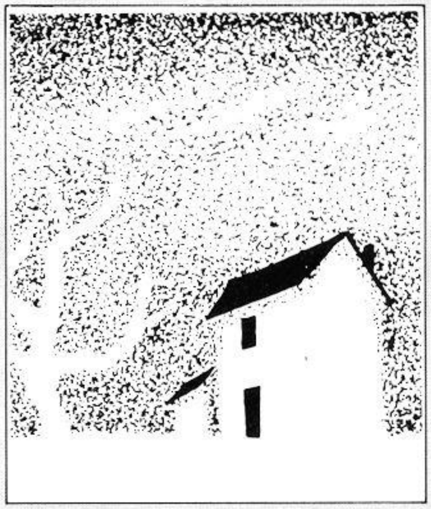

Nuclear war, the atmosphere, and climate

By Kirill Ya. Kondratyev

In recent years great attention has been paid to new assessments of a possible impact of a nuclear war on atmosphere and climate. P. Crutzen (West Germany) and J. Birks (United States) were the first to discover the possible critical impact of urban and forest fires which would be produced as a result of nuclear explosions in the atmosphere.

Such fires must result in the formation of massive amounts of smoke with highly absorbing particles which will strongly attenuate solar radiation at the earth's surface by as much as 95%. This very substantial decrease in insulation will produce climate cooling.

R. Turco, O. Toon, T. Ackerman, J. Pollack, and C. Sagan—TTAPS [a group of Americans who published their study results on nuclear winter in *Science*, April 1984]—made calculations on the basis of a 1-D radiative-convective model for various scenarios of a war. They concluded that the air surface temperature drop over the continents of the Northern Hemisphere would range up to 40°C, due to absorption of solar radiation by smoke.

Further computations made with the use of 2-D and 3-D climate models by various research groups (Lawrence Livermore National Laboratory, NASA Ames Research Center, Computing Center of the USSR Academy of Sciences, National Center for Atmospheric Research) supported these preliminary conclusions about a severe climate cooling and led to the concept of nuclear winter.

The global geographical distribution of climate change has been studied to show that this distribution is very inhomogeneous. Some of the simulations showed that a great change of average meridional circulation can be expected. A single interhemispheric cell of meridional circulation will form instead of the two well-known Hadley cells in the Tropics. The results mean that a nuclear war would be equivalent to a global ecological catastrophe.

KIRILL KONDRATYEV is chief of the Laboratory of Remote Sensing, Institute for Lake Research of the Academy of Sciences, in Leningrad, USSR.

An important question, of course, is the reliability of numerical modeling, which is difficult to assess under the circumstances, although it is quite clear that there are a number of assumptions which need to be verified. They are, to name but a few: rapid global diffusion of smoke particles and their homogeneous distribution in the atmosphere; cloudiness dynamics; evolution of the atmospheric greenhouse effect; particle scavenging; and principal optical properties of smoke particles (single scattering albedo, scattering function).

Such natural analogs as the Tunguska meteor fall in 1907 and more recent volcanic eruptions (specifically El Chichon), may be used for verification purposes, but it has been shown that their significance, the degree of similarity, is very much limited.

Validity-checks

To check the validity of numerical modeling, further improvements to the modeling itself would help; beyond that, we should analyze observed conditions after nuclear tests in the atmosphere during the late 1950s and early 60s. High-altitude balloon measurements of total direct solar radiation at altitudes of about 30 km made by the author and G. Nikolsky (U.S.S.R.) are helpful in this respect.

These balloon measurements revealed a substantial additional decrease of solar radiation by the atmosphere above 30 km after tests —sometimes as much as 6% or 7%. Approximate estimates have shown that this decrease is due to an increase of NO_2 content in the stratosphere produced by nuclear explosions.

On an average, for the Northern Hemisphere, the air surface temperature decreases because of the injected NO_2 during the decade of the 1960s could reach 0.3°C, which coincides closely with observed cooling. Thus it may be concluded that climate cooling during the 60s was due to increased NO_2 content in the atmosphere and the attenuation of solar radiation as a result of nuclear tests.

If we assume now that it is possible to scale the level of climate cooling linearly by taking into account the cumulative power of nuclear explosions—which could be as much as 10^4Mt—then nuclear war on such a scale will lead to a global climate cooling on the order of 10°C due to the NO_2 increase.

Improved modeling

Regarding improved modeling, an important result is connected with results of 1-D calculations made by K. Kondratyev, N. Moskalenko, and S. Gusev (USSR), who took into account more carefully such factors as the evolution of the greenhouse effect due to prolonged process of burning and the vertical distribution of greenhouse components. These calculations revealed a climate warming at the beginning followed by subsequent cooling and then warming again.

The scale of disturbances of the atmospheric chemical composition as a result of multiple nuclear explosions is so enormous that, undoubtedly, this will lead to strong global climate change and ecological catastrophe. It is highly probable, however, that the principal cause of the catastrophe is not just "nuclear winter" but an even more serious strong climatic instability.

Editor's note: This article is a brief summary of a detailed review of the "nuclear winter" scenario which has been published by K. Ya. Kondratyev, S. N. Baibakov, and G. A. Nikolsky in the paper "Nuclear War, Atmosphere and Climate" (*Science in the USSR*, 1985, Nos. 2,3).