B-5-3 The study of mass transport between the troposphere and stratosphere

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Abstract Due to the increase of greenhouse gases, the temperature is expected to raise in the troposphere and decrease in the stratosphere. Therefore, it is possible that the global warming will affect the mass transport between the troposphere and stratosphere through modifications to the atmospheric stability.

The perpetual July integration were run with the Meteorological Research Institute (MRI) 12 layer GCM with the $\pm 2°C$ SST (Sea surface temperature) perturbations. The ozone in the stratosphere decreased while the ozone in the troposphere increased in the $+2°C$ SST perturbation experiment.

The time integration with the 15 layer model was completed for 3 years and compared wit the SST anomaly experiment.

Key Words ozone, mass transport, the troposphere and stratosphere ,sea surface temperature, global warming

1. Introduction

Predicting climate change due to an increase in atmospheric carbon dioxide was first studied using simplified one-dimensional models such as radiative-convective models. These models, however, could not represent the horizontal transport of heat, water vapor, ozone and other substances. Therefore, the three-dimensional general circulation developed at the Meteorological research Institute (MRI) is used in this study to asses the influence of the global warming to the transport of ozone.

2. Research Objective

In order to simulate the current distribution of ozone well, we will make improvement of the MRI GCM. Furthermore, we will estimate the effect of global warming to the redistribution of ozone.

3. Research Method

The first is the perpetual July experiment by the 12 layer MRI GCM with the $\pm 2°C$ SST (Sea surface temperature) perturbations. This was time integrated for

90 days and the last 30 days were analyzed. The results with the global sensitivity and surface fluxes are presented by Cess et al. (1991)[1] and Randall et al. (1992)[2].

The second is the seasonal run by the 12 layer GCM which is started from the atmospheric condition at 12Z 15 December 1982. Stratospheric sudden warmings appear in the course of the experiment. The simulated zonal mean ozone mixing ratio are compared with the observation.

We have developed 15 layer version of the MRI GCM by increasing the vertical resolution in the troposphere. The 15 model levels are approximately 1.39, 2.68, 5.18, 10.0, 19.3, 37.3, 72.0,119, 168, 237, 335, 457, 589, 741, 912 hPa, while the 12 layer model has 5 levels in the troposphere corresponding approximately to 150, 300, 500, 700, and 900 hPa. The model was started from 00Z 1 January 1979 and time integrated for 3 years. The distribution of sea surface temperature is prescribed based on climatological data (Climate RUN). In addition we completed another experiment where the zonally uniform SST anomaly was added to the climatological value and the concentration of the carbon dioxide was doubled (Warming RUN).

4. Result

In the perpetual July experiment, the ozone in the stratosphere decreased while the ozone in the troposphere increased in the $+2°C$ SST perturbation experiment. This result is caused by dynamical effects since the zonally integrated photochemical ozone production rates tend to increase ozone in the stratosphere.

In the seasonal run by the 12 layer GCM, stratospheric sudden warmings appear in the course of the experiment. The simulated zonal mean ozone mixing ratio is compared with the observation. The maximum value and the height over the equator is almost coincide with the observation. Simulated ozone in the this experiment increases in the middle stratosphere while it decreases in the upper stratosphere due to the advective process during the sudden warmings.

Figure 1 shows the zonal mean ozone mixing ratio (ppm) in parts per million by mass for January by the 15 layer GCM. The maximum value and its height over the equator is almost coincide with the observation.

5. Discussion

Figure 2(a) shows the difference of ozone mixing ratio for January between Climate RUN and Warming RUN. Figure 2(b) is the same as figure 2(a) but for the ozone photochemical production rate. The ozone decreases in the upper stratosphere at polar night region, while the ozone increases around 60 °N in the upper stratosphere. The change of ozone in this region is caused by the dynamical process, while at lower latitudes in the stratosphere ozone increases by the photochemical process through the change of temperature in this region. These results, however, have to be checked in the analysis of longer period since the model as well as real atmosphere has considerable variation on interannual time scales.

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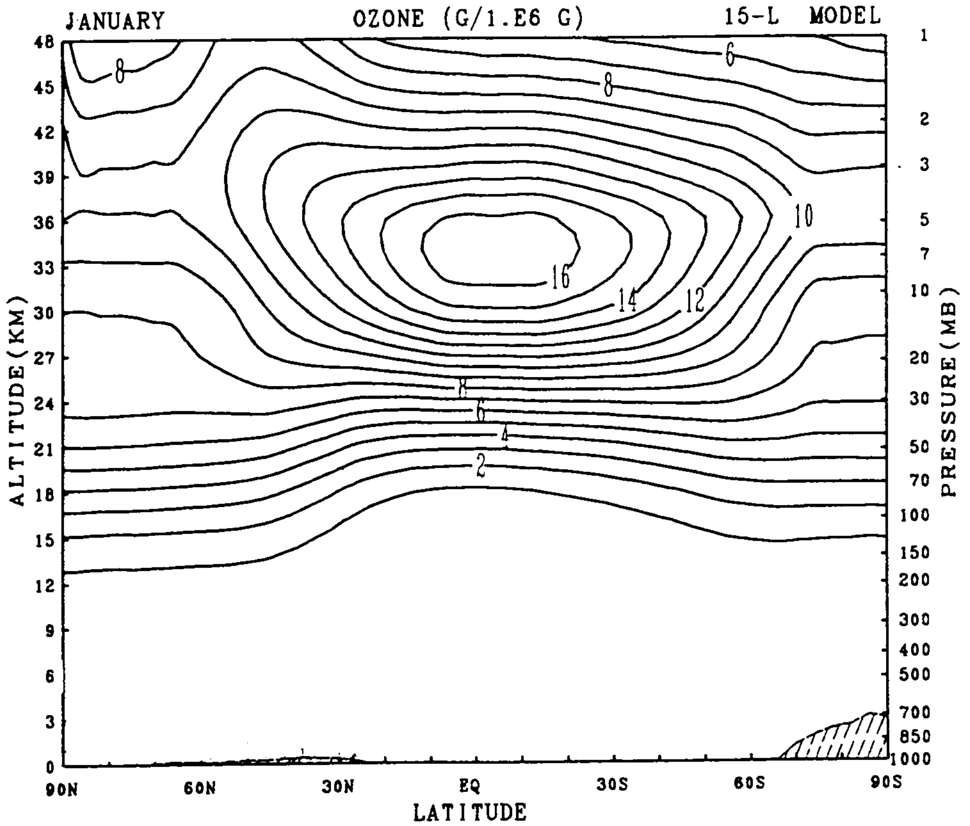
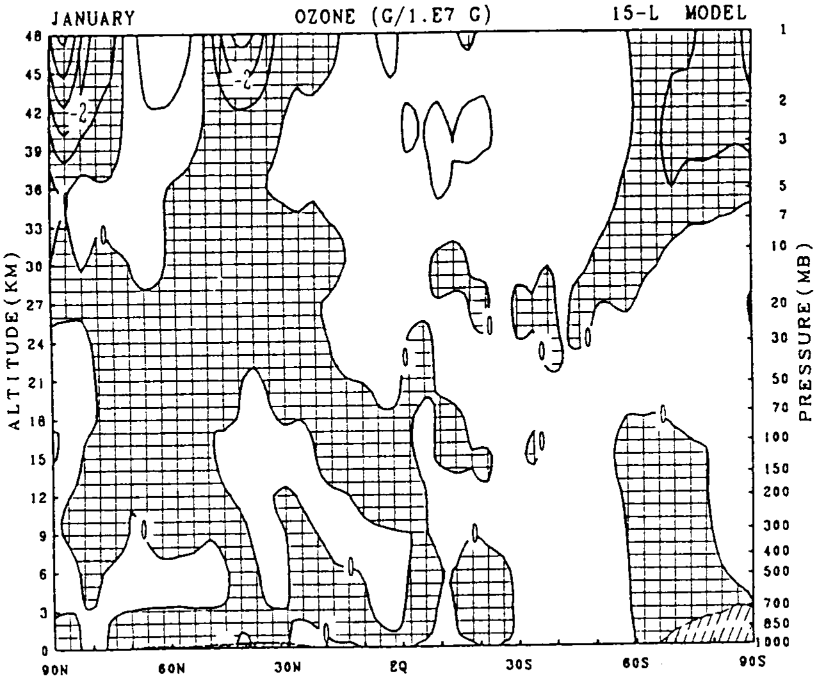


Figure 1: Zonally and monthly averaged ozone mixing ratio (ppm) by the 15 layer MRI GCM (Climate RUN).



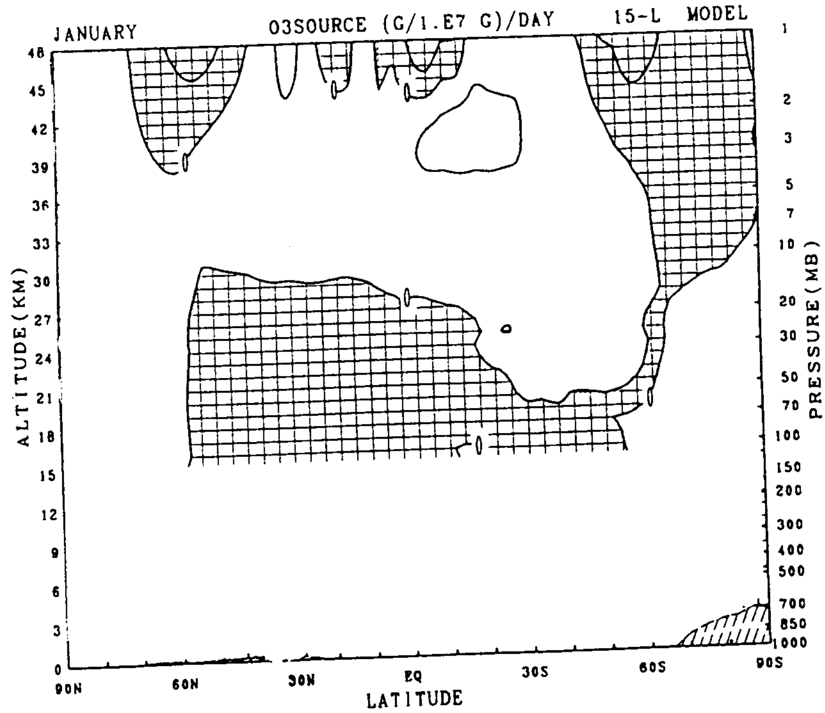


Figure 2(a): The difference of ozone mixing ratio (0.1 ppm) for January, Warming RUN-Climate RUN. Negative values are shaded.

Figure 2(b): The difference of ozone photochemical production rate (0.01 ppm/day) for January, Warming RUN-Climate RUN. Negative values are shaded.