INVESTIGATION OF THE DISPLACEMENTS FROM 1941 TO 2007 USING TERRESTRIAL AND GPS MEASUREMENTS ALONG THE WESTERN PART OF NORTH ANATOLIAN FAULT IN MARMARA REGION

G. Akay[1] and H. Ozener[2,1]
[1]{Bogazici University, Kandilli Observatory and Earthquake Research Institute, Istanbul, Turkey}
[2]{Istanbul Technical University, Civil Engineering Faculty, Geodesy and Photogrammetry Department, Istanbul, Turkey}

TS 6 – Technical Session
FIG Working Week 2008
Stockholm, Sweden 14-19 June 2008

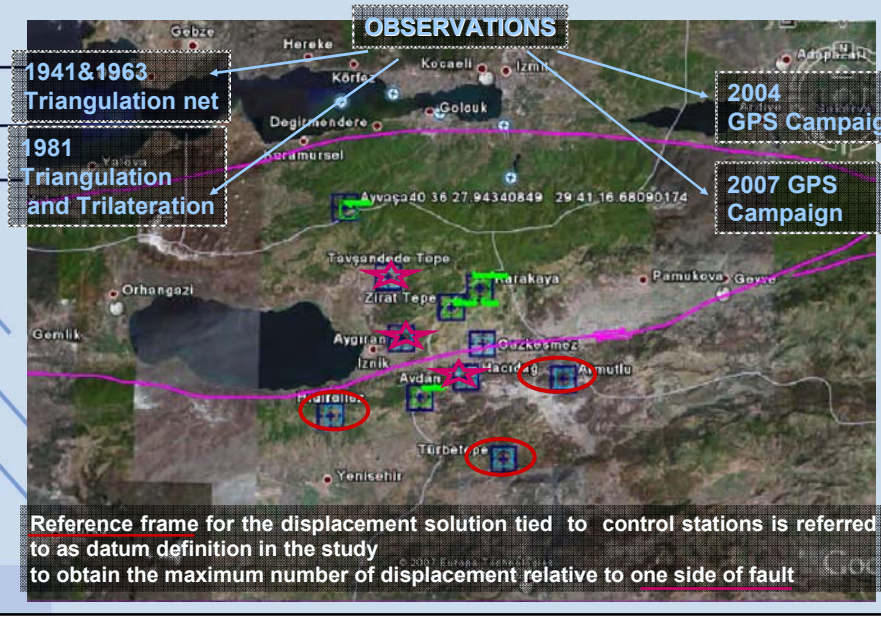
CONTENTS

Research Area Around The Lake Of Iznik

•/ right lateral strike-slip movement
•/ GPS derived velocity 1-2mm/yr (Ucakus-Barka, 2003)

•/ located around west of Geyve, goes along approximately 15 km up to Sakarya River as an right lateral fault (Barka 1993)
•/ then bounds the Geyve basin - leaps over to the right side continuous through Mekece and Iznik Lake in W-SW direction.

THE GCM NETWORK AND OBSERVATION METHODS



Reference frame for the displacement solution tied to control stations is referred to as datum definition in the study
to obtain the maximum number of displacement relative to one side of fault

GCM-ITU NETWORK

Stations	1941/1963	1981	2004/2007
Armutlu	+	+	+
Avdan	+	+	
Ayva□a	+		
Aygıran		+	+
Gazkesmez			+
Hacıdağ		+	+
Hıdırellez	+	+	+
Karakaya	+	+	
Tav□andede Tepe	+	+	+
Türbe Tepe	+	+	+
Ziraat Tepe		+	

GCM-ITU NETWORK

- Stations south of the fault
  - Hidirellez
  - Turbetepe
  - Armutlu stations are fixed.
- Coordinates
  - In ED-50 datum in terrestrial analysis
  - In WGS 84 datum in GPS analysis
  - The network defined by the datum which is form by fixed stations.

INVESTIGATION OF DISPLACEMENT OF GCM-ITU NETWORK BETWEEN 1941 AND 2007

- 1941-1963 triangulation
  - had poor geometry
  - low accuracy.
  - it is decided to unite both measurements and adjust them as a single observation
- 1981 triangulation and trilateration observations
  - Changes in the coordinates of 4215 Tavsandede Tepe, 202 Aygiran and 226 Hacidag stations were examined relative to control stations

2004 VE 2007 ANALYSIS

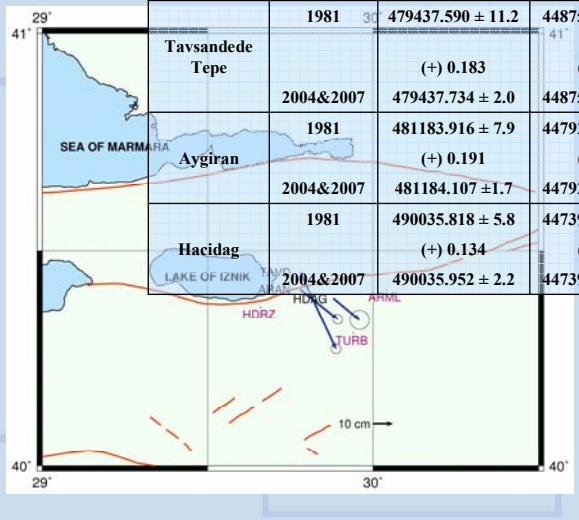
- GPS measurements were carried out in 2004 and 2007 using campaign method.
- Comparing the terrestrial data to the GPS outcomes, baseline components were separated from coordinate results and designating as raw data and then processed individually as trilateration measurements by constrained adjustment with stable stations in ED-50 datum.
- Apart from the individual adjustment of each campaign, we combined them and used as a single trilateration network in free network adjustment in order to increase the degree of freedom.
- The GPS observation analysed for each year.
- While analyzing the adjusted coordinates of GPS observations and their mean square errors, it has been concluded that, because of the datum difference from terrestrial ones

2004 VE 2007 ANALYSIS

- For detecting rotation, scaling and translation factors, the Two Dimensional Helmert Transformation is applied to coordinates gathered from free network adjustment of combined 2004 and 2007 GPS data.
- From Helmert Transformation the scale factor was evaluated -10.814 ppm.
- Then the displacements were investigated between the outputs of constrained adjustment results for Tavsandede Tepe, Aygiran and Hacidag sites from 1981 campaign to combined 2004 and 2007 GPS campaign.

No	Parameter	Value	R.M.S.	Dim
1	Shift dX	0,0250	0,0427	m
2	Shift dY	0,0450	0,0427	m
3	Rotation about Z	0,600	0,6192	["]
4	Scale	-10.814	3,0018	[ppm]

Stations	Campaign Year	Easting+ RMS (m±cm) (±) Differences (m)	Northing + RMS (m±cm) (±) Differences (m)
Tavsandede Tepe	1981	479437.590 ± 11.2	4487596.270 ± 8.8
		(+) 0.183	(-) 0.391
	2004&2007	479437.734 ± 2.0	4487595.879 ± 1.3
Aygiran	1981	481183.916 ± 7.9	4479288.022 ± 6.1
		(+) 0.191	(-) 0.150
	2004&2007	481184.107 ±1.7	4479287.872 ± 1.7
Hacidag	1981	490035.818 ± 5.8	4473934.716 ± 5.0
		(+) 0.134	(-) 0.109
	2004&2007	490035.952 ± 2.2	4473934.607 ± 2.7



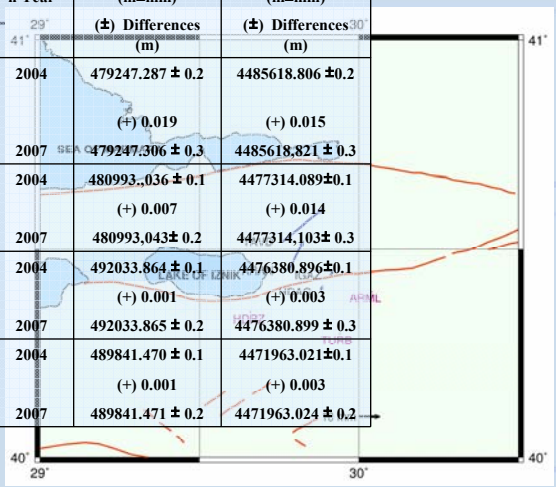
- The displacements of the network between 1981and 2004&2007

INVESTIGATION OF DISPLACEMENT OF GCM-ITU NETWORK BETWEEN 2004 AND 2007

- GCM-ITU Network started to being observed again in 2004 and 2007 using GPS method by KOERI Geodesy Department as a research project supported by Research Fund of Bogazici University (Gurkan et al., 2005)
- However, only six of the stations could survive to this time, so Gazkesmez station was added to densify the northern part.
- The method of static GPS measurement was performed in this study. Therefore the campaigns had been planned to monitor the network at least eight hours, but some environmental problems lessen that time.

INVESTIGATION OF DISPLACEMENT OF GCM-ITU NETWORK BETWEEN 2004 AND 2007

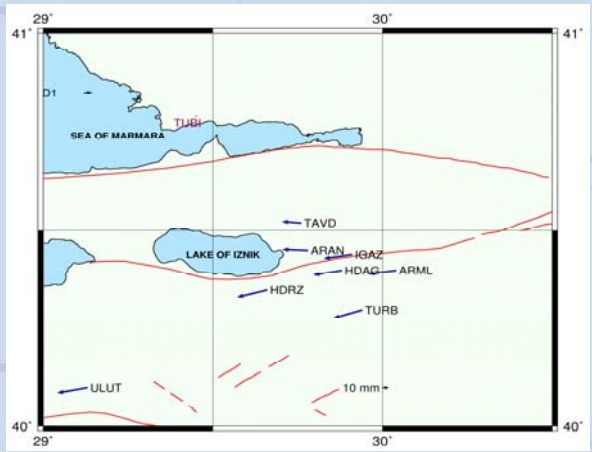
Stations	Campaign Year	Easting+ RMS (m±mm) (±) Differences (m)	Northing + RMS (m±mm) (±) Differences (m)
Tavsandede Tepe	2004	479247.287 ± 0.2	4485618.806 ±0.2
		(+) 0.019	(+) 0.015
	2007	479247.306 ± 0.3	4485618.821 ± 0.3
Aygiran	2004	480993.,036 ± 0.1	4477314.089±0.1
		(+) 0.007	(+) 0.014
	2007	480993.043± 0.2	4477314.103± 0.3
Hacidag	2004	492033.864 ± 0.1	4476380.896±0.1
		(+) 0.001	(+) 0.003
	2007	492033.865 ± 0.2	4476380.899 ± 0.3
Gazkesmez	2004	489841.470 ± 0.1	4471963.021±0.1
		(+) 0.001	(+) 0.003
	2007	489841.471 ± 0.2	4471963.024 ± 0.2



INVESTIGATION OF DISPLACEMENT OF GCM-ITU NETWORK BETWEEN 2004 AND 2007

- In order to investigate other effects on GCM network rather than the Iznik-Mekece fault and to extend the research area, three stations were added into the study from MAGNET (Marmara Continuous Global Positioning System Network).
- This network was established before the Izmit earthquake in 1999 for crustal deformation associated with strain accumulation along the western NAF system (Ergintav, S., 2007). It consists of 18 sites scattered along Marmara Region.
- Although the method of the process was the same, the adjustment model differs from previous one. TUBI station was selected as the stable point and minimally constrained adjustment was applied to data.

INVESTIGATION OF DISPLACEMENT OF GCM-ITU NETWORK BETWEEN 2004 AND 2007



CONCLUSIONS

- Both GPS and terrestrial observations results demonstrated that the stations at both the south and north of the fault have moved to the same direction during the 1981-2007 periods.
- In terrestrial analysis, the north of the fault the movement of Tavsandede Tepe and Aygiran stations is in the direction of southeast. Contrarily, the station Hacidag moves within the same direction, even though the location of the point is different from the others.
- From the terrestrial analysis, we gathered that the baselines moved 3 mm to 9 mm yearly.

CONCLUSIONS

- In GPS analysis all movements are directed to northeast are consistent with the movements of Iznik-Mekece fault. The biggest changes are found in Tavsandede Tepe site which is the furthest one with respect to the fault. Accordingly, the minimum movement is found in Hacidag which is the nearest station to the fault.
- From the GPS analysis, we gathered that the baselines moved approximately 0.5 mm yearly. The baselines TAVD-HDAG and TAVD-ARAN show the same behaviour in both analysis. On the other hand ARAN-HDAG changes its behaviour.
- Furthermore, in the extended network, all sites below the Iznik fault move together to the west relative to TUBI station.

REFERENCES

- Akay, G., 2007, Total Crustal Deformation by the Comparison of terrestrial and GPS measurements in the Marmara Region, M.S. Thesis, Bogazici University.
- Ergintav, S., Dogan, U., Gerstenecker C., Cakmak, R., Belgen A., Demirel H., Aydin C., Reilinger R., 2007, A snapshot (2003–2005) of the 3D postseismic deformation for the 1999, Mw = 7.4 ˙Izmit earthquake in the Marmara Region, Turkey, by first results of joint gravity and GPS monitoring, Journal of Geodynamics.
- Gregorius, T., 1996, GIPSY-OASIS II: How it works, University of Newcastle upon Tyne.
- Gurkan, O., Igdir, I., Ozener, H., Sakallı, Y., Turgut, B., Yilmaz, O., 1999, Results of GPS Measurements for networks designed for terrestrial observations, in the western part of NAFZ, Proceeding of the Third Turkish-German Joint Geodetic Days, 1-4 June 1999, Vol. II, Istanbul.
- Wessel, P., Smith, W.H.F., 1995, New version of the generic mapping tool released, EOS Trans. An. Geophys. Un., 76, 329.
- Zumberge, J. F., Heflin, M. B., Jefferson, D. C., Watkins, M. M., and Webb, F. H., 1997, Precise point positioning for the efficient and robust analysis of GPS data from large networks, Journal of Geophysical Research, 102: 5005-5017.

THANK YOU