



International Civil Aviation Organization

THE FIFTH MEETING OF IONOSPHERIC STUDIES TASK FORCE (ISTF/5)

Okinawa, Japan, 16 – 18 February, 2015

Agenda Item 4b: Task 2 – Iono Analysis

AATR ANALYSIS TOOLS AND CURRENT STATUS OF ANALYSIS OF ISTF DATA

(Presented by Japan)

SUMMARY

This paper introduces AATR (Along-arc TEC rate) analysis tools developed for ISTF data analysis. This paper also presents the current status of AATR analysis of ISTF data.

1. Introduction

1.1 AATR (Along-arc TEC rate) is the temporal variations in slant TEC (total electron content) inversely weighted by the ionospheric mapping factor.

1.2 The 1st ISTF meeting (IST/4) decided to use AATR as a parameter to pick up ionospheric disturbance events.

1.3 AATR can be derived from data in RINEX, GTEX, or GAGAN-TEC (ASCII records of GISTM receiver) among the data contributed to ISTF.

1.4 ENRI developed tools to convert those data into AATR.

1.5 This paper introduces AATR analysis tools developed for ISTF data analysis and reports on the current status of AATR analysis of ISTF data.

2. AATR Analysis Tools

2.1 A converter from RINEX data to AATR (rinex2aatr) is available as a set of source codes written in the C language. Standard C compilers (such as gcc, or visual C) can build executable binary from the source code. It was confirmed to work on platforms of Windows 7 with Visual C or gcc, Linux with gcc, and Mac OSX with gcc. The source code is open and will be placed on the ISTF server for sharing. How to build and use the software is given in the **Attachment 1**.

2.2 A converter from GAGAN-TEC data to AATR (ismra2aatr) is also available as a set of source codes written in the C language. Standard C compilers (such as gcc, or visual C) can build executable binary from the source code. It was confirmed to work on platforms of Microsoft Windows 7 with Visual C or gcc, Linux with gcc, and Mac OSX with gcc. The source code is open and will be placed on the ISTF server for sharing. How to build and use the software is provided in the **Attachment 2**.

2.3 A converter from GTEX data to AATR is under development. It is being written also in C language and will work on Windows, Linux, and Mac OSX with standard C compilers. Once the GTEX format is finalized, the tool will soon be available.

3. Status of AATR Analysis of ISTF data

3.1 Table 1 summarizes the data stored on the ISTF data server and their analysis status.

Table 1. Data stored on the ISTF data server and their analysis status.

Contribution by	Data Period	Data Format	Analysis Status
India	Mar., Jun., Sep., Dec., 2004 Mar., Jun., Sep., Dec., 2008 Mar., Jun., Sep., Dec., 2012	GAGAN-TEC	AATR generation being done by India
Hong Kong	Land Department; Oct. 2000 – Dec. 2009 01 Oct 2012 HKIA: Jul. 2010 – Aug. 2013	NovAtel Binary RINEX RINEX	Being converted to RINEX - AATR generation in progress
Philippines	20081011 20100405 20100803 20100804 20110528 20110605 20110805 20110806 20110926 20111024 20111025 20120309 20120312 20120315 20120424 20120616 20120709 20120715 20120716 20121001 20121008 20121009 20130317 20130601	GTEX0.1	GTEX to AATR conversion tool under development

	20130629 20131002		
Singapore	13-27 Mar. 2013 01 Jun. 2013 02 Oct. 2013 16-30 Sep. 2013 22-29 Oct. 2014	RINEX	AATR being generated
Thailand	VTBS: 2011-2013 VTCC: 2012-2013 VTPP: 2013 VTSB: 2009-2013 VTSS: 2010-2013	NovAtel Binary	Being converted to RINEX
APEC GIT	Jul. 2006 – Jan. 2007	APEC GIT specific binary	To be decoded by MATLAB program provided by APEC GIT

4. Action required by the Meeting

4.1 The meeting is invited to do the following:

- a) consider the AATR generation tool as a standard tool of ISTF;
- b) review the data and analysis status; and
- c) discuss any relevant matters as appropriate.

5. Attachment

- [1] How to build and use the tool to convert RINEX data into AATR (rinex2aatr)
- [2] How to build and use the tool to convert GAGAN-TEC data into AATR (ismra2aatr)

Attachment 1

How to build and use the tool to convert RINEX data into AATR (rinex2aatr) (Prepared by Susumu Saito)

1. General

“rinex2aatr” converts RINEX (OBS and NAV) data to raw AATR (Along-arc TEC rate).

2. List of files

The package includes following files.

== C sources ==

rinex2aatr.c (main program)

read_rinex.c (functions to read rinex data)

gps_orbit.c (some functions for coordinate conversion, time conversion, GPS orbit calculation, etc.)

matfunc.c (matrix calculation functions)

misc.c (miscellaneous functions)

== C headers ==

rinex_my.h

gps_orbit.h

gps_time.h

misc.h

matfunc.h

earth.h

== Build settings ==

Makefile

3. System requirement

Standard C compiler should be enough. (Test environment is gcc-4.2.1)

4. Build

4.1 Modify 'Makefile', if a C compiler other than gcc is used.

4.2 Create executable binary simply by the following command on a command terminal (For example “Command Prompt” on Windows):

```
make rinex2aatr
```

5. Data conversion

5.1 Usage can be displayed by executing rinex2aatr with '-h' option on a command terminal as

```
./rinex2aatr -h
```

to obtain

```
Usage: ./rinex2aatr <options>
```

```
Options:
```

```
-o <RINEX_OBS file> -- RINEX OBS file name
```

```
-n <RINEX_NAV file> -- RINEX NAV file name
```

```
-A <AATR output file> -- AATR NAV file name
```

```
-e <Elevation Mask> -- Elevation Mask (deg.)
```

```
-l <Latitude> -- Latitude (deg.)
```

```
-g <Longitude> -- Longitude (deg.)
```

```
-a <Altitude> -- Altitude (m)
```

```
-p <prn> -- PRN of satellite
```

5.2 The following command is an example to convert RINEX OBS data (201010011000_1100_rcv3.obs) and RINEX NAV data (201010011000_1100_rcv3.nav) with elevation mask of 10 degrees observed at 24.345°N, 124.159°E, and 57.94m. AATR is output to “201010011000_1100_rcv3.aatr”.

```
./rinex2aatr -o 201010011000_1100_rcv3.obs -n 201010011000_1600_rcv3.nav -A  
201010011000_1100_rcv3.aatr -e 10 -l 24.345 -g 124.159 -a 57.94
```

*** IMPORTANT ***

RINEX NAV file must contain ephemeris records in a chronological order.

5.3 Output is in column-based ASCII data with the format of

Hour Minute Second Satellite AATR RawSTEC Azimuth Elevation

The unit of AATR is meter/sec. The AATR value at the first epoch of tracking is set as -99.999. RawSTEC is the raw STEC values calculated from the L1 and L2 carrier-phase measurements, which are not leveled to the STEC derived from code measurements and not calibrated for inter-frequency biases.

Attachment 2

How to build and use the tool to convert GAGAN-TEC data into AATR (ismrb2aatr) (Prepared by Susumu Saito)

1. General

“ismra2aatr” converts GAGAN-TEC data (ASCII records of GISTM receiver) to raw AATR (Along-arc TEC rate).

2. List of files

The package includes following files.

== C sources ==

ismra2aatr.c (main program)

read_gsv4004b.c (functions for reading ISMRB and ISMRA records)

gps_orbit.c (some functions for coordinate conversion, time conversion, GPS orbit calculation, etc.)

matfunc.c (matrix calculation functions)

== C headers ==

common.h

gsv4004b.h

earth.h

== Build settings ==

Makefile

3. System requirement

Standard C compiler should be enough. (Test environment is gcc-4.2.1)

4. Build

4.1 Modify 'Makefile', if a C compiler other than gcc is used.

4.2 Create executable binary simply by the following command on a command terminal (For example “Command Prompt” on Windows):

```
make ismra2aatr
```

5. Data conversion

5.1 Typically, the following command on a command terminal

```
./ismra2aatr -f <input file> -o <output file> -e <elevation mask>
```

will convert ISMRA records in <input file> to AATR in <output file> with elevation mask of <elevation mask> degrees.

“-f <input file>” is always necessary. “-o <output file>” and “-e <elevation mask>” can be omitted. If they are omitted, default values ('output_aatr.dat' for <output file> and 0 for <elevation mask>) will be used.

5.2 Usage can be displayed by executing ismra2aatr with '-h' option as:

```
./ismra2aatr -h
```

5.3 Output is in column-based ASCII data with the format of

Hour Minute Second Satellite AATR RawSTEC Azimuth Elevation

The unit of AATR is meter/sec. The AATR value at the first epoch of tracking is set as -99.999. RawSTEC is the raw STEC values taken from the GAGAN-TEC data.
