Geophysical Research Abstracts, Vol. 9, 05971, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-05971

Transport analysis of tropospheric carbon dioxide

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The purpose of this study is to examine the large-scale tropospheric transport processes and their impact on the seasonal variation of CO_2 in the upper troposphere. The meteorological fields and CO_2 concentration were obtained from the global transport model driven by a nudged general circulation model. The simulated CO_2 distribution is compared with the aircraft measurement over the western pacific. The model well reproduce the observed latitudinal-time CO_2 distributions in the upper troposphere. The largest latitudinal gradient in CO_2 are located around the northern subtropics during northern winter and around the equator from northern mid-winter to spring. Using detailed transport analysis, we discuss the seasonal evolution mechanisms of the latitudinal CO_2 gradient, in which the meridional transport of CO_2 is separated into the mean transport due to Lagrangian mean meridional circulation and the eddy transport due to wave mixing. In the northern extratropics, the eddy transport associated with baroclinic waves carries high concentration CO_2 upward and poleward during autumn and winter. As a result, in the upper troposphere, CO_2 concentration becomes higher with increasing latitude on pressure surfaces during these seasons, since the eddy transport flux is almost parallel to isentropic surface. The mean-meridional circulation decreases the CO_2 concentration in the northern extratropics during winter, but is overcome by the eddy transport from early winter to mid spring. During summer, the convective transport effectively carries low concentration CO_2O from the lower to upper troposphere at northern mid latitude, while the downgradient eddy mixing tends to compensate for this reduction. Our analysis also indicated that the interhemispheric CO_2 transport in the troposphere mainly arises from the Hadley circulation during northern summer, but from the eddy transport during northern winter.