Gigantic jet discharges as possible inducers of sprites

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In this report two possible GJ-induced sprites, which were captured by ISUAL (Imager of Sprites and Upper Atmospheric Lightning), are presented. From the optical image and the spectral data, these two events both show that, ~1ms after the occurrence of GJs, new sprites were found to occur near these secondary GJs without discernible associated lightning signal. One of the events was found to have an associated electromagnetic signal. Thus this GJ is confirmed to be a negative cloud-to-ionosphere discharge and to have a high peak current moment. Based on the spectral data, the optical image and the associated electromagnetic data, the possible conditions for the GJs to induce sprites are discussed.

1. Generating sequence

Between July 2004 and December 2010, ISUAL captured 60 gigantic jets (GJs). Among these GJ events, five secondary GJs [1,2] are identified to occur after the preceding sprites and with curvy or straight luminous columns that span the cloud-top and the lower ionosphere. Two of the five secondary GJs have further intriguing evolution; ~1 ms after the occurrence of the secondary GJs, new sprites were found to occur near these secondary GJs without discernible associated lightning signal. For these two secondary GJs, the complete sequence of event is as following: after the occurrence of the preceding sprites, a secondary GJ emerges about 30-50ms later, and then a new sprite appears near the GJ ~1ms later.

2. Associated electromagnetic signal

For one of these two special events, its associated ULF (ultralow frequency; 0.3Hz to 500Hz) signal was also recorded by the NCKU ULF station in Taiwan. The ULF signal is used to infer the physical characteristics of the GJ including the discharge polarity, the vertical current moment, and the time-integrated charge moment change (CMC). The radio signal indicates that this GJ is a negative cloud-to-ionosphere discharge, and the pulse duration of the GJ signal is ~4ms, the peak current moment is ~210 kA km, and the CMC within the first 4ms is ~380 C km. The peak current moment is much higher than those reported in [3] and [4].

3. Discussion

From analyzing the optical images, the spectral data and the inferred electrical properties, it is possible that the trailing sprites may have been induced by the GJs. We believe that the high current moment of the preceding gigantic jet may be a key factor in the induction of sprites. In these two observed events, the breakdown electric field needed to induce sprites may have gradually built up by a succession +CG discharges and the occurrence of the secondary GJs acts as a final straw to push the E-field over the breakdown threshold for the initiation of sprites.

From previous optical and electromagnetic field observations, a GJ can be considered as a directly electrical current from thundercloud to the lower ionosphere and net charge is transferred to the lower ionosphere in the discharge process. In this report, the recordings of two probable gigantic-jet-induced sprites provide evidence supporting that GJs could lead to new TLE events which are usually induced by lightning.

References

[1] Marshall, R. A. & Inan, U. S., Possible direct cloud-to-ionosphere current evidenced by sprite-initiated secondary TLEs. *Geophys. Res. Lett.* **34**, L05806 (2007).

[2] Lee, L. J. et al., Characteristics and generation of secondary jets and secondary gigantic jets. Submitted to *J. Geophys. Res.* (2012).

[3] Cummer, S. A.et al., Quantification of the troposphere- to- ionosphere charge transfer in a gigantic jet. *Nat. Geosci.* **2**, 617–620 (2009).

[4] Huang, S.- M. et al., Optical and radio signatures of negative gigantic jets. Submitted to *J. Geophys. Res* (2012).