Observations of Changing the Wintertime Mid-Latitude Ozonosphere Over Tomsk in 1995-2001

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Introduction

The role of the stratospheric ozone layer as a spectral regulator of ultraviolet (UV) radiative flux entering the troposphere and reaching the underlying surface is now well recognized. Therefore, to simulate the climate and ecological processes adequately, it is important to know and take into account the tendencies observed in the real ozonosphere.

The long-term ozonosphere changes during the last decade have been linked intimately with powerful Pinatubo eruptions on the Philippine Islands in June 1991. It entailed a 4-year depression period and subsequent recovery of stratospheric ozone layer, also observed over Tomsk, West Siberia. Only starting from summer 1995 to present can the state of the ozonosphere be considered "unperturbed" (Zuev et al. 1999). In this paper, some results of ozone monitoring, including wintertime observations in 1995-2001, are presented and discussed.

Optical ozone monitoring is carried out at Siberian Lidar Station (SLS), Tomsk (56.48 N, 85.05 E, and 160 m asl). The measurement complex consists of a stationary differential absorption lidar (DIAL) and filter ozonometer M-124. Lidar measurements of ozone are performed on clear nights, four times per month on average. Total ozone observations are made every day. Stratospheric ozone and total ozone measurements are accurate to within 10 and 3-5 percent, respectively.

Results and Discussion

We have analyzed the lidar sensing data (65 profiles) obtained from February to March between 1995 and 2001. During these months, the maximum ozone content and variability, as well as the negative ozone anomalies such as migrating ozone mini-holes, were generally observed in the midlatitude atmosphere. Following this approach, it is also possible to remove seasonal variations from ozone time series.

Figure 1 shows ozone variations in the stratosphere over Tomsk from February to March of 1995-2001. As seen in 1995, the ozonosphere was still in a depressed state. Higher values of stratospheric aerosol were observed in 1996, 1998, and 1999. From Figure 1 we see that most pronounced interannual ozone changes occurred in 2000 and 2001. In 2000, considerable ozone growth in the middle stratosphere was accompanied by ozone depletion in the lower layers. The situation has changed significantly in 2001, and ozone content in the stratosphere again came close to its mean 1996-1999 level.

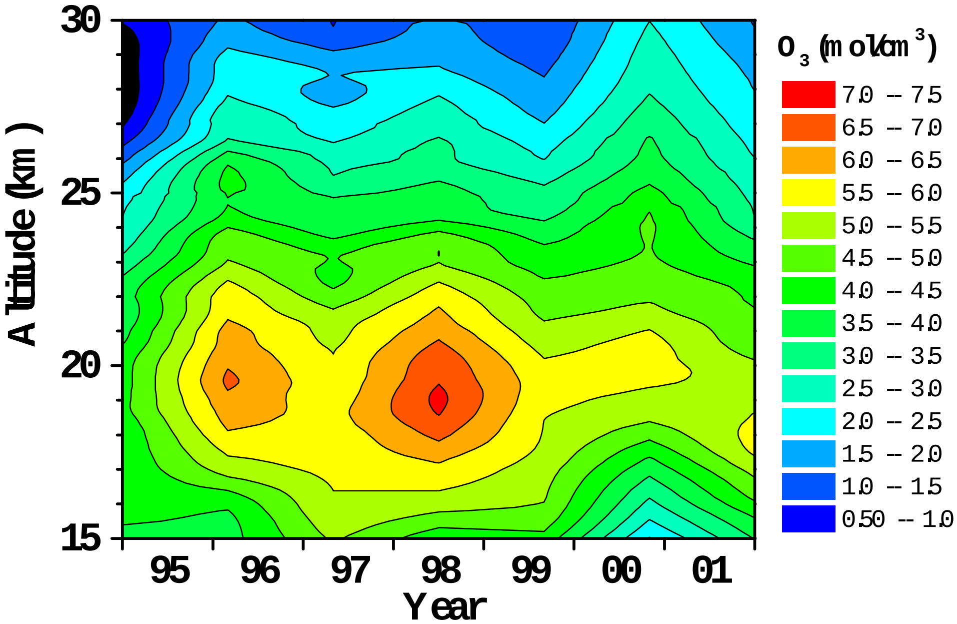

Figure 1. Variations of stratospheric ozone content over Tomsk from February to March of 1995–2001.

Compared with the model curve, the mean ozone profile for Tomsk looks more like that for midlatitudes, but its largest ozone concentrations are in the lower stratosphere. This fact reflects the characteristic local feature of atmospheric circulation, favoring more frequent advection of arctic air in the low latitudes.

As is evident from Figure 1, annual ozone variations are a clear manifestation of the effects of quasi-biennial oscillation (QBO) and El Niño—southern oscillation (ENSO) 1997-1998 event. Generally, the QBO and ENSO effects on ozone are most pronounced in the middle and lower stratosphere, respectively. However, the very powerful ENSO 1997-1998 event, we think, had disturbed the usual QBO cycle. Ultimately, this led to considerable total ozone increases observed in the winters of 1998-1999 (Figure 2).

To estimate possible climate changes of ozonosphere, ozone trend calculations have been made. Using ozone data derived from lidar measurements, we calculated the linear trend of stratospheric ozone changes for February to March of 1995-2001. Figure 3 shows 2-km mean values of ozone trend as a function of altitude. As can be seen in the figure, ozone content tends to decrease in February and increase in March, with low statistical significance in both cases.

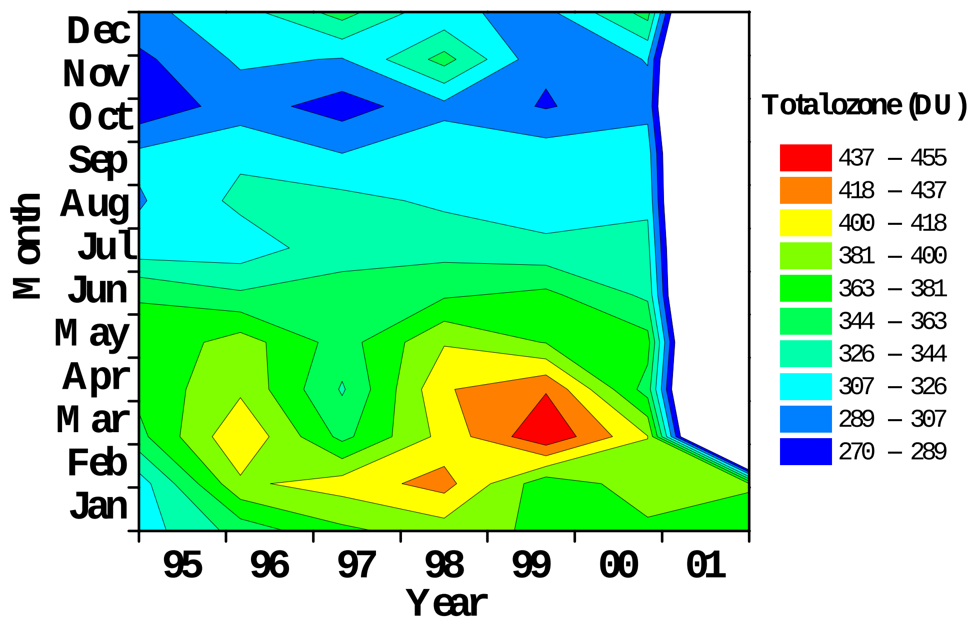

Figure 2. Total ozone monthly means observed at SLS from January 1995 to February 2001.

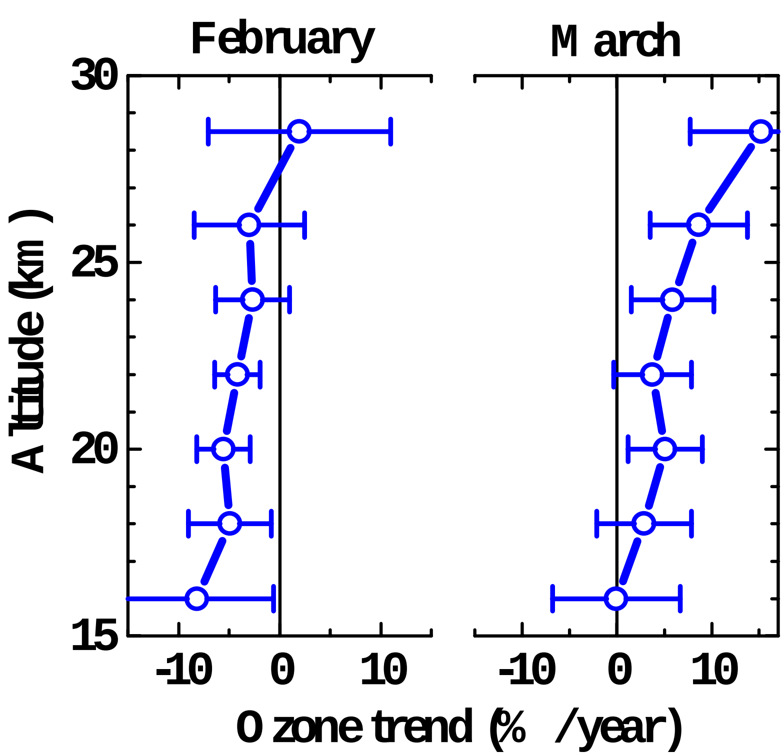

Figure 3. Ozone trends as a function of altitude calculated from measurements at SLS in February and March of 1995-2001.

To calculate the trend of total ozone, we used ozone data inferred from spectrophotometric ground-based measurements at SLS in February and March of 1995-2001. The obtained results are shown in Figure 4. The linear ozone trend is negative (-1.34 ± 1.26% per year) in February and positive (2.91 ± 2.24% per year) in March, again with low statistical significance in both cases.

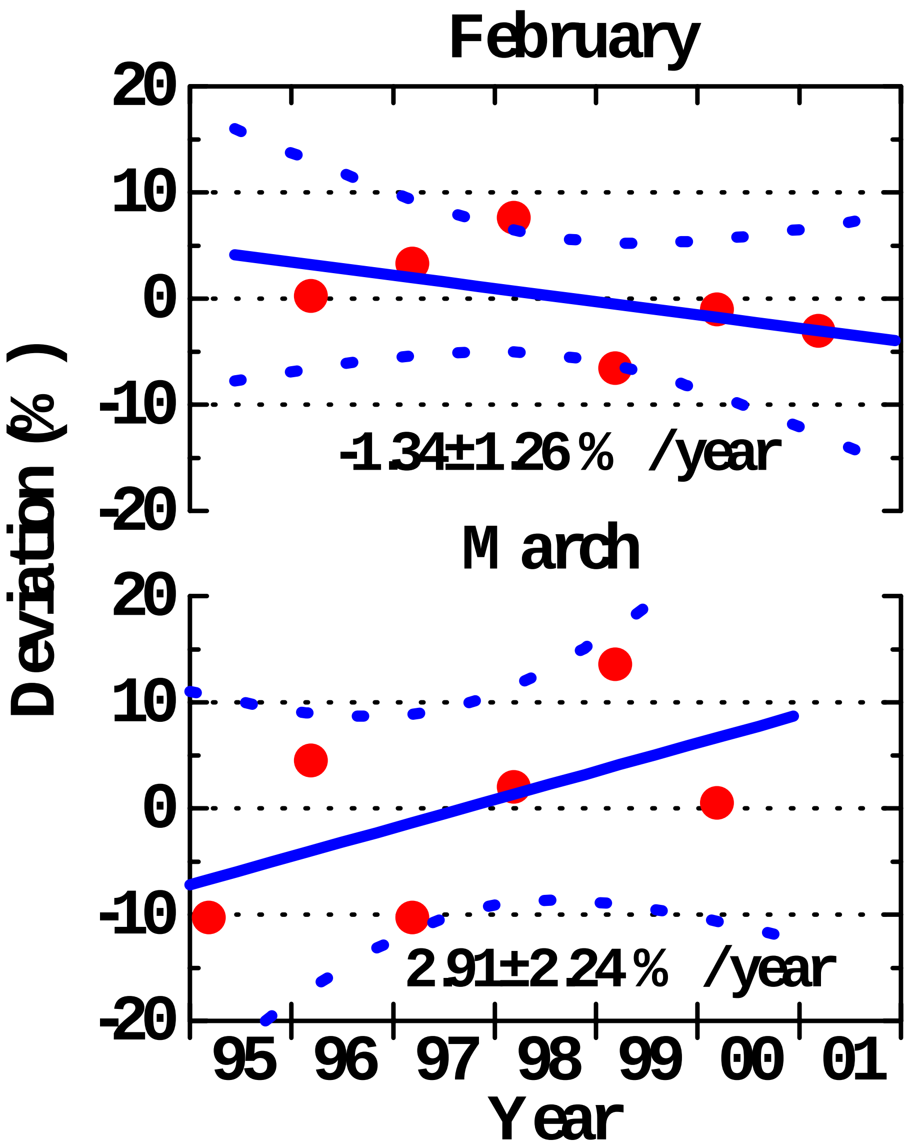

Figure 4. Total ozone trends calculated from measurements at SLS in February and March of 1995-2001. The trends are statistically insignificant at the 95-percent level.

Since the climatic norm of total ozone, like the calculated ozone trends, is larger in March than in February, overall in this winter period we observe a certain, albeit statistically insignificant, ozone growth. Thus, the presumed deceleration of ozone decrease at the frontier of the centuries, first alluded to by Chernikov et al. (2000), seems to really occur.

Conclusion

In February and March 1995-2001 at SLS, lidar, and spectrophotometric measurements of ozone were performed. Statistical analysis has shown that, in the midlatitude ozonosphere over West Siberia, a weak increase of total ozone occurs in March; it decreases in February.

The observations indicate some stabilization of the level of ozone content, also interpretable as the onset of the process of recovery of the Northern Hemisphere midlatitude ozonosphere to the level of the 1960 to 1970s. Seemingly associated changes should also be expected to occur in the radiative processes and in the influence of UV radiation on underlying surfaces.

Acknowledgments

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References

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