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COMMITTEE OF EXPERTS ON
GLOBAL GEOSPATIAL
INFORMATION MANAGEMENT

Saudi Arabia National Spatial Reference System - SANSRS

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General Authority of Survey and Geospatial Information (GASGI),
Saudi Arabia

Kingdom of Saudi Arabia
General Authority for Survey and Geospatial Information



المملكة العربية السعودية
الهيئة العامة للمساحة والعلوم الجيومكانية

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

OUTLINE

- National Geodetic Infrastructure
- Saudi Arabia National Spatial Reference System Components
 - ❑ National geodetic reference frame KSA-GRF17
 - KSA-CORS network and primary geodetic network
 - ❑ National Vertical Reference Frame KSA-VRF14
 - National Vertical Network (NVN)
 - National Gravity Network (NGN) and gravity observations on NVN benchmarks
 - National Vertical Datum – 3d
 - *Current KSA-GEOID17*
 - *Airborne Gravity*
 - *GPS/GNSS for ellipsoidal height determination over Saudi Arabia*
 - *New KSA-Geoid Development*
 - *Role of 3D KSA-Vertical Datum as a link between KSA-GRF & KSA-VRF*
 - ❑ Transition from STATIC to DYNAMIC/TIME VARYING Reference System
- Conclusions and Recommendations



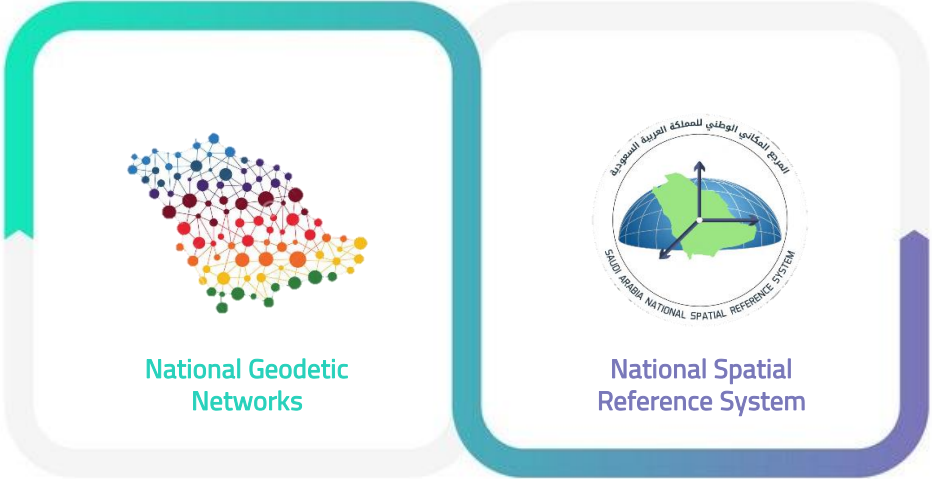


National Geodetic Infrastructure

National Geodetic Infrastructure

It is combination of Spatial Reference System and Geodetic Networks which contribute in establishing and supporting positioning applications in horizontal and vertical directions with high quality & accuracy and national coverage

It is considered the foundation of National Spatial Data Infrastructure (NSDI)



National Geodetic Networks

They are a group of different geodetic networks – major components KSA-GRF and KSA-VRF - which were established to provide the necessary geodetic data for different projects and land surveying activities in KSA.

National Geodetic Networks were established based on International Standards



National CORS Network

209
CORS



National Vertical Network

3893
BM

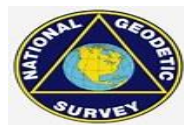
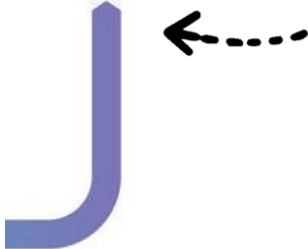
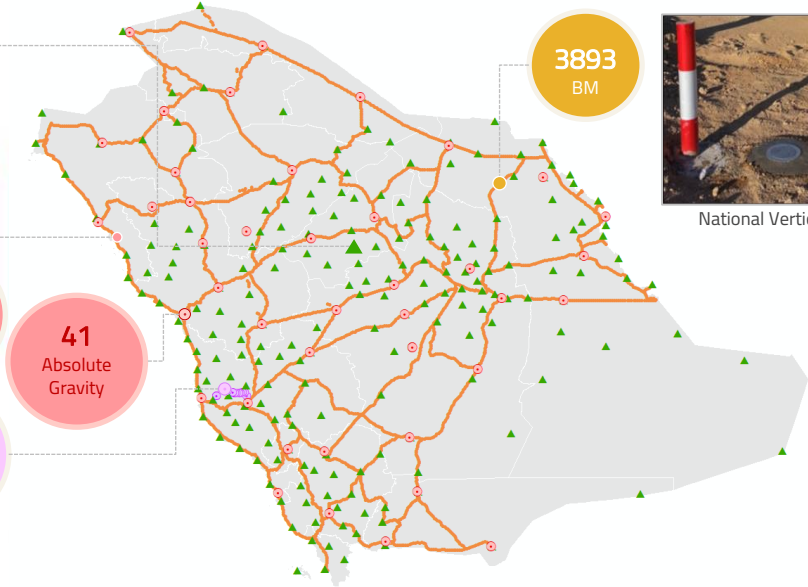


National Gravity Network

3893
Relative Gravity

41
Absolute Gravity

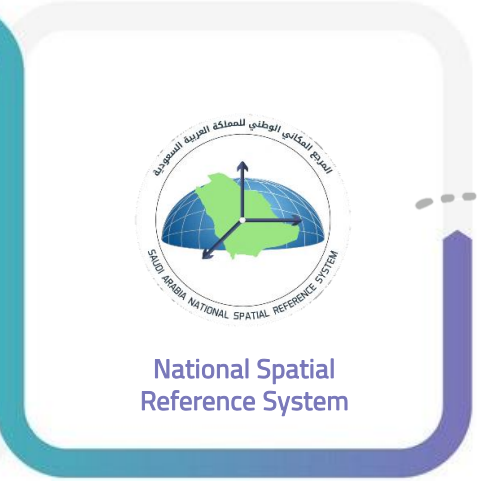
14
Gravity Calibration Base line



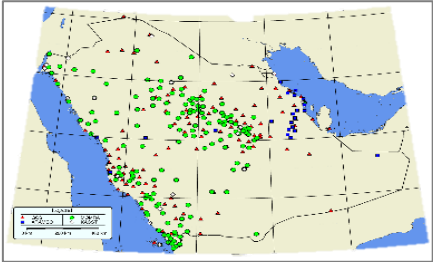
National Spatial Reference System

Spatial Reference System (SRS) is a regional or global reference system which is used in all positioning applications in both dimensions - horizontal and vertical - and also all existing geo-spatial products are reference to it. SANSRS is a national geospatial reference for use in all survey, mapping, locational and positioning services.

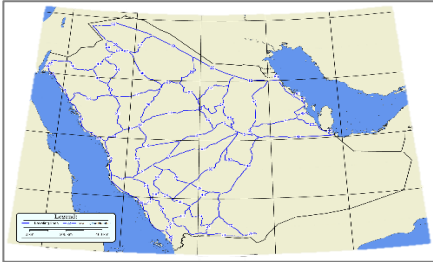
these geodetic components are defined based on data and information from different geodetic networks.



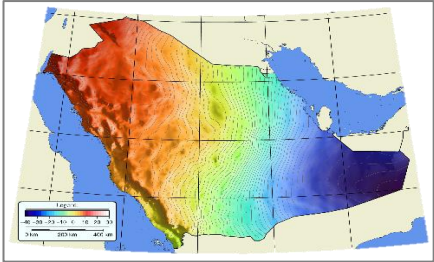
National Geodetic Reference Frame (NGRF)



National Vertical Reference Frame (NVRF)



National Geoid Model



National Geodetic Infrastructure

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National CORS Network



National Vertical Network



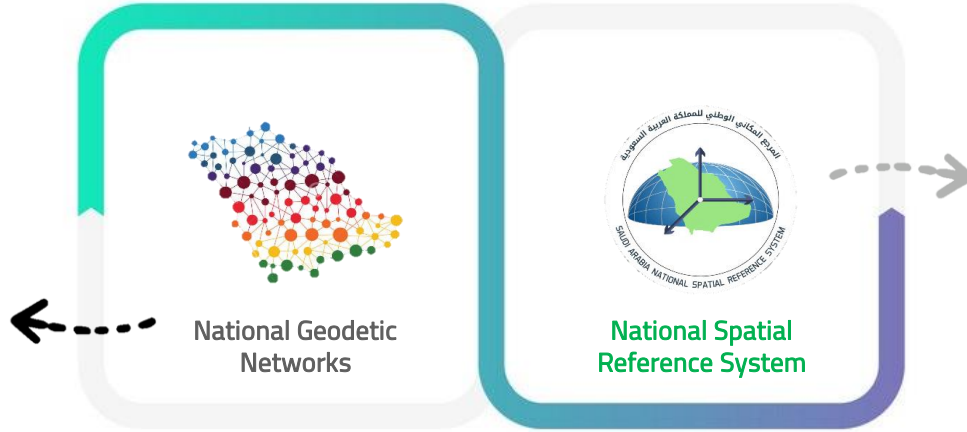
National Gravity Network



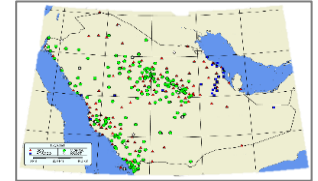
National Tide Gauge Network



Geodetic Network



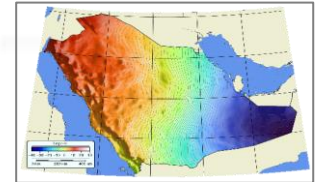
National Geodetic Reference Frame (NGRF)



National Vertical Reference Frame (NVRF)



National Geoid Model





Saudi Arabia National Spatial Reference System Components



National geodetic reference frame KSA-GRF17

National Vertical Datum – 3d

National Vertical Reference Frame KSA-VRF14

KSA-CORS network and primary geodetic network

Current KSA-GEOID17

National Vertical Datum (NVD) – 1d

National Gravity Network (NGN)

Airborne Gravity

GPS/GNSS for ellipsoidal height

National Vertical Network (NVN)

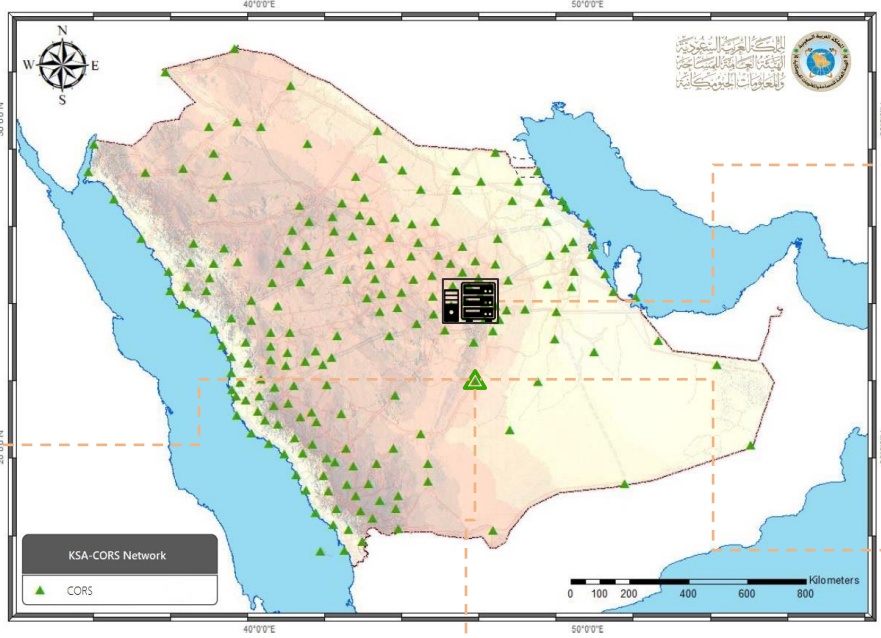
KSA-GEOID21
NEW GEOID

National Geodetic Reference Frame KSA-GRF17

Planned
313
CORS

Current
209
CORS

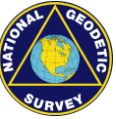
KSA-CORS network - the core of KSA-GRF17 Dissemination



Network Control Center (NCC): to control and monitor KSA-CORS network.



Ground type (GT) & Roof type (RT): for SANSRS definition & precise positioning services



National Geodetic Reference Frame KSA-GRF17

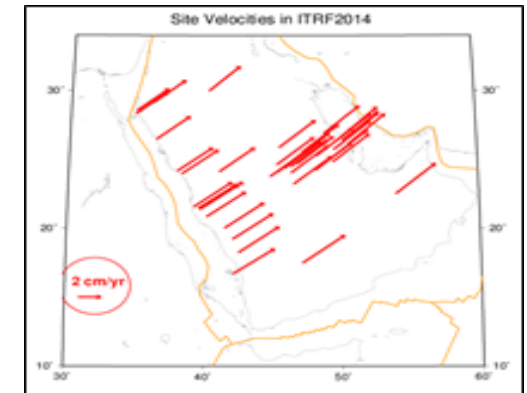
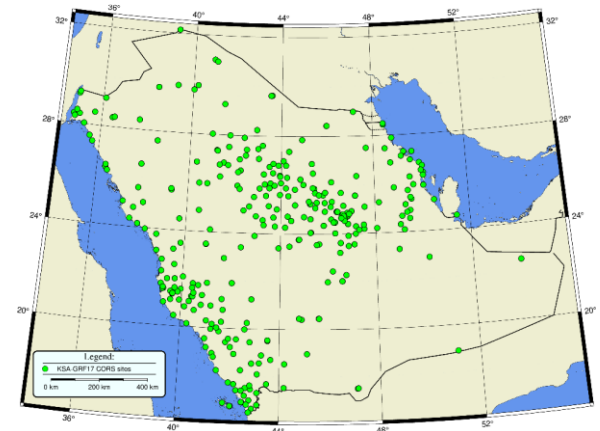
KSA-GRF17

- ❑ Recently, the Kingdom of Saudi Arabia established the unified National Geodetic Reference Frame KSA-GRF17.
- ❑ KSA-GRF17 was computed based on ITRF2014/IGS14 epoch 2017.0. using observations of 51+14 IGS stations used also in definition of ITRF2014.
- ❑ Defined in such way that: it coincides with ITRF2014 at epoch 2017.0.
 - it is moving consistently with the stable part of the Arabian tectonic plate.
 - general transformation formula linking KSA-GRF17 to the ITRF2014, for station positions is given by the following equation:

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{KSA-GRF17}(t) = \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{ITRF2014}(t) + \begin{pmatrix} 0 & -\dot{R}_z & \dot{R}_y \\ -\dot{R}_z & 0 & -\dot{R}_x \\ \dot{R}_y & \dot{R}_x & 0 \end{pmatrix} \times \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{ITRF2014}(t) \cdot (t - 2017.0)$$

For station position at any epoch t :

where: R_x , R_y , R_z are the three components of the Arabian plate rotation pole (or angular velocity) expressed in ITRF2014.



National Vertical Reference Frame KSA-VRF14

NATIONAL VERTICAL NETWORK (KSA-NVN)

Main task

Provide a precise and unified vertical datum for Orthometric heights determination over the KSA.

KSA-NVN

- Number of BMs: 3893;
- Number of level lines: 88;
- Distance between the BMs: 6 km;
- Total length of NVN: 22869 km;

- The a priori accuracy - NGS standards for Second order/Class I double run precise geodetic leveling.
- The provisional accuracy for double run - for entire NVN ± 1.03 mm/km.



NVN has an accuracy better than Second order/Class I according to NGS Standard



NATIONAL GRAVITY NETWORK (NGN) AND GRAVITY OBSERVATIONS ON NVN BENCHMARKS

❑ Main task

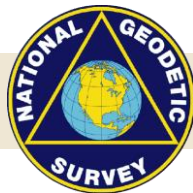
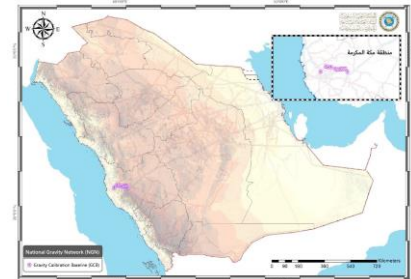
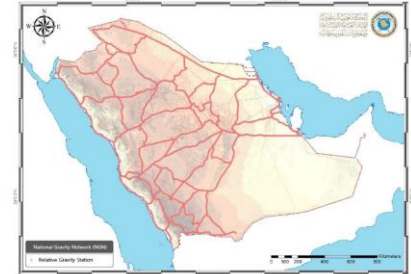
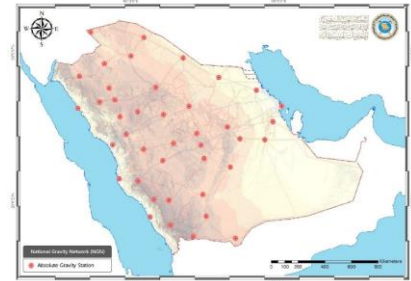
to establish gravity reference system of KSA as part of the SANSRS and to support the realization of gravity standard over the KSA

❑ NGN class 1: gravity base network (GBN) - absolute gravity observations on 41 stations with center and ex-center points;

❑ NGN class 2:

- Primary Relative Gravity network (PRGN) - densification of the absolute gravity sites (mostly 250 BMs from KSA-NVN apart each other 60 km);
- National vertical network gravity measurements at BMs, TG BMs and PGNs (3504);

❑ Service: Gravity Calibration Baseline (GCB) – 14 AG (with center and ex-center points) with achieved average accuracy for relative gravity values: 1.2 μGal (center points); 1.6 μGal (ex-center points). And relative gravity linking them



NGN has an accuracy better than Second order/Class 1 according to NGS Standard



National Vertical Reference Frame KSA-VRF14

KSA-VRF14

KSA Vertical Reference Frame Jeddah'2014

KSA-VRF14 is based on on in-situ observations from tide gauge stations, precise levelling, gravity data, satellite altimetry and GOCE data.

KSA-VRF14 is the latest realization of National Vertical Reference System (NVRS). The main characteristics of KSA-VRF14 are as follows:

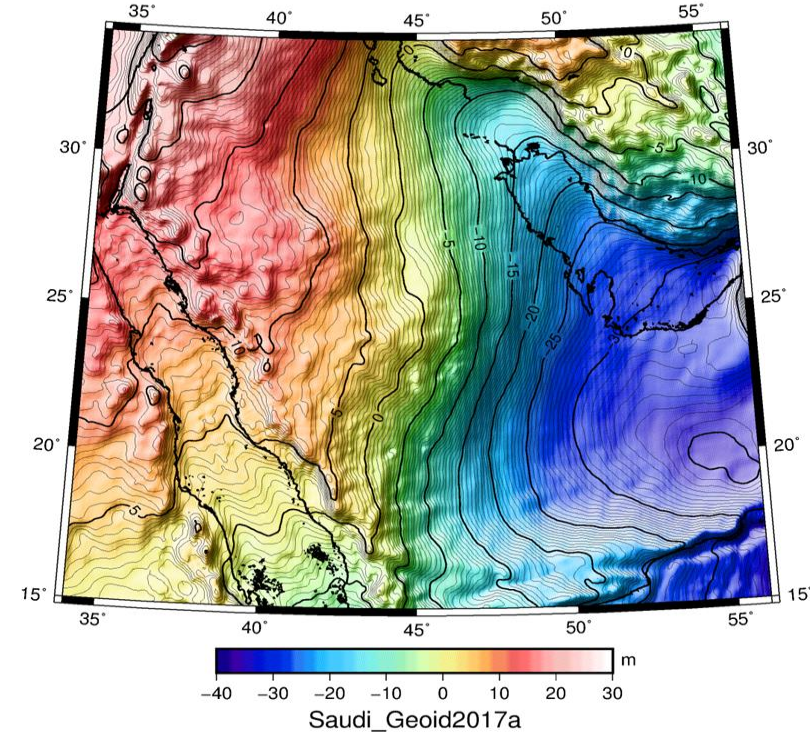
Height system type:	Helmert-orthometric Above Mean Sea Level at JEDDAH Tide Gauge
Least-Square Adjustment type:	Fixed geo-potential number above MSL of Jeddah TGBM-B
Physical Realization Benchmarks:	National Vertical Network
Physical Realization Grid Interpolation:	KSA-GEOID17/KSA-GRF17
Tidal system:	Tide Free
Primary Benchmark:	Jeddah TGBM-B
Latitude:	21.49981 [degree]
Longitude:	39.16161 [degree]
Fixed height above Mean Sea Level of Jeddah TGBM-B	1.7446 [m]
Epoch:	2014.75 year



NATIONAL VERTICAL DATUM – 3D

Current KSA-GEOID 17

- ❑ The current KSA-GEOID 17 model is based on a gravimetric geoid, which is utilizing:
 - EGM **EIGEN6C4** reference field (incorporating GOCE and GRACE satellite data);
 - New **DTU15** satellite altimetry data offshore;
 - More than 500 000 gravity data points from both (GASGI) and older (ARAMCO) data sources;
 - The geoid is fitted to the **KSA-VRF14** through a set of 280 GPS/levelling points along the **NVN**
 - Geoid accuracy:
 - better than **2 cm** in area with gravity data
 - **15-20 cm** in areas without gravity data and gravity related information

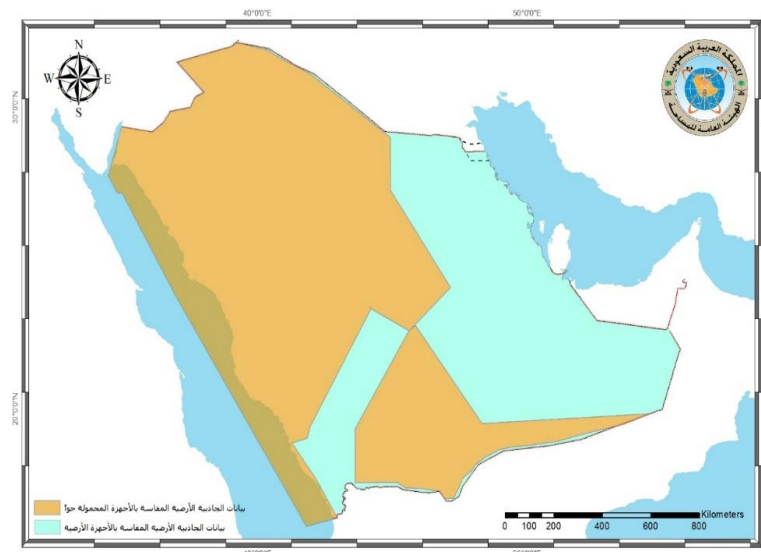
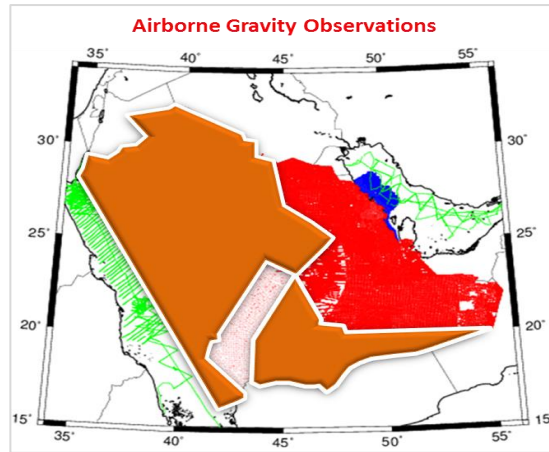


National Vertical Reference Frame KSA-VRF14

NATIONAL VERTICAL DATUM – 3D

AIRBORNE GRAVITY

- ❑ Main task
 - New gravimetric KSA- GEOID to be computed by filling large gaps with centimeter Accuracy;
 - Survey area coverage: ~1.320.000 square km;
 - Accuracy: ~0.7 μGal



National Vertical Reference Frame KSA-VRF14

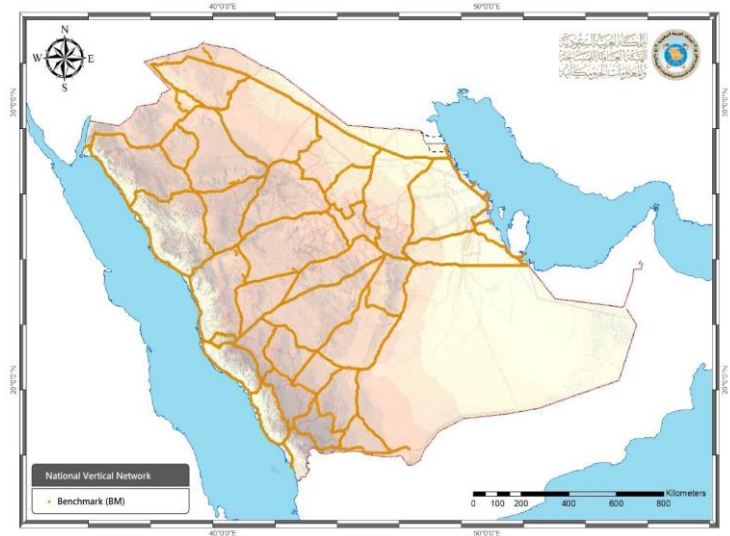
NATIONAL VERTICAL DATUM – 3D

GPS/GNSS FOR ELLIPSOIDAL HEIGHT DETERMINATION OVER KSA

□ Main task

to determine 'hybrid' KSA-GEOID;

- The KSA-VRF needs to be utilized over the territory of KSA by application of GPS/GNSS/leveling technique providing ellipsoidal height with better than 2 cm-accuracy;
- The current regional model of the kingdom fitted to GPS/GNSS/leveling data linked to KSA-VRF14 and KSA-GRF17;
- Observation coverage: entire NVN, TG networks, absolute gravity stations and gravity calibration baseline
- **Outputs:** Ellipsoidal height of all BMs, TG, AG Stations and GCB with **better than 2 cm**

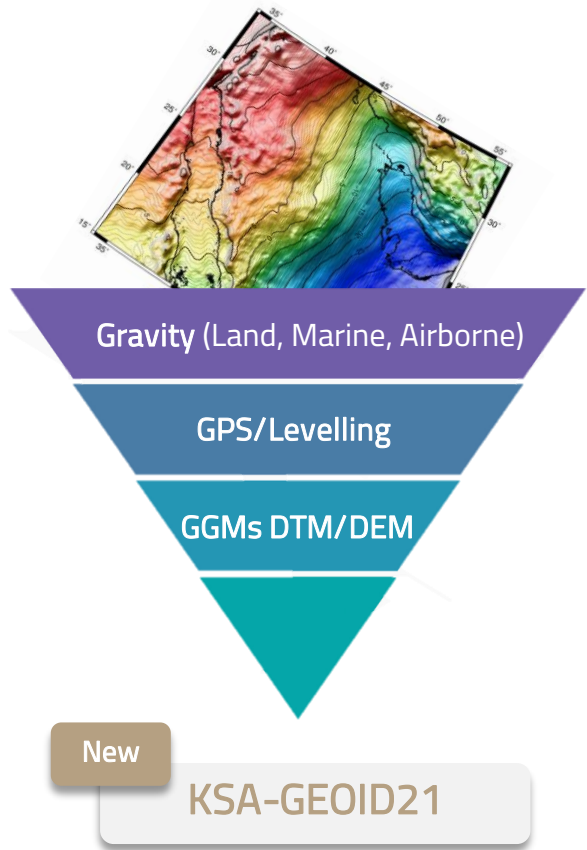
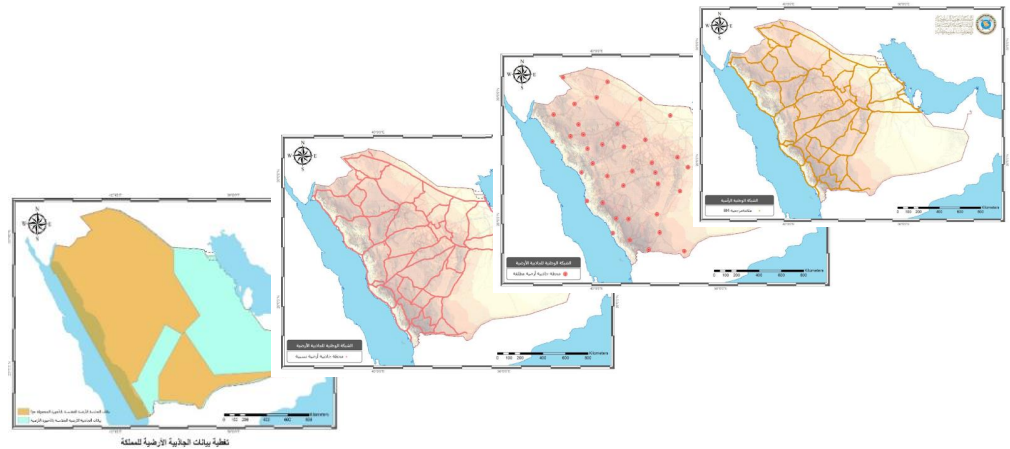


National Vertical Reference Frame KSA-VRF14

NATIONAL VERTICAL DATUM – 3D KSA-GEOID21 (NEW KSA-GEOID)

□ Main task

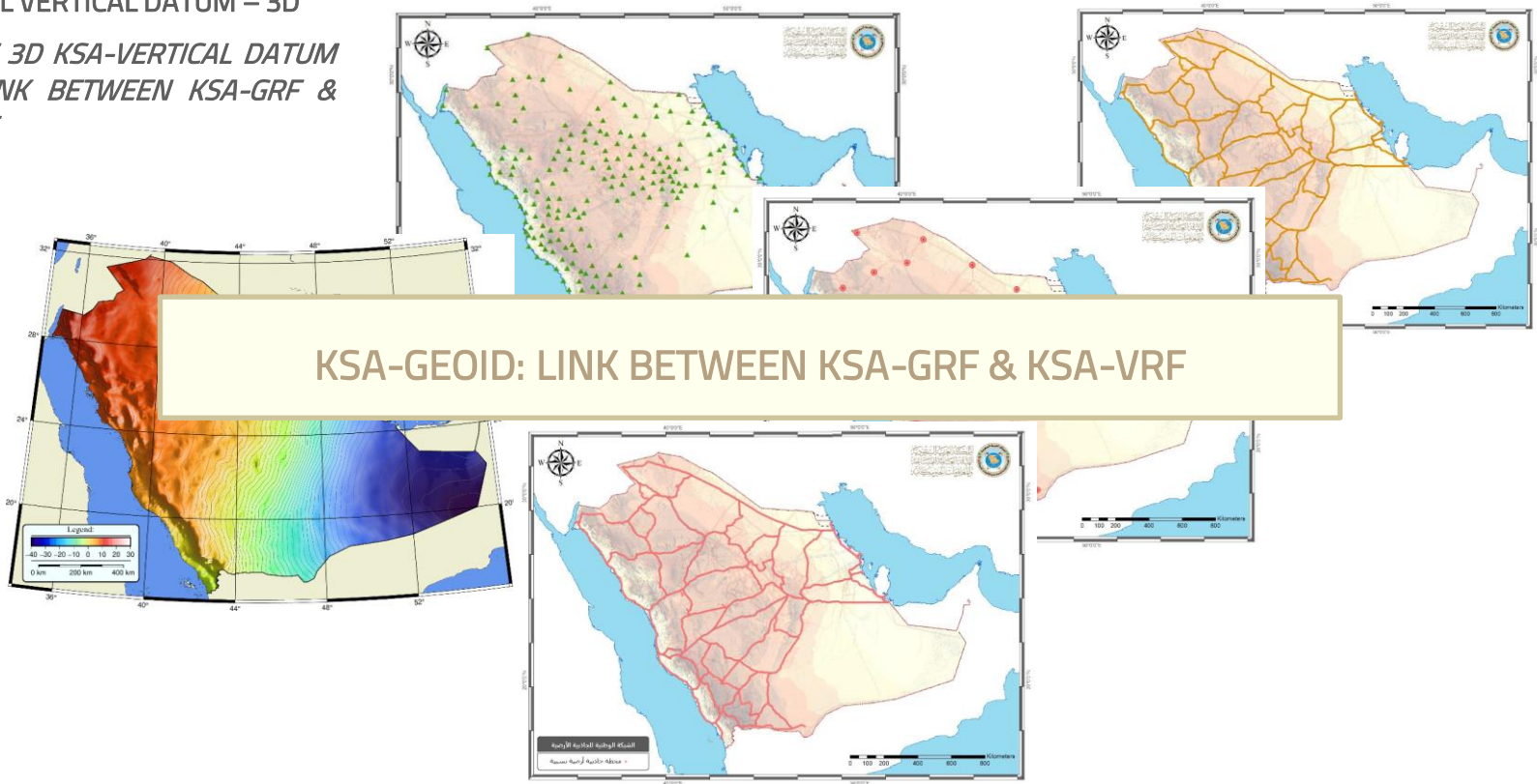
- Determination of a new high-accuracy (1-2 cm) and high-resolution gravimetric geoid model over the territory of KSA
- Determination of a new high-accuracy (1-2 cm) and high-resolution hybrid geoid model over the territory of KSA



National Vertical Reference Frame KSA-VRF14

NATIONAL VERTICAL DATUM – 3D

*ROLE OF 3D KSA-VERTICAL DATUM
AS A LINK BETWEEN KSA-GRF &
KSA-VRF*



KSA-GEOID: LINK BETWEEN KSA-GRF & KSA-VRF



Transition from STATIC to DYNAMIC/TIME VARYING Reference System



Transition from STATIC to DYNAMIC/TIME VARYING Reference System - Currently, GASGI is working on developing a concept for transition from static to dynamic/time varying SANSRS & the following SANSRS components will be considered:

- **Transition of KSA Geodetic Reference Frame (KSA-GRF)** - from static reference frame w.r.t. to Arabic plate to reference frame including interplate and areas with natural & technogenic motions
- **Transition of KSA Vertical reference frame (KSA-VRF)**
 - National Tide Gage Network (TGN) - monitoring the effect of Mean Sea Level and its rate on changes in geo-potential of TG stations
 - National Vertical Network (NVN) – monitoring the effect of geometric movements of Tide Gauge stations, Ground CORS stations and specific areas of interest (Tectonic and technogenic active zones, seismic active, subsiding areas and etc.) on geo-potential changes and separation of pure geometrical movements from physical gravity field changes;
- **Transition of KSA Geoid**
 - National Gravimetric Network – campaign based and permanent Absolute gravity observation
 - Time varying gravity field from old, current and future satellite gravity mission
 - Dynamic KSA Geoid – determination and validation
- **Developing new geodetic earth observation applications over KSA (InSAR, SLR, VLBI and etc.), supporting the transition to time varying SANSRS and those utilizing it**
- **The Concept of transition from static to dynamic/ Time varying SANSRS - part of the National Geodetic Program (NGP), currently under development by GASGI- GDG**





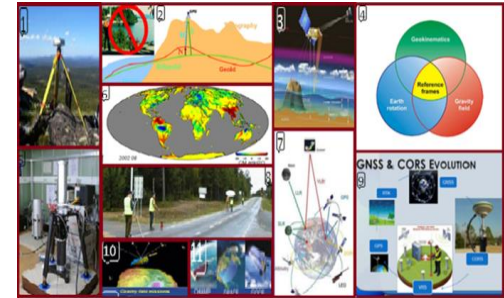
3 Conclusions and Recommendations

Conclusions and Recommendations

- ❑ All geodetic activities at General Directorate of Geodesy (GDG), General Authority of Survey and Geospatial Information (GASGI), and its up to date infrastructure can be considered as a very good background start, which could support different geodesy-linked activities:

KSA-GRF/KSA-VRF/KSA-GEOID is the common geodetic infrastructure for applications linked to Geo-referencing, the Earth's gravity field, geophysics, oceanography, hydrography, hydrology, water flow studies, surveillance of coastal areas and etc.

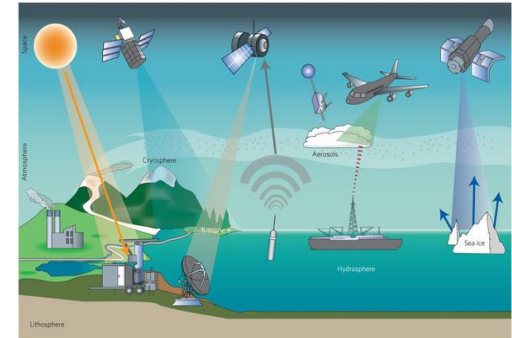
- ❑ General and specific issues regarding future cooperation with different governmental/international organizations, professional and scientific communities – geodetic data and information stakeholders.
- ❑ Different forms of cooperation between GASGI and other communities can be established – bilateral or multi-partner working groups.
- ❑ Different joint activities (workshops, seminars, common projects and etc.) during major conferences and meetings can be planned.
- ❑ in Future; SANSRS includes transforming from **Static (3D)** to **Dynamic (4D)** System, which will allow any product, service or application described time wise.



GEODETTIC APPLICATIONS



GEODETTIC DATA AND INFORMATION STACK HOLDERS



<http://www.nature.com/nclimate/journal/v3/n10/full/nclimate1908.html>



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Thanks

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