



Review on space weather in Latin America. 1. The beginning from space science research

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Abstract

The present work is the first of a three-part review on space weather in Latin America. It comprises the evolution of several Latin American institutions investing in space science since the 1960s, focusing on the solar–terrestrial interactions, which today is commonly called space weather. Despite recognizing advances in space research in all of Latin America, this review is restricted to the development observed in three countries in particular (Argentina, Brazil and Mexico), due to the fact that these countries have recently developed operational centers for monitoring space weather. The review starts with a brief summary of the first groups to start working with space science in Latin America. This first part of the review closes with the current status and the research interests of these groups, which are described in relation to the most significant works and challenges of the next decade in order to aid in the solving of space weather open issues.

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1. Introduction

In recent years, several international efforts have been initiated to improve space weather research and to develop space weather forecasting centers around the world. In 2012, the Committee on Space Research (COSPAR), an interdisciplinary scientific body concerned with the international progress of scientific investigations carried out using space vehicles, established a group called Space Weather Roadmap, which brought together specialists to discuss

space weather from the scientific point of view and provide society with recommended actions. This committee, dedicated to addressing space weather issues and their relation to the technological assets of the modern society, was formed with a large number of space scientist specialists in various fields including solar astrophysics, magnetospheres and magnetic reconnection, geomagnetism, ionosphere, as well as other areas of the solar–terrestrial environment, which indicates that its current space weather monitoring facilities are grounded in space science research.

International space science research has discovered an alternative way to monitor space weather while centers are currently being built to prevent space weather from adversely affecting society, and the Latin American

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research community is part of it. In Latin America, in conjunction with the early international initiatives, the Latin American Space Geophysics Association (ALAGE) was created in 1993 during the third Latin American Space Geophysics Conference. One of its original objectives was to promote the scientific advancement in space geophysics. Recently, ALAGE is endeavoring to extend its aims to include collaboration in space weather research and services.

Therefore, in the present work we review the trajectory of space research in Latin America from near its beginnings (with some of the most significant scientific contributions). We have included highlighted research, which we believe helped prepare some groups to develop space weather operational forecasting centers. In the next section we describe various elements that enabled the international space science research community to provide an alternative shield from adverse space weather effects on society, in three Latin American countries (Argentina, Brazil and Mexico).

2. The beginning of space research in Latin America

Several research groups (or institutions) dedicated to space science have been created in Latin America in the last six decades. In the last ten years, some of these groups have been focusing on space weather research and monitoring. The early 1960s were a very profitable period for space research in Latin America. The Center of Radio Astronomy and Astrophysics Mackenzie (CRAAM) was founded in 1960, and the National Institute for Space Research (INPE) in 1961, both in Brazil. The Department of Outer Space Sciences at the Institute of Geophysics of the National Autonomous University of Mexico (IGF/UNAM) and the National Commission for Outer Space (CONEE) were founded in 1962, in Mexico. The Institute of Astronomy and Space Physics (IAFE) in 1969, in Argentina. After consolidation of the first scientific results of the space race in the late 1980s and early 1990s (Gall, 1987), Latin America created the National Commission on Space Research in Argentina (CONAE) in 1991, the University Program of Space Research and Development in Mexico (PUIDE) in 1992 and the Brazilian Space Agency (AEB) in 1994. Recently, new generations of this category of institutions such as the Brazilian Study and Monitoring of Space Weather (Embrace/INPE) Program in 2007, Mexican Space Agency (AEM) in 2010, and Mexican Space Weather Service (SCiESMEX) in 2014 are being created with a more specific purpose.

In Brazil, like in most of the Latin American countries, space science started earlier than the space race, e.g., the studies of Cesare Mansueto Giulio Lattes (also known as César Lattes, 1924–2005), a Brazilian physicist who was awarded the 1950 Nobel Prize for the co-discovery of the subatomic particle Píon. However, the institutional space science research started in the early 1960s. CRAAM was founded in 1960 as the Group for Radio Astronomy

Mackenzie, originally called GRAM at the Faculty of Philosophy, Sciences and Letters at Mackenzie University, incorporating the experimental activities of a group of physics, engineering, and technical students, as well as the enthusiastic members of the Amateur Astronomer's Association in São Paulo. It contributed pioneering research in the areas of radio-sciences in Brazil, including radio astronomy, solar physics, solar–terrestrial relations, ionosphere physics, astrophysics, radio-scientific instrumentation and space sciences.

In the same period of the early 1960s, the Brazilian government created the National Commission Organization Group of Space Activities (GOCNAE). This group worked in the areas of astronomy, optical tracking of satellite and satellite communications. It was designed to perform space science studies in Brazil on August 3, 1961, which eventually led to what would be the embryo of the INPE, which was installed in São José dos Campos (SP). The initial research was based on the reception of beacon satellite signals from low earth orbiting satellites to measure the total electronic content of the ionosphere over Brazil. This was followed by the monitoring of the cosmic noise intensity by Riometers for the study of the lower ionosphere and the recording of the Earth's magnetic field intensity by magnetometers to observe variations in ionospheric currents. Today, the INPE leads a series of space activities, including space science and space weather, and has facilities covering most of the territory of Brazil, with sites in Santa Maria (RS), São Martinho da Serra (RS), São José dos Campos, (SP), Cachoeira Paulista (SP), Cuiaba (MT), Fortaleza (CE), Natal (RN), São Luís (MA), and Belém (PA). More recently, on February 10th, 1994, the Brazilian government created the AEB, an autarchy associated with the Ministry of Science Technology and Innovations (MCTI) that was designed to formulate and coordinate the space policy in Brazil.

Also in the 1960s, institutional space research was established in Argentina. On December 29th, 1969 the IAFE was created, as a reorganization of the National Center of Cosmic Radiation (CNRC), which originated from the Laboratory of Cosmic Radiation of the National Atomic Energy Commission (CNEA) in the 1950s. IAFE was created by the University of Buenos Aires (UBA) and the National Council of Scientific and Technical Research (CONICET), with the main purpose of doing scientific research in the field of Space Physics and Astronomy, helping interested institutions to develop disciplines, contributing to researchers developing and teaching these disciplines, doing outreach in its fields, and maintaining scientific relationships with similar institutions of Argentina, and of other countries. The development of upper atmosphere research was especially emphasized in Argentina toward the middle of the 1970s, under the coordination of the “Programa Nacional de Radio-Propagación” formed from several institutions in Argentina, such as the “Instituto de Física” and “Instituto de Ingeniería Eléctrica”, both from the National University of Tucumán

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