Technical Corrections
Manuscript ACP-2018-27
Global Warming Potential Estimates for the C_1-C_3 Hydrochlorofluorocarbons (HCFCs) Included in the Kigali Amendment to the Montreal Protocol, Papanastasiou et al.

Co-Editor Decision: Publish subject to technical corrections (13 Apr 2018) by Andreas Engel
Comments to the Author: in general I am happy with most of the answers to the reviewers comments. However, inmany places, comments by the reviewers could have been accounted for by adding short clarifications in the text. This is particularly true for many comments by rev. #1. I suggest to add a few more additions to the text to react to the reviewer comments. I consider this to be "technical corrections". Please revise the manuscript further based on the following reviewer comments which were acknowledged but no action was taken. This was especially true for the following comments:

Author Response: We are glad that the manuscript has been accepted for publication in ACP. We have addressed the mostly tutorial "technical corrections" in a revised manuscript as requested by the editor and described below.

Editor Comment: Abstract: I think it would be good to stress even more that what is derived here are estimtes and that these can be used as proxies in the absnce of experimantal data, in line with rev. #1 comments.

Author Response: The manuscript was revised to include "estimates" in the title, which provides the basis for a strong emphasis that the manuscript provides estimated metrics. In this set of revisions, we have further revised the abstract text as follows: "The results from this study provide estimated policy relevant GWP metrics for the HCFCs included in the Montreal Protocol in the absence of experimentally derived metrics.

Editor Comment: With respect to Rev. #1 comment on FRF (p.6. l. 37 of your response file): I agree that a short sentence stating what FRF describes would be beneficial. The same is true for ODP, GWP and GTP. This would enhance the readability of the manuscript.

Author Response: We have included tutorial statements in several locations in the manuscript. In this set of revisions, we have added the following (added reference given below):

In the introduction, the first mention of GWP: This necessitates knowledge of the global warming potentials (GWPs), a policy relevant metric representing the climate impact of a compound relative to CO_2, of all HCFCs involved in the baseline formulae.

In the introduction, the first mention of ODP and GTP: "The objective of the present work is to provide a comprehensive evaluation of the atmospheric lifetimes, ozone depletion potentials (ODPs), which represents the ozone depleting impact of a compound relative to a reference compound (see WMO (2014) and references within), GWPs, and global temperature change potentials (GTPs), another policy relevant metric representing the climate impact of a compound relative to CO_2, for the HCFCs listed in Annex C of the amended Protocol.

In section 2.2, the first mention of FRF: "*.. f* is the molecules fractional release factor (FRF), which denotes the fraction of the halocarbon injected into the stratosphere that has been dissociated (Solomon and Albritton, 1992), …".

Solomon, S., and D. L. Albritton, Time-dependent ozone depletion potentials for short- and long-term forecasts, Nature, 357, 33-37, 1992.

Editor Comment: With respect to Rev. #1 comment on band below 500 cm-1 (p.8, l. 5 of your response files): please include the blackbody emission of the earth in this argumentation as suggested by the reviewer.

Author Response: We have gone to great lengths in our work to present the relationship between the molecules infrared absorption spectrum and the irradiance profile in the supporting information files. The SI files for each of the molecules included in this study show graphically the irradiance profile (taken from Hodnebrog et al.), the molecules infrared absorption spectrum, and the calculated wavelength dependent radiative efficiency of the molecule. This clearly illustrates the relative importance of the <500 cm-1 region to the molecules radiative efficiency, which as we point out in the text is minor. To address this further we have added the following text in this section to the revised manuscript: "The contribution of vibrational bands in this region to the RE is quantified in our calculations and is usually minor, i.e., <1%. The Earth's irradiance profile, HCFC infrared

absorption spectra, and HCFC radiative efficiency spectra for each HCFC included in this study are included in the Supplementary Material (see Section 5)."

Editor Comment: With respect to Rev. #1 comment on RE (p.10, l. 14 and 22 of your response files): please add the statement that this can only be done when measured accurate spectra are available.

Author Response: We have clarified the text by adding the following: "Note that molecules with strong absorption features near the large CO_2 and O_3 dips in the Earth's irradiance profile would have a greater sensitivity to shifts in the spectrum. In such cases, direct laboratory studies would be invaluable in the determination of the molecules radiative properties."

Editor Comment: With respect to the comment from rev.#2 about the use of FRF factors. the new FRF values presented in the papers by Leedham Elvidge and by Engel et al. are in most cases not very different from those used here. I would suggest to add a brief statements that a new method to calculate FRF values has been suggested by Ostermoeller et al. and applied by the two papers by Leedham Elvdige and Enge and that the general relationship between FRF and stratospheric lifetime is not laregely different (you might want to discuss the differences and include these as additional uncertainties).

Author Response: We agree with the Editor that the relationship between FRF and stratospheric lifetime developed in our work is not largely different from these recent publications. In response to another Editor comment, we have inserted a description of what FRF means and cited the paper by Solomon and Albritton (1992). In section 2.2 we have added the additional text which cites these recent papers as follows: "The fractional release factor and global lifetime for CFC-11 were taken from the WMO (2014) ozone assessment report to be 0.47 and 52 years, respectively. Note that a new method to calculate FRF has been suggested by Ostermoeller et al. (2017a,b), which has been applied by Leedham Elvdige et al. (2018) and Engel et al. (2018). Overall, there is good agreement between the new method and the empirical parameterization applied in this work.". The estimated uncertainties associated with our empirical parameterization have been addressed in our semi-empirical ODP estimate analysis.

New references:

Ostermoller, J., Bönisch, H., Jöckel, P., and Engel, A.: A new time-independent formulation of fractional release, Atmos. Chem. Phys., 17, 3785-3797, doi:10.5194/acp-17-3785-2017, 2017a.

Ostermoller, J., Bönisch, H., Jöckel, P., and Engel, A.: Corrigendum to "A new time-independent formulation of fractional release" published in Atmos. Chem. Phys., 17, 3785-3797, Atmos. Chem. Phys., 17, 3785-3797, doi:10.5194/acp-17-3785-2017-corrigendum, 2017b.

Leedham Elvidge, E., Bönisch, H., Brenninkmeijer, C. A. M., Engel, A., Fraser, P. J., Gallacher, E., Langenfelds, R., Mühle, J., Oram, D. E., Ray, E. A., Ridley, A. R., Röckmann, T., Sturges, W. T., Weiss, R. F., and Laube, J. C.: Evaluation of stratospheric age of air from CF_4, C_2F_6, C_3F_8, CHF_3, HFC-125, HFC-227ea and SF_6; implications for the calculations of halocarbon lifetimes, fractional release factors and ozone depletion potentials, Atmos. Chem. Phys., 18, 3369-3385, doi:10.5194/acp-18-3369-2018, 2018.

Engel, A., Bönisch, H., Ostermoller, J., Chipperfield, M., Dhomse, S., and Jöckel, P.: A refined method for calculating equivalent effective stratospheric chlorine, Atmos. Chem. Phys., 18, 601-619, doi:10.5194/acp-18-601-2018, 2018.

Editor Comment: With respect to reviewer#3 comment to table 1 (p. 17, l. 9 in your author response), I suggest to mention briefly in the manuscript that different IR spectra are sometimes available and that a subjective choice has been made and give some reasoning on the choice.

Author Response: Our response (actually p. 18, l. 9). As stated in our previous response, differences among various reported infrared absorption spectra are usually minor. We have used data from our laboratory, the reliable measurements from Orkin et al., and the spectra reported in the highly reliable PNNL database whenever possible. We have added the following text to the * footnote to Table 1: "Where multiple sources for infrared spectra are available, the spectra reported from the NOAA laboratory (McGillen et al., 2015) and the PNNL database (Sharpe et al., 2004) were used in the analysis."

Editor Comment: With respect to reviewer#3 comment to p.10, l. 9-11 of the original manuscript: I suggest to include some reasoning for the way that the broadening has been calculated.

Author Response: The original reviewers comment was addressing whether including band broadening was an uncertainty or a sensitivity analysis. The text below, taken from the manuscript clearly states that the motivation

for including broadening was to achieve better agreement with actual infrared absorption spectra. Although agreement is better, the functional form of the infrared band shape may not be Gaussian.

"The calculated spectra were broadened using a Gaussian broadening function with a FWHM (full width at half maximum) of 20 cm^{-1}, which reproduces the training dataset spectra reasonably well and provides a more realistic representation of the spectrum and overlap with Earth's irradiance profile. Note that the Gaussian broadening function may not necessarily be an accurate representation of the actual vibrational band shape."