



Global age of air spectrum from the earth surface to the upper troposphere and tropopause: a model study

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Transport of air masses from the surface into the atmosphere occurs via a variety of processes (including clear-air turbulence, atmospheric convection and large-scale circulations), which entails a multitude of transport time scales. This complexity can be characterized in an atmospheric transport model by calculating the age of air spectrum (transit time distribution from the surface). Up to now, mainly the slow time scales of stratospheric and interhemispheric transport (>10 days) have thus been studied. Vertical transport through the troposphere, for which convection is the major player, has only been evaluated using a handful of measured compounds (Radon, CO₂ and SF₆). However, a wealth of chemically relevant species are affected by the detailed structure of the age spectrum. Recent work (Luo et al., 2018) have used this sensitivity in order to gain observational insights into the tropospheric age spectrum, calling for a comparison with models.

To that end, we derive upper tropospheric and tropopause age spectra in the EMAC (ECHAM/MESSy Atmospheric Chemistry) model using the Boundary Impulse Response (BIR) method. Because of the large range of time scales involved in tropospheric transport, which extend from tens of minutes (convective transport) to years (stratospheric intrusions), we rely on a suite of pulses with variable durations providing hourly resolution for short time scales (< 12 hours) and monthly for long ones (> 1 month). We first describe the age spectra obtained and their diurnal and seasonal variability. Then, we examine the transport properties from a few specific surface regions to the upper troposphere and stratosphere, with an emphasis on fast pathways from the tropical Western Pacific and on interhemispheric transport. Finally, we investigate the sensitivity of different transport pathways to changes in some of the available model parameterizations (convection) and to different set-ups (using nudging or not).