RIGC, Yokohama, Japan

November 16, 2010

Dear Anonymous Referee 1,

Thank you for your comments on the paper *"Emission location dependent ozone depletion potentials for very short-lived halogenated species"*.

We have addressed your concerns expressed in your general comments:

1) We have included more discussion about the uncertainties in order to put the ODP values into into perspective. On one hand, the introduction of the convective parametrisation enhances the ODP values. However, without convection and for midlatitudes / high latitudes our estimates are largely within the order of magnitude of those from Wuebbles (2010), the exception being the Asian monsoon season in 2001. The calculated values, as discussed in the text are subject to the validity of the simplifying approximations, including the ones for stratospheric chemistry. Our main result is to stress the dependency on location, which can be calculated at high resolution using the trajectories.

As for the influence of the convective parametrisation, it is based on Emanuel parametrisation implemented in FLEXPART 6.2 [1]. We agree that large uncertainties remain. It is also possible the results would change if we had used other convective parametrisations convective parametrisation. Wuebbles et al used MOZART driven by CCM3 winds. Moist convection in the CCM3 includes the deep convection scheme developed by Zhang and McFarlane (1995) [2], which operates in conjunction with the scheme of Hack (1994) [3].

Tost et al. (2010) [4] compared different convective parametrisation schemes in a global CTM. showing that the choice of the convection parameterisation in a global model of the chemical composition of the atmosphere has a substantial influence on trace gas distributions. In figure 2 of Tost et al. (2010), it is apparent that Emanuel parametrisation injects more mass across the 250 mb surface in the tropics. For example panel b) shows differences of the order of 100% for ^{222}Rn between Zhang and McFarlane and Emanuel above 200 mb. Increased injected mass across the 400 K surface in the tropics may be among the causes

[1] Forster, C., Stohl, A., and Seibert, P.: Parameterization of convective transport in a Lagrangian particle dispersion model and its evaluation, J. Appl. Meteorol. Climatol., 46, 403–422, doi 10.1175/JAM2470.1, 2007.

[2] Zhang, G. J., and N. A. McFarlane, 1995: Sensitivity of climate simulations to the parameterization of cumulus convection in the Canadian Climate Centre general circulation model. Atmos.-Ocean,33, 407-446.

[3] Hack, J. J., 1994: Parameterization of moist convection in the National Center for Atmospheric Research Community Climate Model (CCM2). J. Geophys. Res.,99, 5551-5568

[4] Tost, H., Lawrence, M. G., Brühl, C., Jöckel, P., The GABRIEL Team, and The SCOUT-O3-DARWIN/ACTIVE Team: Uncertainties in atmospheric chemistry modelling due to convection parameterisations and subsequent scavenging, Atmos. Chem. Phys., 10, 1931-1951, $doi : 10.5194/acp - 10 - 1931 - 2010$, 2010.

for the larger ODP estimated in the tropics. Another possible cause is a possible underestimation of the total ozone destroyed by CFC-11. In fact, CFC effect in the stratosphere is estimated using a full description of the stratospheric turnover of the injected masses yielding an expected residence time depending on the latitude and height, rather than a simple global mean residence time. CFC is modelled as being activated above 30 mb, but at this height the expected residence estimated is rather a lower boundary since we have used a 20 year trajectory calculation and at this height trajectories may remain in the stratosphere for longer periods. A full assessment of the stratospheric expected residence time and age of stratospheric air would be advisable to address such an uncertainty.

The changes introduced in the text are as follows:

"The inclusion of the convective parameterization in the FLEXPART trajectory code clearly has a significant impact on our results and may go some way to improving the representation of transport based on large-scale trajectories alone. Nevertheless, large uncertainties remain and it would be interesting to repeat the present experiment with different convective parametrisations. It is also possible the results would change if we had used other convective parametrisations Wuebbles 2010 used MOZART driven by CCM3 winds. Moist convection in the CCM3 includes the deep convection scheme developed by Zhang (1995) which operates in conjunction with the scheme of Hack 1994. Tost (2010) compared different convective parametrisation schemes in a global CTM, showing that the choice of the convection parameterisation in a global model of the chemical composition of the atmosphere has a substantial influence on trace gas distributions. In figure 2 of Tost (2010), it is apparent that Emanuel parametrisation injects more mass across the 250 mb surface in the tropics than the scheme of Zhang and McFarlane. For example panel b) shows differences of the order of 100% for ^{222}Rn between Zhang and McFarlane and Emanuel above 200 mb. Increased injected mass across the 400 K surface in the tropics may be among the causes for the larger ODP estimates in the tropics respect to Wuebbles(2009,2010) in addition to uncertainties related to the treatment of the stratospheric chemistry. It is worth to remark that the divergences appear mainly within the tropical belt and with the Emanuel parametrisation since our values for midlatitudes driven with ERA Interim winds and those in Wuebbles(2009,2010) are of a comparable order of magnitude. "

We intend to stress the strong sensitivity of the calculation to the parametrisation (which is not completely surprising) rather than develop a new, fully accurate convective parametrisation. The main result of this work is the assessment of the spatial and temporal pattern in the distribution of ODPs.

2) The derivation of the equations has been made clearer. We have explained the role of the different ζs:

"The efficiency factors ζ_X^{SG} and ζ_X^{PG} are included since the ozone depletion resulting from the halogen released by breakdown of source gases or product gases will not depend only on the residence time $T_X^{\mathrm{active}}(x_{\mathrm{e}}, t_{\mathrm{e}})$ but also on details of where exactly the halogen is released and on its subsequent path through the stratosphere. For the remainder of this paper ζ_X^{SG} and ζ_X^{PG} are both taken to be equal to 1 (but they could be estimated more precisely from a suitable model calculation). ”

We have also explained more clearly the explicit assumptions regarding the representation of the factor ζ in our calculations with an active fraction χ depending on time and location along the trajectories:

“Therefore we simply set $T^{\text{active}}_{\text{CFC}-11}$ to be a constant value equal to the stratospheric residence time from a starting point in the tropical middle stratosphere, corresponding to an assumption that the production of active chlorine from the partial breakdown of the CFC−11 occurs only at this point. ”

In the original definition, from Solomon and Albritton (1992), the fraction destroyed is molar fraction in the stratosphere, but corresponds to mass fraction released in the troposphere. One can be obtained from other by multiplying by a constant.

“Here $r^{\text{SG}}_X(x_{\text{e}}, t_{\text{e}})$ and $r^{\text{PG}}_X(x_{\text{e}}, t_{\text{e}})$ respectively are the mass fractions of the source and product gases that reach the stratosphere. Mass fractions are converted into molar fractions by the quotient $\frac{M_{\text{CFC}-11}}{M_X}$ of molecular masses of CFC-11 and X. ”

Specific comments:

p. 16286, l.14: The factors are mentioned explicitly(for both factors $r^{\Omega}_X(y, s, x_{\text{e}}, t_{\text{e}})$ and $T^{\text{active}}_X(y, s)$).

p. 16292, l.19: The ODP should be a number that is useful for decision makers. In an ideal situation we would have complete knowledge of the system. As we lack information we need to make assumptions, which introduce uncertainty. We believe that, in this case, it is better to acknowledge rather that ignore the uncertainties associated with the parametrisation of vertical convective transport. This may lead to a range of estimates between the bounds of current uncertainties. In our opinion this is a more realistic reflection of our state of knowledge at the current time. Of course policy makers can be provided the best estimate within this range.

p. 16296, l.23: We have given a hint for such calculation (e.g. considering the wind fields from a climate model).

Technical corrections Affiliations, p. 16277: OK

p. 16285, l.5: The sentence has been split.

p. 16289, l.28: OK

Fig. 3: The caption has been modified.

Yours sincerely,

The authors