Catastrophic Climatic Consequences of Nuclear Conflict

by Steven Starr

U.S. researchers have confirmed the scientific validity of the concept of 'nuclear winter' and have demonstrated that *any* conflict which targets even a tiny fraction of the global nuclear arsenal against large urban centers will cause catastrophic disruptions of the global climate.

New studies show that a 'regional' nuclear conflict, which targeted large population centers in the sub-tropics with 100 Hiroshima-size weapons – about 0.3% of the global nuclear arsenal – could produce as many fatalities as World War II[1] and would significantly disrupt the global climate for at least a decade.[2] Following this 'small' exchange, the world would rapidly experience cold conditions not felt since pre-industrial times.

U.S.-Russian arms accords have reduced by two-thirds the total number of nuclear weapons in the world's nuclear arsenals since nuclear winter was first described in the 1980's. The new research confirms that the smoke produced by a war fought with the current global nuclear arsenal would still produce a nuclear winter.[3] Under such conditions, daily minimum temperatures in the world's large agricultural areas would fall below freezing for a year and cause the collapse of modern agriculture and the starvation of billions of people.

Nuclear Winter

Nuclear detonations within urban and industrial areas would ignite immense mass fires which would burn everything imaginable and create millions of tons of thick, black smoke (soot). This soot would ultimately be lofted into the stratosphere. There it would absorb and block sunlight from reaching the lower atmosphere where greenhouse gases mainly reside, and thus act to reduce the greenhouse effect.[4]

The profound darkness and global cooling predicted to be result of this process (along with massive amounts of radioactive fallout and pyrotoxins[5], and ozone depletion) was first described in 1983 as 'nuclear winter'.[6] Joint research by Western and Soviet scientists led to

---

[1] Toon, Owen B., Richard P. Turco, Alan Robock, Charles Bardeen, Luke Oman, and Georgiy L. Stenchikov, 2007: Atmospheric effects and societal consequences of regional scale nuclear conflicts and acts of individual nuclear terrorism. *Atm. Chem. Phys.*, **7**, 1973.

[2]Robock, Alan, Luke Oman, Georgiy L. Stenchikov, Owen B. Toon, Charles Bardeen, and Richard P. Turco, 2007: Climatic consequences of regional nuclear conflicts. *Atm. Chem. Phys.*, **7**, 2003-2012

[3] Robock, A., L. Oman, and G. L. Stenchikov (2007), Nuclear winter revisited with a modern climate model and current nuclear arsenals: Still catastrophic consequences, J. Geophys. Res., 112, D13107, doi:10.1029/2006JD008235, 1.

[4] Water vapor, carbon dioxide, methane and nitric oxide are the main greenhouse gases in the atmosphere. They allow short wavelength solar radiation to reach the Earth but retain radiation of longer wavelength, which causes warming of the atmosphere. This process occurs naturally and has kept the Earth's temperature about 15 degrees C (59 degrees F) warmer than it would otherwise be. Current life on Earth could not be sustained without the natural greenhouse effect.

[5] A term to designate toxic chemicals released during combustion, particularly from plastics and industrial chemicals. In a nuclear war, sources of such materials would be widespread; mass fires in urban and industrial areas would release enormous amounts of pyrotoxins into the air, land and water.

[6] Turco, R. P., O. B. Toon, T. P. Ackermann, J. B. Pollack, and C. Sagan (1983), Nuclear Winter: Global consequences of multiple nuclear explosions, *Science*, 222, 1283-1292.

the realization that the climatic and environmental consequences of nuclear war, in combination with the indirect effects of the collapse of society, could produce a nuclear winter which would cause famine for billions of people far from the war zones.[7]

These predictions led to extensive international research and peer review during the mid-1980's. A large body of work which essentially supported the initial findings of the 1983 studies was done by such groups as the Scientific Committee on Problems of the Environment (SCOPE), the Swedish Academy of Science, the World Meteorological Organization, and the U.S. National Research Council.

The idea of nuclear winter, published and supported by prominent scientists, generated extensive public alarm and put political pressure on the U.S. and the U.S.S.R. to terminate a runaway nuclear arms race which, by 1986, had created a global nuclear arsenal of more than 65,000 nuclear weapons. Unfortunately, this was anathema to the nuclear weapons establishment and thus nuclear winter created a backlash among many powerful conservative groups, who undertook an extensive media campaign to brand it as 'bad science' and the scientists who discovered it as 'irresponsible'.

Critics used various uncertainties in the studies and the first climate models (which are relatively primitive by current standards) as a basis to denigrate and reject the concept of nuclear winter. In 1986, the Council on Foreign Relations published an article by scientists from the National Center for Atmospheric Research (NCAR), who predicted drops in global cooling about half as large as those first predicted by the 1983 studies and described this as a 'nuclear autumn'.

Subsequent widespread criticism, in such publications as the *Wall Street Journal* and *Time Magazine*, often used the term 'nuclear autumn' to imply that no important climatic change would result from nuclear war. In 1987, the *National Review* called nuclear winter a "fraud". In 1990, *Discover Magazine* published an article which described nuclear winter as one of "The Twenty Greatest Scientific Blunders in History".[8]

Sadly enough, for almost two decades this smear campaign limited serious discussion and prevented further studies of nuclear winter – and such criticism will continue.[9] Yet the basic findings of the nuclear winter research, that extreme climatic changes would result from nuclear war, were never scientifically disproved and have been strengthened by these latest studies.

Regional nuclear conflict fought with low-yield nuclear weapons

To create the new studies, U.S. researchers used the latest NASA Goddard Institute for Space Studies climate model (Model IE, shared by the Intergovernmental Panel on Climate Change), which is able to model the entire troposphere, stratosphere and mesosphere from the Earth's surface up to 80 kilometers. They simulated a small nuclear war between two

[7] Robock, et al., Climatic consequences of regional nuclear conflicts, 2003.
[8] <http://discovermagazine.com/2000/oct/featblunders>
[9] <http://adamant.typepad.com/seitz/2006/12/preherein_honor.html>

countries in the sub-tropics in which each nation attacked the other's most densely populated urban centers with 50 Hiroshima-size (15 kiloton) nuclear bombs.[10]

This scenario is realistic because the smallest nuclear weapon states today (India and Pakistan) are each believed to possess more than 50 Hiroshima-size (15 kiloton) weapons, and an arsenal of this size (or larger) could be acquired by many other nations in the near future. Thirty-two countries that do not now have nuclear weapons own sufficient fissionable nuclear materials to construct weapons, some in a relatively short period of time.[11]

U.S. warplanners aim their extensive nuclear arsenal at a mix of military targets (nuclear forces, conventional forces, leadership and communication facilities, and war-supporting industries)[12] and it is assumed that Russian warplanners do the same. However, it is commonly believed that small nuclear powers with limited arsenals are most likely to aim their weapons at the largest cities of their adversaries.

Toon, et al., calculated that a 'regional' nuclear war which employed this targeting strategy would create 1 to 5 Teragrams (one to five million metric tons) of soot from the burning cities.[13] Robock, et al., used the NASA climate model to demonstrate that this soot would be lofted to near the top of the stratosphere.[14] There the smoke would remain, far above the area where weather occurs, for at least a decade – about ten times longer than previously thought possible.

This new finding provided the basis for rejecting the conclusion of the studies which suggested that 'nuclear autumn' instead of nuclear winter would follow a full-scale war. Robock's team also discovered that smoke in the sub-tropical latitudes would undergo more solar heating than smoke studied in previous nuclear winter scenarios, and this heating would insure that the smoke particles would be lofted into the stratosphere year-round, regardless of the month in which the war would occur.[15]

Consequently, the massive smoke emissions from the fires of a small 'regional' nuclear war would cause a global climate change unprecedented in human history. In a matter of days, temperatures around the Earth would become colder than those experienced during the pre-industrial Little Ice Age (which occurred from approximately 1400 to 1850).[16] Growing seasons in the middle latitudes would immediately be significantly shortened, completely eliminating some crops that had insufficient time to reach maturity.

The studies predict climatic consequences significantly greater and more persistent than those which resulted from greatest volcanic eruption of the past 500 years, the 1815 Tambora eruption in Indonesia. Tambora lofted enormous amounts of volcanic smoke into the stratosphere, which blocked and scattered enough sunlight to cause the 1816 "Year Without

---

[10] Robock, et al., Climatic consequences of regional nuclear conflicts, 2003.
[11] Toon, et al., 1974.
[12] Lortie, B. (2001) A Do-It-Yourself SIOP, *The Bulletin of the Atomic Scientists*, *57* (4), 24.
[13] Toon, et al., 1998.
[14] Robock, et al., Climatic consequences of regional nuclear conflicts, 2006.
[15] Ibid, 2004.
[16] Ibid, 2007.

Summer", when killing frosts disrupted agriculture every month of the summer in New England and widespread harvest failure and famine occurred in Europe.

The long-term global climate, as measured by the average surface temperature over the planet, has not varied by more than 10ºC from current values, during the entire climatic history of the Earth accessible to modern science.[17] Ice Ages represent periods of cooling of about 5ºC below the global average which extend for periods of thousands of years. Modern agriculture is finely tuned to the present climate and would be severely impacted by rapid average temperature declines of even a few degrees Centigrade.

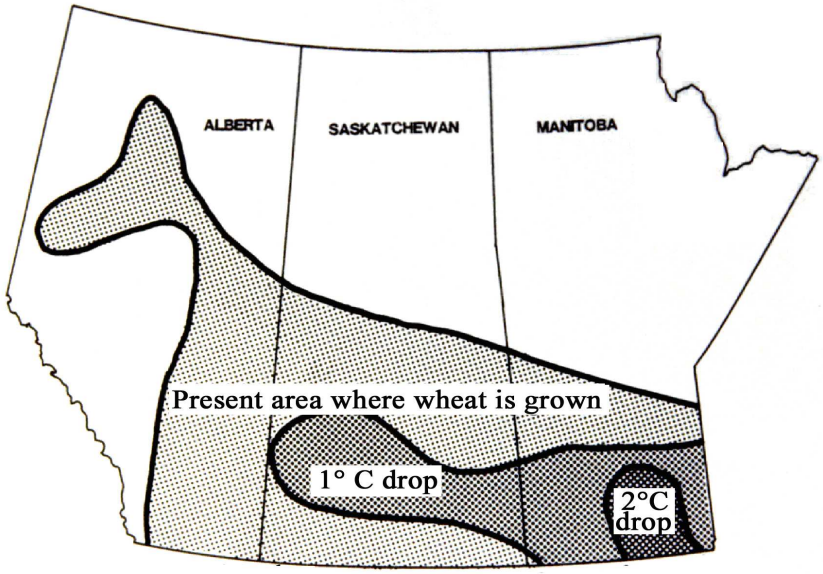

Figure 1: [18] Map showing the present principal area of Canadian wheat production, and the reduction that would result from small decreases in average surface temperature.

Computer simulations of the regional nuclear conflict predict a global average surface cooling of 1.25ºC which would persist for 3 years, with the global average temperature still 0.5ºC below normal a decade after the war. One year after the smoke injection there would temperature drops of several degrees over the grain-growing interior regions of Eurasia and North America. There would be a corresponding shortening of growing seasons by up to 30 days and a 10% reduction in average global precipitation – which would have major impacts on global food supplies.[19]

In addition, the stratospheric smoke plumes from this 'regional' conflict would significantly disrupt the ozone layer, depleting it by 40% over many inhabited areas and by up to 70-80%

[17] Sagan and Turco (1990), *A Path Where No Man Thought – Nuclear Winter and the End of the Arms Race*, p. 42, Random House, New York.
[18] Fig. 4.8a on p. 302 of Harwell and Hutchinson (1985), Env. Consequences of Nuclear War, Vol. II, SCOPE, Wiley&Sons, New York.
[19] Robock, et al., Climatic consequences of regional nuclear conflicts, 2005.

at the poles.[20] This severe ozone depletion would allow intense levels of ultraviolet light to reach the Earth once the smoke cleared. Such levels of ozone loss have previously been forecast only for large nuclear conflicts between the U.S. and the former U.S.S.R.[21]

Nuclear war fought with high-yield strategic nuclear weapons

Using the vastly more modern NASA climate model and new supercomputers, Robock, et al., re-examined the climate response to a range of nuclear wars which detonated moderate and large portions of the global nuclear arsenal in a combination of urban, industrial and military targets.[22] The researchers utilized data from previous studies to calculate that the 'moderate' and 'large' nuclear conflicts would produce 50 and 150 Tg (million tonnes) of smoke[23], which they found would be lofted into the stratosphere, where it would impact surface climate for more than a decade.[24]

The moderate war simulation employed ⅓ of the global nuclear arsenal (1667 megatons) – roughly equivalent to the power of the strategic nuclear weapons now kept at high-alert, launch-on-warning status by the U.S. and Russia.[25] The large war simulation used the current published estimate for the total explosive power of the entire global nuclear arsenal (approximately 5000 megatons). However, the 5000 MT figure appears to be low because it significantly underestimates the explosive power of the Russian reserve stockpile.[26]

A large nuclear war would produce enough smoke and soot to quickly block sunlight from reaching the surface of the entire Northern and Southern Hemispheres. In many areas

---

[20] <http://www.isop.ucla.edu/article.asp?parentid=59428> and <http://news.bbc.co.uk/2/hi/science/nature/6169717.stm>

[21] Birks, John, Stevens, S. (1986), Possible Toxic Environments Following a Nuclear War, *The Medical Implications of Nuclear* W*ar*, National Academy of Sciences, 160-161.

[22] There are approximately 25,300 nuclear weapons in the global nuclear arsenal; 95% of these weapons belong to the U.S. and Russia. About 11,800 of these weapons are fully operational weapons ready for immediate use. An additional 13,500 intact nuclear weapons are in a 'reserve' status. About 7200 of the operational weapons are high-yield strategic nuclear weapons with ≥100 kiloton yield, i.e., having an explosive power equal to or greater than 100,000 tons of high explosive.

[23] Robock, et al., states that this is the greatest area of uncertainty in their calculations, but notes that the amount of smoke affects the amplitude but not the timescale of the climatic response.

[24] Robock, et al., Nuclear winter revisited with a modern climate model and current nuclear arsenals: Still catastrophic consequences, 3.

[25] Approximately 3500 to 4000 U.S. and Russian strategic nuclear warheads remain on high-alert status. These include a very high percentage of the warheads on (1) U.S. and Russian land-based ICBMs, (2) Russian ballistic missile subs (which remain in port virtually all of the time), and (3) all the warheads on the four U.S. Trident subs which are always kept at 'hard alert' status, in position to fire. The total yield of these U.S. and Russian high-alert strategic nuclear forces is the range of 1300 MT to 1700 MT, which is roughly equivalent to the explosive power of the 1667 MT model used in the simulations.

[26] The 5000 MT figure comes from the Carnegie Endowment for International Peace (<http://www.carnegieendowment.org/npp/index.cfm?fa=map&id=19238&prog=zgp&proj=znpp>). They based their figures on data from the National Resources Defense Council (NRDC). Current NRDC data gives about 2500 MT for the entire U.S. arsenal, about 300 MT for the entire Chinese, French and U.K arsenals, and about 1350 MT for the operational Russian arsenal, but no figure is available for the yield of the Russian reserve arsenal, although the NRDC estimates that 9300 weapons are in the Russian reserve. Hans Kristensen of the FAS estimates that the Russian reserve has equal numbers of strategic and tactical weapons. Assuming an average Russian strategic weapon is 550 kT and a tactical weapon is 50 kT, then the yield of the Russian reserve must be about 2790 MT. This increases the yield of the global arsenal to about 7000 MT.

sunlight would be reduced so much that at mid-day it would appear as dark as a moonlit night before the war.[27] The smoke and darkness would persist for years.

This profound darkening of the sky would cause average global surface air temperatures to rapidly cool by 7ºC to 8ºC. Even a decade after the fires had gone out, there would be enough smoke left in the stratosphere to cool the Earth's average surface temperatures by 4ºC. Both the moderate and large nuclear wars would produce cooling equal to or greater than that experienced 18,000 years ago during the coldest period of the last Ice Age[28] – and these temperature drops would occur abruptly in a matter of days or weeks, rather than over centuries or millennia.

The research predicts that a war in which the entire global nuclear arsenal was detonated would result in rapid cooling of more than 20ºC over large areas of North America and of more than 30ºC over much of Eurasia, including all agricultural regions (Figure 2). Daily minimum temperatures in the world's agricultural heartlands would plummet below freezing and nightly frosts would go on for more than a year.

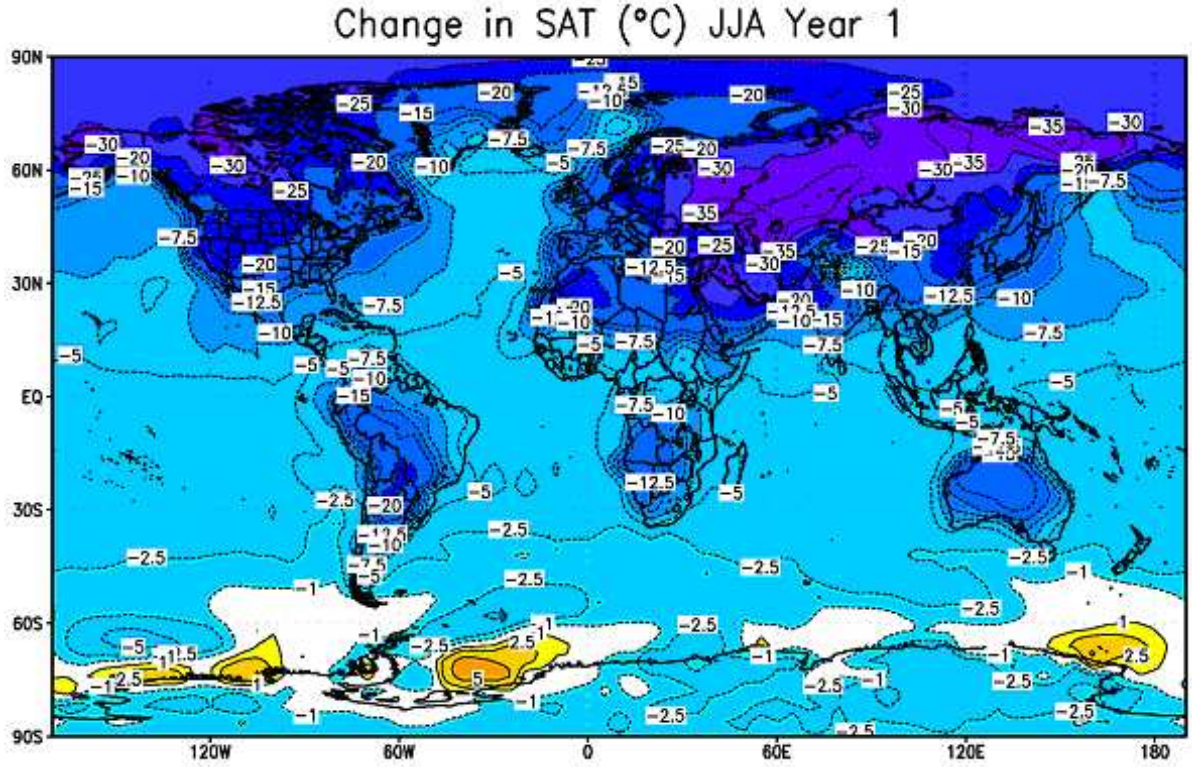

Figure 2: [29] Surface Air Temperature (°C) changes following a full-scale nuclear war averaged for June, July and August of the year following the conflict.

[27] Personal correspondence with Alan Robock, Sept. 9, 2007.
[28] Robock, et al., Nuclear winter revisited with a modern climate model and current nuclear arsenals: Still catastrophic consequences, 6.
[29] Ibid.

Longer-term consequences of the large nuclear conflict are implied by Figure 3, which depicts predicted decreases in the growing seasons during the third and fourth years following the conflict.

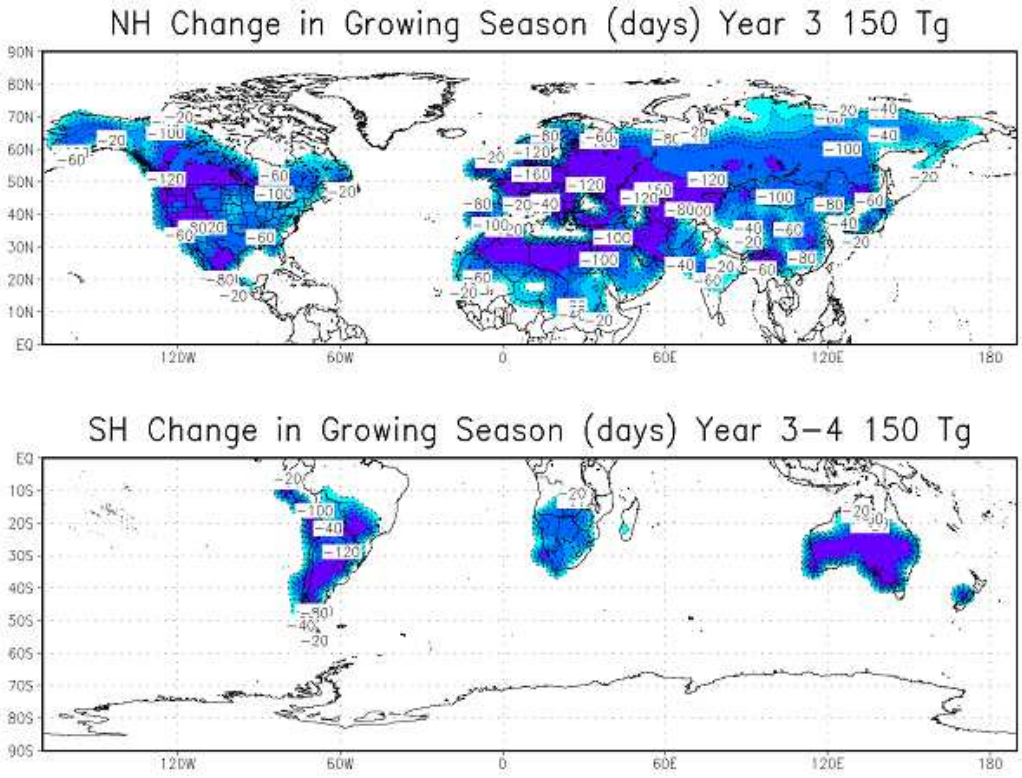

Figure 3: [30] Changes in the growing season (the time period with frost-free days) in the *third year* following a large scale nuclear war which used all the weapons in the global nuclear arsenal.

Agriculture would be affected by not only the catastrophic drops in temperature, but also by a dramatic decrease in sunlight (insolation) and precipitation. The cooling of the Earth's surface would weaken the global hydrological cycle and the Northern Hemisphere summer monsoon circulations would collapse because the temperature differences that drive them would not develop. Consequently, a 45% reduction in average global precipitation is also predicted to occur. Catastrophic climatic effects lasting for many years would occur in regions far removed from the target areas or the countries involved in the conflict.[31]

Nuclear war fought with U.S. and Russian high-alert strategic nuclear arsenals

The failure of the U.S. and Russia to relax their Cold War nuclear confrontation has led each nation to continue to operate under policies that assume the opposing side could authorize a disabling nuclear attack against them. Both nations consequently still maintain a large

[30] Ibid, 11.
[31] Ibid, 6.

fraction of their strategic nuclear arsenals on high-alert status, with their intercontinental missiles able to be launched within 30 seconds to 3 minutes, apparently operating under the policy of launch-on-warning.[32] Thus the 'moderate' war simulated in the new research, which as noted contains a destructive power equivalent to that contained by the high-alert arsenals of the U.S. and Russia, can be ordered and executed by either of these nations in less time than it takes to read this article.

The studies predict that a moderate nuclear war would loft 50 Tg (50 million metric tonnes) of soot in the stratosphere, causing average global surface air temperatures to plummet 3.5ºC to 4ºC, roughly half the drop predicted for the large war.[33] Consider that average global temperature declines of 3ºC to 4ºC would prevent all grain production in Canada, and a single night below freezing is sufficient to destroy the entire Asian rice crop.[34] Because of its rapid onset, even a mild nuclear winter (although the duration would be much briefer) would cause more stress to plant and animal life than would a severe Ice Age.[35]

Climatic consequences of nuclear conflict compared with Global Warming

Climatic changes resulting from nuclear conflict would occur many thousands of times faster – and thus would likely be far more catastrophic – than the climatic changes predicted as a result of global warming.[36] The rapidity of the war-induced changes, appearing in a matter of days and weeks, would allow human populations and the whole plant and animal kingdoms no time to adapt.

It is worth noting that the same methods and climate models used to predict global warming were used in these studies to predict global cooling resulting from nuclear war. These climate models have proved highly successful in describing the cooling effects of volcanic clouds during extensive U.S. evaluations and in international intercomparisons performed as part of the Fourth Assessment of the Intergovernmental Panel on Climate Change.[37]

Predicted drops in average global temperatures caused by small, moderate and large nuclear conflicts are contrasted with the effects of global warming during the last century in Figure 4 and with average surface air temperatures during the last 1000 years in Figure 5.

---

[32] Launch-on-warning (LOW) is the Cold War policy of launching a retaliatory nuclear strike while the opponent's missiles or warheads are believed to be in flight, but before any detonation from the perceived attack has occurred. Early Warning Systems (EWS), high-alert nuclear-armed ballistic missiles, and nuclear command and control systems, all working together, provide the U.S. and Russia the *capability* to launch a nuclear retaliatory strike to a perceived nuclear attack before the attack arrives and is confirmed by nuclear detonations. However, it is the *policy* of Launch on Warning, converted into standard operating procedure, which could lead to the decision to launch solely on the basis of electronic EWS data. The combination of *capability* with *policy* has created what is commonly referred to as launch-on-warning *status*.

[33] Robock, et al., Nuclear winter revisited with a modern climate model and current nuclear arsenals: Still catastrophic consequences, Ibid, 7.

[34] Sagan and Turco, Ibid, 101.

[35] Sagan and Turco, Ibid, 26.

[36] This comparison is not meant to minimize the dangers of global warming, which warrant grave concern, rather it is intended to make the point that the potential environmental dangers posed by nuclear war should receive at least as much attention as is that now being afforded to the issue of global warming.

[37] Robock, et al., Nuclear winter revisited with a modern climate model and current nuclear arsenals: Still catastrophic consequences, 11.

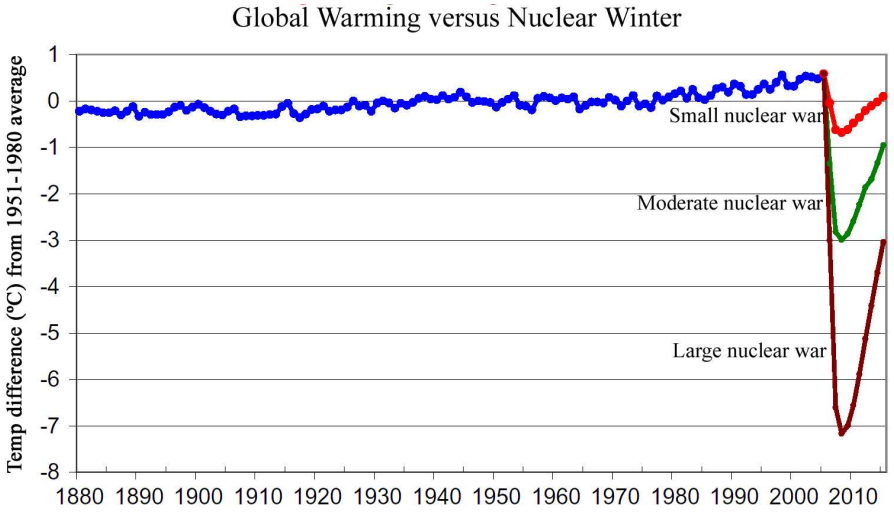

Figure 4: [38] Global average surface air temperature changes from small, moderate and large nuclear conflicts in the context of the climate change of the past 125 years. Predicted temperature drops from the three nuclear conflicts are shown as three separate V-shaped curves, each progressively deeper.

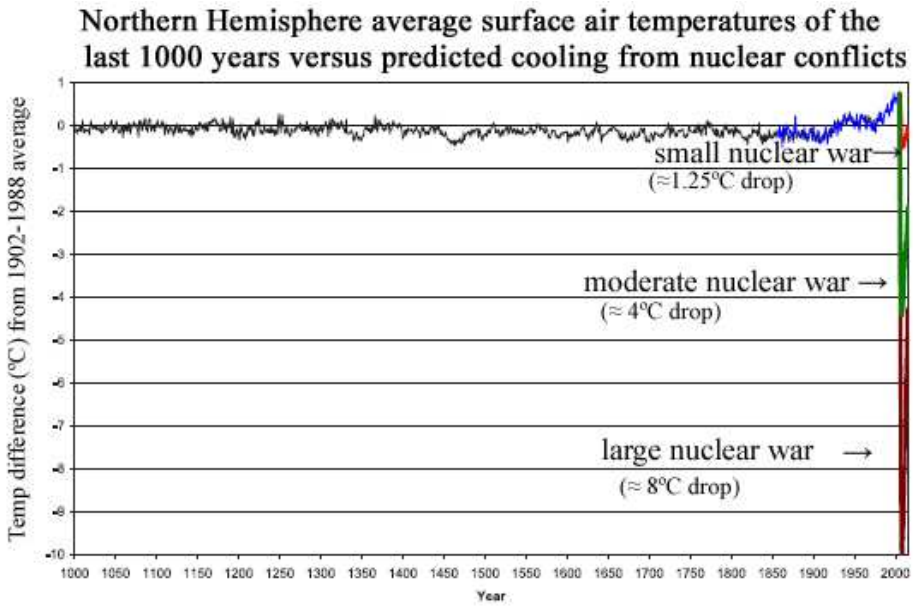

Figure 5:[39] Northern Hemisphere average surface air temperatures during the last 1000 years contrasted with forecast temperature drops from a range of nuclear conflicts.

[38] Robock, et al., Nuclear winter revisited with a modern climate model and current nuclear arsenals: Still catastrophic consequences, Ibid, p. 10.
[39] Ibid.

There are, of course, other important considerations which must be made when estimating the overall environmental and ecological impacts of nuclear war. These must include the release of enormous amounts of radioactive fallout, pyrotoxins and toxic industrial chemicals into the ecosystems. A decade after the conflict, when the smoke begins to clear, there will also be massive increases in the amount of deadly ultraviolet light which will reach the surface of the Earth as a result of ozone depletion. All these by-products of nuclear war must be taken into account when comparing the danger of nuclear conflict to other potential dangers now confronting humanity and life on Earth.

Conclusions

We cannot allow our political and military leaders to continue to ignore the potential cataclysmic climatic and environmental consequences posed by the use of nuclear weapons.

Civilization remains at risk from nuclear winter despite a three-fold reduction in global nuclear arsenals during the last 20 years. This is due in part to the fact that nuclear arms control agreements have focused primarily on the dismantlement of delivery systems and have failed to include the verified dismantlement of nuclear warheads. Future negotiations must consider *all* the potential effects of the *total* number of nuclear weapons in the nuclear arsenals.[40]

The U.S. and Russia must recognize the senselessness of continued planning for a nuclear first-strike which, if launched, would make the whole world including their own country uninhabitable. As a first step, they should end their preparations for the pre-emptive use of their nuclear arsenals, stand-down their high-alert strategic nuclear forces and eliminate the standard operating procedure of launch-on-warning.[41]

It is essential that all the nuclear weapon states be convinced of the need to honor their commitments under Article VI of the Non-Proliferation Treaty, to "act in good faith" to eliminate their nuclear arsenals. As long as they ignore this commitment and maintain nuclear weaponry as the cornerstone of their military forces, they confer validity to the false idea that nuclear weapons provide security to those who possess them, and thus encourage non-nuclear weapon states to follow in their footsteps.

The unalterable conclusion is that a nuclear war cannot be won and must not be fought. Nuclear weapons must be seen not only as instruments of mass murder, but as instruments of global annihilation which put all humanity and civilization under a common threat of destruction.

---

[40] Robock, Alan, Owen B. Toon, Richard P. Turco, Luke Oman, Georgiy L. Stenchikov, and Charles Bardeen, 2007: The continuing environmental threat of nuclear weapons: Integrated policy responses needed. EOS, 88, 228, 231, doi:10.1029/2007ES001816.

[41] Phillips, Alan, Starr, S., 2006, Change Launch on Warning Policy, Moscow Institute of Physics and Technology Center for Arms Control, Energy and Environmental Studies, <http://www.armscontrol.ru/pubs/en/change-low.pdf>