

A Climate Change Primer

By Dr. Steven C. Amstrup

Basic Science

First, the laws of physics require that increased levels of greenhouse gases cause the world to warm. How does this work?

- Energy from the sun that arrives at Earth is **balanced by energy** that is re-radiated to space.
- Atmospheric gases like CO₂, however, **temporarily trap the energy** that arrives from the sun as short-wave radiation. This energy then re-radiates back into space in the form of long-wave radiation.
- It is the **greenhouse effect** of this temporarily trapped energy that maintains Earth in a temperature range allowing life.

When we increase these heat-trapping gases (greenhouse gases or GHGs), we increase the residence time of the sun's energy in the Earth's atmosphere, which means that the Earth warms.

Hence, a world with higher GHG concentrations must be warmer than it would have been with lower GHG concentrations. There is no uncertainty about this.

Fluctuations and “Noise”

Second, although the laws of physics require that the Earth will warm as GHGs are added, the natural chaos in the climate system creates great uncertainty about how fast the earth will warm.

With more GHGs, Earth must be warmer than it otherwise would have been, but exactly how warm it will be at any future point is difficult to predict. **It is certain, however, that these natural fluctuations will occur over a higher and climbing baseline, and it is only a matter of time until the GHG signal emerges clearly from the noise of the climate system.**

- Natural oscillations in atmospheric circulation patterns, such as El Niño (the Southern Oscillation) and the Arctic Oscillation, have huge effects on short-term and medium term weather as well as regional and even global climate.
- Natural oscillations in ocean circulation patterns such as the Gulf Stream (or North Atlantic Drift), can have longer-term effects on weather and climate.

The important point to remember about these natural oscillations is that they will be occurring over a higher and climbing baseline. This means that eventually, the “signal” of GHG forcing will emerge clearly from the natural “noise” of the climate system. **There is no uncertainty about whether the signal will clearly emerge from the noise, but there is great uncertainty about when it might do so.**



Crossing Climate Thresholds

Third, given the certainty of global warming in an increasing GHG world, we are guaranteed to exceed certain thresholds (such as the global mean temperature increase of 2 degrees, or ice-free summers in the Arctic) at some future point. **We cannot predict exactly when these "thresholds" may be crossed, but if GHGs keep rising they ultimately must be crossed.**

- We cannot predict with certainty when the Arctic's first ice-free summer will occur, but with continually increasing GHGs, we are assured ice-free summers will ultimately be the norm.
- We are also assured that the more time that passes, the greater likelihood we will have exceeded that threshold.

Yes, there are uncertainties regarding global warming. All of these things, however, mean that one thing is not uncertain. That is, the longer we wait to do something, the more thresholds we will have exceeded, and the bigger the problems we will have created for our children and grandchildren. They will increasingly be the ones forced to attempt to cope with a world that is very different than the one in which humans became the dominant life force on earth.

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