CHAPTER 1

Introduction

Robert T. Watson, Chair
Ozone Trends Panel

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D. Albritton
J. Barnett
P. Bloomfield
R. Bojkov
R. J. Cicerone
D. Ehhalt
S. Fels
P. Fraser
J. Gille
D. Hartmann
R. Hudson
I. S. A. Isaksen
H. Johnston
M. J. Kurylo
J. Mahlman
J. J. Margitan
M. P. McCormick
M. McFarland
M. McIntyre
G. Megie
M. Prather
H. Rodhe
C. Rodgers
F. S. Rowland
A. Schmeltekopf
M. Schoeberl
R. Stolarski
N. Sundararaman
R. Turco
G. Visconti
S. Wofsy

1.0 INTRODUCTION

1.1 BACKGROUND

For more than a decade, scientists have postulated that manmade pollutants, primarily chlorofluorocarbons and halons, could reduce the amount of stratospheric ozone and hence increase the amount of ultraviolet radiation reaching Earth's surface. Consequently, it is recognized that the ozone layer must be protected in order to protect human health and aquatic and terrestrial ecosystems from damage due to enhanced levels of ultraviolet radiation.

Many governments around the world have now acknowledged that the use of chlorine (chlorofluorocarbons [CFC's])- and bromine (halons)-containing chemicals constitutes a potential threat to the stability of the ozone layer and, hence, to human health and ecosystem productivity. More than 20 nations signed the Vienna Convention for the Protection of the Ozone Layer in Vienna, Austria, in March 1985, and the Montreal Protocol on Substances That Deplete the Ozone Layer, in Montreal, Canada, in September 1987. The Vienna Convention and the Montreal Protocol both call for all regulatory decisions to be based on a scientific understanding of the issues. Thus, timely international scientific assessments are needed as a basis for policy formulation when important new information becomes available, as has occurred since the last major international scientific assessment (WMO, 1986).

In 1985, two important reports of changes in atmospheric ozone were released. The first report was of a large, sudden, and unanticipated decrease in the abundance of springtime Antarctic ozone over the last decade. The second report, based on satellite data, was of large global-scale decreases since 1979 in both the total column content of ozone and in its concentration near 50 km altitude. Data from the ground-based Dobson network also indicated that the total column content of ozone had decreased on a global scale significantly since 1979, although to a lesser extent than suggested by the satellite data. Further, there has been a significant amount of new research focussed on understanding the extent and cause of the depletion of ozone in the springtime over the Antarctic.

In October 1986, the National Aeronautics and Space Administration (NASA), in collaboration with the National Oceanic and Atmospheric Administration (NOAA), the Federal Aviation Administration (FAA), the World Meteorological Organization (WMO), and the United Nations Environment Program (UNEP), formed an Ozone Trends Panel, which involved more than 100 scientists, to study the question of whether carefully re-evaluated ground-based and satellite data would support these findings. This report critically assesses our present knowledge of whether the chemical composition and physical structure of the stratosphere have changed over the last few decades and whether our current understanding of the influence of natural phenomena and human activities is consistent with any observed change. This report is different from most previous national and international scientific reviews in that the published literature was not simply reviewed, but a critical reanalysis and interpretation of nearly all ground-based and satellite data for total column and vertical profiles of ozone was performed. To aid in the interpretation of the results of this reanalysis, a series of theoretical calculations was performed for comparison with the reanalyzed ozone data. In addition, a uniform error analysis was applied to all the data sets reviewed that contained information on the vertical ozone distribution.

The *Report of the International Ozone Trends Panel* covers Spacecraft Instrument Calibration and Stability; Information Content of Ozone Retrieval Algorithms; Trends in Total Column Ozone

Measurements; Trends in Ozone Profile Measurements; Trends in Stratospheric Temperature; Theory and Observations; Trends in Source Gases; Trends in Stratospheric Minor Constituents; Trends in Aerosol Abundances and Distributions; Observations and Theories Related to Antarctic Ozone Changes; and Statistical Approaches to Ozone Trend Detection.

1.2 KEY FINDINGS

1.2.1 Source and Trace Gases

There is undisputed observational evidence that the atmospheric concentrations of source gases important in controlling stratospheric ozone levels (chlorofluorocarbons, halons, methane, nitrous oxide, and carbon dioxide) continue to increase on a global scale because of human activities.

1.2.2 Global Ozone

Calculations using two-dimensional photochemical models predict that increasing atmospheric concentrations of trace gases would have caused a small decrease in ozone globally between 1969 and 1986. Predicted decreases between 30 and 60 degrees latitude in the Northern Hemisphere for this period ranged from 0.5 to 1.0 percent in summer and 0.8 to 2.0 percent in winter, where the range reflects the results from most models.

Analysis of data from ground-based Dobson instruments, after allowing for the effects of natural geophysical variability (solar cycle and the quasi-biennial oscillation [QBO]), shows measurable decreases from 1969 to 1986 in the annual average of total column ozone ranging from 1.7 to 3.0 percent, at latitudes between 30 and 64 degrees in the Northern Hemisphere. The decreases are most pronounced, and ranged from 2.3 to 6.2 percent during the winter months, averaged for December through March, inclusive. Dobson data are not currently adequate to determine total column ozone changes in the Tropics, sub-Tropics, or Southern Hemisphere outside Antarctica.

The model calculations are broadly consistent with the observed changes in column ozone, except that the mean values of the observed decreases at mid- and high latitudes in winter are larger than the mean values of the predicted decreases. The observed changes may be due wholly, or in part, to the increased atmospheric abundance of trace gases, primarily CFC's.

Satellite instruments on Nimbus–7 (Solar Backscatter Ultraviolet [SBUV] and Total Ozone Mapping Spectrometer [TOMS]) have provided continuous global records of total column ozone since October 1978. Unfortunately, they suffer from instrumental degradation of the diffuser plate, the rate of which cannot be uniquely determined. Thus, the data archived as of 1987 cannot be used alone to derive reliable trends in global ozone.

The SBUV and TOMS satellite data have been normalized by comparison with nearly coincident ground-based Dobson measurements in the Northern Hemisphere. The resulting column ozone data, averaged between 53°S and 53°N latitudes, show a decrease of about 2 to 3 percent from October 1978 to October 1985. This period is approximately coincident with the decrease in solar activity from the maximum to the minimum in the sunspot cycle.

Theoretical calculations predict that the total column ozone would decrease from solar maximum to solar minimum by an amount varying between 0.7 and 2 percent depending upon the model assumed for solar ultraviolet variability. Thus, the observed decrease in ozone from the satellite data between late 1978 and late 1985 is predicted to have a significant contribution from the decrease in solar activity during this period.

Theoretical calculations predict that local ozone concentrations near 40 km altitude should have decreased between 1979 and 1985 by 5 to 12 percent in response to the decrease in solar ultraviolet output and the increased atmospheric abundance of trace gases. This range represents the decreases predicted from the different models for the latitude belt 30°N to 60°N for all seasons.

Analyses of satellite (SAGE) and ground-based (Umkehr) data taken since 1979 show small decreases in ozone concentrations; these decreases peak near 40 km altitude with mean values of 3 and 9 percent, respectively. These observational values agree within the range of their errors.

Stratospheric temperatures between 45 and 55 km altitude have decreased globally by about 1.7K since 1979, consistent with decreases in upper stratospheric ozone of less than 10 percent.

Thus, this assessment does not support the previous reports based on SBUV and TOMS data of large global decreases since 1979 in the total column of ozone (about 1 percent per year) or in the ozone concentration near 50 km altitude (about 3 percent per year). These reports used data archived as of 1987, and the trends obtained were erroneously large because of unjustified and incorrect assumptions about the degradation of the diffuser plate common to both the SBUV and TOMS satellite instruments.

1.2.3 Antarctic Ozone

There has been a large, sudden, and unexpected decrease in the abundance of springtime Antarctic ozone over the last decade. Ozone decreases of more than 50 percent in the total column, and 95 percent locally between 15 and 20 km altitude have been observed.

The total column of ozone in the austral spring of 1987 at all latitudes south of 60°S was the lowest since measurements began 30 years ago.

In 1987, a region of low column ozone over Antarctica lasted until late November–early December, which is the longest since the region of low ozone was first detected.

While the column ozone depletion is largest in the Antarctic springtime, ozone appears to have decreased since 1979 by 5 percent or more at all latitudes south of 60°S throughout the year.

The unique meteorology during winter and spring over Antarctica sets up the special conditions of an isolated air mass (polar vortex) with cold temperatures required for the observed perturbed chemical composition.

The weight of evidence strongly indicates that manmade chlorine species are primarily responsible for the observed decrease in ozone within the polar vortex.