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Sensitivity of short timescale variability of CO2 over Narita Airport to the magnitude of regional surface fluxes

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The synoptic scale variability of CO_2 over the Narita International Airport (lat 35.8^{o}N, 140.4^{o}E, 43m a.s.l.) was investigated using measurements obtained from frequent observation by commercial aircraft combined with analyses of results from a transport model simulation for the year 2007. The standard deviation (SD) from fitted curves was considered as the metric of synoptic scale variability of CO_2 mixing ratio. Tagged simulation was conducted to evaluate the relative contributions of regional fluxes to the synoptic scale variability over Narita. Tags were put on anthropogenic (FF) and terrestrial biosphere(TB) fluxes from 6 regions (Japan, East Asia, East Russia, Southeast Asia, India, and Himalaya). The result indicated that the major contribution was made by the fluxes in East Asia (mainly China) in the free troposphere (FT) and by those in Japan in the planetary boundary layer (PBL), respectively.

A sensitivity analysis was performed to evaluate the relative influence of transport and flux variations on the CO_2 SD over Narita for 2007. When the FF fluxes from East Asia and those from Japan were doubled, changes in annual mean SD over Narita with height was; 41% and 3% at 9km, 61% and 4% at 5km, 19% and 83% at 0.5km, respectively. This result indicated that SD over Narita was sensitive to transport (synoptic scale meteorological variability) from upwind in FT, but depends largely dependent on the magnitude of local fluxes in the PBL.

Among 12 tagged fluxes, those that made more than 20% difference in monthly CO_2 SD when flux magnitude was doubled were FF fluxes from Japan and East Asia, and TB fluxes from East Asia and East Russia. Throughout the year, CO_2 SD in the PBL and the FT were most sensitive to the FF flux from Japan and East Asia, respectively. In summer, the contribution of the TB flux from East Asia and East Russia to CO_2 SD was increased in the FT, when strong CO2 uptake makes large negative flux. The TB flux from East Russia affected the most at 2-4km altitude in July, and those from East Asia affected at 8-10km altitude in September. This delay corresponded to the seasonality of the sink magnitude within each tracer region. Meteorological analysis and forward/backward trajectories indicated that low CO_2 airmass affected by TB fluxes in East Russia drifted to the northeast and occasionally transported to Narita by northeasterly behind the cold front whereas those affected by TB fluxes in East Asia were often directly convected to the UT by tropical depression etc., and transported to Narita via UT much more rapidly. These transport mechanisms explained the different altitude ranges that were sensitive to the TB fluxes from East Russia and East Asia in summer 2007.

Keywords: CO2, aircraft observation, short timescale variation, carbon cycle, flux, transport