THE FIRST LANDMARK OF THE BRAZILIAN SPACE WEATHER PROGRAM

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ABSTRACT

The Brazilian Space weather program started at INPE in 2007 under support of Ministry of Science and Technology. Main purpose of the program is to monitor the space climate and weather, from sun, interplanetary space, magnetosphere and ionosphere-atmosphere by satellite and ground based observations, and to provide useful information to space related communities, technological, industrial and academic areas. It is aimed to monitor sun-earth environment physical parameters: the solar radiation and CME event by using radio telescope (BSS, BDA and SPUA), interplanetary environment by muon cosmic ray telescope, equatorial ionosphere scintillation occurrence by GPS receiver net work and ground induced current (GIC) variability by magnetometer net work. Data transmission via internet, construction of data bank system, data assimilation and modeling for future forecasting service and space weather daily bulletin services are under development. Our goal is to establish the whole system to be in operation in 2011.

INTRODUCTION AND OBJECTIVES

A space weather and climate program is being initiated at the Brazilian National Institute for Space Research (INPE) to study events from their initiation on the sun to their impacts on the earth, including their effects on space-based and ground-based technological systems. The program is built on existing capabilities at INPE, which include scientists with a long tradition and excellence in the observation, analysis and modeling of solar and solar-terrestrial phenomena and an array of geophysical instruments that spans all over Brazil from the north to south of the magnetic dip equator. Available sensors include solar radio frequency receivers and telescopes, optical instruments and solar imagers, GNSS receivers, ionosondes, VHF radars, all-sky imagers, magnetometers and cosmic ray detectors.

In the equatorial region, ionosphere and thermosphere constitute a coupled system with electrodynamical and plasma physical processes being responsible for a variety of peculiar phenomena. The most important of them are the equatorial electrojet current system and its instabilities, the equatorial ionization anomaly, and the plasma instabilities/irregularities of the night-time ionosphere (associated with the plasma bubble events). In addition, space weather events modify

the equatorial ionosphere in a complex form and up to now unpredictable manner. Consequently, a main focus of the program will be on monitoring the low, middle and upper atmosphere phenomena and developing a predictive model of the equatorial ionosphere through data assimilation, that could help to mitigate against the deleterious effects on radio communications and navigation systems.

The technological, economic and social importance of such activities was recognized by the Brazilian government and a proposal for funding was approved for the period 2008-2011. New ground instruments will be installed during this period allowing us to extend our current capability to provide space weather observations, accurate forecasts of space weather conditions, and timely hazard alert warnings. The program is expected to be fully operational for the peak activity of the next solar maximum in 2011-2012.

ACTIVITY PLAN IN PRIORITY

The program will take three frontiers, Group 1 covers data collection of Sun-interplanetary space and magnetosphere, Group 2 covers data collection of ionosphere upper atmosphere and geomagnetic field, and Group 3 works on generation of data bank, simulation model and to operate information center. The group 1 is responsible for generation of real time data of the solar radio frequency radiation map, CME event, cosmic ray (muon) variability, in addition to the satellite data (SOHO, ACE, STEREO). The group 2 will take responsibility for real time ionospheric scintillation map, equatorial anomaly map, and plasma bubble activity map. The group 3 collects all of these data and to construct a data center, data assimilation and simulation model operation. Daily publication of bulletin through website is also a task of this group.

Solar CME and Solar wind monitoring

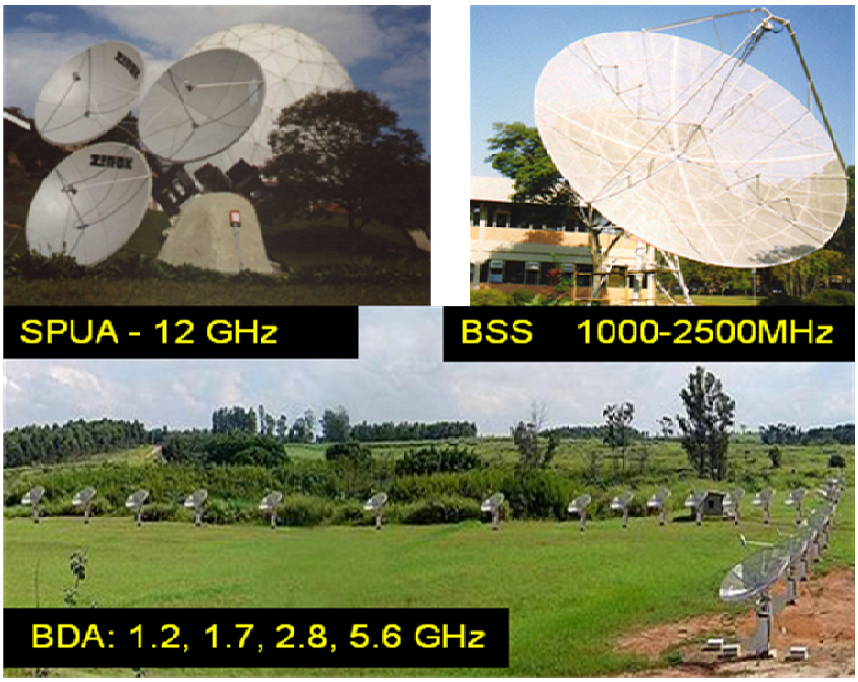

Fig. 1 - Solar radio telescopes for Space weather and climate mission of INPE.

Solar CME event will be monitored by several different type of radio telescope in operation at Itapetinga and in fure at Cachoeira Paulista. SPUA observes the solar surface with 12 GHz frequency. BSS covers 1.0 – 2.5 GHz radiation. BDA(Brazilian decimetric array) antennas map the solar surface with 1.2, 1.7, 2.8, 5.6 GHz frequencies. It will be capable to localize the radiation source region in the solar disc, which is important to predict CME event in the direction of the earth (Sawant et al., 2009). Figure 1 shows BDA, BSS and SPUA antenna view.

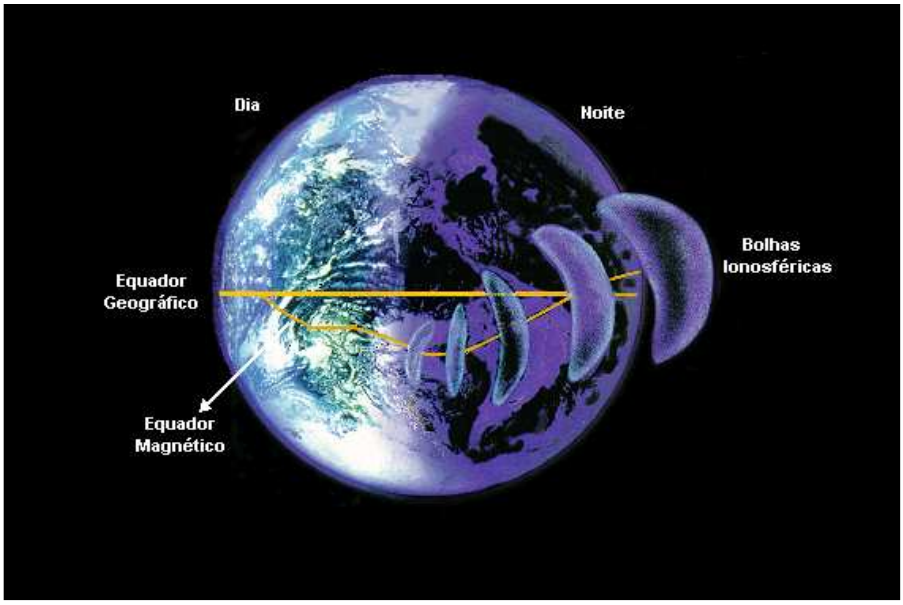

Fig. 2 - Ionospheric plasma bubble generation mechanism in the equatorial region.

Cosmic ray monitoring by muon detector at São Matino da Serra (30°W, 50°W) will be enable us to monitor interplanetary environment. An Increase or decrease of the cosmic ray flux near the earth environment indicates variability of solar flux and CME event (Okazaki et al., 2008).

Equatorial Ionosphere monitoring

In the equatorial and low latitude region, there are regional ionospheric phenomena, equatorial ionospheric (Appleton) anomaly and ionospheric irregularities (plasma bubbles). In Figure 2 generation of the plasma bubble in the local evening side is shown. The ionospheric disturbance causes radio wave scintillation that affects satellite to ground communication and GPS satellite applications. Figure 3 shows scintillation area caused by the plasma bubble activity. Today it is well known that the equatorial ionospheric disturbances are caused by magnetospheric origin from top and also by meteorological activity from below (Abdu et al., 2009).

The present program focuses the subject to ionospheric scintillation effect as the first step. GPS receiver net work deployed in the equatorial region maps the scintillation area. In addition to it, a couple of ionosonde, GPS receiver and magnetometer will be installed at magnetic conjugate points away from the magnetic equator, one at Boa Vista and the other at Campo Grande. The two observation sites monitor ionospheric F-layer uplifting and to predict occurrence of plasma bubbles.

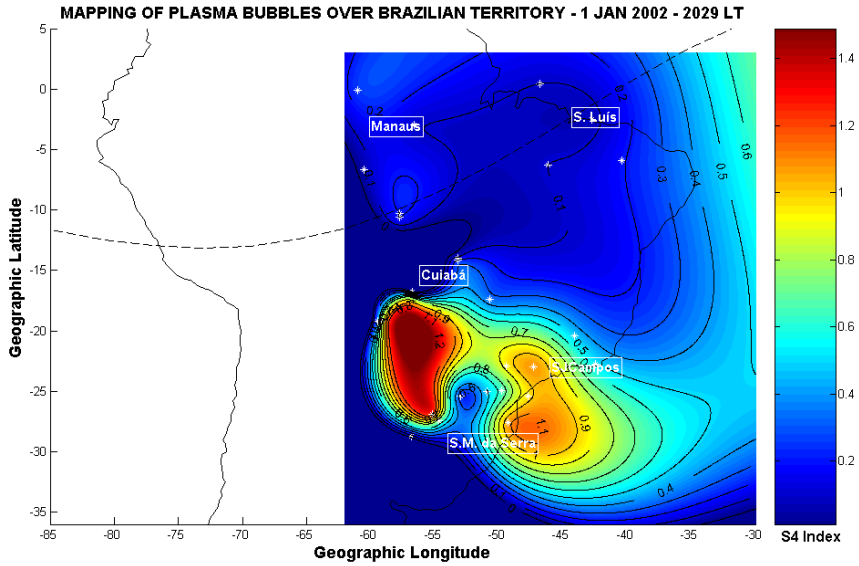

Fig. 3 - Ionospheric scintillation map generated by ground based GPS receiver network.

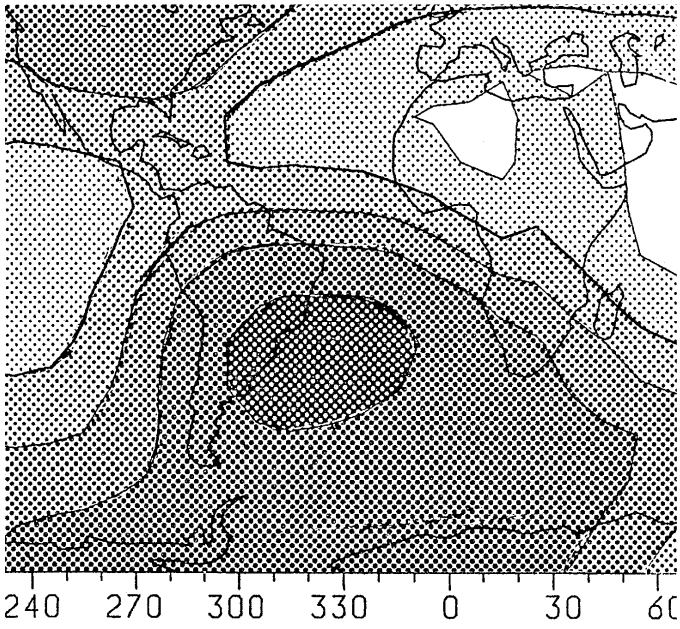

Fig. 4 - Energetic particle precipitation map (in gray scale) in the south Atlantic and American continent region observed by satellite OHZORA (Kohno et al., 1990).

Geomagnetic storm and the South American Geomagnetic Anomaly (SAGA)

The effect of solar flare and solar wind (mass and velocity) are severe in the earth's polar regions. Also important is the region of South American magnetic anomaly region where the magnetic

field is almost a half compared to the other regions. Due to the lower mirror height, energetic particle flux penetrates in the ionosphere. Figure 4 shows particle flux in the SAGA region observed by satellite (Kohno et al., 1990). An increase of malfunction of the satellite in this region has been reported by several previous works. Therefore information of the energetic particle flux is important for satellite operation. The present program plans to provide the magnetic storm information to Brazilian satellite operation center.

BRAZILIAN SPACE WEATHER PROGRAM IN 2008 - 2011

The present program is aimed to create a center for investigation and prediction of the space weather and climate, and to provide the information to space related human activities. Our special interest is, however, rather regional focusing our mission in the equatorial ionosphere weather condition and South American Geomagnetic Anomaly (SAGA) effect.

The space weather and climate program plans to establish following items during the period of 4 years from 2008 to 2011:

(1) To establish a space weather and climate center, and to publish daily bulletin of the space weather information,
(2) To establish ground based space weather monitoring stations, GPS receiver net work, magnetometer net work, ionospheric sounder network, Solar radio frequency telescopes and cosmic ray telescopes.
(3) To establish data bank system for space weather related data from ground-based and satellites.
(4) To establish ionosphere weather map and solar radio frequency radiation map.

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