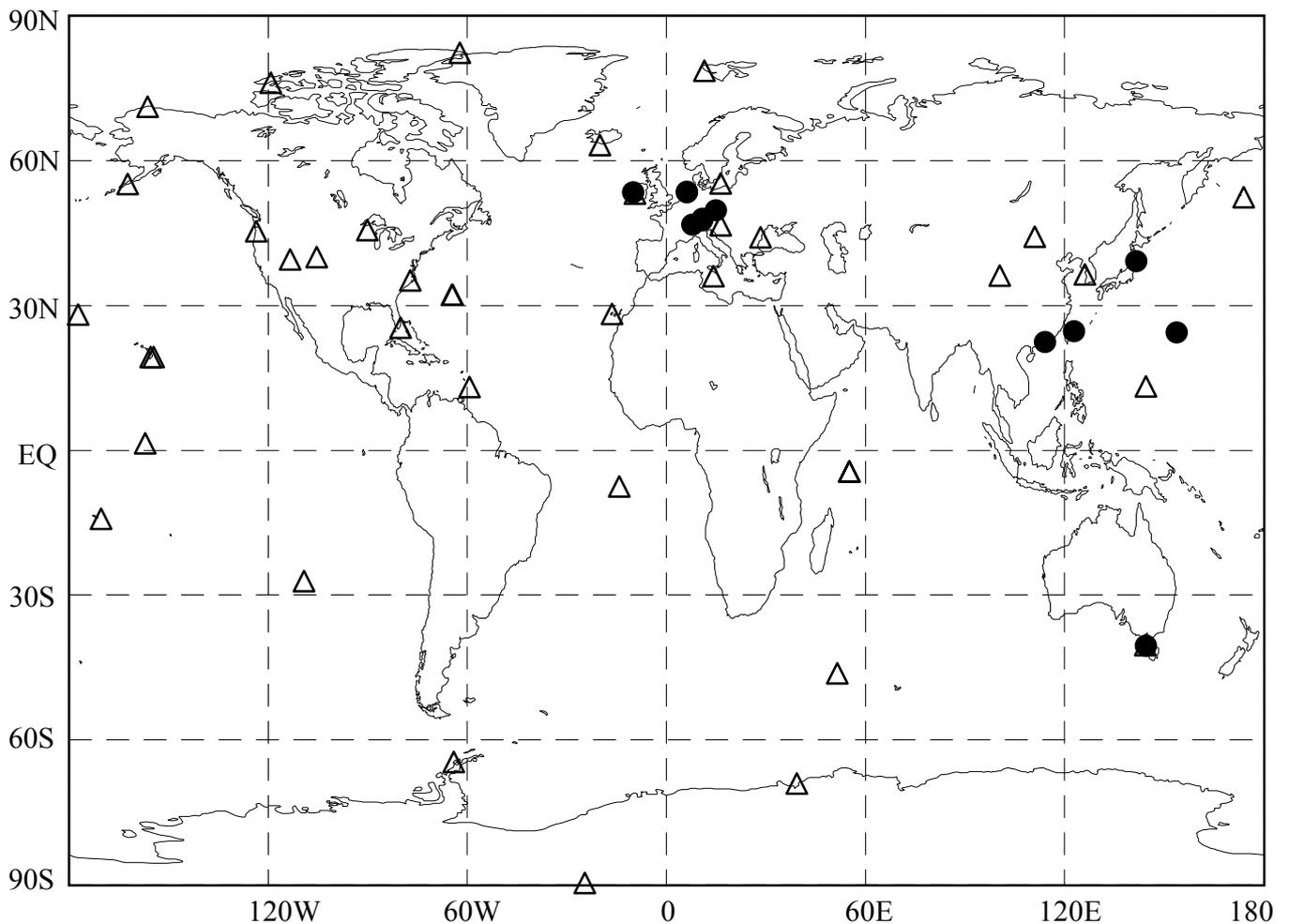


7. Carbon Monoxide (CO)

● : *IN SITU* STATION

△ : NOAA/CMDL AIR SAMPLING NETWORK STATION



7. 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 react with methane and HCFCs, and eventually brings about changes in the concentrations of important greenhouse gases.

CO measurement in ice cores indicates 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 areas of uncertainty in the CO budget (WMO, 1999a). 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.

The location map at the beginning of this chapter shows observation sites that have submitted CO data to the WDCGG, including thirteen *in situ* stations and others in the NOAA flask-sampling network.

7.1 Analysis for global, hemispheric and zonal mean concentrations

Global, hemispheric and zonal mean concentrations were calculated for the periods from 1992 to 1996, except for the southern high latitudinal zone where CO measurement began in 1993. The calculation is based on data from stations with more than 2 years of records that were not seriously affected by the local source.

Figure 7.1 shows the variation of zonal mean concentrations and deseasonalized concentrations from 1994 to 1996. The concentrations are clearly dependent on latitude and have a seasonal variation.

Monthly mean concentrations and their deseasonalized long-term trend for the globe and both hemispheres from 1992/1993 to 1996 are shown in Figure 7.2. Seasonal variation is seen in both hemispheres. The amplitude of the seasonal cycle is larger in the Northern Hemisphere than in the Southern Hemisphere, partly due to the difference in the concentration level. The annual global average concentration was about 95 ppb in 1996.

The increasing trend in CO concentration of slightly less than 1%/year before the mid-1980s appears to have been reversed in the late 1980s (WMO, 1999a). A decrease in CO concentrations was seen globally from 1990 to 1993 based on the data from the NOAA/CMDL flask-sampling network (Novelli *et al.*, 1994). Figure 7.3 shows the growth rates for the globe and both hemispheres from 1992/1993 to 1996. A decrease is also seen in the period of 1993-1996 with an average global growth rate of -0.4 ppb/year.

Figure 7.4 shows the monthly mean concentrations and their deseasonalized long-term

trend for each 30-degree latitudinal zone from 1992/1993 to 1996. Deseasonalized long-term trend curves clearly show that concentration is highest in the northern mid-latitudes, suggesting intense anthropogenic CO sources there.

Figure 7.5 shows the analytical results of the deseasonalized long-term trend and growth rates for each 30-degree latitudinal zone. Though clear, positive growth rates can be seen from 1993 to 1994 in northern latitudes, the decreasing tendency is dominant over this period as a whole. Especially, a distinct negative growth rate can be seen in 1992 in all latitudes. Novelli *et al.* (1998a) also pointed out a clear decline in CO concentrations from late 1991 through mid-1993 and subsequent partial recovery from mid-1993 through mid-1994. The decline in CO concentrations nearly coincides with the decreased growth rate in CH₄ concentrations. This correspondence can be interpreted as a result of the variation of their common sink. Enhanced stratospheric ozone depletion after 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).

Figure 7.6 draws the average seasonal cycles for each 30-degree latitudinal zone. The seasonal cycle of CO is mainly driven by seasonally varying OH concentration that acts as a CO sink, and complementarily by the emission and oxidation as CO sources, and the large-scale transportation of CO. The seasonality of emission and oxidation is relatively weak compared to that of OH concentration, which is highly concentrated around the summer solstice. This seasonality and CO life time of about 2 months produces a steep decrease in early summer and a relatively slow increase in the fall. Semi-annual features evident in the southern low latitudes may be attributed to the large-scale transportation of CO from the Northern Hemisphere.

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

7.2 Analysis of individual stations

Time-series analysis was also applied for stations representing global or regional situations: Barrow (Alaska, U.S.A.), Mauna Loa (Hawaii, U.S.A.), Cape Grim (Tasmania, Australia), the South Pole (Antarctica), Baltic Sea (Poland) and Ryori (Japan). Figure 7.7 shows a time-series of monthly mean concentrations, deseasonalized long-term trends, growth rates for each year and the average seasonal cycle for each of the stations mentioned.

Decreasing trends prevailed until 1996 as a whole at Barrow, Mauna Loa, Cape Grim, the South Pole and Ryori. Ryori experienced a distinct positive growth rate in 1997/1998, which is considered to be due to the influence of severe forest fires in far eastern Siberia in 1998. The amplitude of the seasonal cycle is large at Barrow, Ryori and the Baltic Sea, while small at Cape Grim and the South Pole.