Panel: World climate liable to sudden, rapid change

'The paleoclimate record shouts out to us that, far from being self-stabilising, the Earth's climate system is an ornery beast which overreacts to even small nudges.' Wallace Broecker, a paleoclimatologist at Columbia University, says.[i]

Broecker personally believes that the reaction he fears will be strongly negative and that the climate in the northern hemisphere will cool by as much as 10ºC in as little as ten years if the Gulf Stream halted. This would give Dublin a climate equivalent to that of Spitzbergen. How might this happen? Well, at present the large volumes of warm water that flow from the Gulf of Mexico across the Atlantic to Europe lose heat and freshwater to the air by evaporation along the way. This makes the water cooler (its temperature drops from 12-13ºC to 2-4ºC), saltier and thus more dense until, somewhere off the coast of Iceland, it becomes heavier than the surrounding sea, sinks and flows south along the seabed. Much of it then rounds Africa, joining the Southern Ocean's circumpolar current.

Broecker calls this flow 'The Conveyor' and says that it is equal to that of 100 Amazon Rivers! 'It's similar in magnitude to all the planet's rainfall. The amount of heat carried by the Conveyor's northward-flowing upper limb and released to the atmosphere is equal to about 25% of the solar energy reaching the surface of the Atlantic north of the Straits of Gibraltar.' he says. Hence its massive effect on Europe's climate.

If global warming prevented the Gulf Stream from cooling sufficiently to sink, its flow would stop. This seems to have happened about 8,000 years ago when, it is suspected, fresh water from melting ice in Canada flowed into the Atlantic and, by making the water in the Gulf Stream less salty for about 400 years, caused a mini ice age.

Certainly, the last Ice Age proper started so suddenly it was almost has if something had been turned off. An analysis of pollen deposits in France shows that the switch from a warm inter-glacial climate to tundra conditions in which it was too cold for fruit and nut trees to grow took less than twenty years. The end of that Ice Age was very rapid too. Ice core samples from Greenland show that there was a 5-10ºC rise in temperature in the space of twenty years. Was this the Gulf Stream starting up again?

While they accept that the Earth's climate can flip in a matter of years from one stable regime to another, very different one, most authorities fear that, rather than cooling, the flip might take the form of a rapid warming which would continue until some new balance between heat inflow from the sun and outflow to space was reached. In November 1998 the British Government's Hadley Centre for Climate Prediction and Research issued a set of projections[ii] which showed that if nothing was done to restrict fossil fuel consumption, the rate at which the world warmed would accelerate. Average world land temperatures, which have risen by almost 2^0C since 1900 would soar by a further 3°C over the next fifty years, the report said. This would be the most significant change in the global climate since the end of the last ice age[iii].

The warming would not be uniform, however. Increases around the poles would be much greater than at the Equator, with northern Russia, northern Canada and Greenland acquiring average temperatures some 6-8° C above their current level. Naturally, a lot of snow and ice would melt and the resulting water, coupled with the thermal expansion of the warming seas, would cause sea levels to rise by 21cm. Unless massive defences were built, this rise would put some 78 million people at risk of annual flooding compared with 10 million in 1990. Indeed, this figure is almost certainly a gross underestimate because the model which produced it does not allow for any increase in the number or ferocity of storms.

Although the warming would allow trees in the northern hemisphere to grow closer to the pole and thus take in extra carbon dioxide from the air, forests would contract elsewhere and release greenhouse gases as they rotted or burned. Quite soon, the rate at which forests in one place were releasing CO_2 would outweigh the rate of CO_2 absorption in others. 'Tropical forests will die back in many areas of northern Brazil. In other areas of the world, tropical grasslands will be transformed into desert or temperate grassland' the Hadley report said. 'After 2050, as a result of vegetation dieback and change, the terrestrial land surface becomes a source of carbon releasing approximately [10 billion tonnes of CO_2] into the atmosphere [each year].' Although this release rate is equivalent to a third of current emission levels and would consequently accelerate warming, the report says that the feedback 'is not yet included in climate models.'

A second positive feedback was also left out of the Hadley model because too little is known about it. Huge quantities of methane - a much more powerful greenhouse gas than CO_2 - are stored on the seabed and in permafrost, the permanently frozen earth which covers at least a fifth of the planet. The gas is combined with water or ice to form a solid called methane gas hydrate. 'Rising temperatures destabilise the hydrate and cause the emission of methane' Euan Nisbet of Royal Holloway College, University of London, writes in his book[iv] *Leaving Eden*. 'One of the nightmares of climatologists is that the liberation of methane from permafrost will enhance the Arctic warming because of the greenhouse effect of the methane, and so induce further release of methane and thus increased warming, in a runaway feedback cycle.' He fears that warming will also release methane from hydrate in shallow Arctic seas. 'Any slight warming of the Arctic water will release hydrate from the sea floor sediments almost immediately' he writes[v]. 'The danger of a thermal runaway caused by methane release from permafrost is minor but real… The social implications are profound.'

Several other potentially damaging feedbacks were also omitted from the Hadley study. One is that as oceans warm, they become less capable of absorbing carbon dioxide which therefore builds up in the air more rapidly. A second is that changes in the chemistry of the upper air will affect the rate at which methane - which is relatively short-lived in the atmosphere at present - gets broken down. Taken together, these four effects can only mean that there is a significant risk that warming will spiral out of control during the next half-century unless greenhouse emissions are drastically reduced before then.

[i] *Science*, no. 278: pp. 1582-1588, 1997
[ii] A summary of the results is available at http://www.meto.govt.uk/sec5/CR_div/Brochure98/index.html
[iii] Background Brief, Conference of the Parties 4, UN Framework Convention on Climate Change, Buenos Aires, November 2, 1998.
[iv] E.G. Nisbet, *Leaving Eden: To protect and manage the Earth*, Cambridge University Press, Cambridge, 1991, pp.65-6.
[v] E. Nisbet, Climate change and methane, *Nature*, vol. 347, September 1990, p. 23

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