Researchers to study environmental, human impacts of nuclear war

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Scientists and students led by the University of Colorado Boulder and Rutgers University are calculating the environmental and human impacts of a potential nuclear war using the most sophisticated scientific tools available.

The lead researchers, CU Boulder Professor Brian Toon and Rutgers Professor Alan Robock, have been studying the threat in-depth for decades. They were among the first scientists to formulate the "nuclear winter" theory, which indicated that a nuclear war between two countries could cool parts of the planet and trigger famine and mass starvation, even in nations not involved in the war.

In 1983, Toon, Robock and others—including Cornell University's Carl Sagan—followed on the heels of Dutch scientist Paul Crutzen and now-retired CU Boulder Professor John Birks, who published a 1982 study concluding that smoke from burning forests, cities and oil reserves caused by nuclear blasts would block sunlight and cool Earth. The 1983 nuclear winter paper, which Toon co-authored, was published in *Science* and grabbed worldwide attention from scientists, politicians and the public.

"I find it surprising and frustrating that the potential catastrophic effects of a nuclear war have fallen off the radar of many people following the nuclear winter discussions that began in the early 1980s," said Toon. "One of our goals for this study is inform people how dangerous these weapons are by providing a solid scientific analysis of the issues."

Ongoing threat of 'nuclear winter'

The new study will calculate in detail for the first time the impacts of nuclear war on agriculture and the oceanic food chain and on humans, including food availability and migration activity, said Toon of CU Boulder's Laboratory for Atmospheric and Space Physics. The team is using various scenarios to calculate how much smoke produced by fires in modern cities initiated by nuclear blasts would be produced by urban firestorms and their available fuels, Toon said.

"The most important factor is the amount of smoke which would be generated from fires started by nuclear detonations in cities and industrial areas and lofted into the upper atmosphere," said Robock, a distinguished professor in the Department of Environmental Science at Rutgers. "For the first time, we will model the fires and firestorms, using detailed estimates of what would burn, based on new credible scenarios of how a nuclear war might be fought."

Although the global nuclear arsenal was reduced by about 75 percent following the end of the Cold War in the 1980s, there are still about 15,000 nuclear weapons distributed among nine nations. While the United States and Russia have the bulk of the weapons, the other members of the world's "Nuclear Club" are Britain, China, France, Israel, Pakistan, India and North Korea.

Toon stressed the threats of a nuclear incident have not diminished and could arise from miscommunications, international panic, computer hacking or malfunction, terrorism or action by a rogue leader of a nuclear nation. North Korea, which has 10 to 20 nuclear weapons, continues to flaunt its military power—most recently with the launch of an intercontinental ballistic missile believed capable of reaching Alaska or Hawaii—that was condemned by many nations, including the U.S., Russia and China.

Supercomputers, climate models tell a nuclear war story

The team is using supercomputers and sophisticated climate models developed by the National Center for Atmospheric Research (NCAR) in Boulder to calculate the amount of fire fuels in major cities and how much smoke might be produced by nuclear blasts. The researchers also are using agricultural and world food trade models to assess the impact on crops from a potential nuclear war and the possibility of widespread famine.

"Calculations show there is enough food on the planet to feed people for about 60 days, and an average city has about enough food to feed residents for just seven days," said Toon, also a professor in the atmospheric and oceanic sciences department (ATOC). "The functioning of our society is based in large part on our ability to transport food, fuel and other goods—activities that would be severely affected by a nuclear war."

In 2016 Robock and Toon authored a commentary piece in The New York Times titled Let's End the Peril of a Nuclear Winter. In it they point to their 2007 study on the potential impact of a nuclear war between India and Pakistan, with each country detonating 50 Hiroshima-sized bombs.

One result? Smoke from the explosions would make temperatures plunge, causing wheat, rice, corn and soybean production to be reduced globally by 10 to 40 percent for five years. The explosions also would cause severe depletion of the Earth's ozone layer, damaging human health and the environment, said Toon.

The new project is funded by a three-year, $3 million grant from the

Open Philanthropy Project headquartered in San Francisco. Open Philanthropy focuses on funding projects in four broad categories: U.S. policy, global catastrophic risks, scientific research, and global health and development.

Students involved in research

As part of the Open Philanthropy effort, CU Boulder Professor Yunping Xi and his students will assess the amount of flammable building material in modern cities in various parts of the world, as well as the flammable contents in such buildings. CU Boulder Professor Julie Lundquist and her students will use sophisticated weather research and forecasting models developed at NCAR to run computer simulations on how terrain and surface roughness might impact fire behavior after a nuclear detonation.

Robock is working with several graduate students, including Joshua Coupe, who will be helping on climate modeling. Another of his graduate students, Guangoh Jheong, will work on agricultural modeling with University of Chicago postdoctoral researcher Florian Zabel. Rutgers Associate Professor Gal Hochman and graduate student Hainan Zhang will work on economic modeling for the effort, said Robock.

NCAR scientists Charles Bardeen and Michael Mills, who both received their doctoral degrees at CU Boulder, will use the latest atmospheric and aerosol climate models developed at the center to better understand the response of the climate system to the soot from fires. Based on current scientific knowledge, some could end up in the stratosphere 10 to 30 miles above Earth's surface and remain aloft for years or even decades, said Toon.

Working with Toon, Bardeen and Mills—who previously collaborated with him on nuclear winter simulations—will track the injections of

gases and aerosols from city fires, calculating their transport, removal and the interaction of the particles with clouds, incoming sunlight and climate.

In addition, CU Boulder Assistant Professor Nicole Lovenduski and students will be studying how the oceanic food chain might change in response to the climatic disruption and enhanced ultraviolet radiation from nuclear explosions.

"Our work will provide a much clearer description of the global humanitarian consequences backed up with state-of-the-art calculations of the fires, the climate change and the impact on food production, prices and restrictions for a number of different possible nuclear wars," said Robock.

Provided by University of Colorado at Boulder

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