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A study on a low Earth orbit (LEO) satellite mission using radio propagation characteristics

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We study in this paper an Earth observation mission with a low Earth orbit (LEO) satellite using radio propagation characteristics on L (1.2-1.6 GHz for GPS) and Ka (17.3-20.2 GHz for O3b satellite) bands . In particular, applying GPS radio occultation (GPS RO) technique, we aim to obtain profiles of atmospheric parameters (humidity, temperature and electron density) with a good height resolution, covering a wide area. We also measure cloud water content and vapor distribution by using radiometer technique on Ka-band.

Radio occultation employs propagation delay and bending of radio waves in the atmosphere. Though GPS satellites hitherto has been used for observing radio occultation, we use not only GPS but also other GNSS satellites (GLONASS, Galileo, Beidou, and QZSS), moreover we further use O3b(Other 3 billion people), which is a communications satellite, then, we can increase number of observation points of RO.

Because the observation point of RO is determined by the relative location between the LEO satellite and transmitting satellites, we used a numerical model to investigate the data distribution of RO and proposed an optimal satellite orbit for a new LEO satellites mission. The model analysis shows that using GNSS and O3b satellites for RO the total number of RO data becomes approximately three times larger than those by using only GPS satellites. The analysis also shows that the longitudinal distribution of RO data does not depend on orbit of the LEO satellite, but, the latitudinal distribution is largely affected by an inclination angle of LEO satellite. Data distribution as function of local time varies by inclination and longitude of ascending node of LEO satellite.

We also investigate application of O3b operated on Ka-band, which is approximately ten times higher than L-band. So Ka-band is less sensitive to the ionosphere, but it is greatly attenuated by cloud water and vapor. In GPS RO on L band, atmospheric profiles at high-altitude (50km-) are not determined accurately because of influence of ionosphere. But using Ka-band of O3b we will be able to increase the maximum height of the profiles. Moreover, we expect to measure cloud water content and vapor distribution by using attenuation of Ka-band.

Keywords: GPS radio occultation, Low Earth orbit satellite, Global Navigation Satellite System, Ka-band