New models confirm nuclear winter

Everything from purely mathematical models to forest fire studies shows that even a small nuclear war would devastate the earth. But the Pentagon's only policy conclusion is that nuclear war must be prevented—by Star Wars.

by Alan Robock

THE THEORY OF nuclear winter has provoked arguments since it was first proposed in 1982. While the Defense Department waffles on its consequences, new studies continue to confirm the original conclusions, and the international community has taken notice.

Last December the U.N. General Assembly voted 145–0 (with nine abstentions) to give "the widest possible distribution" to a U.N.-commissioned report on the theory of nuclear winter. The U.N. report, whose authors include 11 scientists from six continents, endorsed and supported nuclear winter theory, stating: "It appears evident that none would escape the awful consequences of a major nuclear war even if the theater of conflict was geographically restricted to a small part of the northern hemisphere." The report concludes: "The direct effects of a major nuclear exchange could kill hundreds of millions: the indirect effects could kill billions."[1] Even the United States, the only U.N. member to vote against initiating the study, merely abstained on the vote to accept its conclusions.

The basic theory of nuclear winter has remained unchanged since it was first described by Paul Crutzen and John Birks in 1982, elaborated by Rich Turco's group, and reaffirmed by Vladimir Aleksandrov and Georgi Stenchikov in 1983.[2] Turco coined the term "nuclear winter" to describe the climatic effects of a large-scale nuclear war. Smoke—especially black, sooty smoke from cities and industrial plants—would block sunlight for weeks or months over most of the Northern Hemisphere. And, if a nuclear holocaust occurred in the Northern Hemisphere in summer, it would affect much of the Southern Hemisphere as well. The cool, dark conditions at the earth's surface would eliminate at least one growing season, resulting in a global famine similar to that seen in Sudan and Ethiopia. In a nuclear war between the United States and the Soviet Union, more people would die in India or China than in the target countries combined.

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RESEARCH CONDUCTED SINCE 1983 has strengthened the scientific basis of the theory. Many groups have made climate model calculations using the same assumptions about the amount and location of smoke that would fill the atmosphere, and arrived at the same conclusions. More than enough combustible material exists in target areas to produce the necessary smoke.[3]

In 1986, Starley Thompson and Stephen Schneider introduced the term "nuclear fall" to describe the results of a different climate model simulation.[4] Their study assumed that smoke would enter the atmosphere at lower altitudes and fall out more quickly. In their model, surface temperatures are more characteristic of late fall. Thompson and Schneider also made clear that their study did not invalidate the effects of nuclear winter theory—agriculture would be tragically disrupted. Unfortunately, the phrase "nuclear fall" has been taken up by opponents of nuclear winter theory to suggest that science has disproved the basic theory.

In contrast to those opponents' optimism, recent evidence suggests that crops are more sensitive than previously thought to cold, darkness, and drought. Even Ronald Reagan's science adviser, William R. Graham, concluded that "crops growing in the mid-latitudes of the Northern Hemisphere could be totally destroyed or production severely reduced for at least the first growing season after a nuclear exchange, if the resulting atmospheric perturbations were to cause temperature decreases on the order of 5 to 15°C for even short periods of time."[5]

The controversy over first-year effects also ignores long-term consequences. Studies show that the lofting of smoke into the stratosphere, above the region where it would be washed out by rain, could extend the effects of nuclear winter for several years. The latest climate model simulations conducted at Los Alamos and the National Center for Atmospheric Research (NCAR) suggest that these changes in atmospheric circulation would also cause 30–50 percent ozone depletion on a hemispheric scale, which would last for several years.

My own work suggests that the cooling effects of ice and snow would also prolong nuclear winter by several years. Thompson at NCAR and Steve Ghan at Lawrence Livermore National Laboratory recently came to similar conclusions.

Working with Andy Volgemann and Bob Ellingson, I have also used my climate model to show that "dirty snow" would not make nuclear winter go away. It had been suggested that as soot darkened snow and ice, making them absorb more sunlight, warmth would counteract the nuclear winter cooling. We found, however, that snow and ice would only be significantly darker when the atmosphere was full of smoke. By the time the atmosphere was clear enough

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Yellowstone Park last summer: Measuring the surface-cooling effects of major forest fires is one way to test nuclear winter theory.
Courtesy AP/Wide World

to admit sunlight so that the reflectivity of the surface had an effect, new snow would have covered the dirty layers.

One way to test parts of the nuclear winter theory without burning cities is to observe the surface-cooling effects of forest fires. I have found that smoke traveling for a few days from fires in British Columbia to the U.S. Midwest lowered daytime surface temperatures 2–4 degrees centigrade, although it did not affect nighttime temperatures. Doug Westphal and Brian Toon of NASA's Ames Research Center used a computer model for this case which calculated the same temperature effects as my actual observations. When they gave their model smoke the properties of smoke from urban or industrial fires, blacker than forest fire smoke, they calculated cooling to be 8–10 degrees centigrade.

My observation of forest fires shows that other mechanisms can exaggerate the cooling effects of smoke. For example, smoke from forest fires in northern California in September 1987 was trapped by an atmospheric inversion, which prolonged cooling of as much as 20 degrees centigrade for more than two weeks in the Klamath River Canyon.

Other studies have examined the agricultural and ecological results of a nuclear winter environment in specific locations, including China, India, Venezuela, and sub-Saharan Africa. Supported by the Rockefeller Brothers Fund and led by Mark Harwell of Cornell, nuclear winter specialists conduct local workshops to discuss the climate model simulations and provide computer models to calculate how various crops will grow under differing environmental conditions.[6] Local scientists familiar with local agricultural practices conduct detailed studies using variations of temperature, light, and precipitation reduction to determine the effect on different crops. One of these workshops was held in China in 1988 and another is scheduled to be held in Africa in September 1989 in Saly, Senegal.

The consensus on nuclear winter is broad. Studies by the U.S. National Academy of Sciences, the Soviet Academy of Sciences, Los Alamos and Lawrence Livermore National Laboratories, the U.S. National Center for Atmospheric Research, the General Accounting Office of the U.S. Congress, the U.S. Office of Science and Technology Policy, the Royal Society of Canada, the United Kingdom Meteorological Office, and the U.S. Department of Defense all support the nuclear winter theory. A three-year study involving more than 300 scientists from more than 30 countries conducted by the Scientific Committee on Problems of the Environment of the International Council of Scientific Unions (SCOPE) has detailed the climatic, environmental, and agricultural effects of nuclear winter.[7] The U.N. report includes details of the latest research efforts, and the June 1988 issue of *Environment* summarizes the current status of nuclear winter theory and research.

BOTH THE SENATE and House held hearings on nuclear winter in 1984 and 1985. For each of the last three years, Congress, through its annual budget authorization, has required the Defense Department to conduct a "detailed

review and assessment" of scientific findings on nuclear winter, including the theory's environmental and biological dimensions, and a "thorough evaluation of the implications" of these findings for the United States' nuclear weapons, arms control, and civil defense policies.

In 1983, after the first reports on nuclear winter theory appeared but before Congress acted, the Defense Department initiated a research program into what the department terms the "Technical Effects" of nuclear holocaust. The Pentagon allocated $400,000 for the program in fiscal 1983, $1.1 million in 1984, $1.5 million in 1985, and $2.5 million per year thereafter. This research program was virtually the only source of funding for university scientists, since other government agencies have regarded the topic as too political to touch. Defense Department funding has produced a large volume of high quality research results, many of which were included in the U.N. report. It has also had important spinoffs, expanding the ability to use climate models to investigate other problems. But these funds were spent on research into the physical effects of nuclear war, with no comparable support for the study of biological effects.

In March 1985 the Defense Department produced a 17-page report which evaluated only two scientific studies of nuclear winter, with only five pages on policy implications. The department stated that the main policy implication was that nuclear war must be prevented, and that this could be accomplished by deterrence, arms control, and Star Wars. Effective deterrence, according to the report, required "maintaining a modern, effective strategic Triad by strengthening each of its legs [missiles, bombers, and ships] and emphasizing secure and survivable command, control and communications." As for Soviet scientists' work on nuclear winter, the department concluded: "It is hard to tell the difference between scientific workers and propagandists." The report did not address environmental and biological effects, and its brevity was attributed in part to the scientific uncertainties surrounding nuclear winter theory.

The second annual report, issued May 9, 1986, presented an even briefer analysis—five pages—with no new discussion of policy implications. Although some details of new research projects were mentioned, no synthesis or evaluation of ranges of uncertainties was presented. Again, environmental and biological effects were ignored. The department's latest communication to Congress was a one-page report, presented a month and a half late, claiming that there is still insufficient information to understand nuclear winter, and that there is no guarantee that three years from now the situation will be any better. By 1989, nearly all department support for university-based studies of nuclear winter had ceased.

The Energy Department—the agency that designs and manufactures nuclear weapons in the United States—spends about the same amount each year on nuclear winter research as the Defense Department does, but nearly all Energy Department funds are spent in-house. Conducted mainly at Los Alamos and Livermore National Laboratories, Energy Department studies have been first-rate.

After its initial flurry of interest, Congress moved on to other things, although the member most active in this area, Colorado Senator Tim Wirth, a Democrat, presented new research results at a press conference in 1987. But there has been little congressional interest expressed since then, and improved relations with the Soviets may continue to lower Congress's level of concern.

IN NEARLY ALL scenarios for possible military action the Defense Department uses the "worst case" approach—planning for the worst possible outcome. Only in the case of nuclear winter does the department become optimistic. Claiming that the theory is still uncertain, the department now intends to wait several years before acting on its possible implications.

The implications of nuclear winter are clear: the use of nuclear weapons would be suicide for all the peoples of the planet. A first strike would kill the aggressors, even if their victims could not retaliate. And the threat of nuclear retaliation, even for a conventional attack, is meaningless if it will also kill the retaliators. Even a "limited nuclear war" would produce these effects. Continuing to produce nuclear weapons decreases rather than increases a nation's security. If the people of the planet are to survive an accidental or intentional use of nuclear weapons, the number of nuclear weapons must be drastically reduced. As Rich Turco and Carl Sagan argue in a forthcoming book, a few hundred weapons on each side would maintain the threat of massive retaliation while drastically lowering the threat of nuclear winter. □

In a war between the superpowers, more people would die in India or China.

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