



**KANDİLLİ**  
OBSERVATORY AND  
EARTHQUAKE RESEARCH  
INSTITUTE

*Presented at the FIG Working Week 2017,  
May 29 - June 2, 2017 in Helsinki, Finland*

1866

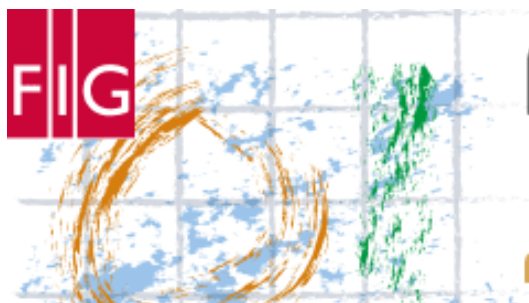


TÜBİTAK



# GPS-constrained estimate of present-day slip rate along major faults of Turkey

Haluk OZENER, Bahadır AKTUG and Aslı DOGRU

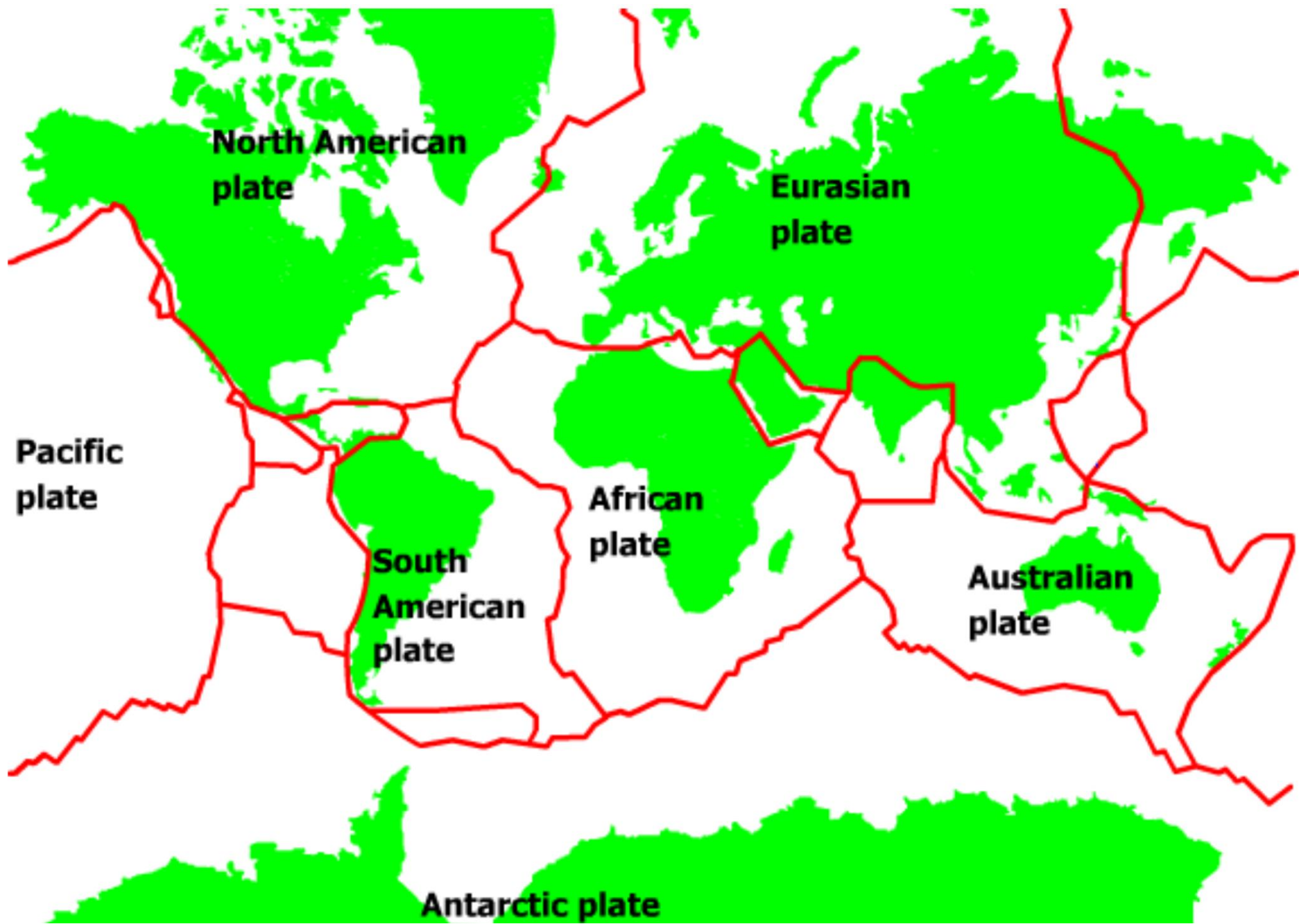


## FIG WORKING WEEK 2017

Surveying the world of tomorrow -  
From digitalisation to augmented reality

May 29 - June 2 Helsinki Finland





**North American  
plate**

**Eurasian  
plate**

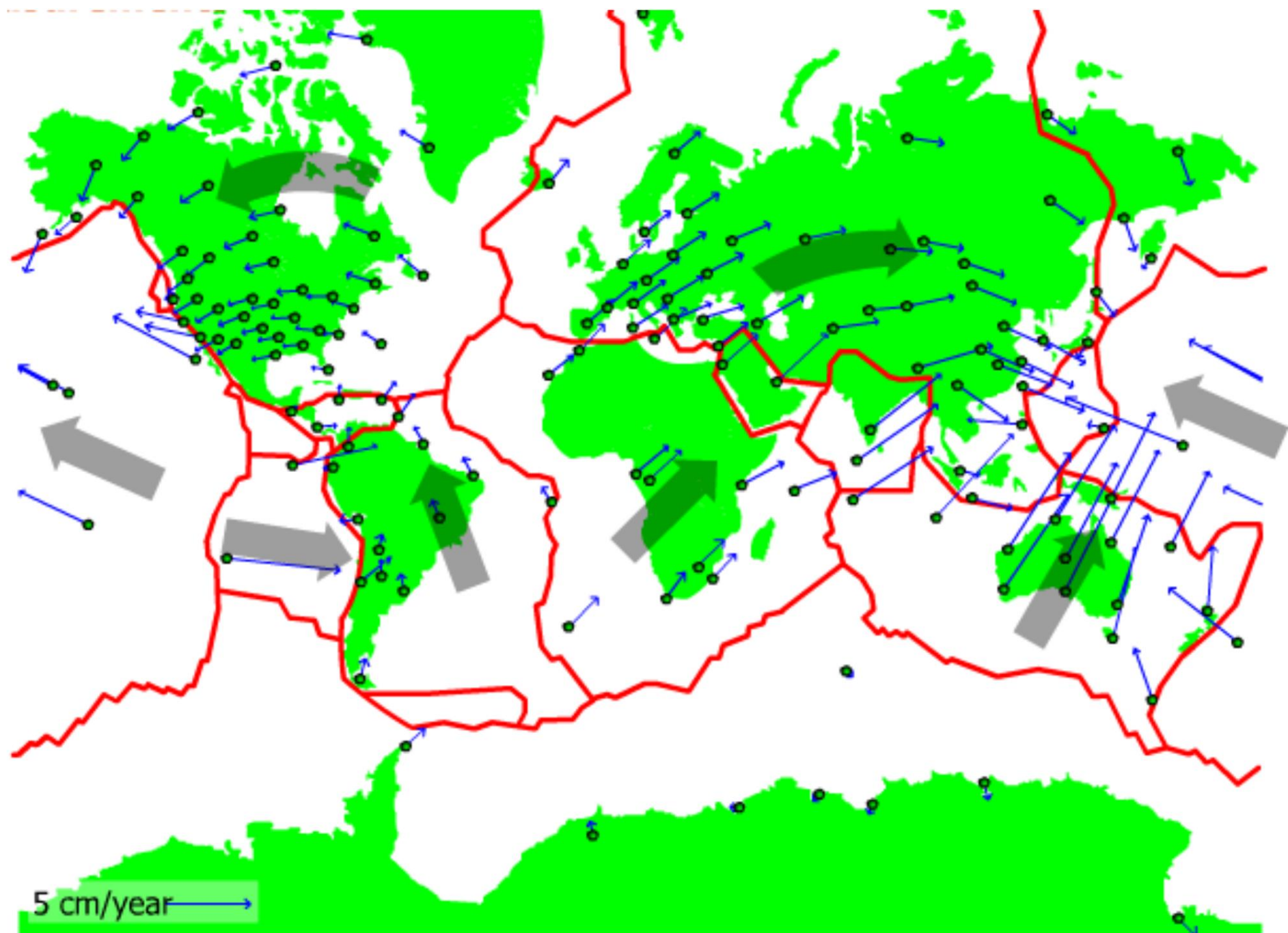
**Pacific  
plate**

**African  
plate**

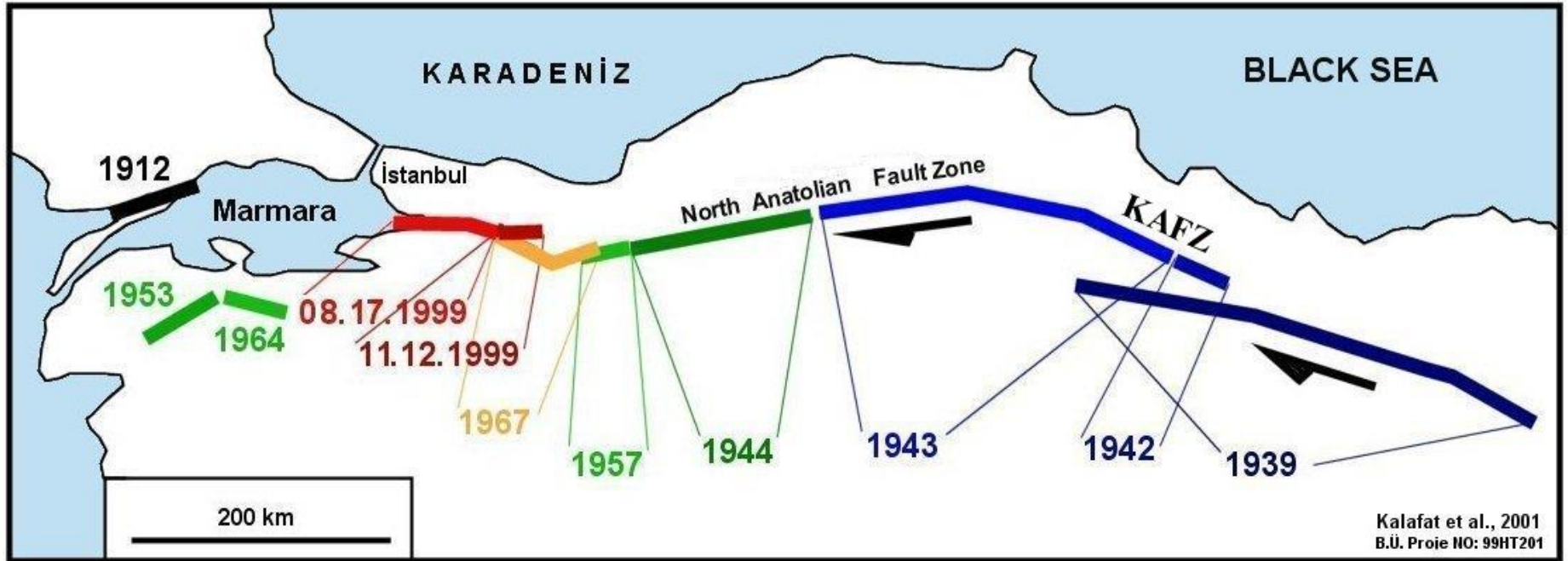
**South  
American  
plate**

**Australian  
plate**

**Antarctic plate**







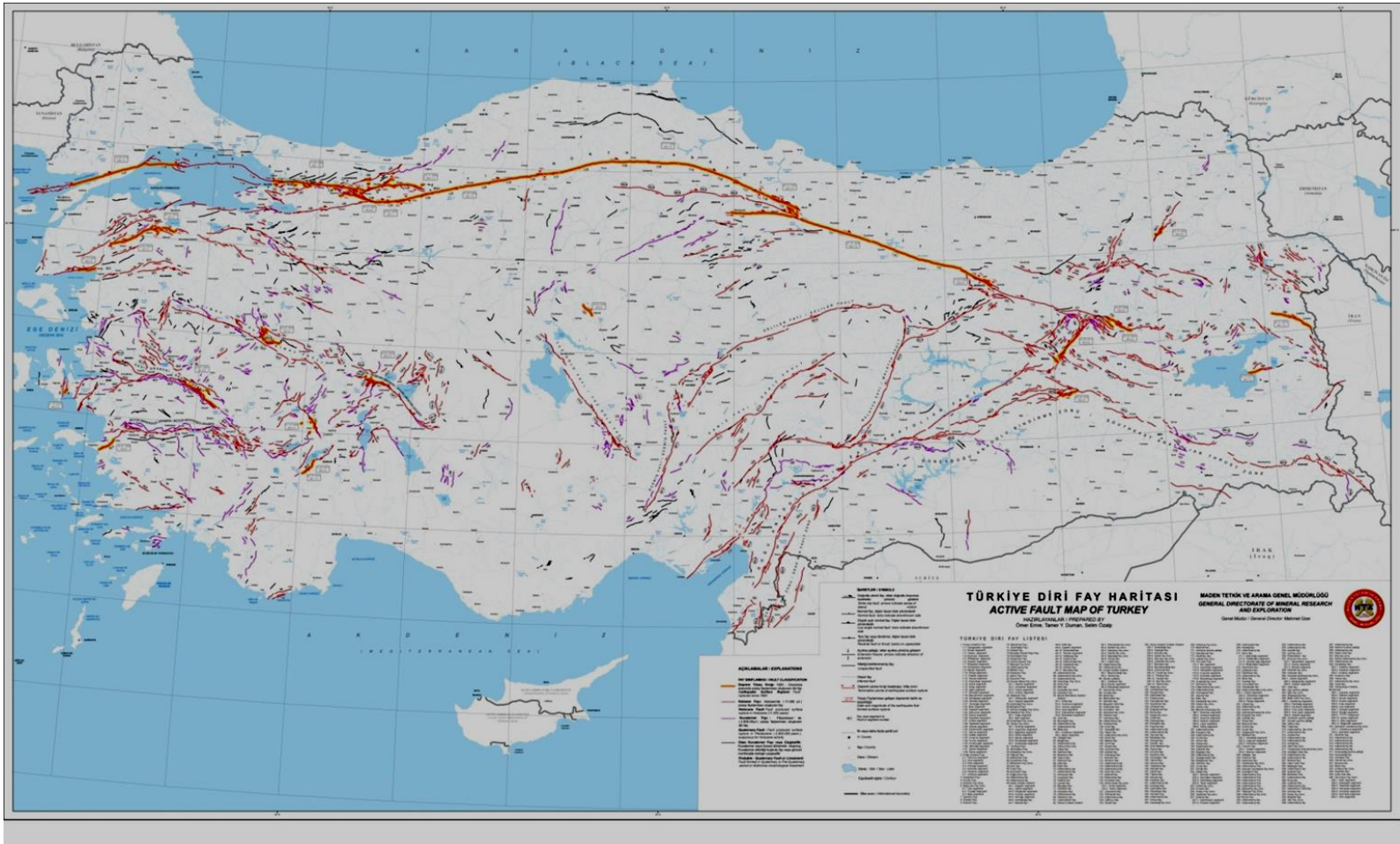
The westward migration earthquakes since 1939 along the North Anatolian Fault

# Turkey Active Fault Map



General Directorate of Mineral Research and Exploration (Şaroglu et al., 1992)

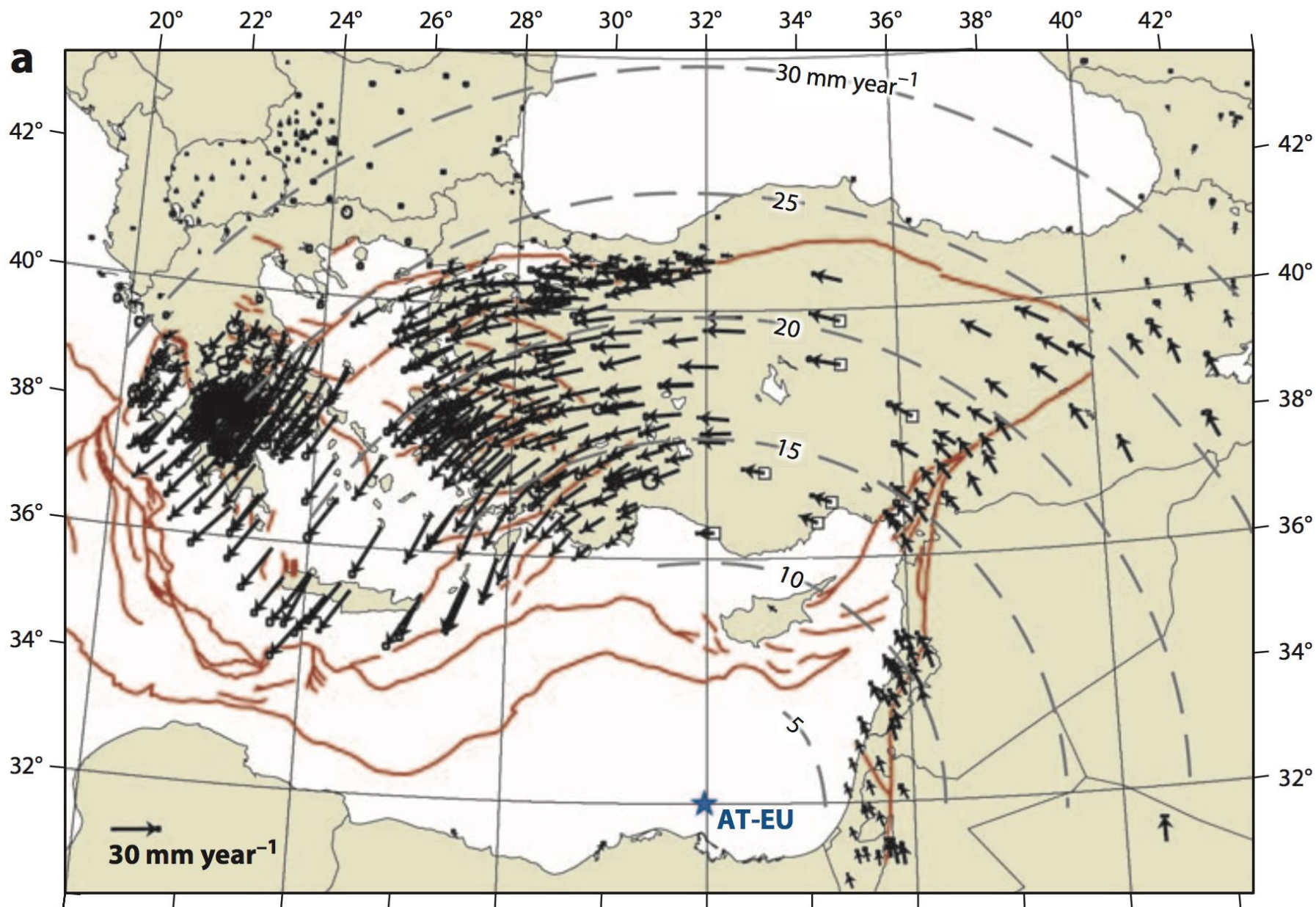
# Updated Active Fault Map of Turkey

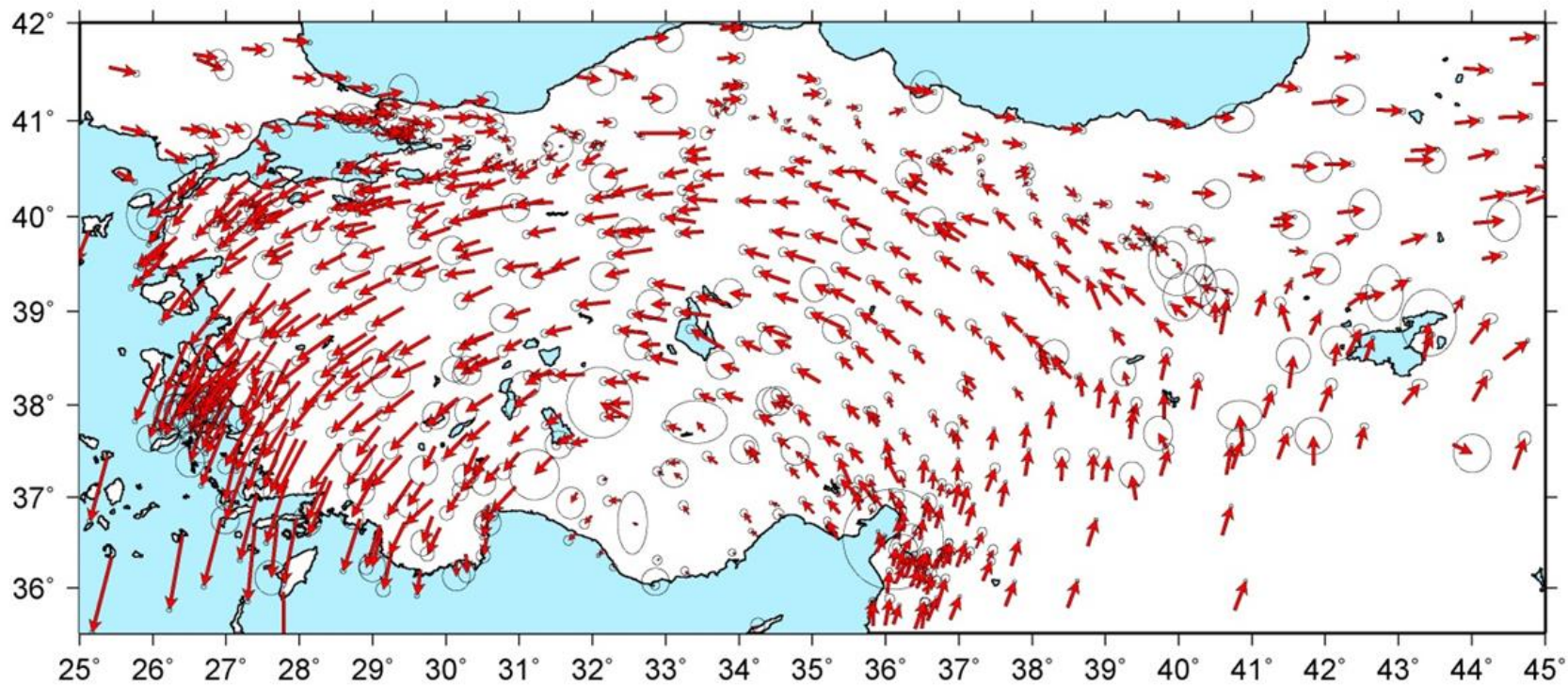


General Directorate of Mineral Research and Exploration (Emre et al., 2013)







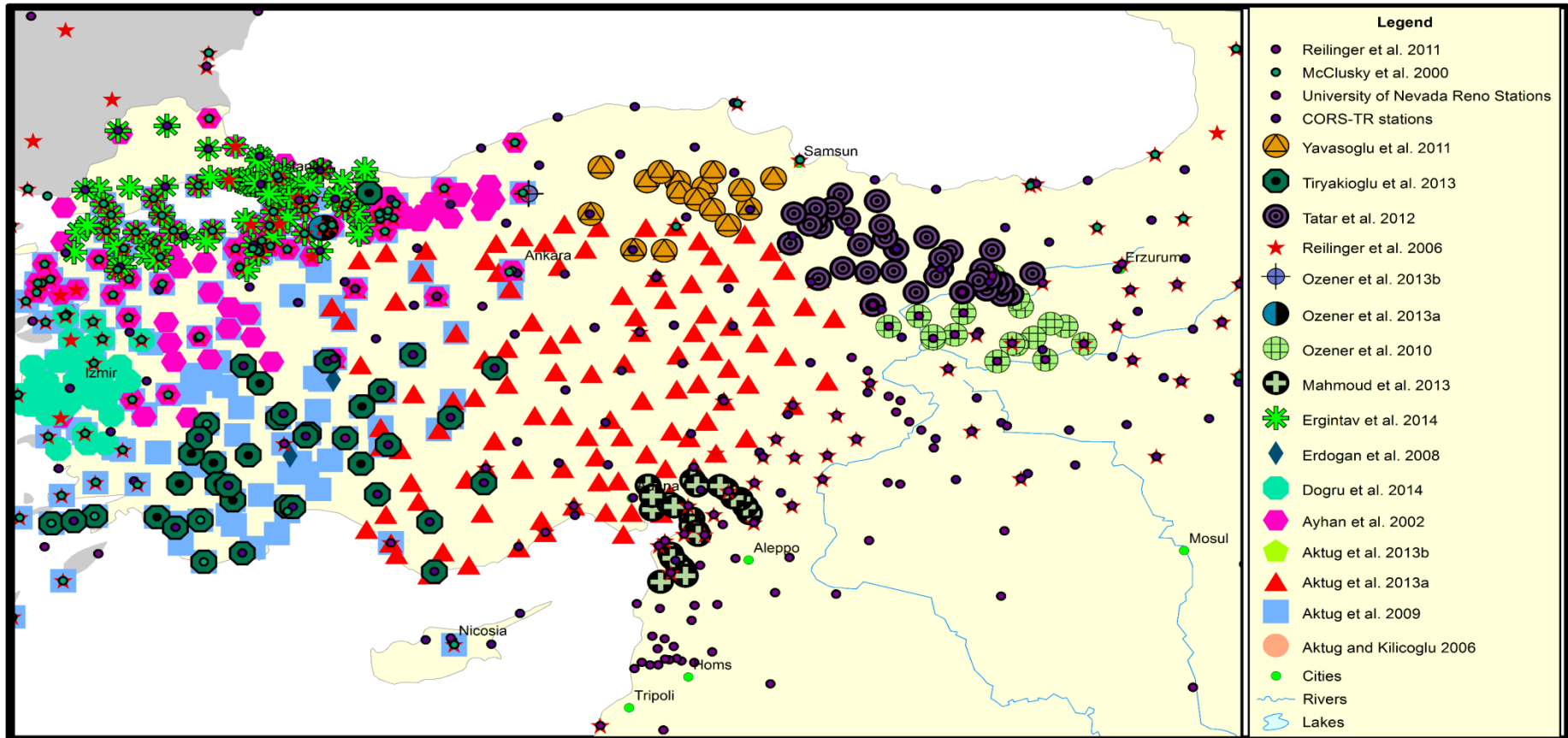


- **Motivation:**
- Updated AFM
- Seismically Active
- GPS 1990, no homogenous VF
- Unpublished local studies
- Seismotectonic map geodetic contribution

# Data

- Turkish National Permanent GPS Stations
- Turkish National Permanent GPS Stations – Active (CORS-TUSAGA-Active)
- Turkish National Fundamental GPS Network
- Episodic GPS Observations (GPS campaigns were held to combine velocity fields)
- Published GPS Velocity Data in the Literature

<b>Current Velocity Fields</b>	<b>Number of Stations</b>
Aktug and Kılıcoglu (2006)	53
Aktug et al. (2009)	204
Aktug et al. (2013a)	137
Aktug et al. (2013b)	133
Ayhan et al. (2002)	136
Dogru et al. (2014)	75
Erdogan et al. (2008)	16
Ergintav et al. (2014)	112
Mahmoud et al. (2013)	44
Ozener et al. (2010)	55
Ozener et al. (2013)	35
Ozener et al. (2013b)	28
Reilinger et al. (2006)	433
Reilinger et al. (2011)	227
Tatar et al. (2012)	48
Tiryakioglu et al. (2013)	39
CORS-TR stations	146
Yavasoglu et al. (2011)	16



Locations of GPS sites used in the study

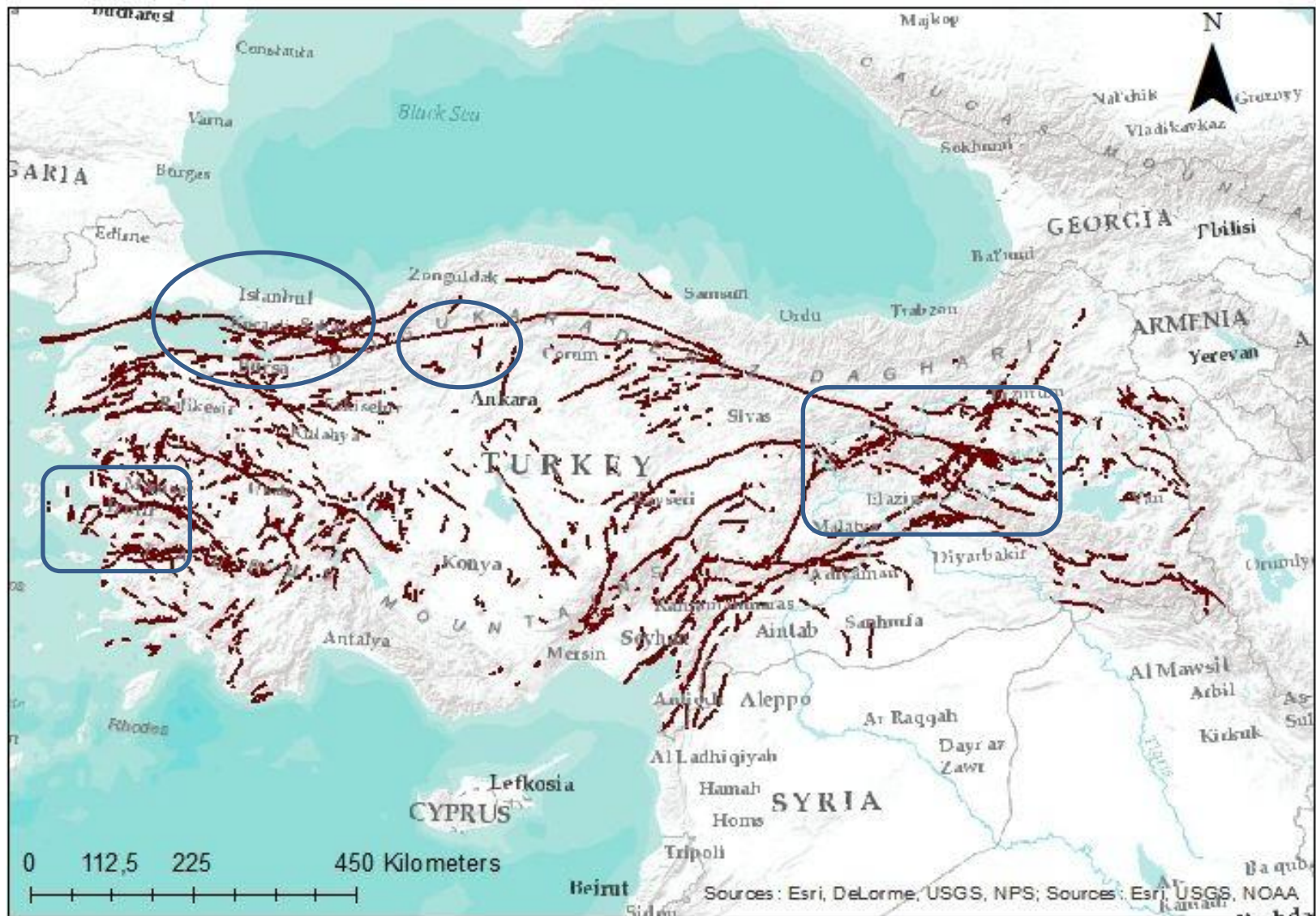
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1 <i>Aktug_and_Kilicoglu_2006.gmt</i>	53	24	17	0	0	1	14	43	0	0	0	9	8	8	7	27	0	10	0	0
2 <i>Aktug_etal_2009.gmt</i>	24	208	30	0	0	4	73	19	10	29	0	33	8	19	8	145	6	8	17	0
3 <i>Aktug_etal_2013a.gmt</i>	17	30	137	0	22	36	4	7	0	0	0	12	8	8	7	34	12	14	1	1
4 <i>Aktug_etal_2013b.gmt</i>	0	0	0	19	6	6	0	0	0	0	0	0	19	0	0	3	10	3	0	0
5 <i>Aktug_etal_2015.gmt</i>	0	0	22	6	137	2	0	0	0	0	0	28	6	0	0	9	6	42	0	19
6 <i>Aktug_etal_2016.gmt</i>	1	4	36	6	2	176	2	1	0	0	1	46	6	0	0	57	66	0	0	0
7 <i>Ayhan_etal_2002.gmt</i>	14	73	4	0	0	2	160	14	0	38	0	8	0	0	0	78	3	0	0	0
8 <i>Dogru_etal_2014.gmt</i>	43	19	7	0	0	1	14	77	0	0	0	6	24	12	13	19	0	4	0	0
9 <i>Erdogan_etal_2008.gmt</i>	0	10	0	0	0	0	0	0	16	0	0	0	0	0	0	6	0	0	14	0
10 <i>Ergintav_etal_2014.gmt</i>	0	29	0	0	0	0	38	0	0	150	0	34	0	17	0	37	0	0	1	0
11 <i>Mahmoud_etal_2013.gmt</i>	0	0	0	0	0	1	0	0	0	0	44	0	0	0	0	0	1	0	0	0
12 <i>Ozdemir_TUSAGA_Aktif.gmt</i>	9	33	12	0	28	46	8	6	0	34	0	250	4	4	4	36	7	9	20	2
13 <i>Ozener_etal_2010.gmt</i>	8	8	8	19	6	6	0	24	0	0	0	4	55	18	18	16	11	8	0	0
14 <i>Ozener_etal_2013a.gmt</i>	8	19	8	0	0	0	0	12	0	17	0	4	18	61	18	22	0	5	0	0
15 <i>Ozener_etal_2013b.gmt</i>	7	8	7	0	0	0	0	13	0	0	0	4	18	18	48	10	0	4	0	0
16 <i>Reilinger_etal_2006.gmt</i>	27	145	34	3	9	57	78	19	6	37	0	36	16	22	10	463	108	14	11	0
17 <i>Reilinger_etal_2011.gmt</i>	0	6	12	10	6	66	3	0	0	0	1	7	11	0	0	108	231	2	1	0
18 <i>Tatar_etal_2012.gmt</i>	10	8	14	3	42	0	0	4	0	0	0	9	8	5	4	14	2	48	0	0
19 <i>Tiryakioglu_etal_2013.gmt</i>	0	17	1	0	0	0	0	0	14	1	0	20	0	0	0	11	1	0	39	0
20 <i>Yavasoglu_etal_2011.gmt</i>	0	0	1	0	19	0	0	0	0	0	0	2	0	0	0	0	0	0	0	16

# Common points

- # Velocity field : 20
- Reference velocity field : Aktug et al. (2009)
- # measurement : 4280
- Meas. co-variance matrix : 4280x4280
- Par. co-variance matrix: 2204x2204
- # parameters : 60
- # points : 1072

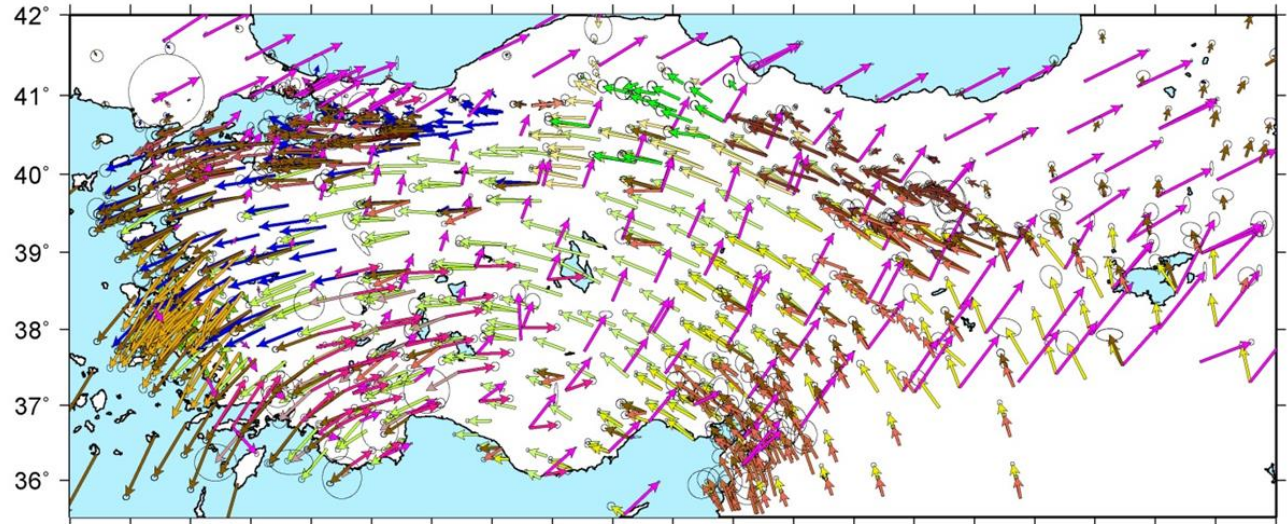


# Episodic GPS Measurements

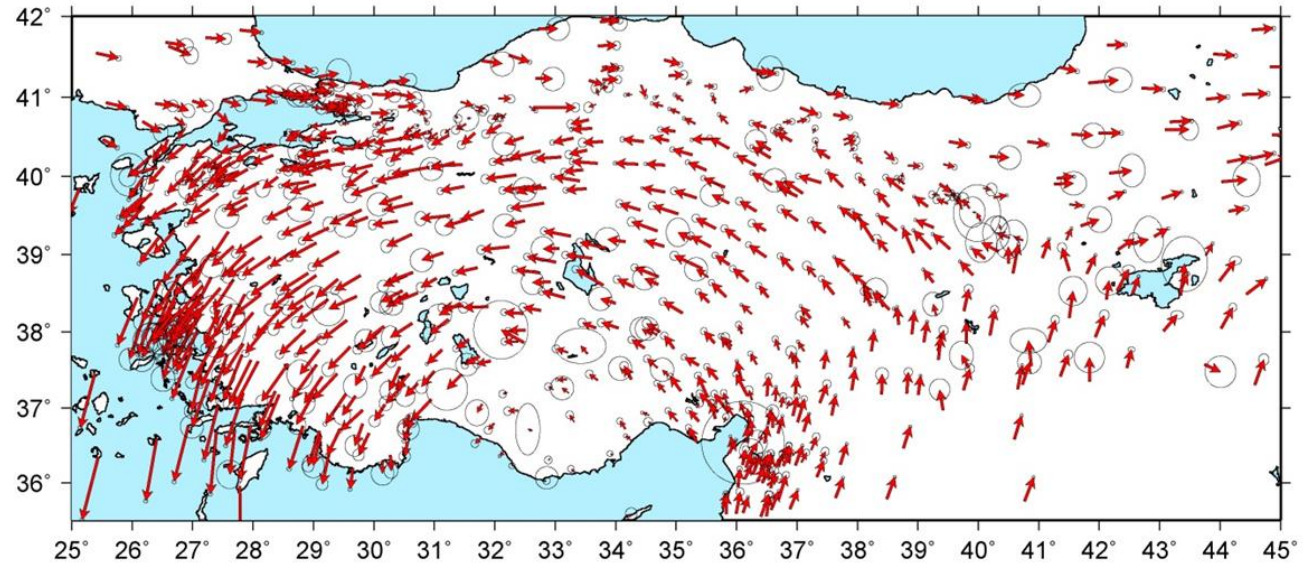


# Velocity field transformation

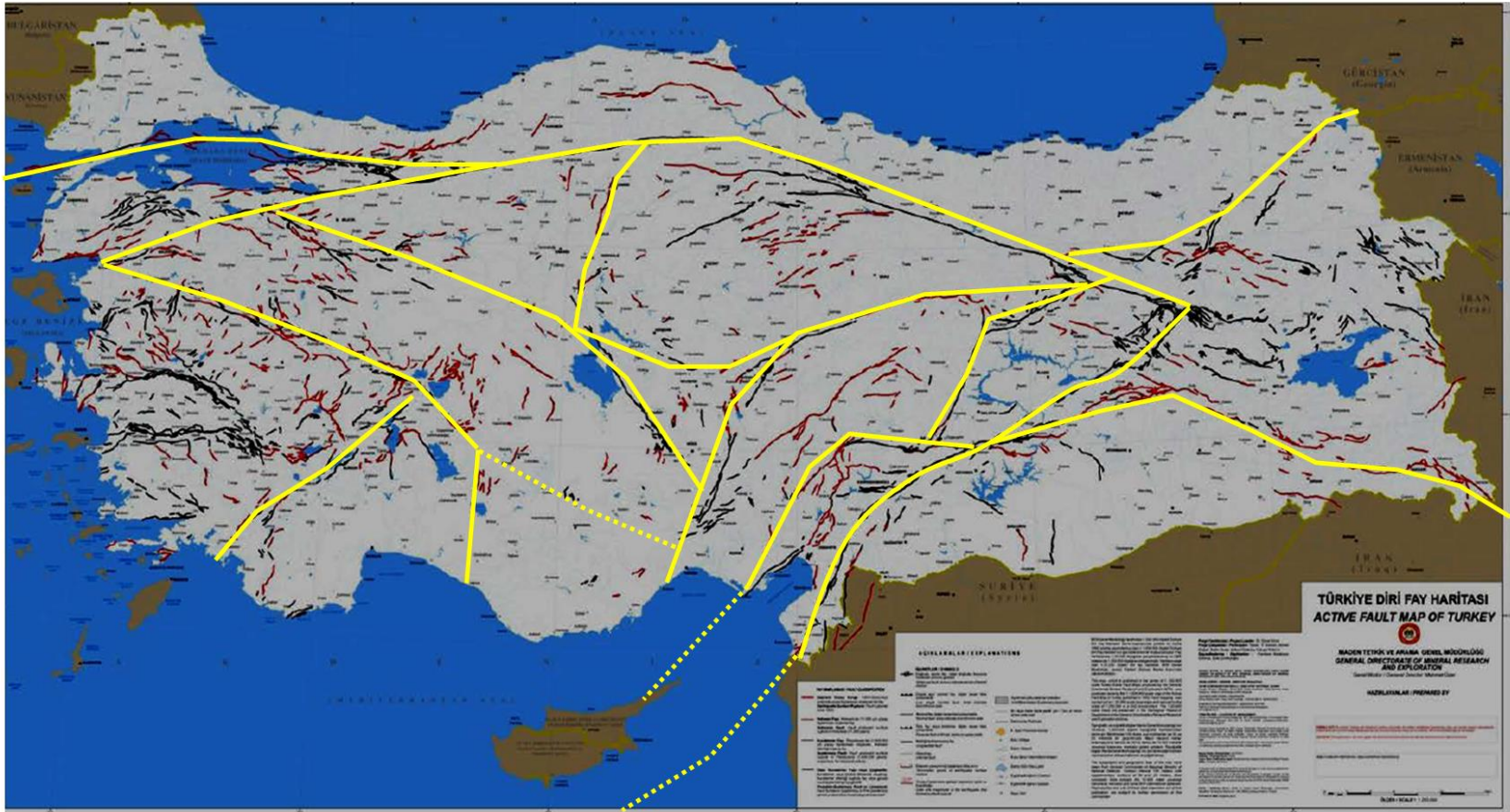
Before



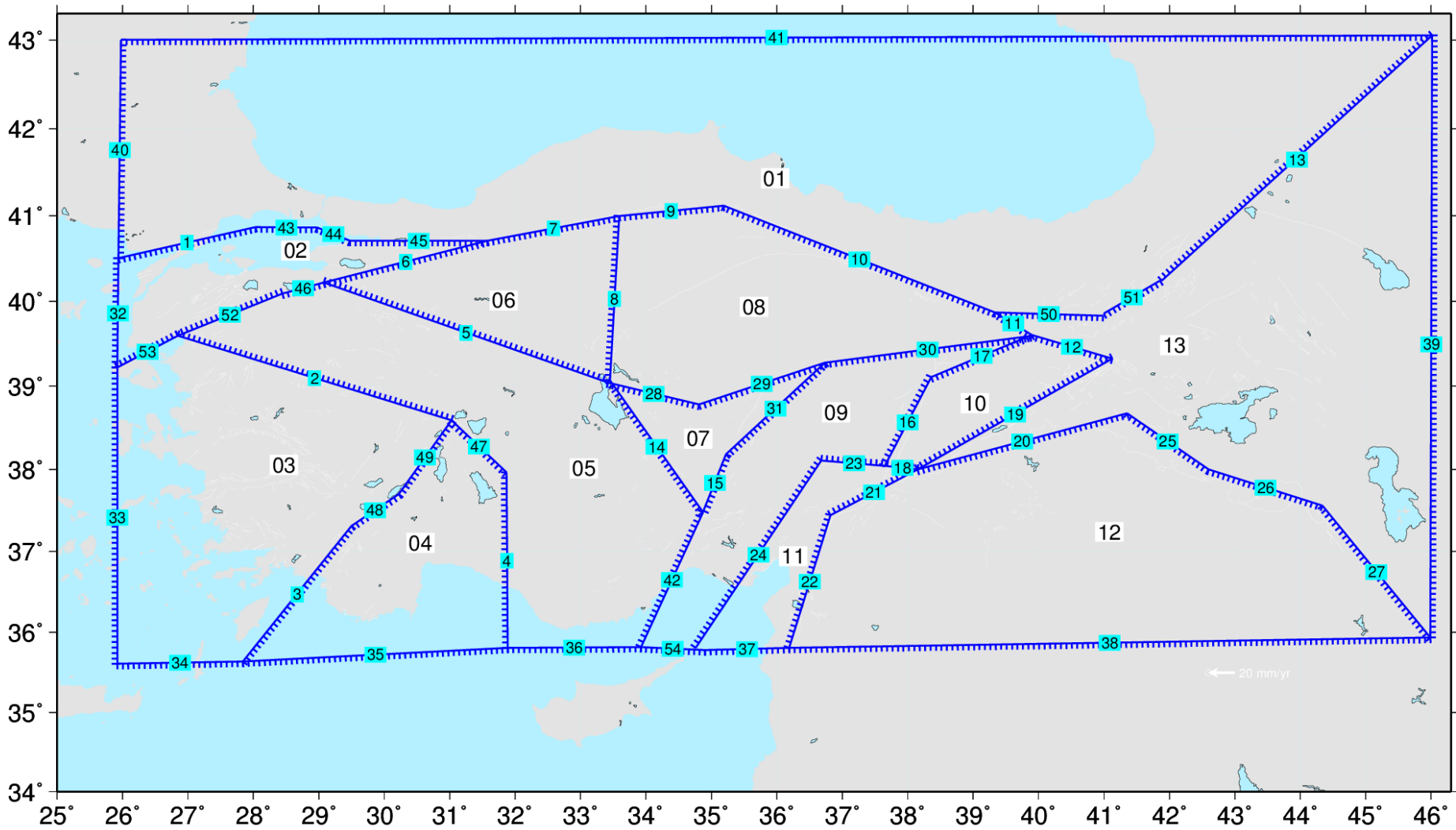
After



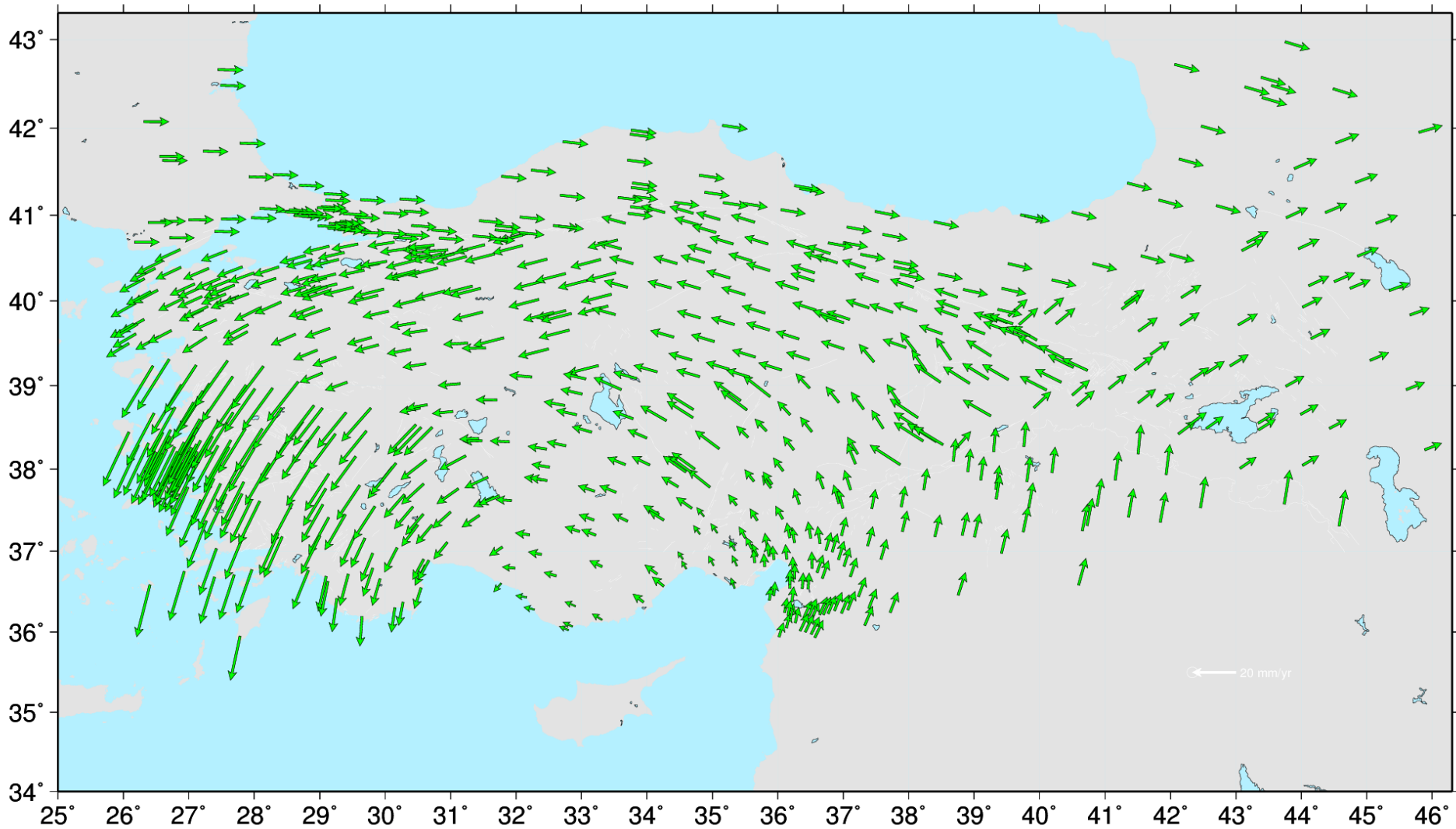
# Block Boundaries



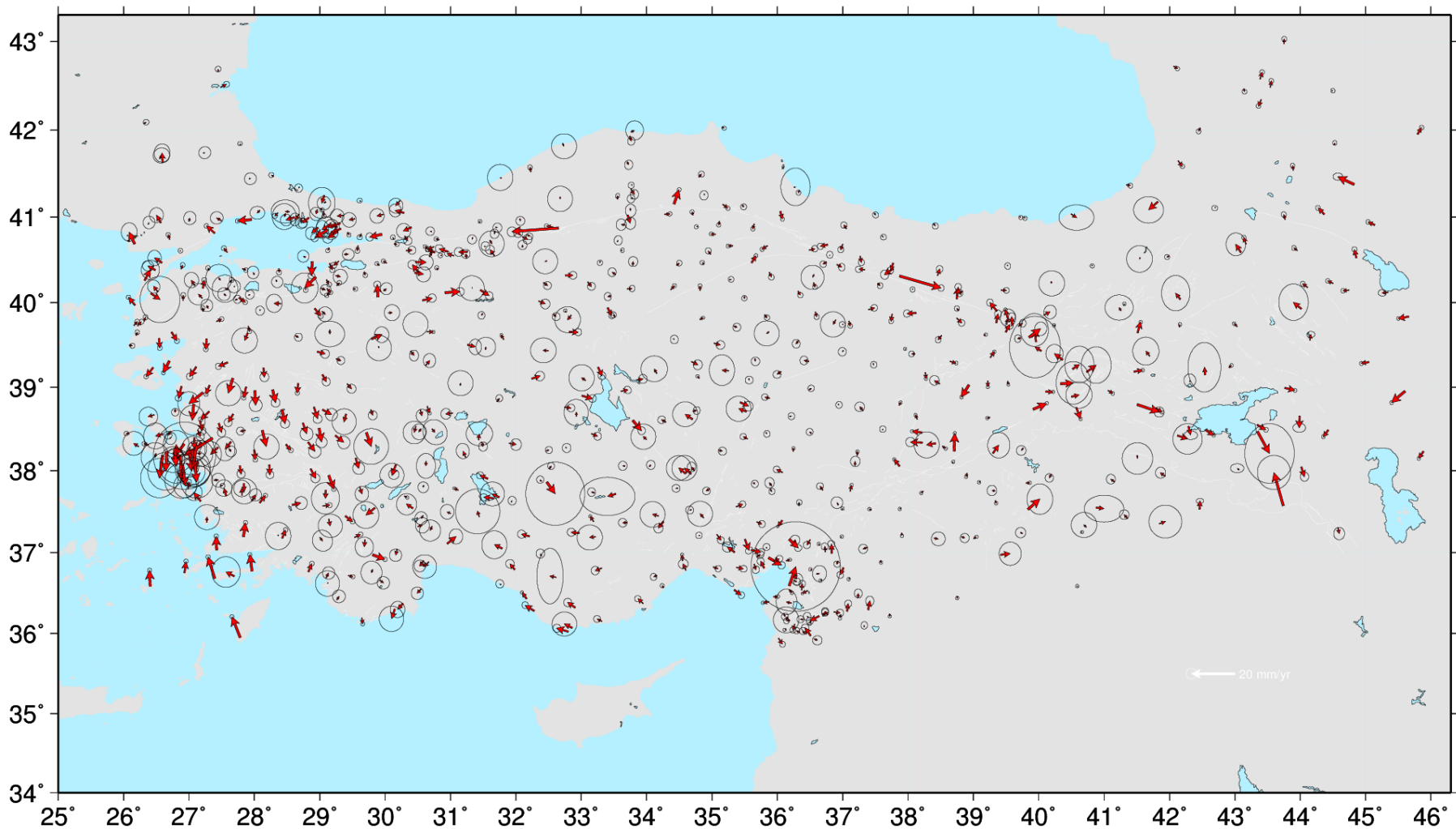
- Optimum # points
- Literature
- Updated fault map



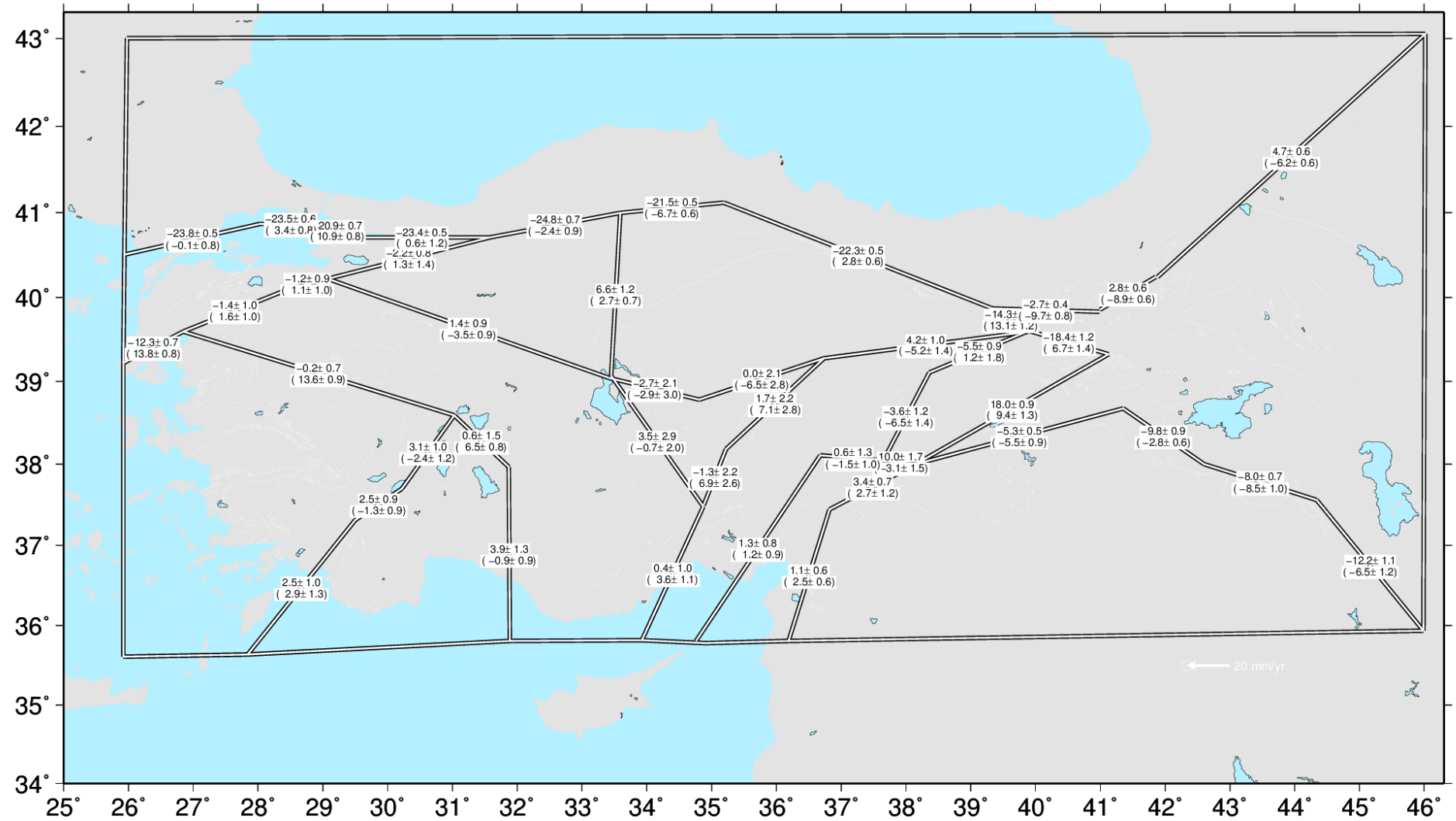
Micro-blocks and fault segments



Velocities of GPS points – micro blocks



Residuals



Slip rates along fault segments

# Result&Conclusion

- Combined, homogenous
- AFM was revised 2012 many new second-order structures helped to find the connection between main block zones.
- 1 st. SR of MF in AFM determined.
- A novel methodology of simultaneously combining velocity fields with different reference frame realizations was adopted



# Result&Conclusion

- The application of Variance Component Analysis (VCA) to the individual velocity fields led to a realistic representation of the obtained velocities
- Adopted block model geometry is consistent with the observed deformation
- except for the western and southwestern Anatolia where different tectonic phenomena are known to take place

# Result&Conclusion

- No deformation - SS of Western NAF
- Strain accumulation - NS of NAF in the Sea of Marmara
- LL – EAF- Karliova SR  $13.1 \pm 1.6$  mm/yr  $4.1 \pm 1.2$  mm/yr
- Slip deficit EAF Palu-Sincik and Çelikhan-Türkoğlu segments (1,82m and 5,16m)  $M_w 7.5$  and  $M_w 7.7$

# Result&Conclusion

- Geodetic database
- Input for Seismotectonic map and Earthquake Zoning map.

Thank you for interest and attention

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