

THE MATHEMATICAL REASON WHY LONG-RUN CLIMATIC PREDICTION IS IMPOSSIBLE

A brief Critique on Climate Models

By

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CLIMATE cannot be accurately predicted more than a few weeks ahead with any respectable degree of reliability. The unpredictability even of a simple mathematical object whose initial state is not known in sufficiently fine detail has long been proven. Climate is a complex, non-linear object (IPCC, 2001) and is, therefore, *a fortiori*, impossible to predict long-term.

Precisely because it has been proven that long-run climate prediction is not possible, it is inappropriate to attempt to state that there is a “consensus” that “global warming” caused by increased greenhouse-gas concentrations will be dangerous if it continues. Scientific dissent on the question of climate is and will always be legitimate, because it is settled, proven science that long-run prediction of the behavior of mathematical objects such as climate is not possible unless the initial climatic state at any chosen moment is known to a fineness of detail that is in practice impossible to attain, and unless the processes for the subsequent evolution of the object are also known in detail, which they are not.

It is the proven characteristic of mathematically-chaotic objects such as climate that neither the magnitude nor the timing of their phase-transitions (in environmentalist jargon, “tipping points”) can be predicted (Lorenz, 1963; IPCC, 2001), because there is simply too little information about the state of the climate in the present to allow us to look as far as 100 years into the future and say with any degree of confidence how little or how much the world will warm.

As Lorenz (1963) put it in the landmark paper with which he founded chaos theory –

“When our results concerning the instability of non-periodic flow are applied to the atmosphere, which is ostensibly non-periodic, they indicate that prediction of the sufficiently distant future is impossible by any method, unless the present conditions are known exactly. In view of the inevitable inaccuracy and incompleteness of weather observations, precise, very-long-range weather forecasting would seem to be non-existent.”

And climate, of course, is very-long-range weather. Recently another scientist has considered the limitations upon climatic prediction with some care. Giorgi (2005) defines two types of prediction:

“In the late 1960s and mid 1970s the chaotic nature of the climate system was first recognized. Lorenz defined two types of predictability problems:

- 1) Predictability of the first kind, which is essentially the prediction of the evolution of the atmosphere, or more generally the climate system, given some knowledge of its initial state. Predictability of the first kind is therefore primarily an **initial-value** problem, and numerical weather prediction is a typical example of it.
- 2) Predictability of the second kind, in which the objective is to predict the evolution of the statistical properties of the climate system in response to changes in external forcings. Predictability of the second kind is thus essentially a **boundary-value** problem.”

Giorgi explains:

“... Because of the long time scales involved in ocean, cryosphere and biosphere processes a first-kind predictability component also arises. The slower components of the climate system (e.g. the ocean and biosphere) affect the statistics of climate variables (e.g. precipitation) and since they may feel the

influence of their initial state at multi-decadal time scales, it is possible that climate changes also depend on the initial state of the climate system ... For example, the evolution of the thermohaline circulation in response to greenhouse-gas forcing can depend on the initial state of the thermohaline circulation, and this evolution will in general affect the full climate system. As a result, the climate change prediction problem has components of both first and second kind which are deeply intertwined. ... The relevance of the first-kind predictability aspect of climate change is that we do not know what the initial conditions of the climate system were at the beginning of the ‘industrialization experiment’ and this adds an element of uncertainty to the climate prediction.”

Giorgi also points out that the predictability of a mathematical object such as climate is adversely affected by non-linearity:

“A system that responds linearly to forcings is highly predictable, i.e. doubling of the forcing results in a doubling of the response. Non-linear behaviors are much less predictable and several factors increase the non-linearity of the climate system as a whole, thereby decreasing its predictability.”

Climatic prediction is, as Lorenz said it was, an initial-state problem. It is also a boundary-value problem, whose degrees of freedom – the quantity of independent variables that define it – are approximately equal to the molecular density of air at room temperature, an intractably large number. It is also a non-linearity problem. It is also a problem whose evolutionary processes are insufficiently understood. When studying the climate we are in the same predicament as Christopher Columbus. When he set out for the Americas, he did not know where he was going; on the way there, he did not know what route he was following; when he got there he did not know where he was; when he returned he did not know where he had been; and, like very nearly every climate scientist worldwide, he did the whole thing on taxpayers’ money.

A thought-experiment

To illustrate the difficulty further, let us conduct a thought-experiment, examining the proven mathematical impossibility of predicting the future state of a complex, non-linear object. For our little experiment we shall use the Mandelbrot fractal, which is defined using the simple, iterative function $f(z) = z^2 + c$. Compare the extreme simplicity of this function with the complications inherent in the million-variable computer models upon which the UN so heavily relies in attempting to predict the future evolution of the climate.

In the function that generates the Mandelbrot fractal, the real part a of the complex number $c = a + bi$ lies on the x axis of the Argand plane; the imaginary part b lies on the y axis. Let $z = 0$. Compare this certainty and clarity with the uncertainty and confusion of the climate object, where, as Lorenz proved, accurate long-term projection into the future cannot be made unless an exceptionally precise knowledge of the initial state of every one of the million-plus variables at any chosen starting point is known to a very great degree of precision. The UN presumes to make predictions a millennium into the future. This, as our thought-experiment will convincingly demonstrate, it cannot possibly do.

With the Mandelbrot fractal, then, there is no initial-state problem, for we can specify the initial state to any chosen level of precision. However, with the climate object, there is a formidable and in practice unsolvable initial-state problem. Likewise, we know the process by which the Mandelbrot fractal will evolve, namely the simple iterative function $f(z) = z^2 + c$. However, our understanding of evolutionary processes of the climate object, though growing, is insufficient, and the computer models which try to project future climatic states continue to be caught by surprise as events unfold. The computers did not predict the severity of the El Nino event in 1998; they did not predict the cooling of the oceans from 2003 onwards; and the operators of one of the UN’s leading computer models have recently admitted that the model makes errors that are orders of magnitude greater than the rather small phenomena which they are trying to predict.

In the Mandelbrot fractal, therefore, we have consciously chosen for our thought experiment an object which is like the climate in that it is chaotic and non-linear, but which is unlike the climate in that it has initial conditions which we can specify precisely, and processes for future evolution that are entirely prescribed.

So to the experiment itself. The game is to take a region of the Argand plane within the field of the Mandelbrot object, and to try to predict – at least in rough outline – the picture that will appear as the specified region of the object is generated. We shall choose values of c , to 16 significant figures, as follows: top left $c = 0.2500739507702906 + 0.0000010137903618 i$; bottom right $c = 0.2500739507703702 + 0.0000010137903127 i$. We shall set the color of each point in our picture by counting the iterations before $|z|$ reaches infinity (or here, for convenience, 1 000). Up to 250 000 iterations will be performed to calculate each individual point.

You have been told the initial state of z , and the range of initial values for c . You have been told the processes for proceeding up to a defined future point. Now, before looking at Figure 1 overleaf, make your prediction. What will the picture of our chosen part of the Mandelbrot fractal look like? In trying to draw the picture, you are in a far better position than the IPCC is in trying to predict future states of the climate. But can you do it? Do you have any idea what the picture might look like?

When you have sketched your predicted picture on a piece of paper, compare your prediction with what the specified portion of the Mandelbrot fractal actually looks like (see Figure 1 overleaf). If your picture looked anything like the picture overleaf, apply at once to the IPCC – they need you. If you were unable to predict what the picture would look like, even though our thought-experiment has been made as easy for you as possible, in that the fundamental initial-state and subsequent-process problems that prevent the IPCC or anyone from predicting the climate accurately have been carefully engineered out of our thought experiment, you will begin to appreciate why Lorenz was right to state that long-term prediction of climate is impossible.

Lorenz's paper – one of the most elegant in the history of mathematics – also used a thought-experiment: an artificial climate object with just five variables. He demonstrated that a near-vanishingly small alteration in the initial state of just one of the variables could produce major phase-transitions (or “tipping-points”) at a later state of the model. This is often called the “butterfly effect” – a butterfly flaps its wings in the Himalayas and a consequent hurricane devastates Florida.

Of course, the computer – on being given the precise co-ordinates we have specified to a precision of 16 decimal places – can model the Mandelbrot object accurately. However, even a very small variation in the initial state of the object, as defined by the co-ordinates expressing the range of values of the complex variable c , leads to an entirely different picture – or even to no picture at all. This is an appropriate illustration of the reason why, even with the aid of the world's most sophisticated computers, climate cannot be predicted for the long term: we do not know the initial state of the millions of relevant variables at any chosen moment with sufficient precision to make reliable projections of the long-term future state of the climate.

This simple mathematical heuristic is a way of demonstrating that anyone who says, “The Debate Is Over,” or “The Science Is Certain,” or “Now We Must Act,” must be wrong. Climate science cannot, by its very nature, be certain. We conclude, and are compelled to conclude, that long-run prediction of future climatic states is not possible, and that accordingly any output from the climate models – however large the models – should be treated with appropriate caution rather than naïve credulity.

Four examples of the unwisdom of assuming that we know all we need to know about the climate:

He should have stuck to movies: Early in 2007, Arnold Schwarzenegger, a B-movie actor turned Governor of California, declared, “The Debate Is Over. The Science Is Certain. Now We Must Act.” A few weeks later, three-quarters of the citrus crop that is the prime agricultural product of the State of California was destroyed, but not by global warming. The fruit was destroyed by a long, hard frost.

The unit of cant is the Miliband: A few weeks later, David Miliband, the UK Environment Minister, said, “The Debate Is Well And Truly Over.” Within days, the heaviest snowstorm for 10 years fell and brought the UK to a standstill, preventing a million children from getting to school.

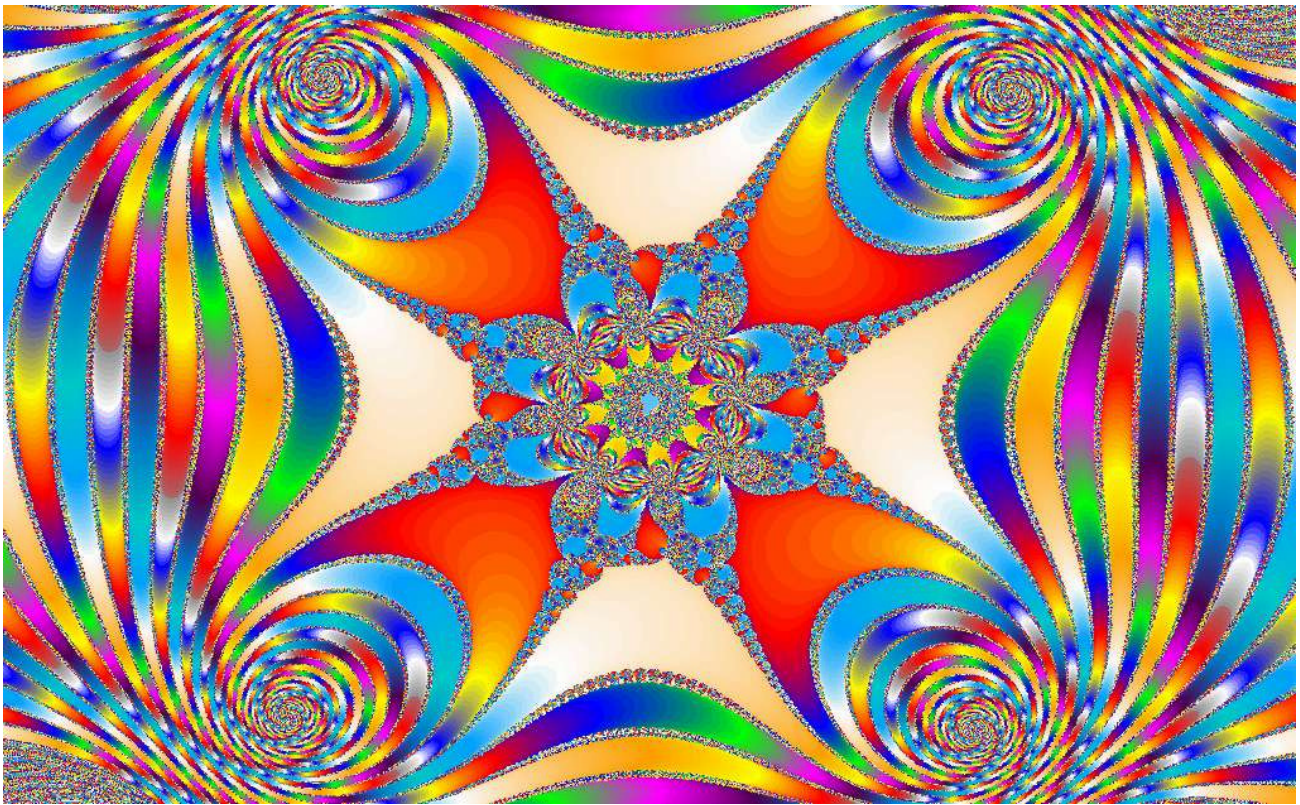
The “long, hot summer of 2007” predicted by the UK Meteorological Office: In the spring of 2007, the Meteorological Office in the UK confidently predicted that, because of “global warming”, the summer would be unprecedentedly long and hot. Within three months of this prediction, the UK had undergone the coldest, wettest June since records began.

The Murdoch diktat: Rupert Murdoch, who owns or controls much of the world’s media of communication, issued an edict to all his editors in the early summer of 2007 to the effect that they were in future to reflect his opinion that “global warming” was the worst threat faced by humankind. Murdoch cited the long drought in Australia as evidence for “global warming” – an instance of the *post hoc ergo propter hoc* fallacy. Within two weeks of the Murdoch diktat, much of Australia had been inundated by unprecedented floods.

Given the proven unpredictability of the climate, anyone who says, “The Debate Is Over” is merely displaying scientific ignorance of a long-established result in elementary chaos theory as applied to the climate.

FIGURE 1

Result of a thought-experiment using the Mandelbrot fractal



Result of a thought-experiment: Surprisingly, this decorative, ribbon-festooned Maltese Cross is not man-made: it is the image resulting from the iterative calculations on the values of c specified in our elementary heuristic. If you predicted anything like this, congratulations! If not, imagine the difficulty of predicting the climate, where, unlike the fractal object of which the above picture is a tiny region, its initial state and its subsequent evolutionary processes are insufficiently known.

References

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