

# COMMENT

**BUSINESS** Roche, Toyota and Nokia on research in the recession **p.277**



**THEATRE** Echos of Chernobyl in staging of Soviet space race **p.282**

**POLICY** PhD 'glut' needed to fix problems with food, energy, health and meteors **p.284**

**OBITUARY** William Nunn Lipscomb Jr, discoverer of a new type of bonding **p.286**



Atomic attacks would cause huge city fires, like this one in San Francisco in 1906, and smoke would cool the planet.

## Nuclear winter is a real and present danger

Models show that even a 'small' nuclear war would cause catastrophic climate change. Such findings must inform policy, says **Alan Robock**.

In the 1980s, discussion and debate about the possibility of a 'nuclear winter' helped to end the arms race between the United States and the Soviet Union. As former Soviet president Mikhail Gorbachev said in an interview in 2000: "Models made by Russian and American scientists showed that a nuclear war would result in a nuclear winter that would be extremely destructive to all life on Earth; the knowledge of that was a great stimulus to us, to people of honour and morality, to act."

As a result, the number of nuclear weapons in the world started to fall, from a peak of about 70,000 in the 1980s to a total of about

22,000 today. In another five years that number could go as low as 5,000, thanks to the New Strategic Arms Reduction Treaty (New START) between the United States and Russia, signed on 8 April 2010.

Yet the environmental threat of nuclear war has not gone away. The world faces the prospect of a smaller, but still catastrophic, nuclear conflict. There are now nine nuclear-weapons states. Use of a fraction of the global nuclear arsenal by anyone, from the superpowers to India versus Pakistan, still presents the largest potential environmental danger to the planet by humans.

That threat is being ignored. One reason for

this denial is that the prospect of a nuclear war is so horrific on so many levels that most people simply look away. Two further reasons are myths that persist among the general public: that the nuclear winter theory has been disproved, and that nuclear winter is no longer a threat. These myths need to be debunked.

The term 'nuclear winter', coined by Carl Sagan and his colleagues in a 1983 paper<sup>1</sup> in *Science*, describes the dramatic effects on the climate caused by smoke from fires ignited by nuclear attacks on cities and industrial areas. In the 1980s my colleagues and I calculated, using the best climate models available at the time, that if one-third of

BETTMANN/CORBIS

▶ the existing arsenal was used, there would be so much smoke that surface temperatures would plummet below freezing around the world for months, killing virtually all plants and producing worldwide famine. More people could die in China from starvation than in the nations actively bombing each other. As many countries around the world realized that a superpower nuclear war would be a disaster for them, they pressured the superpowers to end their arms race. Sagan did a good job of summarizing the policy impacts<sup>2</sup> in 1984: although weapons were continuing to be built, it would be suicide to use them.

The idea of climatic catastrophe was fought against by those who wanted to keep the nuclear-weapon industry alive, or who supported the growth of nuclear arsenals politically<sup>3</sup>. Scientifically, there was no real debate about the concept, only about the details. In 1986, atmospheric researchers Stanley Thompson and Stephen Schneider wrote a piece in *Foreign Affairs* appraising the theory<sup>4</sup> and highlighting what they saw as the patchiness of the effect. They coined the term 'nuclear autumn', noting that it wouldn't be 'winter' everywhere in the aftermath of a nuclear attack. They didn't mean for people to think that it would be all raking leaves and football games, but many members of the public, and some pro-nuclear advocates, preferred to take it that way. The fight over the details of the modelling caused a rift between Sagan and Schneider that never healed. When I bring up the topic of

nuclear winter, people invariably tell me that they think the theory has been disproved.

But research continues to support the original concept. By 2007, models had begun to approximate a realistic atmosphere up to 80 kilometres above Earth's surface, including the stratosphere and mesosphere. This enabled me, and my coauthors, to calculate for the first time that smoke particles would be heated by the Sun and lifted into the upper stratosphere, where they would stay for many years<sup>5,6</sup>. So the cooling would last for much longer than we originally thought.

### DARK DAYS

Many of those who do accept the nuclear-winter concept think that the scenario applies only to a mass conflict, on a scale no longer conceivable in the modern world. This is also false. A 'small' nuclear war between India and Pakistan, with each using 50 Hiroshima-size bombs (far less than 1% of the current arsenal), if dropped on megacity targets in each country would produce climate change unprecedented in recorded human history<sup>5</sup>. Five million tonnes of black carbon smoke would be emitted into the upper troposphere from the burning cities, and then be lofted into the stratosphere by the heat of the Sun. Temperatures would be lower than during the 'Little Ice Age' (1400–1850), during which famine killed millions. For several years, growing seasons would be shortened by weeks in the mid-latitudes (see 'A decade of cooling').

Brian Toon at the University of Colorado in Boulder, Richard Turco at the University of California, Los Angeles, Georgiy Stenchikov at Rutgers University in New Brunswick, New Jersey, and I, all of whom were pioneers in nuclear-winter research in the 1980s, have tried, along with our students, to publicize our results. We have published refereed journal articles, popular pieces in *Physics Today* and *Scientific American*, a policy forum in *Science*, and now this article. But *Foreign Affairs* and *Foreign Policy*, perhaps the two most prominent foreign-policy magazines in English,

**"Fidel Castro summoned me to a conference on nuclear winter in Havana."**

would not even review articles we submitted. We have had no luck getting attention from the US government. Toon and I visited the US Congress and gave briefings to congressional staff on the subject two years ago, but nothing happened as a result. The US President's science adviser John Holdren has not responded to our requests — in 2009 and more recently — for consideration of new scientific results in US nuclear policy.

The only interest at a national level I have had was somewhat surreal: in September 2010, Fidel Castro summoned me to a conference on nuclear winter in Havana, to help promote his new view that a nuclear conflict would bring about Armageddon. The next day, my talk — the entire 90 minutes including questions — was broadcast on nationwide television in prime time, and appeared on the front page of the two national newspapers in Cuba.

As in the 1980s, it is still too difficult for most people to fully grasp the consequences of a nuclear conflict. But it must be grasped. We scientists must continue to push our results out to the public and to policymakers, so they can in turn push political will in the direction of disarmament. Just as Gorbachev, armed with the knowledge of nuclear winter, helped to end the cold war, so too can the politicians of today use science to support further reductions in arms. The New START treaty is not enough. ■

Alan Robock is in the Department of Environmental Sciences, Rutgers University, New Brunswick, New Jersey 08901, USA.  
e-mail: [roboc@envsci.rutgers.edu](mailto:roboc@envsci.rutgers.edu)

1. Turco, R. P., Toon, O. B., Ackerman, T. P., Pollack, J. B. & Sagan, C. *Science* **222**, 1283–1292 (1983).
2. Sagan, C. *Foreign Affairs* **62**, 257–292 (1984).
3. Badash, L. *A Nuclear Winter's Tale: Science and Politics in the 1980s* (MIT Press, 2009).
4. Thompson, S. L. & Schneider, S. H. *Foreign Affairs* **64**, 981–1005 (1986).
5. Robock, A. *et al. Atm. Chem. Phys.* **7**, 2003–2012 (2007).
6. Robock, A., Oman, L. & Stenchikov, G. L. *J. Geophys. Res.* **112**, D13107 (2007).

## A DECADE OF COOLING

The detonation of 100 nuclear bombs could cause fires releasing 5 million tonnes of black carbon, with long-term temperature effects — much greater than those from the 1991 eruption of Mount Pinatubo.

