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ORIGINAL ARTICLE

A comparison of three PPP integer ambiguity resolution methods

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Abstract Precise point positioning (PPP) integer ambiguity resolution with a single receiver can be achieved using advanced satellite augmentation corrections. Several PPP integer ambiguity resolution methods have been developed, which include the decoupled clock model, the single-difference between-satellites model, and the integer phase clock model. Although similar positioning performances have been demonstrated, very few efforts have been made to explore the relationship between those methods. Our aim is to compare the three PPP integer ambiguity resolution methods for their equivalence. First, several assumptions made in previous publications are clarified. A comprehensive comparison is then conducted using three criteria: the integer property recovery, the system redundancy, and the necessary corrections through which the equivalence of these three PPP integer ambiguity resolution methods in the user solution is obtained.

Keywords PPP integer ambiguity resolution · Method equivalence · Single-difference between-satellites method · Decoupled clock model · Integer phase clock model

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Introduction

Precise point positioning (PPP) using ionosphere-free code and phase observations (Zumberge et al. 1997) is able to provide centimeter-level positioning accuracy with a single receiver. However, the ambiguity parameter estimated in the conventional PPP model cannot be resolved to the integer value. In fact, the estimated ambiguity parameter is a combination of the integer ambiguity, the receiver biases, and the satellite biases. This means the integer property of the ambiguity parameter is lost. As a result, fixing the integer ambiguity using the conventional PPP model is not feasible.

Following the investigations on integer ambiguity pseudo-fixing (Gao and Shen 2002) and integer ambiguity resolution with simulated data sets (Wang and Gao 2006, 2007), several PPP integer ambiguity resolution methods have been developed and implemented with real data sets in recent years. Ge et al. (2008) proposed a single-difference between-satellites method characterized by eliminating the receiver biases through a single-differencing. The integer property is recovered by sequentially correcting the satellite wide-lane and narrow-lane fractional-cycle biases (FCBs). Collins (2008) developed a method known as the decoupled clock model and proved that the code biases also contributed to the fractional part of phase ambiguities in PPP. By applying the satellite decoupled clock corrections and estimating the receiver decoupled clock parameters, both the undifferenced integer wide-lane and N_1 ambiguities can be directly estimated. Laurichesse et al. (2008) also developed an integer phase clock model featuring different clock terms for code and phase observations. This model utilizes the wide-lane satellite bias (WSB) corrections to resolve the integer wide-lane ambiguity, whereas the integer N_1 ambiguity is directly estimated.

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