GPS 응용

2025. 3.13.

설 윤 환

학습 목표

- ReadEPH 함수 사용
- ReadSP3 함수 사용
- 궤도 비교

GPS개론 Review

- Navigation RINEX

```
     3.04           NAVIGATION DATA     M                   RINEX VERSION / TYPE
BCEmerge            congo               20220307 004604 GMT PGM / RUN BY / DATE
Merged GPS/GLO/GAL/BDS/QZS/SBAS/IRNSS navigation file       COMMENT
based on CONGO and IGS tracking data                        COMMENT
DLR/GSOC: O. Montenbruck; P. Steigenberger                  COMMENT
GPSA   2.0489e-08  0.0000e+00 -1.1921e-07  5.9605e-08       IONOSPHERIC CORR
GPSB   1.2288e+05 -1.6384e+04 -2.6214e+05  6.5536e+04       IONOSPHERIC CORR
GAL    8.3750e+01 -1.4453e-01  8.0261e-03                   IONOSPHERIC CORR
BDSA   1.3039e-08 -5.2154e-08  0.0000e+00  2.9802e-07       IONOSPHERIC CORR
BDSB   1.3312e+05 -3.2768e+05  8.5197e+05 -3.9322e+05       IONOSPHERIC CORR
QZSA   1.8626e-08 -2.2352e-08 -2.9802e-07  0.0000e+00       IONOSPHERIC CORR
QZSB   1.2083e+05  6.5536e+04 -7.2090e+05 -4.0632e+06       IONOSPHERIC CORR
IRNA   5.2154e-08  3.7253e-07 -2.1458e-06 -7.5102e-06       IONOSPHERIC CORR
IRNB   1.6384e+05 -2.1299e+05 -2.2938e+06 -3.7356e+06       IONOSPHERIC CORR
BDUT -7.4505805969e-09 0.000000000e+00     14 2200          TIME SYSTEM CORR
GAGP  5.8498699218e-09-4.884981308e-15  86400 2200          TIME SYSTEM CORR
GAUT  0.0000000000e+00 0.000000000e+00      0 2200          TIME SYSTEM CORR
GLGP -4.7497451305e-08 0.000000000e+00  86400 2200          TIME SYSTEM CORR
GLUT -1.0244548321e-08 0.000000000e+00  86400 2200          TIME SYSTEM CORR
GPUT -1.8626451492e-09-3.552713679e-15 319488 2200          TIME SYSTEM CORR
IRGL  3.6292476580e-08-9.636735854e-14    288 2200          TIME SYSTEM CORR
IRGP  9.8953023553e-10-7.105427358e-15    288 2200          TIME SYSTEM CORR
IRUT -3.9872247726e-09 1.065814104e-14    288 2200          TIME SYSTEM CORR
QZUT -9.3132257462e-10 0.000000000e+00 266240 2200          TIME SYSTEM CORR
    18    18  1929     7                                    LEAP SECONDS
                                                            END OF HEADER
G01 2022 03 06 00 00 00 4.159510135651e-04-9.208633855451e-12 0.000000000000e+00
     3.900000000000e+01 2.940625000000e+01 3.861946579862e-09 1.666440698058e+00
     1.482665538788e-06 1.148802775424e-02 1.118332147598e-05 5.153673259735e+03
     0.000000000000e+00-3.091990947723e-07-2.285037688146e+00-3.539025783539e-08
     9.870782441823e-01 1.810937500000e+02 8.830811329481e-01-7.743536835105e-09
     2.471531520637e-10 1.000000000000e+00 2.200000000000e+03 0.000000000000e+00
     2.000000000000e+00 0.000000000000e+00 5R.122274160385e-09 3.900000000000e+01
    -7.182000000000e+03 4.000000000000e+00
```

https://server.gage.upc.edu/gLAB/HTML/MGEX_Navigation_Rinex_v3.04.html

- SP3

```
#cP2024  5  5  0  0  0.00000000     289   u+U IGb14 FIT  JPL
## 2313      0.00000000   300.00000000 60435 0.0000000000000
+   31   G02G03G04G05G06G07G08G09G10G11G12G13G14G15G16G17G18
+        G19G20G21G22G23G24G25G26G27G28G29G30G31G32  0  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3  3
++         3  3  3  3  3  3  3  3  3  3  3  3  3  3  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
%c G  cc GPS ccc cccc cccc cccc cccc ccccc ccccc ccccc ccccc
%c cc cc ccc ccc cccc cccc cccc cccc ccccc ccccc ccccc ccccc
%f  1.2500000  1.025000000  0.00000000000  0.000000000000000
%f  0.0000000  0.000000000  0.00000000000  0.000000000000000
%i    0    0    0    0      0      0      0      0         0
%i    0    0    0    0      0      0      0      0         0
/*
/* JET PROPULSION LABORATORY
/*
/* PCV:igs14_2247 OL/AL:GOT4.8AC NONE     YN ORB:CoN CLK:CoN
*  2024  5  5  0  0  0.00000000
PG02 -13437.150958  21529.486328  -6839.310759   -441.898312  9  7  8 191
PG03  -3541.328725  14363.675838 -22214.292944    346.501189  9  8  8 192
PG04  -2485.799292  24413.673857  -9973.190535    353.871254  9  6  8 191
PG05  18547.222201  -7409.911813  17375.687093   -171.539210  9  8  7 190
PG06  18172.960295    799.888667 -19332.298577    289.512978 10  8  9 192
PG07   4118.302006  16439.130289  20856.602474   -121.889193  9  7  7 190
PG08  -8380.641889  17683.385673  17649.304145    160.517555  9  8  8 191
PG09   7731.426301  25295.415843   1990.154747    184.469537  9  7  8 191
PG10 -23931.998421 -10951.491613   4897.544112    -17.918756 10  9  9 192
```

https://files.igs.org/pub/data/format/sp3c.txt

ReadEPH

- 사용법

```
>> eph = ReadEPH_multi('BRDC00IGS_R_20250220000_01D_MN.rnx');
```

- 결과물 형식

Col #1 : GPS Second

Col #2 : PRN

Col #3~ : 위성군 별 상이

	1	2	3	4	5	
1	259200	101	6.6921e-05	2.8763e-11	0	-1.3
2	261872	101	6.7000e-05	2.8763e-11	0	-1.3
3	266400	101	6.7131e-05	2.8763e-11	0	-1.3
4	273600	101	6.7338e-05	2.8763e-11	0	-1.3
5	280800	101	6.7545e-05	2.8763e-11	0	-1.3
6	288000	101	6.7751e-05	2.8649e-11	0	-1.3
7	295200	101	6.7958e-05	2.8649e-11	0	-1.3
8	302400	101	6.8164e-05	2.8649e-11	0	-1.3
9	309600	101	6.8371e-05	2.8649e-11	0	-1.3
10	316800	101	6.8577e-05	2.8649e-11	0	-1.3
11	324000	101	6.8783e-05	2.8649e-11	0	-1.3
12	329376	101	6.8936e-05	2.8535e-11	0	-1.3
13	331200	101	6.8987e-05	2.8535e-11	0	-1.3
14	338400	101	6.9193e-05	2.8535e-11	0	-1.3
15	339280	101	6.9217e-05	2.8535e-11	0	-1.3
16	345600	101	6.9398e-05	2.8535e-11	0	-1.3
17	259200	102	-2.6213e-04	9.2086e-12	0	-1.7

Appendix

#	Content	13	ω
1	t_{oe}	14	Ω_0
2	PRN	15	M_0
3	a	16	$\dot{i}$
4	b	17	$\dot{\Omega}$
5	c	18	Δn
6	T_{GD}	19	SV Health
7		20	C_{uc}
8	IODE	21	C_{us}
9		22	C_{rc}
10	$\sqrt{a}$	23	C_{rs}
11	e	24	C_{ic}
12	i_0	25	C_{is}

<GPS>

#	Content	10	Satellite Y Acceleration
1	t_{oe}	11	Satellite Z Acceleration
2	PRN	12	SV clock bias
3	Satellite X Position	13	SV Relative Frequency Bias
4	Satellite Y Position	14	information age
5	Satellite Z Position	15	
6	Satellite X Velocity	16	Frequency Number
7	Satellite Y Velocity	17	
8	Satellite Z Velocity	18	
9	Satellite X Acceleration	19	Satelite Health

<GLONASS>

PickEPH

- 사용법

```
ieph = PickEPH_multi(eph,PRN,gs);
```

- 입력

  eph : ReadEPH.p 를 통해 읽어들인 방송궤도력 (matlab 변수)

  PRN : 세 자리 PRN 코드

  gs : GPS Second

- 반환

  사용해야 하는 항법 메시지의 행 번호(index)

ReadSP3

- 사용법

```
>> sp3 = ReadSP3('IGS0OPSFIN_20250220000_01D_15M_ORB.sp3');
```

- 결과물 형식

Col #1 : GPS Second

Col #2 : PRN

Col #3 : X coord.(m)

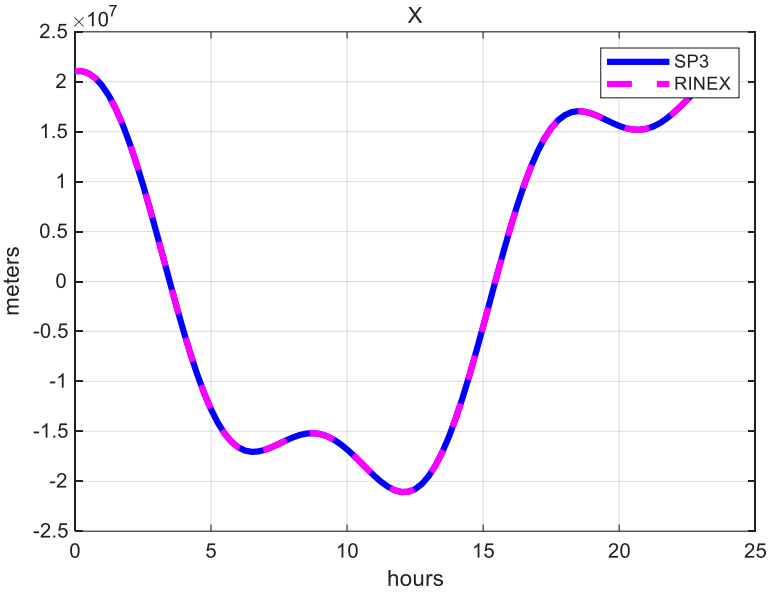
Col #4 : Y coord.(m)

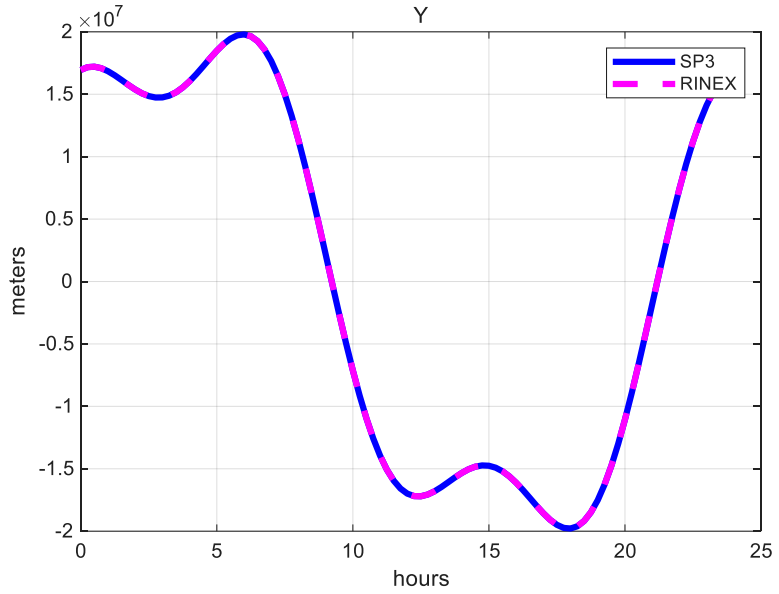
Col #5 : Z coord.(m)

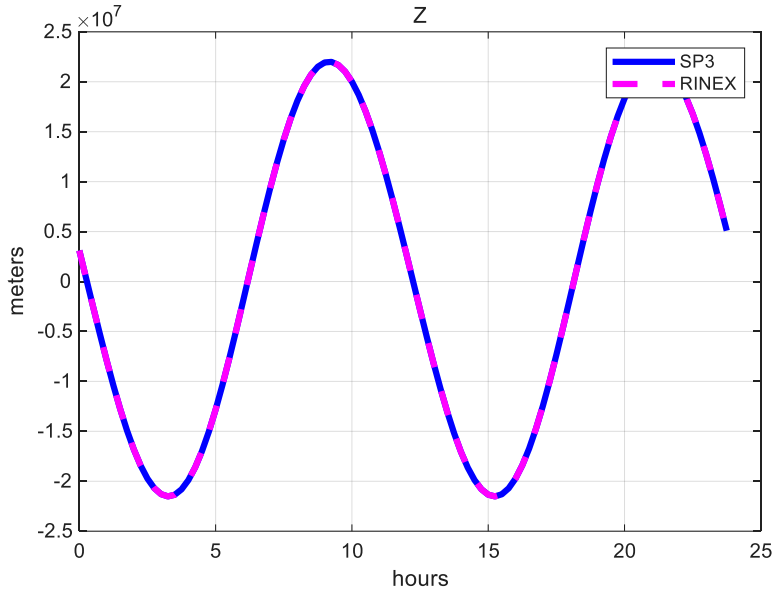
Col #6 : Clock Offset(msec)

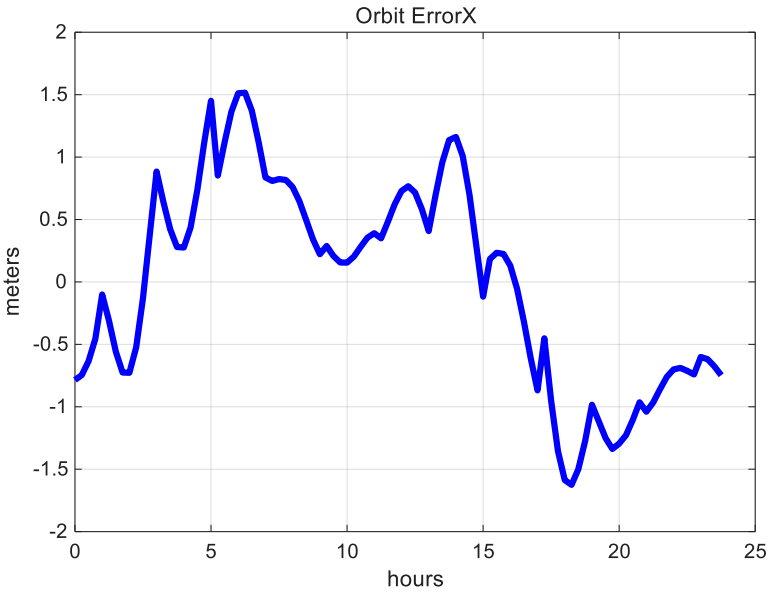
	1	2	3	4	5	6
1	259200	101	1.9989e+07	1.2569e+07	1.2179e+07	1.0000e+06
2	259200	102	2.2078e+07	1.2040e+07	9.6111e+06	-262.1282
3	259200	103	1.4277e+07	3.1332e+06	2.2006e+07	650.4552
4	259200	104	2.5464e+07	1.3080e+06	7.7358e+06	515.5695
5	259200	105	-7.9189e+06	-1.7595e+07	-1.8398e+07	-199.7104
6	259200	106	-4.8255e+05	-1.9244e+07	1.8315e+07	-134.9437
7	259200	107	1.7184e+07	-1.7999e+06	-1.9751e+07	-13.3795
8	259200	108	1.9314e+07	7.8050e+06	-1.6870e+07	465.6202
9	259200	109	2.5740e+07	-6.6160e+06	-1.1721e+06	537.8924
10	259200	110	-1.0164e+07	2.4176e+07	-2.5903e+06	-286.7058
11	259200	111	-1.0358e+07	-2.2838e+07	8.8777e+06	-750.9521

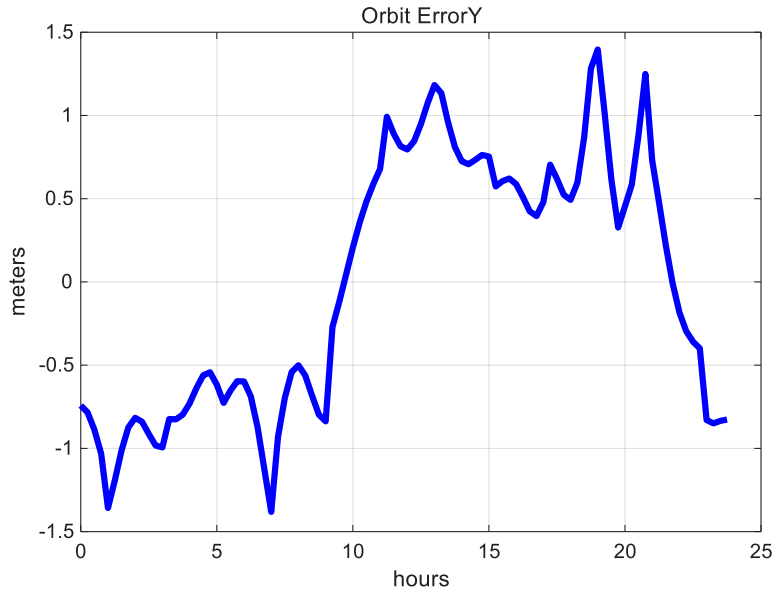
-
-
-

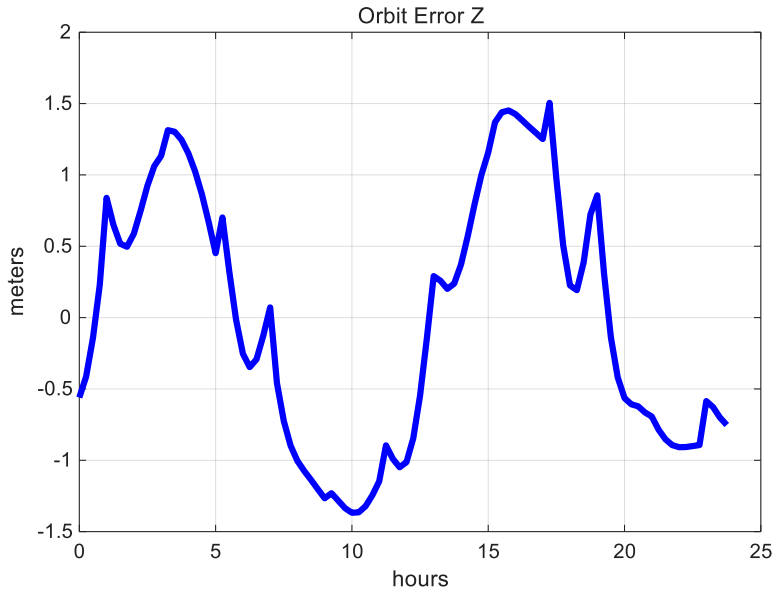

X
×10^7
SP3
RINEX
meters
hours


Y
×10^7
SP3
RINEX
meters
hours


Z
×10^7
SP3
RINEX
meters
hours


Orbit ErrorX
meters
hours


Orbit ErrorY
meters
hours


Orbit Error Z
meters
hours

```
%% Ready
clc;
clear all;
close all;

%% Date setting
PRN_num = 1; % PRN 01번
SYS = 120; % GPS

sp3 = ReadSP3('IGS0OPSFIN_20250220000_01D_15M_ORB.sp3'); %SP3 읽어들이기
eph = ReadEPH_multi('BRDC00IGS_R_20250220000_01D_MN.rnx'); % Navigation RINEX 읽어들이기
```

(Hint) Matlab 내장함수/명령어

1. find
2. unique
3. subplot
4. hold on