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On the permeability of tropopause in extra-tropics

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Previous studies have shown that meridional transport across the extra-tropical tropopause is stronger in summer than in winter. These studies were based on seasonal means of chemical species' abundances or atmospheric diffusivity in geographic or equivalent latitude coordinates. In this study, we use "tropopause coordinates" with the tropopause determined by 3.5 PVU or -3.5 PVU potential vorticity (PV) in the northern or southern hemisphere, respectively. Carbon monoxide (CO) measurements made by Aura/Microwave Limb Sounder (MLS) and PV in Modern Era Retrospective-Analysis for Research and Application (MERRA) are employed. Our analysis shows that the CO and PV meridional gradients on isentropic surfaces are significantly larger around the extra-tropical tropopause than at other latitudes in both the northern and southern hemisphere in all seasons. The seasonal variations of the largest gradients at the tropopause are relatively small compared to their values, with the gradients are slightly smaller in winter than in summer in both hemisphere. The small seasonal variation of the largest CO meridional gradients around tropopause is due to stronger transport from surface to the upper troposphere in summer than in winter, while the small seasonal variation of the largest PV gradients around the tropopause is due to polarward shifting of the tropopause location between winter and summer. These gradients in "tropopause coordinates" are significantly larger than the seasonal mean gradients in geographic or equivalent latitudes coordinates at the tropopause in both winter and summer seasons. Our analysis of the chemical species and the dynamical tracer PV, shows no indication of strong seasonal variations in the 'permeability' of the tropopause in extra-tropics.