CODE's New High-Rate GPS Clock Product

International GNSS Service,
Analysis Center Workshop 2008
2-6 June 2008, Miami Beach, Florida, USA

H. Bock[a], R. Dach[a], S. Schaer[b], M. Meindl[a], G. Beutler[a]
[a] Astronomical Institute, University of Bern, Switzerland
[b] Swiss Federal Office of Topography swisstopo, Switzerland

High-rate GPS clock generation

IGS rapid and final GPS clock products traditionally include clock corrections at intervals of 5 min. On January 24, 2004 (GPS week 1255), CODE started to contribute with high-rate clock products with a sampling of 30 sec.

On May 04, 2008 (GPS week 1478), CODE started officially to generate a clock product with a sampling of 5 sec.

The necessary modifications in the CODE final GPS clock generation procedure are colored in orange in Figure 1:

- **Additional RINEX files with 5-sec sampling are downloaded and used for densification.**
- **Coordinates (CRD) and troposphere zenith delay (TRP) estimation for 5-sec stations, which were not selected for 3 global clusters for 5-min clock solution.**
- **Generation of 5-sec GPS clock corrections based on an efficient algorithm using epoch-differenced phase observations.**

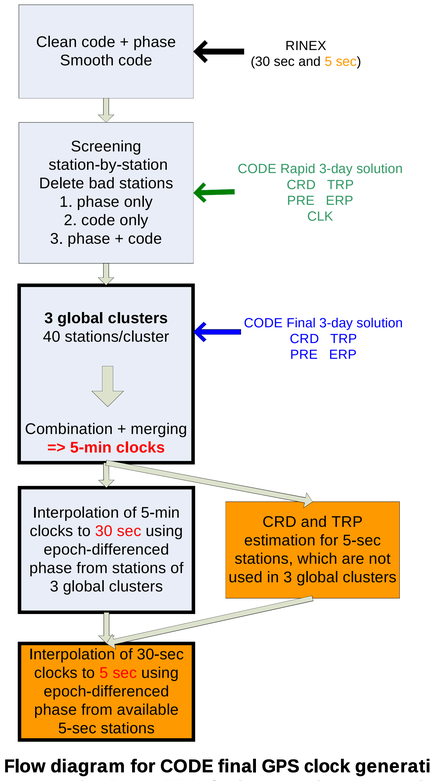

Figure 1: Flow diagram for CODE final GPS clock generation; orange: new parts for 5-sec GPS clock correction generation.

Why 5-sec GPS clock corrections?

For all applications depending on 1-Hz tracking data, (interpolated) 30-sec clock corrections are no longer sufficient for highest quality requirements.

Experiment:

- **Simulation of error-free 1-Hz phase observations for GRACE A and B satellites based on 1-Hz GPS clock corrections.**
- **Kinematic positioning with different GPS clock sets (30, 10, 5, 2 sec linearly interpolated to 1 sec).**
- **Differences to true orbit (Figure 2) show discrepancies up to 6 cm (radial) for interpolated 30-sec GPS clock set.**
- **3D-RMS errors for differences between kinematic positions and true orbit (Figure 3, bottom) for interpolated 5-sec GPS clock corrections (cyan) are below 2 mm.**

Conclusion:

- **Sufficient accuracy for most 1-Hz applications.**
- **Generation time and data volume is 5x less than for 1-Hz GPS clock set.**

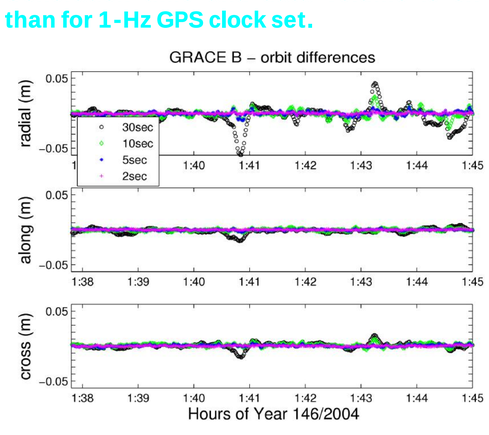

Figure 2: Differences of kinematic positions w.r.t. true orbit. Different sampled GPS clock sets used (interpolated).

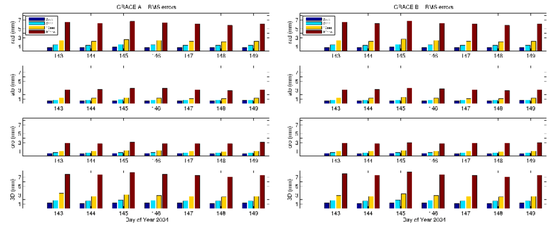

Figure 3: RMS errors (mm) for differences of kinematic positions w.r.t. true orbit, differently sampled GPS clock sets used (interpolated), days 143-149, 2004; left: GRACE A, right: GRACE B.

Validation

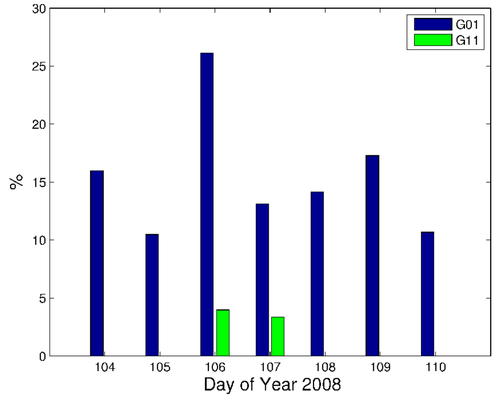

Figure 4: Percentage of missing epochs for satellites G01 (unhealthy), G11 (maneuver on day 106 at 23:05:59). All other satellites have a complete 5-sec clock set available for this GPS week 1475.

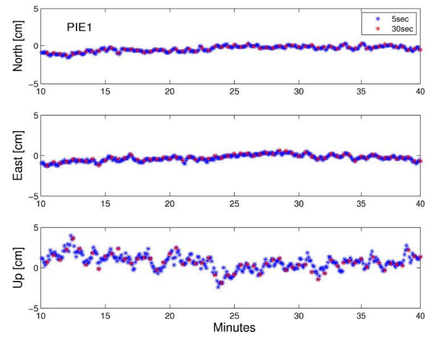

Figure 5: Kinematic positioning for PIE1 (station used for 5-sec clock generation) with 5-sec clock set (blue) and 30-sec clock set (red), differences to coordinate set.

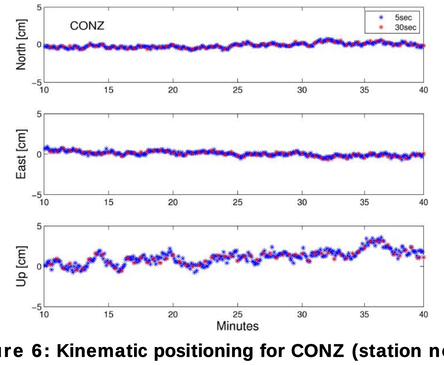

Figure 6: Kinematic positioning for CONZ (station not used for 5-sec clock generation) with 5-sec clock set (blue) and 30-sec clock set (red), differences to coordinate set.

Data Issues

The IGS 1-Hz network consists of ~110 stations, most of them are also part of the hourly and daily network. Part of the 1-Hz data is concatenated from the real-time data stream.

Though the expectation is to have identical data in the 1-Hz and in the 30-sec RINEX files (at 30 sec epochs) data comparisons (# of satellites) between these two file types show differences for several stations (Figure 7).

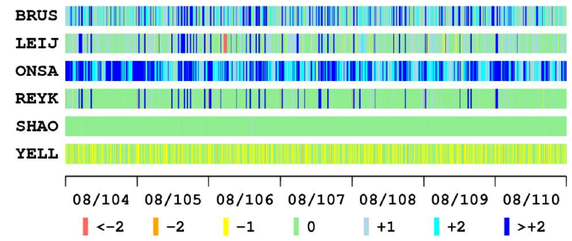

Figure 7: Difference of number of satellites available in RINEX files; difference: 30-sec minus 1-Hz RINEX file (both sampled to 30 sec).

More satellites in 30-sec RINEX file due to:

- **Missing 15-min batches for 1-Hz files (BRUS, LEIJ, ONSA, REYK)**
- **Missing satellites for a complete day in 1-Hz files (ONSA: complete: G01, G29; 1-5 days: G05, G07, G08, G21, G26, G28).**

What are the reasons for this?

- **Network problems, configuration of real-time data stream, of receiver software?**

The fact that partly the 1-Hz files have more satellites available (LEIJ, REYK, YELL) is even more alarming and the reasons for any difference should be found out.

Summary

Since GPS week 1478, CODE is producing 5-sec GPS clock corrections as part of the final CODE clock product. The necessary modifications are an add-on to the existing 30-sec final clock generation procedure.

For most 1-Hz applications, the 5-sec GPS clock corrections can be linearly interpolated without significant accuracy loss.

Data differences between 30-sec and 1-Hz RINEX files still have to be understood and solved.

The files cod*wwwwd*.clk_05s.Z are available at the global data centers of the IGS and at ftp://ftp.unibe.ch/aiub/CODE/*yyyy*.

Poster compiled by H. Bock, May 2008
Astronomical Institute of the University of Bern
heike.bock@aiub.unibe.ch