

Observations of Transient Luminous Events from space and the ground: Review of 5 years of research since the MEIDEX

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We present a review of TLE observations conducted on-board the space shuttle Columbia during the Mediterranean Israeli Dust Experiment (2003, MEIDEX) and in subsequent ground-based campaigns in Israel. From space, absolutely-calibrated video images of 21 orbits was transmitted to the ground (381 minutes), in which $\sim 1/5$ contained useful lightning data over Australia, central Africa and South America. We identified 10 Elves and 7 sprites, and computed an occurrence rate of ~ 12 minute⁻¹ for the tropics. Sprites occurred between ~ 40 -90 km above ground with brightness of 0.3-1.7 MR (in 665nm) and 1.4-1.7 MR (in 860nm). Elves were found near ~ 95 km mostly with arc shapes (no central hole) indicating a production by intra-cloud flashes. A unique Transient Ionospheric Glow Emission in Red (TIGER) was observed south of Madagascar, delayed 0.23s from a preceding visual lightning which was horizontally displaced larger than 1000 km away. The brightness was $\sim 310 \pm 30$ kR but the morphology did not resemble any known class of TLE, suggesting it may be a new type induced by lightning activity in the conjugate magnetic point.

The continuation of the MEIDEX into the ground-based ILAN (Imaging of Lightning And Nocturnal flashes) campaigns concentrated on optical and electromagnetic measurements of TLEs associated with winter thunderstorms in the eastern Mediterranean. We report the results of three observation campaigns conducted during the 2006-8 seasons. We observed winter thunderstorms in the vicinity of Israel and the eastern coast of the Mediterranean Sea from 3 different sites. In 25 out of 50 different nights we detected larger than 100 events from ranges ranging from 250 to larger than 500 km. Sprites were found to be produced by active cells with a vertical dimension of 5-7 km and cloud top temperature ~ -40 C degree, embedded in a much larger matrix of stratiform precipitating cloudiness. This configuration closely resembles the conditions for winter sprites in the Hokuriku region of Japan. Synchronized with the optical observations, ELF data (3-3000Hz) were recorded at two observation stations in Israel and Hungary in order to qualify and quantify parameters of the parent lightning discharge associated with the transient optical emissions in the upper atmosphere. We found that for 87 percent (Israel) and 77 percent (Hungary) of optically observed TLEs, an intense ELF transient event was recorded. All ELF transients that were associated with TLEs were caused by lightning discharges with positive polarity. Calculation of the charge moment change showed values of 1400 ± 600 Ckm. Within the accuracy of one video field (17 ms), it was found that the average time delay between the ELF transient of the parent +CG and its associated sprites was 76 ms (± 34 ms), with some events delayed longer than 120 ms from the parent lightning, much longer than values reported for summer sprites in the US (~ 10 ms). The average time delay for columniform sprites was 65 ± 26 ms while for carrot sprites 80 ± 32 ms, similar to results in winter storms in Japan. Furthermore, based on the ELF data, there were no early identifiable precursors to TLEs occurrence in the regional lightning activity and +CGs with similar characteristics generated TLEs only intermittently. The 3-D structure of columniform sprites was investigated with dual observations from two separate sites. We show that in this type of sprite the elements are arranged in a circular pattern, thus mapping the instantaneous electric field in the mesosphere.