"If I include the CO2 and other forcings during the 20th Century compiled by James Hansen with the PDO-forced cloud changes (solid line labeled PDO+CO2), then the fit to observed temperatures is even closer." (http://www.drroyspencer.com/research-articles/global-warming-as-a-natural-response/)
If we look at the change in the centered 13 month average from 1979 to 2016, it is about 0.7 degrees centigrade. This is the temperature of the lower atmosphere recorded by satellites, not the ground level records. After a great deal of processing, the increase in the temperature of the lower troposphere, most comparable to surface based records, shows an increase of about 0.45 degrees centigrade for about the last 40 years.

http://www.drroyspencer.com/latest-global-temperatures/
Temperature vs Solar Activity

- Red line: Temperature 11-year average
- Light red line: Temperature yearly
- Blue line: Solar Irradiance 11-year average
- Light blue line: Solar Irradiance yearly

Year: 1880 to 2020

Temperature change (°C) on the right y-axis.
Total Solar Irradiance (W m⁻²) on the left y-axis.
A classic of “natural variability”, the year 1816 was unusually cold due to the occurrence of the largest volcanic eruption in the past 10,000 years (Mount Tambora) in 1815 in the middle of a period of low solar irradiance. However, if we look at the right side of the plot, we see that the average solar irradiance has been declining since the early 1950s, yet the average global temperature is going up.
Global temperature anomalies (difference from 1961-90 average) for 1950 to 2016, showing strong El Nino and La Nina years, and years when climate was affected by volcanoes. (World Meteorological Organisation)
Modern vulcanism

Low volcanic activity during the first half of the 20th century was accompanied by rising temperatures. Increasing volcanic activity drove the temperature down, but has been unable to restrain the increases in the past 40 years.

This plot ends at about 1995. Since then we have had 17 volcanic eruptions of a Volcanic Explosivity Index of at least 4, so there has not been a volcano-free period in the last 20 years that might have caused a temperature increase.
Let’s go back to the CO2 release due to rising temperatures since the Little Ice Age in this plot. From the temperature plot, the Little Ice Age was well and truly over before 1800, after which there was another drop in temperature with no corresponding drop in CO2. However, recent work has concluded that humanity has been contributing to atmospheric CO2 for about 8000 years. We started out small, but have improved our performance dramatically in recent years.

I have heard someone state with great certainty that there is no correlation between CO2 and average temperature over geologic time scales (Vostok-ice-core-petit.png: NOAA). This plot contains the best data on CO2 levels and temperature anomalies over the past 420,000 years. The correlation between the two is about 0.75. A very substantial positive correlation. At the bottom is the dust concentration estimated from ice core data. Like the sunspot data, it is not as good an explanation, but it does improve the model.
ATMOSPHERIC CH₄:CO₂:°C
420,000 years BP – present time


*Between 100,000 and 420,000 years BP from IPCC.
The “ideal gas law” explanation.

I have heard it suggested that the greenhouse effect can be explained by application of the ideal gas law. This is that equation some of you learned in school that mathematically models the relationship between pressure, volume and temperature in an adiabatic system. Let’s ignore the fact that a planet is not an adiabatic system for a moment and look at what can be done with the ideal gas law. The fact that the earth is warmer than it should be if it didn’t have an atmosphere is one observation that seems to support the greenhouse effect. Without going through the mathematics of input radiation, thermal conductivity and output radiation, the earth is over 30°K warmer than it would be without an atmosphere. The ideal gas explanation for this is that at some point in the atmosphere, the “black body” temperature is at equilibrium with the incoming solar radiation and the increase in temperature is due to the increased pressure at the earth’s surface. If we go up along the atmospheric temperature profile looking for the “black body” temperature, which is about 252° K, we find it a few kilometers above the surface. At this altitude, the atmospheric pressure is about 39 kilopascals compared to about 101 kpa at the surface. Plugging these figures into the equation, we calculate that the volume of the gas at sea level should be a bit over half of the volume at this altitude, given the expected temperature differential. It’s kind of close, so let’s give it the wiggle room to say that it is close enough. The problem for the ideal gas law explanation is that it’s kind of close until you get into the stratosphere, when the temperature should keep going down but goes up, then goes down and finally as we’re getting out into satellite land, it goes up again. All of which means that you hit the “black body” temperature four times on the way up. It is possible of course to add in factors like ionization, solar irradiation, high clouds and other things to get explanations for this, but this requires a lot of fudging that doesn’t even come close to observations. The real killer however, is that the system is not adiabatic, nor is it at static equilibrium. We all know that hot air rises and that the temperature should move toward equilibrium, but there is a two way flow of energy through the system. Since the energy coming in is equal to the energy going out, or the temperature would change, the only way that the system can maintain a temperature gradient is for the outgoing energy to be absorbed and re-radiated more strongly than the incoming energy. The greenhouse effect. Those fluctuations in the upper atmosphere are due to the same thing in reverse, as oxygen (molecular and ozone) selectively absorbs incoming UV radiation in those regions. Which is why we don’t get toasted when we lie on the beach in that beautiful sunshine.
The answer to why carbon dioxide is only a raw material to plants and not a nutrient is to be found in the number 393.5. That is the number of kilojoules per mole of energy that is released when carbon is converted to CO2. Biologically, little can be done with CO2 except to photosynthesize it into carbohydrates at a cost of just over 300 kilojoules of energy per mole of equivalent carbon. Plus losses due to the appalling inefficiency of photosynthesis. Without light as an energy source, that doesn't happen. So while a true fertilizer such as fixed nitrogen enhances the growth of plants during the day and night, when plants are respiring like us, increased carbon dioxide can only enhance the growth of plants during the day, when it can be chemically altered (“reduced”) into biologically useful materials.

“An increase in the carbon dioxide concentration increases the rate at which carbon is incorporated into carbohydrate in the light-independent reaction and so the rate of photosynthesis generally increases until limited by another factor.”

http://www.rsc.org/Education/Teachers/Resources/cfb/Photosynthesis.htm

All the fuss about additional CO2 enhancing the growth of plants during the day leads us to consider the so-called C4 plants like maize. These little geniuses worked out a solution about 35 million years ago. The reason that they didn't take over the earth a long time ago is interesting in this discussion. What C4 plants do is to concentrate the CO2 where the photosynthetic enzyme can do something useful instead of wasting the energy in what is called photorespiration. This not only means that they use less water in the process, they also gain an advantage in resisting heat stress, which also promotes photorespiration. So C4 plants didn't really start to gain an edge until the Miocene epoch, when temperatures were a few degrees higher than now. Best of all, it explains why C4 plants don't get as much growth enhancement from CO2 enrichment. They worked out how to do it 35 million years ago.
The major contributions of Stewart and Craig Idso have been in the study of the effects of increased CO2 on plant growth. Obviously their conclusions differ from those of others who have reviewed this area. The plots on the right are taken from:


While most scientists reviewing this area use what is called meta-analysis, in which the sizes of effect of different studies are weighted by sample size and combined to estimate the overall effect, Kimball and Idso used the mean of the separate outcomes as shown here. One of the first things that a person familiar with statistics notices is that the distributions of both plots are positively skewed. In such distributions, the mean is a biased estimator, as the values in the “tail” of the distribution are more influential. As there seems to be a fascination with finding bias in the literature, it is surprising that those citing works such as this have not noticed the bias in the estimation of improved productivity.

Also of note is that in this and similar papers, both Craig and Sherwood Idso emphasize the fact that human use of carbon based fuels has been responsible for the observed increase in atmospheric CO2.

“Today, however, the CO2 content of the air is nearly 340 ppm or 25% greater, due largely to mankind's burning of fossil fuels.” (p 55)
We know that the uptake of CO₂ by plants is an important part of the carbon cycle. Thus the enhanced uptake of CO₂ made possible by increased concentrations of the gas in the atmosphere will increase that uptake, other factors remaining constant. This is limited by the efficiency of ribulose 1,5-bisphosphate carboxylase/oxygenase (RuBisCo), the most common of the enzymes employed in natural photosynthesis.

The synthesis of a novel photosynthetic carbon fixation pathway was recently reported in the journal Science. The good news is that its conversion efficiency is 37 times that of RuBisCo. The bad news is that it is called crotonyl–coenzyme A/ethylmalonyl-coenzyme A/hydroxybutyryl-coenzyme A. Fortunately they also devised an acronym - CETCH. Because they are scientists, they did not immediately rush to inform the world that they had solved the CO₂ problem. The pathway has only been realized in vitro, and will take considerable refinement before it can be practically deployed.

However, another innovation in plant biology is the manipulation of nonphotochemical quenching (NPQ) that plants employ to protect themselves from bright light. All this mechanism does is to divert photons from fixing carbon to wasted energy. By allowing this NPQ to be reversed more rapidly, plants can recover their photosynthetic capacity more rapidly when the light level is reduced.


Another result of increased atmospheric CO2 is increased dissolved CO2 in the oceans. As usual, there are objections to the idea that increased CO2 in the oceans will lower the pH of the oceans, that is, make the oceans more acid. Without speculating on the consequences of decreased oceanic pH, I’ll just go through a prominent objection to its existence. The plot on the top at the right shows the average oceanic pH from 1910 to 2012, just as in the illustration on the web page titled, “Oceans not acidifying – “scientists” hid 80 years of pH data” (http://joannenova.com.au/2015/01/oceans-not-acidifying-scientists-hid-80-years-of-ph-data/)

The black points and lines are the actual average pH values for each year except 1914 to 1921, in which World War I presumably interrupted the series. The green and light blue lines are calculated by the Friedman “super smoother” algorithm and a 10 year moving average of the values respectively. The 10 year moving average line (light blue) does not match that on the web page in the early values. After manually calculating some early values, it seems that this gap caused a problem in the original calculations. However, the values from about 1930 onward match quite closely. The red line is the linear regression of the original 10 year moving average and has a slight upward slope. This is claimed to show that the linear regression line in:


was incorrect. Here we have a good illustration of misapplication of statistics. One doesn’t use a linear regression to estimate the parameters of a system that is clearly non-linear. The reason that Feely and colleagues did was because they only used a small number of recent values which would not warrant what we call a “polynomial contrast” to discover curvature. By applying a generalized additive model to the entire data set, an interesting result emerges. There may be a cycle of about 40 years duration in the pH of the oceans. And in the latter part of the 20th century and the beginning of the 21st century, we see that deviation again.
For any who object to the NOAA global average temperature series, here is the HADCRUT4 series compiled on the opposite side of the Atlantic Ocean.

As you can see, the two tell the same story. This illustration of the HADCRUT4 series gives us a bit more information about the hemispheric distribution of heat energy, showing why the largest ice losses are observed in the Arctic.


But wait! There have been changes in the latest version, HadCRUT4! Has this been done to bolster the ailing story of global warming?
Sorry, as you can see from this direct comparison of the two series, the largest difference in the two series is in the decade after World War II. This is where a cool bias was discovered and the temperatures for that interval adjusted upward, thereby reducing the apparent warming in subsequent years.

http://www.skepticalscience.com/hadcrut4_a_detailed_look.html

If you want a really comprehensive analysis of temperature record adjustments

https://judithcurry.com/2014/07/07/understanding-adjustments-to-temperature-data/
For those who claim that the modern records are unreliable, fudged, altered, falsified and reborn, here is the 235 year “thermometer” record from Hohenpeissenberg in Germany, one of the longest continuous local temperature records. The ANOVA table that I have supplied at the top shows the test for an upward linear trend (YEAR) and a quadratic trend (year2) that indicates an accelerating upward trend.