Ice and History

IF YOU PAUSED AT THE TABLE OF CONTENTS, YOU NOTICED THAT THERE IS A LOT ABOUT ICE IN this issue. Ice is important not only because we are losing it but also because it is an archive that has told us much about past climates. But the climate-change debate has focused perhaps too much on the past few hundred years. That baseline has told us much about what has been happening to global temperature lately, but it may not be the best baseline to use in exploring our future.

For that, the relationship between greenhouse gas levels and temperature, evident in data from ice cores, illuminates climates in the geological past and may be a more useful guide to the future. Fifty million years ago, CO₂ levels may have topped 1000 parts per million by volume (ppmv) and sea levels were about 50 meters higher than those today. CO₂ levels gradually decreased as marine organisms fixed carbon through photosynthesis and then buried it by sinking into the ocean basins. This reduction and a corresponding decrease in temperatures allowed ice sheets to develop in Antarctica starting 30 to 40 million years ago. By 3 to 4 million years ago, CO₂ levels probably dropped to or below the preindustrial level of about 290 ppmv, and permanent ice sheets appeared in the Northern Hemisphere. As subsequent glaciations came and went, CO₂ concentration and temperature were tightly linked. When both went down, ice sheets grew and sea levels sank, lower than today’s by more than 100 meters. When both went up, there were relatively stable warm periods with high sea levels.

A central feature of this long baseline is this: At no time in at least the past 10 million years has the atmospheric concentration of CO₂ exceeded the present value of 380 ppmv. At this time in the Miocene, there were no major ice sheets in Greenland, sea level was several meters higher than today’s (envision a very skinny Florida), and temperatures were several degrees higher. A more recent point of reference, and the subject of two papers in this issue, is the Eemian: the previous interglacial, about 130,000 to 120,000 years ago. This was a warm climate, comparable to our Holocene, during which sea levels were several meters higher than today’s, even though CO₂ concentrations remained much lower than today’s postindustrial level.

So what should be the appropriate baseline be for estimating our present climate prospects? Is it the relatively recent evidence of climate change, or is it the developing knowledge from ice cores and the geologic record about past climate equilibria? The Holocene, over its 10,000-year life, has provided us with a comparatively stable period. Now we are changing an important parameter. Evidence presented in two papers, a News story, and two Perspectives in this issue demonstrates an accelerating decay of ice sheets in Greenland and Antarctica. Given the concurrent rapid recent rise in CO₂ concentration, history suggests that we should expect other changes. Will these changes return us to a climate like the Miocene or earlier? Or will we experience a repeat of the Eemian?

Nothing in the record suggests that an “equilibrium” climate model is the right standard of comparison. We are in the midst of a highly kinetic system, and in the past, dramatic climate changes have taken place in only a few decades. Our comfort in the Holocene may have heightened our sense of security, but the expectation that change is unlikely is not a reasonable position. The central question of today’s climate policy discussions centers on whether the change in average global temperature over the past century represents the result of new climate forcing or instead simply reflects natural variation.

That question invites us to examine recent statistics on climate variation and then test the current excursion for significance. But if one is interested in risks and in preparing to meet them, the more interesting question is what the deep historical record can tell us about the circumstances under which climates have changed rapidly in the past and the severity of the consequences. Considered in that way, accelerated glacial melting and larger changes in sea level (for example) should be looked at as probable events, not as hypothetical possibilities. We don’t have to abandon the short-term baseline, but the longer one may give a more realistic picture of our future.

– Donald Kennedy and Brooks Hanson

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