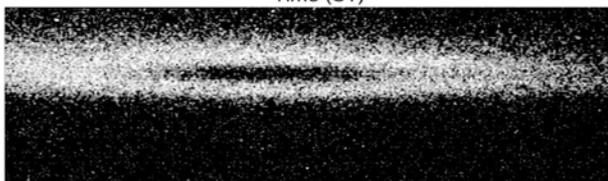
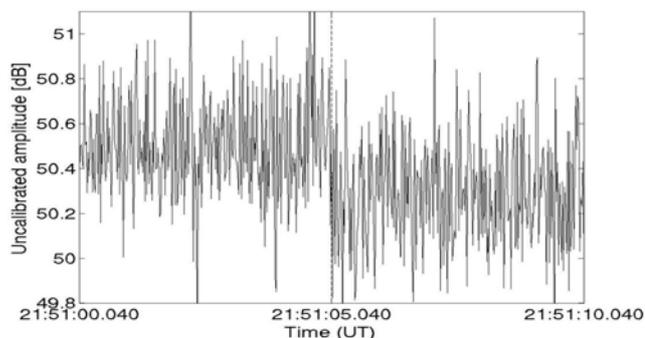


A Study on VLF Perturbations and Transient Luminous Events Using the *EuroSprite-2003* Observations

Agnes Mika and Christos Haldoupis

Department of Physics, University of Crete, Heraklion, Greece

VLF observations made during *EuroSprite-2003* with a narrowband receiver in Crete, Greece and a broadband receiver in Nancay, France, were analyzed in connection with many sprites captured above thunderstorms in central France. The Crete receiver observed early VLF perturbations in nearly one-to-one association with sprites in the signal of a transmitter located in the vicinity of the sprite producing storms. While most of these perturbations were of the early/fast type, several were identified for first time as “early/slow” having onset durations up to ~ 2 s. These “slow” VLF signatures are unexpected, suggesting a mechanism at work which causes a gradual change in the lower-ionospheric conductivity contrary to the case of the “fast” events. We believe that the “early/slow” VLF signature poses an interesting theoretical problem that needs to be identified and modeled. The sprite related early VLF perturbations seen in Crete are attributed to forward VLF scattering from a sub-ionospheric region of enhanced ionization at the sprite location. On the other hand, early VLF perturbations caused by backscatter in the vicinity of the storms were also observed in the bandpass filtered broadband VLF data but in relation only with about 5% of the sprites. The only elve in the dataset was found to associate with an early/fast VLF perturbation in the Crete data, a result that was unexpected because elves are very short lived and occur at higher altitudes near the lower E region. Further, the analysis of the time lags of the sprites to the preceding +CG discharges revealed that at least one third of the sprites were “long-delayed”, with time lags ranging from 30 ms up to 300 ms. In addition, there was no radio-spheric activity observed during these long-delayed sprite events, in sharp contrast to the short-delayed ones, which were escorted nearly always by enhanced, burst-like spheric activity in the broadband data but not in the lightning data. These observations endorse the notion of long-delayed sprites reported in past studies, but also show that their occurrence is much more frequent than thought. In addition, we use the large number of EuroSprite 2003 events and the broadband VLF data in an effort to test recent findings in Japan suggesting the presence of spheric clusters as a signature of intra-cloud discharge action that plays an important role in the generation mechanism of sprites.



Elve at 22 July 2003, 21:51:05.038 UT

Optical image of the elve (bottom panel) and the early VLF perturbation observed simultaneously on the HWV-Crete link (top panel).