Obsevation of the Atmospheric Constituents Related to the Stratospheric Ozone Depletion and the Ultraviolet Radiation

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Abstract

There is a potential threat to the ozone shield for the solar ultraviolet radiation due to anthropogenic emissions of nitrogen oxides and chlorofluoromethanes. Changes in the stratospheric ozone concentration can affect the ultraviolet radiation at the ground and the temperature in the lower stratosphere with corresponding changes in the earth' s weather and climate. The purpose of the present study is to make measurements of the relevant species and the ultraviolet radiation to make clear the effects of anthropogenic emissions on the atmosphere.

Air samples were collected over Japan, and analysed for CF_2Cl_2, $CFCl_3$ and N_2O by a GC -ECD method. Mean mixing ratios in the troposphere were 0.29_4 ppbv for CF_2Cl_2, 0.18_4 ppbv for $CFCl_3$, and 0.32_8 ppmv for N_2O between December 1980 and March 1981. It was also observed that the mean mixing ratios of CF_2Cl_2 and $CFCl_3$ increased by 4% and 14% respectively from October 1978 to March 1981. The mixing ratios of CF_2Cl_2, $CFCl_3$ and N_2O in the stratosphere decreased with increasing altitude in accordance with the photochemical theory.

The atmospheric absorption spectra of CF_2Cl_2, $CFCl_3$, HNO_3, N_2O and CH_4 were observed since October 1979, using the air-borne Fourier transform infrared spectrometer. The measurements of black-body radiation were used to obtain an instrumental calibration function and to correct the spectra. The synthetic spectra were obtained from ray-tracing through the model atmosphere and the line-by-line calculations to compare with the observed spectra.

The mean mixing ratios were 0.280 ppbv for CF_2Cl_2 and 0.183 ppbv for $CFCl_3$ assuming the uniform mixing along the optical path. Assuming the uniform mixing between the altitudes of 18 km and 28 km, the mixing ratio of HNO_3 was estimated to be 9.06 ppbv. The measured transmittances at 2570 $cm^{-1}(N_2O)$ and 6004 $cm^{-1}(CH_4)$ absorption bands were also analysed using the model distributions of N_2O and CH_4.

Aerosol obseravations were made to make clear the role of aerosols for the stratospheric

photochemistry and the mass exchange processes between the stratosphere and the troposphere. Some results concerning the relations between the Mie particles and chlorofluoromethanes in the lower troposphere and the relation between Mie particles and the tropopauses in the upper troposphere were obtained. The aerosol sonde to observe the vertical distribution of Aitken particles was developed and the preliminary profile was obtained.

The spatial distributions of ozone and other constituents were observed around the tropopause gap and the frontal boundaries. The intrusion of the stratospheric air into the troposphere occurred in a thin layer under the jet axis from the cyclonic side to the anticyclonic side of the jet axis. This layer was associated with the high ozone concentration and the low concentration of CF_2Cl_2, $CFCl_3$ and water vapor.

One-dimentional model dealing with the vertical distributions of 34 species in the stratosphere was developed. The mixing ratios of CF_2Cl_2, $CFCl_3$, CH_4, N_2O and water vapor that we observed were used as the lower boundary values. The estimation shows that the total amount of ozone has been decreased by about 0.6% by CF_2Cl_2 and $CFCl_3$, and the maximum decrease (about 6%) of the ozone concentration has occurred at the altitude of 43 km.

The ultraviolet solar radiation in the wavelength region from 300 to 400 nm was measured by using the spectro pyrheliometer and spectro pyranometer. To get the effects of aerosols, the direct, global and diffuse components were measured separately.

The direct component gives the wavelength distribution of the extinction coefficient of the atmosphere. With the aid of the measurements in the visible region using the spectro pyrheliometer and the data of total amount of ozone from the Aerological Observatory, the extinction coefficient was separated into ozone and aerosol component, respectively.

Diffuse component showed a large part of the global ultraviolet solar radiation in the region considered, so the measurement of this component is essential in the problem.