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Observed and simulated short timescale variability of CO$_{2}$ over Narita Airport

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The synoptic scale variability of CO_2 over the Narita International Airport (lat 35.8˚N, 140.4˚E, 43m a.s.l.) was investigated using measurements obtained from frequent observation by commercial aircraft from November 2005 to March 2009, combined with analyses of results from a transport model simulation for the year 2007. The synoptic scale variability of CO_2 mixing ratio, represented by the standard deviation (SD) from fitted curves, increased at all altitudes during the summer, with a noticeable increase in the upper troposphere in the spring. This seasonal/altitudinal change of SD was statistically significant (within 1σ of inter-annual variability) throughout the observation period and the model result agreed with the observation except the underestimation of summertime SD. This discrepancy is probably caused by the combined effect of underestimation of CO_2 uptake by boreal vegetation and uncertainty in the baiu (Japanese rainy season as part of the East Asian summer monsoon) climate dynamics.

Tagged simulation was conducted to evaluate the relative contributions of regional fluxes to the synoptic scale variability over Narita. 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. Tagged simulation clearly showed enhanced transport of the CO_2 flux from East Asia to the upper troposphere over Narita in the spring, suggesting an active passage of Asian outflow. The Asian outflow in the upper troposphere has been investigated previously using reactive species like CO on a campaign to campaign basis. This study is the first to clearly demonstrate the frequency of the Asian outflow in the spring based on the observed high CO_2 fluctuations detected in a multi-year record.

We also conducted a model sensitivity analysis to evaluate the relative influence of transport and flux variations on the CO_2 SD over Narita for 2007. Changes in the surface flux magnitude were found to affect the SD over Narita with height; 41% and 3% at 9km, 61% and 4% at 5km, 19% and 83% at 0.5km when fluxes from East Asia and those from Japan were doubled, respectively. This result indicated that SD over Narita is sensitive to transport (synoptic scale meteorological variability) from upwind in FT, but depends largely on the magnitude of local fluxes in the boundary layer.