Experience from a GPS-RO Mission on EQUARS

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Abstract

In collaboration with INPE, we promoted a project on GPS radio occultation, aiming as a launch of a small LEO satellite named EQUARS (Equatorial Upper Atmosphere Research Satellite) in 2000s. We basically completed design of the satellite together with antenna and receiver system for the GPS RO mission. EQUARS was also planned to carry several sensors for optical airglow, in-situ measurements of ionospheric electron density, and plasma parameters. However, unfortunately, INPE has suspended the whole plan of EQUARS, whose launch was originally planned in 2006. We introduce here outline of the GPS RO mission proposed for EQUAS.

1. Background of GPS-RO Mission

From our recent knowledge of dynamical processes in the Earth's atmosphere, it is well known that the equatorial atmosphere plays an important role with respect to energy sources, transport, and global circulation. Atmospheric waves, such as gravity waves, tides and equatorial waves, generated in the tropical troposphere, play a significant part in transportation of wave energy and momentum flux to the middle atmosphere and ionosphere. Deposition of momentum and energy in the upper atmosphere drives the general circulation of the middle atmosphere. Gravity waves trigger ionospheric disturbances (Plasma bubbles). It is only in recent years that an integrated picture of the energy balance of the middle and upper atmosphere is beginning to emerge.

One of our special interests is to understand the dynamical and plasma characteristics of the equatorial atmosphere over Indonesia, South America and Africa where land-sea-ocean interactions are most active in the world. 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 and La Niña, greatly affect the climate not only in the tropics but also regions at middle and high latitudes.

Recent GPS RO mission; GPS/MET, CHAMP, SAC-C, GRACE, COSMIC, METOP, etc, have provided us a great opportunity to understand a global picture of the atmosphere dynamics and ionosphere irregularities. Further observations with more GPS RO missions are needed. For this reason we encourage the GPS-RO mission promoted by CEReS of Chiba University.

2. GPS-RO on EQUARS

For observations of atmospheric and ionospheric characteristics, the Brazilian space agency (INPE) announced a plan of a small LEO satellite named EQUARS (Equatorial Atmosphere Research Satellite). Then, we proposed a GPS RO measurement on EQUARS. Inclination angle of the EQUARS orbit was less than 20^{o} so it can obtain a dense data-set of temperature, humidity and electron density in the equatorial atmosphere. GPS-RO data are also useful to improve weather forecast at low latitudes through a real-time assimilation for a numerical weather prediction model.

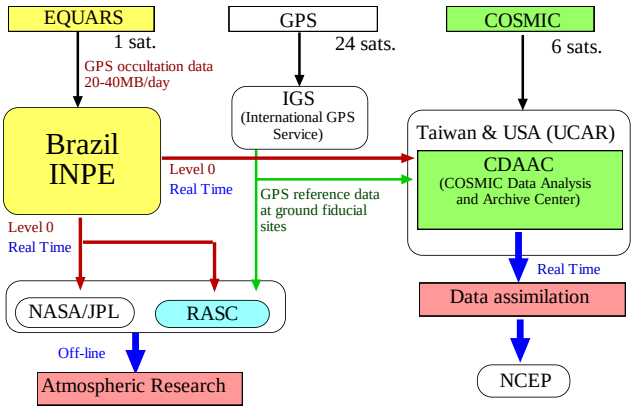


Figure 1 Data acquisition, transfer and analysis system for GPS RO mission of EQAURS

Figure 1 shows our proposal for a data transfer and analysis system of GPS occultation data that was considered for EQUARS. Raw data will be down-loaded to the

Brazilian ground station at Natal (7S, 60W), which, however, misses some orbits in the case that the inclination angle of EQUARS is larger than about 15 degrees. For a real-time data transfer, we needed to find another ground-based tracking station in the East Asia, such as Biak in Indonesia, Darwin in Northern Australia, and Bangalore in India.

We planned to transfer the Level-0 to Japan (RASC) on a real-time basis. The data was also planned to transfer to CDAAC at UCAR for distribution to a wider user community, including meteorological agencies for data assimilation into a numerical weather prediction model.

It is necessary for CEReS to establish a similar data transfer and analysis system for the new LEO experiment. GPS RO data is most useful when they are processed on a real-time basis and transferred to a meteorological agency with latency not longer than a few hours.

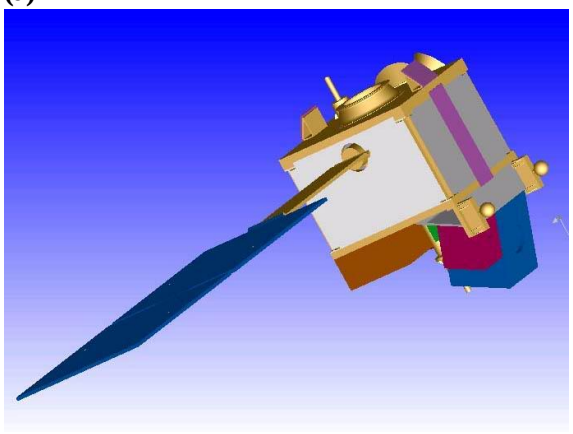
3. Antenna Design for EQUARS

For a GPS RO mission, two types of antennas are normally installed on a LEO satellite. One antenna with a high-gain (about 15 dB) is attached on the side panel of a satellite in the orbit direction. And, it is pointed about 20-25 degrees downward so as to observe limb of the Earth. The other antenna can be a small omnidirectional one for conventional positioning. Two sets of the antenna pairs could be installed on the fore and rear sides of the LEO satellite in order to measure both rising and setting occultation events. Figure 2 shows two examples of the occultation antenna that were considered for EQUARS; phased array with patched antenna and a high-gain antenna.

4. Summary

GPS RO data is useful not only for atmospheric science but also operational meteorology. GPS RO mission needs a careful design for both instruments/firmware on board a satellite and ground-based data analysis system. We hope the new GPS-RO experiment promoted by CEReS will be successful by obtaining intensive supports from international community.

(a)



(b)

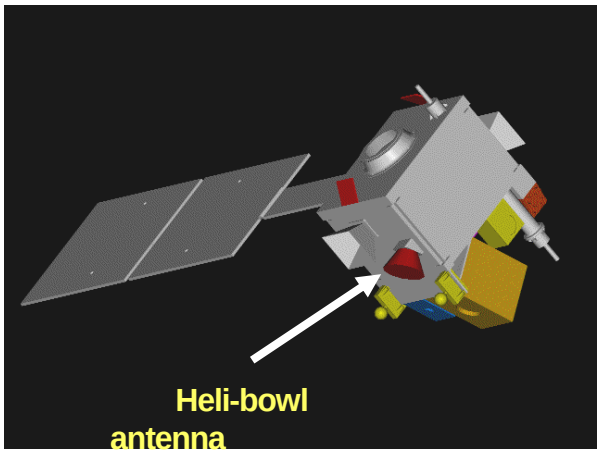


Figure 2 Two examples of antenna for occultation. (a) A phased array consisting of four micro-strip patch panels. Although the antenna is attached to the satellite, antenna core-sight is tilted about 20-30 degrees downward relative to the satellite orbit for pointing toward limb of the Earth. (b) a heli-bowl antenna with high-gain, which was used for CHAMP.