# Determination of Kinematics of Central Marmara Fault Using with GPS
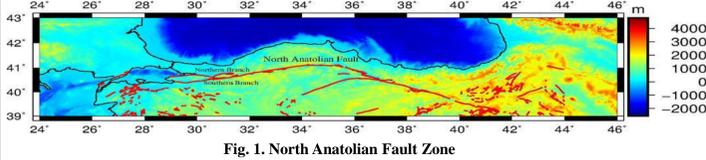
## Volkan Ozbey[1], Hakan Yavasoglu[1], Frederic Masson[2]
### IGS Workshop, Paris, July 2017

## Introduction

Plate motion affecting the Earth's crust have occurred for millions of years. Determination of strain accumulation based on the plate motion is commonly monitored with GPS in recent years. The North Anatolian Fault (NAF) Zone, which is one of the fastest faults in the world, extends along all North Anatolia from Bingöl to Saros Gulf. Several destructive earthquakes occurred there, such as Izmit (in 1999, Mw=7.4) and Duzce (in 1999, Mw=7.2) in last century.


Fig. 1. North Anatolian Fault Zone

## North Anatolian Fault Zone


Fig. 2. Some Main Segments of NAFZ

> The western segment of NAFZ is dividing into southern and northern branches to the east of Marmara region and the Northern branch (Main Marmara Fault-MMF) is crossing the Marmara Sea, starting in from the Gulf of Izmit - Adapazarı and reaching the Gulf of Saros.

> According to recent studies, the MMF is the largest unbroken part of the fault and determination of the deformation accumulated on the MMF has become extremely important especially after the 1999 Izmit earthquake.

> Main Marmara Fault is divided into basins which are Cinarcik, Prince's Island, Central Marmara and Tekirdag.

> Recent studies have demonstrated that the Prince's Island basin is fully locked.

> However, studies that are focused on the Central Marmara basin, that is located offshore Istanbul, a giant metropole that has more than 14 million population, do not conclude about the presence of a seismic gap, capable of generating a big earthquake.
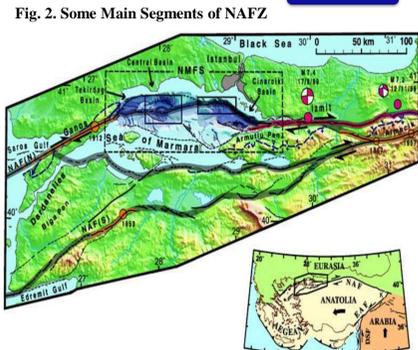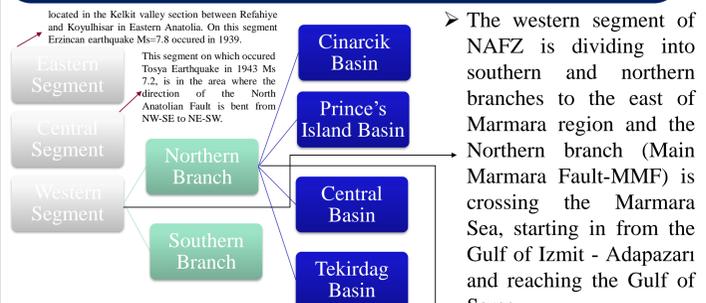

Fig. 3. Active tectonics in Sea of Marmara pull-apart including the new EM300 bathymetry and the newly mapped submarine faults. (Armijo et al., 2000)
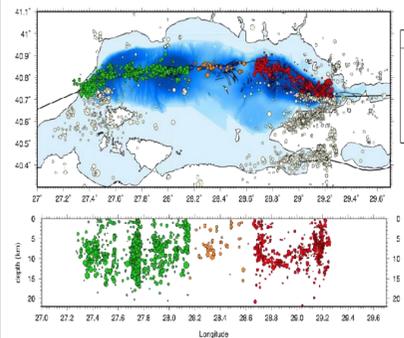

Fig. 4. Marmara segment and sub-branch of North Anatolian Fault. The red circles show the seismic activity on the Island Fault (AF), the orange circles show the seismic activity on the Central Marmara Fault (OMF), and the green circles show the seismic activity on the Tekirdag segment. (Schmittbuhl1 et al., 2015)

## Aim and Scope of The Study

In this study, a new GPS network which is include 60 stations will be created and these stations will be evaluated with GAMIT/GLOBK which is a comprehensive GPS analysis package developed at MIT, the Harvard-Smithsonian Center for Astrophysics (CfA), Scripps Institution of Oceanography (SIO), and Australian National University for estimating station coordinates and velocities, stochastic or functional representations of post-seismic deformation, atmospheric delays, satellite orbits, and Earth orientation parameters. Coordinates of each station and atmospheric zenith delays and variance-covariance matrices will be found using with GAMIT module. GLOBK will be used for determination of velocity field of this region. At the end of the study, the velocity values attained from each station were compared to the results from previous studies in the region. Thus, it was attempt to determine whether the seismic gap found on the Central Marmara Fault was a result of aseismic deformation or not.



## Method

Global Navigation Satellite System (GNSS) observations allow the measurement of crustal deformations. The observations are used in the analysis of strains on the ground, which are powerful parameters for the prediction of the seismic hazards. The use of strain analysis, combined with other geophysical parameters, increases the capability of prediction methods. The accuracy of the point velocities has a direct influence on the accuracy of the strain analysis. Therefore, it is extremely important to obtain the most accurate possible velocity results to ensure the reliability of the strain analysis.
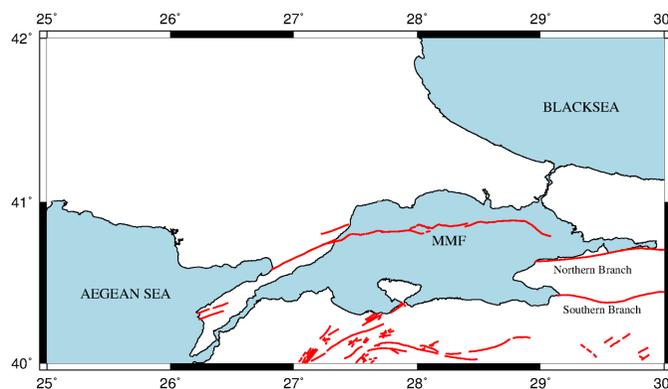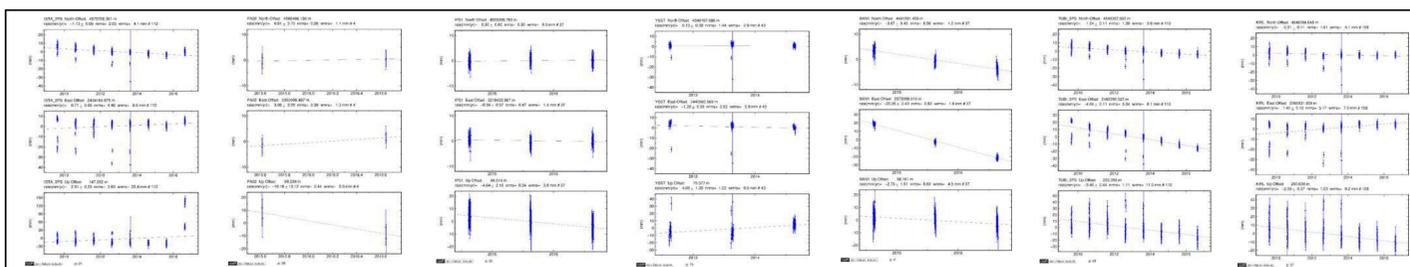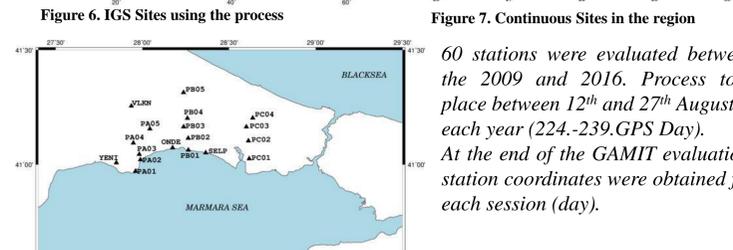
## Application


Fig. 5. Study Area

## GAMIT Evaluation


Figure 6. IGS Sites using the process


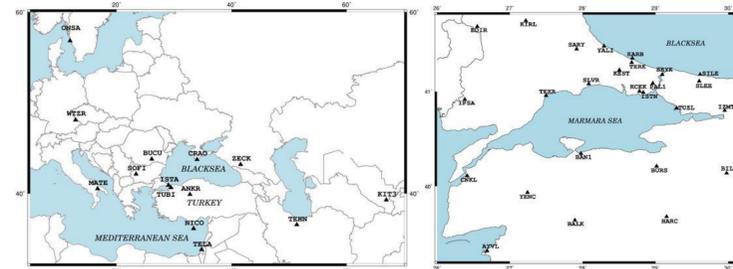Figure 7. Continuous Sites in the region

60 stations were evaluated between the 2009 and 2016. Process took place between 12th and 27th August of each year (224.-239.GPS Day).
At the end of the GAMIT evaluation, station coordinates were obtained for each session (day).


Figure 8. Other Sites which are using process

Table 1. Postfit Normalized Root Mean Square Error (NRMS) of the each session for GAMIT evaluation.



## Generating Time Series


Figure 9. Stab sites and their spread over the world

Table 2. Sites chosen for stabilization and their location.

| Site Name | Location | Site Name | Location |
|---|---|---|---|
| ARTU | Arti/Russia | MATE | Matera/Italy |
| BOR1 | Borowiec/Poland | ONSA | Onsala/Sweden |
| BUCU | Bükrey/Romania | WSRT | Westerbork/Netherlands |
| GLSV | Kiev/Ukraine | WTZR | Bad Koetzting/Germany |
| GRAZ | Graz/Austria | YAKT | Yakutsk/Russia |
| HERS | Hailsham/England | ZECK | Zelenchukskaya/Russia |
| IRKT | Irkutsk/Russia | | |


Figure 10. Time Series of some sites

## Generating Velocity Fields

Table 3. Velocity of each sites.




Figure 11.


Figure 12.

Table 4.

| Site Name | McClusky (2000) | | Özbey (2017) | |
|---|---|---|---|---|
| | $V_{east}$ | $V_{north}$ | $V_{east}$ | $V_{north}$ |
| ANKR | -20.8 | -2.2 | -23.68 | -2.25 |
| KIT3 | 0.5 | 1.4 | -1.3 | 1.01 |
| NICO | -5.3 | 4.1 | -6.58 | 3.05 |
| ONSA | -1.4 | 0 | -0.32 | -0.98 |
| TELA | -2.3 | 8.6 | -4.03 | 7.18 |
| WTZR | 0.2 | 0.7 | 0.49 | -0.24 |
| ZECK | 0.5 | 0.8 | -0.16 | 0.81 |


Figure 13.

Fig 11 shows that velocity field of continuous sites on this region. Fig 12 shows that the results of McClusky et al., (2000) for this region. Fig 13 is the velocity field of campaign sites. Table 4 shows velocity of some IGS Sites which were founded the McClusky et all 2000 and this study.
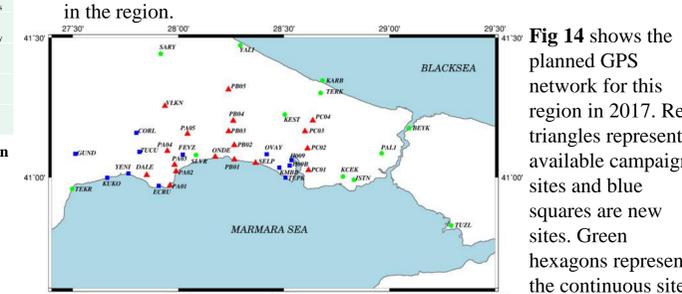
## Results

> Velocity field of continuous sites are coherent with previous studies for this region.

> There is a discrepancy for the velocity field of campaign sites. Because of the not enough data, sites velocities do not give accurate result about the tectonics of the region.

> It is necessary to densify the network in order to obtain more accurate and precise results.

> Previous studies for this region is thought to be inadequate. Therefore, studies should be continued in order to determine the tectonic movement in the region.



Fig 14 shows the planned GPS network for this region in 2017. Red triangles represent available campaign sites and blue squares are new sites. Green hexagons represent the continuous sites.

## Authors

[1] Istanbul Technical University, Civil Faculty, Geomatics Engineering Department, Maslak, Istanbul, Turkey, ozbeyv@itu.edu.tr, yavasoglu@itu.edu.tr,
[2] Univ Strasbourg, Strasbourg Cedex, France, frederic.masson@unistra.fr,