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ORIGINAL ARTICLE

Assessing antenna field of view and receiver clocks of COSMIC and GRACE satellites: lessons for COSMIC-2

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Abstract We provide suggestions for the approved COSMIC-2 satellite mission regarding the field of view (FOV) and the clock stability of its future GNSS receiver based on numerical analyses using COSMIC GPS data. While the GRACE GPS receiver is mounted on the zenith direction, the precise orbit determination (POD) antennas of COSMIC are not. The COSMIC antenna design results in a narrow FOV and a reduction in the number of GPS observations. To strengthen the GPS geometry, GPS data from two POD antennas of COSMIC are used to estimate its orbits. The phase residuals of COSMIC are at the centimeter level, compared to the millimeter level of GRACE. The receiver clock corrections of COSMIC and GRACE are at the microsecond and nanosecond levels, respectively. The clock spectra of COSMIC at the frequencies of 0–0.005 Hz contain significant powers, indicating potential systematic errors in its clock corrections. The clock stability, expressed by the Allan deviation, of COSMIC ranges from 10^{-9} to 10^{-11} over 1 to 10^4 s, compared to 10^{-12} to 10^{-14} for GRACE. Compared to USO-based clock of GRACE, the clock of COSMIC is degraded in its stability and is linked to the reduction of GPS data quality. Lessons for improvement of COSMIC-2 over COSMIC in FOV and receiver clock stability are given.

Keywords Clock stability · COSMIC · Field of view · GPS · Precise orbit determination

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Introduction

The Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) mission consists of six microsatellites, named FM1-FM6, and was launched in April 2006 (Fong et al. 2008). Each satellite is equipped with four antennas connected to one GPS receiver (Fig. 1). Two signal-patch antennas for precise orbit determination (POD) are mounted on the upper part of the satellite body, and the other two antennas for radio occultation (GPS-RO) research are mounted on the bottom part. The POD antenna boresight vector is tilted by 75° toward the flight direction (Hwang et al. 2010). One of the two POD antennas is called the default antenna and is able to receive signals from more than four GPS satellites for POD. The non-default antenna cannot track more than four GPS satellites due to the limited channels of the COSMIC receiver. The COSMIC orbit accuracy using data from the default antenna was assessed by Hwang et al. (2009, 2010) and Tseng et al. (2012) using orbit overlap, applying phase center variation (PCV), and GPS signal quality and satellite attitude quality information.

The GPS occultation receiver onboard a COSMIC satellite is called integrated GPS occultation receiver (IGOR). Like the BlackJack GPS receiver on GRACE, the IGOR was also designed by Jet Propulsion Laboratory

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