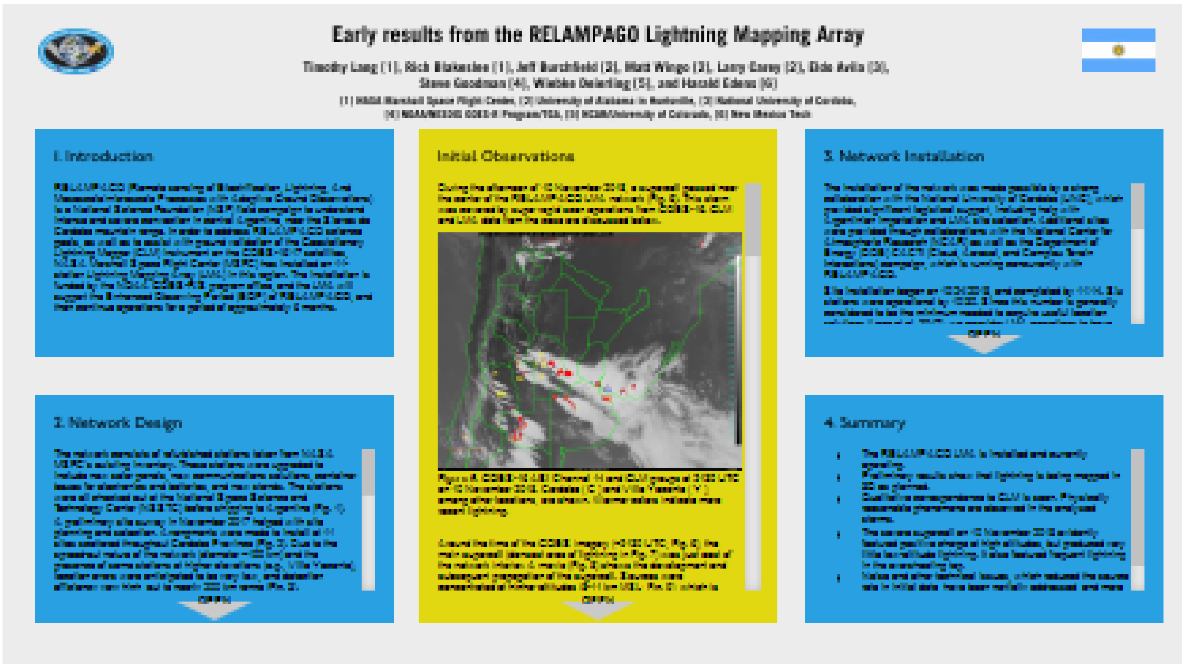
Early results from the RELAMPAGO Lightning Mapping Array



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PRESENTED AT:

1. INTRODUCTION

RELAMPAGO (Remote sensing of Electrification, Lightning, And Mesoscale/microscale Processes with Adaptive Ground Observations) is a National Science Foundation (NSF) field campaign to understand intense and severe convection in central Argentina, near the Sierras de Cordoba mountain range. In order to address RELAMPAGO science goals, as well as to assist with ground validation of the Geostationary Lightning Mapper (GLM) instrument on the GOES-16/17 satellites, NASA Marshall Space Flight Center (MSFC) has installed an 11-station Lightning Mapping Array (LMA) in this region. The installation is funded by the NOAA GOES-R/S program office, and the LMA will support the Enhanced Observing Period (EOP) of RELAMPAGO, and then continue operations for a period of approximately 6 months.

2. NETWORK DESIGN

The network consists of refurbished stations taken from NASA MSFC's existing inventory. These stations were upgraded to include new solar panels, new communications solutions, container boxes for electronics and batteries, and new stands. The stations were all checked out at the National Space Science and Technology Center (NSSTC) before shipping to Argentina (Fig. 1).

A preliminary site survey in November 2017 helped with site planning and selection. Arrangments were made to install at 11 sites scattered throughout Cordoba Province (Fig. 2). Due to the spread-out nature of the network (diameter ~100 km) and the presence of some stations at higher elevations (e.g., Villa Yacanto), location errors were anticipated to be very low, and detection efficiency very high, out to nearly 200 km range (Fig. 3).

Figure 1. Refurbished LMA stations at the NSSTC, prior to shipping.

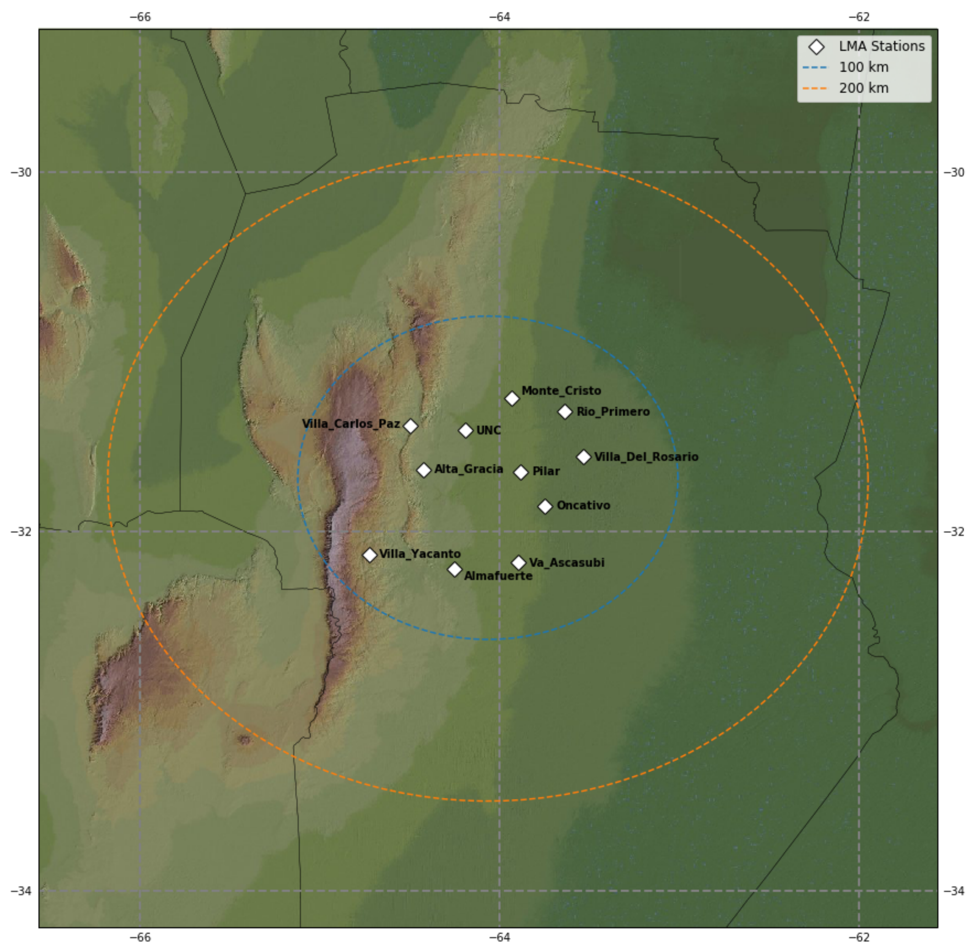

Figure 2. Map of planned LMA station locations prior to installation, with 100-km and 200-km range rings. The Alta Gracia site was swapped during installation to Bosque Alegre Observatory, several km to the WSW. The Villa Yacanto site was moved to Potrero de Garay (south of Bosque Alegre) after Thanksgiving 2018, due to excessive noise at Yacanto.

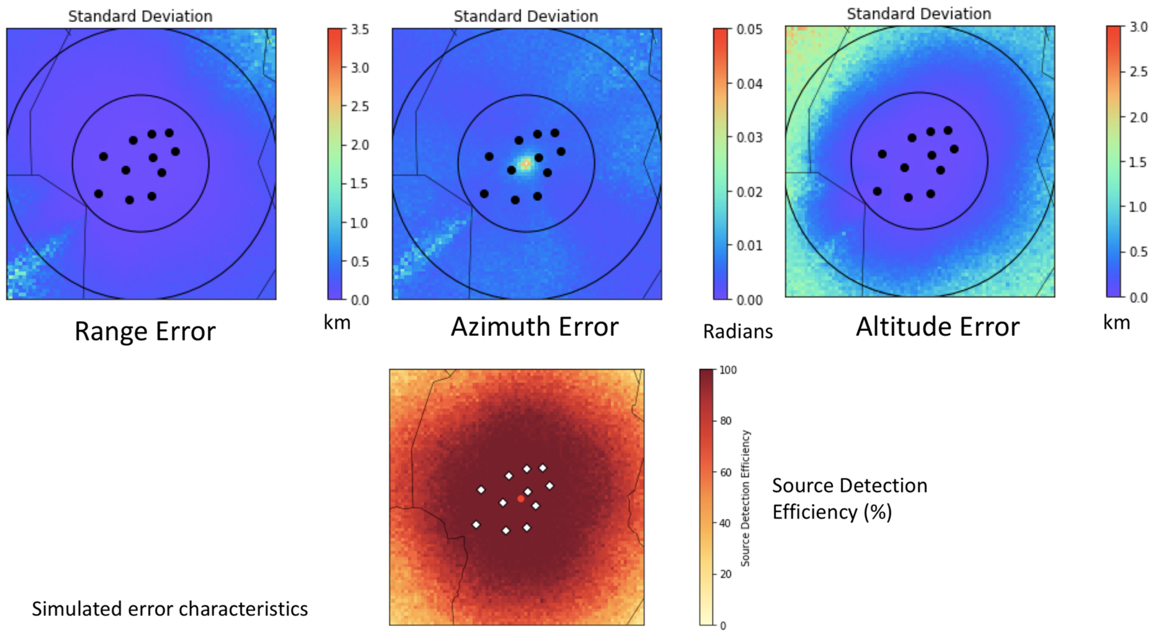

Figure 3. Simulated error and detection characteristics of the RELAMPAGO LMA, following Chmielewski and Bruning (2016). Range rings are every 100 km.

INITIAL OBSERVATIONS

During the afternoon of 10 November 2018, a supercell passed near the center of the RELAMPAGO LMA network (Fig. 6). This storm was covered by super rapid scan operations from GOES-16. GLM and LMA data from the case are discussed below.

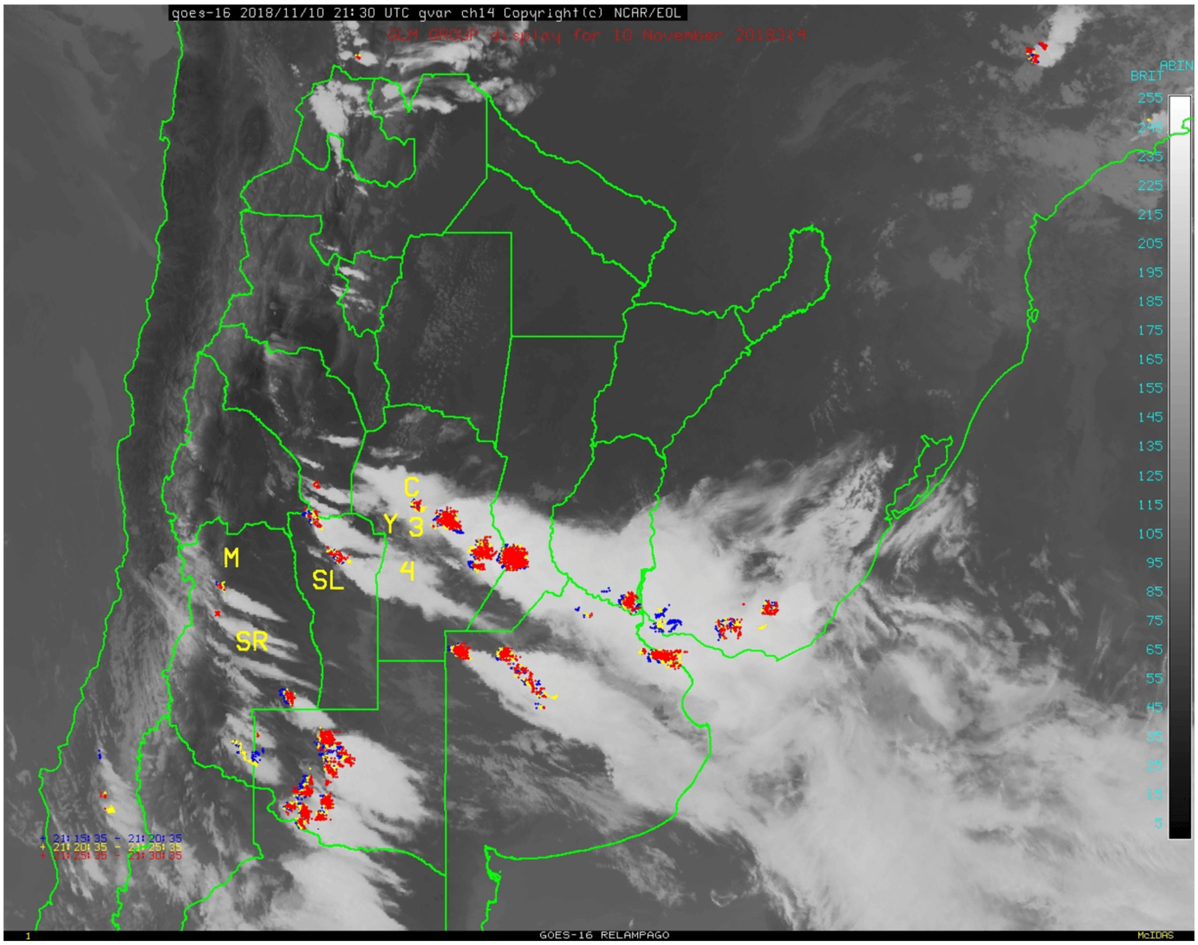

Figure 6. GOES-16 ABI Channel 14 and GLM groups at 2130 UTC on 10 November 2018. Cordoba (C) and Villa Yacanto (Y), among other locations, are shown. Warmer colors indicate more recent lightning.

Around the time of the GOES imagery (~2130 UTC; Fig. 6), the main supercell (densest area of lightning in Fig. 7) was just east of the network interior. A movie (Fig. 8) shows the development and subsequent propagation of the supercell. Sources were concentrated at higher altitudes (8-11 km MSL; Fig. 9), which is suggestive of positive charge in the upper levels (Rison et al. 1999). Compared to GLM (Fig. 6), the LMA appears to detect the four main storms running NW-SE starting from just south of Cordoba (Fig. 7). The LMA also detects an additional storm to the west, between Villa Yacanto and Bosque Alegre (Fig. 10). GLM does not detect lightning there in Fig. 6; however, GLM did observe activity near that same region in neighboring time periods (2115/2145 UTC).

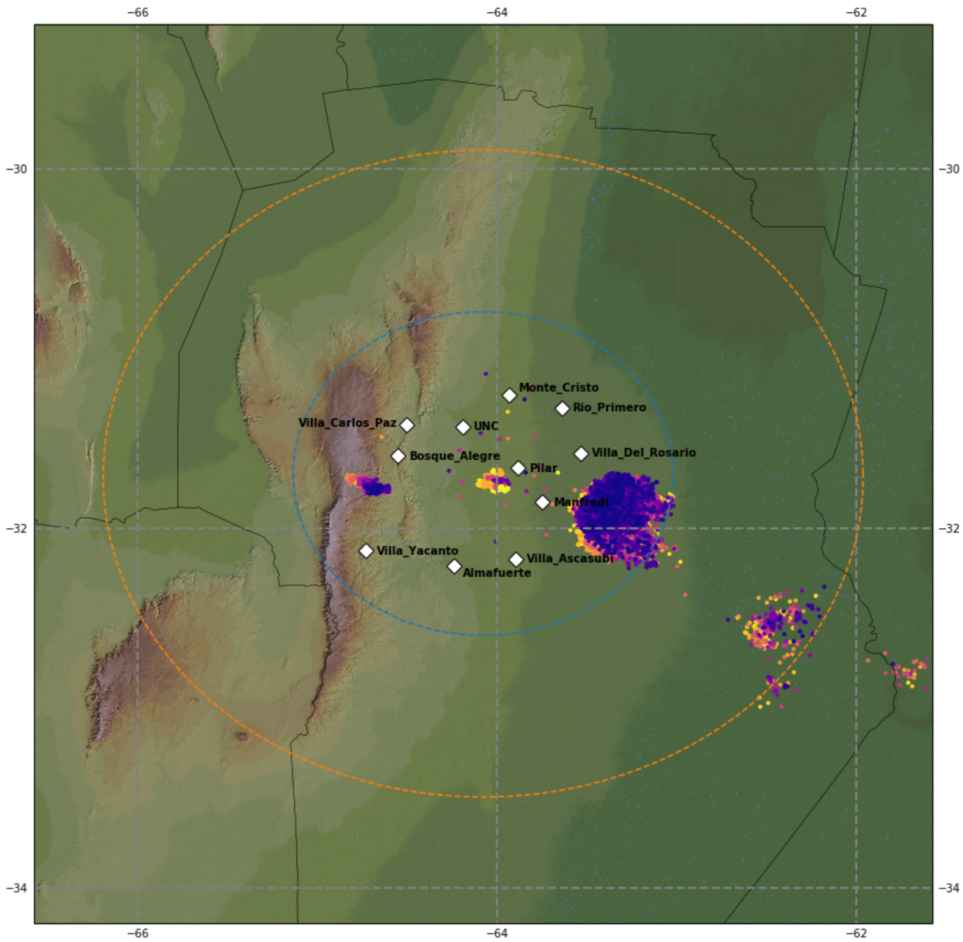

Figure 7. Plan view of lightning during 2130-2140 UTC on 10 November 2018. Also shown are terrain, station positions, and network range rings (100/200 km).

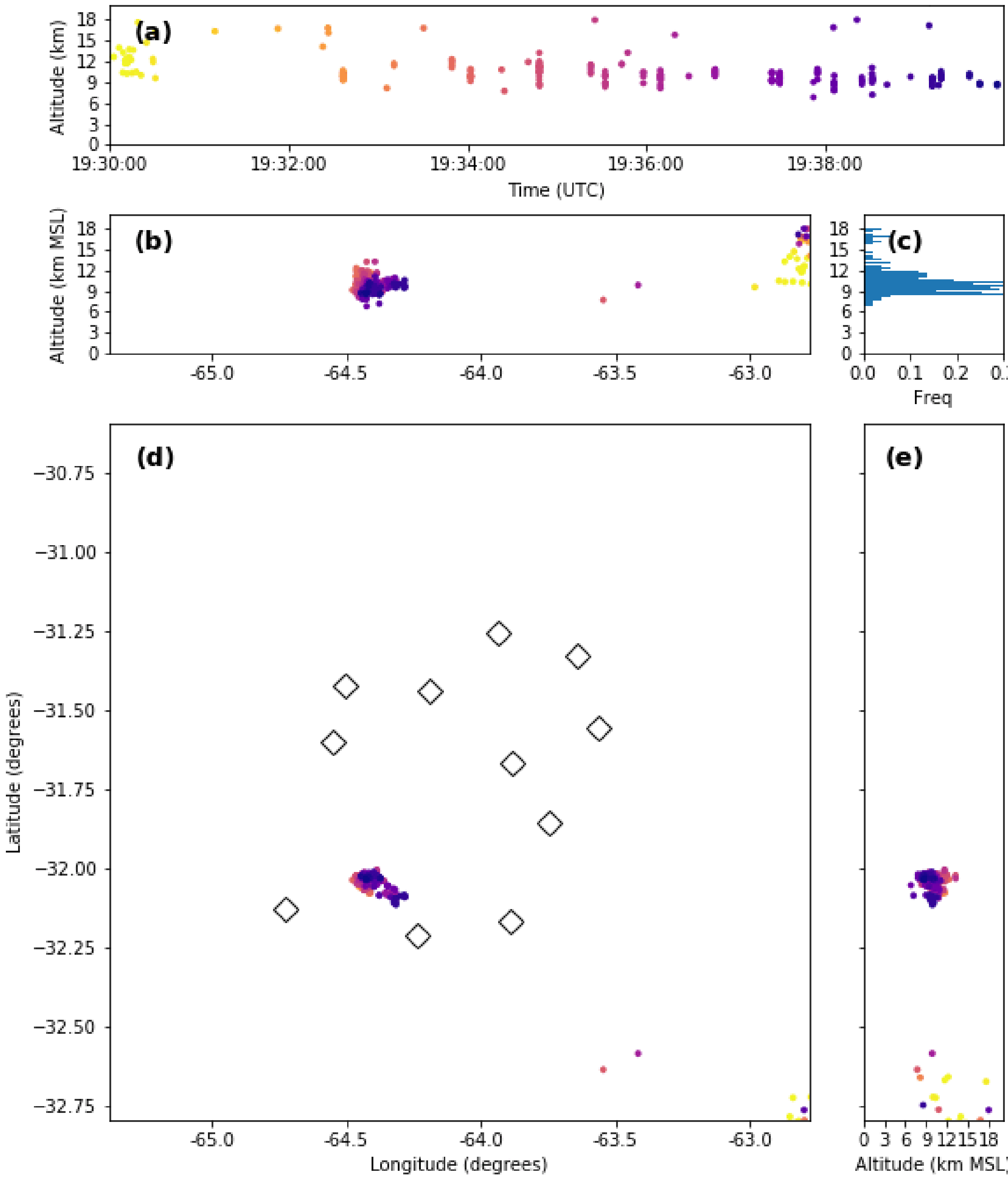

Figure 8. XLMA-style movie of VHF sources observed during 1930-2200 UTC on 10 November 2018. Network effects contribute to the sudden jump in source rates near 2040 UTC.

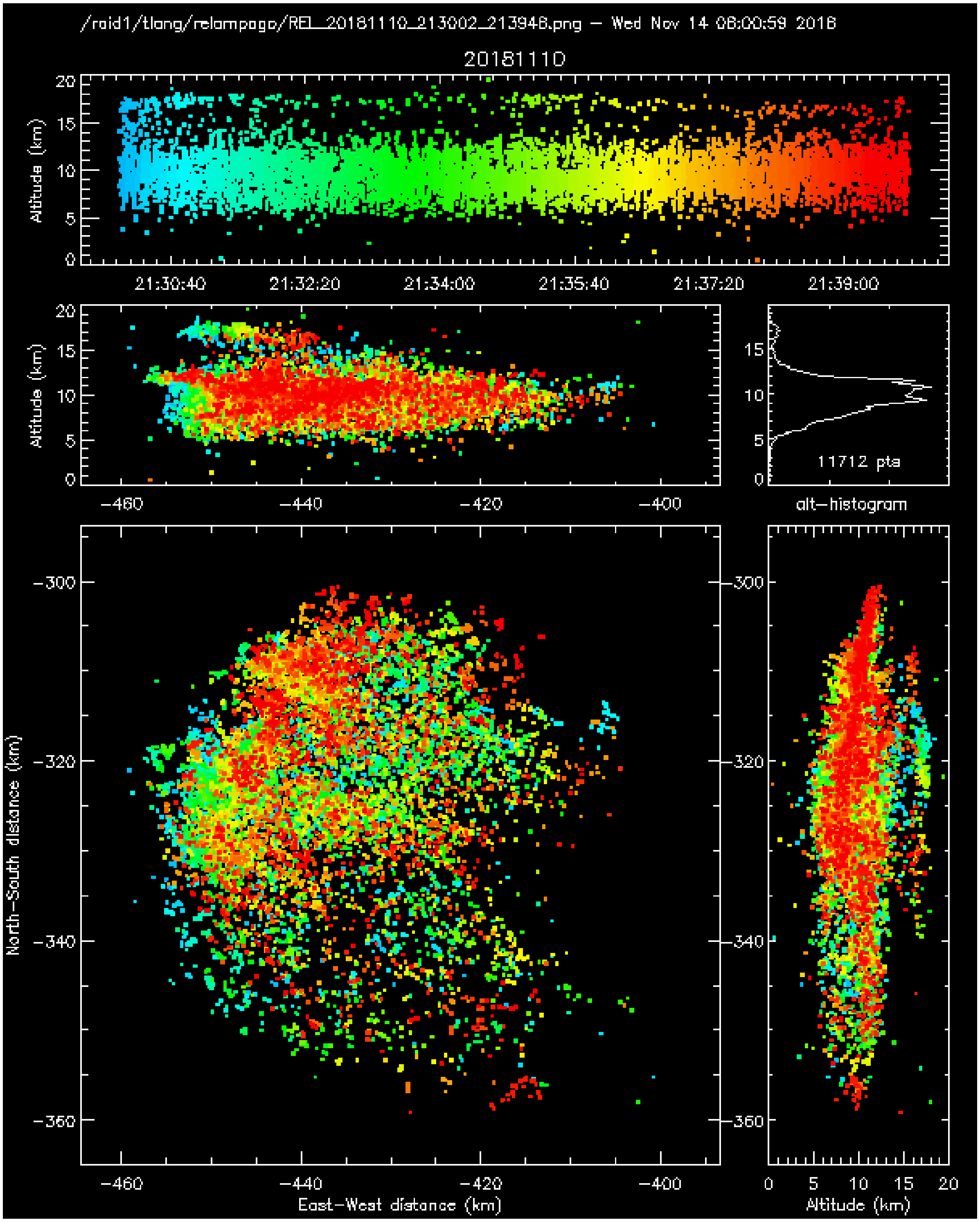

Figure 9. XLMA plot of 10 minutes of data in the 11/10 supercell. Note evidence for frequent intracloud lightning, including in an apparent overshooting top above 15 km MSL.

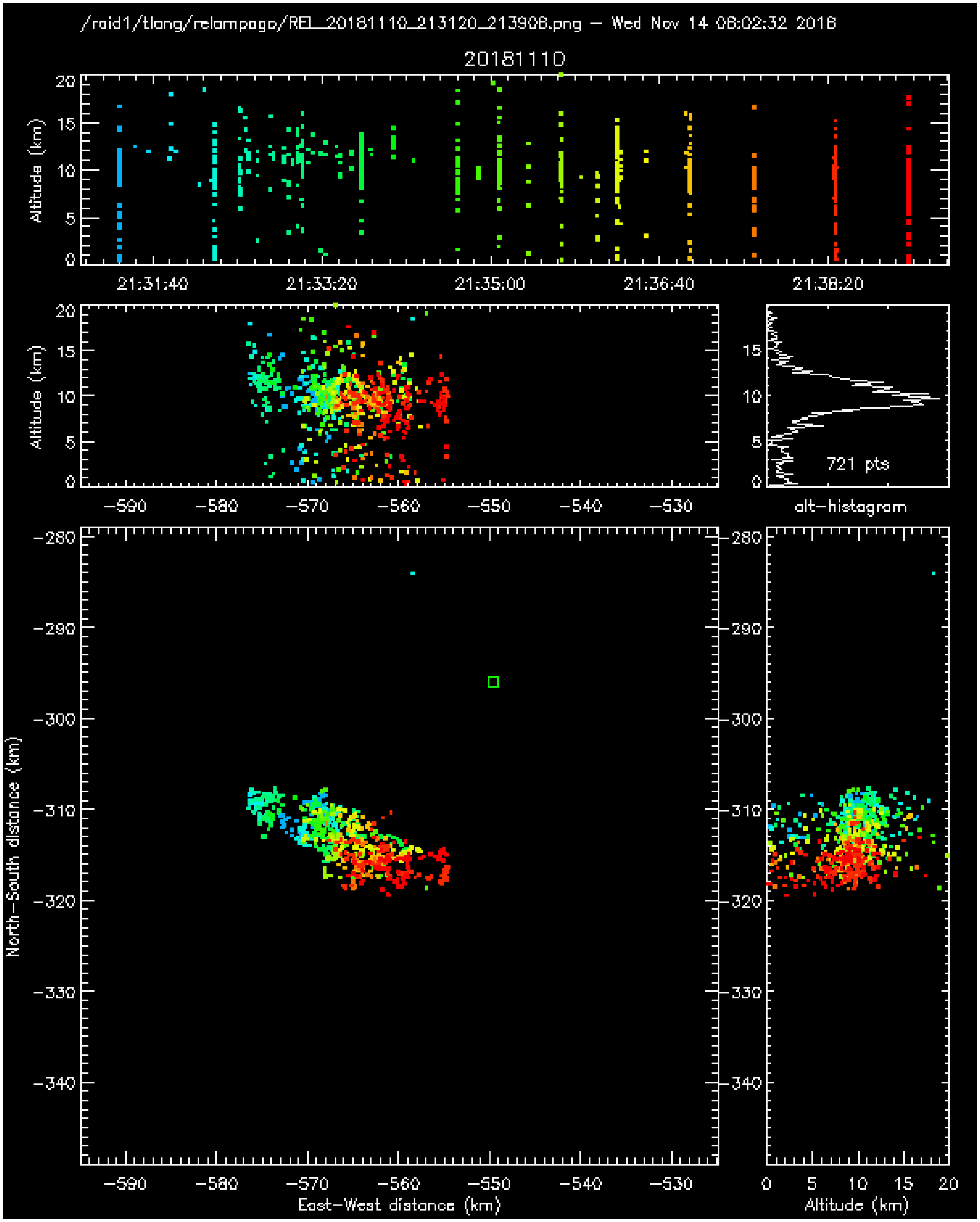

Figure 10. XLMA plot of 10 minutes of data in a small mountain storm just west of the network. Note the prevalence of low-altitude sources, suggesting possible cloud-to-ground lightning.

We have determined that multiple sites have greater noise floors than originally estimated, limiting sensitivity. Additional technical problems have arisen at other sites, which have mostly been addressed as of the end of November 2018. These issues reduced expected source rates in early data (before late November) by a factor of 10-100. The RELAMPAGO LMA remains up and taking data, and we have observed significantly higher source rates in more recent data.

3. NETWORK INSTALLATION

The installation of the network was made possible by a strong collaboration with the National Unversity of Cordoba (UNC), which provided significant logistical support, including help with Argentinian importation and LMA site selection. Additional sites were provided through collaborations with the National Center for Atmospheric Research (NCAR) as well as the Department of Energy (DOE) CACTI (Cloud, Aerosol, and Complex Terrain Interactions) campaign, which is running concurrently with RELAMPAGO.

Site installation began on 10/24/2018, and completed by 11/14. Six stations were operational by 10/30. Since this number is generally considered to be the minimum needed to acquire useful location solutions (Lang et al. 2017), we consider LMA operations to have started officially on 10/30. However, station GPS location pre-processing was not complete until 11/07, so network data before then may not be easily usable. Pictures of individual LMA stations in the field can be found in Figs. 4 and 5.

Figure 4. LMA station on top of roof at UNC.

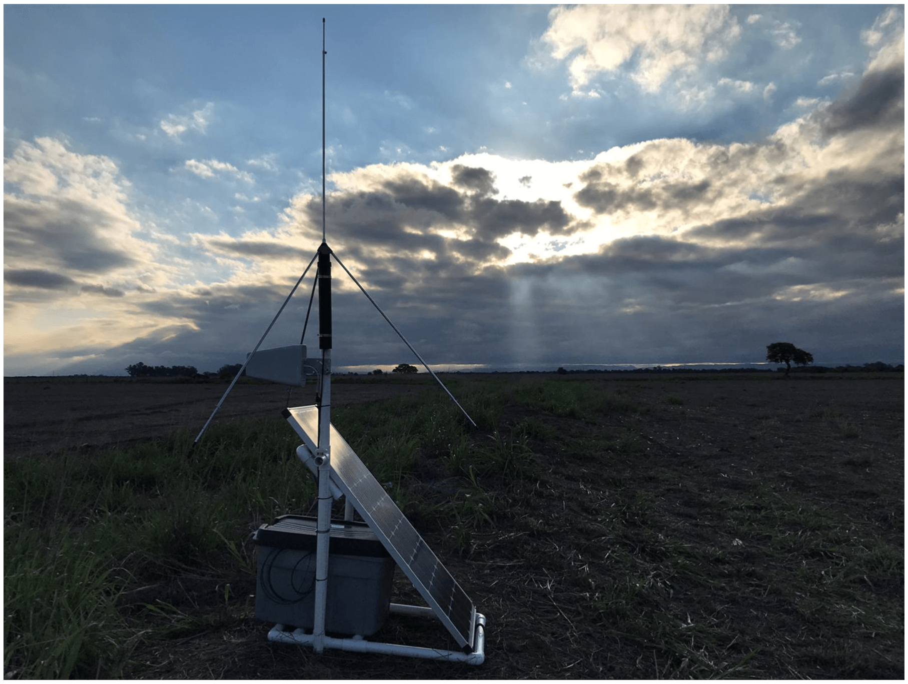

Figure 5. LMA station at Monte Cristo site.

4. SUMMARY

- The RELAMPAGO LMA is installed and currently operating.
- Preliminary results show that lightning is being mapped in 3D as planned.
- Qualitative correspondence to GLM is seen. Physically reasonable phenomena are observed in the analyzed storms.
- The severe supercell on 10 November 2018 evidently featured positive charge at high altitudes, but produced very little low-altitude lightning. It also featured frequent lightning in the overshooting top.
- Noise and other technical issues, which reduced the source rate in initial data, have been partially addressed, and more recent data have significantly improved source rates.

DISCLOSURES

Funding for the RELAMPAGO LMA was provided by NOAA GOES-R Cal/Val project via a reimbursable agreement with NASA MSFC. RELAMPAGO itself is funded by NSF. CACTI is funded by DOE. The RELAMPAGO LMA was imported and installed under the auspices of the following agreement with Argentina: "Agreement between the National Aeronautics and Space Administration (NASA) of the United States of America and the Facultad de Matematicas, Astronomia, Fisica e Informatica (FAMAF) of the Universidad Nacional de Cordoba (UNC) of Argentina Concerning COOPERATION IN GROUND VALIDATION AND SEVERE WEATHER RESEARCH." Bill Rison and Dan Rodeheffer are gratefully thanked for providing technical consultation during network troubleshooting. Michael Solomon and Joy Marich assisted with the LMA station prep work at the NSSTC. Phil Bitzer and Rodolfo Pereyra assisted with the installation of the LMA.

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ABSTRACT

In austral spring of 2018, an 11-station NASA lightning mapping array (LMA) will be installed in the Cordoba region of Argentina, in support of GOES-16/17 Geostationary Lightning Mapper (GLM) calibration and validation, as well as the Remote sensing of Electrification, Lightning, And Mesoscale/microscale Processes with Adaptive Ground Observations (RELAMPAGO) field campaign. This region of Argentina is well known for frequent, intense thunderstorms and severe weather. Lightning observations in storms that initiate, become severe, and grow upscale are expected to be obtained by GLM and the LMA during the LMA's multi-month deployment. We hypothesize that, similar to the analogous U.S. High Plains, anomalously charged thunderstorms with frequent inverted lightning at low levels are common in this region, which may have implications for GLM detection efficiency. Deployment logistics and experimental approach will be explained, and some early results from the LMA (including comparison to GLM) will be presented.

REFERENCES

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Rison, W., R. Thomas, P. Krehbiel, T. Hamlin, and J. Harlin (1999), A GPS-based three-dimensional lightning mapping system: Initial observations in central New Mexico, Geophys. Res. Lett., 26, 3573–3576.