

A Study on Data Distribution Characteristics of the GPS Radio Occultation Measurements

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Global Positioning System (GPS) Radio Occultation (RO) is one of active remote sensing techniques. GPS RO employs a GPS receiver on board a low Earth orbit (LEO) satellite or an airplane to detect the occulted GPS radio signals passing through the atmosphere. GPS RO provides profiles of temperature, water vapor density and electron density, which are characterized by a good vertical resolution and high measurement accuracy. Since the first GPS RO experiment in 1995, a number of follow-on missions are carried out.

When planning a new GPS RO mission, the orbit of a LEO satellite is important, because the orbit decides characteristics of the GPS RO data distribution. While the data distributions of other satellite observations can be predicted directly by their satellite orbits, the GPS RO data distribution depends on the relative positions between the GPS and LEO satellites. In this thesis, we develop a numerical model for the GPS RO data distribution with realistic satellite orbital parameters.

A circular LEO satellite at a high inclination angle has been used in earlier GPS RO missions, since it provides a global data set. However, its spatial data distribution is non-uniform with respect to latitude. The high inclination angle LEO satellite leads to considerably smaller number of observation data in low latitudes. By contrast, a low inclination angle results in a concentration of data at low latitudes. Therefore, a combination of LEO satellites at different inclination angles can achieve the most uniform data distribution.

In addition, we sometimes need to get a uniform distribution with respect to local time, because many weather phenomena are dependent on local time. The data distribution versus local time has two peaks of the number of data in a day. The patterns of the data peaks depend on the right ascensions of ascending node of LEO satellites. A combination of LEO satellites with the right ascensions at equal intervals along 0-360 ° may provide a uniform distribution as a function of local time.

Localized data distribution is also required to compensate for the lack of ground-based observations and get many observation data in important areas for atmospheric and ionospheric studies. The GPS RO measurements with geostationary and quasi-zenith satellites can provide the data distribution localized with respect to latitude and longitude. An equatorial orbit satellite can provide a data distribution concentrated in the equatorial region.

The airborne GPS Down-looking (DL) RO technique uses airplanes instead of LEO satellites. The airborne measurements can produce a lot of data in a particular region. If the measurements with many commercial flights are realized, we will get a lot of atmospheric profiles, for example over Japan.

Although we consider the ideal data distributions computed by the numerical model, data loss problems are often occurred in the real GPS RO missions. In the retrieval process from received signals to atmospheric profiles, many errors are caused at low latitudes and around East Asia. We suppose that the main causes of the errors are the ionospheric irregularities.

Considering that most of earlier GPS RO missions have used the LEO satellites at a high inclination angle and many data losses are occurred around the equator, the mission, which provides a data distribution localized at low latitudes, such as equatorial orbit satellites, is very important for future missions. The lack of data at low latitudes could be also compensated by attaching antennas to lateral or oblique sides of the LEO satellite and observing in the lateral direction relative to the satellite movement. Airborne DL RO is also a strong candidate for future missions, which could give a significant impact on the improvement of weather forecasts in a particular region.