MAJOR SEA LEVEL RISE: HOW LIKELY, HOW SOON?

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NOTE: This essay is adapted from a review of **The Fate of Greenland** by Philip Conkling *et al.* (MIT Press, 2011) and two recent and related articles in *Scientific American.* The full review is posted as the GFB Book of the Month for October 2012.

Forecasters of a major weather event, such as a hurricane, try not to overestimate or to underestimate. Hurricane forecasting has become highly refined, with periodic updates for alternative scenarios of possible courses that an approaching storm might take, as well as their probabilities. This short-term foresight, however, bears little resemblance to long-term forecasting, which is far less certain, but nevertheless deserving attention.

In late October 2012, Hurricane Sandy devastated coastal areas of New Jersey, New York, and Connecticut, due to a storm surge of up to 14 feet. *The New York Times* (31 Oct 2012, A18) reported that scientists had warned about the perils of flooding for years. According to a city-appointed scientific panel, "after rising roughly an inch per decade in the last century, coastal waters in New York are expected to climb as fast as six inches per decade, or two feet by midcentury." Even before "Superstorm Sandy" (as it was widely dubbed), an eerily prescient 9/11-timed feature in the *Times* (11 Sept 2012, p.1) noted the "accelerating" rate of sea level rise and more frequent flooding: "were sea levels to rise four feet by the 2080s, for example, 34% of the city's streets could lie in the flood-risk zone, compared with just 11% now."

But what if this illustrative four-foot rise in sea water for NYC is severely *understated* by a factor of six or more? This possibility is raised in a remarkable book on **The Fate of Greenland: Lessons from Abrupt Climate Change** (MIT Press, April 2011, 216p, with 72 color photos), by Philip Conkling (Island Institute in Maine), Richard Alley (Penn State U), Wallace Broecker (Columbia U), and George Denton (U of Maine). These climate scientists--two of whom, Alley and Broecker, are well-known--made several trips to Greenland to study ice core records and currently melting ice. The ice core provide evidence of scores of abrupt climatic changes over the last 100,000 years, often 10oC or more in roughly a decade or less. "*Greenland appears to be poised at the edge of another rapid climate change… (and we should) pay attention to Greenland because in the fate of Greenland lie clues to the fate of the world."* (p.23; emphasis added)

The four scientists caution that "*we are taking an enormous risk…if the Greenland ice sheet melts, sea level would rise seven meters—or about 24 feet—worldwide. In contrast, if the West Antarctic ice sheet melted, it would cause a five-meter—16-foot—sea level rise."* (p.22)
But this 24-40 foot addition will probably not happen soon: "We don't believe that the ice sheet could fully disintegrate faster than many centuries, but we might cause enough warming within a few decades to cross the threshold leading to ice sheet loss." (p.182) Because different positive feedbacks amplify each other, "the slight chance of a really big change cannot be excluded." (p170). Due to various possible tipping points, "*we must recognize the possibility that we have greatly underestimated the coming damages of climate change. However, we do not find evidence that we have greatly overestimated the damages."*

(p.196) This dire possibility is echoed by U of Washington geologist Peter D. Ward in **The Flooded Earth: Our Future in a World Without Ice Caps** (Basic Books, July 2010), who warns that a not unreasonable 4oF increase in global temperature could raise sea levels by 30 feet by 2100.

The long-hypothesized positive feedback loops, according to John Carey (*Scientific American,* Nov 2012, pp50-55) "may be starting to kick in" and may be pushing the earth into an era of rapid change that is faster than expected. Carey identifies six feedback loops, notably the loss of sea ice allowing the sun to warm ocean water more (which melts more sea ice), and greater permafrost melting that puts more methane and CO2 in the atmosphere (in turn causing more permafrost melting). This is complemented by Peter Wadhams, a Cambridge ocean physicist, who writes in *Scientific American* (Dec 2012, p12) that "things are worse than appearances suggest" because remaining sea ice is thinning so that, at current rates, summer melting of Arctic sea ice will outstrip new ice in winter, and "by 2015…the entire ice cover will collapse." Citing Mark C. Serreze of the U of Colorado National Snow and Ice Center, we will have entered an Arctic "death spiral" that accelerates warming. Wadhams calculates that "*loss of the remaining ice will have the same warming effect on the earth as the past 25 years of carbon dioxide."* Moreover, surface warming will extend to the seabed and melt offshore permafrost, triggering the release of methane, which has 23 times greater warming effect than CO2 (albeit not remaining in the atmosphere as long). He cites a recent Russian-US expedition finding more than 200 sites off the coast of Siberia where methane is welling up from the seabed. And that excludes methane being released from melting tundra!

And thus the official expectation of 1-2 feet of sea level rise by 2050, and perhaps 4 feet more by the 2080s, *may* be greatly underestimated. It is time to put the various trends and forecasts together into a set of continuously updated and widely publicized scenarios that reflect the full range of possibilities, from "not-quite-so-bad" to "far worse than expected" and "catastrophic." What works for hurricane forecasting should also be applied to long-term sea level rise. And anyone involved in long-range planning, foresight, and futures research should be considering these scenarios of the watery world ahead (even as many other areas of the planet are drier, according to climate models).

To sum up, a major sea level rise appears to be a slight possibility in the next decade or so, and, if feedback loops accelerate global warming, a fairly good possibility—if not highly probable—by 2100. We do not have an adequate language to convey these possibilities. Today's "slight possibility" is more than a "Black Swan" (far less than 1% probability) or a classic wild card (a joker in a deck of 52 cards, or 2% probability). It is better seen as a "not-so-wild card" of 10% or so probability, likely growing to 30-40% probability—or more—in the decades ahead. No matter what crude probabilities are assigned, the prospect deserves close monitoring to refine the probabilities as best as possible.

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