



## Settling the Debate on Climate Change

**Scientists are closer than ever to definitively proving that climate change exists and putting the deniers to rest.**

Despite the recent climate agreement in Paris (COP21), where 195 countries adopted the first legally binding treaty to curb climate change, the debate about whether climate change exists or whether it's the fault of human beings still rages on.

Climate deniers, typically extreme libertarians and anti-government free market advocates, characterise themselves as “underfunded” advocates of “free speech” and “reason”. They characterise the views of most climate scientists and environmental groups, such as the Sierra Club and Greenpeace, as “alarmist” and “left-wing dogma”.

The libertarian sceptics and deniers do no original research, but they constantly criticise the “politicisation” of the Intergovernmental Panel on Climate Change (IPCC). They claim that the evidence of “anthropogenic causation” is extremely weak, and that any climate warming taking place must therefore be of natural origin, or otherwise unexplained.

### What can't be disputed

In the interest of academic rigour, it would be useful to analyse the facts and how the deniers see them. First of all, **CO<sub>2</sub> levels are undeniably rising**. The increase, which many sceptics don't deny,

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accelerated after World War II, mainly because of industrialisation of developing countries, increased consumption of electricity, and increased use of private cars and substitution of automotive (and air) transportation for rail-based transport.

But this is the extent of the consensus between climate scientists and deniers. **Despite a broad scientific consensus** on the importance of CO<sub>2</sub> as a driver of climate change, some climate sceptics, and a few outright “deniers” (including the Republican members of the U.S. Congress) still question whether carbon dioxide is actually harmful, on balance. Some argue that carbon dioxide is the “food” for all plants. Plants capture and “fix” that carbon to create the carbohydrate-based food for animals. The natural process (which produces oxygen as a byproduct) is called *photosynthesis*. Without photosynthesis we (and all the other animals) would starve (in fact, we could never have evolved in the first place). Carbon dioxide is the basis of the Earth's food chain. It is also the source of all the carbon embodied in the fossil fuels our industrial economy depends on.

Not only that, the photosynthesis process is also the source of the oxygen in the air. We humans (and almost all animals) require oxygen to metabolise, and without oxygen we would suffocate. In fact, as

the concentration of CO<sub>2</sub> in the atmosphere increases, the rate of production of carbon-fixation in organic matter also increases. This is the well-known “carbon fertilisation effect”, and it is exploited commercially in Dutch (and other) greenhouses. It is said that crop production could increase by up to 15 percent in a more carbon-intensive world.

Furthermore (the argument continues), the ozone layer in the stratosphere protects us (and all terrestrial species) from the harmful effects of ultra-violet (UV) radiation. Ozone is a reactive form of oxygen (O<sub>3</sub>) that is created in the stratosphere by that same UV radiation from the sun. The ozone layer exists because of the oxygen in the atmosphere, which exists because of photosynthesis. Clearly, atmospheric carbon dioxide plays an essential role in the natural world. We could not live without it.

However, most of the climate sceptics and deniers don't argue on the basis of carbon dioxide and photosynthesis. The majority argue that the science is flawed and the true effect of carbon dioxide concentration in the atmosphere is unproven. There have been vicious attacks on individuals as well as institutions researching climate change. For instance, Lord Christopher Monckton of Brenchley calls it a “climate scam”, adding that the scientific endeavour and policymaking on climate change is “the biggest transfer of wealth in human history from the poor to the rich, from the little guy to the big guy, from the governed to those who profit by governing them.”

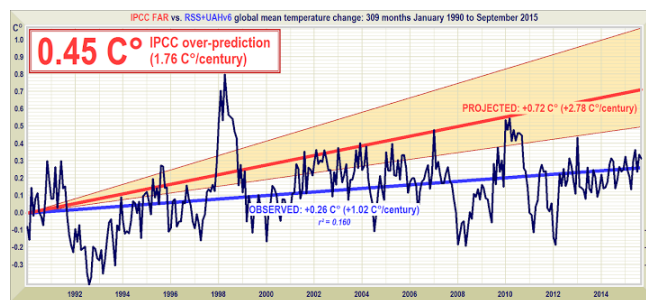
But there is no alternative non-anthropogenic theory to explain rising temperatures and therefore melting glaciers, sea level rises and ocean acidification. To invoke “natural variation” is not a theory about causes.

### The “pause”

Another recent dispute has focused on the so-called “pause” in climate warming after 1998. If one cherry picks the data, then it seems that there was a slowdown in the rate of temperature increase in recent years.

Figure 1 below shows a graph that was widely circulated in the media (by nay-sayers) allegedly proving that the global temperature did not actually increase for a long period of time. The yellow-shaded area represents the range of 1990 IPCC projections, as contrasted with actual temperature measurements.

**Figure 1. IPCC over-prediction from 1990 Report**



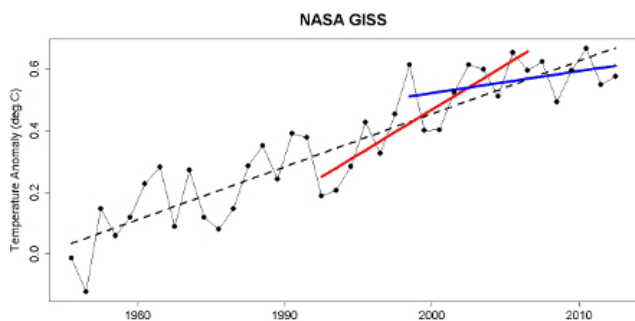
Part of the discrepancy suggested by this graph turns out to have been based on an erroneous temperature database based on satellite data measurements that had not been correctly “converted” to surface temperatures.

The climate sceptics who stress the discrepancy have made several mistakes. First, they got hold of a (leaked) draft of the fourth IPCC Assessment Report (AR) that was visually misleading because of an erroneous misalignment of observations with trends in the year 1990. A number of nay-sayers published this misleading graph on the web and claimed that it proved that there was no climate warming from 1998 to 2012. The error was corrected in the final AR4, but the naysayers did not retract their claims.

Their next mistake was to confuse the average of all model projections with the actual warming trend. The model projections reflect a wide variety of assumptions about natural variability as well as human activity. But these assumptions show the range of possibilities, not the most likely temperature trajectory.

Third, the nay-sayers who prepared Figure 1 engaged in blatant “cherry-picking” of the start and end dates of the period for which they claim there was no warming. The next graph (Figure 2) shows how different choices of start and end dates for 15-year periods can distort the results. The temperature data are from NASA’s Goddard Institute for Space Studies.

**Figure 2. NASA GISS**



Note that the long-term trend (1951-2012 black dotted line), shows a consistent temperature increase over the 61-year period, whereas the period 1998-2012 (blue line) shows very little increase (50 percent less than the long-term rate) because of the very warm starting year (a very strong El Nino), while the period 1992-2006 (the red line) shows a 50 percent greater increase, because of the very mild starting year (due to the eruption of the volcano Pinatubo). Note also that 2015-16 (beyond the range of the chart) is another very strong El Nino year that will make the rate of temperature increase look greater again.

Notwithstanding the points made above, it is true that the surface warming trend from 1998 through 2014 was slower than the model predictions from 1990, or even later ones. In other words, there has been a “pause” although not outside the range of recent model projections. This point has been acknowledged in the IPCC AR5 report. The key point is that the models are not (yet) capable of making accurate forecasts of short-term (10-15 year) climate changes. However, the models, tested by backcasting, appear to be reasonably accurate over longer periods.

In the interests of fairness, we can entertain the deniers to an extent on their claim that the IPCC has consistently overestimated its temperature projections. We now know that the original forecasts were considerably off. The forecasts were based on “General Circulation Models” – mathematical models measuring temperature variations in the circulation of the air, ocean and land – were fairly crude in 1990. For instance, there was little information about the temperature of the ocean so scientists relied on data from ships at sea to report on ocean temperatures at particular times in particular places. But since then, the Argo Programme has been launched, which consists of 4,000 bathythermographs (torpedo-shaped probes, floating in the ocean) measuring temperatures as far down as 2,000 meters. Placed in temperate oceans,

these probes have drastically improved our coverage of ocean temperatures and therefore the quality of data in the models, improving model forecasting capability significantly.

This is particularly important to building an accurate understanding of the climate, which is a difficult job in the absence of key data. The IPCC has to take into account not just ocean temperatures but air and land temperatures as well. Cloud dynamics and the sea-land and ocean-air interfaces are especially critical.

Despite the IPCC’s acknowledged model weaknesses, the long-term trend is not in doubt. The climate is heating up. The evidence suggests CO2 emissions are the cause and an evidence-based alternative theory is something deniers lack. Another line of debate involves “climate sensitivity”, i.e. by how much the temperature actually rises with CO2 levels. But I will save that for my next piece.

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