God and the arrogant species: contrasting nature's intrinsic uncertainty with our climate-simulating supercomputers

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Although the climate has always been in perpetual change, many scientists who support the anthropogenic global warming hypothesis claim that this time it's different, because their climate models show that the increase in carbon dioxide fits the current climate change better than any alternative explanation. This argument is circular, since the models reproduce the hypotheses of their programmers. What is most important, however, is that this way of reasoning is rooted in the fallacy that climate can, in principle, be described in deterministic terms; that if we could analyze the system with sufficient granularity and make sufficient measurements then we would be able to produce sufficiently good predictions; and that there must necessarily exist an identifiable causal agent behind every trend or shift. We explain that climate, like many natural systems, exhibits "Hurst-Kolmogorov behaviour", which means it is intrinsically uncertain, with real limits to the potential for attribution and prediction.

Figure 1: Jörg Breu the Elder (c1475–1537)
"A Question to a Mintmaker" (c1530)

In the middle ages, people were told they were all sinners, and thus they would burn in hell. However, they could buy indulgence: they could pay an amount of money and get a piece of paper which certified that their sins were forgiven. Today, we are told we are all sinners (because we exhale carbon dioxide, give birth to children who do the same, and we also drive cars),

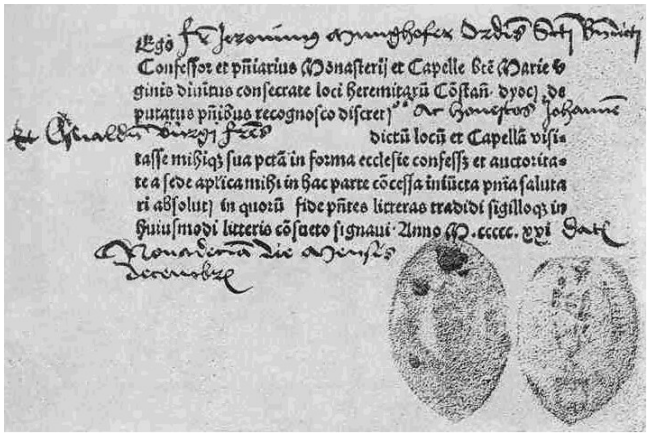

Figure 2: Indulgence of 1521

and thus we will burn in hell as the Earth warms up. However, we can buy indulgence: for example, if you fly to London for the weekend, you can buy indulgence for that particular sin. The indulgence of Figure 3 is similar to that of Figure 2, and it even contains the stamp. Its title, "Offset the carbon emissions", is another way of saying "pay this amount and we'll pretend that you did not make this trip". Other forms

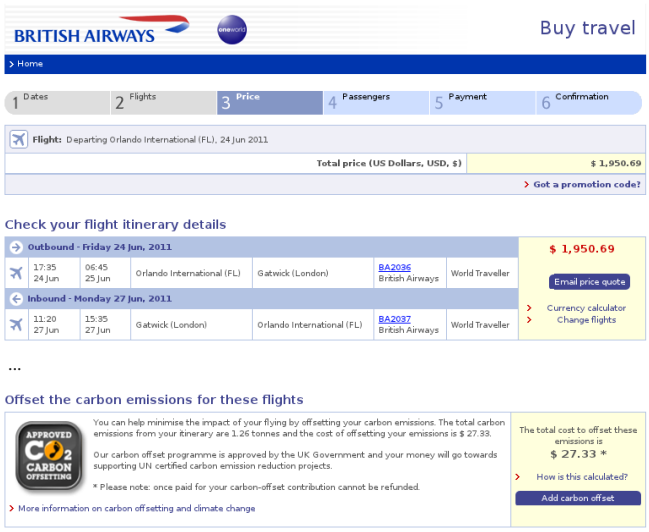

Figure 3: Indulgence of 2011

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of indulgence are compact fluorescent lamps and hybrid cars, which also do not make any difference. To us, climate change is largely a religious issue, which is why we chose to involve God in this presentation.

1. Does God miss his targets?

The reason some scientists think that the Earth will warm up is that their models tell them so. In climate models, the atmosphere is divided in pieces, and then the conditions in each piece in the next time instant are calculated based on the conditions of the neighbouring pieces. This is repeated, and the result of this simulation allegedly tells us how the climate will be in the future. (This is also how weather is predicted; but climate models incorporate the ocean in the simulation, because it affects the long term behaviour of the atmosphere; of course, they also go much farther in time.)

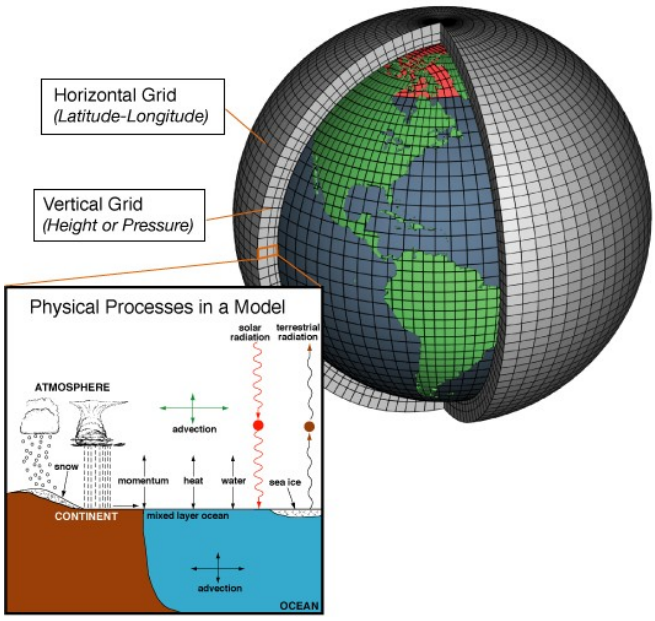

Figure 4: Schematic for climate model

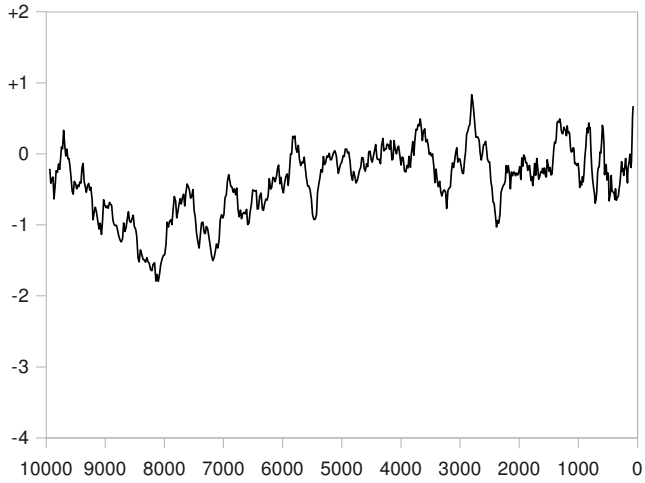

Figure 5: Temperature in the last 10 thousand years, from ice cores (horizontal axis: years ago; vertical axis: difference in °C from today)

Models have parameters, and these parameters need to be calibrated. If you calibrate with one data set and test on another, it's OK; but climate models are not tested in this manner. If you only calibrate and do not test, then "calibration" is a misnomer: it's actually data fitting. So modelers adjust the parameters so that models behave as they have hypothesized they should behave; then they use this behaviour as evidence that their hypothesis is correct.

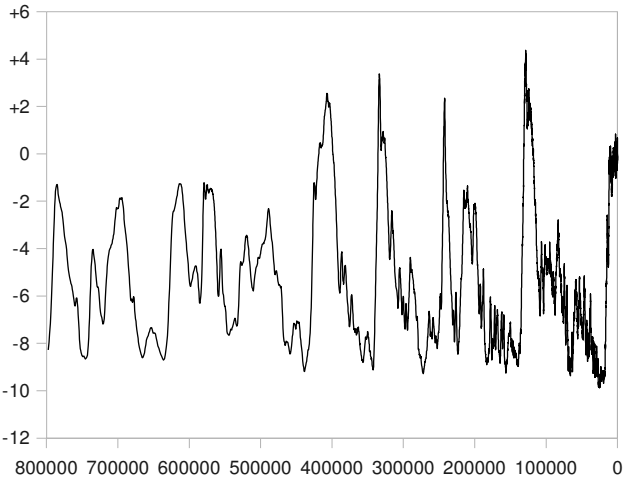

Figure 6: Temperature in last 800 thousand years, from ice cores (values in axes same as in Figure 5)

In climate models, the time step of the simulation is a fraction of a day. However, modelers themselves acknowledge that their model outputs are worthless not only at the daily, but also at the monthly, and at the annual time step. They claim that they don't get the "weather", but they get the "climate". They say that the evolution of temperature consists of a "signal" (the "climate"), plus "noise" (the "weather"). Let's, for a moment, pretend that their thinking is correct. Figure 5 shows the evolution of temperature in the last 10 thousand years, as determined from ice cores. Let's imagine a smoother line that we think is the signal. Now if we zoom out to 100 thousand years, as in Figure 6, does our signal still look like a signal? Or has our former "signal" become "noise" at the new scale?

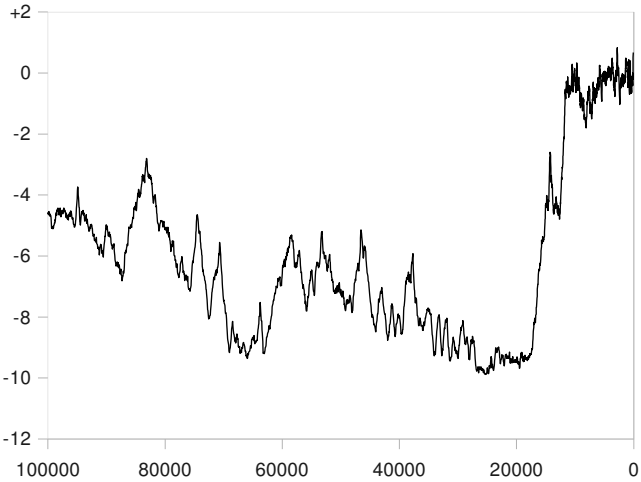

Figure 7: Temperature in the last 100 thousand years, from ice cores (values in axes same as Figure 5)

What if we zoom out to 800 thousand years, as in Figure 7? What if we zoomed in, and examined how the temperature changes second by second? Wouldn't we have a similar shape?

Besides, what is the physical meaning of "signal" and "noise"? In radio communications, the signal is what you want to transmit, and the noise is the difference from what is actually received. What is the physical meaning of signal vs. noise in temperature? Could God possibly want the temperature to be 25°C, but missed and got 27°C instead?

2. Does God plan ahead?

Take this simple sequence:

$$x(t)=k\,x(t-1)[1-x(t-1)]$$

When this is run with k = 3.7 and the initial condition $x(0)$ = 0.65, it gives you the blue line of Figure 8. Now if you run it with the initial condition $x(0)$ = 0.64999, then initially results are practically the same, but after a while they diverge wildly. This sensitivity to the initial conditions is called chaos. Most phenomena in nature are chaotic. The three body problem, in which we try to predict the position of three interacting masses, such as the Earth, Sun and Moon, is chaotic; we can predict eclipses for a few million years ahead, and we also know what eclipses occurred up to a few million years in the past, but we do not know what eclipses happened 100 million years ago, or what eclipses will happen in 100 million years. Things thought of as random, such as dice throwing and roulette, actually follow well-defined, deterministic natural laws, but here the predictable time horizon is a few seconds or a fraction of a second; beyond that, the result is random. The weather is chaotic. The predictable time horizon is a few days, sometimes one week, depending on conditions. So the phrasing of the common example, that a butterfly flaps its wings today and a hurricane occurs two weeks later, conveys a totally wrong impression. The butterfly does not cause the hurricane. What happens is that the formation of the hurricane is so sensitive to its "causes", that causation effectively disappears and the hurricane, like the result of dice throwing, is reduced to a random phenomenon.

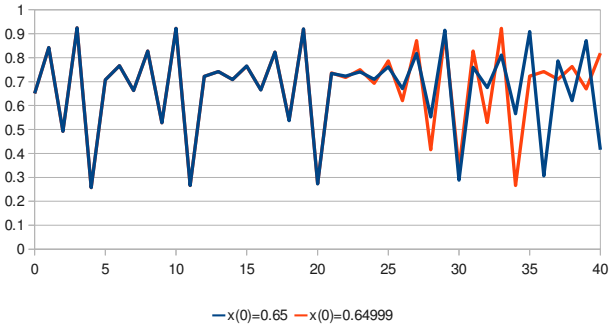

Figure 8: A function with a predictable horizon of about 20 iterations

Climate modelers admit this, but they claim that the chaos is in the weather (the "noise"), and not in the climate (the "signal"), which they assume to be a deterministic, well-defined function of the "causes". We already explained that there is no evidence for that.

3. How much does God reveal about the future?

There is another common misconception. Since the 1950s, it has been known that conditions, such as warm years, wet years, etc., tend to cluster. If this year is warm, there is increased probability that the next year will also be warm. The misconception is that this decreases uncertainty; in fact, it is quite the opposite.

There is no magic in the clustering of events. If this minute it's warm, it is likely that the next minute will also be warm. If it has been raining for three days, it is likely that it will be raining in the next hour. Since sea level has been increasing for about ten thousand years, it is likely that it will continue to increase in the next century. But how is this more uncertain than roulette, where individual outcomes are independent of time? The answer is that if you play all night, you will lose. This is pretty much certain. Of course, if you play for only five rounds, there is uncertainty, but who plays for only five rounds? Roulette only gives you an illusion of uncertainty, but for practical purposes the result is certain and well known (see also Figure 9, and contrast with Figures 5–7). In the real world, God makes no warranties on what will happen in the long term. Yes, the sea will most likely continue to rise in the next century, but beyond that, it is really uncertain what it will do. It is more uncertain than if sea level behaved like roulette.

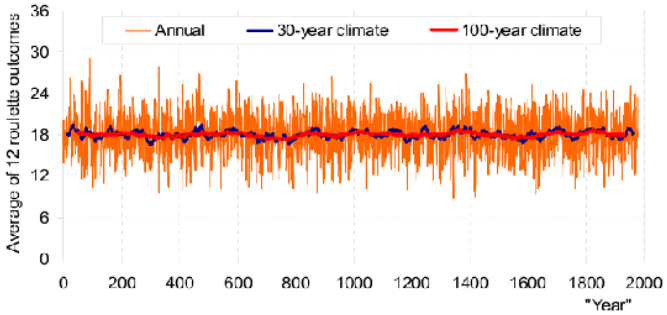

Figure 9: Moving averages of two thousand random roulette outcomes

So when we design a structure, such as a dam, and we try to predict the design flood, then it's not a good idea to use the notion of the "maximum probable precipitation", because there is no such thing, and because it can be (and has been) exceeded; it's also not a good idea to consider a "signal" (e.g. a constant average value) plus "noise" (e.g. variability that follows a distribution), because God does not err, and therefore he does not distinguish between signal and

noise. It is better to use Hurst-Kolmogorov dynamics, with which we do not predict the future in a deterministic sense; instead, we predict the possible range of outcomes given an uncertainty level (or vice versa), without distinguishing between "signal" and "noise". The application of this method results in higher uncertainty estimates than with other methods, which underestimate uncertainty.

Epilogue: How God deals with arrogance

There is a well-known story in the Bible about arrogance. People were speaking one language, engineering progressed, and they started to build a tower which they intended to make so high it would reach the heavens. God thought that if they succeeded, nothing would be impossible for them.

Likewise, today, science and technology have progressed much, and by building these awesome supercomputers, which consume megawatts of energy produced by magnificent power plants and transferred through a highly sophisticated grid, we can be carried away into thinking that we can predict the future; but if we really could, we would be gods ourselves.

Figure 10: The computer of the British Met Office

In the story of the bible, God descended and confused the language of the people, so that they could not understand each other; and then they were scattered all over the earth. I think that the meaning of this can be felt in large conferences, where we are thousands of scientists in hundreds of sessions, each one of us working in his own isolated domain, with hardly any knowledge of nearby domains, let alone of the big picture. So we think that what the story is trying to tell us is that good communication leads to progress, progress is followed by arrogance, and arrogance is followed by loss of communication, which leads to stagnation, which is, we think, where science is now.


Figure 11: Pieter Bruegel the Elder (c1528–1569)
The Tower of Babel (c1563)

Sources and further reading

Figure 4 is from http://celebrating200years.noaa.gov/breakthroughs/climate_model/modeling_schematic.html (accessed 22 June 2011).

The story of the tower of Babel is in Genesis 11.

For the source data of Figures 5–7, and further references to Hurst-Kolmogorov dynamics, see http://hk-climate.org/.

See also Christofides, A., and D. Koutsoyiannis, Causality in climate and hydrology, *European Geosciences Union General Assembly 2011, Geophysical Research Abstracts, Vol. 13*, Vienna, EGU2011-7440, European Geosciences Union, 2011, available at http://itia.ntua.gr/1130.