How Do Greenhouse Gases Actually Work?
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Watch this video:
https://www.youtube.com/watch?v=sTvqIijqvTg - **How Do Greenhouse Gases Actually Work?**

1. Energy from the Sun strikes both the Moon and the Earth, which then re-radiate the energy in the infrared
2. The greenhouse gases in the Earth's atmosphere trap some the infrared radiation, warming the atmosphere by almost 60 degrees F (see Appendix A)
3. Atmospheric CO2 operates as a thermostat to control the temperature of Earth (see Appendix B).
4. Adding CO2 to the atmosphere will raise the Earth's average temperature– the only scientific debate is how much and how fast the temperature will increase (See Appendix C).
5. Since pre-industrial times (about 1870) atmospheric CO2 concentrations have risen about 45% (from 270PPM to 400PPM) and temperatures have risen about 1 Degree C. 2015 will almost certainly be the hottest year in recorded history (see Appendix D)
6. The Earth is absorbing more energy that it is emitting, so it will continue to warm even of all fossil fuel emissions were stopped. The oceans absorb about 93% of this "excess energy" (see Appendix E)

Appendix A - Heating by the greenhouse effect
(http://ase.tufts.edu/cosmos/view_chapter.asp?id=21&page=1)

2. Global Warming

Heating by the greenhouse effect

Our planet's surface is now kept at a comfortable temperature because the atmosphere traps some of the radiant heat from the Sun and keeps it near the surface, warming the planet and sustaining living creatures. Jean Baptise Joseph Fourier (1768-1830) first conceived the mechanism in the 1820s, while wondering how the Sun's heat could be retained to keep the Earth hot. Fourier's idea, still accepted today, is that the atmosphere lets some of the Sun's radiation in, but it doesn't let all of the radiation back out. Visible sunlight passes through our transparent atmosphere to warm the Earth's land and oceans, and some of this heat is reradiated in infrared form. The longer infrared rays are less energetic than visible ones and do not slice through the atmosphere as easily as visible light.

So our atmosphere absorbs some of the infrared heat radiation, and some of the trapped heat is reradiated downward to warm the planet's surface and the air immediately above it. Fourier likened the thin atmospheric blanket to a huge glass bell jar, made out of clouds and gases, that holds the Earth's heat close to its surface.

The warming by heat-trapping gases in the air is now known as the "greenhouse effect", but this is a misnomer. The air inside a garden greenhouse is heated because it is enclosed, preventing the circulation of air currents that would carry away heat and cool the interior. Nevertheless, the term is now so common that we will also sometimes designate the heat-trapping gases as greenhouse gases, and let greenhouse effect designate the process by which an atmosphere traps heat near a planet's surface.

Right now, the warming influence is literally a matter of life and death. It keeps the average surface temperature of the planet at 288 degrees kelvin (15 degrees Celsius or 59 degrees Fahrenheit). Without this greenhouse effect, the average surface temperature would be 255 degrees kelvin (-18 degrees Celsius or 0 degrees Fahrenheit); a temperature so low that all water on Earth would freeze, the oceans would turn into ice and life, as we know it, would not exist.

The gases that absorb the most infrared heat radiation are minor ingredients of our atmosphere. They are water vapor and carbon dioxide, with water vapor absorbing the most. Sixty to seventy percent of the Earth's greenhouse warming is now caused by water vapor and carbon dioxide provides just a few degrees.

The main constituents of the atmosphere, nitrogen (77 percent) and oxygen (21 percent) play no part in the greenhouse effect. The two atoms in these diatomic molecules are bound tightly together and are therefore incapable of absorbing significant infrared radiation. In contrast, water vapor and carbon dioxide molecules consist of three atoms that are less constrained in their motion, so they absorb the heat radiation.

Why doesn't the atmosphere just keep heating up until it explodes? The greenhouse warming rises to a fixed temperature that balances the heat input from sunlight and the heat radiated into space. The level of water in a pond similarly remains much the same even though water is running in one end and out the other.

Appendix B - CO_2 operates as a thermostat to control the temperature of Earth
http://www.giss.nasa.gov/research/briefs/lacis_01/

A study by GISS climate scientists recently published in the journal *Science* shows that atmospheric CO_2 operates as a thermostat to control the temperature of Earth.

There is a close analogy to be drawn between the way an ordinary thermostat maintains the temperature of a house, and the way that atmospheric carbon dioxide (and the other minor non-condensing greenhouse gases) control the global temperature of Earth. The ordinary thermostat produces no heat of its own. Its role is to switch the furnace on and off, depending on whether the house temperature is lower or higher than the thermostat setting. If we were to carefully monitor the temperature of the house, we would see that the temperature does not stay constant at the set value, but rather exhibits a "natural variability" as the house temperature slips below the set value and then overshoots the mark with a time constant of minutes to tens of minutes, because of the thermal inertia of the house and because heating by the furnace (when it is on) is more powerful than the steady heat loss to the outdoors. If the thermostat is suddenly turned to a very high setting, the temperature will begin to rise at a rate dictated by the inertia of the house and strength of the furnace. Turning the thermostat back to normal will stop the heating.

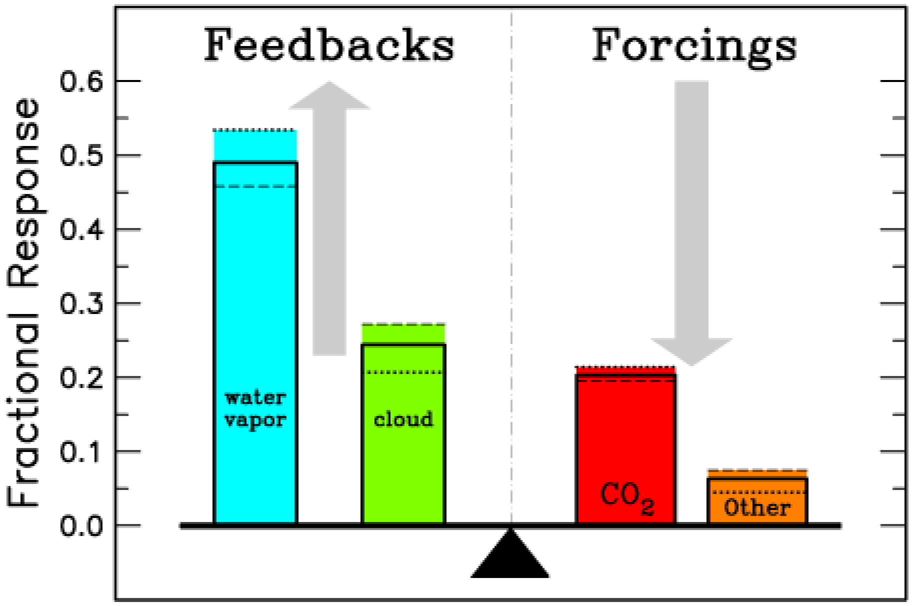

Figure 1. Attribution of individual atmospheric component contributions to the terrestrial greenhouse effect, separated into feedback and forcing categories. Dotted and dashed lines depict the fractional response for single-addition and single-subtraction of individual gases to either an empty or full-component reference atmosphere, respectively. Solid black lines are the scaled averages of the dashed and dotted line fractional response results. The sum of the fractional responses must add up to the total greenhouse effect. The reference model atmosphere is for 1980 conditions.
+ View larger image or PDF

Atmospheric carbon dioxide performs a role similar to that of the house thermostat in setting the equilibrium temperature of the Earth. It differs from the house thermostat in that carbon dioxide itself is a potent greenhouse gas (GHG) warming the ground surface by means of the greenhouse effect. It is this sustained warming that enables water vapor and clouds to maintain their atmospheric distributions as the so-called feedback effects that amplify the initial warming provided by the non-condensing GHGs, and in the process, account for the bulk of the total terrestrial greenhouse effect. Since the radiative effects associated with the buildup of water vapor to near-saturation levels and the subsequent condensation into clouds are far stronger than the equilibrium level of radiative forcing by the non-condensing GHGs, this results in large local fluctuations in temperature about the global equilibrium value. Together with the similar non-linear responses involving the ocean heat capacity, the net effect is the "natural variability" that the climate system exhibits regionally, and on inter-annual and decadal timescales, whether the global equilibrium temperature of the Earth is being kept fixed, or is being forced to re-adjust in response to changes in the level of atmospheric GHGs

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Appendix C How much will Earth warm if carbon dioxide doubles pre-industrial levels?

https://www.climate.gov/news-features/climate-qa/how-much-will-earth-warm-if-carbon-dioxide-doubles-pre-industrial-levels

Scientists say that doubling pre-industrial carbon dioxide levels will likely cause global average surface temperature to rise between 1.5° and 4.5° Celsius (2.7° to 8.1° Fahrenheit) compared to pre-industrial temperatures. (Current concentrations are about 1.4 times pre-industrial levels.) The full process could take hundreds of years—perhaps more than a thousand—to play out. Climate scientists call the full temperature rise from doubled carbon dioxide concentrations the*equilibrium climate sensitivity.*

To understand how sensitive the climate is to carbon dioxide on time frames of a century or less, scientists also study the *transient climate sensitivity.* They imagine that carbon dioxide will continue to increase at roughly the rate it has been, and then ask how much warming would be realized around the time when the concentration has doubled the preindustrial value. On this shorter time scale, it's likely the planet will warm between 1° and 2.5°C (2°-4.5°F).

The difference between *transient* and *equilibrium* sensitivity comes from the fact that some parts of the Earth system—mountain glaciers, sea ice, precipitation—react within years or a few decades to a warming or cooling nudge. Others—including ice sheets, permafrost, and especially the deep ocean—respond sluggishly, sometimes taking centuries to overcome the inertia of their previous state.

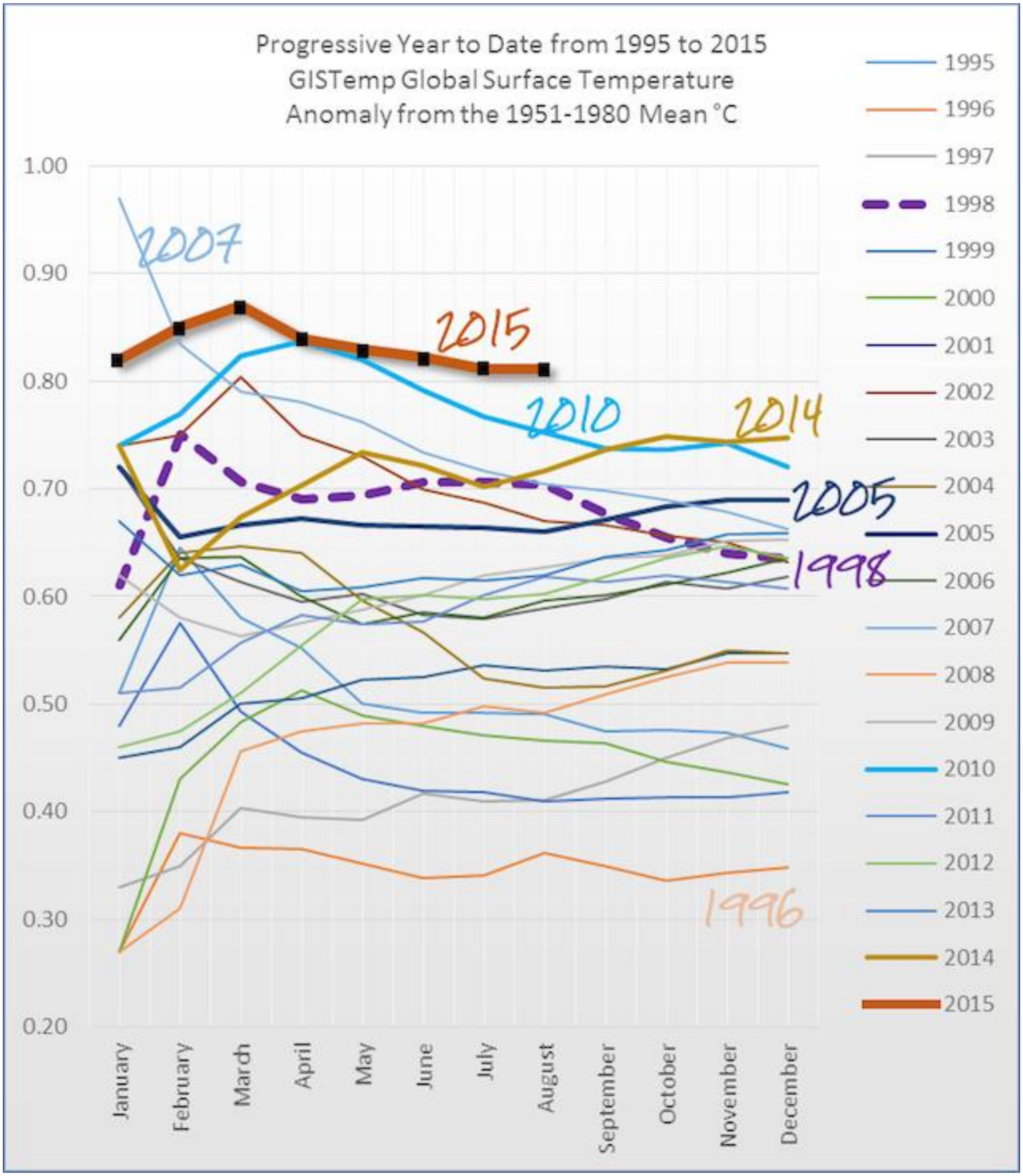
"Sensitivity" is not a prediction of future temperatures

Estimates of climate sensitivity are not the same thing as model predictions of future temperatures. Sensitivity is a way to try to describe how the Earth system is *capable* of reacting if atmospheric carbon dioxide concentrations were to double, not a *prediction* of if or when that might happen. Future temperatures depend, obviously, on how sensitive the climate is to carbon dioxide *and* how much we actually emit.

Preliminary data for 2013 show that the annual average carbon dioxide concentration was around 396 parts per million (ppm). In recent years, carbon dioxide concentrations have been growing at a rate of 2 to 2.5 ppm each year. At those rates, it would take 60-80 years to double the pre-industrial level of 275 ppm. However, the rate of increase over the past half century has not been steady; it's been accelerating by about 0.5 ppm per year per decade. If the acceleration continues into the future, then doubled pre-industrial carbon dioxide concentrations will be reached in about 50 years.

Appendix D Running year-to-date average temperature — for the past two decades

http://thinkprogress.org/climate/2015/09/14/3701298/august-2015-record-warmth/



The datapoint for January of each year just shows the anomaly (temperature above the 1951-1980 mean) for January of that year. "For February it shows the average of January and February for each year," HotWhopper reported. "For March, it's the average of the monthly anomaly from January to March." And so on until December, which is the "annual average temperature for the full year."

As the chart shows, 2015 has set a pace the other years can't keep up with. In all likelihood, 2015 warming will increase over the coming months due to the increasing temperatures in the east-central tropical Pacific associated with the current El Niño, as I discussed in my Saturday post. And that means 2016 could well top 2015.

Indeed, the U.K. Met Office reports that broader trends in the oceans "are consistent with a return of rapid warming in the near term." The long-awaited speed up in global temperatures is here.

Appendix E - Probing the deep: An in-depth look at the oceans, climate change and the hiatus
http://www.carbonbrief.org/blog/2014/10/an-in-depth-look-at-the-oceans-climate-change-and-the-hiatus/

Oceans cover more of the planet than anything else. So it makes sense that we need to know what's happening to them to understand how humans are changing the climate.

If you follow climate science, you'd be forgiven for being a little confused recently by different news reports suggesting the oceans are warming, slightly cooling or doing nothing at all.

So are the oceans hotting up or aren't they? And how does what happens beneath the waves influence what we feel up here on earth's surface? Here's our top to bottom look at the oceans and climate change.

More heat in, less heat out

Scientists have known for centuries that greenhouse gases in the atmosphere, such as carbon dioxide and methane, trap heat and warm the planet. This is known as the greenhouse effect.

Scientists use satellite measurements to monitor how much of the sun's energy enters earth's atmosphere. A different set of measurements tells them how much finds its way out again.

The difference between those numbers is increasing, which means the earth is trapping more heat than it used to. And that means the planet must be warming.

A hiatus in surface warming

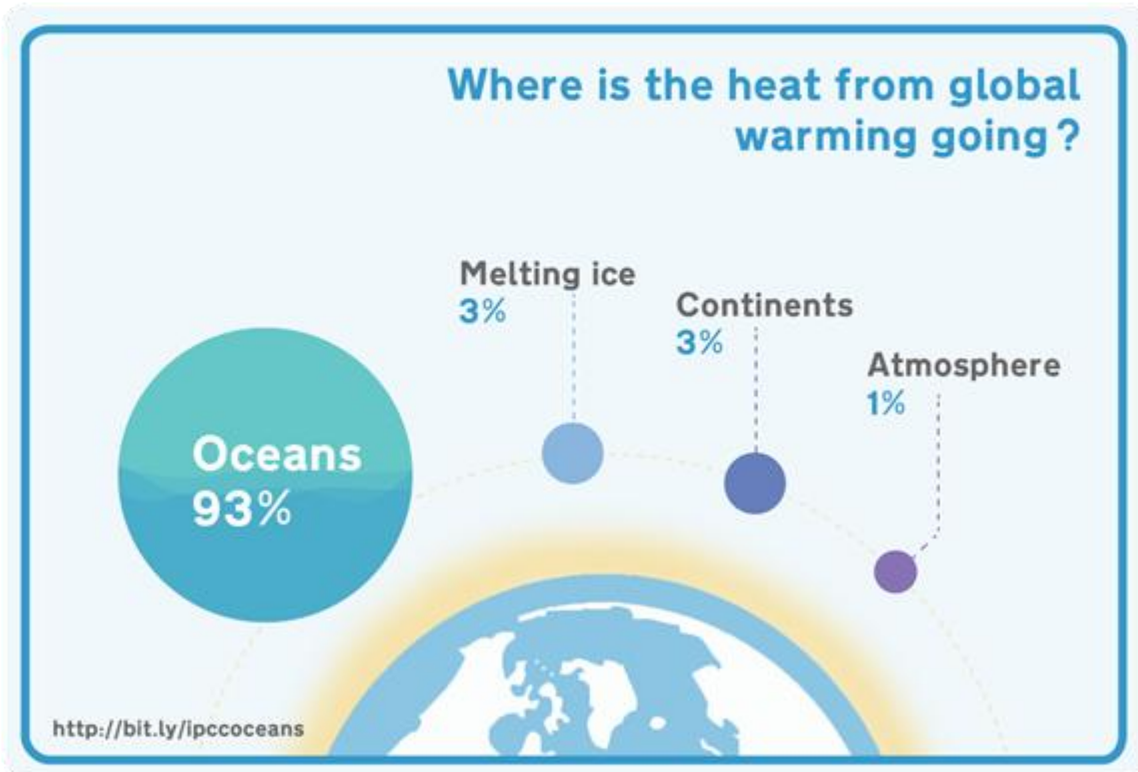
An interesting question is why temperatures at earth's surface - that's the air above land and the very top of the ocean - don't always reflect what's happening to the planet as a whole.

Over the last 15 years or so, surface temperatures have risen much slower than in previous decades, even though we're emitting greenhouse gases faster than we were before.

This is what's become known as the "hiatus", "slowdown" or even "pause" in surface warming.

This raises an obvious question. If earth is gaining heat but the surface isn't warming very much, where is the heat going instead?

Where does the heat go?



The scientific literature is full of discussions about where the extra heat might be ending up.

We tend to be most interested in what temperatures at earth's surface are doing, because that's where humans live.

But actually only about one per cent of trapped heat stays in the earth's atmosphere.

As the oceans absorb more than 90 per cent of the heat the planet traps, it makes sense to begin looking there for explanations of the changes we're seeing at earth's surface.

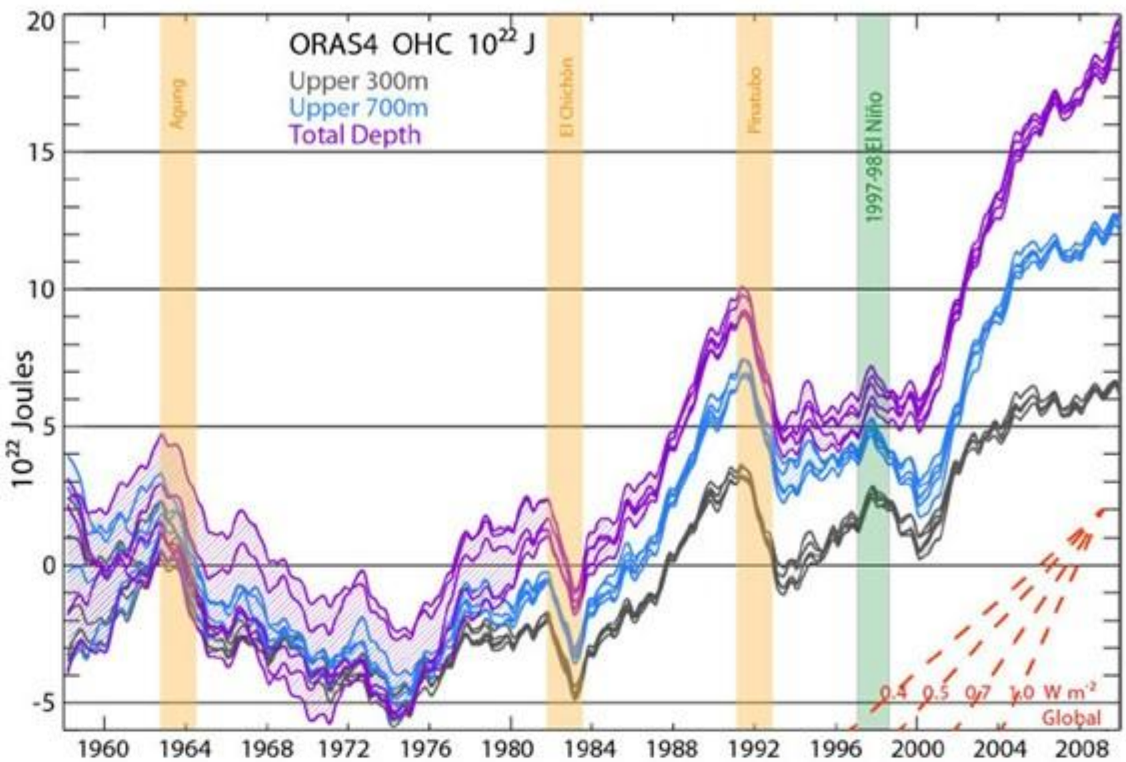
Looking to the ocean

Scientists have been taking the oceans' temperature for centuries - from the days of dipping a thermometer into a bucket of water beside a ship, to the satellites that now encircle the globe.

The coloured lines below use all the data scientists have available to show how the total amount of heat stored in the oceans changed between 1958 and 2009.

The blue lines are the surface down to 700 metres - this is generally referred to as the "upper ocean". You can see a warming trend starting in about 1975, punctuated by short, sharp cooling after major volcanic eruptions and the massive El Niño in 1998.

But since about 2005, the pace of upper ocean warming has slowed quite a bit - especially in the top 300m, shown by the black lines.



How the amount of heat in the oceans changed between 1958 and 2009. Top 300m (black), top 700m (blue) and total depth (purple). Source: Balmaseda et al., (2013)

While warming has been slowing down in the upper ocean, it's been speeding up in other parts. That means the oceans as a whole - shown by the purple line - are warming.

More heat is finding its way to the deep ocean instead of staying near the top. You can see this in the chart above - the gap between the purple line (whole ocean) and the blue line (top 700m) is wider now than it was in the early 2000s.

In fact, the data show the deep ocean - between 700m and 2,000m - is now warming fasterthan at any time in the last 50 years.