First detection of transient luminous events associated with winter thunderstorms in the eastern Mediterranean

Y. Yair (1), C. Price (2), M. Ganot(2), Y. Sherz(2), B. Ziv(1), E. Greenberg(2), A. Devir(1), R. Yaniv(1), J.Bor (3) and G. Satori (3)

(1) Dep. of Life and Natural Sciences, The Open University, Ra'anana 43107 Israel

(2) Dep. of Geophysics and Planetary Sciences, Tel-Aviv University, Tel-Aviv 69978 Israel

(3) Geodetic and Geophysical Research Institute, Sopron, Hungary

(yoavya@openu.ac.il / Phone: +972-9-778-1341)

Transient Luminous Events (TLE) are brief ($<$50 msec) optical emissions that appear in conjunction with thunderstorm activity. In the past they were mostly detected above large MCS-type weather systems that generate intense cloud-to-ground (CG) flashes (Lyons et al., 2000, 2003). More recently TLEs have also been observed in smaller scale winter-type systems in Japan (Hayakawa et al., 2004; Adachi et al., 2005). There are several types of TLEs, which differ in shape, size, duration and generating physical mechanism. For example, ELVES (acronym for: Emissions of Light and VLF perturbations due to EMP Sources) are large circular emissions of light $\sim$300km in diameter, with a distinct hole in the middle that gives them the appearance of an expanding toroid above the location of the parent lightning. Typical occurrence heights of ELVES are $\sim$85-105 km above the ground, coinciding with the emissions of the airglow layers (Fukunishi et al., 1996; Inan et al., 1997). Sprites, the most structurally complex TLE phenomenon (Gerken and Inan, 2003; Pasko et al., 1998) emit in red and blue wavelengths (Hampton et al., 1996) and span a vertical range between 50 and 90 km. They can take weird and magnificent shapes resembling jelly-fish, carrot heads, pearls or columns, and usually have distinct boundaries. TLEs are ubiquitous around the planet, and indeed have been reported over most major centers of lightning activity on Earth. However, their global rate is still elusive and was not unequivocally determined. Globally, thunderstorms occur in northern-hemisphere winter only in very specific regions: the coastal areas of the Sea of Japan, over the Gulf of Mexico and along the Gulf Stream in the Atlantic, and over the coastal areas of the Mediterranean Sea (Yair et al., 1998; Defer et al., 2005; Price and Federmesser, 2006) in southern Europe and the Middle East. Until the present time, TLEs above winter thunderstorms have been observed exclusively in Japan (Fukunishi et al., 1999; Hayakawa et al., 2002, 2004; Takahashi et al., 2003; Hobara et al., 2003; Adachi et al., 2004), with the single exception of the 1999 observation of sprites and ELVES above a winter storm near Albania, during the Leonid-meteor shower airborne observation campaign

in November 1998 (Yano et al., 2000).

Here we present the results from the 2005-6 winter sprite campaign conducted in Israel (ILAN- Imaging of Lightning And Nocturnal flashes, open website URL: http://geophysics.tau.ac.il/personal/ilan/). Optical ground-based observations were conducted from two sites, aiming to detect transient luminous events (TLEs) above winter thunderstorms approaching the eastern coastline of the Mediterranean Sea. We used 2 WATEC cameras, mounted on a pan-and-tilt unit with GPS time-base and event-detection software (UFO-Capture). The system was remote-controlled via the Internet and targets were chosen in real-time based on lightning locations derived from a BOLTEK system stationed in Tel-Aviv. Detailed weather forecasts and careful analysis of lightning probability allowed us to choose between the two observation sites: one near the coast in central Tel-Aviv, and the other from the Wise astronomical observatory in the Negev desert (Mizpe-Ramon). The optical observations were accompanied by ELF and VLF electromagnetic measurements from the existing TAU array (Price et al., 2004). In 6 different storms we detected 31 events - 24 sprites, 6 elves and 1 sprite halo; detection ranges varied from 250 to 450 km. Sprites were found to occur in the height range 50-80 km, with lengths varying from 10 to 35 km. We used the LPATS data of the Israeli Electrical Corporation to determine the ground location of the parent lightning and succeeded in geo-locating 4 events. All TLEs were accompanied by distinct ELF transients, which were clearly identified by the Israel ELF station as well as in the Hungarian ELF station near Sopron, from a range of $\sim$2500km. The relationship between meteorological parameters, storm size, vertical cloud development, lightning properties and charge moment will be presented.