Diagnosing meteorological conditions associated with sprites and lightning with large Charge Moment Changes (CMC) over Oklahoma

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ABSTRACT

Sprites are a category of Transient Luminous Events (TLEs) that occur in the upper atmosphere above the tops of Mesoscale Convective Systems (MCSs). They are commonly associated with lightning strokes that produce large charge moment changes (CMCs). Synergistic use of satellite and radar-retrieved observations together with sounding data, forecasts, and lightning-detection networks allowed the diagnosis and analysis of the meteorological conditions associated with sprites over Oklahoma. One goal of the NASA-funded effort reported herein is the investigation of the potential for sprite interference with aerospace activities in the 20-100 km altitude range, including research balloons, space missions and other aviation transports.

CASE STUDY RESULTS

30 March 2012

Sprite capture time: 05:18:51 UTC

- Radar – strong convective core in western OK
- Surface – OK affected by a cold front. Severe thunderstorm warning issued at 5:30 UTC.
- Upper Air 500hPa – at 12:00 UTC cloudiness dissipated.
- IR – cloud tops temperatures ranging between -50 °C and -64 °C.

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- Radar – heavy convective line in mid OK. Reflectivity reach over 70 dBZ.
- Surface – OK affected by a trough. Tornado warning issued since 20:30 UTC until early June 1st.
- Upper Air 500hPa – strong wind flow around 20.5 m/s.
- IR – storm top temperature ranging <65 °C.

METHODOLOGY

Radar and lightning data for study cases were analyzed using a software programmed in the Interactive Data Language (IDL) on the Relampago workstation at the NSSTC.

- CHARGE MOMENT CHANGE NETWORK (CMCN)

Charge moment change is defined as:

$$\Delta M = Z \cdot Q(t)$$

Where Z (km) is the altitude from which the charge is lowered to ground and Q(t) (C) is the amount of charge lowered as a function of time. Large CMC-discharges (~75 C km) were mapped onto radar reflectivity mosaics.

- NATIONAL LIGHTNING DETECTION NETWORK (NLDN)

The NLDN consists of remotes and ground-based sensing stations located across the United States that instantaneously detect the electromagnetic signals given off when lightning strikes the earth's surface. Flash-level NLDN data were analyzed to examine the CGs characteristics of storms producing negative or positive sprite-class lightning.

- OKLAHOMA LIGHTNING MAPPING ARRAY (OKLMA)

The Oklahoma Lightning Mapping Array (OKLMA) provides three-dimensional mapping of very high frequency (VHF) radiation from lightning.

- NMO NATIONAL RADAR MOSAICS (NMO)

The National Mosaic & Multi-Sensor QPE (NMO) works using radar data from the Weather Surveillance Radar 1988 (WSR-88D), the result is to obtain 3-D mosaics of reflectivity for the entire United States at 5-min intervals.

- RADAR, SATELLITE IMAGERY, SOUNDING AND PHOCAL FORECASTS

- Archive imagery from Mesoscale and Microscale Meteorology (MMM), a division of NCAR.
- PHOCAL is a field 2013 campaign to obtain high-speed video of sprites and their parent within an LMA. Forecast for 30 March 2012 study-case were not available.

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