Inter-annual variability of total ozone deduced from GOME and its relation to observed El Nino of 1997–1998

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The Global Ozone Monitoring Experiment (GOME), a passive imaging spectrometer on-board ERS-2 satellite was launched in July 1995. This sensor measures the radiances in the visible and ultraviolet range. From the measured radiances the total ozone concentrations have been deduced globally. The total ozone concentrations over the Indian sub-continent have been extracted for the period 1996–1999 from the global data set. The overall trend of the monthly mean column ozone over Indian sub-continent is found to be decreasing for the latitude range 28°N–42°N while for the latitude range 6°N–26°N it is more or less the same. The small yearly data set affirms the decreasing trend that has been reported by earlier workers in the northern mid to high latitudes. Further, our detailed analysis shows the effect of the El Nino during 1997–1998 in the total ozone concentrations.

DUE to increasing urbanization and industrialization the chemical composition of the atmosphere is changing on a global scale. In the changing scenario, ozone plays a central role in tropospheric and stratospheric chemistry. The global trend in total ozone column is found to decline[1–3] at the mid latitudes of the Northern Hemisphere during the late winter since 1978. Efforts have been made to find out the extent and type of effect due to climatic phenomena such as El Nino and Southern Oscillations[4]. In this article, we have studied the annual variability of total ozone concentration and the possible effects of El Nino over the Indian sub-continent.

The Global Ozone Monitoring Experiment (GOME) measures the back-scattered earth radiance and solar irradiance in UV/visible wavelength (237 nm to 794 nm) with a spectral resolution of 0.17–33 nm. The spectrum is split into four spectral channels, each recorded by a photodiode array. The total ground coverage is obtained within 3 days at the equator by a 960 km across track swath (4.5 sec forward scan, 1.5 sec back scan) with a ground resolution of 40 × 320 km^2.

In the present study we have used four years of GOME data (January 1996–October 1999) of the Indian sub-continent which have been extracted from the global data set. For the present study, two latitude ranges (lower latitude 6°N–26°N and mid latitude 28°N–42°N) have been considered over the Indian sub-continent and the monthly mean ozone concentrations have been deduced from the

daily measurements. Time series plots for the two latitude ranges are shown with a linear regression model (Figure 1).

Figure 1 *a* shows variations of total ozone column for the middle latitudes (28°N–42°N) during 1996–99. The high values are seen during winter (January–March) over the Northern Hemisphere with the highest value reached around February–March of each year. This is seen to decrease with the start of spring and reach a minimum value during June and July of every year. The overall trend is found to be decreasing which is similar to the declining trend[2–3] found over the middle latitudes of the
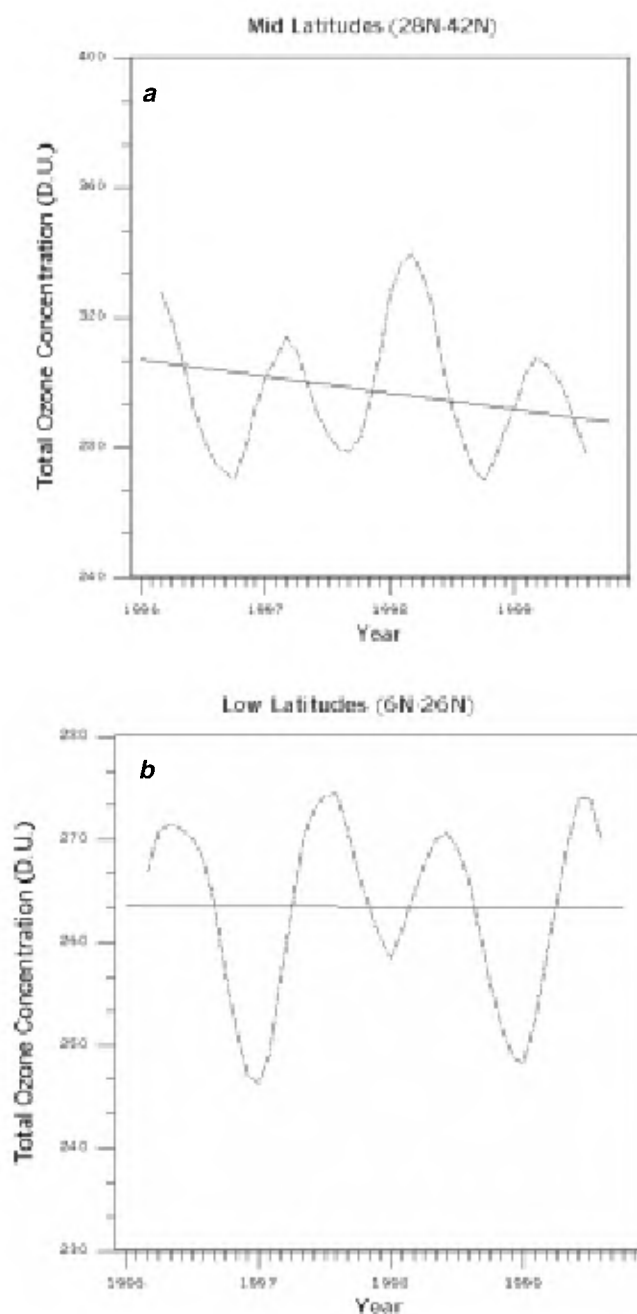

Figure 1. Variations of total ozone during 1996–99 for *a*, middle latitudes (28°N–42°N); and *b*, lower latitudes (6°N–26°N).

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entire Northern Hemisphere. However, the declining trend may be due to meridional mixing of chemically disturbed air from the Arctic polar vortex because of cooler springs in the present decade[5]. A similar time series plot for the lower latitude zone (Figure 1 b) produces no appreciable trend. Chakrabarty et al.[6] using six ground stations measured the ozone data for a longer period. They recently found an increasing trend for four stations, Kodaikanal, Ahmedabad, New Delhi and Srinagar, a decreasing trend for the Varanasi station and no trend for the Pune station. These stations are mostly located over the lower latitudes (6°N–26°N) with the exception of Srinagar and New Delhi and thus may not reflect the decreasing trend, which is more pronounced in the middle to higher latitudes. Incidentally, Kundu et al.[7] have found a negative trend in Srinagar (– 0.260 ± 0.032% per year). Moreover, Chakrabarty et al.[6] have worked with a very large data set, for

the period of 1951 to 1996, due to which the decreasing trend over the recent years may have been overshadowed by the larger increasing trend for the previous years.

The seasonal variations during winter and summer seasons are shown during 1996–1999 for the two latitude zones (Figure 2). The seasonal variations for mid (Figure 2 a) and low latitude zones (Figure 2 b) show contrasting trend. In the mid latitudes, the total ozone concentration for winter is found to show continuously higher values compared to summer while in the lower latitude zones the ozone concentration is higher during summer compared to winter. This agrees well with earlier observations[1–3,6], which is likely due to the change in intensity of the planetary waves from winter to summer.

The monthly variations for each year (1996–1998) over the Indian sub-continent (Figure 3 a–d) show most of the abrupt fluctuations towards the middle latitude. Such fluctuations reduce towards the equator. Further, a close analysis of Figures 1 a and 3 a–d shows a peak of total ozone during 1998. In Figure 1 a much higher peak is seen, centred during March 1998, whereas the monthly mean ozone value exceeds the four years average by 10%. Figure 3 a–d supports this and reveals an overall higher anomalous pattern during December 1997 and June 1998 (Figures 3 b–c). The mean total ozone value for this period (January 1998–June 1998) is 9.6% higher than the mean of a similar period taken over four years.

The total ozone concentration for the winter of 1998 (Figure 2 a) shows higher values compared to the winter of 1996–1997 and 1999, an anomaly against the trend set by the gradual decrease from 1996 to 1997 and from 1997 to 1999. This anomalous increase in the total ozone concentration for the period from January 1998 to April, June 1998 though not very prominent, is still manifested in the low latitude zone as shown in Figures 1 b and 2 b. The fluctuation from winter to summer is less in 1998 compared to that during 1997 and 1999 owing to less significant decrease in the winter of 1998.

The extent of this jump in total ozone can be seen in Figure 4 which shows the distribution of ozone concentrations in Dobson Unit during 1996–1999 for the month of March. A comparative study of the figures reveals a general downward shift in March 1998, of the higher total ozone concentration bands, towards lower latitudes over the Indian sub-continent. The bands are also seen to be more closely spaced with a greater gradient towards the middle to high latitudes over the Indian sub-continent. A similar behaviour is also seen for the months of January and February 1998 (not shown).

The migration of column ozone bands coincides with a warmer than normal temperature over the Indian sub-continent for January to March 1998. The January to July 1998 mean temperature for the Indian sub-continent is found to be 1–3°C higher[8] compared to January to July 1997. This fits well with the observed higher global surface temperature data for January to March 1998.
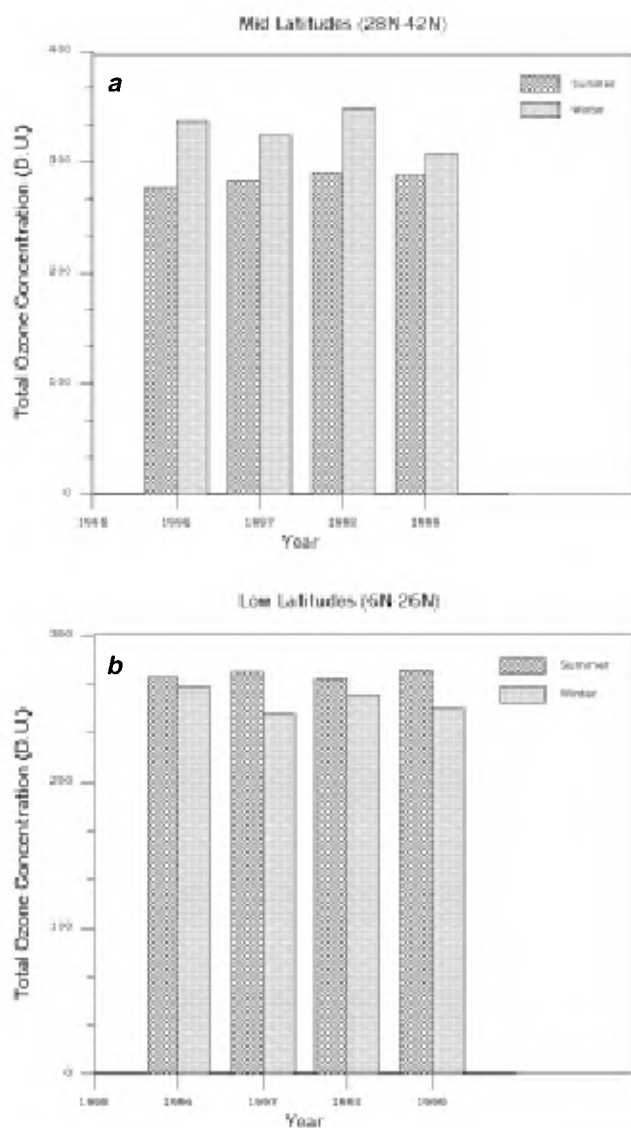

Figure 2. Seasonal variations during 1996–1999 for *a*, middle latitudes (28°N–42°N); and *b*, lower latitudes (6°N–26°N).
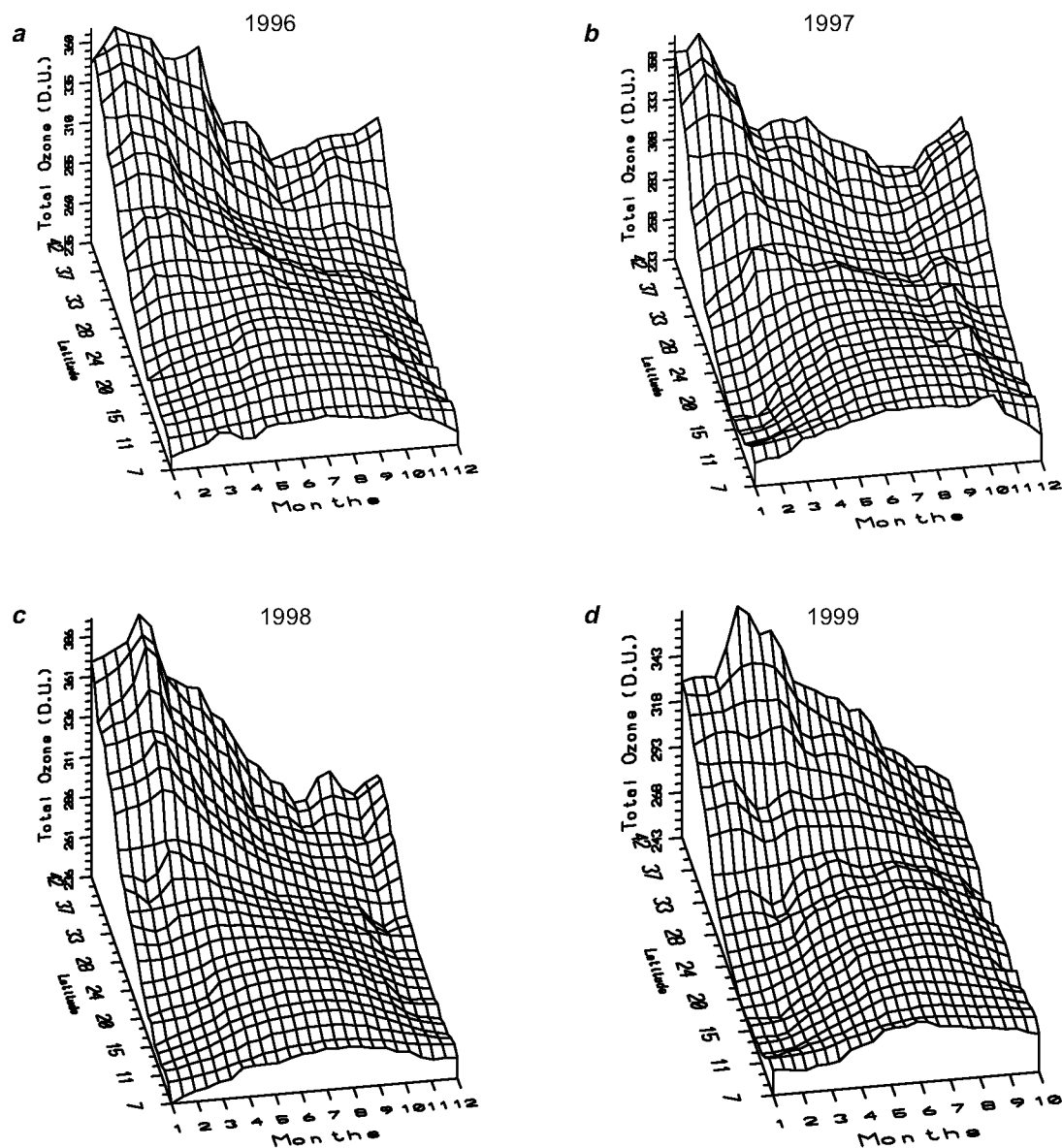
Figure 3. Surfaces showing monthly variations of total ozone concentration for *a*, 1996; *b*, 1997; *c*, 1998; and *d*, 1999 at location 78.3°E.
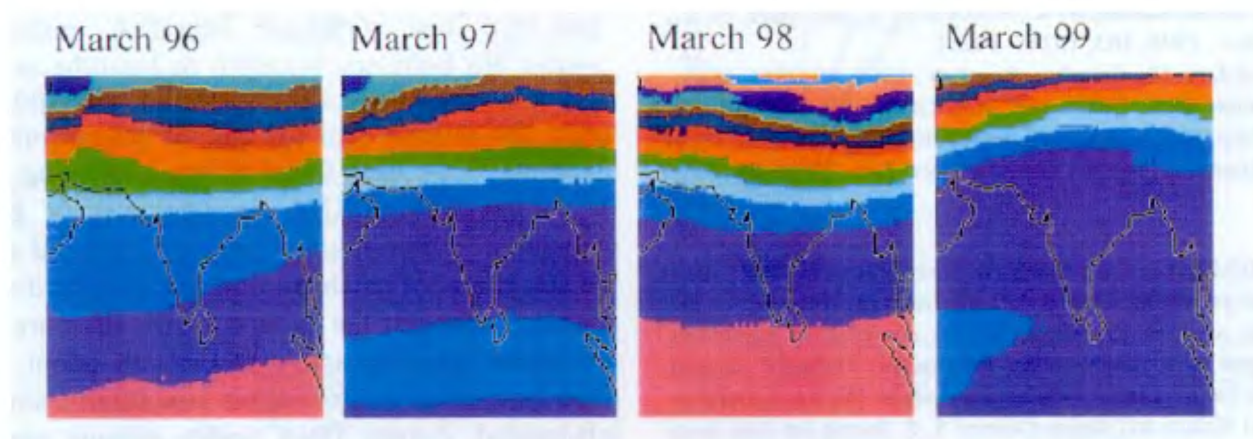

Figure 4. Yearly (1996–1999) distribution of ozone concentration over the Indian sub-continent for the month of March.

The sea-surface temperature (SST) over equatorial Indian ocean has also been found higher during the first few months of 1998. By March 1998, nearly the entire Indian ocean shows considerably warmer SST than normal[9]. This is largely due to the strong El Nino[9] event of 1997–1998. At the same time in the higher latitudes beyond the Indian sub-continent, during January and July 1998 the mean temperature is found to be 1–4°C lower[8] than that observed during January and July 1997. Hence, we infer that cooler higher latitudes along with warmer lower, lower–middle latitudes may have resulted in a more pronounced temperature gradient. This in turn may have led to modulation of Hadley cell and stronger stratospheric transfer of ozone (Brewer Dobson circulation) from lower to higher latitudes. Thus the observed shift in the total column ozone bands over the Indian sub-continent may be attributed to the temperature anomaly caused by the strong El Nino of 1997–98.

Note added in proof:

The total ozone concentration deduced from GOME shows a negative trend for mid latitudes, however, the trend is positive for almost all the Indian stations which is confirmed by TOMS satellite and total ozone ground data observed at Indian stations (data available from IMD, Pune). This ruled out any health hazard at least on the Indian continent. The latest findings will be communicated soon.

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Interaction of sanguinarine with A-form and protonated form of ribonucleic acid structures: Spectroscopic, viscometric and thermodynamic studies

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The interaction of sanguinarine with the A-form and the protonated form of poly(rG).poly(rC) has been investigated using a combination of spectrophotometric, spectrofluorimetric, circular dichroic (CD), viscometric and thermodynamic studies. The formation of the two forms of this structure has been confirmed from UV-absorption and CD spectral characteristics. The binding of sanguinarine to both the A-form and the protonated form RNA structures is characterized by the typical hypochromic and bathochromic effects in the absorption spectrum, quenching of fluorescence intensity, decrease in fluorescence quantum yield of the alkaloid, an increase in fluorescence polarization anisotropy and perturbation in the CD spectrum. Scatchard plots obtained from spectrophotometric and spectrofluorimetric analyses show that sanguinarine binds to both the structures in a non-cooperative manner. The binding parameters, according to an excluded site model, indicate a relatively high affinity of the alkaloid binding to the A-form structure than to the protonated form structure. Viscometric studies demonstrate that there is no increase in the contour length of the sonicated A-form and the protonated form RNA structures upon binding to sanguinarine. Thermodynamic parameters as revealed from van't Hoff plot indicate that the RNA binding of the alkaloid is an exothermic process and it binds more tightly to the protonated form than the A-form structure. The intermolecular interaction of sanguinarine is characterized by negative enthalpy changes and positive entropy changes at the binding site of the two structures.

IN the course of our studies on the DNA polymorphism under the influence of pH and its interaction with plant alkaloids[1–4], we have found a very interesting characteristic of the A-form RNA homopolymer of guanine and cytosine in buffer solution under various pH values from the standpoint of its absorption and circular dichroic (CD) spectra. Although the A-form RNA structure containing alternating guanine and cytosine can adopt left-handed double-stranded conformation structurally similar to the left-handed Z-form DNA under various environmental conditions[5,6], not much information is known about the