Abstract

A two-step TWTT (Two Way Time Transfer) assisted orbit determination approach is proposed. In the first step, the TWTT technique, which is un-affected of satellite orbits error, is used to estimate satellite clocks. Afterwards, the precise clocks are fixed as known or tightly constrained in the POD (precise orbit determination) processing. This method is used for BDS (beidou satellite system) precise orbit determination, in which TWTT data is retrieved from the ground tracking antennas and the GNSS observations are from around 50 globally-distributed stations. Results show that the new approach improves the precision of orbit determination and orbit prediction by more than 15% and 70%, respectively.

Results and Discussion

Two types of POD methods are compared: strategy 1, only observed TWTT clocks are used in POD; strategy 2, TWTT observed and predicted satellite clocks are both used in POD. Compared with strategy 1, much more stable and higher orbit estimation accuracy can be obtained.

Parameter correlation problems

Satellite orbit and clock product of IGS are formed as the weighted averages of solutions contributed by the participating ACs (analysis centers). Usually satellite orbits and clocks are estimated simultaneously in the precise data analysis of each AC, and the conventional dynamic orbit determination approach is used. However, apparent orbit and clock offsets between different IGS analysis centers can be found.

Satellite orbit and clock differences between GFZ and CODE products

In order to eliminate the effects of systematic offset, for each GNSS, one satellite is chosen as the reference satellite. Periodic characteristics of satellite radial orbit differences between GFZ and CODE can be found, and the same is true for satellite clock differences.

Figure 1: Comparison of satellite radial orbit and clock differences between GFZ and CODE products

Strong correlation of satellite radial orbit and clock differences between GFZ and CODE can be found. The correlation coefficients is -0.7, -0.8, -0.9 and -1.0 for GPS, GLONASS, Galileo and BeiDou, respectively. In other words, apparent modelling error still exist in the GNSS precise data processing algorithm. Based on the current data processing algorithm and strategy of IGS, there is strong correlation between satellite radial orbit and clock.

Figure 2: Correlation analysis of satellite radial orbit and clock differences between GFZ and CODE products

Table 1: GEO satellites maneuver information

<table>
<thead>
<tr>
<th>SatID</th>
<th>Start</th>
<th>End</th>
<th>Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>C01</td>
<td>2017-10-23</td>
<td>8:35</td>
<td>10:15</td>
</tr>
<tr>
<td>C02</td>
<td>2017-10-19</td>
<td>8:59</td>
<td>11:15</td>
</tr>
<tr>
<td>C03</td>
<td>2017-10-23</td>
<td>8:46</td>
<td>11:15</td>
</tr>
</tbody>
</table>

Conclusion and future work

1. IGS orbit and clock accuracy is limited by parameter correlations;
2. New strategy with satellite clock modelling is proposed and validated for the precise orbit determination process, especially for satellite in maneuver period;
3. With the new approach, orbit determination accuracy improved by more than 15% and orbit prediction accuracy improved by over 70%.

Further Reading

