

Role of transport in seasonal variation of the 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 CO₂ concentration in the upper troposphere. The meteorological fields and CO₂ concentration were obtained from the global transport model driven by a nudged general circulation model. The simulated CO₂ distribution is compared with the aircraft measurement over the western pacific and ground-based measurement. The comparison shows that the model well reproduce the observed latitudinal-time CO₂ distributions near the surface and in the upper troposphere.

Strong latitudinal CO₂ gradients are located around the northern subtropics during northern winter and around the equator from northern mid-winter to spring. We discuss the seasonal evolution mechanisms of the latitudinal CO₂ gradient from detailed transport analysis, in which the meridional transport of CO₂ 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 CO₂ upward and poleward during autumn and winter. As a result, in the upper troposphere, CO₂ 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 CO₂ 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 CO₂ 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 CO₂ transport in the troposphere mainly arises from the Hadley circulation during northern summer, but from the eddy transport during northern winter.