THE DEVELOPMENT OF THE GNSS-BASED PRODUCTS SERVICE SYSTEM

H.-E. Park, K. M. Roh, S.-M. Yoo, J. Cho

Korea Astronomy and Space Science Institute - South Korea - hpark@kasi.re.kr

ABSTRACT. The Korea Astronomy and Space Science Institute (KASI) is developing a GNSS-based products service system, which regularly generates station positions, GNSS satellite orbits, earth rotation parameters (ERP), and the analysis results, in order to utilize it in the Earth system research and the development of the Korean Positioning System (KPS). The service system consists largely of a Data Processing Server (DPS) and a Data Archive and Service Server (DAS). The DPS collects data necessary for processing data, such as RINEX files, and carries out data processing and data analysis with the Position and Navigation Data Analyst (PANDA) software or Bernese GNSS software 5.2, where various GNSS products are generated. The DAS stores the GNSS products generated by the DPS and serves them to user. In this poster, the architecture of the GNSS-based products service system is introduced and several analysis results for the GNSS products are explained.

1. INTRODUCTION

The Korea Astronomy and Space Science Institute (KASI) is developing a GNSS-based products service system to secure technology for determining GNSS products and to support research on the Earth system and the development of Korean Positioning System (KPS), a Korean navigation satellite system. Our goal is to develop a system that can routinely produce and service GNSS products such as a Terrestrial Reference Frame (TRF), GNSS satellite Ephemerides and Earth rotation by means of automating data collection and data processing. In this poster, the architecture of the GNSS-based products service system and the data processing methods used are briefly introduced, and the GPS satellite orbit and Earth rotation parameters (ERP) obtained from this system are explained.

2. GNSS-BASED PRODUCTS SERVICE SYSTEM

The system consists of two high-performance servers, Data Processing Server (DPS) and Data Archive and Service Server (DAS). Detailed hardware specifications for this system can be found in Table 1. Figure 1 shows the overall structure and function of the system, the flow of data, and the installed software. The DPS collects data from IGS global data center and CODE FTP server and carries out data processing for GNSS products using the Bernese GNSS software 5.2 or the Position and Navigation Data Analysis (PANDA). It also monitors the data processing process and notifies the administrator when a problem occurs. The DAS stores the GNSS products produced by the DPS and services them via the Web and FTP. However, in practice, GNSS products are stored on a Network Access Server (NAS) that is physically away from the DAS for security reasons.

3. GLOBAL GNSS NETWORK

A global network of 134 GNSS stations was used to estimate GPS satellite orbit and ERP. The global network was selected based on IGS14 core sites, taking into account its distribution and observation quality during data processing. Figure 2 shows the distribution of the ground stations

Sever name	DPS: Data Processing Server DAS: Data Archive and Service Server
The specification of the server	Model: HP ProLiant DL360p Gen8 - 2 Intel Xeon E5-2640 (2.0GHz, 8-core) - 512GB SSD 4EA - 2TB HDD 4EA (DAS)
O/S	LINUX
Software	Bernese GNSS software v5.2 PANDA

Table 1: Hardware specifications and installed software of the GNSS-based products service system

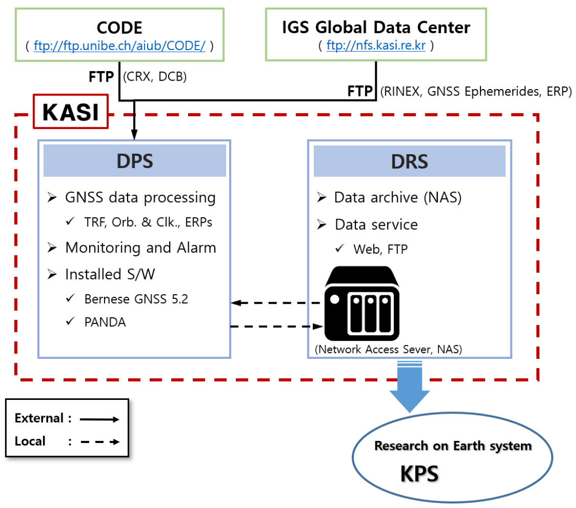

Figure 1: The architecture of the GNSS-based products service system

currently selected. The global network requires continuous optimization.

4. DATA PROCESSING

The GNSS-based products service system is currently under development and the data processing tool to be mounted on the system has yet to be determined. In the current study, GPS satellite orbit was determined using PANDA and ERP was determined using Bernese GNSS v5.2. Table 2 lists the key strategies for each data processing and the models used.

GPS precise orbit determination (POD) was performed by using the PANDA software developed at Wuhan University, China. Undifferenced observation data were used in the data processing for the POD, and the GPS orbit calculated from a broadcast navigation file was used as a priori orbit. Detailed data processing methods and models used for the GPS POD are shown in Table 2. Earth rotation parameters (ERP) was estimated using Bernese GNSS v5.2 developed by the University of Bern in Switzerland. IGS final products were used for GNSS satellite ephemerides for data processing, and IGS ultra-rapid products were used for a priori ERP. The basic strategy of data processing is double difference, and Berneses SNGDIF and MKCLUS modules were used for baselines generation and clustering. In other words, a single differential baseline was created using SNGDIF to maximize the common observation (OBS-MAX option), and clusters of several baseline were constructed using the MKCLUS module. The reason for performing data processing with clusters is because of the large number of baselines to be processed. If data processing is carried out for all stations at once, it may cause time and memory problems. Finally, out of the 134 stations, 62 were used to tie the solution to the IGS14 datum with a No-Net-Rotation (NNR)

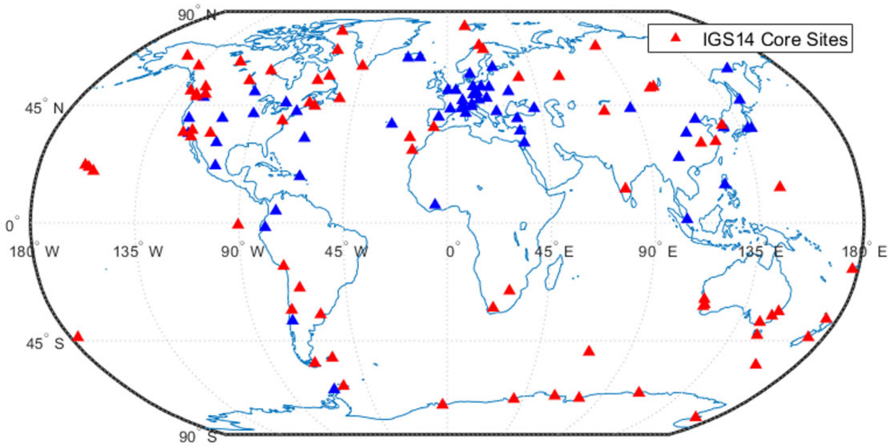

Figure 2: Global GNSS network used in the GNSS-based products service system

condition. Additional information on the data processing can be found in Table 2.

4.1 GPS satellite orbit

The GPS satellite orbit determina-tion product was generated on Jan. 1, 2019. To validate the orbit product, we compared with the IGS final orbit product. Figure 3 shows the 3-D rms position error of the all GPS satellites as a function of time. Most position errors did not exceed 6 cm. In Table 3, the mean position error of GPS satellites from G01 to G10 can be found. Figure 4 graphically shows the position error of all GPS satellites.

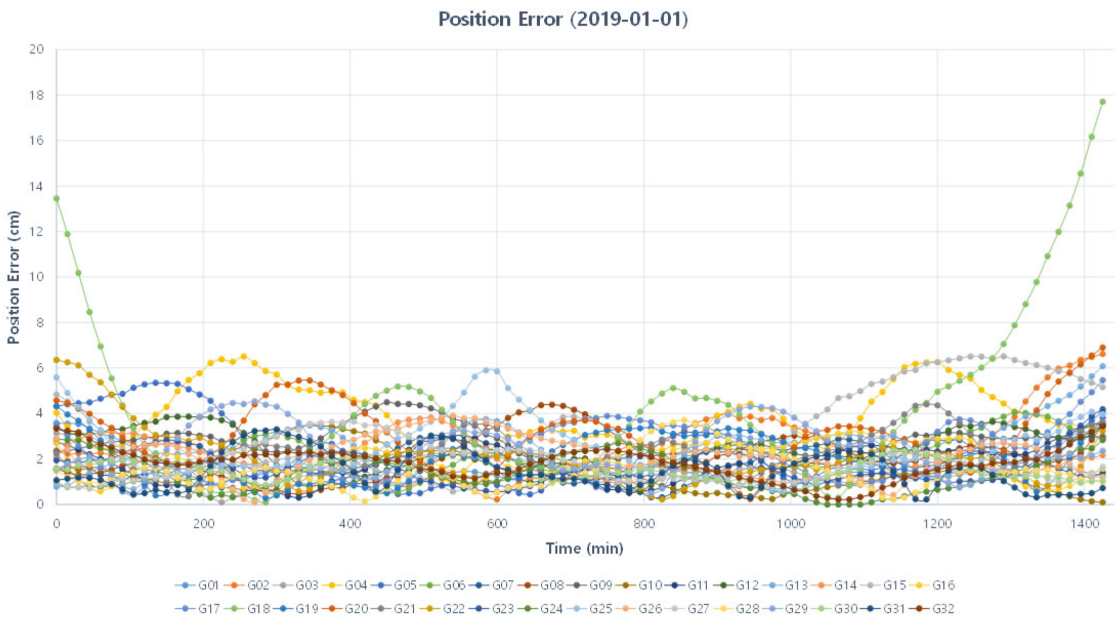

Figure 3: POD results: time series of position errors of all GPS satellites [2019-01-01]

4.2 Earth rotation parameters

The ERPs were estimated from 1 January 2019 to 29 June 2019 (180 days). The values of the estimated ERPs were compared with the IERS C04 and the results are shown in Figure 5 and

Products	GPS Satellite Orbit	Earth Rotation Parameters
Software	**PANDA**	**Bernese GNSS S/W 5.2**
Processing Period	2019.1.1	2019.1.1 – 2019.6.28
Type of Solution	1-Day solution	1-Day solution
Observation	GPS	GPS, GLONASS
A priori Orbit	Broadcast navigation	IGS final products
A priori ERP	IERS final products	IGS ultra-rapid products
Station position & velocity	IGS 2014	IGS 2014
Absolute antenna model	IGS14	IGS14
GNSS network	134	134
Processing Mode	Undifference	Double Difference
Ambiguity resolution	Round	QIF & WL/NL
Earth's Gravity	EGM 12	EGM 2008_SMALL
Subdaily pole model	IERS2010	IERS2010XY
Nutation model	IAU2000R06	IAU2000R06
Solid Earth Tide Model	IERS2010	TIDE2000
Ocean Tides	FES2004	FES2004
Planetary Ephemerides	DE405	DE405

Table 2: Data processing strategies and models used for GPS satellite orbit and ERP

PRN	G01	G02	G03	G04	G05	G06	G07	G08	G09	G10
Radial (cm)	0.779	1.455	0.944	1.334	0.976	1.086	1.110	1.121	1.913	0.597
Along (cm)	1.169	1.634	0.883	3.133	1.953	1.860	1.095	1.863	0.993	1.376
Cross (cm)	0.965	1.655	1.059	2.284	1.614	0.489	1.018	0.850	1.821	0.608
3D RMS (cm)	**1.705**	**2.743**	**1.671**	**4.100**	**2.715**	**2.209**	**1.862**	**2.335**	**2.822**	**1.619**

Table 3: POD results: the mean position error of G01 and G10 satellites [2019-01-01]

7. Figure 5 shows the changes of the estimated polar motion (blue dash line) and one of IERS C04 (red line). The X and Y axes of the horizontal plane are Xp and Yp, respectively, and the vertical axis is the date. Although we could not see the polar motion changing as it was drawn in a circle due to its short data processing period, we could see that the values of the estimated polar motion matched IERS C04. Figure 6 shows the differences from IERS C04 over time for polar motion and UT1-UTC. Most of the Xp and Yp errors did not exceed 0.2 mas and UT1-UTC had a error within 0.2 millisecond. Table 4 shows the difference values between the IERS C04 and the estimated ERP over 180 days. Figure 7 shows the histograms for the differences of ERP.

	Xp (mas)	Yp (mas)	UT1-UTC (ms)
Min	-0.202	-0.255	-0.085
Max	0.304	0.338	0.171
Mean	0.041	-0.002	0.024
Std.	0.100	0.116	0.047
RMS	**0.108**	**0.116**	**0.053**

Table 4: The difference between the estimated ERPs and IERS C04

5. SUMMARY

- GNSS-based products service system is developed to secure technology and to support related research.
- GPS satellite orbit and ERP were determined using PANDA and Bernese GNSS v5.2 respectively.

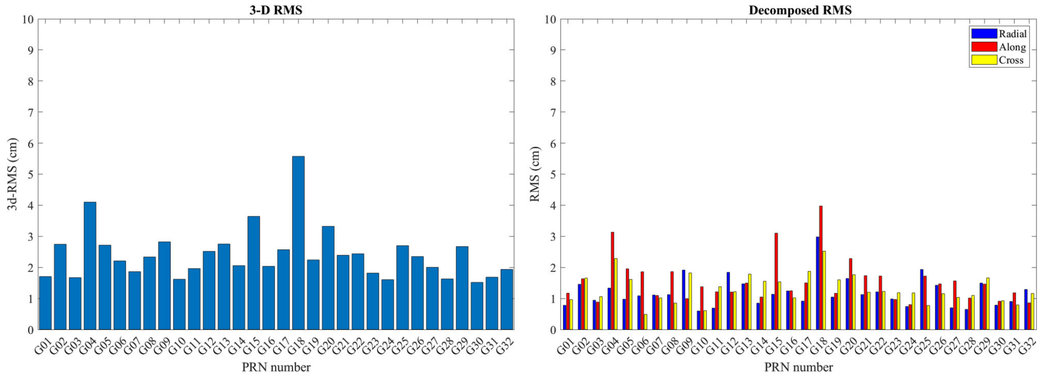

Figure 4: POD results: the mean position errors (3-D RMS: left, decomposed RMS: right) of all GPS satellites [2019-01-01]

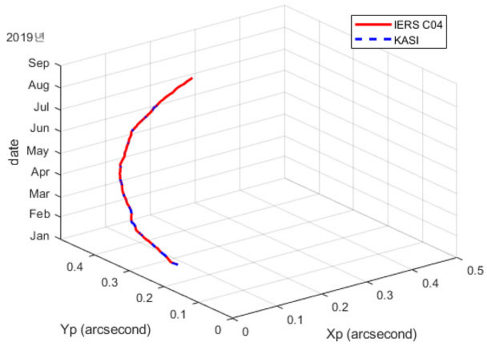

Figure 5: ERP results: a comparison of polar motions in KASI and IERS C04

- Most position errors of GPS orbit were within 6 cm compared to IGS final products.
- The estimated ERP had a difference of about 100 microarcsec in polar motion and about 50 microsec in UT1-UTC compared to IERS C04.

6. REFERENCES

Zhao, Q., Guo, J., Li, M.,Qu, L., Hu, Z., Shi, C., Liu, J., 2013, "Initial results of precise orbit and clock determination for COMPASS navigation satellite system", J. Geodesy 87(5), pp. 475-486.

Dach, R., Hugentobler, U., Fridez, P., Meindl, M., 2007, "Bernese GPS Software Version 5.0. User manual", (Bern: Stampfli publications)

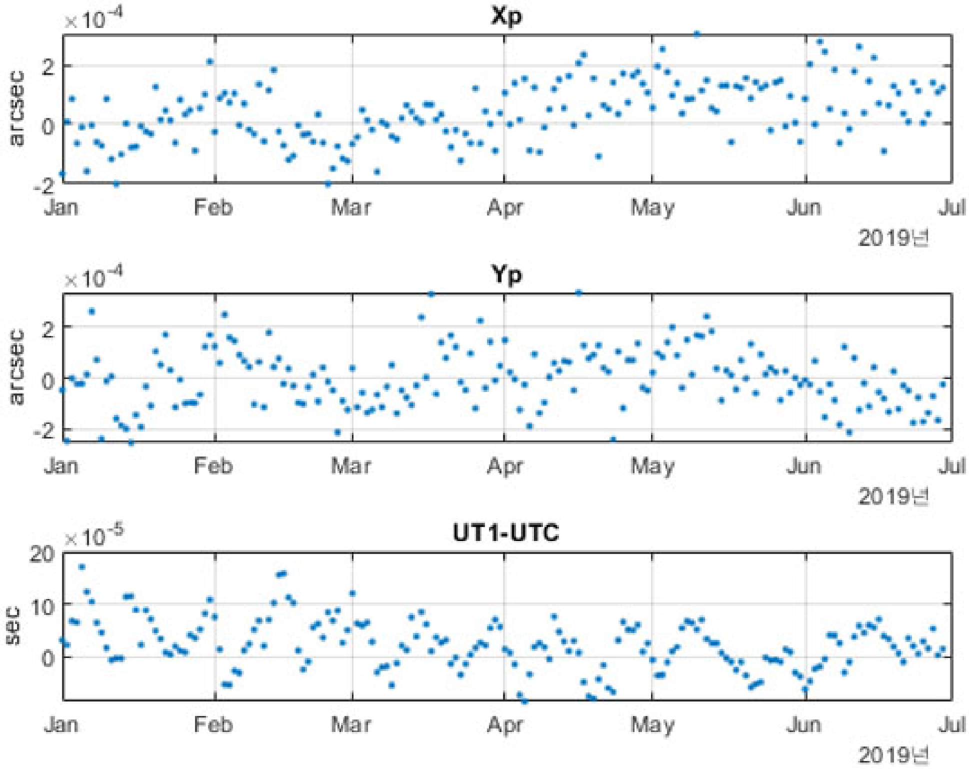

Figure 6: ERP results: time series of the ERP differences between KASI and IERS C04

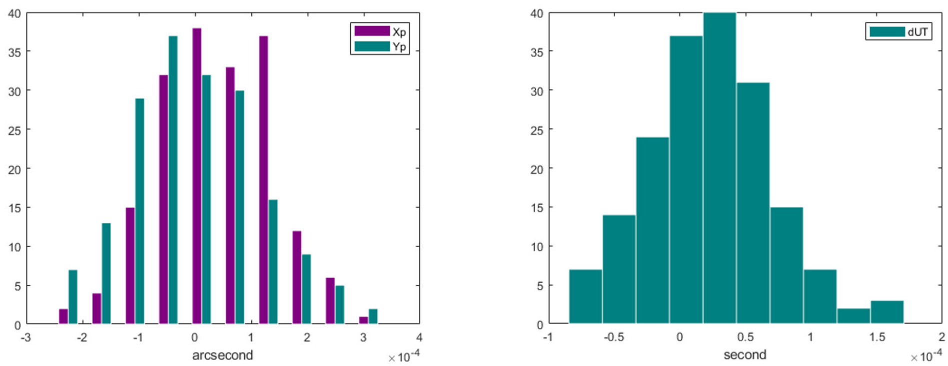

Figure 7: ERP results: histograms of polar motion (left) and UT1-UTC (right) differences between KASI and IERS C04