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Interactive comment on “The impact of parameterising light penetration into snow on the photochemical production of NO_x and OH radicals in snow” by H. G. Chan et al.

Anonymous Referee #2

Received and published: 20 April 2015

This is an interesting and useful paper which assesses the validity of a parameterization of the penetration of actinic flux into snowpack, and its impact on photochemistry. The parameterized method is compared to an explicit calculation over a representative range of different snow conditions, and is shown to perform quite well, especially after the introduction of a correction factor for the variation of the direct solar beam's zenith angle. The stated intention is to develop a method that could be implemented in regional/global models. Such implementation would rely on a parameterization of the distribution of the main input parameter, e-folding depth. A discussion of how this quantity might be defined in an operational context should therefore be added, along with a

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discussion of the effects on calculated fluxes of uncertainty in the e-folding depth.

The manuscript is generally thorough but needs careful copy-editing throughout for English language, to make the text more easily understandable. The logical flow also needs some reorganization: Terms which are introduced to label snowpack types and sensitivity studies should be used more consistently throughout to help the reader, and in some cases need to be more rigorously defined. Tables and Figures should be referred to explicitly at the start of the discussion about the information they hold.

I recommend publication after these points have been addressed.

Specific comments follow: Abstr, line 16: please define the abbreviation 'RT'.

Abstr, line 19: 4 chemical species are mentioned, but only 3 ranges are given for the ratio result. This is confusing. Please clarify (also in numerous other locations in the manuscript). If NO₃⁻ and H₂O₂ have indistinguishable results, might it help to define an aggregate term for the two species?

Pg8611, line 10: Does the emission flux from the snowpack depend also on other factors such as dry deposition or wind-pumping? Perhaps such factors could be briefly mentioned and their potential impact discussed? Please also briefly discuss the inherent assumptions about the nature of the ion-containing medium (snow/ice/brine), with references. (Perhaps the recent paper by Domine et al is relevant here). These assumptions could affect both the absorption characteristics of the molecules and the transfer of photolysis products out of the medium. Of course these factors are the same whichever photolysis model is used, however they do have a bearing on the subsequent chemistry, so should be mentioned.

Pg 8611, line 17: The last sentence in the paragraph needs a subject.

Pg 8612: The discussion of the two snowpack layers could be better organized. Please introduce the names of the two layers more explicitly early on (e.g. in line 6) and use them consistently.

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Pg 8613, line 11: add (θ, z) to $J_{(sub)}z_{(sub-sub)}e$.

Pg 8613, line 16: the term “transfer velocity” suggests (at least to this reviewer) some contributions from physical processes (inter-medium transfer, wind-pumping and so on). I don’t believe you mean to imply this. “Depth-integrated photolysis (or production) rate” is more descriptive.

Pg 8613, line 17: do you mean “which may be CONSIDERED approximately proportional”?

Pg 8613, line 23: Does this also suggest the requirement that photolysis makes negligible difference to $[A]$?

Pg 8614, R1-R4: It would be helpful to include notes on the wavelengths of maximum effectiveness for each reaction, on the same line as the reaction itself.

Pg 8616 line 24: “stratospheric” should not be capitalized.

Pg 8618: Please introduce Figure 2, and discuss the variation of e-folding depth with density.

Pg 8619, lines 2-4: This sentence is a little confusing.

Pg 8619, line 13: do you mean ‘e.g.’ instead of ‘i.e.’?

Pg 8620, line 13: Please introduce Figure 3. It doesn’t appear to be mentioned in the text until later, after the discussion of Figure 4.

Pg 8621, line 22: Please explicitly introduce Figure 6.

Pg 8624, lines 15 & 18, and Table 3: The first snowpack type is inconsistently named: is it “windpack and cold polar”, “windpack” alone, or “general”? The name “general” should be defined in the text and/or in an earlier Table, if it is to be used.

Pg 8625, lines 18-20: This is a very good point, which makes your results more useful in the general case.

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Pg 8626, Conclusions: You focus on under/overestimation, which is important. Can you also say whether you actually recommend your method, and under which conditions it works best? Please add a discussion of how the input parameter e-folding depth might be assessed and distributed for the types of large-scale modeling studies where your parameterization would be applied, and discuss, based on your results, how this would contribute to uncertainty in the chemical production rates.

Tables in general: It would be helpful to include an initial table (I'll refer to it as Table 0) listing the seven hypothetical homogeneous snowpacks (or at least the 3 main types used) by name, along with their characteristics. This would enable a lot of simplification in the text, in the Figure captions, and in Table 1, which could then focus more clearly on how variables change in the sensitivity studies.

Table 1: Since e-folding depth appears to be a major input to your parameterization, it would be helpful to list the calculated reference e-folding depths at 321 nm either in this table or in a summary "Table 0".

Table 1: the "Case" names defined in the Table are not used in the text. Please consider doing so, to help orient the reader.

Table 3: Why do you not list a,b,c for H₂O₂? What is a "general" snowpack? Is it the same as a "standard" one?

Table 4: See comments for Table 3.

Table 5: this table should be either referred to in the Introduction (and renumbered accordingly) or moved to Supplementary Information.

Figures in general: Please add figure keys if possible, in keeping with ACP style. Yellow lines do not show up well. Can you find a stronger alternative color? The captions contain lots of detail. Perhaps this could be simplified by strengthening the Tables, enabling the Figure captions to use snowpack /snow type names as shorthand for the specific parameter lists.

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Figure 3: Please include the term 'Q' explicitly in the first line of the caption.

Figure 4 caption should read "The effect. . . on photolysis rate coefficient"

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 8609, 2015.

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