

Earth Science & Society
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The easiest way to introduce the relationship between Earth science and society is to point out that everything in our economy ultimately depends on the use and extraction of natural resources. Every dollar that flows through Wall Street can be traced back to one of the following:

- Fossil fuel extraction
- Mineral resource mining
- Water
- Agriculture
 - Soil nutrients
 - Water
 - Sunlight
 - CO₂

I challenge you to think of an exception. Clearly the fate of our society is intertwined with the future of Earth's resources and surface environment.

There are many different aspects of this relationship. Today we'll focus on one in particular: Earth science knowledge, public policy, and public relations. The example we'll use is anthropogenic climate change. Our examination of the topic will take the form of an in-class debate. The notes below are to help you think through some of the issues that will likely arise during our debate.

Climate Change, Public Policy, and Public Relations: A conversation

These are modified from a series of articles by Coby Beck titled "How to talk to a global warming skeptic." Although he is not a scientist, Beck has done his homework by talking to many scientists and synthesizing the relevant information in an accessible way. There are several versions online, but I prefer the one at <http://www.grist.org/article/series/skeptics/>. Another great source of accessible information on climate science is <http://www.realclimate.org/>.

Objection: It was way colder than normal today in [insert location], proof that there is no global warming.

Answer:

- The chaotic nature of weather means that no conclusion about climate can ever be drawn from a single data point, hot or cold.
- The temperature of one place at one time is just weather, and says nothing about climate, much less climate change, much less global climate change.

Objection: Global temperatures have been trending *down* since 1998. Global warming is over.

Answer:

- At the time, 1998 was a record high year in both the [CRU](#) and the [NASA GISS](#) analyses. In fact, it blew away the previous record by .2 degrees C. (That previous record went all the way back to 1997, by the way!)
- [According to NASA](#), it was elevated far above the trend line because 1998 was the year of the strongest El Nino of the century. Choosing that year as a starting point is a classic [cherry pick](#) and demonstrates why it is necessary to remove chaotic year-to-year-variability (aka: weather) by smoothing out the data. Looking at CRU's graph below, you can see the result of that smoothing in black. Clearly 1998 is an anomaly and the trend has not reversed.

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- NASA has 2005 breaking the 1998 record, though by very little.

How to choose a starting point? There are lots of options, but usually you go as far back as the record you're analyzing is available. And remember that if we go as far back as the end of the last ice age, around 10,000 years ago, the conclusion is that GHG warming has reversed a long and stable period of slight downward trend, and we are now at a global temperature not experienced in the history of human civilization.

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Objection: It was just as warm in the Medieval Warm Period (MWP) as it is today. In fact, Greenland was green and they were growing grapes in England!

Answer:

- Here is a plot showing the temperature anomaly for the past 2000 years:

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- There is no good evidence that the MWP was a globally warm period comparable to today. Regionally, there may have been places that exhibited notable warmth -- Europe, for example - - but all global proxy reconstructions agree it is warmer now, and the temperature is rising faster now, than at any time in the last one or even two thousand years.
- Anecdotal evidence of wineries in England and Norse farmers in Greenland do not amount to a global assessment.
- Again, it is the rate of the current trend that is alarming.

Objection: Current warming is just part of a natural cycle.

Answer:

- While it is undoubtedly true that there are natural cycles and variations in global climate, those who insist that current warming is purely natural -- or even mostly natural -- have two challenges.
- What is the mechanism behind this alleged natural cycle, and where is the evidence?
- Why is it that a 35% increase in the second most important greenhouse gas does not affect the global temperature. Theory *predicts* temperature will rise given an enhanced greenhouse effect, so how or why is it *not* happening? The mainstream climate science community has provided a well-developed, internally consistent theory that accounts for the effects we are now observing. It provides explanations and makes [predictions](#).

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- Is this graph a candidate for explaining today's warming? A naive reading of this cycle indicates we should be experiencing a *cooling* trend now -- and indeed we were gradually cooling over the length of the pre-industrial [Holocene](#), around .5C averaged over 8,000 years.
- Not only is the direction of the change wrong, but compare the speed of those fluctuations to today's changes. Leaving aside the descents into glaciation, which were much more gradual, even the sudden (geologically speaking) jumps up in temperature every ~100,000 years represent a rate of change roughly *ten times slower* what we are currently witnessing!

Objection: The alarmists were predicting the onset of an ice age in the '70s. Now it's too much warming! Why should we believe them this time?

Answer:

- It is true that there were some predictions of an "imminent ice age" in the 1970s, but a cursory comparison of those warnings and today's reveals a huge difference.
- Today, you have a [widespread scientific consensus](#), supported by national academies and all the major scientific institutions, solidly behind the warning that the temperature is rising, anthropogenic CO2 is the primary cause, and it will worsen unless we reduce emissions.
- In the 1970s, there was a [book](#) in the popular press, a few [articles](#) in [popular magazines](#), and a small amount of scientific speculation based on the recently discovered [glacial cycles](#) and the recent slight [cooling trend](#) from air pollution blocking the sunlight. There were no daily headlines. There was no avalanche of scientific articles. There were no United Nations treaties or commissions. No G8 summits on the dangers and possible solutions. No institutional pronouncements.

Objection: According to the [IPCC](#), 150 billion tonnes of carbon go into the atmosphere from natural processes every year. This is almost *30 times* the amount of carbon humans emit. What difference can we make?

Answer:

- It's true that natural fluxes in the [carbon cycle](#) are much larger than anthropogenic emissions. But for roughly the last 10,000 years, until the industrial revolution, every gigatonne of carbon going into the atmosphere was balanced by one coming out.
- What humans have done is alter one side of this cycle. We put approximately 6 gigatonnes of carbon into the air but, unlike nature, we are not taking any out.
- Thankfully, nature is compensating in part for our emissions, because only about half the CO₂ we emit stays in the air. Nevertheless, since we began burning fossil fuels in earnest over [150 years ago](#), the atmospheric concentration that was relatively stable for the previous [several thousand](#) years has now [risen](#) by over 35%.

Objection: In glacial-interglacial cycles, CO2 concentration lags behind temperature by centuries. Clearly, CO2 does not cause temperatures to rise; temperatures cause CO2 to rise.

Answer:

- When viewed coarsely, historical CO2 levels and temperature show a [tight correlation](#). However, a closer examination of the CH4, CO2, and temperature fluctuations recorded in the [Antarctic ice core records](#) reveals that, yes, temperature moved first.
- These warming periods lasted for 5,000 to 10,000 years (the cooling periods lasted more like 100,000 years!), so for the majority of that time (90% and more), temperature and CO2 rose together. This remarkably detailed archive of climatological evidence clearly allows for CO2 acting as a cause for rising temperatures, while also revealing it can be an effect of them.
- The current understanding of those cycles is that changes in orbital parameters (the [Milankovich](#) and [other](#) cycles) caused greater amounts of summer sunlight to fall in the northern hemisphere. Some number of centuries after that process started, CO2 concentrations in the atmosphere began to rise, which amplified the warming trend even further as an additional feedback mechanism.
- So it is correct that CO2 did not *trigger* the warmings, but it definitely *contributed* to them -- and according to climate theory and model experiments, greenhouse gas forcing was the dominant factor in the magnitude of the ultimate change.
- This raises a warning for the future: we may well see additional natural CO2 come out of the woodwork as whatever process took place repeatedly over the last 650K years begins to play out again. The likely candidates are out-gassing from warming ocean waters, carbon from warming soils, and methane from [melting permafrost](#).

Objection: The earth has had much warmer climates in the past. What's so special about the current climate? Anyway, it seems like a generally warmer world will be better.

Answer:

- The critical issue is not what the temperature is, or may be, or will be. The critical issue is how fast it is [moving](#). Human habits and infrastructure are suited to particular weather patterns and sea levels, as are ecosystems and animal behaviors. The rate at which global temperature is rising today is likely unique in the [history of our species](#).
- Once you look at the impact similar changes had on biodiversity in the geologic record, the existence of historical precedent becomes anything but [reassuring](#). Rapid climate change is the prime suspect in most mass extinction events, including the [Great Dying](#) some 250 million years ago, in which 90% of all life went extinct.

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