
A
Scientific Guide
to the
'Skeptics Handbook'

The evidence that
humans are causing
global warming



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References

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Harries, J. E., et al (2001). Increases in greenhouse forcing inferred from the outgoing longwave radiation spectra of the Earth in 1970 and 1997. *Nature*, 410, 355-357.

Sherwood, S. C., et al, (2008). Robust tropospheric warming revealed by iteratively homogenized radiosonde data. *J. Climate*, 21, 5336-5350.

Wang, K., Liang, S., (2009). Global atmospheric downward longwave radiation over land surface under all-sky conditions from 1973 to 2008. *Journal of Geophysical Research*, 114 (D19).

A Scientific Guide to the 'Skeptics Handbook' is a response to 'The Skeptics Handbook', available at <http://joannenova.com.au/global-warming/>

What evidence is there that CO2 causes **global warming**?

Skeptics often cast doubt on whether humans are causing global warming, with questions such as:

1. Is there a greenhouse signature?
2. Didn't CO2 lag temperature in the past?
3. Is global warming happening now?
4. Is the CO2 effect saturated?

Exploring these issues provides the answer to the first question - the evidence that CO2 is causing global warming.

There are multiple lines of evidence all pointing at the same answer - that humans are causing global warming

The **human fingerprint** on climate change

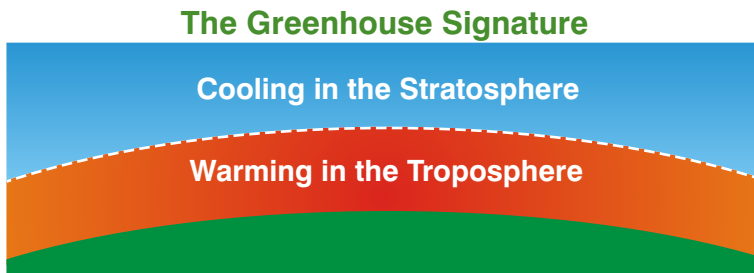
When we look at the full body of evidence, a clear and consistent picture emerges:

- Humans are emitting **billions of tonnes of CO2** into the air every year
- The amount of CO2 in the atmosphere has **increased 40% from pre-industrial levels**
- The **increased greenhouse effect has been directly observed** by a variety of independent measurements

In the next few pages, we'll look at the multiple lines of evidence all pointing to a consistent answer - that human emitted CO2 is causing global warming.

1 Identifying the greenhouse signature

The greenhouse effect leaves a clear signature in the atmosphere. Greenhouse gases stop heat from reaching the upper atmosphere. So we expect to see warming in the lower atmosphere (the troposphere) and cooling in the upper atmosphere (the stratosphere). This is exactly what we observe.



Climate models predict a hot spot about 10 km above the tropics. This is confirmed with the latest data gathered by weather balloons. A common misconception is that the hot spot is a signature of the greenhouse effect -

it's not. It's actually due to changes in the **moist adiabatic lapse rate**.

A common misconception is that the hot spot is a signature of the greenhouse effect - it's not.

As you go higher in the atmosphere, it gets colder. Once it's cold enough for water vapour to condense, heat is released. This partly offsets the cooling rate. In the tropics where the air is more moist, more heat is released. So the hot spot is the result of any surface warming and is not unique to the greenhouse effect.

We measure the atmosphere's temperature using satellites and weather balloons. Several factors affect these measurements like heating of the balloons in sunlight. Once these effects are taken into account, the weather balloon data does find a hot spot above the tropics.

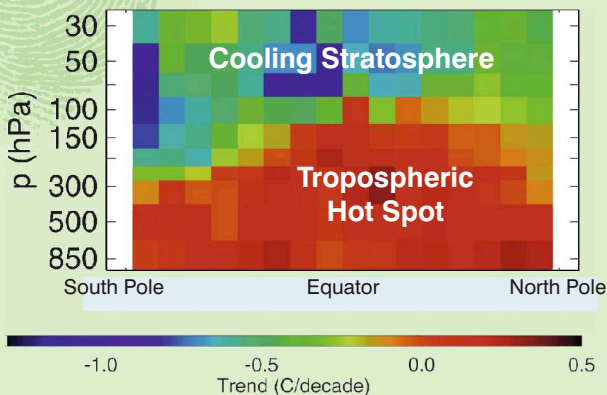
Confirmation of the hot spot comes from measurements of wind trends. As there's a direct relationship between temperature and wind shear, this gives us an independent way to calculate temperature trends. This method finds peak warming above the tropics, just as we expect.

The greenhouse signature, a warming troposphere and cooling stratosphere, is exactly what we observe.

Human Fingerprint #1

Cooling stratosphere

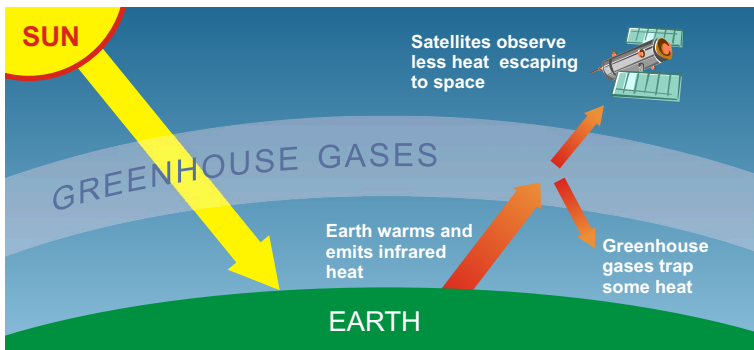
Satellite and weather balloons both find warming in the troposphere and cooling in the stratosphere: a distinct greenhouse signature.



(Sherwood et al 2008)

The evidence that **CO2 causes warming**

Carbon dioxide traps heat. This is directly measured by satellites which find less heat escaping out to space over the last few decades (see **Human Fingerprint #2**). So we have direct evidence that CO2 causes warming.



Ice cores show that in the past, CO2 went up *after* temperature went up. This means temperature affects the amount of CO2 in the air. So warming causes more CO2 and more CO2 causes warming. Put these two together and you get positive feedback.

In the past when the Earth warmed, this caused the ocean to release more CO2 into the atmosphere. This had several effects:

- The extra CO2 in the atmosphere **amplified the original warming**. That's the positive feedback.
- The extra CO2 mixed through the atmosphere, **spreading greenhouse warming across the globe**.

The CO₂ record is entirely consistent with the warming effect of CO₂. In fact, CO₂ warming explains both the dramatic changes in temperature in the Earth's past and how temperature change is able to spread across the globe. The CO₂ lag doesn't disprove the warming effect of CO₂. On the contrary, it provides evidence of a climate positive feedback.

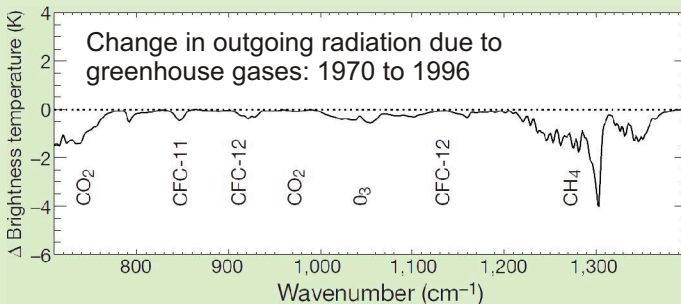
The CO₂ lag doesn't disprove the warming effect of CO₂. On the contrary, it provides evidence of a climate positive feedback.

Human Fingerprint #2

Less heat is escaping out to space

Satellites measure infrared radiation as it escapes out to space. A comparison between satellite data from 1970 to 1996 found that less energy is escaping to space at the wavelengths that greenhouse gases absorb energy. Researchers described this as “*direct experimental evidence for a significant increase in the Earth's greenhouse effect*”.

This result has been confirmed by more recent data from several different satellites



(Harries et al 2001)

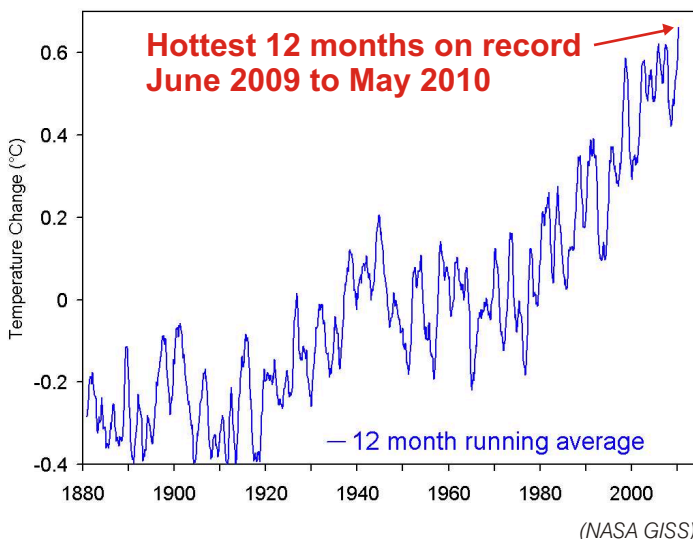
The reality of global warming

Skeptics claim that much of the measured global warming is due to weather stations positioned near air conditioners and car parks. We know this isn't true for several reasons.

For starters, we can compare temperatures from good weather stations to the poorly sited weather stations. Both good and bad sites show the same warming.

Another way to check the accuracy of thermometer measurements is to compare them to satellite data. Satellite measurements show the same amount of global warming. As there are no air conditioners or car parks in space to throw off the measurements, this is confirmation that the thermometers are giving us an accurate picture.

Another claim by skeptics is that it hasn't been warming in recent years. However, there is a strong warming trend over this period. In fact, the



record for the hottest 12 months in the temperature record was broken in March this year, only to be broken again in April and then again in May.

The surface temperature record is only one line of evidence to confirm global warming is a reality:

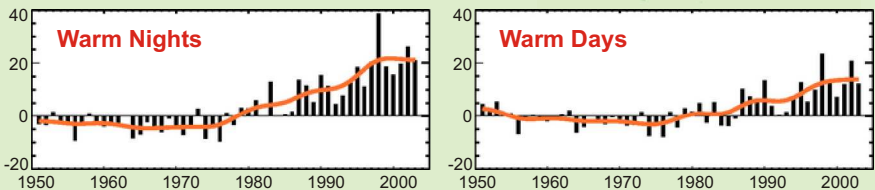
- Ice sheets are melting, losing billions of tonnes of ice each year
- Sea levels are rising at an accelerating rate (largely due to diminishing ice sheets)
- Species are migrating towards the poles
- Glaciers are retreating, threatening water supplies for millions of people

When someone tells you there's no evidence humans are causing global warming, it's because they haven't looked very hard.

To get a full understanding of climate, we need to look at all the evidence. What we see are many lines of evidence all pointing to the same conclusion - global warming is happening and we are the cause. When someone tells you there's no evidence humans are causing global warming, it's because they haven't looked very hard.

Human Fingerprint #3 Nights warming faster than days

An increased greenhouse effect means nights should warm faster than days. This is because the greenhouse effect operates day and night. If global warming was caused by the sun, we would expect the warming trend to be greatest in daytime. Instead, what we see is the number of warm nights increasing faster than the number of warm days.



(Alexander et al 2006)

The CO2 effect is increasing

Humans emit over 30 billion tonnes of carbon dioxide into the atmosphere every year. As we add more CO₂ to the atmosphere, it traps more heat. How do we check this? Real world measurements find that extra CO₂ is trapping more heat. We've already seen that satellites find less heat escaping out to space (see **Human Fingerprint #2**). This is direct observational proof that the warming effect from CO₂ is increasing.

We have further confirmation that extra CO₂ is trapping more heat by surface measurements (see **Human Fingerprint #4**). With less heat escaping out to space, more heat is returning to the Earth's surface. At the surface, we're observing more infrared radiation coming back down to Earth from the atmosphere.

Humans emit over 30 billion tonnes of carbon dioxide into the atmosphere every year. As we add more CO₂ to the atmosphere, it traps more heat.

What about the argument that the CO₂ effect is saturated? This is based on the mistaken notion that our atmosphere is a single layer of CO₂ blocking heat like a Venetian blind. In reality, our atmosphere is made up of many layers and each layer radiates heat.

When we add more CO₂ into the air, it mixes throughout the atmosphere including upper layers. The extra CO₂ in higher layers of the troposphere absorbs radiation from the lower levels. So adding extra CO₂ to the atmosphere is adding to global warming.

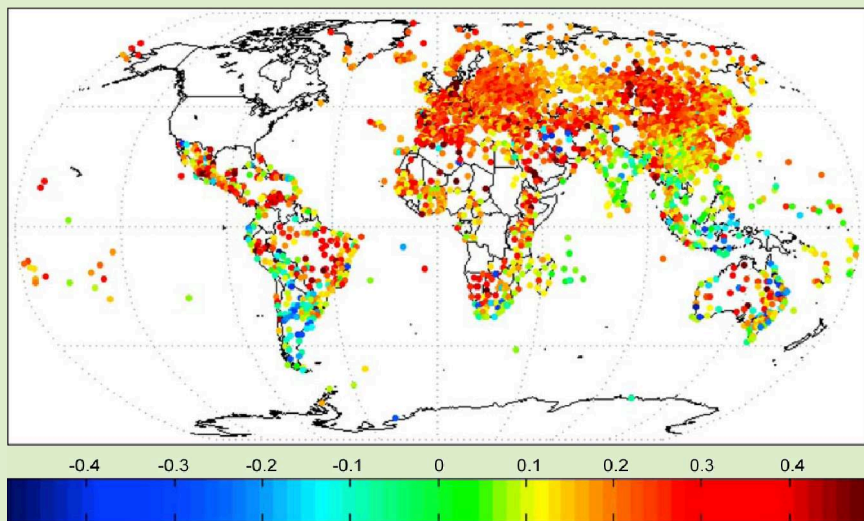
Human Fingerprint #4

More heat is returning to Earth

Surface measurements find more heat returning to earth, due to an increased greenhouse effect. When we take a close look at the spectrum of the downward radiation, we can work out how much each greenhouse gas is contributing to the warming effect. From these results, it was concluded:

“This experimental data should effectively end the argument by skeptics that no experimental evidence exists for the connection between greenhouse gas increases in the atmosphere and global warming.”

Trend in downward infrared radiation



Watts per square metre per year

(Wang et al 2009)

The case for human caused global warming is based on many independent lines of evidence. Global warming skepticism often focuses on narrow pieces of the puzzle while neglecting the full picture.

Our climate is changing and we are the major cause through our emissions of greenhouse gases. The facts about climate change are essential for understanding the world around us, and to make informed decisions about the future.



For more information, visit:

