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Focus On:

Nuclear Winter in the Post-Cold War Era

CARL SAGAN
Laboratory for Planetary Studies,
Cornell University

RICHARD P. TURCO
Department of Atmospheric Sciences,
University of California at Los Angeles
(UCLA)

1. *Nuclear Winter: The Decade-Long Debate*

In the early 1980s, there were some 60,000 nuclear weapons on the planet – all but a few thousand in the hands of the USA and the then Soviet Union. Between 10,000 and 13,000 on each side were strategic weapons that could be carried by missile or aircraft halfway around the world. The remainder were less potent theater or tactical weapons, most of which nevertheless had a higher explosive yield than the bombs that obliterated Hiroshima and Nagasaki. This was also the moment when we were hearing – mainly from US strategists and politicians – that nuclear war was 'survivable' and even 'winnable'.

At just the same time, atmospheric and planetary scientists accidentally discovered that – as bad as the prompt and local effects of nuclear war would be – the delayed and global consequences might be much worse. In 1982, Paul Crutzen and John Birks noted that forest fires ignited in a such a war could generate enough smoke to obscure the sun and perturb the atmosphere over large areas. The following year, we and our colleagues – Turco, Toon, Ackerman, Pollack, and Sagan (TTAPS) – recognized that the smoke from the burning of modern cities would provide a still more serious threat, and quantified the resulting climatic effects from various sources of soot and dust and for a wide range of possible nuclear war scenarios. Provided cities were targeted, even a 'small' nuclear war could have disastrous climatic consequences; a global war, we calculated, might lower average planetary temperatures by 15 to 20°C, darken the skies sufficiently to compromise green plant photosynthesis, produce a witches' brew of chemical and radioactive poisons, and significantly deplete the protective ozone layer. (The climate is thought to recover several years later.) These effects, which had been almost wholly overlooked by the world's military establishments, we described as 'nuclear winter'.

Considering how profound a challenge nuclear winter presented to prevailing nuclear doctrine, it is not surprising that these results were challenged, especially by the weapons establishments. For example, prolonged debate ensued on whether three-dimensional atmospheric general circulation models for a 'standard' nuclear war were best characterized by 10 to 15°C or by 15 to 20°C temperature declines. But all calculations agree that the cooling would probably be at least as severe as the difference between present temperatures and those at the worst of the last Ice Age.

Especially through the destruction of global agriculture, nuclear winter might be considerably worse than the short-term blast, radiation, fire, and fallout of nuclear war. It would carry nuclear war to many nations that no one intended to attack, including the poorest and most vulnerable. Estimates of fatalities remain conjectural. One study, performed by hundreds of scientists from over a dozen countries working for three years under

the auspices of the International Council of Scientific Unions, concluded that billions of people would be at risk.

These inferences strike at the heart of the policy of massive nuclear deterrence – that enormous strategic arsenals are essential to deter adversary nations. With nuclear winter, a massive nuclear attack, even in the absence of retaliatory strikes, is likely to boomerang and, through climatic effects, destroy the aggressor nation, along with many others. Threatening massive retaliation (or de-facto launch-on-warning) became much less credible as an instrument of national policy.

2. *Confirmations from Kuwait*

A small-scale test of something like nuclear winter, but much less severe, has recently been performed. The oil well fires ignited in Kuwait in January 1991 by the retreating Iraqi army constituted an experiment in climate modification on an unprecedented scale, generating the largest soot pall ever recorded. The pitch-black skies of Kuwait were shown on television screens all over the world. There was a strange chill in the air. This was caused by only about one ten-thousandth the soot expected in a nuclear war.

Following the Gulf War, scientific teams were dispatched to the area. The smoke produced turned out to differ from that expected in a nuclear war in several important respects: most of the burning occurred in forced jets with efficient entrainment of atmospheric oxygen, rather than in poorly ventilated, oxygen-restricted fires; the soot emission factor in the Kuwaiti well fires was only about one-tenth of that measured under less favorable conditions for massive oil pools; the oil burned contained a high content of briny water, which rendered the resulting smoke highly hygroscopic and easily rained out of the air; the small size of the individual well fires and their large average separation prevented significant initial buoyant lifting of the smoke plumes; and the meteorological conditions in the Middle East during the period of most intense burning imposed a strong large-scale temperature inversion over the well fires, which prevented injection of the soot into the high atmosphere. Under these circumstances, the effects should not have been, and do not seem to have been, of global scale.

Nevertheless, the darkening of the sky and the cooling of the ground (roughly a 5°C drop) that occurred in Kuwait are just what is predicted by nuclear winter theory for such a soot injection. The regional climatic and environmental perturbations were unprecedented in the historical record of the Persian Gulf. Some analyses of the event also suggest that the soot injections may have altered the Indian monsoon circulation and caused torrential downpours in China. Along with recent discoveries about the 'impact winter' which seems to have caused the extinction of the dinosaurs and most other species of life on earth some 65 million years ago, and the correct forecasting of the much smaller global cooling from the June 1991 explosion of Mt Pinatubo, the Kuwaiti oil fires represent a recent scientific finding that counsels us to take nuclear winter very seriously.

3. *Unprecedented Arms Cuts*

Now the Cold War is over. The Soviet Union is no more. Both sides have relaxed the alert status of their strategic forces. The 'Looking Glass' continuously airborne command post of the US Strategic Air Command – designed to launch US nuclear weapons should Washington, DC be wiped out – has been retired. Tactical nuclear weapons have been withdrawn

to Russia from all over the former Soviet Union and Eastern Europe. American tactical weapons have been removed from Europe, South Korea, and elsewhere. Except for 600 to 700 assigned to American carrier task forces, they are all withdrawn and dismantled. The Pantex facility in Amarillo, Texas, is on two and three shift days – not manufacturing, but disassembling nuclear warheads. Strategic aircraft, their wings and tails sawn off, sit forlornly in open fields so their destruction can be verified by passing reconnaissance satellites.

The START I treaty, ratified both by the successor states of the former Soviet Union and by the USA, mandates a build-down to 6,000 'accountable' strategic warheads by each side. This is the first significant reduction of nuclear inventories in history. The US President suggests that the reductions go further, down to 3,500 weapons; the Russian President raises him – or better, lowers him – to 2,500. There is an arms race in reverse. With START II, each side would settle down to 3,500 strategic warheads by the year 2003.

Unfortunately, this is not nearly enough. Nuclear arsenals had reached such absurd levels that even bringing the tactical inventories nearly to zero and cutting the strategic inventories by two-thirds reduces the potential dangers hardly at all. Let us ask how many cities there are. If we define a city as having more than 100,000 people, then there are some 2,300 cities on the planet. This means that *after* START II is fully implemented, the USA or Russia could destroy every city on the planet and have 2,300 weapons left over. The residual arsenals after START II will still endanger almost everyone. The prospects of accidental or unauthorized launches, or misunderstood orders, or ethnic and religious rivalries sweeping up nuclear-armed nations, or a madman coming to power in such a state should not be dismissed. This is, after all, the century of Hitler and Stalin.

For such reasons many analysts, East and West, are proposing further weapons cuts. Many of the suggestions hover around 1,000 strategic warheads, but justifications for this number are vague. We wish to point out that there is a reason, flowing out of nuclear winter, for maximum inventories of this order or less. With hundreds of city centers ablaze, and firestorms carrying smoke directly into the upper atmosphere, planet-wide nuclear winter effects are likely to follow. If we wish to arrange a world in which no miscalculation, no technological error, no misunderstood orders, no fit of ethnic or religious passion, and not even a conspiracy of madmen could bring about a global environmental catastrophe, then we must arrange a world with fewer than several hundred nuclear weapons. A regime of minimum sufficient deterrence is possible, in which nations with small arsenals deter others, similarly armed, but where even the detonation of the full global arsenals cannot bring about nuclear winter. Getting down to zero seems an unrealizable goal for the foreseeable future, because, in a regime of minimum sufficiency, the temptation in a crisis to launch a few nuclear weapons *is* – short of global effects – deterred by the knowledge that the adversary can retaliate in kind.

4. *Remaining Dangers*

For many years, nuclear weapons and their delivery systems were restricted to a few nations with immense resources and tight controls on the use of the weapons. But the manufacturing methods have become cheaper and the technology is more widely available. The equipment, and even fissionable material, can be purchased or stolen. Controls in new nuclear-armed nations may be much looser. Every year those nations that have nuclear weapons express deep apprehension that other nations might possess them. Every year there are new nations on their lists. In neighboring, rival states, warning times would be

much shorter than in the US/Soviet confrontation, and the temptation to launch-on-warning or pre-emptive nuclear attack correspondingly greater. As we write, for example, there are publicly voiced concerns about China shipping components of medium-range surface-to-surface missiles to Pakistan, and about North Korea violating its treaty obligations by developing nuclear weapons. North Korean leaders announced that they will withdraw from the Nuclear Nonproliferation Treaty 'to protect our supreme national interest', and then announced that they had changed their minds. New nations join the nuclear club because they are worried that their neighbors might be developing nuclear weapons and delivery systems; or because their neighbors already have such weapons; or simply because they wish to be taken seriously in global power politics. Perhaps there are even cases where leaders wish to acquire such weapons for ideological combat, or to dispose of the civilian population of a declared enemy, or to settle long-standing scores, or to earn a 'place in history'. At the same time, perhaps inspired by the end of the Cold War, other nations have moved away from nuclear weapons: Brazil and Argentina, for example, have jointly agreed not to develop nuclear weapons or ballistic missile carrier systems. Formerly, each had justified the development of such weapons by pointing to the prospect that the other would.

In the preamble to the Limited Test Ban Treaty, the USA, the UK, and the Soviet Union declared their 'principal aim' to be a 'discontinuance of all explosions of nuclear weapons for all time'. That was 1963. The USA has 'tested' more than 1,000 nuclear weapons, most of them since then, and the former Soviet Union a number almost as great. Many of these tests had as their prime function the intimidation of the potential adversary and its allies. Many of the leading designers of nuclear weapons have stressed the high reliability of the weapons, and also the fact that they can be tested in other ways besides nuclear explosions. Without nuclear testing, though, no nation intent on *developing* nuclear weapons could be sure that its warheads would really work. That uncertainty would provide a major constraint on the use of nuclear weapons in a crisis. A Comprehensive Test Ban Treaty would work to lower the inventories of nuclear-armed nations, but especially to prevent the spread of nuclear arms.

As we write, a de facto but not a de jure test moratorium is in place both for the USA and for Russia. This year is the 30th anniversary of the Limited Test Ban Treaty. If the USA, say, continues exploding nuclear weapons, it will become very hard to convince France or China, or nations that aspire to nuclear potency, to forego testing. However, an amendment process is built into the Limited Test Ban Treaty: if a majority of the 117 signatories, including the USA, the UK, and the nuclear-armed successor states to the Soviet Union, agree to upgrade to a Comprehensive Test Ban Treaty, such an upgraded treaty is immediately in force. It would apply to all signatories, whether they were part of the majority in this vote or not – including such nations as India and Pakistan, Iran and Iraq, and the Ukraine. But whatever the diplomatic route, the long-term safety of the human species requires an end to nuclear testing.

Preventing the spread of nuclear weapons to uninitiated nations, and ensuring the security of strategic weapons and their delivery systems under the chaotic conditions of the former Soviet Union, are matters of considerable importance. But there is a matter of still higher priority: while the explosion of even a single nuclear weapon over any city on earth would be a great tragedy, it would not threaten the global civilization. Only nations with a hundred or more deliverable warheads can do that. There are many who worry about a Muammar Qaddafi or an Ayatollah Khomeini or a Saddam Hussein getting nuclear weapons. But because their countries could obtain so few nuclear weapons, this is far from

the greatest threat to our species. The greatest threat is that someone equally sure of the rightness of his cause, and equally willing to consider extreme measures, would come to power in one of the nations with hundreds or thousands of nuclear weapons. At the present time, the following nations are on this list: the USA, Russia, Belarus, the Ukraine, Kazakhstan, the UK, France, China, and Israel. It is a matter of simple prudence to devote our main efforts in avoiding nuclear war to the kind of nuclear war that constitutes the greatest threat to humanity.

Massive reductions in the global arsenals and continuing education of politicians, military leaders, and the general public on the consequences of large-scale nuclear war should receive urgent attention.

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CARL SAGAN, b. 1934, PhD in Astronomy and Astrophysics (University of Chicago, 1960); David Duncan Professor of Astronomy and Space Sciences and Director of the Laboratory for Planetary Studies, Cornell University (1968–). A Pulitzer Prize-winning author, he is also creator of the television series *Cosmos*.

RICHARD P. TURCO, b. 1943, PhD in Electrical Engineering/Physics (University of Illinois, 1971); Professor of Atmospheric Sciences at the University of California at Los Angeles (1988–). With several colleagues, Drs Turco and Sagan are recipients of the American Physical Society's Leo Szilard Award for Physics in the Public Interest for the discovery of the Nuclear Winter phenomenon.