Estimation of Locations and Altitudes of Upward Electrical Discharges Observed Above Tropical Depression Dorian
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Abstract

Jets and Gigantic Jets are electrical discharges that form inside the cloud, escape from the cloud, and can be observed from the ground. Geometrically similar to a tractor beam from Star Wars, a jet is a thin, up to the vertical part of the troposphere, at about 15-20 km, and the lower ionosphere, at about 80-90 km, (Pasko et al., Nature, 416, 152, 2002; Krehbiel et al., Nat. Geosci., 1, 233, 2008); the existence of these phenomena is a relatively new discovery (e.g., Wescott et al., Geophys. Res. Lett., 22, 1209-1212, 1995); so there has been a lot of research work being done to understand these atmospheric phenomena. On 3 August 2013, the Geospace Physics Lab at Florida Tech captured videos of six jet events and one starter event above Tropical Depression Dorian. Of the six jet events, four of them are classified as 'gigantic jets' and two as regular jets. In order to analyze the development of these events, their accurate locations and altitudes must be determined. In this talk, we present an analysis combining star-fields with the data from National Lightning Detection Network (NLDN) to determine those important parameters.

To conduct the analysis, we first enhanced the contrast of the original images to make stars clearly visible. Once a handful of stars were visible, they were identified by using Stellarium. We then used the Graphical Astronomy and Image Analysis tool (GAIA), which fits the stars in the image to a star map and gives the Right Ascension / Declination for each pixel in the image. The RA/Dec coordinates were then converted to azimuth and altitude angles, which gave the direction from the horizon. The recorded lightning strokes from the NLDN were then plotted on a weather map with the infrared radar image of the storm overlaid. The azimuthal angles of the events were then plotted on the map as well. Finally, the locations of the events were estimated based on the lightning strokes around the respective azimuthal directions, taking into account the proximity in time from the lightning events to the jet events. Once the locations were determined, altitude measurements could then be made on the events, allowing for the size and speed of the events to be calculated.

Introduction

Transient luminous events (TLEs) are electrical discharges that occur in the middle and upper atmosphere above thunderstorms. Reports of sightings of upward lightning-like phenomena have been around for a century, but it wasn’t until the late 1980's that an event was accidentally caught on film during a test of a low-light television camera (Franz et al., 1990). Since then scientists all over the world have been filming, and studying these atmospheric phenomena.

Storm and Lightning Analysis

To find the distance, the Alt/Az data was cross referenced with data from NOAA and the NLDN. The infrared radar images of the storm were acquired from NOAA, and the lightning strike information was obtained from the NLDN. The radar image was uploaded into MATLAB and the lightning strikes were plotted directly onto it. This gives the location of each recorded strike relative to the storm itself, along with the position relative to the internal convection cells of the storm. By taking into account the time of each recorded lightning strike, and only plotting the strikes directly before an event, one can compare those locations with the plotted azimuthal lines of the event and obtain the location of each event. Once the location is known, initial and terminal altitudes, vertical and lateral sizes, along with speed of propagation, can all be calculated.

Altitude and Speed Analysis

Once the locations of the events were determined the initial and terminal altitudes could be determined along with speed of propagation. All of the events were found to initiate at an altitude of 20 km above the event.

Conclusion

1) We have obtained the locations and altitudes of seven jet events observed above Tropical Storm Dorian by performing an analysis of combining star maps with lightning data.
2) We find that when lightning strikes in the storm seem to be concentrated to two regions of convection and all of the events described here appear to originate from just one of the convective cells (the west-most cell).
3) The speed of the jet fluctuates around 5 x 10^5 m/s, with the speed of a gigantic jet steadily increases from about 2 x 10^5 m/s to 2.1 x 10^5 m/s before the final jump. The speed of the gigantic jet during its final jump is at least 2.5 x 10^5 m/s.

Acknowledgements and References

Spiva, N., M. Morrison, and N. Liu (2012), Upper atmospheric electrical discharges, in the Lightning Flash, in press.