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Atmospheric Chemistry and Physics
Discussions

# *Interactive comment on* "A new time-independent formulation of fractional release" *by* Jennifer Ostermöller et al.

**Anonymous Referee #1**

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**General:**
A new definition of the fractional release factor (FRF) is proposed. It takes into account the fact that chemical loss during transport changes the weighting of different transit times. Consequently, a slightly changed definition of the reference tracer is proposed to quantify chemical loss in the stratosphere. The biggest advantage of the new FRF is that it removes some undesirable dependence on the trends of the considered species. This fact is validated with the model where halocarbons with idealized sources without trends as well as with realistic sources and trends are implemented. This important contribution is supported by well-performed figures. However, the way of explaining this approach has to be improved (see major point). Also the disadvantages of the new definition (the reference tracer is difficult to understand) are not discussed. I think that the very experienced co-authors could help to do this job. The paper may be



acceptable after a major revision improving these points.

**Major points:**

1. All definitions of the fractional release factors $f$ (FRF) have the form

$$f = \frac{R - \chi}{R} \tag{1}$$

with $R$ being a kind of reference and $\chi$ denoting the mixing ratio of the considered species. All quantities are space-time functions, i.e. of $(r, t)$.

The first possible choice for the reference function $R$ is (your relations (1) and (2) following Salomon and Albritton, 1992):

$$R(r, t) = \chi_E(t - \Gamma(r, t)) \tag{2}$$

with $\chi_E(t) = \chi(r = r_E, t)$ where $r_E$ means the entry point like the tropical tropopause. However, to simplify arguments I would recommend to use the Earth's surface where trends of all relevant species are known. The second possible choice according to Newman et al., 2007 is (your eq. (8)):

$$R(r, t) = \int_0^\infty \chi_E(r, t - \tau) G(r, t, t - \tau)\, d\tau\,. \tag{3}$$

Note that (3) reduces to (2) only for a linear tracer (Hall 1994). Furthermore, definition (2) is very simple to use because only the knowledge of the mean age $\Gamma$ is necessary.

The third choice is your relation (19), i.e.:

$$R(r, t) = \int_0^\infty \chi_E(t - \tau) G_N^*(r, t, t - \tau)\, d\tau\,. \tag{4}$$

Even if you get much better agreement with your idealized species without any trends, the interpretation of (4) is much less clear than for (2) and (3). The reference functions (2) and (3) can be understood as passively transported “reference species”. This type of interpretation is much more difficult for definition (4).

My main criticism is that it is very difficult to get a clear picture what you did. I would recommend to rewrite both introduction and section 2. Even if I am familiar with the concept of age spectrum it was difficult for me to follow your arguments (and your notation).

**Minor points:**

1. Abstract and Introduction
   “steady state” - This is one of the central concepts related to the FRFs. FRFs should be independent of time even if the emissions have a trend and the dynamics (Brewer-Dobson circulation) is changing. You should more carefully introduce this concept. E.g. it is important to explain that the effect of changing dynamics cannot be removed and the effect of changing emissions should be removed and why it is so difficult to do it. All the definitions of $R$ as a ratio remove the dependence on emissions, or not ?. If not why ?
2. Abstract (L. 5)
   “for a given atmospheric situation” - do not understand what you want to say in context of “steady state”
3. Abstract (L. 8)
   “current formulation” - it is difficult to understand without reading the paper what you mean here
4. Abstract (L. 8)
   “tropospheric trends” - difficult to understand, maybe “trend in the emissions”



5. Abstract (L. 10)
   “reduces the time-dependence in correlations” - even after reading the paper I do not understand what you mean here. For me “reduces the time-dependence in FRFs” would be enough.
6. Introduction (P. 1, L. 20)
   ...which intensify ozone destruction. (sounds better for me)
7. Introduction (P. 2, L. 3)
   ...when the ODS are completely depleted.
8. Introduction (P. 2, L 14)
   “tropospheric trends”: I would recommend to use “trends in the emissions” instead of “tropospheric trends” that does not sound very clear to me. Here is also the place where the concept of “steady state” should be explained in all details (see my first minor comment)
9. Introduction (P. 2, L 18)
   “current formulation” - please explain it more detailed (widely used method of calculation, especially for the calculation of ODS (citations...)
10. Introduction (P. 2, L 32)
    It is purpose of this paper to find a steady state formulation... - here you can see, how important is it to understand first why steady state formulation is so important
11. Section 2
    I would recommend, to reformulate following my “major point”
12. Section 3
    Starting from here, paper really improves

13. General question
    Following your procedure, you significantly reduce the time dependence of the FRF calculated with realistic emissions. However, it seems to be like a “magic effect” without any deeper explanation why it works. Including chemistry into the age spectrum calculation is a formal step, but once again, all definitions of FRFs which are relative definitions (see my major point) should be independent on the trends of emissions.

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