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Memo to: The Climate Club -- C759 22 July 1989
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Provocation No. 271
Chaos and the Greenhouse Warming

This week I attended a lecture by Edward Lorenz, usually credited as the person whose experiments at MIT brought theories of "chaos" to scientific attention. Ed told us it is too soon to be sure we are experiencing the greenhouse warming just from looking at the 100 year temperature trend. It could be the product of chaos.

Back in 1960, Lorenz put together a highly simplified computer model weather system and was doing experiments with it. His computer was an ungainly contraption made up of a whole bunch of vacuum tubes and wires, and it was constantly breaking down. Once a minute it printed out the results of a simulated day's passage of time as a row of numbers on a page of paper.

Ed would insert an initial set of numbers to specify the start of a weather experiment, and then run it forward to get a prediction from that initial state. He knew how to read these numbers as the products of a hypothetical weather prediction system. The difference between what he was doing then and the results of today's big weather simulations is mainly that our present models are thousands of times more realistic, the computers work millions of times faster, and the results are in a more familiar format.

One day Lorenz interrupted his computer after a run, put in what he thought was essentially the same initial weather for a second run, and went out for a cup of coffee. To his amazement, when he returned the weather forecast was radically different from the first. In checking, he found that he had rounded off 0.506127 to 0.506, a difference of only one part in a thousand. But it made a world of difference. He had discovered that very tiny disparities in the initial state can result in huge deviations in the final result.

He planned to write a paper about this for a scientific meeting. To dramatize the subject a colleague, Phil Merilees, suggested "Can the flap of a butterfly's wing over Brazil alter the weather over North America?" Ed told me he would have preferred a seagull to a butterfly, but Phil liked the butterfly. The point is the same. A tiny perturbation can grow apace in a complex non-periodic system, making the future behavior essentially unpredictable, chaotic. Later he did many runs using small initial differences, and showed that vastly different predictions can result.

Lorenz also showed us this week a 400 year simulation run he made in 1984 with a more complex model. He found you can get global temperature graphs that show just as big trends as the real weather warming over the last 100 years, even though greenhouse gases are held constant. It exhibited both warming and cooling trends like those in the real world, and they came about from "chaos," from the inherent instability of the system to small initial perturbations. No outside forcing, as by greenhouse gases, was needed.

Thus, he argued, you cannot conclude that the warming we see has been forced by the greenhouse gases simply from the 100 year temperature records. You must instead, base your confidence on the theory of the greenhouse effect, since you know from other evidence that the greenhouse gases have risen, and will continue to do so. If you draw a sloped straight line through the 100 year temperature record making a rise of 0.6 C, the amount you'd expect from the 25% increase in greenhouse gases, the deviations from the line are a reasonable representation of the random fluctuations expected. But you cannot conclude that we are seeing a greenhouse warming just from the fact that this trend line fits the data. Chaos could be doing it.

This uncertainty will be difficult to explain adequately to heads of state and other policy makers! It may even imperil resolute international action to deal with the increasing greenhouse effect. Lorenz's argument, to my mind, reinforces the desirability of focussing on strategies to control the release of greenhouse gases only when those strategies will bring benefits to human societies even if future research, in the unlikely case, shows no greenhouse warming. Most such strategies, like strong energy conservation or reforestation, not only reduce greenhouse gases, but provide cost savings and stimulate productivity. Thus we should start on them now.

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