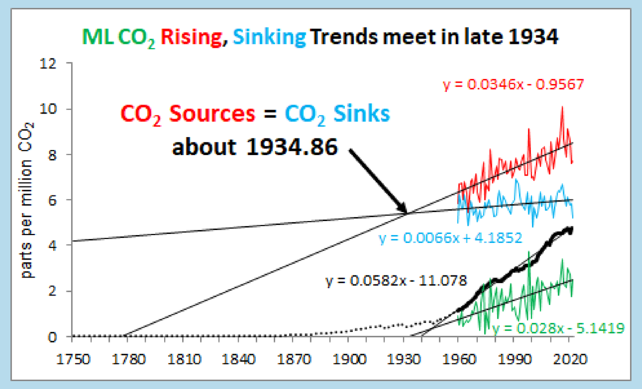
Most all MME CO_2 has already sunk into the climate. Sunk CO_2 in blue is shown as positive, and is subtracted from the rising phase.

Figure 13. Mauna Loa trends indicate possible zero net fluxes



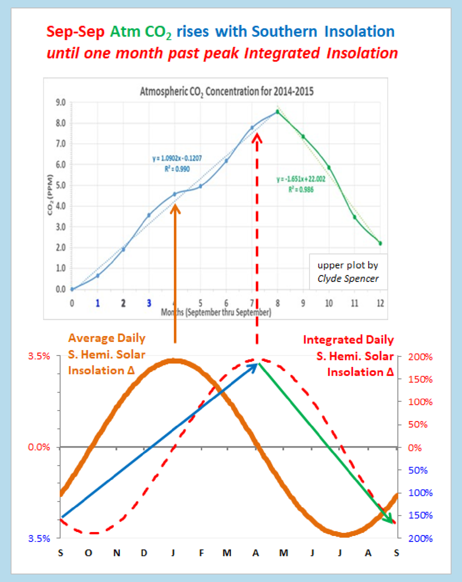
Ernst Beck's CO_2 reconstruction from chemical methods has a large 1940s spike (not shown here). If that did not happen, then it would have been likely the ML CO_2 rising phase did equal the sinking phase with zero net flux in the early 1930s, just before the 70-year long Solar Modern Maximum of 1935-2004 that warmed up the ocean.

Figure 14. Mauna Loa CO_2 phase trends converge in late 1934



Deconstructed ML CO_2 phases also indicate a time of possible zero net CO_2 flux just before the 1935 start of the Solar Modern Maximum. Sinks are again shown as positive numbers, subtracted from the rising flux phase.

Figure 15. Annual CO_2 cycle is driven by Sun's Insolation Cycle

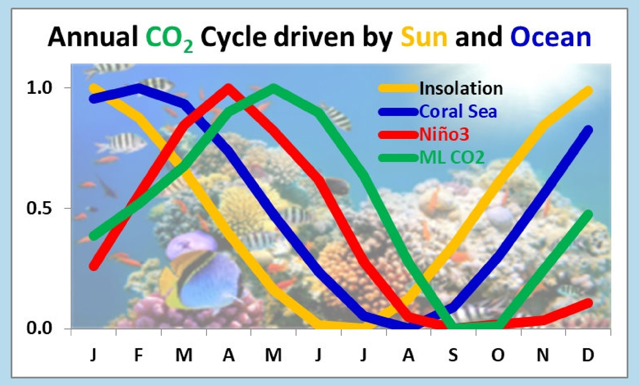


The SH summer insolation peak appears in the annual ML CO_2 cycle evolution, as a lagged effect of the sun's daily integrated SH insolation.

Seasonal warming/cooling of the tropical ocean, where corals live, is the mechanism that drives CO_2 solubility.

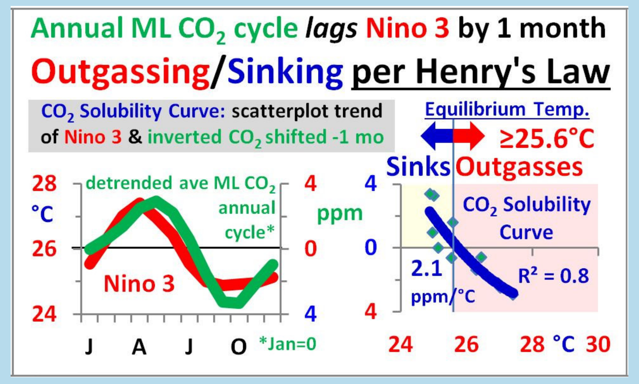
Seasonal NH CO_2 sinking (ie uptake) every year is parallel to ocean CO_2 contributions.

Figure 16. Annual CO_2 cycle tropical temperature dependence



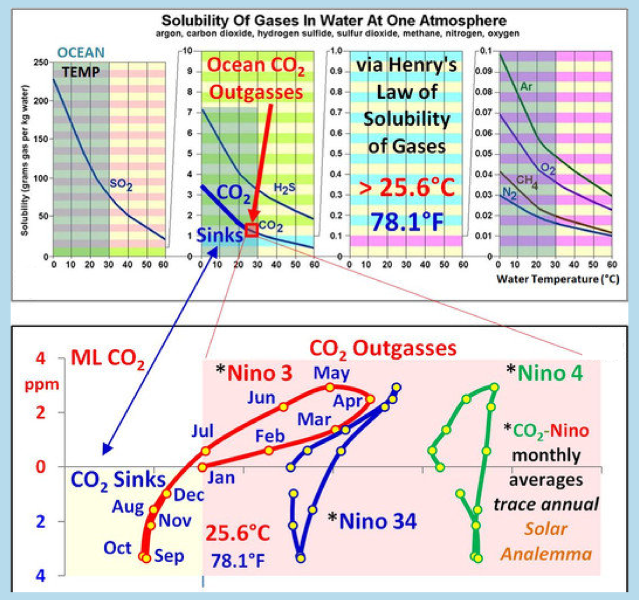
The sun's lagged warming effect on the southern ocean via solar insolation drives the clockwork outgassing and sinking of CO_2.

Figure 17. CO_2 Outgassing/Sinking Equilibrium set by Niño3



Like clockwork, the ocean's CO_2 solubility is totally governed by the central Pacific equatorial ocean heat content and it's effect on the Niño3 surface T.

Figure 18. CO_2 Solubility, Temperature & Effect on Niño regions



The 25.6°C CO_2 solubility curve threshold, Fig. 17, responds to the different Niño regions evolving annually due to the sun's annual insolation cycle. Solar analemmas are mapped out by the different CO_2 Niño regions and temperature.

Figure 19. So. Ocean Temp. is below CO_2 Solubility Threshold

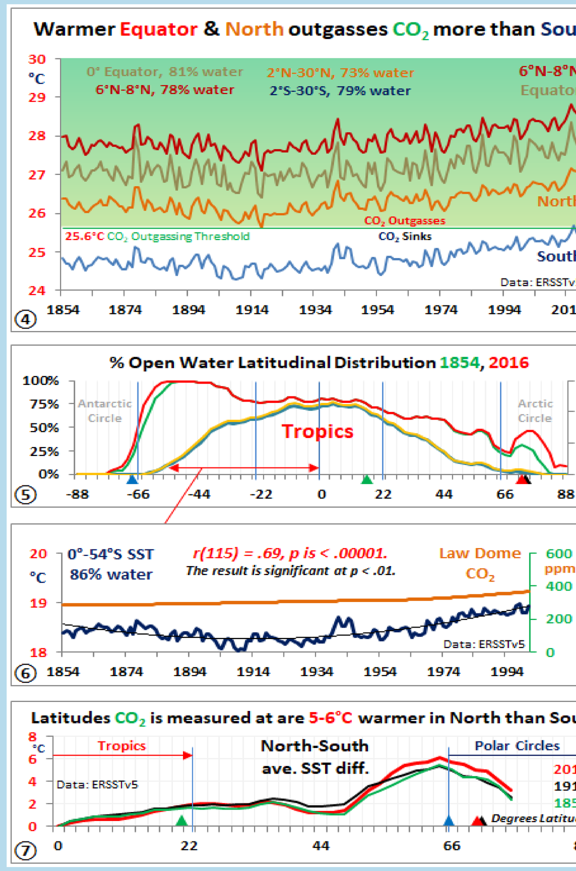


Fig. 19 panels 4-7 indicate the SH ocean has been too cold for net CO_2 outgassing since the 1850s.

Conclusion

It is clear NOAA overestimated the man-made emissions role in atmospheric CO_2 by a factor of 7. It is likely more of the ocean was too cold for net CO_2 outgassing in long periods during the CE, particularly through the Little Ice Age when the long-term solar activity was responsible for ocean cooling below the CO_2 threshold.

Clearly, modern CO_2 is largely due to outgassing, not MME.

Data Acknowledgements:
SIDC, NOAA, NASA, ESRL, WSO, UW, BOM, MET, PSL, SWPC, LASP, PMOD, KNMI

The Sun drives warming, cooling, extreme events, and CO_2.

Author conducted & funded research presented Oct'23 in Flagstaff, AZ

Climate change is fundamentally reducible to sunshine, not CO_2.

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