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Variations of GHGs from the lower-troposphere to the UT/LS revealed by two Japanese regular aircraft observation programs

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A Japan-centered observation network consisting of two regular aircraft programs have revealed the greenhouse gases variations from the lower-troposphere to the upper-troposphere/lower-stratosphere (UT/LS) regions. In the Comprehensive Observation Network for Trace gases by Airliner (CONTRAIL) project, in-situ continuous measurement equipment (CME) onboard commercial passenger aircraft world-widely observes CO_2 profiles in vertical over tens of airports and in horizontal in the UT/LS regions. The CONTRAIL-CME has revealed three-dimensional structure of the global CO_2 distribution and has exposed significant inter-hemispheric transport of CO_2 through the upper-troposphere. In inverse modeling, the CME data have provided strong constraints on CO_2 flux estimation especially for the Asian tropics. Automatic flask air sampling equipment (ASE) is also onboard the CONTRAIL aircraft and has been observing CO_2 mixing ratios as well as those of methane, carbon monoxide, nitrous oxide and other trace species in the upper-troposphere between Japan and Australia. The observation period of the ASE has reached 20 years. In recent years, the ASE program has extended to the northern subarctic UT/LS region and has given an insight of transport mechanisms in the UT/LS by observing seasonal GHGs variations. In the other aircraft observation program by Japan Meteorological Agency, variations of GHGs have been observed by flask-sampling onboard a C-130H aircraft horizontally in the mid-troposphere over the western North Pacific as well as vertically over Minamitorishima-Island. The C-130H aircraft has persistently observed high mixing ratios of CH4 in the mid-troposphere, which seems to be originated from fossil fuel combustion throughout the year as well as from biogenic sources during summer in the Asian regions. Those above aircraft observation programs have a significant role for constraining GHGs flux estimates by filling the data gap of the existing surface measurement network specifically in the regions of Asia and the western North Pacific.