STRATOSPHERIC OZONE

Dr. Richard W. Stewart

For several years, some of my colleagues and I have been engaged in studies of the photochemistry and thermal structure of the atmospheres of Mars and Venus as part of the program for interpreting data returned by the various Mariner spacecraft.

In the past several months, we have begun to apply the techniques developed in this work to a study of the photochemical and transport processes in the Earth's stratosphere. We are especially concerned with the effects of certain trace constituents such as water vapor and oxides of nitrogen on the stratospheric ozone distribution.

This study has been motivated in part by recent discussions of pollutants associated with engine exhaust from high-altitude aircraft. We have been encouraged to pursue this program by Dr. Tepper, and we expect initial results from a combined photochemical and vertical transport study in February 1972.

The work has thus far yielded two results, which I will describe shortly. The major goal of this study is to determine the changes in the surface ultraviolet radiation levels which result from changes in the chemical composition in the stratosphere. The problem consists of three related studies that are being carried out by Dr. Hansen and Dr. Hogan, in collaboration with myself: first, the study of the photochemistry of ozone and various trace constituents in the stratosphere, which involves roughly 60 chemical reactions among about 20 constituents; second, a study of the vertical and horizontal transport of these constituents by diffusion and large-scale atmospheric motions; and third, a study of the transmission of ultraviolet radiation through the atmosphere, which requires a multiple-scattering calculation for an inhomogeneous, partially absorbing medium.

To some extent, the absorption and scattering of ultraviolet radiation influences the thermal structure of the stratosphere. Study of the full problem involving all three of these related studies has not been attempted previously.

We have two preliminary results from the third part of this study. Figure 1 shows an increase in the surface radiation levels for various assumed ozone reductions. One of the next steps is to calculate the ozone reductions for a given level of pollution in the stratosphere. This calculation takes into

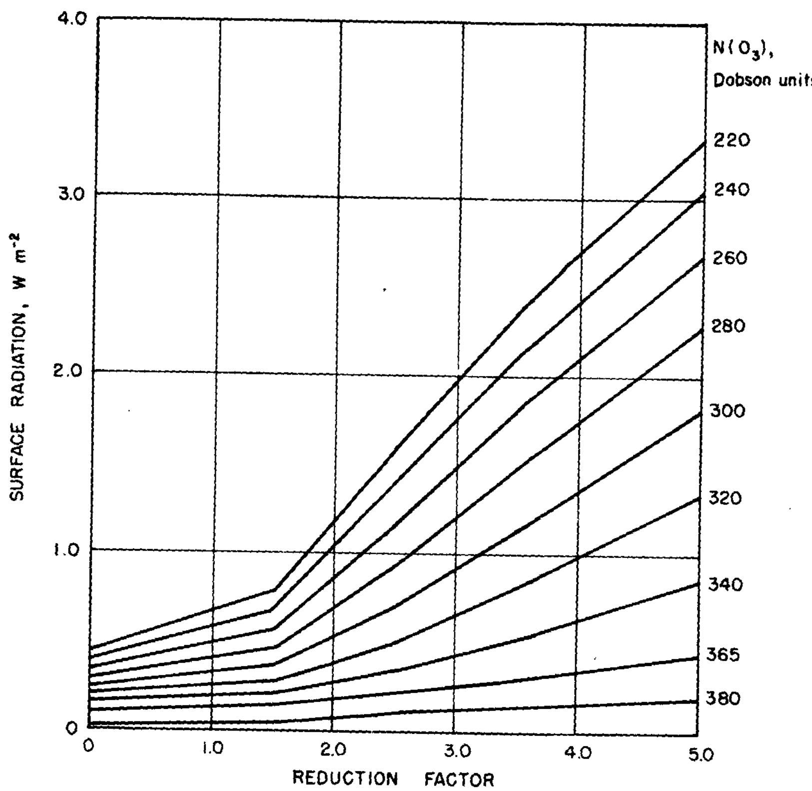

Figure 1–Surface radiation levels for various assumed ozone reductions.

account only the absorption by ozone. The top curve is for the Equator and the successive curves below that are for 10° increments in latitude. The bottom curve represents the increase in flux levels at 80° latitude. Longitude is 0.0°. The ozone amounts are listed to the right of each curve.

For a factor of 2 reduction in ozone, as postulated in a recent paper by Johnson (Ref. 1), these calculations would indicate about, or close to, a threefold increase in radiation levels. This radiation, by the way, is in the biologically significant range from 290 to 300 nm.

As I have said, this graph is an overestimate because it does not take into account the effects of aerosol and molecular scattering. Dr. Hansen has completed calculations of the transmission of the atmosphere at 290 nm, assuming the complete absence of ozone. He finds that even if all the ozone were to be removed from the atmosphere, the transmission of the atmosphere would still be about 30 percent. You would not get the solar constant down on your head if all the ozone were gone because radiation scattering would become of increasing relative importance as the ozone was reduced.

The essence of Hansen's calculation is the multiple scattering of photons by molecules and atmospheric aerosols, and he states that as a result the back-scattering is far greater than if the problem was done as a superposition of single scatterings.

To our knowledge, the effect of scattering in diminishing the ultraviolet intensity has not been fully appreciated in previous studies of this problem.

CHAIRMAN:

Are there any questions for Dr. Stewart?

MEMBER OF THE AUDIENCE:

What is the process in the atmosphere that will reduce ozone? Is there any process that will reconvert molecular oxygen to ozone?

DR. STEWART:

Speculation seems to center about the effect of oxides of nitrogen. That is a catalytic process. You start with nitrogen dioxide and the effect is to destroy odd oxygen. It converts both oxygen and ozone to O_2. So if you put these oxides into the atmosphere, you will destroy ozone and produce O_2. Of course, ozone is created in the first place because there is molecular oxygen in the atmosphere. This dissociates and the atomic oxygen reacts. It is certainly true that if you destroy ozone and get back more oxygen, some of that oxygen is going to produce ozone. We always have a balance between production and loss; but if you take the present equilibrium and put in constituents that rapidly convert oxygen and ozone to molecular oxygen, it seems to me you can only go in that direction. That is, you will shift the equilibrium toward more molecular oxygen and less ozone.

REFERENCE

1. Johnson, Harold: Catalytic Reduction of Stratospheric Ozone by Nitrogen Oxides. UCRL-20568, Univ. of California, 1971.