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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A new formulation of equivalent effective stratospheric chlorine (EESC)" *by* P. A. Newman et al.

M. Weber (Referee)

weber@uni-bremen.de

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1 General comments

This paper reports on a refined calculations of the EESC (Equivalent Effective Stratospheric Chlorine) which has been widely used as a measure of the stratospheric halogen loading. The EESC has been an important parameter to assess the past ozone depletion as well as to predict future evolution of the halogen loading according to some emission scenario and its impact on ozone. With the levelling off and starting slow decline of the halogen laoding, there is a large interest in evaluating how ozone is expected to recover in the next decades. The EESC itself is derived from source

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gas concentrations at the surface (or better tropical tropopause, the stratospheric entry point, neglecting the short transport scales in the troposphere). The amount of Cly and Bry in any part of the upper atmosphere is then determined by taking into account transport times, stratopheric source gas amounts (relative to CFC-111), and release rates for halogens from the source gas.

As summarised in the most recent WMO assessment 2006, many ozone trend studies started to estimate the EESC trend in past ozone (as one of many factors contributing to ozone variability) replacing the more common downward linear trend as reported in earlier studies. They mostly used the *classic* EESC that assumes a simple time shift of 3 years with respect to the source gas concentrations. As the authors show in this paper and also Newmann et al. (2006), this is not valid at least for high latitudes, where stratospheric mean age approaches five to six years, thereby, shifting the EESC peak from around 1997 to 2000 and slightly later.

In this paper the authors refine the EESC calculation by replacing the simple time shift in source gas concentrations (relative to the tropospheric values) by a more sophisticated calculation of transport times (accounting in addition to mean age-of-air also for the age distribution) and locally varying stratospheric fractional release rates. The largest uncertainties in the EESC calculation comes from the fractional release rates that are indirectly inferred from stratospheric mean age that are derived from rather sparse tracer observations.

In the first part of the paper the refined EESC calculations are presented and the impact of uncertainties in various parameters like mean age-of-air, fractional release rates, age spectrum, bromine alpha, and others on EESC are discussed. In the second part of the paper, the impact of the EESC calculation on expected recovery dates (with respect to halogen levels in 1980) and their uncertainties are discussed. One important point made here is that the mean air age is probably time dependent and is believed to get younger by climate change due to a faster stratospheric circulation as was also discussed by Austin and Li (2006).

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Overall the paper is well written and figures are clearly presented. Before final acceptance, there are few points which should be addressed to further improve the paper.

2 Major points

Abstract. I find that the abstract is not well summarising the content of the paper. It mostly focuses on the second part of the paper which investigates the impact of the EESC calculations and their uncertainties on recovery dates. A few more words on the first part regarding the EESC calculation and the major uncertainties associated with the input parameters, in particular the release rates, would balance the abstract more towards what is in the paper.

Introduction, p. 3966, 2nd para. In this paragraph the use of the EESC curve in ozone trend studies are briefly summarised. An important point here is that most of the trend studies as reported in the WMO assessment 2006 used the *classic* EESC that assumes a peak in the stratospheic halogen burden in around 1997. This should be more clearly stated here, since it motivates re-evaluating the EESC as done in this paper.

p. 3969, lines 1-3; p.3970, paragraph starting im line 22; p. 3972, paragraph after line 25. In these paragraphs the calculation of fractional release rates and their uncertainties are described and discussed. This is a very important part of the paper, since as the authors state, the largest uncertainties in the EESC prediction, comes from uncertainties in the fractional release rates that are, somehow, derived from the mean age-of-air and/or stratospheric lifetime. A more detailed description how the fractional release rates are determined should be given here (not merely citing Newman et al.. 2006 as done on p. 3969). In Newman et al. 2006, the reader is then referred to Schauffler et al., (1999 and 2003) regarding the released fractions from ODS. The authors should provide a clearer summary of the fractional release rate calculations in

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this paper. Did they do something different than Schauffler et al. (2003)? What are the author's additions to Schauffler's work? On p. 3973, the authors discuss the possible source of errors in the different release rates, on one hand from Schauffler et al. (2003) and Solomon and Albritton (1992). They claím that transport uncertainties in the 2D model as used by Solomon and Albritton (1992) unlikely explain the differences in the release rates to the *observed* values from Newman and Schauffler. It is known that models have their problems in getting transport and circulation right and also models have evolved with changes in chemistry and dynamics since the early 1990s. Plerase clarify.

3 Minor points

p. 3964, line 23: There were several adjustments to the Montreal protocol (change adjustment to adjustments)

Introduction, p. 3965, lines 18-29: I have some problems with understanding properly the second metric for ODS emission scenarios. How is the *relative integrated changes in EESC between 1980 and a later time* used as a metric? Some rephrasing would be helpful here.

p. 3966, line 7: order of citations for Stolarski et al. 2006a and 2006b should be switched.

p. 3968, line 23-24: Shouldn't it be Eq. 4 rather than Eq. 1?

p. 3981, line 2: The choice of 1980 as a reference date for recovery levels may not be as arbitrary as it seems. 1980 is roughly (rounded to a decade) the start of the satellite era in ozone measurements.

Table 1: Very little information is given on the origin of the stratospheric lifetime. A few

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more words than just *Jackman, private communication* would be helpful here.

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