Because chemical lifetimes in the lower stratosphere are long, stratosphere-troposphere exchange (STE) has a large influence on the distribution of trace species in the upper troposphere and lower stratosphere (UT/LS). The mechanisms of STE are not fully understood due to the existence of multiple transport pathways and the episodic occurrence of many exchange events in the UTLS. We present an analysis of tropospheric and stratospheric exchange events observed during the Stratosphere-Troposphere Analyses of Regional Transport 2008 (START08) experiment using kinematic and chemical diagnostics. Trajectory analyses shows that tropospheric intrusions are related to Rossby wavebreaking over the Pacific Ocean. Intruding air masses can be traced back to the tropical UT/LS. In situ chemical observations of the tropospheric intrusions are used to estimate the mixing timescales of the observed intrusions through use of a simple box model and trace species with different photochemical lifetimes. We estimate that the timescale for a tropospheric intrusion to mix with the background stratospheric air is 5 to 6 days. Detailed analysis of small-scale features with tropospheric characteristics observed in the extratropical lower stratosphere suggests frequent irreversible transport associated with tropospheric intrusions. The START08 dataset provides the first direct measurement of moist convective mixing in a stratospheric intrusion (tropopause fold). Synoptic analysis of additional events using high-resolution model analyses and three-dimensional radar reflectivity allow us to develop a schematic of the synoptic features conducive to convective mixing in stratospheric intrusions.