DYNAMICS OF THE VERTICAL DISTRIBUTION OF CO_2 AND CO CONCENTRATIONS OVER WESTERN SIBERIA (1997-2003)

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Abstract: In this paper we present some results of airborne measurements of main greenhouse gases over the southern part of West Siberia, which were started in 1997 within the framework of a joint Japanese-Russian Project on the study of greenhouse gases in Siberian ecosystems.

Key words: greenhouse gases, carbon oxides, vertical distribution

1. INTRODUCTION

Airborne measurements of greenhouse gases over the southern part of western Siberia were started in 1997 within the framework of a joint Japanese-Russian Project on the study of greenhouse gases in Siberian ecosystems (Belan et al., 2000). The study region and the flight routes are shown in Figure 1. The measurement procedure consists of flask sampling of ambient air at various elevations using an Antonov-30 aircraft laboratory. After the flight all flask samples were analysed at the National Institute of Environmental Studies (Japan). Measurements were carried out in the 0 to 7 km atmospheric layer at the end of each month, all year round, and as such a seven-year database now exists which includes CO_2, CO, CH_4, H_2 and N_2O concentration distributions. A NDIR gas-analyser (LI-6262) mounted on board the aircraft was used to perform continuous CO_2 measurements as a control of the flask sampling measurements.

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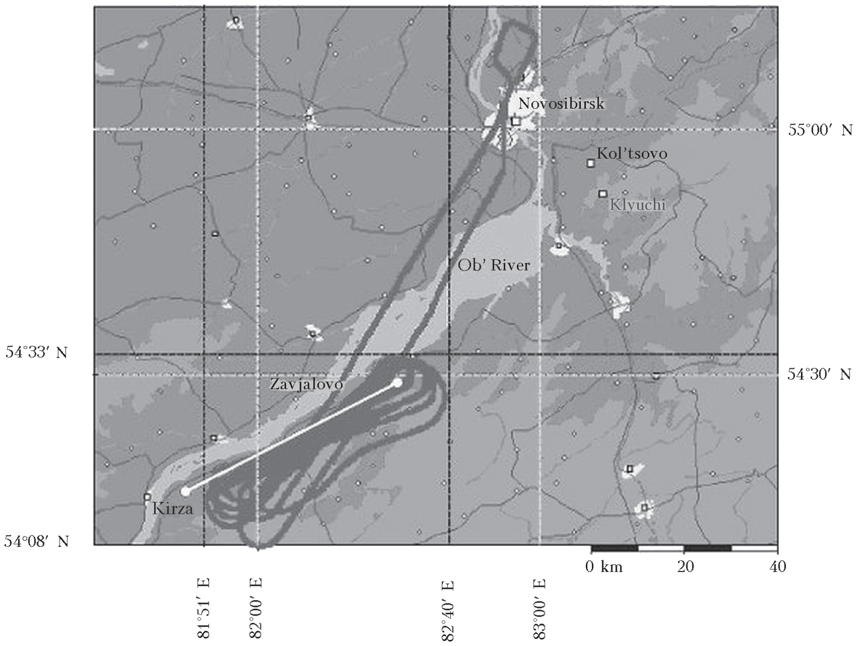


Figure 1. Region of airborne surveys.

2. RESULTS

Long-term variations in CO_2 and CO mixing ratios are shown in Figure2. This figure shows that carbon dioxide concentrations had a positive trend during the study period, which is a global characteristic feature. At the same time carbon monoxide concentrations tended to decrease.

In spite of the fact that a summer minimum and a winter maximum is typical for both gases there is one important difference in there variations. It is clear that the higher mixing ratio values of the carbon oxides observed in the lower troposphere during the winter are the result of anthropogenic emissions and vegetation respiration. Also the presence of frequent temperature inversions, which are typical for Siberia in the winter, lead to the accumulation of CO and CO_2 in the atmospheric boundary layer and higher mixing ratios in the lower troposphere as compared to the free troposphere. Differences are due to the fact that carbon monoxide concentrations are higher during the whole year at lower altitudes, while CO_2 concentrations in the summer are significantly lower compared to the free troposphere, as seen in Figure 3.

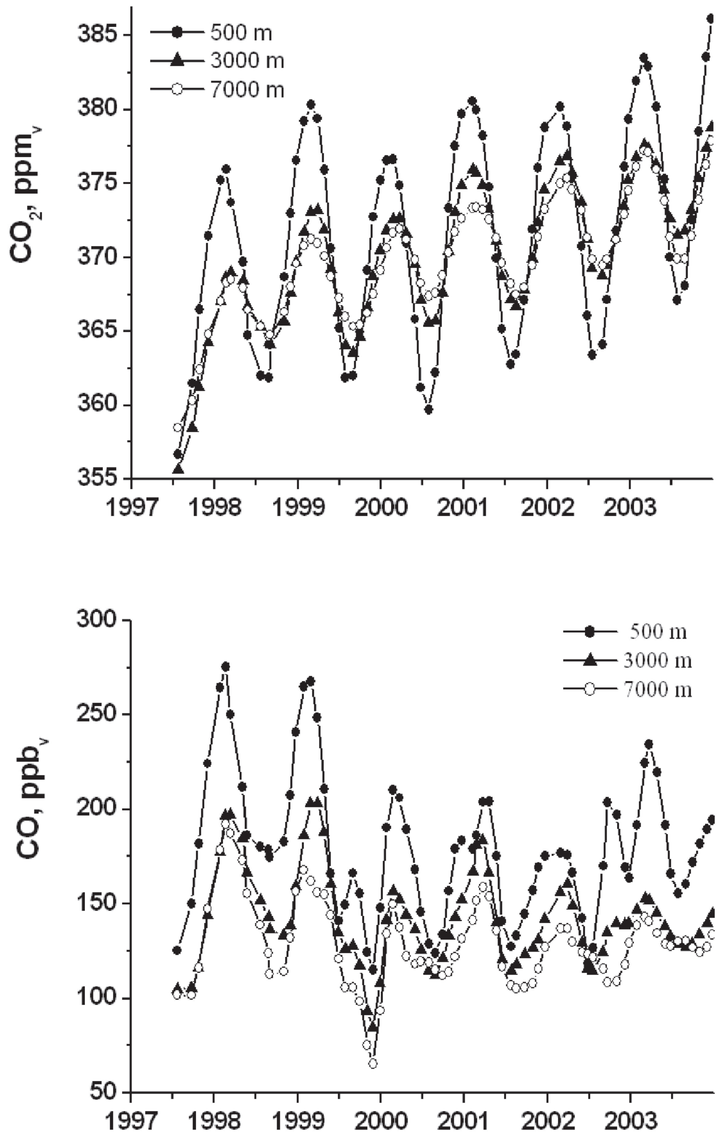
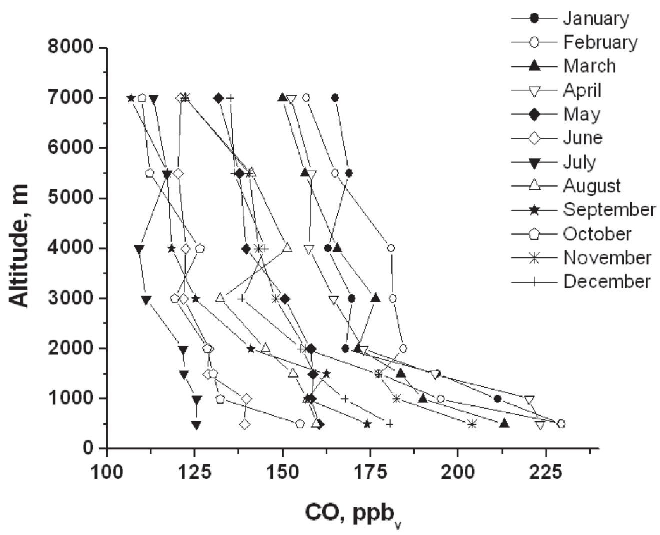


Figure 2. Long-term variations in CO_2 and CO mixing ratios.



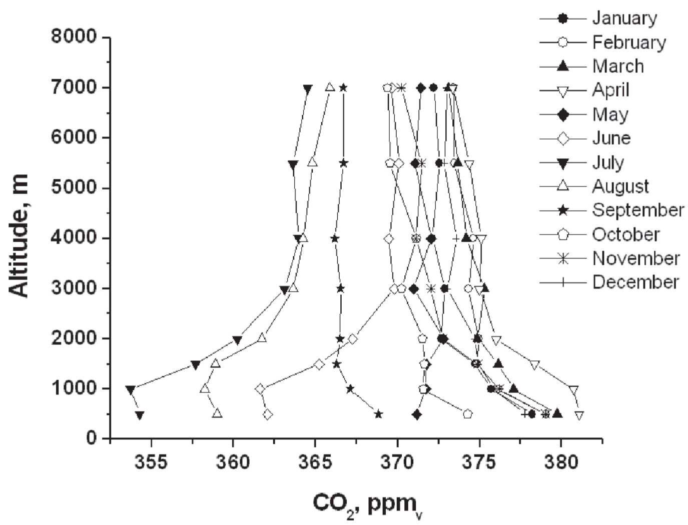


Figure 3. Averaged vertical distributions of CO_2 and CO mixing ratios.

During the summer photosynthesis leads to the decrease of CO_2 mixing ratios in the surface atmospheric layer, and well-developed vertical mixing results in distribution homogeneity in the boundary layer. As for CO, the difference in its mixing ratio at higher and lower altitudes becomes smaller during the summer, that is it does not vary with altitude.

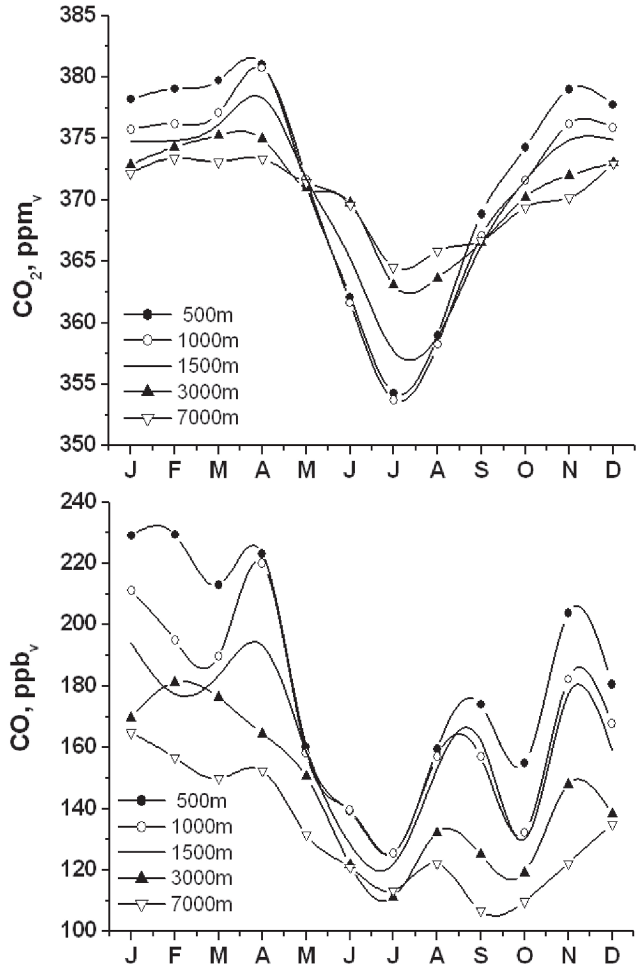


Figure 4. Averaged seasonal behaviour of CO_2 and CO mixing ratios.

The vertical CO_2 distributions observed in September and May, when CO_2 concentrations are practically invariant with altitude, represent two opposite intermediate processes. In May photosynthesis is increasing in strength while in September it is weakening. Averaged seasonal variations are shown in Figures 4 and 5. Large amplitudes are observed in the atmospheric boundary layer.

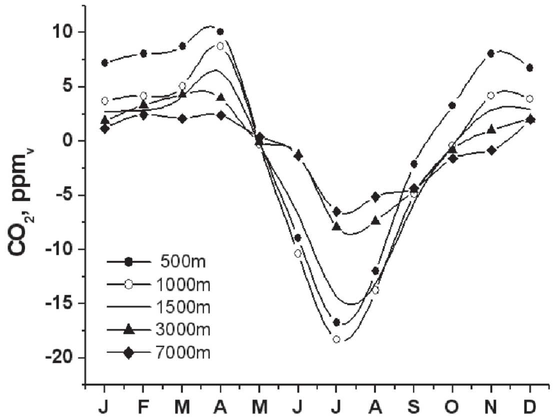


Figure 5. Seasonal amplitudes of CO_2 a nd CO mixing ratios.

3. CONCLUSIONS

The study has shown that long-term variations of carbon dioxide in the free troposphere have a positive trend during all seasons. At the same time there is no such tendency for the boundary atmospheric layer where CO_2 concentrations remain constant from year to year during summertime, that leads to increase of seasonal amplitude. So, we can draw the conclusion that Siberian forests are an important CO_2 sink. However, the question of what leads to the global increase of carbon dioxide still needs to be addressed. At present it is generally recognized that this is a result of direct industrial and transportation emissions. But analysis of variations of CO_2 and CO mixing ratios in the lower troposphere suggests that anthropogenic activity can affect the biosphere, which leads to changes in vegetation activity and, consequently, plants respiration behaviour; this can result in global increase of carbon dioxide being a very powerful source of carbon on a global scale.

REFERENCES

Belan, B.D., Inoue, G., Machida, T., Nadeev, A.I., Panchenko, M.V., Plotnikov, A.P., 2000, Variations of atmospheric greenhouse gases over Siberia. *Proceeding of the 8th Symposium on the Joint Siberian Permafrost Studies between Japan and Russia*. National Institute for Environmental Studies, Tsukuba, Japan, 2000, pp. 275-279.