Getting Started with KSA-CORS Network

JULY, 2024
Version 2.0

DOCUMENT IDENTIFICATION SHEET

DOCUMENT DESCRIPTION	
Document Title Getting Started with KSA-CORS Network	
Subject An Introductory guide for users who are new to the KSA-CORS network. The document covers the overview the network, account registration and access, products and services, and connecting to real-time services.	
Keywords GNSS, Positioning, KSA-CORS, KSA, VRS, RTK, NRTK, DGNSS	
Version	**2.0**

DOCUMENT HISTORY		
Date	**Version**	**AMENDMENTS**
Dec 2020	1.0	New document
Jul 2024	2.0	– Updated agency acronym and logo. – Updated responsible directorate name. – Updated KSA-CORS registration process. – Included online post-processing hands-on user guide. – Updated images and new services. – Updated links to FAQ.

Table of Content

1. Introduction

The Kingdom of Saudi Arabia Continuously Operating Reference Station (KSA-CORS) network is operated by the General Authority for Survey and Geospatial Information (GEOSA). The network currently consists of over 200 active CORS, with new stations constantly expanding. This user guide will guide you through the process of registering for a KSA-CORS account and using the network's online products and services.

The aim of the KSA-CORS network is to provide a reliable and accurate Kingdom-wide GNSS positioning service. One of the objectives of the network is to create, distribute and maintain a national geodetic reference frame called KSA-GRF17.

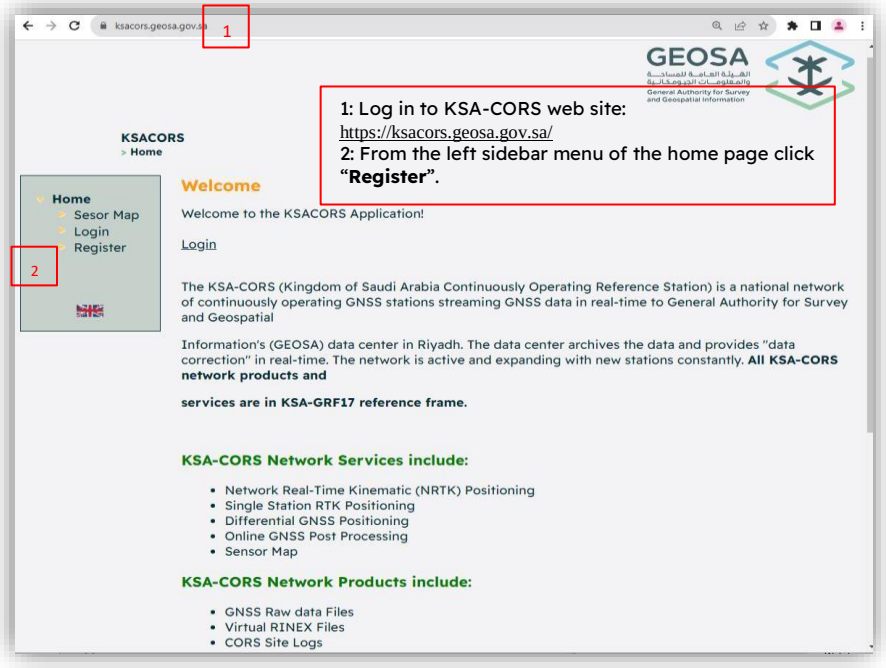
ENQUIRY	
Telephone	920000427 | Ext: 8009
Fax	4647693
Web site	https://ksacors.geosa.gov.sa
Technical Support	KSA-CORS@geosa.gov.sa

2. KSA-CORS Registration

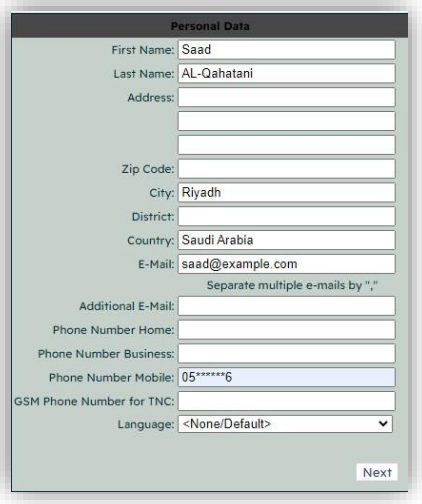
To get started, you will need to register an create and account for the KSA-CORS network, you need to:

1. Create a KSA-CORS Network Account
   - Visit KSA-CORS website at https://ksacors.geosa.gov.sa.
   - Click on the Register button on the left sidebar menu of the page to start the registration

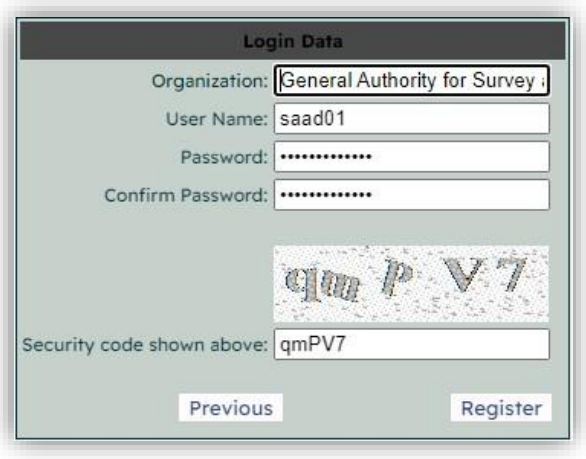
process as shown in the image below



- Complete the following **mandatory fields** to get your registration approved:



- First Name
- Last Name
- Address
- City
- E-mail
- Phone Number



• Click **Next** to continue the registration process in the Login Data page.

Complete the following requirements as shown above:

○ **Organization Name**: Please provide the **FULL** organization name. For example, "General Authority for Survey and Geospatial Information" is a **complete** organization name, while "GEOSA" is not. ○ Username

○ Password

• Lastly enter the security code and click Register.

NOTE:

- Please note that the above information is mandatory to get a KSA-CORS account.
- The KSA-CORS Administration Team will review the request for completeness before approval.
- After approval, the Internet Protocol (IP) and port number for configuration will be sent to the user by email.

3. KSA-CORS Services

The KSA-CORS network provides a number of positioning services in real-time basis described in the following points

1. Network Real Time Kinematic (NRTK) Positioning

The KSA-CORS network provides a real-time positioning service called Network RTK. This service uses a network of reference stations to provide accurate and reliable positioning data to users. The data stream is available via the internet. Network RTK can be used in a variety of applications, including topographic mapping, construction, machine guidance, surveying, navigation, monitoring, and many other applications.

2. Single Station RTK Positioning

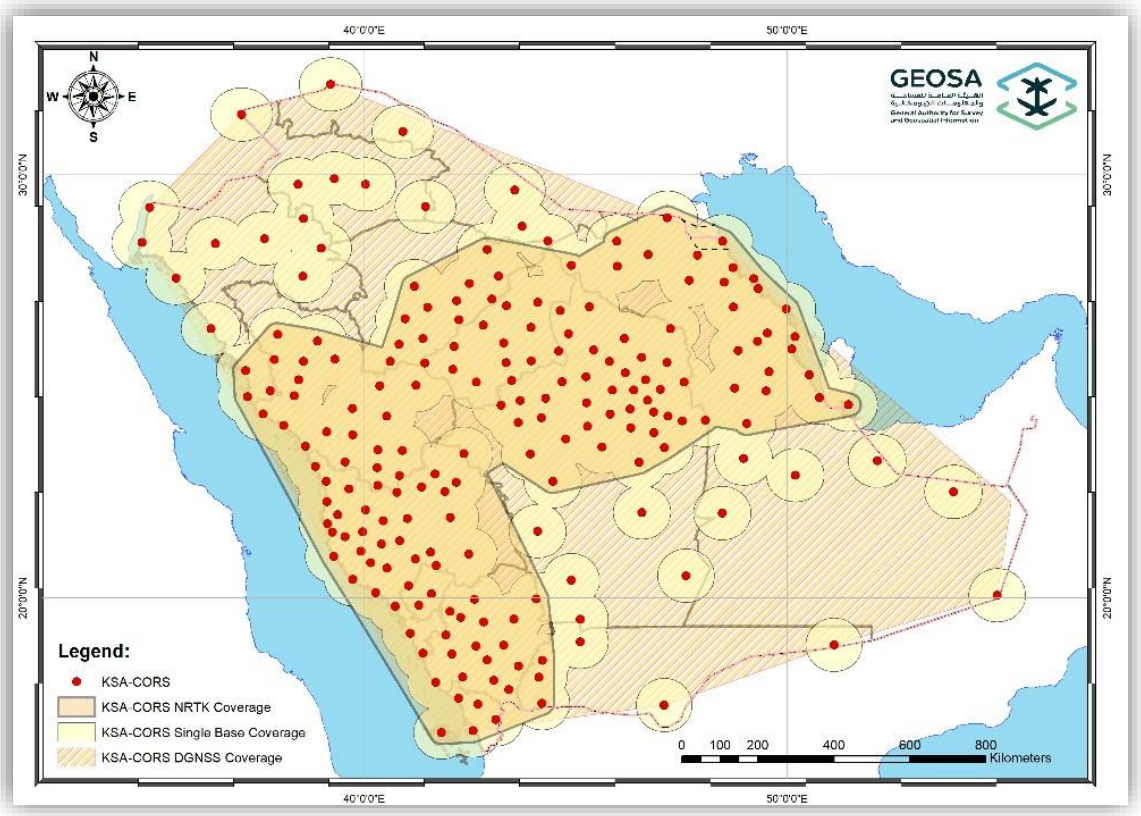
The Single station RTK service is dedicated for use in areas where no network RTK service is available. Due to the RTK technology limitation, its accuracy is strictly limited to the distance from the closest CORS, and this distance is getting shorter mostly within higher ionosphere activity. Single station RTK campaign from more distance from the

CORS is also possible, however it requires from the end user to be aware of the limitation and to conduct additional quality checks and accuracy estimation (e.g. on local or established benchmark points).

3. Differential GNSS (DGNSS) Positioning

The KSA-CORS network produces the DGNSS correction data stream to users by means of the KSA-CORS NTRIP server. Users can obtain the DGNSS correctional data stream via the internet. DGNSS are not as accurate as NRTK corrections. The service can be applied in navigation (land and sea), fleet management, mobile GIS systems among others. DGNSS corrections are available in more areas than NRTK corrections within the kingdom.

The image below shows all GNSS CORS real-time services coverage.



Real-Time Network Coverage Map

4. Online Post Processing Service

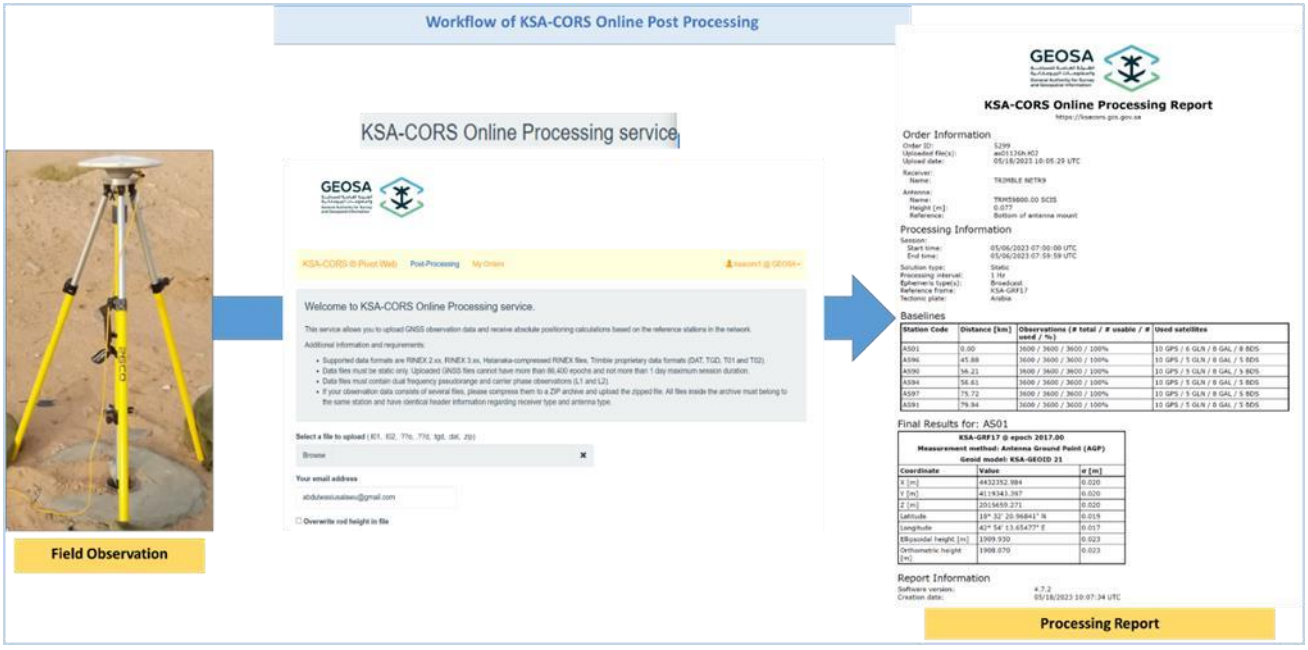
The KSA-CORS network offers an innovative web-based service that enables users to upload their field observation data to our system and receive precisely calculated positions in the national reference frame.

The data processing is done with multiple KSA-CORS stations. This user manual will guide you through the simple and streamlined workflow of our online post-processing

tool, enabling you to generate detailed reports and download your data in either XML or PDF formats.

Why should you use KSA-CORS Online Post-Processing?

Real-time kinematic solutions may not always be feasible or sufficient for certain applications, especially those requiring high accuracy. The KSA-CORS online postprocessing service provides reliable and precise positioning even in areas with limited or no real-time correction availability. The system has a user-friendly interface makes it easy to use, even for those without extensive scientific GNSS processing knowledge. The image below illustrates the workflow of the KSA-CORS online post-processing service.



Online Post-Processing Service Workflow

5. KSACORS Sensor Map

The KSA-CORS web sensor map is the certified source for acquiring coordinate values for SANSRS active monuments throughout the Kingdom. The sensor map can be found on the KSA-CORS website. This service enables users to view coordinates and ellipsoidal heights in SANSRS. Other information includes health status pertaining to each specific CORS, and each CORS location picture. This tool also provides users with historical data information from storage.

4. KSA-CORS Products

1. GNSS Raw Data File

The KSA-CORS network offers GNSS raw data files, which are available in different formats such as RINEX (Receiver Independent Exchange Format) versions 2.10, 2.11,

3.02, and 3.03, as well as Trimble raw data formats like T02, T01, DAT, and TGD binary formats. These raw data files can be used for post-processing by computing 3D baselines (ΔX, ΔY, ΔZ) using GNSS raw data from the user's rover receiver.
One advantage of using the KSA-CORS network is that users do not need to have their own base station running. Instead, they can set up their GNSS receiver at the survey site and download the raw data either from the KSA-CORS website for their specific observation time or from a virtual reference station near their survey site. This product allows users to perform static surveys in remote locations where the KSA-CORS network or mobile communication coverage may not be available.
The precise coordinates for each CORS are available in all formats of the downloadable raw data files.

2. Virtual RINEX File

A Virtual RINEX file is a file that has not been measured by a receiver but has been computed from a real-time network model. KSA-CORS network generates Virtual RINEX files from KSA-CORS observations using interpolation methods. These files can be generated for any point within KSA-CORS real-time network coverage, allowing users to simulate a reference station at their working location as long as it is within the NRTK coverage. A virtual RINEX file is a software-generated file that imitates the functionality of a real RINEX file but contains only simulated data.

3. CORS Metadata

Site log files are available for each KSA-CORS station. This file contains all the historical equipment (receiver/antenna) used at that station, approximate location, and owner and operating agency, among other information. The site log should be requested by email through info@geosa.gov.sa.

5. Requirements to use KSA-CORS RTK services

1. A KSA-CORS Network Account 2. A GNSS Receiver

NOTE: A GNSS receiver capable of supporting NRTK is required to receive the correction data and compute the final position solution. The KSA-CORS network transmits GNSS corrections in the RTCM 3.x and 2.3 formats. Your rover receiver should be capable to receive GNSS corrections in the non-proprietary RTCM 2.3 or 3.x formats used by the KSA-CORS to transmit GNSS corrections.

3. Internet Connection

A stable and fast internet connection is crucial for seamless service delivery. Ensure that the area where you will be conducting your survey has adequate internet data coverage.

Choose an internet provider based on the best data internet coverage at your project location. We recommend selecting a provider offering unlimited data service over fixed bandwidth. There are two primary ways to establish an internet connection for KSACORS RTK services:

a. Wi-Fi hotspot
- Many GNSS receivers are capable of connecting to Wi-Fi networks.
- Multiple GNSS units can use the same Wi-Fi device.
- Consult your GNSS receiver manufacturer or local support in KSA for additional information.

b. Internet Modem
- You will require a data service contract.
- Select your preferred provider (such as STC, Zain, Mobily etc.) based on the best data internet coverage at your project location.

4. Configuring your Rover Receiver for Using the KSA-CORS Correction Services:
To utilize the KSA-CORS correction services, follow these steps to configure your rover receiver:

a. Configure Receiver Settings

To connect to the KSA-CORS correction service, enter the following settings into your rover receiver:

Settings	***Value***
Hostname or IP:	ksacors.geosa.gov.sa
TCP/IP Port:	2101
Username: **Password:**	Your Username = Organization Name/Username Your Password
Access Point Name (APN):	Check the APN setting with the service provider if you are inserting a SIM in the GNSS receiver. OR Just connect your receiver to a Wi-Fi.
Mount Point	a. NRTK_VRS_KSAGRF17_RTCM_3 b. NEAREST_RTK_KSAGRF17_RTCM_3 c. NDGPS_VRS_KSAGRF17_RTCM_2
Real-time Network Correction Type/Model	Virtual Reference Station (VRS) concept

b. Contact Your Receiver Local Support (Optional)

If you have limited knowledge in GNSS receiver configuration, we recommend consulting your local support in the Kingdom for assistance. They can guide you through the process and provide personalized support.

c. Selecting a mount point

A **mountpoint** is a set of parameters that define the characteristics of a GNSS correction stream. These parameters include the type of processor used, the satellite constellations supported, the format of the correction messages, and the reference frame that relates to the data stream.
When connecting to KSA-CORS real-time network, a mount point list is generated for users to select from.
The following options are available when using the KSA-CORS network.

Mountpoint	Mount Point Names	Explanation
RTCM 3.1	NRTK_VRS_KSAGRF17_RTCM_3_1	Carrier and Code differential corrections from a network of CORS for high precision NRTK type application. This format supports GPS and GLONASS satellites and provides NRTK data stream optimized for the user's location
RTCM 3.1	NEAREST_RTK_KSAGRF17_RTCM	Carrier and Code differential corrections from a single CORS for high precision NRTK type application
RTCM 2.3	NDGPS_VRS_KSAGRF17_RTCM_2_3	This mountpoint provides a sub-meter differential solution optimized for the user's location.

6. KSA-CORS Web Instructions

The webpage for KSA-CORS network products and services is available at the following URL: https://ksacors.geosa.gov.sa/ .

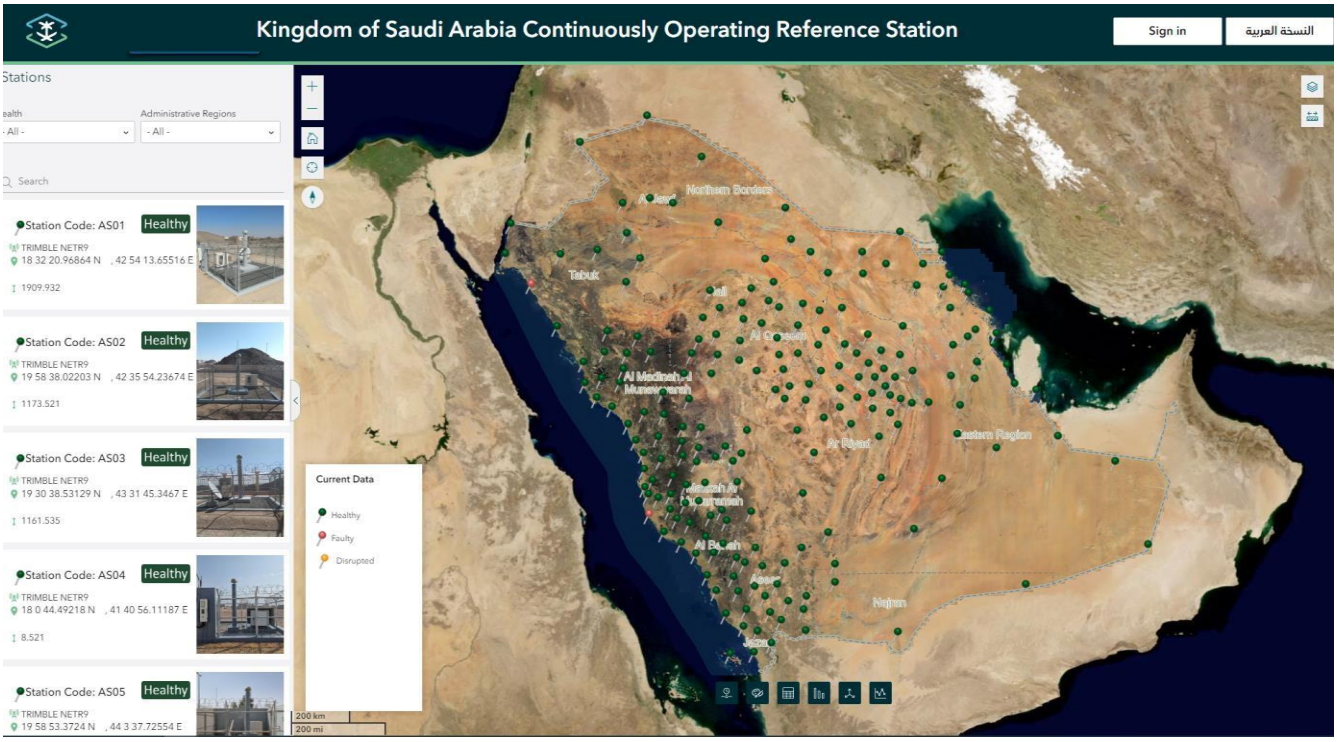
1. Home Page

The home page of the KSACORS website provides an overview of the KSA-CORS network and its offerings. It also provides downloadable resources such as this document "Getting Started with KSA-CORS Network" guide and a list of KSA-CORS stations' approximate locations. It also provides information on how to contact the KSACORS team for technical support.

2. Logged out of Environment

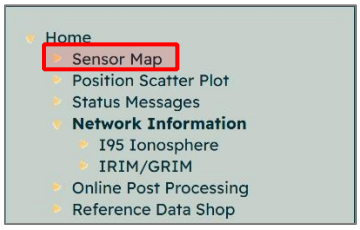
To login to KSA-CORS network, you are required to enter your Organization name, User name and Password you received through e-mail.

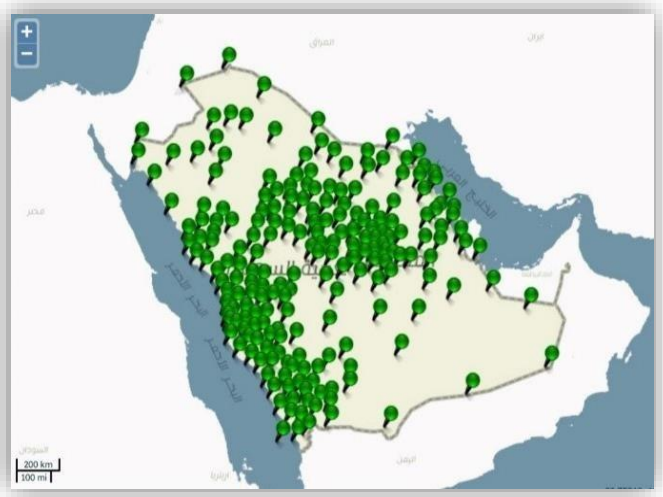
When you click Sensor Map in the Logged-Out Environment, it shows you the KSA-CORS network distribution, station photographs, you can also measure distances between places of interest.



To Register or Logging, click the Sign-in button at the top right corner.

3. Logged-In Environment – Sensor Map

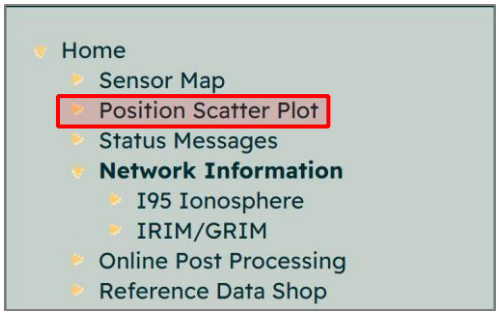


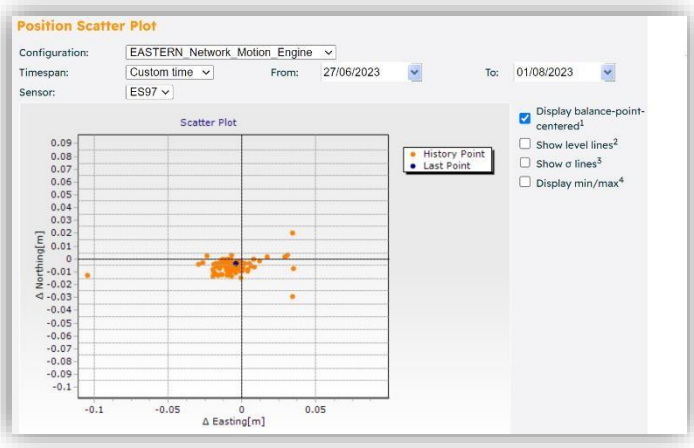


The Sensor Map allows the user to visualize live update of KSA-CORS geographic distribution, health status, data availability and CORS receiver type.

The user can click on a CORS on the sensors to display more information such as station health and storage status. Station pictures can also be viewed from the Sensor map.

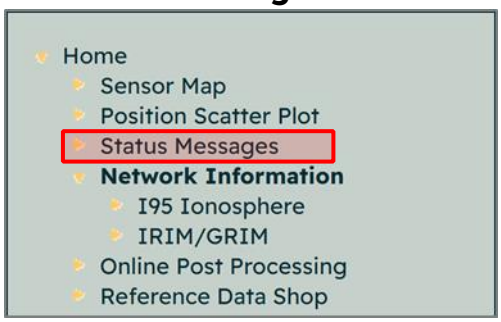
4. Position Scatter Plot





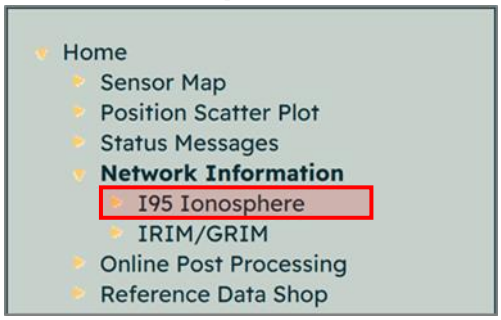
The **Position Scatter** Plot displays horizontal errors as a Northing vs. Easting scatter plot. This interactive tool lets users check 2D position of a station over time. Users can zoom in and out by dragging a binding box around the area of interest. Start from Top Left to Bottom right to zoom in and the other way around to zoom out.

5. Status Messages

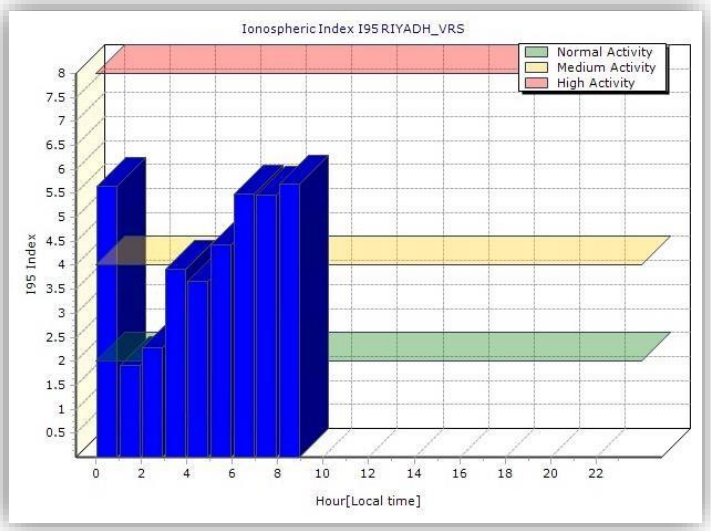


The **Status Messages** on the KSA-CORS web provides important information about the health and performance of the CORS network, as well as any upcoming maintenance or announcements. By regularly checking the status messages, users can ensure that they are always up to date on the latest information about the KSA-CORS network and can take appropriate action if necessary.

6. I95 Ionosphere

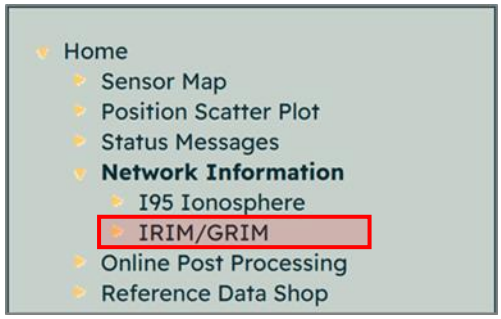


The I95 Ionosphere link in the KSA-CORS website generates the Index 95 charts (ionospheric model) based on 3 regions within the kingdom. The I95 index is the 95th percentile of all ionospheric residuals across all stations over a period of one hour and is in units of PPM.

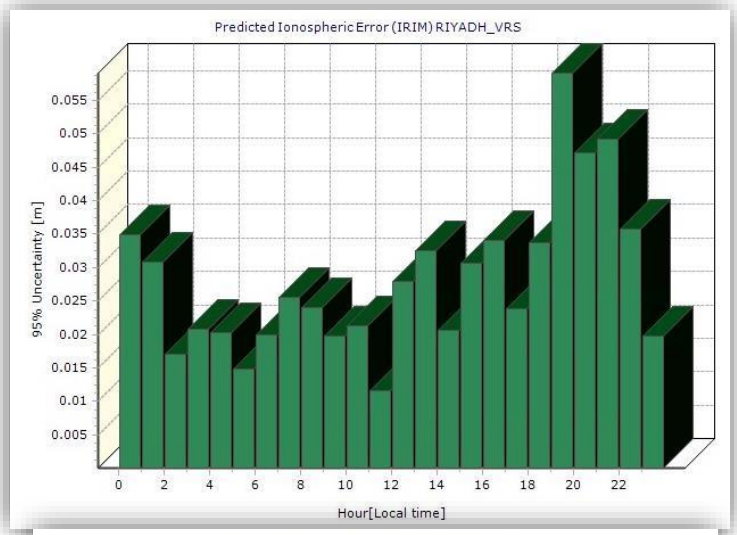


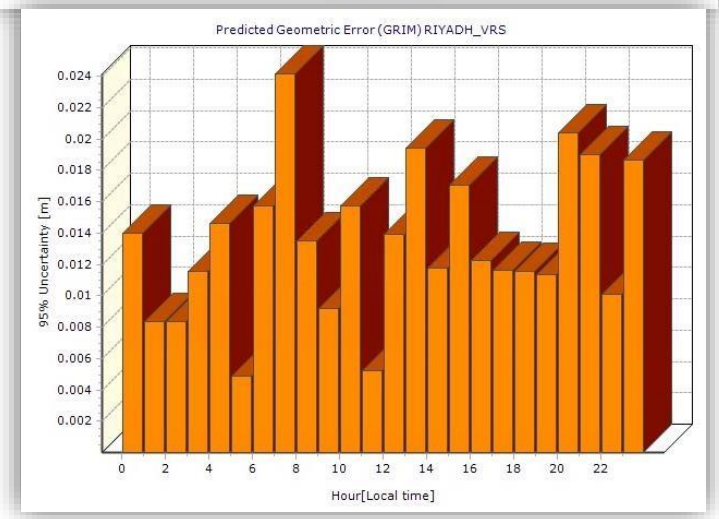
The information reflects the intensity of the ionospheric activity, i.e., the expected influences onto the relative GNSS positions. It includes both current and historical I95 activity. The plot on the left shows the ionospheric model for Riyadh region.

7. IRIM/GRIM



The **Ionospheric Residual Integrity Monitoring (IRIM)** index indicates by how much the ionospheric delay differs from a linear spatial variation.





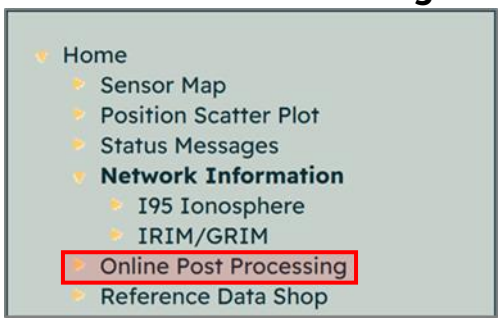
IRIM

Under disturbed ionospheric conditions, ionospheric residuals cannot be considered as linear. It is computed by differencing ionospheric delays measured at a station with the delays modeled with that station removed from the network. Reported values represent the 95th percentile of the weighted RMS residual values accumulated over a one-hour period in units of meters. Network-wide IRIM values are also accumulated.

GRIM

The Geometric Residual Monitoring index (GRIM) analogously represents the 95th percentile of geometric residuals. GRIM is calculated by taking the average of the geometric residuals of all the stations in the network. A lower GRIM value indicates a betterquality network.

8. Online Post Processing

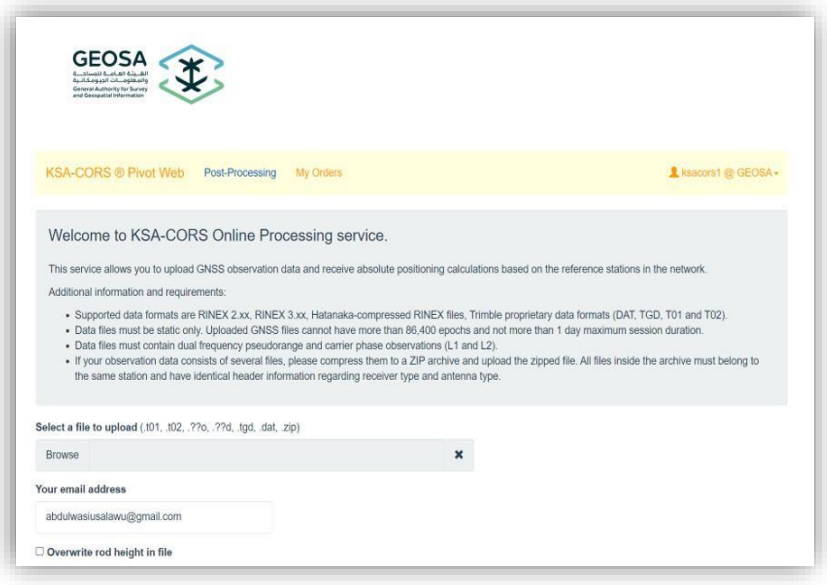


Click on the Online Post Processing to go to a new page that allows you to upload GNSS observation data and receive absolute positioning calculations based on the reference stations in the KSA-CORS network. The service uses GPS, GLONASS and Galileo satellite data in processing.

Supported data formats are RINEX 2.xx, RINEX 3.xx, Hatanaka-compressed RINEX and Trimble proprietary data formats (T02, T01, TGD and DAT). Data to be submitted to the system MUST be static only and the files cannot have more than 86,400 epochs and not more than 1-day maximum session duration. The files must contain dual frequency pseudo range and carrier phase observations (L1 and L2). If your observation data consists of several files, please compress them to a ZIP archive and upload the zipped file. All files inside the archive must belong to the same station and have identical header information regarding receiver type and antenna type. The user interface is clicking the **Browse** button and select a GNSS file to upload.

Enter your E-mail. If you have a precise antenna height recorded for your file, check the button next to **Overwrite rod height in file** to add the height of antenna reference point.

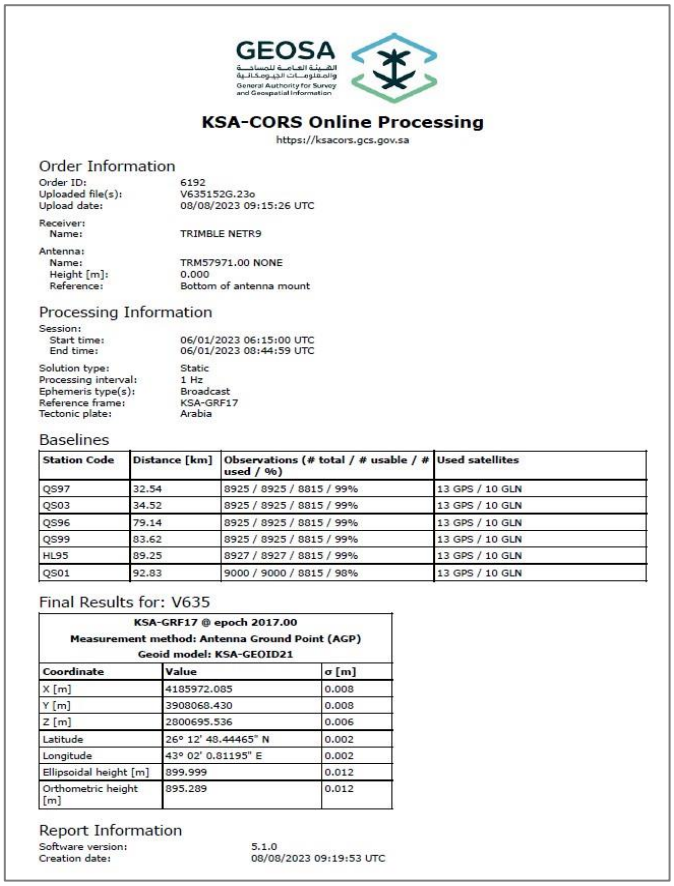
Click Submit to start the processing.



If you click **My Orders** link in the header menu you will find a list of your Orders in Progress and Processed Orders.

- The processing solution datum is KSA-GRF17.0. The coordinates in KSA-GRF17.0 are referenced to the Earth's center of mass at January 1, 2017, 00:00:00 UTC.

- The system automatically sends the processing report in PDF to the user's registered email as shown below.



GEOSA

KSA-CORS Online Processing

https://ksacors.gcs.gov.sa

Order Information

Order ID:	6192
Uploaded file(s):	V635152G.23o
Upload date:	08/08/2023 09:15:26 UTC
Receiver:	
Name:	TRIMBLE NETR9
Antenna:	
Name:	TRM57971.00 NONE
Height [m]:	0.000
Reference:	Bottom of antenna mount

Processing Information

Session:	
Start time:	06/01/2023 06:15:00 UTC
End time:	06/01/2023 08:44:59 UTC
Solution type:	Static
Processing interval:	1 Hz
Ephemeris type(s):	Broadcast
Reference frame:	KSA-GRF17
Tectonic plate:	Arabia

Baselines

Station Code	Distance [km]	Observations (# total / # usable / # used / %)	Used satellites
QS97	32.54	8925 / 8925 / 8815 / 99%	13 GPS / 10 GLN
QS03	34.52	8925 / 8925 / 8815 / 99%	13 GPS / 10 GLN
QS96	79.14	8925 / 8925 / 8815 / 99%	13 GPS / 10 GLN
QS99	83.62	8925 / 8925 / 8815 / 99%	13 GPS / 10 GLN
HL95	89.25	8927 / 8927 / 8815 / 99%	13 GPS / 10 GLN
QS01	92.83	9000 / 9000 / 8815 / 98%	13 GPS / 10 GLN

Final Results for: V635

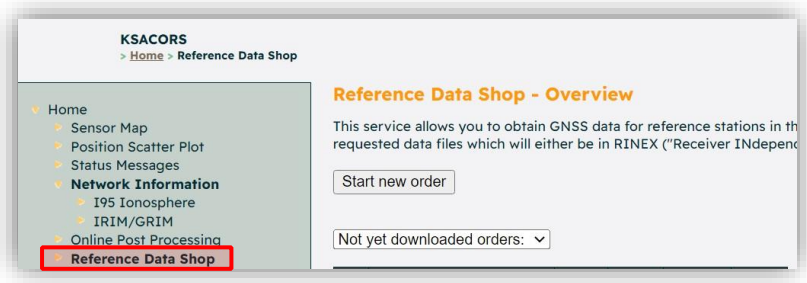
KSA-GRF17 @ epoch 2017.00 Measurement method: Antenna Ground Point (AGP) Geoid model: KSA-GEOID21		
Coordinate	**Value**	**σ [m]**
X [m]	4185972.085	0.008
Y [m]	3908068.430	0.008
Z [m]	2800695.536	0.006
Latitude	26° 12' 48.44465" N	0.002
Longitude	43° 02' 0.81195" E	0.002
Ellipsoidal height [m]	899.999	0.012
Orthometric height [m]	895.289	0.012

Report Information

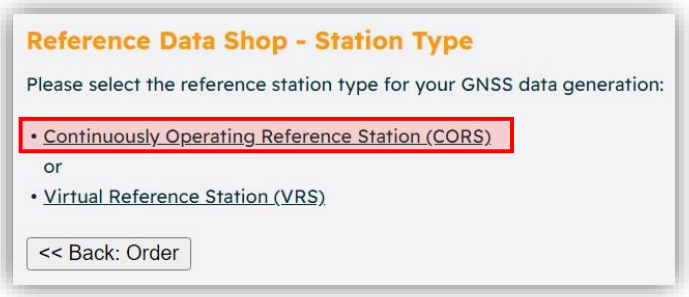
Software version:	5.1.0
Creation date:	08/08/2023 09:19:53 UTC

9. Reference Data Shop (RDS)

The Reference Data Shop (RDS) is where user can access archived GNSS data files in RINEX format or in a number of other formats.

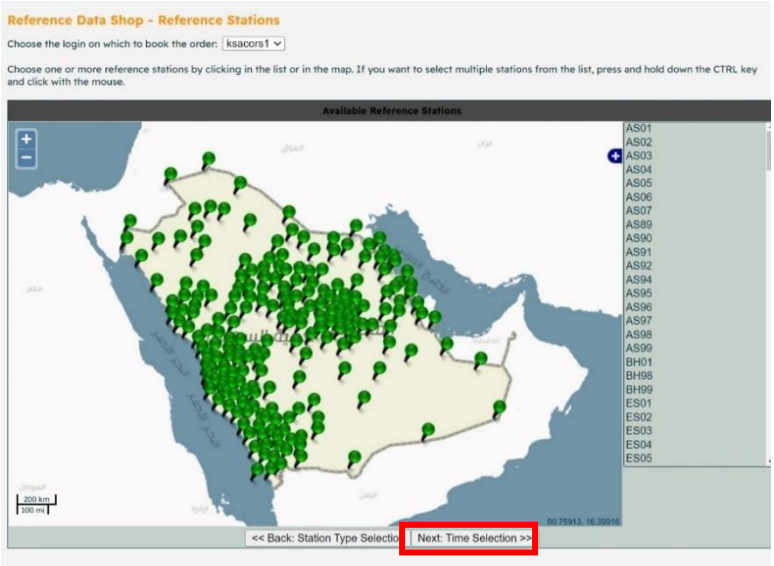


The first time a user accesses the RDS, he will be asked to start a new order. After that, the user will be given the options of choosing to **View/submit order**, **add order** items or **Cancel** order. The user can also view a list of orders not yet downloaded and already downloaded orders.

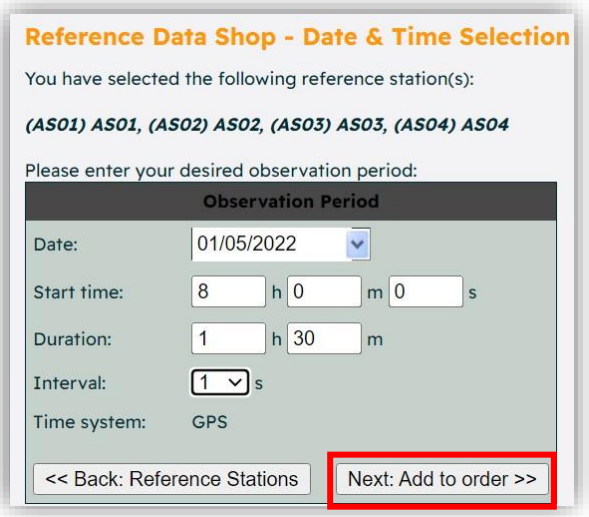


When ordering data, the user is given the option of ordering **Continuously Operating Reference Station (CORS)** data or **Virtual Reference Station (VRS)** data. CORS data is the data observed at the KSA-CORS sites while VRS data is virtual data generated for a user specified location within the virtual reference network.

– **Using Continuously Operation Reference Station (CORS) for data download**

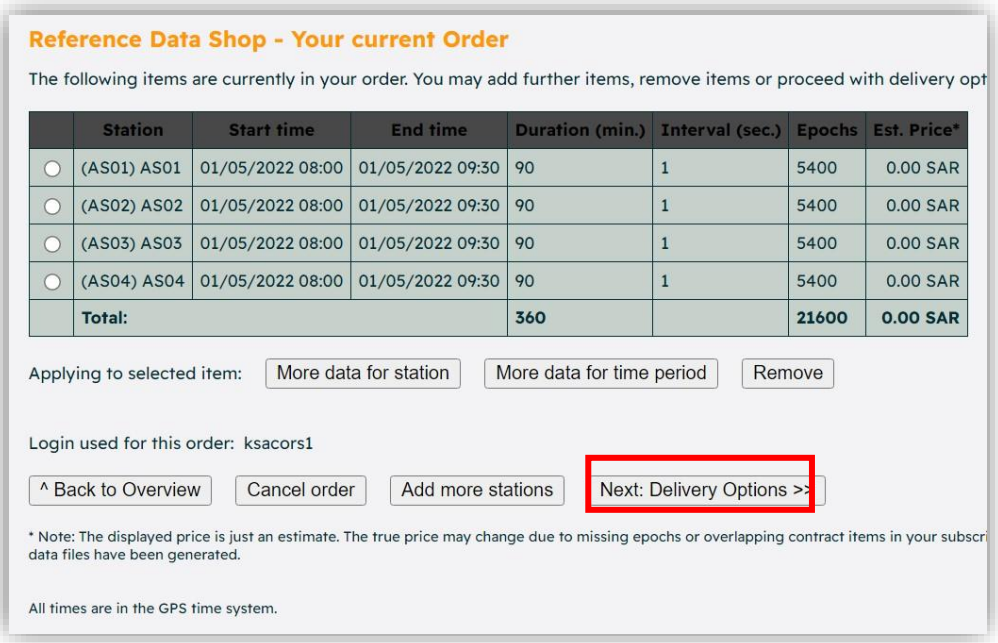


When selecting the CORS Stations for which a user would like to download the data, the user can either select one or many stations from the list or select them by clicking on the map. Once the selection is complete, click **Next: Time Selection**.

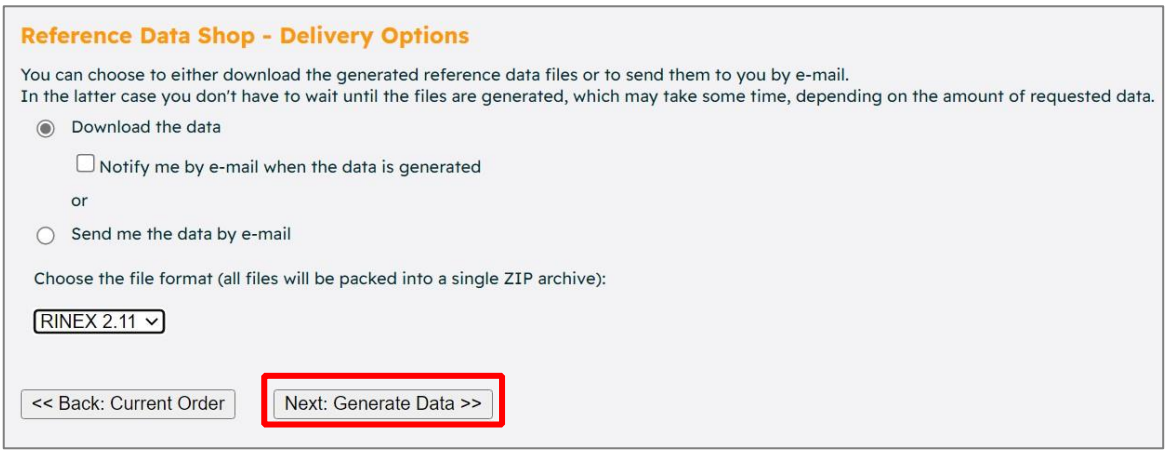


Select the **date**, **start time** , **duration** and **interval**. **NOTE**: Please note that the time system used is GPS time (GMT) and not Saudi Arabia Standard Time. The user will need to subtract three hours from Saudi Arabia Standard Time to determine the appropriate GPS time.

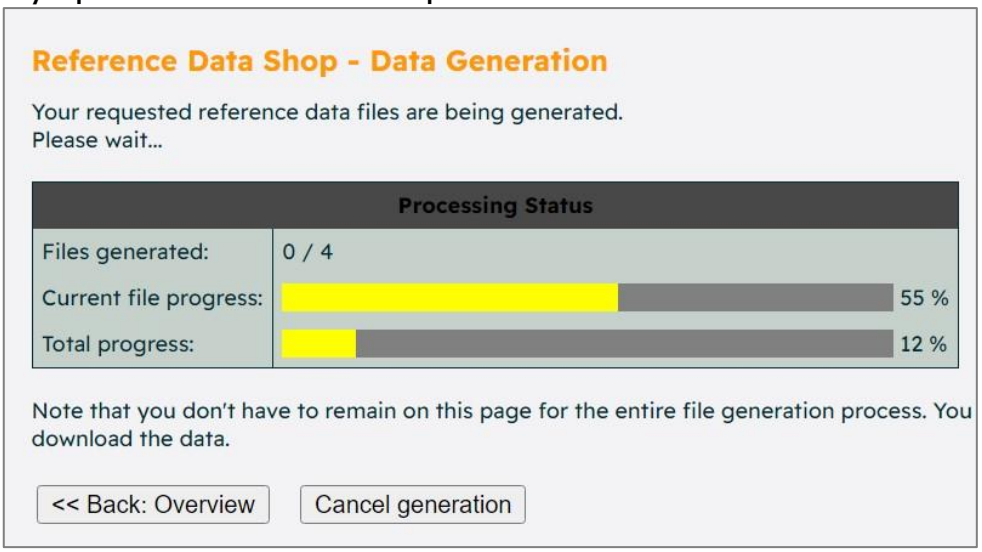
Once your Time Selection details are complete, click **Next: Add to order**



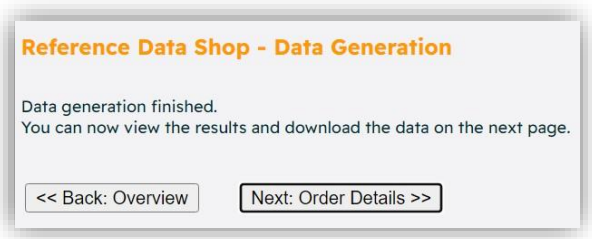
Here the user can either select to add additional order items through a number of options. The service is currently free of charge. Once your order is complete, click **Next: Delivery Options**



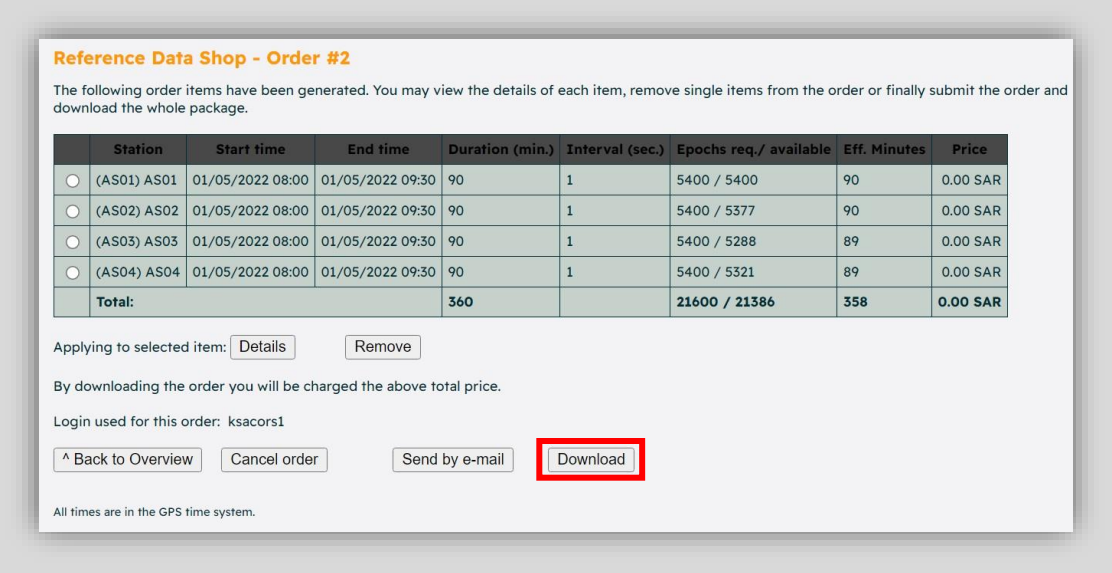
The user has the choice of downloading the data in a number of formats. These are RINEX 2.11, RINEX 3.2, DAT, TGD, T01 and T02. In addition, you have the option to download the data directly on your desktop or be sent to you through e-mail. When your delivery options selection is complete click **Next: Generate Data**



A table indicating the **Processing Status** of the order will appear. You can close this screen and the data generation will continue. For big orders, it may be preferable to return later to retrieve the data once this generation is completed.



Once the data generation is complete, click on **Next: Order Details**.



Reference Data Shop - Order #2

The following order items have been generated. You may view the details of each item, remove single items from the order or finally submit the order and download the whole package.

	Station	Start time	End time	Duration (min.)	Interval (sec.)	Epochs req./ available	Eff. Minutes	Price
○	(AS01) AS01	01/05/2022 08:00	01/05/2022 09:30	90	1	5400 / 5400	90	0.00 SAR
○	(AS02) AS02	01/05/2022 08:00	01/05/2022 09:30	90	1	5400 / 5377	90	0.00 SAR
○	(AS03) AS03	01/05/2022 08:00	01/05/2022 09:30	90	1	5400 / 5288	89	0.00 SAR
○	(AS04) AS04	01/05/2022 08:00	01/05/2022 09:30	90	1	5400 / 5321	89	0.00 SAR
	Total:			**360**		**21600 / 21386**	**358**	**0.00 SAR**

Applying to selected item: Details Remove

By downloading the order you will be charged the above total price.

Login used for this order: ksacors1

^ Back to Overview | Cancel order | Send by e-mail | Download

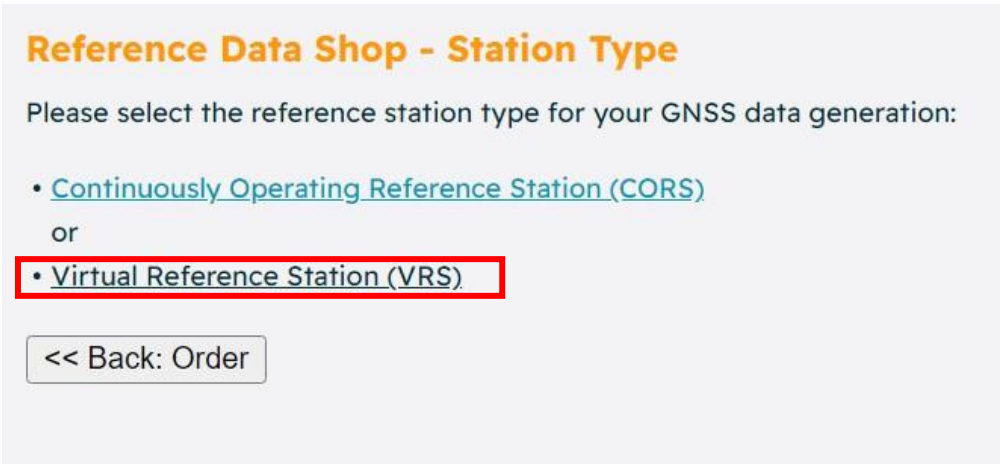
All times are in the GPS time system.

Here you will see a summary of the order including the completeness of the data. **Select** an order item and click on **Details** to see further information. Click on **Remove** to **delete** an order item from the list. Click on **Download** to retrieve the data.

The data will be delivered in a compressed zip file at the lower left corner of your screen. Within the zip file, the user will find three RINEX files: the observation file, GPS navigation file and the GLONASS navigation file. You will also find a text file, which summarizes the data ordered including the completeness of the data.

– **Using Virtual Reference Station (VRS) RINEX to create RINEX**

Virtual Reference Station (VRS) RINEX can be generated within the area for KSA-CORS Network RTK. Users are advised to test VRS RINEX to determine whether it is appropriate for their application.



Reference Data Shop - Station Type

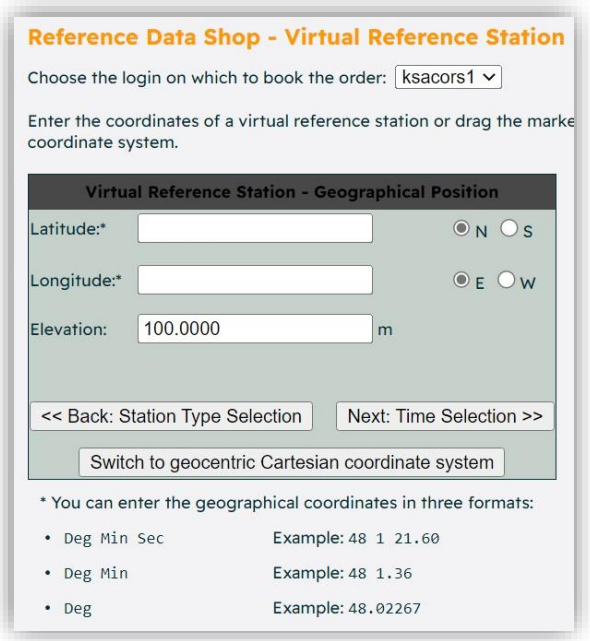
Please select the reference station type for your GNSS data generation:

- Continuously Operating Reference Station (CORS)

or

- Virtual Reference Station (VRS)

<< Back: Order



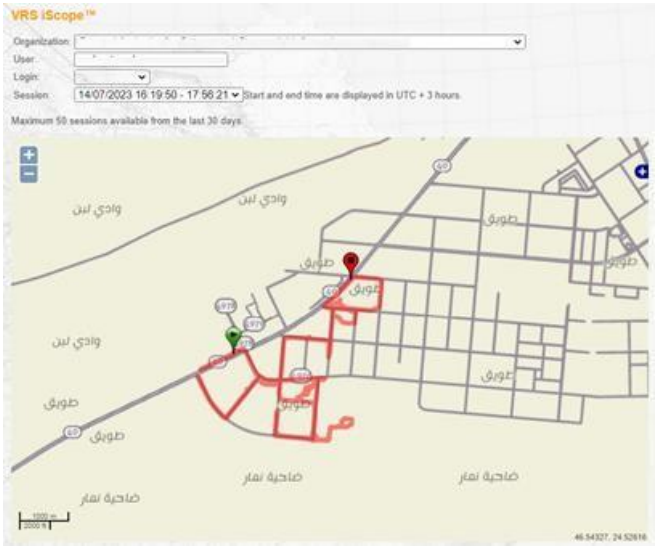
Enter the coordinates of a virtual reference station or drag the marker to the desired location in the map below. You can switch between the geographical and geocentric coordinate system if needed.

NOTE: To generate Virtual RINEX, your location must be within the network RTK as shown in Real-Time Network Coverage Map in page 6.

10. My Account

My Account provides two purposes. Change Password button allows users to change password for login.
The Sessions button allows users to view their KSA-CORS network usage history over varying periods. Usage history is summarized in terms of total organization usage, total login usage and total resource usage (for example RINEX or real-time.)

11. VRS iScope



The VRS iScope is a KSA-CORS web application which is designed to monitor and manage GNSS rover sessions. Registered users can access detailed information about the rover's measured session. This includes data about the duration of the session(s), the start time, and the duration for which the rover was connected to the network.

12. For VRS iScope Live!

The VRS iScope Live is a more advanced feature within the KSA-CORS network that offers an even more dynamic and real-time view of the status and performance of GNSS rovers and their sessions. It shows live visualization of rover activities in real-time. Users can see updates as they happen, making it particularly valuable for monitoring rover activities during dynamic fieldwork or data collection. It also shows the mountpoint details the user is connected to, campaign start time of the user's campaign and for how long the user was connected, satellites tracked by user, distance to the nearest physical KSA-CORS.

13. Active Subscription

This page lists the details of the user's current subscription, including the contract type, the services included, pricing, and the subscription start and end dates.

7. Advantages of using KSA-CORS Real-time Network

- **National Reference Frame**: KSA-CORS products and services are provided in KSA-GRF17 and are consistent with other products and services for SANSRS Orthometric heights, Geoid heights and transformation facilities.
- **Cost-Effectiveness**: Using the KSA-CORS network eliminates the need to set-up traditional RTK base station (with radio communication infrastructure) thereby reducing initial startup costs.

- **Accuracy:** It minimizes the ionospheric effects within the VRS network therefore greatly improving measurement accuracy.
- **Better Scalability:** KSA-CORS can handle large numbers of simultaneous users and devices without compromising performance, making it ideal for applications where high capacity is needed.
- **Reliability:** The KSA-CORS real-time service is fast initialization, accurate and reliable.
- **Wider Coverage**: The KSA-CORS network also provides coverage over part of the Red Sea in the shallow water areas.
- **Expansion**: KSA-CORS is constantly expanding and new coverage area will be available.

8. Other website information on KSA-CORS Network

- Saudi Arabia National Spatial Reference System Implementation Guidelines: https://www.geosa.gov.sa/En/Products/Products_v1/Geodesy/Documents/SANSRS_Implementation_Guidelines_V_2_0.pdf
- Establishment of KSA-CORS Network, its Performance and Future plans: https://www.fig.net/resources/proceedings/fig_proceedings/fig2023/ppt/ts04g/TS04G_al-qahtani_salawu_et_al_12208_ppt.pdf
- The Maintenance of KSA-CORS Network in Saudi Arabia's Desert Areas: https://www.fig.net/resources/proceedings/fig_proceedings/fig2024/papers/ts08f/TS08F_al-qahtani_salawu_et_al_12505.pdf
- KSA-CORS Publication: https://meetingorganizer.copernicus.org/iag-comm4-2022/iag-comm4-2022-33.html
- KSA-CORS network in the news: https://www.spa.gov.sa/2158003.
- SANSRS: https://www.refag2022.org/wp-content/uploads/2022/10/42.pdf