Ozone Seasonal Variations simulated with a General Circulation Model

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1. Introduction

Total ozone variations have been studied by using TOMS (total ozone mapping spectrometer) data which gives 14 years of nearly global excellent data. However, TOMS data are not available in polar night regions, and precise global ozone amount variations were hence unable to study. In this preliminary report we studied the seasonal variation of global ozone amount simulated by a general circulation model (GCM) and found semiannual component in it.

2. Research Objective

As reported in the simulation aspect by Graf and Yagai et al., (1995) ozone and its effect on climate are a matter of concern.

There is a possible feedback loop linking polar cooling and ozone depletion. So far the ongoing cooling/depletion is interrupted regularly by the redistribution of stratospheric circulation in the annual cycle. It is uncertain, however, whether a part of the effect of the ozone destruction survives the annual cycle in a way that could increase the ozone depletion in the following year.

The development of a well defined and persistent ozone hole so far has not occurred in the Northern Hemisphere due to the higher variability of the polar winter vortex there. This is due to the more intense planetary wave activity, which in extreme cases leads to a breakdown of the vortex during major stratospheric warmings.

The climate sensitivity to ozone changes is sensitive not only to the column amount but also to the altitude where the changes actually occur. Hence, it is necessary to investigate several scenarios of ozone change profiles. At least the changes in the lower stratosphere and in the upper troposphere must be distinguished.

The circumstances mentioned above is primary relating to the long term trend of ozone. It will take much more effort and need further development of model and observations. This preliminary report is therefore restricted on the annual cycle and its higher modes.

3. Results

Near-global (70°N-70°S) ozone changes by the TOMS data from 1979 to 1993 are analyzed by Callis et al. (1997) which the data is essentially the same as that by Gleason et al. (1993) Figure 1 by Callis et al. shows not only regular annual cycle of near-global of ozone but also the higher mode of semiannual cycles. They did not mention the possibility of semiannual oscillations. The near-global and global ozone are different from each other; if the air mass from the polar regions with small amount of ozone flows out to the high latitude regions, there can be such change of near-global of ozone amount but the global amount is still the same. If we try to eliminate such possibilities we have to use complete global data. Currently this is not possible. Figure 2 is the zonally averaged ozone time series by Gleason et al. (1993). The change of zonally averaged ozone in the southern hemisphere at high latitudes is quite different from that in the northern hemisphere. This indicates the importance of ozone depletion over Antarctic regions.

The model used here is the 12-layer general circulation model of the Meteorological Research Institute (MRI GCM) with the top of 1 hPa. The current model roughly simulates the seasonal variation of zonal mean ozone mixing ratio and regional distribution of ozone in the Northern Hemisphere at winter to spring time when the dynamical effect on ozone distribution dominates. (Yagai, 1996). The current model incorporates simple ozone photochemistry and does not have chlorine-containing compounds. However, the ozone over Antarctica decreases in the model due to dynamical effect with the too cold temperature at lower stratosphere. Such features are seen in Figure 3: the simulated zonally averaged ozone mixing ratio for the month of August. Figure 4 shows the seasonal change of the globally averaged total ozone. The smallest value appears in January and another minimum appears in July which is caused by the too small value over Antarctic region. In this case the total amount of

ozone on the earth still increases due to the insufficient ozone destruction processes near the ground. Therefore the result is a preliminary one. Further studies from the view point of data analyses and GCM simulation are required in this field.

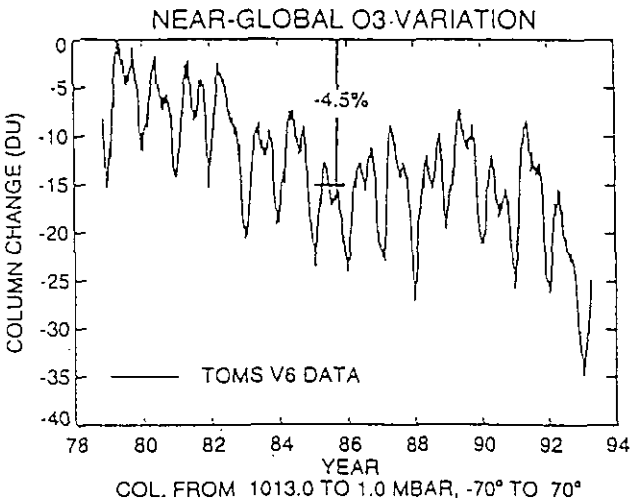


Figure 1: Column ozone change in Dobson units as derived from total ozone mapping spectrometer (TOMS) data averaged from 70°S to 70°N. [Callis et al., 1997]

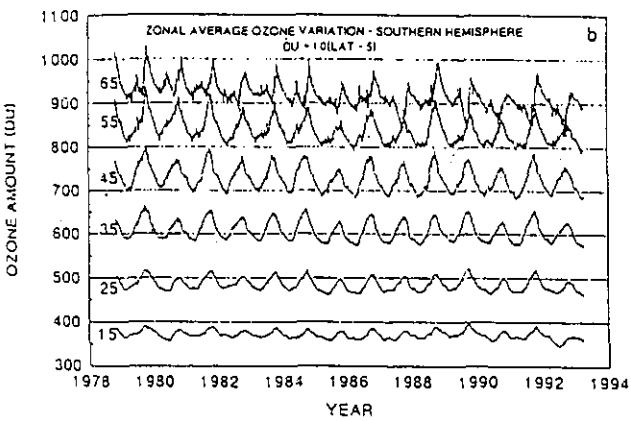
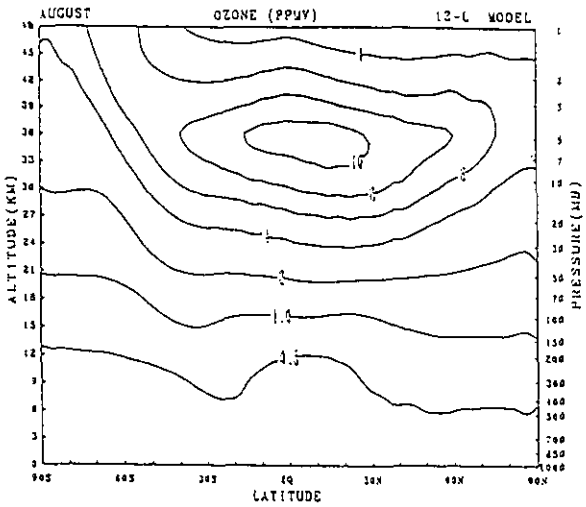
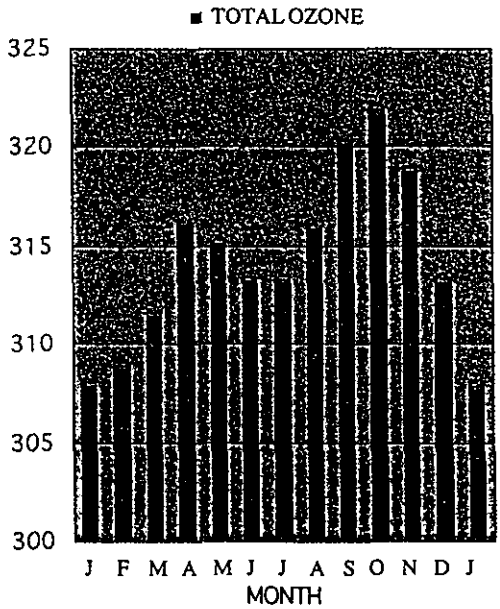


Figure 2: Zonally averaged ozone time series for 10° latitude bands in the southern hemisphere. The ozone data have been shifted vertically to show the ozone variation within each latitude band without overlap. [Gleason et al., 1993].

Figure 3: Zonally and monthly averaged ozone mixing ratio (ppm) in August from the result by the MRI GCM.

Figure 4: Seasonal change of the globally averaged total ozon in Dobson units from the result by the MRI GCM.





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