URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Measuring the Electric Field in Thunderstorms Through Observations of Cosmic Ray Extensive Air Shower Rate Variations by the Telescope Array Surface Detector.

R. Abbasi [(1)]
(1) Loyola University Chicago, Physics, Chicago, USA.

Abstract.

Knowledge of the electric field strength and structure inside a thunderstorm is key to understanding lightning initiation. Despite decades worth of electric field measurements, the measured values of the observed electric fields are not sufficient to create a leader or stroke on the kilometer scale. This means that either the electric field measurements are inaccurate or that our understanding of how lighting is initiated is incorrect. The common approach to making these electric field measurements is to use balloons and planes to fly through the storm. There are some obvious limitations to obtaining such electric field measurements in this manner. For example, thunderstorms are violent events, so flying a balloon or plane through the storm in order to take measurements is very dangerous. Additionally, thunderstorms can be very large, so large that the scale of measurements made from balloons or planes simply too localized, leaving much of the electric field unknown, and increasing the chances of missing the relevant electric field.

Observations of variations in the cosmic ray Extensive Air Shower (EAS) variation intensity, using the Telescope Array Surface Detector (TASD), allows us to study the electric field inside thunderstorms on a large scale without dealing with all the limitation of narrow exposure in time and space using balloons and aircraft detectors. The Telescope Array detector is located in the southwestern desert of the State of Utah. Currently it is the largest Ultra High Energy Cosmic Ray (UHECR) experiment in the Northern Hemisphere. The surface detector array part of the TA experiment, is composed of 507 scintillator detectors on a 1.2 km square grid covering a 700 km^2 in area, 1400 m above sea level. The TASD combination of size and elevation makes it a unique tool that allows the study of thunderstorms as they progress across the detector.

Using data collected between 2008-2019 by the TASD, we found multiple observations with EAS intensity variations greater than $\pm 0.5\%$. Some events were found to correlate with lightning reported by the National Lightning Detection Network (NLDN) in both time and location and some were found to correlate with thunderstorms. The size of the footprint of these variations on the ground ranged from 4-24 km in diameter and lasted for 10s of minutes.

To interpret the electric potential developed above the TASD detector, we performed simulation work where cosmic ray EAS was propagated through the atmosphere and through multiple electric field models using COsmic Ray SImulations for KAscade (CORSIKA). The dependence of the cosmic ray EAS intensity variation on electric fields inside thunderstorms will also be presented.

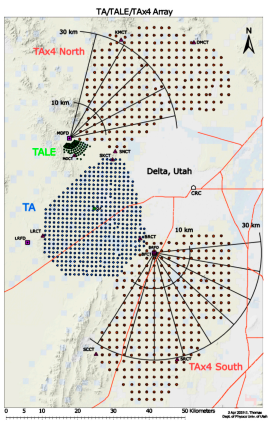

Figure 1. The Telescope Array Surface Detector.