

Plows, Plagues& Petroleum

How Humans Took Control of Climate

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Is the Climate changing, and if so are we humans responsible for it, and after all is this global warming necessarily a bad thing? Ruddiman is a climatologist, who has throughout his professional life shied away from public pronouncement, trying as so many scientists steer a middle course between the alarmist, often hysterical, stands taken by environmentalists and the cynical attitudes presented by industrialists. In the media-coverage understandably both extremes get pride of place, and Ruddiman remarks that two unbalanced views seldom combine to form a true and balanced one. As his later findings have received the attention of the media, he has found himself bombarded by the other, the contrarian side, and discovered to his amazement and dismay a parallel universe, in which ordinary rational and fair scientific interchange has been replaced by wilful obfuscation and selective ignorance of basic scientific facts, almost always by people and institutions paid for by industrial interests. This discovery of an innocent has greatly disgusted him, and as he makes clear in his epilogue, there is no longer any question of where his sympathies lie. Still is global warming such an unmitigated disaster, especially in view of the fact that waxing and waning of ice-sheets have been with us for the last two or three million years, and from a longer geological perspective far more extremes climates than those we expect to encounter in the next couple of centuries have prevailed. True, climate change means a more or less total revampment of prevalent ecology, and man as an ecological creature may not survive a replacement of the ones to which he has been adapted. On the other hand man is also considered to be more than just a product of evolution, his very much celebrated intelligence, notwithstanding its evolutionary progeny, makes him transcend his origins as well as the process of natural selection, through technological innovation, enabling him to continue evolution, though be it with other means. Ruddiman does not speculate along such exalted lines but is content to point out that the immediate costs of halting the present trends would involve huge sacrifices for benefits which are vague and far into the future. No politician would hesitate when faced with such an equation. To cynics this might be a case against democracy, after all totalitarian movements are almost always motivated by the abstract human good, often placed far into the future¹ Yet, people are living here and now, and personal concerns seldom go beyond those pertaining to our proverbial grandchildren² As to the question of the seriousness of the issue, Ruddiman

¹ The totalitarian potential of the environmental movement is seldom appreciated, its proponents often depicting themselves as harmless tree-huggers propagating for a return to a lost Eden. There has not (yet?) been any environmental terrorism, the closest to it (so far?) being the benign antics of Greenpeace.

² We do not care as much for the grandchildren of our grandchildren, as we do for our own, thus showing that ostensible unselfishness is nothing but the usual self-serving egotism.

points out that it depends on your priorities. Global warming will certainly cause havoc to the arctic regions, and the lives those sustain; but as people in industry point out, the polar regions form but a small peripheral part of the world, and most people will feel no direct effects of Polar bears going extinct. True global warming will have serious consequences on other latitudes as well, although it would be unfair not to admit that some regions would definitely profit from it, not only economically. Consequences which, after the writing of the book, has recently been attached with price-tags³. What Ruddiman really worries about is the usual environmental story, the mindless squandering of nature's free gifts, like fresh groundwater, fertile topsoil, and fossilized fuel, things that have taken geological timescales to produce, and will not be easily replenished, no matter how smart we happen to be. The spectre of climate change is of fairly recent vintage, catching the imagination of the public, because it highlights that what we humans do actually effect the solid earth from which we draw our sustenance, in a significant and disturbing way. The conclusion of Ruddiman is that human societies have for a long time competed with natural processes as to the shaping of the climate, and in fact that the majority of the refurbishing of the earth's surface is no longer effected by weather, but by human intervention like bulldozers scraping. This has in recent years been accelerated but the main thesis of the author is that this has been going on for millenia, ever since humans started to till the soil, the most momentous of human revolutions. This might appear paradoxical, considering the scarcity of people and their primitive technologies, on the other hand, they had had time working in their favour. As Ruddiman points out the tortoise makes up for his slowness by having a long headstart.

So what exactly are the controversial issues connected with global climate change? Climate is not the same thing as weather, the crucial difference being that weather is concerned about specific events, notoriously difficult to predict as to location and timing, while climate has to do with what kind of events can occur. Thus the usual quip about meteorologists having trouble forecasting the weather for a few days, how can they ever hope to predict it for hundreds, nay thousands of years, misses the point. True, as we will see, longterm predictions of climate share many of the uncertainties connected with prediction of weather, but be it on a far coarser scale, and much criticism and scepticism can, (and should be?) levied against various computer calculations and the particular models which guide them; but the basic features of climate and its change can actually be fully explained by rather simple mathematics. Climatology is not a field that will inspire conceptual mathematical breakthroughs.

The climate is driven by the sun, and the variations of sunlight based on seasons and latitudes. This is very basic, and to deny it would be tantamount to put yourself on the same level as those who claim that the earth is flat. In fact it is easy, if (before computers) laborious, to compute those solar radiation curves. And those curves are sufficient to explain the main features of the climate of earth, features we almost take for granted, such that the closer we get to the poles, the colder it gets, and that while there maybe a drastic difference in winter temperatures between middle and higher latitudes, such differences are greatly ameliorated during summers. However given such curves it is not so

³ A report whose name evades me for the moment

easy to translate those into actual temperatures. In order to find out the global average⁴ temperature so we need also to take into account the albedo of the Earth, the greenhouse capacity of the atmosphere. And to predict local behaviour, we need also take into account local albedos, distribution between land and ocean, patterns of wind and above all oceanic currents. Such predictions based on first principles would be very difficult to make. What comes to our rescue is the historical record which we can take as our basis for fixing further parameters⁵. Such features highlight the difference between scientific consensus on one hand and controversy on the other. And what seems not particularly appreciated, maybe because it is so obvious, is that a large part of the earth (the temperate zones) temperatures hovers around the freezing point of water, an accident with profound biological, as well as it turns out, climatological consequences. If the temperature variations would only marginally affect that magic level, climatological variations would be far less dramatic.

To return to the initial solar radiation curves. Those are subjected to rather minute changes over extended periods due to predictable variations of the tilt of the earths axis as well as variations of the earths excentricity. The earth axis wobbles, not only in terms of direction (precession) but also in actual tilt, the former having important consequences as to the timing between solstices and aphelion and perhelion passages. All of those variations, ultimately derived from the perturbing influences of Jupiter and Saturn, can be worked out and various periodicities calculated which may either reinforce each other or cancel out. Such laborious calculations were performed by Milankovitch at the beginning of the 20th century as to provide an explanation for the various ice-ages that had occurred in the past⁶. What Milankovitch realised was that an Ice-sheet does not form because so much from cold winters, as cold summers (joined by mild and wet winters) preventing snow from fully melting and thus enabling it instead to slowly accomodate year by year. While solar radiation averages about equally over the years, the distinction between summers and winters depend on the orbital elements of our planets rotation around the sun as well as around its axis, therein lies the true significance of the climatological effect. The solar effects may be marginal, but there is climatological resonance. As ice-sheets start to form, the albedo increases as more light is reflected back in space and less light is absorbed by dark vegetation. Also, which is less well understood, greenhouse gases like CO_2 and CH_4 also start to decline⁷, causing further decreases in temperature. Milankovitchs theo-

⁴ In L^4 meaning, due to Boltzmanns law

⁵ Crucial to any climatological understanding is the fact that ocean currents seem fairly stable for some reasons. In the past the Gulf Stream has occasionally been thwarted in its northern thrust, with disastrous consequences for northern Europe. Within years the temperature dropped precipitously

⁶ The realization of a past Ice-Age was formed in the early 19th century, and the geologist Agassiz is usually credited with the claim. Later one realized that there had not just been one episode, but a succession, and at the time of Milankovitch it was understood that there had been four, each of them duly named. We nowadays know that there have been several during the past two and a half million years or so, coinciding with the appearance of hominids, and that it may not be so easy to delineate the individual periods, as there has been a jagged line of glaciations interrupted by interglacial interludes. Further back in geological times there has been other Ice-Ages, and it is now believed that for several hundred million years ago the whole Earth may have frozen over.

⁷ One reason could be that a cold ocean is capable of absorbing carbob-dioxide at a faster rate than a

ries, although aesthetically satisfying, did not receive general confirmation until the 70's⁸, when the orbital cycles of the Earth could actually be matched against the records of past temperatures stored in ice, as well as ice-age debris stored in the sedimentation along continental shelves. This actually highpoints a difference between mathematics and sciences. The principles in the latter are often very easy to understand, but to actually work them out in practice relies on a large network of technological innovations that need to be in place. Also what is so simple in principle, leads to all kinds of snags and complications, each of which require great ingenuity to work out, when you get down to implement them. So science proceeds partly by the brilliant insight and the fruitful idea which get recognition and general exposure and partly by drudgery, taxing on its own, but anonymous and unappreciated, but without which there would never be any actual progress. Obviously in any popular account you will be treated to the general ideas, never bogged down by the particulars.

Stepping back a little, we realise that the earths climate can in principle be calculated into the future, ultimately by straightforward celestial mechanics⁹, we do hereby ignore the possible variation of solar radiations, but such variations are acts of God and for which we (like insurance companies and travel agents) should take no responsibility. Now according to the regular waxing and waning of ice formation we should in the last few thousand years be heading towards a new ice-age, with an ice-sheet well under way on Baffin Island; but obviously we are not. All the indications show the contrary. The concentration of greenhouse gases are increasing rather than diminishing as they ought to would they follow the natural scenario. What goes wrong?

Human intervention. And as this discrepancy goes back long before the Industrial revolution, in fact some 8000 years or so, it must involve pre-historic man. This is the startling thesis of the author, and to corroborate it he needs both to get some reliable estimates of population numbers and the size of a human 'foot-print'. The latter he gets from an unlikely source, the Doomsday book compiled after the Conquest of William a thousand years ago. It turns out that already back then a large part of Britain was already deforested¹⁰ and one could estimate the need of about 0.09 square kilometers of clearing to feed a new mouth¹¹ From this it is easy to estimate how much forest has been cleared in the world (in fact most of it) and what its CO_2 contribution would be to the atmosphere.

warm ocean

⁸ I happened to learn about them through a book by Imbrie and Imbrie (Not husband and wife, but father and daughter) which I bought at Duke in the spring of 1989 and read a few years later. I recall being a bit sceptical, the whole thing seemed a bit too neat, as if presented by someone with a conspiracy theory to reveal. Later I have learned that the theory is now part of scientific consensus, and that Imbrie himself was instrumental in vindicating the old Serb referred to as a mathematician.

⁹ There is an irony in that the passages of Jupiter and Saturn on the sky, may not influence individual destiny, but do tangibly affect the climactic destiny of our planet.

¹⁰ There were long into historical times pockets of forests for the upper classes to hunt in, thus the latter unwittingly acting as environmental conservers.

¹¹ such estimates should also be obtainable from general principles such as individual caloric intake and the productivity of the land, but such parameters are subject to great uncertainties, and historical records are to be preferred whenever available.

It all more or less tallies, once again illustrating that the most crucial conclusions are based on very elementary mathematical considerations.

The next step is to look at second order variations, i.e. small bumps on the general trends. When you do so, you naturally embark on much shakier and speculative grounds, and the conclusions you can draw are far more liable to refutation. Ruddiman wonders whether those bumps can be correlated to events in human history, like wars, famines or pestilence. He is no historian, and there is almost something touching about the way he reminds himself of the Black Death or refers to the eight million Germans and Belgians [sic] who perished in the Thirty Years War. He concludes that wars and famines cannot have had any global demographical consequences, but pandemics certainly could have, and he sees in fact a rough correlation between the curves of greenhouse gases and documented curses by plagues and other pestilences. In the past those could reap more than half of the afflicted populations, and less people less impact on the environment. The most drastic such culling happened to the New World, whose exposure to the colonizers of the old, turned out to be a disaster to its indigenous populations. It is only lately it has been appreciated how big the pre-Columbian population was, and to what extent it had really occupied the land. Those virgin forests the European settlers cleared, turned out not to be virgin after all, but were regrowths in the wake of vanished populations¹².

Forest clearing can only go so far until almost all arable land is put on the plough, what has changed in the last two hundred odd years, is the steady use of fossilized fuel, burning up coal and releasing energy stored under millions of years. This is what acceleration is all about, and as he reminds the reader, the full impact of it is still to be seen, as we do not live through a time of equilibrium, but the increased heat will steadily build up in the years to come, so even if we would be able to slash emissions drastically the consequences of past sins would still manifest themselves dramatically. In short the climatological system has a certain response time. In terms of ice-sheets this is counted in millenia, and those spectres of melting ice inundating us all are exaggerated, at most we can speak about a rise of the ocean by a meter or so within the next century. As to other factors it is harder to estimate. And this is where the controversy lies, not so much in the fact of increased greenhouse gases and the invariable increase in heat they will induce, this is beyond doubt, but in an exact prediction of how much the temperature will rise within the next century, keeping as much as possible fixed. This ties in with the problem of translating energy inputs into actual temperatures, which I touched upon in the beginning. Then different models of various complexity step in, all giving, not surprisingly slightly different results. Local predictions are of course even harder, one ironic consequence of global warming could be changing the direction of the Gulf Stream, with disastrous consequences for northern Europeans. This is of course very speculative, but meant to highlight what kind of uncertainties riddle predictions of the future. The human impact on the climate is big enough to lead to uncontrollable issues, in spite of the undertitle of the book - how humans took control of climate.

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¹² Forest reclamation is fast, typically abandoned pastures are fully forested in fifty years time