GPS Solut
DOI 10.1007/s10291-013-0333-9

ORIGINAL ARTICLE

Triple-frequency carrier ambiguity resolution for Beidou navigation satellite system

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Received: 26 December 2012 / Accepted: 21 June 2013

Abstract The Chinese Beidou system, also known as Compass, has entered its trial operational stage and can already provide services for triple-frequency users. Using triple-frequency signals is expected to be of great benefit for ambiguity resolution. Based on error characteristic analysis of the Beidou frequencies, we introduce the procedure of selecting the best combinations of triple-frequency signals. The geometry-based model and geometry-free model of triple-frequency signals are presented. Three triple-frequency carrier ambiguity resolution (TCAR) methods are described, which include the cascading rounding method, the stepwise AR method and the modified stepwise AR method. In order to evaluate the performance of these methods, observations from baselines of various lengths were collected using Beidou triple-frequency receivers and were processed epoch-by-epoch using the three methods. The same observation data were also processed in a dual-frequency mode for comparison. The results show that, compared to the dual-frequency based solution, the single epoch ambiguity resolution success rate with triple frequency improved nearly 30 % for the short baselines (<20 km) and 100 % for the mid-length baselines (20–50 km) using the proposed modified stepwise AR method.

Keywords Triple frequency · Beidou navigation satellite system · Ambiguity resolution

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Introduction

Beidou satellite system is transmitting triple-frequency signals centered at B1 (1,561.098 MHz), B2 (1,207.140 MHz) and B3 (1,268.520 MHz). According to previous research, the efficiency and the reliability of carrier ambiguity resolution (AR) for long baselines can be significantly enhanced with applying triple-frequency signals, which is rather crucial in the real-time precise positioning implementation.

Since the third signal was projected to be added to European GNSS-2 (later called Galileo Project) and American modernized GPS, significant progress has been made toward carrier phase AR using triple-frequency signals. Forssell et al. (1997) and Vollath et al. (1998) described the three carrier ambiguity resolution (TCAR) approach. The former underlined that the TCAR method was an extension of the wide-laning technique, and the later emphasized that this method worked in a stepwise procedure. Hatch (1996), Jung (1999), Jung et al. (2000) and Hatch et al. (2000) proposed the cascading integer resolution (CIR) method, which was similar to TCAR. Han and Rizos (1999) proposed several new combination measurements with longer effective wavelength and less noise, for AR in the multiple-frequency cases and with or without the distance constraints.

Essentially, the TCAR and the CIR methods use the same geometry-free model to estimate the integer ambiguities of the selected optimal combinations, with a three-step rounding procedure. Teunissen et al. (2002) compared the TCAR, CIR and the least-squares ambiguity decorrelation adjustment (LAMBDA) method in the triple-frequency case, and suggested that the former two methods are both geometry-free integer boot-strapping procedures, using the pre-set Z-transformation and that the LAMBDA method (Teunissen 1995) is an integer least-squares estimation used for both the geometry-free model and the geometry-based model. Following his

Published online: 09 July 2013