

Monitoring environmental variables and earth system phenomena from space using nanosatellite technology

Dr. Kleber P. Naccarato

MINISTÉRIO DA
**CIÊNCIA, TECNOLOGIA,
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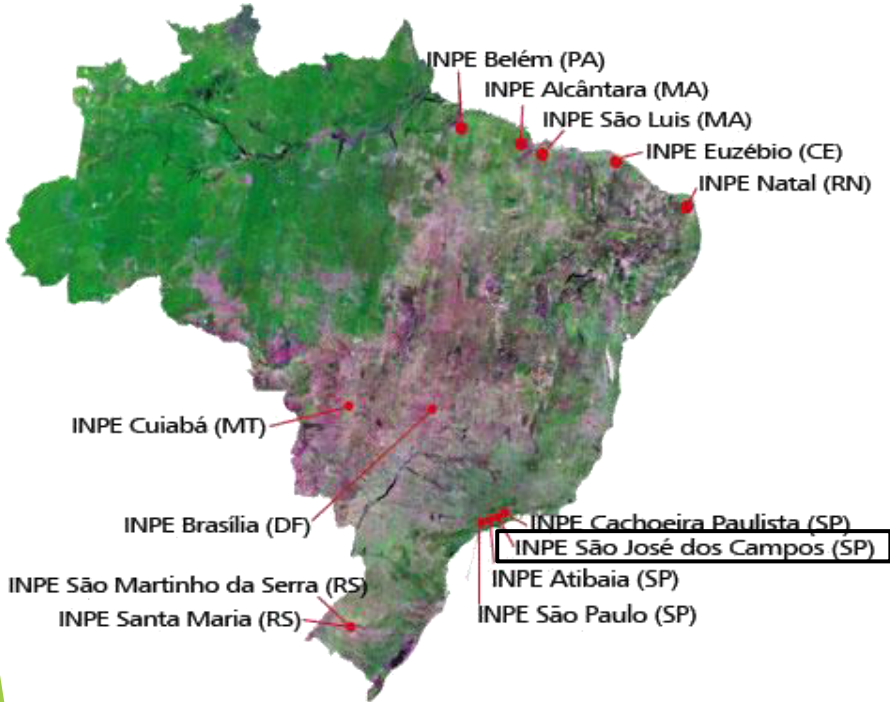
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Ciência para sustentabilidade



NATIONAL INSTITUTE FOR SPACE RESEARCH



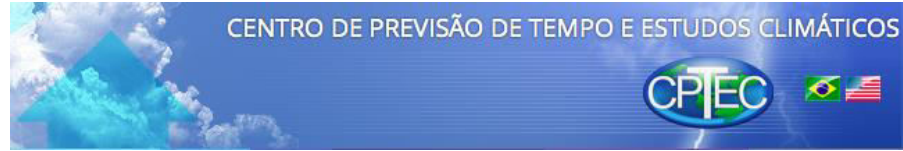
MISSION: To produce science and technology in the space and terrestrial environment areas and to offer singular products and services for the benefit of Brazil.

VISION: To be a national and international reference in the space and terrestrial environment areas by producing knowledge and attending the development and life quality demands of the Brazilian society.



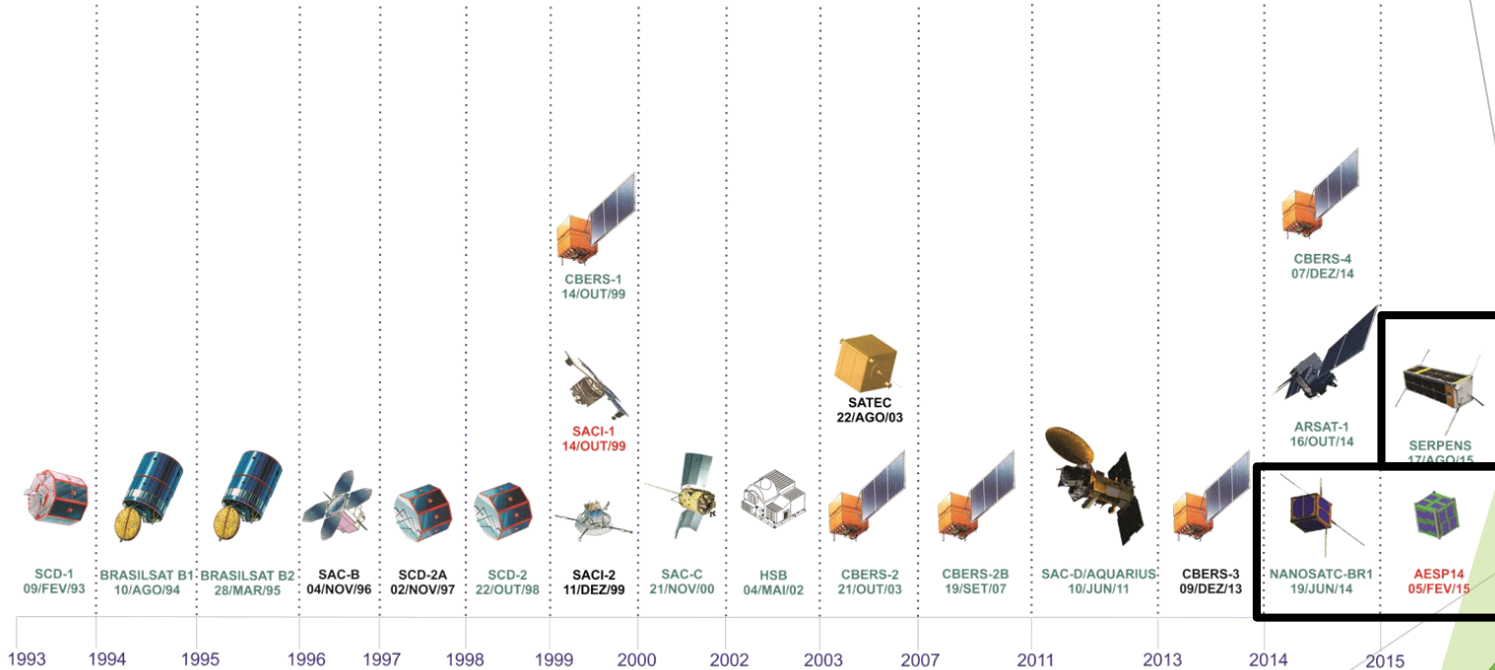
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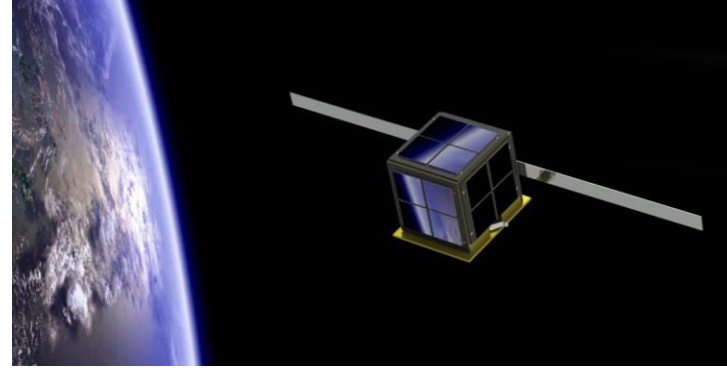
SPACE PROGRAM ACTIVITIES





CUBESAT

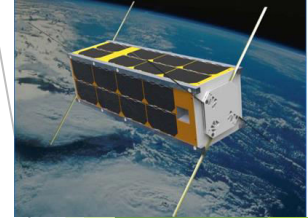
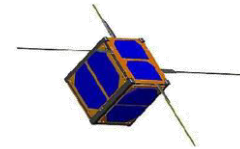
- ▶ A type of miniaturized satellite (U-class spacecraft) that is made up of **multiples of $10 \times 10 \times 10$ cm cubic units**;
- ▶ Have a **mass of no more than 1.33 kg** per unit and often use **commercial off-the-shelf (COTS) components**;
- ▶ Can be put in orbit by **deployers on the ISS, or launched as secondary payloads on a launch vehicle**.
- ▶ In **1999, Cal Poly Univ. and Stanford Univ. developed the CubeSat specifications** to promote and develop the skills necessary for the design, manufacture, and testing of small satellites intended for low Earth orbit (LEO).
- ▶ **Academia accounted for the majority of CubeSat launches until 2013**. By 2014 most newly deployed CubeSats were for commercial or amateur projects that **perform a number of scientific research functions and explore new space technologies**.



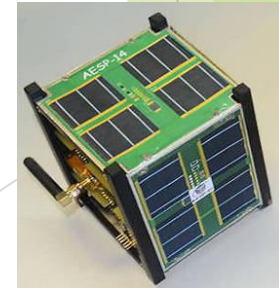
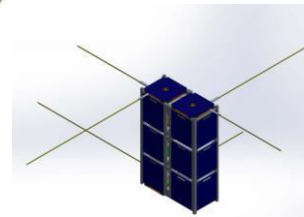


BRAZILIAN'S CUBESATS' INITIATIVES

- ▶ **NANOSATC-BR1 (UFSM / INPE)**
 - ▶ 2014, 1U Architecture, 600km Altitude, <http://www.inpe.br/crs/nanosat/>
 - ▶ **Assess data from South America Magnetic Anomaly & Brazilian's Ionospheric Electrojet**
- ▶ **SERPENS-1 (AEB)**
 - ▶ 2015, 3U Architecture, International Colaboration
 - ▶ UnB, Univ. Vigo, Sapienza, Cal Poly, Morehead, UFSC, UFMG, UFABC, IFF
- ▶ **CONASAT**
 - ▶ First CubeSat constellation (in development)
- ▶ **Tancredo I (UbatubaSat Project)**
 - ▶ 2017, TubeSat (~10x13cm), <http://www.ubatubasat.com/>
- ▶ **ITASat-I (ITA)**
 - ▶ 6U Architecture (in development), <http://www.itasat.ita.br/>
- ▶ **AESP-14 (ITA / LIT-INPE)**
 - ▶ 2015, 1U Architecture, 400km Latitude, <http://www.aer.ita.br/~aesp14/>



CONASAT





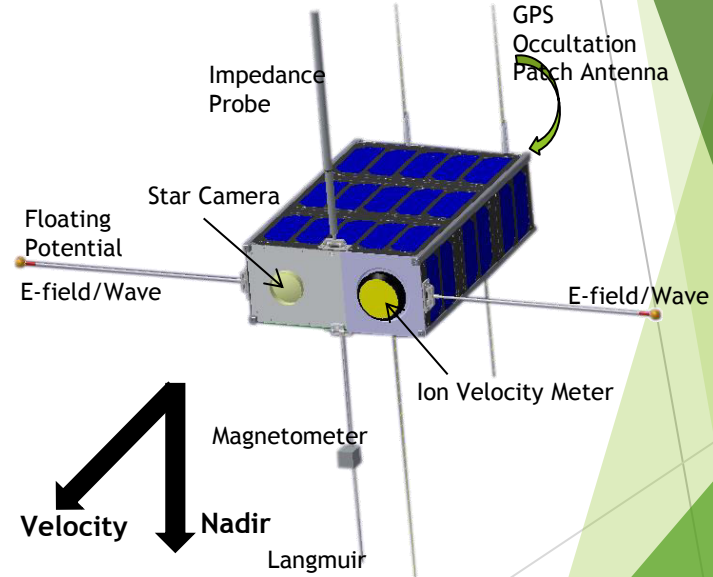
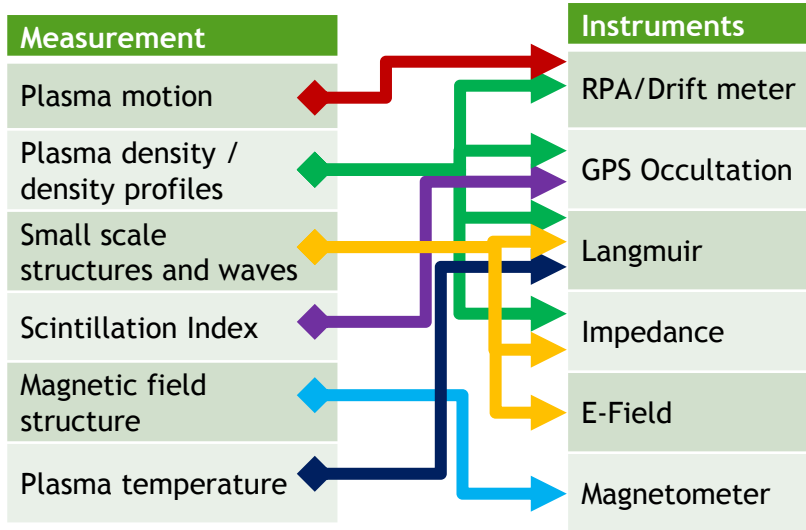
BRAZILIAN'S CUBESATS' INITIATIVES

- ▶ NANOSATC-BR2 (2U)
 - ▶ **Langmuir Probe (CEA / INPE)**
 - ▶ **Magnetometer (UFSM/UFRGS)**
 - ▶ Altitude Control System (INPE / UFMG / UFABC)
- ▶ SPORT - Scintillation Prediction Observations Research Task
 - ▶ International cooperation: NASA / AEB / CEA-INPE / ITA
 - ▶ **To study ionosphere plasm bubbles, which severe compromise / block satellite signal transmissions from / to Earth**
 - ▶ Scientific payloads: Ion Velocity Meter, GPS Occultation Receiver, Electric Field Probe, Langmuir Probe, Fluxgate Magnetometer and Swept Impedance Probe
- ▶ ITASat-2 (ITA)
- ▶ SERPENS-2 (AEB)
- ▶ FloripaSat (UFSC)
- ▶ 14BISat (IFF)
- ▶ Tancredo-2 (UbatubaSAT Project)



SPORT

Space Weather Studies





BRAZILIAN'S CUBESATS' INITIATIVES

▶ GARATEA-L

- ▶ To conduct tests to evaluate the effects of the cosmic ray exposure of bacterial colonies and human tissues (biological payload)

▶ TIM Project

- ▶ International cooperation formation flying mission (constellation)
- ▶ Brazil will build a robust nanosatellite to be part of the formation flying proof-of-concept

▶ Alpha CubeSat Project

- ▶ First of a 3-Cubesat program called Technological Capacitation in Space Engineering (CTEE)
- ▶ For students is a hands-on experience; for community is an open-source nanosatellite platform; and for INPE is a low-cost platform to test new technologies and experiments

▶ **RaioSAT (CCST / INPE)**

- ▶ Intends to detect total lightning (cloud-to-ground and intra-cloud discharges) from a low cost, open standard 2U/3U CubeSat platform, using optical and VHF measurements
- ▶ **First initiative of Earth System Science Centre (CCST) to start monitoring the Earth System from space for sustainable development purposes**





Ciência para sustentabilidade

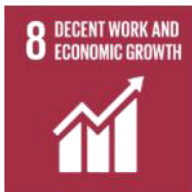
EARTH SYSTEM SCIENCE CENTRE Sustainability and Climate Changes





Ciência para sustentabilidade

EARTH SYSTEM SCIENCE CENTRE Sustainability and Climate Changes

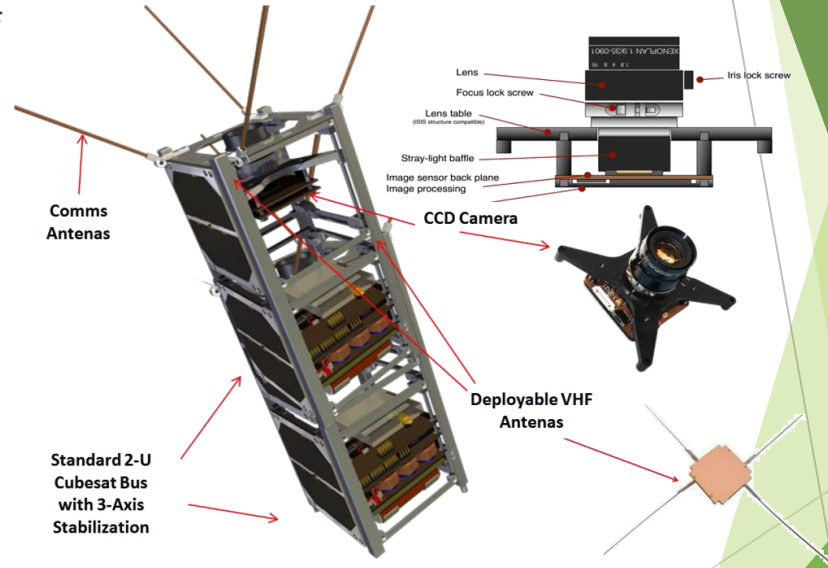




- ▶ Nowadays, in Brazil there are dozens of **ground networks** composed by different types of sensors that provide earth system measurements, including **lightning and/or thunderstorm sensors, greenhouse gases, wind and solar potential for energy generation**, among others.
- ▶ However, now we demand data with a **more spatially uniform and time-continuous coverage** to deep understand earth system phenomena in terms of **sustainability and climate change**.
 - ▶ Prediction of extreme weather events (one of the major features of climate changes) requires high-resolution NWP models and the **maximum amount of observational data available** (atmospheric lightning discharges are a key information);
 - ▶ Remote observation of surface properties (both over land and sea) can be very useful for **land use studies, deforestation impact assessment, forest healthy, land degradation, and interaction of the vegetation with the climatic system**;
 - ▶ Assessment of atmospheric gases from space (e.g. N and CO₂) can improve the **studies of the greenhouse effect and global warming**.

RaioSAT PROJECT

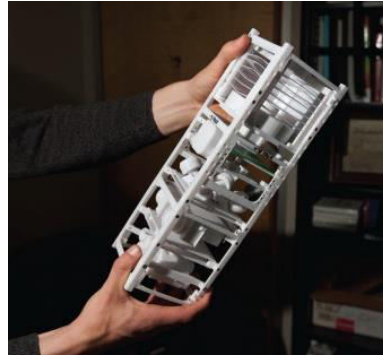
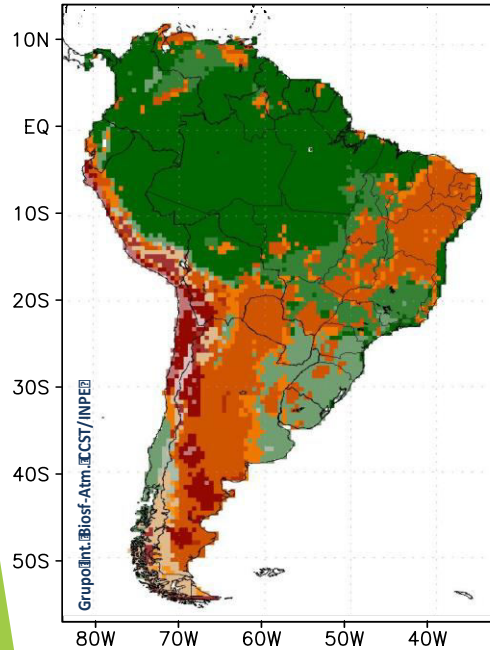
- ▶ A broad spectrum radio antenna to detect the electromagnetic emissions of the radioactive component, ranging from 50 to 200MHz.
- ▶ A spectral imaging camera (SIC) to detect visible emission of the lightning flashes from space (within the spectral range of 700 to 900nm) with high-performance image processing capacity and large data storage memory
- ▶ 2U / 3U CubeSat platform
- ▶ LEO (<650km), inclination of about 35°
- ▶ Complete orbit of 98 min
- ▶ Footprint over Brazil of approximately 15 to 20 min



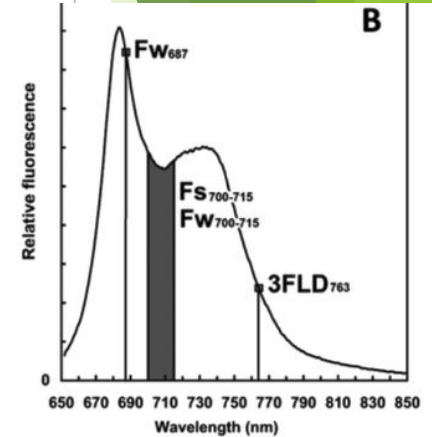
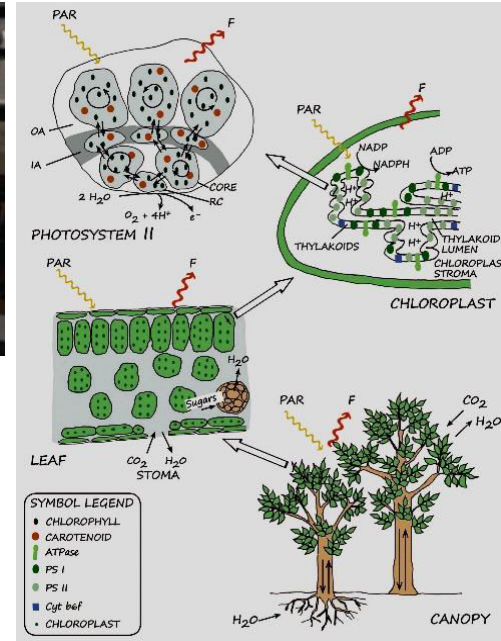
FOREST HEALTH

Photosynthesis Activity

The health of forests is very important for sustainable development in Brazil



A CubeSat is planned to monitor the forests health in Brazil using data of photosynthesis activity linked to chlorophyll fluorescence



SPACE AS A DRIVER FOR SOCIO-ECONOMIC SUSTAINABLE DEVELOPMENT

“The advent of new satellites and airborne missions has provided powerful tools that have enable breakthroughs in the capacity to measure some parameters and enhance our ability to interpret results” (Pag. 368, IPCC, 2013)*

The importance of monitoring land use and identify changes in a timely manner to avoid land degradation helping the sustainable development



**Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.K.Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Migley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.*