Smoking out the facts of nuclear winter

The theory of nuclear winter made nuclear war unthinkable. Now they are having a rethink. Last week, a conference in London heard about nuclear autumn

Marcus Chown

"THE PROPER response to nuclear winter," says Carl Sagan, "is to reduce nuclear weapons to a level below the threshold for triggering a climatic catastrophe." Sagan was speaking at a conference in London last week, organised by the British Association for the Advancement of Science. His proposed policy of "minimal deterrence" would mean, he says, a cut in the numbers of warheads around the world from 55 000 to less than 1000.

But is there really a threshold above which a nuclear war would disrupt the climate? And would any climatic change be as severe as a nuclear winter? According to the latest study, from the National Center for Atmospheric Research (NCAR), in Boulder, Colorado, there would be no winter after a war: merely "nuclear autumn".

A year ago, the theory of nuclear winter seemed incontrovertible fact. An exhaustive study by the Scientific Committee on Problems of the Environment (SCOPE), the work of 300 scientists from 30 countries, showed, apparently, that a nuclear war would change the world climate. Smoke from burning cities would be lofted high into the atmosphere where it would obscure the Sun, possibly plunging much of the planet into freezing darkness.

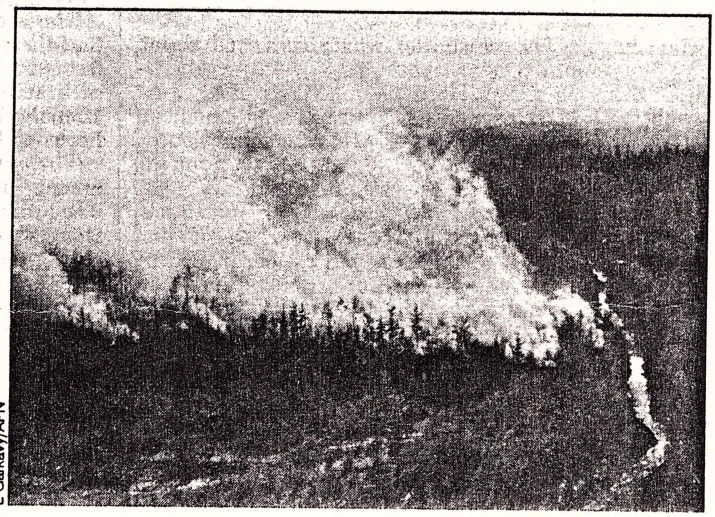
The committee said: "Any disposition to minimise or ignore the widespread environmental effects of nuclear war would be a fundamental disservice to global civilisation." But, in the past year, nuclear winter has been largely ignored by the makers of policy on nuclear weapons. The sticking point remains the science. Is the science known well enough to warrant a change of policy on nuclear weapons?

The scientific uncertainties result from an incomplete knowledge of the physical processes of nuclear winter. Into this category go the optical properties of smoke particles, the height to which smoke from fires will rise, the characteristics of large fires, and the mechanisms by which smoke particles are removed from the atmosphere by rain.

In the final analysis, of course, it is the war itself that will determine any effect on the climate. Nobody can predict reliably the exact number of weapons that will be used, or their yields, the targets, the height of each detonation or the season of the conflict. One consequence is that the exact amount of smoke to be expected is in doubt. Uncertainties such as these can be resolved by nothing short of the declaration of nuclear war.

The US's Department of Defense thinks nuclear winter is a risk, not a certainty. The administration says it wants more research before it commits itself to action. "Policy assessments," according to the President's Office of Science and Technology, "could be four or five years away".

That position would seem to have been strengthened by the latest results. Starley Thompson and Stephen Schneider of the NCAR say the results from their computer model of the global climate in the aftermath of a nuclear war make "it look more like nuclear fall than nuclear winter". Their model predicts a drop in temperature of 10-15 °C in the centre of a continent for anything from a day to a month. This compares with the 20-30 degree drop forecast by SCOPE.



L Garkavy/APN

Forest fires: anything to tell us about the nuclear aftermath?

According to Sir Frederick Warner, chairman of the SCOPE study, speaking at last week's conference, "the SCOPE study always recognised there would be a variation in the effects predicted by studies. The NCAR results are within the range we predicted."

Have promoters of the idea of nuclear winter made the mistake of overemphasising the most extreme of a range of climatic effects that a nuclear war might bring? Sagan says, no. "Double standards are being used," he says. With the military, great emphasis is always put on the worst-case scenario: What is the worst an enemy can do to you? "But with nuclear winter," he says, "the worst case is suddenly not acceptable."

Thompson and Schneider use a three-dimensional computer model of the atmosphere with a resolution of 5 degrees in latitude and 7 degrees in longitude. Their model includes transport of smoke by winds and its removal by rain. The results show that if burning cities inject 180 million tonnes of smoke into the atmosphere in a war in July, the average temperature drop in mid-latitudes of the northern hemisphere will be about 12 °C, a week after the war (see diagram). But, the authors warn, there could be considerable local fluctuation from this figure.

Thompson and Schneider cite several reasons for their less severe effects. "We found," they say, "that the oceans, with their vast storage of heat, would reduce the magnitude of the average continental cooling, by a factor of two."

Also, three-quarters of the smoke in their simulation is removed from the atmosphere within 30 days, as "black rain". Lastly, Thompson and Schneider consider the "greenhouse effect" of the smoke in warming the surface. It is a strange quirk that soot in the atmosphere, being black and therefore a good absorber of sunlight, actually increases the heat the Earth retains from the Sun. Unfortunately, that heat stays in the upper atmosphere, while the surface below cools.

The "nuclear-autumn" study, published in a semi-popular form in the summer edition of the American journal, *Foreign Affairs*, has yet to be published in its entirety so that the scientific community may assess it properly. However, Richard Turco, who developed the original theory with Sagan, thinks there is an obvious reason for the less sensational results.

In their model, Schneider and Thompson have injected smoke low in the atmosphere, allowing it to be "washed out" quickly. In climate models, says Turco, smoke is customarily injected at a range of heights. The centre of the "injection profile" used by Schneider and Thompson was 3·8 kilometres. Turco's previous study used 5·7 kilometres, while SCOPE assumed firestorms would inject soot to stratospheric altitudes of up to 10 kilometres. The stratosphere is the layer above the weather systems. "It has been known since the earliest studies," said Turco, that, "the lower in the atmosphere the smoke is introduced, the less severe the cooling of the ground beneath."

George Golitseyn, speaking at the London meeting, said much could be learnt from historical fires. Golitseyn, from the Institute of Atmospheric Physics in Moscow, pointed to Siberian fires in 1915. There, he said, an area of about 140 000 square kilometres had burnt, releasing between 20 and 40 million tonnes of smoke into the atmosphere. This smoke from natural fire did not absorb heat as much as the smoke expected from burning cities. Nor was it propelled as high into the atmos-

phere as would be likely in a firestorm after nuclear war. However, the amount of smoke is close to that used in many models of nuclear winter. Contemporary records show some regional effects from the Siberian fires—cooling by 5-15 °C for 10-30 days.

Sagan points out that an explosion in 1815 of the Indonesian volcano, Tamborn, had a similar effect. It injected fine particles into the atmosphere, far fewer than in a nuclear winter. Nevertheless, 1816 became known around the world as "the year without a summer". That summer, on the equator near the volcano, there were damaging frosts and crops were destroyed.

"The distinction between nuclear winter and nuclear autumn is irrelevant," says Sagan. "SCOPE found that a single night below freezing is enough to destroy rice crops; a four-degree drop in temperature over the growing season is enough to destroy all Canadian wheat and barley." It is the vulnerability of the world's major food that leads people to liken the aftermath of a nuclear war to Ethiopia rather than Hiroshima.

India has food supplies for only 25 days and China for 50 days. Britain would be lucky to survive for four months.

The study by Thompson and Schneider has been used by some to argue that nuclear winter is discredited. One passage reads: "We intend to show on scientific grounds the global apocalyptic conclusions of the initial nuclear winter hypothesis can now be relegated to a vanishingly low level of probability."

Russel Seitz used the quote in a much publicised article in an American magazine, *The National Interest*. Seitz is a visiting scholar at Harvard University who believes that 'Soviet propagandists have seized upon nuclear winter in their efforts to debilitate the political will of the alliance".

Thompson and Schneider talk elsewhere in their article, however, of the indirect effects of a nuclear war, including climatic effects, causing "unprecedented worldwide human misery". Taken together, they say, "they could threaten more people *globally* than would the direct effects of explosions in a large nuclear war".

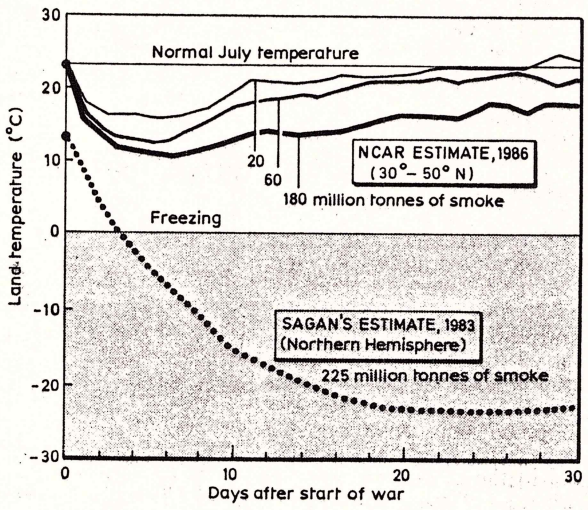
"It is unfortunate," they say, "that in some of the media coverage of our article an impression was given that somehow we believe nuclear war is now acceptable just because the continental-scale temperature effects have been reduced and human extinction is highly improbable.

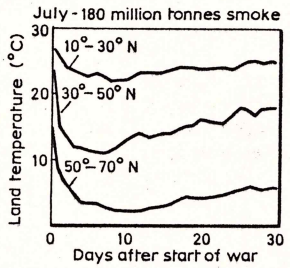
"In an attempt to contrast the most soothing of our statements with the most alarming of Carl Sagan's, some analysts misrepresent both of our positions."

Seitz has pulled into the debate Freeman Dyson, a prominent theoretical physicist at the Institute of Advanced Study in Princeton. Seitz quotes him as saying, about nuclear winter: "It's an absolutely atrocious piece of science." Coming from someone of Dyson's standing in the scientific community, this would be damning. Dyson, however, told *New Scientist* that he had never said such a thing, nor did he know of Seitz.

Dyson's misgivings are that nuclear winter has become synonymous, in the public eye, with the evils of nuclear war. He believes this is dangerous because, if it is proved wrong, nuclear war may appear acceptable.

Is there a threshold number of nuclear explosions, above which climatic change is likely and below which it is unlikely? Sagan puts the threshold at a few tens of millions of tonnes of smoke. The threshold exists, he says, simply because of the optical properties of smoke: for small quantities there is essentially no reduction of sunlight, whereas for large amounts there is essentially complete attenuation.





Comparing apples with oranges? Thompson and Schneider of NCAR compare Sagan's prediction with their own model. But, says Sagan, his is an all-land model, whereas NCAR considered the effect of the sea

Thompson and Schneider say, however, that "any potential global threshold is obscured simply by the inherent averaging of dense and thin smoke clouds over numerous disparate geographic locations".

Such a dispute, taken together with the uncertainty over whether or not the nuclear-winter scenario is realistic, is sure to stay the hand of the politicians a little longer.

The Pentagon dismissed the findings of SCOPE on the grounds that it had not been subject to peer review—despite the fact it was an international effort from several hundred scientists, from both sides of the Iron Curtain.

In March 1985, the US defence secretary, Caspar Weinberger, concluded that the findings of nuclear winter "strengthen the basic imperative of US national security—that nuclear war must be prevented".

"The real political success of nuclear winter," says Sagan, "is that it brings into the nuclear debate for the first time other countries." SCOPE showed that countries such as India stood to lose most from any climatic change. Disruption of the monsoons could deprive hundreds of millions of people of rice.

Of all countries, New Zealand is the one which has taken nuclear winter the most seriously. Proving that it's an ill wind that blows nobody any good, the country has used part of the £13 million compensation paid by France for the sinking of the *Rainbow Warrior* to fund a study to investigate what a nuclear war in the northern hemisphere would mean to New Zealand.

The study will look at what practical steps New Zealand and other South Pacific countries should take now to ensure they could function after a war.

In the US, research is carried out under the Interagency Research Program, chaired by the President's Office of Science and Technology Policy. Money has come from the government for research. But, according to Wirth, the Pentagon's research programme is "narrow and underfunded". Ironically, he says, the uncertainty which has prevented policy changes has also "kept it and other federal agencies from providing serious funding for the study of nuclear winter".

Wirth is proposing that research be done on the biological and ecological consequences of nuclear winter. At present, the programme has no funds assigned to life sciences.

Nevertheless, $5·5 million has been allocated for the coming year. Wirth is asking for a further $8·5 million for each of the next five years, which he contrasts with the $24-36 billion the US invests annually in its nuclear arsenal.

The highest research priorities are to look at the major uncertainties in characteristics of smoke and fire and to improve the computer models of the global climate after a nuclear war.

Fires in remote areas such as the Californian hills should improve knowledge of the smoke and soot which drives climatic models. But they are expensive—costing from $400 000 to $1 million a time (see page 22). And the question arises: do the results apply to city fires?

Sagan warns that models may still be underestimating some effects. For instance, all studies have predicted only minor effects in the southern hemisphere, assuming no cities there are targeted. But, says Sagan, the computer models have only looked at the evolution of the climate over the month following a nuclear war. It takes longer than that, he says, for smoke, lofted into the stratosphere, to drift south of the equator. "There is a real possibility that effects in the southern hemisphere could be severer than the global climate models have so far predicted."

Sagan warned of synergisms—the working together of some effects to produce something greater than their sum. Birds, he pointed out, are more sensitive to cold than insects. In the aftermath of a nuclear war, there could be a plague of insects, causing a "global pandemic". The very idea of nuclear winter was missed for 38 years, he says. "What else have we missed? What other consequences?" □