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The Analysis of GPS Data in Different Observation Periods Using Online GNSS Process Services

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Dear colleagues;

We are very glad to meet you with “International Journal of Environment and Geoinformatics” special issue which is a compilation of proceedings presented in “SELÇUK INTERNATIONAL SCIENTIFIC CONFERENCE ON APPLIED SCIENCES” held on 27-30 September in Antalya/Turkey.

Besides Turkish scientists, The Selçuk ISCAS 2016 brought together Russian, Ukrainian, Kazakhstan, Azerbaijani, Persian, Algerian, Nigerian, Netherlander, Scottish, Liberian, Philippines and Czech Republican scientists. Turkey General Directorate of Land Registry and Cadastre, Republic of Turkey Ministry of Food, Agriculture and Livestock Undersecretary, International Federal of Surveyors (FIG) and International Society for Photogrammetry and Remote Sensing (ISPRS) contribute to The Selçuk ISCAS 2016 at board of director’s level.

The Selçuk International Scientific Conference on Applied Sciences (The Selçuk ISCAS 2016) held in Antalya on 27-30, September 2016. The Selçuk ISCAS 2016 is a candidate of one of the most important event in the scientific schedule and tenders a possibility for researchers and academicians who researches on applied sciences. You can find a first class programme of plenary speakers, technical sessions, exhibitions and social events in this book. You will be able to catch up with the developments in Geographical Information Sciences, Information Technology, Environmental Management and Resources, Sustainable Agriculture, Surveying, Photogrammetry and Remote Sensing, meet friends and experience the traditional and fascinating culture of TURKIYE. As an international conference in the field of geo-spatial information and remote sensing, The Selçuk ISCAS 2016 is devoted to promote the advancement of knowledge, research, development, education and training in Geographical Information Sciences, Information Technology, Environmental Management and Resources, Sustainable Agriculture, Surveying, Photogrammetry and Remote Sensing, their integration and applications, as to contribute to the well-being of humanity and the sustainability of the environment. The Conference of Selçuk ISCAS 2016 will provide us an opportunity to examine the challenges facing us, discuss how to support Future Earth with global geo-information, and formulate the future research agenda.

195 scientists from 13 countries attended to the symposium. 105 oral presentations, 40 fast oral presentations and 50 poster presentations are presented during the symposium. 145 oral and fast oral presentations take place in 24 technical sessions in two days. On the other hand, 5 invited speaker presentations held in the plenary session in the first day.

The conference is carried out with the support of the organizations as the Selçuk University, General Directorate of Land Registry and Cadastre, General Directorate Of Agricultural Reform, Turkish Cooperation and Development Agency (TIKA), International Federation of Surveyors (FIG) and International Society for Photogrammetry and Remote Sensing (ISPRS). In addition, the symposium is also supported by the commercial organizations of Paksoyteknik, Mescioğlu, Geogis, Körfez, Tümaş, 4B Ölçüm, GNSS Teknik, Arbiotek ve Anıt Hospital.

Best wishes.

Assoc. Prof. Dr. Ekrem Tuşat

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The Analysis of GPS Data in Different Observation Periods Using Online GNSS Process Services

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Abstract

The usability and the accuracy of internet-based position determination services which have gained importance in recent years is one of the up-to-date subjects of studies. Online processing services have more advantages than commercial and scientific software; since they are easy to use, require less experience and free because they get quick results. In this study, GPS observation files in rinex format belonging to 6 stations were evaluated using Auspos, Magic-GNSS and Opus services then the results were obtained. Three systems showed the similar results for the results obtained according to 24-hour measurement period. In the second study, observation files were divided into 12, 6 and 2 hour groups and after the results were obtained they were compared to 24-hour results. According to the reports, it was seen that the accuracy decreased as the observation period got shorter. In all three systems, 24 and 12-hour observation accuracy occurs in cm measures. In 6 and 2 hour periods where the observation period is shorter, accuracy value reaches to 3-4 cm. According to these results, it is seen that although it generally depends on observation period, internet-based position determination services sustain adequate accuracy for basic geodetic network application that the topographical engineering needs.

Keywords: GPS, Geodetic networks, Online processing services

Introduction

It is possible today to determine the position with high accuracy by making use of GNSS systems. Geocentric Cartesian coordinates of the current point are determined by means of observations and calculations carried out from a point with an unknown position to a point with a known position. GPS satellites are used as a point with a known position (Anonymous, 2016). GPS system used by the United States is the most famous of the GNSS systems(Hoffman-Wellenhof et al ., 2001). GPS provides the real time determination of three-dimensional coordinate, time and speed in all weather conditions and in every location where the GPS receiver can see the blue sky (Grewal ve ark., 2007).

In the environments where the number of the satellites is not adequate or the signal quality is poor, it is possible to determine the position with high accuracy and safety by getting data from more satellites when GPS and GLONASS systems are used together. Accurate position determination is possible today in cm-dm measure as a result of the developments in data processing and data analysis (Alkan et al., 2014). Position can be determined with high accuracy statically and kinematically by Precise Point Positioning (PPP) , using precise orbital products and making some other corrections, by means of a single GNSS receiver without a need for another data apart from the collected one (Alçay et al., 2013).

The Evaluation of GNSS Data

There are various options to determine position through PPP methods. Although scientific GNSS evaluation software has been used only until quite recently, commercial GNSS evaluation software and online evaluation systems are also used widely nowadays.

Commercial Software

Commercial firms themselves produce this software because the receivers record the signals from the satellites in specific formats. These are the software that are generally sold with GNSS receivers. Commercial software allow ease of use and they let the users produce more in less time (Yılmaz, 2011).

Scientific Software

Scientific software were created to use in many geodetic measurements required high precision such as monitoring tectonic movements, strain measures, foundation of geodetic network of the country and the determination of datum parameters. The use of scientific software is more complicated than the other alternatives, so the user needs knowledge and experience.

Internet based software

The use of these services which have become common in recent years is quite easy. In comparison to commercial and scientific software, the user needs less knowledge and experience. The user can get the required results when the data obtained from the receivers is recorded into the system transforming them into rinex format and when, in addition, the information such as the type and height of antenna is input. In internet based services, fixed station points belonging to IGS or CORS network are accepted as reference points for solution. Point coordinates are calculated depending on these reference stations (Bahadur and Üstün, 2014).

Australian Online GPS Processing Service (AUSPOS)

It is an Australian GPS Processing Service run by Australia. Data files can be loaded into the system in two ways: by means of internet site or ftp services. What the users have to do is to record the number of the RINEX files into the system writing the antenna type / height of the files. Maximum 20 different monitoring files can be uploaded in total. After the uploading process finishes, the final report is sent to the e-mail in a few minutes.

The data must be collected at 30 second intervals (IGS standard) by double-frequency receivers using the static method to make this system show result. The files whose data length is less than two hours are not processed considering the data that is real-time, kinematic and collected by single frequency receiver. Besides, while the GPS data of the observation files are being used, GLONASS and GALILEO data are ignored. In the processing service, 15 fixed points belonging to IGS in a suitable closeness are used as reference points. There is information about referenced IGS stations, Cartesian and geodesic coordinates in the final report sent by E-mail. All coordinates are calculated in ITRF2008 datum.

The Automatic Precise Positioning Service (APPS)

APPS is an internet based GPS evaluation service run by NASA Jet Propulsion Laboratory. Apps online service offers the options such as static, kinematic, near real time and high accuracy (Most Accurate). When the data file is uploaded, the information like antenna height, type and e-mail address is filled up. The final report is received through an e-mail soon afterwards. There are X, Y, Z coordinates, ITRF2008 and error rate in the final report.

Online Positioning User Service (OPUS)

It is an internet based data evaluation service founded by American National Oceanic and Atmospheric Administration. The data file used in Opus service must contain the data with at least 2-hour length, recorded by a fixed antenna. On the other hand, the data collected by single-frequency receiver are not processed by Opus but the data collected by double-frequency receivers at 1, 2, 3, 5, 10, 15 and 30 intervals are evaluated. The service offers various evaluation methods as statics and rapid statics according to data acquiring type. In static method, the length of data file must be between 2 hours and 48 hours while the data between 15 min. and 2 hours are evaluated in rapid static method. In the report, as well as geocentric coordinate values of the point there is also information like the software that is used, stopping and ending time of the data file, the type and height of the antenna, the name of the file.

Trimble CenterPoint RTX Post Processing (Trimble RTX)

It is an online position determination service that Trimble Tirm offers. It supports Trimble service by means of a global reference network founded by itself (Bahadur and Üstün, 2014).

It can evaluate the data files obtained by GPS, GLONASS, QZSS, Galileo and Beidou satellite systems. The length of the uploaded data must be minimum 1 hour and maximum 24 hours. Trimble service does not evaluate the data files before 14th May 2011. The results are sent to e-mail address in PDF.

CSRS Precise Point Positioning (CSRS-PPP)

It is an evaluation service that Natural Resources Canada (NRCAN) offers. A membership to the service is required for evaluation process. It is a system that can evaluate both static and kinematic measurements. The data collected by double or single receivers are processed in the final report.

Magic-GNSS

It is an internet based service that evaluates the files containing GPS and GLONASS data with precise positioning technique. However, GPS data before 3rd May 2000 and GLONASS data before 1st January 2010 cannot be evaluated by this service. If the users become the member of the system, they get 1 GB memory free of charge. When you use the service without a membership, you can get the final report sending the data to magicppp@gmv.com. Magic-GNSS service supports rinex format and all compressed format. Observation data files may be collected statically or kinematically at 1, 5, 10, 15 and 30 second intervals. It needs precise orbit and hour information published by IGS. After the results are calculated they are sent to the user in pdf.

Gaps

This service performs data processing, predicts ionospheric delay and corrects satellite time error as well as position determination. The users of Gaps service can not only get the results of position determination by uploading data files to the system to be processed but also carry out this process by writing command line. In this way, it becomes possible to process large amount of GPS data easily (Urquhart et al., 2014).

Material and Method

In this study, the observation data dated 20.01.2011 and belonging to 6 CORS-TR stations called ANRK, CANK, CMLD, KIRS, KKAL and SUNL were used. The coordinates are the degraded projection coordinates according to TM projection 33 degree central meridian, at ITRF2008 epoch 2011. The comparisons were made in terms of dN, dE, dh projection coordinates and ellipsoid heights.

Figure 1. The positions and distributions of the stations used in the application

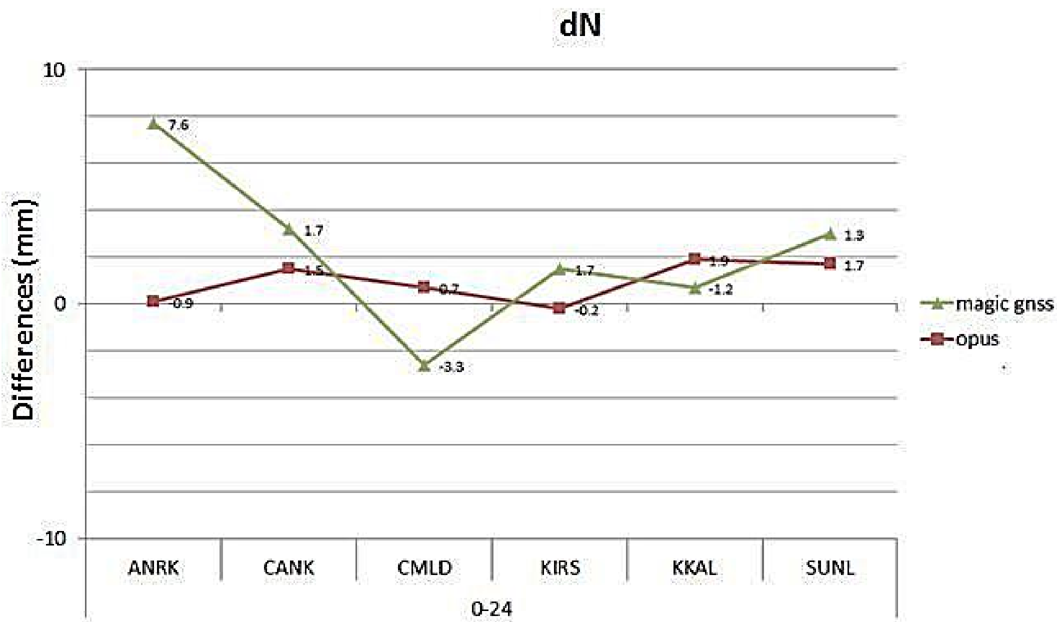
The Evaluation of 24-hour observation data in various systems

The results were obtained about 24 hour rinex observation files related to the points using three systems called Magic GNSS, AUSPOS and OPUS. The evaluations were carried out by means of static PPP method in all three systems. There are the values of latitude, longitude and ellipsoid heights about 6 stations in the final reports. These coordinates were turned into TM projection coordinates. In 3 degree-system, zone central meridian was taken as 33 degrees and its differences were calculated according to AUSPOS system. These differences are given at Table-1 by taking them in mm measure.

Table 1: The differences of 24 hour data with AUSPOS service

		dN (mm)	dE (mm)	dh (mm)
OPUS	**ANRK**	-0.9	-0.4	13.0
	CANK	1.5	-4.0	2.0
	CMLD	0.7	-1.8	6.0
	KIRS	-0.2	-1.5	6.0
	KKAL	1.9	-2.7	8.0
	SUNL	1.7	-1.5	8.0
MAGICGNSS	**ANRK**	7.6	-5.9	3.0
	CANK	1.7	-8.6	-3.0
	CMLD	-3.3	-3.3	-1.0
	KIRS	1.7	-4.6	2.0
	KKAL	-1.2	-3.7	-1.0
	SUNL	1.3	-7.4	12.0

As seen above, the results of 24-hour rinex data, which were evaluated in all three systems, are similar to each other. The difference of all coordinates value is below 1 cm. This shows that the results don't have a significant difference for the coordinates obtained from 24 –hour data no matter which internet based system is used.



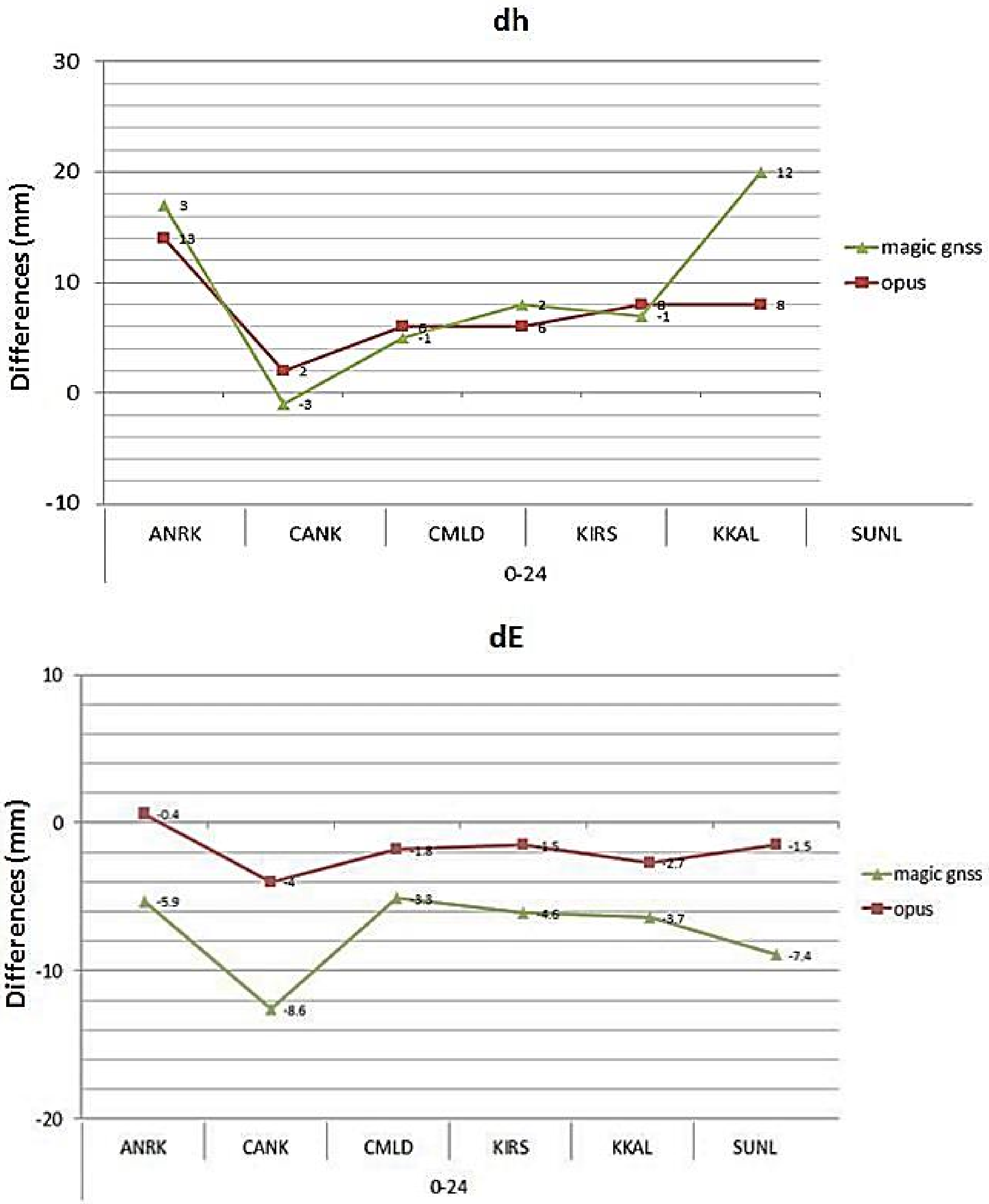


Figure 2. The differences between coordinates components for 24-hour data obtained by taking AUSPOS as a reference

As seen above, the results of 24-hour rinex data, which were evaluated in all three systems, are similar to each other. The difference of all coordinates value is below 1 cm. This shows that the results don't have a significant difference for the coordinates obtained from 24 –hour data no matter which internet based system is used.

The evaluation of the data with different observation period

Rinex observation files were divided into time periods as 12, 6 and 2 at a time so as to see the effects in different systems in case the observation periods may change. In this way, rinex observation files were obtained as two 12

-hour sessions, four 6 -hour sessions and twelve 2 -hour sessions for each station. The time periods of observation files are seen at Table 2.

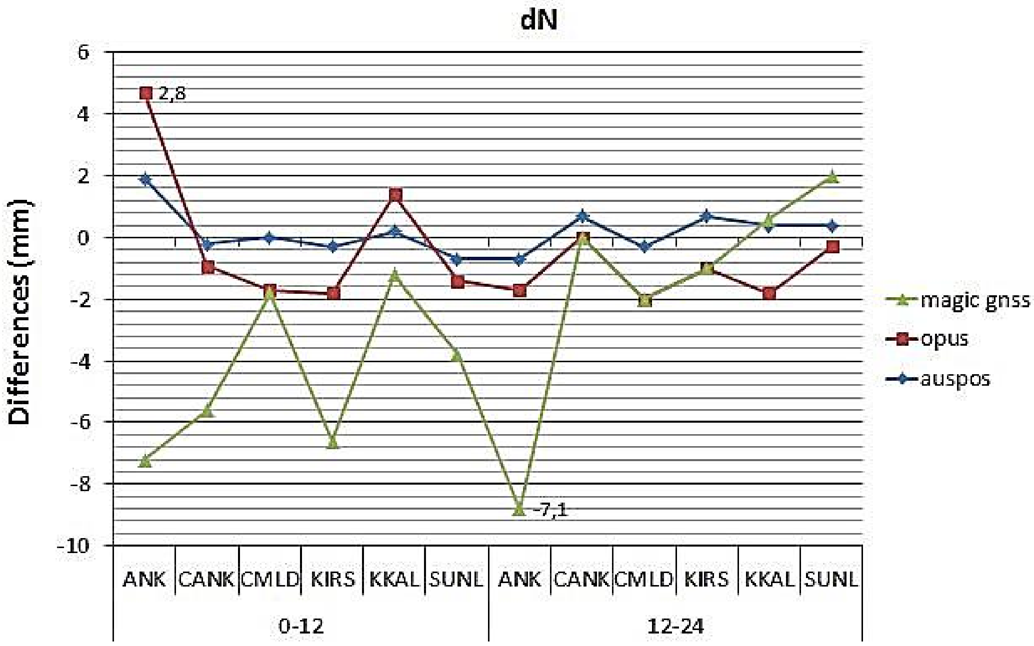
Table 2: Time periods of RINEX observation files

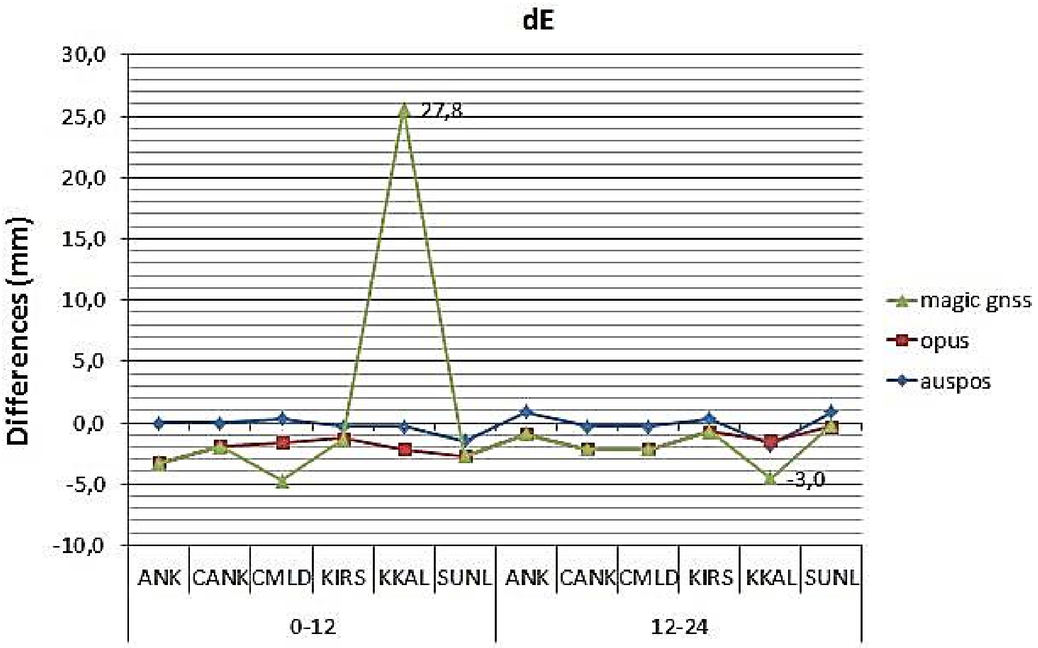
	Rinex File observation period											
24 hour	0-24											
12 hour	0-12						12-24					
6 hour	0-6			6-12			12-18			18-24		
2 hour	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24

The evaluation of 12 hour data

Observation data files were divided into 12 hour periods, and then 24 hour results in each system and the differences between them were taken.

In an evaluation performed in 12 hour observation periods, it is seen that one value of Magic-GNSS is bigger than 2 cm. This error is in the Y component of KKAL station between 0-12 hours. Besides, both values are bigger than 1 cm in the same system. Both of these errors are in ANK station. In AUSPOS and OPUS systems, difference values are below 1 cm and they generally give similar results. Some values are nearly the same with 24 hour observation values.





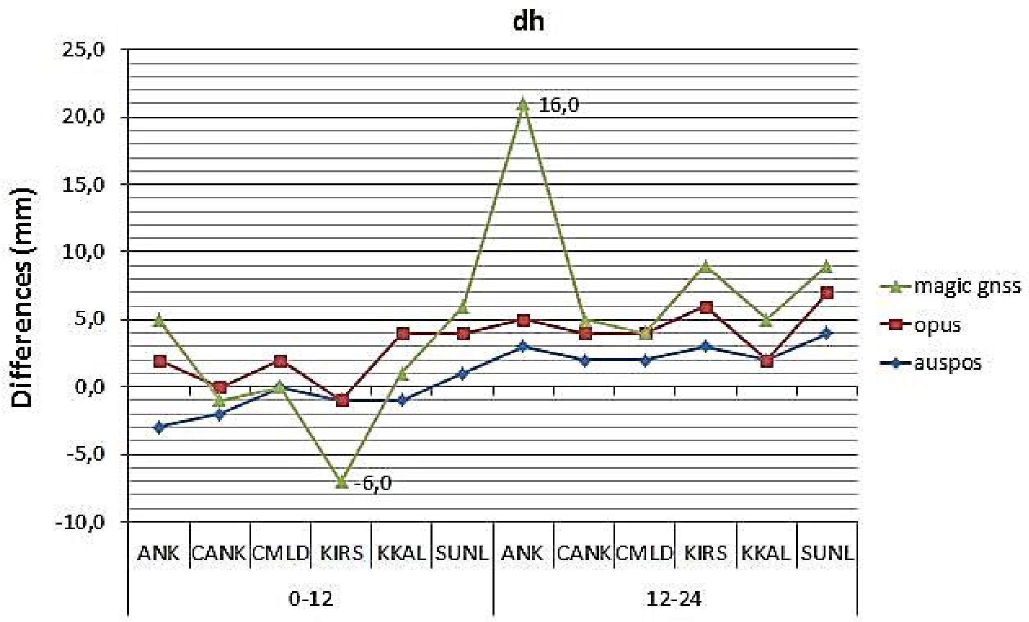
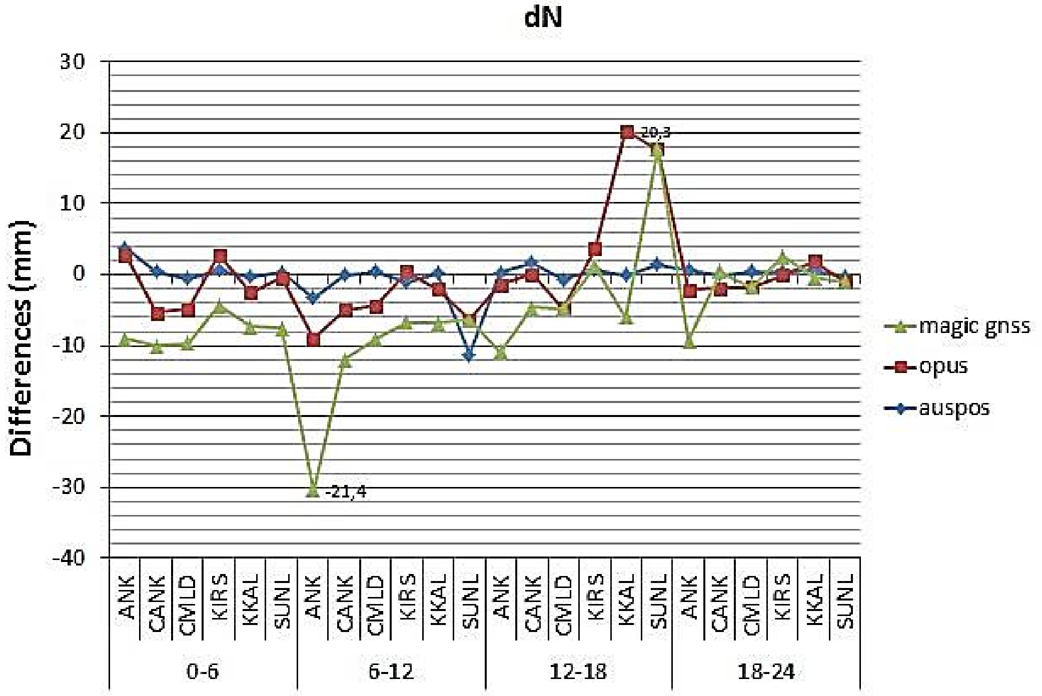


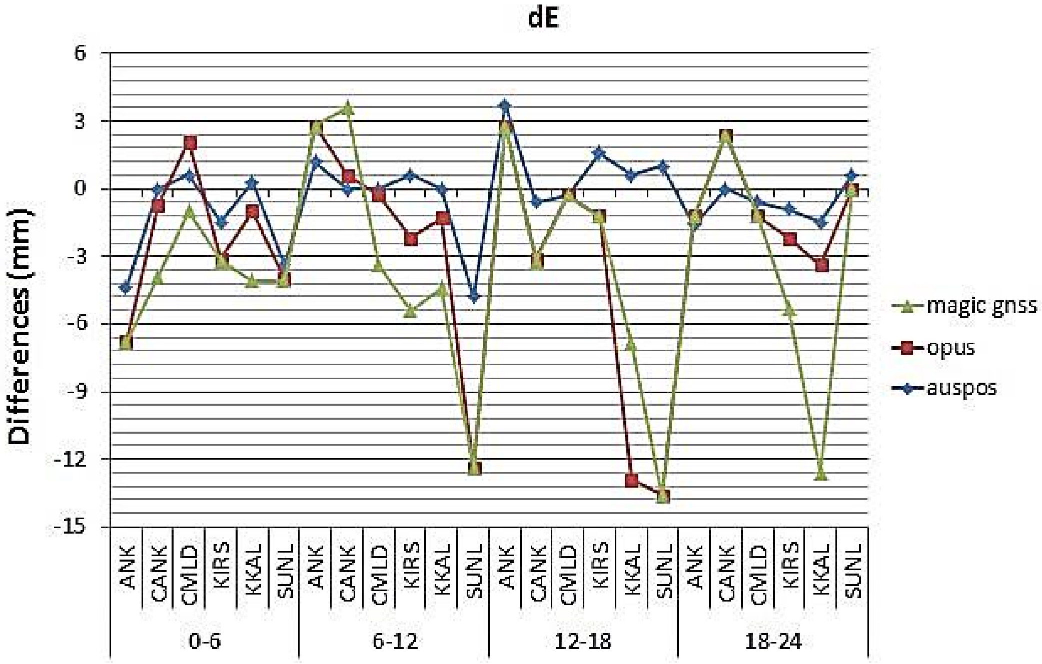
Figure 3: the differences of coordinates components for 12-hour data

The evaluation of 6- hour data

Observation data were evaluated by dividing into 6-hour periods. Besides, 24 hour results in each system and the differences between them were taken.

According to 6-hour evaluation results, it is seen that AUSPOS and OPUS services give similar results in dN and dE values. 7 values in total, which consist of one value in AUSPOS, two values in OPUS and four values in Magic-GNSS service, gave an error bigger than 2 cm. Considering the errors between 1-2 cm, it is seen that Magic-GNSS contains more errors. Besides, in all three systems the errors are generally in dh components.





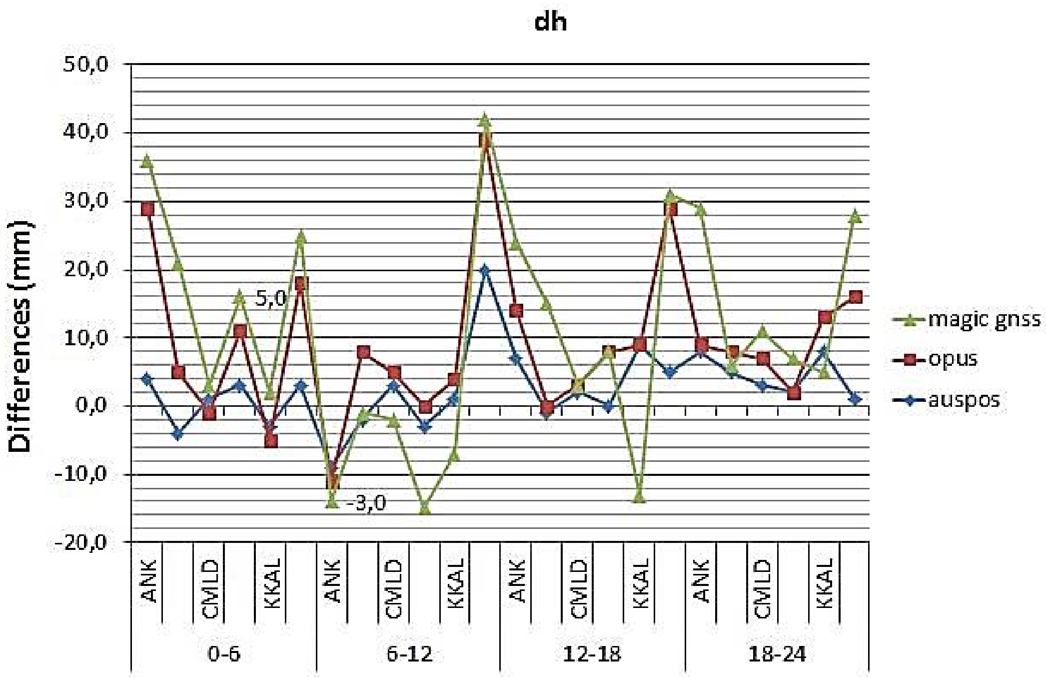


Figure 4: The differences of coordinates components for 6 hour data

The evaluation of 2-hour data

The processes performed for 12 and 6-hour data files were repeated for 2 -hour data as well. The highest, the lowest and the average values for dN, dE and dh components were given in a table to understand the results of the 2-hour data better.

Table 3: The minimum, maximum and average values for 2-hour data

		dN (mm)	dE (mm)	dh (mm)
The minimum difference	AUSPOS	0.00	0.00	0.00
The maximum difference		-23.80	-29.60	-38.00
The average		-11.90	-14.80	-19.00
The minimum difference	OPUS	0.00	0.00	0.00
The maximum difference		-35.20	-35.50	-37.00
The average		-17.60	-17.75	-18.50
The minimum difference	MAGIC-GNSS	0.00	0.00	0.00
The maximum difference		-38.10	-36.20	39.00
The average		-19.05	-18.10	19.50

In the evaluation of 2 hour observation files, there are points with more than 3 cm error in all three systems. The system that gives the fewest errors is AUSPOS. In all systems, there are more than 2 - cm error in two - hour results. The error rate is generally higher in dN, dE and dh coordinates at ANK points. There is a significant increase in error rate in comparison with 12 and 6 hour data. However, this increase in all three systems shows that it typically gives similar results.

Results and Discussion

Many studies were carried out for the accuracy research of the results of internet based evaluation services. 24-hour measurement files which were collected in NCTU and DONS IGS stations between 1st-31st March 2001 in Taiwan were evaluated in OPUS, AUSPOS, SCOUT, Auto-GIPSY and Auto-BERNESE services. Besides, comparisons were made separately by dividing 24 hour measures into 2,4 and 6-hour data. When calculating maximum and minimum errors by taking BERNESE software as a reference, the differences between horizontal coordinates in all services stayed in cm measure. However, there were 10-20 cm and 2-3 cm differences in the obtained values of height. (Liu and Shih, 2007). In an another study performed at Athens University, 24,6 and 1 hour measurements taken from 8 different IGS stations were used. When comparing current coordinates of IGS points with the results received from CSRS-PPP, Auto-GIPSY, SCOUT and AUSPOS online services, the accuracy is 1-2 cm level for 24-hour data in all services. Significant differences occur between the services as the observation period decreases (Tsakiri, 2008). In another study 24-hour measurement data, which was collected on 16th May 2009 and 6th November 2009 at 6 fixed stations belonging to ISKI-UKBS network founded by ISKI, were evaluated in OPUS, AUSPOS and SCOUT services. The differences from three services were found separately by basing the results calculated in BERNESE software. It was seen that it approached in 1-2 cm accuracy in the position components of online services and a few cm accuracy in the height components (Subaşı and Alkan, 2011).

In a study carried out in America, the measurement data belonging to a single day was evaluated in Auto-GISPY, OPUS and SCOUT services and compared to the coordinates calculated by Graf Net software (MacDonald, 2002). Likewise, the daily data collected at UNB1 IGS station in Canada were set as separate data sets of 24 hour and 10 hour and the results were calculated by AUSPOS, SCOUT, OPUS, Auto-GIPSY and CSRS-PPP services. The obtained coordinates were compared to the current coordinates of UNB1 station. Considering that the measurement time is also effective in these studies, it is seen that the accuracy rates a range between 0.1-20 cm in horizontal coordinates and 0.1-54 cm in height (Ghoddousi-Fard and Dare, 2006).

In this application, Auspos, Magic-GNSS and Opus systems were evaluated between each other and each system was evaluated in itself by different observation periods. It was seen that Opus and Auspos gave more similar results when the systems were searched between each other according to the same observation periods. However, the differences between three systems were below 1 cm according to 24hour observation results and there was not a significant difference. In the results which were obtained by changing the observation periods in the application, as the observation periods got shorter, error rate increased proportionally. Especially when the observation period reduced to 2 hours, nearly 3-4 cm differences occurred and the number of different values increased in dN, dE and dh values of the stations. Namely, it is more suitable for the users to choose the observation periods according to the intended accuracy rate.

Conclusions

As PPP methods gain importance today, internet based evaluation services have stated to be commonly used. The most important advantage of these systems is that the results can be obtained by one receiver. This makes it easy to calculate to a great extent. On the other hand, the fact that the services are free and easy to be used provide an advantage in terms of the cost and labour. In these systems, the errors that result from the users without sufficient knowledge are prevented because the other software require GNSS speciality and experience.

Internet based services choose the stations near the application area automatically in the application process. When the conditions are provided by a single GNSS receiver in terms of sufficient satellite number and observation period, the accuracy is obtained in cm measurement. This system can be used efficiently if there is a national network that consists of fixed GPS frequency stations. In this way, it can be said that internet based evaluation services sustain adequate accuracy and provide more advantage in terms of time and cost than the classical method for topographical engineering applications.

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