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Assessment of the GNSS Data Collected at the Main Continuously Operating Reference Stations (CORS) of the Iraqi Geodetic Network

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ABSTRACT

The Continuously Operating Reference Station (CORS) network has several stations that collect and record data from Global Navigation Satellite System (GNSS) constellations. These stations run continuously in an automated manner to collaborate and interact with different users for positioning services. In this study, the collected GNSS data at five CORS sites of the Iraqi Geodetic network was assessed to determine if there were any significant changes in the positions of these stations for a long time. This change gives a clear interpretation of the impact of different geophysical phenomena (e.g. tectonic plate motion) on the stability of positions within time. Therefore, the collected data at ZAXO, ISER, ISBA, ISKU and ISNA stations were analysed for seven years 2015 – 2022 (i.e. from 1st Jan 2015 to 31st Dec 2021). The daily position of each station can be computed from 24-hour recording data at a 30-second rate using GAPS or CSRS free software for Precise Point Positioning (PPP). Thus, 8806 observation daily files were used. The processed data was represented as a time series in Easting, Northing and Up coordinates for each station to analyse the trend of movement in these stations. It was found that the change in both Easting and Northing coordinates has a linear trend, which agrees with the general trend of tectonic motion in this part of the world. The mean yearly change was within 22-27 mm. On the other hand, the change in the Up coordinate with time had a fluctuated change over time "wave behaviour" or exhibited periodic variations.

Keywords: CORS, Iraqi geodetic network, GNSS data, Precise Point Positioning (PPP).

1. INTRODUCTION

Besides collecting and recording GNSS data of the 3D positioning, the CORS stations can be used for meteorology, space weather, and other survey activities for various applications **(Prusky, 2001)**. Establishing these stations is the responsibility of different organizations in diverse locations around the world for national or global CORS networks **(Snay and Soler,**

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2008). The National Geodetic Survey (NGS) of the Department of National Oceanic and Atmospheric Administration (NOAA) is responsible for managing the data in most of these stations worldwide. In addition, the NGS organization offers free online service by providing the 3D real positioning of CORS sites through the website (www.ngs.noaa.gov/CORS/).
The beginning of using the CORS system was based on GPS-only. Therefore, (**Stone, 2000)** addressed an overview of GPS-CORS for various activities in surveying, mapping, and other positioning applications. He mentioned using reference stations in GPS relative positioning to improve the required accuracy of the collected data in different stations; see also **(Gordini, et al. 2006)**. In addition, he presented overall information about the development of CORS facilities regarding the hardware, site configuration, and archived data.
In the same manner **(Rizos et al., 2003)** described the establishment of the CORS network in the Sydney area to support the RTK network to overcome the limitations in GPS positioning. One of the main limitations in GPS positioning is multipath. Therefore, **(Hilla and Cline, 2004)** evaluated the pseudorange multipath effect at more than 390 sites in the National CORS network throughout the United States. They collected data from GPS measurements of dual frequency over one year to detect the most and least affected sites in the whole network. They found that the least affected sites were equipped with receivers of choke ring antennas, which mitigate the pseudorange multipath. For deformation monitoring, **(Zhang et al., 2005)** investigated the possibility of using regional CORS sites to verify the deformations in the Victoria region. The results of the GPS net show an efficient and cost-effective technique to analyze the deformation based on the CORS network.
After that, (**Stone, 2006**) explained the CORS network development, its status, and the offered services. It was clear that the initial CORS was established by the National Geodetic Survey (NGS) in early 1994, located in Gaithersburg city in the United States. Then, the number of CORS became five stations at the end of 1994. Afterward, the network grew with time by adding other stations to around 1,000 site milestones in 2005. In addition, the observational GPS data at CORS sites can be downloaded free from the Online Positioning User Service (OPUS) **(Soler et al., 2006)**. Similarly, **(Rizos, 2007)** discussed the establishment of the CORS network for geodetic and other geoscientific applications in the previous two decades by government agencies and research institutes. Furthermore, it can process the submitted GPS observation of the CORS network via email. The permanent GNSS stations of CORS networks can be used to define the global and regional reference frames. Consequently, **(Schwieger et al., 2009)** provided a procedure for realizing the link between the GNSS-CORS and the available reference frames. Furthermore, **(Burns and Sarib, 2010)** described the main standards, procedures, and recommended practices for operating and establishing the GNSS-CORS system in Australia for multi-positioning services.
As above mentioned, there are different positional applications of the CORS network. The availability of highly accurate coordinates enabled various users to examine the collected data for specific applications. For example, **(Weston et al., 2010)** investigated the conducted data of the National CORS Network in the United States to detect GPS temporary interference. They processed hourly RINEX files (i.e. the Receiver Independent Exchange format) that were collected from different CORS sites to compute their positions for every epoch. The determined position of each epoch is compared with the mean position of hourly data to detect the variance in position. From this analysis, it can identify the outliers and if there is any significant change in the position to verify the occurring trend of the CORS station. This investigation helps to identify the existence of temporary or regional interference in the position of the CORS station.

The Precise Point Positioning (PPP) method can be used to determine the absolute positions of CORS sites with a single GNSS receiver. It can achieve cm-level positioning accuracy for the Real-Time Kinematic (RTK) concept based on the corrections from the CORS-Network and successfully fixing the integer ambiguity of carrier phase observations **(Teunissen et al., 2010)**.

After that **(Zhang et al., 2011)** demonstrated a proposed novel concept of un-differenced PPP-RTK to have accurate results. The validation of results was tested on two GPS CORS Networks in both Northern China and Perth in Australia. It was proven that the PPP technique is a powerful tool in different requirements of positioning when fixing ambiguity in a short time. Consequently, **(Li et al., 2011)** presented a new strategy with a regional CORS network to augment PPP solution from instantaneous ambiguity resolution. Also, **(Grinter and Roberts, 2011)** discussed the development of the PPP method during the last two decades. They reviewed the advances in PPP for the existing CORS network. Also, they focused on the services of the International GNSS Service (IGS) to perform products of orbit and clock corrections in real-time and near real-time. To achieve an accurate GNSS positioning of high precision, the ambiguity resolution of carrier phases must be fixed successfully with a strength model.

The main requirements for an absolute PPP solution are the precise satellite orbit and clock parameters, which are derived from different stations of the global network. There are different services to provide corrections that improve the final results. Thus, the products of the IGS (International GNSS Service) can be used for this purpose **(Sturze et al., 2012; Jiang et al., 2012).** To achieve an accurate GNSS positioning of high precision, the ambiguity resolution of carrier phases must be fixed successfully with a strength model. In this manner, **(Li and Teunissen, 2014)** applied a measurement concept by arranging multiple antennas in an array of known geometry instead of using a single antenna to have multiple models with more collected data. This will need to resolve the CORS ambiguity resolution with a shortened convergence time (preferably zero).

Different studies investigated the possibilities of the PPP approach to establish CORS networks with different software. For example, **(El-Hattab, 2014)** processed GPS data by Bernese and CSRS-PPP software. From the comparison, the derived accuracy from the PPP approach is suitable for establishing the CORS network. This was agreed with the results of **(Lilje et al., 2014; Rabah et al., 2016).**

One of the limitations to achieving accurate continuous positioning is the occurrence of cycle slip of carrier phase measurements. Therefore, **(Chen et al., 2016)** proposed an automated method of cycle slip detection and repair on preprocess data of the CORS network.

To show the impact of the GNSS-CORS network on satellite positioning, **(Dardanelli et al., 2020)** described the main steps adopted by the University of Palermo to realize the GNSS-CORS network. This will help to have a realistic evaluation of the network operating service and the quality of the recorded data during the period (2008 – 2012). The time series of the analyzed period has a linear trend for all GNSS CORS.

For Iraq, there are several CORS stations distributed to form the Iraqi CORS network. Several studies demonstrated this network. For example, **(Ur et al., 2013)** explained the control network of the Iraqi Geospatial Reference System (IGRS) which consists of six CORS stations, which were established and managed by the U.S. National Geodetic Survey (NGS).

To process and analyze the GNSS recorded data at CORS sites, there are different software either free or offline. **(Tariq et al., 2017)** investigated the possibilities of different online software such as OPUS, AUSPOS, and CSRS-PPP to evaluate the accuracy of surveyed points.

The results of relative and absolute techniques were used. It was found that the results of AUSPOS software are regular with the observation period when taken for a long period.
On the other hand, **(Alhamadani and Saeed, 2018)** processed the collected GNSS data over seven years and a half at Erbil CORS station (ISER). The conducted data were used to detect the Arabian tectonic plate motion over this long period. They employed a CSRS_PPP free online software in processing and then presented the time series using GPS Interactive Time Series Analysis. They found that there is a shift per year to be +20.9 mm, +27.2, and -11.3 mm in the East, North, and up-down components, respectively.
In the same sense, to show the important role of GNSS data at CORS sites in studying the movements of tectonic plates and other activities, **(Jasim et al., 2018)** analyzed the GNSS data collected at two main CORS stations. The first one was in Erbil city (ISER) for a period (Nov. 2008 - Jan 2018), while the second one (ISNA) was in Najaf city for a period (Jul. 2009 - Jan. 2018). From these collected data, the authors determined the velocity vector of the movement in each site and their directions. The velocity vector of ISER data was 38mm/yr. at N 40°48′E direction, while it was 40mm/yr. at N 45°06′E direction in the ISNA site.
Furthermore, (**Isawi et al., 2022**) processed the daily data of the Iraqi GNSS network that comprises 7CORS stations for five-year period. They based on the Earth Parameter and Orbit System software (EPOS.P8) in processing to find the PPP solutions at the concerned stations. They analyzed the time series of each station during this period (2013 up to 2018) to study the trend of movement. The final results were estimated to be (25 to 27.6 mm/year) for the velocity range for the north component, while it was (22.1 to 24.8 mm/year) for the east component.
In this study, the collected GNSS data at five CORS sites of the Iraqi Geodetic Network will be analyzed. Therefore, the recorded daily data (24 h of 30 sec rate) of GNSS observations will be downloaded to compute their PPP solution in each station using suitable geodetic software. Then, the computed positions will be represented in a time series to study the trend of change in their positions with time. It is aimed to study the trend for a long duration of seven years at intervals of 2015-2022 (from 1st Jan 2015 to 31st Dec 2021) to have 8806 observation files. Moreover, the data will analyze for yearly trends to see the changes in their positions. Also, the correlation will analyze between the different coordinates.

2. CASE STUDY AREA

The Iraqi geodetic network consists of seven CORS stations as shown in **Fig. 1**. The Authority General of Surveying (AGS) is responsible for the administration of Continuously Operating Reference Stations (CORS). It is the adoption recommendation of the US Geodesy Authority (NGS). The station name consists of four letters that started with an ID of "IS", which means Iraqi Survey and the last two letters refer to the name of the city. In this way, ZAXO, ISER, ISSD, ISBA, ISNA, ISKU, and ISBS are located in the cities of Zakho, Erbil, Salah Adin, Baghdad, Najaf, Kut, and Basra respectively (see **Fig. 1**).
The detailed positions of these stations are given in **Table 1**, which shows both the geodetic (φ, λ, h) and Projected in (E, N) coordinates of the Universal Transverse Mercator (UTM) for each station. For mathematical computations of UTM (see **(Snyder, 1987; Mahdi, 2006)**. The coordinate system is related to the International Terrestrial Reference Frame (ITRF), which is an ideal reference system that uses the WGS84 as a reference spheroid. Moreover, all the GNSS data recorded at these stations can be downloaded for free when logging into the site (NGS). According to this site, the information for each station can be defined, such as the status of the operation, sampling rate, availability, and the received data from GNSS

constellations. Unfortunately, there is no available data for ISSD and ISBS, therefore, the study will restricted to the other five stations only.

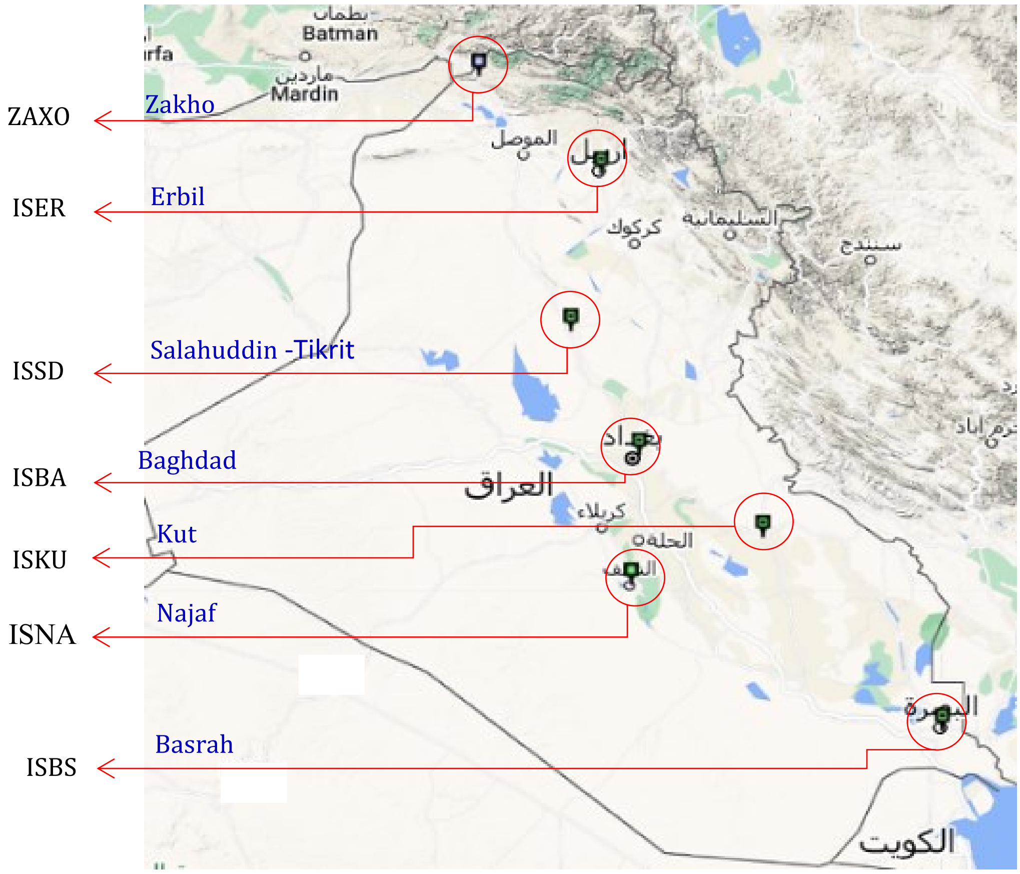

Figure 1. The locations of Iraqi CORS sites (**National Geodetic Survey, 2023**)

Table 1. The geodetic and UTM coordinates of each Iraqi CORS **(GNSS Analysis and Positioning Software, 2022)**

Sta	Geodetic Coord.			UTM Coord.	
	Lat. (φ) *E*	Long. (λ) N	(h) m.	E (m.)	N (m.)
ISER	36° 09’35.47789”	44° 00’39.38483”	431.2773	411 037.289	4 002 132.033
ISBA	33° 20’29.10058”	44° 26’18.25648”	72.3555	447 740.748	3 689 278.255
ISKU	32° 30’06.82154”	45° 48’30.16130”	26.1704	575 937.852	3 596 357.020
ISNA	32° 00’45.15841”	44° 21’11.80886”	49.2211	438 921.608	3 542 008.839
ZAXO	37° 06’49.83594”	42° 40’13.99957”	431.2773	293 028.954	4 110 041.025

3. MATERIALS AND METHOD

The methodology is based on sequential steps in this study. As shown in **Fig. 2** below, it starts with logging into the website of (NGS) which provides all the recorded GNSS data of CORS stations. It can download the required data from the User-Friendly CORS (UFCORS) field, which supplies a specific block of GNSS data. After defining specific details of GNSS data, such as the date, duration, and sampling rate, it is possible to obtain the required data in Rinex format ver. 2.11. This means the main data will be available for the next stage.

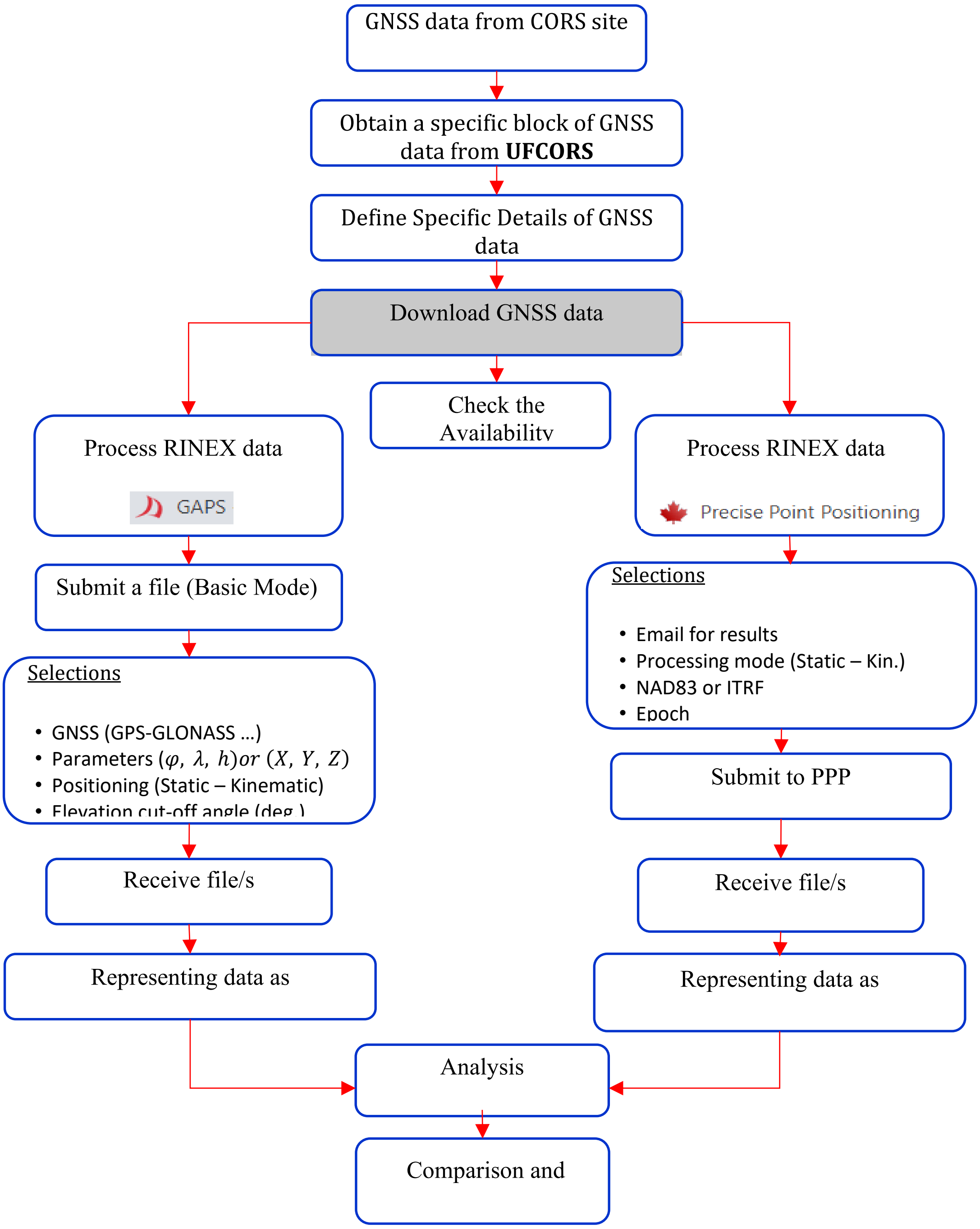

Figure 2. Flow Chart of The Main Procedure.

It can be checked the availability of daily data over a long period. In addition, to find the absolute position of each station, there are different options based on the implemented software. For this purpose, there is two different software will be used in this study as geodetic tools. The first one is the Canadian "GNSS Analysis Positioning Software (GAPS-PPP)" to compute the price point Positioning from RINEX observation data, while the second one is "Canadian Spatial Reference system software (CSRS-PPP)" for the absolute position also.

process the archived data, the observation file will be sent via email to the website of each software as an input file. This will need a selection of different parameters (i.e., GNSS constellations To, coordinate system, processing mode either static or kinematic, etc.) as well as the Email to receive the output data. However, the output data will have different files, the main required files are the coordinate ones. Next, the available coordinates data can be represented in time series for a long duration by MATLAB software. This enables us to study the trend of each component of the coordinates. Moreover, it can analyze the data for different evaluations **(Hussein and Msaewe, 2023).**

3.1 Availability of the Observation Data

After downloading the data, there were missing recorded data in some intervals. Consequently, the availability of data was analysed to check the continuous recording of data. This analysis will affect the study of the trend of movement in the positions of these stations. Therefore, **Fig. 3** shows the availability of GNSS observation data for all Iraqi CORS stations for seven years. From this figure, it is clear that there is no available data for the ISKU station after the end of 2019. Similar to the ZAXO station that has no data after the beginning of 2020. However, the ISNA station did not start exactly at the beginning of 2015, there was continuous data until the end of 2021. To check the percentage of available data, **Table 2** illustrates this procedure.

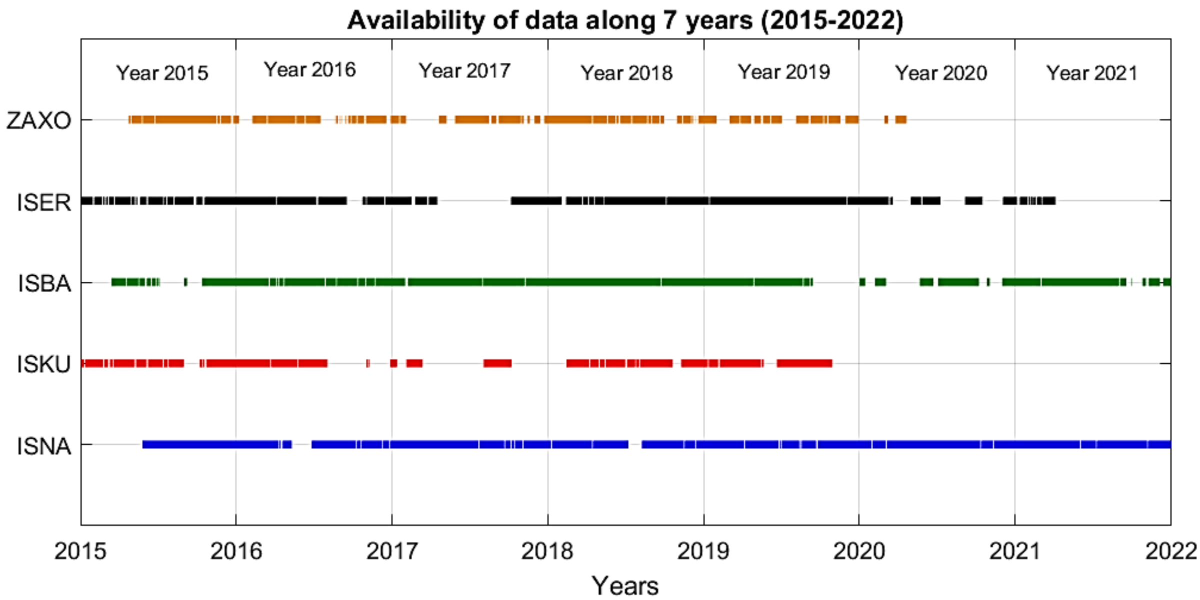

Figure 3. The availability of daily data at five CORS stations for 7 years

After defining specific details of GNSS data, such as the date, duration, and sampling rate, it is possible to obtain the required data in Rinex format ver. 2.11. This means the main data will be available for the next stage. It is clear that the ordered high availability at these stations was recorded at Najaf, Baghdad and Erbil stations with percentages of 90.18%, 80.52%, and 72.31%, respectively for the seven years durations, while the minimum availability was recorded at Kut station 47.56%.

Table 2. The availability of daily data at five CORS stations for every year

Station	Available daily data/year									
	Location	2015	2016	2017	2018	2019	2020	2021	Sum	%
ZAXO	Zakho	244	271	235	315	274	37	0	1376	53.81
ISER	Erbil	331	324	183	351	363	216	81	1849	72.31
ISBA	Baghdad	199	357	358	364	253	211	317	2059	80.52
ISKU	Kut	311	226	116	296	267	0	0	1216	47.56
ISNA	Najaf	221	313	360	331	357	362	362	2306	90.18
Sum / year		1306	1491	1252	1657	1514	826	760	8806	

4. PROCESS THE DATA

As above mentioned, there is a possibility to process the GNSS observation data by using either (GAPS-PPP) or (CSRS-PPP) free Canadian software. In processing, each software will convert the RINEX observation data to an absolute position of that CORS station in static mode along the specific intervals. Thus, the position of each CORS station will be computed from GNSS data gathered at that station with a single receiver.

4.1 Processing GNSS Data by GAPS Software

GAPS is an abbreviation of "GNSS Analysis and Positioning Software", which was first designed in 2007 and is still managed by the University of New Brunswick (UNB) in Canada **(Leandro et al., 2007)**. This application allows users to process the GNSS observation file(s) that are collected with a single receiver with free online PPP software. The provided position is based on the precise orbit and clock products, which are taken from a trusted source such as the International GNSS Service (IGS). When applying a static mode, the achieved positional accuracy can reach a centimeter-level within the appropriate convergence time.
After logging into the website (http://gaps.gge.unb.ca/) and selecting the "basic mode" of submitting a file, the GNSS observation file can be uploaded. It requires an Email to send the output positioning file of this application. Also, by selecting the GNSS constellation (GPS-only or combined GPS with other systems), it can receive the output file of coordinates. However, the Cartesian geodetic coordinates (X, Y, Z) can be computed for the corresponding observation recorded data of (φ, λ, h) for every 30 sec, the final position along 24h is required. Thus, all available observation files of five CORS sites (i.e. ZAXO, ISER, ISBA, ISNA, and ISKU) are uploaded gradually to the GAPS website and also gradually received the output files. There are no output files after 2019, due to the website was under maintenance. Although the observation files were in mixed systems of GPS and GLONASS, the processing data was for GPS-only because there is no selection for GLONASS in this software.

4.2 Processing GNSS Data by CSRS-PPP Software

Another software in this study is the Canadian Spatial Reference System (CSRS) for PPP solution, which has free services provided by the Natural Resources and Canadian Geodetic Survey. It can process GNSS data of GPS and GLONASS with single or dual frequencies that use either a static or kinematic mode. This application enables the user to perform the PPP solutions.
It requires an Email to send the processed data after entering the main options, which are the mode of processing (static or kinematic), the type of the geodetic frame (ITRF, usually

ITRF2014), and the selection of the RINEX observation file. After that, it is possible to submit to a PPP solution. In post-processing, the software processes the data with an interval of 30 seconds. Therefore, when the continuous daily data are recorded every 30 sec along the day (24h), there are 2880 daily epochs. In this study, for the whole period of seven years, the observation files were uploaded online gradually to have output files from January 2015 to November 2021 for the five CORS sites.

5. RESULTS AND DISCUSSION

After processing the daily observation data either with (GAPS-PPP or CSRS-PPP) software, the precise geodetic coordinate results can be represented for the whole period. Therefore, the time series of each component of coordinates will be generated with MATLAB software. A time series is a set of information recorded at equal intervals and indexed and ordered by time steps.

5.1 Representing the Results as Time Series

The difference in coordinates of each component (Easting, Northing, and up) will be computed to represent the final results of the change in coordinates within time. This can be determined by subtracting the subsequent daily (PPP) solutions at each station from the initial values of that station. Thus, it can evaluate the horizontal component of Easting and Northing and the vertical component of Up coordinate. As the final daily positions are extracted from two different software, the results will have some differences in quality and precision. Consequently, the results of GAPS software (**Fig. 4**) have jumps and outliers due to processing with a single GPS constellation.

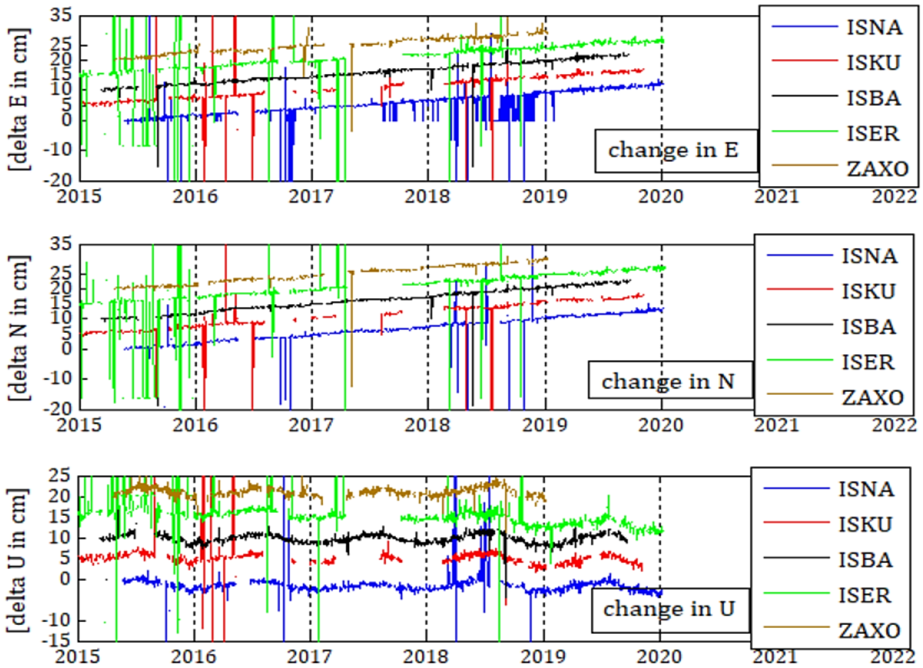

Figure 4. The time series results of change in coordinates of E, N and U components by GAPS software for different 5 CORS sites (with a 5 cm shift between them).

On the other hand, the results of CRCS software are smoother and homogenous (**Fig. 5**) to be more reliable than other software, as a result of processing with combined GPS and GLONASS constellations (**Msaewe et al., 2017 and 2021**). In comparison, the time series of CSRS software shows the results from the duration 1st of January 2015 to the 31st of December 2021, while the duration of GAPS software gave the results from the 1st of January 2015 to the end of 31st of December 2019 for some stations. Therefore, to evaluate the trend of movement, the results of CSRS will adopted. The comparison shows why the results of CRCS are better than the results of GAPS. Also, to have more relevant results as well as not restricted to one software.

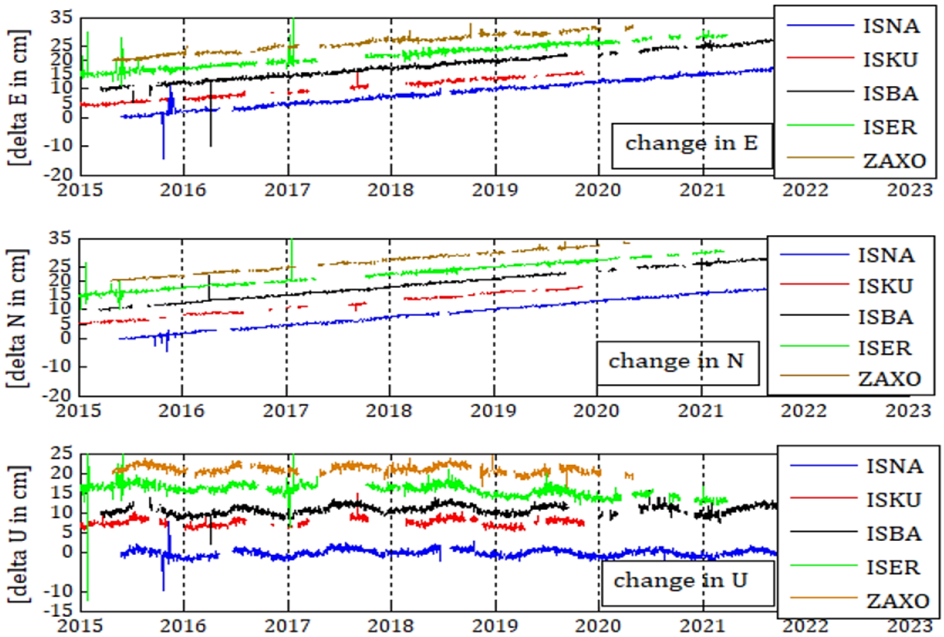

Figure 5. The time series results of change in coordinates of E, N and U components by CSRS software for different 5 CORS sites (with a 5 cm shift between them).

5.2 Discussion of the Trend Analysis of the Change in Coordinates of CORS Sites

According to **Fig. 5**, it is clear that each horizontal component of the Easting and Northing has a linear trend of movement, while the vertical Up component has a wave trend of movement within time.
Based on the difference in horizontal positioning of each CORS site, it can extract the change in their positioning for a long time. Therefore, the processing of GNSS data during the long interval (seven years) will be analysed to detect the trend of movement from the difference in (Easting and Northing) coordinates for all periods of study. Then, analysing the result of the difference in horizontal coordinates between initial and other daily solutions will give an obvious picture of the trend in that period of study.
To estimate the value of yearly change in horizontal coordinate for each CORS site, this required available continuous data along specific years. For this purpose, the year 2016 had the most available data to study the trend of change for all stations as illustrated in **Table 3.**

Table 3. The change in horizontal coordinates for every year at each CORS site.

Years	ZAXO			ISER			ISBA			ISKU			ISNA		
	days	ΔE	ΔN	days	ΔE	ΔN	days	ΔE	ΔN	days	ΔE	ΔN	days	ΔE	ΔN
2015	252	21	17	365	18	28	292	21	21	365	17	29	220	19	18
2016	366	24	27	366	23	25	366	26	29	366	24	28	366	25	29
2017	365	20	27	365	21	22	365	26	28	278	22	19	365	24	29
2018	365	20	22	365	21	26	365	23	30	292	17	25	365	25	30
2019	363	22	29	365	23	21	365	30	24	301	21	22	365	26	26
2020	53	2	2	366	22	27	366	25	27	x	--	--	366	26	28
2021	x	--	--	93	7	7	365	24	27	x	--	--	365	27	27
Interval	1825 days			2287 days			2486 days			1764 days			2414 days		
∑ΔE	109 mm			135 mm			175 mm			101 mm			172 mm		
∑ΔN	124 mm			156 mm			186 mm			123 mm			187 mm		
E./yr.	23 mm			22 mm			25 mm			22 mm			27 mm		
N./yr.	26 mm			25 mm			27 mm			27 mm			28 mm		

It is clear from **Table 3** that the change in horizontal coordinates in the year 2016 fluctuated from 23 to 26 mm for the Easting component, while it was within 25 to 29 mm for the Northing component. Also, the change in the Northing component was greater than the Easting component within 2-4 mm. for each station at any year. For other years, it can estimate the value of change based on the available data along a specific period and compute the change between the initial and final solution at this period. In addition, it can analyse the trend of change for the whole period. Thus, the mean yearly change in horizontal components was within 22-27 mm. The trend of the movement in horizontal coordinates for CORS stations agrees with the trend of the movement of horizontal motion for the tectonic plate in the Arabian area **(Isawi et al., 2022)**. To illustrate the above results of **Table 3** in visual form for the whole period to have an obvious interpretation. For example, it can explain the trend of movement in a specific station as given in **Fig. 6**, which shows the results of the ISBA station of the most available data.

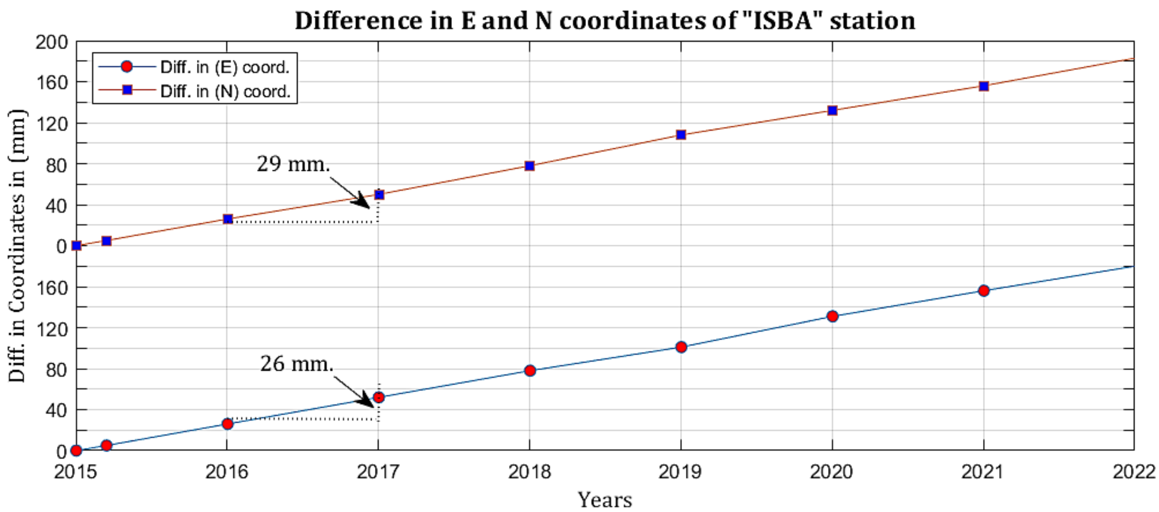

Figure 6. The trend of difference in E and N coord. for ISBA site along 7 years

From the above figure, it is obvious that the trend is linear and the change value in 2016 was 24 and 26 mm for Easting and Northing respectively. In the same way, it can illustrate the trend of movement in any other station as well as, it is possible to compare the trend for all stations as given in **Fig. 7**, which shows the comparison between the movement in the Easting component of all five stations.

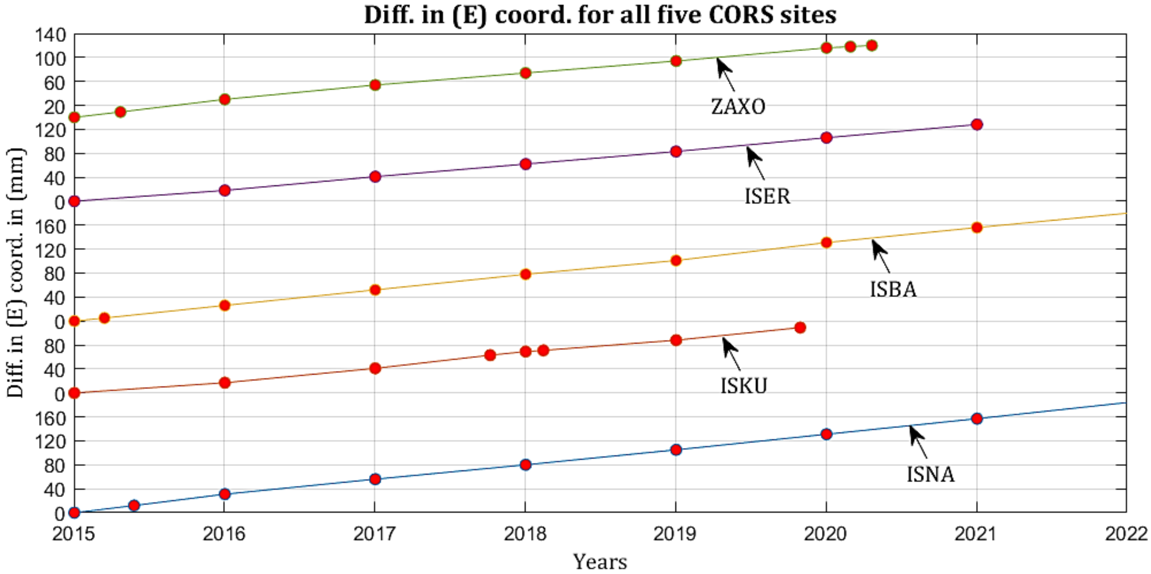

Figure 7. The trend of difference in E component for each CORS site along the whole period

6. CONCLUSIONS

The purpose of this study is to check the availability of GNSS data for a long period (seven years duration from the 1st of January 2015 to the 31st of December 2021) to determine the trend of change in positions of CORS sites of the Iraqi Geodetic Network, it was found that the available data was restricted only to five stations from a summation of seven stations. Furthermore, the available data was discontinuous. However, the assessment of movement gives vital results. Based on the processing of data using free software (i.e. GAPS and CSRS) for the PPP solution, it was found the combined solution of GPS and GLONASS gives smoother and more homogenous results than the GPS-only solution. When analyzing the trend of each horizontal component of the Easting and Northing, it was found that both components have a linear trend, while the vertical Up component has a wave trend of movement within time. The change in horizontal coordinates in the year 2016 fluctuated from 23 to 26 mm for the Easting component, while it was within 25 to 29 mm for the Northing component. Also, the change in the Northing component was greater than the Easting component within 2-4 mm. for each station at any year. Thus, the mean yearly change in horizontal components was within 22-27 mm. The trend of the movement in horizontal coordinates for CORS stations agrees with the trend of the movement of horizontal motion for the tectonic plate in the Arabian area. This change gives a clear interpretation of the impact of different geophysical phenomena (e.g. tectonic plate motion) on the stability of positions within time.

Credit Authorship Contribution Statement

Hussein Alwan: Writing the original draft review & editing, with creating all the plots or Figures. Ehssan Ali collected the data and worked on the Software.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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تقييم بيانات الGNSS التي تم جمعها في المحطات المرجعية العاملة بشكل مستمر (CORS) للشبكة الجيوديسية العراقية

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الخلاصة

تحتوي شبكة محطة التشغيل المرجعية المستمرة (CORS) على عدة محطات تقوم بجمع وتسجيل البيانات من مجموعات النظام العالمي للملاحة عبر الأقمار الصناعية (GNSS). تعمل هذه المحطات بشكل مستمر بطريقة آلية للتعاون والتفاعل مع مختلف المستخدمين لخدمات تحديد المواقع. في هذه الدراسة، تم تقييم بيانات GNSS المجمعة في خمسة مواقع CORS تابعة للشبكة الجيوديسية العراقية لتحديد ما إذا كانت هناك أي تغييرات كبيرة في مواقع هذه المحطات لفترة طويلة. ويعطي هذا التغيير تفسيرا واضحا لتأثير الظواهر الجيوفيزيائية المختلفة (مثل حركة الصفائح التكتونية) على استقرار المواقع خلال الزمن. لذلك، تم تحليل البيانات المجمعة في محطات ZAXO وISER وISBA وISKU وISNA لمدة سبع سنوات 2015 – 2022 (أي من 1 يناير 2015 إلى 31 ديسمبر 2021). يمكن حساب الموقع اليومي لكل محطة من بيانات التسجيل على مدار 24 ساعة بمعدل 30 ثانية باستخدام برنامج GAPS أو CSRS المجاني لتحديد المواقع بدقة (PPP). وبذلك تم استخدام 8806 ملف مراقبة يومي. تم تمثيل البيانات المعالجة كسلسلة زمنية بإحداثيات الشرق والشمال والأعلى لكل محطة لتحليل اتجاه الحركة في هذه المحطات. وقد وجد أن التغير في إحداثيات الشرق والشمال له اتجاه خطي، وهو ما يتوافق مع الاتجاه العام للحركة التكتونية في هذا الجزء من العالم. وكان متوسط التغير السنوي في حدود 22–27 ملم. من ناحية أخرى، فإن التغير في الإحداثي الأعلى مع الزمن كان له تغير متقلب مع مرور الوقت "سلوك موجي" أو أظهر اختلافات دورية.

الكلمات المفتاحية: المحطات المرجعية للتشغيل المستمر، الشبكة الجيوديسية العراقية, بيانات النظام العالمي للملاحة بالأقمار الصناعية, الموقع النقطي الدقيق.