GTEX

The **G**NSS-**T**EC **EX**change Format

Version 1.0

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1. REVISION HISTORY

01 Apr 2015 - Creation of the document

2. INTRODUCTION

The purpose of the GTEX (GNSS-TEC Exchange Format) is to share slant TEC data from each GNSS receiver. By sharing slant TEC data which are not converted to the map data of vertical TEC, various ionospheric studies would be possible without affected by specific analysis procedures such as satellite/receiver bias estimation or different mapping heights.

The structure of GTEX is designed in such a way that the structure is as close to RINEX 2 [1] as possible, because RINEX 2 is a *de facto* standard in exchanging GNSS observation data and potential users of GTEX would be familiar with RINEX 2. GTEX may include more data relevant to TEC analysis in the later revisions. The format is designed to allow future extension.

3. GENERAL FORMAT DESCRIPTION

The GTEX version 1.0 format consists of a single ASCII file containing necessary information for ionospheric studies. The file is composed of two sections, a header section and a TEC data section.

The header section contains global information for the entire file and is placed at the beginning of the file. The header section contains header labels in columns 61-80 for each line. These labels are mandatory and must appear exactly as given in these descriptions and examples. All the items defined in RINEX 2 can be used in GTEX as well. There are some additional header items, such as “POSITION LON LAT ALT”, “ # / TYPES OF DATA”, “RINEX FILE NAME” and so on.

The TEC data section starts from a line with a time stamp and list of satellites with the same format as “EPOCH/SAT” field of RINEX 2. Following the EPOCH/SAT field, TEC data as defined in “# / TYPES OF OBSERV” are recorded. After the record of TEC data for all the satellites, data set of the next epoch follows.

The format has been developed to mimic the RINEX 2 in order to maintain as much compatibility as possible. In computer systems allowing variable record lengths the observation records may be kept as short as possible. Trailing blanks can be removed from the records. There is no maximum record length limitation for the observation records.

The actual format descriptions as well as examples are given in Appendix at the end of the paper.

4. THE EXCHANGE OF GTEX FILES

It is recommended the following naming convention:

ssssddd0.yy_TEC

```
|  |   |
|  |   |
|  |   |
|  |   +----  yy:  two-digit year
|  +---------  ddd:day of the year of first record
+------------- ssss:        the four-character marker name
```

5. GTEX VERSION 1.0 FEATURES

The data for the TEC parameters will follow the RINEX 2 channel allocation, but tailored to the needs of the ionospheric community.

A. Main data

The main data is raw slant TEC including bias ("R1") or absolute slant TEC ("A1"). Observation data which is used for the derivation of "R1" or "A1" is shown as "1O". If the main data is "A1", the information of bias-estimation program is recommended to be shown in the header section.

B. System identifier

For including TEC data which is derived from other satellite systems than GPS, such as GLONASS, the different satellite systems must be distinguished by using the 2-digit satellite number following a system identifier.

satellite system identifier

G or blank :	GPS
R :	GLONASS
S :	Geostationary signal payload
E :	Galileo

2-digit satellite number

PRN (GPS, Galileo)
slot number (GLONASS)
PRN-100 (GEO)

6. REFERENCES

[1] Werner Gurtner and Lou Estey "RINEX/ The RInex Independent Exchange Format, version 3.11"

7. APPENDIX:

A1. GTEX Format Definitions

TABLE A1
GTEX FILE - HEADER SECTION DESCRIPTION

HEADER LABEL (Columns61-80)	DESCRIPTION	FORMAT	
GTEX VERSION / TYPE	- Format version : 1.00 - File type: GTEX DATA	F9.2,11X, A1,19X, 20X	
PGM/ RUN BY	- Name of program creating current file - Name of agency creating current file	A20, A20, X20	
EXPONENT OF TECU	Exponent of TECU	I6,A54	*
BIAS ESTIMATION PGM	Program name for bias estimation	A60	**
COMMENT	Comment line(s)	A60	*
MARKER NAME	Name of antenna marker	A60	
REC # / TYPE / VERS	Receiver number, type, and version	3A20	*
ANT # / TYPE / VERS	Antenna number and type	3A20	*
APPROX POSITION XYZ	Geocentric approximate marker position (Units: Meters, System: ITRS recommended)	3F14.4	*
POSITION LON LAT ALT	Ellipsoidal approximate marker position (Units, degrees and meters, System: WGS84 recommended)	2F14.8, F14.4	
# / TYPES OF OBS	- Number of different observation types stored in the original RINEX file	3X,A2	
	- Observation types -Observation code -Frequency code	11(3X, A1, A1)	
	The following observation types are defined in RINEX Version 2.11: Observation code (use upper case only): C: Pseudorange GPS: C/A, L2C Glonass: C/A Galileo: All P: Pseudorange GPS and Glonass: P code L: Carrier phase D: Doppler frequency S: Raw signal strengths or SNR values as given by the receiver for the respective phase observations		
	Frequency code GPS Glonass Galileo SBAS 1: L1 G1 E2-L1-E1 L1 2: L2 G2 -- -- 5: L5 -- E5a L5 6: -- -- E6 -- 7: -- -- E5b -- 8: -- -- E5a+b --		

# / TYPES OF DATA	- Number of different data types stored in the file - Data types The following data descriptors are defined in GTEX Version 1.0: R1: raw slant TEC including bias A1: Absolute slant TEC 1F: TEC status flag 1O: Observation data used for TEC ZN: satellite zenith angle AZ: Satellite azimuth angle R1 or A1 is necessary. The sequence of the observations in the observation records has to correspond to the sequence of the types in this record of the respective satellite system.	3X,A2 11(3X,A2)
INTERVAL	Observation interval in seconds	F10.3
TIME OF FIRST OBS	- Time of first observation record (4-digit- year, month, day, hour, min sec) Time system: - GPS (=GPS time system) - GLO (=UTC time system) - GAL (=Galileo System Time) - QZS (= QZSS time system) - BDT (=BDS Time system) Compulsory in mixed GNSS files Defaults: GPS for pure GPS files GLO for pure GLONASS files GAL for pure Galileo files QZS for pure QZSS files BDT for pure BDS files	5I6,F13.7, 5X,A3
TIME OF LAST OBS *	- Time of first observation record (4-digit- year, month, day, hour, min sec) -Time system: Same value as TIME OF FIRST OBS record	5I6,F13.7, 5X,A3
END OF HEADER	Last record in the header section	60X

Records marked with * are optional.
A record marked with ** is optional if the main data is “R1”.
All the items defined in RINEX 2 can be also used in GTEX.

TABLE A2
GTEX FILE - HEADER SECTION DESCRIPTION

OBS. RECORD	DESCRIPTION	FORMAT
EPOCH/SAT	- Epoch	
	- year	1X,I2.2,
	- month, day, hour, min	4(1X,I2)
	- sec	F11.7
	- Epoch flag 0: OK	2X,I1,
	1: power failure between previous and current epoch	
	>1: Event flag	
	- Number of satellites in current epoch	I3,
	- List of PRNs (sat. numbers with system identifier, defined in section IV) in current epoch.	12(A1,I2),
	If more than 12 satellites: Use continuation lines	32X 12(A1,I2)
TEC data	- Observation Repeated within record for each data type (same sequence as given in header) This record is repeated for each satellite given in EPOCH/SAT- record	
	TEC status flag 0: normal data 1: Lack of observation (TEC=999.) 2: Too large TEC (TEC=999.) 4: Cycle Slip (TEC discontinuity) 5: Cycle slip (LLI) 6: Beginning of arc	
	Units of observables R1: TECU A1: TECU ZN: degrees AZ: degree, clockwise from north	

A2. Example of GTEX file ver 1.0 with a main data of "R1"

```
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
    1.0           GTEX DATA          GNSS                 GTEX VERSION / TYPE
RNX2GTEX V1.1.3    NICT, JAPAN                            PGM / RUN BY
    16                                                    EXPONENT OF TECU
     TEC values in 10^16 el/m^2 (1 TEC Unit)              COMMENT
     Types of data   = R1 : Raw slant TEC including bias  COMMENT
                       A1 : Absolute slant TEC            COMMENT
                            R1 or A1 is necessary         COMMENT
                       1F : TEC status flag               COMMENT
                       1O : Observation data used for TEC COMMENT
                       ZN : Satellite zenith angle        COMMENT
                       AZ : Satellite azimuth angle       COMMENT
     TEC status flag  = 0 : Normal data                   COMMENT
                        1 : Lack of observables (TEC=999.)COMMENT
                        2 : Too large TEC (TEC=999.)      COMMENT
                        4 : Cycle slip (TEC discontinuity)COMMENT
                        5 : Cycle slip (LLI)              COMMENT
                        6 : Beginning of arc              COMMENT
                                                          BIAS ESTIMATION PGM
01321310.12o  01321320.12o  01321330.12o                  RINEX FILE NAME
0132                                                      MARKER NAME
00000               TPS NETG3           3.4 EG3 Jul,02,2010 REC # / TYPE / VERS
                    TRM29659.00     GSI                   ANT # / TYPE
 -3690821.3891  2897721.3097  4305504.4426                APPROX POSITION XYZ
       42.7294      141.8640        0.0486                POSITION LAT LON ALT
     6    L1    C1    L2    P2    S1    S2                # / TYPES OF OBSERV
     5    R1    1F    1O    ZN    AZ                      # / TYPES OF DATA
    30.0000                                               INTERVAL
  2012     5    11     0     0    0.0000000     GPS       TIME OF FIRST OBS
                                                          END OF HEADER
 12  5 11  0  0  0.0000000  0  9G21G 9G18G15G28G 5G27G 8G26
 -61.7242  0  L1L2C1P2  35.83  119.68
 -33.4733  0  L1L2C1P2  68.20   75.21
 -49.7988  0  L1L2C1P2  82.81  161.85
 -55.8391  0  L1L2C1P2  69.68  293.96
 -43.6837  0  L1L2C1P2  62.79   48.64
 -38.7060  0  L1L2C1P2  34.70   49.99
 -44.8228  0  L1L2C1P2  38.39  125.89
 -31.3004  0  L1L2C1P2  72.63  312.53
 -48.7940  0  L1L2C1P2  47.29  138.96
 12  5 11  0  0 30.0000000  0  9G21G 9G18G15G28G 5G27G 8G26
 -61.6869  0  L1L2C1P2  35.72  119.30
 -33.6267  0  L1L2C1P2  68.15   74.99
 -49.8773  0  L1L2C1P2  82.63  161.75
 -55.8704  0  L1L2C1P2  69.69  293.74
 -43.7446  0  L1L2C1P2  62.99   48.64
 -38.6187  0  L1L2C1P2  34.90   50.23
 -44.7950  0  L1L2C1P2  38.24  125.56
 -31.1374  0  L1L2C1P2  72.55  312.35
 -48.7579  0  L1L2C1P2  47.09  138.75
```

A3. Example of GTEX file ver 1.0 with a main data of "A1"

```
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|
    1.0           GTEX DATA          GNSS                 GTEX VERSION / TYPE
RNX2GTEX V1.1.3    NICT, JAPAN                            PGM / RUN BY
    16                                                    EXPONENT OF TECU
     TEC values in 10^16 el/m^2 (1 TEC Unit)              COMMENT
     Types of data   = R1 : Raw slant TEC including bias  COMMENT
                       A1 : Absolute slant TEC            COMMENT
                            R1 or A1 is necessary         COMMENT
                       1F : TEC status flag               COMMENT
                       1O : Observation data used for TEC COMMENT
                       ZN : Satellite zenith angle        COMMENT
                       AZ : Satellite azimuth angle       COMMENT
     TEC status flag  = 0 : Normal data                   COMMENT
                        1 : Lack of observables (TEC=999.) COMMENT
                        2 : Too large TEC (TEC=999.)      COMMENT
                        4 : Cycle slip (TEC discontinuity) COMMENT
                        5 : Cycle slip (LLI)              COMMENT
                        6 : Beginning of arc              COMMENT
                                                          BIAS ESTIMATION PGM
01321310.12o  01321320.12o  01321330.12o                  RINEX FILE NAME
0132                                                      MARKER NAME
00000               TPS NETG3           3.4 EG3 Jul,02,2010 REC # / TYPE / VERS
                    TRM29659.00     GSI                   ANT # / TYPE
 -3690821.3891  2897721.3097  4305504.4426                APPROX POSITION XYZ
       42.7294      141.8640        0.0486                POSITION LAT LON ALT
     6    L1    C1    L2    P2    S1    S2                # / TYPES OF OBSERV
     5    A1    1F    1O    ZN    AZ                      # / TYPES OF DATA
    30.0000                                               INTERVAL
  2012     5    11     0     0    0.0000000     GPS       TIME OF FIRST OBS
                                                          END OF HEADER
 12  5 11  0  0  0.0000000  0  9G21G 9G18G15G28G 5G27G 8G26
  28.4668  0  L1L2C1P2  35.83  119.68
  29.6417  0  L1L2C1P2  68.20   75.21
  33.5112  0  L1L2C1P2  82.81  161.85
  21.7009  0  L1L2C1P2  69.68  293.96
  28.2723  0  L1L2C1P2  62.79   48.64
  33.2430  0  L1L2C1P2  34.70   49.99
  27.8022  0  L1L2C1P2  38.39  125.89
  38.0416  0  L1L2C1P2  72.63  312.53
  25.0200  0  L1L2C1P2  47.29  138.96
12  5 11  0  0 30.0000000  0  9G21G 9G18G15G28G 5G27G 8G26
  28.5041  0  L1L2C1P2  35.72  119.30
  39.4883  0  L1L2C1P2  68.15   74.99
  33.4327  0  L1L2C1P2  82.63  161.75
  21.6696  0  L1L2C1P2  69.69  293.74
```