MONITORING OF CRUSTAL MOVEMENTS IN EGYPT USING GPS TECHNIQUE

By

Salah M. Mahmoud

Professor of Geophysics and
Head Department of Geodynamics
National Research Institute of Astronomy and Geophysics (NRIAG), Helwan, Cairo, Egypt

United Nations/United States of America International Meeting on The Use and Applications of Global Navigation Satellite System
13 – 17 Dec. 2004 Vienna, Austria
TOPICS TO BE FOCUSED

- TECTONICS
- SEISMICITY
- GPS OBSERVATIONS
- CONCLUSIONS & RECOMMENDATIONS
Global Tectonic Setting

- **Major tectonic elements:**
  
  - Africa moves north relative to Eurasia (name of the combined Europe and Asian tectonic plates) at ~10 mm/yr.
  - To the west the mid-Atlantic ridge is opening at rate of ~20 mm/yr.
  - To the east the rapidly move Indian Plate is converging on the Eurasian Plate at ~45 mm/yr.
  - To the north east the Arabian plate is converging on Eurasia at ~25 mm/yr.
  - The eastern part of Africa is being rifted by the East African Rift.

- **Consequences of these motions are earthquakes and volcanoes.** 10 mm/yr = 1 meter of motion in 100 years.
Global Plate motions

- Convergence of Africa and Eurasian Plate
- Proposed Somalia Plate
- Spreading of mid-Atlantic Ridge
Earthquakes 1977-1997

• North African events are collision events

• Events in East Africa are associated with rifting

• Southern boundary of rift system not distinct
Historical earthquakes in Egypt from 2200BC to 1900AD (Polrer and Taher, 1980; Mamoun et al., 1984; Ambraseys, et al., 1994).
Seismic activity of Egypt from 1900 to July 1997 based on data from NRIAG with the proposed seismic active zones.
The Egyptian National Seismic Network Stations (ENSN)

- The Network consists of:
  - 64 Short Period Stations SS-1.
    - Natural Frequency 1 Hz, Sampling rate = 100 Sample per Second
  - 4 Very Broad Band stations STS-2.
    - Natural Frequency 0.008 Hz, Sampling rate = 100 Sample per Second
  - Broad Band Station SJ13 at High Dam (Aswan).
    - Natural Frequency 1 Hz, Sampling rate = 100 Sample per Second
  - 24 Portable Stations LC4.
    - Natural Frequency 1 Hz, Sampling rate = 100 Sample per Second
Geographical distribution of ENSN stations that transmit their data to Helwan main center
The Egyptian National Seismic Network (ENSN)
The Egyptian National GPS Network

The GPS Network Stations are classified into:

- **Permanent GPS Network:**
  - 1 Network Consists of 9 Stations.

- **Survey Mode Networks:**
  - 4 Networks:
    - Aswan Network: Consists of 11 Stations,
    - Sinai Network: Consists of 11 Stations,
    - Greater Cairo Network: Consists of 11 Stations,
    - Middle Part of Egypt Network: Consists of 10 Stations.
Instrumentation Facilities

- **GPS Instruments**
  - 20 Trimble Receivers 4000 SSI
  - 2 Total Stations TC 1100L
  - 4 Trimble RTK 4800
  - 2 Kern (GK2-A)
  - 4 Trimble RTK 5700
  - 1 Leica (NA3003)

- **Gravity Instruments**
  - A Permanent GPS Station of choke ring antenna connected with TurboRogue Receiver
  - Lacoste & Romberg- model G
  - Abenica & Romberg- model D
Monumentation of the GPS Station
Survey Mode GPS Station: Antenna Connected with Trimble Receiver
There are several uses to GPS in different fields such as:

- The Coast Guard
- Offshore Exploration
- Natural Resource Management
- Navigation
- Transportation and Fleet Management
- Agriculture
- Crustal Deformation Studies
Crustal Deformation Studies

The following steps have been followed for monitoring movements in Egypt:

- Design and establishment of GPS network.
- Carrying out the repeated measurements.
- Final analysis of repeated measurements using the scientific software (e.g. Bernese V4.2 & 5.0; GAMIT).
<table>
<thead>
<tr>
<th>Station ID</th>
<th>Campaign year</th>
<th>Geographic coordinate</th>
<th>ITRF2000 velocity</th>
<th>Nuvel1-A velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cath</td>
<td>97, 98, 99, 00, 02, 03</td>
<td>Lat(°), Long(°)</td>
<td>V_N(mm/6y), V_E(mm/6y)</td>
<td>V_N(mm/6y), V_E(mm/6y)</td>
</tr>
<tr>
<td>Daha</td>
<td></td>
<td>28.639, 34.000</td>
<td>15±0.1, 23±0.2</td>
<td>19.5, 25.1</td>
</tr>
<tr>
<td>Derb</td>
<td></td>
<td>28.329, 34.470</td>
<td>18±0.1, 22±0.2</td>
<td>19.5, 25.1</td>
</tr>
<tr>
<td>Garb</td>
<td></td>
<td>28.163, 33.228</td>
<td>19±0.2, 24±0.1</td>
<td>19.6, 24.9</td>
</tr>
<tr>
<td>Gems</td>
<td></td>
<td>27.686, 33.494</td>
<td>19±0.1, 24±0.1</td>
<td>19.6, 25.0</td>
</tr>
<tr>
<td>Hurg</td>
<td></td>
<td>27.267, 33.869</td>
<td>18±0.2, 23±0.0</td>
<td>19.6, 25.1</td>
</tr>
<tr>
<td>Kens</td>
<td></td>
<td>43.788, 41.565</td>
<td>17±0.1, 22±0.3</td>
<td>19.6, 25.0</td>
</tr>
<tr>
<td>Mat</td>
<td></td>
<td>27.919, 40.649</td>
<td>19±0.2, 23±0.0</td>
<td>19.6, 24.9</td>
</tr>
</tbody>
</table>
Displacement vectors in Aswan network for the period from 1997-2000
Distribution of GPS geodetic station between Egypt and Yemen.
Displacement vectors in Egypt –Yemen network for the period from 2000 to 2003
Some details of Northern Collision

Measured GPS Motions in Turkey and Greece

Continuously operating GPS systems allow these types of dense networks
Generalized Regional Motions Model of the Eastern Mediterranean Region
GPS observations in Egypt were applied for the first time since 1994 and how to cover different regional networks (e.g. Sinai, Aswan, Greater Cairo and Middle Part of Egypt).

A generalized model of the regional plate motions in the eastern Mediterranean has been deduced.

Adjustment and analysis of the repeated GPS campaigns from the different networks prevailed significant motions.
It should be emphasized that all concerned authorities, research institutes and universities in the countries surrounding the Red Sea and the Gulf of Aqaba to cooperate in a program for studying the crustal movements using GPS technique to evaluate the seismicity and earthquake hazards in these regions.
THANK YOU