Preparation and validation of WEC time corrections for year 2001

Keith Yearby, 22 March 2006

Contents

1 Introduction

For precise time stamping of Cluster science data it is necessary to accurately determine the UT time at which each VC0 reset pulse occurs onboard. This pulse is time correlated with the transmission of the first bit of the housekeeping virtual channel (VC0) and the contents of the onboard time counter at this time is recorded in the On-board Time (OBT) field of the VC0 transfer frame (EID-A section 3.3.1.3.1 and 3.3.7.2.2). The time of the pulse is called the Spacecraft Event Time or SCET, and is given to a standard accuracy of +/- 2ms.

However for inter-spacecraft comparisons of EFW and STAFF waveform data a much higher accuracy is needed. This is achieved by preparing time correction (TCOR) files. The process is described in general in the document 'Precise reconstitution of the Spacecraft Event Time (SCET)'.

The purpose of the present document is to describe the precise procedure used for year 2001. Unlike the earlier trial TCOR datasets which were organised by time correlation period, the 2001 data is organised in periods of 3 calendar months. This should be more convenient for application. The 'maketcor' software tool was updated for this reason to allow the use of multiple TCAL files.

Updates to the 'maketcor' and 'apptcor' software tools were also needed to account for the 'duplicate frame' problem that was present in the 2001 raw data. This is where duplicate telemetry frames, with time stamps differing by a few milliseconds, are present in the telemetry. Both software tools were updated to detect this occurrence and use only the real time data. This is a similar solution to that eventually employed by ESOC.

2 Data and references

Source data:

ESOC DIFF measurements for 2001.
WBD data DVDs for 2001.
Cluster RDM for 2001.

Documents:

Precise reconstitution of the Spacecraft Event Time (SCET), Keith Yearby, 2004 July 7

Software:

wbddiff, version 1.0, 2004-06-11
maketcor, version 3.4, 2006-03-03
apptcor, version 1.4, 2006-03-10
veritcor, version 1.0, 2005-07-19

convtcor, version 1.1, 2005-08-08
tcor2cef, version 1.4, 2006-03-02

Derived datasets

Point valid DIFF measurements

010101_1_diff.xls	010101_1_diff.prn
010101_2_diff.xls	010101_2_diff.prn
010101_3_diff.xls	010101_3_diff.prn
010101_4_diff.xls	010101_4_diff.prn
010401_1_diff.xls	010401_1_diff.prn
010401_2_diff.xls	010401_2_diff.prn
010401_3_diff.xls	010401_3_diff.prn
010401_4_diff.xls	010401_4_diff.prn
010701_1_diff.xls	010701_1_diff.prn
010701_2_diff.xls	010701_2_diff.prn
010701_3_diff.xls	010701_3_diff.prn
010701_4_diff.xls	010701_4_diff.prn
011001_1_diff.xls	011001_1_diff.prn
011001_2_diff.xls	011001_2_diff.prn
011001_3_diff.xls	011001_3_diff.prn
011001_4_diff.xls	011001_4_diff.prn

ASCII TCOR files

010101_1_tcor2.txt
010101_2_tcor2.txt
010101_3_tcor2.txt
010101_4_tcor2.txt
010401_1_tcor2.txt
010401_2_tcor2.txt
010401_3_tcor2.txt
010401_4_tcor2.txt
010701_1_tcor2.txt
010701_2_tcor2.txt
010701_3_tcor2.txt
010701_4_tcor2.txt
011001_1_tcor2.txt
011001_2_tcor2.txt
011001_3_tcor2.txt
011001_4_tcor2.txt

Binary TCOR files

010101_1_tcor_v01.dat
010101_2_tcor_v01.dat
010101_3_tcor_v01.dat
010101_4_tcor_v01.dat
010401_1_tcor_v01.dat
010401_2_tcor_v01.dat
010401_3_tcor_v01.dat
010401_4_tcor_v01.dat
010701_1_tcor_v01.dat
010701_2_tcor_v01.dat
010701_3_tcor_v01.dat
010701_4_tcor_v01.dat
011001_1_tcor_v01.dat
011001_2_tcor_v01.dat
011001_3_tcor_v01.dat

```
011001_4_tcor_v01.dat
```

CEF TCOR files

```
C1_CP_DWP_TCOR__20010102_V01.cef
C1_CP_DWP_TCOR__20010403_V01.cef
C1_CP_DWP_TCOR__20010702_V01.cef
C1_CP_DWP_TCOR__20011001_V01.cef
C2_CP_DWP_TCOR__20010101_V01.cef
C2_CP_DWP_TCOR__20010401_V01.cef
C2_CP_DWP_TCOR__20010701_V01.cef
C2_CP_DWP_TCOR__20011001_V01.cef
C3_CP_DWP_TCOR__20010102_V01.cef
C3_CP_DWP_TCOR__20010401_V01.cef
C3_CP_DWP_TCOR__20010702_V01.cef
C3_CP_DWP_TCOR__20011001_V01.cef
C4_CP_DWP_TCOR__20010103_V01.cef
C4_CP_DWP_TCOR__20010401_V01.cef
C4_CP_DWP_TCOR__20010701_V01.cef
C4_CP_DWP_TCOR__20011001_V01.cef
```

3 Preparation of the Point Valid DIFF measurements

The ESOC and WBD DIFF measurements are sometimes subject to errors so must be validated before use. The strategy used here is to regard the ESOC measurements as the primary measurement, and use the WBD data to validate it. For a further validation, the DIFF just prior to each new time correlation is determined by analysis of the TCAL files on the Cluster RDM.

The DIFF measurements received from ESOC for 2001 are unsigned, so the sign is determined by comparison with the WBD or TCAL DIFFs. During 2001, WBD data is quite sparse, so there are some periods when it is difficult to be sure what is the sign of the DIFF. However, this is always when the DIFF is small, so the error that would be introduced by an incorrect sign is also small (typically less than 50 μs.

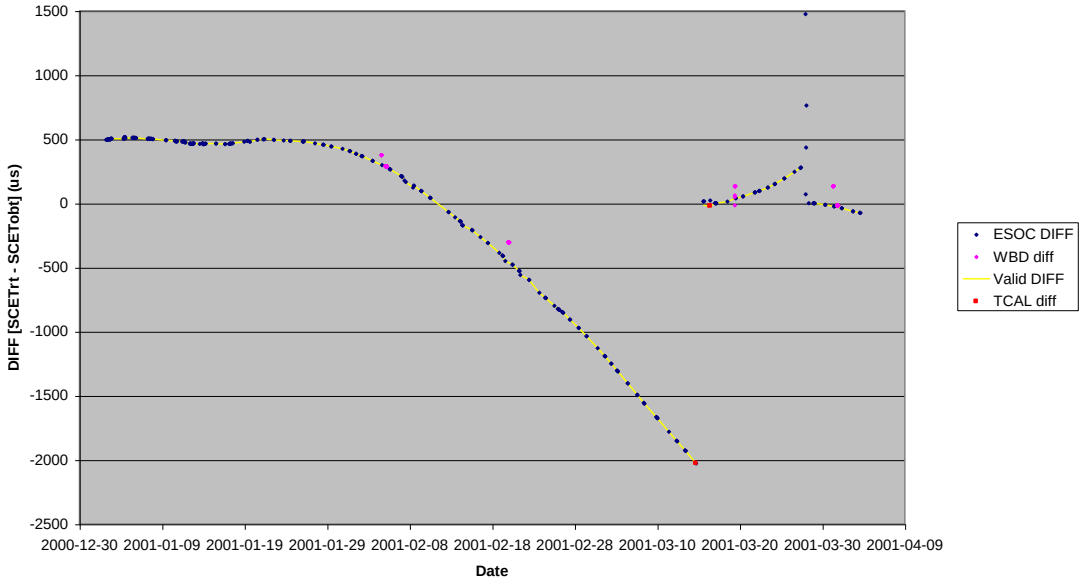
The ESOC and WBD data are copied into Excel worksheets. A duplicate is made of the ESOC data which will become the final validated data. A chart (XY scatter) is then produced, plotting points only for the raw ESOC and WBD data, and a line for the validated data.

It is fairly clear which points have large errors and these are simply deleted from the validated data worksheet. The following charts show the data for the period of the time correlations, and the four spacecraft. Note that the vertical scale of each figure is different. Each figure is ‘Chart1’ in the Excel format DIFF files listed in section 2.

Once the valid ESOC data has been selected, its accuracy is checked by comparing each WBD measurement with a linear interpolation between the nearest ESOC measurements before and after.

The point valid DIFF files are organised in periods of 3 calendar months, the same as the ESOC DIFF measurements. Where possible, at least one point before and after the nominal 3 month period is included, so the DIFF at the boundaries of the nominal period may be obtained by interpolation.

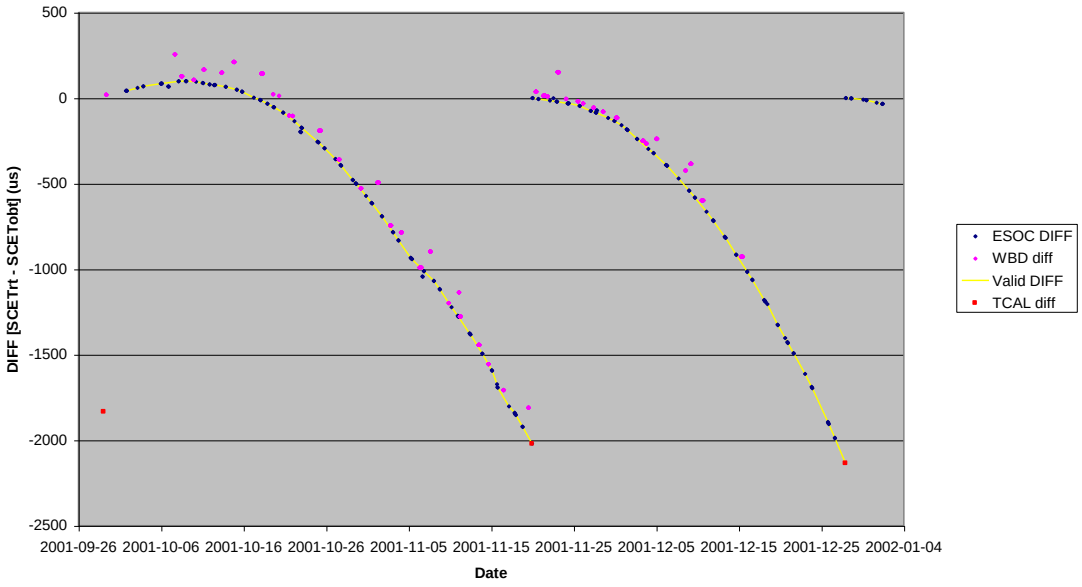
Cluster SC1 ESOC & WBD DIFF for 2001/01..03



Cluster SC1 ESOC & WBD DIFF for 2001/04..06

Cluster SC1 ESOC & WBD DIFF for 2001/07..09

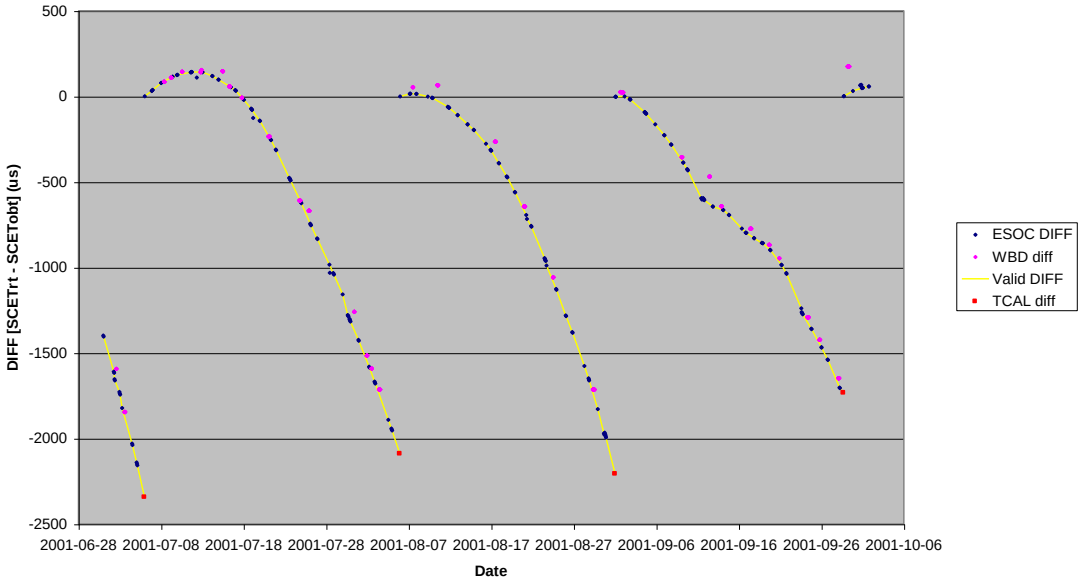
Cluster SC1 ESOC & WBD DIFF for 2001/10..12



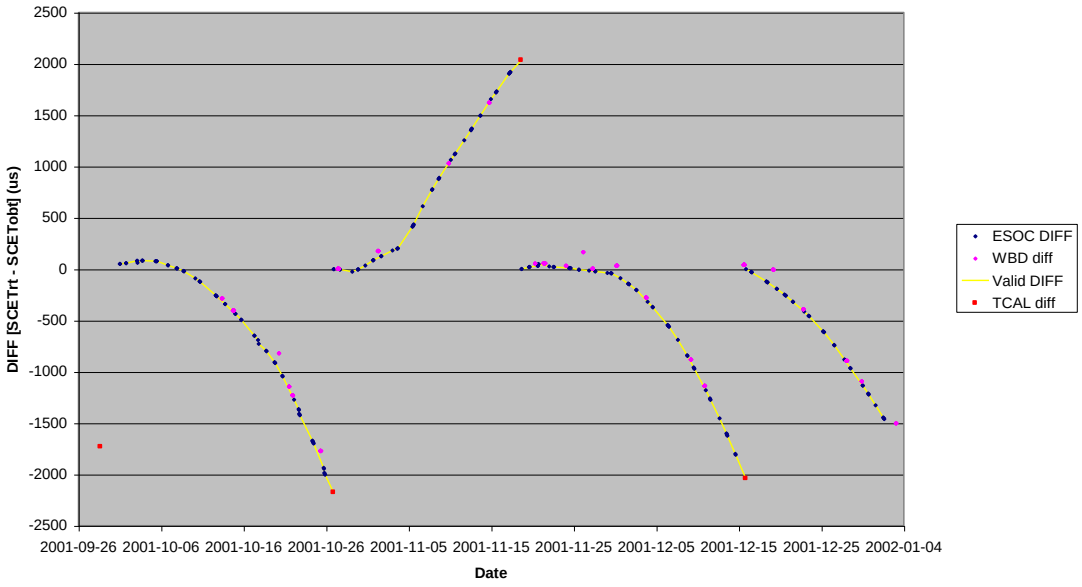
Cluster SC2 ESOC & WBD DIFF for 2001/01..03

Cluster SC2 ESOC & WBD DIFF for 2001/04..06

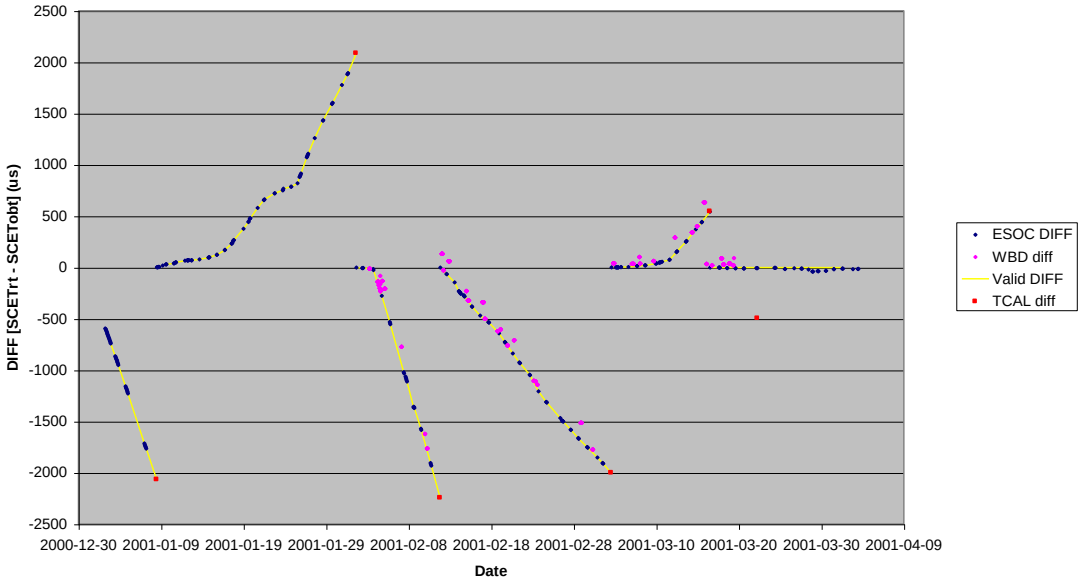
Cluster SC2 ESOC & WBD DIFF for 2001/07..09



Cluster SC2 ESOC & WBD DIFF for 2001/07..09

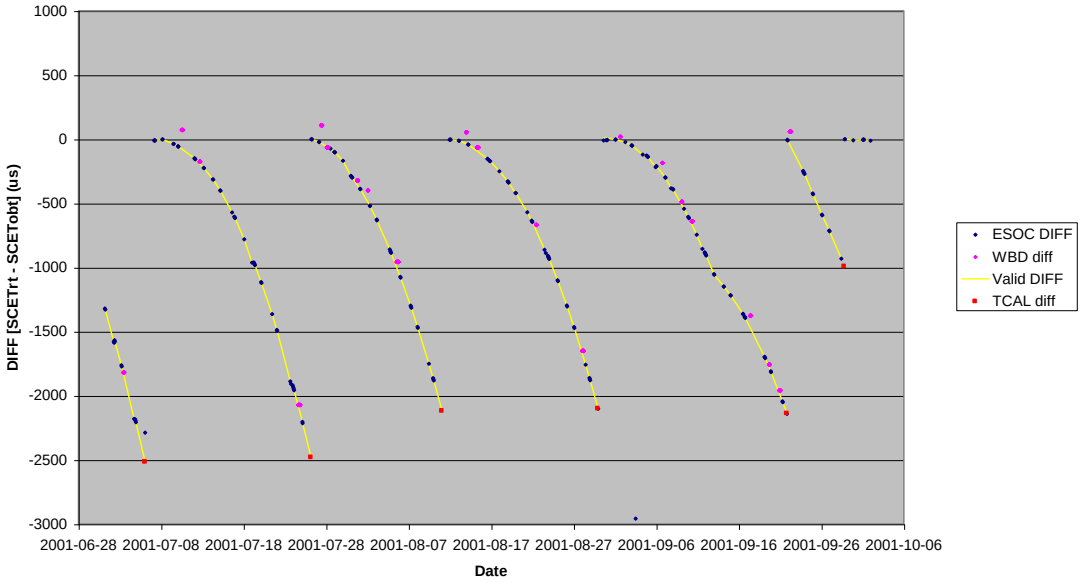


Cluster SC3 ESOC & WBD DIFF for 2001/01..03



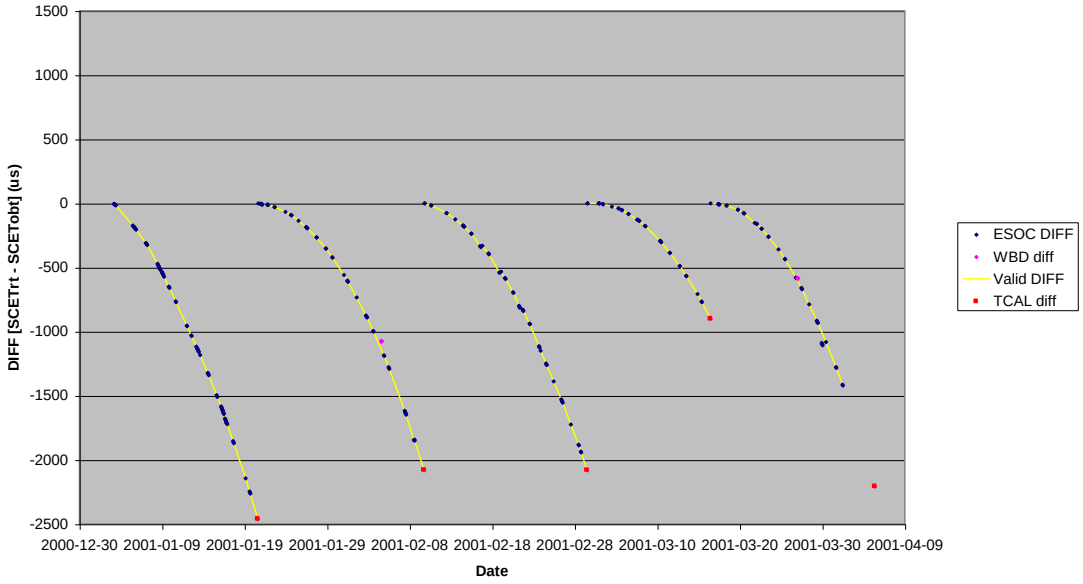
Cluster SC3 ESOC & WBD DIFF for 2001/04..06

Cluster SC3 ESOC & WBD DIFF for 2001/07..09

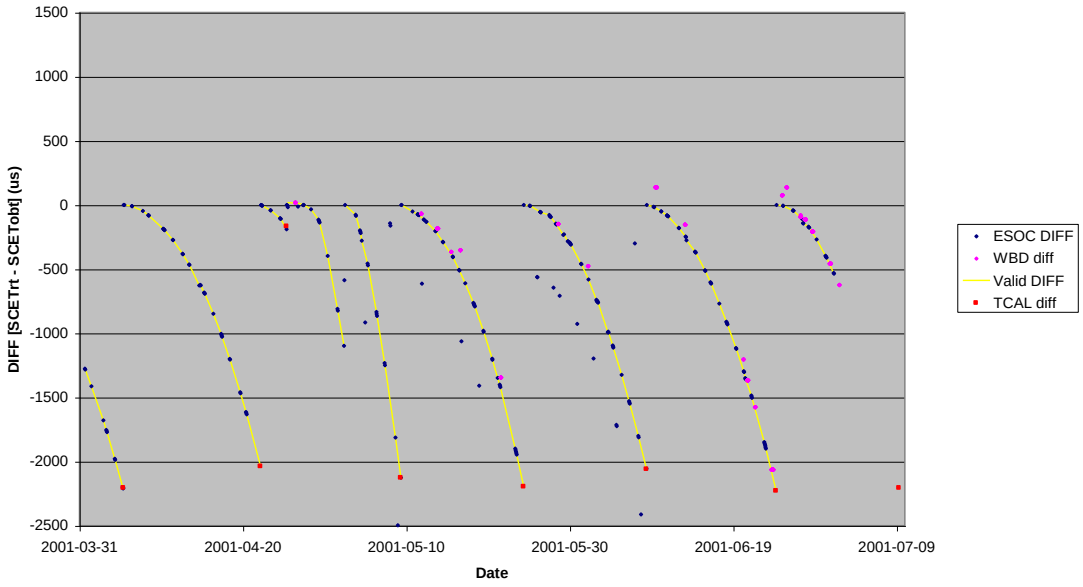


Cluster SC3 ESOC & WBD DIFF for 2001/10..12

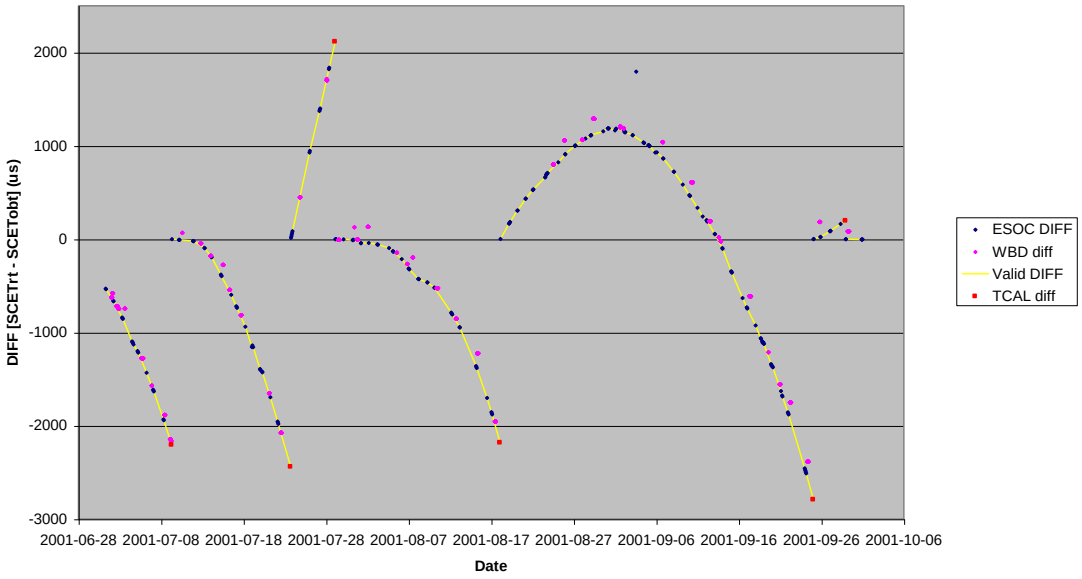
Cluster SC4 ESOC & WBD DIFF for 2001/01..03



Cluster SC4 ESOC & WBD DIFF for 2001/04..06



Cluster SC4 ESOC & WBD DIFF for 2001/07..09



Cluster SC4 ESOC & WBD DIFF for 2001/10..12

4 Generation of the ASCII TCOR files

The generation of the ASCII TCOR files is performed on the Sun network where direct access to the Cluster RDM is available.A list of the full path names of all HK and TCAL files for each spacecraft is obtained using the Unix 'find' command. The individual lists must be in chronological order. They should be written to files named like *yymmdd_s*_hkla_files.txt. The following script was used to produce the 2001 TCOR files.

```
maketcor3 -d 010101_1_diff.prn -f 01_1_hkla_files.txt -s 010101 -e 010331 > 010101_1_tcor2.txt
maketcor3 -d 010101_2_diff.prn -f 01_2_hkla_files.txt -s 010101 -e 010331 > 010101_2_tcor2.txt
maketcor3 -d 010101_3_diff.prn -f 01_3_hkla_files.txt -s 010101 -e 010331 > 010101_3_tcor2.txt
maketcor3 -d 010101_4_diff.prn -f 01_4_hkla_files.txt -s 010101 -e 010331 > 010101_4_tcor2.txt
maketcor3 -d 010401_1_diff.prn -f 01_1_hkla_files.txt -s 010401 -e 010630 > 010401_1_tcor2.txt
maketcor3 -d 010401_2_diff.prn -f 01_2_hkla_files.txt -s 010401 -e 010630 > 010401_2_tcor2.txt
maketcor3 -d 010401_3_diff.prn -f 01_3_hkla_files.txt -s 010401 -e 010630 > 010401_3_tcor2.txt
maketcor3 -d 010401_4_diff.prn -f 01_4_hkla_files.txt -s 010401 -e 010630 > 010401_4_tcor2.txt
maketcor3 -d 010701_1_diff.prn -f 01_1_hkla_files.txt -s 010701 -e 010930 > 010701_1_tcor2.txt
maketcor3 -d 010701_2_diff.prn -f 01_2_hkla_files.txt -s 010701 -e 010930 > 010701_2_tcor2.txt
maketcor3 -d 010701_3_diff.prn -f 01_3_hkla_files.txt -s 010701 -e 010930 > 010701_3_tcor2.txt
maketcor3 -d 010701_4_diff.prn -f 01_4_hkla_files.txt -s 010701 -e 010930 > 010701_4_tcor2.txt
maketcor3 -d 011001_1_diff.prn -f 01_1_hkla_files.txt -s 011001 -e 011231 > 011001_1_tcor2.txt
maketcor3 -d 011001_2_diff.prn -f 01_2_hkla_files.txt -s 011001 -e 011231 > 011001_2_tcor2.txt
maketcor3 -d 011001_3_diff.prn -f 01_3_hkla_files.txt -s 011001 -e 011231 > 011001_3_tcor2.txt
maketcor3 -d 011001_4_diff.prn -f 01_4_hkla_files.txt -s 011001 -e 011231 > 011001_4_tcor2.txt
```

5 Validation of the ASCII TCOR files

The software tool 'maketcor' performs some automatic validation as the files are produced. Data that fails validation is not included in the output files.

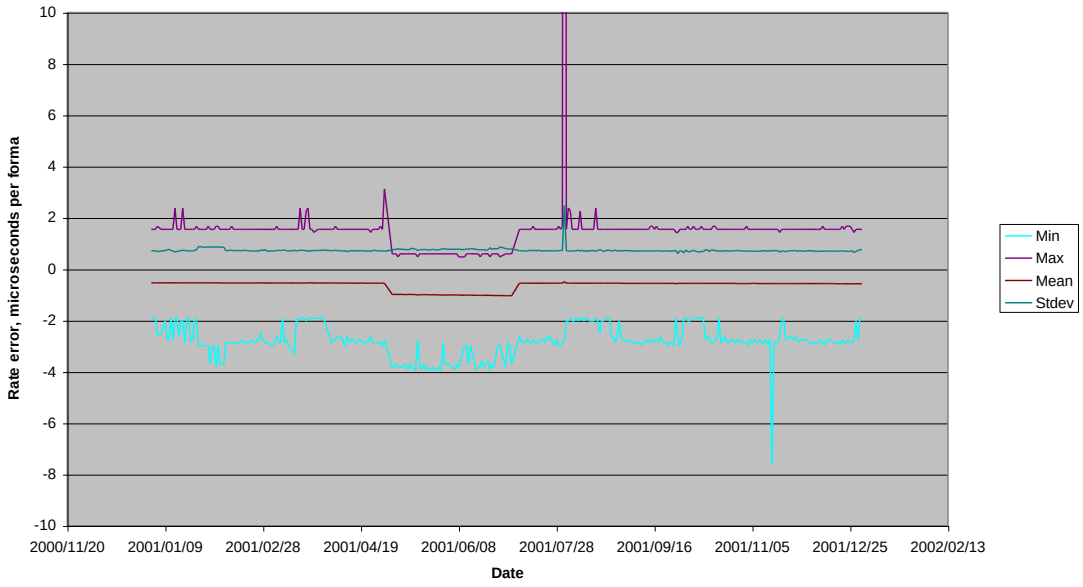
Further validation of the TCOR files is performed by using the files to produce HK files with time corrections applied, then analysing the time tags of these files. Anomalies identified in the corrected files may then be related to errors noted in the TCOR file comments, and the TCOR records deleted or corrected. The process is then repeated until no anomalies are found. Comments in the ASCII TCOR files show indicate where such corrections have been made.

The production of the time corrected HK files is done using 'apptcor' (see appendix 1). This doesn't presently have a 'file list' option, so a script must be prepared to run apptcor for every HK file within the period of the TCOR files. HK files which span the boundary between one TCOR file and the next must be processed using both TCOR files.

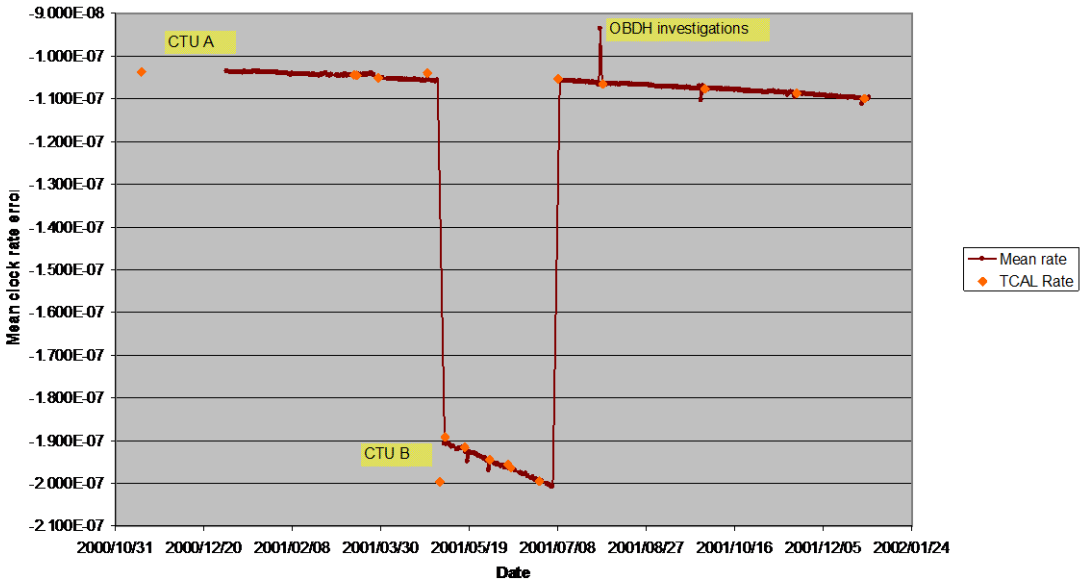
The time corrected HK files are analysed using 'veritcor'. This takes the time increment between each pair of records in the file, subtracts the nominal value of 5.15222168 seconds, and accumulates the minimum, maximum, mean and standard deviation over each 24 hour period. On SC1 and SC3 it is known that time jumps of -125.9 us occur occasionally. These are counted and removed before further analysis. Gaps in the file are allowed for, and by default 'veritcor' only processes records that are marked as time corrected.

The mean increment is a measure of the rate error of the on board clock. A similar measure may be obtained from the TICK values in the TCAL files (rate error = (TICK - 1.0e12) / 1.0e12). The two measures are compared in the following charts.

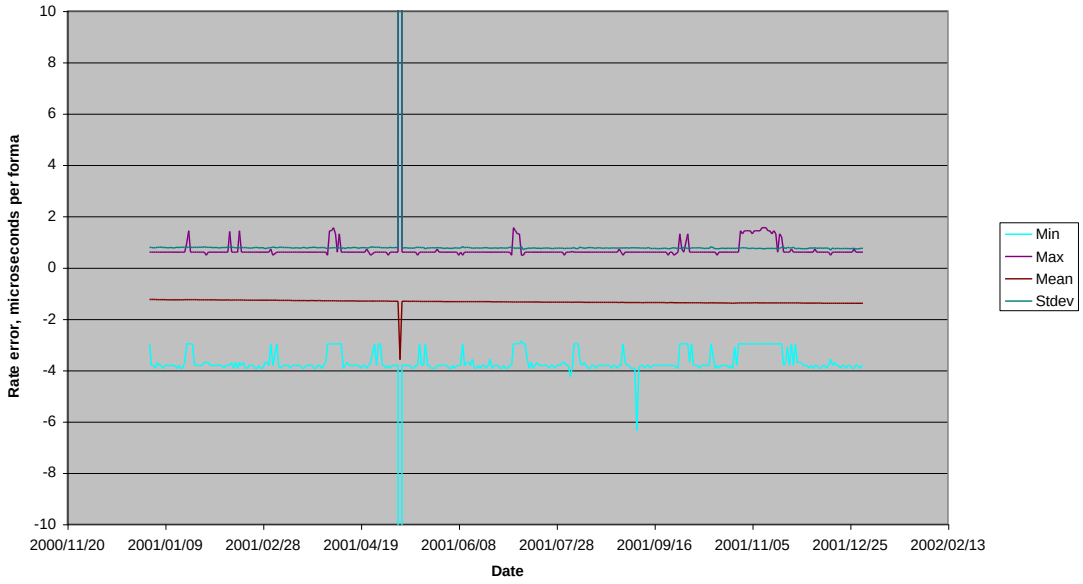
Cluster SC1 timing analysis, year 2001



Cluster SC1 clock rate error, year 2001

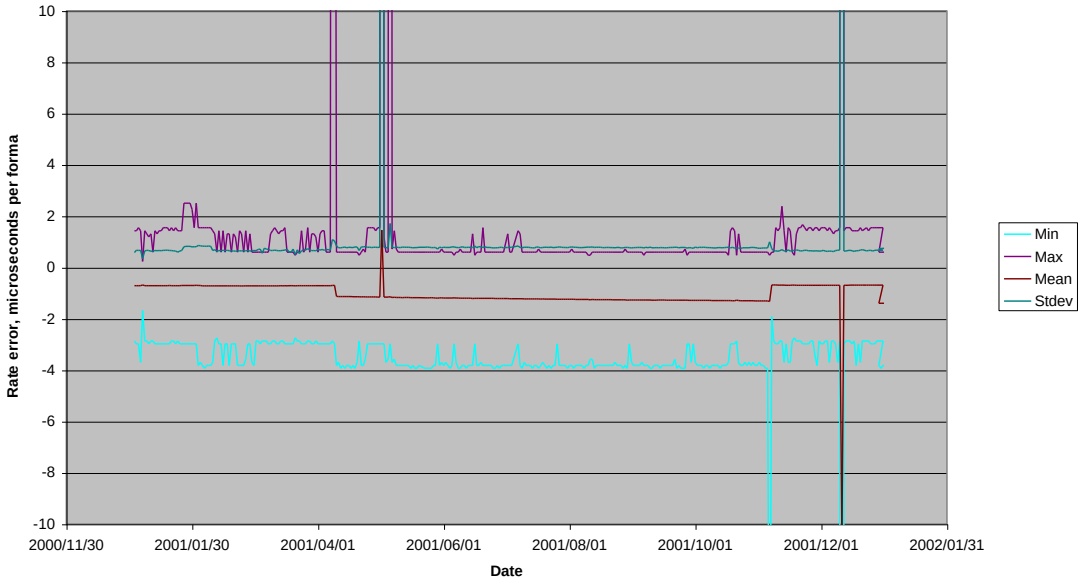


Cluster SC2 timing analysis, year 2001

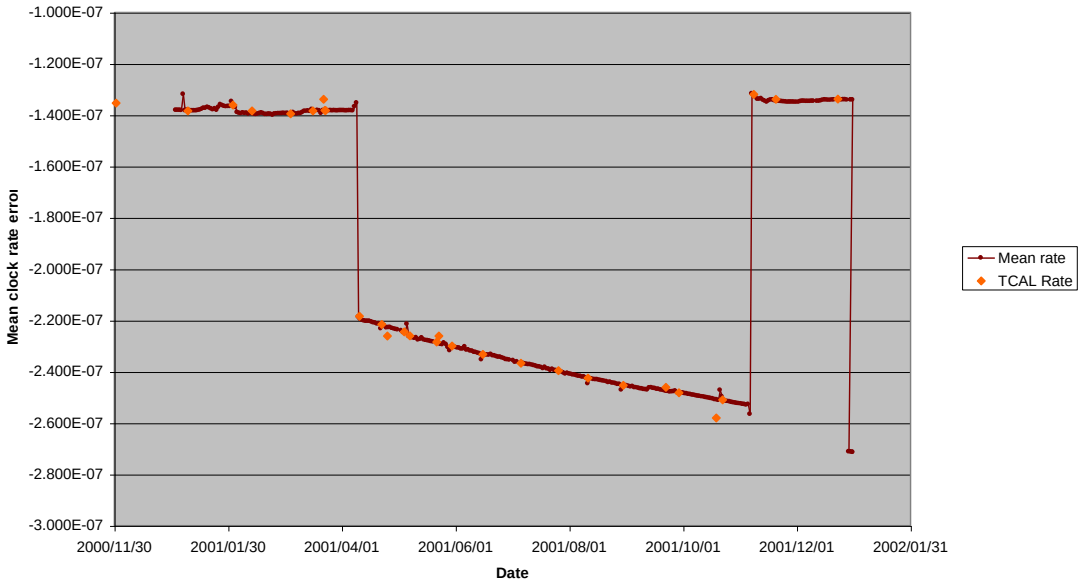


Cluster SC2 clock rate error, year 2001

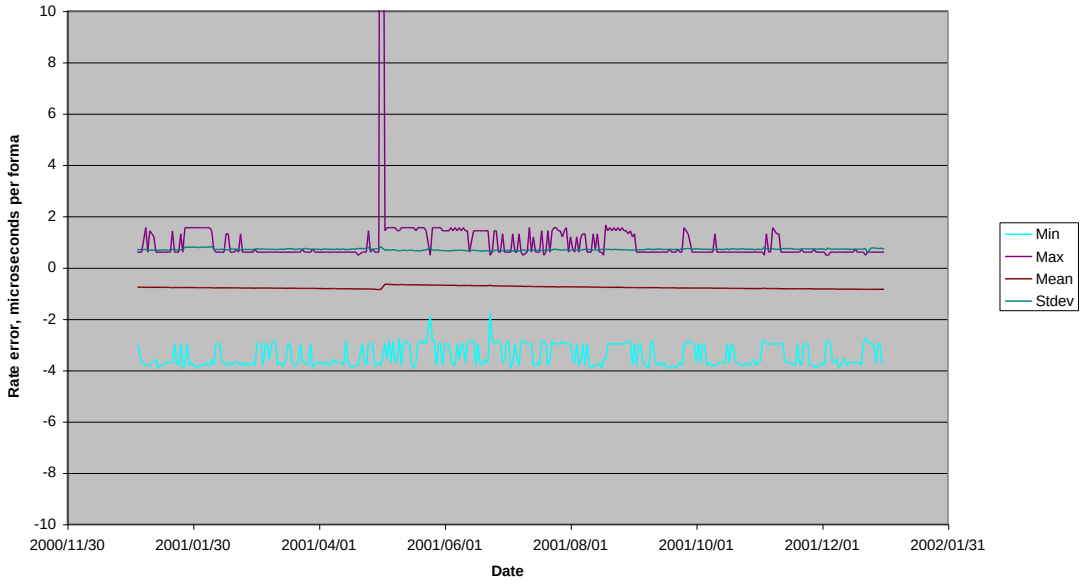
Cluster SC3 timing analysis, year 2001



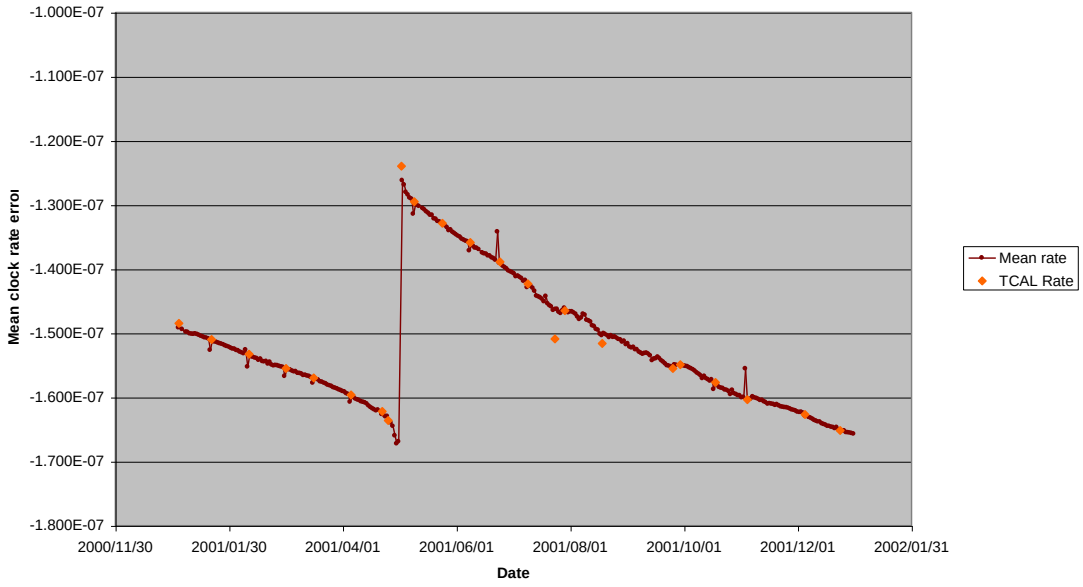
Cluster SC3 clock rate error, year 2001



Cluster SC4 timing analysis, year 2001



Cluster SC4 clock rate error, year 2001



6 Production of the CEF files

The CEF files are produced by running TCOR2CEF on the validated ASCII format TCOR files.

The CEF file name is generated automatically using information contained in the file (except for the version number which is specified). Note that the date included in the name is the date of the first data actually present in the file, which may not be the same as the start of the nominal period covered by the file. For example the file covering January to March 2001 for SC1, is dated 2001-01-02 because there is no data for 2001-01-01.

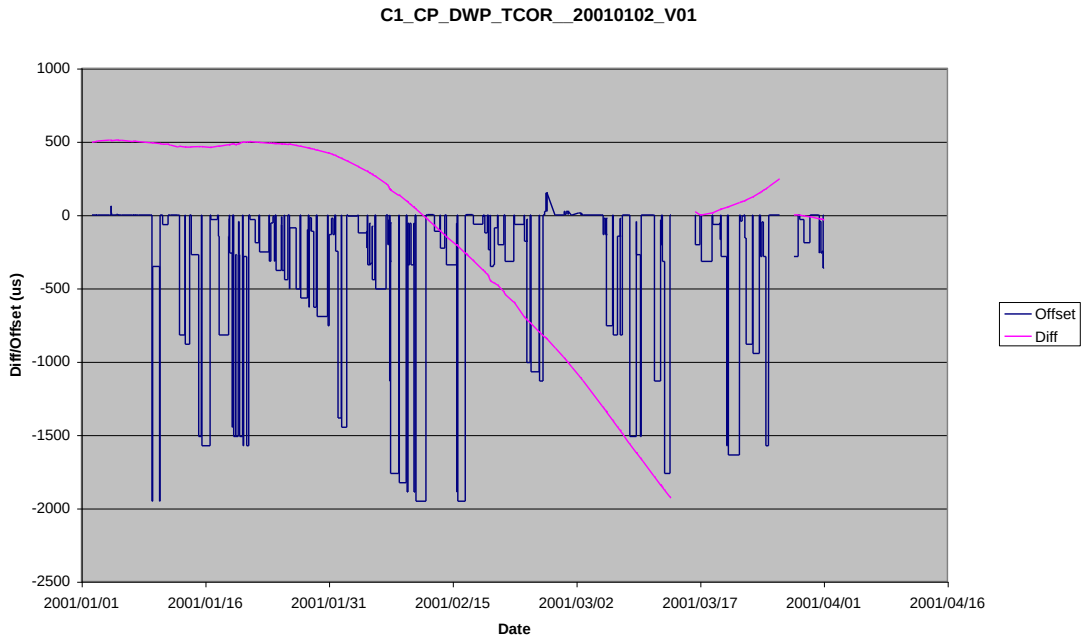
The standard output from TCOR2CEF is listed below. This includes a measure of what proportion of the time corrections are available.

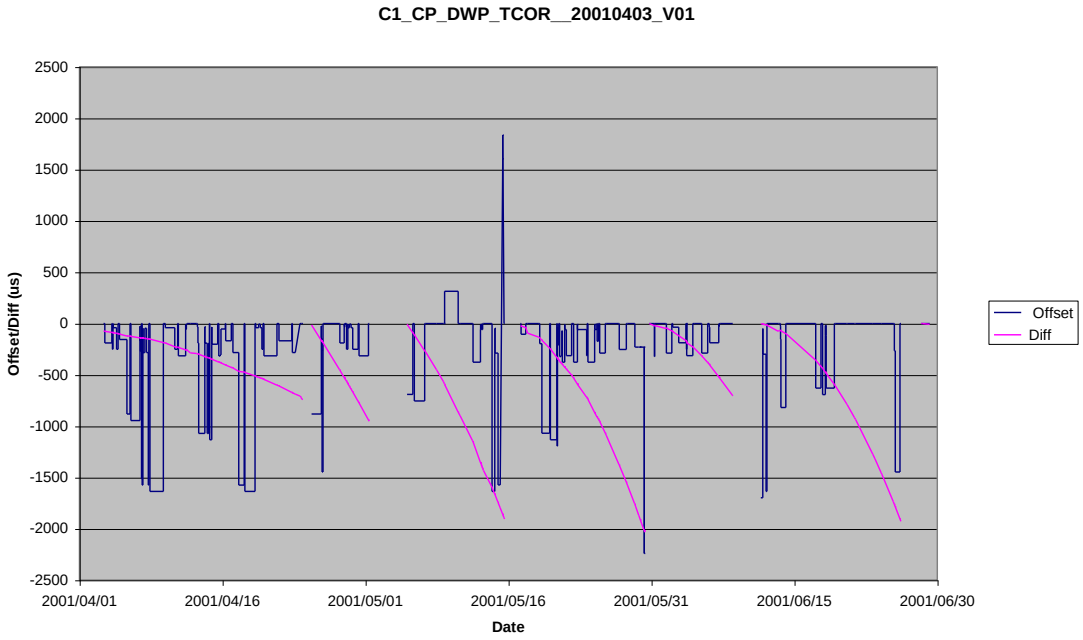
A final validation of the CEF files was performed by importing them to Excel and plotting charts of the data. These are included below.

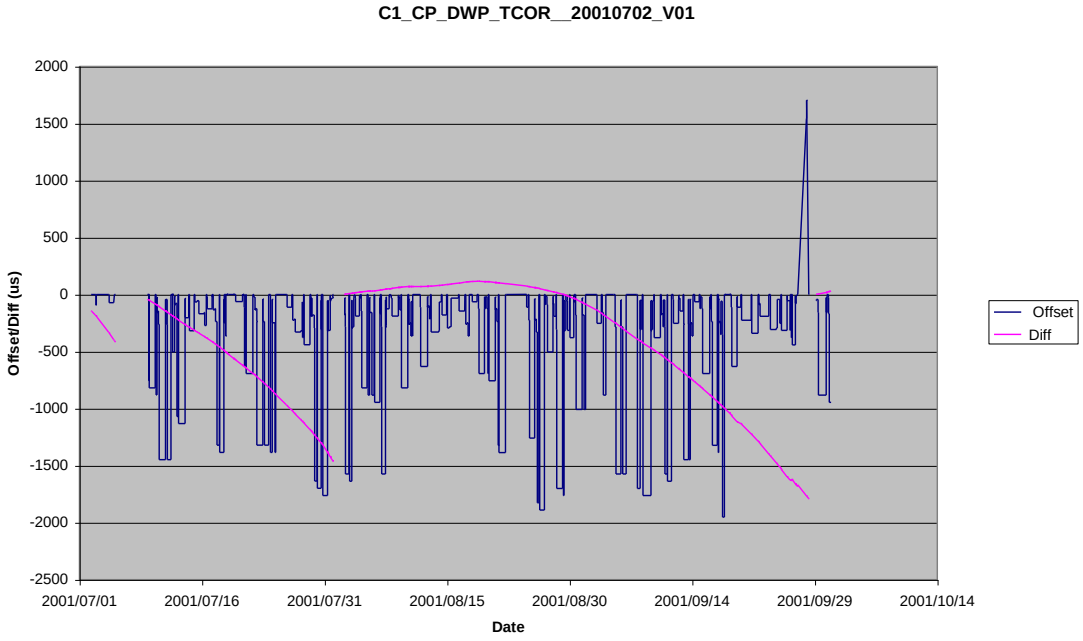
```
C:\cluster\timing\2001>tcor2cef -t 010101_1_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          010101_1_tcor2.txt, s/c: 1, records: 275
Time range:         2001-01-02T06:40:29Z to 2001-03-31T23:59:59Z
Generated CEF name: C1_CP_DWP_TCOR__20010102_V01
Finished, CEF size: 32813 bytes
Total duration:     7665570 seconds
Corrected:          5969645 seconds (77.9 %)

C:\cluster\timing\2001>tcor2cef -t 010101_2_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          010101_2_tcor2.txt, s/c: 2, records: 322
Time range:         2001-01-01T18:04:52Z to 2001-03-31T15:42:16Z
Generated CEF name: C2_CP_DWP_TCOR__20010101_V01
Finished, CEF size: 38558 bytes
Total duration:     7681044 seconds
Corrected:          6548269 seconds (85.3 %)

C:\cluster\timing\2001>tcor2cef -t 010101_3_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          010101_3_tcor2.txt, s/c: 3, records: 446
Time range:         2001-01-02T18:25:28Z to 2001-03-31T13:27:50Z
Generated CEF name: C3_CP_DWP_TCOR__20010102_V01
Finished, CEF size: 52308 bytes
Total duration:     7585342 seconds
Corrected:          5955718 seconds (78.5 %)

C:\cluster\timing\2001>tcor2cef -t 010101_4_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          010101_4_tcor2.txt, s/c: 4, records: 332
Time range:         2001-01-03T05:27:01Z to 2001-03-31T23:59:59Z
Generated CEF name: C4_CP_DWP_TCOR__20010103_V01
Finished, CEF size: 39672 bytes
Total duration:     7583578 seconds
Corrected:          6968720 seconds (91.9 %)

C:\cluster\timing\2001>tcor2cef -t 010401_1_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          010401_1_tcor2.txt, s/c: 1, records: 237
Time range:         2001-04-03T12:50:28Z to 2001-06-29T04:36:50Z
Generated CEF name: C1_CP_DWP_TCOR__20010403_V01
Finished, CEF size: 28793 bytes
Total duration:     7487182 seconds
Corrected:          4241036 seconds (56.6 %)

C:\cluster\timing\2001>tcor2cef -t 010401_2_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          010401_2_tcor2.txt, s/c: 2, records: 448
Time range:         2001-04-01T04:48:30Z to 2001-06-30T23:59:59Z
Generated CEF name: C2_CP_DWP_TCOR__20010401_V01
```

```
Finished, CEF size: 53129 bytes
Total duration:     7845089 seconds
Corrected:          7309415 seconds (93.2 %)

C:\cluster\timing\2001>tcor2cef -t 010401_3_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          010401_3_tcor2.txt, s/c: 3, records: 491
Time range:         2001-04-01T12:43:14Z to 2001-06-30T23:59:59Z
Generated CEF name: C3_CP_DWP_TCOR__20010401_V01
Finished, CEF size: 57882 bytes
Total duration:     7816605 seconds
Corrected:          6340805 seconds (81.1 %)

C:\cluster\timing\2001>tcor2cef -t 010401_4_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          010401_4_tcor2.txt, s/c: 4, records: 411
Time range:         2001-04-01T00:00:00Z to 2001-06-30T23:59:59Z
Generated CEF name: C4_CP_DWP_TCOR__20010401_V01
Finished, CEF size: 48882 bytes
Total duration:     7862399 seconds
Corrected:          6254058 seconds (79.5 %)

C:\cluster\timing\2001>tcor2cef -t 010701_1_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          010701_1_tcor2.txt, s/c: 1, records: 441
Time range:         2001-07-02T10:17:57Z to 2001-09-30T23:59:59Z
Generated CEF name: C1_CP_DWP_TCOR__20010702_V01
Finished, CEF size: 52359 bytes
Total duration:     7825322 seconds
Corrected:          6378165 seconds (81.5 %)

C:\cluster\timing\2001>tcor2cef -t 010701_2_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          010701_2_tcor2.txt, s/c: 2, records: 535
Time range:         2001-07-01T01:53:20Z to 2001-09-30T23:59:59Z
Generated CEF name: C2_CP_DWP_TCOR__20010701_V01
Finished, CEF size: 63127 bytes
Total duration:     7941999 seconds
Corrected:          6942236 seconds (87.4 %)

C:\cluster\timing\2001>tcor2cef -t 010701_3_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          010701_3_tcor2.txt, s/c: 3, records: 494
Time range:         2001-07-02T06:39:08Z to 2001-09-30T23:59:59Z
Generated CEF name: C3_CP_DWP_TCOR__20010702_V01
Finished, CEF size: 58571 bytes
Total duration:     7838451 seconds
Corrected:          6899472 seconds (88.0 %)

C:\cluster\timing\2001>tcor2cef -t 010701_4_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          010701_4_tcor2.txt, s/c: 4, records: 509
Time range:         2001-07-01T08:12:17Z to 2001-09-30T23:59:59Z
Generated CEF name: C4_CP_DWP_TCOR__20010701_V01
Finished, CEF size: 59932 bytes
Total duration:     7919262 seconds
Corrected:          6773066 seconds (85.5 %)

C:\cluster\timing\2001>tcor2cef -t 011001_1_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          011001_1_tcor2.txt, s/c: 1, records: 509
Time range:         2001-10-01T19:02:42Z to 2001-12-31T17:11:38Z
Generated CEF name: C1_CP_DWP_TCOR__20011001_V01
Finished, CEF size: 60542 bytes
Total duration:     7855736 seconds
Corrected:          7341150 seconds (93.4 %)

C:\cluster\timing\2001>tcor2cef -t 011001_2_tcor2.txt -v 1
TCOR2CEF, version 1.4
```

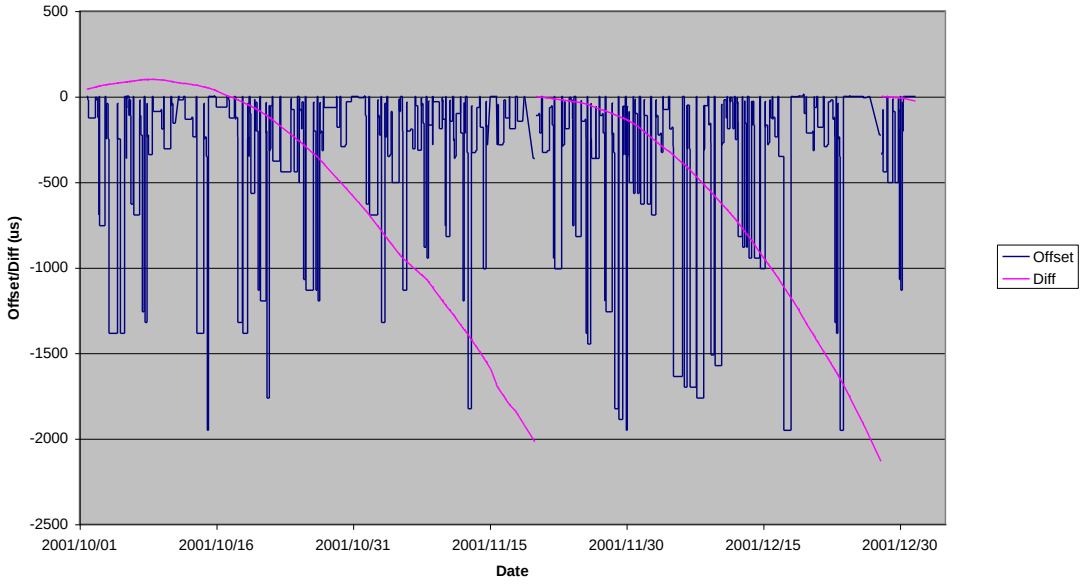
```
TCOR file:          011001_2_tcor2.txt, s/c: 2, records: 439
Time range:         2001-10-01T01:36:14Z to 2001-12-31T14:32:06Z
Generated CEF name: C2_CP_DWP_TCOR__20011001_V01
Finished, CEF size: 51811 bytes
Total duration:     7908952 seconds
Corrected:          7246125 seconds (91.6 %)

C:\cluster\timing\2001>tcor2cef -t 011001_3_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          011001_3_tcor2.txt, s/c: 3, records: 453
Time range:         2001-10-01T04:47:21Z to 2001-12-31T14:42:02Z
Generated CEF name: C3_CP_DWP_TCOR__20011001_V01
Finished, CEF size: 53882 bytes
Total duration:     7898081 seconds
Corrected:          6654814 seconds (84.3 %)

C:\cluster\timing\2001>tcor2cef -t 011001_4_tcor2.txt -v 1
TCOR2CEF, version 1.4

TCOR file:          011001_4_tcor2.txt, s/c: 4, records: 502
Time range:         2001-10-01T00:37:10Z to 2001-12-31T18:31:27Z
Generated CEF name: C4_CP_DWP_TCOR__20011001_V01
Finished, CEF size: 59101 bytes
Total duration:     7926857 seconds
Corrected:          7105751 seconds (89.6 %)
```



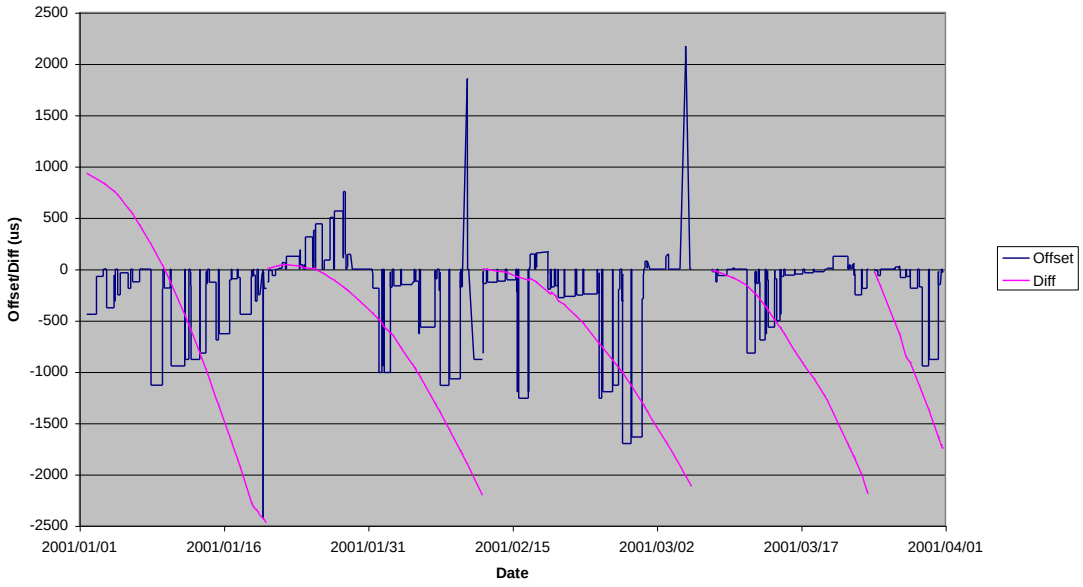

C1_CP_DWP_TCOR__20010403_V01
2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
Offset/Diff (us)
2001/04/01
2001/04/16
2001/05/01
2001/05/16
2001/05/31
2001/06/15
2001/06/30
Date
Offset
Diff


C1_CP_DWP_TCOR__20010702_V01
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
Offset/Diff (us)
2001/07/01
2001/07/16
2001/07/31
2001/08/15
2001/08/30
2001/09/14
2001/09/29
2001/10/14
Date
Offset
Diff

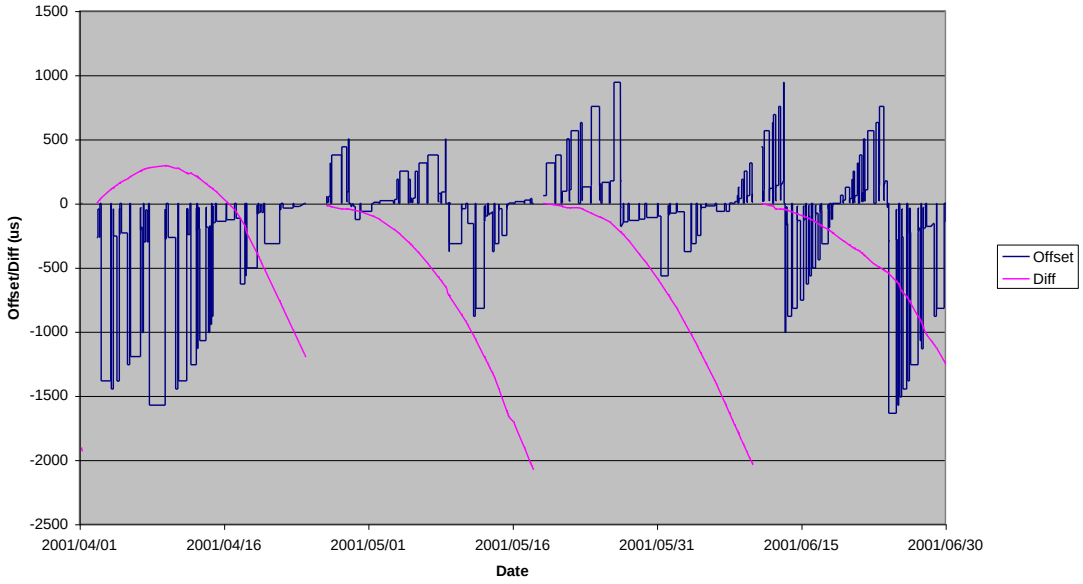
C1_CP_DWP_TCOR__20011001_V01



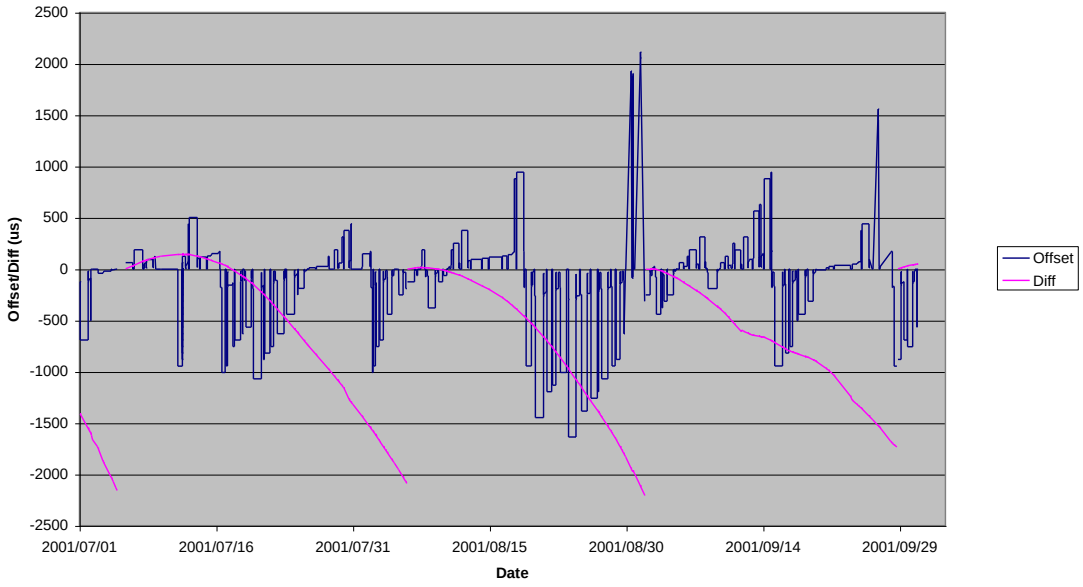
C2_CP_DWP_TCOR__20010101_V01



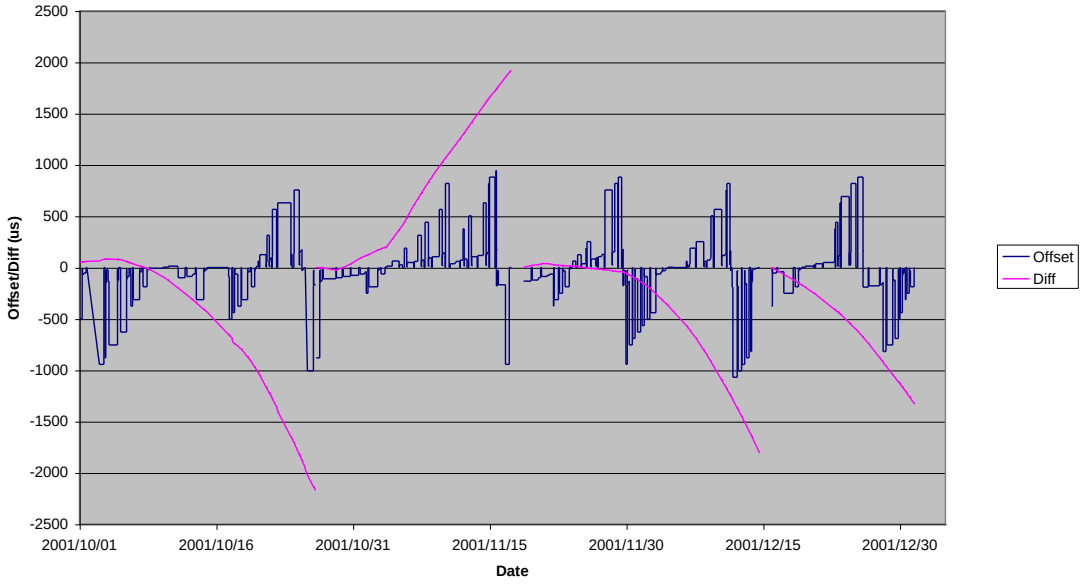
C2_CP_DWP_TCOR__20010401_V01



C2_CP_DWP_TCOR__20010701_V01



C2_CP_DWP_TCOR__20011001_V01



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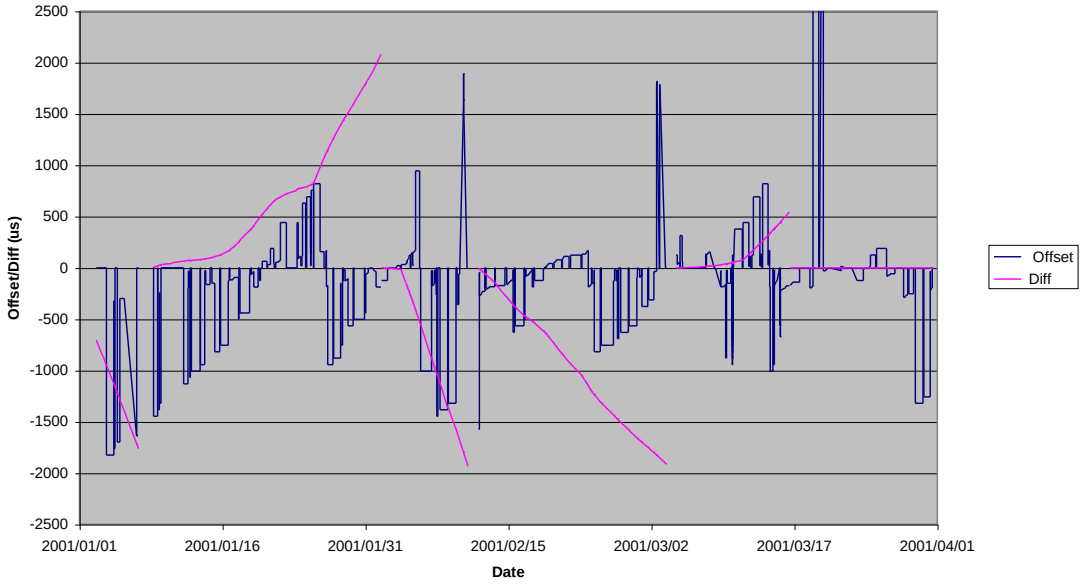
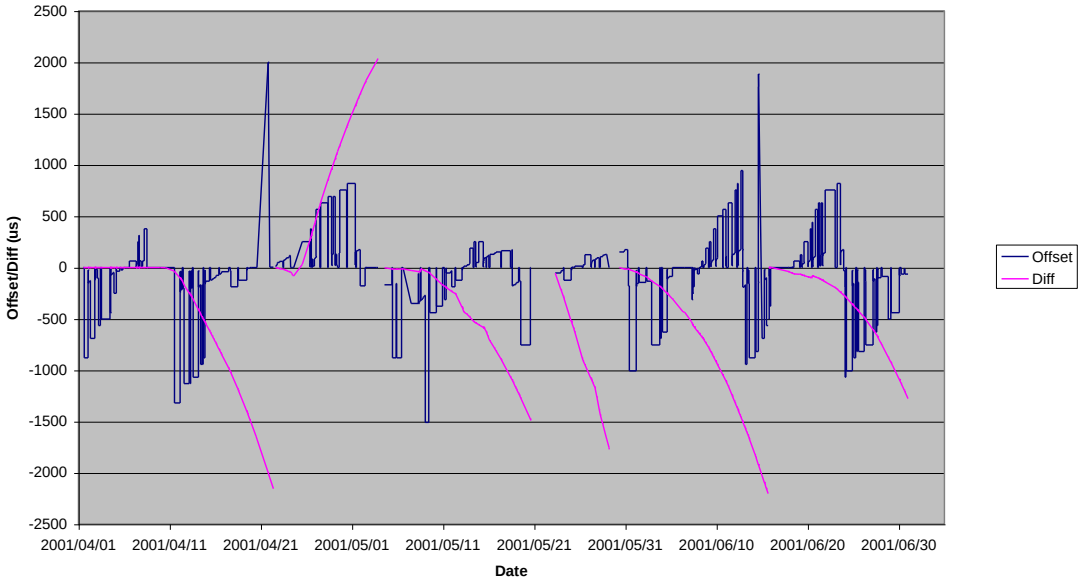
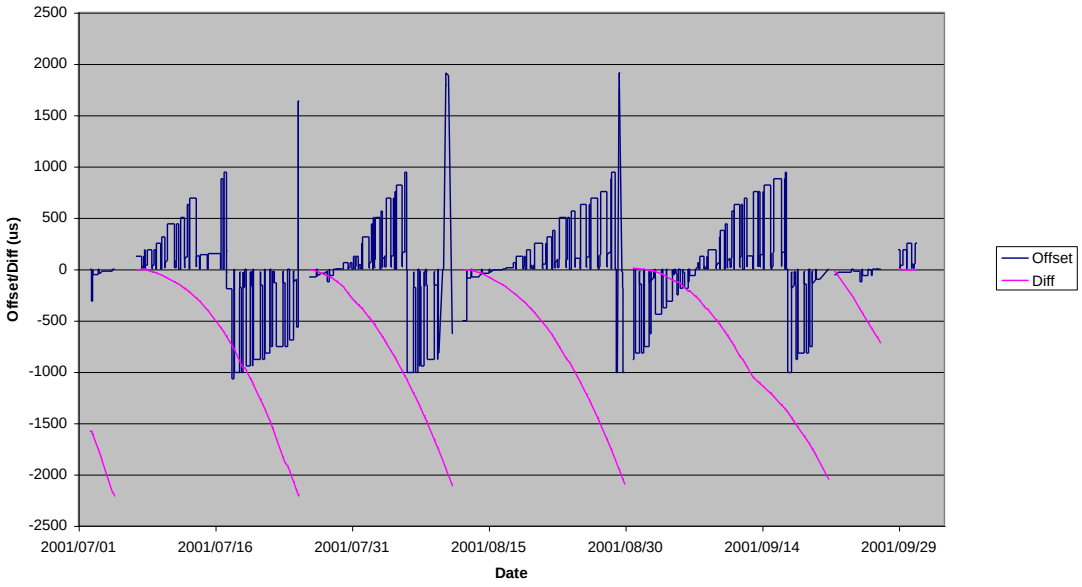
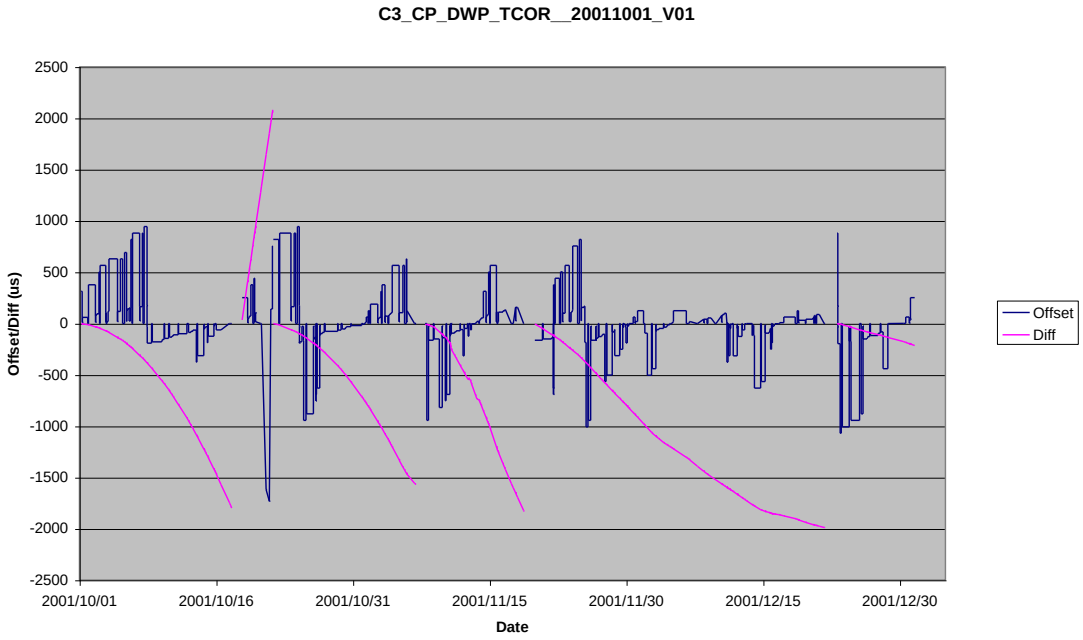


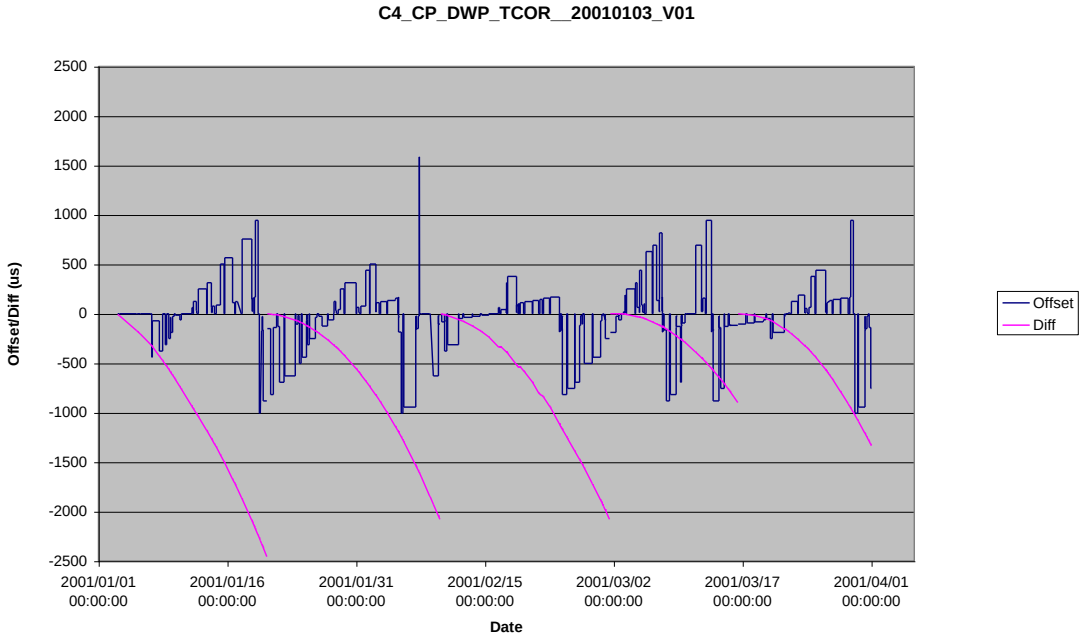
C3_CP_DWP_TCOR__20010401_V01



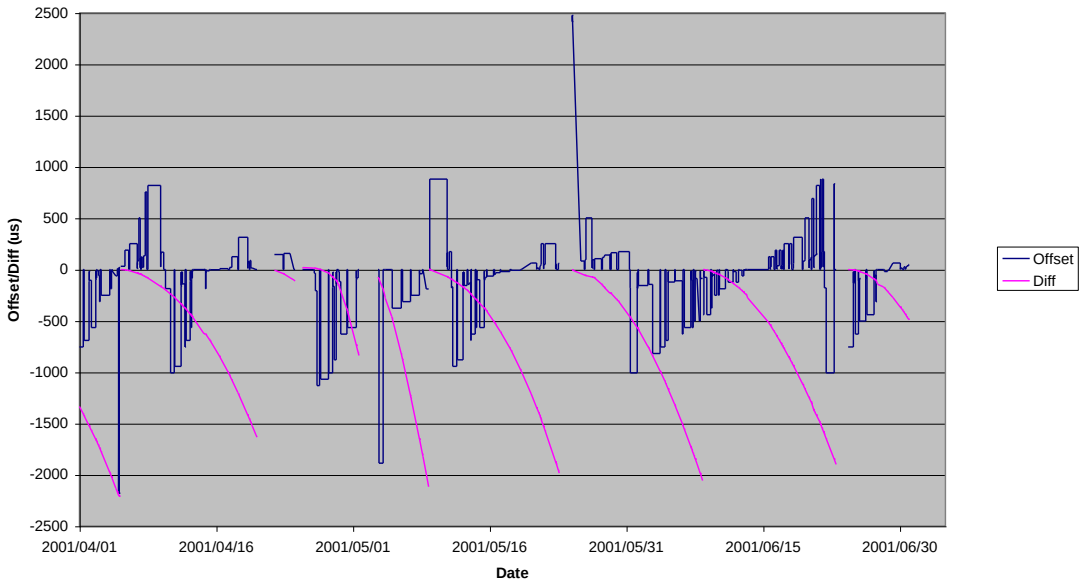
C3_CP_DWP_TCOR__20010702_V01



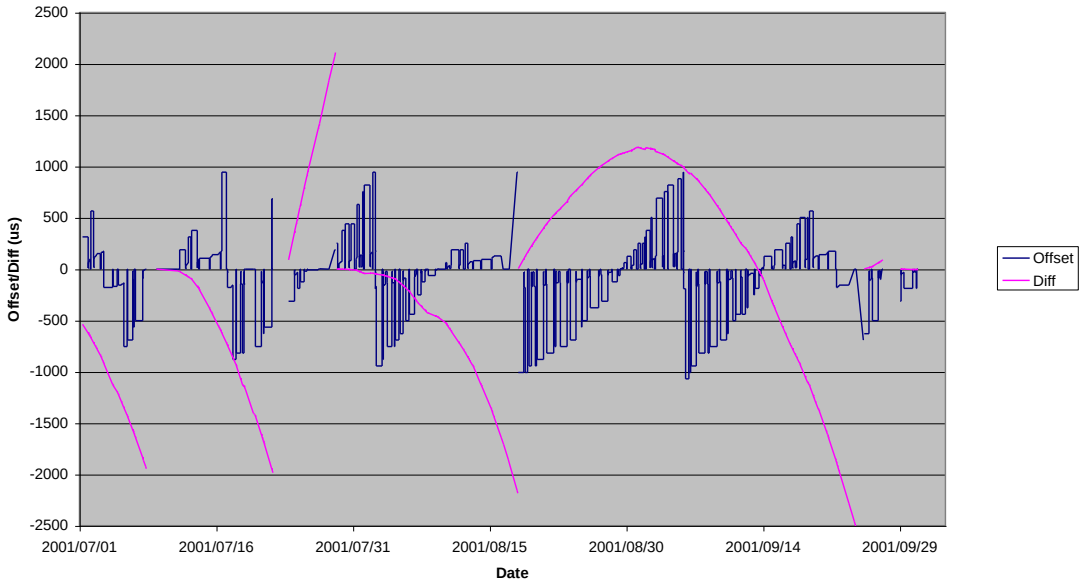

C3_CP_DWP_TCOR__20011001_V01
2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
Offset/Diff (us)
2001/10/01
2001/10/16
2001/10/31
2001/11/15
2001/11/30
2001/12/15
2001/12/30
Date
Offset
Diff

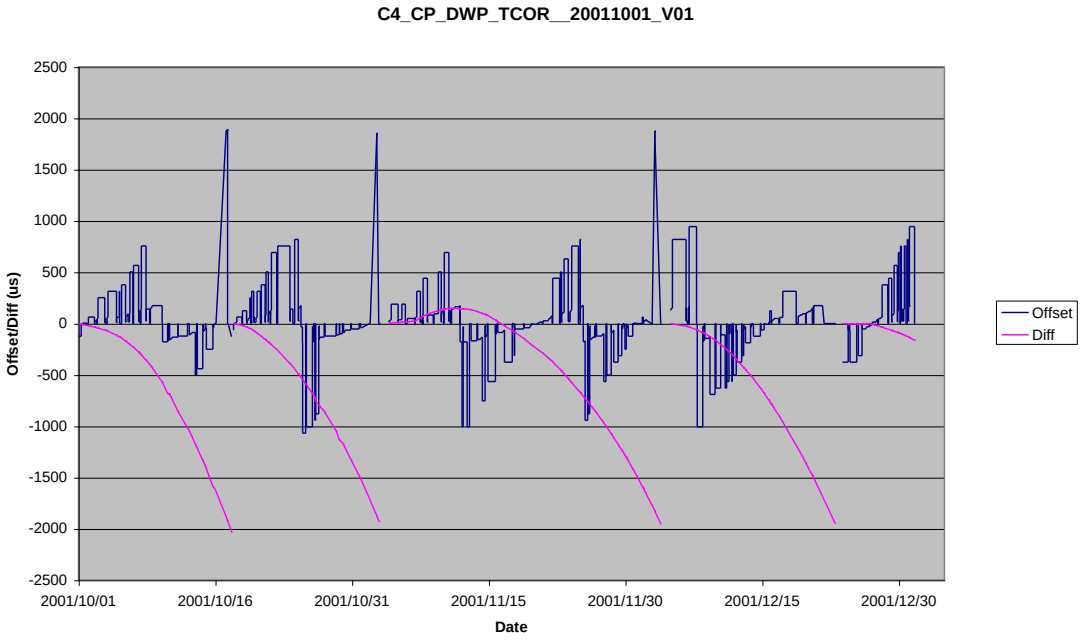

C4_CP_DWP_TCOR__20010103_V01
2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
Offset/Diff (us)
2001/01/01 00:00:00
2001/01/16 00:00:00
2001/01/31 00:00:00
2001/02/15 00:00:00
2001/03/02 00:00:00
2001/03/17 00:00:00
2001/04/01 00:00:00
Date
Offset
Diff

C4_CP_DWP_TCOR__20010401_V01



C4_CP_DWP_TCOR__20010701_V01




C4_CP_DWP_TCOR__20011001_V01
Offset/Diff (us)
2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
2001/10/01
2001/10/16
2001/10/31
2001/11/15
2001/11/30
2001/12/15
2001/12/30
Date
Offset
Diff

7 Caveats

The following general caveats apply to all year 2001 TCOR data:

Use with caution. If published results depend critically on timing accuracy it is recommended that the DWP team should re-verify the TCOR data in question.

TCOR data is not available at all times. In the version 1 files, any data that fails validation is simply deleted from the files. For 2001, TCOR coverage is typically around 80%.

The DIFF measurements received from ESOC for 2001 are unsigned, so the sign is determined by comparison with the WBD or TCAL DIFFs. During 2001, WBD data is quite sparse, so there are some periods when it is difficult to be sure that the sign has been determined correctly. However, this is always when the DIFF is small, so the error that would be introduced by an incorrect sign is also small (typically less than 50 μs). Usually DIFF is set to zero in such periods to minimise any possible error.

The 'duplicate frame' problem was present in the 2001 raw data. This is where duplicate telemetry frames (real time and playback), with time stamps differing by a few milliseconds, are sometimes present in the telemetry. In this case the TCOR corrections apply to the real time data only, and 'apptcor' will include only the real time data in the output file.

In the 2 days or so prior to a new time correlation, it is not certain whether the old or new time correlation applies to a particular period of data. Incorrect determination of which time correlation was used could result in an error of 2ms or more in the corrected time. In most cases data in error will have been removed during validation, but there is a small chance some may remain.

Interpolation between TCOR records is only permitted in limited circumstances. The time corrections are provided at the start and end times of each period of the same telemetry mode. The OFFSET is constant throughout each period, and the same value will be written in the records at the start and end of the period. If the OFFSET values before and after the required time are different, or either has the fill value of -1e31, then OFFSET is not available for that period. No interpolation of OFFSET is allowed. The DIFF may be obtained by linear interpolation of the DIFF values immediately before and after the required time. However, if either DIFF has the fill value of -1e31, then DIFF is not available for that period.