

would typically be half as great as those in summer.

The estimates of temperature effects are based on sophisticated new modelling techniques that include the interaction between absorption of radiation and movement of the atmosphere, smoke represented as originating from regional sources and the use of scavenging rates determined by precipitation predicted by the model.

The new models can also lead to a lofting of the smoke due to warming that leads to a changed atmospheric temperature profile; the tropopause in the Northern Hemisphere can be lowered to 5 km, and the smoke above the new tropopause would not be efficiently scavenged, again leading to longer residence times (and decreased precipitation). The effect is more pronounced in summer because there is more solar energy to loft the smoke.

SCOPE has made new estimates of the quantity of smoke that would probably be produced in mass fires resulting from a 6,000 MT exchange. It arrives at an estimate of from 30 to 150 million tonnes once early scavenging has removed between 30 and 50 per cent of gross input; about 30 million tonnes of the remaining total would be strongly light-absorbent amorphous elemental carbon which, if spread over the Northern Hemisphere, could reduce insolation at the ground by 90 per cent. But the SCOPE authors admit that the effects of early scavenging represent one of the greatest sources of uncertainty, and the parameters are acknowledged as simplistic. Because of the strong concentration of fossil fuels and related products around cities and towns, the near-total burnout of less than one hundred of the

world's largest industrialized areas would cause the burning of 25-30 per cent of the combustible materials of the developed world.

The SCOPE study explicitly disavows the term "nuclear winter", which it says is too restricting for the multitude of possible effects of a nuclear war. The study makes some assessment of the effect of toxic substances other than smoke likely to be produced in a nuclear exchange. Nitrogen oxides, which may destroy atmospheric ozone, are seen as significant. And there are new gamma-ray dose estimates that suggest that under the same 6,000 MT exchange (about half the world's nuclear arsenal), lethal external gamma-ray doses (assuming no protective action) would cover 7 per cent of the land area of the United States, Europe and the Soviet Union. If spent nuclear fuel rods were distributed in the environment, the dose could be trebled. SCOPE also considers the effects of electromagnetic pulses (EMPs) caused by nuclear explosions.

SCOPE breaks new ground in its assessment of the biological consequences of cooling effects. The report considered the effects for a range of possible attack scenarios. Stress due to lowered temperatures, lowered light intensities and increased levels of ultraviolet light is found to have very serious consequences for agricultural systems in particular and, when taken in conjunction with levels of food in store in different countries, threatens starvation on a large scale. Even rather modest decreases in average temperatures — say 5° C for a growing season — would, for example, make the cultivation of wheat in Canada impossible. Many staple food crops, especially rice, are extremely vulnerable to temperature shifts, particularly during the growing season. The report recommends urgent research to clarify the effects of stress on crops as well as a comprehensive programme on the physics of smoke plumes and scavenging.

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