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ORIGINAL ARTICLE

Enhancement of the accuracy of single-epoch GPS positioning for long baselines by local ionospheric modelling

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Abstract Single-epoch relative GPS positioning has many advantages, especially for monitoring dynamic targets. In this technique, errors occurring in previous epochs cannot affect the position accuracy at the current epoch, but careful processing is required, and resolving carrier phase ambiguities is essential. Statistical ambiguity resolution functions have been used to determine the best values of these ambiguities. The function inputs include as a minimum the known base station position, the approximate roving antenna "seed" position, and the dual-frequency carrier phase measurements from both receivers. We investigate different solutions to find the ambiguity function inputs that achieve the highest ambiguity resolution success rate. First, we address the rover seed position. A regionally filtered undifferenced pseudorange coordinate solution proves better than a double-differenced one. Multipath errors approximately repeat themselves every sidereal day in the case of static or quasi-static antennas; applying a sidereal filter to the pseudorange-derived positions mitigates their effects. Second, we address the relative carrier phase measurements, which for medium to long baselines are significantly affected by ionospheric propagation errors imperfectly removed during differencing. In addition to the International GNSS Service ionospheric model, we generate a local pseudorange-based ionospheric correction. Applying this correction improves the quality of the phase measurements, leading to more successful ambiguity resolution. Temporally smoothing the correction by means of a Kalman filter further improves the phase measurements. For baselines in the range 60–120 km, the mean absolute deviation of single-epoch coordinates improves to 10–20 cm, from 30–50 cm in the default case.

Keywords GPS · Single-epoch positioning · Ambiguity resolution · Sidereal filter · Ionosphere · Kalman filter

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Introduction

Using single-epoch GPS positioning has many advantages in high-multipath and restricted sky visibility situations, especially when monitoring dynamic targets where sudden and unpredictable movements occur. In this technique, each data epoch is processed independently and so measurement errors and outages occurring in previous epochs cannot affect the current epoch's accuracy. However, double-differenced GPS carrier phase measurements are biased by an unknown integer number of cycles, often called the double-difference ambiguity. Resolving this ambiguity efficiently and correctly remains one of the greatest challenges, especially for epoch-by-epoch GPS applications where the number of observations is limited by the number of observed satellites at each epoch. A variety of ambiguity resolution functions has been introduced (Kim and Langley 2000). These functions attempt to resolve the ambiguities for each epoch of processed data separately. On occasion, there may not be any redundancy in the observations and then the goodness of fit of the ambiguity resolution cannot be tested. As a result, strict attention must be paid to the other positioning errors such as receiver-dependent biases, satellite-dependent biases, and signal propagation biases, i.e., ionospheric and tropospheric delays. These errors must be eliminated to ensure

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