Concatenation of Hourly RINEX Files

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Abstract

A subset of the IGS stations submits hourly RINEX observation files additionally to the daily files to be used for near real time applications. These hourly files could be concatenated to a daily file and could replace it. In order to compare such concatenated files with the original daily files each data field has to be inspected according to the RINEX format definition. Differences have to be removed before any replacement could be performed.

Introduction

Since the beginning of the IGS in 1992 daily RINEX observation files are used to generate most of the final IGS products (IGS satellite orbits, Earth rotation parameters, ...). If the daily files are used, the observations are too late available at the analysis centers for the generation of "near real time" products, e.g., "ultra rapid orbits" and troposphere parameters. Therefore, currently a subset of the IGS stations submits hourly RINEX observation files additionally to the daily files. Each observation of such sites will be transmitted twice within the IGS data flow. If it is possible to concatenate successfully the hourly files to a daily one, the daily file transfer may be cancelled. Such a procedure would benefit from the more stable transfer of small data files and from the availability of the daily files immediately after the completeness of the 24 files of a day at the data centers. However, it has to be demonstrated that the "original" daily files and the concatenated hourly files include exactly the same observations and site information.

Requirements to Hourly Files

The daily RINEX files may be replaced by the concatenated hourly files if those fulfill the following requirements:

- All 24 hourly files have to be available at the data center.
- The information of the file header have to be identical to that of the original daily file.
- The observations have to be logged continuously and must not produce jumps at the one hour boundaries.
- The phase observations of each hourly file must not be reduced to small numerical numbers (as some RINEX conversion programs did in the past).
- All digits of the numerical data fields have to be identical to that of the original daily file in order to guarantee the same results from the analysis of the two different file types.

A comparison between the daily and the concatenated hourly files for a limited period of time may show the achievement of all the requirements.

Comparison between Daily and Concatenated Hourly Files

In order to remove computer specific differences between the two files the full ASCII RINEX files have to be reconstructed from the "Compact RINEX" format and from the compressed files (assuming *D.Z files in the data base). A character by character comparison as performed by some commands of the computer operating systems (e.g., the Unix command "diff") may not be used, because some differences are unavoidable, e.g., different file creation dates or acceptable, e.g., a blank string is used instead of a leading zero. We have to read each RINEX file following the format definition and may then compare the content of each data field. The Federal Agency for Cartography and Geodesy (BKG) uses the program "RNXDIFF" for such a comparison.

The Program RNXDIFF

The program RNXDIFF makes use of subroutines of the Bernese GPS Software to read the content of each data field and successively compares the fields of the daily files with that of the concatenated hourly files. For each field a so called "error code" is defined which is set to "1" in the case of an acceptable difference and to "9" in the case of an unacceptable difference. The error codes remain "0" if no differences are detected. The sum of the error codes of all data fields is called "quality code" of the file and is given in the daily summary files of RNXDIFF and in a plot file as station specific time series, too.

Table 1 shows the RNXDIFF summary file of the station WTZR for the day of year 155, 2000. The head of this file includes a list of the data fields that are compared and the definition of the corresponding error codes 1 or 9. In the comparison shown in Table 1 there were differences in two types of data fields detected, namely the "signal noise ratio" and the "epoch" fields. Different signal noise ratios were detected in 11 observations. Because this type of data field has the error code 1 the quality code for the file has been increased by 1. The last epoch was missing in one of the files compared. One missing epoch may be accepted and we defined the error code as 1 for this case. However, if more that one different epochs would be detected the corresponding error code will be set to 9. In the summary

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file of Table 1 the quality code was increased by 1 because of the different epoch that was detected. After taking into account all types of data fields the quality code results to 2 as given in the last line of the summary file and also indicated in the file name WTZR155**2**.00S. Following the definitions of the quality code we may conclude that the concatenated hourly files may replace the daily files, if the quality code is smaller than 9.

Figure 1 shows all quality codes of the station WTZR as computed from RNXDIFF for the period April, 12 to June 5, 2000. 94 % of the quality codes are smaller than 9 and

allow the interpretation that the hourly files of the station WTZR may be concatenated with such reliability.

Figure 2 shows the reliability of all stations that submit hourly data files to BKG. It is given in percentage according to Figure 1. Only 4 stations (KIR0, MAR6, VIL0, and VIS0) reach 100 % reliability, but it has to be taken into account that these stations have submitted hourly files since 3 days only. A detailed study of the data flow of each station has to be performed in order to improve the reliability of the concatenation. The transfer of the daily files may be cancelled on condition that the reliability of the concatenation of the hourly files amount to 100%.

Table 1: RNXDIFF Summary File WTZR1552.00S

```
RNXDIFF  V1.0.1 UX                              04-JUN- 0 19:48

 COMPARSION OF 2 RINEX OBSERVATION FILES
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 IGS DATA CENTER
 BKG, FRANKFURT

 RINEX FILE 1 : WTZR1550.00O
 RINEX FILE 2 : WTZR155C.00O

 CHECKED FOR:

    RINEX FORMAT VERSION            |9| RINEXVER  |
    SATELLITE SYSTEM TYPE           |9| SATSYS    |
    SITE NAME                       |9| SITENAME  |
    SITE NUMBER                     |9| STANUMBER |
    OBSERVER                        |1| OBSERVER  |
    AGENCY                          |1| AGENCY    |
    RECEIVER NUMBER                 |9| RECUNIT   |
    RECEIVER TYPE                   |9| RECTYPE   |
    RECEIVER FIRMWARE               |9| RECVERS   |
    ANTENNA NUMBER                  |9| ANTNUMBER |
    ANTENNA TYPE                    |9| ANTTYPE   |
    ANTENNA ECCENTRICITY            |9| ANTECCENT |
    NUMBER OF OBSERVATION TYPES     |9| NUMOBSTYP |
    OBSERVATION EPOCHS              |9| EPOCH     |
    NUMBER OF SATELLITES IN EPOCHS  |9| NUMSATEPO |
    OBSERVATIONS                    |9| OBSEPO    |
    SIGNAL NOISE RATIO              |1| SIGNAL    |
    LOSS OF LOCK INDICATOR          |1| LLI       |

 SIGNAL     : ( 0:47:30.000) SIGNAL NOISE RATIO
 SIGNAL     : ( 1:40:  .000) SIGNAL NOISE RATIO
 SIGNAL     : ( 5:24:  .000) SIGNAL NOISE RATIO
 SIGNAL     : ( 5:46:  .000) SIGNAL NOISE RATIO
 SIGNAL     : (12:31:30.000) SIGNAL NOISE RATIO
 SIGNAL     : (13:45:  .000) SIGNAL NOISE RATIO
 SIGNAL     : (17:44:  .000) SIGNAL NOISE RATIO
 SIGNAL     : (22: 4:30.000) SIGNAL NOISE RATIO
 SIGNAL     : (22:57:30.000) SIGNAL NOISE RATIO
 SIGNAL     : (23:37:30.000) SIGNAL NOISE RATIO
 SIGNAL     : (23:50:  .000) SIGNAL NOISE RATIO
 EPOCH      : (23:59:30.000) DIFFERENT EPOCH

 SUMMARY:
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 EPOCHS FILE 1:  2880
 EPOCHS FILE 2:  2879

 COMPARISON QUALITY CODE:
 (0=NO DIFFERENCE, 1-8=NEGLIGIBLE DIFFERENCE, 9=FATAL DIFFERENCE)
 2
```
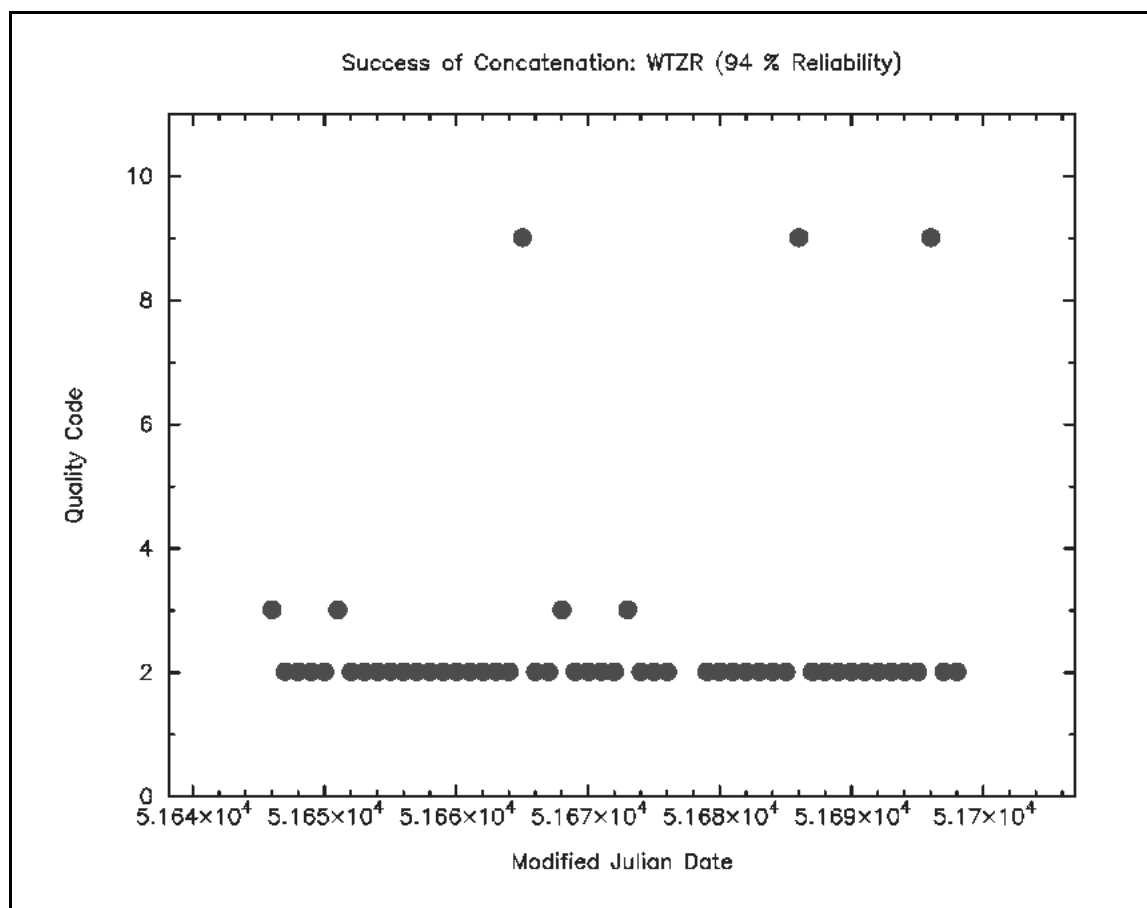
Figure 1: RNXDIFF Quality Code for Station WTZR

The occurrence of differences separated for each type of the data fields is given in *Figure 3*. It shows the number of files which were detected to have a difference in the specified data field as the percentage of the total number of files for the period April, 12 to June 5, 2000. In 77 % of the files a difference in the observation epoch was detected. It has to be mentioned that most of the messages were caused by a detected difference in exactly one epoch of the file, e.g., the last epoch in the hourly file of the station WTZR is "23:59:00", but it is "23:59:30" in the daily file. The next most frequent differences are the "loss of lock indicator (LLI)" and the "signal to noise ratio" data fields. *Table 2* shows an example for such type of difference. The GPS satellites SVN numbers 29 and 30 came up as new satellites in the epoch given in Table 2. Whereas the original daily RINEX files shows a LLI and signal to noise ratio of "1", this data fields are left blank in the concatenated file. The difference seems to be caused by the RINEX con-catenation program and will probably not affect the analysis results. It has to be discussed whether such differences may be accepted. In this case the percentage of files showing differences in Figure 3 would be much smaller.

Conclusion

The comparison of daily and concatenated hourly files has been demonstrated by usage of the program RNXDIFF. We found differences for most of the stations, but the most frequently differences do not affect the analysis results. Remaining differences have to be removed before the concatenated files could replace the daily ones.

References

GURTNER W. (1997): *RINEX, The Receiver Independent Exchange Format Version 2, updated revision*, Astro-nomical Institute University of Berne.

Figure 2: Reliability of Concatenation of all Stations

Figure 3: Error Frequency from RNXDIFF

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┌──────────────────────────────────────────────────────────────────────────┐
│                           Original Daily File                              │
├──────────────────────────────────────────────────────────────────────────┤
│                                                                            │
│     2              OBSERVATION DATA    G (GPS)           RINEX VERSION / TYPE │
│ GPS-DATA Ver 1.08                                        PGM / RUN BY / DATE │
│ ...                                                                        │
│ 00  6  5  0 56 30.0000000  0  9G02G05G07G09G21G23G26G29G30                 │
│  24491272.72805  24491277.60405   3793908.16505   3076292.75805    -3255.001 │
│     -2536.366                                                               │
│  22114544.74508  22114550.23108 -14814452.13708 -11359188.94708    2318.174 │
│     1806.366                                                                │
│  22380138.83008  22380144.08108 -10412707.03808  -7965747.02408    -858.687 │
│     -669.107                                                                │
│  20408297.14309  20408301.43309 -20430454.88709 -14777553.80709     214.022 │
│      166.771                                                                │
│  24189931.96305  24189938.55105  -5718742.24405  -4321438.60005     303.064 │
│      236.145                                                                │
│  23466415.78105  23466422.12306  -7157669.21606  -5420564.84006    -1972.672 │
│     -1537.149                                                               │
│  21990865.10009  21990870.04709  -5776160.90809  -4352051.79909    -3197.496 │
│     -2491.555                                                               │
│  24914892.41505          .00001  -51341.91501          .00011     3019.125 │
│         .000                                                                │
│  25477673.83404          .00001  -54512.57701          .00011     3206.270 │
│         .000                                                                │
│                                                                            │
├──────────────────────────────────────────────────────────────────────────┤
│                        Concatenated Hourly Files                           │
├──────────────────────────────────────────────────────────────────────────┤
│                                                                            │
│     2              OBSERVATION DATA    G (GPS)           RINEX VERSION / TYPE │
│ CCRINEXO V2.2.2 UX  BKG, Frankfurt/M.   06-JUN- 0 03:25  PGM / RUN BY / DATE │
│ Concatenate RINEX hourly files                          COMMENT            │
│ CCRINEXO V2.3.0 UX  LPT               05-JUN-00 03:04   COMMENT            │
│                                                          COMMENT            │
│ GPS-DATA VER 1.08                                        COMMENT            │
│ ...                                                                        │
│ -2482.766                                                                  │
│   0  6  5  0 56 30.0000000  0  9 02 05 07 09 21 23 26 29 30                │
│  24491272.728 5  24491277.604 5   3793908.165 5   3076292.758 5    -3255.001 │
│     -2536.366                                                               │
│  22114544.745 8  22114550.231 8 -14814452.137 8 -11359188.947 8    2318.174 │
│      1806.366                                                               │
│  22380138.830 8  22380144.081 8 -10412707.038 8  -7965747.024 8    -858.687 │
│      -669.107                                                               │
│  20408297.143 9  20408301.433 9 -20430454.887 9 -14777553.807 9     214.022 │
│       166.771                                                               │
│  24189931.963 5  24189938.551 5  -5718742.244 5  -4321438.600 5     303.064 │
│       236.145                                                               │
│  23466415.781 5  23466422.123 6  -7157669.216 6  -5420564.840 6    -1972.672 │
│      -1537.149                                                              │
│  21990865.100 9  21990870.047 9  -5776160.908 9  -4352051.799 9    -3197.496 │
│      -2491.555                                                              │
│  24914892.415 5                   -51341.915 1                     3019.125 │
│                                                                            │
│  25477673.834 4                   -54512.577 1                     3206.270 │
│                                                                            │
└──────────────────────────────────────────────────────────────────────────┘
```
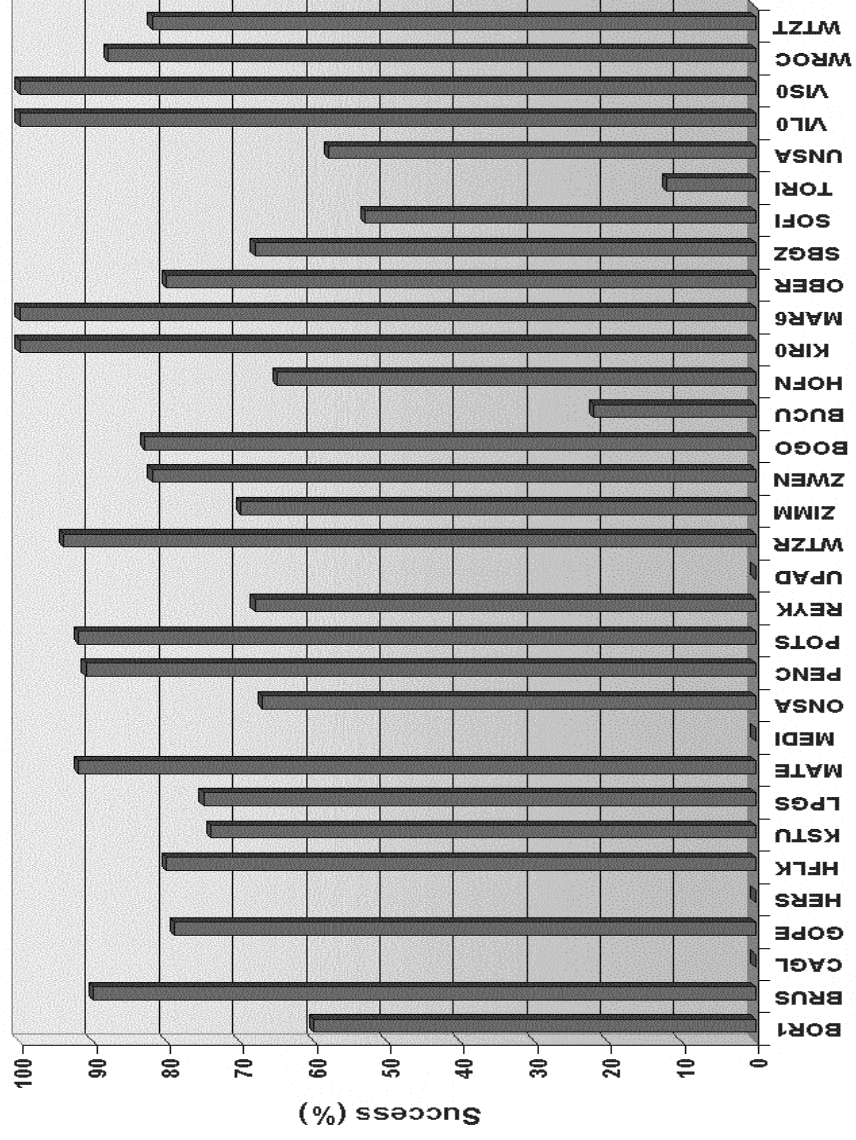
Table 2: Detected Difference for Station ZIMM

Reliability of Concatenation (April 12 - Juni 5, 2000)

Total Number of Files: 1280
Total Number of Errors: 2626

Files with Error (%)

80　70　60　50　40　30　20　10　0

EPOCH
LLI
SIGNAL
OPSEPO
STENAME
ANTNUMBER
RECCUNT
STANUMBER
OBSERVER
AGENCY
RECTYPE
ANTTYPE
NUMOBSTYP
ANTECCENT
RECVERS
RINEXVER
SATSYS
NUMSATEPO

Field Type