

The Method for Open-Loop Data Recovery

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Abstract

Radio occultation (RO) technique has been used in planetary science to obtain reliable and accurate temperature profiles of the other planets' atmosphere for decades. Since the ray path of radio waves is affected by the gradient of the atmospheric refractivity, it is possible to retrieve refractivity, pressure and temperature profiles of Earth's atmosphere using occultation data from Global Positioning System (GPS). When the RO signal propagates through the moist troposphere under some abnormal situations, multipath and strong fluctuation in phase and amplitude of the signal can be observed. In order to resolve this problem, open loop (OL) technique has been used to replace phase lock loop (PLL) technique. However, the phase of the signal is polluted by the navigation data, which remain in the signal always in coded form. In this paper, a procedure is proposed to resolve this problem satisfactorily.

Introduction

Radio occultation (RO) technique has been used to observe planetary atmosphere for more than thirty years (Fjeldbo et al., 1971 and Tyler, 1987) since NASA began to explore planets in solar system. With the development of Global Positioning System (GPS), a lower earth orbit (LEO) satellite MicroLab-1 has been launched to receive GPS signal to observe atmospheric parameters and distribution of electron density in ionosphere (Ware et al. 1996). This mission has verified that it is possible to get atmospheric parameters by using LEO to do RO observation. Thus, many proposals of RO observation have been brought up, such as Oersted (Escudero et al., 2001), SUNSAT (Mostert and Koekemoer, 1997), CHAMP (Wickert et al., 2001), and SAC-C. In April 2006, FORMOSAT-3 has been launched. Presently, more than 1500 RO data from FORMOSAT-3 satellites and 300-400 RO data per day can be available for us to develop our retrieval technique.

Generally, there are three modulation methods in communication systems, as shown in Figure 1. In GPS system, phase shift keying (PSK) has been applied to modulate the signal carrier. The phase of GPS signal changes to π or $-\pi$ radians

when the code of navigation message changes. To retrieve the information of interest from the GPS signal, the phase of the signal has to be recovered first. In OL, unlike PLL, calculated phase model is used to catch signal. The calculated phase has no information about navigation data. The influence of the navigation data on RO data is shown in Figure 2. The three lines in Figure 2 indicate the period of OL and introduce ambiguity associated in the process of data retrieval. We would show a method to resolve the effect of OL and the problem of cycle slip.

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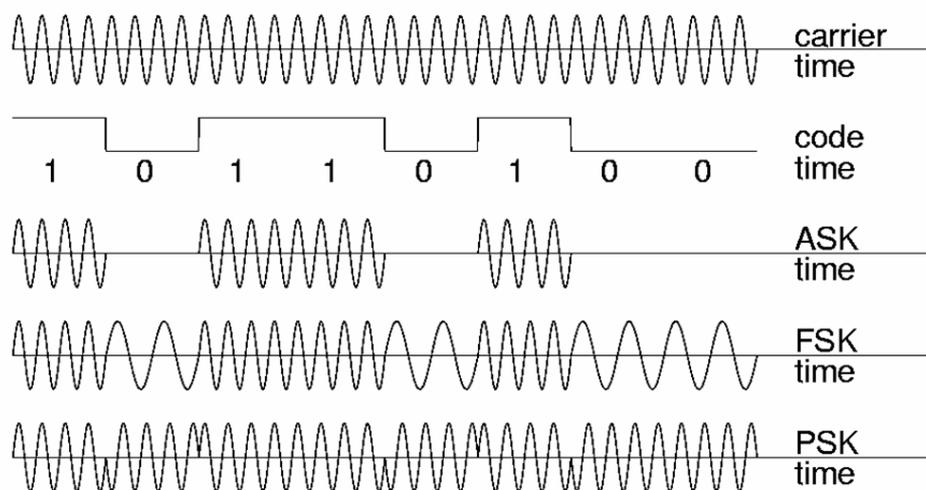


Figure 1. GPS signal structure. GPS use PSK form to transport signal.

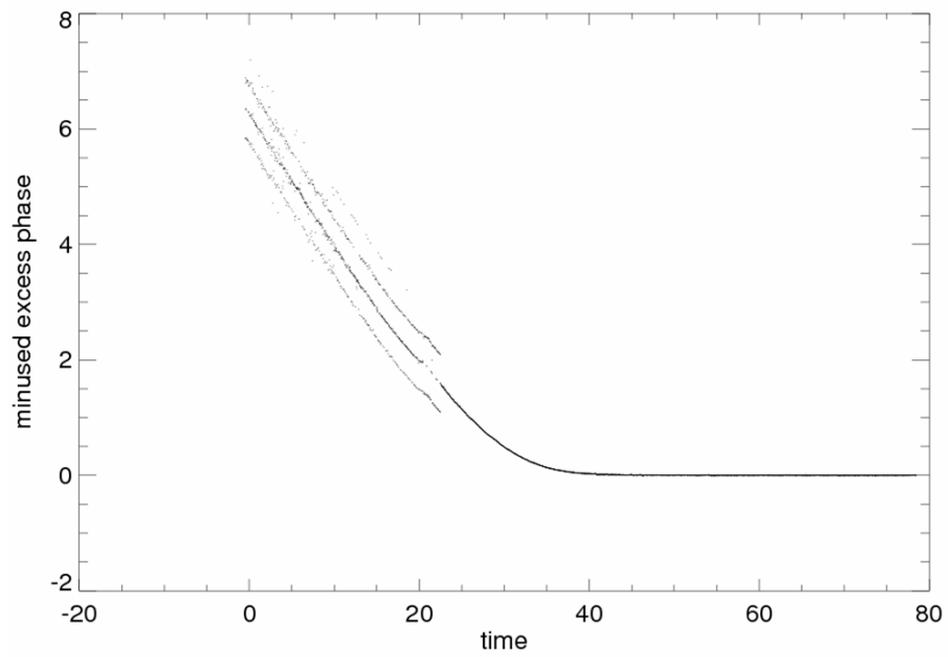


Figure 2. The difference of excess phase changes with time