EGU21-4995
https://doi.org/10.5194/egusphere-egu21-4995
EGU General Assembly 2021

New Fractional Release Factors, Ozone Depletion Potentials, and Lifetimes for Four Long-Lived CFCs: CFC-13, CFC-114, CFC-114a, and CFC-115

Elinor Tuffnell[1,2], Johannes Laube[2], Emma Leedham Elvidge[4], Bill Sturges[5], Karina Adcock[1,5], Paul Fraser[3], Paul Krummel[3], Ray Langenfelds[3], Dave Oram[1,5,6], Eric Fleming[7,8], Qing Liang[7], and Thomas Roeckmann[9]

[1]The University of East Anglia, Environmental Science, Norwich, United Kingdom of Great Britain – England, Scotland, Wales (e.tuffnell@uea.ac.uk)

[2]Institute of Energy and Climate Research: Stratosphere, Jülich Research Centre, Jülich, 52428, Germany.

[3]Climate Science Centre, CSIRO Oceans and Atmosphere, Aspendale, Victoria, Australia.

[4]Faculty of Science, University of East Anglia, Norwich Research Park, Norwich, NR4 7TJ, UK.

[5]Centre for Ocean and Atmospheric Sciences, School of Environmental Sciences, University of East Anglia, Norwich, UK.

[6]National Centre for Atmospheric Science, School of Environmental Sciences, University of East Anglia, Norwich, UK.

[7]NASA Goddard Space Flight Center, Greenbelt, MD, USA

[8]Science Systems and Applications, Inc., Lanham, MD, USA.

[9]Institute for Marine and Atmospheric research Utrecht (IMAU), Utrecht University (UU), Utrecht, the Netherlands.

Knowing the stratospheric lifetime of an Ozone Depleting Substance (ODS), and its potential depletion of ozone during that time, is vital to reliably monitor and control the use of ODSs. Here, we present improved policy-relevant parameters: Fractional Release Factors (FRFs), Ozone Depletion Potentials (ODPs), and stratospheric lifetimes, for four understudied long-lived CFCs: CFC-13 ($CClF_3$), CFC-114 ($CClF_2CCCLF_2$), CFC-114a (CCl_2FCF_3), and CFC-115 (C_2ClF_5). Previously derived lifetime estimates for CFC-114 and CFC-115 have substantial uncertainties, while lifetime uncertainties for CFC-13 and CFC-114a are absent from the peer-reviewed literature (Carpenter & Danie *et al*, 2018).

This study used both observational and model data to investigate these compounds and this work derives, for the first time, observation-based lifetimes utilising measurements of air samples collected in the stratosphere. We also used a version of the NASA Goddard Space Flight Center (GSFC) 2-D atmospheric model driven by temperature and transport fields derived from MERRA/MERRA-2 reanalysis.

FRFs for these compounds, which had been lacking until now, were derived using stratospheric air samples collected from several research flights with the high-altitude aircraft M55-Geophysica, and the background trend from archived surface air samples from Cape Grim, Tasmania.

By using a previously-published correlation between lifetime and FRF for seven well-characterised compounds (CF_4, C_2F_6, C_3F_8, CHF_3, HFC-125, HFC-227ea and SF_6), we were able to derive lifetimes

for these four new species. Lifetime estimates for CFC-114a agreed within the uncertainties (agreement to one sigma) with the lifetime estimates compiled in Burkholder *et al*. (2018), while the one for CFC-114 agreed within 2 sigma (measurement-related uncertainties) with those cited in Burkholder *et al*. (2018). However, observation-based lifetimes for CFC-13 and CFC-115 only agreed with those in Burkholder *et al*. (2018) within 3 sigma. The lifetime uncertainties in this study were reduced compared to those in Carpenter & Danie *et al* (2018).

As our lifetime estimates for these latter two compounds are notably lower than previous estimates, this suggests that these two compounds may have had greater emissions than previously thought, in order to account for their abundance. It also implies that they will be removed from the atmosphere more quickly than previously thought.

New ODPs were derived for these compounds from their new lifetimes and FRFs. Since for two of these compounds (CFC-13 and CFC-114a), there is an absence of observation-derived ODPs in the peer-reviewed literature, this is new and relevant information. The ODPs for CFC-114 and CFC-115 are comparable with estimates from the most recent Scientific Assessment of Ozone Depletion (Burkholder *et al*., 2018). Providing new and updated lifetimes, FRFs and ODPs for these compounds will help improve future estimates of their tropospheric emissions and their resulting damage to the stratospheric ozone layer.

References

Burkholder *et al*. (2018). Appendix A, Table A-1 in *Scientific Assessment of Ozone Depletion: 2018, Global Ozone Research and Monitoring Project*, Report No. 58, World Meteorological Organization, Geneva, Switzerland, http://ozone.unep.org/science/assessment/sap.

Carpenter, L.J., Danie, J.S. *et al* (2018). Scenarios and Information for Policymakers Chapter 6, Table 6-1 in *Scientific Assessment of Ozone Depletion: 2018, Global Ozone Research and Monitoring Project*, Report No. 58, World Meteorological Organization, Geneva, Switzerland.