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Examination of the kinematic structures in İzmir (Western Anatolia) with repeated GPS Observations (2009, 2010 and 2011)

Abstract

The Western Anatolia and the Aegean Sea regions are one of the most significant seismically active and rapidly deforming fields in the world. Generally, seismic activities cause deformations and these deformations are monitored with Global Positioning System (GPS) / Global Navigation System (GNSS). In this context, GPS data were used to determine the deformation of İzmir and its surrounding to estimate the relative plate motions. In this study, the kinematic structures of the faults, which control the seismic hazard in İzmir and its surroundings, processing results of the three-year (2009, 2010 and 2011) episodic GPS observations and the estimation of displacements for 21 GPS stations were presented. The aim of this study is to examine interplate motion of the stations and their relations with the tectonic structures, seismicity and paleomagnetism and additionally, to interprete the motions of the study area relative to different block motions. Consequently, the mean motion of the study area was found approximately 25 mm/yr (towards the SSW) in the Eurasia fixed frame solution. The Aegean block fixed frame and the Anatolian block fixed frame solutions were computed relative to Euler vectors. In Aegean and Anatolian block solutions it was determined that the stations move separately, not as a group. In Euler pole solution, some stations are separated from each other and meanwhile some stations are grouped by considering the differences and similarities of the station motions. According to this solution three lines and two regions were described in the study area. The relations between seismicity and paleomagnetic studies and the kinematic structures determined in Anatolian block fixed frame and Euler pole solution were also investigated. When the Anatolian block fixed frame

solution and the earthquakes occurred between the years 1973 and 2011 were evaluated together, it was found that in the high seismically active region especially near to Sığacık bay, the motions of GPS stations were different even though their locations were close to each other. As a result of this, the relationship between the vector directions and active tectonism was determined. Additionally, in the Euler pole solution directions of the motion were found to be coherent with the paleomagnetic results, particularly in Urla and its surroundings. Here, the block fixed frame and Euler pole solutions and additionally, relations of them with seismicity and tectonism were mentioned as difference from previous studies. Besides, in this study, high importance was given to locate each station in main geological formations of the study area.

Keywords: GPS/GNSS, Western Anatolia, İzmir, Tectonic features

1. Introduction

The study region locates in the west side of the Western Anatolia and it is very active extensional area. In this region with the effect of the high seismicity, a N-S trending extensional zone was described as “West Anatolian Extensional Province” by Bozkurt (2001). This zone is bordered by the North Anatolian Fault (NAF) and the Hellenic-Cyprus arcs, in north and south, respectively. (McKenzie, 1972; Le Pichon and Angelier, 1979; Eyidoğan and Jackson, 1985; Jackson and Mckenzie, 1988; Westaway, 1990; Taymaz and Price, 1992; Yılmaz et al., 2000; Bozkurt, 2001; Aktuğ and Kılıçoğlu, 2006) (Fig. 1).

In İzmir Bay and its surroundings, 24 earthquakes (Table 1) that had destructive effects occurred between 17 (AD) and 1883 (Emre et al., 2005). The largest one occurred on 10 July 1688 (Poirier and Taher, 1980) and it damaged grate part of İzmir. The 1739 Foça and 1788 İzmir earthquakes followed this earthquake (Altınok et al., 2005). In the instrumental time-period, the region was shaken with the 1992-Doğanbey (M=6.0), 2003-Urla (M=5.7) and 2005-Sığacık Bay (M=5.7, 5.8, 5.9) earthquakes (Akyol et al., 2006; Benetatos et al., 2006; Zhu et al., 2006; Aktar et al., 2007). The seismicity is described with a weakness zone which is called as the İzmir-Balıkesir Transfer Zone (İBTZ) (Fig. 2) (Sözbilir et al., 2003a , 2003b; Sözbilir et al., 2004; Emre et al., 2005; Özkaymak and Sözbilir, 2008; Uzel and Sözbilir, 2008; Sözbilir et al., 2009). This zone lies throughout the Kuşadası Bay-Torbalı-Kemalpaşa-Akhisar line in eastern side. This line also corresponds to the line where the E–W trending graben system turns into to the NE–SW trending strike slip fault basin.

Dramis and Blumetti (2005) defined two fundamental groups for the structures which are formed by co-seismic and pre-seismic effects, namely, seismotectonic (landforms related to tectonic stress) and seismogravitational (landforms related to the seismic shaking and earth's gravity) structures. The formations associated with the tectonic stresses which are called as seismotectonic structures, are the geothermal fields, the ridges, the faults and, horst-graben systems. The occurred earthquakes up to present have generated the deformation in Western Anatolia, particularly in and around İzmir. Additionally, in the study of Pamukçu et al. (2015a), these relations were investigated with gravity data and in the study of Pamukçu et al. (2015b) realized in the surrounding of Sığacık Bay, the seismic activity of the region was described in details with the GPS/GNSS solutions and the changes on gravity anomalies.

In the study of Nyst and Thatcher (2004) the dissimilarities in the GPS vectors between in and around İzmir and Western Anatolia were identicated. By this knowledge, for monitoring the kinematic motions of the seismically active faults near to İzmir and its surroundings, GPS measurements were realized in 2009, 2010 and 2011 at 21 GPS stations which located in the south of İzmir.

In this study, Eurasia fixed frame solutions, additionally, unlike previous studies (Aktug and Kılıçoğlu, 2006; Dogru et al., 2014) Aegean-Anatolian block fixed frame solutions and interplate motions (Euler pole) were calculated. According to Eurasia fixed frame solutions, the mean motion of the study area was found approximately 25 mm/yr towards the SSW. In Aegean block and Anatolian block fixed frame solutions the velocity directions were generally towards N and S, respectively.

According to the Euler pole solutions two regions were described in the study area by taking account of the similarities of the motion directions. Besides, some stations are separated from each other with three lines by noticing the directional differences of the station motions.

Consequently, the velocity fields observed by GPS measurements were examined with the vector directions of paleomagnetic studies and seismicity based on the distributions of earthquake focal depth.

2. Geologic Settings of Study Area

The study area which covers İzmir and its surroundings, locates in the western part of an area called as "West Anatolian Extensional Province" (WAEP) by Bozkurt (2001) (Fig. 1 and Fig. 2). Additionally, İBTZ which is located around the study area forms the westward of WAEP (Uzel and Sözbilir, 2008; Sözbilir et al., 2009; 2011; Uzel et al., 2012) (Fig. 2).

In the study area, the NE–SW directional dextral strike-slip faults are dominant and among them the most significant faults, Seferihisar fault (SF) and Orhanlı fault zone (OFZ), border the Seferihisar High. The length and wide of SF, which extends along İzmir Bay and Sığacık Bay, is 30 km and 2–5 km, respectively (İnci et al., 2003; Emre et al., 2005; Sözbilir et al., 2009; 2011). OFZ, which is 45 km in length and extends along İzmir Bay and Kuşadası Bay, contains some NE-SW directional faults (Uzel and Sözbilir, 2008). The other dextral strike slip fault is Gülbahçe fault zone (GFZ) and its length is 70 km from N to S. This fault corresponds with the east border of the N-S trending Karaburun Peninsula (Emre et al., 2005). Karaburun fault zone (KFZ) which dominates the southwestern of İzmir Bay is 2–4 km in wide and 25 km in length (Uzel et al., 2013) (Fig. 2). The E–W directional faults are generally normal faults and they are located throughout northern and southern of the inner of the İzmir Bay (Fig. 2). The İzmir Fault (IF), which locates in the southern of the inner of İzmir Bay, is approximately 2–4 km in wide and 40km in length (Sözbilir et al., 2011; Uzel et al., 2012). SF, OFZ, GFZ, KFZ and IF are Holosen faults (Emre et al., 2011; Emre and Özalp, 2011). The other significant fault of the study area is Manisa Fault Zone (MFZ) and it is located in northern side and its length is approximately

10 km (Fig 2). Since Miocene at least three distinct movements reactivated this zone (Özkaymak and Sözbilir, 2008).

3. Processing of the GPS Data

GPS measurements were realized in 2009, 2010 and 2011at 21 stations of the GNSS network which were built in the south of İzmir (Fig. 3). As the first campaign in 2009, The GPS observations were performed in two groups (Day of Year/DOY: 183-185 and 186-190). In each group, 10 stations were observed per session for 10 hours. The station “UZUN” was observed for four days in 2009 campaign. In the 2010-campaign, the observations were performed in three groups (DOY: 184-186, 187-189 and 190-192) with three sessions for 10 hours in each group. In 2010 campaign, UZUN and DU12 stations were observed for nine days. In 2011, 10-hour measurements were realized at 21 stations in three groups, each consisting of three session days (DOY: 183-185, 186-188 and 189-192). During this campaign DU05, DU12 and UZUN stations were observed continuously.

For linking the local network with the ITRF (International Terrestrial reference Frame) global network International GNSS Service (IGS) stations were also included in the processing. These IGS stations allow the estimation of necessary parameters in analysis of the GPS data (station coordinates, earth orientation parameters, atmospheric zenith delays etc.). 12 IGS stations were used to characterize the Eurasia-fixed reference frame; ISTA, TUBI, ANKR (Turkey), ZECK (Russia), NSSP (Armenia), NICO (Cyprus), MIKL, GLSV (Ukraine), BUCU (Romania), PENC (Hungary), WTZR (Germany) and MATE (Italy) (Fig 4a). ITRF2008 coordinates of these IGS stations were used as reference stations in the computations. The GPS observations were processed by using GAMIT/GLOBK software (King and Bock, 2002; Herring et al., 2010).

Velocity vectors of 3-year GPS campaigns (2009, 2010 and 2011) and displacement vectors of 2009-2010 and 2010-2011 are shown in Fig. 4b. The components of the velocity field of 3 years combined solutions in the Eurasia-fixed frame and 1-sigma (σ) uncertainties are shown in Table 2.

Reilenger et al. (2006) developed an elastic block model for African, Arabian, Eurasia plates for constraining present day plate motions (relative Euler vectors). Besides, Anatolia was separated into 3 blocks (plates) as Anatolian block, Aegean block and Southwest Anatolian block and for determining the block model and the Euler vectors were calculated relative to Eurasia. The Euler vectors are 30.8°N, 32.1°E and 1.231°/Myr for Anatolian and 15.9°N, 52.3°E and 0.563°/Myr for the Aegean block fixed solutions (Reilinger et al., 2006) (Fig. 5). In this study, Aegean and Anatolian block fixed velocity vectors were calculated by using Euler vectors (Reilinger et al., 2006) which represent general kinematics in relative coordinate system (Fig. 6 and Fig.7).

As the last application, a single Euler pole was estimated using these GPS stations and thus the mean motion of these stations was evaluated (Fig. 8). The Euler pole solutions are calculated with a weighted least square solution with the unknown parameters being the rotation rates around the XYZ axes. The partials used in the estimates are;

$$v_x = Z_{wy} - Y_{wz}$$
$$v_y = -Z_{wx} + X_{wz}$$
$$v_z = Y_{wx} - X_{wx}$$

where v_x, v_y, v_z are the station velocities in XYZ frame, wx wy wz are the rotation rates around the XYZ axes. Other quantities are computed using standard analytic formulas and propagation of variance-covariance matrices assuming that the errors in wx, wy, wz are small compared to their estimates.

4. Results and Discussion

In this study, the Eurasia fixed frame, Aegean-Anatolian block fixed frames and Euler pole solutions were calculated for investigating the kinematic structures of Izmir and its surroundings (Western Anatolia). The mean motion of the study area was found approximately 25 mm/yr towards the SSW in Eurasia fixed frame solutions (Fig. 4). In the Aegean block fixed frame solutions, the velocity directions are approximately towards N, NE and NW (Fig. 6) and in the Anatolian block fixed frame solutions, the velocity directions are approximately towards S, SE and SW (Fig. 7). In Anatolian block fixed frame solutions (Fig. 7), an approximately N-S directional transition zone was estimated throughout from UZUN to DU12. The direction of same line was monitored in Aegean block fixed frame (Fig. 6) as NE-NW

According to the Euler pole solutions (Fig. 8) the study area was described by three lines and two regions (Fig. 9). DU09, DU10 and DU16 which had the most important movements relative to other stations (DU01, DU02, DU03, DU04, DU05, DU06, DU07, DU08, DU11, DU12, DU13, DU14, DU15, DU17, DU18, DU19 and UZUN) were showed in the same region called as "region A" (Fig. 9).. The N-NW directed velocity vectors of the stations in "region A" were bigger than DU01, DU02, DU03, DU04, DU05, DU06, DU07, DU08, DU11, DU12, DU13, DU14, DU15, DU17, DU18, DU19 and UZUN (Fig. 9). Therefore, it can be said that the largest deformation occurs in this area. The displacements of the stations in region A (Fig. 9) show the activation of Karaburun and Menemen basins (Fig. 2). DU01, DU06, DU13 and DU14 were defined in “region B” due to their similar velocity vector directions (Fig. 9). The velocity vectors of these stations were smaller than the stations in “region A”. Additionally; it was seen at Fig. 9 that the stations which are located outside of “region A” and “region B” had different velocities and vector directions.. The region B is seemed coherently with the east and west branched hypothetical fault which is described by Aktar et al. (2007) for Sığacık Bay. In the area of the Line No.1 (Fig. 9) which was drawn by noticing the differences on the directions of velocity vectors of DU06 and DU07, it is thought that this area may have a thrust fault mechanism. The opposite velocity vector directions of DU10 and UZUN (NW and SE, respectively) which were located at eastern side of Karaburun were shown at Line No. 2 (Fig. 9). This line might correspond to the continuation of Gülbahçe fault zone (GFZ) (Fig. 2) It is seen that the velocity vector directions of UZUN and DU16 are different from each other. Therefore, a boundary (Linr No:3, Fig. 9) was determined. This boundary may be related with the NW-SE directed normal fault (Dondurur et al., 2011; Uzel et al., 2012).

If Aegean (Fig. 6), Anatolian block fixed frame (Fig. 7) and Euler pole (Fig. 8) solutions are evaluated together, it can be said that the vectors partially line up because the motion of the stations are transitioning between these blocks i.e. one of the blocks (Aegean or Anatolian) in partially pushing or pulling the stations in its direction.

Additionally, in this study, in order to determine the motion differences between İzmir and the Western Anatolia graben system (Fig 2, İBTZ), DU18 was built. As seen in the Aegean block, Anatolian block and Euler pole solutions (Fig. 6, 7 and 8) the motion of DU18 is different from other 20 stations.

It is determined that the velocity vector directions of DU09 and DU10 (located in the north of Karaburun Peninsula) (Fig. 3), are different from each other (Figures 6, 7and 8). The existence of KFZ between DU09 and DU10 may effects the kinematic structure of Karaburun. .By noticing the differences on velocity vector directions of DU04, DU11, DU13 and DU14 (Fig. 6 and 7) it can be said that these differences are related with extensional regime of the region.

In order to investigate seismic activity of the region, the earthquakes which occurred in the study area between 1973 and 2011 were obtained from the USGS (U.S. Geological Survey) (Fig. 10) and additionally, the 2005 earthquake series and other earthquakes which occurred in GPS campaigns years (2009, 2010 and 2011) from Boğaziçi University (BU), Kandilli Observatory and Earthquake Research Institute (KOERI) National Earthquake Monitoring Center. These earthquakes with focal depths ranging from 0 to 39.9 km were given with the Anatolian fixed frame solutions in Fig. 11a-c.

In Fig.10 it is seen that the seismicity was high in the GPS campaigns years (2009, 2010 and 2011). In Fig.11.a, it is shown that the earthquakes between the years 1973 and 2011 occurred in the entire region; the earthquake intensity was high particularly in Sığacık Bay and its surrounding. Besides, in the Anatolian block fixed frame solutions, the differences on the vector directions were noticed in Sığacık Bay and its north. In Fig. 11.a, when the earthquakes and GPS solutions are compared together, it is pointed out that although the locations of DU05, DU11 and DU13 are close to each other, these stations show different directional characteristics. It may be thought that this case can be related with 2005 series of earthquakes which are given in Fig. 11.b, hence there is no earthquake intensity to create this deformation between the years 2009 and 2011 (Fig.11.c). This case cannot be interpreted completely since there is no GPS/GNSS data in the same points before 2009. These approaches are valid for the Aegean block fixed frame (Fig. 6).

In the comparisons of the results of this study with the previous paleomagnetic studies (Kissel et al., 1987; Zanchi et al., 1993) some changes were determined while passing from Karaburun to İzmir city center (Fig. 12). It was noticed that the directions of paleomagnetic rotations (Fig 12) are similar with Euler pole solutions of DU05, DU09 and DU16 (Fig. 8). Kissel et al. (1987) noticed that paleomagnetic rotations were difficult to explain of the global geodynamical evolution of the Western Anatolia and these rotations were most likely associated with the local tectonic regime.

Additionally, according to the field observations, there is a shallow water table at the west side of DU05 and there are geothermal natural outflows at the east side of this station. As a result of the GPS/GNSS observations, it was observed that the horizontal displacement direction of DU05 was different relative to other 20 stations (Figures 4, 6, 7 and 8). This difference can be related with the local tectonic characteristic of the location of DU05 and its surrounding. As a result, the deformation of this station and its surrounding may be shaped by paleomagnetic effects and geothermal features.

5. Conclusions

In this study, the dissimilarities on the structural elements of Western Anatolia graben system and İzmir and its surroundings were determined and the kinematic mechanism of the study area was presented in detail. Particularly, according to the Anatolian block fixed and Euler pole solutions, the boundaries which control the tectonics of İzmir and its surroundings and the motions of the kinematic structures which are effective on seismic activity of the region were defined. Besides, the border which separates the E-W directional graben system of Western Anatolia from the N-S directional structural elements of İzmir and its surroundings was established. Additionally, due to the similarities between the paleomagnetic rotations and recent GPS velocities, it was pointed out that the movements of some regions in the study area have not changed a lot in long geological time scale.

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Tables

Table 1. Large historical earthquakes occurred in İzmir and its surroundings (Modified from Emre et al., 2005)

Time	Latitude (N°)	Longitude (E°)	Intensity (I_o)
17	38.40	27.50	X
105	38.90	27.00	VIII
176 and 177	38.60	26.65	VII
178	38.30	27.10	VIII
688	38.41	27.20	IX
1039	38.40	27.30	VIII
20th March 1389	38.40	26.30	VIII
20th May 1654	38.50	27.10	VIII
2nd June 1664	38.41	27.20	VII
1668	38.41	27.20	IX
14th February 1680	38.40	27.20	VII
10th July 1688	38.40	26.90	X
13th January 1690	38.60	27.40	VII
September (October) 1723	38.40	27.00	VIII
4th April 1739	38.50	26.90	IX
24th November 1772	38.80	26.70	VIII
3rd – 5th July 1778	38.40	26.80	IX
13th October 1850	38.40	27.20	VIII
3rd November 1862	38.50	27.90	X
1st February 1873	37.75	27.00	IX
29th July 1880	38.60	27.10	IX
15th October 1883	38.30	26.20	IX
1st November 1883	38.30	26.30	VIII

Table 2: Velocities of Eurasia-fixed frame from 3-year (2009, 2010 and 2011) GPS data and 1-σ uncertainties in ITRF2008 frame (in Fig. 4b).

Station	Longitude(°)	Latitude (°)	v_E (mm/year)	v_N (mm/year)	σ_{vE}[a] (mm/year)	σ_{vN}[a] (mm/year)	ρ_{vEvN}[b]
DU01	27.06	38.39	-21.79	-19.11	1.06	1.30	-0.007
DU02	26.96	38.31	-19.42	-15.94	1.01	1.26	0.053
DU03	26.92	38.31	-18.95	-14.94	0.90	1.14	0.012
DU04	26.82	38.27	-17.47	-19.16	0.99	1.23	0.008
DU05	26.58	38.32	-13.11	-20.60	1.44	1.71	-0.018
DU06	26.47	38.30	-20.37	-22.34	1.00	1.22	0.007
DU07	26.29	38.28	-15.87	-21.37	0.87	1.09	0.038
DU08	26.47	38.39	-19.16	-19.95	0.92	1.14	0.021
DU09	26.40	38.56	-18.15	-15.05	0.93	1.14	0.017
DU10	26.55	38.53	-23.03	-18.16	1.13	1.34	-0.005
DU11	26.69	38.23	-21.98	-18.52	0.95	1.18	0.0013
DU12	26.76	38.35	-19.02	-19.80	0.67	0.89	0.067
DU13	26.61	38.19	-19.84	-21.92	0.99	1.24	0.008
DU14	26.87	38.14	-20.09	-19.40	1.01	1.25	0.007
DU15	27.11	38.21	-18.57	-17.20	1.29	1.56	-0.014
DU16	27.13	38.55	-24.24	-11.94	1.05	1.31	0.010
DU17	27.38	38.55	-20.50	-16.01	1.07	1.32	-0.035
DU18	27.53	38.30	-16.80	-16.14	1.04	1.30	0.002
DU19	27.30	38.32	-22.72	-17.13	1.37	1.66	-0.019
DU20	27.08	38.01	-16.04	-20.48	1.13	1.39	-0.024
UZUN	26.71	38.47	-18.76	-21.77	0.54	0.71	0.153
NSSP	44.50	40.22	3.45	7.30	1.36	1.05	-0.363
ZECK	41.56	43.78	1.67	0.48	0.91	0.52	-0.108
NICO	33.39	35.14	-4.82	2.04	0.52	0.89	-0.484
ANKR	32.75	39.88	-21.90	-2.31	0.79	0.92	-0.131
MIKL	31.97	46.97	0.63	-0.18	0.49	0.63	0.191
GLSV	30.49	50.36	-0.45	0.24	0.44	0.82	0.163
TUBI	29.45	40.78	-3.85	-1.77	0.43	0.55	-0.049
ISTA	29.01	41.10	0.00	-2.39	0.36	0.47	0.001
BUCU	26.12	44.46	-0.06	-1.20	0.43	0.46	-0.074
PENC	19.28	47.78	-0.41	1.54	0.73	0.56	-0.520
MATE	16.70	40.64	-0.48	4.50	0.88	0.55	0.540
WTZR	12.87	49.14	-1.43	0.24	1.09	0.62	-0.531

[a] 1-σ uncertainties

[b] Correlation coefficient between east and north uncertainties

Figure Captions

Figure 1: The main tectonic framework of the Western Anatolia and its surroundings (Makris and Stobbe, 1984; McClusky et al., 2000; Bozkurt, 2001; Gönenç and Akgün, 2012).

Figure 2: Main geological structure of the Western İzmir (modified from Uzel et al., 2013). Black dotted lines show the borders of İBTZ. Dotted red rectangle shows the study area.

Figure 3: Observed GPS stations in study area which given in Fig 1 with red circle. The high topography is in black color.

Figure 4.a: The locations of IGS stations which were used in processing. **b:** The black vectors show the 3-year (2009, 2010 and 2011) GPS data, red vectors and green vectors show the displacements of 2009-2010 and 2010-2011, respectively with 95% confidence ellipses of the project stations computed in Eurasia-fixed frame from in ITRF 2008.

Figure 5: The red point shows the location of the reference point (15.9°N, 52.3°E given at Reilinger et al., 2006) used in the calculation of Anatolian block fixed frame and the orange point shows the reference point (30.8°N, 32.1°E given at Reilinger et al., 2006) used in the calculation of Aegean block fixed frame (Google Earth was used for creating this figure).

Figure 6: The velocity field with 95% confidence ellipses of the stations computed in the Aegean block fixed frame from 3-year (2009, 2010 and 2011) GPS data.

Figure 7: The velocity field with 95% confidence ellipses of the stations computed in the Anatolian block fixed frame from 3-year (2009, 2010 and 2011) GPS data.

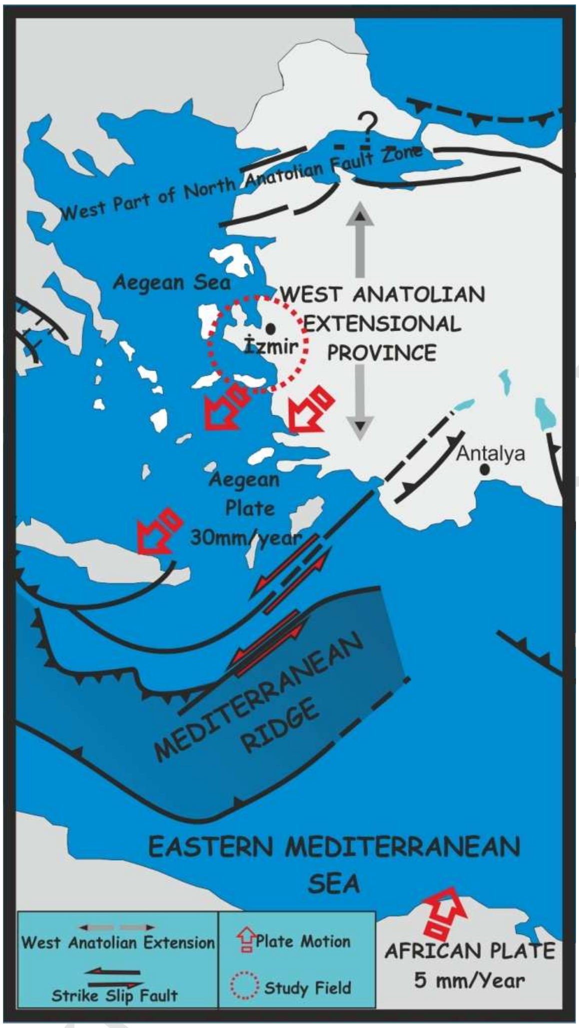
Figure 8: The Euler pole solutions with 95% confidence ellipses.

Figure 9: The interpretation of interplate motions which shown in Fig. 8.

Figure 10: Number of earthquakes occurred in the study area between 1973 and 2011 (obtained from the USGS).

Figure 11: The focal depth distributions of the earthquake occurred in the study area and the velocity vectors of Anatolian fixed frame solutions. **a:** The focal depths of earthquakes ranging from 0 km to 39.9 km between the years 1973 and 2011 in the study area from USGS) **b:** The focal depths of earthquakes ranging from 0 km to 39.9 km in 2005 in the study area (from BU, KOERI, National Earthquake Monitoring Center) **c:** The focal depths of earthquakes ranging from 0 km to 39.9 km between the years 2009 and 2011 in the study area (from BU, KOERI, National Earthquake Monitoring Center). Generic Mapping Tools (GMT) (Wessel and Smith, 1995) was used to create these figures.

Figure 12: The reverse directions were inverted through the origin (modified from Kissel et al., 1987).



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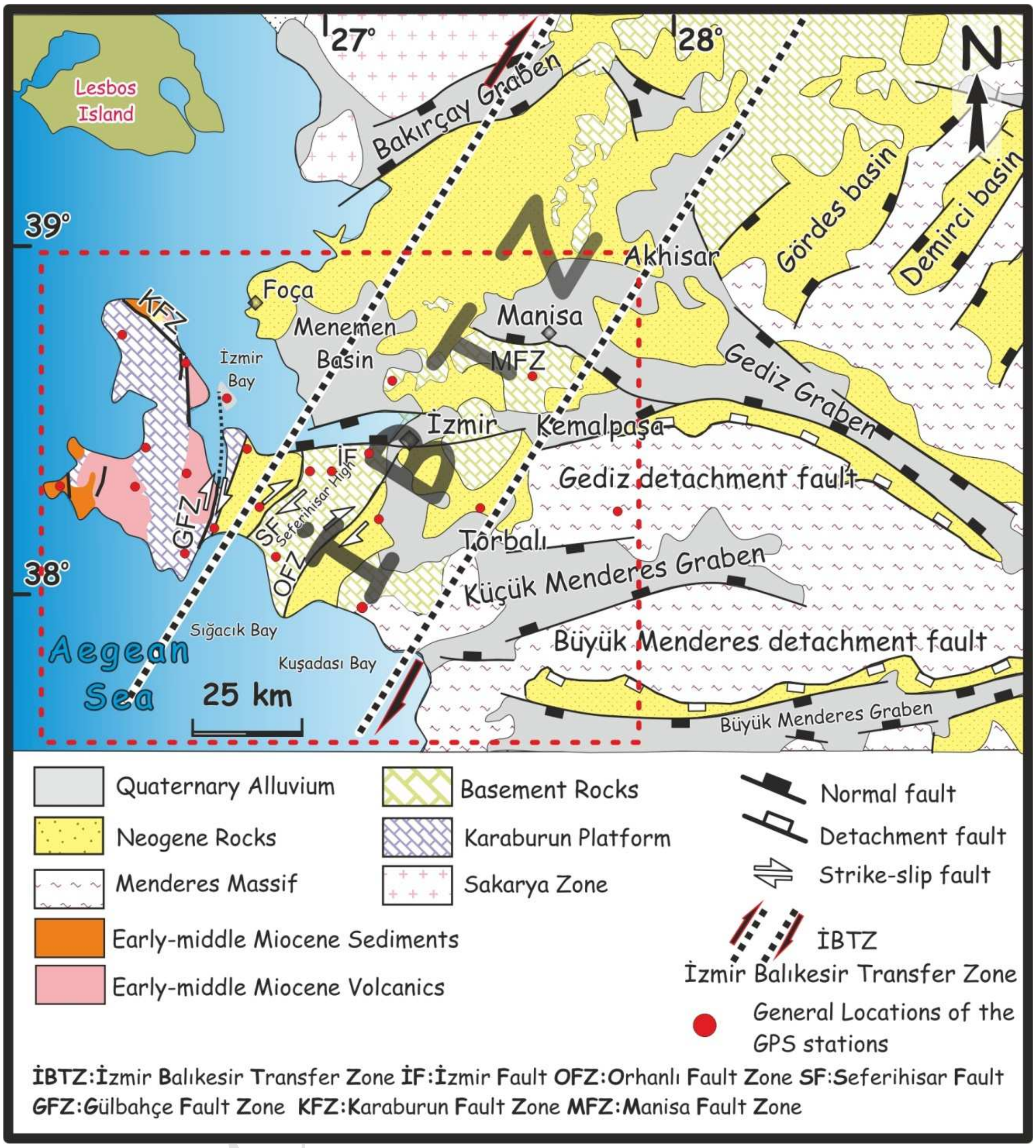

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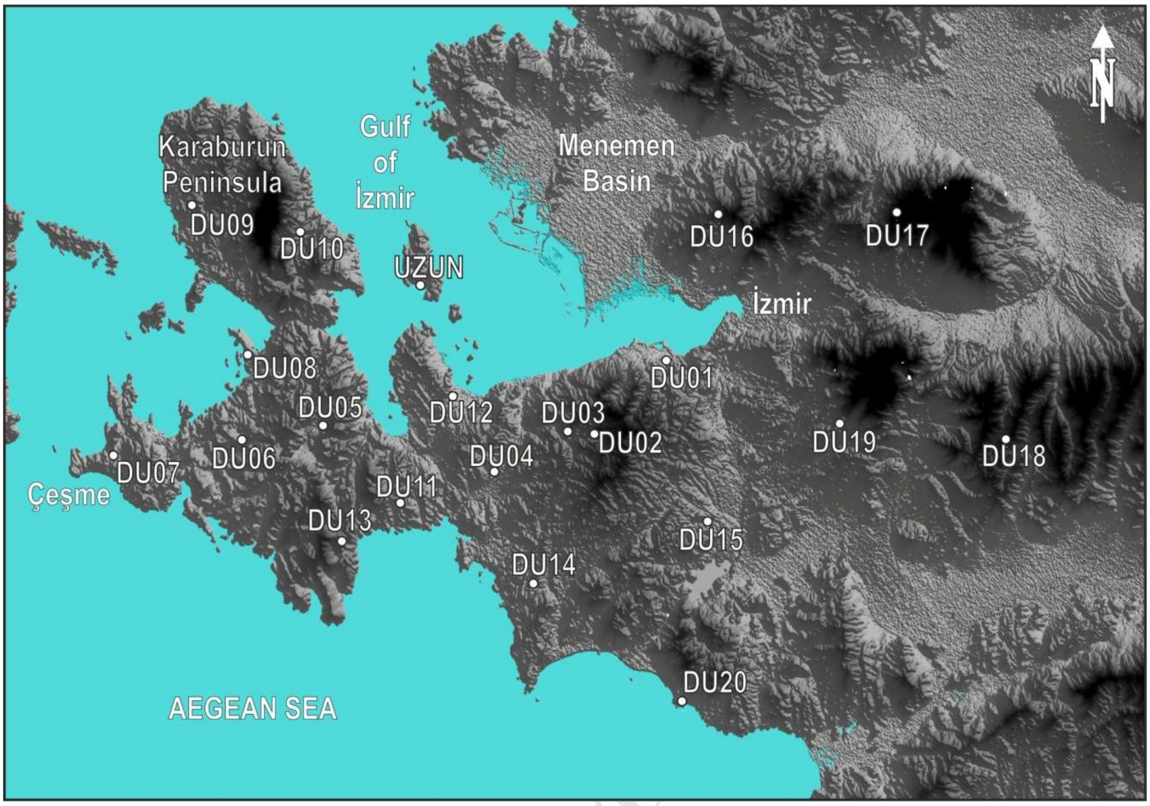

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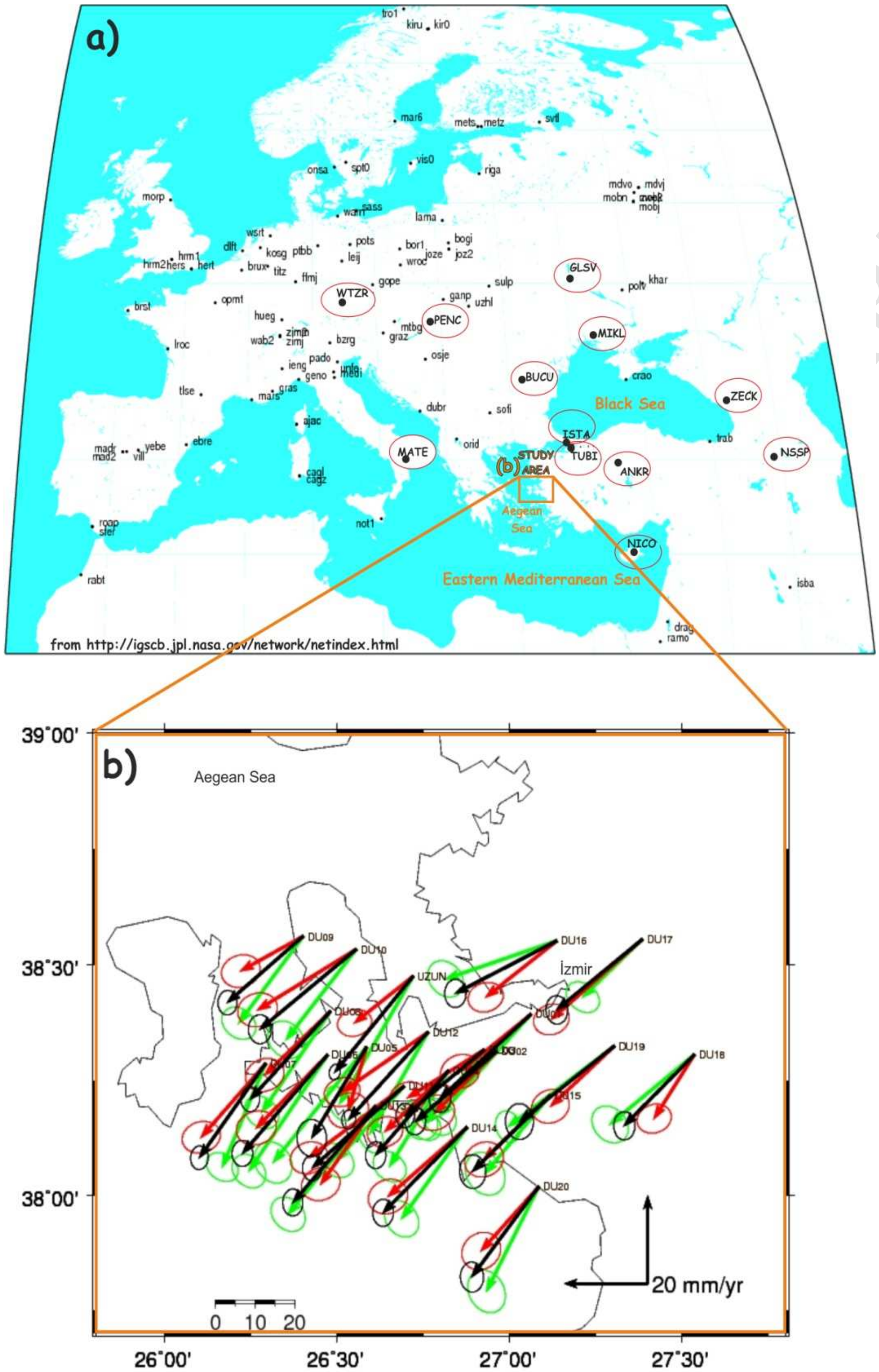

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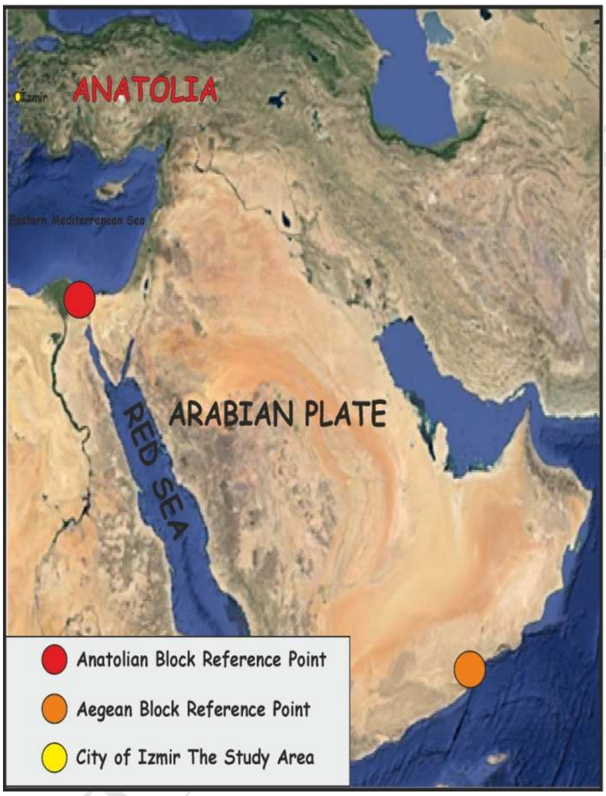

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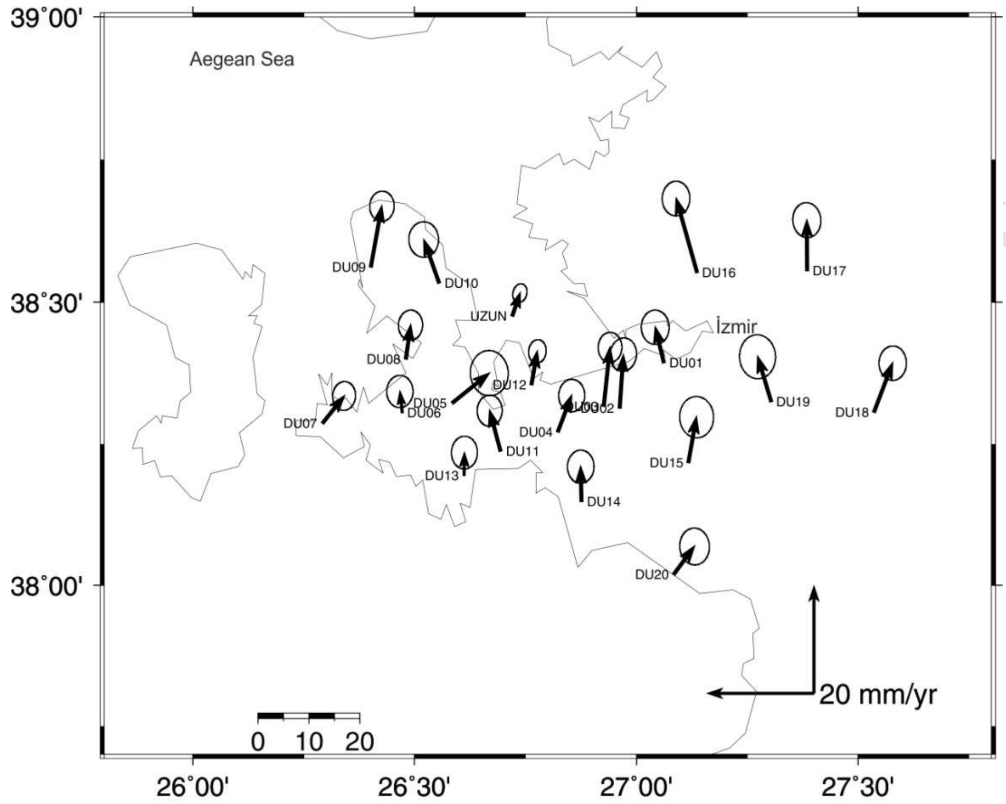

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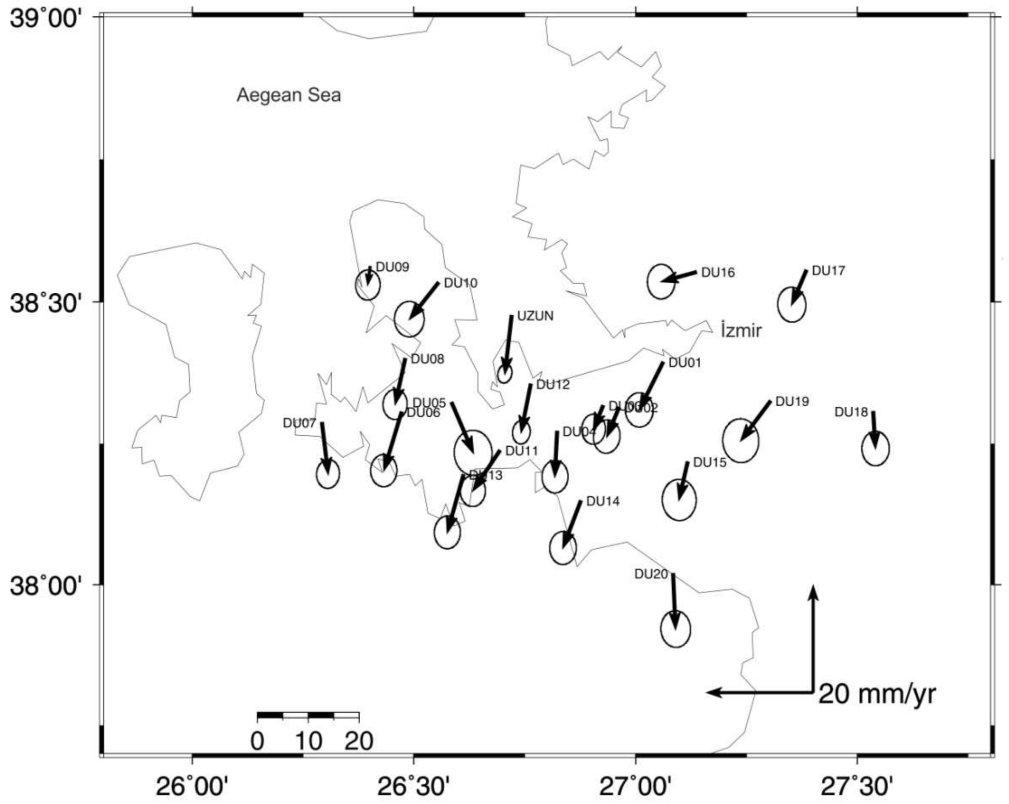

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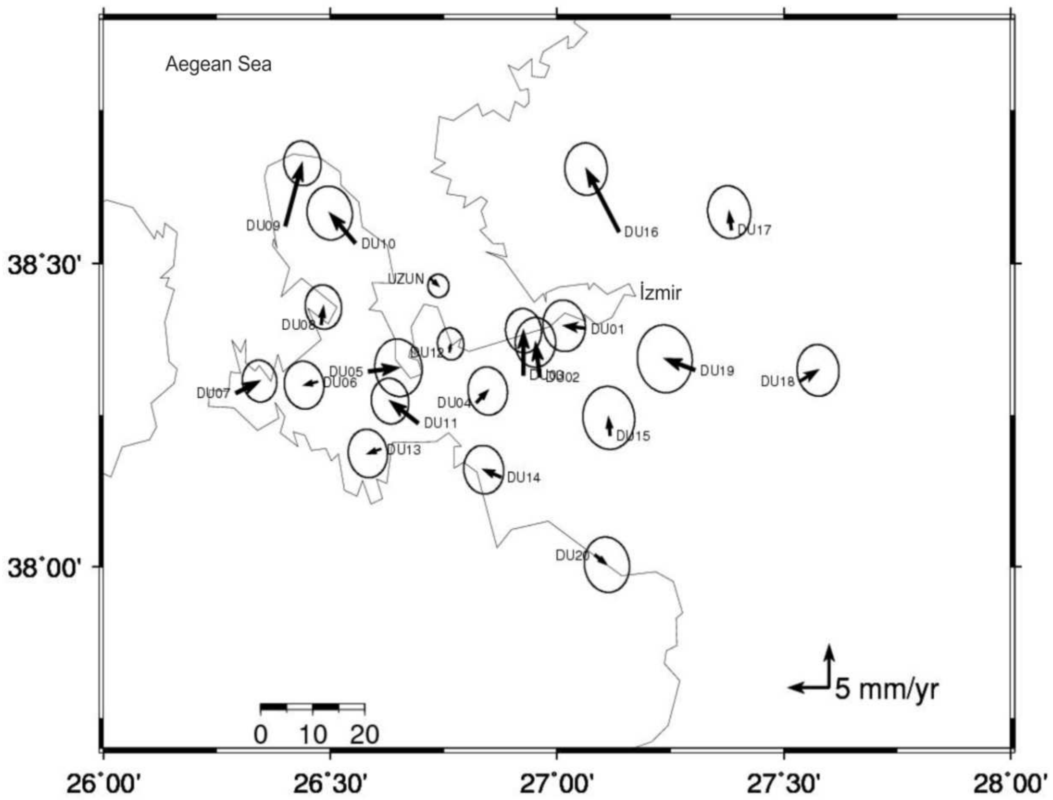
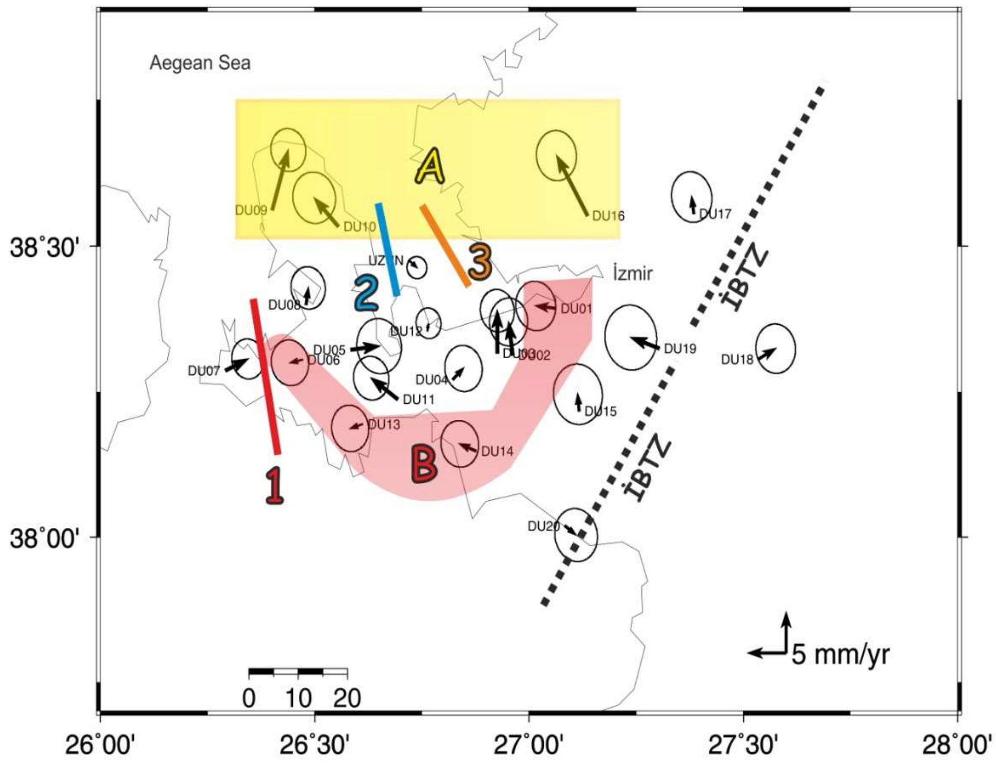


Figure 8: The Euler pole solutions with 95% confidence ellipses.



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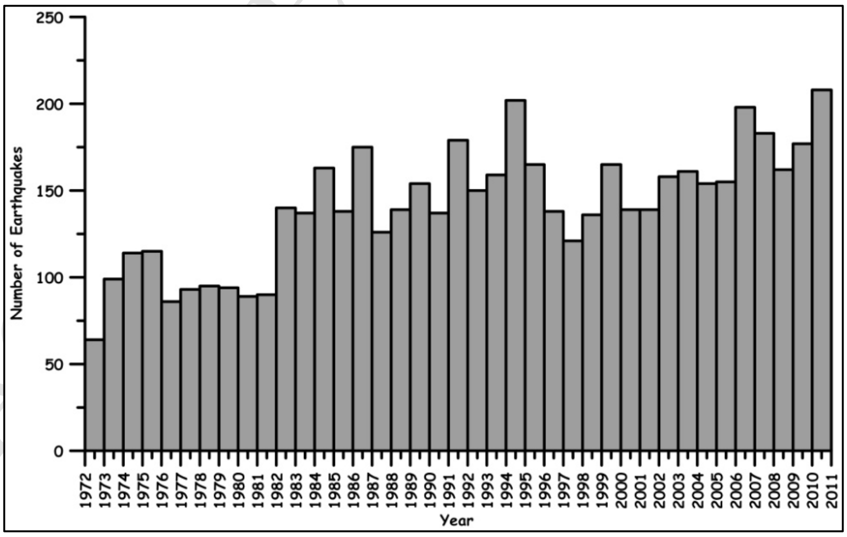

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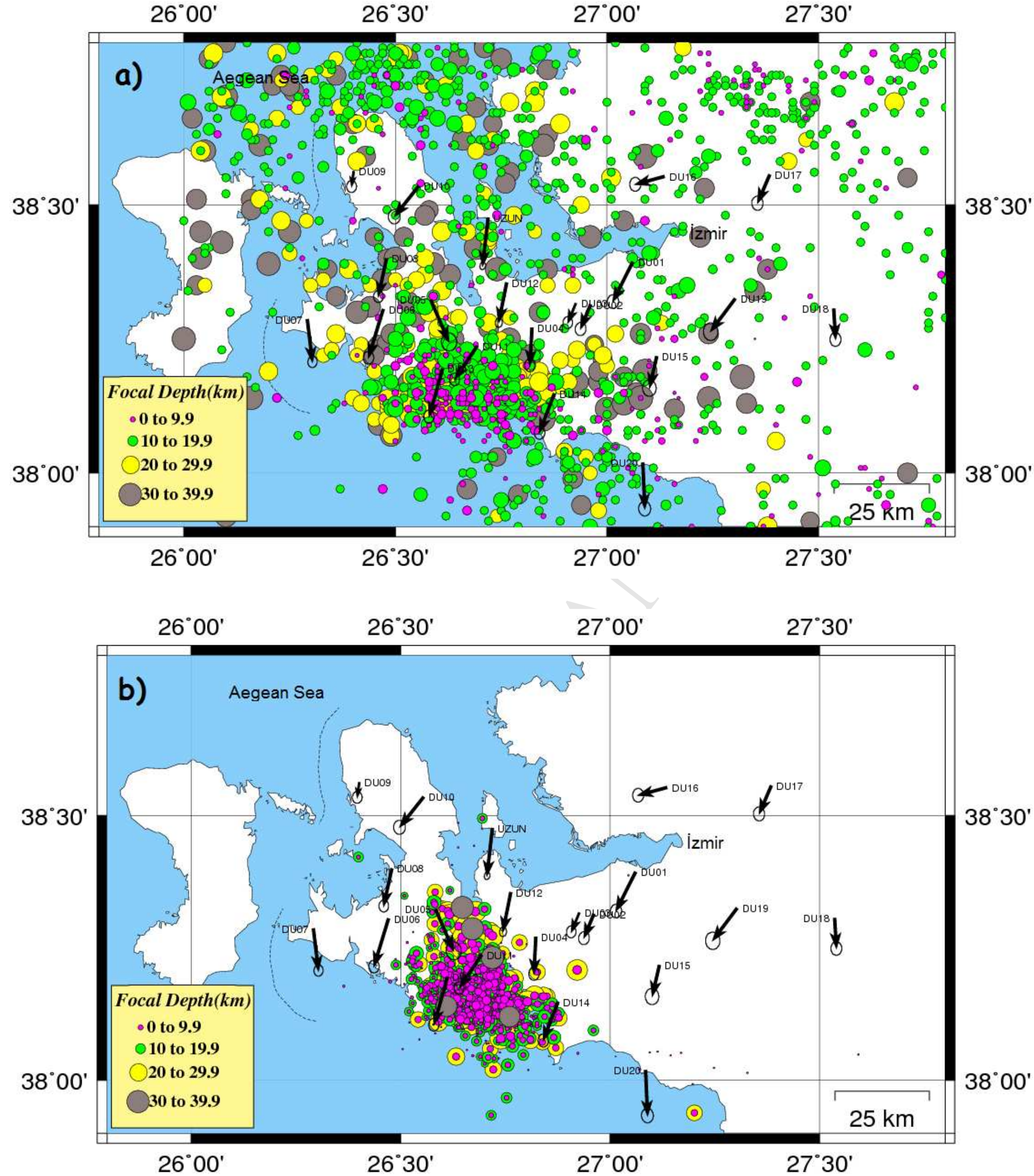
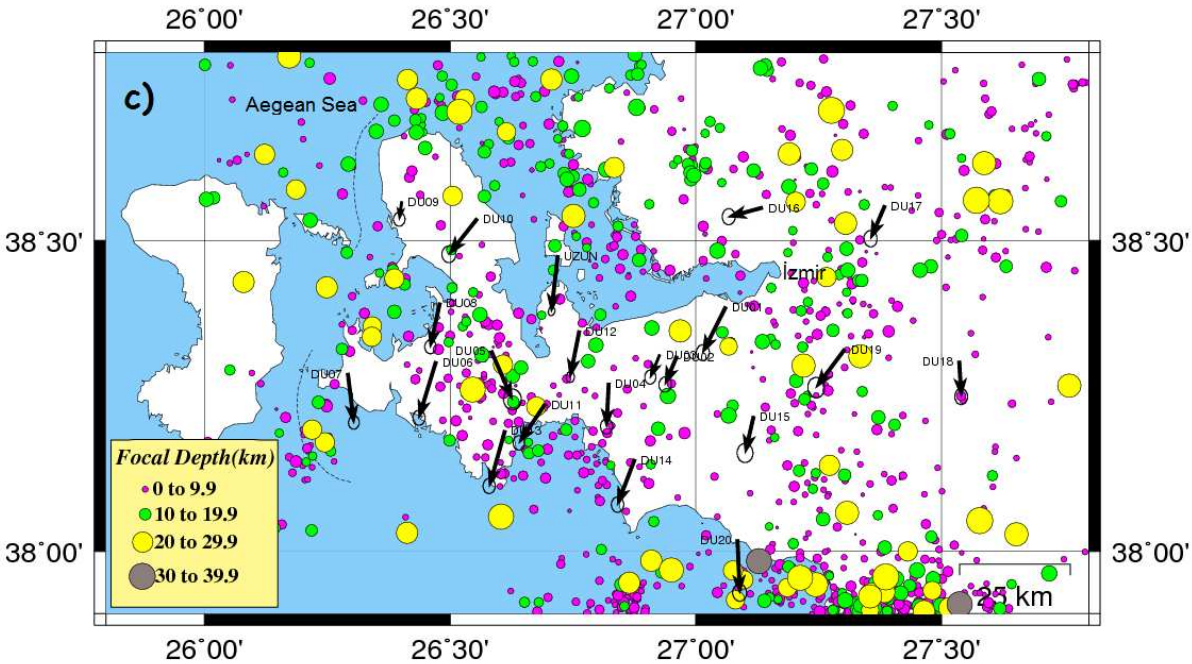


a)
b)
Aegean Sea
İzmir
26°00'
26°30'
27°00'
27°30'
38°30'
38°00'
Focal Depth(km)
0 to 9.9
10 to 19.9
20 to 29.9
30 to 39.9
25 km
DU01
DU04
DU05
DU06
DU07
DU08
DU09
DU10
DU12
DU14
DU15
DU16
DU17
DU18
DU19
DU20
UZUN



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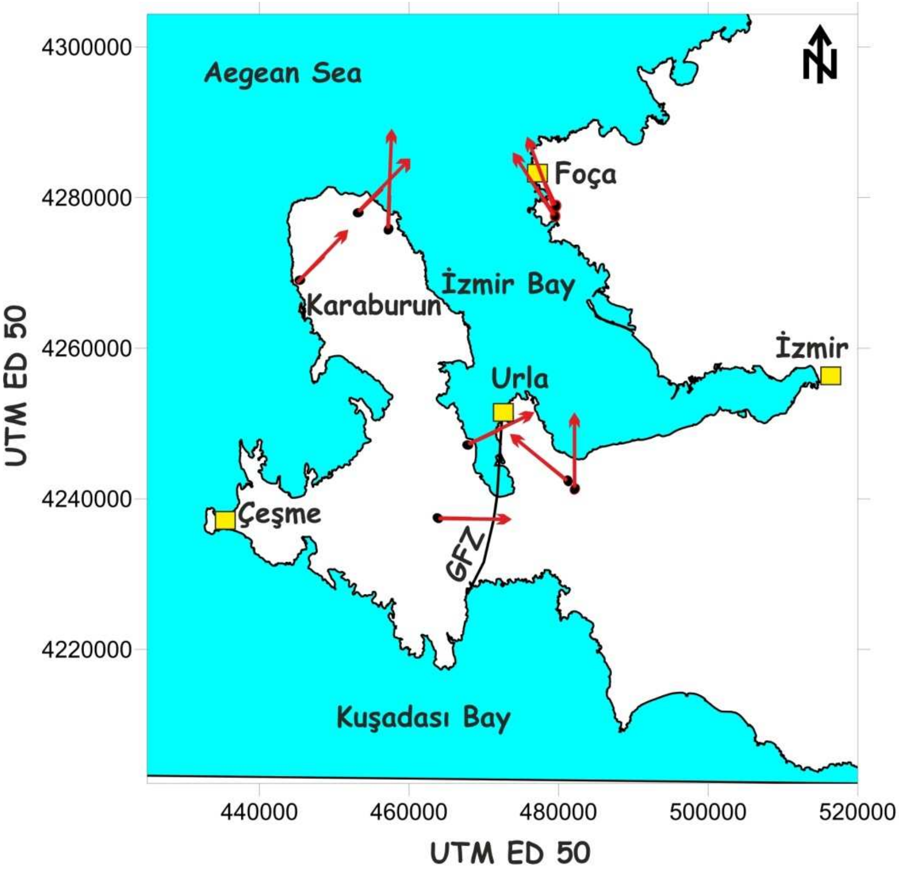

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Highlights

1. The motions of the tectonic structures of İzmir and its surroundings were defined.
2. Processing results of three years GPS campaigns were presented.
3. Aegean and Anatolian block fixed frames were calculated relative to Euler vectors.
4. Three lines and two regions were described in study area by Euler pole solutions.
5. Results of the solutions were compared with seismicity and paleomagnetic studies.