Significance of Transient Luminous Events to Neutral Chemistry: Experimental Measurements

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Red sprites were first recognized by the scientific community about 20 years ago. The first image focused attention on the atmospheric region above thunderstorms, and lead to the identification of a whole host of new phenomena, now collectively termed "Transient Luminous Events" (TLE). It quickly became obvious that red sprites were not a cold phenomena, and involved orders of magnitude increases in middle atmosphere ionisation. Scattering of subionospheric transmissions were first related to sprite occurrence and subsequently shown to be due to a "hot electron" discharge process, leaving an ionisation increase which persisted for as long as tens to hundreds of seconds [Nunn and Rodger, GRL, 1999], depending on altitude.

It has long been known that lightning discharges are a significant producer of odd nitrogen in the troposphere. Some authors have speculated that red sprites might have a significant impact upon the chemistry of the stratosphere and mesosphere, by virtue of their location. It has been common for researchers in this field to speculate that TLE may significantly impact the middle atmosphere, playing an important role on the regional scale, or indeed on larger scales. One of the specific enquiries of the European Coupling of Atmospheric Layers training network focused on chemical changes to the stratosphere and mesosphere, as part of the wider question "are these high-altitude discharges only pretty and beautiful like rainbows, or do they significantly impact the atmosphere"? The link between ionisation increases and significant neutral atmospheric variations is a natural one. Ionisation increases results in enhancement of odd nitrogen (NO_x = NO + NO_2) and odd hydrogen (HO_x), which play a key role in the ozone balance of the middle atmosphere.

In this study we make use of nighttime NO_2 observations by the GOMOS instrument to test whether TLE are producing significant NO_x enhancements in the middle atmosphere on a regional scale. Comparing regional variations of NO_2 with 2-3 order of magnitude variations in lightning activity, we show that there is no significant impact of red sprites, giant jets or blue jets upon NO_x levels in the stratosphere and mesosphere (20-70 km), within the detection levels of the instrument. While individual TLE may cause a local variation in NO_x, these do not appear to be significant on regional scales (or beyond).