MEASUREMENTS OF CO_2 MIXING RATIO IN AND ABOVE PBL OVER THE FOREST AREA IN SIBERIA

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ABSTRACT

To understand the difference in CO_2 behavior between planetary boundary layer (PBL) and free troposphere (FT), we conduct CO_2 measurements using a small aircraft and a tower at the forest area in West Siberia. More than 120 vertical CO_2 profiles were observed by newly developed small CO_2 measurement device. Seasonal amplitude in PBL (36.9 ppm) is two times larger than that in FT (15.7 ppm). Diurnal variation in CO_2 profile is affected not only by PBL growth but also by horizontal advection and entrainment flux from FT to PBL.

EXPERIMENTAL

CO_2 mixing ratios are measured continuously using a radio communication tower (90m height) located in Berezorechka village (56.17 ºN, 84.33 ºE), West Siberia. Detailed measurement methods are available in Watai et al [this issue].

Small CO_2 measurement device based on single-cell NDIR (LI-800, LI-COR) equipped with flow and pressure regulation system was developed and installed in a small aircraft, An-2. Two standard gases are introduced into NDIR every 5 minutes. Overall measurement precision is estimated to be ±0.3ppm when we use 2 seconds averaged data.

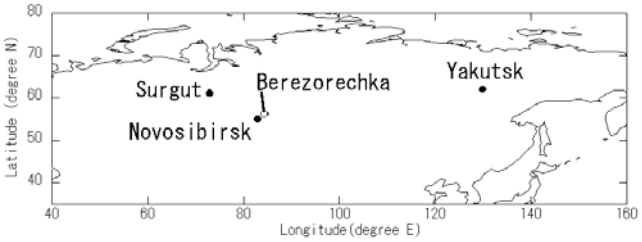

Fig.1 Location of observation site.

The aircraft ascend to 2km or 3km above Berezorechka tower and then descend to 0.15 km to obtain the vertical profile of CO_2 mixing ratio. The routine aircraft measurement has been conducted in the afternoon with the frequency of 2-4 times a month. We recorded more than 120 profiles since October 2001. Intensive flights to measure diurnal variation in vertical profile of CO_2 mixing ratio was conducted 5 days in 2002, 6 days in 2003 and 4 days in 2004.

RESULTS AND DISCUSSION

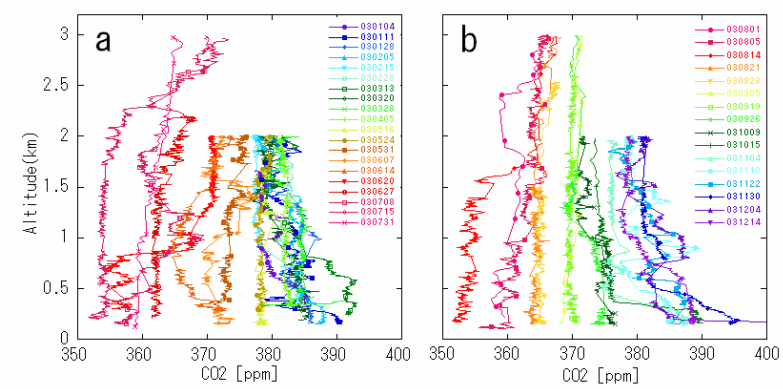

Fig.2 Vertical CO_2 profiles over Berezorechka (a) from January to July 2003 and (b) from August to December 2003.

Figure 2 shows the vertical profiles of CO_2 mixing ratio observed by routine flight from January to December 2003. The maximum flight altitude was set to 3km during the summer season. CO_2 mixing ratios show almost constant or slightly higher in lower altitude in winter season. In summer, there are large day-to-day variation both in absolute CO_2 mixing ratio and vertical CO_2 structure, which are well correlated with temperature and humidity profiles.

To compare the temporal CO_2 variation between in the planetary boundary layer (PBL) and free troposphere (FT), we defined the PBL height using vertical profiles of CO_2, temperature and humidity. CO_2 mixing ratios are averaged in each layer and plotted against the observed date in Fig.3. CO_2 values in PBL are 10 ppm lower than those in FT in summer and 3-4 ppm higher in winter. Peak-to-peak amplitude in seasonal variation is two times larger in PBL (36.9 ppm) than in FT (15.7 ppm). Annual mean CO_2 mixing ratio in PBL are 2 ppm higher than those in FT due mainly to rectifier effect.

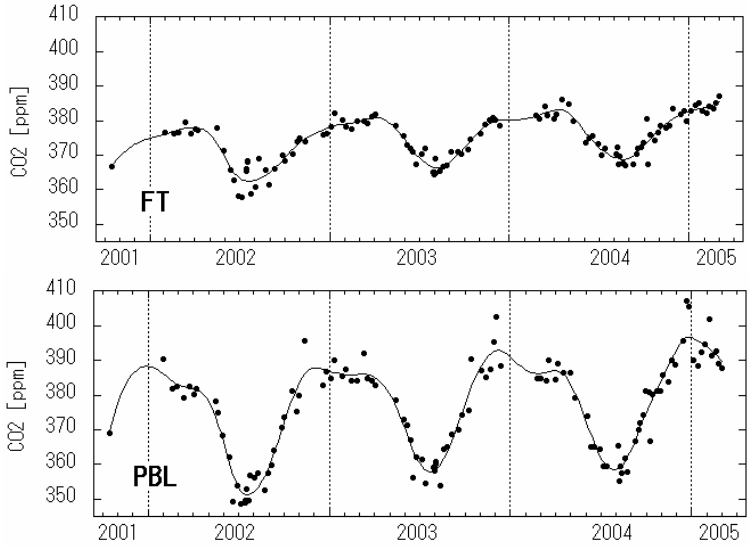

Fig. 3. Temporal variations of CO_2 mixing ratio in the PBL and FT over Berezorechka. Solid circles represent observed data, solid line best fit curves.

Three examples of diurnal variations in vertical CO_2 profile are shown in Fig.4. Typical CO_2 decrease associated with PBL growth during the daytime was observed by ~30% of measurement days. The CO_2 in PBL was often affected by horizontal advection and entrainment flux which was significantly related to PBL structure and the concentration in FT. Those variations were closely coupled with mesoscale atmospheric condition. Except for early morning, diurnal change of the CO_2 in PBL shows good agreement with that observed at tower.

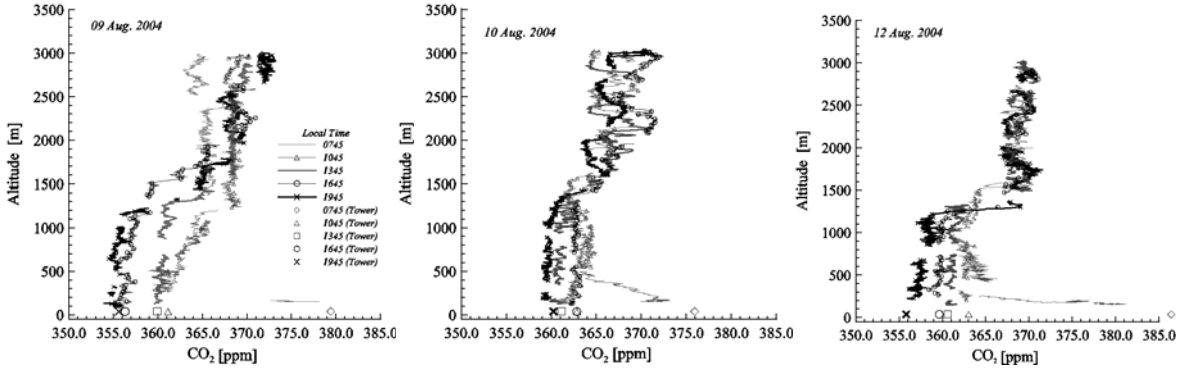

Fig. 4. Diurnal variations in vertical profile of CO_2 mixing ratio observed on August 9, 10 and 12, 2004.