

 **Spotlight on Climate****How Long Have We Known?**

It turns out we have known about human-caused climate change for quite a long time. In the last column we took the history of climate change research back to the late 1800's in Flagstaff, but our understanding started long before then.

In 1824, Joseph Fourier determined that the Earth is warmer than it should be, given its distance from the Sun. He proposed that gases in the atmosphere hold in heat, like a glass container holds in heat when placed in sunlight. This later became known as the Greenhouse Effect. You see this effect whenever you park your car too long in sunlight. In 1854, American scientist Eunice Foote showed that carbon dioxide (CO₂) absorbs heat, confirming that CO₂ was one of the gases influencing Fourier's observations. And, in 1896 Svante Arrhenius, who happens to be Greta Thunberg's ancestor, quantified the relationship between CO₂ concentration and Earth's temperature, using "Stefan's Rule" (Isn't history great sometimes?).

Scientists didn't just stop with "Stefan's Rule." They have been working out many details of climate change ever since. We now know that methane, water vapor, nitrous oxide, CFC's, and ozone are also greenhouse gases. We know, thanks to the careful measurements of Charles David Keeling starting in the 1950s, that CO₂ is the main greenhouse gas affected by human activity. Before the Industrial Revolution, in the mid-1800s, atmospheric CO₂ concentration was 280 parts per million (ppm). By 1958 Keeling was measuring 315 ppm, and just this spring we topped 420 ppm for the first time in 23 million years.

By the 1960s, studies already projected that a doubling of CO₂ in the atmosphere would likely raise Earth's average temperature by 2°C (= 3.6°F). Concern grew substantially among atmospheric scientists throughout the 1970s and 1980s. A 1987 study by NASA's James Hansen and colleagues showed that global temperatures had already risen by 0.5 to 0.7°C (= 0.9 to 1.3°F) since 1880. In response, the United Nations and the World Meteorological Organization established an international scientific team to assess this problem in greater detail. Since 1988 this team, called the Intergovernmental Panel on Climate Change (IPCC), has compiled results of scientific studies and reported the results for policy makers, the press, and the public.

Thousands of scientists from all over the world have contributed to IPCC reports. Some of those scientists live here in Flagstaff and conduct research at NAU. Professors Scott Goetz, Kevin Gurney, Darrel Kaufman, Yiqi Luo, Michelle Mack, and Ted Schuur have all authored IPCC reports, and studies by many other NAU and USGS climate researchers have also been included. Future columns will highlight these local discoveries that are helping us to understand climate change and find solutions to this global challenge.

The first IPCC report in 1990 presented data showing greenhouse gas concentrations and the Earth's average temperature steadily rising. IPCC reports in 1995 and 2001 firmly established that human activity was indeed the cause of increasing greenhouse gases. The main contributors were fossil fuel combustion, agriculture, and natural habitat destruction. Soils and other natural habitats contain large

amounts of carbon in the form of living organisms and dead and decaying materials. When habitats are damaged or disturbed, they release that carbon into the atmosphere.

In 2007 the IPCC confirmed that current climate change is caused by human activities and not by natural causes. All of the natural causes of temperature change, such as changes in Earth's orbit or volcanic activity, do not explain the sudden recent rise in Earth's average temperature.

In 2018, an IPCC Special Report showed that human activities are now emitting more than 40 Gigatons of CO₂ every year. While some still question the reality of climate change, this IPCC report clearly documented that our emissions had already raised Earth's average temperature by more than 1°C (= 1.8°F). To avoid raising temperatures by 1.5°C (= 2.7°F), which would trigger major tipping points, we need to reign in our emissions to zero by 2040. Can we do this in time? The IPCC and many other studies show that we can do this by using wind, water, and solar technologies already available. Will we do this in time? What part will you play?

Future columns will explore the effects of climate change and promising solutions. Please stay tuned.

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