

# LIMELIGHT AT LAST? 200 YEARS OF CLIMATE CHANGE SCIENCE AND A HEATING DEBATE

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## Emerging Climate Science

We are well on the way towards a remarkable anniversary. In just four years, in 2024, it will be exactly 200 years since French mathematician and physicist Jean-Baptiste Joseph Fourier in 1824 published his article "Remarques Générales sur les Températures du globe terrestre et des espaces planétaires" in *Annales de Chimie et de Physique*. This might be considered the starting point of modern atmospheric climate science, as Fourier described a mechanism that we today call the greenhouse effect, after his calculations showed that according to the amount of incoming solar radiation, Earth in the absence of such effect would be a lot cooler. Not too much later Irish scientist John Tyndall, who received his education at Philipps-Universität Marburg and as an enthusiastic alpinist was eager to explain glaciation, in 1859 conducted careful laboratory experiments measuring the absorption of infrared radiation by carbon dioxide and water vapor. Tyndall thus showed that water is the most important greenhouse gas in the Earth's atmosphere and that carbon dioxide, despite its much lower concentration, plays a critical role as well. Notably, Tyndall suggested that a decrease in the greenhouse effect of carbon dioxide might be the cause of the ice ages. During the following years and decades the understanding of matter improved and Ludwig Boltzmann explained the relationship between particle movement and temperature, advancing the branch of thermodynamics within physics. Boltzmann attracted the likes of Walther Nernst and Svante Arrhenius to visit him in Graz, where he held a professorship, and Arrhenius, a chemist, eventually attempted to quantify the effect of an increased concentration of carbon dioxide in the atmosphere. This was now relevant as the Coal Age was in full swing and scientists started to wonder if burning ever increasing amounts of coal would alter the climate. Arrhenius in 1896 estimated that a doubling of the carbon dioxide concentration in the atmosphere would increase the global average temperature by 5 to 6 C, but ten years later, in 1906, he had revised this figure down to 4 C - which is fully in line with our current understanding - in a remarkable publication called "Worlds in the Making" in English translation.

## Positive and Negative Views

"Worlds in the Making" was directed at a general audience and reflected a positive attitude towards climate change as caused by anthropogenic carbon dioxide emissions. Arrhenius suggested that such emissions might be effective enough to prevent the world from entering a new ice age, and that a warmer Earth would be needed to feed the rapidly increasing population. This attitude in turn persisted for much of the twentieth century, and even then-young Swedish meteorologist Bert Bolin still in the 1970ies tentatively suggested that industrial carbon dioxide emissions might help humanity by delaying the end of the current interglacial period [1].

However, there were also critical voices. Most prominently, Austrian Hans Suess and American Roger Revelle working at the Scripps Institute of Oceanography in California in 1957 pointed out that the connection between carbon dioxide and the climate suggests that we are carrying out a large-scale geophysical experiment. That same year they started routine measurements of atmospheric carbon dioxide at the observatory on Mauna Loa, Hawaii, a site isolated enough to avoid interference of local carbon dioxide emissions with the measurements. After just a few years, these measurements clearly demonstrated a gradual increase of carbon dioxide present in the atmosphere. Still, hardly any action to protect the climate was taken by governments, in part because global average temperatures remained quite stable during the third quarter of the twentieth century despite unprecedented carbon dioxide emissions. Momentum was gained when scientists restored a full record of the planet's environmental temperature and atmospheric composition for the past 200,000 years by drilling ice cores out of the polar ice caps in the mid-1980ies. It showed that atmospheric carbon dioxide concentrations and temperatures had moved up and done in concert during this entire period, and in 1988 the United

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Nations' Intergovernmental Panel on Climate Change was established with Bert Bolin serving as the founding chairman. Just four years later, in 1992, the United Nations Framework Convention on Climate Change (UNFCCC), an international environmental treaty aiming to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" was opened for signature, entering into force in 1994 after a sufficient number of countries had ratified it.

### **Still No Serious Action?**

Given the wide support formally confirmed by numerous governments, it seems a bit surprising that anthropogenic carbon dioxide emissions are still so high. Less developed countries felt they had a right to catch up without strongly limiting their emissions, and climate concern appeared to be modest in developed countries. The initial effect of the ice core results somewhat faded away, as it became clear that correlation doesn't mean causation. The ice age cycles are presumably caused by cyclical changes in the Earth's orbit according to the Milankovitch theory, and the changing atmospheric carbon dioxide concentration of the past hence to be the result rather than the cause of changing temperatures. What is more, global average temperatures remained quite stable for twenty years following the twentieth century peak year in 1998. Natural records showed that this global temperature level was similar in the Middle Ages despite carbon dioxide concentrations then being much lower, and the best available climate models had assumed that current temperatures would be substantially higher given current carbon dioxide levels. Nevertheless, we know quite well how carbon dioxide acts in the atmosphere and the Suess-Revelle warning that we should not carry out an uncontrolled experiment on our own habitat is more valid than ever. It is therefore to be welcomed that the current grassroots climate action movement carried by young parts of the population is pulling the climate change issue further into the limelight.

### **References**

- [1] M. Weissenbacher, The Problem of Climate Change. Chapter 36 in: M. Weissenbacher, Sources of Power- How Energy Forges Human History. Volume 2: The Oil Age and Beyond. Santa Barbara/Denver/Oxford: Praeger, 2009.