Dynamics of Antarctic ozone hole dissipation revealed by balloon and satellite observations

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In order to examine the dynamics of Antarctic ozone hole dissipation processes, an intensive observation was performed using ozonesondes at Syowa Station (39.6E, 69.0S) in June 2003 through January 2004 when the ozone hole was developed into the second largest in the past. Ninety two vertical profiles of ozone were successfully obtained. Observed ozone partial pressure increased earlier at higher altitudes in the dissipation phase of the ozone hole, which is marked contrast with the developing phase when it decreased almost simultaneously in the ozone layer at altitudes of 14–21 km. The earlier ozone recovery at higher altitudes started already in late August, indicating the importance of downward transport by diabatic circulation. Thus, our analysis is focused on the descent rate of a level of a particular ozone mixing ratio (1.0 ppmv) around 20 km for a time period of late September through late October before the polar vortex was broken. Using satellite data by ILAS-II distributed at many longitudes in the Antarctic, it is shown that the descent rate of ozone is not constant zonally in the polar vortex but modified significantly by a dominant quasi-stationary planetary wave. This result suggests that downward transport across the isentropes is faster in particular regions with warm anomaly where the radiative cooling acts effectively. An analysis is extended to the ILAS-II data of N_2O as a long-lived species. The mean descent rate around 20 km (N_2O mixing ratio of 60 ppbv) is 1.6 km month^{-1} which is only half that of ozone (2.3 km month^{-1}), indicating that the ozone is recovered faster than expected by diabatic transport even before the polar vortex breaking. It is also shown from the difference in descent rates between isentropes and N_2O, the radiative heating is about 0.77 K day^{-1} during the time period.