# Modelling the ion chemical impact of sprites at night and during daytime

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The impact of a sprite event at 54km is studied by a plasma chemistry model for both daytime and nighttime conditions. For the prescribed electric field pulse (450Td for 2µs) the electron density increases by about 7 orders of magnitude. Due to the higher background electron abundance, the impact of a sprite at noon is significantly larger than at midnight. There are considerable chemical perturbations, e.g. a significant production of nitric oxide. Additionally, it is found that there is a liberation of chlorine from the reservoir HCl. This chlorine activation could potentially be important for the ozone chemistry after sprites and has yet not been considered.

## 1. Introduction

Mesospheric electric breakdown events (sprites) are mainly nighttime phenomena. Consequently, the ion chemical impacts of sprites have commonly been studied for nighttime conditions [1-4]. In the presence of sunlight, the conductivity of the mesosphere is higher than during night, and electric breakdown would occur at lower altitudes than for nighttime conditions. Stanley et al. [5] have reported on the detection of a daytime sprite after an exceptionally large positive cloud-to-ground stroke providing the required large electric field for breakdown at ~54km. We present model studies of the ion chemical impacts of sprites at 54km for both nighttime and daytime conditions.

## 2. Approach

A plasma chemistry model has been set up to simulate the evolution of 19 negative, 36 positive, and 31 uncharged species under the influence of an electric pulse at 54km. The electric field is an external parameter (450Td for 2µs) based on the scaling relations in [6]. In order to account for the effects of sunlight, photo-detachment of electrons, and photo-dissociation of negative ions are considered. The background ionisation is due to galactic cosmic rays (1/cm³/s).

## 3. Primarily results

Figure 1 shows the electron density during and after the electric breakdown event for both daytime and nighttime conditions. Due to the photo-detachment of electrons, the background electron density at noon is significantly larger (~10/cm³) than at midnight (0.1/cm³). During the electric pulse, the electron density increases by about 7 orders of magnitude in both cases. It can be seen from Fig. 1 that the effect of electron photo-detachment becomes important after a few hundred milliseconds.

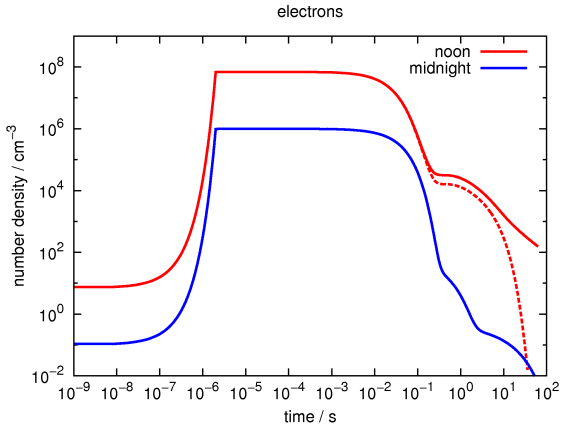


Figure 1: Time profiles of the electron densities for daytime (red) and nighttime (blue) conditions at 54km for an electric field pulse of 450Td lasting for 2µs. The dashed red line corresponds to deactivated photo-detachment.

In figure 2 it is depicted how NO (nitric oxide) responses to the sprite event during both daytime and nighttime. There is considerable formation of nitric oxide. The absolute NO increase is larger at noon than at midnight.

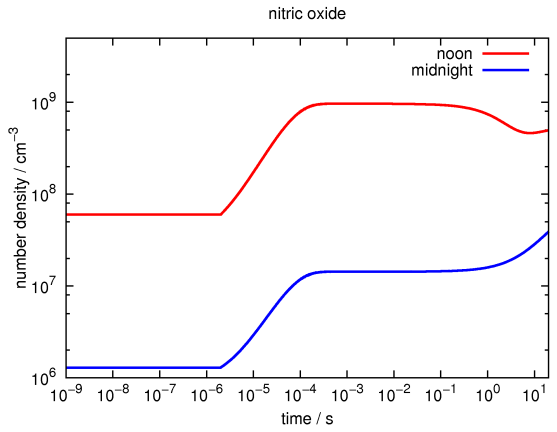


Figure 2: Time profiles of nitric oxide densities for daytime (red) and nighttime (blue) conditions at 54km for an electric field pulse of 450Td lasting for 2µs.

Figure 3 shows that after the electric pulse there is a release of chlorine atoms from HCl (not shown here). Chlorine radicals play an important role in the middle atmosphere's chemistry. To the authors best knowledge, this is the first time, that the chlorine activation due to sprites has been shown.

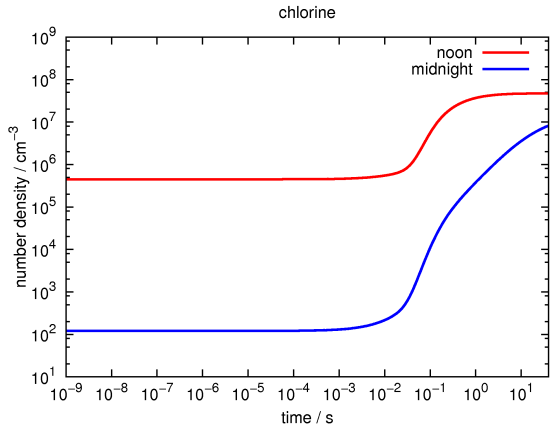


Figure 3: Time profiles of atomic chlorine densities for daytime (red) and nighttime (blue) conditions at 54km for an electric field pulse of 450Td lasting for 2µs.

## 3. References

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