PART I

ANTHROPOGENIC GREENHOUSE GASES IN THE ATMOSPHERE

Sources, Concentrations and Processes

STUDY OF LONG-TERM VARIATIONS OF CO_2 AND CO CONCENTRATIONS IN THE GROUND ATMOSPHERIC LAYER NEAR THE CITY OF TOMSK (WESTERN SIBERIA)

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Abstract: Continuous measurements of carbon dioxide near Tomsk started in 1992 while CO monitoring began in 1998. Both analyzers operate at the TOR Station of the Institute of Atmospheric Optics. All readouts are recorded every hour all year round. In this paper we present some results of these measurements.

Key words: surface long-term measurements, carbon dioxide, carbon monoxide, air mass transport.

1. INTRODUCTION

The TOR automated monitoring station was designed and put into operation within the framework of the Tropospheric Ozone Research Project of the EUROTRAC Programme (Belan et al., 1992; Arshinov et al., 1994). This station allows for the continuous monitoring of the main greenhouse gases, aerosol content, and standard meteorological parameters. Real-time data of these observations are presented at the web page of the Institute of Atmospheric optics (http://meteo.iao.ru).

Continuous measurements of carbon dioxide at the TOR-Station were initiated in December 1992. Until 1995 a GIAM CO_2 gas-analyser (Russian manufactured) was used, which was subsequently replaced with a NDIR Vaisala GMM-12 gas-sensor. Monitoring of CO was started in 1998 using an electrochemical sensor. Prior to analysis an air sample is pumped through tubing for 10 minutes for ventilation and calibration.

S. Lombardi et al. (eds.),
Advances in the Geological Storage of Carbon Dioxide, 3–9.

Although the measurement site is located in a boreal forest area near the city of Tomsk, this location cannot be considered as a background observational point because it is sometimes influenced by industrial pollution sources from the city (Fig. 1). However, the analysis of long-term measurements reveals local, regional and even global variations of these atmospheric parameters.

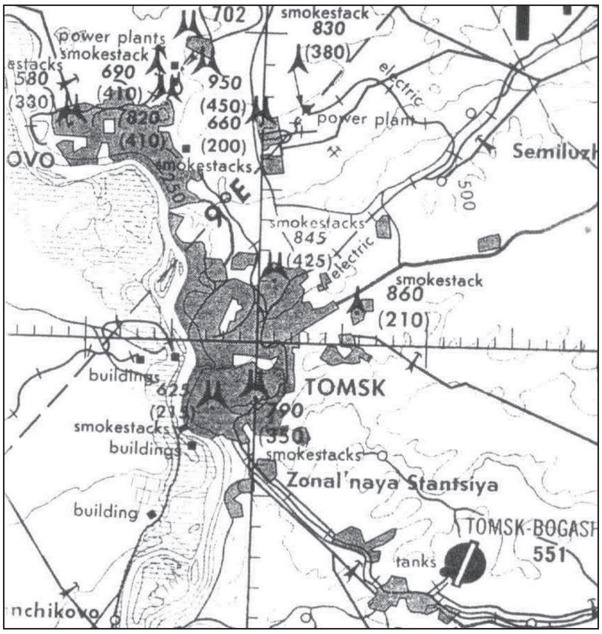

Figure 1. Arrangement of the measurement site relative to Tomsk.

2. RESULTS

This paper presents the results of the last decade of observations.

It can be seen from Figures 2 and 3 that long-term behaviour of CO_2 and CO exhibit opposite tendencies. The concentration of carbon dioxide increases from year to year while carbon monoxide concentrations generally decrease.

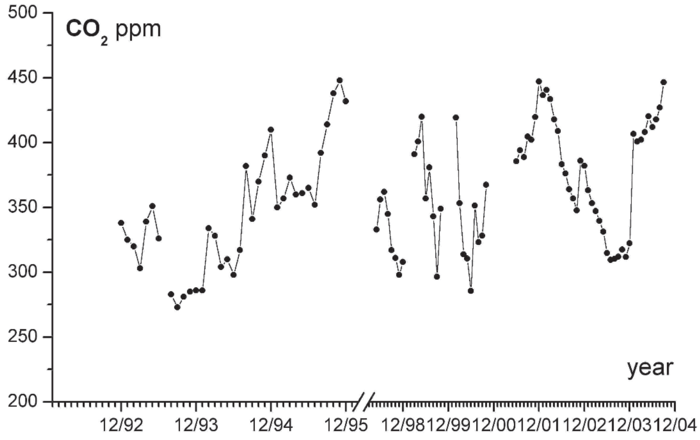

Figure 2. Long-term variations of carbon dioxide concentrations. (1992-2004).

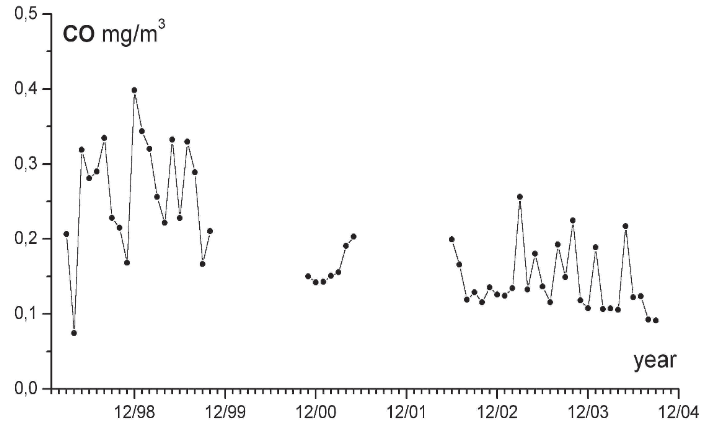

Figure 3. Long-term variations of carbon monoxide concentrations. (1998-2004).

Figures 4 and 5 show that gases of the carbon cycle have similar seasonal variations, with concentration maximums during the cold period of year and minimums during the warm period. Such behaviour reflects the normal annual cycle of vegetation activity in the region. Analysis of the seasonal variations of carbon oxides also allows one to conclude that the strength of the carbon sink exceeds the source during a four month period (from April to July). This can mean that in spite of the fact that Siberia has vast areas of forestry, on the whole the region is an additional source of one of the main greenhouse gases.

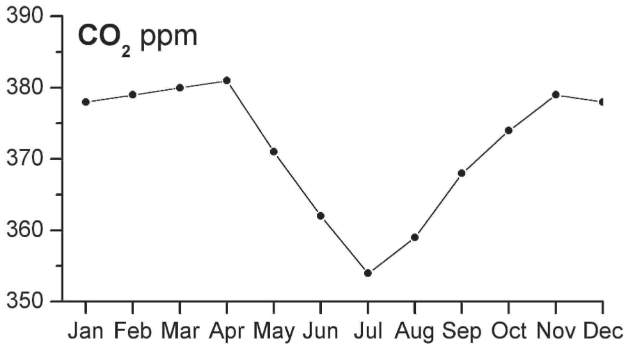

Figure 4. Seasonal variations of carbon dioxide concentrations near Tomsk.

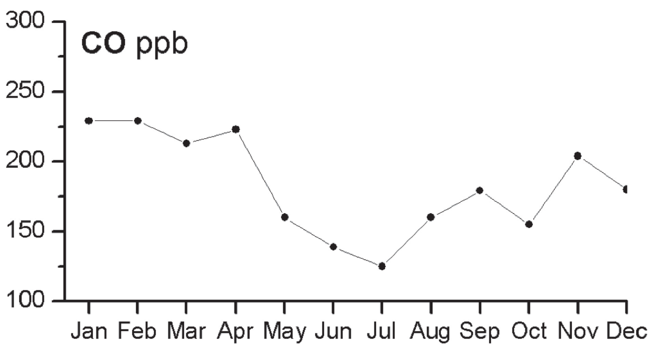

Figure 5. Seasonal variations of carbon monoxide concentrations near Tomsk.

The terrestrial surface is a natural source of nitrogen monoxide. Vegetation generates nitrous oxide, and then N_2O transforms to NO (Crutren, 1974). It can be seen from Figure 6 that nitrogen monoxide concentrations are higher during the warm period of year when the ground surface is not covered by snow. During the winter season nitrogen monoxide concentrations decrease significantly. Nitrogen dioxide is formed from nitrogen monoxide as result of interaction with ozone or hydroxyl radicals, and thus NO_2 has a seasonal variation which is similar to that of NO. That said, nitrogen dioxide concentrations do not decrease as significantly as does nitrogen monoxide during the cold period.

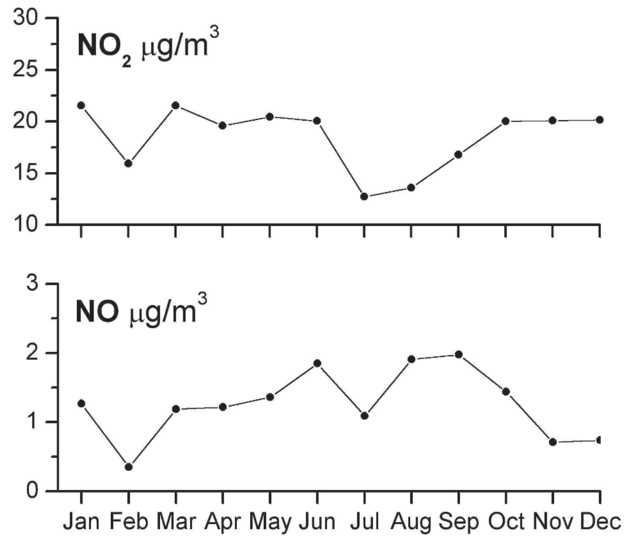

Figure 6. Seasonal variations of nitrogen dioxide and nitrogen monoxide near Tomsk.

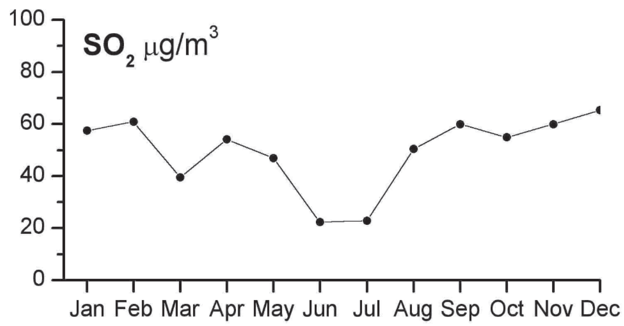

Figure 7. Seasonal variations of sulphur dioxide concentrations near Tomsk.

The seasonal variations of sulphur dioxide concentrations are shown in Figure 7. It is clear that SO_2 has a primary minimum during the summer and two secondary minima in March and October. Since the main natural source of sulphur dioxide in the atmosphere is hydrogen sulphide generated from the ground surface this kind of seasonal behaviour is typical for this region, although it should be remembered that the burning of coal, natural gas, etc.

in western Siberia is also a comparable source of SO_2. During the summer, when the mixing layer reaches maximum altitudes and turbulence is well developed, sulphur dioxide is redistributed in a larger volume, so its surface concentration decreases under the condition of a stable source. In general during the winter, when both mixing layer height and the inversion layer are lower, accumulation of impurities occurs in smaller volumes and the surface concentration of SO_2 increases. Most likely the minima in March and October are caused by wet deposition, but this assumption should be verified by measurements of precipitation acidity.

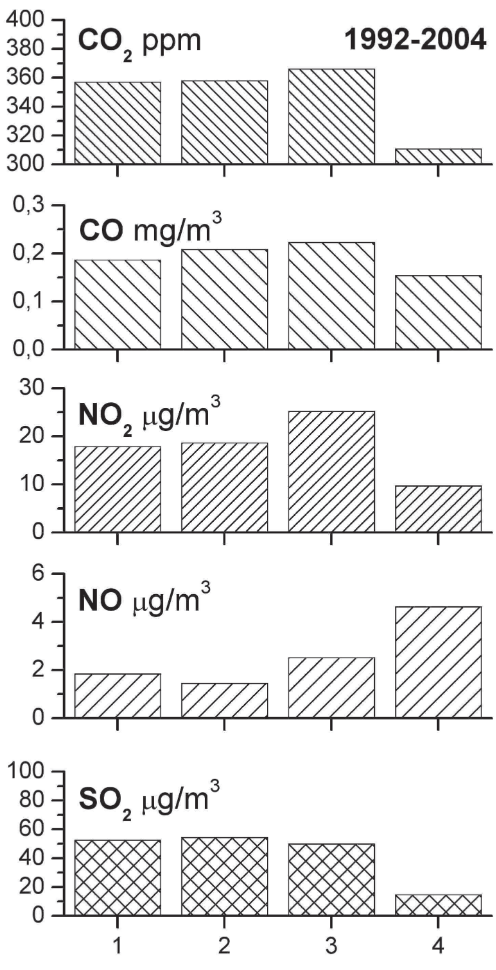

Figure 8. Gas parcel concentrations for different types of air masses near Tomsk: 1- arctic, 2 – temperate, 3 – subtropical, 4 – tropical.

The average concentration of trace gases observed in different air masses is shown in Figure 8. It can be seen from this figure that for CO_2, CO, NO_2, and NO the warmer the air mass the higher the observed concentration, except for the tropical air mass (which can be explained by poor statistics for this unit in the Siberian region).

3. CONCLUSIONS

In summary long-term tendencies of seasonal gas variations in the surface atmospheric layer reflect the influence of both regional sources and sinks as well as of long-range transport of background air mass values.

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