DIFFERENCES BETWEEN RESULTS OF LONG-TERM SPECTROSCOPIC MEASUREMENTS OF COLUMN ATMOSPHERIC CO_2 AT THE ISSYK-KUL STATION (NORTHERN TIEN SHAN) AND CO_2 MIXING RATIONS IN THE SURFACE LAYER FROM 1981 TO 2004

V. Semenov[1], P. Tans[2], V. Sinyakov[1], F. Kashin[3], V.Aref'ev[3], N.Kamenogradsky[3], and N. Gavrilov[1]

[1]*Kyrgyz National University, 547,Frunze, Bishkek, Kyrgyzstan; svk@elcat.kg*
[2]*Climate Monitoring and Diagnostics Laboratory, NOAA, 325 Broadway, Boulder, CO 80305-3328;*
[3]*Institute of Experimental Meteoroiogy, SPA"Typhoon",82, Lenina, Obninsk, Kaluga reg., Russia*

ABSTRACT

The measurement results of CO_2 average concentration obtained in the atmospheric column at the Issyk-Kul station (IK) (42.6^{0}N, 77.0^{0}E, 1650 m a.s.l.) in 1980-2004. A comparison was made with the MBL data (for the IK latitude) presenting mean zonal CO_2 concentrations reduced to the sea level and with the measurement results of CO_2 concentrations obtained at KZD (44.45^{0}N, 77.57^{0}E, 412 m a.s.l) and KZM (43.25^{0}N, 77.88^{0}E, 2519 m) sites. The IK station is about 100 km distant from KZM and 220 km distant from KZD.

INTRODUCTION

At present at the majority of CO_2 monitoring stations the method based on the determination of CO_2 relative concentration in air samples taken near the ground are used [*Conway et al*., 2004] is applied. When the stations are not far from the sources and sinks of carbon dioxide it is reasonable to apply the spectroscopic method for determining CO_2 content in the atmospheric column from the spectra of solar radiation absorption. The data obtained so can be used for validation of satellite data. At the Issyk-Kul station (IK) (Kyrgyzstan) regular spectroscopic measurements of column content of atmospheric CO_2 are carried out since 1980 and up to now. Since October 1997 air samples have been regularly taken in the surface layer at two stations of Kazakhstan under the NOAA/CMDL program. The first station (KZD) is located between the steppe and the foothills (44.45^{0}N, 77.57^{0}E, 412 m a.s.l.). The second station is located in the mountains of the Northern Tien Shan (43.25^{0}N, 77.88^{0}E, 2519 m a.s.l.). Both stations are located to the North of the IK (42.6^{0}N, 77.0^{0}E, 1650 m a.s.l.). The IK, and KZD and KZM stations are separated by mountain ridges (with the height of 3.5-4.5 km) surrounding the Issyk-Kul lake. All three stations are located practically in the same longitude. The KZM and KZD stations are distant of about 100 and 220 km from IK, correspondingly. The measurement results obtained at three stations were compared with the average monthly values of zonally averaged Marine Boundary Layer monthly mean (MBL) CO_2 concentrations for 42.6^{0}N.

MEASUREMENT METHOD AND RESULTS

The spectroscopic method is based on the registration of solar radiation spectra within the CO_2 absorption band $4\nu_2+\nu_3$ with the center at 2.06 μm with the resolution of 3 cm^{-1} [*Kashin et al*., 2000]. The CO_2 integral content in the atmospheric column is measured with the spectroscopic method. As far as the lifetime of CO_2 makes up several years, it is well-mixed in the troposphere and one can assume under the first approximation that its relative concentration is constant in the atmosphere if there are no powerful sources and sinks of CO_2 in the atmosphere. Therefore it is possible to determine over the integral content of CO_2 in the atmosphere the effective height-averaged relative concentration of CO_2 that can be properly compared with the results of measurements made in the air near the ground or from aircraft (airplanes and air balloons of different designs). A single measurement error of CO_2 integral content in the atmosphere is equal to ±1%.

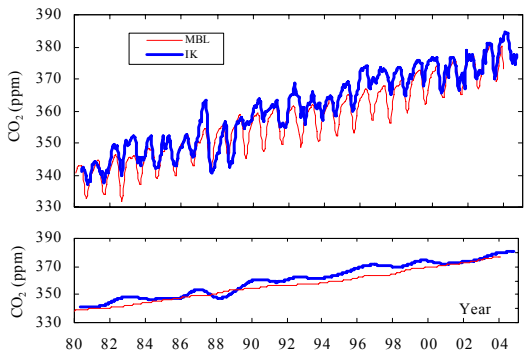

Fig. 1 Temporal variations of monthly mean CO_2 column averaged mixing ratio over IK and MBL mixing ratio (upper panel). The long-term trends represent in lower panel.

Fig. 1 gives mean monthly CO_2 contents in the atmosphere obtained at the IK station in 1980-2004 and the MBL data (upper panel). From Fig. 1 it is seen that the CO_2 concentrations according to IK measurements are higher than those of MBL. On the average the discrepancy makes 3.2 ppm and can be a result of an impact of natural continental sources of carbon dioxide (biosphere) on the atmospheric composition. The CO_2 trends (IK and MBL) are shown in the lower panel. According to the IK data the CO_2 average accumulation rate in the atmospheric column for the whole observation period makes up 1.69 ppm/year. It differs slightly from the

MBL of this period that was equal to 1.60 ppm/year. Note that in the IK time series some anomalies of CO_2 seasonal fluctuations were observed in 1987-1989. These anomalies can essentially influence the estimations of the average seasonal trend. Therefore we have carried out a comparison of average seasonal trend only for the period 1990 - 2003. It is shown in Fig. 2. It is seen, that double amplitude of seasonal variations according to IK data is by about 4.7 ppm (or 0.6 of the MBL amplitude) and it is less than that for MBL. This deviations fit to airplane measurement data [*Keeling et al*., 1968; *Bolin and Bishoff*, 1970, *Tanaka et al*., 1987].

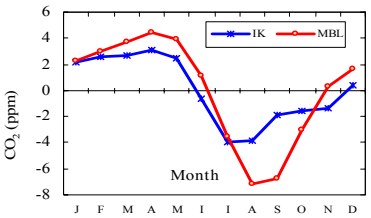

Fig. 2 Average seasonal cycle CO_2 over IK and MBL for 42.6^0 N from 1990 to 2003.

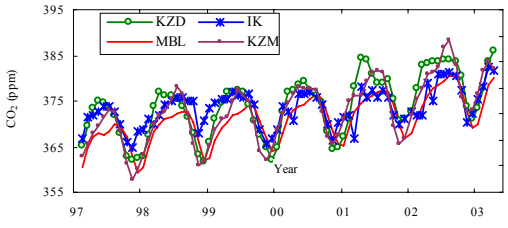

Fig.3 Temporal variations of monthly mean CO_2 over IK, KZD and KZM and MBL for 42.6^{0}N.

Fig. 3 shows the comparison of average monthly values of CO_2 mixing ratios in the surface layer (KZM, KZD and MBL) and the CO_2 mixing ratios measured at IK since October 1997 till December 2003. For a longer period of observations (Fig. 1) CO_2 fluctuations at IK differ from the MBL fluctuations, these differences during the whole year being the largest in 1998-2000 and in autumn of 2002. A considerable difference is observed between KZD and KZM data as well, but the values almost do not differ from MBL values.

Fig. 4 presents average for 6 years annual fluctuations of CO_2 for four data series under comparison. As well as for the 14-year period of observations (Fig. 2) doubled amplitude of annual variations at IK is by about 42% less than the KZD average amplitude, by 34% less than the average amplitude of KZM, and by 26% less than the MBL amplitude. An average CO_2 accumulation growth rate in the atmosphere during the whole observation period for MBL makes up 1.60 ppm/year, and for IK it is equal to 1.69 ppm/year. So, IK data are close to the average global CO_2 growth rate in the atmosphere that is equal to 1.6 ppm/year (*Conway et al*., 2004). But the accumulation growth rates vary from year to year, for the MBL they change from 0 to 4 ppm/year. According to the IK data these values are essentially less than the variations in CO_2 accumulation growth rate that changes within the limits of minus 3 ppm/year to plus 5 ppm/year since January 1990 till December 2003.

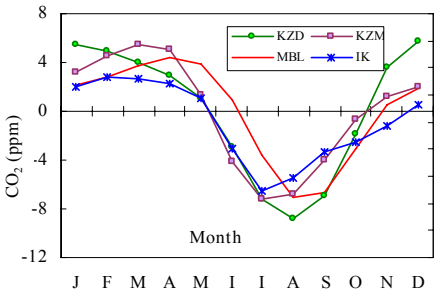

Fig. 4. Average seasonal cycle CO_2 over IK, MBL for 42.6^{0}N, and for KZD, KZM.

Acknowledgment. The studies have been carried out under a financial support of the International Science and Technology Center (Grant ISTC Kr-763).

REFERENCES

Bolin, B., and W. Bishoff (1970), Variations of the carbon dioxide content of the atmosphere in the northern hemisphere, *Tellus*, *22*, 431-442.

Conway, T. J., et all. (2004), 2. Carbon Cycle. Climate Monitoring and Diagnostics Laboratory № 27. Summary Report , Boulder, Colorado, USA.

Conway, T. J., P. P. Tans, L. S. Waterman, K. W. Thoning, D. R. Kitzis, K. A. Masarie, and N. Zhang (1994), Evidence for interannual variability of the carbon cycle from the National Oceanic and Atmospheric Administration/Climate Monitoring and Diagnostics Laboratory Global Air Sampling Network. *J. Geophys. Res. 99*(D11), pp. 22 831-22 855.

Kashin F. V., Aref'ev V. N., K. N. Visheratin, N. Ye. Kamenogradsky, V. K. Semenov, and V. P. Sinyakov (2000), Results of Experimental Studies of Radiatively Active Atmospheric Constituents in the Center of Eurasia. Izvestia, *Atmospheric and Oceanic Physics*, *36*(4), pp. 425-453. (Engl. transl.).

Keeling, C. D., T. B. Harris, and E. M. Wilkins (1968), Concentration of atmospheric carbon dioxide at 500 and 700 millibars, *J. Geophys. Res*., *73*, pp. 4511-4528.

Tanaka, M., T. Nakazawa, and S. Aoki (1987), Time and space variations of tropospheric carbon dioxide over Japan. *Tellus*, *39B*, pp. 3-12.