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Title: **Remote Sensing of Thundercloud Electric Fields**

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Remote Sensing of Thundercloud Electric Fields

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Abstract

This is the final report of a three-year, Laboratory-Directed Research and Development project at the Los Alamos National Laboratory (LANL). Theoretical and experimental work was performed on the emission of photons from the air within and above thunderclouds and within lightning channels. Predictions were made of the telltale emissions from ionized nitrogen molecules and these emissions were recorded. The measurements will be utilized to help to understand the nature of thundercloud-produced airglow.

Background and Research Objectives

The purpose of this LDRD project is to explore the information that can be gathered by examining 3914-Å emission from thunderclouds and lightning. The 3914-Å line emission from air is an indicator of the presence of energetic electrons in the air. For thunderclouds, enhanced 3914-Å emission is expected to occur from regions where the thundercloud electric fields are strong enough to accelerate cosmic-ray secondary electrons beyond their dE/dx deceleration. For lightning, the emission of 3914-Å photons would be an indicator that energetic electrons are produced in the lightning discharge.

Importance to LANL's Science and Technology Base and National R&D Needs

Los Alamos National Laboratory has been acting to develop a research effort in atmospheric electricity to support its R&D efforts in treaty verification technology and NASA-funded technology. Knowledge about the presence of anomalous amounts of energetic electrons in the atmosphere is important for the understanding of natural radio emissions, for the understanding of atmospheric chemistry, and for the understanding of the global electrical circuit.

Scientific Approach and Accomplishments

This project has a theoretical and an experimental aspect. The theoretical aspect is

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focused on predicting the optical emissions from thunderclouds and from lightning under various assumptions about the physical processes acting in these two regions. For thunderclouds the emissions are calculated for the assumption of a measured bath of cosmic-ray-produced energetic secondary electrons in a strong, large-scale electric field. For lightning the calculations involve estimating the amount of energy dissipated in lighting strokes to obtain optical-emission efficiencies from measured optical emissions. The theoretical aspect is focused on detecting 3914-Å emissions above background levels with the use of dual photometers optically filtered near 3914 Å.

The temporal profiles of lightning emission in the region around 3914 Å were obtained with the dual photometers. Owing to the narrowness of the optical filtering used on the photometers, lightning signatures in daylight were obtained in addition to signatures in darkness. Near 3914 Å, the emission profile of the lightning discharges was repeatedly found to be flat. The time profiles of several lightning strokes were analyzed and successfully compared with time profiles measured by previous researchers. Owing to information obtained while calibrating the photometers on radioactive sources in air, more accurately tuned optical filters were ordered and obtained. The experimental work was interrupted in FY 1995 when the (then) principal investigator, M. I. Buchwald, left the project.

In FY95 the new principal investigator, J. E. Borovsky, organized the LDRD-related conference "The IGPP Workshop on the Physics of Lightning" on November 14-15, 1994 in Albuquerque. There, 89 attendees discussed the properties and measurements of thunderclouds and lightning.

A new theoretical methodology for estimating the energy budget of lightning was developed. This new method leads to estimates of the efficiencies of optical emission that are higher than previous estimates.

A ground-based campaign in Fort Collins, Colorado in the summer of 1996 obtained images and photometric measurements of sprites and sprite tendrils. Broadband, intensified television cameras were used along with a high-time-resolution photometer filtered at 4278-Å, which is part of the 3914-Å band of ionized, molecular nitrogen. These data are being used to rate the various theories about the origin of sprites above thunderclouds.

Publication

Borovsky, J. E., "Lightning Energetics: Estimates of Energy Dissipation in Channels, Channel Radii, and Channel-Heating Risetimes," to appear in *J. Geophys. Res.* (1997).