

Good morning. I come to you today as the current State Climatologist for Ohio. I am a husband and father raising 3 kids here in Ohio, and as a citizen I also serve as Ohio State University Professor teaching about climate change, an elder in Bethel Presbyterian Church, an Eagle Scout volunteer in Columbus Troop 474, and a Lego-league coach. I want to testify today about our scientific understanding about our climate, and address specifically how science informs our understanding of the impact our decisions have on our climate and well-being. My points are simply these:

1. science is a powerful means to test and know things about our world;
2. our climate results from complex dynamics of our Earth System (atmosphere, lithosphere, biosphere, hydrosphere, cryosphere) ultimately driven by the planetary radiative energy balance;
3. scientific understanding based on many convergent observations conclude there has been an unequivocal warming of our Earth System caused by our fossil fuel energy conversion that enhances a natural greenhouse effect on a global scale by altering the planetary carbon balance and changing our planetary energy balance;
4. impacts of this enhanced greenhouse effect are evident on many scales, have negative and costly consequences especially for those least able to adapt, and these but will continue to unfold without mitigating this carbon balance problem;
5. The understanding of this human-caused climate alteration and its problem to humanity is acknowledged by all major scientific agencies and religious faiths; and
6. policy decisions made here in Ohio therefore matter globally and decisions about energy conversion at the local State scale should be motivated and informed by these realities and understandings.

Scientific knowledge is powerful, and informs much of our society for the better. It is based upon falsifiable hypothesis testing. Facts matter. Explanatory power comes with understanding fundamental physical processes. Measurements are made, hypotheses posed and tested by experiment, observation and models, and confirmed with multiple examples. In the context of climate change linked to human energy conversion, the scientific understanding has been developing for long time. I spend a full semester teaching the fundamentals of what we know, and how we know it. It is well-developed, going back to 19th century experiments and continuing today with our most advanced computing and satellite observations. The key here is that not only are the observations of what is happening consistent, but the mechanism causing the changes is well-tested.

What does science say about climate change?

There is a natural greenhouse effect that is essential to life on the planet. A very small proportion of the atmospheric composition is responsible for a balance of energy that allows for water to exist at all 3 phases in the natural range of temperatures at Earth's surface. What our fossil fuel combustion does is increase the concentration of carbon dioxide and other greenhouse gases in the atmosphere, enhancing the natural greenhouse effect, raising the temperature of the Earth System. Most of this heat is being absorbed in the oceans. But the atmospheric temperature has risen significantly, with many associated changes in the climate.

Scientifically, to counter this, a successful case would have to do two things: 1. show how the fundamental physical mechanisms of radiative balance do not work as we understand them to; and 2. provide a better alternative explanation for all the observations we have compiled. So far, no one has been able to do either.

I want to make it very clear that there is not a meaningful debate within our scientific community about either the reality of the warming, or of the cause. Based on well-established evidence, about 97% of

climate scientists have concluded that human-caused climate change is happening and puts the well-being of people of all nations at risk. This is not based on single studies, but on converging streams of evidence over decades. I borrow from the compendium put together by the AAAS about just what we know (<http://whatwewknow.aaas.org/get-the-facts/>):

**The Reality:** climate is changing, caused by human activity in the form of energy conversion based on carbon-based fossil fuels. Average global temperature has increased by about 1.4° F over the last 100 years. Sea level is rising, and some types of extreme events – such as heat waves and heavy precipitation events – are happening more frequently. Recent scientific findings indicate that climate change is likely responsible for the increase in the intensity of many of these events in recent years.

**The Risk:** There is strong scientific consensus that we are at risk of pushing our climate system toward abrupt, unpredictable, and potentially irreversible changes with highly damaging impacts. Earth's climate is on a path to warm beyond the range of what has been experienced over the past millions of years (facts from the National Research Council, 2013). The range of uncertainty for the warming along the current emissions path is wide enough to encompass massively disruptive consequences to societies and ecosystems: as global temperatures rise, there is a real risk, however small, that one or more critical parts of the Earth's climate system will experience abrupt, unpredictable and potentially irreversible changes. Disturbingly, scientists do not know how much warming is required to trigger such changes to the climate system.

**The Response:** Science informs us that we should act sooner, to reduce risks and costs of negative consequences of climate alterations. There is an imperative that arises from what science tells us about the potential impacts of our continued trajectory: we need to take action to reduce the use of fossil fuels in our energy portfolio. Waiting to take action will inevitably increase costs, escalate risk, and foreclose options to address the risk. The CO<sub>2</sub> we produce accumulates in Earth's atmosphere for decades, centuries, and longer. It is not like pollution from smog or wastes in our lakes and rivers, where levels respond quickly to the effects of targeted policies. The effects of CO<sub>2</sub> emissions cannot be reversed from one generation to the next until there is a large- scale, cost-effective way to scrub carbon dioxide from the atmosphere. Moreover, as emissions continue and warming increases, the risk increases.

I want to advocate that you as policy makers adhere to the science that strongly advocates taking action to reduce the risk.

Thank you for your service and leadership for Ohio and our world.

Sincerely and respectfully,  
Bryan Mark

Professor and State Climatologist  
Geography Department  
Byrd Polar and Climate Research Center