Brazilian scientific satellite EQUARS for remore sensing of the Equatorial Atmosphere dynamic coupling

Hisao Takahashi, Himilcon C. Carvalho, Walter G. Alarcon, Primavera B. de Souza, INPE, Brazil

Abstract

The Brazilian National Institute for Space Research - INPE is promoting a new scientific satellite mission to study the equatorial low, middle and upper atmosphere-ionosphere. The main objective is to study dynamical, photochemical and ionospheric processes in the equatorial atmosphere, with a special emphasis on, tropospheric cloud convection, generation and propagation of gravity waves, tidal and planetary scale waves, and generation and development of plasma bubbles in the ionosphere. In order to achieve the mission 8 scientific instruments are in consideration, (1) GPS receiver, (2) Airglow, lightning and sprite measurement imager (ALIS), (3) Gravity wave imager(GWIM), (4) Mesopause temperature imager(MLTS), (5) Plasma sensors to measure electron density and temperature in the ionosphere, (6) Energetic particle detector (EPM), (7) Low energy particile detector (ELISA), and (8) Beacon transmitter (CERTO). The proposed satellite orbit is equatorial and 750 km (LEO) of altitude, with a low inclination (20 degree) orbit. Launch is scheduled to be in 2006 and it is expected to have a close collaboration scheme with an on-going COSMIC satellite project by USA and Taiwan.

Introduction

From our recent knowledge of dynamical processes in the Earth's middle and upper atmosphere, it is well known that the equatorial atmosphere plays an important role with respect to energy sources, transport, and global circulation. With the generation of atmospheric gravity waves in the troposphere and tidal forcing in the stratosphere, the equatorial atmosphere plays an significant part in the propagation of these wave energies to the upper atmosphere and ionosphere. Furthermore, deposition of momentum and energy in the upper atmosphere generates large scale travelling waves (Planetary waves) and ionospheric disturbances (Plasma bubbles). These waves in turn propagate to middle and high latitudes. It is only in recent years that an integrated picture of the energy balance of the upper atmosphere is beginning to emerge. There can be no doubt that we need better global data if we are to understand the forces at work. Satellite observations can provide the data needed.

The Brazilian National Institute for Space Research, INPE, has been working in the area of space science and technology since 1962. One of our special interests is to understand the dynamical and chemical characteristics of the equatorial atmosphere. Brazil has a large geographical extent in the equatorial regions. Plasma bubbles in the ionosphere directly affect satellite telecommunications. Changes in the global scale circulation of the lower atmosphere, such as those associated with El Niño e La Niña, greatly affect the climate of the Southwest and Northeast regions of Brazil. Ground-based observations carried out until now are not sufficient to understand such large scale phenomena. Further observations on a global scale are needed. For this reason a satellite-based observation scheme for monitoring the equatorial upper atmosphere on a global scale has been proposed by the Brazilian scientific community. Recent global scale measurements of the upper atmosphere organized by PSMOS-EPIC/SCOSTEP have also shown the necessity for global scale observation. In the coming SCOSTEP program CAWSES, an attention is also being focussed on coupling mechanisms in the equatorial low, middle and upper atmosphere. We hope that the EQUARS satellite will make an important contribution to the international communities.

EQUARS Scientific mission:

Global scale monitoring of the Earth's equatorial low, middle and upper atmosphere-ionosphere.

EQUARS Objectives:

Science: Study of the dynamical, photochemical and ionospheric processes in the equatorial low, middle and upper atmosphere. Special topic to be investigated are: Tropospheric water vapor content, cloud convection activity, lightning and sprite activity, gravity wave generation and propagation, tidal and planetary wave propagation, and generation and development of the ionospheric plasma bubbles.

Application: Real-time monitoring of the tropospheric water vapor, stratospheric temperature profile, and electron contents in the ionosphere by GPS occultation measurements will be applied for numerical weather and climate predictions and space weather monitoring, respectively. In order to achieve it, close collaborative operation with COSMIC project is proposed.

EQUARS Scientific Payloads

Proposed scientific instruments, physical parameters to be observed, principal investigators and institutions in collaboration are listed in Table 1. At present 8 instruments are in consideration to achieve the mission.

EQUARS Satellite Characteristics

- Satellite total mass: 105 kg

- Orbit: Equatorial, circular, 750 ± 50 km of altitude.
- Orbit inclination: 20 deg.
- Payload mass: 35 Kg
- Volume: 60 x 70 x 40 (cm)
- Energy consume: 62 (W)
- Data storage capacity: 1.4 Gbits/24 h
- Attitude Control: Active 3 axis
- Satellite pointing: To the earth center
- Pointing precision: ± 1.0
- Attitude information: ± 0.2
- Command from ground: available
- Real time data transmission: available
- On board command: available
- Ground station for downlink: 2 stations (desirable)

EQUARS Mechanical configuration:

The satellite mechanical configuration is shown in Figure 1.

EQUARS Project Time Frame:

- 05/ 2001: Announcement of Opportunity
- 11/ 2001: 1st. workshop on EQUARS, proposal of the scientific instruments and mission definition.
- 10/2002: Definition of EQUARS project at INPE
- 02/2003: EQUARS Project Phase A start.
- 03/ 2003: Final definition of the scientific payload and project PI members
- 08/2003: 2nd workshop on EQUARS, definition of "Interface Control Document and Specifications"
- 09/2003: Project Phase B, project design and construction start
- 01 - 12/2004: Satellite construction and software development
- 09/ 2005: Integration and test phase
- 07/ 2006: Launch window

EQUARS Project Science Committee:

Hisao Takahashi (Project manager)
<hisao@laser.inpe.br>

Mangalathayil Abdu <abdu@dae.inpe.br>

Barclay R. Clemesha <clem@laser.inpe.br>

Inez S. Batista <inez@dae.inpe.br>

Polinaya Muralikrishna - murali@dae.inpe.br

INPE's Organization related to the EQUARS Project:

Coordenation of Space Science and Atmosphere (CEA)

Dr. João Braga <braga@das.inpe.br>

Coordination of Scientific Satellite Program of CEA

Dr. Walter Demetrio Gonzalez Alarcon
<gonzalez@dge.inpe.br>

Coordination of Scientific satellite and Experiments (SCE/ETE)

Dr. Himilcon de Castro Carvalho
<carvalho@dss.inpe.br>

Table 1. Scientific Instruments on board EQUARS (proposed)

	1	2	3	4	5	6	7	8
Experiment	**GPS-EQUARS**	**ALIS**	**GWIM**	**MLTS**	**IONEX**	**ELISA**	**EPM**	**CERTO**
Instrument	**GPS receiver**	**Atmos. Limb Imager**	**Gravity wave imager**	**Temperature Imager**	**HFC, LP, ETP Probes**	**Electro Static Analyser**	**Particle detector**	**Beacon**
Principal Investigator	T. Tsuda	H. Takahashi	R. Lowe	M. Taylor	M. Abdu	R. Dallaqua	W. Gonzalez	P. Bernhardt
Institution	RASC / Univ. de Kyoto / Japan	INPE	UWO / Canadá	USU / EUA	INPE	INPE	INPE, USP	Naval Research Laboratory
Observation	- Water vapor - Temperature profile, - Electron contents (TEC)	Airglow OI5577, OH Lightning Sprites	- Mesopause gravity wave activity	- Mesopause temperature	- plasma density - electron temperature	Electron energy spectra	- Flux of energetic particle	Ionospheric irregularity

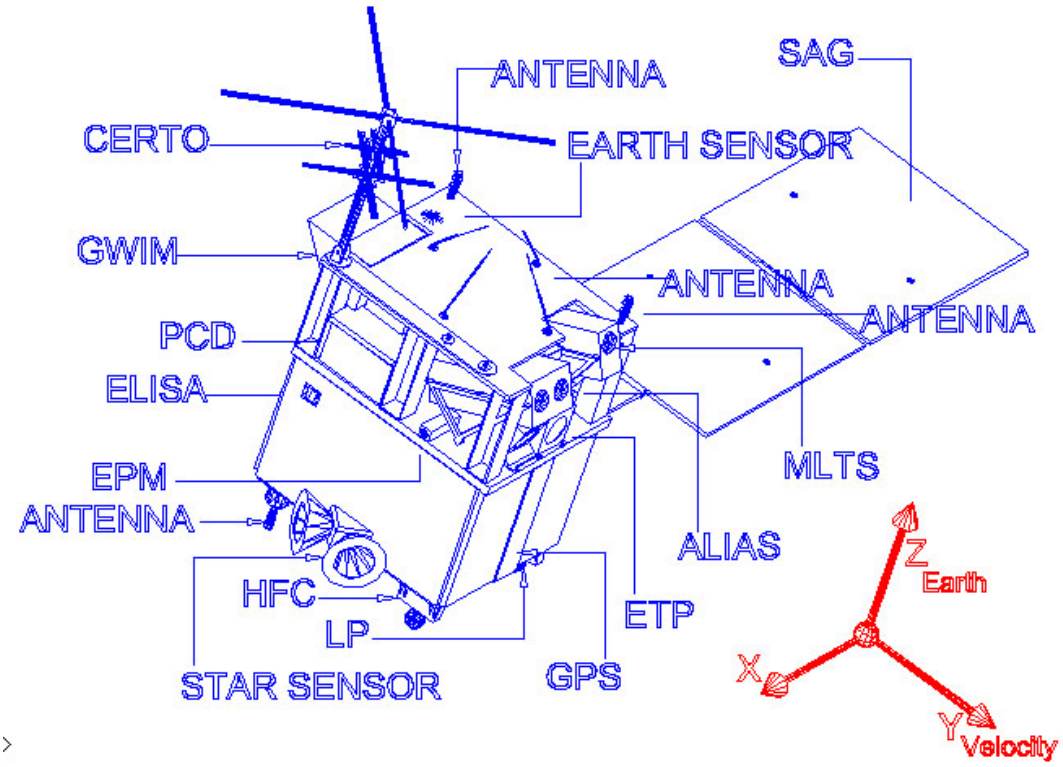

Fig. 1. Mechanical Design View of EQUARS satellite (preliminary).