# LONG-TERM OBSERVATION OF VERTICAL PROFILES OF $^{13}C/^{12}C$ RATIO OF ATMOSPHERIC $CO_2$ OVER SIBERIA AND JAPAN

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## ABSTRACT
We have conducted long-term regular monitoring of vertical profiles of $^{13}C/^{12}C$ ratio of atmospheric $CO_2$ over three sites in Siberia and a site in Japan. Time-series and seasonality of the $^{13}C/^{12}C$ ratio at each altitude levels at the four site were examined. Apparent isotopic signature was calculated from the relationship between $CO_2$ mixing ratio and the $^{13}C/^{12}C$ ratio in individual vertical profiles.

## EXPERIMENTS
Regular observations of vertical profiles of atmospheric $CO_2$ and its $^{13}C/^{12}C$ ratio over continental interior will help to understand how the terrestrial isotopic signature is transported to troposphere. At four sites over Siberia and Japan, Surgut (61°N, 73°E; since July 1993), Yakutsk (62°N, 130°E; since October 1996), Novosibirsk (55°N, 83°E; since July 1997), and Sagami-Bay (35°N, 139°E; since December 1996), we collect air samples from aircrafts at different altitudes through atmospheric boundary layer and free troposphere at monthly or semimonthly intervals and analyze them for $^{13}C/^{12}C$ ratio of $CO_2$. Among the four sites, there is clear difference in surface condition associated with source/sink of $CO_2$. Surgut site is located in a natural boreal wetland. Novosibirsk and Yakutsk sites are in boreal forests dominated by evergreen needleleaf trees and deciduous needleleaf trees, respectively. Sagami-bay site is in coastal area close to the Tokyo metropolitan area populated by more than 30 million people.

## RESULTS
Over the sites in continental interior, time-series of $^{13}C/^{12}C$ ratio of atmospheric $CO_2$ has gradual decreasing trend with regular seasonal cycle at all the altitudes. The $^{13}C/^{12}C$ ratio of atmospheric $CO_2$ observed at altitude of 3000m shows that there is significant difference in the amplitude of its seasonal variation between the sites though the altitude is usually in the free troposphere. The amplitude is greater over Yakutsk, Surgut, Novosibirsk, and Sagami-Bay in that order (Fig. 1). The mean isotopic signature (defined as intercepts of $1/CO_2$-vs-$^{13}C/^{12}C$ plots) derived from detrended time-series at 3000m also shows difference between the sites (-27.3%PDB at Surgut, -26.8%PDB at Novosibirsk, -27.5%PDB at Yakutsk and –28.1%PDB at Sagami-Bay; calculated from 97-98 data). Then we calculate apparent source isotopic signature from individual vertical profiles of $CO_2$ and its $^{13}C/^{12}C$ ratio. The apparent source isotopic signature becomes higher during vegetative season and lower in non-vegetative season. This feature is common to all the continental sites. In wintertime, the isotopic signature over Siberia often reaches the value lower than –30%PDB (Fig. 2a). The values of those isotopic signatures are inexplicable only from contribution of biospheric components. This excessive depletion of isotopic signatures is formed most likely from $^{13}C$-depleted $CO_2$ originated from fossil fuels in Russia. Elevation in carbon monoxide mixing ratio at lower altitudes suggest that it contains contributions from combustion sources. At lower altitudes

over Sagami-Bay influence of urban pollution is often observed throughout the year. The apparent source isotopic signature over Sagami-Bay is scattered around –28‰PDB and has no significant seasonality (Fig. 2b).

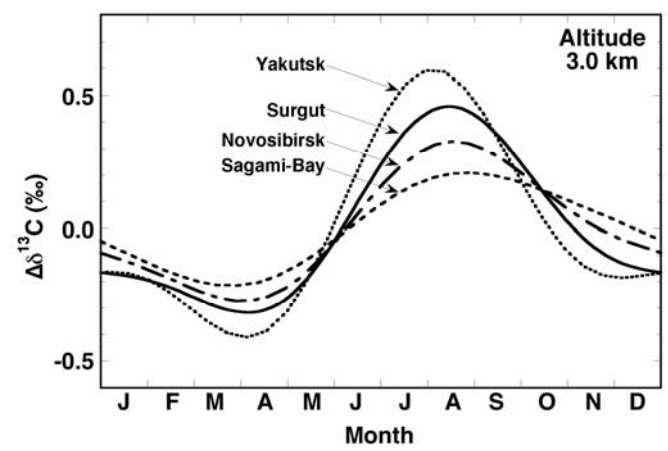


Fig. 1 Seasonality (Harmonics component) in $^{13}C/^{12}C$ ratio of atmospheric $CO_2$ observed at 3.0km altitude at four sites.

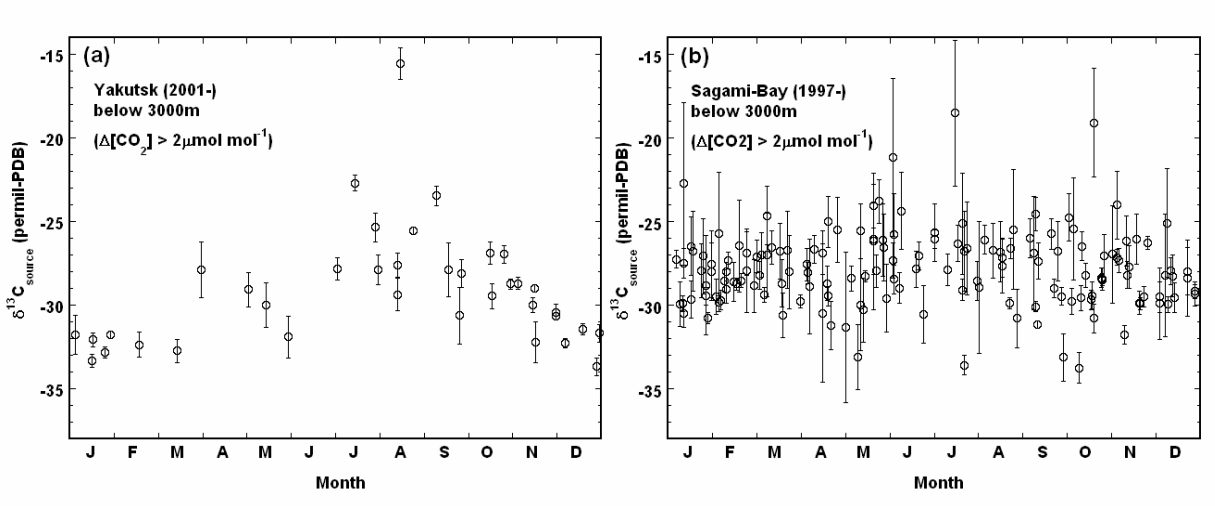


Fig. 2 Apparent source isotopic signature calculated from vertical profiles of $CO_2$ and $^{13}C/^{12}C$ ratio observed below 3.0km altitude for (a)Yakutsk and (b)Sagami-Bay.