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## A new look at stratosphere-troposphere exchange: residence-time partitioned flux and mass distributions

Clara Orbe[†]; Mark Holzer; Lorenzo Polvani
[†] Columbia University, USA
Leading author: co2203@columbia.edu

We perform the first diagnosis of stratosphere-troposphere-exchange (STE) that acknowledges that the flux of air from the stratosphere into the troposphere cannot meaningfully be characterized by a single rate. While our calculations are performed using an idealized GCM, the methodology can be applied to any atmospheric circulation model. It is a physical consequence of (eddy-)diffusion that the one-way flux across the tropopause is infinite, due to air that stays arbitrarily short times in the stratosphere. Therefore, the flux across the tropopause must be characterized as a distribution partitioned according to residence time in the stratosphere. Using the boundary propagator formalism, we here diagnose the full distribution of air mass flux into the troposphere across a time-varying tropopause, partitioned according to stratospheric residence time and entry and exit regions at the tropopause. For the ensemble-mean flow, this flux distribution allows us to partition the mass of the stratosphere according to stratospheric residence time and entry and exit locations. From this we quantify important pathways connecting different regions of the tropopause and the associated transport rates and mean residence times. We emphasize that using flux distributions affords insight into STE that is not available from current transport diagnostics, such as mean age and the residual-mean circulation. For example, we show that, while mean age decreases everywhere in the upper stratosphere in response to an increased Brewer-Dobson circulation, the mean residence time of air entering the troposphere increases at certain latitudes, a fact that is not immediately intuitive.