Bogazici University
Kandilli Observatory and
Earthquake Research Inst.
Geodesy Department

ANALYSIS OF STRAIN ACCUMULATION OF THE FAULTING ZONES BY THE HELP OF CONTINIOUS GPS STATIONS

***Asude Arslan Sørensen*[1]** *and Onur Yilmaz*[2,1]

[1]{University of Bergen, Faculty of Mathematics and Natural Sciences, Seismology Department, Norway}

[2]{Bogazici University, Kandilli Observatory and Earthquake Research Institute, Istanbul, Turkey}

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CONTENT

- North Anatolian Fault (NAF)
- Stress Changes through NAF
- Marmara Region
- Study Area and techniques used for the study
- Summary

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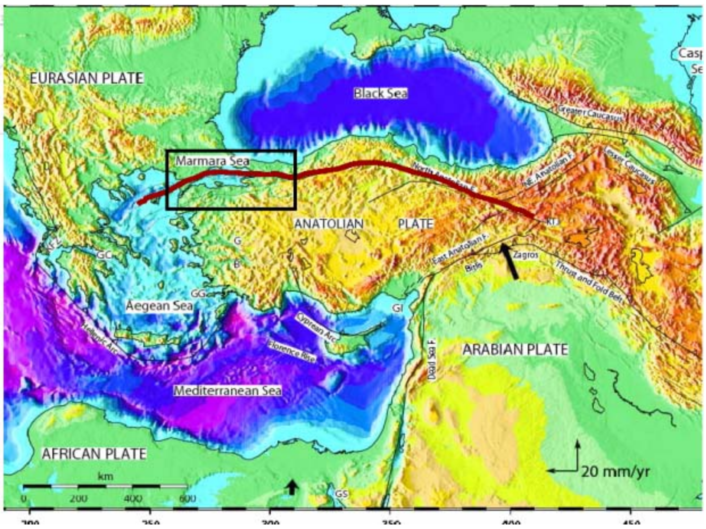
- Collision of the Arabian and African plates with the Eurasia



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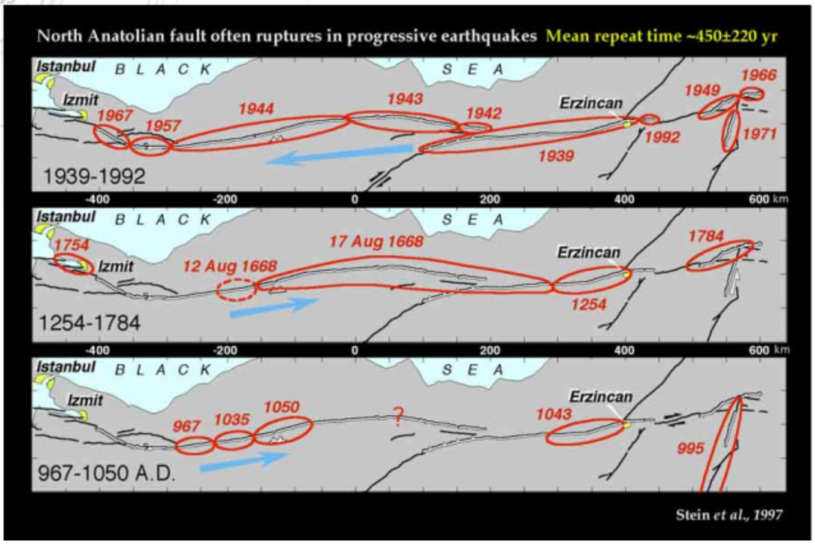

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Izmit earthquake, 17 august 1999, Mag:7,4

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❖ Right lateral Strike Slip Fault

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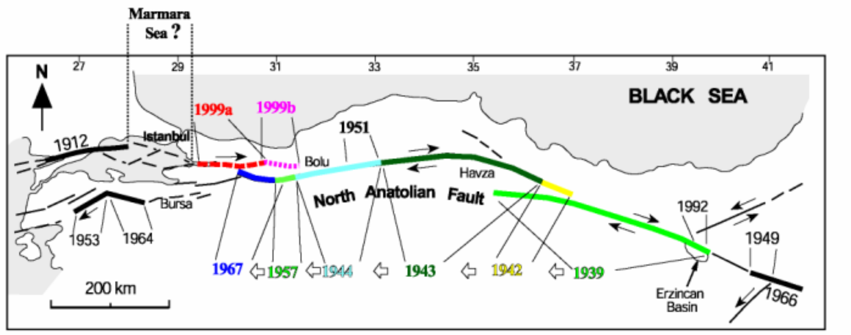
Westward migration of earthquakes on the NAF



after Barka et. al. (2002)

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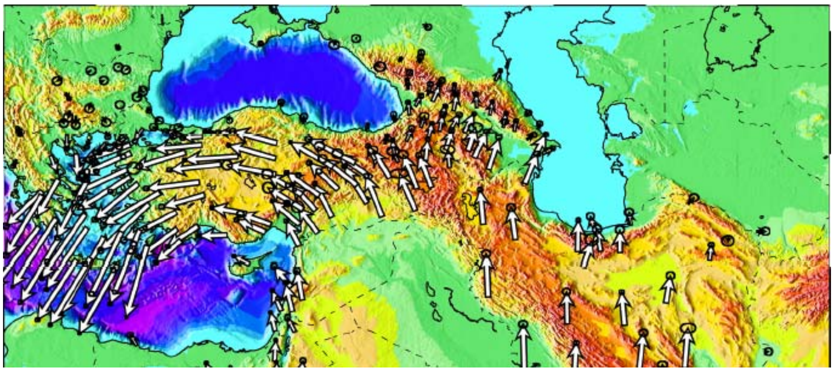
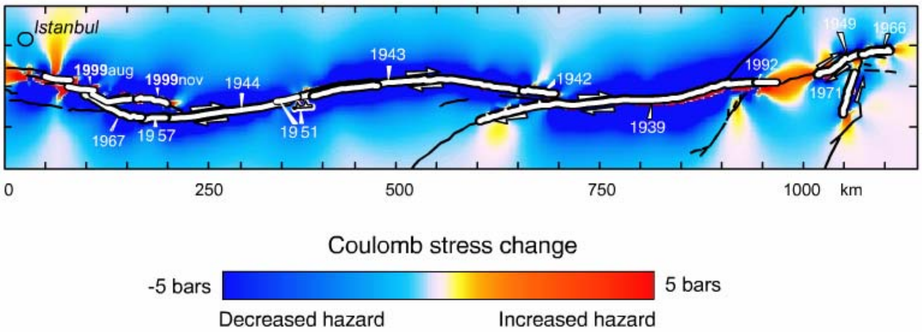


- **The GPS-derived velocity field (1988–2005)**
- **indicates counterclockwise rotation of a broad area of the Earth's surface**
- **including the Arabian plate, adjacent parts of the Zagros and central Iran, Turkey, and the Aegean/Peloponnesus relative to Eurasia**
- **At rates in the range of 20–30 mm/yr.**

Stress Change



Animation by Rachel Margrett, Ross Stein and Serkan Bozkurt , US Geological Survey
For other animations see our website at: http://quake.wr.usgs.gov/~ross

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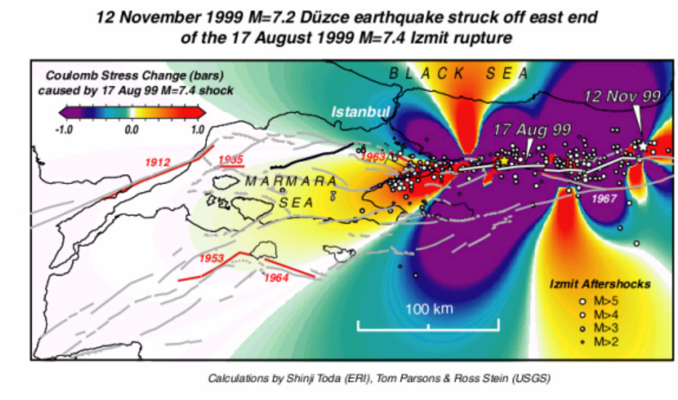
Coulomb Failure Stress Change after the 1999 Izmit earthquake



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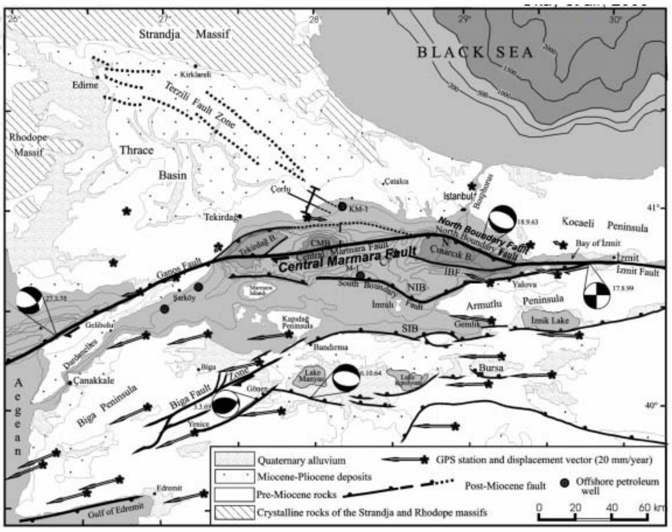
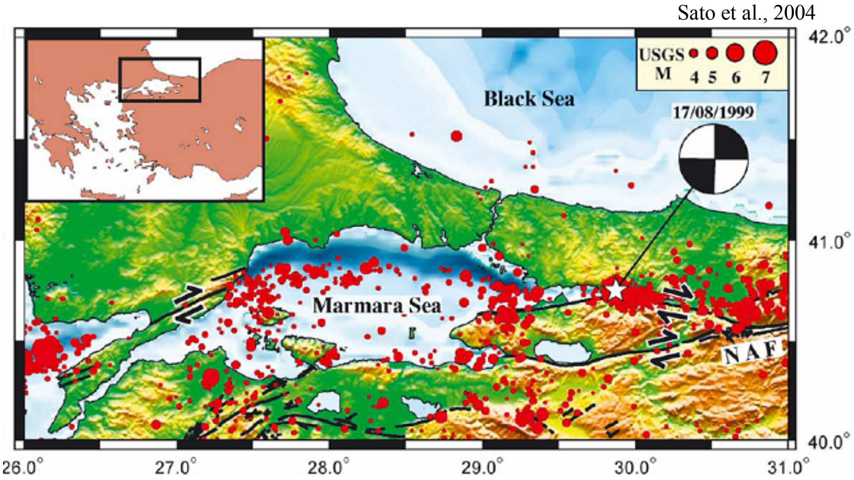
Complexity of NAF in Marmara Sea



Okay et al,, 2000

Seismicity of NAF at Marmara Region, 1996-2000

Sato et al., 2004



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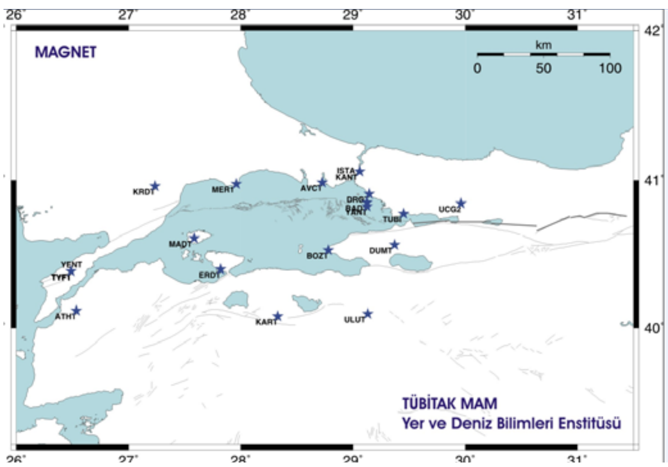
Marmara Continuous GPS Network (MAGNET)



DATA COLLECTION

Space Weather effects on Satellite Navigation Systems:

- Changes in the ionosphere caused by proton events, solar flares, or geomagnetic storms can cause positional errors as large as several miles.
- Ionospheric conditions also affect radio waves from Global Positioning System (GPS) satellites.
- Changes in the ionosphere can refract and slow GPS radio waves, introducing significant errors in position.
- GPS receivers can experience a loss of signal lock when the signal traverses an ionospheric disturbance (scintillation).

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To get rid of problems related with ionosphere;

1. The days which have solar winds were determined,
2. These days were not included in processing,
3. All 3 years (2002-2003-2004) were investigated if there are any space weather effects.

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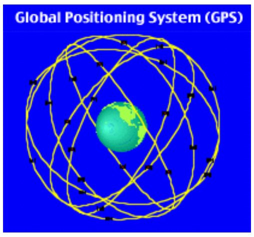
GIPSY-OASIS II

(GPS Inferred Positioning System / Orbit Analysis and Simulation Software)

Importance;

- for precise positioning over distances of m. to thousands of km.
- can accommodate static positioning,
  rapid static positioning,
  kinematic tracking of receivers.
- precise GPS orbit determination using a world wide aperture network of receivers



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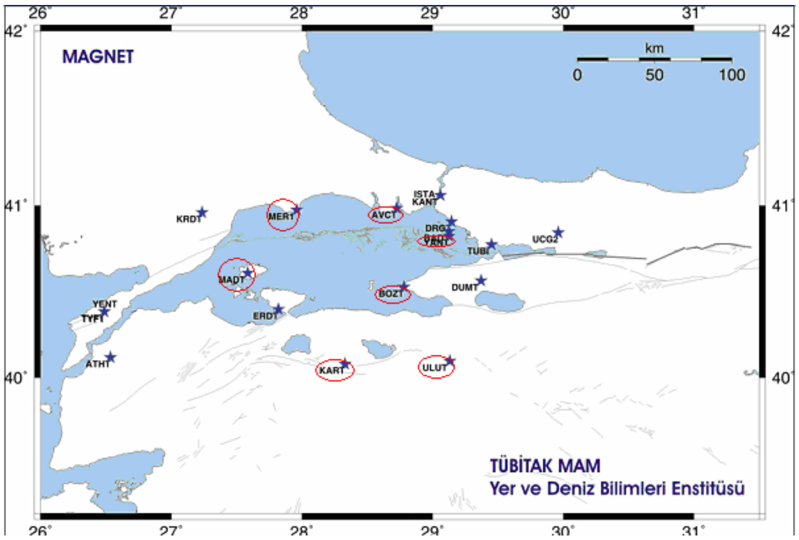
In this study;



STRAIN ACCUMULATION WITH GEODETIC TECHNIQUES

repated geodetic observations provide;

Parameters	Length	Azimuth	Angle	GPS
Area Deformation (Δ)	+			+
Shear Strain (γ)	+	+	+	+
Eigenvalues (ε_1 , ε_2)	+			+
Rotation Angle (φ)	+	+	+	+
Angular Strain (ω)		+		+

The base line vectors that derived from GPS require scale and rotation parameters.

By these measurements all the strain parameters can be determined.

STRAIN ACCUMULATION WITH GEODETIC TECHNIQUES

In this study;

- Triangulation
- Infinitesimal homogeneous strain model

Triangulation method:

$$\varepsilon = \frac{S' - S}{\Delta t . S}$$

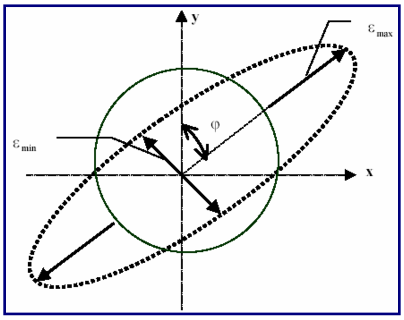
$$\varepsilon = e_{xx}\cos^2 t + e_{xy}\sin 2t + e_{yy}\sin^2 t$$

Maksimum strain:

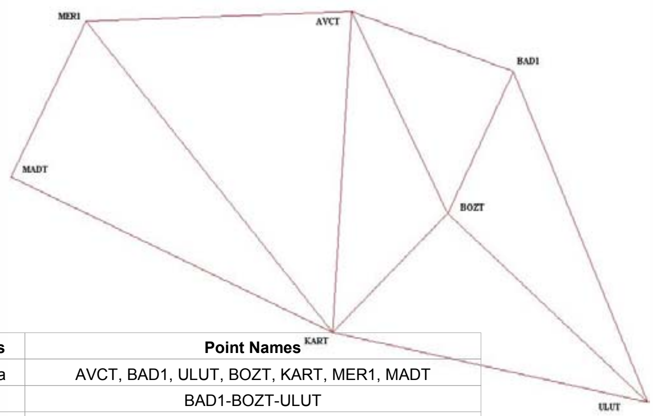
$$\varepsilon_{max} = \frac{1}{2}\left[\left(e_{xx} + e_{yy}\right) + \sqrt{\left(e_{xx} + e_{yy}\right)^2 + 4e_{xy}{}^2}\right]$$

Minimum strain:

$$\varepsilon_{min} = \frac{1}{2}\left[\left(e_{xx} + e_{yy}\right) - \sqrt{\left(e_{xx} + e_{yy}\right)^2 + 4e_{xy}{}^2}\right]$$



Triangulation Method:



Regions	Point Names
Whole area	AVCT, BAD1, ULUT, BOZT, KART, MER1, MADT
Triangle 1	BAD1-BOZT-ULUT
Triangle 2	BAD1-BOZT-AVCT
Triangle 3	BOZT-ULUT-KART
Triangle 4	BOZT-AVCT-KART
Triangle 5	MER1-AVCT-KART
Triangle 6	MER1-MADT-KART

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TRIANGLE CORNER POINTS	PRINCIPLE STRAIN COMPONENTS		Ψ (deg)	E_{INTER} (μs)	E_{SHEAR} (μs)
	ε_1 (μs)	ε_2 (μs)			
BAD1-BOZT-ULUT	0.5828	-0,0859	6,9826	0,2485	0.3344
BAD1-BOZT-AVCT	0.7782	-0,3067	30,9725	0,2357	0,5425
BOZT-ULUT-KART	0,2189	-0,5221	-89,9999	-0,1516	0,3705
BOZT-AVCT-KART	0,4077	-0,1395	47,9029	-0,4935	0,9012
MER1-AVCT-KART	0,4102	-0,075	54,0592	0,1676	0,2425
MER1-MADT-KART	0,5001	-0,0426	40,9145	0,2287	0,2714

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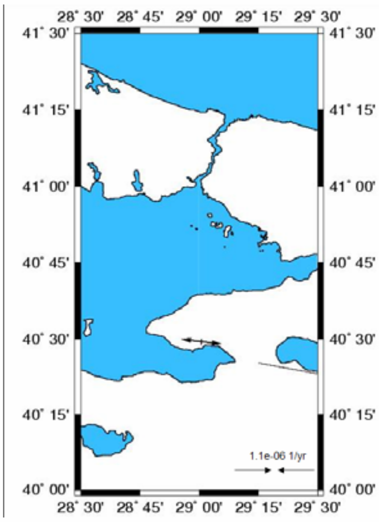
BAD1 (Buyukada), BOZT (Bozburun) and ULUT (Uludag)



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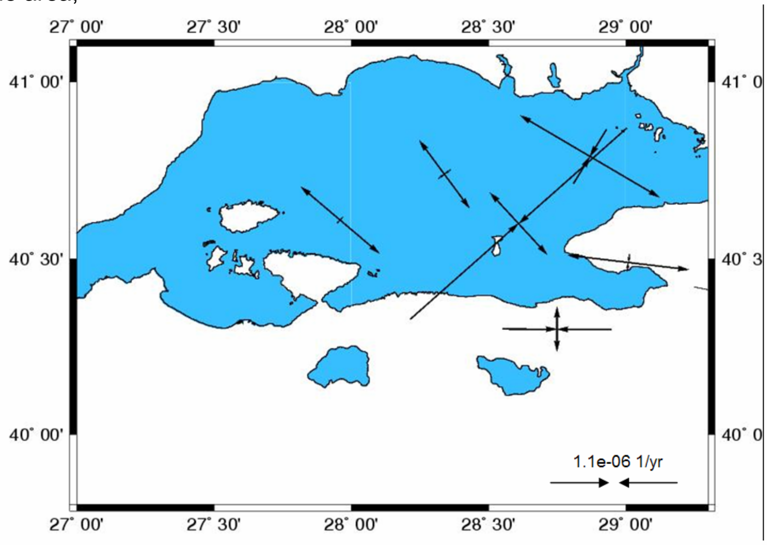
Whole area;



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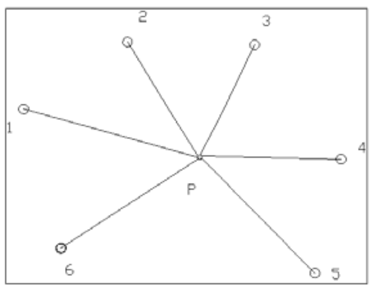
Infinitesimal homogeneous strain model:



$$dx_i = x_i e_{xx} + y_i e_{xy} + t_x$$
$$dy_i = x_i e_{yx} + y_i e_{yy} + t_y$$

$$\begin{vmatrix} dx \\ dy \end{vmatrix} = \begin{vmatrix} 1 & 0 & x & y & 0 & 0 \\ 0 & 1 & 0 & 0 & x & y \end{vmatrix} \begin{vmatrix} t_x \\ t_y \\ e_{xx} \\ e_{xy} \\ e_{yx} \\ e_{yy} \end{vmatrix}$$

$$x = X_i - X_P$$
$$y = Y_i - Y_P \quad \text{i=1,....n}$$

STATION ID	Principle strain parameters		β (deg)
	ε_1 (μs)	ε_2 (μs)	
KART	-0,16	-0,36	63,721
MER1	0,13	-0,48	48,121
AVCT	0,56	-0,31	13,968
BOZT	0,22	-0,08	23,227
ULUT	0,15	0,05	42,705
BAD1	0,70	-0,09	85,418

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SUMMARY

- ✓ Displacements of the stations at the northern branch of NAF at the Marmara Region have bigger values,
- ✓ The compression at the Marmara sea close to Bozburun has to be considered,
- ✓ Decreasing of postseismic character by the years,
- ✓ Extensions are perpendicular to the fault.


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THANK YOU......
asudeas@gmail.com