Evaluation of Ambiguity Estimator between Reference Stations

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Abstract

In order to apply the network adjustment, the correct ambiguities between each of reference stations must be calculated. This paper focused on the comparison of ambiguity resolution between the reference stations. Three hours test data with different baseline length from 20 km to 60 km have been analyzed. The results show that the time-to-fix between 20 km and 40 km is typically under 1 minute. However, over 60km baseline, the time-to-fix performance degrades.

Keywords: medium baseline, ambiguities between reference stations

1. Introduction

One core issue for medium scale network RTK is how to generate carrier phase correction which could reduce distance-dependent error such as ionospheric delays. As a first step of procedure for carrier phase correction, resolving ambiguities between reference stations are required. However, in the case of medium baseline, even with precisely known coordinates, it is not easy to fix ambiguities between reference stations in real-time. In this paper, the optimal method for estimation of ambiguities between reference stations was tested using different medium baselines from 20km to 60km.

2. Calculation of Ambiguities between Reference Stations

This section describes the implemented algorithm used in the analysis. The ionosphere weighted Kalman Filter appro ach is provided.

2.1 Ionosphere weighted ambiguity estimation model

Because the residual atomospheric delay, especially due to the ionosphere, is distance dependent, ambiguity resolution over medium baselines becomes difficult. To overcome this problem, the ionosphere weighted model is applied. This means that ionospheric delays are not modeled as completely unknown parameters. Hence, the parameter vector x can be written as:

$$x = (\nabla\Delta N_{L1}{}^{i,n^T}, \nabla\Delta N_{L2}{}^{i,n^T}, \nabla\Delta I_{L1}{}^{i,n^T})^T$$

where $\nabla\Delta N^{i,n}$ and $\nabla\Delta I^{i,n}$ are the integer ambiguity and the double-differenced ionospheric error, respectively, for satellite pairs i and n. Subscripts indicate the GPS frequency.

The observable vector for epoch k can be written as:

$$z_k = (\nabla\Delta\phi_{L1}{}^{i,n} \cdot \lambda_{L1}{}^T, \nabla\Delta\phi_{L2}{}^{i,n} \cdot \lambda_{L2}{}^T, \nabla\Delta P_{L1}{}^{i,n^T}, \nabla\Delta P_{L2}{}^{i,n^T})^T$$

where $\nabla\Delta\phi \cdot \lambda$ and $\nabla\Delta P$ are the double-differenced phase observable and pseudorange observable, respectively.

Using the characteristic of this Kalman Filter approach, float ambiguities can be obtained optimally irrespective of the baseline length.

3. Easy Test Results

3.1 Test baselines

To test the effect of the distance dependency and the performance of ambiguity estimation for this method, three different baselines were used in the analysis. Figure.1 shows the configuration of three baselines.

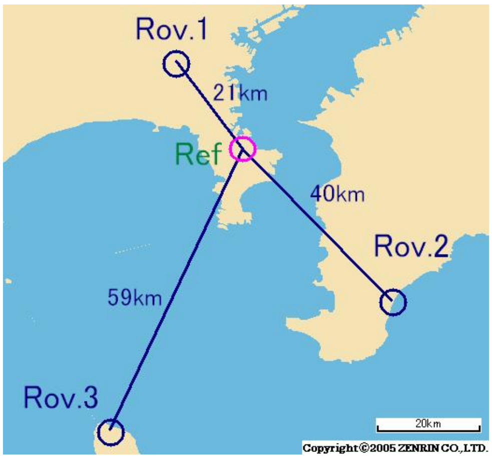

Figure.1 Configuration of three baselines

Three hours of 1 Hz data were gathered on December 1st 2004 around Tokyo area. All the receivers and antennas were Trimble 4000SSE.

3.2 Ionospheric Errors

Figure.2 shows the stochastic ionospheric errors over three baselines (about 20km, 40km, and 60km). The RMS values of ionospheric errors are summarized in Table.1.

Table.1 RMS value of each baselines

	20km	40km	60km
RMS value[cm]	0.65	1.11	1.24

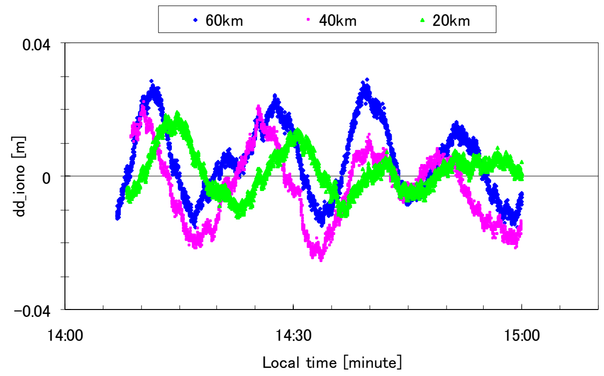

Figure.2 L1 double-differenced residual ionospheric errors of each baselines for PRN 19-3

3.3 Float Ambiguity and Time-to-Fix

In order to evaluate the performance of ambiguity estimation under different ionospheric condition, we compared the convergence of the float ambiguity and the time-to-fix the ambiguity with same satellites pair. The constellation of satellites is shown in Figure.3.

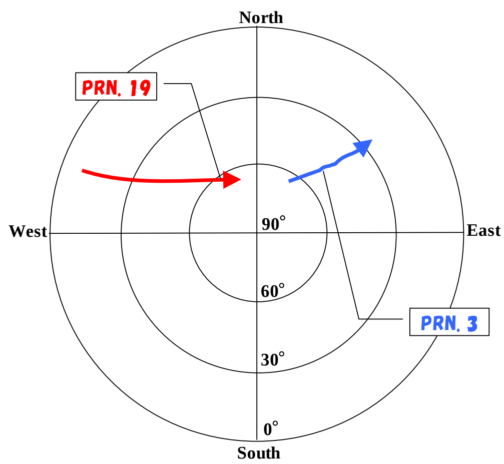

Figure.3 Sky plot of PRN 19 and 3

Table.2 shows the performance of time-to-fix. In this case, there is no difference for time-to-fix between 20km and 40km baseline. The time-to-fix is typically under 1 minute. However, over 60km baseline, the time-to-fix performance is quite different. The time-to-fix is over 5 minutes.

Figure.4,5 and 6 illustrate the estimated float ambiguity of each baselines. Float ambiguities of all the baselines have the convergence property that the accuracy improves with time.

Table.2 Ambiguity resolution performance of each baselines for Time-to-Fix

	20km	40km	60km
Time to Fix [epoch]	51	56	340

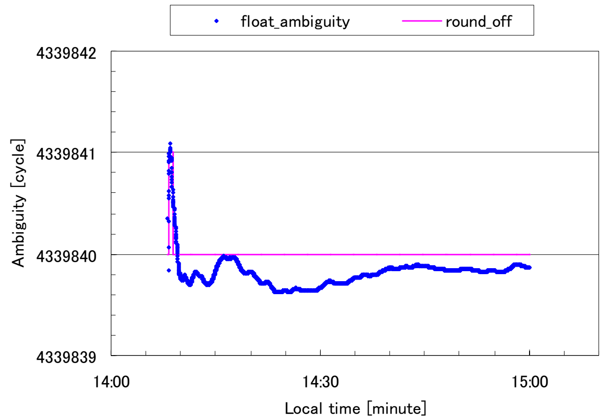

Figure.4 Estimated ambiguity of 20km baseline length for PRN 19-3

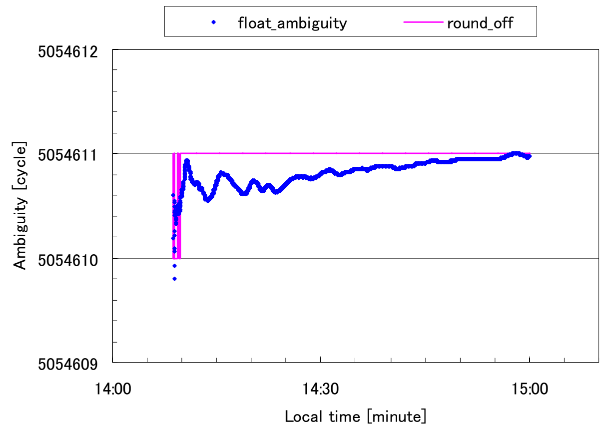

Figure.5 Estimated ambiguity of 40km baseline length for PRN 19-3

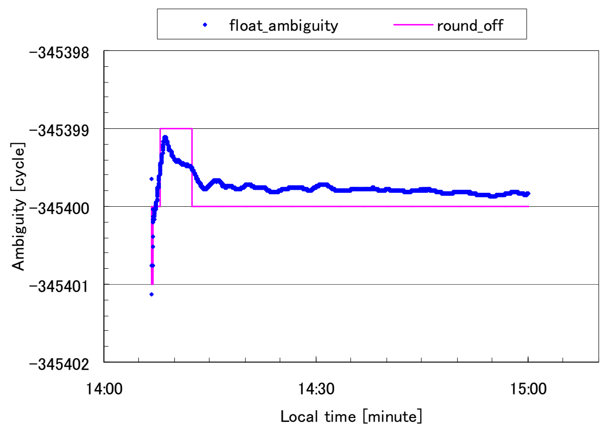

Figure.6 Estimated ambiguity of 60km baseline length for PRN 19-3

4. Summary

The time-to-fix were compared over various baseline length using ionosphere weighted float ambiguity estimation approach. Over 60km baseline, the time-to-fix performance degrades.

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