

the WINNOWER

[REDDIT](#)

We are Gavin Schmidt and Reto Ruedy, of NASA's Goddard Institute for Space Studies, and on Wed., Jan. 20 we released our analysis that found 2015 was the warmest year — by a lot — in the modern record. Ask Us Anything!

[R/SCIENCE](#) NASA EARTHRIGHTNOW

Hi Reddit!

My name is [Gavin Schmidt](#). I am a climate scientist and Director of the NASA Goddard Institute for Space Studies. I work on understanding past, present and future climate change and on the development and evaluations of coupled climate models. I have over 100 peer-reviewed publications and am the co-author with Josh Wolfe of "Climate Change: Picturing the Science," a collaboration between climate scientists and photographers. In 2011, I was fortunate to be awarded the inaugural AGU Climate Communications Prize and was also the EarthSky Science communicator of the year. I tweet at [@ClimateOfGavin](#).

My name is Reto Ruedy and I am a mathematician working as a Scientific Programmer/Analyst at the Goddard Institute for Space Studies. I joined the team that developed the GISS climate model in 1976, and have been in charge of the technical aspects of the GISS temperature analysis for the past 25 years.

You can read more about the NASA 2015 temperature analysis [here](#) (or [here](#), [here](#), or [here](#)). You can also check out the [NOAA analysis](#) — which also found 2015 was the warmest year on record.

We'll be online at 1 pm EST (10 am PST, 6 pm UTC) to answer your questions — Ask Us Anything!

UPDATE: Gavin and Reto are on live now (1:00 pm EST) Looking forward to the conversation.

UPDATE: 2:02 pm EST - Gavin and Reto have signed off. Thank you all so much for taking part!

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CORRESPONDENCE:

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How much did the warming El Niño trend contribute to this finding? Is there a way to 'normalize' the data for these types of oscillations?

[SirT6](#)

ENSO generally has an influence on the year following an event because there is a lag in the global response to tropical perturbations. The annual mean is most correlated to Nov-Dec-Jan ENSO index at the beginning of the year/end of the last year. Thus the 2015/2016 El Niño will most affect 2016, not 2015. However, we've been in El Niño conditions since the summer, and we saw an spike in Oct/Nov/Dec that was related to that.

UPDATE: Here's a calculation of this effect:

<https://twitter.com/ClimateOfGavin/status/690271546829586433/photo/1>

As one of the commenters points out below, you can normalise the index using these regressions, and get an ENSO-corrected version. 2015 would still be a record. - gavin

I feel like I often see conflicting reports about temperature trends. One is that each new year is the hottest year on record (as you have found), and another is that there has been a "pause" in global warming for the last 17-or-so years. For example there have been articles about how climate scientists

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have explained this pause by looking at deep ocean temperatures.

Where does the disconnect lie between the two? Is the "pause" based on cherry-picking data around the 1998 anomaly year?

[jorgfeflkd](#)

There are many ways to look at the data which all have some interest for some people. Working out what makes a difference from year to year or in any one decade etc. is an interesting study, and the shorter the interval, the more the attribution will be to internal climate oscillations (like ENSO) or short events like a volcanic eruption. The longer you look the clearer the attribution is greenhouse gases and 'global warming'. The shorter the period, the greater the noise.

People should be careful to distinguish between questions like why was 1998 warmer than 2011, and whether there is a change in the long term trend.

I put together a small animation to show that there is no evidence of a slow-down in the longer term trend: <https://twitter.com/ClimateOfGavin/status/689845553782493186>

But there is certainly lots of interesting science in (separately) trying to look at decadal variations in the short term. Some specific comments on the 1998-2012 period are available in a short article we wrote last year: <http://pubs.giss.nasa.gov/abs/ma03110j.html> - gavin

If humans were able to change Earth's climate so dramatically, do you think that in the near future we will be able to change another planet's climate enough to make it habitable?

Also, is there an irreversible point in the climate change, and if so, then where do we stand now?

[george_i](#)

What we are doing is fiddling with a thermostat - the amount of greenhouse gases in our atmosphere - turning it up. Changing the much stabler equilibrium of a planet is a totally different enterprise. There is an irreversible point, but we are not anywhere close to it in my opinion. Reto

I waited patiently in the queue to ask my question(s) yesterday, but never made it to the front. Hence I'm trying here instead!

We're often told that the Arctic is warming faster than most places on the planet, but

1) How do both NOAA and NASA handle surface temperatures over/under sea ice? Air temps or water temps or not at all? In the NOAA graphic in particular the Arctic seems to be a large "grey area"!

2) How, if at all, do the satellite and radiosonde graphs on slide 10 incorporate data from above the Arctic?

TIA

[JimHunt](#)

The NASA GISTEMP product is trying to estimate the surface air temperature globally since that is what we can most easily compare to models. In the open ocean, SST is a reasonable estimate of the SAT above (though see some recent work on that by Kevin Cowtan and colleagues), but SST under ice doesn't tell you anything about the air temperature above the ice (since SST is always going to be about -1.8°C). Thus we use interpolation from land-based weather stations. Comparisons of this to Arctic Buoy records shows a pretty good relationship. Satellite MSU records aren't great in the Arctic because of the changes in surface emissivity associated with ocean/ice transitions and miss some area near the pole because of their orbit. Additionally, the weighting functions of the satellites are generally focused above the lower boundary layers that are warming fastest in the Arctic. That's a contrast to the tropics where the atmosphere is more connected vertically through convection. - gavin

What do you say to those who have responded to this report by saying that, according to satellite observations, 2015 was not the hottest year in record?

[pensivebadger](#)

The satellite (MSU) records are important complements to the surface data, but have different characteristics that make simple comparisons tricky. First, they don't measure the same levels - satellites are integrating air temperatures up to 5 to 15km above the surface - so different things can be happening there. Second, the atmosphere is more affected by ENSO than the surface is (because the winds in the tropics homogenise the temperatures more) - by a factor of 2 or more. So the long-term warming signal is obscured by a higher level of 'noise'. Thirdly, putting together the satellite record is difficult - there are multiple satellites with individual calibrations to be made, drifts to be corrected for and with different overlaps. Historically there have been important systematic errors in these records which have been corrected over time, but there may still be other (unrecognised issues).

We can normalize the MSU records for ENSO and there is still a discrepancy between the MSU data and the surface. The balloon/radiosonde data are a useful point of comparison and that's a little mixed - the radiosonde surface data looks like the surface data, and the upper atmosphere numbers look somewhat like the satellites. - gavin

What do you say to the folks who don't believe your work? The folks that don't believe in global warming?

[MajorD](#)

'Belief' is not the right word. Scientists talk about anthropogenic global warming because that's the best explanation we have for a whole host of different observations we have that is rooted in basic (and well-understood) physics.

Some people have a hard time with this conclusion - often because of the perceived policy implications, sometimes because of more philosophical or religious objections, sometimes because of something they were told. It is rarely the case that just showing more science is helpful here and doing so can get frustrating.

But many people don't know what to believe because they don't know who to trust in a very polarised debate. For those people, if they have the time and inclination, inviting them to dive into the details for themselves can be useful and so being open and transparent with our codes, data and analysis can be useful. (Note that all the data and code for the GISTEMP analysis is available for all).

In other circumstances, it is helpful to find people who they do trust to be messengers to them or their community. - gavin

What do you say to the folks who don't believe your work? The folks that don't believe in global warming?

[MajorD](#)

All I can do in this case is remind them that nature is not kind to the unaware. The laws of physics will do their thing whether we accept them or not. I personally don't understand the law of gravity, nobody could explain to me why a stone falls to the ground without being pushed or pulled by something visible. However, I will not step off the roof of a high building expecting that my not understanding will protect me. Reto

What's needed in order for global warming to be considered a "fact" by all instead of just the ones who agree with the facts given?

Im just getting tired of how people don't seem to agree that global warming is an issue and im just

wondering whats needed to be made clear once and for all

[coccyx420](#)

You need to find the actual reason why people are resistant and address that. Many of these conversations are proxy conversations for something else entirely. - gavin

What can I do, as an individual or family, that can have the biggest impact? How can we compete with events like the natural gas leak in California?

[as1126](#)

Electing and working for a government that takes science seriously is probably your most potent weapon. Reto

Gavin, one thing that I think is missing from the headlines about 2015 is that it pales in comparison to projected global temperatures over this century.

Since El Nino contributed to 2015's warmth (and we might expect *relatively* lower temperatures for a few years -- e.g., post-1998 el nino), when might we expect temperatures similar to 2015 to become "normal"?

[lawdy lawd](#)

The current long term trend is ~0.15°C/decade, so for an anomaly like 2015 which is ~0.1°C above trend, you can expect 2015 levels to be normal in about 7 years. - gavin

What is the deviation on the temperatures? Is that growing as well? If so, would that mean that temperature swings are getting more dramatic, but trending up?

[nallen](#)

Finding evidence for changes in variations is always harder than finding evidence for changes in the mean, and I'm not aware of any convincing study that has suggested that temperature variations are increasing in time.

Locally, there are shifts towards warm extremes, and less cold extremes, but that is best characterised by a shift in the mean, rather than a spreading out of the tails. The story for precipitation is a little different, with an increase towards the more intense deciles. - gavin

What is the deviation on the temperatures? Is that growing as well? If so, would that mean that temperature swings are getting more dramatic, but trending up?

[nallen](#)

You are asking about the variability of temperature changes. I don't think there is any evidence yet for such changes. More time is needed for that. Reto

Are we seeing any evidence of feedback loops that would accelerate rising temperatures to a meaningful degree (yet)?

[spankmybuttock](#)

No - we are at the point where we can observe the trend, but not yet the changes of a trend. Reto

What would you say to the current Presidential Candidates (republican, democratic, and independent) about their stances on climate change? How would you attempt to change their minds? What is our best option to get society more invested in climate change and science in general?

Thank you for taking the time to read and answer questions.

[andlight91](#)

Speaking personally, I'd like all policy-makers to take this seriously and craft their policies on the environment and energy with as much input from the science community as possible. The resources available to help decision makers estimate the climate and air quality impacts of their choices are vast, and should be better utilized than they have been. - gavin

Atmospheric scientist here. Thanks for taking the time to do this.

I'm curious about how uncertainty is handled in computing average temperature. Do NASA and NOAA use significantly different assimilation techniques for computing global average temperature from observations? Do any of the techniques used provide a posterior estimate of the average temperature with well-defined confidence limits?

[bellcrank](#)

The best estimate of errors in these analyses is done using a full MC ensemble including the variation in possible choices, and the best version of that comes from the Hadley Centre in the UK. The spread of the ensemble, then gives you confidence limits for the record. Currently, the uncertainty for an individual year is ~0.05°C which gets larger further back in time. Most of this uncertainty is related to spatial sampling and we can get a good handle on that from the weather forecast models. - gavin

What's gong on with methane emissions from thawing Arctic regions?

[ksiyoto](#)

This is being closely monitored. There is evidence from paleo-climate and direct observations for an amplifying feedback from methane, but there isn't any evidence from the last few hundred thousand years that this is a large effect for temperatures near where we are now. Human emissions of methane (from mining, natural gas leaks, landfill, agriculture, etc.) have had a much more profound impact, more than doubling CH₄ levels over the pre-industrial level. The feedbacks we expect are much smaller than this, at least for the next few decades. - gavin

I heard that Earth has been through warming and cooling phases for a very long time. First, how do we measure what the Earth's temperature was before modern technology? Second, how do we decide what is natural global warming and what is human affected warming?

Thanks

[mantooth09](#)

There are lots of pieces of evidence of past climate changes - ice cores are important, cave records, ocean sediment etc. - and, yes, they do reveal a dynamic range of climate variability in the past - particularly before the Holocene (the current interglacial period). Understanding what causes those changes is a big part of climate science and an important test of the climate simulations that my group (and others) do.

The second part of your question refers to 'attribution' and for that we try and calculate the fingerprints of change that would be associated with any particular cause or some specific internal oscillation. For the 20th Century and more recently, we have looked at multiple possible causes - volcanoes, the sun, deforestation, air pollution and greenhouse gases and find that the human fingerprint is increasingly

dominant. The Bloomberg data visualization using our results is quite clear: <http://www.bloomberg.com/graphics/2015-whats-warming-the-world/>

and there is some more general discussion of the topic here:
<http://www.realclimate.org/index.php/archives/2010/05/on-attribution/> - gavin

I heard that Earth has been through warming and cooling phases for a very long time. First, how do we measure what the Earth's temperature was before modern technology? Second, how do we decide what is natural global warming and what is human affected warming?

Thanks

[mantooth09](#)

What you are saying is correct, but the speed of a trend is important. What we experience now is a change that is much faster than anything humanity experienced so far and it can only be explained by taking the greenhouse effect and the increase in greenhouse concentration into account. The models are extremely useful and trustworthy to answer that question. Reto

We know that the oceans are absorbing most of the energy, and that carbon dioxide is causing the oceans acidification. How soon until the ocean isn't able to absorb any more carbon dioxide? And how soon until it causes all of the ocean life to die? I realize that it is already affecting coral growth.

[zycamzip](#)

Eventually, all of the CO2 will be mopped up by the ocean and be buried in sediments - but that will take ~100,000yrs or so. In the meantime, there will be an ocean acidification signal that starts at the surface and slowly makes its way down to the depths. Read up on the Paleocene-Eocene Thermal Maximum for an example of something analogous 55 million years ago. - gavin

From what I know, one of the major climate change factors is fossil fuel burning. I also know that the fossil fuels available for extraction (specifically oil) is going to run out eventually. If we were to keep on increasing our fossil fuel burning (which would be a terrible decision), how drastic would the changes to our climate be when all the approximated fuels have been used up? How reversible would this affect be?

I ask this only to imagine the worst case scenario where the governments of the world don't take appropriate action to fix the problem,

[Zeinoun](#)

I don't know and hopefully we will never get to that point. It will definitely be a different planet, less habitable. But our models are not equipped to handle enormous changes - inevitable surprises are not programmed in. Models are too conservative. Reto

How can I best convince my educated, intelligent friend that climate change is caused by human activity (acknowledging that it may not be possible to convince him at all)?

[Schump97](#)

Listen to them first, and find out what their real concern is. It is very likely not what you first thought of. - gavin

Let me preface this by saying that climate change is absolutely real and the amount of carbon dioxide

being pumped into the atmosphere is more likely than not causing global warming.

That said, after reading and interpreting the Vostok ice cores experiment from which a lot of climate change theory is based on, why are we so preoccupied with yearly fluctuations of temperatures? The predictions clearly show that the levels of CO2 operate on a time lag with assumed temperature differences, on an order of thousands of years.

Even quibbling about that, the CO2 cycle for the earth is approximately 100,000 years long. We can quote records as much as we want but scientists that rely on making assessments about global health based on computing yearly data seems incomprehensible to me. Why are we so concerned with (relatively) minor fluctuations around the mean when in truth people are worried about the greater trend for the future - looking forward thousands of years?

Thank you so much for your time guys, hope to hear from you.

[nickphoto](#)

We are talking about totally different time frames. The CO2 problem is relevant for the next few decades/centuries. The forcings that caused the ice ages are much too slow to have an effect for that period. Not being a prophet, I will not make predictions about what could happen in the next few thousand years, however I am concerned what kind of a planet we leave for the next few generations.
Reto

Climatologist Jason Box tweeted "we're f'd" a year ago and moved to Sweden. [Esquire wrote an article about it earlier this year](#) saying "**Among many climate scientists, gloom has set in. Things are worse than we think, but they can't really talk about it.**"

Would you talk about it? Do you feel gloom and doom? Are things worse than we think?

[toccoblator](#)

I was quoted in that article, and no, I don't feel 'gloom and doom'. There are many signs that people are taking this seriously and many positive developments (including Paris). I don't think nihilism is the right attitude on this, or much anything else. - gavin

Hey Gavin and Reto! I had two questions I wanted to ask you:

Is there any way to tell if the warming of our planet is completely caused by mankind's actions, partially caused by man partially caused by natural heating-cooling cycles of the earth, or completely caused by natural cycles?

Also, this is a bit of a tangent regarding climate change, but what's your opinion on Elon Musk's idea to explode nuclear devices at the poles of Mars to sublimate carbon ice?

Thanks for taking the time to chat!

[BurstSloth](#)

See the response to the earlier question:

https://www.reddit.com/r/science/comments/41zr2t/science_ama_series_we_are_gavin_schmidt_and_reto/cz6s1zx

Is the warming arctic ocean going to destabilize the methane clathrates in the East Siberian Arctic Shelf. I've read opinions ranging from any day now to extremely unlikely. I do note the maximum atmospheric temperature anomaly was over Siberia as well.

[someguyinthebeach](#)

Very unlikely. - gavin

Hi Gavin, I'm a huge fan and I really appreciate you taking the time for this AMA. Do you have any data or evidence of climate related events or phenomena you didn't expect to see? I'm just curious if there are changes happening that may be catching you and your team off guard. What is the scariest part of abrupt climate disruption in your opinion?

[DjingoismUnchained](#)

2015 was a big deal. I didn't see that coming last year... - gavin

Dr. Schmidt,

Elon Musk has mentioned heating up Mars for eventual colonization by humans by detonating a nuclear bomb. What are your thoughts on this? What would you say needs to be done to create a less hostile climate and livable human conditions on Mars?

Others may have asked already, what things could the U.S. do at this point to help remedy global warming on Earth?

Thank you for your time!

[Grace-Tech](#)

Not my field, sorry! - gavin

How would you respond to people like Judith Curry who is trying to show that all climate warning data is flawed and should not be trusted?

[akivest](#)

No science is perfect; that does not mean that scientific results are useless. The important thing is to estimate the reliability, the margin of error. In many cases, science gives you an idea how probable certain results are. Reto

The recent maps show an area of "persistent cooling" in the North Atlantic. I think I've read this may be caused by Greenland meltwater. Is this correct and is this phenomenon included in current climate models? What are the possible consequences of this cool zone?

[dfume](#)

I'm not so sure that meltwater is necessarily the cause - it may be related to the overturning, but it could be simple internal variability or a response to warming more generally. This needs more investigation though - gavin

I have a friend who touts that because we have only been keeping temperature data since 1880 this doesn't demonstrate anything important. How would you respond to this?

[Jyran](#)

We have a lifespan of ~75 years. We should be interested in changes on that time scale. - gavin

Do you think 2016 will break the record again?

[Collawrence](#)

I'd give this better than evens odds. - gavin

I did a quick search and found that for some decades now, the global temperature has been rising. Can we bounce back? If we were to impose large taxes and increase usage of alternate energy sources, can we undo the decades of temperature rise?

[TimeKeeper2](#)

No. The planet has not yet caught up to the emissions so far, and we are continuing to increase emissions. So it's highly unlikely we are going to turn things around to undo the rise so far. The challenge is to limit the rise to come. - gavin

Thank you for doing an amazing and important job! I've heard that global warming will affect different regions of the earth differently, and that some areas may even become colder as winds and currents and such may change. Is this true, and if it is, can you see such differences already?

[Damejeanne-vandamme](#)

The changes we are talking about are very small compared to regional daily temperature changes. Some regions may well be favored by the current changes, but as global warming progresses, the damages (inundation, droughts, etc) will be much worse than the benefits. Reto