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Egyptian Permanent GPS Network (EPGN) and Geodynamic Studies using the Global Positioning System Data: A case study of Stationary Network in Egypt.

By

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❑ Outlines

- *Introduction.*
- *History & Development of GPS network in Egypt.*
- *How to use GPS in studying geodynamic (A case study in Egypt).*
  - *Data Acquisition.*
  - *Data Analysis.*
  - *Results.*
- *Summary and Conclusion.*

Introduction

- After the intermediate earthquake that occurred on November 14,1981 with magnitude of 5.6 at kalabsha area, 60 km south of the High Dam.
- The National Research Institute of Astronomy and Geophysics (NRIAG) started its scientific program for monitoring recent crustal movements and its relation to earthquake activity.
- Cairo earthquake on 12 October, 1992 in Dahshour area with magnitude 5.9 resulted in 554 people being killed, about 20,000 people being injured and over one billion US$ reported as property losses.

- It was applied around the seismic active regions in Egypt such as Gulf of Suez, Nile valley, Greater Cairo, Aswan and Abu Dabbab.
- In 2006, NRIAG started the establishment of the Egyptian Permanent GPS Network (EPGN).
- By the end of 2015, the number of this network increased to cover most of the Egyptian territory.

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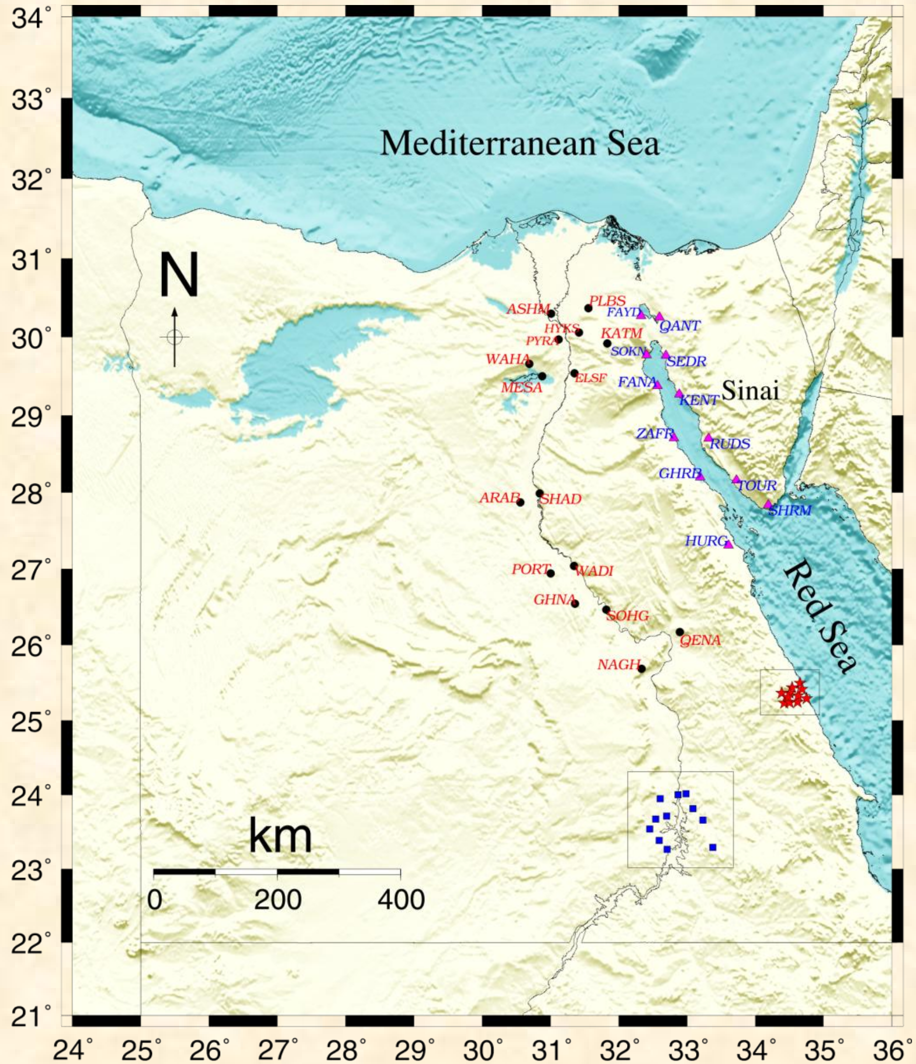
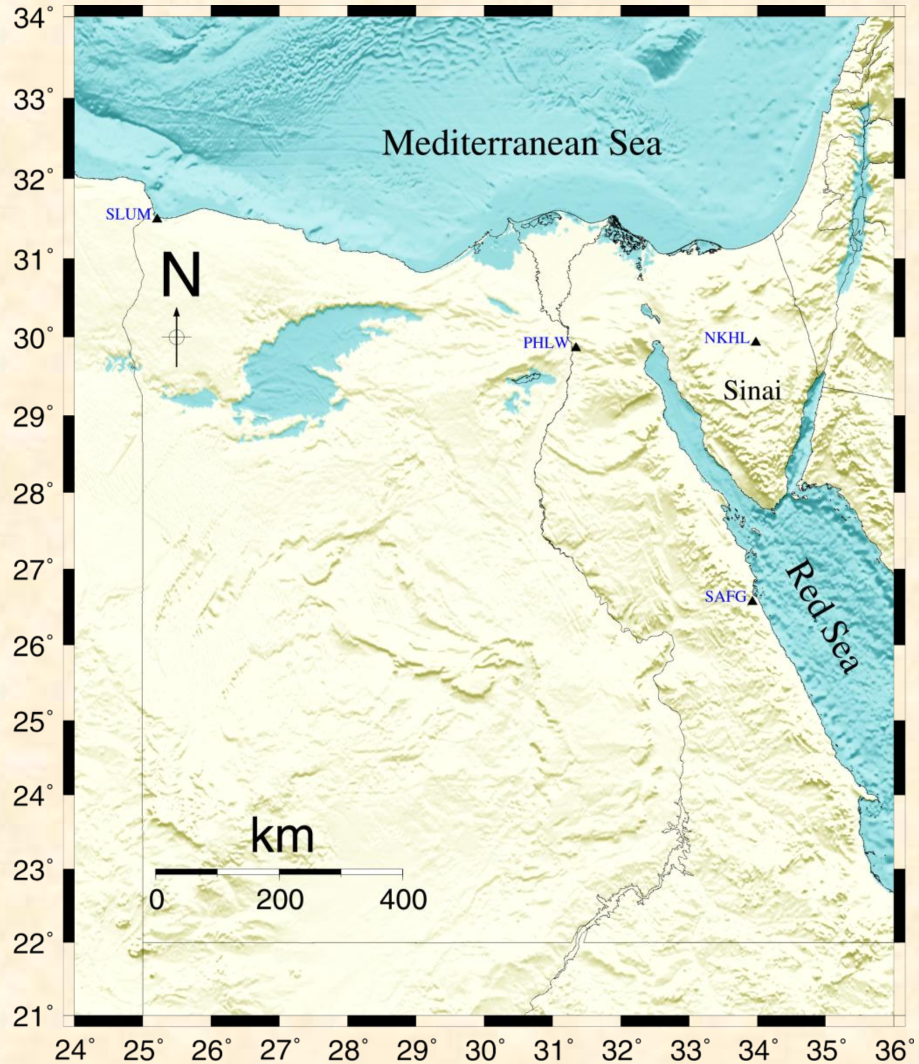
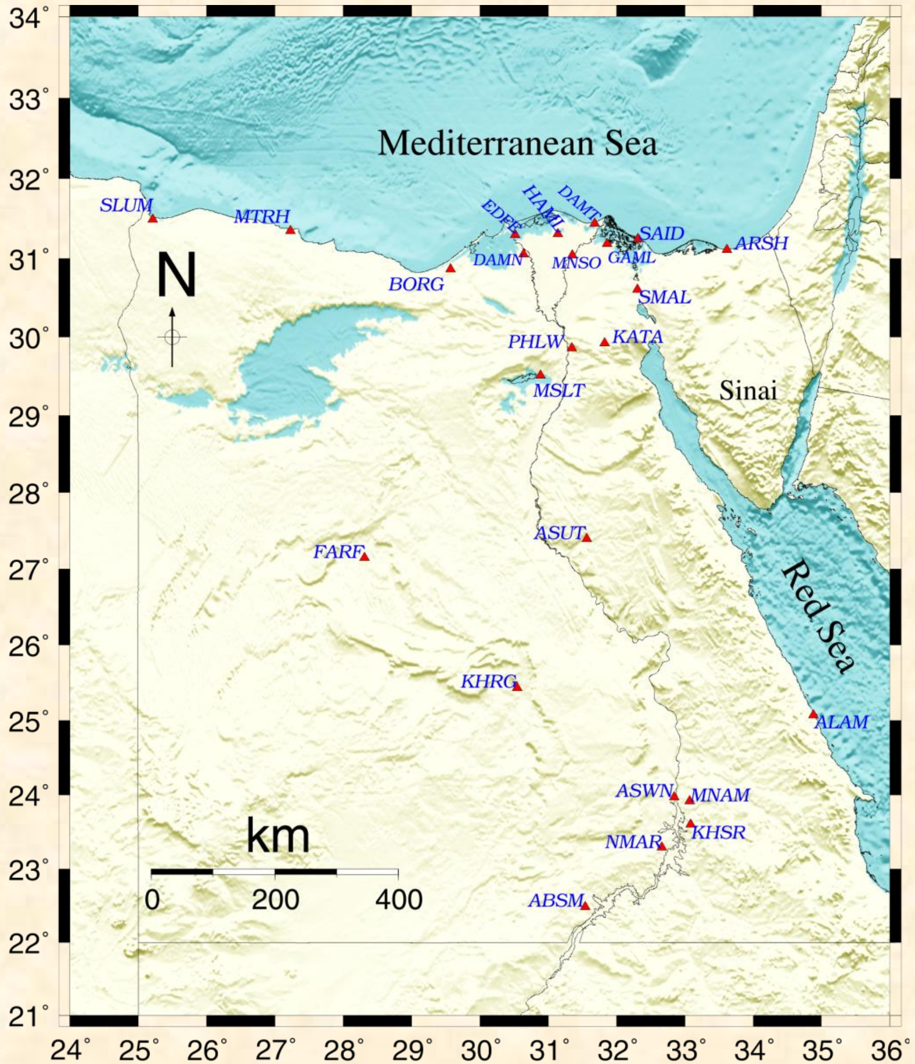
Distribution of Local Network in Egypt.

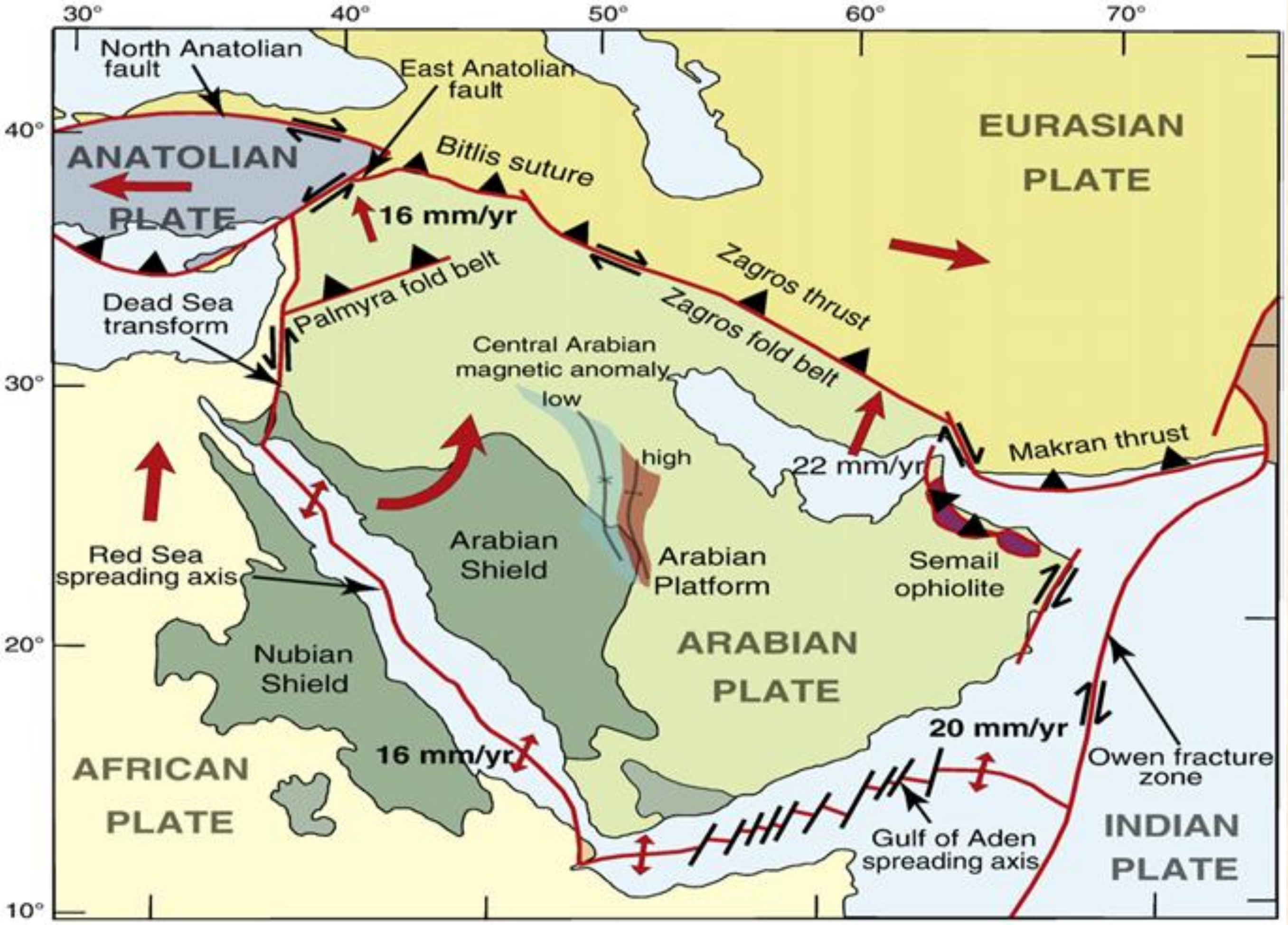


Distribution of Egyptian Permanent GPS Network (EPGN) in 2006.



Distribution of Egyptian Permanent GPS Network (EPGN) by the end of 2015.





Simplified map of the Arabian Plate, with plate boundaries, approximate plate convergence vectors, and principal geologic features (after Stern and Johnson, 2010).

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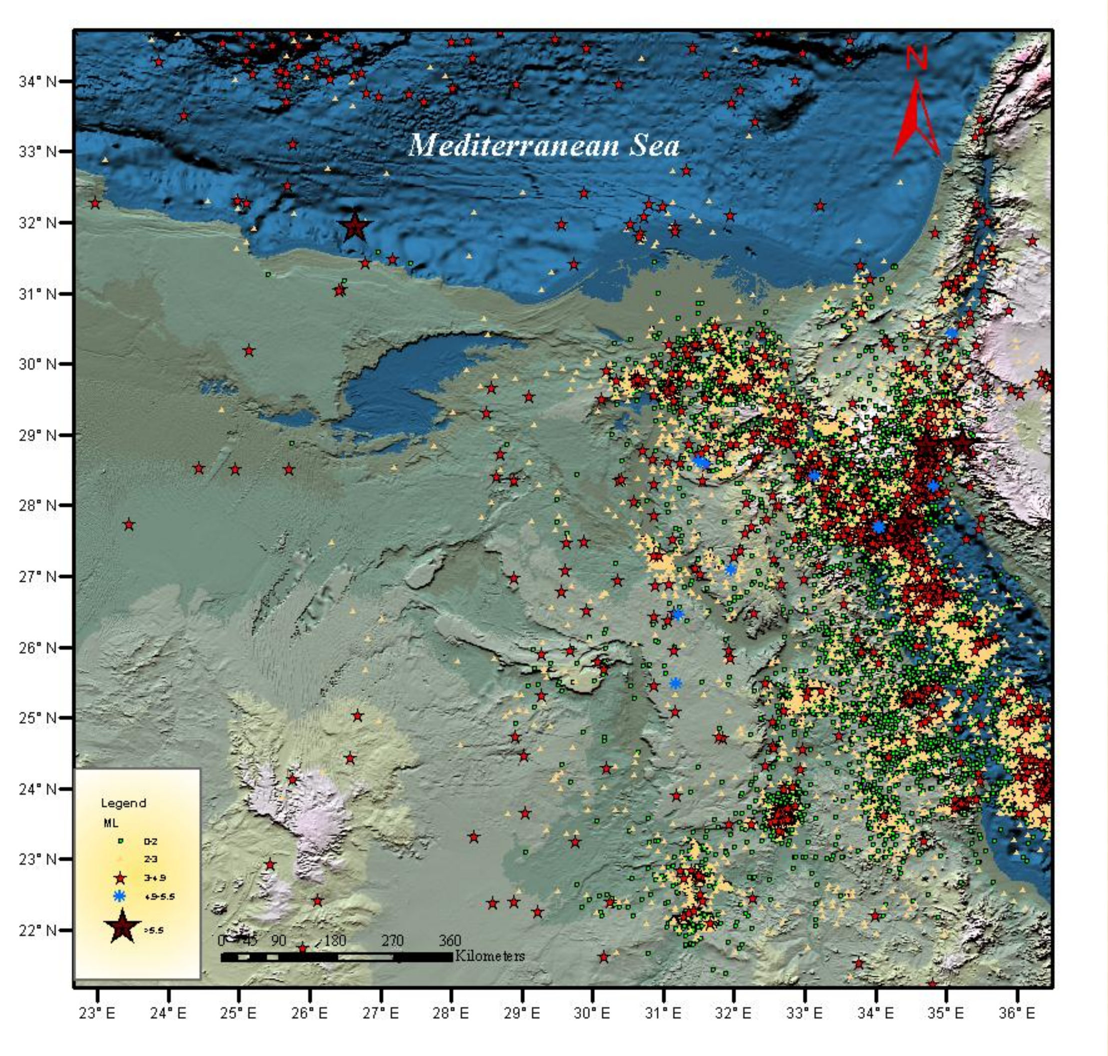
Seismicity of Egypt from 1997 to 2016



❑ *How to use GPS in studying geodynamic (A case study in Egypt).*

1. Data Acquisition

- In this study we used 13 stations from the Egyptian Permanent GPS Network (EPGN) .These stations were chosen to cover most of the Egyptian territory. The GPS data were covered the period from 2013 to 2014 .

Geographic distribution of the Egyptian Permanent GPS network (EPGN) stations that used in analysis

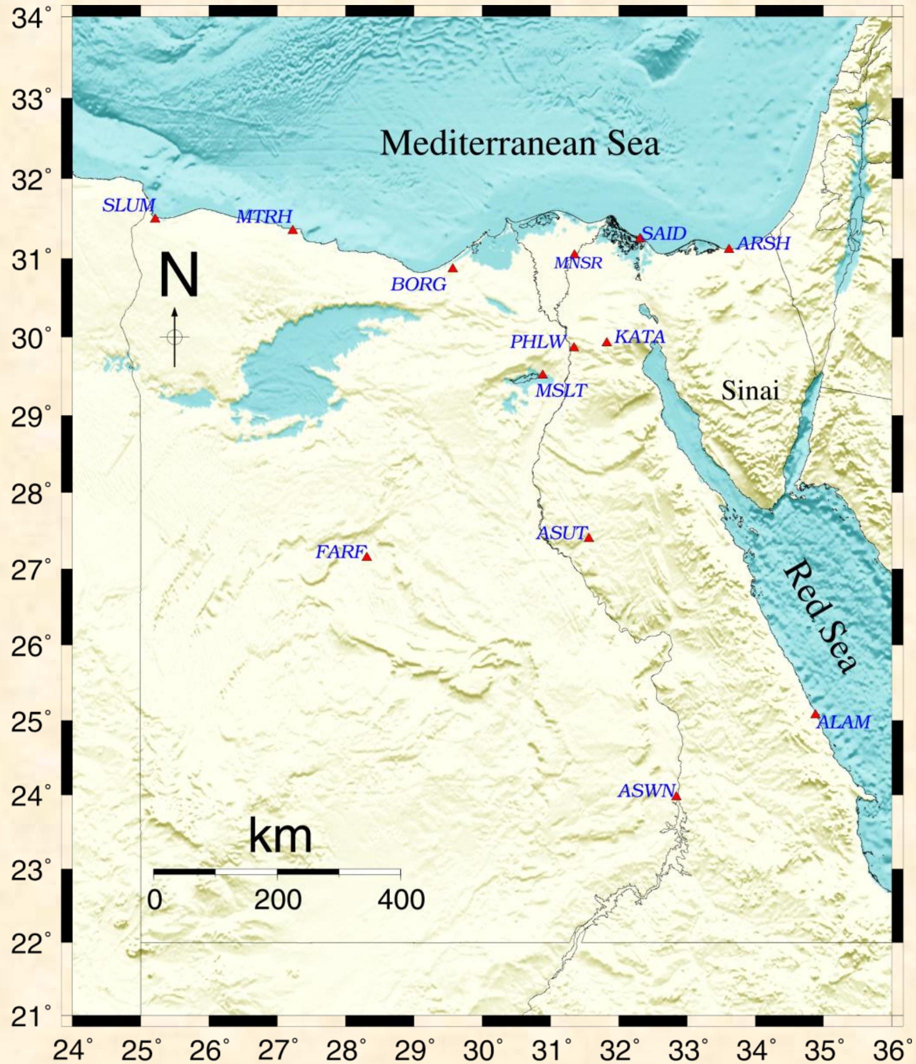


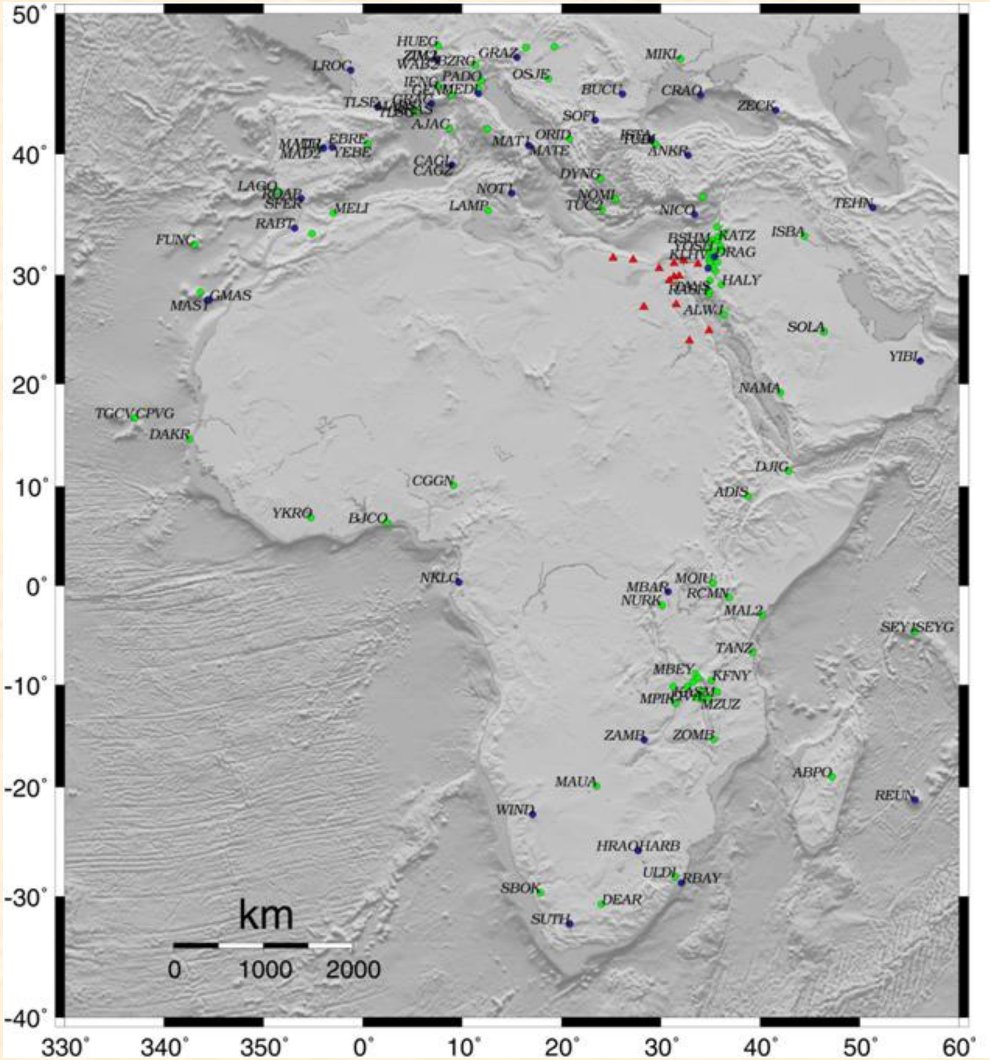
Chart availability of the EPGN stations.

2. Data Analysis

2.1. Processing step

- Beside the data from EPGN, we downloaded data from 123 permanent stations from different sources as: International GNSS Service (IGS), European permanent Network (EPN), University NAVSTAR Consortium (UNAVCO) and Scripps Orbit and permanent Array Center (SOPAC).
- 31 out of these 123 stations are included in the International Terrestial Reference Frame 2008 (ITRF2008) (Altamimi et al., 2011) and were used for datum definition.

Permanent Egyptian stations (Red triangles) and the international stations (IGS, EPN, UNAVCO and SOPAC) are green circles and blue circles are stations used in datum definition.

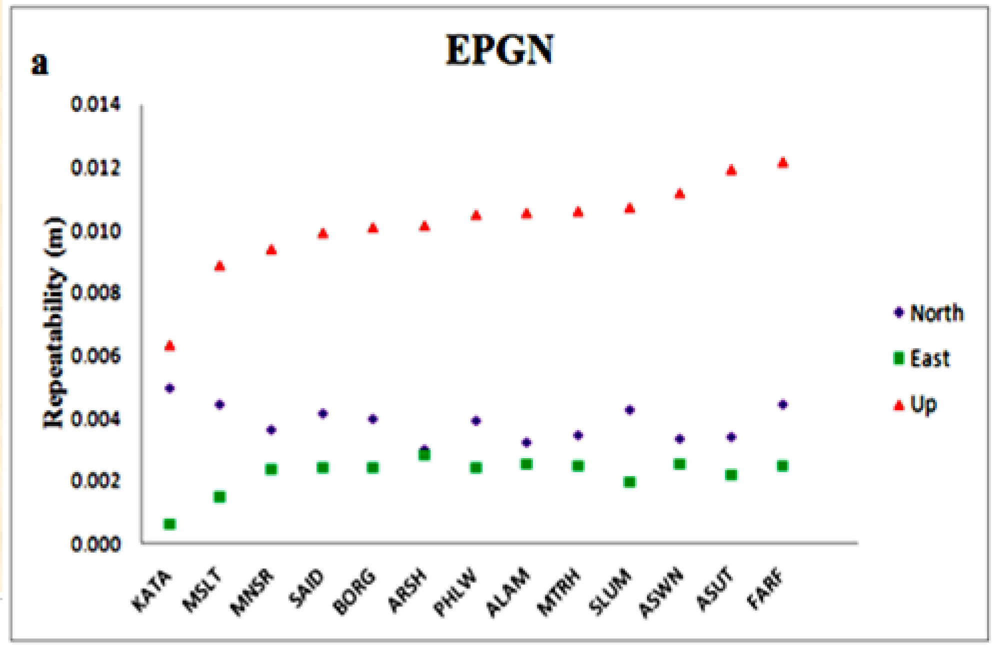


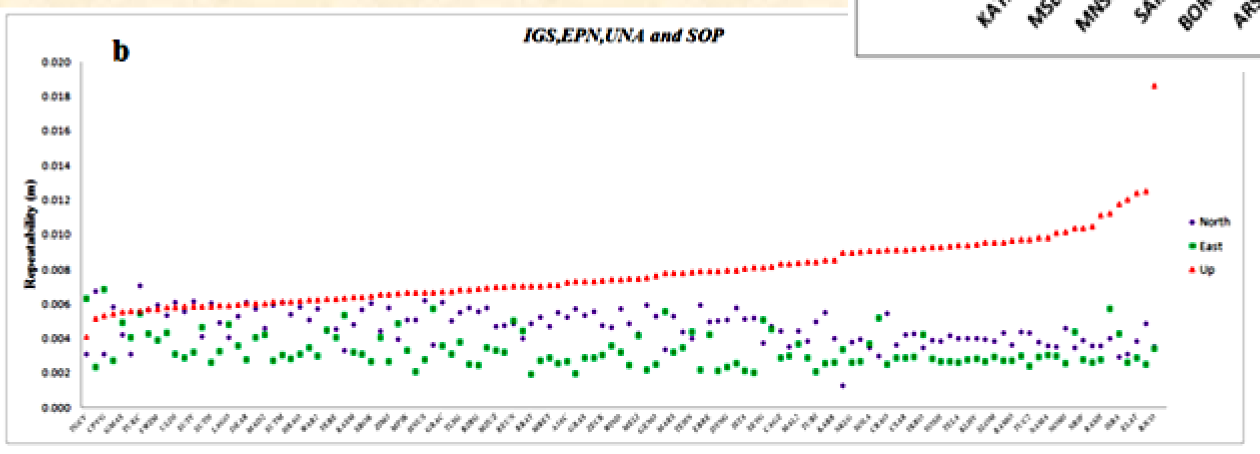
- The data were processed using Bernese software V.5.2 (Dach et al., 2015) using some computational strategy.
- As a result of these processing, 730 daily normal equations were generated.
- The combination tool in Bernese software (ADDNEQ2) was used to combine all these normal equations using minimum constrained solution.
- All estimated parameters (coordinates, velocities, ...) are stored in the normal equation files to be stacked later.

2.2. Error Scaling

- In case of combining several daily solutions, another more realistic precision can be obtained by using the residuals of the daily solutions with respect to the combined solution to calculate a uncertain standard deviation (usually called repeatability).
- A ratio between the formal standard deviation and the repeatability can be used to scale the variance-covariance matrix to end up in a more realistic error scaling.

Repeatability of EPGN (a) and Repeatability of IGS, EPN, UNA and SOP stations (b)





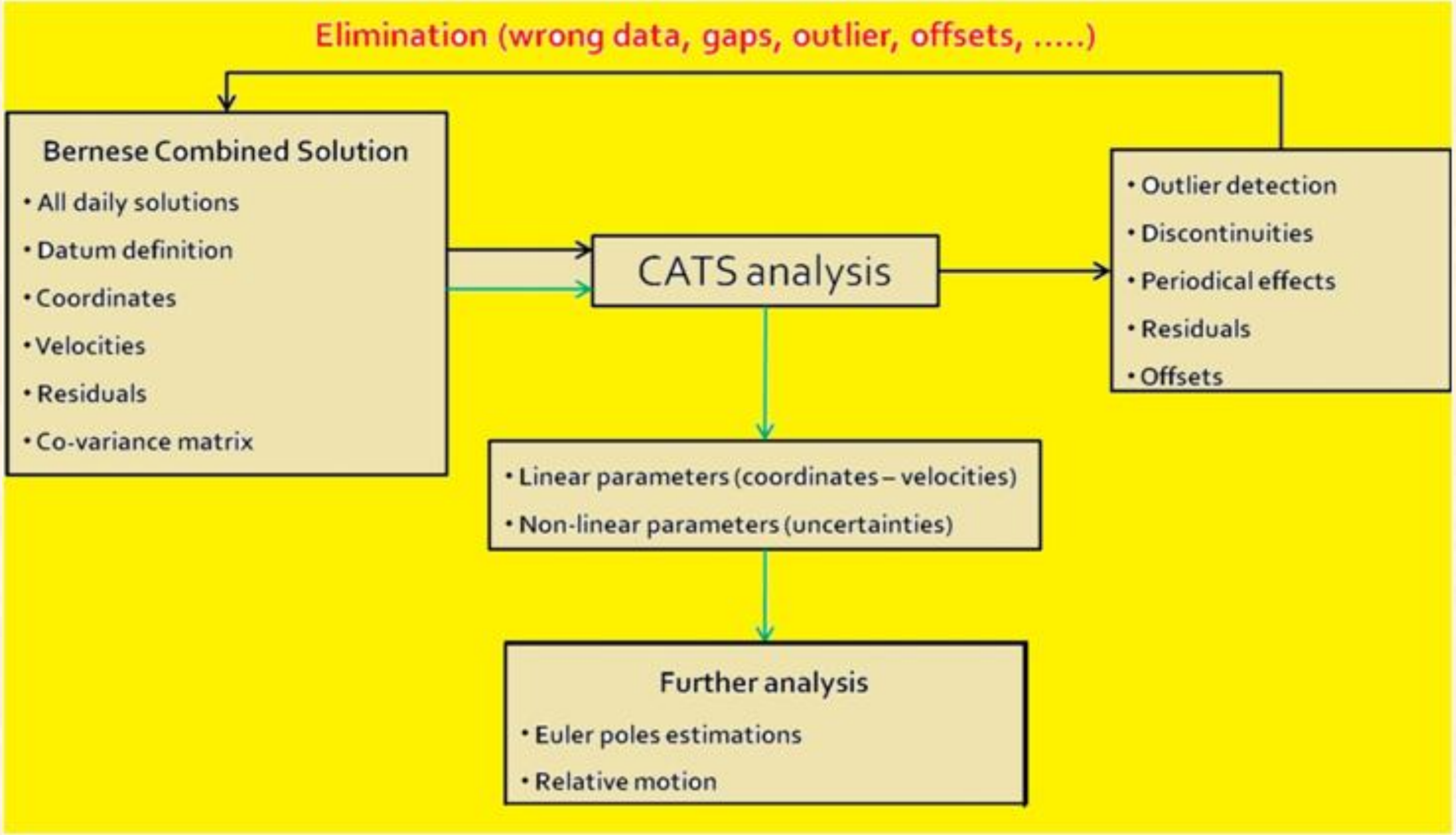
2.3. Time Series Analysis

$$P_x (f) = P_0 (f / f_0)^k \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1) Agnew1992}$$

$$C = a^2 I + b^2_k \; J_k \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

where

- f : is the spatial or temporal frequency.
- P_0 and f_0 : normalizing constants
- k : the spectral index ranging from (-3 : 1)
- a and b_k: scale factors of the amplitude of the white noise and colored noise, respectively,
- I: is the identity matrix.
- J_k : is the covariance matrix for the respective colored noise.



Flow diagram of the CATS processing scheme

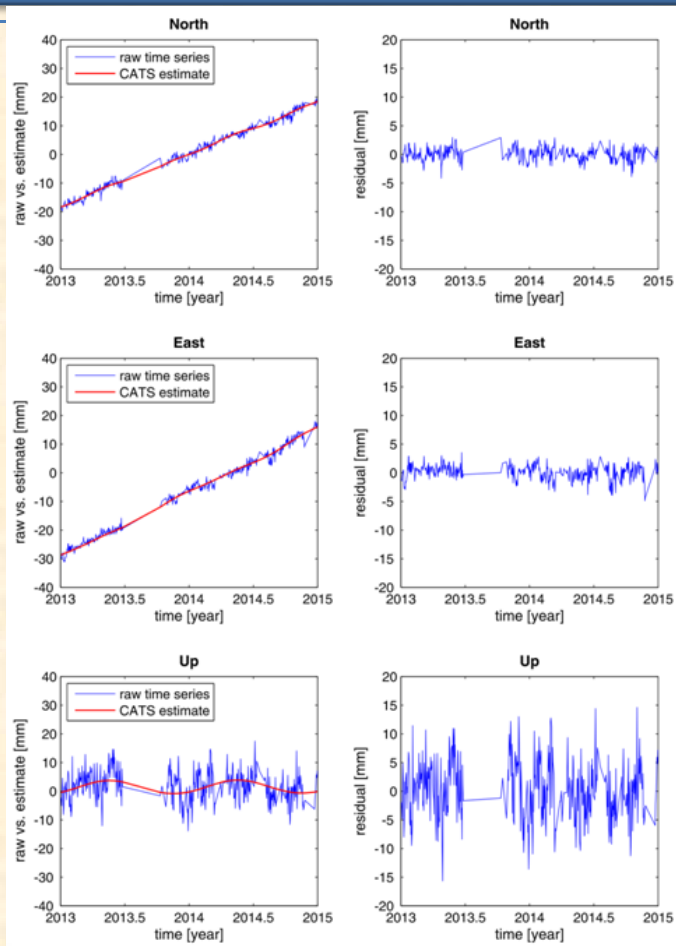
3. Results

A-

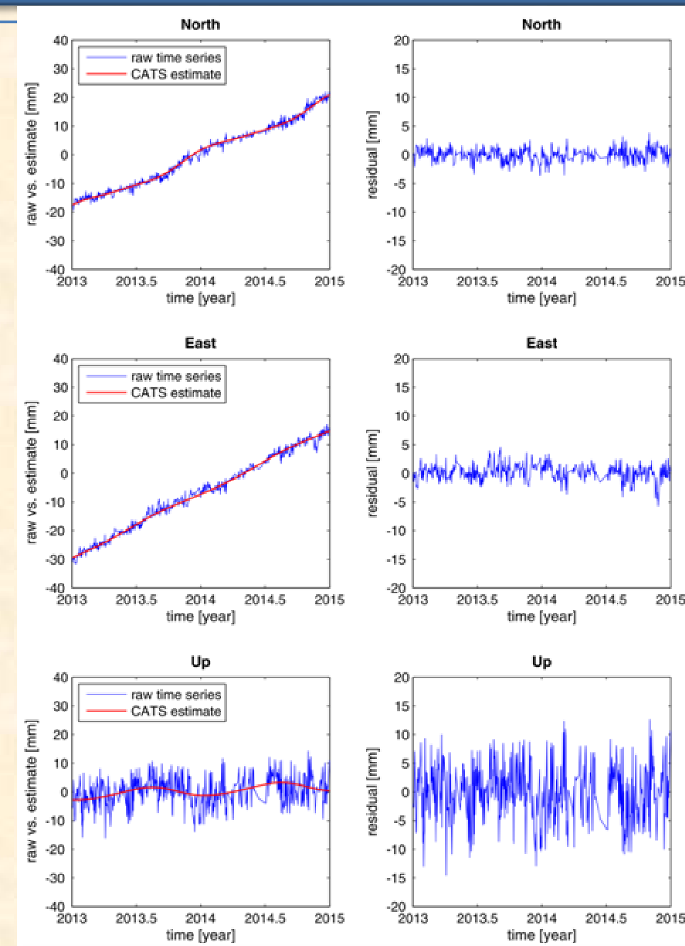
		Bernese Scaled error	CATS white noise	CATS white noise + power law noise
PHLW	East	27.70 ± 6.99	22.02 ± 0.13	22.38 ± 0.46
	North	22.95 ± 4.74	18.33 ± 0.12	18.41 ± 0.36
	Up	-1.43 ± 9.81	-0.75 ± 0.51	0.16 ± 1.62
KLHV	East	28.06 ± 6.90	21.87 ± 0.11	22.15 ± 0.46
	North	23.11 ± 5.18	19.30 ± 0.09	19.26 ± 0.27
	Up	2.04 ± 7.57	1.18 ± 0.38	1.63 ± 1.06

Velocities and their standard deviations from Bernese, white noise and white noise plus power law noise stochastic models in mm / yr.

a

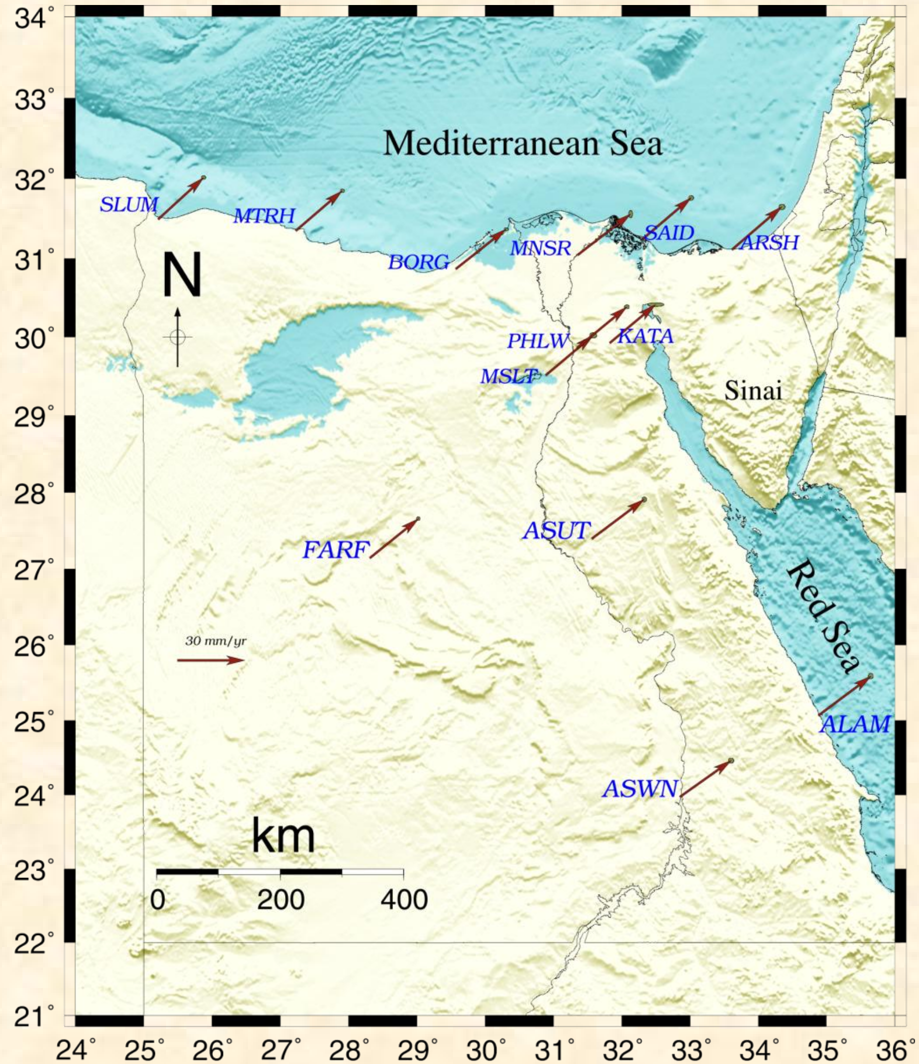


b



Bernese raw time series (blue line) and the estimated CATS time series (red line) in the left side and residual in the right side in each component using white noise plus power law noise model for stations PHLW (a) and KLHV (b).

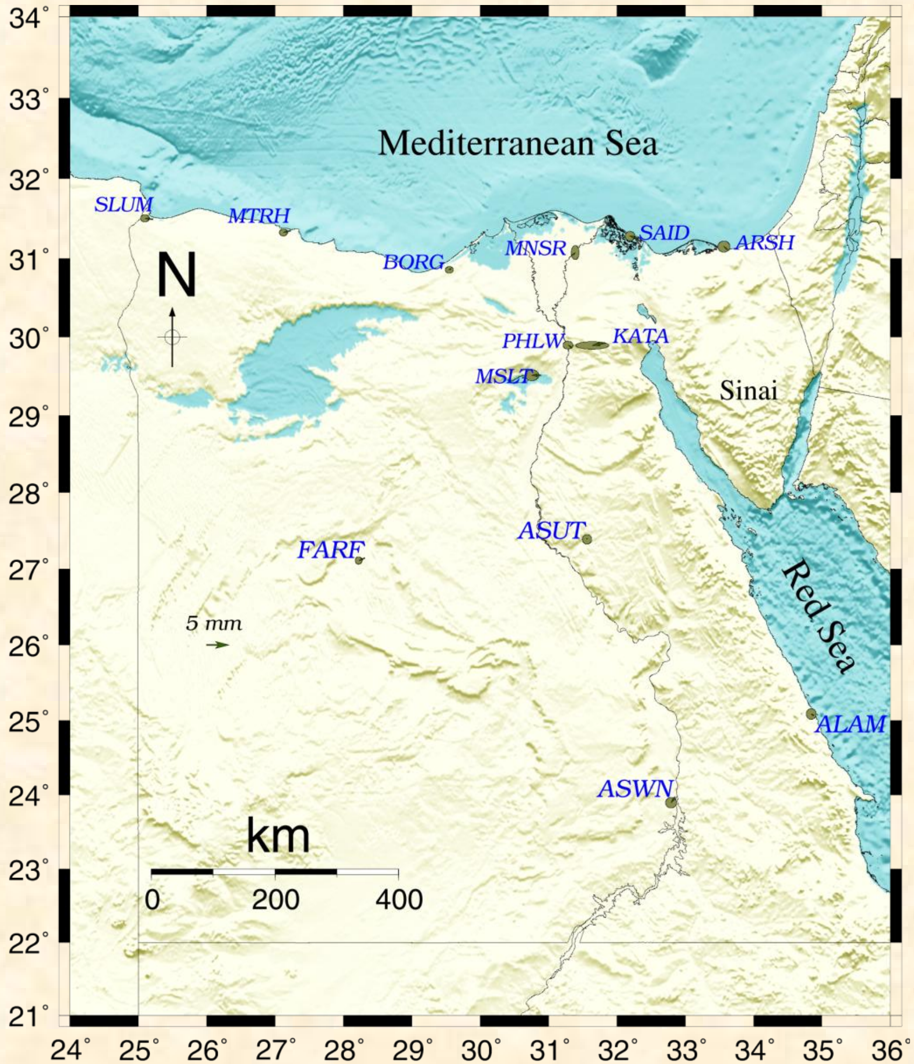
b- Absolute Horizontal Velocity Field



Estimated ITRF2008 horizontal velocities of EPGN stations with 95% confidence level.

c- Relative Velocity Field

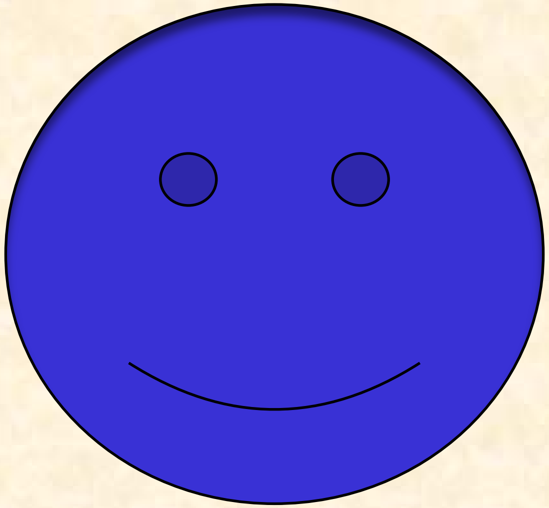
GPS horizontal velocities of EPGN with 95% confidence level in Nubia fixed frame.



Summary and Conclusion

- This study is attempt to give a clear picture on the development of the Egyptian Permanent GPS network from 1981 till now .
- It’s application in studying geodynamic behavior (A case study in Egypt).
- 13 Permanent stations from EPGN in addition to 123 International stations (IGS, UNAVCO,EPN and SOPAC).
- The data were processed using Bernese software v5.2 and CATS.

- Two stochastical models were used ; these models are white noise and white noise plus power law noise.
- Based on white noise plus power law noise results, Almost of the Egyptian stations are moving in North East direction with Magnitude 28.29 ± 0.7mm/yr.
- GPS horizontal velocities of EPGN are 4 mm/yr ±1 in Nubia fixed frame.



THANK YOU