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A nine-year characterisation of Stratosphere-Troposphere Exchange based upon frequency distributions of ozone observations from the satellite instrument Odin-OSIRIS

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In this paper, we present a nine-year characterisation of Stratosphere-Troposphere Exchange (STE) based upon ozone satellite data from Odin-OSIRIS re-mapped on a Potential Vorticity - Potential Temperature (PV-THETA) grid using ECMWF ERA-Interim reanalysis data. All individual ozone data of the existing nine years of ozone retrievals (2002-2010) are mapped to collocated PV and THETA, separately for each season and year. This provides in each point of this grid a frequency distribution of ozone mixing ratios whose properties allow identifying regions of STE. Here, we focus on the highest and lowest centile values, consistently with the rarity of STE while still allowing robust results almost everywhere. Since regions of STE can be identified almost directly from observational data, this method valuably complements existing, mostly model-based, assessments of STE. First centile maps on the PV-THETA grid show that fresh lower-tropospheric air is readily seen above the 2 PVU isoline and upper-tropospheric air is widely found above the 450 K isentrope, well within the stratosphere. Last centile maps highlight where air from the lower stratospheric polar vortex is injected into the upper troposphere / lower stratosphere (UTLS) above the jet streams in the winter hemispheres, and reveal signatures of quasi-isentropic STE from the lower stratosphere to the 340 K isentrope in the troposphere in spring and summer. Histograms of ozone volume mixing ratios in different regions of the atmosphere are also presented and provide a reference against which individual years can be compared. It is found that in the period under study, the year 2005 was exceptional in terms of STE in the SON season, both from the stratosphere to the troposphere and vice-versa.