Spectrum

More news on nuclear winter

As long as the threat of a large nuclear war continues to exist, the possibility of resulting drastic changes to the atmosphere, and thereby Earth's climate, also remains. Our knowledge of the specific effects of such a 'nuclear winter' are being refined as research continues on what is still a relatively new idea.

Since 1982 the CSIRO Division of Atmospheric Research has been involved in studying how Australia may be affected by a nuclear war fought predominantly in the Northern Hemisphere. We reported some of the early results in *Ecos* 39 and in greater detail in *Ecos* 49, which mentioned the International Year of Peace grant from the Department of Foreign Affairs for the Division to further its research on nuclear winter 'down under'.

Now Divisional scientists Dr Barrie Pittock, a specialist in climatology, and Mr Ian Galbally, an atmospheric chemist, have completed their report on the work undertaken with this grant.

Using a powerful computer, programmed with equations that describe the motion of our atmosphere, Dr Pittock and co-workers ran a model that simulated some aspects of the behaviour of the global weather system. (The planet's atmospheric dynamics system is far too complex to model accurately in its entirety: if we could do that we'd never have a mistaken weather forecast.)

Into the simulation they added one crucial component — a uniform layer in the upper atmosphere, capable of absorbing about 20% of the incoming sunlight (the precise figure depends on the angle of the sun). This represents the result of an injection of 170 million tonnes of smoke in the Northern Hemisphere, during their summer, which other workers have calculated that a major nuclear conflict between the superpowers, and with targets only in the Northern Hemisphere, could release.

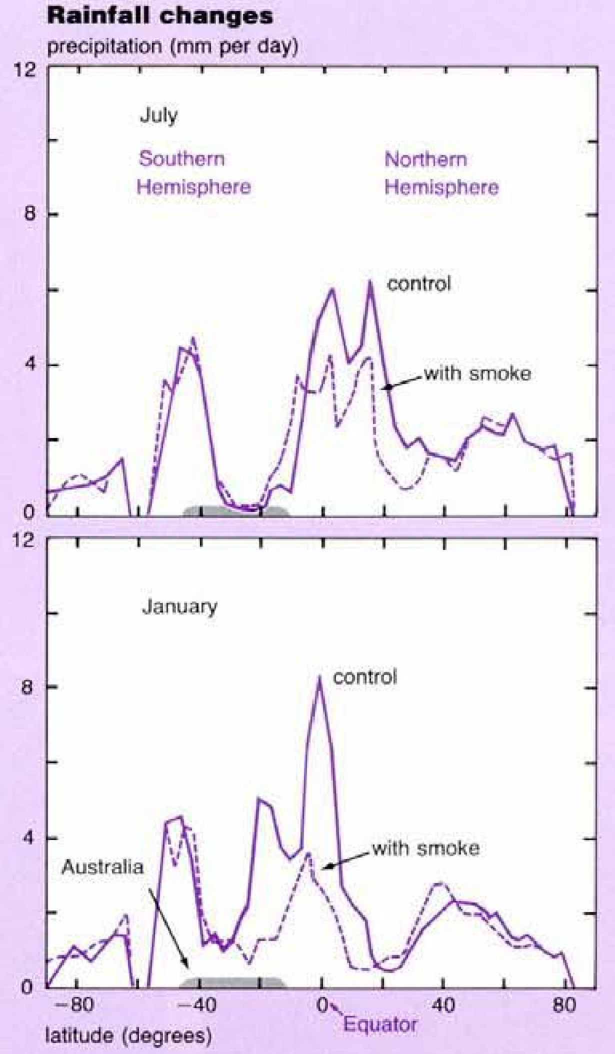
Confirmation

When the scientists ran the model, it confirmed many of their original findings, reported in *Ecos* 49. Australia would survive the immediate effects of a nuclear winter, but certainly would not escape unscathed.

Indeed, our climate would suffer several unwelcome changes: rainfall would decrease by half in the tropics and parts of the subtropics; day length would fall; and daily maximum temperatures would drop by 5°C or more over large areas of Australia, especially during the dry season — although average daily surface cooling would be less, and night-time temperatures would be only slightly reduced. Local warmings could occur in areas where reduced rainfall led to drier soils. The surface layer of the seas around us would cool by about 2–3°C after 1 year.

Now all of this would obviously have an effect on our agriculture. Using another model that relates net primary productivity to annual rainfall and average temperature, the scientists calculated that, on average, our agricultural production would be reduced by about 30%.

Such a decline would not lead to serious shortages of food, because Australia produces far more than its own population consumes. However, the agricultural model did not take into account the reduced intensity of sunlight and the reduced day length; nor did it consider another important effect of large nuclear explosions — the production of nitrogen oxides.



The graphs show the results of simulations with and without (control) injection of the predicted smoke layer. They show big reductions in rainfall in the tropics and regions that rely on monsoons. Rainfall figures are 30-day averages.

These form when the nitrogen and oxygen in the air react together at temperatures above about 2000°C, which they reach in the fireball and shock wave from a nuclear explosion. The compounds eventually enter the stratosphere, where they react with ozone to break it down. Smoke and increased temperatures in the stratosphere would also contribute to ozone reduction.

As everybody should know by now, ozone shields us from much of the sun's damaging ultraviolet light, especially the UV-B, the most dangerous type. An increase of UV-B would harm most organisms, including plants. (It would also cause a raised incidence of human skin cancer in the long term.) How much this would affect agricultural production we don't know.

Other significant unknowns are the effect of the loss of imported agricultural technology, such as fertilisers, pesticides, machinery, and veterinary supplies, as world trade collapsed. The possible arrival of refugees from the north could add to food shortages; any breakdown in our strict quarantine could lead to devastating diseases of plants, livestock, or even humans, which would obviously have serious consequences.

New findings

The International Year of Peace study found that some consequences suggested previously were not likely to occur. One of these concerns the fate of carbon in nuclear fireballs.

Strategic targets, such as cities and fuel-storage areas, contain materials rich in carbon. Nobody knew the precise fate of the substance in a fireball; the possibility existed that a high loading of carbon, with perhaps insufficient oxygen present in the fireball to oxidise it, would remain as black soot, so adding to the absorption caused by the smoke from fires (see *Ecos* 49).

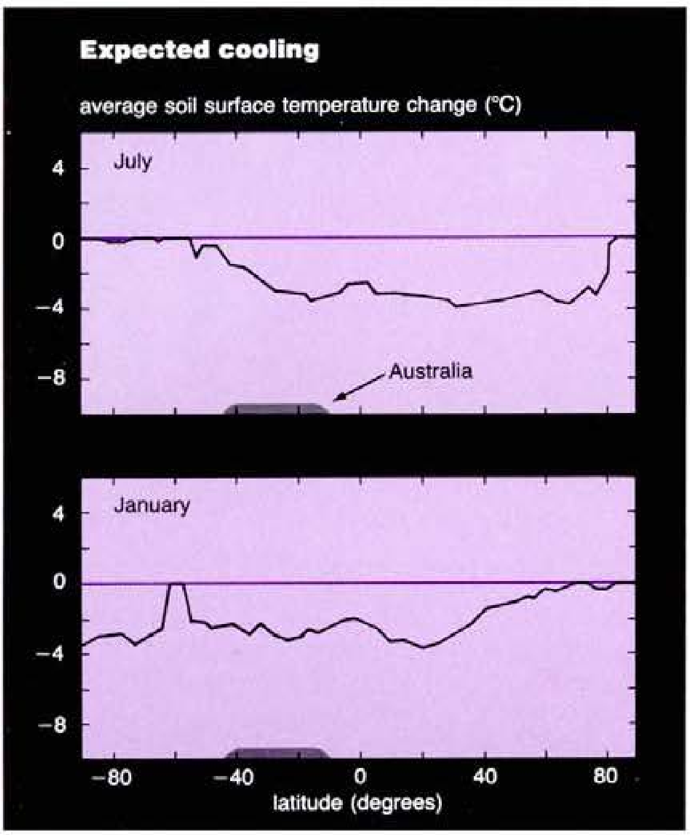
However, using a computer model of a rising fireball, Mr Galbally and co-workers showed that large quantities of oxygen would, in effect, be sucked into the fireball and

that therefore most of the carbon would be burnt.

Another area of possible 'good' news — or, rather, 'less-bad' news — concerns the quantity of nitrogen oxides. Mr Galbally found that previous calculations probably overestimated the quantity carried upwards.

Researchers assumed that all the nitrogen oxides formed in the fireball would rise and

Effects of smoke injection on soil surface temperature would vary substantially with latitude and time of year, the model shows.



come in contact with the ozone. But Mr Galbally now believes that those molecules produced in the shock wave of the fireball would stay in the lower atmosphere, with only those in the centre of the fireball reaching the upper atmosphere.

This work is not quite complete but it does suggest that the ozone layer may not be as greatly depleted after a nuclear war as scientists had at first thought. However, there is little cause for rejoicing, as some loss of ozone would undoubtedly still occur, due to the presence of smoke, the unusually high stratospheric temperatures, and the release of some nitrogen oxide.

The computer models that the scientists used are not, of course, perfect; they are merely approximations and they have their limitations. But the report argues that it is probably not worth refining the climate models and increasing their accuracy much further while the initial conditions, such as the number and positioning of bombs and the weather conditions current at the time of a war, remain so uncertain.

What the research shows is that — given a possible scenario of nuclear war between the two superpowers, based on knowledge of the numbers and strength of the warheads and what their likely targets are — we can predict the nature and the approximate scale of some of the effects on the atmosphere, and the consequent changes of climate in Australia.

The research on climate change and its effects does not take into account the radioactivity released during nuclear explosions. Obviously this would be most serious in the countries involved.

The Scientific Committee on Problems of the Environment (SCOPE) prepared a report suggesting that, provided no bombs were dropped in the Southern Hemisphere, only small quantities of radioactivity would reach us. This would be sufficient over many decades to increase the incidence of radiation-induced disorders such as cancers, but in the short term would not cause death — see *Ecos* 49 again. (Any deliberate bombing of nuclear power installations in the north would significantly increase our radiation dose.)

Of course, that we would survive the climatic effects of a nuclear winter brought about by war in the Northern Hemisphere does not mean that we would survive a nuclear war on or near our own territory. Obviously, any direct targeting of Australia would result in consequences far more grave than those outlined here.

Roger Beckmann

Climatic effects of smoke and dust produced from nuclear conflagration. A.B. Pittock, J. S. Frederiksen, J. R. Garratt, and K. Walsh. In 'Aerosol and Climate', ed. P.V. Hobbs and M.P. McCormick. (A. Deepak: Hampton, Virginia, 1989.)

General circulation model of mild 'nuclear winter' effects. A. B. Pittock, K. Walsh, and J. S. Frederiksen. *Climate Dynamics*, 1989, **3**(in press).