



High-frequency and long-range observations of atmospheric CO₂ by CONTRAIL project

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Regular air sampling using Boeing 747 commercial airliner had been carried out since 1993 to observe CO₂, CH₄ and CO mixing ratios between Japan and Australia. The observation was improved to add the in-situ CO₂ measurement onboard the aircraft. The advanced research project “Comprehensive Observation Network for TRace gases by AIrLiner (CONTRAIL)” has started in 2005 using newly developed Continuous CO₂ Measuring Equipment (CME) and improved Automatic Air Sampling Equipment (ASE) onboard two Boeing 747-400 aircraft and three 777-200 aircraft operated by Japan Airlines (JAL). In October 2010, two 747-400 aircraft retired for operation. We are planning to modify additional two 777-200 aircraft to install CME in 2011-2012.

Long-term CO₂ data from 1993 to 2009 obtained by ASE show clear seasonal variation and increasing trend in the upper troposphere over the western Pacific. During five-years CME observation, more than 9,000 vertical profiles over 43 sites as well as the horizontal distribution in the upper troposphere and lower stratosphere are obtained and the CO₂ seasonal cycles were well defined over 25 sites. Seasonal amplitudes in CO₂ mixing ratio are different both in altitude and latitude. CO₂ amplitudes at 2 km are 10.5 ppm over north Europe, 7.6 ppm over Honolulu and 1.5 ppm over Australia. Seasonal variations over the sites in northern mid-high latitudes largely decayed with altitude, while CO₂ amplitudes at upper troposphere over Australia are slightly larger than those in lower altitudes. Transport of northern air with high CO₂ mixing ratio into southern upper troposphere from April to July contributes to enhance CO₂ seasonality at higher altitudes over Australia.

Annual mean CO₂ in the free troposphere shows latitudinal gradient from southern mid-latitude to tropics, but the gradient within northern hemisphere is rather small. Higher values are observed over Japanese airports, while rather low CO₂ are found over Delhi, India. CO₂ difference between northern and southern hemisphere in the free troposphere is smaller than that observed near the surface.

By analyzing dense observation data in free troposphere, short-term (synoptic) variabilities in CO₂ mixing ratio are found. Almost daily change of CO₂ in the free troposphere was observed over Narita, Japan, because most of the aircraft onboard the CME return to Narita international airport. The short-term variability at 2km over Europe is 1.5ppm (1 standard deviation), which is more than 2 times larger than that observed over Honolulu, being 0.6ppm. This difference implies that the difference in heterogeneity of CO₂ flux bring a substantial influence in CO₂ variation in free troposphere.