

Science AMA Series: We just published a paper showing recent ocean warming had been underestimated, and that NOAA (and not Congress) got this right. Ask Us Anything!

*ocean_warming_AMA*¹*and/ScienceAMAs*¹

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Abstract

Hello there /r/Science! We are a group of researchers who just published a new open access paper in Science Advances showing that ocean warming was indeed being underestimated, confirming the conclusion of a paper last year that triggered a series of political attacks. You can find some press coverage of our work at Scientific American, the Washington Post, and the CBC. One of the authors, Kevin Cowtan, has an explainer on his website as well as links to the code and data used in the paper. For backstory, in 2015 the National Oceanic and Atmospheric Administration (NOAA) updated its global temperature dataset, showing that their previous data had been underestimating the amount of recent warming we've had. The change was mainly from their updated ocean data (i.e. their sea surface temperature or "SST") product. The NOAA group's updated estimate of warming formed the basis of high profile paper in Science (Karl et al. 2015), which joined a growing chorus of papers (see also Cowtan and Way, 2014; Cahill et al. 2015; Foster and Rahmstorf 2016) pushing back on the idea that there had been a "pause" in warming. This led to Lamar Smith (R-TX), the Republican chair of the House Science, Space, and Technology Committee to accuse NOAA of deliberately "altering data" for nefarious ends, and issue a series of public attacks and subpoenas for internal communications that were characterized as "fishing expeditions", "waging war", and a "witch hunt". Rather than subpoenaing people's emails, we thought we would check to see if the Karl et al. adjustments were kosher a different way- by doing some science! We knew that a big issue with SST products had to do with the transition from mostly ship-based measurements to mostly buoy-based measurements. Not accounting for this transition properly could hypothetically impart a cool bias, i.e. cause an underestimate in the amount of warming over recent decades. So we looked at three "instrumentally homogeneous" records (which wouldn't see a bias due to changeover in instrumentation type, because they're from one kind of instrument): only buoys, satellite radiometers, and Argo floats. We compared these to the major SST data products, including the older (ERSSTv3b) and newer (ERSSTv4) NOAA records as well as the HadSST3 (UK's Hadley Centre) and COBE-SST (Japan's JMA) records. We found that the older NOAA SST product was indeed underestimating the rate of recent warming, and that the newer NOAA record appeared to correctly account for the ship/buoy transition- i.e. the NOAA correction seems like it was a good idea! We also found that the HadSST3 and COBE-SST records appear to underestimate the amount of warming we've actually seen in recent years. Ask us anything about our work, or climate change generally! Joining you today will be: Zeke Hausfather (@hausfath) Kevin Cowtan Dave Clarke Peter Jacobs (/u/past_is_future) Mark Richardson (if time permits) Robert Rohde (if time permits)

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Traditionally, scientists are taught to remain unbiased and to avoid political discourse, sticking to just presenting the data. In a political era of misinformation and post-truth, it seems to have become a moral obligation for the climate science community to have a more passionate and public role in communicating the implications of climate change.

How do you appropriately balance the demands of doing 'good science' while stepping up to the plate to advocate for action on anthropogenic climate change and to communicate the complexities of the climate system?

I'm a first year PhD student in atmospheric & oceanic science and work primarily in quantifying internal variability in model projections. I can already see that *advocacy* may be an important role in my future as a scientist, which isn't the norm in most fields. I want to make sure I act appropriately as an advocate for this issue, without poorly impacting my role as a scientist.

[bradyrx](#)

Hello there!

Thanks for a great question! As a fellow PhD student, let me take a quick moment to give you a virtual fist bump in solidarity over the work ahead.

Speaking only for myself here-

I happen to agree with the line of argument that, as with journalism, science has fallen into a trap of trying to appear to be a sort of view-less source of pristine objectivity that isn't how any individual really operates in the real world, and that this is ultimately going to undermine scientists' credibility with the public in the long run.

Everyone has biases, prejudices, hopes, fears, etc. I think a lot of scientists are afraid that if they're perceived as advocates that this will cost them public trust. But what I think those people fail to understand is that the part of the public that is already likely to turn on them probably already has, and are probably already imputing to them motivations far more nefarious than even their own worst sins.

Even scientists who are not necessarily strongly personally political probably advocate for things all the time whether they realize it or not. Just arguing that science is a public good and deserves funding is a type of advocacy, yet a lot of researchers I know who are scared to be considered advocates have no qualms about advocating for those kinds of positions.

Engaging in advocacy is a personal choice, but research that some of my colleagues at George Mason in the social sciences are working on suggests that it's not nearly as off-putting to the public as one might fear.

There's also the issue that has been raised by social scientists that the tone and actions of people talking about climate change don't seem to match the magnitude of the consequences we say will occur if we don't rein in emissions. The fact that we're not running around screaming at the top of our lungs when we're talking about driving famine, flooding, wiping out species, etc. creates a sense of dissonance for the public.

So for me personally, I think science is going to suffer if people are scared to speak up, to speak out, to act out. And very much will suffer if we're cowed into not tackling subjects that have political implications. **Just taking the temperature of the Earth or measuring the amount of CO2 in the air has political ramifications.** I don't think trying shove my head in the sand and hope to never appear biased is going to help anyone.

tl; dr: I believe (and there is some social science evidence to support) that clearly articulating one's own position about what you think and believe actually defuses a lot of the negative consequences that are feared to accompany being seen as an advocate.

Now I should caveat all of this heavily. I think it may strongly depend on the cultural environment one is talking about. I have noticed that my European colleagues both seem to be far more reluctant to be perceived as advocate and that they also seem to maybe not really fully understand how different the situation is in the US with regards to topics like climate science, evolutionary biology, reproductive health, etc.

~ Peter

What in your opinion is the probability that there are other yet unnoticed flaws in current research that could cause similar under/over estimations of the effects of global warming?

[Scrapheaper](#)

That's a good question.

When it comes to the weather station record, I think we've got a pretty good handle on it because the data is massively redundant - we can work with quite small subsets and get the same results.

However the sea surface temperature record is another matter. The adjustments are large and uncertain, and because the ships move about and change their properties with loading it is rather harder to make an assessment of bias. This is apparent in the differences between sea surface temperature records on a multidecadal timescale - see this new paper for an indication of the problem: <http://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-15-00251.1>

I think now that we have multiple independent sources we have a fairly clear picture of the last two decades. But I think that there are going to be further changes to the sea surface temperature record. We know for example that ERSSTv4 has a spurious feature in WW2.

~Kevin Cowtan

I have seen some recent post about the North Atlantic current might get disrupted by global warming. What would this look like and where would the current go instead?

[turkey45](#)

Interestingly the latest paper on this came out in the same journal as ours, on the same day. Read about it here: <http://www.realclimate.org/index.php/archives/2017/01/the-underestimated-danger-of-a-breakdown-of-the-gulf-stream-system/>

In many ways it is a much more interesting paper scientifically, and I'm sad it was competing for attention with ours. Ours of course got more attention mainly because of the manufactured controversy around the NOAA study.

~Kevin Cowtan

To me, every new bit of information seems to paint a darker picture. Never it's a new finding of a mitigating factor in climate change.

Is it hopeless?

[AlmostTheNewestDad](#)

Hi Almost,

I for one think there is a lot to be hopeful about. Pretty much every country on Earth got together last year in the largest meeting of world leaders in history to hammer out an agreement to address climate change. Its not a solution in and of itself, but its a good first step and shows that the international community is taking this problem seriously.

At the same time, cleantech is advancing at breakneck speeds. Countries and private individuals are putting close to a trillion dollars into research, development, and development, with China announcing just this week announcing that they will be spending \$361 billion by 2020.

Prices of solar, batteries, and wind have fallen precipitously in recent years, and the majority of electricity capacity (though not generation quite yet) installed in the U.S. last year was renewable. There are now regions where renewables outcompete both coal and gas without subsidies (though with a caveat that intermittency may incur additional costs at large scales of deployment).

In short, its not all grim.

-Zeke

To me, every new bit of information seems to paint a darker picture. Never it's a new finding of a mitigating factor in climate change.

Is it hopeless?

[AlmostTheNewestDad](#)

Hello there!

This is a great source of confusion, and I think that it's an area in which the public has really been done a disservice by communicators.

Climate change is not an all or nothing scenario. I think people have been led to believe it's either something that we fix 100% or something we fail 100%, and that's just not the case.

It is too late to avoid changing the climate at all- we've been doing it for centuries if not millennia (cf the Early Anthropocene hypothesis). But how much further anthropogenic change we can avoid is up to us. It can be a lot, or a little, or none. So any mitigating action we take will avoid some climate change, therefore there's always something to be hopeful about.

In terms of hopeful information, I think that the advances not just in clean energy technology but the economics of clean energy are an enormously hopeful sign. Maybe the least reported, best news on this whole subject. Even in the absence of a strong carbon price (i.e. setting aside climate change) there are already places where it's already just financially smarter to use clean energy rather than fossil fuels.

To be sure there is enormous work left to do, politically, economically, technologically. But a future in which we avoid the worst impacts of climate change while improving lives overall is very much still possible.

If the question was more on the physical science side, as in "we never hear about a large negative (i.e. dampening) feedback that will save us from climate change without us having to do anything", then no there's no good news coming on that front. We've got basically the entire paleoclimate record stretching back many millions of years telling us the climate is in fact sensitive to changes in energy like what we're doing now by increasing greenhouse gas levels.

~ Peter

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[\[deleted\]](#)

I'm not aware of any *mainstream* predictions 8 degrees. The most aggressive IPCC scenario runs to about 6 degrees, but that requires extracting a lot of the more expensive and harder-to-access fossil fuels and maintaining massive industrialization in a rapidly changing world. It's hard to see how that could happen. The highest emissions scenarios are probably even harder to achieve than the lowest.

Also the predictions of imminent massive Arctic methane emissions come from only a handful of researchers, and are not widely accepted in the climate science community.

~Kevin Cowtan

Have we already passed the tipping point where this trend can be reversed? If so, will this trend continue to escalate since the process seems to feed off of itself?

[bom_chika_wah_wah](#)

Hello there!

If you're asking about whether we're on a trajectory for a runaway positive feedback, the answer is no.

The amount of warming we will see is going to be larger than just what we would expect from our direct changes in energy (radiative forcing) alone would imply- in that sense the net response of the climate system feedbacks is positive on human timescales. But we can still very much stabilize our influence on the climate system by cutting emissions.

~ Peter

Hi everyone and thanks for the AMA!

My question is for Dr. Cowtan. First I want to thank you for all your hard work - I work in crystallography and have made extensive use of your software for my own research.

My question: How did you bridge the gap between these fields and get involved with climate science from such a different field?

[superhelical](#)

Largely coincidence. I encountered people arguing about climate science and thought 'I ought to be able to settle this'. Unfortunately it turned out to be harder than I thought, because there were so many sources. I eventually I had to go back to the raw data and produce my own version of the temperature record. After that I encountered people arguing about which version of the temperature record was better, and I got really interested in the differences. I've been working on that ever since. Bridging the gap wasn't so hard - data analysis is the same in any field. However there have been some ideas from crystallography which have helped in my climate work. For example I've made a lot of use of cross validation and hold-out tests, inspired by the use of the Free-R factor in crystallography.

-Kevin

How can someone who is just a regular old guy know what is evidence and what is just speculation?

[Piscotikus](#)

Hi Piscotikus,

In science we have facts, which are observations, and theories, which are hypotheses to explain observations.

For climate we observe global temperatures to be rising:

https://s30.postimg.org/ix9a5qku9/global_temp_comps_1880_2016.png

We observe sea levels to be rising: <https://i1.wp.com/climateadaptation.hawaii.gov/wp-content/uploads/2015/11/Brief-1-Figure-4.png>

We observe sea ice to be decreasing:

https://nsidc.org/sites/nsidc.org/files/icelights/files/2010/11/mean_anomaly_1953-2010.png

We observe atmospheric CO2 and other greenhouse gases increasing:

https://www.esr.org/outreach/climate_change/mans_impact/co2_new.jpg

We hypothesize (based on the physics of radiative transfer) that addition greenhouse gases warm the earth. We develop physics-based models to predict how the Earth's temperature will change. These models do a pretty good job of predicting both current and past temperatures:

https://s29.postimg.org/3rzfkedg7/Models_and_observations_annual_1880_2020_baselin.png

We hypothesize (based on these models) that with emissions unabated we will end up with somewhere around 4 degrees C (7 degrees F) warming globally by 2100, though there will be about ~30% more than that over land (where we all live).

-Zeke

How can someone who is just a regular old guy know what is evidence and what is just speculation?

[Piscotikus](#)

Great question!

So this comes down to evaluation of sources, which is one of the skills of critical thinking. Unfortunately, in the presence of carefully prepared misinformation, it's pretty hard.

One way is to check for yourself. But that takes a lot of time, and potentially a fair bit of skill, depending on what you are checking. I'm a big fan of citizen science - it's how I got into climate - but we can't expect everyone to have either the time or the skill to replicate the science for themselves.

Otherwise I'd start like this. Whenever you see a climate story in the media, hunt back till you get to the primary source. Then compare the original source to the story. That'll give you an idea of the reliability of different media organizations.

Also look into the nature of the primary sources. What is the balance between evidence and persuasive language in the primary work? Are the data available? Can the work be cross-checked against other research? How does it fit in with other fields of science?

~Kevin Cowtan

The issues of ocean warming, global warming and climate change are clearly complex and can be difficult to understand at a deep level without prior technical training. If you only had one plot/graph to show to the general public that demonstrates that global warming is real and has major consequences, what would that plot/graph be?

[edwinksl](#)

Hello there!

If I could cheat and not rely on a static graph, I'd go with this nice visualization piece by Bloomberg:

<https://www.bloomberg.com/graphics/2015-whats-warming-the-world/>

~ Peter

The issues of ocean warming, global warming and climate change are clearly complex and can be difficult to understand at a deep level without prior technical training. If you only had one plot/graph to show to the general public that demonstrates that global warming is real and has major consequences, what would that plot/graph be?

[edwinksl](#)

For me NASA's GISTemp global temperature record since 1880 is pretty startling and compelling (and note 2016 will be even hotter than 2015): http://www.realclimate.org/images/gistemp_pre1_2015.jpg

-Zeke

The journal publishing scientific work is often an indication of the quality of that work. The journal you've published in, *Science Advances*, is a new journal (first published articles in 2015) with little prestige,

which has received criticism for forcing authors to pay additional fees to allow for the commercial re-use of their work.

This in mind:

Was this paper rejected for publication by better known journals (and if so, why)? Or did you have some reason for choosing *Science Advances* specifically (if so, why)?

[Baldwon](#)

Hi Baldwon,

Science Advances is a new(ish) journal, but its part of the family of journals run by the American Association for the Advancement of Science (AAAS) and generally considered high impact. Its sister journal Science (along with Nature) is the most prestigious scientific journal in the world. The page fees cover open access to the journal article, and are comparable to the open access fees (~\$3k) charged by other journals.

In terms of the trajectory this paper took, it was originally submitted to both Nature and Science, both of whom liked the paper but ultimately decided it was not of broad enough scientific interest (both of whom have ~5% acceptance rate). Science passed it along to Science Advances, where it was published.

In general, it is harder to get replication papers (which ours largely was) published, which is a bit of shame given the ongoing replication crisis in some fields of science. We discuss this a bit in our recent Scientific American op-ed: <https://blogs.scientificamerican.com/guest-blog/political-investigation-is-not-the-way-to-scientific-truth/>

-Zeke

Would you mind detailing where you got your funding from for this study?

Further, what's your response to those who think/suggest that work like yours is funded by (and thus possibly biased by) organizations or people interested in pushing a "climate change myth agenda"?

Full disclosure: I'm also a scientist (a biologist) and I know I could look up your funding, since that information is likely publicly available. I'm asking this so I can link your response to people who think that work like this is the result of scientists being "paid to give" the desired results. Claims such of these make my blood boil in general, but they are so commonly leveled against climate change scientists in this day and age that I was wondering if you'd be interested in giving a response.

P.S. Great work! ~*high five*~

[sssasssafrasss](#)

I do my climate work primarily in my spare time, and unfunded.

My day job is funded by an independent research fellowship from STFC, which in turn is paid for from the fees raised by licensing my software and that of my colleagues to companies in the biotech sector.

~Kevin Cowtan.

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P.S. Great work! *~high five~*

[sssasssafrasss](#)

This work was a side project for all of us, with no dedicated grants. Thankfully we all have employers who are willing to support us in doing research that we are interested in even if it won't directly bring in more funding (or, in the case of a few of the authors, we care so much about it we are will to do extra work on nights and weekends).

-Zeke

How much of a role do you believe people play in environmental issues such as global warming & ocean warming? The earth has gone through many different phases. How long is it realistic to expect the earth's climate to remain as we know it?

[Dingus21](#)

Hi Dingus,

We have overwhelming evidence that the majority of warming (both ocean and global) in the past 50 years is due to human activities. For some background on the science, see this recent report (written for a lay audience) by the U.S. National Academy of Sciences and the U.K. Royal Society:

<http://dels.nas.edu/resources/static-assets/exec-office-other/climate-change-full.pdf>

Regarding natural changes to the Earth's climate, while it has certainly changed in the past (witness ice ages), it tends to do so at a fairly slow rate over thousands or tens of thousands of years. Recent warming, by contrast, is much more rapid. This recent comic by XKCD provides a good depiction of recent warming in the context of the past 20,000 years (there are more scientific sources I could provide you, but this one is a lot easier to understand!): <https://xkcd.com/1732/>

We also have a pretty good understanding of natural climate forcings (changes in solar output, changes in the Earth's orbit, volcanoes, etc.) in recent years, and none of these can explain recent warming. If anything, natural factors would have resulted in a slight cooling in the last 50 years:

<https://www.epa.gov/sites/production/files/2016-07/models-observed-human-natural.png>

-Zeke

I've read that most scientist are against geoengineering techniques such as iron fertilization. I'm using iron fertilization as an example of the type of situation that I'm describing and I'm not trying to have a discussion on iron fertilization.

Are there geoengineering techniques that could help us stop or roll back global warming? If there is or were, would you be in favor or against using said technologies and why?

[javo93](#)

This isn't something we really address in our paper, but there has been a lot of focus in the scientific

community in recent years on geoengineering through solar radiation management by injecting sulphur dioxide (or other similar reflective aerosols) into the stratosphere. Essentially, creating artificial volcanoes to cool the Earth (similar to the way natural volcanoes behave).

There are a couple downsides. First it doesn't in any way solve the underlying problem, just buy us time. Second, if we ever stop doing it without reducing atmospheric greenhouse gas concentrations we will experience very rapid warming back to where we would have been without geoengineering. Third, models suggest it could change or disrupt precipitation patterns in ways that could negatively impact some regions. Finally, it would make the sky less blue, which some people wouldn't really like.

But it would give us a way to buy more time to solve the problem if we can't get our act together in the next few years. But its certainly not an excuse for inaction today.

-Zeke

How far are we actually from the methane clathrate gun, given this underestimation of ocean temperatures?

[slayerz](#)

The imminent methane clathrate gun idea comes from quite a small but vocal group of scientists, and is not very widely accepted in the broader climate science community.

~Kevin Cowtan

Could you explain a bit more in depth the differences between the Argo datasets in your [new Science Advances paper](#)? The RG2009 dataset (the one I am most familiar with) is quite different from the other two. In particular, I don't understand how APDRC used Aviso Sea Surface Heights for such a mapping. Anyways, I've been looking for a paper like this so thank you guys for your work!

Edit: thanks for linking the new paper

[HenriDrake](#)

That's a very good question, and one which we would really like to answer. Unfortunately while we made a little progress on it, we didn't reach a conclusion. I suspect the Argo people will need to look at it.

What we do know is that the co-located ADPRC and H2008 time series are much more similar to eachother than to RG2009. And that the buoy record is more similar to ADPRC and H2008 than to RG2009, although the differences are a bit bigger between buoy and Argo than between Argo and Argo. That pattern is preserved even if you eliminate the trend difference. So the most parsimonious explanation is to identify RG2009 as an outlier, and the remaining Argo-buoy difference as arising from differences in sampling locations or similar.

We also tried correlating the difference between H2008 and RG2009 with the map series, which suggested that the differences are concentrated in the ENSO region. However I haven't done enough of that kind of calculation to draw a conclusion.

Finally, the differences do not look like depth effects. The depth effects are small to 20m. They get much larger to 50m, but they are conserved across the Argo datasets and don't look like the differences between the Argo datasets.

(p.s. This is all from memory: if you are need any of this for further research email me and I can check

my notes.)

~Kevin Cowtan

There is a [quote I remember from Gavin Schmidt](#) that, I think, sums up how many people feel about the discussion of whether there was a slowdown in the pace of global warming in the early 2000s:

Gavin Schmidt, director of NASA's Goddard Institute for Space Studies in New York, is tired of the entire discussion, which he says comes down to definitions and academic bickering. There is no evidence for a change in the long-term warming trend, he says, and there are always a host of reasons why a short-term trend might diverge — and why the climate models might not capture that divergence.

"A little bit of turf-protecting and self-promotion I think is the most parsimonious explanation," Schmidt says. "Not that there's anything wrong with that."

To what extent do you agree with Gavin? Is this discussion mostly an artifact of academic bickering? Is there room for nuanced discussion about the short term zigs in the warming data? Or do you think the issue has become too politicized?

[SirT6](#)

Hello there!

Speaking for myself, I am squarely on the side that argues that the "hiatus/pause" whatever was grossly overblown. And I do indeed think that after problems with the initial claims were pointed out, some folks had a problem backing down gracefully and just moved goalposts.

That being said, there's no such thing to me as too much discussion of either variability or longer term trends. I think one of the coolest things to come out of the field recently is the advent of large ensembles (e.g. the CESM [LENS](#) and [LME](#) projects) to explore exactly this tension.

~ Peter

There is a [quote I remember from Gavin Schmidt](#) that, I think, sums up how many people feel about the discussion of whether there was a slowdown in the pace of global warming in the early 2000s:

Gavin Schmidt, director of NASA's Goddard Institute for Space Studies in New York, is tired of the entire discussion, which he says comes down to definitions and academic bickering. There is no evidence for a change in the long-term warming trend, he says, and there are always a host of reasons why a short-term trend might diverge — and why the climate models might not capture that divergence.

"A little bit of turf-protecting and self-promotion I think is the most parsimonious explanation," Schmidt says. "Not that there's anything wrong with that."

To what extent do you agree with Gavin? Is this discussion mostly an artifact of academic bickering? Is there room for nuanced discussion about the short term zigs in the warming data? Or do you think the issue has become too politicized?

[SirT6](#)

I would agree with Gavin that there was never any compelling evidence of a change in the long-term trend. The simple reality is that 10-15 years is nothing at all when it comes climate. For much the same reason, no one should panic about the last few years of exceptional warmth. We don't yet understand these small, short-term fluctuations well enough to be able to say what they mean.

Words like "hiatus", "pause", and "slowdown" conjure up a vision of some fundamental change in the underlying process of global warming. Such words have power, and in this case, probably much more power than they deserve.

However, I would also suggest that understanding the short-term changes is still important. Weather and climate are ultimately physical processes. Complicated, chaotic, and challenging physical processes, but they aren't random or magical. In the medium-term weather variations are a complex blend of internal variability (e.g. El Nino) and external forcings (e.g. greenhouse gases, air pollution, solar activity, etc.). As scientists we need to understand both the potential patterns of internal variation and the important external driving factors.

We'll never have perfect knowledge of the weather or climate. However, we should care whether or not our models can explain the decade-to-decade changes. The "bickering" about the last decade is a sign that as scientists we still have room to improve. If we all agreed about what was happening and why, there would be nothing to bicker about.

-Robert

Is there a source of the buoy data on-line somewhere?

[Justdoitalways](#)

We provide links to all the data used at the end of the paper:

<http://advances.sciencemag.org/content/3/1/e1601207.full>

Buoys come from ICOADS, available here: <http://icoads.noaa.gov/products.html>

-Zeke

What is your next challenge?

[WTFCarlos](#)

Figuring out what happened to ocean temperatures during the WW2 period (the official records produced by various groups disagree a lot during that period).

Also, figuring out why satellite-based microwave sounding unit measurements show less warming over land than surface observations (they are pretty similar over the oceans). They are measuring two fairly different things (surface vs. 3 miles up in the atmosphere), but should probably agree more than they do.

A few other projects as well...

-Zeke

Hi there- I was just wondering if you had seen Judith Curry's response to your paper, and what your rebuttal to her would be?

<https://judithcurry.com/2015/06/04/has-noaa-busted-the-pause-in-global-warming/>

I personally think she is full of hot air, but I'd like an educated response to her points if possible

[airwalker12](#)

Hello there!

That isn't a response to our paper. It's a criticism of the original 2015 Karl et al. *Science* paper. Her complaints about the post-1998 ocean data adjustments made by Karl et al. are exactly what we tested in our paper, and we found that the new version of ERSST was more accurate than the previous one (i.e. the adjustments seem valid and necessary).

On her blog from what I've seen, Curry does a lot of "I'm not convinced of X"; "Y might be an issue"; "we need more study of Z" but doesn't seem to back any of her concerns up with actual analysis.

She was suspicious of the post-1998 adjustments but didn't do any tests. We did. The adjustments were good. Science beats thinking with your gut. The end.

Weird, huh?

I personally think she is full of hot air, but I'd like an educated response to her points if possible

I am going to refrain from editorializing further, but I am not going to argue with your assessment.

~ Peter

My Grandparents and father are 70+ years old immigrants from the former Soviet Union, they came to the USA in 1980. My father is a software engineer and my grandpa a dentist and neither believe in climate change/global warming/whatever you want to call it. They believe that "Scientists are making all of this up to make money," while I try to reason with them oil companies hid all this info for decades because there's way more money in hiding these results. I guess my question is how do I get them to start taking this stuff seriously?

[JewFaceMcGoo](#)

If scientists are making this up to make money, we aren't very smart. We get paid a lot less to do science than nearly anyone with equivalent education or quantitative skills in the private sector. A tenured professor (who has been teaching for 20 years) makes the same in many places as a software engineer right out of college.

In terms of convincing your grandparents, you could try explaining the science (this NASA page is helpful: <http://climate.nasa.gov/evidence/>). Alternatively, if you don't want to get into the technical details, you could simply tell them that pretty much every scientific society on Earth agrees that its warming and we are the cause: https://www.opr.ca.gov/s_listoforganizations.php

-Zeke

If someone wanted to pursue a career in this area of science, what would they have to do/be interested in to do well?

[Leethorne](#)

Develop good quantitative skills. Knowing how to code goes a long way in science today. Python or R are two good choices.

Also take a decent amount of physics.

-Zeke

It seems like many of the climate models have been wrong in the past. This paper corrects a previous paper. How do you explain to skeptics that we have a good understanding of climate change?

[Optioncrops](#)

Climate models are far from perfect, but have generally done a good job at predicting temperatures. For example: [Models and observations annual 1880-2020 baselin.png](#)

-Zeke