

## Scientific ballooning activities in Brazil

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Since 1940, when Arthur Compton, Cesar M Lattes and their collaborators started measuring the cosmic rays in the region of Bauru, the Brazilian ballooning activities have been growing. The first important scientific campaign using stratospheric balloons took place in 1968 at INPE, Brazil, to study the precipitation of charged particles and X-rays in the upper atmosphere of the Brazilian magnetic anomaly region. Since then, an impressive number of scientific balloon flights were carried out through international co-operation. The development and construction of stratospheric balloons using polyethylene films manufactured in Brazil started in 1989. With the understanding and co-operation of the participating institutions UNICAMP, INPE and UNESP, a project for a permanent site for launching large balloons (1.5 million m<sup>3</sup>) is underway in the Bauru region. This Bauru Stratospheric Balloon Center would include a telemetry station, laboratories and test equipment, a meteorological station with a weather radar and an auto-tracking antenna receiver RD-67.

### 1 Introduction

The work in the field of cosmic ray research and nuclear monitoring in the stratosphere started in Brazil at the University of Sao Paulo, SP, as early as 1940, using neoprene and other types of balloons. These balloons were launched from the cities of Natal, RN, and Bauru, SP. From the late sixties, the Brazilian Space Research Institute, INPE, took keen interest in the study of space geophysics, astrophysics and atmospheric chemistry, using stratospheric balloons. From 1984 to 1990 the University of Campinas, UNICAMP, the Institute of Meteorological Research, IPMet, the Institute of Theoretical Physics, IFT, from the State University of Sao Paulo, UNESP, joined the INPE in the pursuit of cosmic ray research, astrophysics and astronomy, air quality measurements and meteorological research, using polyethylene balloons.

The geography of Brazil as shown in Fig. 1, extending from equator to 30° S, favours the use of balloons to carry out experiments in the stratos-

phere, mainly near 22° S for long duration flights, such as, "turn around world" type. In 1988 the zero pressure polyethylene balloon development programme in Brazil was initiated at UNICAMP. The development, construction and flight tests of these balloons became one of the principal activities at UNICAMP, UNESP and INPE. The main objective is the complete manufacturing of a series of polyethylene balloons with volumes ranging from 10 000 to 30000 m<sup>3</sup>, for monitoring ozone and air quality conditions in low atmosphere and stratosphere over the Amazon and the southern and the central regions of Brazil.

### 2 Important balloon campaigns

From 1940 to 1968, a series of polyethylene and neoprene balloons of volume up to 5000 m<sup>3</sup> were flown up to stratospheric altitudes, to study cosmic radiation and nuclear debris in Brazil; these balloons were launched from near Bauru, SP, and Natal, RN. These experiments were conducted by the research

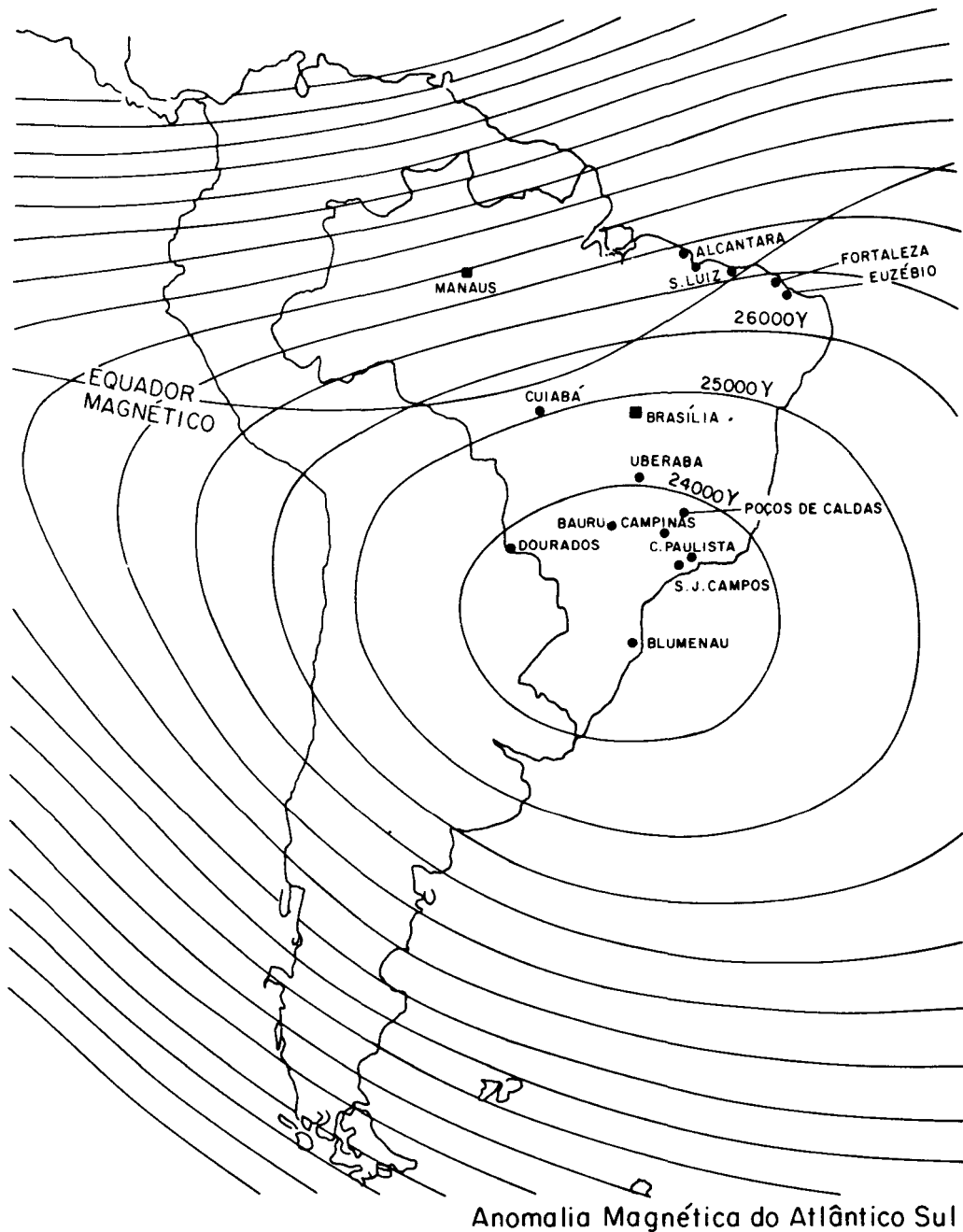


Fig. 1—Launching sites of stratospheric balloons used from 1968 to 1990 in Brazil and the Brazilian magnetic anomaly region, (shown as contour maps)

group at the University of Sao Paulo<sup>1</sup>. Since 1968 a group of researchers and technicians working at INPE, Sao Jose dos Campos, SP, began to work with scientific balloon activities in Brazil. Engineers and technicians were sent to Aire-sur-l'Adour-CNES, France, to learn the French techniques in telemetry and balloon launch facilities.

The first international co-operation with INPE and CNES balloon team took place in June, 1968 in Sao Jose dos Campos, SP. Three tetrahedric bal-

loons of 54000 m<sup>3</sup> were launched with X-ray and gamma ray detectors to study particle precipitation in the South Atlantic magnetic anomaly region<sup>2</sup>. A series of 12 balloons of 54000 m<sup>3</sup> were flown from Bauru (SP) airport during the period 1969-1972, in order to investigate the production of charged particles and X-rays and gamma-rays by cosmic ray interactions in the Brazilian magnetic anomaly region<sup>3-5</sup>.

Since March 1973, a series of balloon flights with

balloon volumes ranging from  $10^4$  m<sup>3</sup> to  $10^6$  m<sup>3</sup> were launched from Brazilian territory by INPE and UNICAMP<sup>6</sup>. Experiments were carried out with these balloons to study low energy cosmic ray electrons, protons and neutrons, and ozone intensity, in collaboration with foreign groups. It is envisaged that from 1990 to 1995 our programmes would involve efforts towards long duration balloon flights from Brazil to Australia and back to Brazil, following the Tropic of Capricorn. Figure 2 shows the time duration of these flights and it is seen that the best periods are January and July in each year.

### 3 Balloon facilities and launching sites in Brazil

The construction of scientific instruments and the development of telemetry, telecommand, on-board and ground electronics are carried out in various laboratories. They include INPE, located in Sao Jose dos Campos, SP, and in Cachoeira Paulista, SP and other laboratories from UNICAMP including NUCATE Center and the Cosmic Ray Department of the Physics Institute. A new balloon centre is now under construction in the UNESP, and IPMet installations in Bauru. This station will have all facilities including auto-tracking receivers operative in the frequency range 1660-1680 MHz, meteorological radar, launching site, hangar and RF laboratory.

Airports are being used as launching sites. They are located in several regions of Brazil as illustrated in Fig. 1. Launch truck and hydrogen supply trailer can be rented in any part of South Brazil. The te-

lemetry used is PCM/FM system (for fixed and mobile stations) with all IRIG B-channels in the frequency range 220-240 MHz and digital microcomputer telecommand with RF-link in frequency range 440-460 MHz. For balloon tracking, an auto-tracking receiver RD-67 operating in the frequency range 1660-1680 MHz and an OMEGA system are used.

### 4 Summary

The scientific balloon activities have been growing since 1940 in Brazil. From 1968 to 1990 a total of 132 balloons of volume  $> 10^4$  m<sup>3</sup> were launched. Further, the development, construction and tests of polyethylene zero pressure balloons using Brazilian films were undertaken. All the participating Brazilian institutions are working together in the development of a new centre located at the University of State of Sao Paulo, UNESP, in Bauru region. This facility will include all equipment and staff working in scientific ballooning in Brazil. They have decided to continue the scientific and technical international co-operation in the area of monitoring of the air quality in the upper atmosphere, including ozone intensity measurements, in the Amazonian and the southern regions of Brazil. The projects for X-ray and gamma-ray astronomy, and for the study of precipitation of charged particles in the atmosphere near the Brazilian magnetic anomaly region, and for carrying out balloon launches 'turn around world' in the southern hemisphere with scientific experiments, are being initiated for the future.

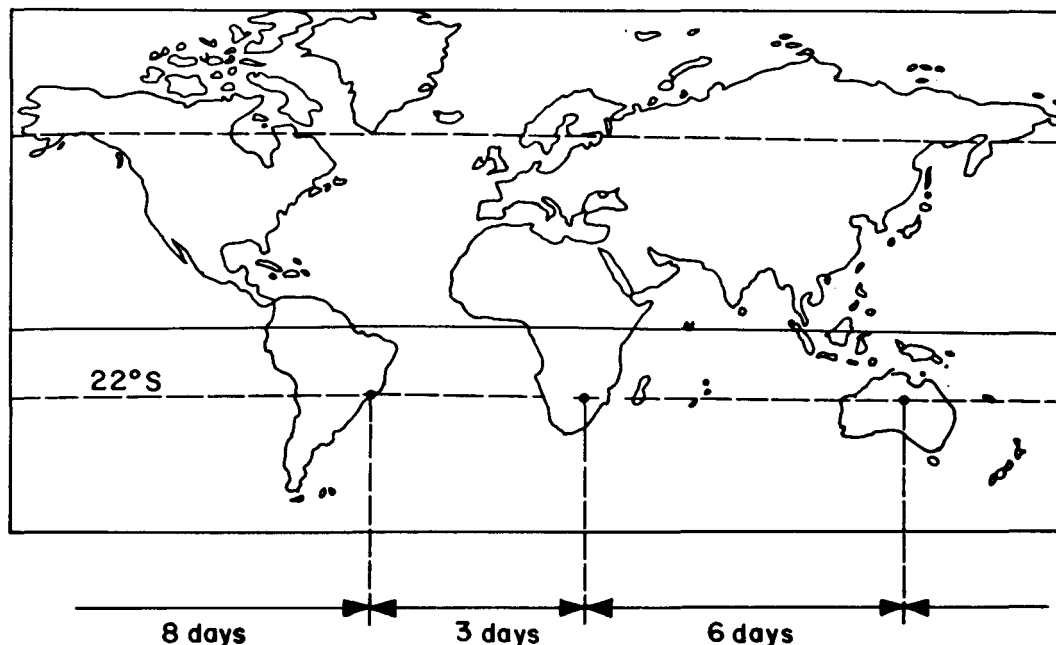


Fig. 2—January and July long duration stratospheric balloon flights route in southern hemisphere

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