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Investigating Thunderstorm Electric Fields using Radio Emission from Cosmic-Ray Air Showers

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We report on an investigation of the atmospheric electric field during thunder storm conditions over the core of LOFAR, the Low-Frequency Array, for 11 events in the period of December 2011 till September 2014 using a non-intrusive detection method based on the detection of radio emission from cosmic-ray air showers. LOFAR is a software radio telescope primarily used for astronomy and build from a large number of simple dipole antennas. The core of LOFAR, where the antenna density is highest, lies in the northern part of The Netherlands.

Energetic cosmic rays penetrating the atmosphere create a particle avalanche. The atmospheric electric fields induce electric currents in the plasma at the front of this avalanche. These currents emit radio waves since their strength varies as function of distance to the ground. The atmospheric electric fields can be deduced from the polarization and intensity pattern of the emitted radio waves in the frequency band of 30-80 MHz as measured for each cosmic-ray event at LOFAR.

Here we report on the analysis of several events. Most of the events we measure are consistent with the lower positive charge regions occurring near the 0 isotherm as determined from GDAS data. We have observed rather large horizontal component of the electric fields. In some cases where there is clear triple layered structure while there are also some where only two charge layers are detected.

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