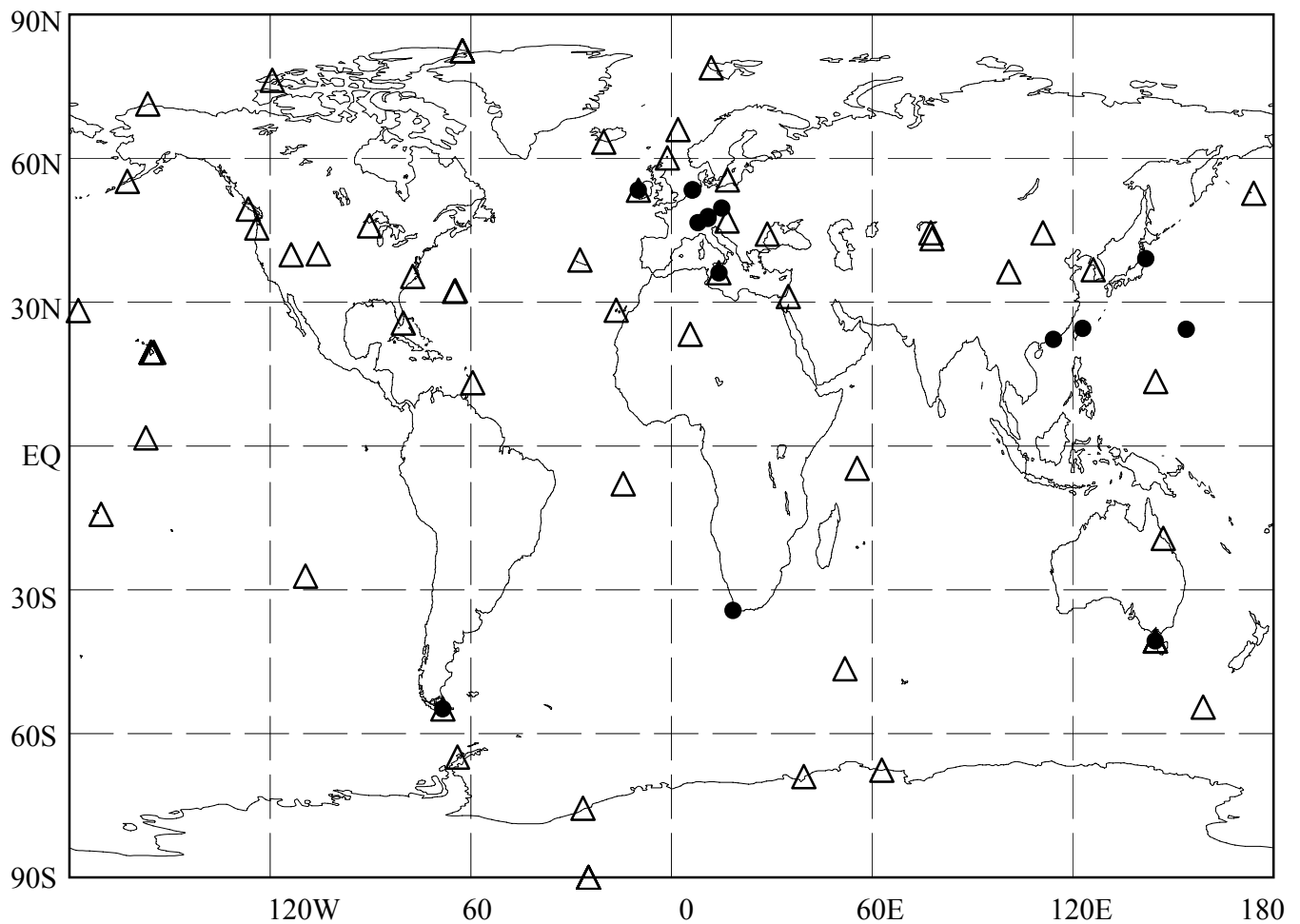


8. CARBON MONOXIDE (CO)

● : *IN SITU* STATION
△ : FLASK STATION



8. Carbon Monoxide (CO)

Carbon monoxide (CO) is not a significant greenhouse gas as it absorbs little infrared radiation from the Earth. However, it does have an influence on oxidization in the atmosphere through interaction with hydroxyl radicals (OH), which also react with methane, halocarbons and tropospheric ozone. Eventual indirect influence of current CO emission on radiative forcing is estimated to be larger than the direct influence of N₂O (Daniel and Solomon, 1998).

CO measurements in ice cores indicate that the CO concentration has not changed much during the last two millennia over central Antarctica and that it has been increasing in northern high latitudes in Greenland since 1850 (Haan and Raynaud, 1998). Most of the significant sources and sinks of CO have been identified, but there are large uncertainties in the CO budget. Sources of atmospheric CO include fossil fuel combustion and biomass burning along with the oxidization of methane and non-methane hydrocarbons (NMHC), both natural and anthropogenic. Major sinks are primarily the reaction with OH and secondly surface deposition (IPCC, 2001). The measurement of carbon isotopic partitioning in CO should provide constraints for reducing the uncertainties. Issues of calibration and the consistency of measurements between laboratories remain a concern.

The location map at the beginning of this chapter shows observation sites that have submitted CO data to the WDCGG.

Global, hemispheric and zonal mean concentrations were calculated for the period from 1992 to 2002. The calculations were based on data from stations that were not seriously affected by the local sources.

Plate 8.1 shows the variation in zonal mean concentrations and deseasonalised concentrations from 1992 to 2002. The concentrations are clearly dependent on latitude and exhibit a seasonal variation.

Plate 8.2 shows the time series of monthly mean concentrations of CO for individual stations, colour-coded to indicate the concentration level. Please note that the data on CO is reported in various units, viz., ppb, $\mu\text{g}/\text{m}^3$ -25°C, $\mu\text{g}/\text{m}^3$ -20°C and mg/m^3 -25°C. All units are converted to ppb as follows:

$$X_p [\text{ppb}] = (R * T / M / P_0) * 10 * X_g [\mu\text{g}/\text{m}^3]$$

$$X_p [\text{ppb}] = (R * T / M / P_0) * 10^4 * X_g [\text{mg}/\text{m}^3]$$

where R is the molar gas constant (8.31451 [J/K/mol]),

T is the absolute temperature reported by an individual station,

M is the molecular weight of CO (28.0101), and

P₀ is the standard pressure (1013.25 [hPa]).

Global and hemispherical monthly mean concentrations and their deseasonalised long-term trends from 1992 to 2002 are shown in Figure 8.1. CO concentrations are generally higher in northern regions than in southern regions. A seasonal variation is seen in both hemispheres.

In most observation stations in the Northern Hemisphere, the concentration is higher in the winter season. Amplitudes of the seasonal cycle are larger in the Northern Hemisphere than in the Southern Hemisphere. The global annual mean concentration was about 98 ppb in 2002.

The increasing trend in CO concentration of slightly less than 1% per year before the mid-1980s appears to have been reversed in the late 1980s (WMO, 1999a). Figure 8.2 shows the growth rates for the globe and both hemispheres from 1992 to 2002. Growth rates were high in 1993/1994, 1997/1998 and 2002, and low in 1992 and 1998/1999. The significant long-term global trend is not seen.

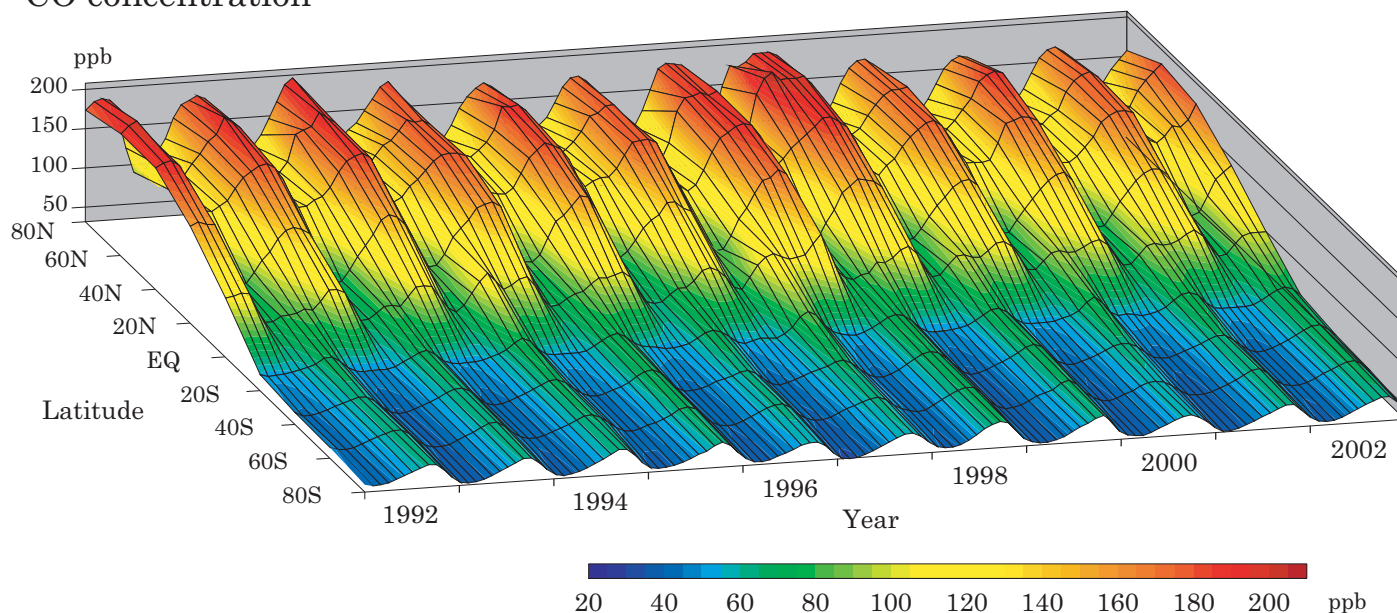
Figure 8.3 shows the monthly mean concentrations and their deseasonalised long-term trend for each 30° latitudinal zone from 1992 to 2002. Deseasonalised long-term trends clearly show that concentrations are highest in the northern mid-latitudes, suggesting intense anthropogenic CO sources there.

Figure 8.4 shows the deseasonalised long-term trend and growth rates for each 30° latitudinal zone. A negative growth rate can be seen in 1992 in all latitudes. Novelli *et al.* (1998) pointed out a clear decline in CO concentrations from late 1991 through mid-1993 and a subsequent recovery from mid-1993 through mid-1994. The decline in CO concentrations nearly coincides with the decreased growth rate in CH₄ concentrations. This can be ascribed to the variation of their common sink. Enhanced stratospheric ozone depletion due to the increase in volcanic aerosols from the eruption of Mt. Pinatubo in 1991 may have increased the concentration of OH that reacts with CO and also with CH₄ (Dlugokencky *et al.*, 1996). An increase in CO concentrations is observed from 1997 to 1998 in northern latitudes and southern low latitudes. This increase is attributed to the severe biomass burning around Indonesia in late 1997 and that around Siberia between summer and autumn 1998 (Novelli *et al.*, 1998). The concentrations returned to normal levels after 1999, but the growth rates in the Northern Hemisphere increased again substantially in 2002.

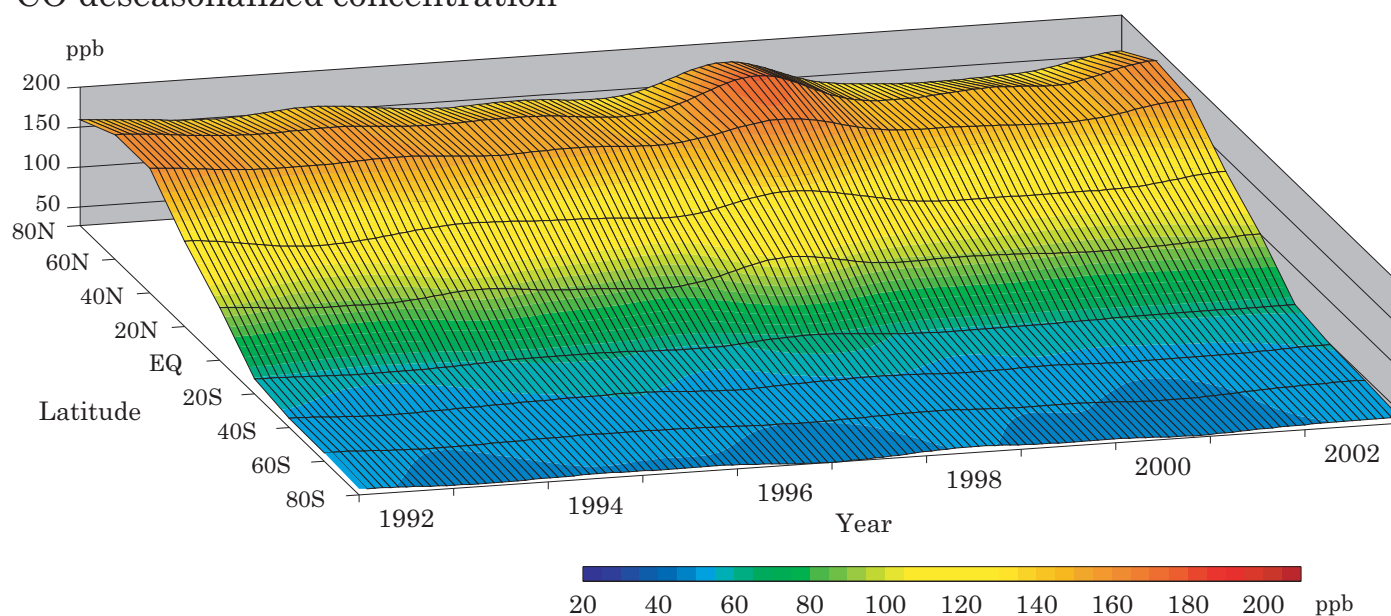
Figure 8.5 shows the averaged seasonal cycles for each 30° latitudinal zone from which the long-term trends are subtracted. The seasonal cycle of CO is mainly driven by seasonal variations in OH concentration, which acts as a CO sink. Furthermore, emission and oxidation as CO sources and the large-scale transportation of CO are additional factor, even though the seasonality of emission and oxidation is relatively weak compared with that of the OH concentration. This seasonality and the roughly 2-month lifetime of CO produces a steep decrease in early summer and a relatively gradual increase in autumn. Semi-annual features evident in the southern low latitudes may be attributed to the cross-equatorial transportation of CO from the Northern Hemisphere.

Direct CO emission also brings about an intense seasonal variation on some occasions. Novelli *et al.* (1998) showed with a model of a box representing the well-mixed northern layer and a box representing the southern boundary layer that seasonal cycles are strongly affected by changes in the emission from biomass burning in both hemispheres. Matsueda *et al.* (1998) showed using observed data for the upper troposphere that high CO concentrations in southern low latitudes from October to November were enhanced by tropical biomass burning.

CO concentration



CO deseasonalized concentration



CO growth rate

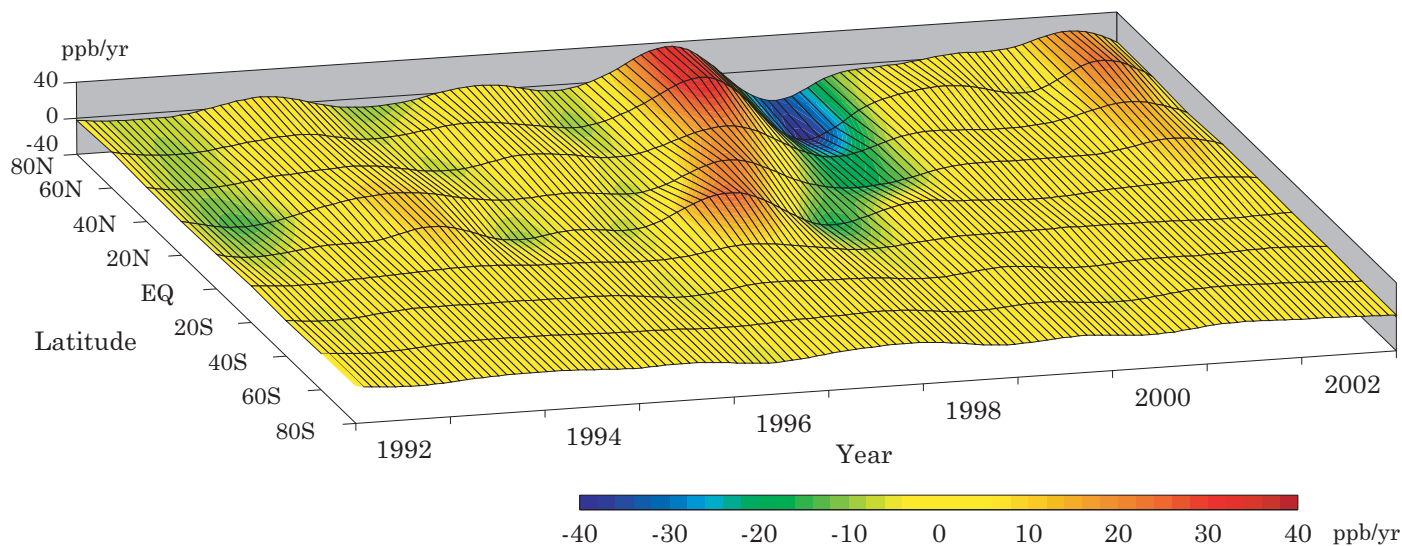


Plate 8.1 Variation of zonally averaged monthly mean CO concentrations (top), deseasonalized concentrations (middle), and growth rates (bottom). Zonally averaged concentrations are calculated for each 20° zone. Deseasonalized concentrations and growth rates are derived as described in Chapter 2. Seasonal variations can be seen clearly.

CO Monthly Data

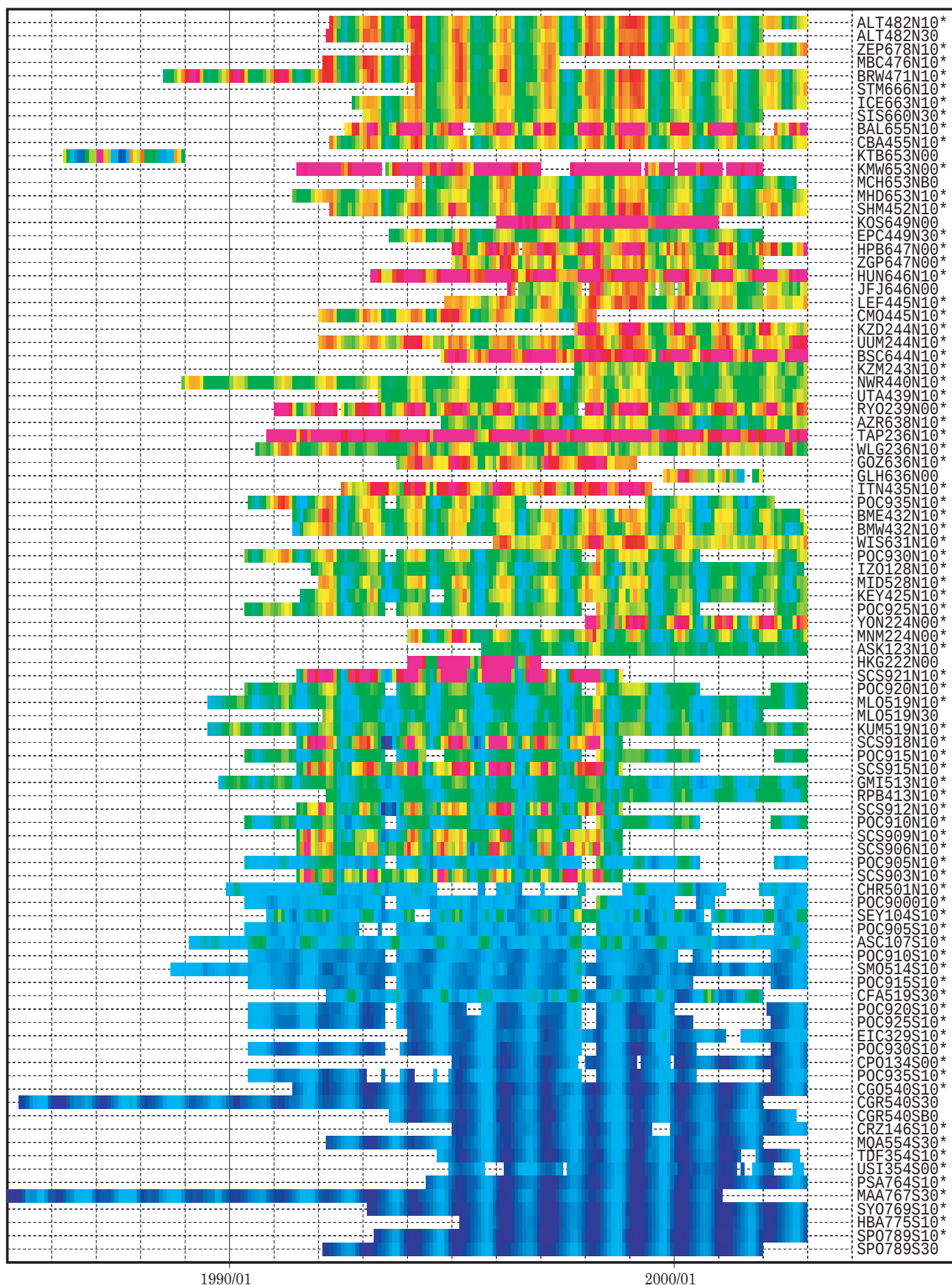
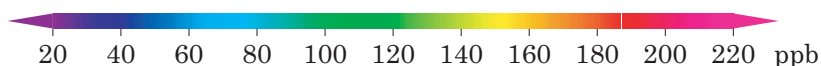


Plate 8.2 Monthly mean concentrations of CO for all stations reported to the WDCGG. The stations are set from north to south. Station index with an asterisk shows the station used in the analysis shown in Plate 8.1.

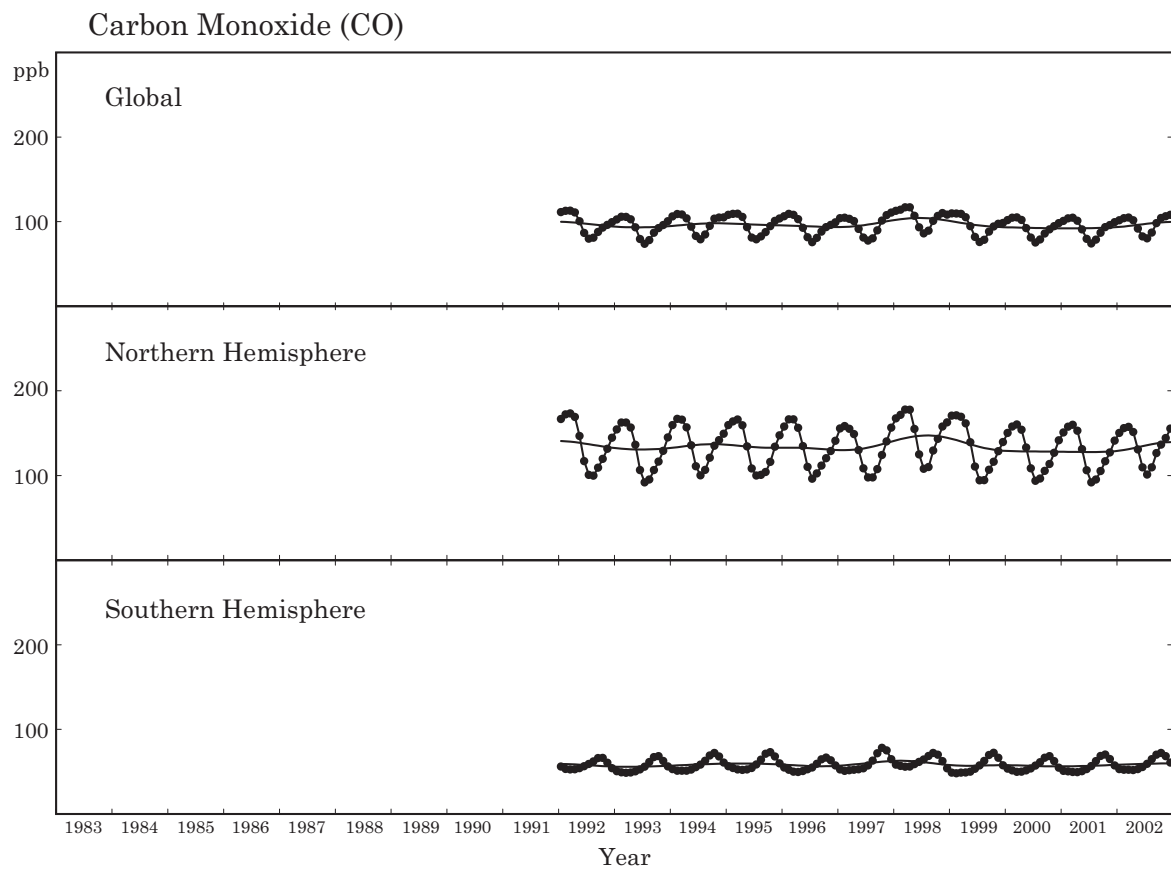


Fig. 8.1 Monthly mean concentrations (dots and thin line) and deseasonalized long-term trends (thick line) from 1992 to 2002 for the globe and both hemispheres.

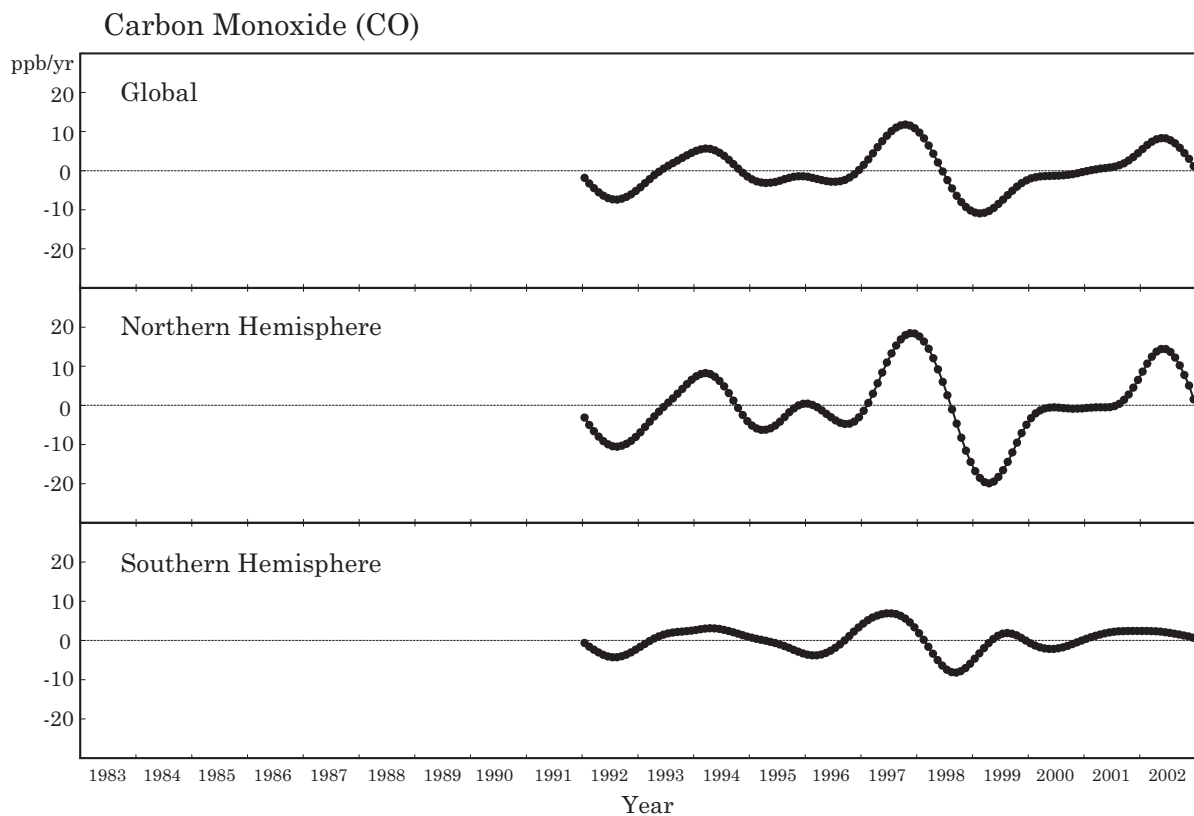


Fig. 8.2 Growth rates from 1992 to 2002 for the globe and both hemispheres.

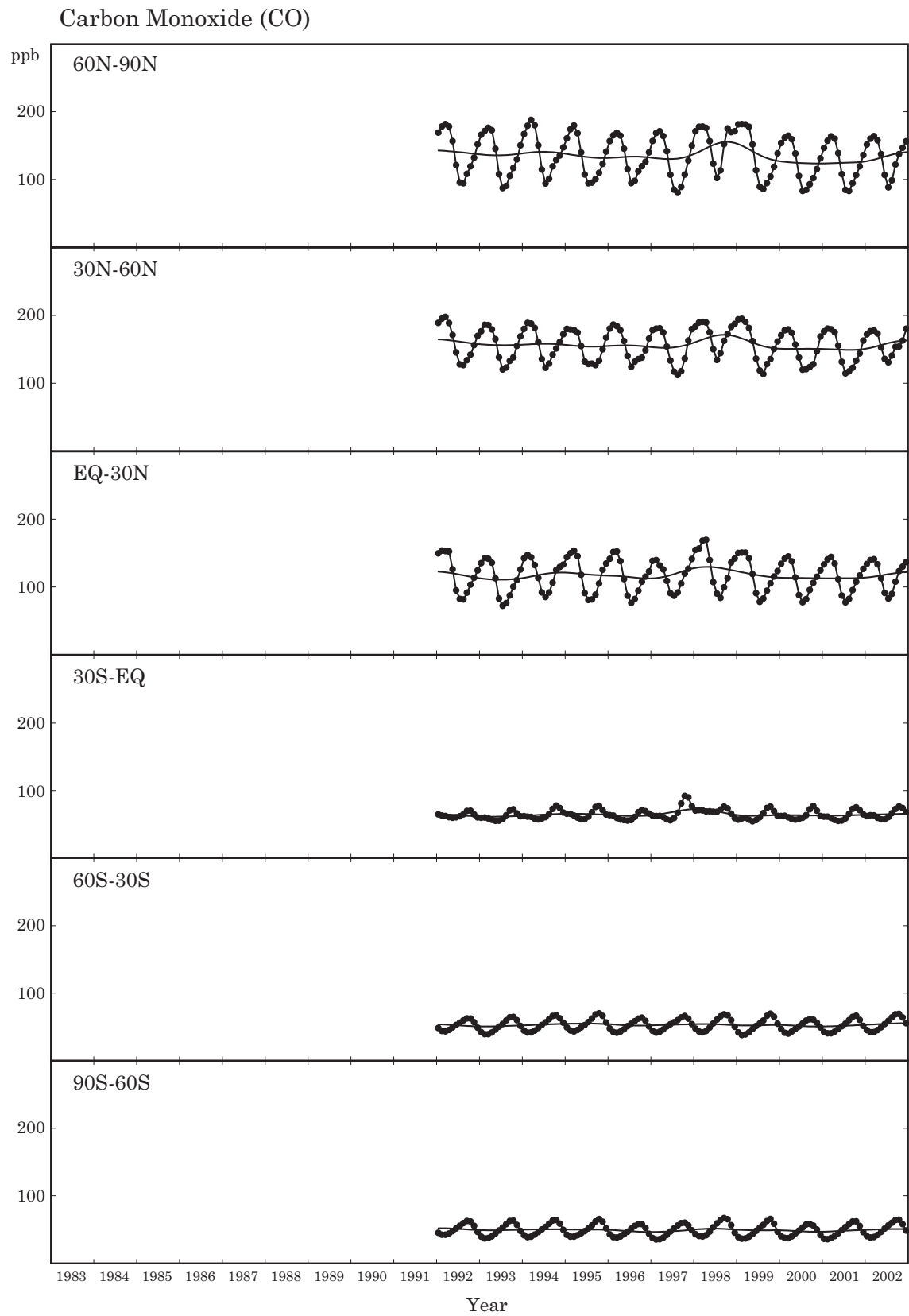


Fig. 8.3 Monthly mean CO concentrations (dots and thin line) and deseasonalized long-term trends (thick line) from 1992 to 2002 for each 30° latitudinal zone.

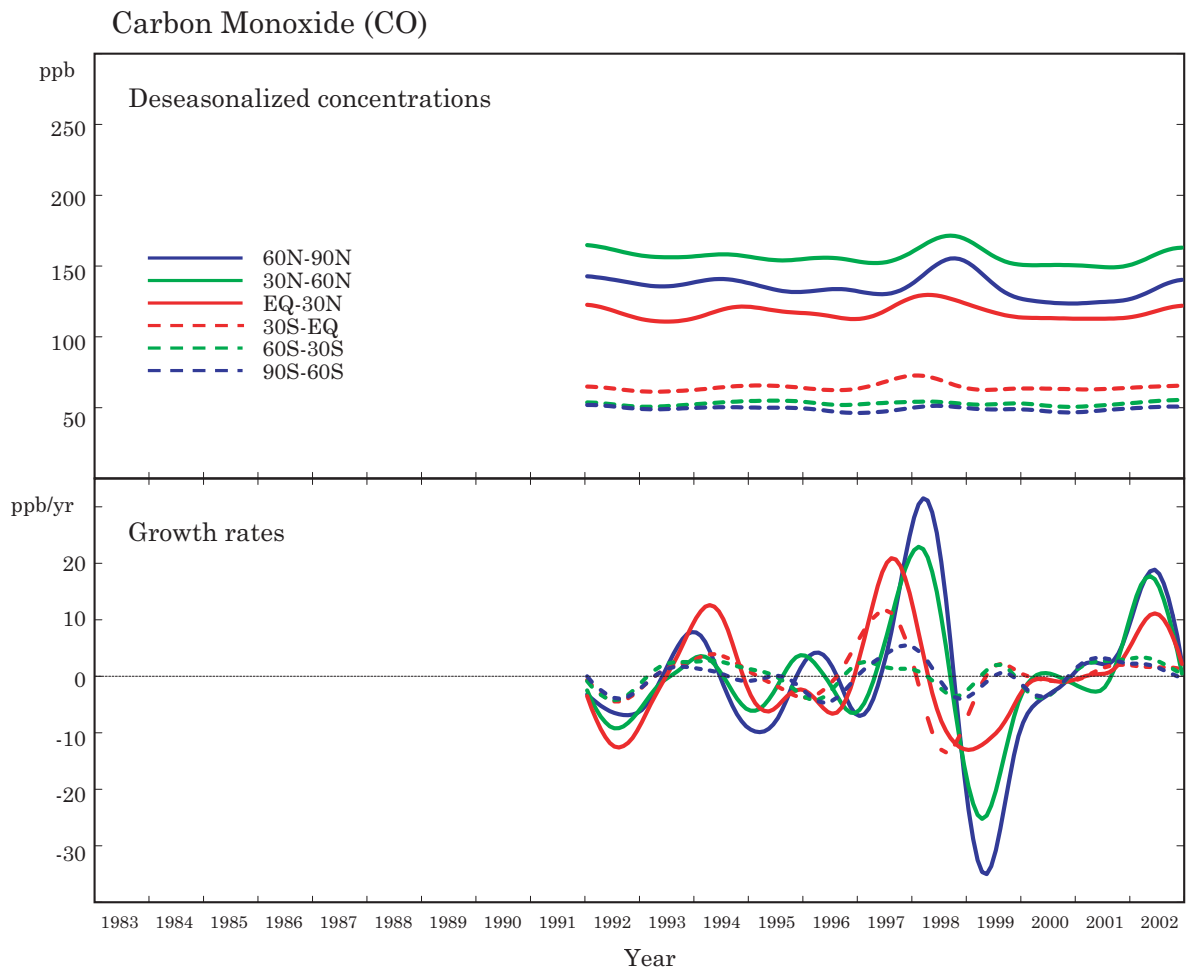


Fig. 8.4 Deseasonalized long-term trends (top) and growth rates (bottom) for each 30° latitudinal zone.

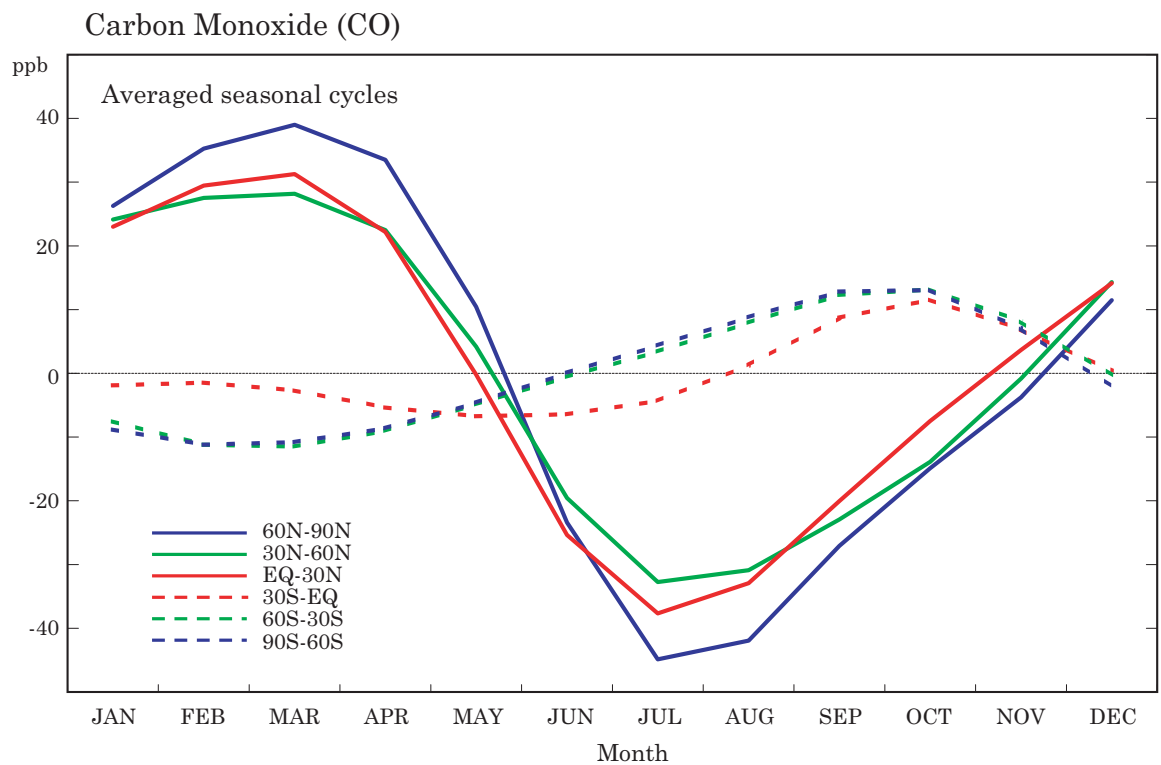


Fig. 8.5 Averaged seasonal cycles for each 30° latitudinal zone from which the long-term trends were subtracted.