

General comments:

The authors have improved the description of the basic approach employed here, particularly the difference between the two MIFs used. However, there is still a lack of information on the exact procedure, especially related to the results presented in Fig. 6 (see also the specific comments below). And I still think that you should provide error estimates for the daily meteoroid mass influx into the Earth system. Without error estimates the relevance of your estimates remains unclear.

Response:

We thank the reviewer for the comments. We further clarified the solving procedures and included the error estimations. Please see the point-to-point responses below.

Specific comments:

Lines 35/36, bullet point 2: Please provide an uncertainty estimate for the values given.

Response:

The uncertainty estimation is now provided.

Line 64: „The MIF is a function designed to model the impact of the temporal and spatial variability ..“

I suggest replacing this by: „The MIF is a function designed to model the temporal and spatial variability ..“, i.e. delete “impact of the”

Response:

Done.

Lines 117 – 122: Thanks, this is now very clear!

Equation (1): I still don't understand, how the units of the different terms in this equation are treated. What are the units of a_0 and b_0 ? They have the same units, i.e. x_1 is dimensionless. Does this make sense?

Response:

Eq. (1) is a first-order exponential integrator for numerical simulation. The units are consistent with the unit of the rate coefficient used in the numerical model. In our case, the units of x_0 and x_1 are $1/\text{cm}^3$. The units of a_0 and b_0 are $1/\text{cm}^3/\text{second}$.

Line 171: „Na(2p)“ -> „Na(^2P)“

Response:

Na(2p) has been changed to Na(^2p) in Table 2 and in the caption.

Line 187: The figure caption is not precise. Not the data is shown, but the available hours of observation.

Response:

The figure caption has been replaced by 'Available hours of lidar observations. CSU lidar (1990-2020, upper plot) and ALO lidar (2014-2019, lower plot).'

Line 209: „Finally, we further smooth the profiles by fitting them with a skew-normal 209 distribution“

This is a vertical smoothing, right? Please mention this explicitly, otherwise it is not entirely clear (to me, „profiles“ are always vertical profiles, but the term is also used for time series etc.).

Response:

It is a vertical smoothing. The sentence has been revised to “Finally, the vertical profile for each time step is further smoothed by fitting it with a skew-normal distribution (Azzalini & Valle, 1996), using the least squares error method.”

Line 224: „The time resolutions of the lidar measurements typically vary between 1 and 10 minutes, depending on the experiment, and are linear interpolated to 0.1 seconds.“

? Is the variation of the lidar data throughout the night used at all? My understanding was that you use nightly averaged data?

Response:

The lidar data variation throughout the night is included. The averaged lidar measurements are then interpreted to a resolution of 0.1 seconds to be consistent with the numerical simulation's time resolution.

Line 229: „The seasonal column densities“ -> „The seasonal variation of the column densities .. IS similar ..“

Response:

Done!

Line 266, equation (2): This is not very intuitive. It would have been better to define the sensitivity factor as a ratio of the Na columns, not the total Na content columns (and keeping total Na constant, rather than Na). I don't really understand the motivation for this choice.

Response:

The goal of the sensitivity factor is to shed light on the significance of each background species to sodium chemistry. The ratio of Na columns remains the same whether Na or total Na content is held constant in the steady state. We believe that keeping Na constant is more intuitive, as Na can be directly measured, whereas the total Na content cannot be measured at present.

Line 308: „The diffusion coefficient is found to be highly correlated with the sodium sink due to the dimerization reaction mostly occurs at lower altitudes.“

This is not "found" in your study, because diffusion is not considered, right? The statement is misleading and the grammar is also not correct. Please improve.

Response:

The sentence has been revised to “The study by Plane (2004) found that the diffusion coefficient is highly correlated with the sodium sink, primarily because the dimerization reaction occurs predominantly at lower altitudes.”

Line 313: „Logarithmic meteor radiant source distribution ...“

Ok, it is a logarithmic quantity, but what are the units of the original data? I'm not an expert and this is not clear to me. Do the absolute values have any meaning? I don't want to be picky, I just want to understand what exactly is shown here and this is not well explained.

Response:

The result is in arbitrary units. Therefore, the absolute values carry no meaning. The unit of this figure is [1/unit time/cell of equal area]. It means that the radiant directions in color of 0.5 ($10^{0.5}$) encounters 30 times of meteors compared to the region in color of -1 (10^{-1}) per unit area per unit time. The units have been added in the caption.

Line 320: „Relative seasonal ...“

Relative or normalized to what? To the maximum value? Please mention this explicitly.

Response:

The values shown in the figure were normalized to its maximum value. The caption has been revised to explicitly state this for clarity.

Text discussing Fig. 6: It should be mentioned here again, that MIF(m) is actually dimensionless and is manually (?) scaled here to match the values of MIF(s)? How is this matching done?

Response:

The matching is done exactly like what you described. The goal of the matching is to minimize the difference between MIF(m) and relative MIF(s), i.e., finding the smallest least squared error during the matching process. This process is solved algorithmically. The results from the solving process are illustrated in the figures attached to the responses of the previous revisions. Please see the figures in the previous response. The Response Fig. 1 depicts the difference between MIF(m) and relative MIF(s), and the Response Fig. 2 shows several cases of the uptake value used and the corresponding least squared error. As you can see, this process will find an uptake factor that minimizes the square error between the MIF(m) and relative MIF(s). This is a very standard widely used numerical procedure.

Fig. 6, top two panels: ? I don't understand why the relative seasonal variation of MIF(m) depends on whether the Na uptake on meteoric smoke is switched on in the model or not. MIF(m) - at least its relative variation - should be independent of the model?? It is not clear, what was actually done here.

Response:

The relative seasonal variations of MIF(m) on the top panels of Fig.6 were the same. The panels in Fig. 6 are not on the same scale.

MIF(m) in panel 1 is between 30281 and 18919. MIF(m) in panel 2 is between 8652 and 5406. The maximum to minimum ratio for both MIF(m) in the top two panels is about 1.6.

Fig. 6, bottom two panels: The relative amplitude of the seasonal variations in MIF(m) is also different between the two cases (uptake on/off) for ALO. This should not be the case, right?

Response:

The relative amplitudes of MIF(m) for the lower two plots are the same.

MIF(m) in panel 3 is between 32025 and 16953. MIF(m) in panel 4 is between 7117 and 3767. The maximum to minimum ratio for both MIF(m) is about 1.89.

Line 346: „ .. pattern should follow the Earth's axis rotation.“

The working here is not very precise: "rotation of the Earth's axis". What exactly do you mean? The orientation of the Earth's axis is fixed relative to the stars.

Response:

The sentence has been revised to “... relative to the ecliptic plane”.

Line 353: „The MIF(s) with smoke uptake on is represented by a purple line, while the MIF(s) with smoke uptake turned off is depicted by an orange line.“

No, it is the other way around!

Response:

The “on” and “off” were misplaced. The sentence is now consistent with the figure.

Line 371/372: Error estimates of the daily meteoroid input should be estimated and presented here.

Response:

The error estimations of the sodium injection rate, as well as the meteoroid material input are now presented. The error is determined by calculating the standard deviation of the detrended, unsmoothed raw MIF(s). Note that the MIF(s) presented in Fig.6 is smoothed by a 15-day running average.