IN DEPTH

As permafrost thaws, riverbanks in Alaska are slumping, releasing long-sequestered carbon.

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CLIMATE

Warming transforms the oceans and poles

United Nations report forecasts dire effects, adding urgency to a week of climate action

By **Paul Voosen**

Water, liquid and frozen, occupies most of Earth's surface, with oceans covering two-thirds of it and ice another 10th. All is being transformed by climate change, posing greater threats to life and human society than scientists had realized, according to a special assessment of climate science focused on oceans and ice released this week by the United Nations.

The report, from the Intergovernmental Panel on Climate Change (IPCC), comes during a week when the world is fixated on what many now call the climate crisis. The planet has already warmed 1°C since preindustrial times, and July was the hottest month in the modern record. Last week, crowds including many schoolchildren turned out in cities worldwide to demand action. And in New York City, the United Nations convened its first climate summit since 2014, calling on nations to commit to more ambitious carbon cuts than they did under the 2015 Paris agreement. Without such commitments—followed by action—the world could experience 2.5°C of warming above preindustrial levels, or more, in coming decades.

The new *Special Report on the Ocean and Cryosphere in a Changing Climate* stresses that the watery parts of the planet are already entering a new state. After 0.2 meters of sea level rise since the late 1800s, some coastal cities flood routinely during high tides. With the Arctic warming at double the global rate, sea ice is in rapid decline, causing severe disruption to Indigenous communities and wildlife. Permafrost is thawing, undermining infrastructure and releasing uncertain amounts of buried carbon. The ocean is warming at all depths, and heat waves increasingly strike its inhabitants. "There are changes in the ocean we can't stop," says Nerilie Abram, a report author and paleoclimatologist at Australian National University in Canberra.

Compared with the last U.N. climate report, in 2014, the new assessment paints a grimmer picture of the future. By 2100, within the lifetime of those striking children, global sea level would likely rise by up to 1.1 meters if greenhouse gas emissions continue unabated; the last IPCC report had set the upper limit at 0.98 meters. Even with steep cuts in fossil fuel burning, the oceans will rise between 0.29 and 0.59 meters, the report adds. "There's no scenario that stops sea level rise in this century. We've got to deal with this indefinitely," says Michael Oppenheimer, a report author and climate scientist at Princeton University.

Without action, rare, catastrophic storm surges will become common within 30 years, Oppenheimer says. "What was a 100-year event is a yearly event by 2050." Rising waters pose a particular threat to small island nations near the equator, where storms are rare and sea level typically varies little, allowing infrastructure to be built close to the ocean. There are also examples of resilience: Shanghai, China, for example, pumped water back into its underground aquifers to counteract subsidence that had made the city more vulnerable to sea level rise—a challenge also facing many other coastal cities.

The ocean's structure and composition are changing in less obvious ways, says Nathan Bindoff, a physical oceanographer at the University of Tasmania in Hobart, Australia, and a report author. Over the past 15 years, an array of 4000 autonomous floats has documented steady, continuous warming extending to the ocean depths. This warming makes surface waters less dense and more buoyant and re-

duces mixing with deeper layers. Fewer nutrients well up from the deep, and less oxygen mixes downward. "The oxygen minimum zones are expanding," Bindoff says. In warmer, oxygen-poor waters, "The fish aren't remaining the same size, they're getting smaller," he says. "The less valuable fish are more common, and the more valuable fish are less common."

Across the Arctic, the thawing permafrost could amplify climate change by releasing carbon it has held for millennia. But when the impact of those extra emissions will be felt is unclear. Warmer temperatures are causing the Arctic to become greener, and the increasingly luxuriant plants are capturing extra carbon and storing some of it in the soil. At some point, however, the carbon released is likely to overwhelm the carbon absorbed, says Ted Schuur, a report author and permafrost ecologist at Northern Arizona University in Flagstaff. "When will that switch take place? Or is it already taking place?"

Like all IPCC reports, this week's assessment reflects only science submitted for publication, which means it is already out of date. In a study due out later this year, for example, a team led by Schuur estimated that the rapid collapse of some permafrost landscapes as they thaw could increase emissions from permafrost by 50%. Nor could the current report draw on next-generation climate models developed for the next major IPCC report, due in 2021. Most of those models forecast faster warming than their predecessors (*Science*, 19 April, p. 222). Robert DeConto, a glaciologist at the University of Massachusetts in Amherst, calls their omission "a little bit frustrating."

Perhaps the biggest struggle for IPCC scientists has been assessing the speed of future sea level rise, which hinges largely on the fate of the West Antarctic Ice Sheet. The odds are low that the ice sheet will collapse this century, which would eventually drive meters of extra sea level rise. But in recent years, several of its vital buttressing glaciers have slid toward the sea, and an international team is now studying its most at-risk glacier, Thwaites. Scientists continue to debate whether an unstoppable collapse has already begun. But it's a risk people need to know about, DeConto says. "Antarctica has big potential to do something really scary. It may be low likelihood outcome, but the impacts would be monumental."

It's one more reason for the world to make big cuts in carbon emissions, right away. "We can save the cryosphere," Schuur says. "The rapidity of change sometimes leads people to think it's too late, and it's not." ■

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SOCIAL SCIENCE

Privacy concerns could derail Facebook data-sharing plan

Foundations to suspend funding for unprecedented collaboration with academic researchers

By **Jeffrey Mervis**

Last year, social scientists who study how democracies function got an offer from Facebook that made them salivate: access to demographic data on the site's 2 billion users.

The potential treasure trove would let researchers explore, among other topics, the explosive question of whether the ubiquitous social platform is helping sway elections and undermine political institutions around the world. There would be no restrictions on what researchers could publish from the data set, which contains the website addresses that Facebook users have publicly shared, some characteristics of those URLs, and aggregated information about the sharers, including their age, gender, location, and political leanings. Seven charities put up $11 million to fund the grants that would be awarded under the initiative, and the first round of 12 research teams was chosen in April as part of a 1-year pilot.

But that research is not yet underway and, at the end of this month, the funders are expected to suspend their support for the project because many of the data have not been released. Privacy concerns are the holdup. Facebook decided to adopt a rigorous statistical technique known as differential privacy to ensure that individual users cannot be identified. But the company is still figuring out how to apply differential privacy to all the data, and it's not clear when—or whether—the scientists will ever have access to them.

Despite the disappointing news, grantees seem to accept the need for delay. "Everybody wants this research to be done," says Joshua Tucker, a political and data scientist at New York University in New York City who leads a team that received a $50,000 grant to study how misinformation spreads across different social media platforms. The Facebook effort "could revolutionize the types of online data to which researchers can get access, and the questions that people who are not employees of that platform can ask." But Tucker says the company is "trying to invent a system by which we can do research in a way that mathematically preserves the privacy of everybody in the data set. And the cost has been to slow down its availability."

The data-sharing arrangement is the brainchild of Gary King, a quantitative social scientist at Harvard University. It was launched in April 2018, shortly after the news broke that Cambridge Analytica, a U.K. firm, was selling voter profiles to candidates

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