Climate Change 8 —Apocalypse Soon? Positive Feedback

So far we have discussed climate changes that occur very slowly. Are there processes that could accelerate change, making it more difficult to deal with? The answer seems to be that acceleration is possible, though we don't know whether it will actually occur. Because it might, however, it is worth understanding. There are two ways in which the acceleration could occur: positive feedback and sudden tipping.

Positive feedback occurs when one change sets in motion other changes, which then increase the original change, causing it to accelerate. In previous white papers, we noted that positive feedback involving water vapor was an integral part of the theory of climate change. Another example involves methane hydrate, which we described in the white paper on alternative sources of natural gas. It is methane frozen into a lattice of ice. It can exist only in very cold places under pressure. One such place is the permafrost in the Arctic. Should the permafrost melt, methane would be released into the atmosphere. Methane is a powerful greenhouse gas, however, with a global warming potential some 21 times that of CO_2. If the melting permafrost starts releasing methane, it will accelerate warming, which will accelerate the melting of the permafrost, which will release more methane, which will accelerate warming, etc. The result might be greatly increased warming. We don't know that such a scenario will occur, but it is one possibility.[i]

Sudden tipping is a common experience. When your gas tank gets low, your car doesn't go progressively slower. Rather it works until it runs out of gas, then it stops. Similarly, during a high wind, a tree may slowly bend further and further. If it breaks, however, it falls suddenly to the ground. The car and the tree illustrate sudden tipping points. Only in the last 15 years or so have climate scientists discovered that there have been times in the past when global climate patterns experienced quick, dramatic shifts, over a period as small as a decade or even less. These sudden tips in climate seem to be associated with cessation of an important ocean current known by several names. The IPCC calls it the *Meridional Overturning Current (MOC).*

In the Atlantic, the MOC is a surface current that carries warm salty water from the Equator to the North Atlantic near England (the Gulf Stream is part of the MOC). There, the warm water is responsible for giving the British Isles their moderate climate in winter (palm trees can grow in Cornwall, even though it is farther north than Minneapolis[ii]). The water then cools and sinks, returning along the bottom to the Equator, where it warms, rises, and begins the journey again. But when warming melts the ice at the poles, it prevents the warm water from cooling and sinking. Thus, it could interrupt the cycle, which would shut down the currents. In a decade or less, England would become more like Minneapolis, while the Caribbean would become warmer. Climate scientists believe that interruption of the MOC has caused abrupt swings in global climate patterns several times in the distant past.[iii]

There are additional types of positive feedback and sudden tipping that might occur, leading to rapid climate change. We can't be sure that any of them will occur, but these are the kinds of nightmares that keep climate scientists awake at night.

[i] For a general discussion of methane hydrates, see *Methan clathrate*. Wikipedia. Retrieved online 2/3/2008 at http://en.wikipedia.org/wiki/Methane_hydrate. A more technical discussion of how methane hydrates fit into global climate models is provided by the IPCC report, especially chapters 7 & 8.

[ii] Land's End in Cornwall lies at 50° North, while Minneapolis lies only at 45° North. For a photo of a palm-shaded beach in Cornwall, see Hhttp://gouk.about.com/od/picturegalleries/ig/Top-UK-Sights/Near-St--Ives.htmH. For an article with average monthly temperatures in Cornwall, see http://en.wikipedia.org/wiki/Cornwall.

[iii] The Meridional Overturning Current is also called the Thermohaline Circulation. For a general article describing it, see *Thermohaline circulation,* Wikipedia, retrieved online at http://en.wikipedia.org/wiki/Thermohaline_circulation. For a more scientific discussion, see Chapter 5 of the IPCC report, especially Box 5.1, p. 397. Bindoff, N.L., J. Willebrand, V. Artale, A, Cazenave, J. Gregory, S. Gulev, K. Hanawa, C. Le Quéré, S. Levitus, Y. Nojiri, C.K. Shum, L.D. Talley and A. Unnikrishnan. (2007). Observations: Oceanic Climate Change and Sea Level. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Available online at http://www.ipcc.ch.