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Stratospheric lifetime ratio of CFC-11 and CFC-12 from satellite and model climatologies

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Chlorofluorocarbons (CFCs) play a key role in stratospheric ozone loss and are strong infrared absorbers that contribute to global warming. The stratospheric lifetimes of CFCs are a measure of their stratospheric loss rates that are needed to determine global warming and ozone depletion potentials. We applied the tracer-tracer correlation approach to zonal mean climatologies from satellite measurements and model data to assess the lifetimes of $CFCl_3$ (CFC-11) and CF_2Cl_2 (CFC-12). We present new estimates of the CFC-11/CFC-12 lifetime ratio and the absolute lifetime of CFC-12, based on a reference lifetime of 52 yr for CFC-11. We analyzed climatologies from three satellite missions, the Atmospheric Chemistry Experiment-Fourier Transform Spectrometer (ACE-FTS), the HIgh Resolution Dynamics Limb Sounder (HIRDLS), and the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS). We found a CFC-11/CFC-12 lifetime ratio of 0.47 ± 0.08 and a CFC-12 lifetime of $112(96-133)$ yr for ACE-FTS, a ratio of 0.46 ± 0.07 and a lifetime of $113(97-134)$ yr for HIRDLS, and a ratio of 0.46 ± 0.08 and a lifetime of $114(98-136)$ yr for MIPAS. The error-weighted, combined CFC-11/CFC-12 lifetime ratio is 0.46 ± 0.04 and the CFC-12 lifetime estimate is $113(103-124)$ yr. These results are in excellent agreement with the recent Stratosphere-troposphere Processes And their Role in Climate (SPARC) reassessment, which recommends lifetimes of $52(43-67)$ yr for CFC-11 and $102(88-122)$ yr for CFC-12, respectively. Having smaller uncertainties than the results from other recent studies, our estimates can help to better constrain CFC-11 and CFC-12 lifetime recommendations in future scientific studies and assessments. Furthermore, the satellite observations were used to validate first simulation results from a new coupled model system, which integrates a Lagrangian chemistry transport model into a climate model. For the coupled EMAC/CLaMS model we found a CFC-11/CFC-12 lifetime ratio of 0.48 ± 0.07 and a CFC-12 lifetime of $110(95-129)$ yr, based on a ten-year perpetual run. Closely reproducing the satellite observations, the new model system will likely become a useful tool to assess the impact of advective transport, mixing, and photochemistry as well as climatological variability on the stratospheric lifetimes of long-lived tracers.

Reference:

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