

Interactive comment on “Atmospheric observation-based global SF₆ emissions – comparison of top-down and bottom-up estimates” by I. Levin et al.

Anonymous Referee #1

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This paper is an excellent account of the application of consistent high quality long term records of atmospheric SF₆ to calculate global emissions of this gas with a comparison based on a box model to simulate atmospheric distribution using emissions estimated from production and usage. The authors prove that the measurements are necessary to check global emissions of this very inert heavy gas that because of its electronegative properties is used in high voltage switching gear, but by the very same properties can be measured by electron capture down to very low levels and as shown here with considerable precision. To obtain long term consistent, traceable records is a major achievement.

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Like once Dr. Clarisa Spivakovsky referred to MCF in decline with reference to assessing OH abundance, something like “last services of a parting friend” we shall speak here about “continuing service of a long lived undesired guest” But getting rid of certain types of guests is very difficult, particularly when the counting is not done properly, and they appear at important venues without invitation.

The authors and all those involved in acquiring and applying these experimental data are to be congratulated. Below are the reviewer’s comments that hopefully help to refine their manuscript.

The title perhaps should be changed, as in its present form, consisting of two statements, it is not optimal. “Observations” perhaps should be reserved for remote sensing, whereas here we deal with GC measurements. The first statement is too cryptic, and on its own illegible. The second statement suggests the reader that comparisons are made between two different types of estimates in general. Maybe: “Using measurements of atmospheric SF₆ for calculating its emissions, and a comparison with bookkeeping attempts to estimate its emissions”

There is an inconsistency in the use of English and German for the respective German institutions.

The lifetime of SF₆ is given as being between 800 and 3200 years. In the abstract it is ~ 3000 years. Is 3000 years an estimate of the most probable value?

Page 26655. Line 15. I hope not only men are to blame, perhaps it were the anthropogens who did it. Line 17. Facility is perhaps not the correct word. Line 17. “Anthropogenic emissions from the electricity sector”, the first word is superfluous, be it that electrified rodents occasionally cause leaks in facilities. Line 18. The word “intentional” is difficult to use and leaks are also emissions. Perhaps “leakage and venting”. The emission is not intentional, the release is however (for instance for maintenance purposes it is known known collateral environmental damage). Line 23 “practically”, perhaps one can simply give the % that accumulates. “Practically” is a bit sloppy for a

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scientific paper, unless there is no other way to quantify a process.

Page 26656. Line 5. The word “recent” is perhaps not the best word. Line 12-13. List the countries given here in order of emission size. Line 15, perhaps a comma after “1990s”. Line 22. data is (should be) plural, therefore “comprise”, or perhaps “data sets”.

Page 26657. Line 21-24. It is stated something like “uniform mixing ratios are connected by a decrease”, please reword.

Page 26658. Line 15-16, perhaps use past tense.

Page 26658. This statement must either be changed or substantiated. The more people work on emission scenarios using electrical light, computers and the like, the higher SF6 emissions will be, be it by a very small amount. Moreover, the statement compares “changes” with “inventory” (inventory changes?). Or do the authors suggest that the emission scenarios are partly based on the atmospheric measurements? I suggest to email Sir Dr. Edgar and ask him. Either give proof, or better, drop the statement.

Page 26660. Line 3. To what does the word “them” pertain? Please phrase better.

Page 26661. Line 19. Line 20. should “and” be “or” ?

Page 26662. Line 5. The model used is fairly adequate for this long lived gas, although the gas has concentrated sources (electrical light intensity around the globe may be a measure?) and is increasing at a substantial relative rate. A question is to what degree one can get “really independent validation”. Perhaps the model, because of its structure, a priori cannot get transport correctly simulated. SF6 in fact has been used to validate transport in more complex models as the authors state themselves. Line 16. Here the authors mention high resolution models, but state that these must be “very well validated”. Various ECMWF models are astoundingly good in forecasting many physical atmospheric properties. Such would not be possible if transport were

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not highly correct. GCM Models using “nudged” transport may be suitable.

Page 26662. Line 21-21. “Suggest . . . may be too low” perhaps better “Indicates . . . may be too low” or alternatively “Suggest. . . are too low”. Line 25-26. Why is it implausible that Non-Annex 1 SF6 emissions per electricity production (sic) are 2 up to 4 times higher than for Annex 1 countries? Note that pollution in some Non-Annex 1 countries for a range of production processes is much higher, so why not for SF6 spillage?

Page 26663. Line 10. “top-down verification” Perhaps once should simply write verification by atmospheric measurement. The “top down” and “bottom up” revolutionary jargon has confused e.g. oceanographers because it sounds upside down to them (they want bottom-down approaches), and also in New Zealand it has different meanings I believe. Further.. “A dense network of high precision atmospheric observations” It seems to me that a project like this CARIBIC that uses passenger aircraft may be a way to get regularly, many atmospheric observations from across much of the globe” It also helps to solve issues of transport (in models). The AGAGE network installs automated mass spectrometers which give information on many trace gas species, but is in practice rather expensive of course. This development also shows how the flask networks have evolved from only CO2 to presently many species, and at times even on line.

Page 26663. Line 16. “gases with well known sinks such as SF6, and other fluorinated and chlorinate compounds”. This statement is not formulated carefully enough. Perhaps replace “and” by “or”. Or drop the first “and”. Moreover the reviewer notes that the sink of SF6 is not well known because, as the authors state, its lifetime is 800 to 3200 years. Better write “defined”, or gases with well known or negligible sinks. Question from the reviewer: what are these gases, one or two examples?

Final comments. When considering the effort in obtaining the measurement results presented by the authors, the application of 3D models is warranted. It does not seem to be difficult to include a virtually conserved tracer in model runs. The role of the mon-

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soon in inter-hemispheric transport and the effect from using surface measurements (in particular Alert, Arctic Haze) will be better parameterized then. Also, this would show whether the model used is adequate. If space allows a figure could perhaps show the fluxes between the boxes. It would give the reader some insight in transport. The authors give potential methods to better calibrate their model (Page 26662, .."A possible tracer for transport validation may be 85Kr"). But is it really the heart of the matter? It is then mentioned that 85Kr after all is not suitable. It may well be that when this model is "calibrated" for one tracer (with a given lifetime, rate of increase, and source distribution) it is not for another tracer.

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