APPLICATIONS OF THE BRAZILIAN REMOTE SENSING SATELLITE (SSR) TO MONITOR THE AMAZON REGION

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ABSTRACT

Remote sensing by satellite in the optical region of the electromagnetic spectrum has a great potential to monitor many aspects of the Earth's natural resources. However, the frequent cloud cover, especially in the south equatorial region, limits the acquisition of useful images. A new concept for the Brazilian Remote Sensing Satellite (SSR) is under discussion. Its main feature is the low equatorial orbit, which will allow data to be acquired at a very high temporal resolution (approximately every 100 min.). This should make it possible to acquire cloud free images, either directly or via multitemporal composed images. The SSR will cover the region limited by 5°N and 15°S, with a spatial resolution that ranges from ~100 m at nadir (Equator) to a maximum of ~200 m at 15°S. The spectral bands proposed for the SSR sensor correspond to bands 3, 4 and 5 of Landsat-TM. Additionally, the sensor may include a band in the blue region (0.459 to 0.479 μm). Several applications are being proposed to monitor and study the Amazon region with the SSR images, such as: a) quantitative evaluation of deforested areas, especially new deforested areas; b) detection of burned and burning areas and evaluation of their extent; c) characterization and classification of vegetation cover; d) regrowth of natural vegetation; e) phenology of vegetation; f) agricultural activities; g) flood and inundation; and h) mining activities. It is also thought that the SSR images will provide important information for desertification studies, oceanology, geology and solar radiation. The satellite is expected to be launched in three to four years. Its data will undoubtedly provide relevant information to governmental and non-governmental agencies. It will also allow the scientific community to understand better the impact of human activities and natural phenomena in the Amazon region.

INTRODUCTION

Brazil is a country with continental dimensions and has around 8 millions of square kilometers. It has the biggest tropical forest of the planet, the greatest continental water volume and a fantastic diversity of natural resources and ecosystems that are not completely known due to its huge territorial extension.

A global territorial overview is required to study and monitor large scale processes, natural events, and impacts of human activities. Therefore, remote sensing satellites can give a significant contribution to these studies by providing high quality images over our planet.

Brazil was one of the first countries to receive remote sensing satellite images on a regular basis. They have been extensively used since the beginning of the seventies. The remote sensing technique is currently wide spread all over the country at universities, research centers, governmental and non governmental agencies, and private companies. Although the use of this technique is still limited, it has a great potential to be expanded to include new applications as well as to be implemented on an operational basis to support important areas of interest such as crop forecasting, for instance. Remote sensing images are basically characterized by their temporal, spectral and spatial resolutions which in turn are defined by the satellite and sensor characteristics. Since an improvement in a given resolution is very likely to compromise another one, the sensor and satellite characteristics have to be carefully defined so that the best compromise among the different resolutions can be found, based on the state of the art of the technology.

BRAZIL AND THE CURRENT REMOTE SENSING SATELLITES

The Brazilian contribution to the definition of current remote sensing satellites characteristics has been minor. In general, they are established by the scientific community of the countries that are responsible for the construction of the satellites and sensors; however this doesn't imply that they aren't adequate to Brazil. As previously mentioned, Brazil was one of the first countries to use remote sensing images in several areas involved with studies and researches of natural resources through the National Institute for Space Research (INPE) and several other institutions.

However, the acquisition of cloud free images from remote sensing satellites is the greatest restriction to monitor natural resources from space. Radar images are not susceptible to cloud cover, but the great majority of current remote sensing images are still being acquired in the optical region of the electromagnetic spectrum where clouds are a barrier to observe the Earth surface. An alternative to this problem is to increase the temporal resolution of the system in order to increase the chance of obtaining cloud free images.

THE BRAZILIAN ALTERNATIVE

The Brazilian Complete Space Mission (MECB, *Missão Espacial Completa Brasileira*) was conceived in the late seventies and included the construction of two meteorological and two remote sensing satellites along with a satellite launching system (VLS, *Veiculo Lançador de Satélites*). Nonetheless budget restrictions, the first Data Collecting Satellite (SCD-1, *Satélite de Coleta de Dados*) was successfully launched on February of 1993 and is still in operation. The SCD-2 shall be launched later this year.

The characteristics of the remote sensing satellites of the MECB program were defined in the late eighties. The satellites should carry a sensor denominated Wide Field Imager (WFI) which would cover a large surface area. The revisit time at equatorial locations should be of four days and the spatial resolution was specified as ~260 m (an intermediate resolution between Landsat/TM and NOAA/AVHRR satellites). Recently launched satellites such as the Russian RESURS-1 (160 m) and the Indian IRS-1C (188 m) have similar characteristics. This kind of satellite/sensor combination will undoubtedly provide a great improvement in global change monitoring.

Also in the late eighties, Brazil signed a cooperation with China for a space program called China-Brazil Earth Resources Satellites (CBERS). The program comprised the construction of two remote sensing satellites (with some characteristics similar to Landsat and Spot satellites) that are much more sophisticated than those from the MECB program. At that time, it was also decided to include the WFI sensor on board of CBERS-1 and -2. This, in turn, brought the MECB program to a recent new evaluation.

The increasing relevance of the Amazon region in studies related to global change processes, and the demand for information to monitor this region on a systematic basis have promoted the redefinition of the MECB Remote Sensing Satellites (SSR, *Satélite de Sensoriamento Remoto*) to meet some of the remote sensing applications for this important part of the world. The major limitation to obtain data from the optical spectral region, in the Amazon, are clouds. For instance, in some areas the presence of clouds is so intense that no more than a few useful Landsat images were acquired, over the last twenty years. Therefore, a satellite with a low equatorial orbit was chosen to allow several overpasses over the same area on a given day. However, this feature will confine the imaged swath to the latitudes between 5°N and 15°S (figure 1).

Figure 1. South America and imaged swath by the equatorial orbit of the Brazilian Remote Sensing Satellite (SSR).

THE BRAZILIAN REMOTE SENSING SATELLITE

Changes in the orbit, sensor, and data transmission system of the Brazilian Remote Sensing Satellite (SSR) are suggested in the new project (Bogossian et al., 1995; Rudorff et al., 1995; Santana, 1995). Two satellites should be launched with an expected lifetime of four years each. The SSR shall be launched by the VLS (satellite launching system), from the launching center in Alcântara, Maranhão State, Brazil. Each satellite shall have a mass of 230 kg, stabilized at three axes, and hydrazine propulsion. The mean altitude shall be at ~893 km allowing a temporal resolution of less than two hours. This means that the satellite will cover a swath width of 2,200 km, having a spatial resolution of ~100 m close to the Equator and ~200 m at the 15°S limit. These characteristics impose the use of 2 or 3 modular sensors.

The greatest innovation on the SSR is the equatorial orbit, which will minimize the cloud cover problem on the images. Also, partially cloud covered images, acquired at different times or days, can be registered, resulting in a single cloud free or almost cloud free composed image. The sensor should use state of the art technology with four spectral bands (blue, red, near- and mid-infrared). Another great innovation of the SSR concerns the data transmission mode. It can be done directly to the users, from a relatively close area around their stations (500 x 500 km) as well as to a central receiving station located in Cuiabá, Mato Grosso State, for the whole swath that covers Brazil.

APPLICATIONS OF SSR DATA TO ENVIRONMENTAL MONITORING

The SSR images will provide information to monitor and study several activities and phenomena in the North, Northeast and Central-West regions of Brazil above the parallel 15°S. This part of the country has undergone continuous changes in the recent past, particularly over the last half century. Increasing agricultural and cattle activities in the savanna region, the occupation of large areas in the Amazon, mining activities, and the construction of hydroelectric power plants have deeply altered the soil use. Routes for migration and agricultural production flow have been constructed and enlarged, in a non stopping growing cycle. In order to monitor the dynamic of these complex changes, the use of remote sensing techniques is required.

The evaluation of the extent of deforested areas in the Amazon region is usually done with Landsat or Spot images; however, not only the frequency of clouds but also the long time span between the satellite data transmission to the central receiving station and the delivery of the image to the user, have imposed restrictions to provide accurate and updated information. In general, cloud free images, from different years, are used to evaluate the deforested areas according to their availability.

The combination between the high temporal resolution and the 1 to 4 ha spatial resolution of the SSR should allow not only the identification but also the quantification of burned areas, especially through color composed images with visible, near- and mid-infrared spectral bands. Currently, the detection of burned areas is performed with NOAA/AVHRR (Setzer et al., 1992) images acquired once a day during late afternoon (fires are mostly set during the morning period), with a spatial resolution of approximately 120 ha at nadir.

Short period phenomena, such as flood and inundation, need to be observed with high temporal resolution sensors due to their dynamic and cloud cover problem. None of the current remote sensing satellites is able to properly monitor these phenomena. Even the Earth Radar Satellite (ERS-1) has a temporal resolution of only 35 days, although, availability of data from radar satellites are to increase significantly in a recent future.

Studies on classification, identification, regeneration, and phenology of vegetation should benefit from SSR data. These studies are relevant to several aspects in the Amazon region related to climate, photosynthesis and reabsorption of emitted carbon dioxide to the atmosphere through burning and decomposition of biomass. Other applications of SSR data should include the detection of impacts on the natural environment caused by legal and illegal mining exploration activities. It is believed that the proposed spatial resolution of SSR will be adequate and that small features with low contrast borders may be identified with the SSR but shall be further analyzed with images of other satellites (e.g. Landsat, Spot, CBERS).

It is also expected that SSR data should be useful to oceanographic and meteorological studies. A spectral band in the blue region (0.459 to 0.479 μm) should allow the identification of suspended sediments, submarine ecosystems and oceanic islands and atolls. The possibility of acquiring real time SSR data through remote receiving stations may lead to further interest in these studies.

Between the conception and the execution of this project there is still a long way to go. At the present INPE is seeking an ample participation of the user community to evaluate the potential of the SSR data in order to make the project viable. A workshop was recently held at INPE with the participation of a large number of potential SSR data users. Financial resources for the SSR project are yet to be allocated. It is expected that the satellite will be soon in operation (3 to 4 years) to provide the world wide remote sensing user's community with relevant information from the Amazon region.

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