Evaluation of the Deformation Parameters of the Northern Part of Egypt Using Global Navigation Satellite System (GNSS)

Presented by
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Outlines

1 • Introduction

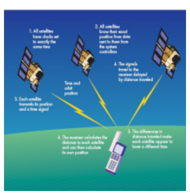
2 • Applications

3 • A case study

Introduction

-Global navigation satellite system (GNSS) : is a system of satellite that provide autonomous geo-spatial positioning with global coverage .

-GNSS is made of a combination of several satellite systems:



GPS

GLONASS

Galileo

Compass

IRNSS

QZSS

Introduction

- A scientific programme for monitoring recent crustal movements and its relation to earthquake activity was started in 1983,after the major earthquake that occurred on November 14,1981 with magnitude 5.6.

- At the early stages of this programme terrestrial technique were used around the active faults in the area

- Starting from 1996 global positioning system(GPS) technique was used. It was applied around the most active regions in Egypt such as around the northern part of Lake Nasser -Gulf of Suez-Sinai Peninsula & red sea .

Introduction

- In 2006 , National Research Institute of Astronomy and Geophysics started the establishment of Egyptian permanent GPS network (EPGN).

- The site selection was carried to cover geographically all the Egyptian territory and considering the tectonic setting of Egypt.

- The selection of chosen placed based on clear view with out any obstructions, away from any electromagnetic sources &accessibility.

Introduction

Distribution of GPS Network


11 2:57PM


Trimble
5700
5

Trimble R8

Trimble
SV 8
Logging
Esc
Enter
Bluetooth

Trimble

Application of GPS

Since GPS is an all-weather, real-time, continuously available, economic, and very precise positioning technique, almost unlimited possibilities are opened up for its use in geodesy, surveying, navigation, and related fields, including:

A. Geodynamics
B. Control surveys.
C. Monitoring and engineering problems.
D. Precision navigation.
E. Photogrammetry.
F. Marine and glacial geodesy.

-Crustal movement is the deformation of the lithosphere (including the crust and the upper mantle). The movement of plates is resulted due to the release and redistribution of energy from Earth's core (convection current).

-When the plates move it will cause stress where rock might bend, slide or break. As a result, earth's interior will have fractures and folds or bends in the rock structure.

- The effects of this stress can be seen clearly on the surface of the earth in the form of subsidence, either a depression in the crust, or uplift of crustal materials.

- Deformation of plates also involves the formation of mountain ranges, such as Himalayan mountains, which resulted due to folding, faulting, and volcanic activity.

Purposes

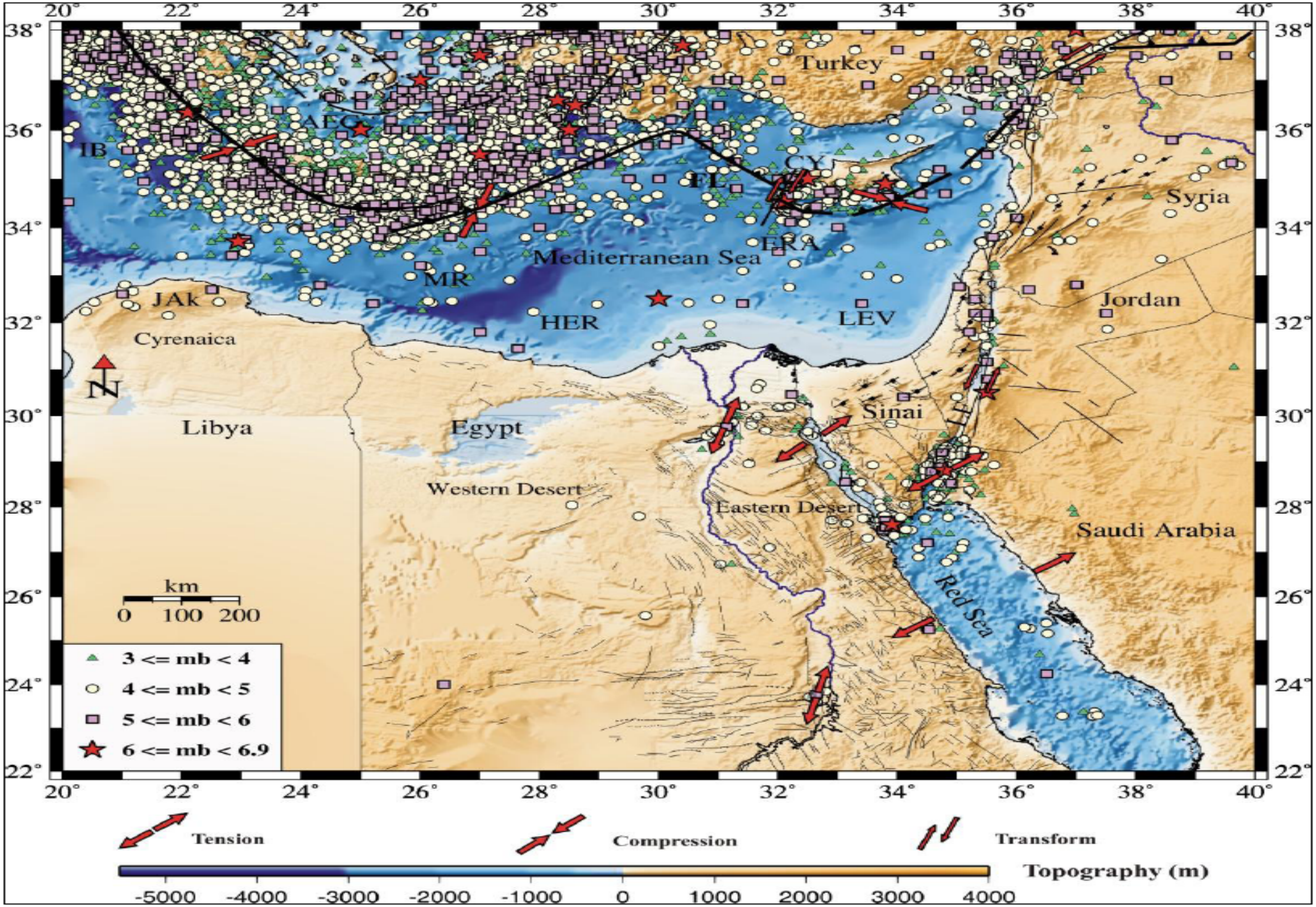
- **Practical**
  - Assessment of the degree of geological hazards and the detection of earthquakes
  - Checking the stability of soil structures
- **Scientific**
  - Testing new theories which are applied to the design of structures and determining prediction methods
  - Understanding of deformation mechanism

Case Study (Northern part of Egypt)

This study aim to throw light upon the present state of recent crustal movements and its relationship to seismicity in the Northern part of Egypt

- 3.1 Tectonic setting
- 3.2 Collecting of GPS data
- 3.3 Computational Strategy
- 3.4 Results

3.1 Tectonic setting



Tectonic deformation of Egypt (Abou El Enean and Hussein, 2007)

3.1 Tectonic setting

Previous subsurface studies indicated that northern Egypt underwent three subsequent phases of deformation from early Mesozoic to present.

The first phase:

- Is Neotethys, rifting of northern Africa in early Triassic to early Jurassic with development of an extensive system of E–W trending rift basins.
- During cretaceous, a new phase of extension reactivated the E–W Jurassic basins and formation of new NW-SE trending rifts.

- This phase of extension is mainly due to the clockwise rotation of stress field in the north and central Africa associated with opening of the south Atlantic.
- It was resulted in the formation of a system of E-W to ENE-WSW faults (normal and strike-slip faults with lateral sense of motion.

The second phase:

- is represented by NW-SE to WNW-ESE oriented normal faults.
- During the late cretaceous, the relative motion between African and Eurasian plates changed from sinistral divergent (transtension) to dextral convergent (transpression).

- These stresses resulting from the arc collision with the northeast coast of Africa- Arabia in late Santonian.

- The deformation effect extends from Libya to Levant in a series of folds (NE-SW) accompanied with thrust faults (Syrian Arc System).

The latest phase:

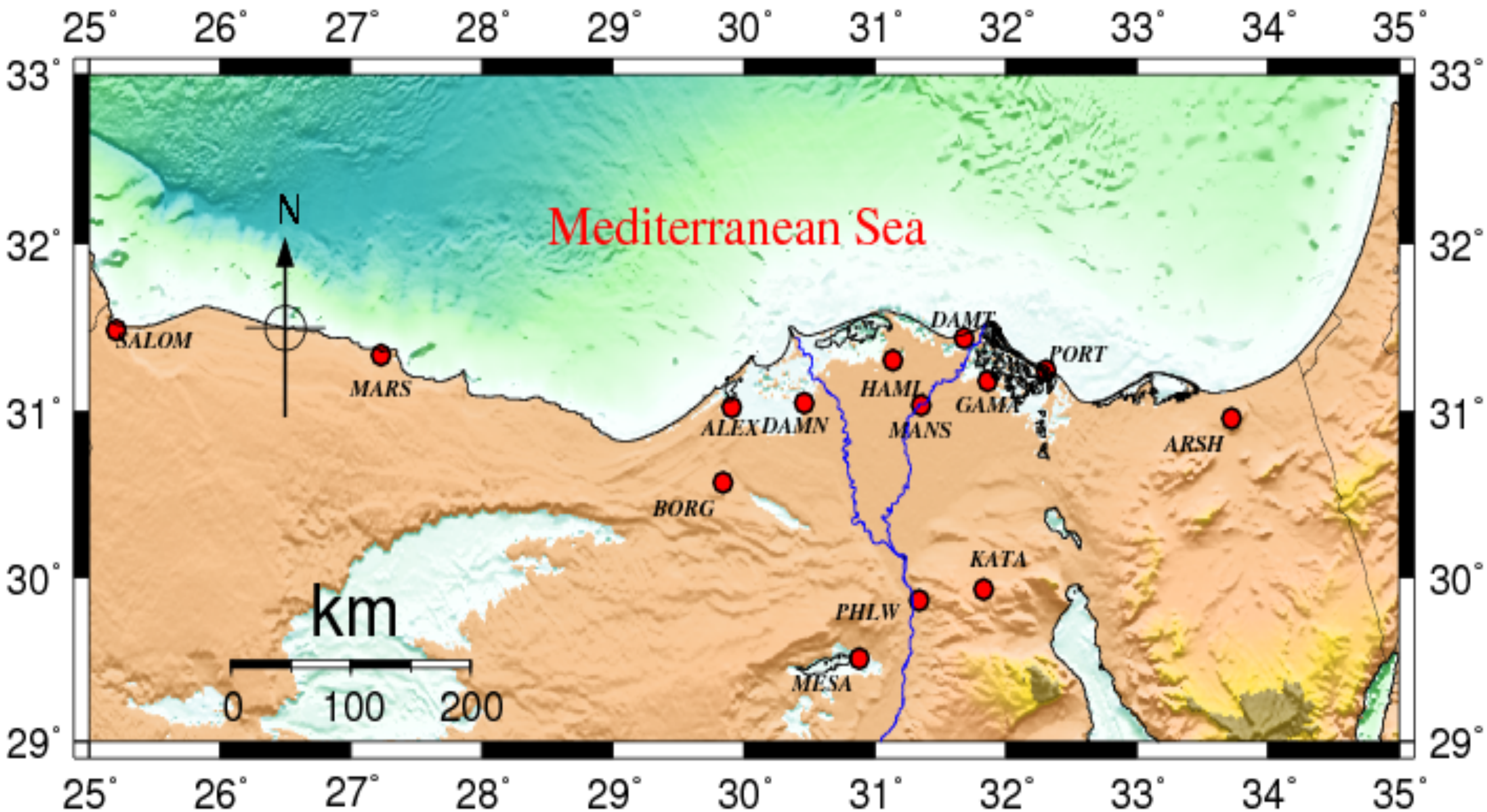
- Started from late Eocene and continued up to recent and is dominated by three fault trends.

- NNW-oriented Gulf of Suez normal faults.

- NNE-trending fault related to the development of Gulf of Aqaba rift that started to form since Miocene by left lateral oblique slip movement.

- The N-S fault trend.

3.2 Collecting of GPS data



Distribution of GPS Network in Northern Egypt

3.3 Computational Strategy

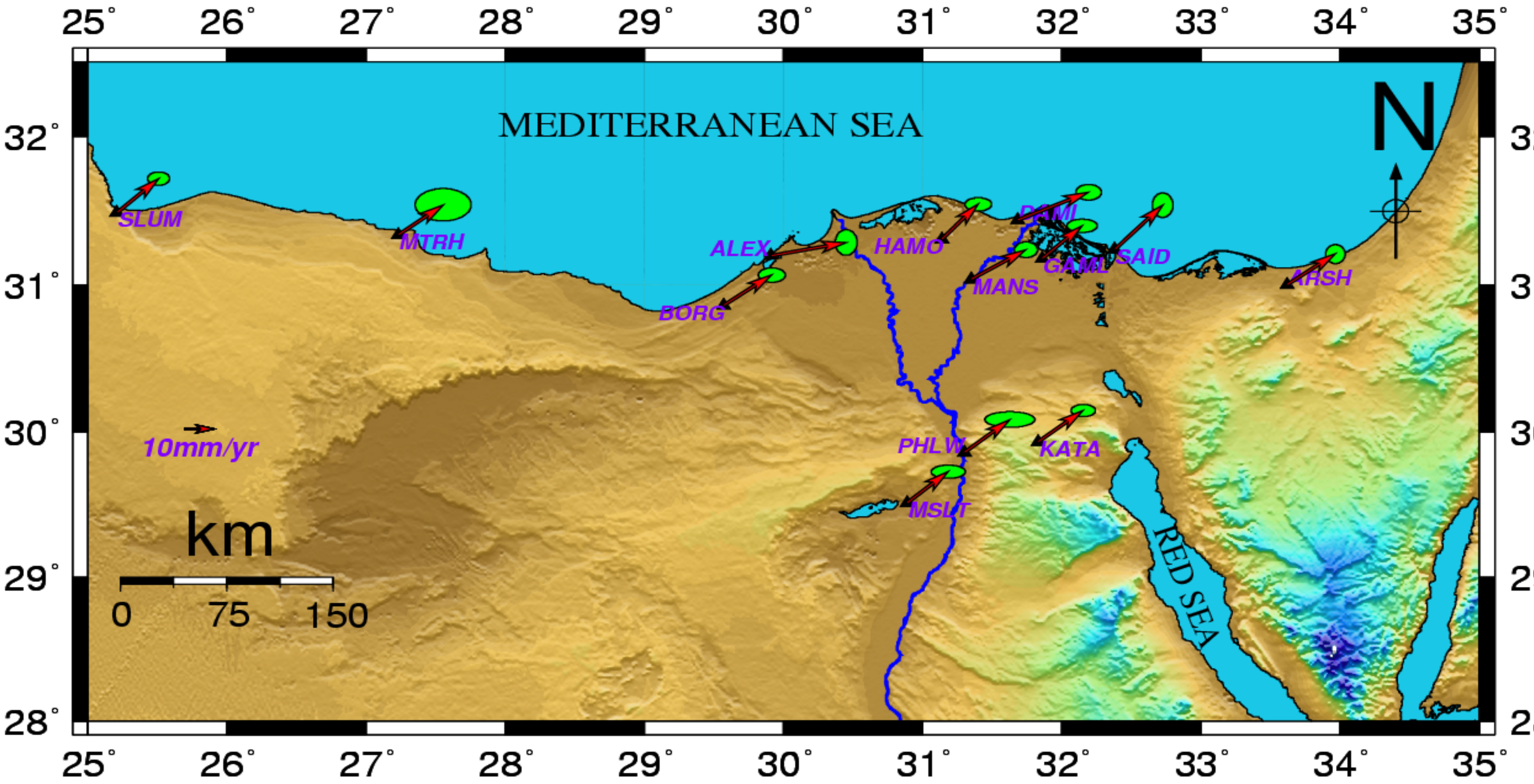
The GPS data were processed using software Bernese V.5.0 (Dach et al., 2007), using the following computational strategy:

1. **Reference frame ITRF 2008.**
2. **Velocity model of tectonic plate motion NNR-NUVEL1A.**
3. **Usage of IGS final orbits and satellite clocks and IGS final Earth orientation parameters.**
4. **Automatic forming of baselines based on OBS-MAX strategy (usage of maximum number of observations) for phase observation processing.**
5. **QIF (quasi-ionosphere-free) strategy of phase ambiguity resolution.**
6. **Ionosphere-free frequency L3 eliminating the influence of ionosphere.**
7. **Elevation cutoff angle 3°.**
8. **Troposphere model Dry Niell, consideration of mapping function for hourly zenith path delay (Wet Niell) and daily horizontal gradient (tilting)**

Result

Points	Abbreviations	Ve (m)	Vn (m)	Mean Velocity(m)
Arish	ARSH	0.0236	0.0166	0.028
Port Said	SAID	0.0235	0.0238	0.033
Mansoura	MANS	0.0268	0.0158	0.031
Gamalyia	GAMA	0.0195	0.0175	0.0262
Damietta	DAMI	0.0347	0.0149	0.0377
Hamoul	HAML	0.0178	0.0189	0.0259
Alexandria	ALEX	0.0368	0.0070	0.037
Borg Al-Arab	BORG	0.0236	0.0164	0.0287
Marsa Matrouh	MARS	0.0221	0.0161	0.0273
Salum	SLUM	0.0204	0.0182	0.0273
Katamyia	KATA	0.0221	0.0169	0.0278
Helwan	PHLW	0.0223	0.0176	0.0284
Mesalat	MESA	0.0202	0.0169	0.0263

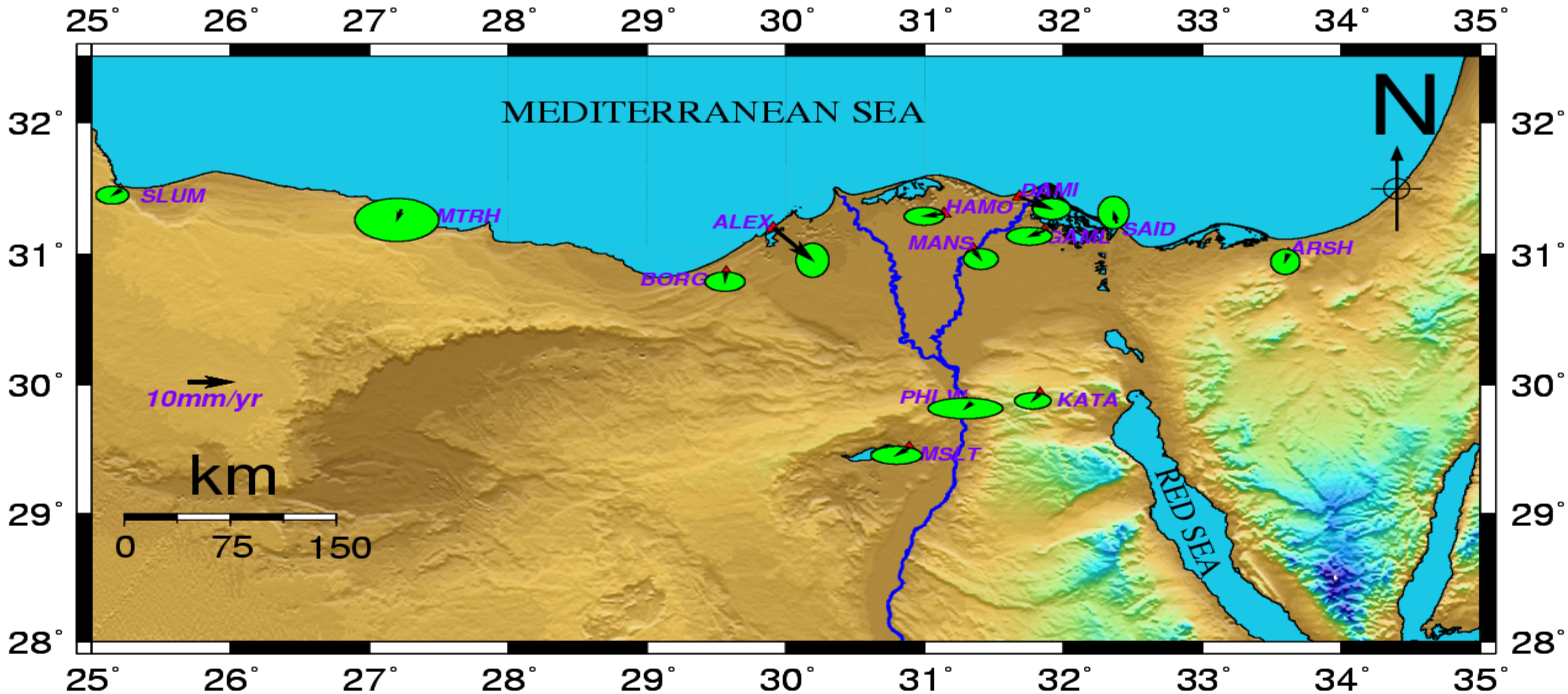
Regional horizontal velocity in ITRF 2008 from 2012 to 2014



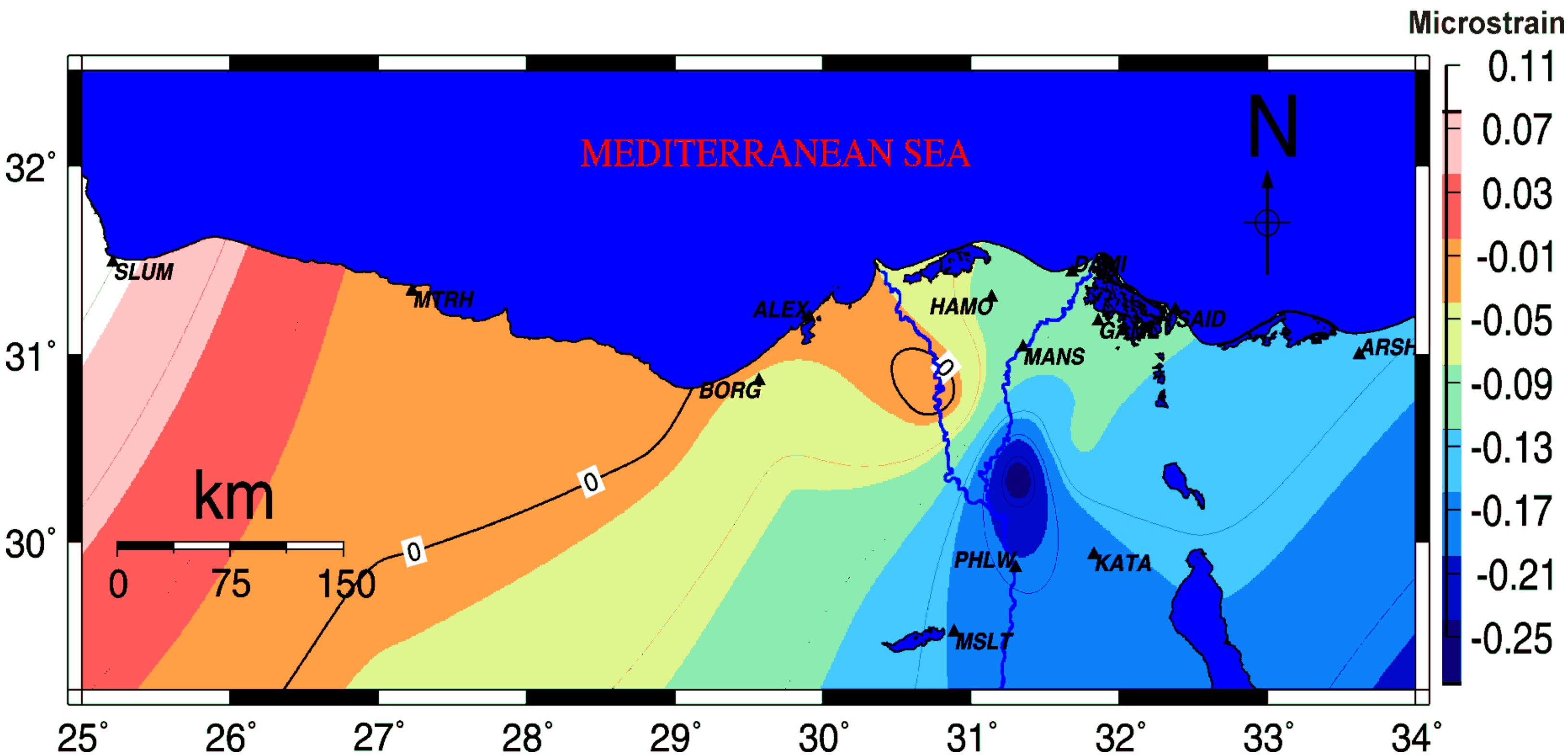
Regional horizontal velocity in ITRF 2008 from 2012 to 2014

Points	Abbreviations	Ve (m)	Vn (m)	Mean Velocity(m)
Arish	ARSH	-0.0010	-0.0030	3.16×10^{-3}
Port Said	SAID	-0.0009	0.0041	4.197×10^{-3}
Mansoura	MANS	0.0025	-0.0040	4.716×10^{-3}
Gamalyia	GAMA	-0.0048	-0.0022	5.28×10^{-3}
Damietta	DAMI	0.0105	-0.0049	0.011
Hamoul	HAML	-0.0064	-0.0009	6.46×10^{-3}
Alexandria	ALEX	0.0128	-0.0129	0.018
Borg Al-Arab	BORG	-0.0003	-0.0036	3.61×10^{-3}
Marsa Matrouh	MARS	-0.0014	-0.0041	4.33×10^{-3}
Salum	SLUM	-0.0027	-0.0021	3.42×10^{-3}
Katamyia	KATA	-0.0023	-0.0028	3.62×10^{-3}
Helwan	PHLW	-0.0021	-0.0022	3.04×10^{-3}
Mesalat	MESA	-0.0041	-0.0029	5.02×10^{-3}

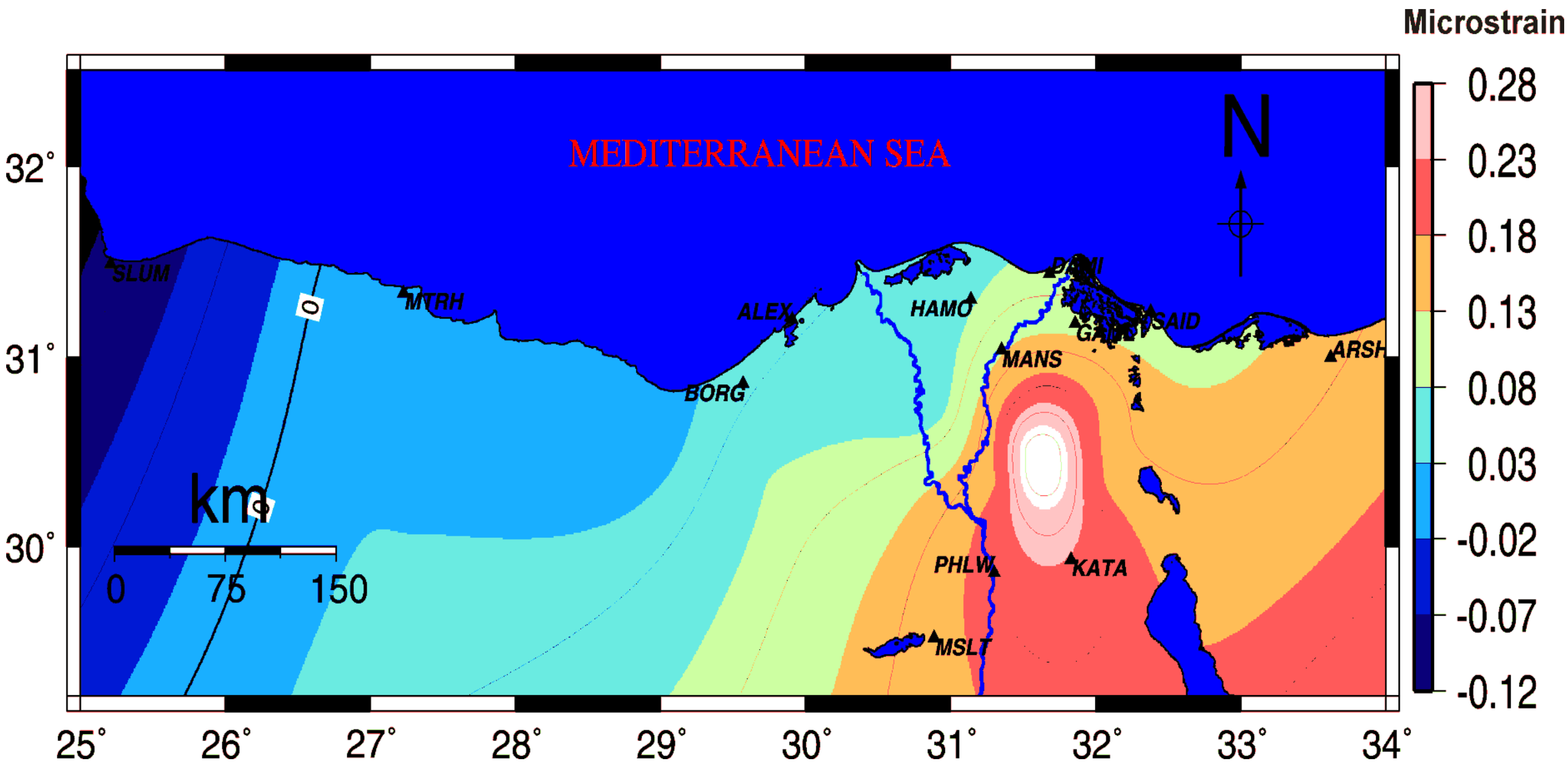
Local Horizontal Velocity in ITRF 2008 from 2012 to 2014



Local horizontal velocity in ITRF 2008 from 2012 to 2014

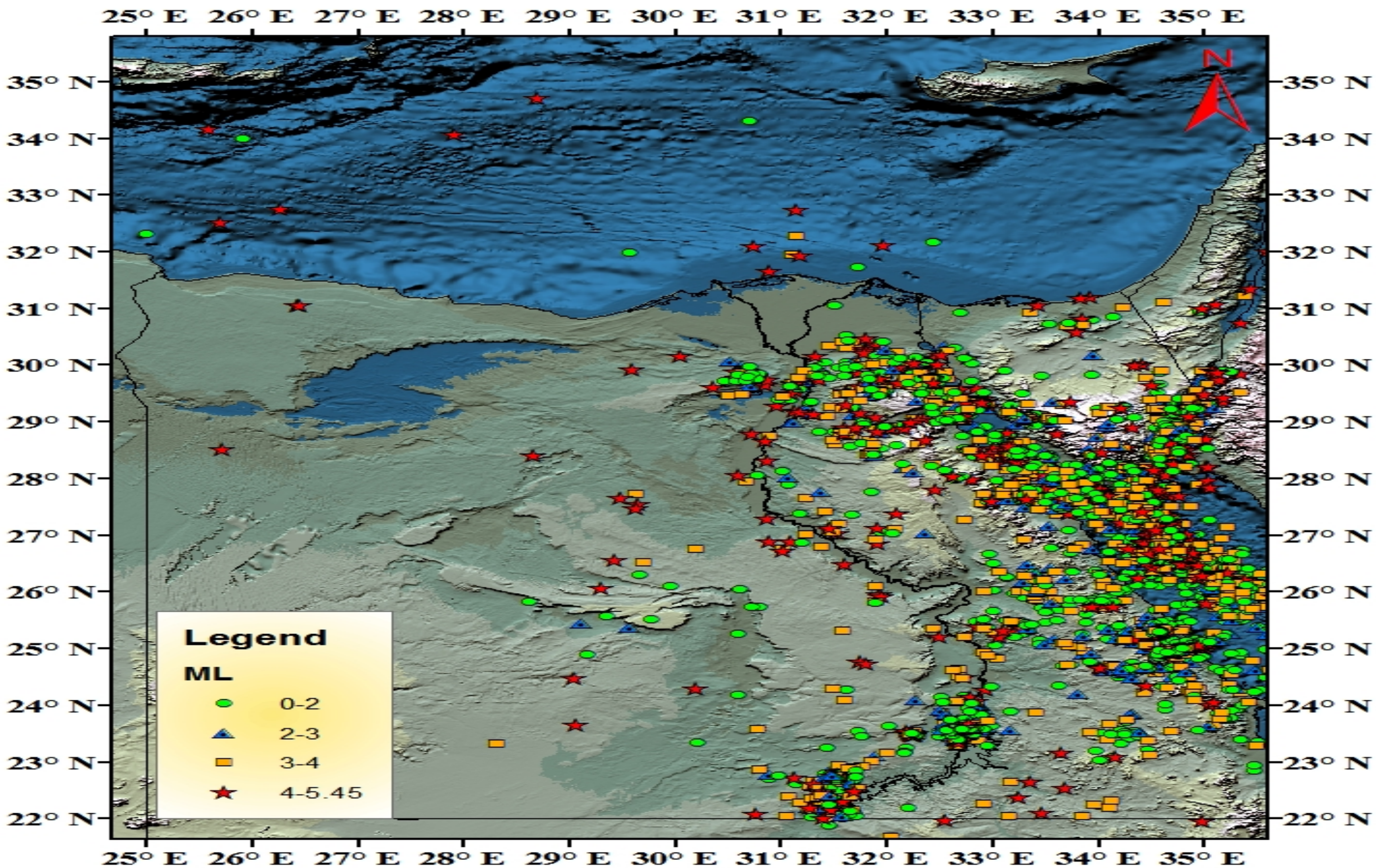


Distribution of dilatation of Strain from 2012 to 2014



Distribution of Maximum Shear of Strain at the area for the period 2012- 2014

Seismicity



Seismicity of Egypt from 2011 to 2014

1- Parameters of the Eastern Desert events:

No	Date Y	M	D	Time H	M	S	Location Lat	Long	H (Km)	Ml
1	2013	3	25	12	40	40	29.04	32.30	22.06	4.2
2	2014	7	18	20	01	29	30.01	32.23	24.09	4.2

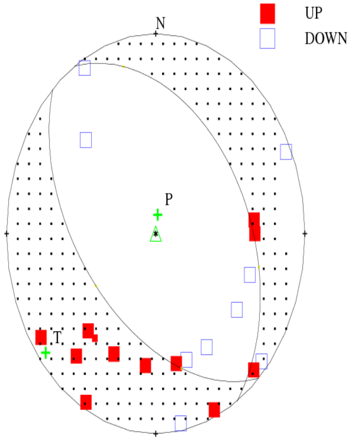
The focal mechanism parameters of the Eastern Desert:

No	P-axis		T-axis		Nodal plane 1			Nodal plane 2		
	AZ.	PL.	AZ.	PL.	ST.	Dip	Rake	ST .	Dip	Rake
1	8	82	231	6	327	40	-82	136	51	-97
2	358	36	263	7	34	60	-23	136	71	-148

-It reflect that area affected by normal fault

- Nodal planes trending :

NE- SW & WNW - ESE

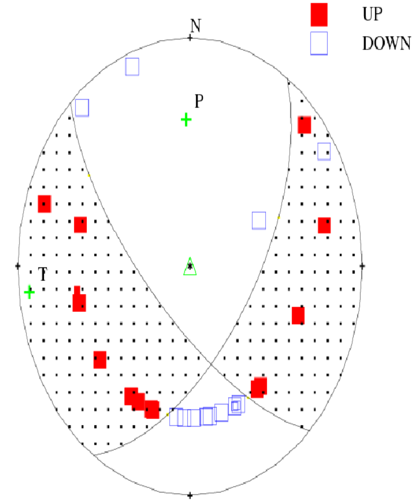


Focal mechanism of event no . 1

-It reflect that area affected by normal fault with strike slip

- Nodal planes trending :

NE- SW & NW - SE



Focal mechanism of event no . 2

2- Parameters of the western Desert events:

No	Date			Time			Location		H	Ml
	Y	M	D	H	M	S	Lat	Long	(Km)	
1	2011	8	5	06	41	33	29.09	31.09	5.17	3.18
2	2012	2	16	02	15	12	29.65	30.66	3.027	3.7

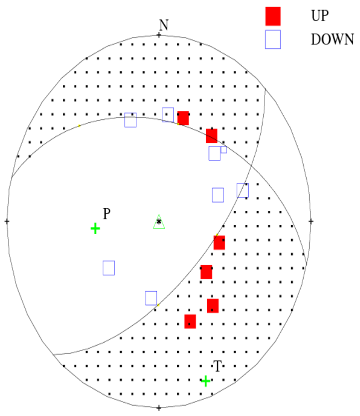
The Focal mechanism parameters of the western Desert:

No	P-axis		T-axis		Nodal plane 1			Nodal plane 2		
	AZ.	PL.	AZ.	PL.	ST.	Dip	Rake	ST .	Dip	Rake
1	265	55	160	10	44	63	-128	283	45	-40
2	261	23	353	6	39	70	-167	305	78	-21

-It reflect that area affected by normal fault with minor strike slip component

- Nodal planes trending :

E- W to NW - SE

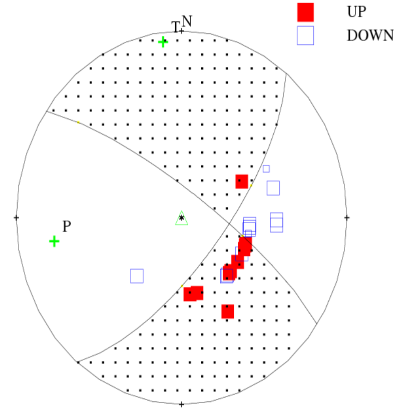


Focal mechanism of event no . 1

-It reflect that area affected by normal fault with strike slip fault.

- Nodal plane trending:

  E-W to WNW - WSE



Focal mechanism of event no . 2

3- Parameters of Gulf of Suez event.

No	Date			Time			Location		H	Ml
	Y	M	D	H	M	S	Lat	Long	(Km)	
1	2013	3	8	23	20	11	29.14	32.71	3.37	3.34

The Focal mechanism parameters of the Gulf of Suez.

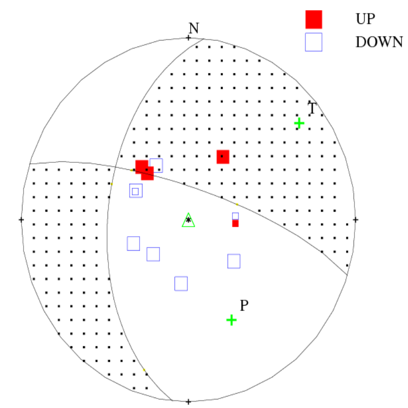
No	P-axis		T-axis		Nodal plane 1			Nodal plane 2		
	AZ.	PL.	AZ.	PL.	ST.	Dip	Rake	ST .	Dip	Rake
1	155	39	51	16	288	76	-138	185	50	-19

-It reflect that area affected by normal fault with slightly strike slip fault

- Nodal planes trending :

WNW-ESE.

-T-axis along the gulf is NNE-SSW



Focal mechanism of event no . 1

Conclusions

- Global Positioning System(GPS) is an effective tool in crustal movements study.
- Based on GPS data:
    - ❑ Horizontal velocity around the study area is very small.
    - ❑ Distribution of dilatation in the study area indicate that the eastern part is suffered from compressional force especially in Abu Zaabal and Cairo-Suez district.

- Distribution of shear reflected that the most value concentrated in Suez, Cairo and Ismailia. This triangle is of high seismicity but it's value decreases towards the west.

- The focal mechanism of some earthquake events recorded during the study period demonstrates mainly normal faulting with strike-slip sense.

- Our results are matched with the geological interpretation of major tectonic trends.

Thank you