

COMPLEXITY IN CLIMATE CHANGE SCIENCE

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Summary

The Earth's climate is a complex system, and yet the basic science of climate change is clear: the average temperature of the Earth's surface has increased about 0.8 degrees Celsius since the Industrial Revolution. Deniers of climate change science have taken advantage of its complexity to discredit the consensus conclusion that the climate is changing most likely as a consequence of human activities, with potentially very negative impacts on society. Examples of findings that are often questioned include the average surface temperature increase inferred from global measurements, and the conclusion that the recent waves of extreme weather events are most likely connected with such an increase.

Climate change represents one of the most important challenges for society in the 21st century. Drastic cutbacks in activities such as burning of fossil fuels and deforestation are needed in order for mankind to limit its impacts on the Earth's climate.

There is little doubt that the climate of our planet is a complex system. A consequence is that there are uncertainties in our understanding of the science of climate change; nevertheless the scientific basis of the problem is very well established. From the Industrial Revolution to the present day the average temperature of the Earth's surface has increased by around 0.8°C, and the consensus among experts is that the probability that this increase has been caused by human activities is extremely large.

The risk of causing changes in the climate system with potentially catastrophic consequences rises rapidly if the average temperature of the Earth's surface is increased by more than 2 or 3°C. Thus, according to most energy and economics experts a reasonable goal for society is to limit the average temperature increase of the Earth's surface below 2°C in order to prevent dangerous interference with the climate system. Achieving this goal will require most likely an international agreement that places directly or indirectly a price on the emission of greenhouse gases.

It is often stated that the two-degree goal is what science tells us; it is clear, though, that science does not tell us what to do; it only advises us what might happen as a result of different courses of action. The 2°C figure comes in part because the risk of triggering nearly irreversible and potentially very damaging changes in the Earth's climate increases rapidly if the temperature increases

by more than 2°C. But equally important is the fact that there are technological solutions to the problem at hand, and that the cost of taking the necessary measures to achieve the 2°C goal is relatively small, namely of the order of only one or two percent of the gross world economic product. But, most importantly, the consensus among economic analysts is that the cost of not implementing such measures is very likely significantly higher. In fact, postponing action and thus risking a temperature increase of five or more degrees could imply astronomical costs for future generations, threatening both our economic systems and our governance systems, and making it truly difficult to eradicate poverty on the planet.

There are, in fact, a number of well-documented scientific findings that tell us that if we continue with unabated emissions of greenhouse gases there is a significant risk of achieving a temperature increase of 5°C or more towards the end of the century, with the likelihood of reaching certain tipping points that could lead to changes in the Earth's climate system that, for all practical purposes, will be irreversible, such as melting of the poles, drying of the Amazon forest, or a disappearing Indian monsoon. Such catastrophes could have devastating consequences for literally hundreds or even thousands of millions of the Earth's inhabitants. And even if the probability that such events will occur is a mere five or ten percent, if society chooses to continue to move along a business-as-usual path, economics experts agree that this risk is the one that should actually dominate economic considerations, let alone ethical considerations, rather than the risk associated with the most probable outcomes.

If the basic conclusion of the scientific community is that the climate is indeed changing as a consequence of human activities with potentially very serious consequences for society, why, then, has the problem not been solved? The main reason is that there remain many political difficulties, and furthermore there are powerful interest groups that have mounted a very successful public relations campaign to discredit climate change science. The consequence has been that all sorts of media reports have stated that the basic scientific conclusion connecting climate change to human activities is questionable.

As stated above, the scientific community is, of course, aware that because of its complexity the current understanding of the science of climate change is not perfect, and that much remains to be learned, but nevertheless enough is known to estimate the probabilities that certain events will take place if society continues with "business as usual" emissions of greenhouse gases. The existing body of climate science is robust and extensive, and is based on many hundreds of studies and measurements conducted by thousands

of highly trained scientists, with transparent methodologies, and with publications in the open scientific literature which have been rigorously peer-reviewed. The point is that the available scientific information is quite sufficient for society and decision-makers in government to assess the risk associated with the continued emissions of gases that affect the climate.

Furthermore, there are now numerous scientific studies that conclude that climate change is indeed the cause of many of the extreme weather events that are occurring with increasing frequency. The scientific understanding is not that such events would not have occurred in the absence of human-induced climate change; instead, it is the severity of the events in question that has been affected by this change in climate, which is of human origin.

In closing, the climate change challenge is urgent and society should adopt the necessary measures to reduce greenhouse emissions as soon as possible. Here I am not speaking as a scientist, but rather as an individual who strongly supports universal ethical values, and who values the wellbeing of future generations. We have an ethical responsibility to leave future generations a planet where its inhabitants can enjoy a quality of life on a par with, or better than, that of the present day. There is still time to act, although the window of opportunity is rapidly closing.