Tipping Points and Climate Change

We encounter simple tipping points in our daily lives. Every cook knows not to whip cream for too long, or it will suddenly and irreversibly turn into butter. Every sailor knows not to sail too close to the wind, or the smooth flow of air will suddenly break, the sail will flap, and its power will be lost.

Everything seems to be going along just fine until the tipping point is reached. Then the situation quickly changes from one state to another. Cream becomes butter; a powerful sail becomes a flapping rag. In the first example, the change is irreversible (butter cannot be changed back into cream), in the second, a push on the tiller can swing the boat around and fill the sail from the other side.

Climatologists have identified a number of "tipping elements" in the earth's climatic system. These tipping elements are components of the climate which may change abruptly from one state to another, and which are sensitive to global warming. Among these are the world's great ice sheets.

Their gradual melting may suddenly accelerate causing their disintegration and disappearance. Each mass of ice is, however, structurally different, and each will behave differently. The Greenland ice sheet covers dry land, the Arctic sea-ice sits on water, and the West Antarctic ice sheet is grounded below sea level.

The land and sea-ice seems to be the most sensitive to increased temperatures. Some say that the Arctic sea-ice has already passed its critical threshold and will not persist through future summers. Calculations made in 2007 predicted that Antarctic ice was more resilient and would probably need local summer temperatures five to eight degrees higher than today to reach tipping point. However, 3D models published in 2010 suggest that the Antarctic Pine Island Glacier has probably passed a critical threshold and is irreversibly on track to lose 50 per cent of its ice in as little as 100 years, significantly raising global sea levels.

It is clear that all is not clear about the behaviour of ice sheets.

The next category of "tipping elements" is the forests, particularly the boreal (northern, cold forests) and Amazon rain forest. If things get hot enough, both are likely to suffer drought and heat stress, with an eventual collapse of the ecosystem. Global warming of three to five degrees would probably be enough to tip the forests over. However these calculations exclude the effects of deforestation. A 2009 study by Brazilian scientists calculate that man-made clearance of the Mato Grosso region of the Amazon, would, by itself, be sufficient to convert rain forest to dry savannah. Throw global warming into the mix, and the tipping point suddenly becomes much closer.

Oceanic water bodies and currents are also on the list. Foremost among these is the well known body of water in Pacific known as "El Niño" (when the water is cold) or La Niña (when it is warm). This current interacts with the atmosphere to create the "El Niño-Southern Oscillation" (ENSO). Cold and warm phases fluctuate every four to twelve years and are associated with the severity of floods, droughts and tropical cyclones in many regions of the world. Reports ten years ago suggested that global warming might increase the frequency of these fluctuations. Recent calculations disagree. They say the effects may become more severe rather than more frequent.

The ocean current system which concerns most people in Europe is the North Atlantic Heat Pump. Warm sea water flows along the surface from equatorial regions to the North Atlantic, where it cools, sinks, and then returns to the south as a cold, deep water current. This system could be tipped by an excess of fresh water in the northern sinking areas. Fresh water is less dense than salt water, and if too much is added to the sea -through melting ice or increased rainfall-, then no matter how cold the surface waters become, they cannot become dense enough to sink. This would shut down the heat pump and result in regional cooling from eastern North America to Europe. Thus in a warming world, we would have regional cooling. When is this likely to happen? Computer model predictions range from no change at all to shut down within 50 to 75 years. Take your pick.

Then there are the monsoons, particularly in relation to the local climates of India and Africa. In India, monsoons are expected to become erratic. In West Africa they may result in drying, or in wetting, or in long periods of drought....or...

Marine biologists describe how the sea is becoming more acid through the absorption of carbon dioxide, and fear that the coral reefs will eventually die since the reef animals will be unable to grow their calcium skeletons. Geologists warn of the vast amounts of methane currently locked away as methyl clathrates in the permafrost of the tundra. Methane is a powerful green house gas, so warming will be accelerated if this is released. News media are full of imminent Armageddon.

Tipping points are wonderfully dramatic, which is why environmentalists and scientists who firmly believe in global warming often cite them to emphasise the seriousness of man-made climate change. They are also very difficult to predict. A real danger is that too much alarm can lead to public cynicism and disbelief.

This situation has not been helped by the IPCC (Intergovernmental Panel on Climate Change) report which said that Himalayan glaciers would melt away in 35 years. This assertion was based on wild speculation in a popular science magazine, and is not backed up by research. The report also misinterpreted an unpublished study and claimed that an apparent increase in the severity and cost of natural disasters was linked to global warming. When the authors of the study finally published it in 2008, they included this sentence: "We find insufficient evidence to claim a statistical relationship between global temperature increase and catastrophic losses".

If moves are to be made to limit man-made global warming, it is important that climatologists retain their credibility by being scrupulously honest about what is known and what is unknown. Tipping points are real. We do have evidence that the climate has tipped abruptly in the past, but scientists have only sketchy ideas as to why.

One of the most famous examples is the Younger Dryas or "Big Freeze" - a sudden cooling of about seven degrees in the northern hemisphere which happened about 12,800 years ago and which created a mini ice age lasting 1300 years. Until recently it was thought that this cooling took place over the period of a decade or so, but recent microscopic studies of mud from Lough Monreagh, a lake in western Ireland, show that it took only a few months. The warming, when came, was similarly abrupt - a 10 degree rise in temperature over ten years. This information lies locked in ice cores and sediment records. Why and how the events occurred remains a mystery.

Theories abound. One idea suggests that there was an escape of large amounts of cold, fresh water from a huge lake (Lake Agassiz), formed by melting ice in what is now southern Manitoba. This would have been enough to stop the thermo-haline heat pump, but this theory does not explain all the observations. Another idea is that reduced concentrations of CO2 and methane caused the north Atlantic to cool. And yet another, that an impact by a meteor initiated cooling through increased cloudiness. Finally, another theory weakly surrenders and blames "some hitherto unknown climatic cycle."

So, if we don't know what caused elements of the climate to tip naturally in the past, what hope have we to predict when (with a push from Man's helping hand) they will tip in the future? Not much hope at all.

However, not knowing when is no excuse for sitting around doing nothing. We can reduce the chances of forcing man-made tipping points by controlling our actions. This means moving towards a carbon neutral society as fast as possible.

If you keep on whipping that cream, sooner or later it will turn into butter.

by Christine Betterton Jones - BSc. (Zoology), PhD (Parasitology)

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