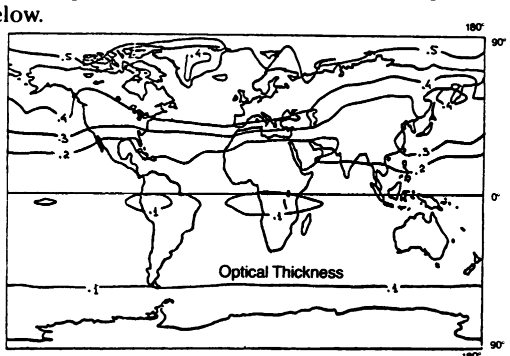
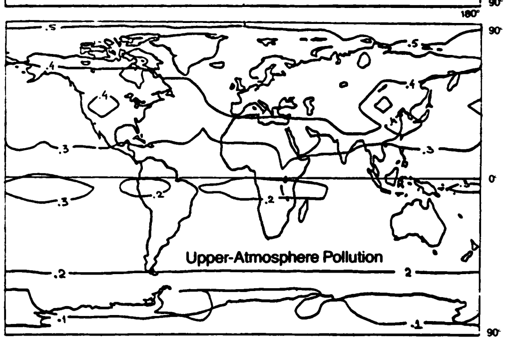
*Janet Raloff reports from the National Bureau of Standards in Gaithersburg, Md., at the Conference on Large [nuclear war] Scale Fire Phenomenology*

## New Soviet 'nuclear winter' maps

At a "nuclear winter" meeting in Washington last year, Vladimir V. Aleksandrov of the USSR Academy of Sciences Computing Center in Moscow unveiled maps indicating major temperature perturbations that might result from soot injected into the atmosphere by fires burning in the wake of a nuclear war (SN: 11/12/84, p. 317). Qualitatively, the maps' data tended to validate the types of temperature changes that had been predicted by two different teams of U.S. climate modelers. But a major limitation of all three studies was that the computer models on which each had been based could not move smoke around within the atmosphere. Their resulting simulations of potential interactions between regional soot-mediated atmospheric heating and associated planet-surface cooling were therefore considered extremely crude.

Now Aleksandrov has revised his global-circulation climate model to account for such smoke transport. Completed only six weeks ago, two new maps from that revised or "smoke coupled" model appear below.




Maps: Aleksandrov

The upper one shows how sunlight transmission might be filtered from earth by light-absorbing soot in the atmosphere on day 99 following a war that left between 200 and 1,000 of the world's largest cities burning. As a gauge of the severity of effects suggested by that map, its "optical thickness" values of 0.2, 0.3 and 0.5 would roughly correspond to a diminishing of sunlight reaching the planet's surface during mid-morning or mid-afternoon of roughly 30, 45 and 65 percent respectively, according to Frederick Luther at Lawrence Livermore National Laboratory (LLNL) in Livermore, Calif.

Luther works on an LLNL project that is also attempting to model climate in a post-nuclear-war environment. Recently the LLNL project has also been able to incorporate smoke transport in its calculations. And, says Luther, comparisons of the U.S. and Soviet results show that "Aleksandrov's optical thickness values were similar to ours" — a qualitative validation of both teams' efforts.

Before the addition of smoke transport, both groups' calculations suggested that large-scale pockets of severe temperature drops might develop. Their new "smoke coupled" results now suggest instead that "there would be a smoothing out of the distributions of the smoke to become more uniform with longitude," Luther explains. Another effect seen in both models during the initial three months or so after the war was a movement of the smoke at high altitudes from high latitudes — where the fires had occurred — to low latitudes, approaching the tropics. This is suggested in the lower map. Aleksandrov says "the pollution levels shown are in relative units," meaning 0.2 is twice the level indicated by 0.1 and half that in areas labeled 0.4.

## Estimating nuclear forest fires

Those modeling the climatic effects of an atmosphere laden with soot generated in post-nuclear-war fires frequently cite forests and wildlands as a primary fuel source for the fires. How much fuel—and hence soot—can these contribute? According to Craig Chandler, an Arlington, Va.-based forest-fire consultant, that depends on when a war breaks out and what period after the closing salvos one wants to consider.

One widely quoted "reasonable estimate" of the forested land that might be set afire constitutes an area 20 times larger than what is annually consumed by wildfires. Chandler suspects, however, that this overestimates how much land would actually prove burnable. One reason, he says, is that "the area burned annually by wildfires is the summation of all fires throughout the year which start on days that they *can* start." For most of the year in most locations, however, the probability of a fire starting is less than 50 percent. In fact, during winter, northern forests are almost immune to ignition, he says, because fires never start "when the ground is snow covered, during a rain or whenever the amount of water in the fuel [is 50 percent or higher, and thus] exceeds the amount of dry matter."

A commonly circulated estimate for the biomass of the average forest is 22 kilograms (kg) per square meter ($m^2$). Since the maximum fuel a good forest can produce is 2.6 $kg/m^2$ times the square root of the age of the stand of trees, Chandler says, that would make this "average forest" a mature stand 70 years old—"not a bad figure." But its needles and living twigs won't contribute substantially to a burn, except in a crown (treetop) fire — an event that occurs only in about 5 percent of all forest fires. Moreover, the bulk of a mature forest's biomass—80 percent—resides in tree trunks. Not only are these trunks "not consumed in even the most intense conflagration," he says, but more importantly, they actually serve "as heat sinks, absorbing more calories of thermal radiation than their outer layers liberate when they char." So, of the 22 $kg/m^2$ living biomass, only about 2.6 $kg/m^2$ should burn, he says, and then only in the hottest fires. And, because trees in Canadian and Russian forests are generally smaller, one should estimate a somewhat smaller fuel loading for their fires, he notes.

In fact, Chandler says, a forest's living biomass usually represents a poor measure of its fuel loading, since all fires—except the rare running crown fire—tend to be sustained by dead debris on a forest floor. For the average 70-year-old stand of conifers, he says, one should expect between 1 and 2 $kg/m^2$ of dead needles, branches and logs on the forest floor.

Two primary factors in a nuclear winter analyst's estimation of a forest's fuel potential, Chandler believes, have almost always been overlooked: steam and ionizing radiation. Even when the forest-floor debris is dry, fires don't ignite simultaneously throughout the entire exposed area. "Moisture in the living foliage is expelled explosively as steam in the thermal pulse and shields the fuels below from the [non-ionizing] radiation emitted later in the pulse. This was demonstrated in the Nevada [above-ground nuclear weapons] tests with very dry fuels and low-kiloton-yield devices," he notes. "Steam shielding should be even more effective when megaton devices are exploded over temperate forests where thermal pulse times will be much longer and living fuel moistures much higher." Under these circumstances, he predicts, fires would occur only in the tops of trees protruding through a forest's canopy and at the edges of clearings where ground fuels would be in a fireball's direct line of sight.

Finally, Chandler notes that pines are even more radiation sensitive than are humans—that is, it takes less ionizing radiation to kill them. "In this regard," he says, "I would be much more worried about forest fires in the late post-attack period, one to 10 years after the event." Because there will be no fallout shelters for pines, he says, "the spectre of hundreds of thousands of acres of dead forests baking in the summer sun that follows the nuclear winter are a *real* cause for concern."