

REVIEW OF PAPER

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Determination of the atmospheric lifetime and global warming potential of sulphur hexafluoride using a three dimensional model

The following comments rely mainly on the presentation of the results of a work of good quality. The redaction has to be revised to bring more numerical precision with the aim of the justification of the conclusions.

GENERAL COMMENTS

- All along this paper, there is a need of more precision: References, numerical values, in particular when conclusions are given. Very often, only overall appreciation is given, without documented justification.
- The authors make the hypothesis that the reader has “under hands” their previous papers including necessary information. In any case, it should be necessary to provide some very short reminders for not totally familiar reader with the subject and the publications of the authors.
- The figures are of poor qualities; it is especially difficult to read included numerical values.

I Introduction

General comments:

- This introduction is too long and has to be restructured.
- Organization of the paper with key study points should be clearly and shortly given.
- The sentence of lines 106-107: “The definitions of these radiative terms are discussed in detail in our recent publication Totterdill et al. (2016)” should be associated with an Appendix where definitions of ALL the radiative terms, as used all along the paper, should be recalled.
- Sub-paragraphs included in section: 2. (Methodology), and section 3. (Results) are misplaced or too much developed at this stage (Introduction) of the paper, i.e.:
 - Lines 60 to 75 should be associated with lines 311 to 334.
 - Lines 76 to 101 should be associated with lines 261 to 286.
 - Lines 151 to 161 should be associated with lines 179 to 185.

Other comments

Line 46 Surface measurements show that SF₆ increased by about 7%/year during the 1980s and 1990s

Line 47 (Geller et al., 1997; Maiss and Brenninkmeijer, 1998).

No information available during the 1990’s-2016’s ??

Lines 64 and 65: Precise units for the quantities in (E1)

Lines 151 and 152: Quote Kovacs et al. (2016) and give a short reminder on D region and its altitude, in particular.

Section 2 Methodology

2.1 WACCM 3D model

General comments

- Paragraphs of this section to be associated with those of the introduction are identified above (may be non-exhaustive list)
- Some complementary brief reminder on the “Lyman- α photolysis”, as used in WACCM, should be given.

Other comments

Lines 162 to 178: The discussion is not enough numerically documented. It relies mainly on short (non-numerical/appreciation) comments from poor quality numerical values implemented on the figures. More information should be given on the plotted values, with possibly short information tables. Please, be so kind as to revise.

Lines:

185WACCM was run for the
186 period 1990-2007, and the first five years were treated as spin-up. For the analysis the monthly
187 mean model outputs were saved and later globally averaged for the lifetime calculations

Those lines would be better placed after line 120.

Why this restricted chosen time period?

2.2 Infrared absorption spectrum and radiative forcing

Lines:

190 Previous quantitative infrared absorption spectra of SF₆ have been compared in Hodnebrog et
191 al. (2013) (their Table 12). There are differences of ~10% between existing integrated cross
192 section estimates, and the measurements cover different spectral ranges.

Again, please, add complementary precision

Section 3 results

3.1 Global distributions of SF₆ from WACCM simulations

General comment

From lines 214 to 260 revision should occur to include more numerical precision in the given conclusions, which very often only stem from figure displays (Fig. 3 and Fig. 5, in particular), with sparse or missing included numerical values.

Other comment

Line 234: Figure 5 shows the zonal mean annual mean SF₆ distribution: which unit?

3.2 Atmospheric lifetime

General comments (already made).

In any case, the definition of “Atmospheric life time”, should be given earlier in the text, as already suggested.

Complementary definition to provide, as well: “*partial lifetime*” and “*overall lifetime*”.

Other comment

Lines:

300 *Finally, if we do not include the electron scaling factor to reduce the electron*
301 *density below 80 km due to negative ion formation, then the SF6 lifetime decreases to 776 years*
302 *(not shown), which is similar to the value obtained by Morris et al. (1995).*

Please, document this sentence: “then the SF6 lifetime decreases to 776 years (not shown), which is similar to the value obtained by Morris et al. (1995). »

Section 3.4 Radiative Efficiency and Forcing

The references for SF6 cross-sections, as provided

Lines 370-372, i.e:

370 *To determine the radiative efficiency and global warming potential of SF6, integrated cross-*
371 *sections were taken from the GEISA: 2011 Spectroscopic Database (Varanasi, 2011), the*
372 *HITRAN 2012 Molecular Spectroscopic Database (Rothman et al., 2012),*

should be quoted differently. The following necessary modification in the text should be made, i.e.:

To determine the radiative efficiency and global warming potential of SF6, integrated cross-sections were taken from two public Molecular Spectroscopic Databases, i.e.:

- GEISA-2009/2011 (Jacquinet-Husson et al., 2011): data of Varanasi (2001) and Hurley (2003);

- HITRAN 2012 (Rothman et al., 2012): data of PNNL (Pacific Northwest National Lab) IR Database, Sharpe et al. (2004)

- **The references should be updated accordingly, i.e.:**

- Jacquinet-Husson, N., Crepeau, L., Armante, R., Boutammine, C., Chédin, A., Scott, N.A., Crevoisier, C., Capelle, V., Boone, C., Poulet-Crovisier, N., Barbe, A., Campargue, A., Chris Benner, D., Benilan, Y., Bézard, B., Boudon, V., Brown, L.R., Coudert, L.H., Coustenis, A., Dana, V., Devi, V.M., Fally, S., Fayt, A., Flaud, J.-M., Goldman, A., Herman, M., Harris, G.J., Jacquemart, D., Jolly, A., Kleiner, I., Kleinböhl, A., Kwabia-Tchana, F., Lavrentieva, N., Lacome, N., Li-Hong, Xu, Lyulin, O.M., Mandin, J.-Y., Maki, A., Mikhailenko, S., Miller, C.E., Mishina, T., Moazzen-Ahmadi, N., H.S.P. Müller, A. Nikitin, J. Orphal, V. Perevalov, A. Perrin, D.T. Petkie, A. Predoi-Cross, Rinsland, C.P., Remedios, J.J., Rotger, M., Smith, M.A.H., Sung, K., Tashkun, S., Tennyson, J., Toth, R.A., Vandaele, A.-C., J. Vander Auwera, J.: The 2009 edition of the GEISA spectroscopic database. J. Quant. Spectrosc. Radiat. Transfer 112, 2395–2445, 2011; <http://cds-espri.ipsl.fr/etherTypo/?id=950>
- Varanasi P., 2001: Private communication
- Hurley, M.D., 2003 : Private communication.

- Sharpe, S.W., Johnson, T.J., Sams, R.L., Chu, P.M., Rhoderick, J.C.: Gas-Phase Databases for Quantitative Infrared Spectroscopy, Appl Spectrosc. 58(12), 1452-1461, 2004.

- **Table 4 should be revised accordingly, as well**

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.....
Line 384: Varanasi (2001): please correct Ref. in the text; no other comparison data available ?

Lines 412-414: References should be corrected as in lines 370-372 (see above).

Lines 423-424: Give reference and numerical values for: “*somewhat higher than previously published values* »

Line 434: Same comment as above for: “*shows a significant dependence on the solar cycle*”