An Evaluation of C_1-C_3 Hydrochlorofluorocarbon (HCFC) Metrics: Lifetimes, Ozone Depletion Potentials, Radiative Efficiencies, Global Warming and Global Temperature Potentials

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Hydrochlorofluorocarbons (HCFCs) have been used as chlorofluorocarbon (CFC) substitutes in a number of applications. Although HCFCs have lower ozone depletion potentials (ODPs) compared to CFCs, they are potent greenhouse gases. The twenty-eighth meeting of the parties to the Montreal Protocol on Substances that Deplete the Ozone Layer (Kigali 2016) included a list of 274 HCFCs to be controlled under the Montreal Protocol. However, from this list, only 15 of the HCFCs have values for their atmospheric lifetime, ODP, global warming potential (GWP), and global temperature potential (GTP) that are based on fundamental experimental studies.

Here, we present a comprehensive evaluation of the atmospheric lifetimes, ODPs, radiative efficiencies (REs), GWPs, and GTPs for all 274 HCFCs to be covered under the Montreal Protocol. In the absence of direct laboratory studies, atmospheric lifetimes were estimated based on HCFC reactivity with hydroxyl (OH) radicals and signlet oxygen ($O(^1D)$), as well as their removal by ultraviolet (UV) photolysis using structure activity relationships and reactivity trends. ODP values are based on the semi-empirical approach. Radiative efficiencies were estimated, based on infrared spectra calculated using theoretical electronic structure methods. GWPs and GTPs were calculated using our estimated atmospheric lifetimes and REs.

This study provides a consistent set of HCFC metrics in support of the Montreal Protocol. We emphasize that accurate metrics for a specific HCFC, if desired, require direct fundamental laboratory studies to better define the OH reactivity and infrared absorption spectrum of the compound of interest.

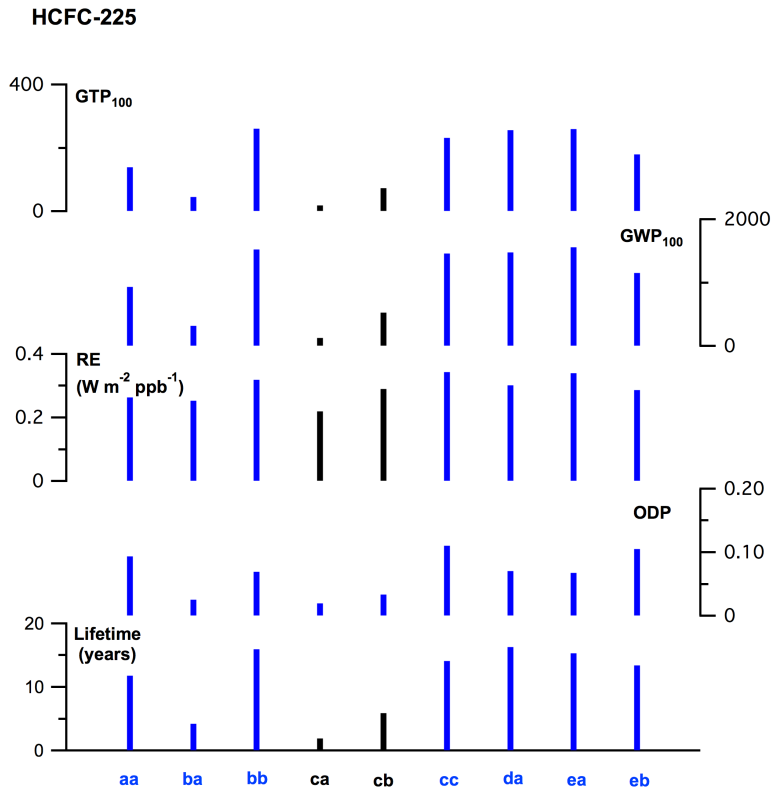

Figure 1. HCFC-225 example of isomer metric dependence. Isomers in blue values were calculated in this study, while isomers in black were derived from available experimental data.