



Central Coast Climate Science Education  
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## Why Do Climate Deniers Deny? Last edit: February 21, 2019

*This essay is an extended version of a column published in the February 22<sup>nd</sup> edition of The Atascadero News. It is in response to a February 1<sup>st</sup> column in that paper written by Mr. Al Fonzi. See **Appendix 1** for that column.*

I've given many talks on climate science and responded to innumerable denials of the reality of human-caused climate change. Examining the reasons underlying these denials, one thing is clear: It's never objective examination of the science.

Then what is it? Occasionally it's based on fundamentalist religious grounds: Some argue that it is foreordained, quoting a Biblical passage like that in 2 Peter 3:10 that the "elements shall be melted with heat, and the earth, ... shall be burnt up." More frequently, I hear that "it will be too costly to deal with." Or, "I like my life style and won't change it one bit."

But by far the most frequent is purely ideological: A typical example was the overwrought column in the February 1<sup>st</sup> Atascadero News with the title "A pretense to save the planet." There we read that the real agenda by "Progressive/Democrats" in combating climate change is the "redistribution of wealth and the elimination of free-market capitalism, to be replaced by a command economy."

(A command economy is "a system where the government, rather than the free market, determines what goods should be produced, how much should be produced and the price at which the goods are offered for sale".

( <https://www.investopedia.com/terms/c/command-economy.asp>)

Actually, the urgent concern about human-induced climate change arises not from a political agenda, but from an intellectual discipline called *science*. In that February 1<sup>st</sup> column the evidence from science is ignored, aside from a brief

reference to hurricanes and to “thousands of scientists who strongly object to misuse of their work.” (What work? Published in what professional journals?)

This is typical of deniers with this mind set. I predict no denier will read this post, or if they do, will rummage through denier websites to produce factoids that are incorrect or totally misleading. In **Appendix 2** I provide an example from a previous column by the same February 1<sup>st</sup> author.

A real climate scientist I correspond with has 42 peer-reviewed publications in professional journals between 2015 and January 2019. Which “scientist” does the February 1<sup>st</sup> column rely on? Joe Bastardi, whose comparable publication record is--zero. Here is one of the more remarkable statements by Mr. Bastardi:

*"CO2 cannot cause global warming. I'll tell you why. It doesn't mix well with the atmosphere, for one. For two, its specific gravity is 1 1/2 times that of the rest of the atmosphere. It heats and cools much quicker. Its radiative processes are much different. So it cannot -- it literally cannot cause global warming."*

The scientist referenced above commented: "Utter rubbish. Sorry to be so direct, but that is just the case." Indeed, it is; my 11-year old granddaughter knows better. I deconstruct Mr. Bastardi’s nonsense and explain the basic physics involved in **Appendix 3**.

The February 1<sup>st</sup> column notes that there is as yet no firm evidence that hurricanes are increasing in intensity and implies from this that there is no reason to take seriously the concerns of climate scientists about the need to reduce greenhouse gas emissions. The formation and intensity of hurricanes depend on complex competing processes which vary, as do the quality of observations, from ocean to ocean and from year to year, making detection of a ‘signal’ thus far difficult. Here is email from a hurricane expert.

*“There has certainly been an increase in Atlantic hurricane activity since the early 1980s, but many of us believe that may be due to diminishing anthropogenic aerosols [i.e. human produced particulates] rather than increasing greenhouse gases. But the theory and modeling of hurricanes points robustly towards an increase in the incidence of high intensity storms and in hurricane rainfall. With current observational technology, we expect that signal to become robust in the data within the next few decades. The signals we see already are consistent with*

*our expectation, but do not rise to the 95% confidence criteria.”* (I discuss the concept of “confidence levels” in **Appendix 4**.)

Here is a link to another recent summary of research on the complicated subject of future hurricane development: <https://www.gfdl.noaa.gov/global-warming-and-hurricanes/> . There, attention is called to new research pointing to increasingly rapid hurricane intensification. This can lead to insufficient warning for evacuation or other preparations as we saw for Hurricane Michael, with devastating results.

In a phone call with one of the scientists involved in this update, it was pointed out that the observational record as well as modeling make it difficult to accurately determine the role of natural yearly or multi-year variability of hurricane properties and that makes establishing trends more challenging.

Other measures of climate change, however, *are very robust*: **The annual loss of ice from Antarctica is now 6 times greater than in 1980-1990.**

<https://news.uci.edu/2019/01/14/uci-jpl-study-antarctica-losing-six-times-more-ice-mass-annually-now-than-40-years-ago/>

**Sea level isn't just rising, but rising at an accelerating rate.**

<https://climate.nasa.gov/news/2680/new-study-finds-sea-level-rise-accelerating/>

Fueled by ice loss from Greenland and Antarctica it is projected to rise about 3 feet by 2100 even in an ‘intermediate’ scenario, and there are increasing concerns about stability of the ice sheets of Greenland and Antarctica, so that a rise of 6 feet is not out of the question. (I will discuss projections of regional and global sea level rise in a forthcoming post.)

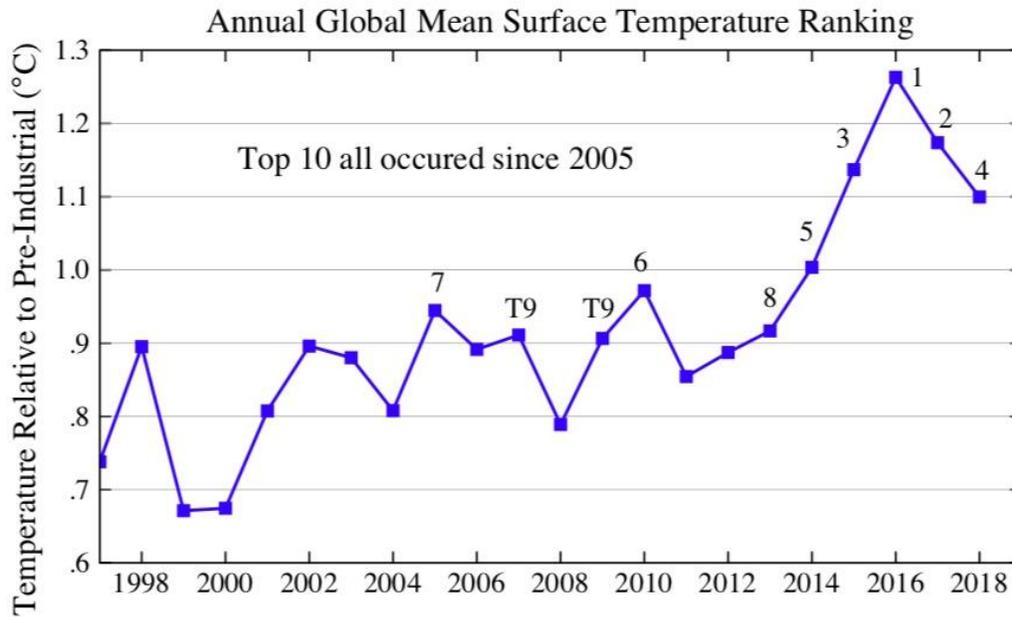
**The ocean is heating up at an accelerating pace**, setting a new temperature record in 2018, and threatening much marine life.

<https://link.springer.com/content/pdf/10.1007%2Fs00376-019-8276-x.pdf>

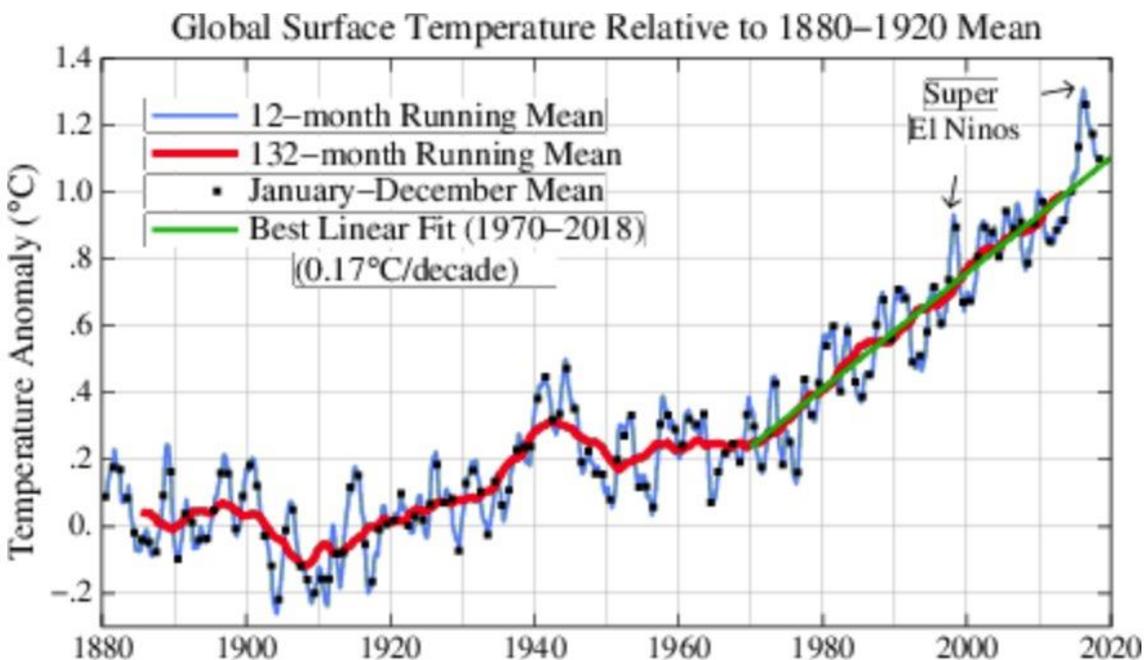
This is not simply a surface phenomenon but the **total heat deposited throughout the depths of the ocean is accelerating**:

<http://science.sciencemag.org/content/363/6423/128/tab-pdf>

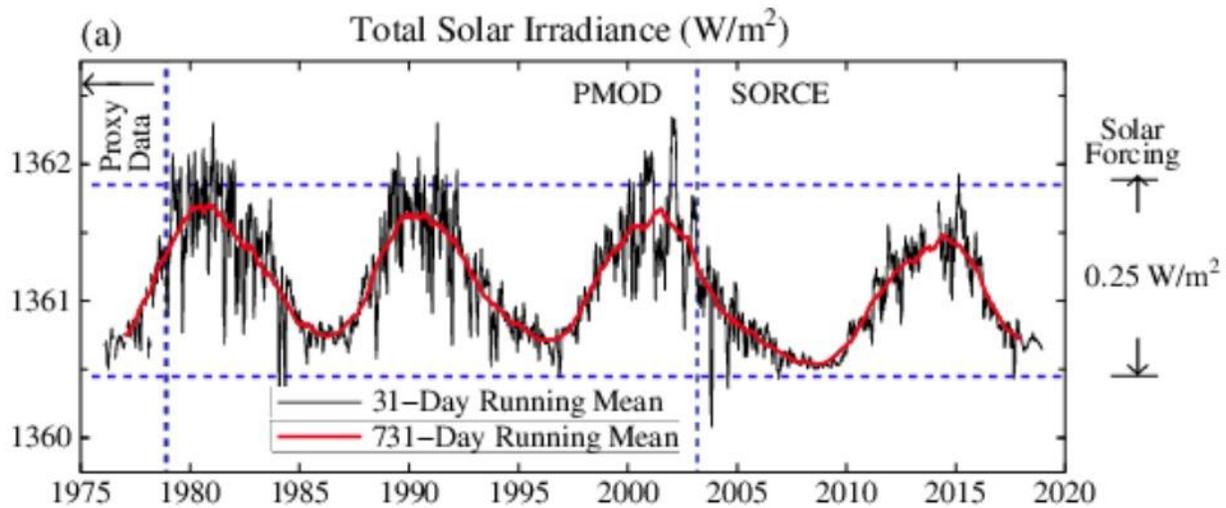
In 140 years of instrumental **surface temperatures, the hottest 5 all occurred since 2014 and the top 10 since 2005.**



Except for the up and down excursions associated with the El Nino/La Nina oscillations, the dramatic steady upward trend of surface temperatures since around 1970 is obvious:



And, in case you think this dramatic rise since 1970 is “just the sun” as many deniers are fond of saying: No, it is not:



You can see the 11-year cyclic sunspot cycle, *but averaged over these cycles the sun as decreased slightly in brightness.*

***In summary, these pieces of evidence, and many others, point with certainty “beyond a reasonable doubt” to a strong warming trend that has no viable scientific explanation except the increase in greenhouse gases caused by fossil fuel combustion.***

Returning to the February 1<sup>st</sup> column, the author suggests that fossil fuels are “moral,” citing the correlation of fossil fuel use with standard of living. But correlation isn’t causation, as we know. In Jared Diamond’s book “Guns, Germs and Steel” he describes the circumstances leading to the western world’s dominance in technology. With that technology came the extraction and use of energy in the form of fossil fuels and increased living standards. But abundant energy *per se* is the key—whether it is energy is derived from coal, solar, wind or nuclear. But their impacts are not equal. There is nothing ‘moral’ about mercury poisoning, ruined streams, foul air, and black lung disease from coal, or from catastrophic oil spills, not to mention the unmistakable impact on the climate, as detailed above.

Do we need lubricants and other products derived from hydrocarbons.? Yes, and there is active research on lubricants derived from renewable sources. See <https://www.sciencedaily.com/releases/2019/02/190207123223.htm> More generally, for renewable sources for hydrocarbon fuels, including jet aircraft, see:

[https://afdc.energy.gov/fuels/emerging\\_hydrocarbon.html](https://afdc.energy.gov/fuels/emerging_hydrocarbon.html)

Is making the transition to clean energy a "job-killer" as is often claimed? In 2017 solar energy employed more people in electrical power generation than coal, gas and oil combined. In many locations solar and wind out-compete coal and compete with natural in cost. The following plot shows just how dramatically the cost of solar panels has dropped, and wind power costs are sharply dropping as well.

## Economics: Global price of solar modules and experience curve

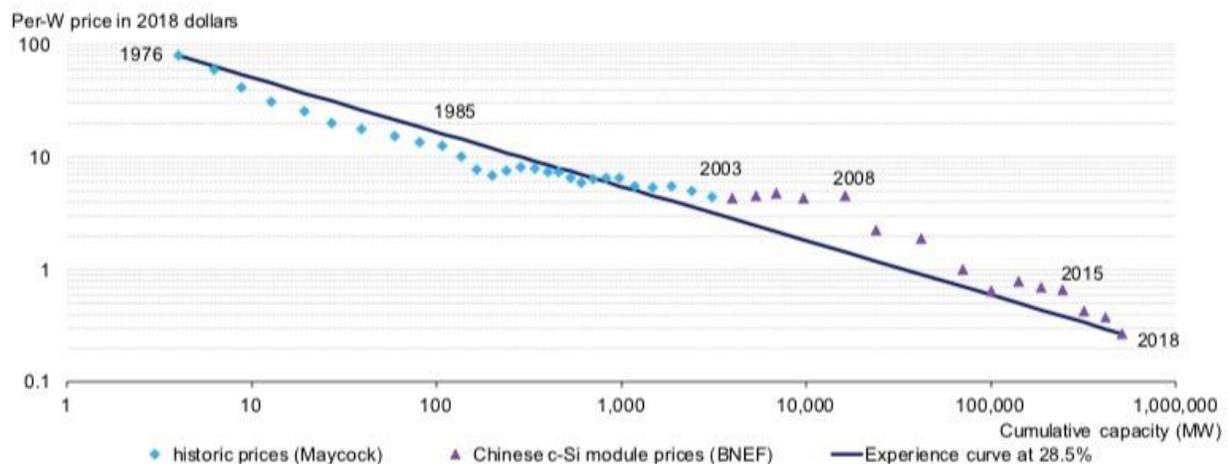


Figure taken from [2019-Sustainable-Energy-in-America-Factbook.pdf](#)

Do we need to invest in better batteries for vehicles, improved electrical storage technology and modernized electrical grids? Absolutely.

Should there be financial incentives for making this energy transition? A group including distinguished Republicans Henry Paulson, George Shultz and James Baker have proposed a carbon tax for such incentives. Recently, so did 45 leading economists from across the political spectrum, including 27 Nobel Prize winners, 4 former chairs of the Federal Reserve, and 15 former economic advisers to Presidents of both parties. (And their proposal was published in *The Wall Street Journal*!) See **Appendix 5** for their statement and the names of these 45. Are all these distinguished individuals really closeted members of a fevered group of socialists bent on destroying capitalism and imposing a command economy!

If either ignorance of the observational evidence or of the basic laws of physics

bearing on the urgent need to reduce greenhouse gas emissions were simply due to lack of intellect, it might be excused. But that isn't the case. The columnist in question is intelligent, but obsessed with the notion that dealing with climate change will inevitably lead to a socialist society. Ignoring the reality of the science and portraying concern about climate change as a cover for a socialist agenda isn't just wrong, it is deeply irresponsible.

**Appendix 1:** Text of Mr. Fonzi's Column

February 1<sup>st</sup>, Atascadero News

(This text is taken from the following link):

<https://pasoroblespress.com/article/commentary-a-pretense-to-save-the-planet>

*A PRETENSE TO SAVE THE PLANET*

*“The urge to save humanity is almost always only a false face for the urge to rule it.” — H.L. Mencken*

The above quote strips away the pretense of the Progressive/Democrats efforts to “save the planet” from the perils of climate change/global warming. Their agenda, well documented by statements from the leadership of the Intergovernmental Panel on Climate Change (IPCC) is the redistribution of wealth and the elimination of free-market capitalism, to be replaced by a command economy. For those too young to understand, the old Soviet Union and present-day Cuba were and are command economies. Under the Soviet model, the government decided what would be produced and in what quantities, models, style (any style as long as it was black and plain) and price to be sold. Cuba dictates that along with what occupations are permitted and who works in them; the result of both systems are perennial shortages and a thriving black market.

The most recent example of social upheaval produced by centralized government control of everything is Venezuela, once the most prosperous nation in South America with a vibrant middle-class. Twenty years after a “Bolivarian socialist revolution” the middle-class has been destroyed, the economy wrecked, the population starving. Tens of thousands of Venezuelans cross borders every day to find food. Children are issued a chit at 4 a.m. that entitles them to a crust of bread in the afternoon. To protect their revolution the socialist leadership imported thousands of Cuban internal security police forces to monitor their own police and military and to persecute their people. Hundreds of thousands of Venezuelans have taken to the streets to protest the socialist dictatorship's oppression, which by the way started out as advocating “democratic socialism.” The regime disarmed the populace early on and the people face heavily armed security forces with only stones. Can't happen here? The Venezuelan people voted this regime into power under many of the same slogans we're hearing from the American Progressive Left today. By the way, among the shortages inflicted upon the nation with the largest

oil reserves in the world are a complete absence of medication in public hospitals, a requirement to import refined oil, even though they were a leading exporter and toilet paper has been scarce for several years. But I digress.

Fossil fuels are moral and we need more of them, not less. We are blessed with some of the largest oil and natural gas reserves in the world but we are being propagandized into “keeping them in the ground.” As stated in Alex Epstein’s book, *The Moral Case for Fossil Fuels*, “oil is an ultra-concentrated form of energy-liquid energy- so it’s ideal for any moving vehicle. Every portable power source needs to carry its fuel with it, which means that size and weight are of paramount consideration. Oil has the ultimate strength to weight ratio. A gallon of gasoline has 31,000 calories-the amount of energy you use in fifteen days.” No alternative fuel source (except uranium) comes close to having that level of efficiency and power.

Progressive/Democrat critics will insist that fossil fuels are destroying the planet, we are facing catastrophic consequences from a warming planet and climate change and have limited time left to radically alter our use of energy to non-carbon sources, such as wind and solar. They’ve been saying this for the last 30 years or more and have been consistently wrong. They cite recent hurricanes as evidence of more severe storms, counting on the lack of historical knowledge of average Americans. The 1950’s produced record numbers of major hurricanes making landfall on the East coast and previous decades produced the most powerful and destructive hurricanes we’ve ever recorded. Dollar damage is greater now as we’ve built in extremely vulnerable areas on the coasts, areas undeveloped in decades past so the dollar losses are naturally greater.

Underlying the Progressive agenda is a disdain for ordinary people. When critics of their statist policies point out that people are also part of the environment their rejoinder is that we are not; the true believer thinks of humanity as a “cancer on the planet” that must be eliminated to recreate their version of a naturalist Garden of Eden, sans humans. They let this philosophy slip in their writings and when they think nobody is listening at their conferences.

Quoting Epstein again, he points out a “strong correlation between life-expectancy, fossil fuel use and average income. Money provides resources and time and opportunity to pursue...happiness. It’s hard to be happy when you don’t know where your next meal is coming from.”

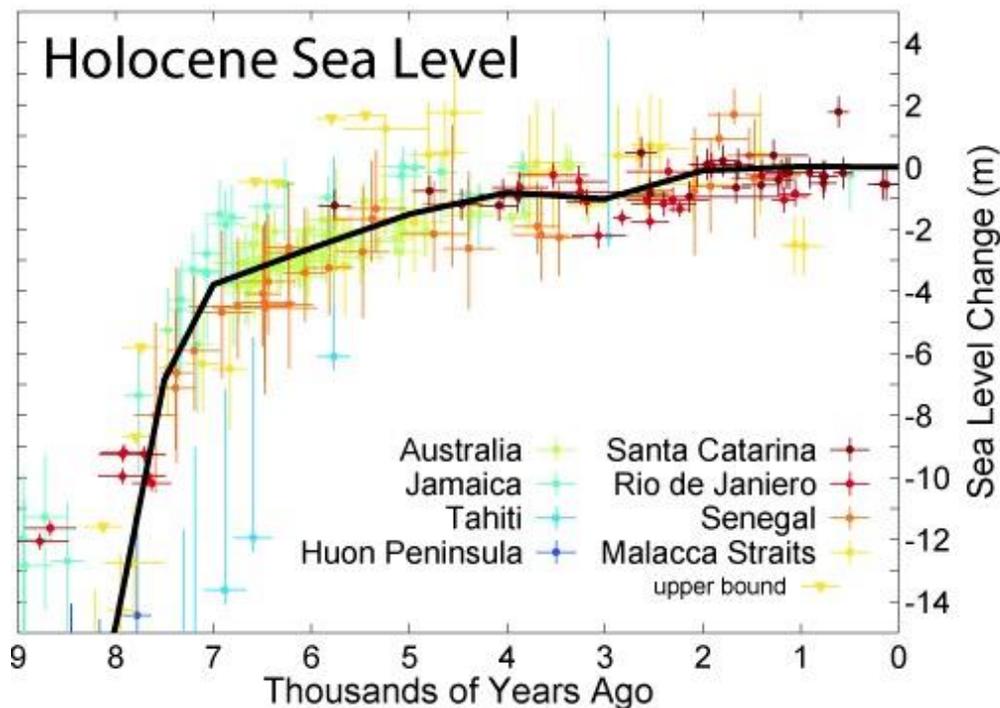
Our neighbors south of the Grade (City of SLO) have adopted a “keep it in the ground” resolution so I must ask if this isn’t just more “virtue signaling” by the Left? Have they ordered the revocation of all business licenses for gas stations, refuse to wear clothing made from hydrocarbons or employed hydrocarbons in their manufacture or transportation? How about food? Do they decline agricultural products grown with fertilizer or being transported by diesel-powered trucks? Ninety-three percent of all U.S. transportation uses fossil fuels. Windmills use fossil fuel lubricants and both solar and wind generators incorporate materials constructed from fossil fuels.

Before you are taken in by the emotion of the moment, I suggest reading Alex Epstein’s book, *The Moral Case for Fossil Fuels* and climatologist Joe Bastardi’s recent book, “*The Climate Chronicles: Inconvenient Revelations You Won’t Hear From Al Gore—And Others.*” There are dozens of books refuting climate hysteria and thousands of scientists who strongly object to the misuse of their work to promote radical climate agendas. Knowledge is power; to be forewarned is to be forearmed.

## Appendix 2

### Factoids and Facts

Some climate change deniers simply make up facts, but sometimes they will quote result which are indeed factually correct but severely misleading in the context of the point they were trying to make. I call those ‘factoids.’ An example of this occurred in an older column by the author of the February 1<sup>st</sup> column. The gist of it was that over the past 8000 years the average rate at which sea levels are rising is just about the same as it right now, suggesting it is only ‘alarmists’ that point to currently rapidly rising sea levels. The statement about the rates is, factually, approximately correct. Here is a graph of sea level rise during the last 8000 years.

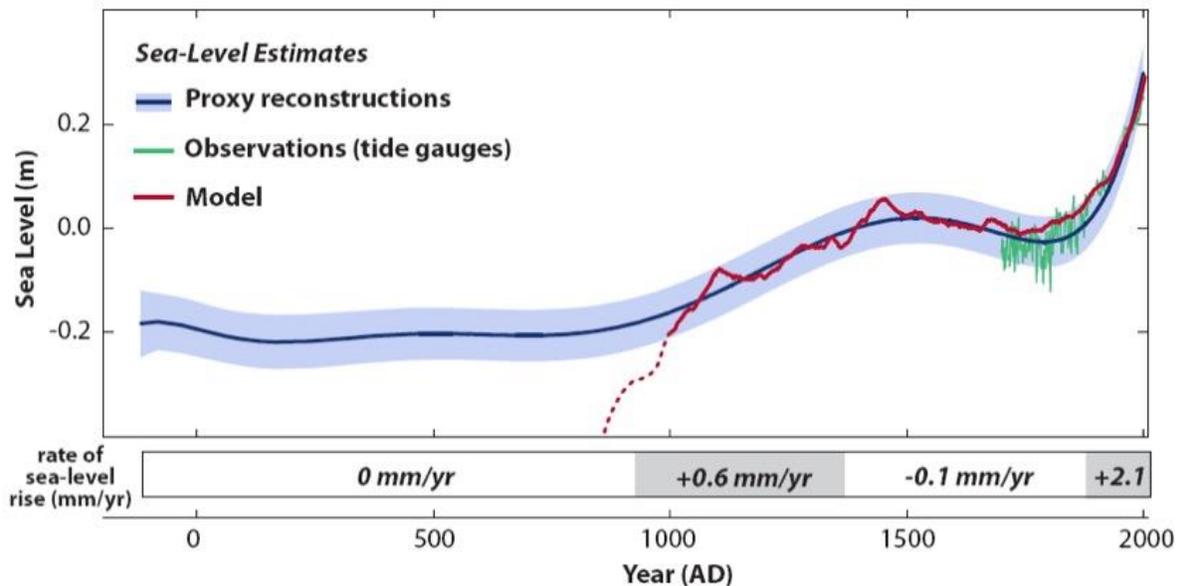


Sea level rise during the past 9000 years. Taken from [https://commons.wikimedia.org/wiki/File:Holocene\\_Sea\\_Level.png](https://commons.wikimedia.org/wiki/File:Holocene_Sea_Level.png)

This graph shows that during the past 8000 years sea level has risen about 15 meters or 15,000 mm, so that the average rate over this period is 15,000/8000 or

about 1.9 mm/year. From 1993 to the present, sea level is rising at about 3.2mm/yr (see "vital signs of the planet: sea level" at <https://climate.nasa.gov/> )

But notice that the bulk of this took place over the 1000 years between 7 and 8 thousand years ago, during the earth's emergence from the last ice age. Ice ages have occurred several times but *at intervals of about 100,000 years*. But note also that during the last 2000 years, sea level was relatively very stable. Here is another plot of sea level history during these last 2000 years.



Reconstruction of sea level rise over the last 2000 years. (From <http://www.realclimate.org/index.php/archives/2011/06/2000-years-of-sea-level/>)

It is important to emphasize that the current rate of sea level change is not constant but is *accelerating*, and for the emission pathway the world is currently on, by the end of this century, the rate is projected to be vastly greater—15 mm/year even for the 'intermediate scenario'. (I will describe projected global and US coastal sea level rises in a forthcoming post.)

Stating the 'factoid' that the average rate of rise over the past 8000 years is comparable to the present rate and implying that there is nothing striking about the present rate is grossly misleading as the graphs and discussion above illustrate. This is a frequent tactic of deniers; whether it is simply being naïve or deliberately misleading I cannot say.

### Appendix 3: Deconstruction of the statement by Joe Bastardi on CO2

*"CO2 cannot cause global warming. I'll tell you why. It doesn't mix well with the atmosphere, for one. For two, its specific gravity is 1 1/2 times that of the rest of the atmosphere. It heats and cools much quicker. Its radiative processes are much different. So it cannot -- it literally cannot cause global warming."*

Joe Bastardi, has a B.S. in meteorology from Penn State and is a weather forecaster, associated with AccuWeather and subsequently WeatherBell Analytics.

He is one of the better-known deniers of the major role of increased carbon dioxide produced by fossil fuel combustion in the rapid global warming and associated climate change.

Consider the first two assertions: *It doesn't mix well with the atmosphere, for one. For two, its specific gravity is 1 1/2 times that of the rest of the atmosphere.*

I have no idea what he means by 'it doesn't mix well with the atmosphere' aside from the implication that because CO2 is heavier (at a molecular weight of 44 compared to the nitrogen molecule (28) and the oxygen molecule (32)). If the Earth's atmosphere were *absolutely* still, with no vertical motion in the atmosphere whatsoever, then after a *very, very* long time, the CO2 would settle below the oxygen and nitrogen. (This is called 'gravitational settling' and occurs by 'diffusion'.) But even if this occurred there would still be a greenhouse effect—the CO2 would still intercept about the same amount of infrared radiation from the Earth's surface and return it to the surface, which is the essence of the greenhouse effect.

But of course, this complete absence of vertical mixing does not remotely apply. Sources of carbon dioxide produced by local sources are rapidly distributed by wind currents both horizontally and vertically and there is very little variation in the ratio of CO2 to oxygen and nitrogen until *very* high in the upper reaches of the atmosphere. That is why CO2 (along with methane and nitrous oxide) are called *well-mixed* greenhouse gases, in contrast to water vapor, which is not well-mixed and varies strongly with horizontal and vertical location in the atmosphere.

*It heats and cools much quicker. Its radiative processes are much different.*

I find it hard to respond to these two sentences since I really have no idea what they mean. The correct physical situation is the following: The oxygen and nitrogen molecules, because of their simple structure and symmetry cannot,

following the laws of quantum physics, absorb infrared radiation. But carbon dioxide, with its somewhat more complex structure (as well as the other greenhouse gases) can. The infrared energy is absorbed by the carbon dioxide molecules, causing them to vibrate and rotate more vigorously with this additional absorbed energy. If the density of molecules in the atmosphere were vastly less than it is, they would re-radiate this energy before sharing it with the oxygen and nitrogen molecules. Perhaps this is the basis for Bastardi's misunderstanding. But in fact, collisions of the CO<sub>2</sub> molecules and the oxygen and nitrogen molecules cause this energy to be quickly shared, with the result that there is no discernable difference in temperature between the CO<sub>2</sub> molecules and the oxygen and nitrogen molecules comprising the bulk of the atmosphere.

I have produced a video explaining how CO<sub>2</sub> produces the greenhouse effect, including the energy sharing just described. See it here:

<https://www.youtube.com/watch?v=9DaohdBhbfQ&feature=youtu.be>

It is frankly rather disturbing that someone with a B.S. degree in science from a very good University can have so little understanding of basic physics. Regrettably, this example is not the only instance of Mr. Bastardi's ignorance of basic climate science. For other examples see:

[https://skepticalscience.com/Joe\\_Bastardi\\_art10320.htm](https://skepticalscience.com/Joe_Bastardi_art10320.htm)

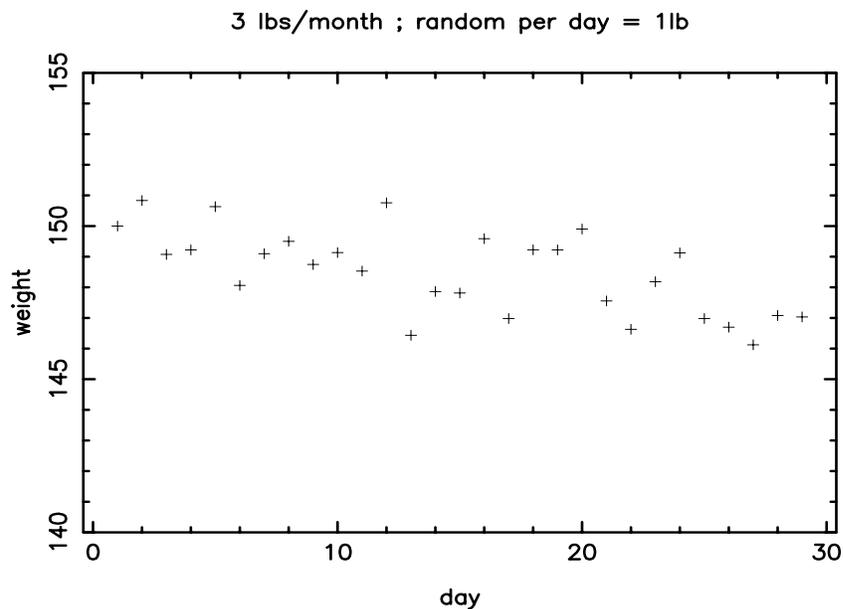
There are many reliable sources for scientifically correct information on climate change, some of which are referenced in this post. Mr. Bastardi is most certainly not one of these sources.

## Appendix 4: Signal, noise and confidence intervals

### and their relevance to climate change

The concept of “signal-to-noise” arises in many branches of science and engineering, including indicators of climate change. If you find yourself in a crowded, noisy cocktail party and (like me) are a bit hard of hearing, you probably found it hard to follow all the conversation in the small group you are in. Such a conversation is the ‘signal’, but it may be largely masked because of the ‘noise’ from all the other voices speaking in the room. When you have no difficulty being able to follow the conversation (perhaps by asking those in your group to speak more loudly) then you can say that the ‘signal’ has risen above the ‘noise’.

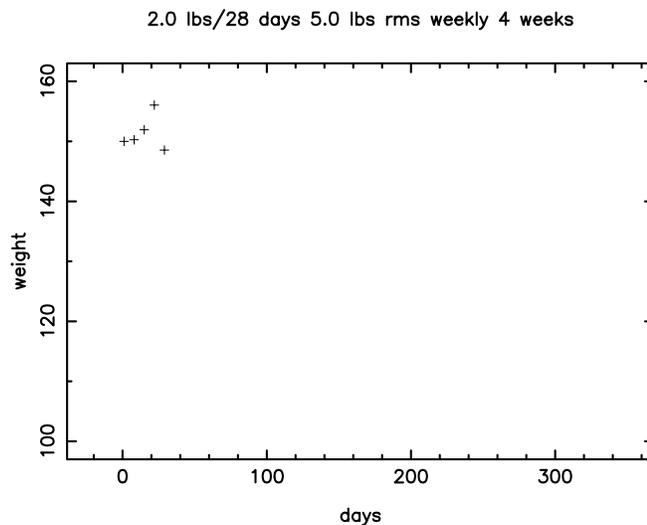
Here is another example: Suppose Jane is trying to lose weight. She has the goal of losing 3 pounds in four weeks. She is very careful with her diet, weighs herself unclothed upon arising at exactly the same time each morning and records her weight from the scale. After four weeks her plot might look something like this:



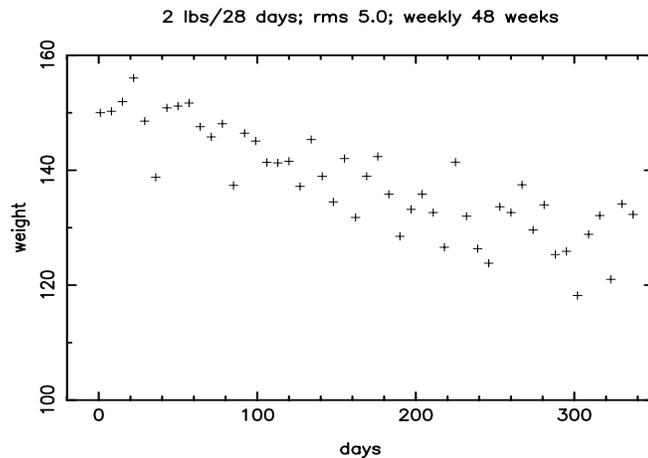
If a ‘best fitting’ straight line were to be drawn through these points (according to standard statistical procedures) it would convincingly show that she had lost about three pounds. But even without doing this, it is obvious that she really has lost

weight, even though there are day-to-day random variations. These random variations cause ‘noise’ in the weight ‘signal’, mostly due to variable amounts of water retention, but also because there may be random errors in the scale itself. But we can be very confident that the apparent loss of weight (the ‘signal’) was not just due by chance to these random variations deceiving us into thinking the loss was ‘real.’ There are rigorous statistical procedures for establishing the probability that these random fluctuations cannot account for a false ‘signal’ and for estimating the limits within which the ‘true’ loss weight lies if we were able to eliminate these random fluctuations. For example, it might turn out that there is a 95% chance that the true weight loss lies between 1.5 and 4.5 pounds. These probability limits are generally termed ‘confidence limits.’ It would likewise be possible to estimate the even smaller probability that the true weight loss was zero or that she had actually gained weight. Clearly, in Jane’s case the ‘signal has emerged from the noise.’

On the other hand, Joe also wants to lose weight, but he is not as serious, and his goal is only 2 pounds per 4 weeks. Moreover, he only weighs himself once a week at random times of the day, sometimes after a big meal, sometimes barefoot and sometimes with boots on. As a consequence, there is a much larger amount of random variation in his weigh-ins and after 4 weeks his plot might look like this:



Note that on this plot the “days” axis has been extended to 48 weeks, but it would be rash indeed to conclude that after just 4 weeks he had (or had not) lost any weight. Any signal is lost in the noise and a statistical test would confirm this. But Joe persists and after 48 weeks his plot looks like this:



It is now obvious that Joe *has* lost weight and a formal statistical test would reveal that zero loss or a gain can be ruled out with a high degree of confidence, so in his case because of the less frequent weigh-in and especially the much larger random variations, it took much longer for the ‘signal to emerge from the noise’.

There are assumptions made in applying such tests and in these two very simple simulations one of them was that the random error in an individual weigh-in is completely independent from the preceding one. This may or may not be the case. For example, it would not help Jane much to get a more accurate picture of her progress by weighing herself every 5 minutes because there is *correlation* of the random errors (like variable water retention) over such short periods of time.

In the case of climate science these same considerations apply to sampling in *space* as well as *time*. Sampling the temperature inch-by-inch would not make much sense, but having one sampling point in the United States, one in Canada and one in Mexico etc would introduce a lot of noise in estimating a trend in North American temperatures. But there are parts of the globe where weather stations are few and far between, notably in the polar regions and some portions of the ocean. In those cases, it takes sophisticated ‘interpolation’ schemes to try to fill in these gaps.

Detecting changes in the climate is much easier for some climate indicators than for others. In some cases, like the plot of *global surface temperature*, (the 2<sup>nd</sup> graph shown in the main text above) there are obvious year to year or slightly longer random fluctuations mostly caused by the El Nino/La Nina phenomenon. (Here, ‘random’ means that they are irregular *internal variations*, not caused by external

influences on the climate.) But there may be small longer-term internal variations caused by fluctuating ocean currents. As humans rapidly deposited more and more CO<sub>2</sub> into the atmosphere (about ½ of the total emitted since the industrial revolution has occurred in just the last 40 years) the signal becomes stronger and is now highly statistically significant. To estimate the influence of the longer term variations, climate scientists run ‘controlled’ computer simulations in which no external influences are present.

Detecting trends in hurricane intensity is more difficult, as described in the main text by the quotes from the hurricane experts. Hurricane observations are poorer and not complete or uniform in quality as one goes back in time. The intensity criteria are not even the same in the Pacific and the Atlantic. Moreover, the climate models are still not able to model hurricane formation and strength as well as global temperatures and so estimating natural variations is challenging. However, the models still point to a ‘robust’ detection of a change in hurricane strength sometime in the coming several decades, just as Joe could detect the signal of his weight loss after 48 weeks.

## Appendix 5: Statement and Signatories of

### “Economists’ Statement on Carbon Dividends”

One of the organizers of this statement described it as “*the most cost-effective, equitable and politically-viable national climate solution*” and further stated “*now more than ever, it is critical for economists to point the way forward and coalesce around a bipartisan climate policy.*”

Here is the statement:

### Economists' Statement on Carbon Dividends

Global climate change is a serious problem calling for immediate national action. Guided by sound economic principles, we are united in the following policy recommendations.

I. A carbon tax offers the most cost-effective lever to reduce carbon emissions at the scale and speed that is necessary. By correcting a well-known market failure, a carbon tax will send a powerful price signal that harnesses the invisible hand of the marketplace to steer economic actors towards a low-carbon future.

II. A carbon tax should increase every year until emissions reductions goals are met and be revenue neutral to avoid debates over the size of government. A consistently rising carbon price will encourage technological innovation and large-scale infrastructure development. It will also accelerate the diffusion of carbon-efficient goods and services.

III. A sufficiently robust and gradually rising carbon tax will replace the need for various carbon regulations that are less efficient. Substituting a price signal for cumbersome regulations will promote economic growth and provide the regulatory certainty companies need for long-term investment in clean-energy alternatives.

IV. To prevent carbon leakage and to protect U.S. competitiveness, a border carbon adjustment system should be established. This system would enhance the competitiveness of American firms that are more energy-efficient than their global competitors. It would also create an incentive for other nations to adopt similar carbon pricing.

V. To maximize the fairness and political viability of a rising carbon tax, all the revenue should be returned directly to U.S. citizens through equal lump-sum rebates. The majority of American families, including the most vulnerable, will benefit financially by receiving more in “carbon dividends” than they pay in increased energy prices.

Here is the list of the 45 economists who signed the statement:

**George Akerlof**

Nobel Laureate  
Economist

**Robert Aumann**

Nobel Laureate  
Economist

**Martin Baily**

Former Chair, CEA

**Ben Bernanke**

Former Chair, Federal  
Reserve

Former Chair, CEA

**Michael Boskin**

Former Chair, CEA

**Angus Deaton**

Nobel Laureate  
Economist

**Peter Diamond**

Nobel Laureate  
Economist

**Robert Engle**

Nobel Laureate  
Economist

**Eugene Fama**

Nobel Laureate  
Economist

**Martin Feldstein**

Former Chair, CEA

**Jason Furman**

Former Chair, CEA

**Austan Goolsbee**

Former Chair, CEA

**Alan Greenspan**

Former Chair, Federal  
Reserve

Former Chair, CEA

**Lars Peter Hansen**

Nobel Laureate Economist

**Oliver Hart**

Nobel Laureate Economist

**Bengt Holmström**

Nobel Laureate Economist

**Glenn Hubbard**

Former Chair, CEA

**Daniel Kahneman**

Nobel Laureate Economist

**Alan Krueger**

Former Chair, CEA

**Finn Kydland**

Nobel Laureate Economist

**Edward Lazear**

Former Chair, CEA

**Robert Lucas**

Nobel Laureate Economist

**N. Gregory Mankiw**

Former Chair, CEA

**Eric Maskin**

Nobel Laureate  
Economist

**Daniel McFadden**

Nobel Laureate  
Economist

**Robert Merton**

Nobel Laureate  
Economist

**Roger Myerson**

Nobel Laureate  
Economist

**Edmund Phelps**

Nobel Laureate  
Economist

**Christina Romer**

Former Chair, CEA

**Harvey Rosen**

Former Chair, CEA

**Alvin Roth**

Nobel Laureate  
Economist

**Thomas Sargent**

Nobel Laureate  
Economist

**Myron Scholes**

Nobel Laureate  
Economist

**Amartya Sen**

Nobel Laureate  
Economist

**William Sharpe**

Nobel Laureate  
Economist

**Robert Shiller**

Nobel Laureate  
Economist

**George Shultz**

Former Treasury  
Secretary

**Christopher Sims**

Nobel Laureate  
Economist

**Robert Solow**

Nobel Laureate  
Economist

**Michael Spence**

Nobel Laureate  
Economist

**Lawrence Summers**

Former Treasury  
Secretary

**Richard Thaler**

Nobel Laureate  
Economist

**Laura Tyson**

Former Chair, CEA

**Paul Volcker**

Former Chair, Federal  
Reserve

**Janet Yellen**

Former Chair, Federal  
Reserve  
Former Chair, CEA