Preliminary Comparison of Climatological Ozone Data Sets

James S. Boyle

Program for Climate Model Diagnosis and Intercomparison
Lawrence Livermore National Laboratory
Livermore, CA USA

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Abstract

This report provides a brief overview of some recently compiled ozone climatologies. The purpose of the comparision is to aid in deciding what ozone data should be recommended for the AMIP II integrations.

The data sets examined are products from efforts at the State University of New York ant Albany (SUNYA) , U. K. Universities Global Atmospheric Modelling Programme (UGAMP) and Free University Berlin / Royal Netherlands Meteorolgical Institute (FUB/KNMI). All these data set are generated from ozonesondes and satellite retrievals from a number of platforms. Each group employed different techniques for merging the data from the disparate sources. The base data are also from different time periods. The tropospheric estimates represent the greatest observational uncertainty.

Compared to an older data set, all the new compilations show the presence of ozone depletion in the austral spring near the South Pole.

1. Introduction

Three ozone data sets have been obtained by PCMDI for the purpose of exploring the various possibilities for an AMIP recommended data set. There appears to be some desire in the modeling community for PCMDI to recommend an ozone data set that describes the climatological seasonal cycle and is representative of the AMIP II period. The three data sets obtained were produced by efforts at State University of New York ant Albany (SUNYA) , U. K. Universities Global Atmospheric Modelling Programme (UGAMP) and Free University Berlin / Royal Netherlands Meteorolgical Institute (FUB/KNMI). For the purposes of comparison, the zonal mean data distributed with the NCAR CCM2 and the initial release of the CCM3 is also included. This latter data is taken to be representative of the older (~1974) data. In the following sections some brief descriptions and comparisons of the data will be presented.

2. SUNYA

The SUNYA data set is described by Wang et al. (1995).

The total column values for these data are based on the TOMS (Total Ozone Mapping Spectrometer) measurements. These are provided as monthly-mean values from November 1978 to January 1992 on a 1.25 x 2, longitude, latitude grid. The missing values at high latitudes during the winter were filled with available ozonesonde observations near the poles. The stratospheric vertical distribution is based on the data from the SAGE II (Stratospheric Aerosol and Gas Experiment) which provides data up to 60 km at 1 km resolution from October 1984 to November 1989. Above 60 km a single mean value at 100 km taken from McClatchey et al. 1992 is used to calculate the mixing ratios assuming a linear relationship between the logarithm of the ozone value and pressure. Troposphere data was taken from Logan(1985) and Spivakovsky et al. (1990), which have values at 1000, 900, 850, 800, 700, 500, 300, 200, 150, and 70 mb at a 10 to 20 degree latitude resolution. Linear interpolation is used to calculate the values between 12 and 17 km. The vertical ozone distribution is shown in Figure 1 for March and October which represent months of the extreme variation at the poles. Figure 5a displays the seasonal cycle of the column integrated, zonal mean for these data.

The SUNYA procedure is to calculate the ozone path length distribution at each radiation step of the model given the current surface pressure, the time dependent climatological vertical distribution and constraining the column integrated values to the TOMS climatology.

3. UGAMP

The UGAMP data set is described in a UGAMP Internal Report, Li and Shine (1995).

These data are a combination of satellite data from SBUV (Solar Backscatter UltraViolet instrument) and SAGE II, and supporting data from ozonesondes and other satellite observations such as SME (Solar Mesosphere Explorer) and TOMS. The SBUV data were available from November 1987 to June 1990. The SAGE II data used is from October 1984 to early 1990. The SBUV was chosen as the main data set for this climatology (at pressures above 70 mb and below 1mb) with SAGE II used as a supplement. A two dimensional (latitude, height) ozone climatology of the troposphere and lower stratosphere based on ozonesonde observations by London and Liu (1992) provided data for the lower atmosphere. Combining the data sets from different instruments, on various satellites is a complex task and the reader is referred to the UGAMP technical report for the details. Also in the report there is a description of the polar night interpolation scheme that was used to fill in the satellite data that is missing during this time. The data obtained from UGAMP was for the period 1985 to 1989. Figure 2 shows the zonally and time averaged ozone distribution for these data for March and October. Figure 5b displays the seasonal cycle of the column integrated, zonal mean for these data.

4. FUB/KNMI

The FUB/KNMI data are not the final version but provide another independent perspective on a difficult analysis. These data are an attempt to merge the CIRA ozone reference model with ozonesonde data to better describe the troposphere and lower stratosphere in a climatological sense. The data procedures are described in Fortuin and Langematz (1994). The improvement of the polar night high latitude representation mentioned in this paper is included in the data set shown here.

The CIRA data was compiled using five satellite instuments, LIMS, SBUV, AE-

2 SAGE, SME-UVS, and SME-IR to define profiles from 20 to 0.003 hPa. The data were for the time period from November 1978 to December 1983. The ozonesonde data set is a compilation of sonde data of the troposphere and lower stratosphere for a wide range of time periods at a number of locations. The time periods covered and length of records vary widely from station to station. The data include times from 1966 to 1993. Fortuin and Langematz (1994) provide a detailed listing of the ozonesonde stations and their observational periods. The sonde stations were grouped into latitudinal bands. The monthly mean ozone values of the stations within each band were added together and weighted by the number of soundings taken during the month. The sonde data are rather inhomogeous in space and time, and effort was made to have the data coincide with the CIRA data. The sonde climatology for surface to 30hPa was coupled to the CIRA profiles for 70 to 0.003 hPa. In the overlap region the climatological values were adjusted towards the more reliable observations, which vary by month and latitude. Figure 3 shows the zonally averaged ozone distribution for these data for March and October. Figure 5c displays the seasonal cycle of the column integrated, zonal mean.

5. CCM2/CCM3 ozone data

For a representative older climatology the two dimensional (latitude, pressure) data provided with the CCM2 (Community Climate Model 2, NCAR) release and the initial release of the CCM3 was selected. These data are derived from values in a climatology compiled by Dutsch (1978). They represent data available up to 1974. Wang et al. (1995) compared these data set to the SUNYA product. Figure 4 shows the zonally averaged ozone distribution for these data for March and October. Figure 5d displays the seasonal cycle of the column integrated, zonal mean.

6. Comparisons

The above sketches of how the various data sets were compiled was not meant to be comprehensive but to give an indication of the number of decisions that need to be made constructing an ozone climatology. Because of this, each effort to construct a climatology will probably follow a different path or use different input data, the resulting data set will be unique. The decision to be made here is the appropriate data set to be used in AMIP II. It appears to be agreed that the column integrated values for the TOMS and SBUV instruments are accurate; the large uncertainty is the distribution in the vertical, especially in the troposphere. There are also differences in the manner of filling the data voids from the solar backscatter instruments during the polar winters.

The four data sets shown here represent means over distinct time periods. The SUNYA data is for 13 years from about 1978 to 1992, the UGAMP data is for the 5 year period from 1985 to 1989. The FUB/KNMI data is nominally for 1978 to 1983. The CCM3 data is representative of the period prior to 1974. Since the ozone distribution has undergone significant changes over the last 15 years, the differences in averaging periods cannot be ignored.

The vertically integrated, seasonal cycle plots, Fig. 5, show that the three contemporary data sets, SUNYA, UGAMP and FUB are in reasonable agreement. These data are also comparable to the CCM3 data, with the strong exception of the South Pole region in the austral fall. The newer data sets are all picking up the existence of the “ozone hole” near the South Pole. The SUNYA seasonal cycle has a gradual depletion of ozone near the South Pole proceding from the austral winter to summer while the FUB/KNMI and UGAMP data indicate a rather more abrupt decrease starting around August. The pressure, latitude sections, Figs. 1 to 3 , exhibit some artifacts apparently caused by the extrapolation of data poleward of 80 degrees.

There is some question as to whether the longitudinal variations are known well enough to recommend a data set that is zonally varying for use in AMIP II. For the upper levels, the combination of the satellite data probably can force a reasonable variation. In the troposphere, the ozonesonde data is so sparse as to seriously question the representativeness of the resulting fields.

7. References

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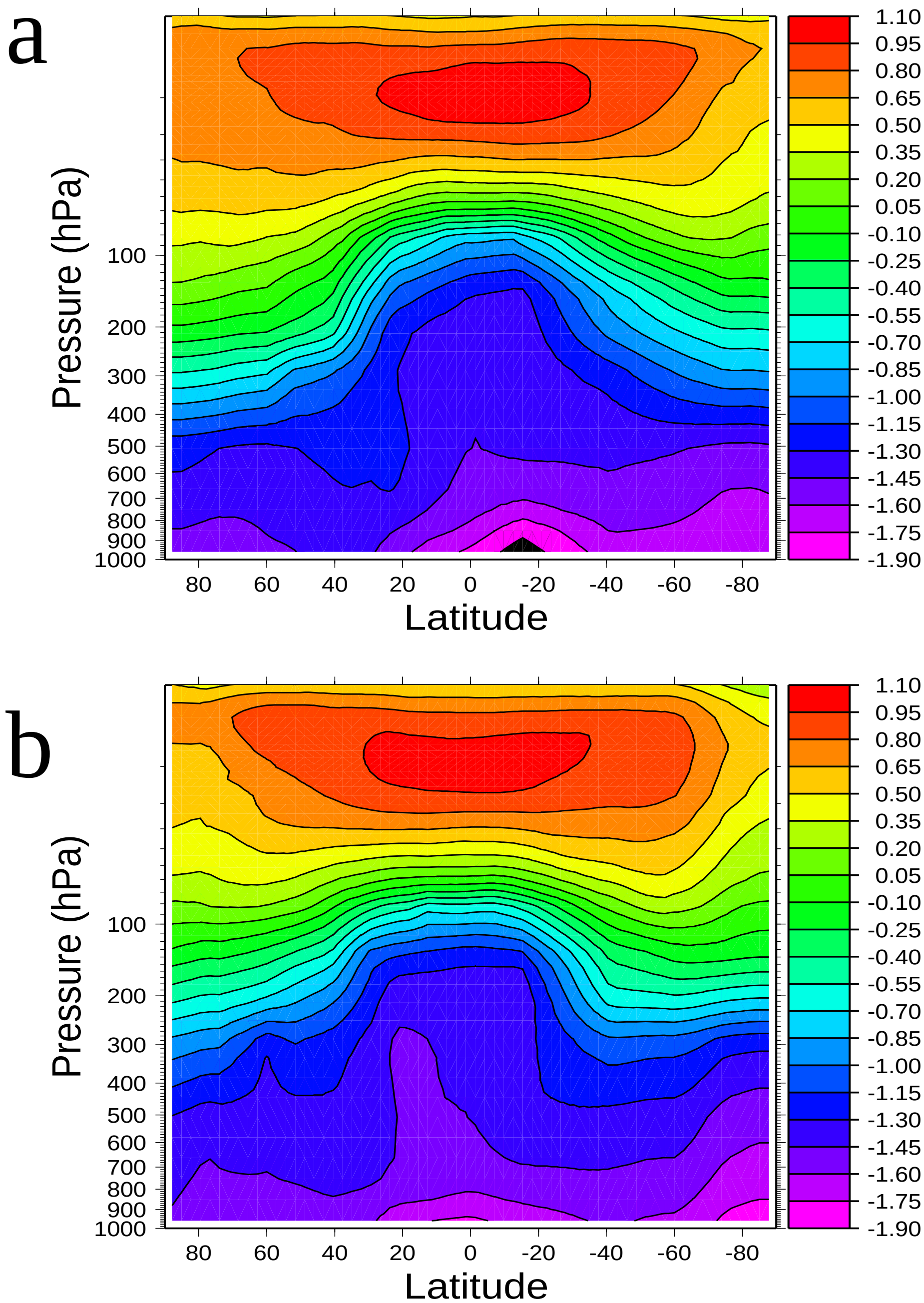

Figure 1. (a) A latitude pressure cross-section of the ozone distribution for the SUNYA data set for March. In order to be able to present the entire depth of the atmosphere on a single diagram the logarithm (base 10) is taken of the original data that was in units of parts per million by volume(ppmv). It is this log data that is plotted on the figure.
(b) As in (a) except for October.

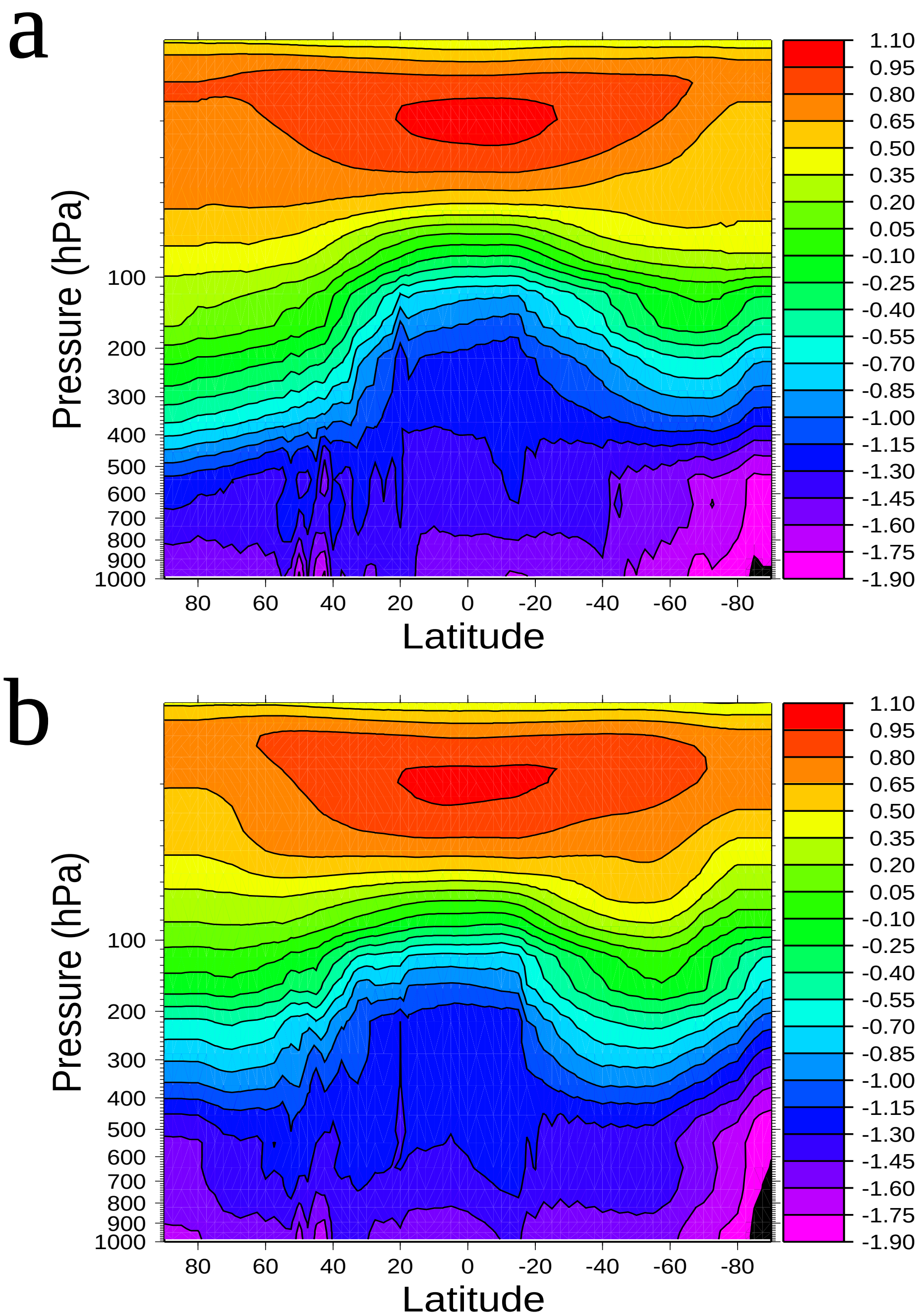

Figure 2. (a) A latitude pressure cross-section of the ozone distribution for the UGAMP data set for March. In order to be able to present the entire depth of the atmosphere on a single diagram the logarithm (base 10) is taken of the original data that was in units of parts per million by volume(ppmv). It is this log data that is plotted on the figure.
(b) As in (a) except for October.

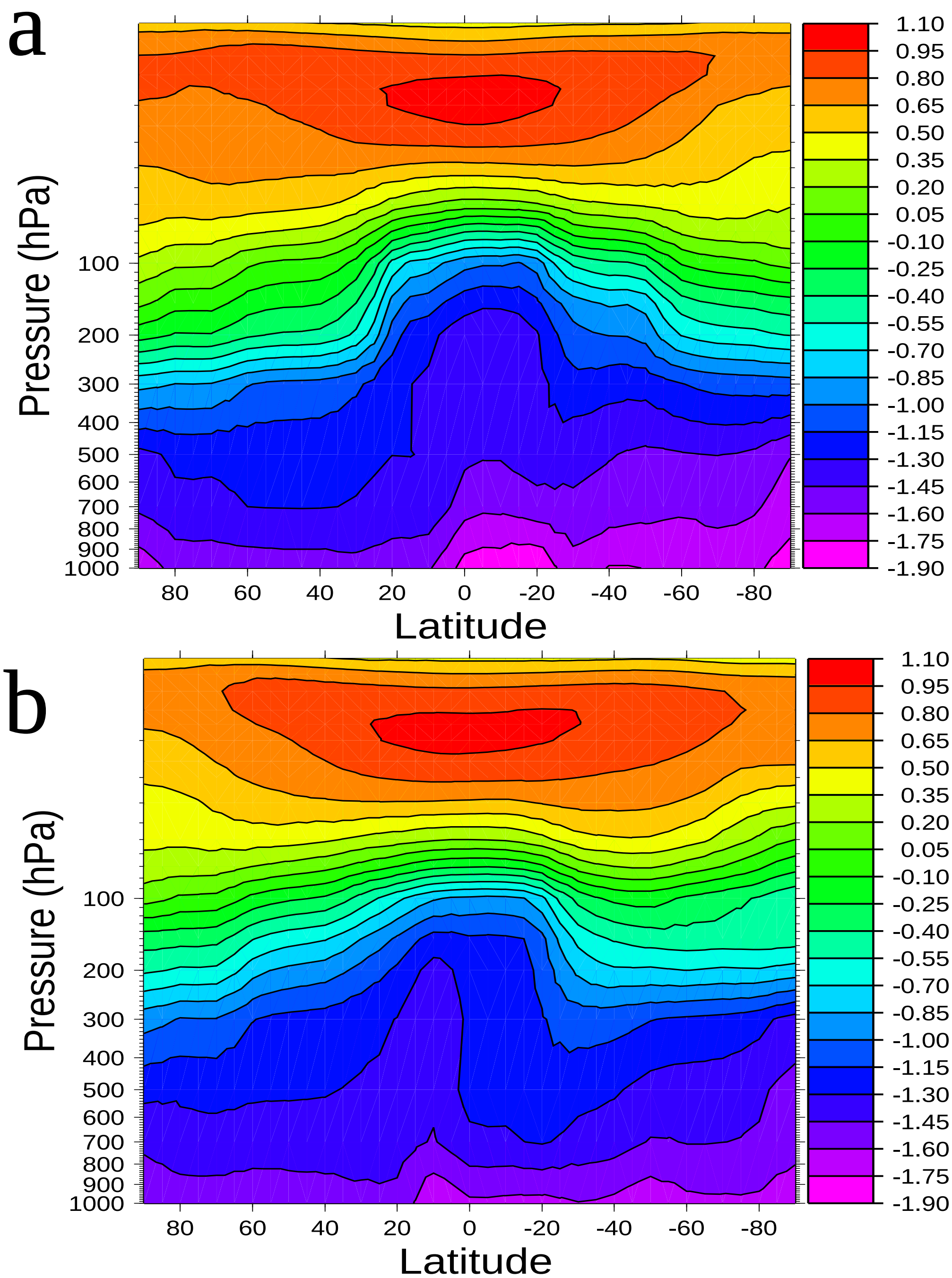

Figure 3. (a) A latitude pressure cross-section of the ozone distribution for the FUB data set for March. In order to be able to present the entire depth of the atmosphere on a single diagram the log-arithm (base 10) is taken of the original data that was in units of parts per million by volume(ppmv). It is this log data that is plotted on the figure.
(b) As in (a) except for October.

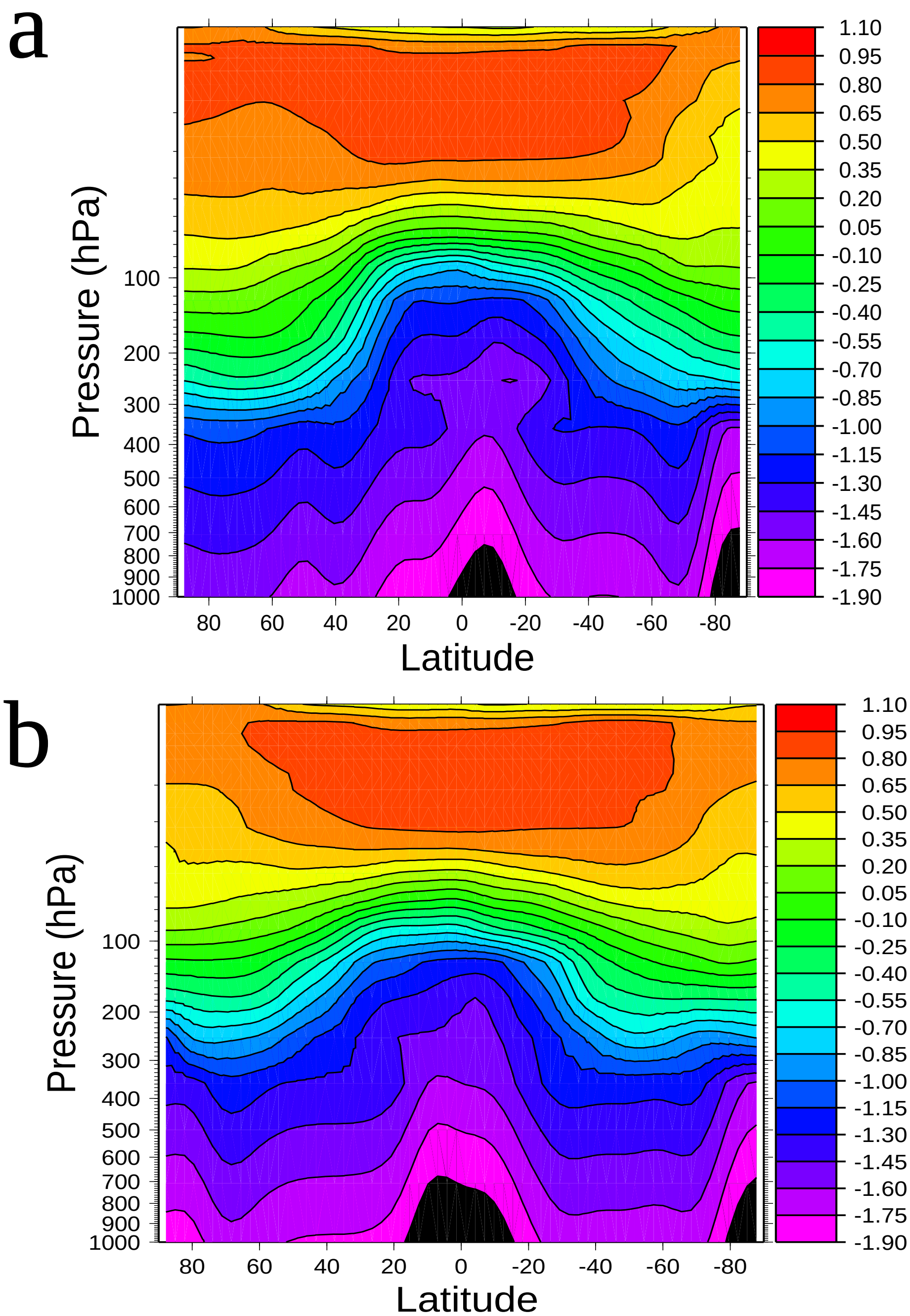

Figure 4. (a) A latitude pressure cross-section of the ozone distribution for the CCM3 data set for March. In order to be able to present the entire depth of the atmosphere on a single diagram the logarithm (base 10) is taken of the original data that was in units of parts per million by volume(ppmv). It is this log data that is plotted on the figure.
(b) As in (a) except for October.

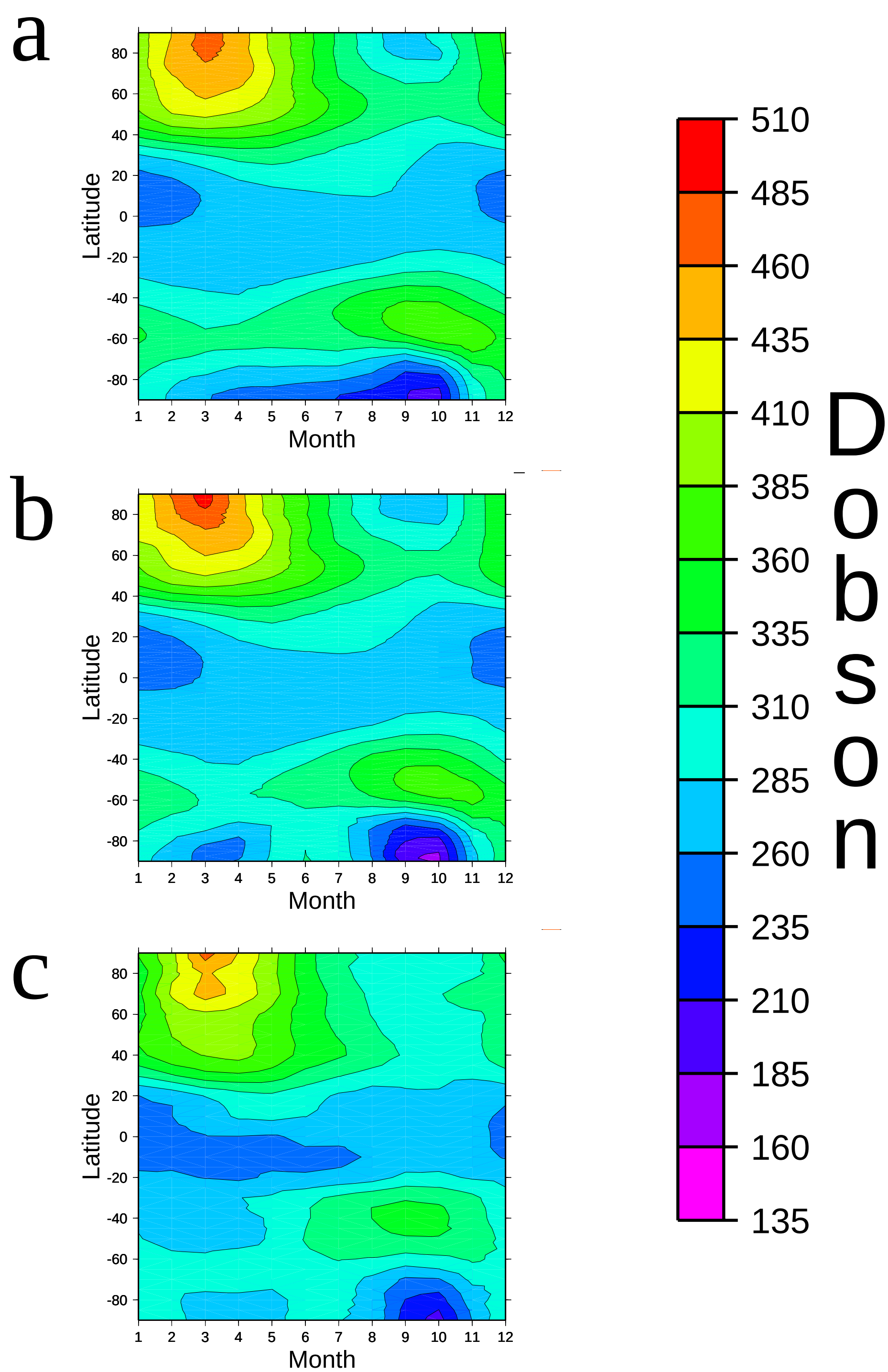

Figure 5. Zonally averaged, column integrated seasonal cycle of the (a) SUNYA, (b) UGAMP, and (c) FUB/KNMI ozone data sets. The units are in Dobson units. The months run from 1 = January, to - 12 = December..

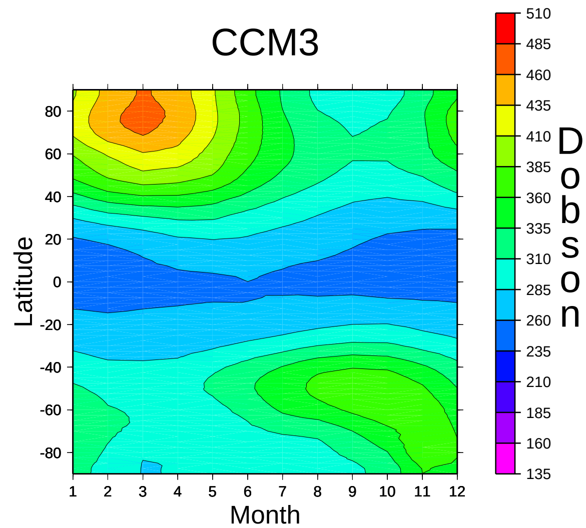

Figure 5. (d) Zonally averaged, column integrated seasonal cycle of the CCM3 ozone data set. The units are in Dobson units. The months run from 1 = January, to 12 = December