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Simulation of Age-of-Air with the Global Climate Model EMAC-ATTILA

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We have extended ATTILA (Atmospheric Tracer Transport in a LAgrangian model), a Lagrangian tracer transport scheme, which is on-line coupled to the global ECHAM/MESSy Atmospheric Chemistry (EMAC) Climate model, with a combination of newly developed and modified physical routines, and new diagnostic and infrastructure submodels. The new physical routines comprise a parametrisation for Lagrangian convection, a formulation of diabatic vertical velocity, and a new submodel to calculate the mixing of compounds in Lagrangian representation. We further use a new diagnostic tool to calculate on-line vertical mass-fluxes through the tropopause level.
We performed two climate simulations in free-running mode with prescribed sea surface temperatures with EMAC-ATTILA in T42L47MA resolution from 1950 to 2010, one with the diabatic and one with the kinematic vertical velocity. Mean age-of-air, the transit time of air parcels in the stratosphere, is a common metric to quantify the overall capabilities of a global model to simulate stratospheric transport. It is calculated from an inert tracer with linearly increasing emissions at the surface. Our simulated age-of-air distribution with the diabatic vertical velocity appears more in accordance with observations, whereas the simulation with the (standard) kinematic vertical velocity shows a too low mean age-of-air. We will show age spectra for different regions and their local trends in the stratosphere. The stratosphere-troposphere exchange is characterized by upward mass fluxes in the tropics and downward mass fluxes in the extra-tropics. The simulation with diabatic vertical velocity captures these typical features with a net upward flux in the tropics between 30°S and 30°N and a net downward flux from 40° to 90° north and south. However, with the kinematic vertical velocity, the mass transport unfortunately appears rather noisy.