

A Handy Guide for Climate Skeptics

A Serious (but not Solemn) Conversation about Global Warming

Okay, so you're not a climate scientist. Maybe you're a climate skeptic, or even a politician, and you don't know whether to believe what climate scientists say. The problem is, you don't want to say stupid things like 'the planet is warming because the Sun's getting brighter' or 'all the thermometers are in big cities and we have a well known urban heat island effect'. You'd rather say sensible, thoughtful things like 'it now seems likely that the wheat crop in Saskatchewan will improve if there is global warming'. Well, this column will give you lots of handy tips to argue sensibly with climate scientists who go on about 'the evidence'. We'll start with easy stuff then go on to more subtle things that you can impress people at parties with and get good dates.

How can you climate scientists predict anything when we don't know the laws of nature? What's all this about string theory changing everything?

Unfortunately for your argument, string theory, whether it's right or wrong, won't change anything that affects our climate. The laws of physics that do determine climate, like Newton's Laws and the laws of thermodynamics and electromagnetism, won't be affected one iota by string theory. And we know these laws very well -- that's why they are called 'laws' -- and the climate has to obey them.

Well, all right. But look, you can't even get weather forecasts right for a few days ahead, how can you pretend to predict climate?

Okay, a bit better. But think about that a bit more. Next winter is going to be colder than next summer.

And on average Mexico City is going to be warmer than Montreal next year, even if there are a few days when it isn't. And we can predict that a pinball will eventually come down to the bottom of the table, even if we can't predict its exact path. And suppose we heat a pan of water; we know the water will get hotter, but we don't know where the bubbles will appear when it starts boiling. So we can predict general trends even if sometimes we can't predict the exact detail. (Oh, and by the way, weather forecasts for a few days ahead are actually pretty good these days.) I'm afraid you'll have to do a bit better than that, my friend.

My scientist neighbor says that science doesn't progress through consensus; it's the maverick who makes science advance, like that bald fellow at MIT. So if a majority of climate scientists believe in global warming, doesn't that make it wrong?

Hmm. I think the Greeks called this kind of argument Sophistry. It's true that we don't vote on which theories to believe, but just because scientists believe something doesn't make it wrong. Ultimately it is the laws of nature, and the empirical evidence supporting them, that we believe in and we'll come to that later. But it's good to be on our guard against groupthink, so you get a brownie point for that.

What scientists seem to be saying is that if we burn coal and oil we add carbon dioxide to the atmosphere and the planet warms. But wasn't the planet much warmer in the past, before we started burning fossil fuels? So that can't really be the cause, can it?

Good try! Yes, it does seem to be the case that there were periods in the past that were warmer than today. The last time was about 120,000 years ago, in an interglacial period called the Eemian. The carbon dioxide level was high then, too -- we know that because we can measure the composition of little bubbles trapped in ice records. In fact, if we look at the record of temperature and carbon dioxide for the past few hundred thousand years there's a strong correlation.

Ah, but even I know that correlation does not imply causation! Gotcha! In fact I read that in the last ice age the variations in temperature came *before* the variations in greenhouse gases! So temperature variations are the cause, and carbon dioxide levels are the consequence.

I'm impressed. That's a good point, and one worth considering. Similar claims have been made about the Eemian period, too. Understanding the variation of carbon dioxide at the last ice age is actually one of the most difficult and important challenges climate scientists face. The first thing to realize is that variations in carbon dioxide are not the ultimate cause of ice ages; rather, they are caused by the Earth wobbling on its axis a bit on long timescales, so that the Sun's radiation comes in at a different angle, changing the seasons and so changing the climate. What happened in the last Ice Age, about 20,000 years ago, is that small shifts in the circulation then caused more carbon dioxide to be absorbed by the ocean, which then further cooled the planet, and so on. Other feedbacks came into play too --- a colder planet has more ice, which will reflect sunlight and cool the planet. And a cold ocean absorbs more carbon dioxide than a warm one, causing still more cooling. When feedbacks like this occur it's almost impossible to disentangle cause from effect just from the observed record, without knowing what mechanisms are at work. Fortunately, we do know how carbon dioxide levels influence climate, and we'll come to that soon.

Yes, but then there's the little Ice Age. Isn't the warming we see just us coming out of the little Ice Age?

Not really. It does seem that, over a few hundred years in the last millennium, parts of the planet, and especially Europe, were a little colder than we might have expected. But over the last 100 or so years the warming we have seen has been massively larger than just an emergence from a little Ice Age. In fact, the warming has been more rapid, and of greater magnitude, than anything we've seen in the past few hundred thousand years. (And no, it's not just that we measure temperature in cities giving us an 'urban heat island effect'; that is the first thing that is taken into account.)

Come on. You're just coming up with separate little arguments to counter my points. You really don't have a good strong argument, do you?

Here, my friend, you are dead wrong and you've lost all your brownie points. There is a single, overwhelming argument that explains the observations very well, and predicts what will happen in the future. Carbon dioxide is a 'greenhouse gas', meaning that it prevents radiation emitted from the Earth's

surface going into space. Methane is another greenhouse gas. The radiation is re-emitted by the atmosphere down to the surface, keeping us warm. Without greenhouse gases the Earth would be so cold as to be uninhabitable. We are adding greenhouse gases to the atmosphere by burning oil and coal (just as you said earlier) and this is warming us up. The overall effect is as simple as that -- it's not rocket science. But we do need to do some rocket science to find out how much warming should have occurred and how much will occur, and when we do that calculation it does give us about the same amount of warming that we've seen over the last 100 or so years, namely about one degree Celsius or two degrees Fahrenheit. And it tells us that the warming will continue, perhaps by another degree or two Celsius (that's two to four degrees Fahrenheit) in the next 50-100 years, depending on just how much oil and coal we burn.

But my physicist friend tells me that all these big models you use to predict the warming are fixed up to give the right answer for the past warming. And then they all give different answers for the future. So we just can't trust them at all, can we?

Well, upon my word, you've stumbled upon a real scientific issue. Definitely not a foolish conversation piece if you happen to be at a cocktail party in Boulder or Exeter or one of those left-leaning climate cities where they eat tofu and drink craft beer.

But the first point to make is that we don't believe in global warming because of these big models. We believe it because it is a consequence of applying the laws of physics in a fairly simple way. The climate would have to behave in a really strange way for it not to warm if we add greenhouse gases, and that would be even more worrying than global warming itself. These laws of physics go into the big models -- we call them General Circulation Models -- and they produce warming too, as they should. The issue is that the models (there are about 50 of them in the world) are extremely complicated, and they differ from each other in subtle ways. And, just like a car engine, once made they have to be tuned to work properly -- some parts of a model are tweaked to compensate for misalignment in another part. There are so many feedbacks in the climate system that differences in tuning give rise to different answers; for example, the clouds in some models behave differently than the clouds in another. It is these differences in the models, along with imperfect knowledge about the past, that give rise to much of our uncertainty in how the climate will behave in the future. But the key point is that all the major models behave in the same general fashion, because they are all obeying the same laws of physics, and they all predict warming.

Well what about these cold spells last winter. Wasn't Chicago way colder than usual? And what about the fact that the planet didn't warm at all over the first 15 or so years of this century?

You are grasping at straws when you talk about cold spells, and you know it. We will continue to get cold spells and heat waves, and individually none of them tell us much about whether the planet is warming. Of course, global warming will almost certainly give us more warm extremes that can have terrible consequences, as we have seen in Australia recently. And over the whole planet, last year was actually much warmer than it used to be.

The 17 year hiatus in warming (from about 1998 to 2015) was in way just a prolonged cold spell probably caused by natural variability in the ocean, but we are back on a clear warming trend now. Had the hiatus continued another 10 years we would certainly have had to rethink some of our ideas (and secretly some climate scientists were glad when it started warming again!).

Well, suppose it is going to get warmer over the next few decades, I don't really see what the fuss is about. Why should the present climate be the best one, after all?

Good point, and you are right in some ways. If the natural level of carbon dioxide in the atmosphere were a bit higher, and the planet had always been bit warmer, we might be just fine. The problem is that we, and the whole ecosystem we live in, have evolved, both biologically and socially, to fit into our present climate. It is the rapid change that is the problem, as this throws everything out of kilter. And the change we are undergoing really is far more rapid than any climate change we've seen in the past. So rainfall patterns will change, sea-level will rise, glaciers and sea-ice will melt, all on timescales of decades. This means animal habitats will have to change, agriculture will have to change, some species will go extinct, some cities will be flooded more frequently, some low-level islands will disappear, and so on. The economic cost alone will be in the trillions of dollars, not to mention the cost of human suffering.

I suppose that's what these climate accords are all about then, like this Paris target of 1.5 degrees

Celsius (that's about 3 degrees Fahrenheit, right?). So if we limit the warming to 1.5 degrees we'll be okay, and if we don't we'll fall of a cliff?

You've touched on a delicate point here among climate scientists and policy makers. Not everyone agrees that these targets are a great idea. You see, it seems likely that we will sail past the 1.5 degree target (remember, that means 1.5 degrees from pre-industrial times, and we've already warmed 1 degree). Even without you-know-who in the White House, there probably isn't enough political will worldwide to reduce emissions to the really minimal level we would need to reach that target. And if and when we do go past that target, nothing catastrophic will immediately happen and the political will to cut back may well erode further, and the situation will then just get slowly worse. Still, other people argue it is good to have some kind of target to aim for, and that we *can* achieve the 1.5 degree target (2.7 degrees Fahrenheit, to be exact) if we act prudently.

If we know its going to get warmer, can't we prepare for that and minimize the consequences?

If only! The problem here is that we don't know in sufficient detail how the climate will evolve, and we don't know how the weather might change in a particular region. This has to do with the models that we use not being perfect, and because of all the feedbacks in the climate system. For example, it is sometimes said that wet places will get wetter and dry places will get dryer. So we stand to get both more floods and more droughts! But that turns out to be an oversimplification and we don't actually know with any confidence how rainfall patterns will change over land (which is where most people live, after all). And although we expect Arctic sea ice to slowly diminish, we don't really know what the consequences of that might be for the weather and climate over Europe and North America. Without knowing these things its hard to minimize their effects. And some effects we just can't adapt to without wholesale changes --- sea level will continue to slowly rise in the years ahead no matter what, and if global warming continues unabated then it is quite likely that all the ice on Greenland will eventually melt and sea level will rise by over 20 meters -- that's over 65 feet! Goodbye Miami. That's a very long term danger (hundreds of years, possibly), but a real and quite likely one.

This sounds like doom and gloom to me. We've faced challenges like this before, so can't we overcome it with technology? Build mirrors in the sky to keep the planet cooler, for example?

Well, we should be using technology where we can. Use solar and wind power to generate electricity, maybe nuclear power too -- but that's controversial, so I'm not going there today! We should fly less, and climate scientists should go to fewer conferences in far away places. The other kind of technological solution is 'geo-engineering', but that is really controversial. We might try, for example, to put millions of tiny particles into the atmosphere to reflect sunlight and cool the planet, but no-one really knows if it would work and it's not a practical proposition today. We can try to bury the carbon dioxide that is emitted from power plants so that it doesn't go into the atmosphere, but these vast underground reservoirs might eventually leak and then we've just passed the problem on to the next generation.

Suppose I accept that warming is a problem (just for the sake of argument, mind you). We have lots of other problems too --- poverty, malaria, pollution, crime. Unemployment, putting food on the table, economic depression. The price of gasoline. Let's face it, in the grand scheme of things climate change doesn't seem so bad.

That's a fair point, and one that we sometimes forget. But here is the issue. Ignoring climate change isn't going to help solve those other problems; rather, *climate change is making some of them worse*. Poverty and malnutrition may well be more serious problems than climate change, and if the choice were between eliminating them and preventing climate change I'd go for eliminating poverty and malnutrition any day. But that's a false choice. I grant you, though, that we do need to be very careful about implementing solutions to global warming that cost so much that we cure the disease but kill the patient. You can certainly make this point at cocktail parties without looking stupid, but be prepared to get into heated arguments.

Well, okay. I'll have to think about all these things, but I think I have some ammunition for my next cocktail party.

Good luck with that! Remember, you have a right to be skeptical about what scientists might say. Hold their feet to the fire! But being a climate denier or holding on to preposterous theories is another matter entirely. So don't try to argue against the laws of physics, or against the observed temperature record.

Don't say that it is the increasing temperature that has caused carbon dioxide to rise, and don't presume that temperature and sea level aren't going to carry on rising for years to come. Any potential date worth their salt will laugh you out of the room. Your best tactic is to stroke your chin thoughtfully and emphasize the uncertainties, and wonder if we really do know very much about how global warming will affect rainfall or regional climate. And that line about Saskatchewan isn't so bad, too. If you want to heat things up you could try saying that global warming is a problem that middle class liberals like to discuss while on a jet plane flying to meetings in Davos or New Zealand. You'd have a point, but it wouldn't change the facts -- it's not *just* that. And don't forget that we climate scientists are human too, with all the flaws of the rest of humanity, and some special ones all of our own.