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Spatial and temporal distribution of total ozone over China

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Abstract—In this paper the grid data of total ozone mapping spectrograph (TOMS) installed on Nimbus-7 satellite (1978 to 1994) was used and the spatial and temporal distribution of total ozone over China was analyzed. The research indicates that the Qinghai-Tibet Plateau destroyed the latitudinal distribution of total ozone of China and the low value closed center emerged over Qinghai-Tibet Plateau. Long time change trends of seasonal total ozone of Qinghai-Tibet Plateau are provided. It shows that the most obvious decrease of total ozone occurs in winter (Jan.), then in summer (Jul.), the relevant slow change occurs in autumn (Oct.) and spring (Apr.).

Keywords: total ozone, TOMS, Qinghai-Tibet Plateau.

1 Introduction

Ozone is one of the trace gases in atmosphere. It can absorb nearly all solar ultraviolet radiation (UV-B) ranged from 0.20—0.35 μm. The change of stratospheric ozone concentration and its vertical structure will influence the temperature structure of stratosphere. The decrease of stratospheric ozone concentration will lead to the change of general circulation of atmosphere and global climate. The stratospheric ozone protects livings from harmful impacts of solar ultraviolet radiation such as the suppress of the immune system, the risk of skin cancer and cataract and so on.

The concentration of ozone in troposphere is very low. Being a strong oxidizer, ozone plays an important role in various kinds of atmospheric chemistry progress. At ground-level ozone is a key pollutant. It damages the immune system of animal and humans, the forest and plants(reduce leaf area, shoot length and ability to photosynthesize), the membrane change of cells, protein destruction and hormone inaction. On the other hand, due to its strong absorption belt in infrared window of atmosphere ranged 9.6 μm, ozone is an important greenhouse gas in troposphere.

Due to the cheap price and steady property of Freon (CFCs), it is widely used in industry and commerce. The increase rate of CFC-11, CFC-12 is about 4%—5% per year. The bad influence on ozone shield of Freon and Halons has been realized at the end of the 1970s. It is found that the life time of Freon (e.g. CFC11, CFC12) in atmosphere is about 80 years. It possess a steady chemical feature and does not break down promptly, so it can passes through the troposphere into stratosphere. If we want to restore the ozone level of pre-industry, the only way is to prohibit using the CFCs and the Halon. The CFCs gases will still exist in atmosphere nearly 70 years in spite of action of phased out CFCs by 1996.

2 The spatial and temporal distribution of global total ozone

Based on the grid data of total ozone mapping spectrograph (TOMS) installed on Nimbus-7 satellite, the spatial and temporal distribution of total ozone over China from 1978 to 1994 is analysed. TOMS has 6-spectrum bandings, the wavelength of each spectrum is 312.5nm, 317.5nm, 331.3nm, 339.9nm, 360.0nm and 380.0nm respectively. These spectra have very strong absorption of ozone. Comparing with the ozone absorption, the absorption of other gases can be omitted.

Fig. 1 shows the global distribution of total ozone of 1981(a), 1985(b) and 1991(c). It can be concluded from Fig. 1 that the global distribution of total ozone along longitude is not well distributed. There are three high value centers in north hemisphere that located Northeast Asia, North American and West Europe respectively. The highest center is in Northeast Asia. The lowest is in West Europe. These three high value centers appear every year, but their strength and scope are different each year. The three high value centers of total ozone over north hemisphere correspond with atmospheric wave of 500 hPa westerly belt of north hemisphere. This form of distribution indicates that the general circulation of atmosphere and the feature of land-sea distribution have an important influence on the distribution of total ozone. The latitudinal distribution of total ozone appears mainly in the middle latitude region. Due to the influences of complex terrain, this kind of latitudinal distribution was broken down and the relative low value emerged.

The total ozone increases from the equator to two polar regions gradually. The low value appears in the equator and low-latitude region. With the increase of latitude, the total ozone rises rapidly and gets its maximum value at 60°N, 60°S. In the south hemisphere, the total ozone has a relatively homogeneous distribution because the ocean is wide and the land area is limited. The maximum value appears at 60°S, 100°E. The existence of land also breaks down the homogeneity of its latitudinal distribution. The global distribution of the total ozone changes with time and have a distinct decrease trend. From 1981 to 1991, the intensity and scope of the three high value centers in north hemisphere have decreased dramatically. For example, in Northeast Asia the 400 DU isopleth in 1981 was changed to 380 DU in 1985 and 370 DU in 1991. The scope of 360 DU isopleth in North American reduced dramatically from 1981 to 1991. The same phenomenon appeared in south hemisphere. The 360 DU isopleth of 1981 disappeared. Comparing with 1985 the scope of 340 DU isopleth reduced rapidly. It can be concluded that the reduction of total ozone has emerged globally.

3 The spatial and temporal distribution of total ozone over China

China locates on the edge of Northeast Asia high value center according to the global distribution of total ozone. Due to the existence of Qinghai-Tibet Plateau, the total ozone distribution has its evident characteristic. It is very important to analyse carefully the spatial and temporal distribution of total ozone of China. This is very significant for understanding the regional climatic feature of China.

3.1 The geography distribution of total ozone over China

The distribution of total ozone of China presents latitudinal distribution generally. Due to the influences of terrain and general circulation of atmosphere in Qinghai-Tibet Plateau, the latitudinal distribution has been destroyed and a relatively low value area emerged. The total ozone of east region of China is parallel with latitude. Comparing the total ozone distribution diagram of 1981 (Fig. 2a), 1985 (Fig. 2b), 1991 (Fig. 2c) and 1997 (Fig. 2d), it can be found out that the total

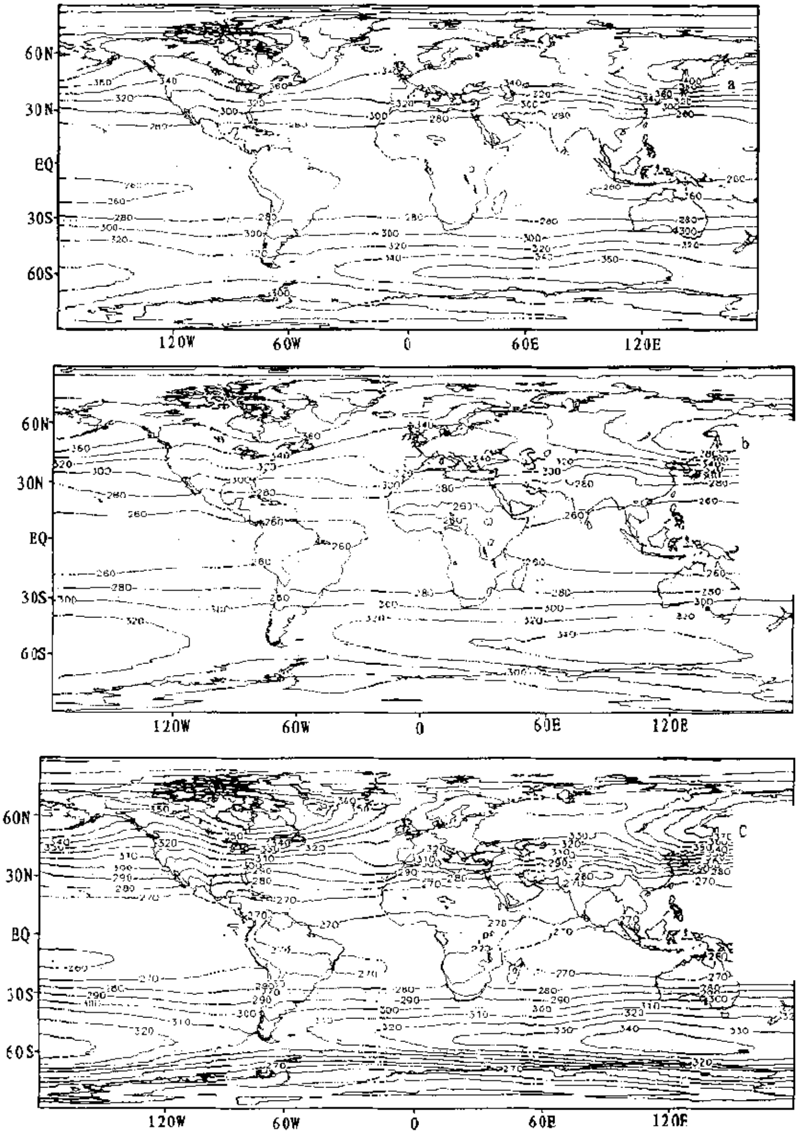

Fig. 1 The global distribution of total ozone of 1981, 1985 and 1991

a. the global distribution of total ozone in 1981;

b. same as a except for 1985;

c. same as a except for 1991 (from TOMS ozone gridded data)

ozone decreases gradually over time. The closed circle of 280 DU in 1981 over Qinghai-Tibet Plateau decreased to 270 DU at the end of 1997. The change ratio reached 3.57%. The most obvious decrease occured in 1985, at that time the 260 DU closed circle appeared in Qinghai-Tibet Plateau.

3.2 Temporal change of total ozone

Two regions are chosen as a typical example of temporal change: a latitudinal(27.5°N—37.5°

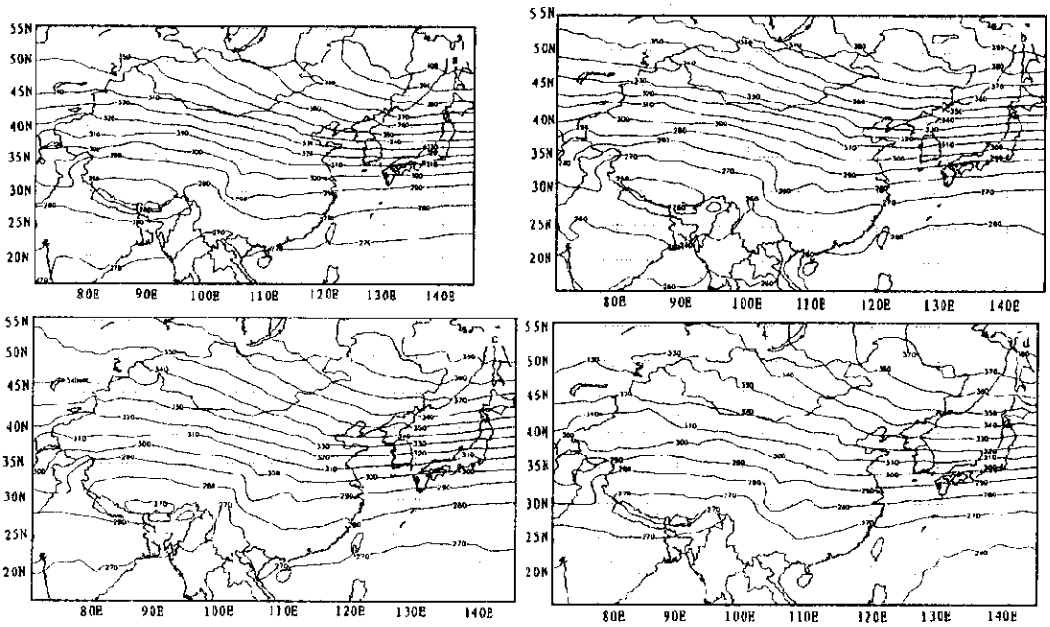

Fig. 2 The geography distribution of total ozone over China in 1981, 1985, 1991 and 1997
a. the geography distribution of total ozone over China in 1981;
b. same as a except for 1985;
c. same as a except for 1991;
d. same as a except for 1997

N and longitudinal (79.375°E—100.625°E) average total ozone.

From the long time change trends of November 1978 to April 1993 of total ozone (Fig.3), both latitudinal and longitudinal averages of total ozone have slow decrease trend. The maximum decrease of latitudinal average appears in 1987 and in 1985 there are a low valley. The longitudinal average varies smoothly and steadily.

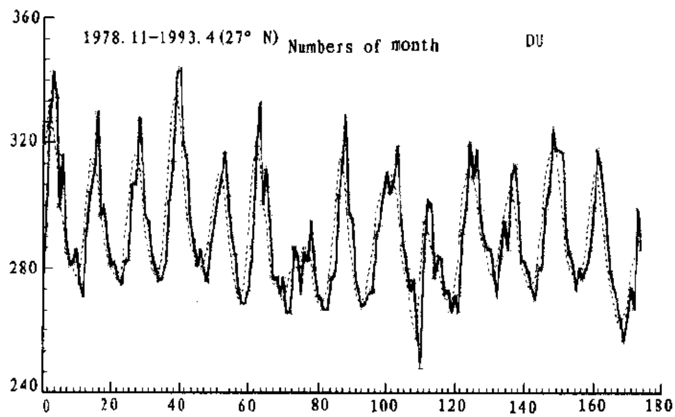

Fig. 3 The long time trend of latitudinal average of total ozone over Qinghai-Tibet Plateau (Dashed denote the 5 point average)

Long time change trends of seasonal total ozone of Qinghai-Tibet Plateau indicates that the most obvious decrease of total ozone occurs in winter (Jan.), then in summer (Jul.), the relevant slow change occurs in autumn (Oct.) and spring (Apr.). It is shown in Fig.4.

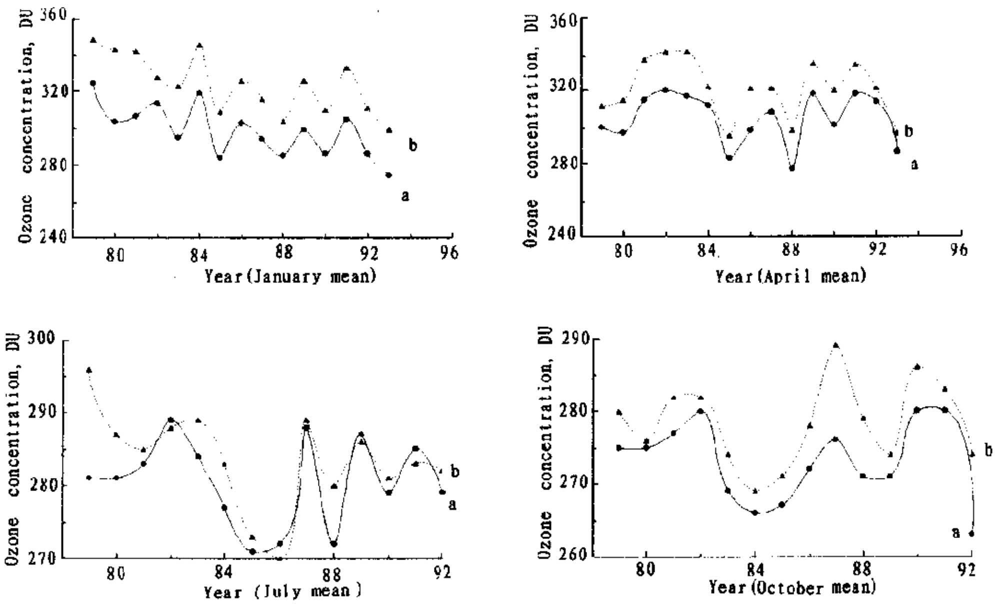

Fig.4 The seasonal trend of latitudinal average of total ozone over Qinghai-Tibet Plateau (curve a denotes the latitudinal average; curve b denotes the longitudinal average)

The stratospheric aerosol and gas experiment Ⅱ (ASGE Ⅱ) is a joint experiment of the National Aeronautics and Space Administration (NASA) with other research institutions. The SAGE Ⅱ instrument has continuously monitored aerosol, ozone, water vapor and nitrogen dioxide in the stratosphere down to troposphere cloud top or surface boundary layer. In vertical direction they're 14 levels i.e. 700 hPa, 500 hPa, 200 hPa, 100 hPa, 70 hPa, 50 hPa, 30 hPa, 10 hPa, 5 hPa, 2 hPa, 1 hPa and 0.4 hPa respectively.

In this paper 8 typical points in China are chosen to use SAGE Ⅱ experimental data describing the vertical profile of ozone and nitrogen dioxide of January and July in 1991. Fig.5 gives the vertical profile of ozone of January in 1991. From the diagram, it can be found out that the vertical profile of total ozone can be divided into 4 phases, i.e. increase, stale, re-increase and decrease. At the beginning the total ozone increases with altitude. In 300 hPa to 150 hPa heights the concentration of ozone maintains constant. Then the ozone concentration increases rapidly to its maximum point (> 6 ppmv) near 55 hPa (about 36 km height). The low layer ozone concentration of 120E exceeds that of other regions of the same latitude. This phenomenon indicates that the human activities have great influences on the total ozone distribution.

4 Conclusions

The main conclusions are as follows:

The stratospheric ozone protects plants and animals from harming by solar (UV-B) ultraviolet radiation. But it is depleted by CFCs and Halon gases; furthermore the ground-level ozone is a key pollutant. Its concentration increases rapidly with increasing use of automobiles. Ozone is one of the important greenhouse gases in troposphere.

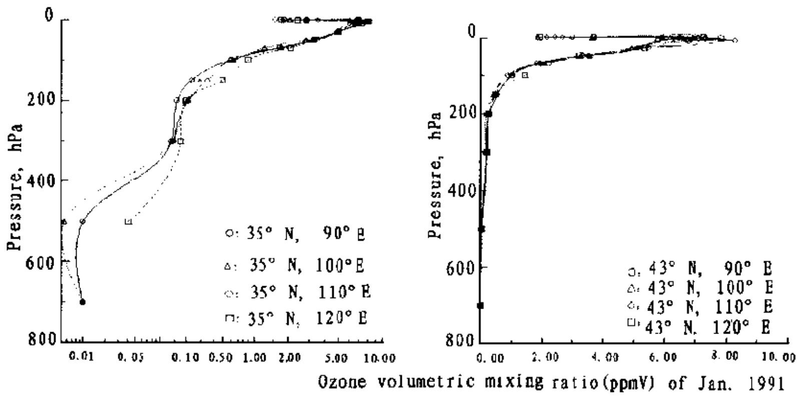

Fig.5 The vertical profile of ozone in January 1991

The emission of Freon is a global problem that few countries can solve it. Chinese government takes ozone protection as a very important task and takes a series of measures to limit the CFCs production.

The reduction of total ozone has emerged globally. With the influences of terrain and general circulation of atmosphere in Qinghai-Tibet Plateau, the latitudinal distribution has been destroyed and a relatively low value area emerged.

The most obvious decrease of total ozone occurs in winter (Jan.), then in summer (Jul.), the relevant slow change occurs in autumn (Oct.) and spring (Apr.).

The vertical profile of total ozone can be divided into 4 phases: increase, stale, re-increase and decrease.

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