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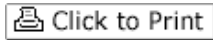
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Cloudy With a Chance of Chaos

Climate change may bring more violent weather swings -- and sooner -- than experts had thought.

By Eugene Linden

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(FORTUNE Magazine) - A disturbing consensus is emerging among the scientists who study global warming: Climate change may bring more violent swings than they ever thought, and it may set in sooner. Lately John Browne, the CEO of BP, has been jolting audiences with a list of proposed solutions that hint at the vastness of the challenge. It aims at stabilizing the concentration of carbon dioxide in the atmosphere at about double the pre-industrial level while continuing economic growth. To do that, carbon emissions would have to be reduced ultimately by seven gigatons a year. A gigaton, or a billion tons, is even bigger than it sounds. Eliminating just one, argues Browne, would mean building 700 nuclear stations to replace fossil-fuel-burning power plants, or increasing the use of solar power by a factor of 700, or stopping all deforestation and doubling present efforts at reforestation. Achieve all three of these, and pull off four more equally large-scale reallocations of capital and infrastructure, and the world would probably stabilize its carbon emissions.

There's just one catch: Even change on this vast scale might not stop global warming.

What if the secret behind civilization is that we've had really good weather? Humankind has prospered and multiplied during one of the most benign climate eras in the history of the planet. And the past two centuries -- which witnessed the great expansion of the Industrial Revolution, a sixfold increase in human population, the triumph of the consumer society, and the rise of the integrated global economy -- have been particularly stable. One would have to go back 115,000 years to find a time as tranquil and warm as the present.

Even so, during the relative calm of recorded history, climate has periodically turned angry. And while this moodiness is but a shadow of the cataclysmic weather violence of the Ice Ages, it has been sufficient to shake or destroy civilizations. A sudden cooling and drying 8,200 years ago set back the development of the first cities in the Fertile Crescent. Some 4,000 years ago, decades of drought accompanied by howling winds scoured the Mesopotamian plain of the Akkadians, the most powerful civilization of the region. The Mayans never recovered from intense drought in the first decade of the tenth century A.D. And were it not for the Little Ice Age that thwarted the expansion of Viking civilization just six centuries ago, Europeans living in Canada and the U.S. might be speaking Norse rather than English.

Now climate is changing again. Most scientists recognized the reality of global warming more than a decade ago; most also agree that humans play a role in the changes. The consensus on climate change has solidified to rival the medical consensus on the dangers of smoking--but in the matter of climate, public perception has yet to catch up. Like the tourists on Phuket beaches who stood and gazed at an oncoming tsunami because it was outside their experience, society is reacting to the coming wave of climate change without urgency. People still believe that the science is controversial and the threat of climate change far off in the future; and while a few businesses, notably major insurers, have begun to adapt, governments are responding only slowly, as the lack of progress at this fall's international forum in Montreal showed.

The wave is coming, though. The last decades of the 20th century saw an unmistakable and extraordinary warming. During this same period, we suffered by some measures the strongest El Niño in 130,000 years and a swarm of statistically extraordinary droughts, floods, and other weather extremes. In 2005 precedents continued to fall, as wave after wave of tropical Atlantic storms continued right through the end of the year. The hot ocean waters that helped nurture storms in 2005 may also play a role in an intense drought in the Amazon rain forest, normally one of the wettest places on earth.

These and other weather surprises make scientists uneasy because they resonate with a new understanding of how climate changes. Just 40 years

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ago the consensus was that climate shifted from warm to cold and vice versa, smoothly and over many centuries. Since the early 1990s, however, scientists have been coming to see climate change as less like a dial and more like an on-off switch. The transition from, say, warm to cold is far more abrupt—taking decades, not centuries—and far more chaotic than previously supposed (though still not as fast as in *The Day After Tomorrow*, the 2004 disaster flick in which a new Ice Age arrived in a matter of days). Scientists now compare such transitions to the flickering of a flame or a fluorescent bulb—where the "flickers" may be quite violent, marked by fluctuations in temperatures of more than 18 degrees Fahrenheit in just a few years, as well as extreme variation in wind speeds and precipitation.

The Earth's heat-distribution system has already begun shifting massively in response to rising levels of greenhouse gases. Precipitation patterns, the change of seasons, storm intensity, sea ice, glaciers, temperatures on the tundras—all are in flux. As scientists nervously monitor sea and air currents for signs of major shifts, many believe that today's proliferation of weather extremes may be the prelude to another epochal transition—a possibility first flagged by the great oceanographer Wallace Broecker in the journal *Science* in 1997.

How bad could it get? Imagine Europe suffering floods and heat waves on a vastly greater scale than those endured in 2002 and 2003, while northern regions experience intermittent deep freezes as atmospheric and ocean circulations struggle to find new equilibrium. At the same time, droughts and floods not seen since ancient times would afflict some of the most densely populated regions on earth. The probability of drought in the American breadbasket would rise, and along with it the possibility that the U.S. grain surplus—which accounts for the dominant share of world grain exports—would disappear.

A flickering climate wouldn't just clobber countries with the wealth and technological resources to try to cope. It would affect every part of the planet, and in so doing reduce the resiliency of the global community. With every nation dealing with local emergencies, it would be more difficult to mobilize resources to aid victims in other areas, and there would be fewer resources to mobilize.

Municipalities around the world would struggle under the burden of greatly increased demands on funds to maintain and repair basic infrastructure. Forget about safety nets—FEMA and its ilk would be bankrupt. In the world's tightly coupled markets, financial tsunamis would surge through the system, leaving banks and corporations insolvent. Financial panics, largely absent for more than 70 years, would return with a vengeance.

Here at home, a flickering climate would impose an enormous tax on every individual and business. Property values in most places would plummet as buyers disappeared and costs of insurance and maintenance soared. The upper-middle-class American family, today so well protected against external shocks, would find its layers of insulation gradually stripped away as fuel, food, jobs, and social order became less certain. Katrina's aftermath exposed how quickly extreme weather can reduce an orderly society to dysfunction.

Some of the calamities that may happen—droughts that last more than a century, an advance of arctic zones southward, incessant and epic storms—simply overwhelm the imagination when we try to envision them in a world of six billion people depending on an exquisitely balanced food system. Earlier civilizations destroyed by climate did not have modern technologies or markets as a bulwark against nature's stresses. But changing climate won't challenge only markets and economies; it will stress the environment too, and by decimating ecosystems, we have undermined crucial buffers against weather extremes.

INEVITABLE SURPRISES

The storms, floods, and other weather calamities of recent years are just a start.

Consider the "500 year" floods in the Midwestern U.S. that caused \$27 billion of damage in 1993. Decades of development had channeled and otherwise altered the Mississippi and other great rivers of the Midwest, reducing their access to floodplains that had absorbed and moderated the effects of extreme rainfall. Without those buffers, the rivers in 1993 rose higher than they might have in years past. When they breached dikes and other barriers, they spilled into the old floodplains, now largely occupied with farms and homes, amplifying the damage. We saw this pattern repeated in New Orleans after Hurricane Katrina and in the Christmas tsunami of 2004. While the tsunami killed more than 280,000 people and destroyed settlements over a swath of several thousand miles, a series of powerful tsunamis in that part of the world during the 19th century passed with far less damage and loss of life. They took place before protective buffers of mangroves were destroyed, before hundreds of millions of people moved into the potential path of the waves, and before cars, trucks, and other contrivances proliferated only to become projectiles when the 2004 tsunami swept them up.

Around the world, humanity has reduced nature's capacity to dampen extremes to an astonishing degree: more than 59% of the world's accessible land degraded by improper agriculture, deforestation, and development; half the world's available fresh water now co-opted for human use at the expense of other species and ecosystems; more than half the world's mangroves destroyed; half the world's wetlands drained or ruined; one-fifth of the world's coral reefs (including crucial barrier reefs) destroyed and one-half damaged—the list goes on and on.

Nature does not alert us to all her tripwires. Perhaps that's why in recent years the unprecedented has become increasingly ordinary. When pushed past a certain magnitude, the damage of natural events increases exponentially, and that threshold falls as natural buffers are eliminated. Research led by MIT climatologist Kerry Emanuel suggests that hurricanes have doubled in intensity during the past 30 years as the oceans have warmed. Hurricane Katrina surged to its immense power when the storm passed over a deep layer of 90-degree Fahrenheit water in the Gulf of Mexico. Hurricane Rita transfixed meteorologists when it strengthened from Category 2 to 5 in less than 24 hours while moving over those same hot seas. And in October, Wilma bested that by strengthening from tropical storm to Category 5 hurricane in a single day.

Since we are dismantling natural buffers just at the point when we really need them, it's tempting simply to conclude that humanity has a self-destructive streak. The explanation, of course, is not masochism but a collective failure of imagination—compounded by the fact that we are only now learning to weigh the threat. There are no models to estimate the economic impact of rapid changes in temperatures, storm tracks, precipitation, and so on. In a 2001 report entitled "Abrupt Climate Change: Inevitable Surprises," the National Research Council, the principal operating unit of the National Academy of Sciences, noted that most modeling of impacts has been confined to cases in which changes are gradual and moderate. Modeling the effects of abrupt change is a lot harder, but the study makes a couple of important points.

First, economies can minimize the effects of a gradually changing climate if people recognize the threat and respond. With abrupt climate change, however, things happen so rapidly that neither markets nor ecosystems have time to adapt. Moreover, a dynamic market economy with capacity to respond to intermittent crises by spreading risk and reallocating assets may be unable to respond when crisis is ubiquitous and risks loom

everywhere.

Second, even gradual climate change would pose immense challenges. Tim Barnett, an oceanographer at Scripps Oceanographic Institution, took part in a study of the likely effects of climate change on the Los Angeles area. Surprisingly, he says, even modest decreases in rainfall during what he called a "best-case scenario for future climate change" (a gradual and small change, decades in the future) could reduce available water for the area by 50% by 2050. The region has limited storage capacity for water and relies on the winter snowpack that builds up in the Sierra Nevada and the Rockies for water during the dry summer months. Under even modest climate-change scenarios, however, the snowpack would be smaller and would melt earlier. The region would dry up before its driest months.

Angelinos wouldn't necessarily go thirsty. California has plenty of agricultural water that could be diverted to human needs. The ancillary effects would be harder to manage. Farm output would be reduced, and water shortages could idle hydroelectric plants. Drought also makes trees more vulnerable to pests, such as the pandora moth that afflicts ponderosa pine. Dead trees are tinder for wildfires, like the ones that destroyed hundreds of homes in Southern California in 2003. Such impacts would roil the economy. Consider how increased fire risk and other effects of acute water scarcity might affect housing prices or the job market.

Keep in mind that the 50% reduction of available water was a best-case scenario. And while the richest state in the world's richest nation has some ability to weather a drought, such shifts would not be occurring in isolation. The changing climate that brought drought to Southern California would also be affecting weather throughout the American West and beyond—damaging property, disrupting agriculture, and spurring migrations.

PREMIUM HELL

You're in unsure hands.

The terrorist attacks of 9/11 opened insurers' eyes to a catastrophic risk that they had been assuming for free. Their reaction provided a foretaste of how the global market might react to abrupt climate change. Following 9/11, insurers stopped writing policies that automatically included coverage of terrorist attacks. A number of major construction projects had to halt because banks would not finance them without terrorism coverage. Ultimately Congress passed and President Bush signed a law shifting responsibility for \$100 billion in damage from future terrorist attacks to the U.S. government, and the construction projects got rolling again.

As climate change starts inflicting losses, insurers will again pull back, shifting financial risk to businesses and homeowners, the banks that finance them—and finally to taxpayers. In Florida, huge increases (up to 40%) in insurance rates are already making it harder for people to sell homes, according to the South Florida Sun Sentinel.

More than 1,000 miles from New Orleans, in Cape Cod, Mass., a far-flung echo of Katrina has been the 20% rise in reinsurance costs (reinsurers are financial institutions that backstop insurance companies). The increase prompted Hingham Mutual Group, a property and casualty insurer, to drop coverage for 6,500 commercial properties. Customers left in the lurch have a fallback in FAIR (short for Fair Access to Insurance Requirements), a program mandated by various states and run by insurers. But Massachusetts's FAIR plan recently requested big rate increases, arguing that past weather patterns may no longer be a guide to estimating future climate risks. That rationale was "unprecedented," a team of industry experts noted in a report entitled "Availability and Affordability of Insurance Under Climate Change"; it's a vivid example of how insurance has difficulty adapting to changing climate.

For insurers the hazards of climate change become more concrete each year. Andrew Dlugolecki, a risk analyst at the Tyndall Center for Climate Change Research in Britain, recently estimated that if climate gradually warms, the chances of the industry getting wiped out by weather-related catastrophes will rise from about one in 100 worldwide today to nine in 100 by 2050. A ninefold increase in the risk of collapse places a heavy burden on insurers, but the risks may be far greater than that. Asked in 2003 how climate change that's abrupt and chaotic might affect those odds, Dlugolecki speculated that the risk of catastrophic weather-related losses rises to about nine chances in 100 by as early as 2010. To insure a property or business affected by that degree of risk, a carrier would have to charge annual rates as high as 12% of insured value—most businesses and individuals start self-insuring (industry-speak for dropping their coverage and taking their chances) when premiums reach 3% of value.

Already the pain of weather-related insurance risks is being felt by owners of highly vulnerable properties such as offshore oil platforms, for which some rates have risen 400% in one year. That may be an omen for many businesses. Three years ago John Dutton, dean emeritus of Penn State's College of Earth and Mineral Sciences, estimated that \$2.7 trillion of the \$10-trillion-a-year U.S. economy is susceptible to weather-related loss of revenue, implying that an enormous number of companies have off-balance-sheet risks related to weather—even without the cataclysms a flickering climate might bring.

Corporate leaders could soon feel the heat too. In 2004, Swiss Reinsurance, a \$29 billion financial giant, sent a questionnaire to companies that had purchased its directors-and-officers coverage, inquiring about their corporate strategies for dealing with climate change regulations. D&O insurance, as it is called, insulates executives and board members from the costs of lawsuits resulting from their companies' actions; Swiss Re is a major player in D&O reinsurance.

What Swiss Re is after, says Christopher Walker, who heads its Greenhouse Gas Risk Solutions unit, is reassurance that customers will not make themselves vulnerable to global-warming-related lawsuits. He cites as an example Exxon Mobil: The oil giant, which accounts for roughly 1% of global carbon emissions, has lobbied aggressively against efforts to reduce greenhouse gases. If Swiss Re judges that a company is exposing itself to lawsuits, says Walker, "we might then go to them and say, 'Since you don't think climate change is a problem, and you're betting your stockholders' assets on that, we're sure you won't mind if we exclude climate-related lawsuits and penalties from your D&O insurance.'" Swiss Re's customers may be put to the test soon in California, where Governor Arnold Schwarzenegger is pushing to restrict carbon emissions, says Walker. A customer that ignores the likelihood of such laws and, for instance, builds a coal-fired power plant that soon proves a terrible bet could face shareholder suits that Swiss Re might not want to insure against.

TURNING DOWN THE HEAT

How business can take action—and why it needs political backup.

As businesses begin to recognize the dangers of climate change, markets will help economies adjust, pricing the risks and shifting resources. Yet markets have blind spots: They typically underprice long-term or novel risks. In the case of climate change, where large-scale actions must be taken lest change hit with full force, a purely market-based response would be too little, too late. To address the risks, governments need to get involved.

With the Earth's atmosphere already warming dramatically, we are probably stuck with some form of climate change. Yet the energy economy is still in the process of squeezing rather than easing the pressure on the trigger. China and other emerging economies are ramping up their consumption of fossil fuels, while the U.S., which is the world's largest producer of greenhouse gases, continues to resist international efforts to rein them in.

In November and December, delegates from scores of nations convened in Montreal to negotiate emissions-control goals for greenhouse gases in the years following the expiration of the Kyoto treaty in 2012. But days of haggling produced nothing more than a resolution to discuss the issue further in coming years. (The U.S. and Saudi Arabia were the last to agree even to that.)

By itself, the Kyoto treaty will have minimal impact on the global-warming threat. Very few of the 160 countries that ratified the treaty (which went into force last February) will meet the targets of reducing emissions 5% below 1990 levels by 2012. The U.S. rejected the treaty, and China, which is likely to surpass the U.S. as a greenhouse-gas producer in the coming years, is not governed by its provisions. Says Elliot Diringer of the Pew Center for Climate Change: "Unless there is continued action after Kyoto expires, it will have been nothing more than a blip" in the buildup of carbon in the atmosphere.

Up to now, the primary objection by the Bush administration and other opponents of reducing greenhouse gases has been economic impact. The unknowns of climate change have made projecting costs and benefits an economist's guessing game. For instance, in 2002 the White House Council on Environmental Quality cited estimates by the federal Energy Information Administration that achieving Kyoto's goals would erode U.S. economic output by \$400 billion in 2010. That estimate was the worst of seven scenarios examined by the EIA; another put the cost at only \$7 billion to \$12 billion by 2010. Other studies, like a recent one sponsored by HSBC and entitled "Carbon Down, Profits Up," cites dozens of companies, cities, and regions that have found reducing carbon emissions to be profitable, in part because carbon reduction is often synonymous with increased efficiency.

But as the weather grows worse, such exercises will become moot. The ambitious proposals that BP's John Browne has been talking about—building nukes by the hundreds, for example—would stabilize the concentration of carbon dioxide in the atmosphere at 500 parts per million by 2050, vs. 380 ppm today. Yet even that might not be enough to prevent climate chaos. Says Chris Mottershead, a distinguished advisor at BP: "Nobody knows whether climate's tipping point is at 400 ppm, 700 ppm, or if there is a tipping point." Science does know, however, that today's concentration of carbon dioxide is higher than any in 650,000 years; past climate flips took place with far less carbon in the air. What's more, BP developed its proposals with physicist Robert Socolow and ecologist Stephen Pacala, professors at Princeton University who worked with models of gradual, not abrupt, climate change.

Despite the daunting gap between present actions and what's required, plenty more can be done. Politics enables markets: An international agreement limiting carbon that includes the U.S. and the developing nations would supply the discipline necessary for carbon markets to flourish. (Carbon trading lets developed countries achieve emissions-reduction targets by paying to reduce emissions in developing countries.) According to an upcoming study of carbon markets by Ecosystem Marketplace, a website devoted to popularizing environmental derivatives, the carbon market in Europe has already surpassed \$4 billion in trading value as utility, industrial, and insurance companies experiment with this new tool.

If U.S. politicians eventually conclude that action on the scale of the BP plan is necessary, they could jump-start change by redirecting the purchasing power of federal, state, and local treasuries—more than \$1 trillion a year. Once government at all levels commits to purchasing clean technologies, making efficiency improvements, and using alternative energy where possible, this massive spending would provide economies of scale that would help speed the commercialization of new technologies as well as prepare society for the shift away from fossil fuels. Equally sensible would be to reduce subsidies and tax advantages that abet the waste of fossil fuels.

Such proposals have been on the table since the early 1990s. Many are even more salient today. By not taking action on greenhouse emissions, we are betting our well-being that climate change poses little threat. If we are wrong, we will meet our fate.

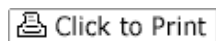
*This article has been adapted by the author from his new book, **The Winds of Change: Climate, Weather, and the Destruction of Civilizations** (Simon & Schuster); see also eugenelinden.com.*

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