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From jimr@maia.usno.navy.mil Wed Mar 15 06:32:07 EST 2000
Received: (from jimr@localhost)
        by maia.usno.navy.mil (8.9.3 (PHNE_18979)/8.9.3) id GAA15170
        for gpst@maia; Wed, 15 Mar 2000 06:29:05 -0500 (EST)
From: Jim Ray (USNO 202-762-1444)
Message-Id: <200003151129.GAA15170@maia.usno.navy.mil>
Subject: new IGS pseudorange bias convention
To: gpst@maia.usno.navy.mil
Date: Wed, 15 Mar 2000 6:29:05 EST
X-Mailer: Elm [revision: 212.5]
Status: RO

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IGS Electronic Mail      15 Mar 02:06:15 PST 2000      Message Number 2744
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Author: Jim Ray


Dear Colleagues,

At the La Jolla Analysis Center workshop in June 1999, recommendations were
made for handling pseudorange data from a mix of receiver types which use
different tracking techniques.  Please refer to IGS Mail 2320 (24 June 1999)
at http://igscb.jpl.nasa.gov/mail/igsmail/1999/msg00564.html for background
and details.

The (C1,P2') pair available from cross-correlation style receivers (e.g.,
AOA TurboRogue and Trimble 4000) have satellite-dependent biases compared
with the (P1,P2) observables provided by newer generation receivers (e.g.,
Ashtech Z-XII, AOA Benchmark/ACT, etc.)  To avoid mixing data with different
satellite biases, which would degrade the IGS satellite clock products,
recommendations were presented last year for RINEXing and analysis to
maintain backwards compatibility with the heritage of TurboRogue receivers
by modifying data from the newer receivers.

It was stated then that when "a sufficient fraction of stations is upgraded
... a uniform switch of the IGS to the new observables can be made."

The IGS Analysis Centers have agreed to make this switch in IGS pseudorange
bias convention starting with data collected on 02 April 2000 (start of GPS
week 1056).  Specifically, this involves 1) cease making any changes to
pseudorange data from modern receivers and 2) begin modifying data from
cross-correlation style receivers by transforming:
   C1  -->  C1 + f(i)      [becomes compatible with modern P1]
   P2' -->  P2'+ f(i)      [becomes compatible with modern P2]
where f(i) are empirically-determined long-term average bias values
i for satellites PRNi.

After discussions with other colleagues, we have agreed to adopt the
following set of f(i) bias values:

    average  biases (mm) in PRN order:

    -67  -308    52   458  -195   172  -296  -240   117  -465     PRN01-10
    -35         526   172  -297  -202  -266    52    70          PRN11-20
    -84  -469  -147   132   242   433    -7         296   541     PRN21-30
   -183                                                          PRN31-40
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These values were determined by Ron Muellerschoen (JPL) based on 8 days of 1-second data from 14 Ashtech Z-XII receivers maintained in stable conditions. The raw data were collected between 3-Jan-2000 16:00 and 11-Jan-2000 21:00. These biases have been renormalized to zero mean across the constellation in order to leave the net receiver clock bias unchanged for the older receiver types. Ron, Pierre Heroux (NRCanada), and Yang Gao (U. Calgary) have contributed to the analysis of biases. We have found that significant receiver-dependent differences in bias values can be seen for some satellites. The most problematic satellites tend to be PRN16, PRN23, PRN10, PRN24, and PRN08. In addition, temporal variations can be found in some cases (notably PRN07). It is estimated these effects limit the long-term RMS accuracy of these biases to roughly 5 cm overall.

I have written a converter utility (cc2noncc) that analysts can use to transform AOA TurboRogue, AOA ICS-4000Z, and Trimble 4000 RINEX files. An output file will be created only when an input RINEX file indicates that the receiver type is one of these types, so it is vital that the RINEX headers be reliable. Note that this conversion should only be applied to create intermediate files for analysis purposes and should never be used for general distribution of RINEX files! The Fortran code is available at ftp://maia.usno.navy.mil/pub/biases/cc2noncc.f
(version 1.3, 09 Mar 2000).

For your information, here are some reasons for making this switch at this time:

* The IGS network has evolved rapidly toward the newer receiver types.

* In the new IGS clock combination system that Tim Springer has implemented, it is clear that different ACs have different clock biases for the same station, up to several ns. Most of this is probably due to differences among the ACs in the way corrections are applied for the satellite-based biases. These station biases should be much smaller if all use the same bias corrections.

* It appears that the amplification of observation noise can be significant when using the previous noncc2cc approach of synthesizing C1 and P2' observations from P1 and P2, at least in certain cases where the multipath is high.

* To the extent that any compatibility method will inevitably degrade the modified data to some extent, it is probably better now that the new receivers be used to fullest advantage without any degradation.

* As the older receivers continue to be replaced, this entire issue will gradually fade away. Further changes by the IGS probably will not be needed. However, the issue of remaining receiver-dependent differences among the new-generation receivers requires further study.

In addition to the IGS Analysis Centers, users of IGS products should also consider following these recommendations if you use IGS clock products with a mix of receiver types, and strict internal consistency is desired.

Best regards,
--Jim

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Jim Ray e-mail: jimr@maia.usno.navy.mil
U.S. Naval Observatory, EO Dept. phone : 202-762-1444
3450 Massachusetts Avenue, NW fax : 202-762-1563

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