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AFTER 'THE DAY AFTER TOMORROW'

What Will Society Learn from the Inevitability of Rapid Climate Change Events?

Durwood Zaelke, Oran Young, and Scott Stone

In the film *The Day After Tomorrow*, melting polar ice alters ocean salinity and shuts down ocean currents that warm much of the planet. Tidal waves pummel Manhattan, five-pound hail pounds Tokyo, tornadoes punish L.A., and sub-zero temperatures plunge the Northern Hemisphere into a new Ice Age. Panic ensues and civilization teeters on the brink of collapse.

And all in only five days. But could the climate really change that fast? Hollywood's timeframe is, of course, absurd for a shutdown of the thermohaline circulation system that transports heat from the tropics to the North Atlantic. But the film's underlying premise is solid: Climate change can cause catastrophes that will catch society by surprise.

But not in five days. Perhaps not even in ten years. But possibly within our lifetimes, and likely within the lifetime of our children or grandchildren. The earth's climate history is punctuated by abrupt shifts in temperature and sea levels. With current atmospheric concentrations of carbon dioxide higher than any time over the last 650,000 years, abrupt changes to the climate are not only possible, but probable.

The Scientific Consensus on Climate Change

Climate change has been dogged by claims that the science is incomplete. But the door has closed on the skeptics. The Intergovernmental Panel on Climate Change (IPCC) concluded this year in its draft Fourth Assessment Report that "there is widespread evidence of anthropogenic warming of the climate system in temperature observations taken at the surface, in the free atmosphere and in the oceans." More than 2,500 leading climate scientists contribute to the IPCC assessments. The evidence is irrefutable, and it is becoming increasingly clear that climate change is happening at a faster rate than previously projected as anthropogenic emissions of "greenhouse gases" such as carbon dioxide, methane, and nitrous oxide

are accumulating in the atmosphere, trapping heat reflected from the earth's surface and warming the planet.

Over the 20th century, the global average surface temperature rose 0.6° to 0.8° C. The year 2005 was the hottest year on record for the Northern Hemisphere, followed by 1998, 2004, 2003, and 2002. The last few decades of the 20th century were the warmest in the past 400 years and probably in the past 1,000. Additional warming also has been "banked" in the oceans and will contribute another 0.6° C as it is released over the century.

The rise in temperature closely tracks the rise in greenhouse gas emissions and their atmospheric concentrations. The emissions come mainly from the use of coal, oil, and natural gas. In 2004, the U.S. emitted nearly 6,300 million tons of CO₂-equivalent, the largest amount ever produced by a single country and representing about one-quarter of the world's total. China and India will pass the U.S. around 2010, and by 2030, emissions from Asian countries may double North America's.

Without drastic cuts in greenhouse gas emissions by mid-century, temperatures will rise by at least another 2° to 4.5° C by 2100. Temperatures could rise an additional 1.5° C through "positive feedbacks" in the climate system, which accelerate warming. Examples include melting snow and ice that reduce the earth's "albedo," or reflectivity, by exposing land and water that absorb heat, and the melting of permafrost in the Arctic that releases stored methane, a gas 23 times more potent than CO₂. The temperature shift that ended the Ice Age 10,000 years ago was 5° to 8° C.

Rising temperatures have reduced snow and ice cover by about 10 percent since the late 1960s. In the Arctic, winter sea ice reached all-time lows in March 2006; at this rate the region will be ice-free by 2030, for the first time in nearly one million years. Greenland's ice sheet is disintegrating at a rate that

doubled in the last 10 years. The loss of Antarctic land ice is accelerating, including the collapse of an ice sheet the size of Rhode Island in 2002 – an event unprecedented in the last 10,000 years.

Combined melting of Greenland and the East and West Antarctic ice sheets could raise sea levels 80 meters. Greenland alone would be 6.5 meters. But even a 1.5 meter rise would threaten 36,000 square miles of land along the Atlantic and Gulf Coasts with flooding. At 10 meters, 25 percent of U.S. population could be flooded.

Rising temperatures increase the frequency and intensity of extreme weather events. Last year produced a record 25 named storms in the Atlantic and resulted in approxi-

mately \$100 billion in damages. Wildlife and ecosystems are showing signs of strain. Polar bears are drowning and turning to cannibalism to survive. A mass extinction of frogs in Central America

is attributed to a fungus expanding due to shifts in temperature and cloud cover. Coral reefs are in severe decline and at the current rate will disappear by 2065. Earlier springs are disrupting wildlife migration, development, and reproductive cycles, threatening the very existence of our natural communities.

Climate change is impacting human health, with rising temperatures and extreme weather events causing record heat waves and spreading infectious diseases among humans, wildlife, livestock, agriculture, and marine life. Certain pests and insects will flourish. Already, the mountain pine beetle has killed twice as many trees in British Columbia as Canadian loggers cut in a year. The devastation, still unchecked, is a “a silent forest fire.”

Food production will suffer, particularly in arid regions in developing countries; two billion more people will join the 450 million already malnourished. In Asia, shrinking Himalayan glaciers could reduce freshwater by about 40 percent and cut agricultural production by about 10 percent over the next 50-100 years.

Previous changes to the earth's climate have included non-linear changes, coming on suddenly, with little warning, and with catastrophic consequences.

But climate change is not just a “linear” problem. Previous changes to the earth’s climate have included non-linear changes, coming on suddenly, with little warning, and with catastrophic consequences. This is the threat we need to focus on to avoid dangerous levels of climate change.

Rapid Climate Change Events

The study of Rapid Climate Change Events, or RCCEs, indicates that rising temperatures make the climate more vulnerable to dramatic shifts that can take place over a short time, perhaps even 10 to 20 years. While considerable uncertainties exist, there are thresholds beyond which the climate will shift rapidly and irreversibly, although we do not yet know what the thresholds are.

According to the National Academy of Sciences report *Abrupt Climate Change: Inevitable Surprises*, “Available evidence suggests that abrupt climate changes are not only possible, but likely in the future, potentially with large impacts on ecosystems and societies.”

The Day After Tomorrow is based on the “big RCCE,” a scenario where melting polar ice lowers the salinity of the North Atlantic Ocean and causes a shutdown of the thermohaline circulation system. The thermohaline circulation (THC) is a vast network of deep ocean currents driven by differences in temperature and salinity, circulating warm water from the tropics to the North Atlantic and making it possible for London to be warmer than Labrador, its latitudinal counterpart.

Today, melting polar ice is diluting the salty North Atlantic with freshwater. As a result, the warm water from the tropics is encountering increasingly less salty and less dense North Atlantic waters – which are less likely to sink and draw the warm water northward. Already the THC is beginning to slow down, with a recent study revealing that nearly a third of the warm water that used to flow northward remains trapped in the subtropical Atlantic. This contradicts earlier predictions that a slowdown of this magnitude would not occur until 2100 or later.

A THC shutdown is like a light switch, where the “freshening” of North Atlantic waters eventually pushes the THC past its threshold – “just as the slowly increasing pressure of a finger eventually flips a switch and turns on a light.” The Woods Hole

Oceanographic Institution estimates a THC shut-down would cool the North Atlantic region by 3° to 5° C, resulting in “winters twice as cold as the worst winters on record in the eastern United States in the past century.”

Climate Change and National Security

The Pentagon takes RCCEs and their implications for national security seriously enough to prepare its own analysis. The 2003 report, *An Abrupt Climate Change Scenario and Its Implications for United States National Security*, envisions “scenarios” where RCCEs destabilize the geo-political environment, provoking “skirmishes, battles, and even war.”

The Pentagon report focused on a THC shut-down (as did *The Day After Tomorrow*), where a sudden plunge in temperatures would catastrophically disrupt the world’s natural, social, and economic capacity to support the human population and trigger worldwide military conflicts over food, water, and energy supplies. A 2006 report by the U.K.’s Oxford Research Group seconded the Pentagon’s analysis, noting that by comparison, terrorism is “actually a relatively minor threat.” Indeed, until just a few hundred years ago, wars were generally fought over resources and usually killed off about a quarter of a country’s male population. This is the shadow of our future.

In particular, the vulnerability of energy supplies to RCCEs adds to the risks of continued U.S. dependence on foreign oil and presents another national security justification for addressing climate change through energy independence.

Governance Scenarios: Choosing Our Future

How society responds to climate change is a question of governance. We can still choose the future we want. But our choices are narrowing. Governance includes the responses from governments in the form of new laws and institutions at all scales, and this will be the centerpiece of climate governance. But governance also includes all of society’s strategies for changing human behavior, as well as the behavior of our institutions, including universities, environmental organizations, human rights groups, labor unions, and churches, as well as the businesses of the world, from multinationals to small and medium size business.

Society faces three choices: We can stumble into chaos, persist in the current business-as-usual, or make the great transition to a sustainable world. The choice is ours, at least for a while longer.

Chaos and the Fortress Future

Chaos and the Fortress Future result from our failure to act: the world fails to use law and institutions and other governance mechanisms to guide human behavior away from our over-consumption patterns and toward lifestyles of health and sustainability, and fails to ignite a revolution in technology. Food, water, and other shortages spark regional conflicts that quickly tip the world into chaos. The rich build higher walls and bigger armies. Their future is the Fortress, amid the sea of chaos.

Business-as-Usual Governance

While we could tip inadvertently into chaos, it is more likely we will continue our current strategy of using international treaties and international institutions to address climate change.

The climate regime, including the Kyoto Protocol, which the U.S. has declined to join, would reduce developed country emissions by about 5.2 percent of 1990 levels by 2012. This falls far short of the 60-80 percent reduction in worldwide emissions needed to avoid dangerous anthropogenic interference with the climate system and limit the overall temperature increase to 2° C by 2100. Kyoto’s greatest value is the introduction of market-based mechanisms to identify the most cost-effective emissions reductions. Its emissions trading system is helping to create a global carbon market, valued at more than \$10 billion in 2005 and projected at \$25-30 billion in 2006. This is spurring investment in climate-friendly technologies, and businesses are starting to see the considerable cost-savings from controlling their carbon budgets. (BP reduced emissions by 10 percent and saved \$650 million.)

But the carbon market is not capable of doing the job itself. Also needed are binding and enforceable emissions targets and Manhattan Project-style research and development and capacity building programs. The U.S. should take leadership in these areas to enhance global and homeland security, capture business opportunities, and perhaps even set a moral example for the rest of the world. The longer

the United States waits to lead, the further behind we will be, with each year of delay costing two years to catch up.

Even when treaties have strong goals, they are only as good as the national laws the parties enact to implement them. Unfortunately, many developing countries lack the capacity for effective implementation. The Montreal Protocol on Substances that Deplete the Ozone Layer has ways to address this. After a ten year grace period for developing countries, the Montreal Protocol provides financing to help developing countries meet their deferred obligations. The Montreal Protocol has gained the enthusiastic support of business and political organizations. And it is critical for climate, as ozone depleting substances also are potent greenhouse gases, and by controlling them, the Montreal Protocol is making a greater contribution to slowing climate change than the Kyoto Protocol. This could change if the ozone treaty is not updated in 2007, at the 20th anniversary meeting of the parties, to adopt a “Life-Cycle Atmospheric Performance” approach that would ensure ozone and climate concerns are addressed jointly in each instrument. U.S. leadership is needed here also.

Great Transitions: the Way To Go

Business-as-Usual will not save us from Rapid Climate Change Events. The question is whether the positive elements of governance that exist today contain the genetic material to evolve into the Great Transition governance scenario – where a robust and sustainable governance framework is developed to respond to climate change.

We need to think about the future beyond our children and grandchildren, and devise strategies to ensure that future generations are guests at our table today, and that we leave them the same abundance when they set their own table in the future.

We need to learn what works with governance, at all scales, including what the necessary conditions are for good governance and the rule of law, in all countries of the world. We need to understand the relationship between the ascendant globalizing market forces and governance mechanisms that redirect and harness these forces for climate protection. We need to pioneer an environmental Moore’s Law, which predicted the doubling of computer power every 18 months and helped fuel one of the most

creative and profitable technology developments in history. Solving the climate challenge requires the same inventive genius and same accelerating technology development. It also has the same potential for profit and wealth creation.

Addressing climate change will challenge the way people live. But if we don’t use governance to change society for the better, then we will be unable to prevent nature from changing society for the worse. We have perhaps 50 years to cut greenhouse gas emissions by 60-80 percent from 1990 levels and promote technologies and land use changes that can draw down atmospheric CO₂. We have the technologies; we lack only the will to act. At some point, it will be too late to mitigate the impacts of climate change, which will then become so disruptive that our social and economic institutions will be too unstable to see us through to tomorrow – and the day after tomorrow. •

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