STUDIES OF TECTONIC MOVEMENTS IN SAUDI ARABIA USING CORS

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SUBJECT TO TALKS

- BACKGROUND
- GEODETIC NETWORK OF SAUDI ARABIA AND FIDUCIAL STATIONS
  - GFN OF Saudi Arabia in 2004.0 Based on ITRF2000 Datum
  - GFN OF Saudi Arabia in 2012.7 Based on ITRF2008 Datum
- TECTONIC DISPLACEMENTS FROM 2004 TO 2012
- CONCLUDING REMARKS

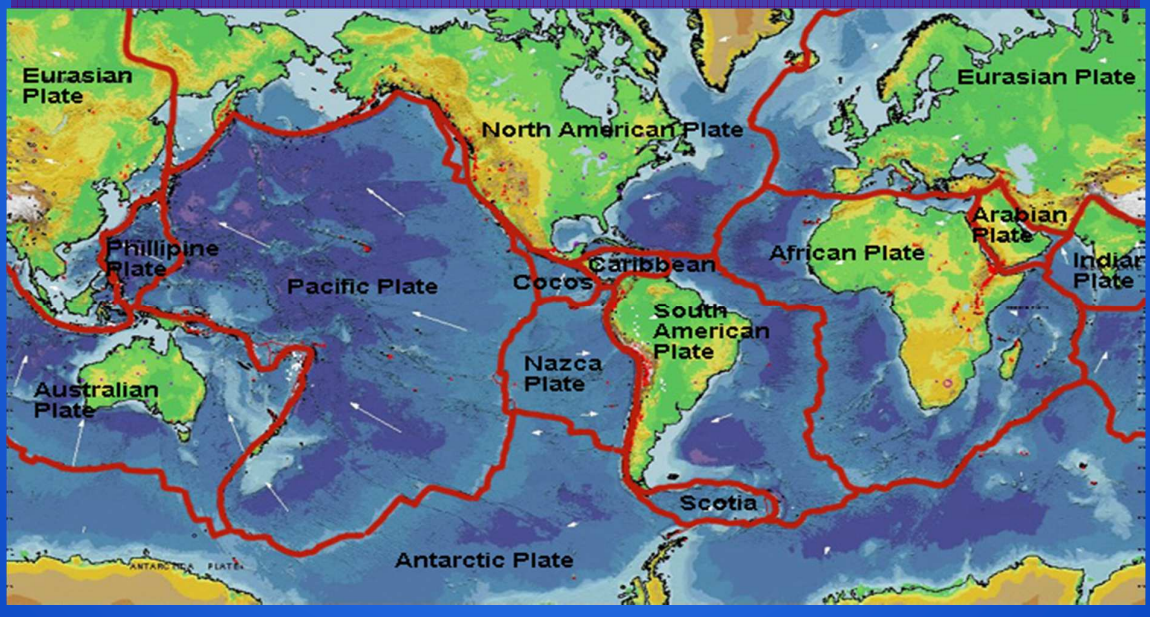
BACKGROUND

Scientific contribution of national CORS

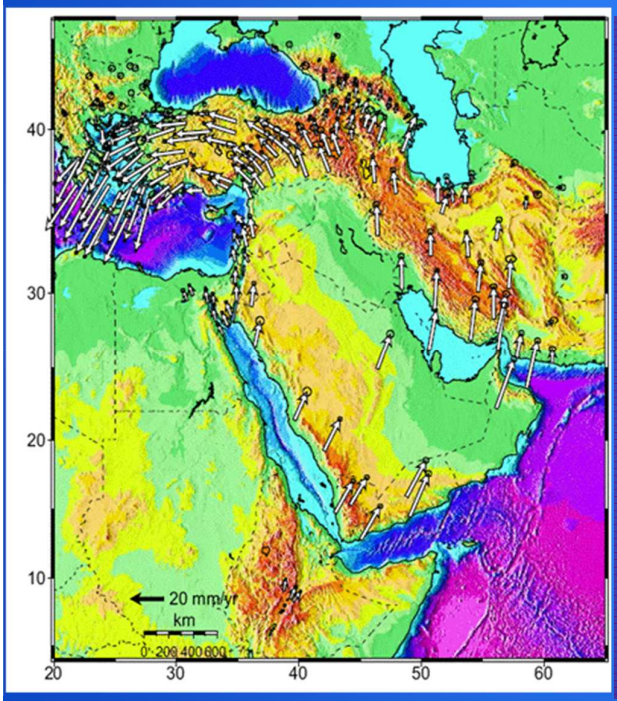
- National CORS effectively serve the scientific studies related to atmosphere and ionospheric phenomena.
- Another scientific contribution of national CORS is the precise determination of displacements due to earthquakes, plate tectonics, volcanic eruptions, landslides etc.

BACKGROUND

- The Earth is made of many plates.



BACKGROUND



Tectonic setting of Turkey together with Arabian Plate (from Reilinger et al., 2006)

The Arabian plate moves towards the Eurasian plate, squeezing Anatolian plate

Earthquakes have been the great natural hazard that threatens the Middle East region socially and economically.

Hence, it is crucial to have knowledge on the characteristics and dynamics of the tectonic fault lines to mitigate this hazard

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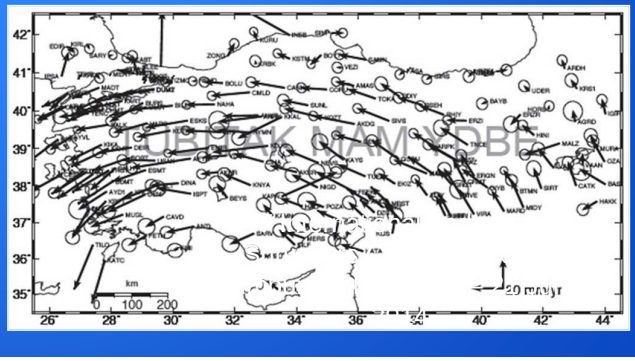
BACKGROUND

❑ Earthquake prone countries, like Turkey, need to take precautionary measures in advance to mitigate the consequences of natural hazards. During recent decades, the studies aimed at learning the plate mechanisms accelerated after the introduction of space-based application tools such as GNSS and radar image acquisition systems.

❑ CORS-TR data from **141 stations** recorded during January 1st 2009 and November 30th 2009 were processed using the **GAMIT/GLOBK** program. The maximum displacement estimated ranged 19.9 mm/year toward southwest and 23.2 mm/year toward northwest.

Plate displacements from 11 months CORS-TR surveys in 2009



GEODETIC NETWORK OF SAUDI ARABIA AND FIDUCIAL STATIONS

- GFN OF Saudi Arabia in 2004.0 Based on ITRF2000 Datum
- GFN OF Saudi Arabia in 2012.7 Based on ITRF2008 Datum

- A project was started in 2004 in order to establish a new geodetic network based on ITRF2000 datum (Epoch: 2004.0), known as MTRF2000.

It consists of two parts:

- Geodetic Fiducial Network (GFN: 13 stations)
- Geodetic Main Network (GMN: 659 stations)

GFN OF Saudi Arabia in 2004.0 Based on ITRF2000 Datum

- The GFN consisted of 13 highly accurate Fiducial stations across Saudi Arabia, each with a permanently tracking iCGRS Ashtech Global Positioning System (GPS) receiver.

- The coordinates of all GFN stations were determined together with eight IGS stations using 10 days observations.

- The statistics of GFN GPS Surveys and Computations are:

- 8 x IGS stations were used as fixed reference stations
- 10 days data in 2004 (DOY 96-101, i.e. 5 – 10 April 2004) collected in 13 GFN sites,
- ITRF-2000 datum used,
- Processed the data for 1997.0 and 2004.0 epochs using the Geo++ GPS software
- Network adjustment was carried out and mm-level accuracy was obtained for each GFN station (i.e. about 0.01 ppm precision results).

MTRF-2000 DEFINITION

Datum	MGD-2000
Reference Frame	ITRF-2000 (International Terrestrial Reference Frame 2000), Epoch:2004.0
Ellipsoid	GRS80
Semi-major axis (a) **Inverse flattening (1/f)**	6,378,137.0 meters 298.257222101
Grid coordinates **(Universal Transverse Mercator)**	Map Grid of MGD-2000

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GFN OF Saudi Arabia in 2014.3 Based on ITRF2008 Datum

❑ Due to recent developments in technology, iCGRS Ashtech Global Positioning System (GPS) receivers replaced with **Leica GR25 GNSS** receivers capable of measuring, GPS, GLONASS and Galileo signals, during January – July 2012.

❑ The new coordinates of all GFN stations were determined together with eight IGS stations using 11 days observations.

❑ The statistics of GFN GPS Surveys and Computations are:

❖ **8 x IGS stations** were used as fixed reference stations,

❖ **11 days data in 2014** (DOY 14 - 24, i.e. 14 -24 January 2014) collected in 12 GFN sites,

❖ **ITRF-2008 datum** used,

❖ Processed the data **for 2014.3 epoch** using **BERNESE** software packages

❖ Network adjustment was carried out and **mm-level accuracy** was obtained for each GFN station (i.e. **about 0.01 ppm precision results**).

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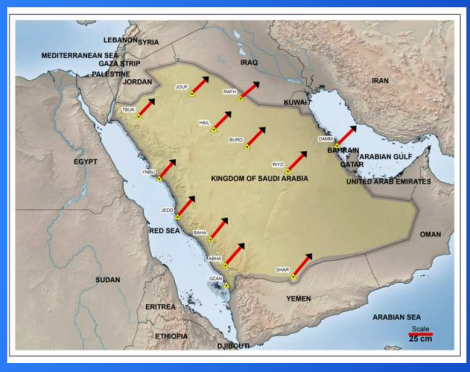
TECTONIC DISPLACEMENTS FROM 2004 TO 2014

The precise positions at **ITRF2000 datum (Epoch: 2004.0)** were compared against the precise positions determined at **ITRF2008 datum (Epoch: 2014.3).** The results show a displacement of about **40.6 cm in NE** direction between **2004.0 and 2014.3**, corresponding to a **velocity of about 4.1 cm / year in NE** direction.

STATION	2014.03 - 2004.0 Differences					
	dN (m)	dE (m)	dh (m)	Azim (o)	ds (m)	ds/year (m)
ABHA	0.297	0.337	-0.135	48.6068	0.449	0.045
BAHA	0.268	0.325	-0.155	50.5227	0.421	0.042
BURA	0.285	0.291	-0.153	45.5998	0.408	0.041
DAMM	0.299	0.294	-0.199	44.6013	0.419	0.042
HAIL	0.268	0.269	-0.150	45.0855	0.380	0.038
JEDD	0.270	0.316	-0.193	49.4319	0.416	0.042
JOUF	0.261	0.254	-0.154	44.2568	0.365	0.036
RAFH	0.294	0.245	-0.185	39.8809	0.383	0.038
RIYA	0.293	0.297	-0.199	45.3933	0.418	0.042
SHAR	0.291	0.348	-0.168	50.1550	0.454	0.045
TABU	0.247	0.264	-0.179	46.9191	0.362	0.036
YANB	0.254	0.289	-0.183	48.6337	0.385	0.038
RMS (m) →	0.278	0.296	0.172		0.406	0.041

Displacements at CORS sites during 2004.0 and 2014.3 (IGS stations constrained)



The displacements can be interpreted as the tectonic movement of Arabian plate with respect to African and Asian plates.

We also wanted to see the displacements / deformation within the Arabian plate as far as Saudi Arabia concerned.

After fixing Riyadh CORS site in both epochs to the same value, the precise positions of 13 x CORS sites in both epochs were calculated and were compared against each other.

NAME	2014.03 - 2004.0 Differences					
	dN (m)	dE (m)	dh (m)	Azim (o)	ds (m)	ds/year (m)
ABHA	-0.004	-0.028	-0.064	-98.3219	0.028	0.003
BAHA	0.025	-0.019	-0.044	-36.4419	0.031	0.004
BURA	0.008	0.002	-0.046	14.6127	0.008	0.001
DAMM	-0.005	-0.002	0.000	-162.1253	0.006	0.001
HAIL	0.025	0.024	-0.048	43.9590	0.034	0.004
JEDD	0.023	-0.012	-0.006	-28.7141	0.026	0.003
JOUF	0.032	0.033	-0.045	46.5725	0.046	0.005
RAFH	-0.001	0.045	-0.014	90.8081	0.045	0.005
RIYA	0.000	0.000	0.000	0.0000	0.000	0.000
SHAR	0.003	-0.038	-0.031	-86.0376	0.038	0.004
TABU	0.045	0.027	-0.020	30.3888	0.053	0.006
YANB	0.039	0.011	-0.016	15.5798	0.040	0.005
RMS (m) →	0.022	0.024	0.033		0.032	0.004

The result can be interpreted as relative displacements within the Kingdom , only 4mm/year.

The results show a displacement of about 3.2 cm between 2004.0 and 2014.3, corresponding to a velocity of about 4 mm / year in NE direction.

CONCLUDING REMARKS

- Since the mid 1980's GNSS has been serving users throughout the world with navigation and geodetic positioning data. With the introduction of network based CORS, GNSS is now providing these services more accurately and economically.

- The GNSS data together with other types of data such as InSAR, seismic, etc. shall effectively serve studies related to geohazards, disaster management, and early warning.

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CONCLUDING REMARKS

- Here, very precise coordinates (mm-level precision) of 13 x GFN stations were determined in the latest ITRF2008 datum and epoch 2014.3. Thus, once again, **Saudi Arabia has very precise fiducial stations to be used as reference** throughout the Kingdom.

- The results show that a **displacement of about 40.6 cm** in NE direction **between 2004.0 and 2014.3**, corresponding to a **velocity of about 4.1 cm / year** in NE direction **although relative displacements within the Kingdom is only 4 mm /year**. These numbers show that the coordinates based on MTRF2000 datum has about **41 cm offset** in NE direction with respect to the coordinates computed at the present with reference to IGS stations.

THANK YOU FOR YOUR ATTENTION