Geophysical Research Abstracts
Vol. 20, EGU2018-11094, 2018
EGU General Assembly 2018
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Climatological variations of tropospheric CO_2 over the Asia-Pacific region observed by the CONTRAIL commercial airliner measurements

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CONTRAIL (Comprehensive Observation Network for Trace gases by Airliner) is an ongoing project that measures atmospheric trace gases during intercontinental flights of Japan Airlines. From > 12 thousands of flights since 2005, we have obtained > 8 million in-flight data points of CO_2 mole fraction along flight tracks of ascent/descent and cruise. In this study, we present CONTRAIL-based climatological variations over the Asia-Pacific region. The high-frequency CO_2 measurements reveal a clear seasonal variation of CO_2 in the upper troposphere (UT), with a maximum occurring in April–May and a minimum in August–September. The CO_2 mole fraction in the UT north of 40° N is low and highly variable in June–August caused by the arrival of air parcels with seasonally low CO_2 due to the summer uptake in boreal Eurasia. For August–September in particular, the UT CO_2 is noticeably low within the Asian summer monsoon anticyclone influenced by the convective transport of strong biospheric CO_2 uptake signal over South Asia. Vertical profiles of CO_2 over cities across the Asia-Pacific region show a spreading of this low CO_2 area in the UT during September as the anticyclone decays. Simulation results indicate significant interplay of seasonally-varying CO_2 fluxes and atmospheric circulation pattern in the seasonal evolution of the spatial CO_2 distribution over the Asia-Pacific region. It is indicated that a substantial contribution to the UT CO_2 over the northwestern Pacific comes from the continental East Asian emissions in the spring, but switches to South Asian air masses in the summer monsoon season. The observed increase in the CO_2 variability over East Asia in the spring is associated with active cyclonic passages of air masses imprinted with the continental East Asian emissions.