P512

Monitoring Atmospheric Electrification for Operations and Collaborative Studies at the U.S. Army West Desert Test Center

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1. Introduction

The West Desert Test Center (WDTC) located at Dugway Proving Ground in western UT is the primary testing facility for Department of Defense chemical and biological defense. In addition to chemical and biological defense testing, the range hosts a variety of training and live fire exercises throughout the year. In support of the missions at WDTC, the Meteorology Branch of the Data Sciences Division maintains a vast array of observation systems, sensors, and capabilities covering the range and the surrounding area. During the warm season, thunderstorms present a threat to the safety of range personnel and equipment, particularly during late July and August when the North American Monsoon is active. To mitigate the risk that thunderstorms pose to personnel and equipment, the Meteorology Branch maintains a twelve-station lightning mapping array (LMA) and a mesonetwork of CS110 electric field mills (EFM).

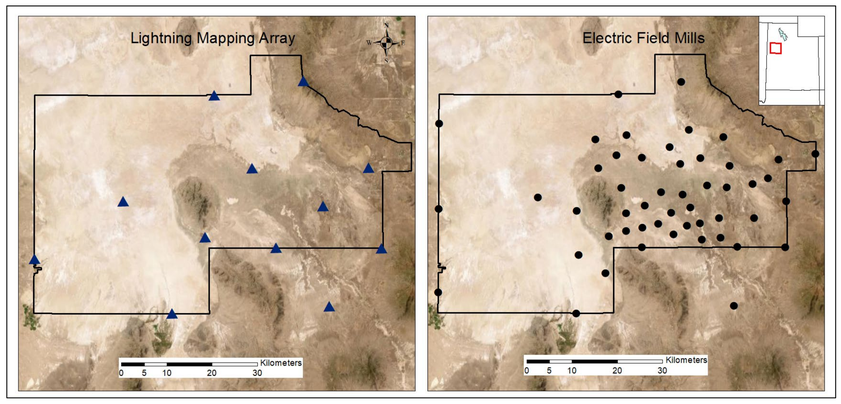


Figure 1: Lightning Mapping Array locations in the left panel, Electric Field Mill sites in the right panel.

2. Lightning Mapping Array

WDTC's LMA network pinpoints sources of radio frequency radiation in an unused very high frequency (VHF) television band (60-66 MHz). VHF radiation sources are known to be associated with lightning. At least 6 active LMA stations are required to develop a 3D time series that determines latitude, longitude and altitude of VHF sources emitted by lightning. This remote sensing technology provides more detailed observations and hence warning of in-cloud and cloud-to-ground lightning for high-impact targets across the test range. Each station consists of a VHF antenna and receiver, a GPS antenna and receiver, LMA motherboard, PC104 computer, pre-amplifier, logarithmic amplifier, a Redline radio and antenna to provide communications. Solar panels with batteries provide power to the LMA station and communications relay. WDTC's LMA network consists of 12 LMA stations (Figure1) strategically located near and across the range, as well as a central processing server that hosts the data ingest, station monitoring, production of real time density and point source images. The LMA website is also hosted on the central processing server that allows users to access a repository of historic graphical data products and raw data files.

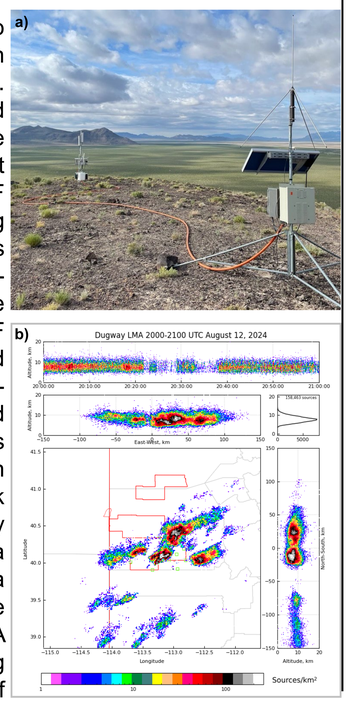


Figure 2a) WDTC LMA station and radio relay. b) 1-hour VHF Source Density Imagery example from the WDTC LMA website.

3. Electric Field Mill Network

Each EFM site as shown in Figure 3 consists of a CS110 mounted downward facing at a height of 2m on a galvanized steel tripod. A small solar panel is connected to a charge controller and 12V 80Ahr deep cycle battery inside a fiberglass enclosure. A Freewave P-CE spread-spectrum (1350-1370MHz) radio connected to a Astron Wireless Technologies Model 1370-8 Yagi antenna provides two-way communication with the instrument.



Figure 3. Campbell Scientific CS110 electric field mill station.

4a. Dust Storm Observations: 18 April 2023

On 18 April 2023, a negatively tilted short wave trough moved across the Great Basin region. A cold front associated with the short-wave trough moved south across Utah, crossing the range midday. Post-frontal winds from the NW increased with gusts to 40kts and lofted a large amount of dust. The weather observer at Michael Army Airfield recorded a surface visibility of ¼ of a statute mile (SM) for the 1850UTC METAR. A Vaisala PWD22 at the airfield recorded a 1-minute average visibility of 0.7SM at the time of the METAR. EFM19 and other nearby EFM station measurements shown in Figure 4a document magnitude of the triboelectrification during the event with ceilometer data in Figure 5 showing the backscatter from the dust in the boundary layer. EFM19 located at the airfield recorded a peak charge of 13000 V/m at 1854UTC. Figure 4b shows the dramatic increase in charge concurrent with the sharp decrease in visibility as the dust arrived.

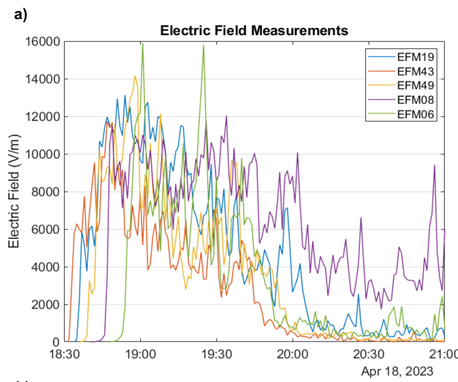


Figure 4a) EFM measurements showing the increase in electric field as the front progressed over the range. b) Electric field from EFM19 and the visibility from the nearby PWD22 sensor.

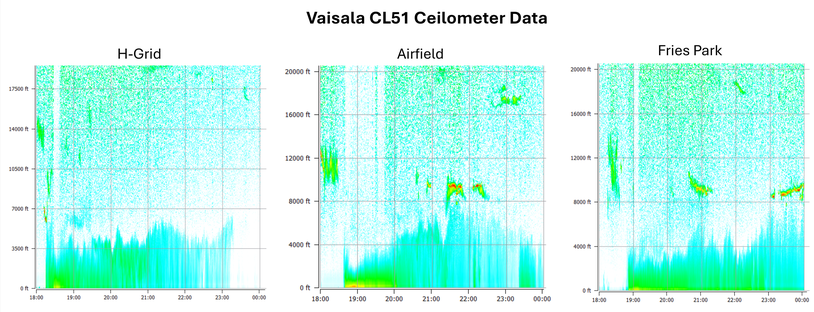


Figure 5. Ceilometer backscatter data from three CL51 instruments at WDTC. H-Grid is the farthest west, Fries Park is the farthest east. The increase in backscatter associated with the dust extends above 3000ft AGL.

4b. Blowing Dust Observations: 17 June 2024

On 17 June 2024, a dry cold front crossed the range in the afternoon, reaching the airfield between 2000-2100UTC. The prefrontal winds were out of the NW at 10-15kts gusting to 20kt and post-frontal winds increased to 25-30kts with a peak gust of 44kts from the NW (Figure 6a). Surface visibility decreased after 2000UTC from 25SM to 10SM at 2100UTC and the final manual observation of the day at 2300UTC surface visibility at the airfield was 5SM. The PWD22 recorded visibility (Figure 6b) aligns with the manually observed report and the decreased visibility coincided with increased electric field measurements. Other EFMs near the airfield showed elevated electric field values though the peak values among the stations vary considerably (Figure 7). In Figure 6c the CL51 backscatter data at the airfield shows the increase in dust with the arrival of the front, and the depth of the frontal layer with enhanced elevated backscatter at the airmass transition. Ultimately, shallow clouds formed at the top of the frontal layer beginning around 2300UTC, at the same time as the maximum low-level backscatter from the dust is recorded.

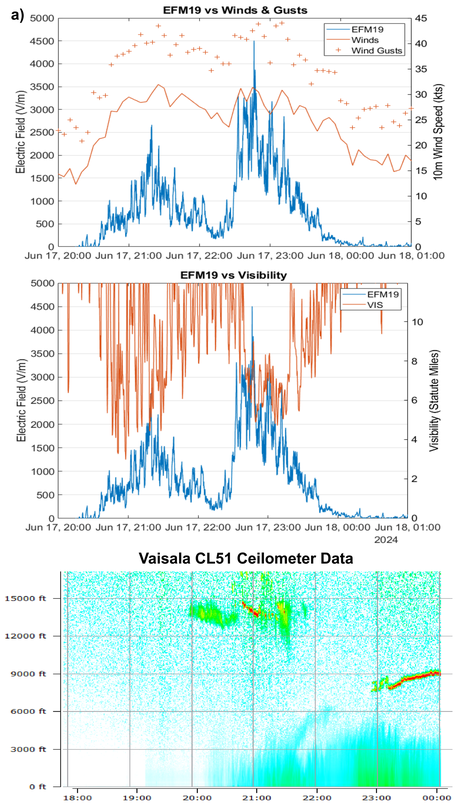


Figure 6a) EFM19 1-second electric field measurements with 5-minute sustained wind speed and gusts. b) EFM 1-second electric field measurements with the PWD22 1-minute mean visibility. c) Airfield ceilometer backscatter.

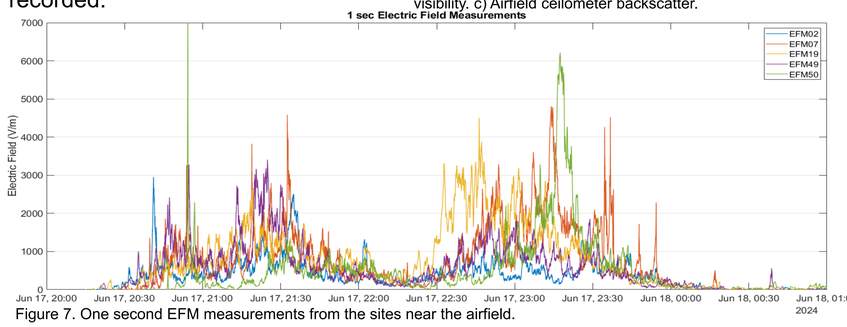


Figure 7. One second EFM measurements from the sites near the airfield.

5. Future Work and Collaboration

WDTC Meteorology Branch will continue to collect LMA and EFM data for phenomena of interest to range operations and those interests submitted by the meteorology community. The relationships between wind speed, visibility, dust and electric field measurements will be investigated as more cases are collected. The Branch currently does not have a method to quantify the aerosol concentration and size distributions, but we are looking into cost effective outdoor measurement systems for sampling high aerosol concentrations to identify the aerosol properties that result in the triboelectrification measured by our EFM network. The dust cases shown here may be useful to the Lightning Advisory Panel for developing launch commit criteria for blowing dust and dust storm conditions. The University of Utah operates a 15-station LMA centered approximately 60 miles to the south, and combining data from both arrays may be a potential collaboration effort.