**GTEX**

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

Version 0.1

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# REVISION HISTORY

|  |  |
| --- | --- |
| 01 Apr 2015 | - Creation of the document |
|  |  |

# 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.

# 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.

# 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

# 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)

# REFERENCES

1. Werner Gurtner and Lou Estey “RINEX/ The RInex Independent Exchange Format, version 3.11”

# APPENDIX:

1. **GTEX Format Definitions**

+----------------------------------------------------------------------------+

| TABLE A1 |

| GTEX FILE - HEADER SECTION DESCRIPTION |

+--------------------+------------------------------------------+------------+

| HEADER LABEL | DESCRIPTION | FORMAT |

| (Columns61-80) | | |

+--------------------+------------------------------------------+------------+

|GTEX VERSION / TYPE | - Format version : 1.00 | F9.2,11X, |

| | - File type: GTEX DATA | A1,19X, |

| | | 20X |

+--------------------+------------------------------------------+------------+

|PGM/ RUN BY | - Name of program creating current file | A20, |

| | - Name of agency creating current file | 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 | 3F14.4 |\*

| | (Units: Meters, System: ITRS recommended)| |

+--------------------+------------------------------------------+------------+

|POSITION LON LAT ALT| Ellipsoidal approximate marker position | 2F14.8, |

| | (Units, degrees and meters, System: | F14.4 |

| | WGS84 recommended) | |

+--------------------+------------------------------------------+------------+

| # / TYPES OF OBS | - Number of different observation types | 3X,A2 |

| | stored in the original RINEX file | |

| | - Observation types | 11(3X, | | | -Observation code | A1, |

| | -Frequency code | 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 | 3X,A2 |

| | stored in the file | |

| | - Data types | 11(3X,A2) |

| | | |

| | 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. | |

+--------------------+------------------------------------------+------------+

|INTERVAL | Observation interval in seconds | F10.3 |

+--------------------+------------------------------------------+------------+

|TIME OF FIRST OBS | - Time of first observation record | 5I6,F13.7, |

| | (4-digit- year, month, day, hour, min | |

| | sec) | |

| | Time system: | |

| | - GPS (=GPS time system) | 5X,A3 |

| | - 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 | |

+--------------------+------------------------------------------+------------+

|TIME OF LAST OBS | - Time of first observation record | 5I6,F13.7, |\*

| | (4-digit- year, month, day, hour, min | |

| | sec) | |

| | -Time system: Same value as TIME OF | 5X,A3 |

| | FIRST OBS record | |

+--------------------+------------------------------------------+------------+

|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 | 12(A1,I2), |

| | identifier, defined in section IV) | |

| | in current epoch. | |

| | | |

| | If more than 12 satellites: | 32X |

| | Use continuation lines | 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 | |

| | | |

+----------------------------------------------------------------------------+

1. **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

1. **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