Accuracy evaluation of QZS-1 orbit solutions with Satellite Laser Ranging

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1. Introduction

Quasi-Zenith Satellite System (QZSS) is a Japanese navigation satellite system. QZSS can provide a seamless service from a high elevation angle to improve the positioning availability and enhance GPS performance in downtown and mountainous areas. QZSS also transmits the L-band Experiment signal (LEX) which contains more accurate information about orbit and clock biases to improve the accuracy of positioning for Precise Point Positioning (PPP) users. In order to provide the precise GNSS orbit and clock products, JAXA have developed a precise orbit determination tool for PPP experiment with QZSS LEX signal. The tool, named MADOCA, requires the orbit accuracy of 7 cm for QZSS. Therefore, SLR observation data is necessary for the evaluation of the accuracy of QZSS orbit solutions. This article provides a brief overview of the accuracy evaluation of QZS-1 orbit solutions compared to SLR observations.

2. SLR residuals of QZS-1 orbit processed with MADOCA

SLR observations were used to evaluate the accuracy of QZS-1 orbit solutions processed with MADOCA. The orbit solutions were computed using different periods of 5-7 days. In Table 1, the mean, STD and RMS of SLR residuals are summarized for different orbit solutions using the SLR observations from a total number of 5 stations. As indicated in Table 1, the apparent SLR biases of QZS-1 orbit solutions existed in each period. Moreover, Figure 1 shows the SLR residuals of QZS-1 orbit solutions in Arc-1. The U-shaped residuals of P-P 25 cm are found in Figure 1. The reasons of periodic appearance of SLR residuals should be studied.

Table 1 Statistics of SLR residuals of the QZS-1 orbit solutions

Evaluation period	SLR residuals (cm)		
	Mean	STD	RMS
Arc-1 : 2011/09/02 00:00 ~ 09/07 00:00	14.2	7.5	16.0
Arc-2 : 2011/11/19 00:00 ~ 11/24 00:00	-15.3	9.4	17.9
Arc-3 : 2011/12/15 00:00 ~ 12/22 00:00	-24.1	11.0	26.5

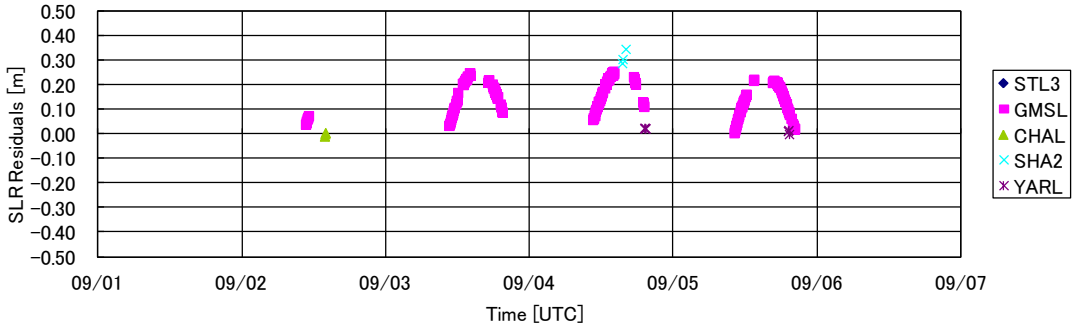

Figure 1 SLR residuals of the QZS-1 orbit solutions in Arc-1

3. QZS-1 orbit estimation with SLR observations

Figure 2 shows the accuracy evaluation procedure of QZS-1 orbit solutions processed with MADOCA. QZS-1 orbit solutions were also computed by JAXA and Hitotsubashi University (HIT) with SLR observation data. The arc lengths of these orbits are 5-10 hours (Short arc) and 5-7 days (Long arc). The QZS-1 configuration parameters, the dynamics and observation models used by JAXA and HIT are shown in Table 2.

Figure 3 shows the QZS-1 orbit differences between JAXA/HIT orbits and MADOCA orbits. While JAXA and HIT orbits matched by about 20 cm level in the radial direction, the orbits in the cross and along directions were not so sensitive. More SLR data of QZS-1 is required to evaluate the QZS-1 orbit solutions processed with MADOCA. QZS-1 tracking campaign is desirable to get SLR observation at 3 or more SLR stations for short arc solution.

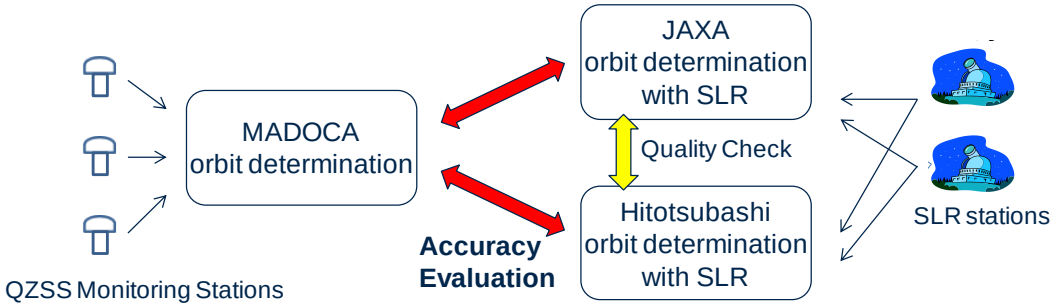

Figure 2 Accuracy evaluation process of QZS-1 orbit

Table 2 Technical specification of QZS-1 orbit solutions

Models / Parameters	JAXA	Hitotsubashi University
Site position	ilrsb	ITRF2008
Satellite mass	2280.7 [kg] (common)	
Center of mass	(Xs, Ys, Zs) = (-0.8, 2.9, 1819.3) [mm]	
Optical reflection center	(Xs, Ys, Zs) = (-1150.0, -550.0, 4517.64) [mm]	
Troposphere delay model	Marini-Murray model	Mendes & Pavlis model
SRP model	Canon ball	
Cross-section area	60.0 [m^2]	52.0 [m^2]
Estimation parameters	Orbit elements, SRP correction coefficient, constant and 1/rev accelerations in the along-track direction	

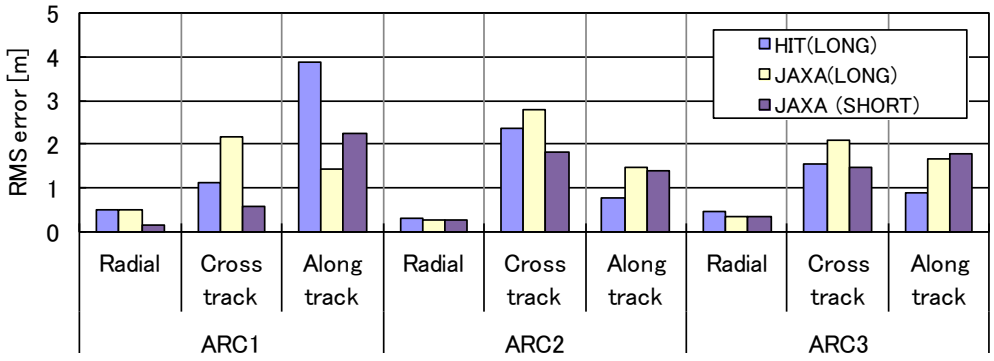

Figure 3 QZS-1 orbit differences between JAXA/Hitotsubashi and MADOCA