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ORIGINAL ARTICLE

GNSS multi-frequency receiver single-satellite measurement validation method

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Abstract A method is presented for real-time validation of GNSS measurements of a single receiver, where data from each satellite are independently processed. A geometry-free observation model is used with a reparameterized form of the unknowns to overcome rank deficiency of the model. The ionosphere error and non-constant biases such as multipath are assumed changing relatively smoothly as a function of time. Data validation and detection of errors are based on statistical testing of the observation residuals using the detection–identification–adaptation approach. The method is applicable to any GNSS with any number of frequencies. The performance of validation method was evaluated using multi-frequency data from three GNSS (GPS, GLONASS, and Galileo) that span 3 days in a test site at Curtin University, Australia. Performance of the method in detection and identification of outliers in code observations, and detection of cycle slips in phase data were examined. Results show that the success rate vary according to precision of observations and their number as well as size of the errors. The method capability is demonstrated when processing four IOV Galileo satellites in a single-point-positioning mode and in another test by comparing its performance with Bernese software in detection of cycle slips in precise point-positioning processing using GPS data.

Keywords Validation · Quality control · GPS · Galileo · GLONASS · Multi-frequency GNSS

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Introduction

Successful GNSS software should include a pre-processing step for screening of data. During this pre-processing step, the most severe irregularities in the data should be detected if necessary repaired. Several techniques were presented for this purpose. For instance, the receiver autonomous integrity monitoring (RAIM) algorithms are generally based on checking consistency of solutions from different combinations of satellite data (Farrell and Van Graas 1992; Lee 2012). Other methods estimate cycle slips as additional unknowns in a least-squares or Kalman filtering processing (Banville and Langley 2010). Some methods used linear combinations of the observations or their time difference to estimate cycle slips (Blewitt 1990). The detection–identification–adaptation (DIA) is another method for quality control of single-baseline GNSS observations, which has been discussed in Teunissen (1990, 1998) and De Jong and Teunissen (2000). De Bakker el al. (2009a) used the DIA method to investigate quality control of single-receiver single-satellite geometry-free model with a focus on the analysis of the minimal detectable bias (MDB), which is a measure for the size of the errors that can be detected with a certain power and probability of false alarm.

While most attention was given to validation of GPS observations, some studies consider multi-constellation GNSS. For instance, quality control of GPS with GLONASS was discussed in De Jong et al. (2001), and GPS with Galileo was considered in Ene et al. (2007), De Bakker el al. (2009b), and Neri et al. (2011). Most studies consider the case of dual-frequency observations due to the fact that signals availability was limited to only GPS and GLONASS (Kim and Langley 2002). Some recent studies consider triple frequencies from GPS or Galileo (Guo et al. 2011). With the availability of new systems such as