Identification of TIDs and plasma depletions using the LISN observatory

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Abstract

The Low-latitude Ionospheric Sensor Network (LISN) is a distributed observatory designed to nowcast the state and dynamics of the low latitude ionosphere. The LISN observatory is comprised of GPS receivers, flux-gate magnetometers and Vertical Incidence Pulsed Ionospheric Radar (VIPIR) ionosondes. LISN strives to measure the day-to-day variability of the low-latitude ionosphere with a regional scope (50° in longitude), and to conduct investigations of the low latitude ionosphere to develop forecasts of the electric fields, densities and equatorial spread F (ESF) over the South American continent. During the first years of operations the following tasks have been conducted: (1) Maps of total electron content (TEC) over South America. (2) Maps of TEC depletions and TEC perturbations associated with the passage of traveling ionospheric disturbances (TID). (3) Campaigns to detect medium-scale (~100 km) TIDs using 3 GPSs separated by 5-20 km. This presentation shows initial results on the seasonal/ longitudinal distributions of TEC depletions over South America and the relationship of these distributions with the variability of TEC and the occurrence of TEC perturbations associated with gravity waves.

Introduction

One of the oldest problems in the low latitude aeronomy consists of the appearance of plasma structures and irregularities during the nighttime, a process commonly designated as equatorial spread F (ESF). Since its discovery, more than 70 years ago, its interpretation has defied all theories that try to predict its occurrence. Consequently a forecasting capability of the approximate time and place where plasma bubbles will develop is not attainable at this moment. Part of the problem is the fact that the electrodynamics and ion-neutral coupling at low latitudes is not completely understood [*Heelis,* 2004]. In addition, we believe that the term ESF has been loosely used to designate processes that may have different initiation history, evolve following different instability mechanisms and certainly present inherent different morphological characteristics. Another problem is that observing techniques (e.g. scintillations), when used individually, are not able to distinguish or single out between competing processes, or are marred by temporal/space ambiguity.

Recently two new theories have been proposed to explain the onset of plasma bubbles: the wind-driven gradient drift instability [*Kudeki et al*., 2007] and the altitude modulated E_s layer that creates a large-scale wave structure [*Tsunoda, 2005*, 2006]. These two mechanisms offer large growth rates that clearly rival the generalized R-T instability seeded by atmospheric gravity waves (AGW). However, no definitive prove exists of any one being the dominant mechanism, or if all 3 can coexist or act at different local times, locations, or magnetic conditions. The last point that we would like to add consists of the non-local nature of the plasma bubbles. It is the whole flux tube that becomes unstable (encompassing the E and F regions and the plasmasphere), consequently multi-point observations especially during the early phases of ESF development have been always desired but conducted only during few dedicated campaigns.

The LISN Observatory

Figure 1 displays the locations of the GPS receivers that presently form part of the LISN–GPS network (in green). A total of 40 GPS receivers are connected to the Internet. Fifteen additional receivers are operating in Argentina, Bolivia, and Chile without Internet connectivity (red dots).

The LISN project provided financial support for the design and construction of a new 3-axis flux-gate magnetometer at the Jicamarca Radio Observatory. Three magnetometers are installed and operating in the cities of Leticia, Colombia, Puerto Maldonado, Peru and El Leoncito observatory in Argentina. Two other magnetometers are installed at the cities of Alta Floresta and Cuiba, both in Brazil forming another baseline able to provide electric fields at the center of the continent.

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The last component of the LISN project consists of 5 vertical incidence pulsed ionospheric radars (VIPIR) ionosondes, which will be placed closely aligned with the magnetic field line that crosses the magnetic equator near 67° W longitude. We selected the VIPIR ionosonde due to its state-of-the-art technology, reliability, flexibility, and technological adaptability to execute simultaneously multiple experiments. This modern ionosonde allows us to interleave pulse-to-pulse routine measurements with dedicated special operational modes. The first of the LISN ionosondes was temporarily installed at Jicamarca, where a world-class log-periodic transmitting antenna was erected. This ionosonde was relocated to P. Maldonado in October 2010.

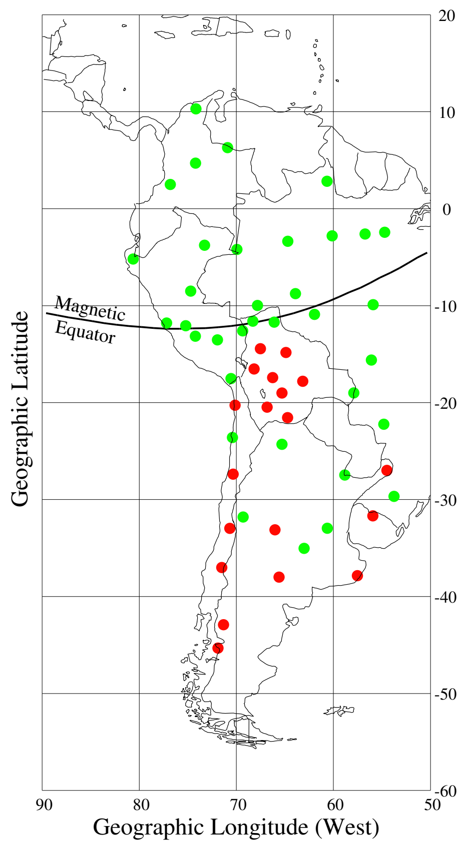

Figure 1. Geographic location of the GPS receivers (in green) of the LISN network

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