Simulation of Age-of-Air with the Global Climate Model EMAC-ATTILA
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Age-of-Air is a measure of the speed of the stratospheric circulation. It is the transit time of a stratospheric air parcel since entering the stratosphere. We applied two ways to calculate Age-of-Air: a) from parcel clocks and b) from an inert synthetic tracer (SF6_AOA), nudged by Newtonian relaxation towards a linearly increasing mixing ratio in the lowest model layer.

We used the Lagrangian advection scheme ATTILA (Atmospheric Tracer Transport in a Lagrangian model, Reithmeier and Sausen, 2002, Brinkop and Jöckel, 2019), a submodel of EMAC (ECHAM/MESSy Atmospheric Chemistry Climate model, Jöckel et al., 2016) with a diabatic vertical velocity scheme and a Lagrangian convection scheme in a transient model simulation from 1950 – 2010 in T42L47MA resolution and with prescribed sea-surface temperatures. The QBO was nudged.

Age-of-Air Compared to Observations
- Zonal mean Age-of-Air at 20 km height from SF6_AOA tracer over the years 2000-2010.
- red: LG(dias) Lagrangian simulation
- green: LG(bin) Lagrangian simulation
- blue: LG(bin) Lagrangian simulation
- Transp: Age from 196 to 20 km, from Waugh and Hall (2002)
- black dashed thin lines: minimum and maximum AoA, respective; thin black line: mean AoA from LG at 20 km from Andrews et al. (2001).

Seasonal Age-of-Air Spectra
Simulated Age-of-Air spectra from
- left) clocks on the Lagrangian air parcels simulated with ATTILA
- right) pulse tracer from a simulation with CLAEMS
- JJA age spectrum: highest frequency for young air → relatively high amount of young air
- DJF age spectrum: lowest frequency of young air, but the distribution is the broadest → less young air is mixed in

Brewer-Dobson-Circulation
Latitude and isentrope zonal bands, for which the mean annual age spectra have been estimated

Mean Annual Cycle of Age Spectra – Origin of Air Masses Dependent on Age

0.5-year old air masses: They come directly from the tropics and there from levels between the tropopause and 500 K.

1-year old air masses: 0.5 years before, the air mass was in the same isentropic level but mainly in the tropics. One year ago the air mass was in the tropics, too, but below 500K.

2.5-year old air masses: They are transported downwards from a broad range of levels between 400K and 1000K. Via the Brewer-Dobson circulation they came originally from the mid-latitudes (2 years old) from the same 500K-600K level, and before from the tropics (1.5 years old) from levels below 600K.

In the polar and mid-latitudes the annual cycle of the Age-of-Air spectrum is different in the 500K-600K height level.
However, the annual cycle of the Age-of-Air spectrum is similar in mid-latitudes at the 400K-500K height level showing a maximum of young air masses in the respective summer months.

References:
Brinkop and Jöckel, ATTILA-4.0: Lagrangian Advection and Convection Transport of Passive Tracers within the ECHAM/MESy Chemistry Climate Model, Geosci. Model Dev. Discuss., http://www.dlr.de/ipa/10.5194/gmd-2018-321, 2019