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

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*Referee: Abstract: It is a bit confusing; for example it is not fully clear if O increases both during day and night-time events, as seen in Fig 4.*

Response: Indeed, this was confusing. And it was not even precise. There are three



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phases: 1. ion-chemical ozone loss, 2. ozone formation because of atomic oxygen, and 3. catalytic ozone depletion. The abstract was re-written, it now reads: " The chemical processes in daytime sprite streamers in the altitude range of 30–54 km are investigated by means of a detailed ion-neutral chemistry model (without consideration of transport). The focus lies on nitrogen, hydrogen and oxygen species, and in particular on ozone perturbations. Initial effects of the breakdown electric fields at the tip of sprite streamers include a short-term loss of ozone due to ion-chemical reactions, a production of nitrogen radicals, and a liberation of atomic oxygen. The latter leads to a formation of ozone. In terms of relative ozone change, this effect decreases with altitude. The model results indicate that the subsequent ozone perturbations due to daytime sprites streamers differ considerably from the ones of nighttime events. For nighttime conditions...(as before)" Corresponding changes have been made in Sec. 4 Results, and 5. Summary and Conclusions. Note that an additional Figure (No. 9) has been included showing the diurnal cycle of ozone, and the streamer ozone values. It is dicussed at the end of section 4 Results.

*Referee: Section 1: The significance of the results depends on the occurrence frequency of daytime sprites. It would really be worth investigating how to detect daytime sprites for statistical purposes. To my understanding some of the results are only indications, not one-to-one correlated with daytime sprites.*

Response: That is true. We are not experimentalists enough to make any suggestion here on how to seek for daytime sprites. I suppose that it would be very hard to detected them optically (although Stanley et al. (2000) state that probably their event was unusually bright). In the manuscript we have changed "There are only a few reports on daytime sprites." to "As far as the authors know, there are only three published reports on..."

*Referee: Sections 3-4, model description: I have made no attempts to validate the*



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*chemical reaction scheme and find up-to-date rate coefficients. How was the model developed, from scratch or based on an existing chemistry model?*

Response: The model is a new development, and this is the first publication based on it. It's reaction scheme has carefully been assembled and tested. As stated in the manuscript, most of the reactions, and rate coefficients are taken from Kossyi (1992), Kazil (2002), Gordillo-Vázquez (2008), and Sentman et al. (2008b). In Sec. 3.3 of the manuscript we have replaced "model...has been set up" by "model...has been developed", and 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."

*Referee: Furthermore, does it consider ionisation by the UV emission from excited species ($N_2^+$ might also be important), or is only photoionisation by solar radiation taken into account?*

Response: In Sec. 3.3 is was added: "The model considers photoionisation of nitric oxide by solar Lyman-$\alpha$ radiation. Emissions from excited species are not accounted for." Additionally, a "Lyman-$\alpha$" was inserted at the corresponding entry in Tab. 3.

*Referee: It also ought to be experimentally verified that daytime sprites initiate at the altitude of conventional breakdown like the night-time ones, but for now this assumption has to be made.*

Response: Yes, indeed. We would appreciate if this could be verified because it is an important assumption we had to make.



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*Referee: Results: As the authors point out it would be important to run the present model for different conditions and also model mixing with the ambient air and transport of the produced NOx and Ox . So this paper contains important suggestions for further work!*

Response: We totally agree on that.

*Referee: Minor details:*
*p. 29530 l. 11: a productions → a production*
*p. 29531 l. 14 concentration ... decrease → concentration ... decreases*
*Table 2, Fig 2, titles and captions: maybe "negative species" instead of "negative ions", since usually electrons and negative ions are distinguished from each other.*

Response: Singular/plural was adjusted. Those “negative ions” and “anions” were changed to “negative species”. Correspondingly, “cations” turned to “positive species”.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/13/C11859/2014/acpd-13-C11859-2014-supplement.pdf

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Interactive comment on Atmos. Chem. Phys. Discuss., 13, 29521, 2013.