TLE and HEET Research in South America with the LEONA Collaborative Network

F. T. São Sabbas[1]

[1] *Instituto Nacional de Pesquisas Espaciais – INPE, Av. dos Astronautas 1758, São José dos Campos, SP, Brazil*

South America is one of the most active thunderstorm regions of the world. Up to date, six campaigns, between 2002 and 2012 have been successfully performed in Brazil to make TLE observations. More than 700 events, mainly sprites, have been recorded over thunderstorms in different places in South America. Given the high thunderstorm electrical activity in our region, we expected to have an extremely high TLE occurrence rate as well as intense emission of High Energy Emissions from Thunderstorms – HEET. This paper will introduce the LEONA: Transient **L**uminous **E**vent and Thunderstorm High Energy Emission C**o**llaborative **N**etwork in Latin **A**merica. It will be composed by 21 optical observation sites all over South America, as well as one neutron detector in southern Brazil. LEONA will provide ground support to several upcoming satellite and stratospheric balloon missions, such as TARANIS, ASIM and COBRAT.

1. Introduction

South America's combination of intense thunderstorm activity and geomagnetic characteristics creates a unique natural laboratory for investigating a variety of atmospheric phenomena and their possible coupling. Its large latitudinal extent, from ~12° N to ~55° S, encompass equatorial, tropical and subtropical regions with conditions that makes South America the second most active thunderstorm and lightning, and consequently one of the most active Transient Luminous Events -TLEs region of the globe.

In Northern South America, the presence of the magnetic equator allows for the investigation of the Appleton Anomaly, the Equatorial Electrojet, ionospheric irregularities and plasma bubbles. In the subtropics is the South America Magnetic Anomaly – SAMA, centered ~29° S and ~54° W, over Brazil, creating a region of enhanced ionospheric plasma density with serious implication for satellites.

The prolific occurrence of gravity waves and TLEs, both resulting from the intense thunderstorm activity in South America, may contribute to mechanical and electrodynamical coupling of the atmospheric layers from the troposphere to, at least, the ionosphere. This characteristic has motivated the execution of 5 TLE observation campaigns in different regions of Brazil up to date, with more than 700 TLEs recorded.

It is within this context that in 2012 the *Atmospheric and Space Electrodynamical Coupling – ACATMOS* group was created at INPE, in Brazil, and that LEONA Network project was conceived.

2. LEONA Collaborative Network

LEONA is the Transient **L**uminous **E**vent and Thunderstorm High Energy Emission C**o**llaborative **N**etwork in Latin **A**merica. It's goal is to study the electrodynamical coupling of the atmospheric layers signaled by TLEs and High Energy Emissions from Thunderstorms – HEET in South and Central America in a collaborative manner. We are developing a network of 21 TLE camera stations to be installed in different locations in South America, one in Central America, and one neutron detector to be installed in southern Brazil to measure neutron bursts from thunderstorms. Each camera will have an approximate range of 800-1000 km. They will be remotely operated via internet from any location worldwide where internet connection is available.

The current team of collaborators is presently composed by research scientists from:

Brazil:

- National Institute for Space Research – INPE
- Instituto Tecnológico SIMEPAR
- Center for Radioastronomy and Astrophysics Mackenzie – CRAAM
- Lebedev Physical Institute – LPI/Russia via CRAAM collaboration
- Federal University of Mato Grosso do Sul – UFMS
- University of São Paulo – USP

Argentina:

- Observatorio Astronómico, Universidad Nacional de Córdoba – UNC
- Consejo de Investigaciones Científicas y Técnicas – CONICET

Peru:

- Jicamarca Radio Observatory – JRO

Mexico:

- National Institute of Astrophysics, Optics and Electronics– INAOE

Figure 1 shows a map of South America with LEONA initial configuration, the regions of COBRAT balloon flights (white lines), and supporting instrumentation sites. Green and yellow circles represent the 800-1000 km radius of coverage of the cameras. The smaller red circles are the ~240 km coverage of meteorological radars. The dotted black lines are the current coverage of RINDAT lightning detection network in Brazil.

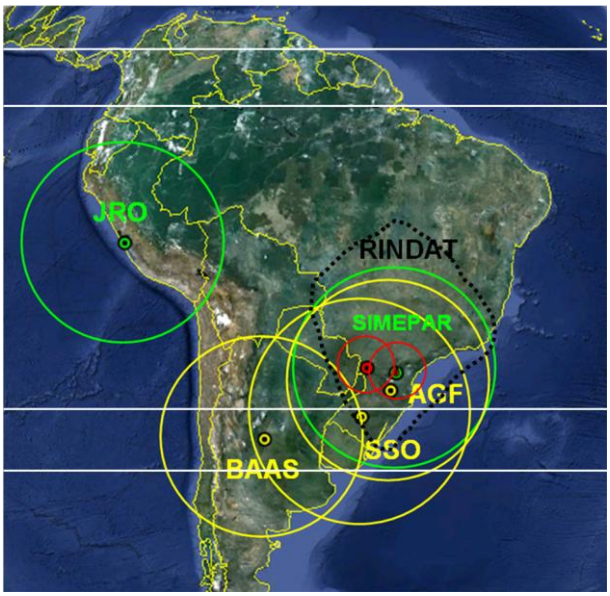

Figure 1. LEONA initial prototypical configuration.

3. Expected Results

The collaboration network and the data collected will lead to the following scientific results:

- The determination of the TLE geographic distribution and occurrence rate in South America;
- The investigation of possible effects of the SAMA in TLE morphology and possible interaction with other geophysical phenomena;
- The measurement and study of thunderstorm neutron emissions in a region of intense activity;
- The possible simultaneous detection of TLEs and thunderstorm neutrons for the first time;
- The study of the convective systems producing the detected TLEs and neutrons;
- The estimate South American TLE contribution to the local and global atmospheric electrical budget;

We also plan to have 2 field campaigns to perform high-speed observations of TLEs using our Phantom camera to investigate details of the temporal-spatial evolution of the TLEs and gain extremely valuable insights of the microphysics of TLE development that may be used to improve the current understanding of their generation mechanism and current models. We will also attempt to make simultaneous high-speed measurements of TLEs and thunderstorm neutron emissions for the first time ever.

4. Conclusions

LEONA will nucleate this research in other institutions in Brazil and other countries in South America, providing continuity for this important research in this region. The camera network will allow for consistent long term TLE observation. In fact this type of ground network is the only way to build a TLE climatology of South America. Thus this project is not only a potential benchmark in TLE research, by creating a collaborative network in Latin America and nucleating this research locally, it is also strategic since LEONA's camera network will be able to fill up the gap left by most satellites in South America.

The network will collaborate with 3 space missions and have the potential to do that with many more missions to come. For example, LEONA will provide ground support for CHIBIS-M satellite mission. Simultaneous measurements with LEONA cameras will allow us to unambiguously discriminate what type of TLEs are being detected by CHIBIS-M. We will collaborate with the project COBRAT to detect TLEs and HEETs with instrumentation onboard long and short duration stratospheric balloons to be launched from French Guiana and Brazil in 2017-2019. And LEONA will provide ground support to TARANIS French Micro-satellite and ASIM mission onboard the International Space Station (ISS), which are scheduled to be launched in 2017-2018 and carry suites of instruments to observe TLEs and TGFs.

LEONA welcomes all scientists from Latin-American institutions interested in joining the team, and welcomes all scientists from European and other institutions worldwide interested to collaborate in this research.