Power plant gases source of puzzling rural ozone clouds

Davis and Klauber

Chemists use specially equipped Cessna to sample pollutants emitted from Morgantown, Md., power plant.

Scientists have been finding some strange things while measuring pollutants in the air over rural areas of the United States. For years, they have been detecting high levels of ozone. This caused concern, because ozone in the lower atmosphere can be damaging to the human lungs and to agricultural plants. Presumably, excess ozone is formed when hydrocarbons are emitted into the air and interact with sunlight and atmospheric oxygen. The scientists expect to find high ozone levels near big cities where vehicles emit tons of hydrocarbons, but not in rural areas with few vehicles and wide-open spaces. An explanation for this strange situation has now been presented, and the answer may have important implications for the problem of balancing the desire for a clean environment with increasing energy needs.

Chemists Douglas D. Davis and Gary Klauber of the University of Maryland at College Park proposed the explanation this week at the American Chemical Society's southeast regional meeting in Norfolk, Va. Ozone clouds, Davis says, are forming downwind from electric power plants. The team suspects that a complex series of chemical reactions takes place involving the pollutants emitted. Nitric oxide (NO) and sulfur dioxide (SO_2) float away from the tall smokestacks in plumes often 50 or 60 miles long. It is within these trailing plumes that the ozone-producing chemical reactions take place, but due to the type of chemical reactions involved and the speed of the wind, the high ozone levels first start to appear as far as 20 to 30 miles downwind from the plant.

Ozone has been causing concern among scientists on two fronts in recent weeks and has become an ironic symbol of technological advancement. While ozone clouds build up in the lower atmosphere, there is also evidence that man is destroying the protective ozone layer in the upper atmosphere (SN: 9/21/74, p. 180; 10/5/74, p. 212). Too much ozone in the lower atmosphere damages sensitive lung tissues and decreases the yield of agricultural plants, but too little in the upper atmosphere allows carcinogenic ultraviolet light to penetrate the earth's protective envelope with greater intensity. Unfortunately, the atmosphere doesn't mix in the right way to redistribute the substance, and the earth's surface may suffer the deleterious effects of both conditions.

Prior to the current plume study, Davis says, no one "had the foggiest notion" that ozone could be coming—directly or indirectly—from power plants. The general feeling of chemists and environmentalists trying to predict the possible environmental effects of power plant emissions has been that as the gases drift away from the plant and are dispersed by the wind, the interaction of the chemicals contained slows and finally stops. "Now," Davis says, "we have obtained direct field and laboratory data on the kinetics of these pollutants which indicate that the interactions can actually turn on and increase with distance. This is 180 degrees out of phase with past thinking."

The team took air samples in the field from October 1973 to July 1974 using Cessna airplanes rigged with sampling devices over the cockpits to ensure that engine exhausts did not mix with the sampled air. Most of the samples were taken in the plume from the Morgantown, Md., power plant located 55 miles south of Washington, D.C., and analyzed for O_3, NO, NO_2 and SO_2. The chemists suspect that naturally occurring hydroxyl (OH) radicals interact with the other pollutants measured, and are the key to ozone formation. Samples of the pollutants were taken in four other power plant plumes, too, and data from all five were presented at the ACS meeting. A report on the Morgantown plume will appear in a November issue of SCIENCE.

The catalytic cycle the team proposes starts perhaps 10 miles from the plant with a reaction between OH radicals in the ambient air and SO_2 molecules emitted from the stacks. During this reaction, the free radical HSO_5 is produced and this in turn can react with NO to form HSO_4 radicals and NO_2 molecules. The NO_2 formed is broken up in the presence of sunlight into NO and atomic oxygen (O), and the O reacts with atmospheric oxygen (O_2) to form ozone (O_3).

There are five main steps in the proposed chemical reaction (the above representation is simplified) with a net production of two ozone molecules per cycle. Davis emphasizes that the rates are not yet known for several of the reactions. "It is hard to assess how many times the catalytic cycle occurs, but we think that for every HSO_4 formed in the plume, as many as 200 molecules of ozone could be formed." The conversion of SO_2 to HSO_4 is slow, Davis says, but "we assume that all of the SO_2 eventually does get converted to HSO_4." Davis thinks another reaction, the conversion of some of the HSO_4 to the corrosive H_2SO_4 (sulfuric acid) probably is going on during ozone production too.

Davis told SCIENCE NEWS the findings could have direct bearing on several important issues: whether or not to switch to high sulfur fuels; where to locate new power plants; how high to build smokestacks; whether or not to use stack scrubbers, and at which levels emission standards should be set. "Because of the necessity of sunlight to drive the chemical reactions, they are slower in the winter and don't occur at night. If plants do switch to higher sulfur coal to meet increasing demands for energy, the preferred time of burning would have to be winter," Davis says.

The chemists are interested in learning about the effects of these ozone clouds, particularly as they accumulate from several power plants. They will study the cumulative effects along the eastern seaboard of the United States next summer.

Environmental Protection Agency chemists are studying results from the Davis team and others, and a spokesman says all of the results are too preliminary at this time for regulatory action to be taken on emission standards. Davis agrees about the preliminary nature of the findings, and says that the highest priority now should be to learn as much as possible about the chemical interactions in power plant plumes so that intelligent standards can be set later. □