

# Seasonal variations of CO<sub>2</sub> near the tropopause observed by commercial aircraft

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## **Abstract**

We present variations of CO<sub>2</sub> in the tropopause region obtained by frequent *in-situ* measurements aboard commercial aircraft. The data were obtained from a total of 373 flights between Japan and Europe during the period November 2005 to September 2007. The local phase and amplitude of the CO<sub>2</sub> seasonal cycle varied with distance from the tropopause. In the upper troposphere and in the region just above the dynamical tropopause, a strong seasonal cycle with a springtime maximum and a relatively sharp minimum in July was observed. In the region bounded by potential temperatures 10K to 30K above the extratropical tropopause, no significant seasonal cycles were found. In the region greater than 30K from the tropopause (i.e., at higher altitudes), sharp CO<sub>2</sub> increases in summer followed by gradual decreases were found, resulting in a slightly increasing seasonal cycle amplitude with distance from the tropopause. The observed CO<sub>2</sub> distributions also showed that CO<sub>2</sub> isopleths followed the tropopause during the winter and spring, whereas in the summer they tracked potential temperature surfaces crossing the tropopause. The observed seasonal variation in CO<sub>2</sub> suggests that the lowermost stratospheric region is influenced by a combination of (1) fast meridional transport of high CO<sub>2</sub> from the tropical troposphere in the summer, (2) active subsidence of low CO<sub>2</sub> from higher altitudes in the spring, and (3) relatively weak vertical mixing near the tropopause.