LETTERS

"Nuclear Winter" Calculations

The description by Turco *et al.* of the possible global consequences of multiple nuclear explosions" (23 Dec 1983, p. 1283), represents an important attempt to quantify the effects of a nuclear war on global climate. In common with other preliminary studies (*1*), the numerical model simulations of Turco *et al.* suggest that heating of the earth's surface by solar radiation might be drastically reduced by the dust raised in high-yield nuclear blasts and by smoke from city and forest fires ignited by the blasts. However, in view of uncertainties in important inputs to the models and in many of the physical processes involved, as well as inadequacies in the models themselves, the predictions of a nuclear winter must be viewed as a possible, rather than the definite, outcome of a nuclear war. While this caveat has generally been made in scientific articles on the subject, and has been reemphasized in an excellent report by the National Academy of Sciences (*2*), it is often neglected in communications with the general public.

To further underscore the tentative nature of the nuclear winter predictions, I list below some of the scientific uncertainties associated with the numerical model calculations (*3*).

1) The amounts of material that would burn are not well quantified (for example, How widespread will forest fires be in winter?).

2) There are large uncertainties about the quantities of smoke particles that would be emitted into the atmosphere from various types of fires. On the basis of limited field data available (*4*), it appears that Turco *et al.* may have overestimated these emissions.

3) Clouds generally form above large fires, and these clouds often produce rain. This provides a mechanism for the prompt removal of some of the smoke particles, which would further reduce the effective (widespread) emissions of smoke.

4) The radiative properties of smoke particles are not well known. In view of the complex nature of smokes, these properties need to be established by field studies of the plumes from large fires.

5) Widespread smoke will change the radiative properties of clouds. Possible effects include enhanced absorption of terrestrial (long-wave) radiation by smoke particles when they are covered with water, decreases in the average size of cloud droplets (*5*), and decreases in the ice content of clouds (*6*). In view of the profound effects that clouds have on the radiative balance of the earth, these effects should be included in numerical simulations of the effects of smoke particles on atmospheric temperatures.

While some of these effects would tend to diminish the predicted decreases in temperature at the earth's surface, others would tend to enhance the lowering in surface temperatures. Clearly, at this juncture, there are too many uncertainties and simplifications in the numerical simulations of the effects on climate of a nuclear war to place much reliance on their predictions. Reduction of these uncertainties will require dedicated research efforts to better quantify the amounts and nature of the smoke particles from various types of fires, the rates of removal of smoke particles from the atmosphere (particularly prompt removal), and the radiative properties of smokes and clouds affected by smoke, as well as to improve numerical models of global climate. The importance and urgency of the problem dictates that these research tasks be given top priority.

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References and Notes

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2. *The Effects on the Atmosphere of a Major Nuclear Exchange* (National Academy Press, Washington, D.C., 1984).
3. A more detailed discussion of the scientific uncertainties is given in P. V. Hobbs, L. F. Radke, D. A. Hegg, *ICSU-SCOPE Workshop on the Nuclear Winter Scenario, Proc. 9th Intern. Cloud Physics Conf. (1984)*, Tallinn, Estonia, in press.
4. L. F. Radke, J. H. Lyons, D. A. Hegg, P. V. Hobbs, *Final Report from the Cloud and Aerosol Research Group, University of Washington, to Lockheed-EMSCO for Project Nos. AM526 and AM680* (1984); D. E. Ward, in preparation.
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7. I thank L. F. Radke, D. A. Hegg, C. Leovy, and S. Warren for helpful discussions.

Diagnostic Ultrasound

Our initial report on increased frequency of sister chromatid exchanges (SCE's) after in vitro exposure of human lymphocytes to pulsed diagnostic level ultrasound (*1*) has been confirmed and extended in publications from five laboratories in the United States and elsewhere (*2–4*). The increase has now been detected after continuous wave insonation and after in vivo exposure (*4*). The