

Procedure for computing raw difference of GPS code measurements for geodetic receivers

Version 2.1 25/03/2015: Operational version 17/03/2015 of the dclrinex software used by the BIPM

Version 2.2 22/03/2016: Operational version 17/03/2016 of the dclrinex software used by the BIPM

Version 2.3 27/07/2017: Operational version 27/07/2017 of the dclrinex software used by the BIPM; change of source for the p1c1bias file.

Version 2.4 23/02/2018: Operational version 23/02/2018 of dclrinex + more info

This document describes the computation procedure to obtain raw differences of the GPS code measurements from the Rinex files of two geodetic receivers operated in the same site. These raw differences are subsequently used to compute the results of the calibration trip (See Annex 4). The main items are [highlighted in blue](#).

[A single command runs a script that generates the raw code differences from the Rinex files, along with plots that display the code differences and their time stability. This single step provides the values and statistical uncertainties of the raw code differences. The script is described in section A.](#)

[As an option, an additional script is provided that allows verifying the consistency of the code measurements of the Rinex files of a geodetic receiver with the CGGTTS P3 files (if any) generated by the same receiver. This script is described in section B.] **This will be provided later (reserved for future use).**

The scripts and programs are available [here](#). They have been tested but bugs may subsist. Please report any problem to Gérard Petit (gpetit@bipm.org) and Laurent Tisserand (ltisserand@bipm.org).

A. Script to compute the raw code differences from two Rinex files

A.0. Quick summary

Details on the script and programs can be found in the following sections. For simplicity, the standard operation of a P1/P2 comparison may be summarized as follows:

- Retrieve the script `dclrinex.sh` and the program `dclrinex.f` [here](#).
- Retrieve Rinex observation files for the two receivers to be compared, and Rinex navigation files.
- Run the script `dclrinex.sh <sss1> <sss2> <yydoy> <dur>` (see details in section A.2)
- Extract raw code differences and uncertainties from `ss1sss2yydoy_dur_P12.pdf`, check the file `ss1sss2yydoy_dur.sum` (see a description of the files in section A.3), and provide both files.

A.1. Basic principles

A FORTRAN program named `dclrinex.f` reads GPS observations from two Rinex files taken by two systems on the same site, forms the L1 and L2 phase differences, checks for gross phase outliers and cycle slips by comparing the evolution of the L1 and L2 phase, and solves for the baseline between the phase centers of the two antennas.

Then it forms the GPS C1, C2 (if any), P1 and P2 pseudorange differences, accounting for the geometric effect of the computed baseline. The list of differences is provided along with a statistical analysis for each code. Starting with the version 27/07/2017, the program may read either Rinex 2 or Rinex 3 (3.01) formats. The standard set-up is that the two systems have the same reference clock, but an option exists to process two systems with two different references.

A.2. Operation

The `dclrinex` executable should be generated from the FORTRAN source. The script `dclrinex.sh` runs the `dclrinex` executable and automatically produces plots with pseudorange differences (System 1 – System 2)

and statistical data. It assumes that all useful files are in the current directory. To use this script you have to install ghostscript and GMT (Generic Mapping Tools) software which are available in many Linux repositories. Alternately, it is possible to only use the dclrinex executable that does not generate the plots. The script and the executable both need the following arguments (the first four are mandatory and the last one is optional):

```
dclrinex.sh <sss1> <sss2> <yydoy[.xxxx]> <dur> [<OPTION>]
```

where:

sss1 = The four-character code of station 1 (traveling system), used to name its Rinex files
sss2 = The four-character code of station 2 (local system), used to name its Rinex files
yydoy = first day of Rinex files (last two digits of year + three digits of day of year number)
.xxxx = option to specify precise start time as a fraction of the first day
dur = number of consecutive days to process (maximum advised is 9)
OPTION = P1ISC1: Use C1 measurements instead of P1, for a system with no P1 data
LZYYYY: Use files LZYYYYmj.day to report system 2 to the same reference as system 1.
By default (no option), the two systems have P1 data and use the same reference.

Note Version 2.2: The option of specifying the start time as a fraction of the first day (e.g. 14344.25 to start at 6:00 on day 344 of 2014) is provided to accommodate possible bad data at startup of the systems.

The needed input files are, for each day to be processed:

- One Rinex observation file per system, with the usual standard name ssssdoy0.yyo;
- One Rinex navigation file with broadcast GPS ephemerides, named brdcday0.yyn (any Rinex navigation file with at least one record per prn can be used). brdc navigation files are available e.g. at <ftp://cddis.gsfc.nasa.gov/gps/data/daily/> .
- If the option LZYYYY is used, one file named LZYYYYmj.day linking the reference of System 2 to that of System 1.
- If the option P1ISC1 is used, the Rinex files should first be corrected for satellite C1P1 biases through the program cc2noncc and p1c1 bias taken from, e.g., the file p1c1bias.1994p available at <ftp://ftp.unibe.ch/aiub/bcwg/cc2noncc/>.

Three ASCII output files are created: and named sss1sss2yydoy_dur.EXT

where

sss1sss2yydoy_dur.sum [Summary with essential information \(see example below\)](#)
sss1sss2yydoy_dur.lis Long listing including all warning messages (For debugging purposes only)
sss1sss2yydoy_dur.dif List of code differences at 300s interval

Warning: Previous files with the same filename should be removed before running the script!

One output file with name [ss1sss2yydoy_dur_P12.pdf](#) (see example below) which contains plots of the P1/P2 (respectively [ss1sss2yydoy_dur_C12.pdf](#) for C1/C2) differences and Time deviations.

In addition, temporary ascii files named ZZ.tmp, medZZ.tmp, tdevZZ.tmp where 'ZZ' is the code (C1/C2/P1/P2) are created and overwritten at each run.

A.3. Example of run and output files

Compute the raw differences of the traveling system BP0U with the local system BP0R for 5 days of operation starting 10 December 2014 with the line command:

```
dclrinex.sh bp0u bp0r 14344 5
```

A.3.1 Summary file bp0ubp0r14344_5.sum (Comments are included **in red** below)

[Running options and filenames]

DCLRINEX Version 17/03/2015
Outfile = bp0ubp0r14344_5.dif
Output interval (s) = 300

Code threshold (ns) = 20
Residual threshold (m) =0.050
brdc3440.14n
bp0u3440.14o
bp0r3440.14o
....(list of files continued)

COMPUTATION OF BASELINE

[This section computes the L1/L2 baseline between the two antennas. The results of several steps are shown, the details of which are not necessary. The section ends with information on the computed L1/L2 baselines where the RMS of residuals should not exceed ~0.01m]

Computed baseline L1 (X,Y,Z)/m = 0.099 0.031 0.179
RMS of residuals L1 /m = 0.004
Computed baseline L2 (X,Y,Z)/m = 0.120 0.033 0.192
RMS of residuals L2 /m = 0.004

Final baseline L1 (X,Y,Z)/m = -5.197 -0.764 4.469
Final baseline L2 (X,Y,Z)/m = -5.175 -0.761 4.481

COMPUTATION OF CODE DIFFERENCES

[This section provides the results of code differences: First the global average of all individual differences]

Number of code differences = 61695

Global average of individual differences

Code #pts, ave/ns, rms/ns
C1: 61665 -96.439 1.493
C2: 0 -NaN -NaN
P1: 61555 -93.197 2.381
P2: 61549 -89.780 2.748

[Then the results of code differences with 1 point per 300s epoch and per prn]

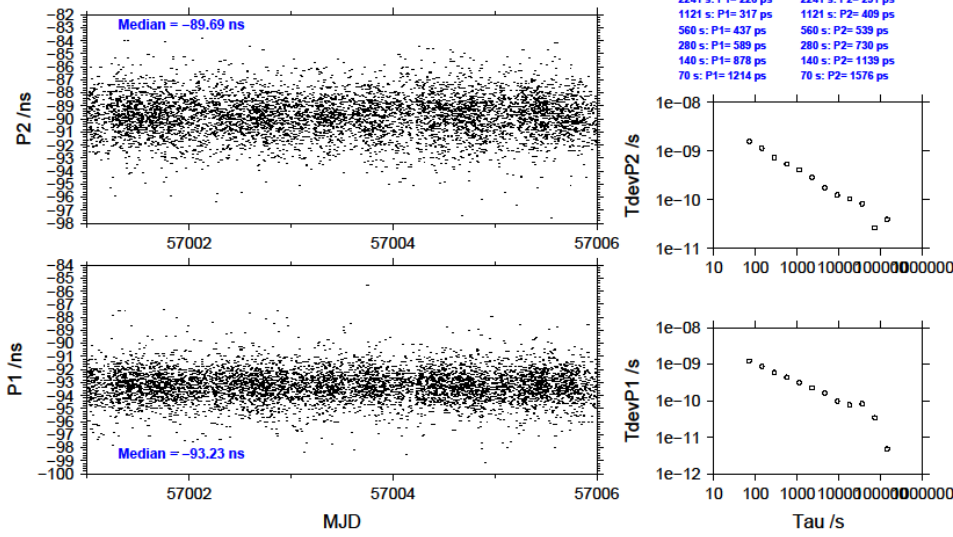
Number of 300s epochs in out file = 1438

Code #pts, median/ns, ave/ns, rms/ns
C1: 6169 **-96.428** -96.430 0.854
C2: 0 0.000-NaN -NaN
P1: 6165 **-93.229** -93.225 1.224
P2: 6165 **-89.692** -89.737 1.567

A.3.2 Plot file bp0ubp0r14344_5_P12.pdf

The plot contains the P1/P2 differences, median values of differences, and Tdevs and is generated by the script from the files P1.tmp, P2.tmp, medp1.tmp, medp2.tmp, tdevp1.tmp, tdevp2.tmp. Users may produce other plots if they wish so. A similar plot exists for C1/C2.

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A.3.3 Use of the results

To compute the calibration results (Annex 4) it is recommended :

- to use the median values (in dark blue in the example .sum file above, and in the plots) for the values of the raw differences;
- to estimate the uncertainties as the top of the flicker plateau in the Tdev, or to use 0.1 ns as default value if the Tdev continuously decreases to lower values.

B. Script to check the consistency of code measurements in the Rinex and CGGTTS files **This section will be finalized later (reserved for future use).**

B.1. Basic principles

If a geodetic receiver generates both Rinex and CGGTTS files, the script will transform the Rinex files into CGGTTS files using the latest version of the R2CGGTTS program issued by the BIPM, then will compare these CGGTTS files with the ones generated by the receiver and will produce a summary of the differences.

B.2. Operation