

UN update: climate change hitting sooner and stronger

With a handful of weeks remaining before the climate convention meeting in Copenhagen, the UN Environment Programme (UNEP) has released an updated summary of the findings of the Intergovernmental Panel on Climate Change (IPCC). The report, *Climate Change Science Compendium 2009*, warns that many predictions that were at the upper ranges of 2007 IPCC forecasts are increasingly likely, and some events that were seen previously as probable over the long term are on the verge of occurring or are occurring already. “The pace and the scale of climate change is accelerating, along with the confidence among researchers in their forecasts,” UNEP Director Achim Steiner states in the document.

The analysis incorporates results from more than 400 major studies published since 2007 and addresses impacts on Earth systems, glaciers and ice sheets, oceans, and ecosystems. Increasingly, scientists are framing some of these transformations as “commitments”—inevitable events that will play out even after the climate stabilizes. Fundamentally, the centuries-long buildup in atmospheric concentrations of greenhouse gases “has most likely committed the world to a warming of 1.4–4.3 °C [by 2100], above pre-industrial surface temperatures,” the report says. The study points to the 21st-century expansion of the global economy and continued reliance on high-carbon-intensity fuels as obvious factors that contribute to warming. In addition, the report notes an increasing number of signs that carbon sinks in oceans and on land are becoming less capable of absorbing excess carbon. “All of these changes characterize a car-

bon cycle that is generating stronger-than-expected and sooner-than-expected climate forcing, including faster sea-level rise, ocean acidification, melting Arctic sea-ice cover, warming polar land masses, freshening ocean currents, and shifts in circulation

deira of Stanford University, one of nearly 60 scientific reviewers of the new report. “Those assessments present only what’s agreed upon by the 180 participating countries, yet a lot of what we’re concerned about pertains to what *might* happen, which this report treats.”

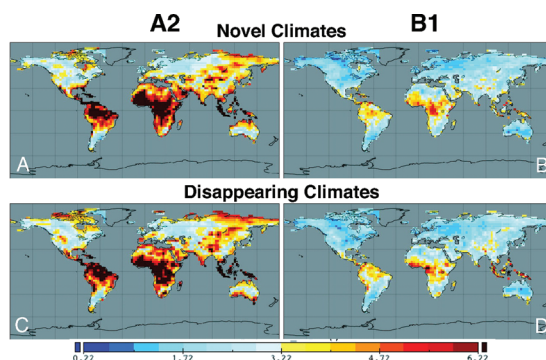
Obsolete storylines

Grim as previous projections have seemed, they have underestimated the probable effects of climate change, the analysis asserts, because even the most extreme scenario underlying IPCC forecasts failed to capture the magnitude of emissions growth. Global emissions have jumped by 38% since 1990, with the annual increase since 2000 more than tripling that of the previous decade. “The scenarios were formulated in 1990, and they

all assumed that greater efficiencies, the development of renewable energy, and other economic forces would slow down emissions by now,” Caldeira explains.

Fortunately, new strategies are on the horizon. “There’s ongoing discussion among global modeling centers over the types of experiments, assumptions, and scenarios that will run the experiments for the next IPCC report,” says Ghassem Asrar, director of the World Climate Research Programme. “Working with fixed numbers [CO₂ concentrations] without accounting for human activities that produce them has been a limitation,” he explains. “Future experiments will factor in different combinations of variables, such as industrial development and deforestation, to investigate what pathways will produce a given degree of warming to better reflect the real world.”

Meanwhile, Asrar points out, much of the new science summa-



Under a “business-as-usual” emissions scenario, 12–39% of the planet’s terrestrial surface could experience novel climate conditions by 2100, and 10–48% could suffer disappearing climates. (Adapted with permission from *Proc. Natl. Acad. Sci. U.S.A.* 2007, 104, 5738–5742. Copyright 2007 National Academy of Sciences, U.S.A.)

patterns in the atmosphere and oceans,” the analysis concludes.

IPCC scientific reviewer Michael MacCracken of the Climate Institute calls the compendium a “very accessible summary of IPCC findings, which updates the science and shows what’s already happening to the environment.” Notably, he says, “past assessments paid scant attention to ocean acidification and didn’t deal with the ice-melting issue. Despite considerable scientific controversy, the 2007 assessment concluded that net ice-sheet melting would be negligible until the end of this century, and because a consensus couldn’t be reached, the report didn’t quantify these effects on sea-level rise.”

“This compendium reminds us that the risks we face may be much greater than what’s generally represented in IPCC assessments, which, by their nature, are very conservative,” adds Ken Cal-

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rized in the UNEP report does reflect recent progress in climate modeling and results from technologically advanced and expanded observations from land, sea, and space. “More observations are essential for validation of model predictions and for making regional assessments as we move beyond mitigation to adaptation,” he says. “We’ve made significant progress in understanding the physical side of the climate, and we’re getting a better grasp on the uncertainties. But the biological side—for example, marine ecosystem responses to ocean acidification—still needs a lot of work.”

Tipping points

The gravest climate change risks are represented in the emerging concept of “tipping points”—the idea that certain large-scale Earth systems are vulnerable to abrupt, irreversible alteration if forced across some critical threshold. The compendium lays out nine such components, along with current estimates of the temperature increases that could push them into altered states. These include the disappearance of Arctic sea ice, severe disruption of monsoon cycles in India and Africa, widespread dieback of the Amazon and Boreal forests, weakening of Atlantic thermohaline circulation, sharply increased frequency of the El Niño–Southern Oscillation, and thawing of the Greenland and West Antarctic ice sheets.

Caldeira cautions against taking the notion of tipping points too far. “The damage and risk to systems from higher CO₂ levels in most cases is progressive. There’s a political danger in assigning temperature thresholds to these processes, as it gives the impression that if you stay below that limit, things won’t go too badly. And if you exceed the specified threshold and the sky doesn’t fall, scientific credibility suffers,” he says.

But Asrar contends that many climate-sensitive systems may be

on “nonlinear” pathways, and if tipping points are reached, there’s a potential for chain reactions. “We must factor the possibility of these eventualities into our planning for mitigation and adaptation,” he says.

Given recent record-setting retreats of sea ice, the Arctic is already at a critical juncture, the compendium stresses, noting that International Polar Year scientists have concluded that the probability of sea-ice recovery is “very low”. In addition, new estimates suggest that, combined with thawing of the Greenland ice sheet, this could add as much as two meters to sea levels this century. The ramifications would likely be profound for atmospheric and ocean circulation, the Atlantic thermohaline circulation, and marine and terrestrial ecosystems around the Arctic region.

Poleward expansion of Earth’s tropical belt also is exceeding projections for the 21st century, affecting the Pacific Intertropical Convergence Zone and other climate drivers that influence precipitation patterns worldwide. Ecosystems, agricultural productivity, and water resources are showing a range of effects as a result of shifting climatic zones, from changes in species distributions and seasonal biological phenomena to more frequent extreme weather events. Recent studies project that if atmospheric CO₂ escalates to 450–600 parts per million over the next few decades—the so-called business-as-usual scenario—“dustbowl” conditions could prevail in many regions during the dry season. The latest data also reveal that melting on glaciers that supply water for up to one-quarter of humanity has doubled since 2000, compared to previous decades.

Avoiding the unmanageable and managing the unavoidable

On a somewhat more hopeful note, a host of possible strategies are available to avert climate change’s

most catastrophic impacts and assist human populations and natural systems to adapt, the analysis says. “Immediate, cohesive and decisive action to both cut emissions and assist vulnerable countries adapt” is critical to avoiding the worst possible scenarios, the report emphasizes. Other essential steps include switching to environmentally sound energy sources; halting tropical deforestation; sustainably managing fisheries, forests, agriculture, and other ecosystem services; and developing effective means for long-term sequestration of carbon. The costs of insuring the planet against climate disaster are hardly prohibitive, according to a newly released economic analysis; cost estimates for rebuilding the world economy around carbon-free technologies range from 1 to 3% of world output (measured as GDP) per year.

Geoengineering also may have a deterrence role to play, although to date only small-scale applications of carbon capture and sequestration have proven successful. But Caldeira, Asrar, and MacCracken stress that it’s critical to understand the possible effects of large-scale measures, and they note that deploying geoengineering solutions raises huge governance and liability issues. Still, interventions with specific objectives focused on problems at local scales are worth investigating, MacCracken says. “If we could figure out a way, without a lot of side effects, to limit Arctic warming—say, by injecting sulfate aerosols into the lower stratosphere—that would be a great benefit.”

For his part, UN Secretary-General Ban Ki-moon calls the compendium a “wake-up call”. “The time for hesitation is over,” he says. “We need the world to realize, once and for all, that the time to act is now, and we must work together to address this monumental challenge.”

—NOREEN PARKS