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Comment on acp-2021-779

Anonymous Referee #1

Referee comment on "Comparison of mesospheric sodium profile retrievals from OSIRIS and SCIAMACHY nightglow measurements" by Julia Koch et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-779-RC2>, 2021

This manuscript provides a comparison of zonally and monthly averaged nighttime sodium climatologies from OSIRIS and SCIAMACHY (and to some extent from GOMOS). The retrieval method of combining data from different satellites and MSIS is sound and well described, including limitation. Some question about the comparisons remain open, and some findings concerning e.g. seasonal or inter-annual variations could have discussed more in the light of model expectations etc. Still, I see this paper as an important contribution to our knowledge about mesospheric metal layers. I certainly recommend this paper for publication after addressing some issues that I list below.

1. Some clarifications are needed when it comes to reactions and reaction coefficients:

- You first introduce the basic Chapman mechanism (your equations 1-3). You then introduce the extension by Slanger (your equations 4-5) in order to explain the variable ratio of D1/D2 observed in the nightglow. In order to make this scheme consistent you should make clear that equation 1 describes specifically the production of NaO(A), not NaO in general.

- You should be consistent when referring to the effective branching ratio. In section 1, f_A is the branching ratio in the original Chapman mechanism and you refer to the effective branching ratio introduced by Xu et al. (2005) as f . In the section 3, however, you refer to the effective branching ratio as f_A (line 152).

- In line 146-147, you state "These are reactions 2 and 3 of the Chapman mechanism...". I suppose that this should be reactions 1 and 2 instead.

- In equation 6 you introduce the reaction coefficient k_3 . However, a coefficient k_3 is already used in equation 4. So one of these coefficients needs to be renamed.

2. It would be good to add some clarification about the OSIRIS database used for this study. While it can be discussed whether Figure 1 is the most instructive way of providing an overview of this database, I certainly appreciate the creativity that went into developing this figure. Still, one clarification should be added: In line 87 you state that only solar zenith angles (SZA) larger than 101 degrees are used in the analysis. However, as I understand it, no restriction in SZA is applied in Figure 1. What fraction of the data in Figure 1 remains once the SZA limit of 101 degrees is applied?

3. A discussion is needed about possible biases introduced by the data analysis:

- You set negative radiance values to zero. Please discuss how much this can affect the mean values used in the analysis.

- Variables like ozone, temperature etc. do not enter the retrieval relationships linearly. Still, your retrieval is based on applying the retrieval relationships to monthly averages of the individual variables. Please discuss how much the nonlinearity may affect your monthly mean sodium results.

- In lines 205-211 you discuss the absolute error of the retrieval. You list uncertainties of N_2 , O_2 , O_3 and temperature as contributing factors. However, you do not mention uncertainties in the absolute calibration of OSIRIS and SCIAMACHY, which I assume can be critical. Please discuss this.

4. I am confused about the units of the limb emission rate. e.g in Figure 4, Figure 5, Figure 7 and in the text. I suppose that the correct unit should be that of a radiance (photons $\text{cm}^{-2} \text{s}^{-1} \text{sr}^{-1}$) rather than photons $\text{cm}^{-2} \text{s}^{-1}$.

5. The very high monthly averages ("outliers") in the SCIAMACHY retrievals in early 2008 and mid 2010 are astonishing (Figure 8). You state that the exact reasons are currently not fully understood. I understand that this may be beyond the scope of this paper. Still, it should be possible to provide some basic analysis. Are sodium concentrations during these entire months systematically high? Or is there a limited set of sodium profiles with very high (erroneous?) values that strongly affect the monthly average?

6. As a possible reason for the deviation between SCIAMACHY and OSIRIS you list different latitudinal sampling (lines 221-223). I suppose that this could easily be checked by selecting of a subset of the datasets and making sure that averaging is done over

consistent latitudes for both instruments.

Here are also some other minor comments:

Line 5: Replace "earth's' " by "earth's".

Line 13: Replace "in the same order of magnitude" by "of the same order of magnitude".

Line 18: I suggest to remove "sometimes". Considering nightglow etc. the sky is never completely dark.

Line 19: Replace "Ångstrom" by "Ångström" (two times).

Line 26: In this sentence, it is better to replace "sodium concentrations" by "peak sodium concentrations". Away from the peak, concentrations in the altitude range 70-110 km can be much lower than 500 cm^{-3} .

Line 37: Please be consistent with the number of decimals: "589.0 nm (D2) and 589.6 nm (D1)".

Line 65: Replace "(See Picone et al. (2002))" by "(Picone et al., 2002)".

Section 2.1: Both the altitude of the orbit and the equator passage time have shifted continuously during the Odin satellite mission. Hence, in line 73 I suggest to write "about 600 km" and in line 74 I suggest to write "about 6:00". In the next sentence it does not make sense to write about "now" since the equator passage time is still shifting. You should always refer to a specific time period.

Line 104: Define "sampling ratio".

Figure 4: As I understand it, these profiles show an average over all data from April 2004 in the latitude range +/- 30 degrees. What do the error bars represent in that case? Explain this in the text or the figure captions.

Figure 8: Clarify in the figure caption that the data shown are monthly and zonal averages.

Line 186: Replace "cylcle" by "cycle".

Line 236: You find that low ozone concentrations are related to high retrieved sodium concentrations. You could point out that this is consistent with the retrieval equation 7.

Line 249: Add "the" before "sodium layer".

Line 258: Remove "s" from "concentrations".

Line 269: Is 6:50 p.m. an equator passage time that is reasonably representative for the entire analysis period 2003-2011?