Replies to Comments of Reviewer 1:

We thank the reviewer for his/her constructive comments that helped to improve the manuscript.

1. Reviewer Comment: 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.

Reply: We clarified that reaction 1 produces NaO(A) and not NaO in general

Reviewer Comment: 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).

Reply: We now refer to the effective branching ratio as "f" and to the two branching ratios in the original and the extended mechanism as fA and fX, respectively.

Reviewer Comment: 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.

Reply: Thanks for pointing out that we referred to the wrong equations. This is now corrected.

Reviewer Comment: 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.

Reply: We renamed the reaction rate coefficients of equations 4 and 5 to make sure that there is no ambiguity

2. Reviewer Comment: 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?

Reply: We updated figure 1 so that it now shows only measurements with SZA > 101° and changed the caption accordingly. We also made clear that it only shows measurements that were carried out on the ascending leg of the satellites flight path.

3. Reviewer Comment: 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.

Reply: The reviewer points out that setting negative values to zero could lead to a positive bias in the retrieved sodium concentrations. We admit that this is true but we are not sure

how to quantify this effect because the retrieval method only allows for values greater than or equal to zero. This is the case, because the self-absorption correction requires an iterative retrieval of the Na concentrations. If negative LERs would be allowed, the Na concentrations will or may become negative and the retrieval stops. For this reason, we have to reject the negative LERs. We think we can accept the bias because negative values never occur in the peak regions but only at high altitudes.

Reviewer Comment: 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.

Reply: Thanks for this comment. We tested how the non-linearity of the sodium sensitivity to ozone affects the overall sodium profiles by retrieving sodium profiles with all the individual ozone profiles before averaging those to obtain the monthly ozone profile. We then took the average over all the resulting sodium profiles and compared this to the sodium profiles that was obtained with the monthly ozone profile. We found out that the effect in most months is +- 5% of the sodium peak concentration. And only a few months in which the effect is larger than 20%. We added a discussion on this to the paper.

Reviewer Comment: 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 an SCIAMACHY, which I assume can be critical. Please discuss this.

Reply: The VER error also affects the total sodium density error. This is now mentioned in the text.
The absolute calibration error of OSIRIS is estimated to be between 5 and 10 percent and for SCIAMACHY between 2 and 4 percent (For more information see the SCIAMACHY read me file for the Level 1b version 8.0X dataset). To estimate how this affects the sodium retrieval we changed the LERs by +- 10 percent. This leads to a change in the sodium concentration of about 15 %. This is now mentioned in the text.

4. Reviewer Comment: 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 cm^{-2} s^{-1} sr^{-1}) rather than photons cm^{-2} s^{-1}.

Reply: The units are correct, as we carried out a conversion from limb radiance to limb emission rate.

5. Reviewer Comment: 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?

Reply: As stated in the results section we believe that the very high values of the sodium concentrations are a result of very low ozone concentrations because those outliers only

occur in months were ozone concentrations are lowest. As we showed small variations of the ozone concentrations lead to large variations in the sodium concentrations.

6. Reviewer Comment: 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.

Reply: We are very thankful for the idea to just use a subset of the SCIAMACHY data for the analysis. We did the analysis only with SCIAMACHY measurements that fall in the same latitude range as the OSIRIS measurements in the corresponding month. Unfortunately this leads to more outliers in the SCIAMACHY sodium concentrations. This is attributed to SCIAMACHY'S low signal-to-noise ratio. So, a large amount of SCIAMACHY measurements needs to be averaged to obtain spectra that are suitable for sodium retrieval. See von Savigny et al. (2016)

Minor comments:

Thanks for all the minor comments. The errors have been corrected and what needed clarification was clarified

References

von Savigny, C., Langowski, M. P., Zilker, B., Burrows, J. P., Fussen, D., and Sofieva, V. F.: First mesopause Na retrievals from satellite Na D-line nightglow observations, Geophys. Res. Lett., 43, 12,651–12,658, https://doi.org/10.1002/2016GL071313, 2016.