# Az/El-dependent AMCS Phase Residuals

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## 1 Introduction

While analyzing AMCS-mode data, I found that the AMCS-mode residuals are affected by the baseline vector between the two antenna phase centers. For the schematic diagram of phase centers, please refer to Pedro's report, "Geometry of the AMCS antenna system". The vector $\vec{b}$ of the phase reference point of the parabolic antenna with respect to the phase center of the Trimble antenna was computed to be (-20.820 8.394 -1.866) meters in the ENV reference frame. However, when this vector was slightly adjusted, the characteristics (e.g. RMS and geometric shape of the residuals) of AMCS-mode residuals changed significantly (refer to Figure 1). Thus, I became to believe that some of the strange features of AMCS-mode residuals (which were discussed in the previous meeting) maybe due to errors in the baseline vector.

## 2 Data Sets and Routine Analysis

Table 1 shows the tests conducted for this report. Tests were done by collecting ZBL data for the first 10 minutes and AMCS data for the next 10 minutes. $\Delta T$ (time offset) is calculated in the ZBL-mode analysis. Figures 2, 3, and 4 show the residuals, SNR, and satellite angular offset. The AMCS-mode residuals repeat nicely for each PRN. The SNR characteristics are the same for PRN 18 and 30. PRN 5 shows an interesting change in SNR. Angular distance is within 2.5° in all cases.

Figure 1: PRN 7 on May 17th, 2001. In (a) the original baseline vector from Per's analysis is used, and in (b) a 10-cm offset (in the east direction) was introduced from the original vector. AMCS-mode RMS: (a) 1.9 mm; (b) 1.4 mm.

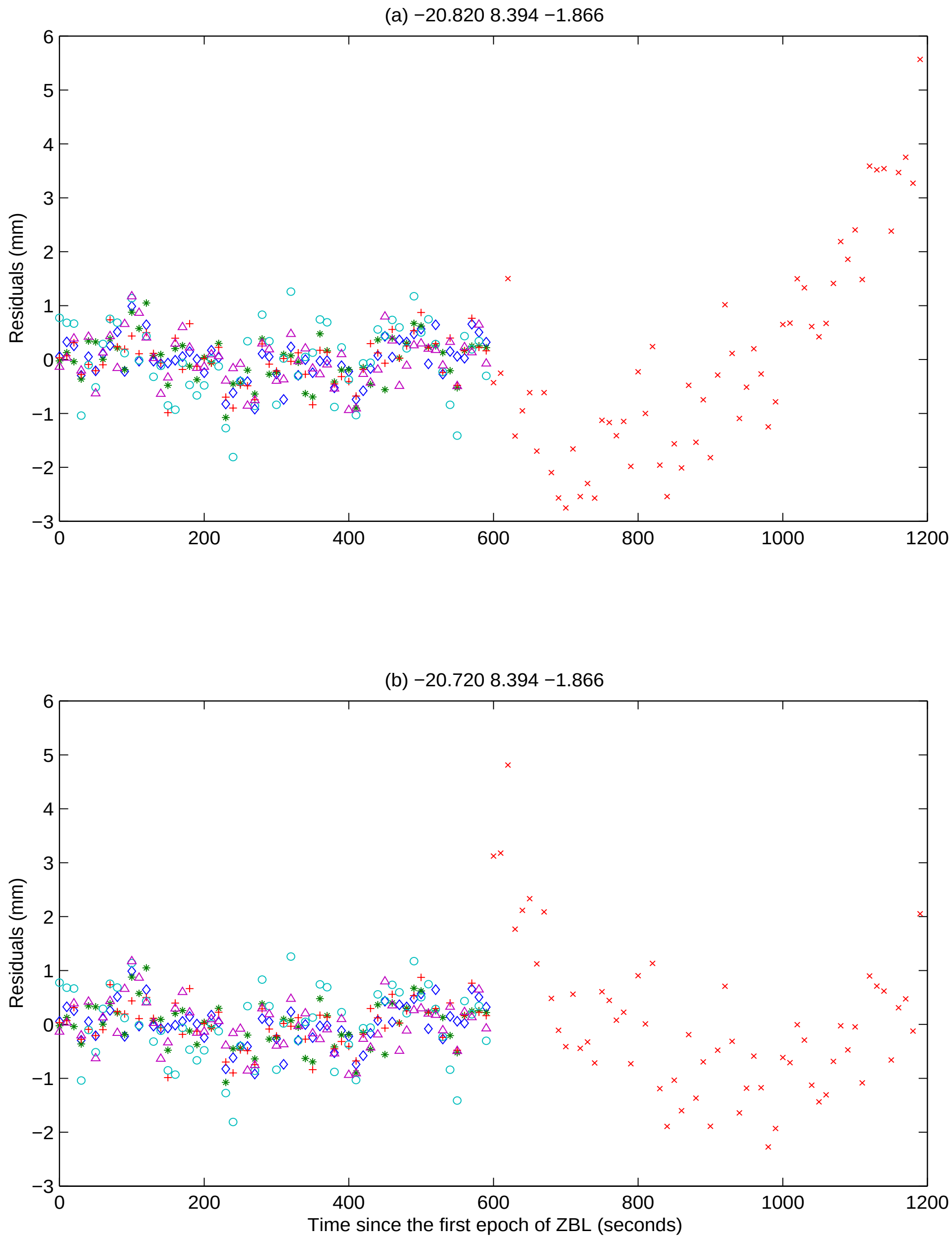

Figure 2: PRN 18 on JUL 06 and JUL 07.

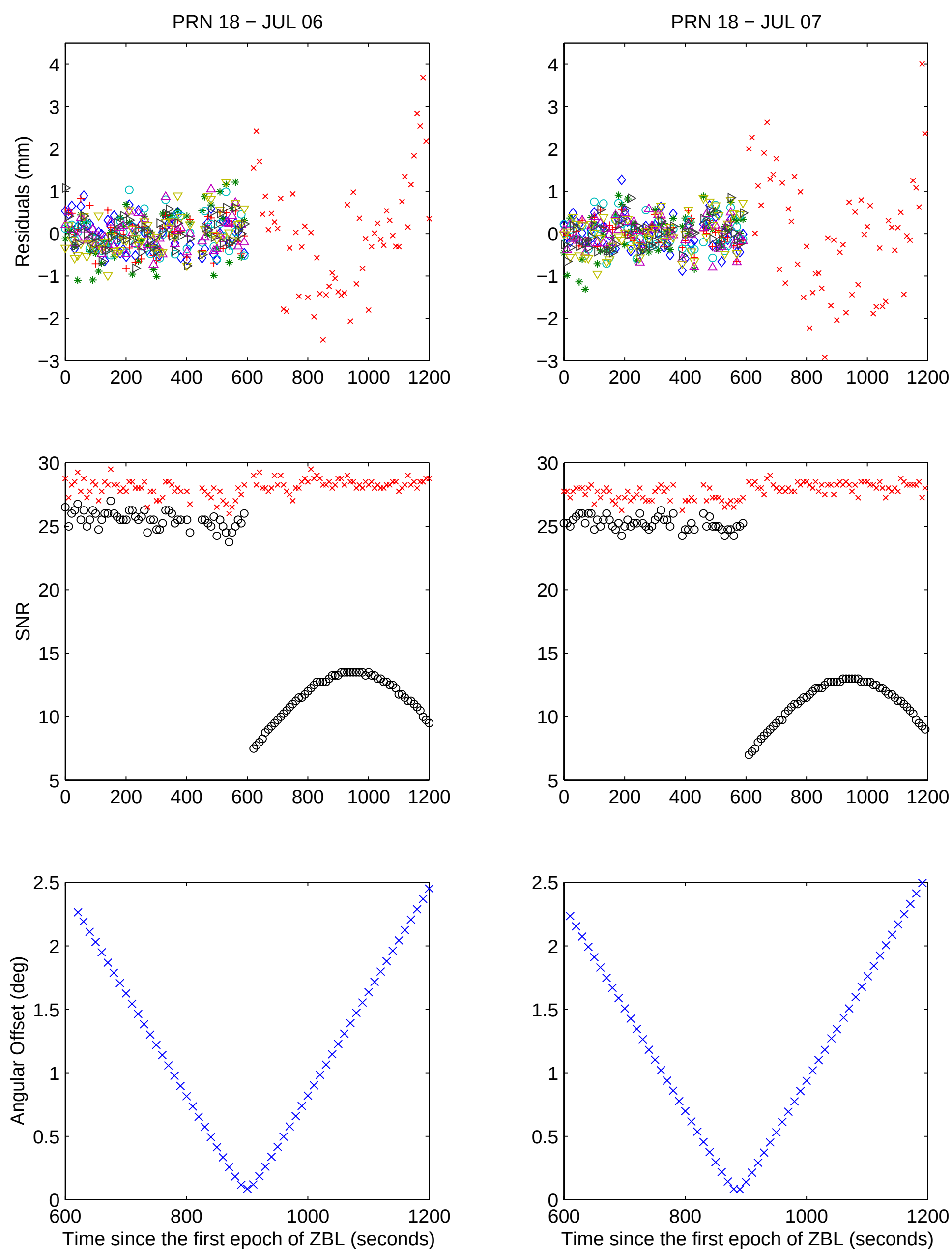

Figure 3: PRN 5 on JUL 05 and JUL 07.

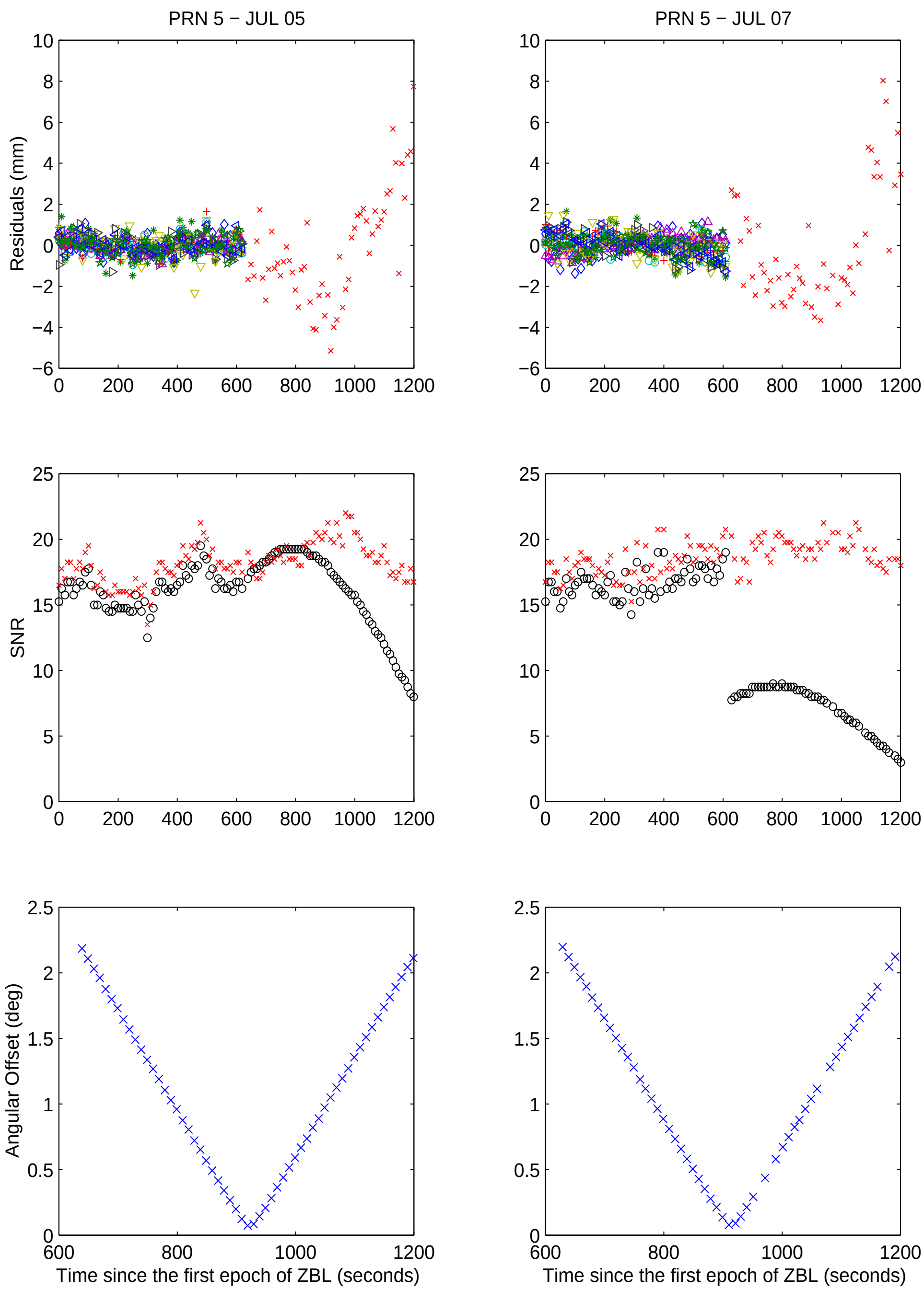

Figure 4: PRN 30 on JUL 06 and JUL 07.

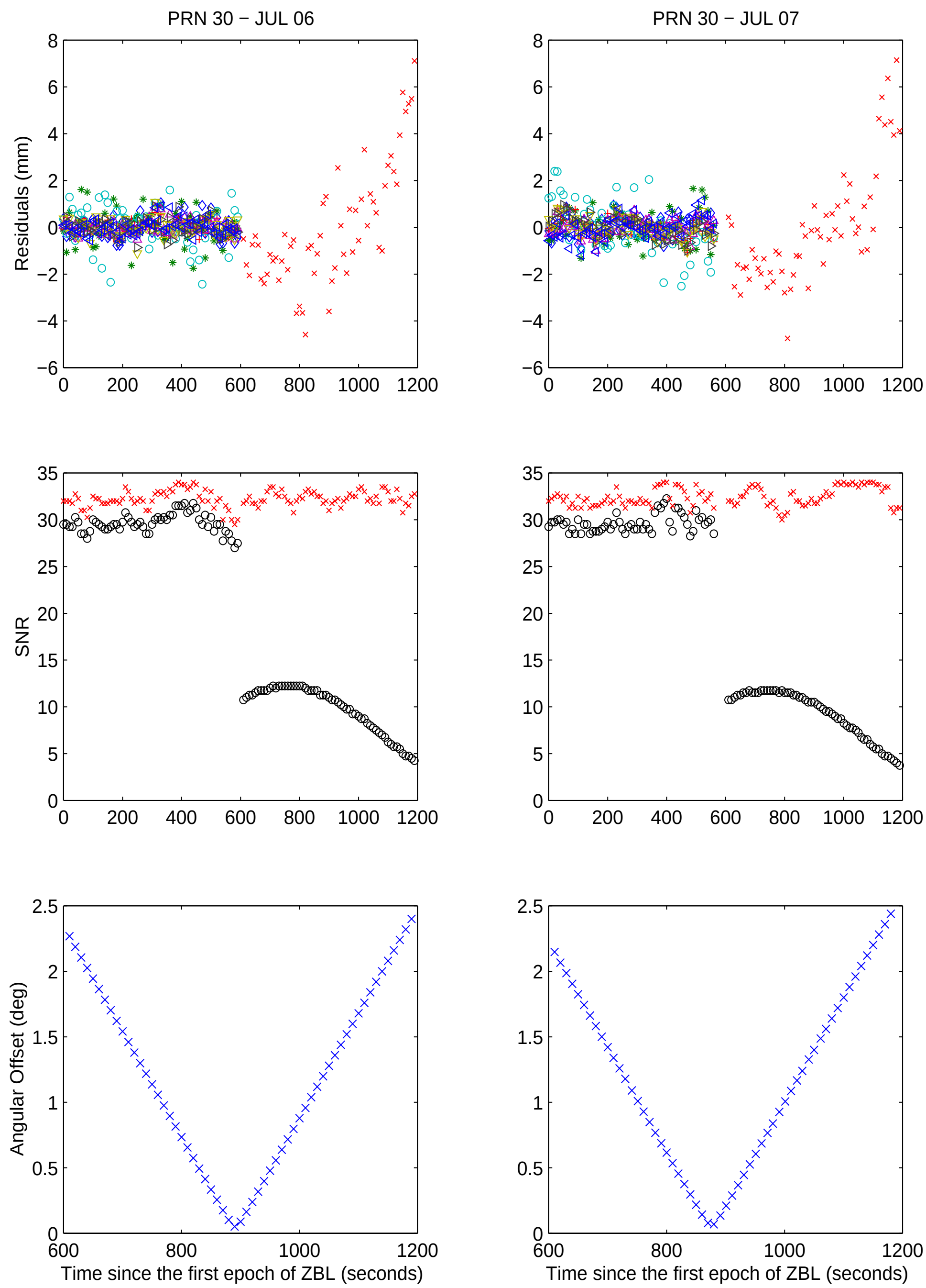

Table 1: Test data sets. P is for GPS PRN number. $\bar{\theta}$ and $\bar{\epsilon}$ is the fixed azimuth and elevation angle of the parabolic antenna. $\delta\theta/\delta\epsilon$ is the azimuth and elevation angle variation during the AMCS-mode data collection. $a/b/c$ denotes $\Delta T$(msec)/ZBL-RMS(mm)/AMCS-RMS(mm).

| P | $\bar{\epsilon}$ | $\bar{\theta}$ | $\delta\theta/\delta\epsilon$ | JUL05 | JUL06 | JUL07 |
|---|---|---|---|---|---|---|
| 23 | 77° | 34° | 20°/0.2° | n/a | - | -0.59/0.47/1.01 |
| 18 | 82° | 43° | 32°/0.5° | n/a | -0.59/0.42/1.01 | -0.59/0.38/1.15 |
| 21 | - | - | - | n/a | - | - |
| 5 | 40° | 83° | 6°/0.3° | -0.57/0.45/2.77 | - | -0.53/0.52/2.88 |
| 30 | 53° | 91° | 8°/0.1° | - | -0.57/0.50/2.47 | -0.54/0.58/2.40 |

# 3 Analysis of Az/El-dependence

The AMCS-mode phase residuals were projected onto three components ($\Delta N$, $\Delta E$, and $\Delta V$). Then, $\sin\theta$ and $\cos\theta$ were expanded up to the fist-order terms; $\sin\theta = \sin\theta_0 + \Delta\theta\cos\theta_0$ and $\cos\theta = \cos\theta_0 - \Delta\theta\sin\theta_0$, respectively. The same expansion was done for $\sin\epsilon$ and $\cos\epsilon$. Refer to the derivation below. We estimated three constants $c_0$, $c_1$ and $c_2$ in the final equation: $\Delta\phi = c_0 + c_1\Delta\theta + c_2\Delta\epsilon$. Table 2 lists how much reduction of RMS was achieved and Figure 5 shows the flattened scatter of the AMCS-mode phase residuals after the estimation.

$$
\begin{aligned}
\Delta\phi &= \Delta N\cos\theta\cos\epsilon + \Delta E\sin\theta\cos\epsilon + \Delta V\sin\epsilon \\
&= \Delta N(\cos\theta_0 - \Delta\theta\sin\theta_0)(\cos\epsilon_0 - \Delta\epsilon\sin\epsilon_0) \\
&\quad +\Delta E(\sin\theta_0 + \Delta\theta\cos\theta_0)(\cos\epsilon_0 - \Delta\epsilon\sin\epsilon_0) \\
&\quad +\Delta V(\sin\epsilon_0 + \Delta\epsilon\cos\epsilon_0) \\
&= c_0 + c_1\Delta\theta + c_2\Delta\epsilon
\end{aligned}
$$

Figure 5: Scatter reduction after the estimation. Please refer to Table 2.

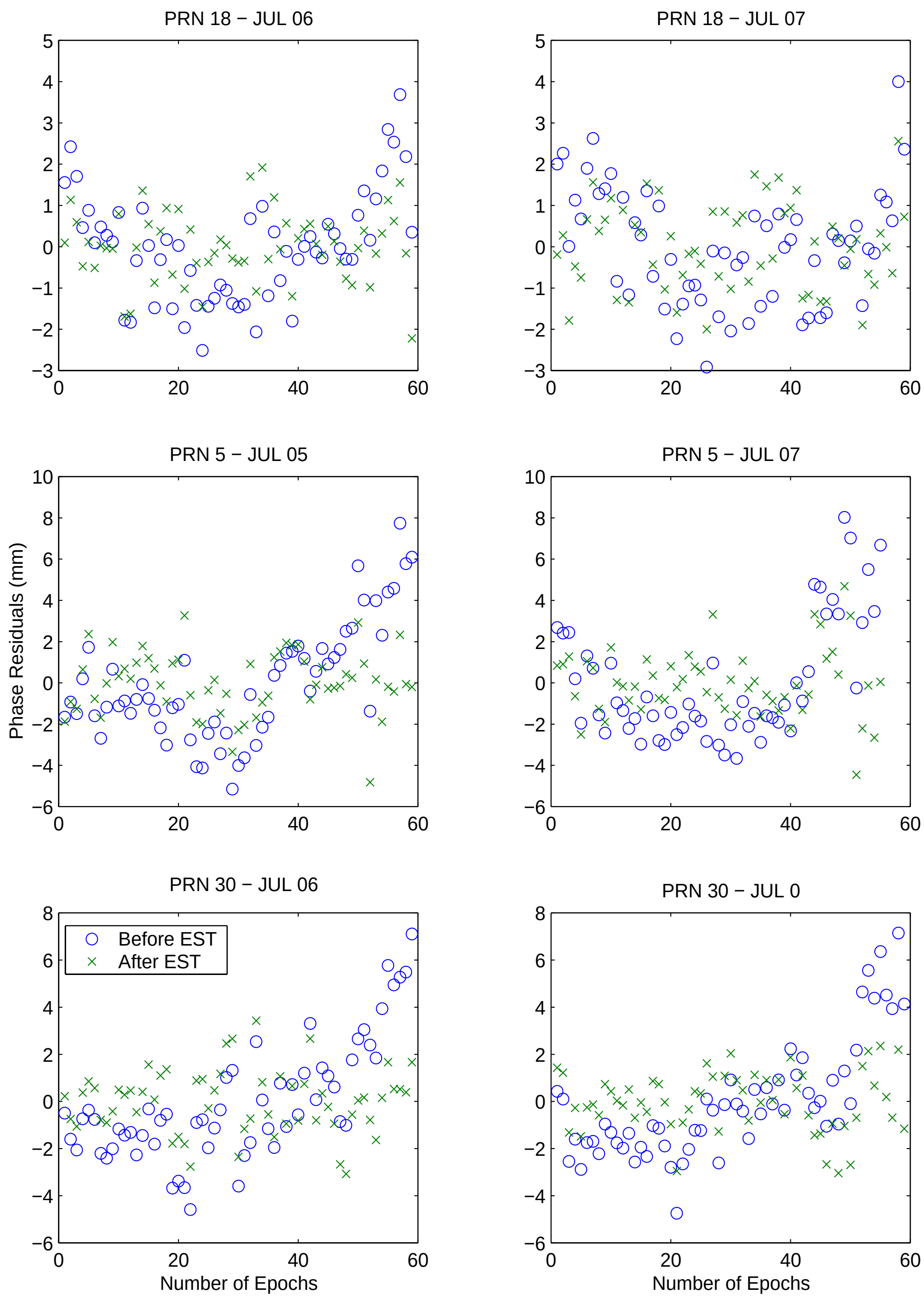

Table 2: Reduced RMS and estimated values of $c_0$, $c_1$, and $c_2$. Reduction of RMS was significant for all cases. Estimated values of three parameters were consistent for the same GPS satellite.

| PRN | Day | RMS (mm) Reduction | $\hat{c}_0$ (mm) | $\hat{c}_1$ (mm/rad) | $\hat{c}_2$ (mm/rad) |
|---|---|---|---|---|---|
| 18 | JUL 6 | 1.3/0.8 | 1.5 $\pm$ 0.4 | 0.9 $\pm$ 0.8 | -593 $\pm$ 81 |
| | JUL 7 | 1.4/1.0 | 2.2 $\pm$ 0.4 | -1.9 $\pm$ 0.8 | -560 $\pm$ 80 |
| 5 | JUL 5 | 2.8/1.5 | 0.2 $\pm$ 0.4 | -54 $\pm$ 4 | -3870 $\pm$ 329 |
| | JUL 7 | 2.9/1.6 | 1.9 $\pm$ 0.4 | -34 $\pm$ 4 | -4972 $\pm$ 338 |
| 30 | JUL 6 | 2.5/1.4 | -0.7 $\pm$ 0.4 | -42 $\pm$ 3 | -2085 $\pm$ 244 |
| | JUL 7 | 2.5/1.3 | -1.0 $\pm$ 0.4 | -42 $\pm$ 3 | -1892 $\pm$ 244 |