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Determination of Effective Diffusivity and its Role in the Exchange Between the Upper Troposphere and Lowermost Stratosphere

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HIRDLS measurements with 1 km vertical resolution have shown the existence of thin layers (laminae) of low or high ozone mixing ratios on potential temperature () surfaces extending toward high or low latitudes respectively. The contribution of these features to stratosphere-troposphere exchange has been assessed in the uppermost troposphere (340-380K) by zonally averaging ozone mixing ratios on surfaces for each day for the years 2005-2007, using the recently released Version 5 data. These are then compared to similarly averaged potential vorticity (PV) contours and tropopause locations based on Goddard Modeling and Assimilation Office (GMAO) version 5 data. During winter in each hemisphere, it is found that low ozone values at low latitudes are constrained equatorward of the PV = 4 PVU (1 PVU = 10-6 K m2/kg s) contour, while higher values from high latitudes are constrained poleward of the PV = 6 PVU contour. The thermal tropopause lies between these PV contours. The results indicate that the PV contours act as elastic membranes that experience considerable latitudinal deformation under the influence of baroclinic waves, but that permit very little cross contour transport. Calculation of the effective diffusivity, an indicator of the locations and strengths of transport barriers as well as regions of strong mixing, leads to distributions very similar to those shown by Haynes and Shuckburgh's (2000) modeled values, but there are notable inter-annual differences. The values are also in broad agreement with calculations based on runs of the WACCM model. Considering the latitudinal gradients near the barrier, and changes across it, we obtain an estimate of the minimum diffusivity k0 and the absolute value of effective diffusivity, which controls the time scale of cross-tropopause mixing. Calculations of equivalent length at lower altitudes, based on WACCM model runs, indicate weaker barriers, allowing more exchange, consistent with the calculations of Nakamura (2007).