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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The chemistry of daytime sprite streamers – a model study" *by* H. Winkler and J. Notholt

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We thank Anonymous Referee #1 for his or her constructive comments. This is also announced in the Acknowledgements. Please find below our reply to the specific comments, and a description of the corresponding changes made to the manuscript. The manuscript comes as a supplement.

Referee: P 29523, l 7: From my understanding the downward propagation is followed by an upward propagation also, see e.g. Cummer et al. (2006)

Response: Upward streamers have not been observed in all sprite events. We have added the sentence: "Upward propagating streamers, when present, develop later and from lower altitudes, e.g. Cummer et al. (2006); Stenbaek-Nielsen and McHarg (2008)."

Referee: P 29523, l 9: "conductivity of the middle atmosphere is higher than at night": This is only true for the mesosphere, but not for the stratosphere, where cosmic rays are the only ionization source, ion-ion recombination and ion-aerosol attachment rates are also not day/night time dependent. See e.g. Tinsley and Zhou (Initial results of a global circuit model with variable stratospheric and tropospheric aerosols, JGR, 2006, 111, 16205). What altitude range is most important for the electric breakdown/sprite generation? In section 3 you state that this is likely to occur at 54 km, which is below the region of day/night time dependence of conductivity. Therefore, conductivity is unlikely to affect differences in nighttime vs daytime sprites.

Response: This was indeed a misleading statement. We have tried to make it clearer by writing: "During day, the ionospheric conductivity is significantly higher than at night and conventional breakdown is prevented at mesospheric altitudes. Therefore, daytime sprites have to be initiated at lower altitudes. Due to the higher atmospheric density, larger electric fields are required to cause air breakdown. As a result, only exceptionally large lighting events can trigger daytime sprites (Stanley et al., 2000)."

Referee: P 29523, l 20: You might also want to mention the well-established NOx formation by lightning in the troposphere

Response: It now reads:" Tropospheric lightning is a well-known source of reactive nitrogen, e.g., Price et al. (1997), and in recent years, the chemical impacts of sprites gained some interest."

Referee: P 29525, section 3. While some parts of the model originate from previously published models, it seems like the model infrastructure used here is new. An evaluation and comparison against established models or measurements would have been desirable, and would have helped other scientist to reproduce or built upon this publication. However, I realize that such an evaluation would exceed the extent of the paper. If such a publication is in preparation, it would be good to indicate this here. Results: For a discussion and to put the results into context, what is the diurnal cycle variability of ozone (i.e. related to solar zenith angle/chemistry at the three different altitudes? See e.g. Studer et al. (A climatology of the diurnal variations of stratospheric and mesospheric ozone over Bern, Switzerland, ACPD, 13, 22445-22485, doi:10.5194/acpd-13-22445-2013, 2013.) Many ion-chemistry reactions have large error bars, is there any possibility to estimate or discuss their effect on your results?

Response:

1st point: The model is a new development, and this is the first publication based on it. In Sec. 3.3 “model...has been set up” was replaced by “model...has been developed”. It was added:“The model has been tested by comparison with the well-documented model results of Gordillo-Vázquez (2008), and Sentman et al. (2008a). Generally, there is very good agreement with the results of those model studies if the simulation parameters are the same. In particular this includes the electric field pulse, the rate coefficients of the electron impact reactions, and the concentration of the seed electrons. A study on the impact of those parameters on sprite chemistry simulations will be published elsewhere.” After the description of the calculation of the ion-photo reaction rates it was added: “This is the same approach as in Winkler and Notholt (2013).”

2nd point: An additional figure has been included. It shows the diurnal cycle of ozone and the sprite streamer ozone changes. At the end of section “4 Results” it was added: “In order to put the results into context, Fig. 9 shows the modelled diurnal cycle of ozone, and the streamer ozone values. In this Figure, the changes during the fifteen minutes of the streamer model time can hardly be resolved. However, it gives an im-

pression of how the sprite streamer ozone changes compare to the diurnal variations. At 54 km, ozone has decreased by about 250 ppb in the daytime sprite streamer after fifteen minutes. This values is of the same order as the diurnal ozone variation at that altitude. Again it is apparent that the nighttime event has basically no effect at 54 km. At 42 km, ozone increases by about 100 ppb in both nighttime and daytime streamer. In the daytime case this is followed by a rapid ozone decrease of more than 100 ppb compared to the initial ozone value. At 31 km, the impact of daytime and nighttime streamer are very similar. Both of them lead to an ozone increase of almost 800 ppb.”

3rd point: This is of course the killing question. It is not possible to address the model errors without a detailed consideration of reaction rate uncertainties including the electron impact rates. For this purpose, one would have to dig deep into the references. It is planned to address the effect of different electron impact rates on the model results in a parameter study.

Referee: Minor comments: Fig. 6. the bottom panel is labelled “NIGHT”, please add “DAY” to the top panel. I suggest to replace the word “plot” e.g. with “panel”.

Response: All “plots” have been replaced by “panels”, and in all figures comparing day and night (Fig. 4, 5, 6, and 8) “DAY” was added to the upper panel.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/13/C11855/2014/acpd-13-C11855-2014-supplement.pdf

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