SPACE AND GROUND-BASED OBSERVATIONS OF TLES DURING THE MEIDEX MISSION ON BOARD THE SPACE SHUTTLE COLUMBIA

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ABSTRACT

In January 2003, sprites and ELVES (also known as transient luminous events – TLEs) were observed by the astronauts on board of the Columbia space shuttle flight STS-107, during the Mediterranean Israeli Dust Experiment (MEIDEX). This is the first time such calibrated measurements have been obtained from space. A total of 14 TLEs were observed during the 16-day mission. During the STS-107 mission less than 10 hours of TLE observations were allocated to the MEIDEX team, with 7.5 hours of data down-linked during the flight, and therefore not lost in the tragic end of the Columbia flight. TLEs are known to be triggered by intense lightning discharges in the thunderstorms below. These lightning discharges are sources of intense radio emissions at all frequencies. In the extremely low frequency range (ELF: 3-3000 Hz) these electromagnetic waves can propagate a number of times around the globe before decaying. For this reason ELF recording stations can often detect transient signals from intense lightning discharges anywhere around the globe. During the space shuttle flight, ELF electromagnetic data at four ground-based stations (Israel, Hungary, Japan and Antarctica) were collected to geo-locate and determine the parameters of the parent lightning that triggered the TLEs. Each station was equipment with 2 horizontal magnetic induction coils and GPS clocks for timing of the events. Two of the stations (Israel and Hungary) also had vertical electric field measurements. From our analysis 7 ELVES and 7 sprites have been analyzed. ELF transients were detected for 5 of 7 ELVES at all ground stations with accurate geo-location of these events. However, none of the sprites were associated with ELF transients. This is contrary to the present theories of TLE formation, and may require some new thinking into the mechanisms that produce sprites and ELVES. Since ELF transients in the earth-ionosphere cavity are primarily generated by cloud-to-ground (CG) lightning, is it possible that the sprites observed by the astronauts were produced by intracloud lightning? Is it possible that if CG discharges did produce the sprites, but they were too weak to produce ELF transients at any of the four stations? It is generally believed that sprites are triggered by the most intense CG discharges. We estimate that if this is the case, the discharges had charge moments less than 100 Ckm. However, the lack of ELF signals for these events implies there may be many more sprites out there than previously believed, caused by weaker, more frequent CGs.