Seasonal variations of ^{18}O and ^{13}C of CO_2 in the upper troposphere and lower stratosphere over Siberia

Yoichi Inai[1,5], Shotaro Chida[1], Shinji Morimoto[1], Shohei Murayama[2], Shuji Aoki[1], Takakiyo Nakazawa[1], Toshinobu Machida[3], Hidekazu Matsueda[4], Yousuke Sawa[5], Kazuhiro Tsuboi[4], Keiichi Katsumata[3,6], Ryo Fujita[1,4]

[1]*Graduate School of Science, Tohoku University, Japan*

[2] *National Institute of Advanced Industrial Science and Technology, Tsukuba, 305-8560, Japan*

[3]*National Institute for Environmental Studies, Japan*

[4]*Meteorological Research Institute, Japan*

[5]*Japan Meteorological Agency, Japan*

[6]*Takachiho Chemical Industrial Co., Ltd., Japan*

Carbon and oxygen isotope ratios ($\delta^{13}C$ and $\delta^{18}O$) of atmospheric CO_2 provide us useful information on an understanding of the global carbon cycle owing to their dependencies on sources or sinks. To reveal temporal and spatial variations of $\delta^{13}C$ and $\delta^{18}O$ of CO_2 in the upper troposphere/lower stratosphere (UT/LS) over Siberia, we analyzed air samples collected on board commercial airliners between France/Russia and Japan by the Comprehensive Observation Network for TRace gases by AIrLiner (CONTRAIL) project. The CONTRAIL project has also measured mixing ratios of several long-lived chemical species, including SF_6, using the same collected air samples. The CO_2 mixing ratio and $\delta^{18}O$ show a secular increase during the observation period from April 2012 to May 2017, while $\delta^{13}C$ shows a secular decrease during the same period. The negative correlation between the CO_2 mixing ratio and $\delta^{13}C$ is also observed in the seasonal timescale variations in the UT. The change rate of -0.043 ‰ ppm^{-1} suggests that they are seasonally driven by the carbon exchange between the terrestrial biosphere and the atmosphere. The similar negative correlation is also shown in the LS, according to the relationship with SF_6 mixing ratio, however, it is interpreted as due to seasonal cycle in stratosphere-troposphere exchange (STE) processes including the Brewer-Dobson circulation (BDC) in the stratosphere. The SF_6 distribution also suggests that the STE process plays more crucial role on the seasonal relationship between CO_2 and $\delta^{18}O$. In particular, air mass transport from deep stratosphere to the UT/LS region during winter/spring is important for the ^{18}O distribution in the UT/LS because such air masses have high $\delta^{18}O$ derived from stratospheric ozone.