UNIVERSITY OF WEST ATTICA
Department of Surveying and Geoinformatics Engineering
Research Unit Geodesy – Surveying and GNSS

Velocity and strain field estimation from episodic GNSS campaigns (2012-2021) for the region of Attica, Greece

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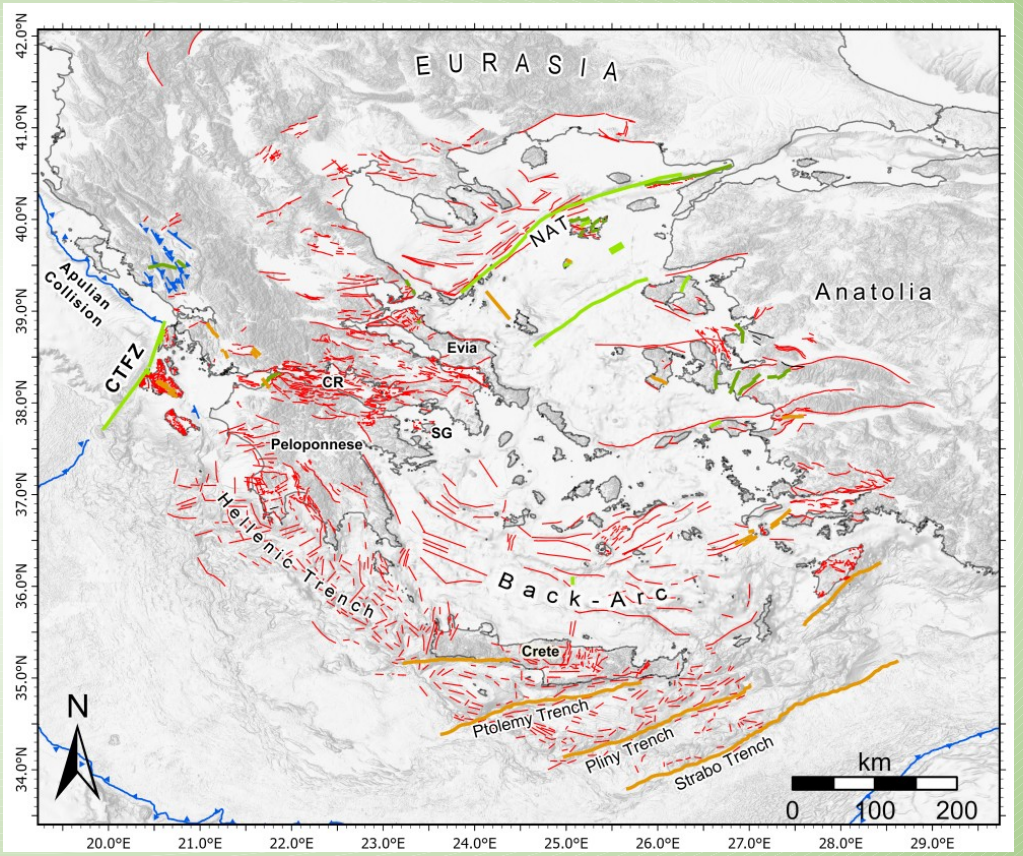
THESSALONIKI - GREECE

STRUCTURE

- Study area
- Network distribution
- Observation epochs
- Processing
- Velocity fields
- Strain Rates

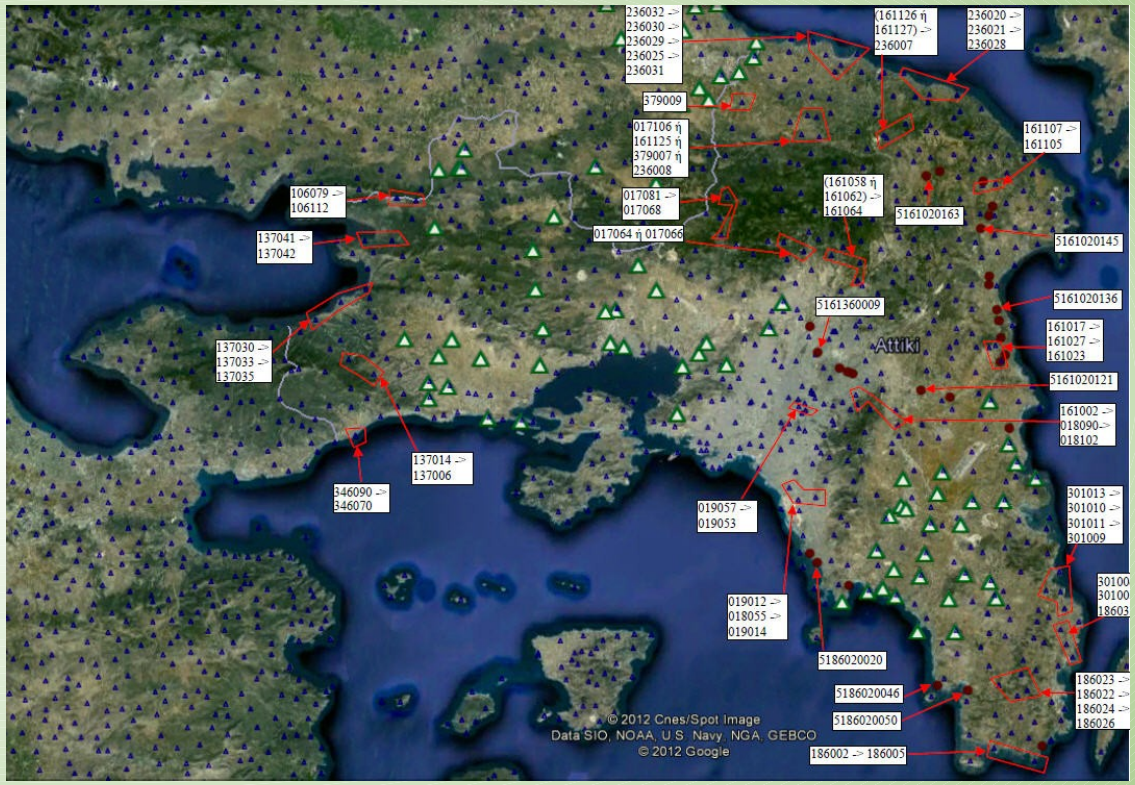
TECTONIC BACKGROUND

- The study area in this presentation includes the wider area of the Region of Attica.
- Attica has intense seismicity as well as active faults and is interesting for being the largest urban center with 5 000 000 inhabitants and huge structures.
- The wider area of Athens is essentially a transitional area between the regions of Corinth and Viotia, which are characterized by intense seismic activity, and those of South Attica and the Cyclades with low rates of deformation.



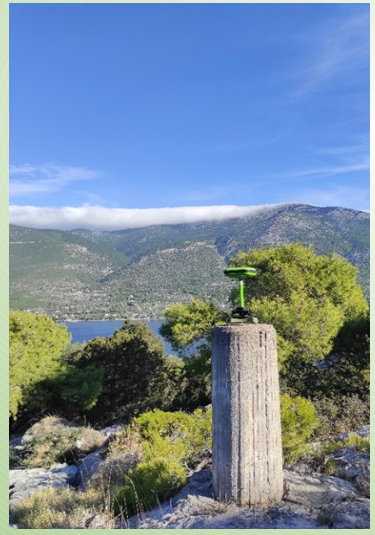
OBSERVATION EPOCH: 2012.7

- As part of the ARCHIMEDES research project, GPS measurements were carried out in order to evaluate the height information of the geodetic and trigulation network in Greece, in the context of the integration of the European vertical reference systems.
- The observations had been carried out at points selected based on the criteria defined by the precision specifications and controlling the ease of access and the visible horizon for the measurements by satellite techniques.
- Sites of the state network (trigonometric, geodetic network) of the Hellenic Military Geographical Service (HMGS.) were selected.
- 28 sites.
- A Topcon Hiper Pro antenna and the corresponding receiver were used.
- Duration of observations 1-3 hours.



OBSERVATION EPOCH: 2021.9

- 14 campaign sites (13 geodetic pillars)
- Equipment: JAVAD TRIUMPH1
- Observation duration: 1-2 hours



OBSERVATION EPOCH: 2021.9

Station Codes

HMGS	2012	2022
17064	17064	AR01
161064	161064	AR02
379009	379009	AR03
161125	161125	AR04
236030	236030	AR05
161126	161126	AR06
161105	161105	AR07
5161020145E	5161020145E	AR08
161017	161017	AR09
137014	137014	AR10
137041	137041	AR11
137030	137030	AR12
186002	186002	AR13
19053	19053	AR14

Network distribution

PROCESSING

Processing with different software:

Precise Point Positioning

- CSRS online processing engine
- PRIDE PPP-AR

Double Differences

- Leica Infinity

Reference Frame: ITRF2014
Implemented using DYNG IGS station

Processing options *(Leica Infinity)*

DYNG-TEIATH1		DYNG-AR-XX	
Data	**Used**	**Data**	**Used**
Cut off Angle	10°	Cut off Angle	10°
Frequency	L1/L2	Frequency	L1/L2/L5
Sapling Rate	30,00 sec	Sapling Rate	30,00 sec
Staelite System	GPS	Staelite System	GPS
Ephemeris Type	Broadcat	Ephemeris Type	Broadcat
Antenna Calibration Set	NGS Absolute	Antenna Calibration Set	NGS Absolute
Processing Strategy		**Processing Strategy**	
SolutionType	Phase Fixed	SolutionType	Phase Fixed
Tropospheric Model	Copmuted	Tropospheric Model	VMF with GPT2 model
Ionospheric Model	Computed	Ionospheric Model	Computed

PROCESSING RESULTS | AMBIGUITY STATISTICS

Double differences

Epoch	Baseline	Ambiguity Statistics	
2012		L1[%]	L2[%]
	DYNG-AR01	56,72	59,93
	DYNG-AR02	87,34	85,79
	DYNG-AR03	87,07	88,19
	DYNG-AR04	99,69	100,00
	DYNG-AR05	95,76	95,63
	DYNG-AR06	98,17	98,28
	DYNG-AR07	99,90	100,00
	DYNG-AR08	99,52	100,00
	DYNG-AR09	96,10	96,01
	DYNG-AR10	100,00	100,00
	DYNG-AR11	99,44	99,92
	DYNG-AR12	100,00	100,00
	DYNG-AR13	0,00	6,93
	DYNG-AR14	99,84	99,84

Epoch	Baseline	Ambiguity Statistics		
2021		L1[%]	L2[%]	L5[%]
	DYNG-AR01	87,65	85,24	83,02
	DYNG-AR02	99,46	99,70	99,37
	DYNG-AR03	95,50	95,50	100,00
	DYNG-AR04	100,00	100,00	100,00
	DYNG-AR05	100,00	100,00	100,00
	DYNG-AR06	99,45	99,45	99,77
	DYNG-AR07	100,00	100,00	100,00
	DYNG-AR08	97,95	98,36	100,00
	DYNG-AR09	96,50	96,40	100,00
	DYNG-AR10	99,90	99,90	99,77
	DYNG-AR11	91,37	91,30	91,40
	DYNG-AR12	93,29	98,86	98,47
	DYNG-AR13	100,00	100,00	100,00
	DYNG-AR14	99,57	99,57	100,00

Epoch	Baseline	Ambiguity Statistics	
2012		L1[%]	L2[%]
	DYNG-TEIATH1	89,70	86,46
	TEIATH1-AR13	98,88	98,29

Precise Point Positioning

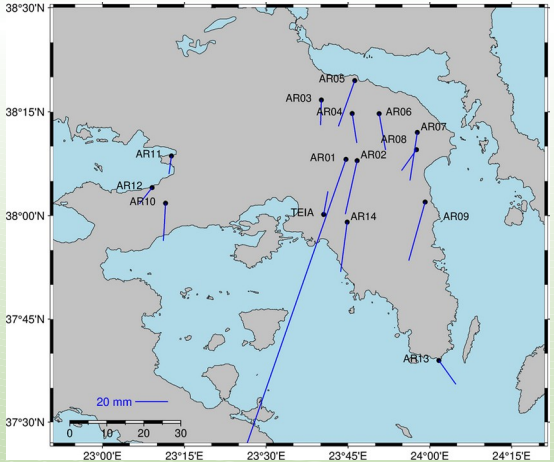
Epoch	Sites	Fixed Amb.
2021		
	AR01	54.23%
	AR02	87.43%
	AR03	97.37%
	AR04	99.39%
	AR05	94.81%
	AR06	92.80%
	AR07	95.27%
	AR08	95.20%
	AR09	93.70%
	AR10	99.80%
	AR11	100.00%
	AR12	87.36%
	AR13	100.00%
	AR14	97.97%

Stations	Fixed Amb.
DYNG305	99.03%
DYNG308	99.61%
DYNG315	99.64%
DYNG316	99.87%
DYNG334	96.33%
DYNG336	98.77%
TEI305	98.49%
TEI308	98.52%
TEI315	98.86%
TEI316	98.84%
TEI334	97.51%
TEI336	97.64%

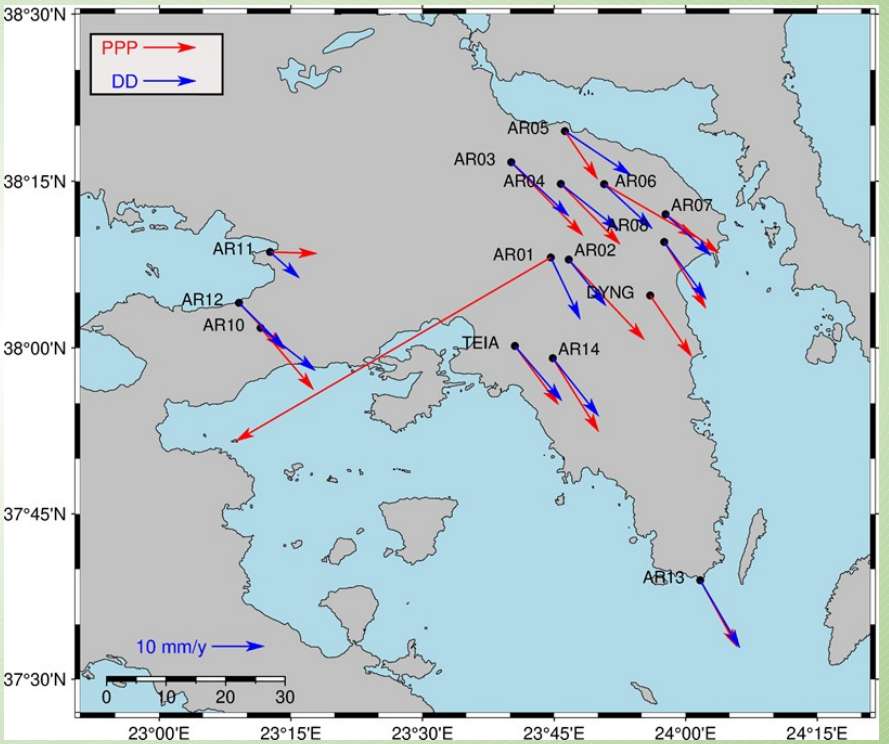
DIFFERENCES: PPP - DD

Coordinates 2012.7

Coordinates 2021.9

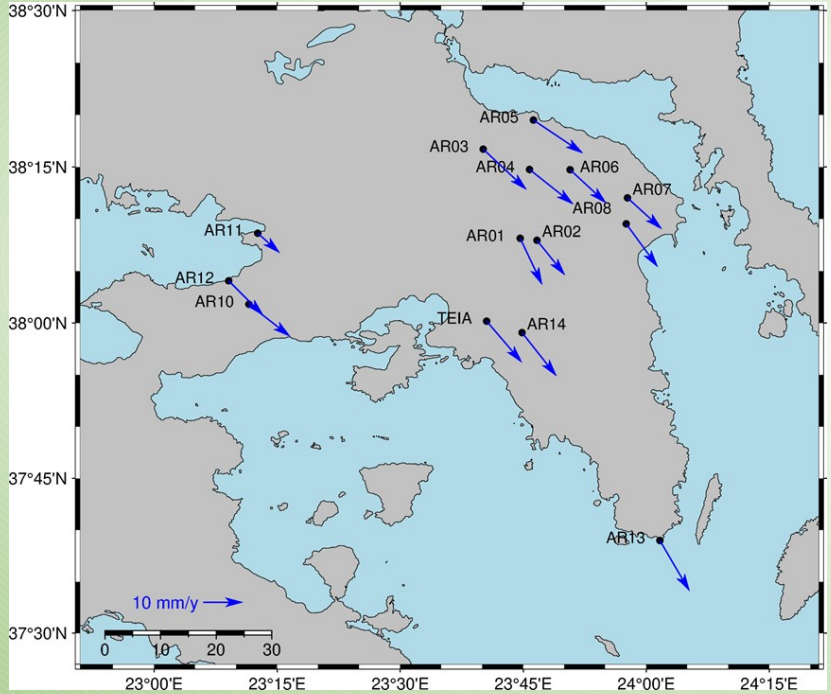


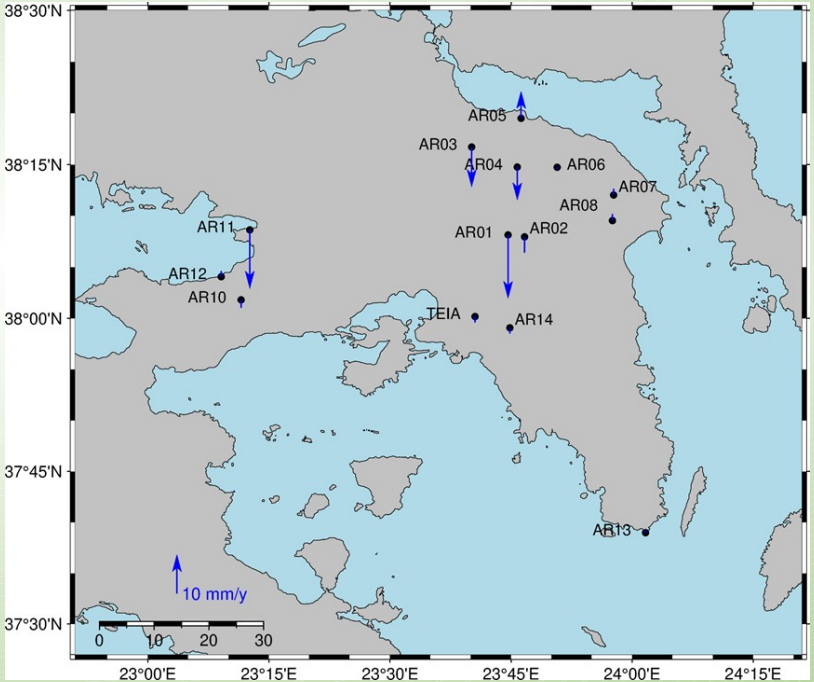
Velocities PPP - DD



VELOCITY FIELD IN ITRF2014

- Uniform movement SW
- Vertical displacements are very small throughout the region.



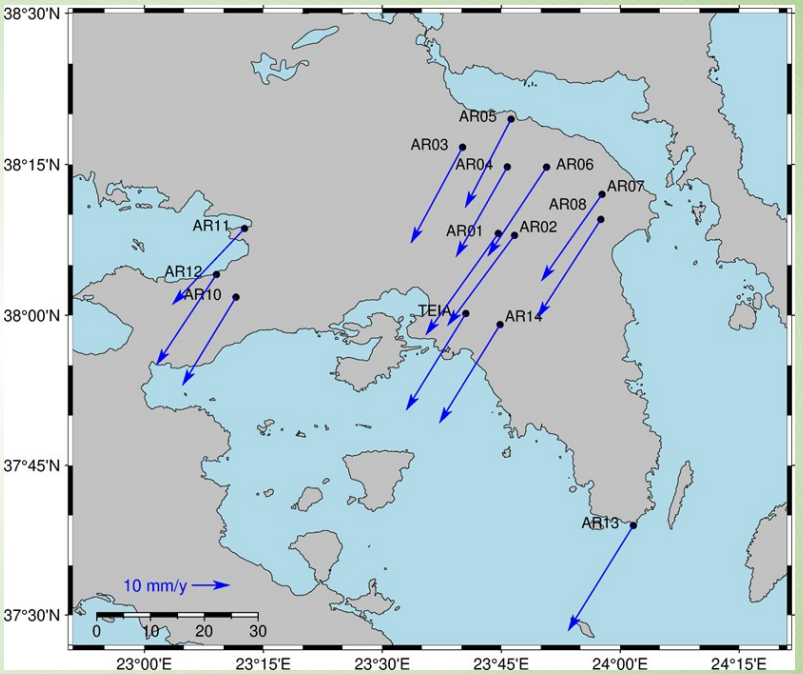


VELOCITY FIELD W.R.T. A STABLE EUROPE

- Computation of horizontal European plate velocities of each site using GRSM v2.1 model (Kreemer, et al., 2014)
- The velocities range from -20 to -27 mm/yr in the North-South direction and from -12 to -19 mm/yr in the East-West direction.
- AR08 Comparison to DYNG

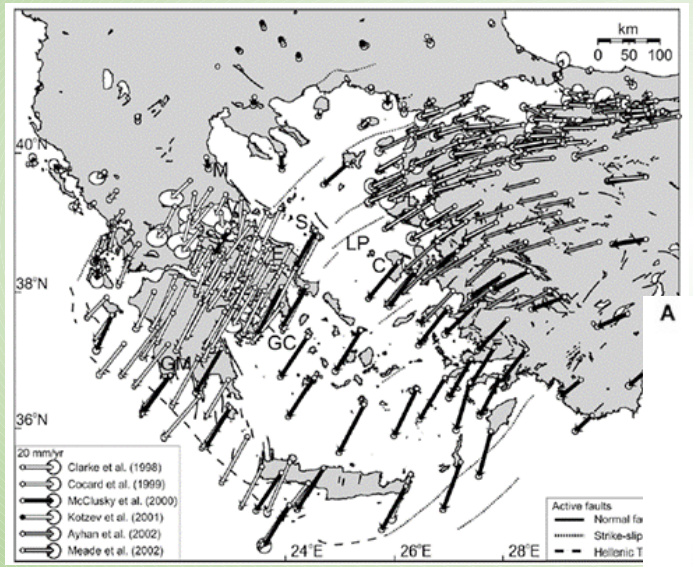
CODE		vNorth (mm/yr)	vEast (mm/yr)	vUp (mm/yr)
DD PROCESSING				
AR08		-25.8	-16.7	1.4
EUREF PUBLISHED VELOCITIES				
DYNG		-25.5	-16.1	0.2

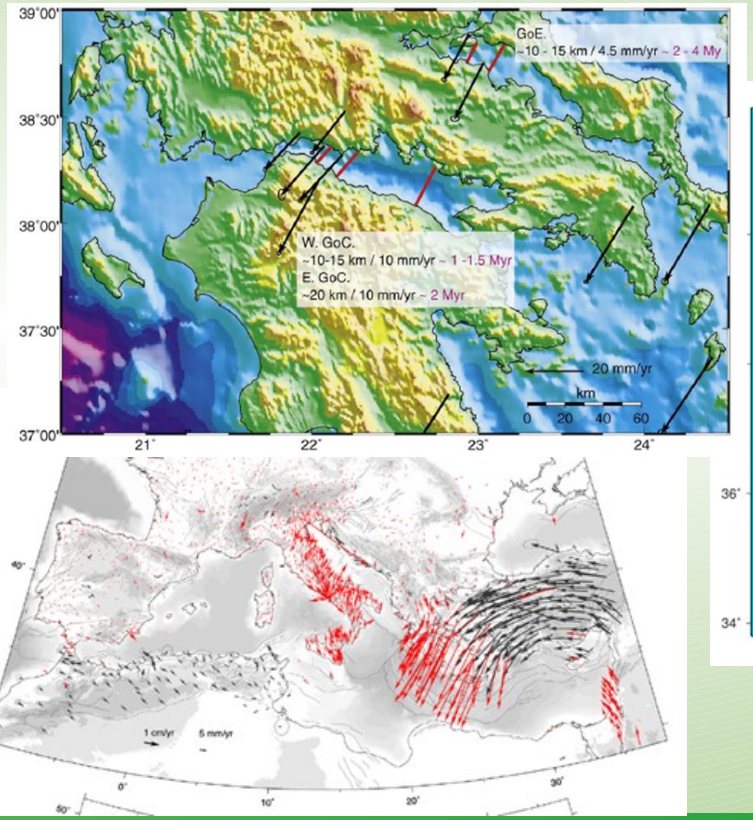
wrt Stable Europe		
Code	vNorth	vEast
	(mm/yr)	
AR01	-26.7	-19.1
AR02	-23.7	-17.6
AR03	-25.2	-13.6
AR04	-23.7	-13.5
AR05	-23.3	-12.1
AR06	-23.4	-15.5
AR07	-22.8	-16.0
AR08	-25.8	-16.7
AR10	-23.2	-14.1
AR11	-20.0	-19.0
AR12	-23.8	-15.8
AR13	-27.7	-17.2
AR14	-25.9	-16.0
TEIA	-25.4	-15.7

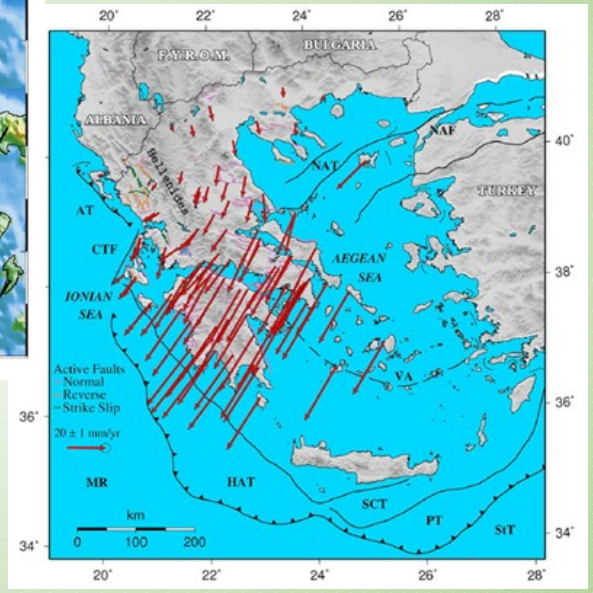


COMPARISON to PREVIOUS STUDIES

- (Nyst & Thatcher, 2004), (Reilinger, et al., 2010), (Chousianitis, et al., 2015) και (Serpelloni, et al., 2022)

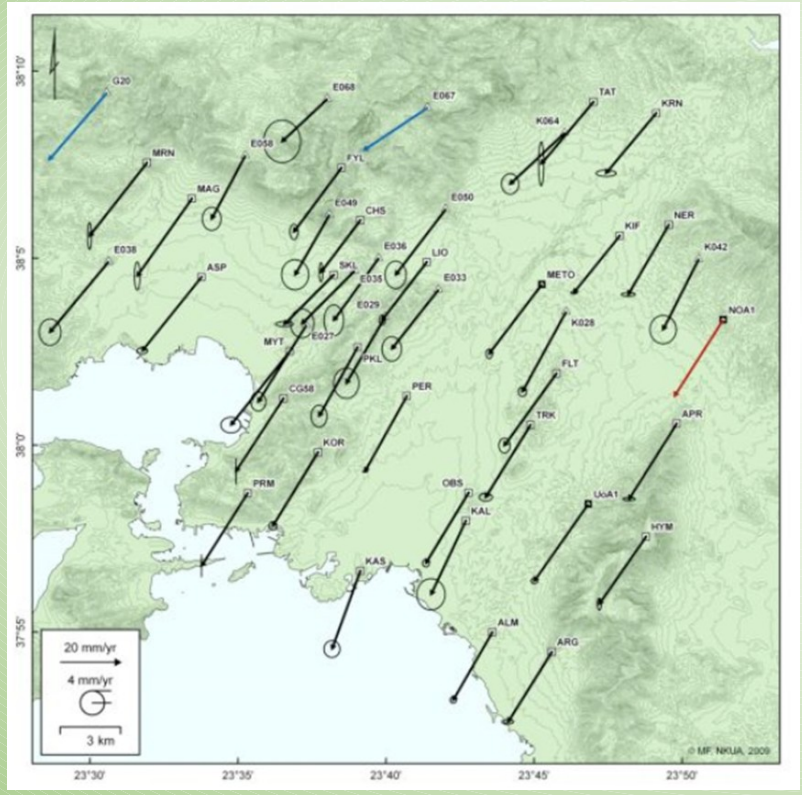




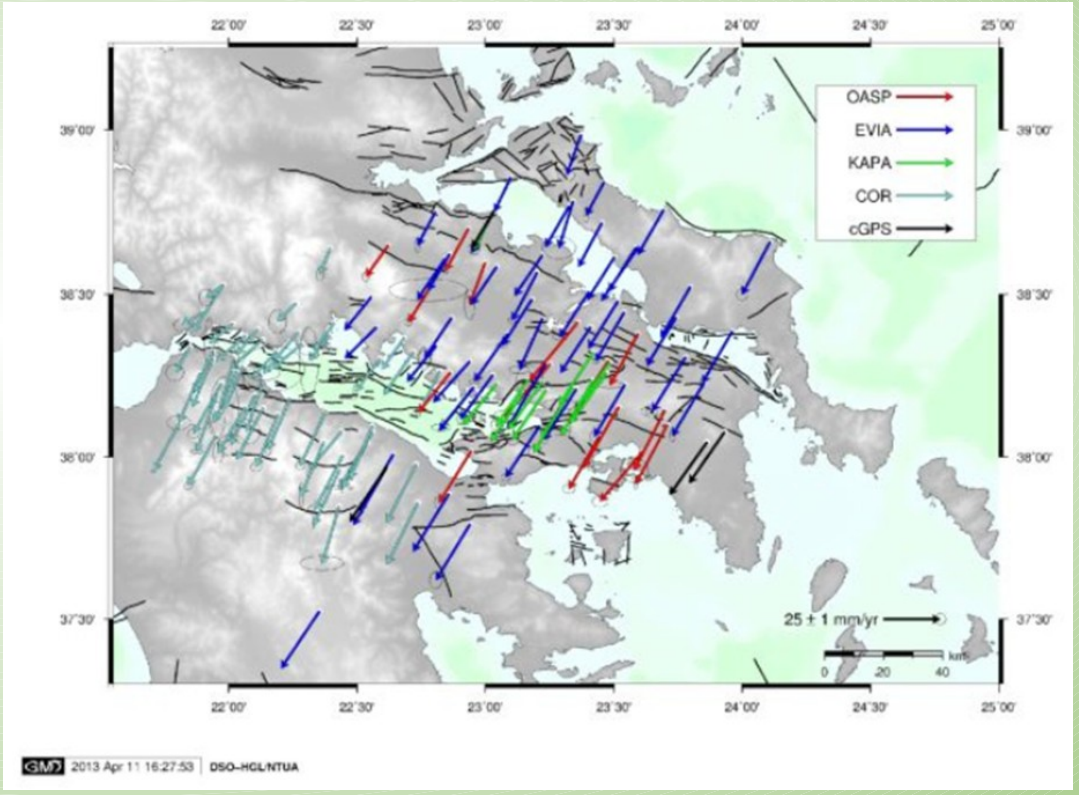


COMPARISON to PREVIOUS STUDIES

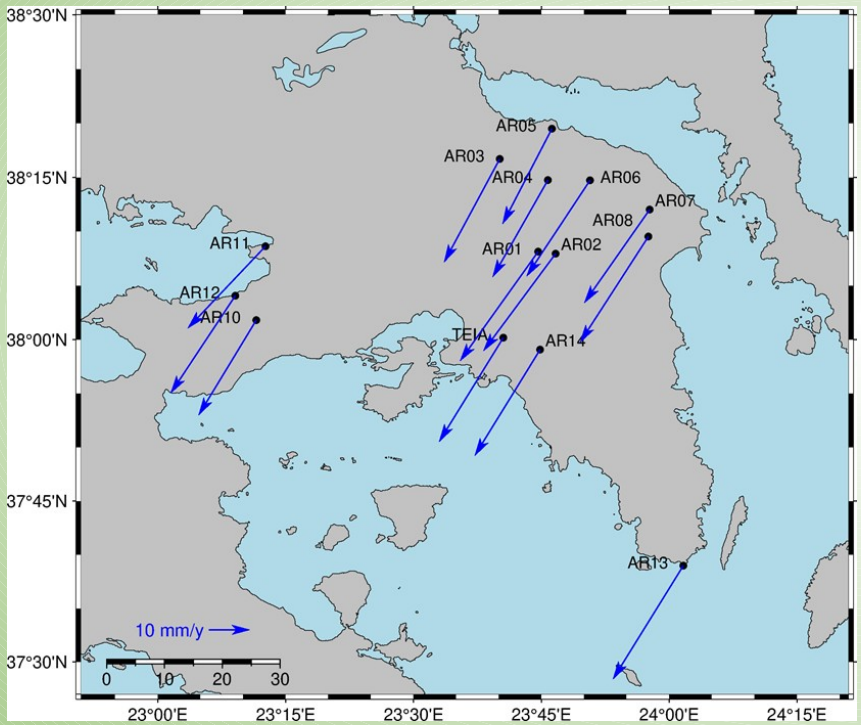
(Foumelis, 2009)



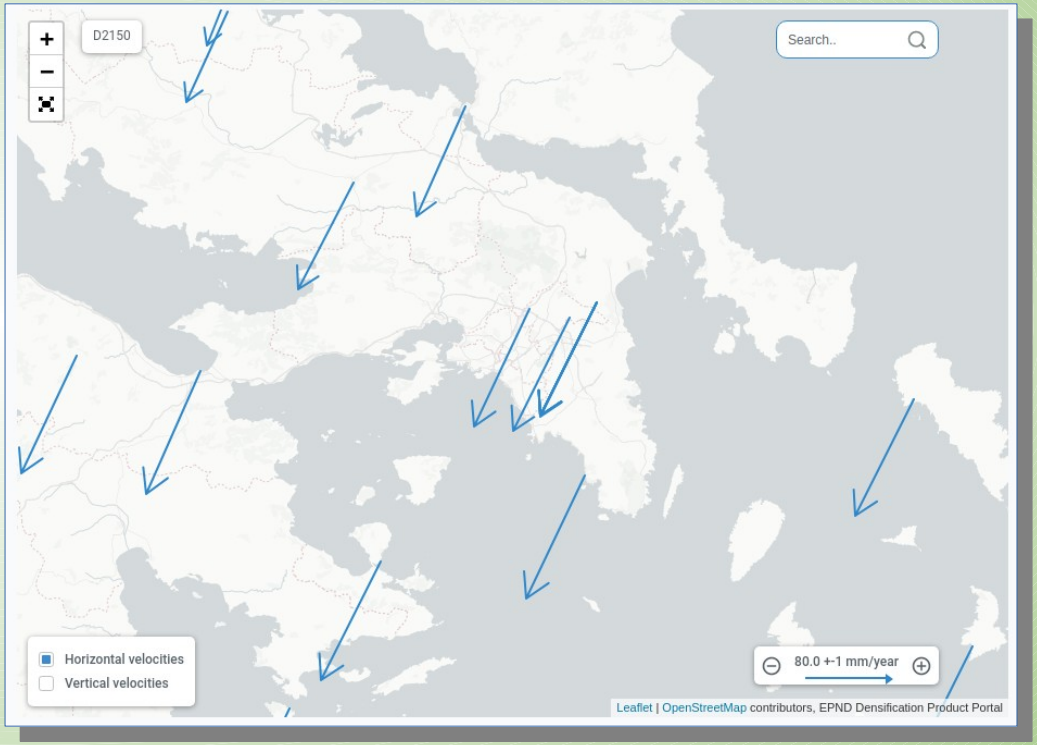
(Marinou, 2014)



COMPARISON to PREVIOUS STUDIES



EUREF – Densification Project Velocity field

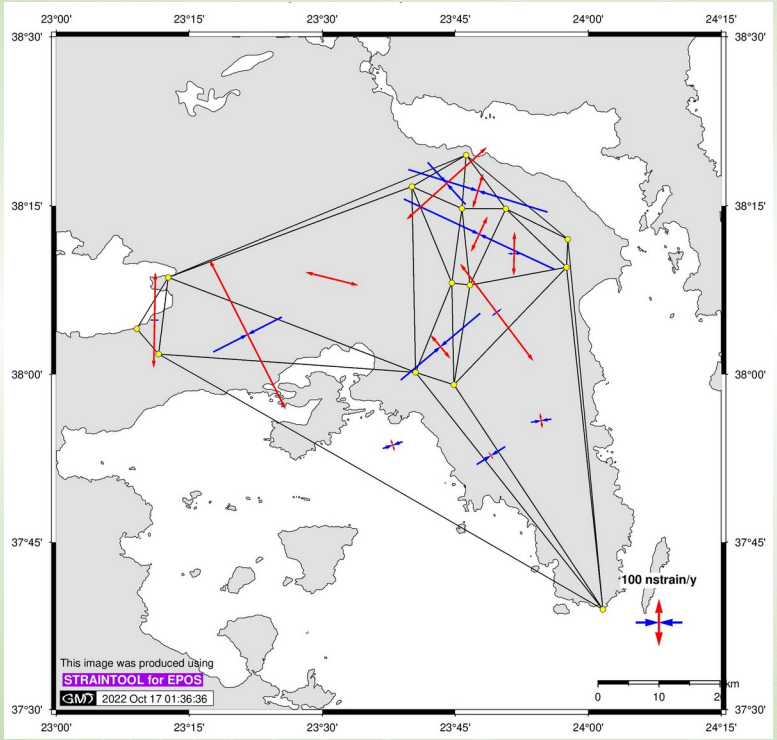


STRAIN RATES

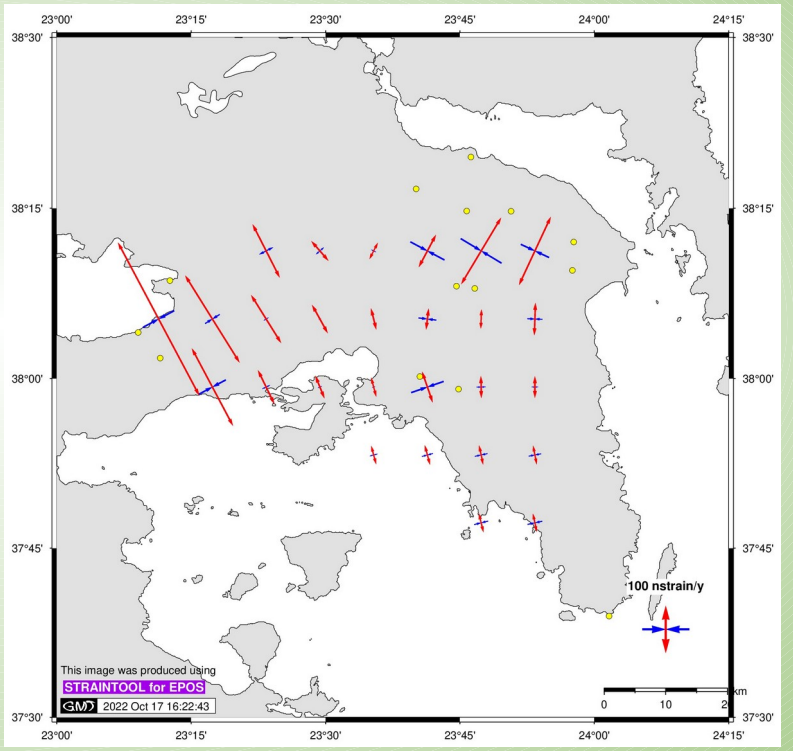
StrainTool:

Estimate principal axes of strain tensor

Delaunay Triangles | Veis algorithm

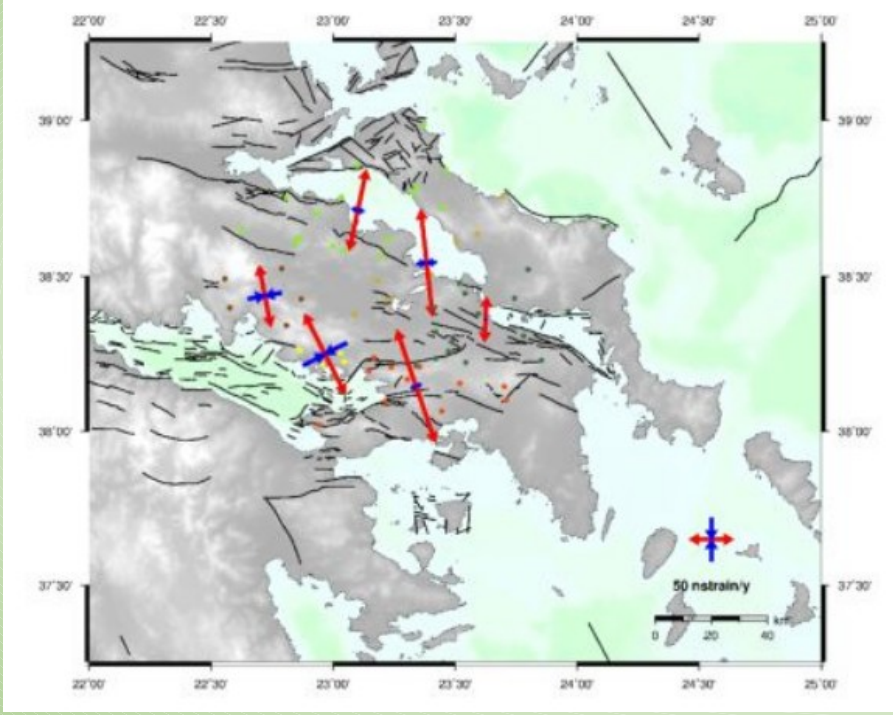


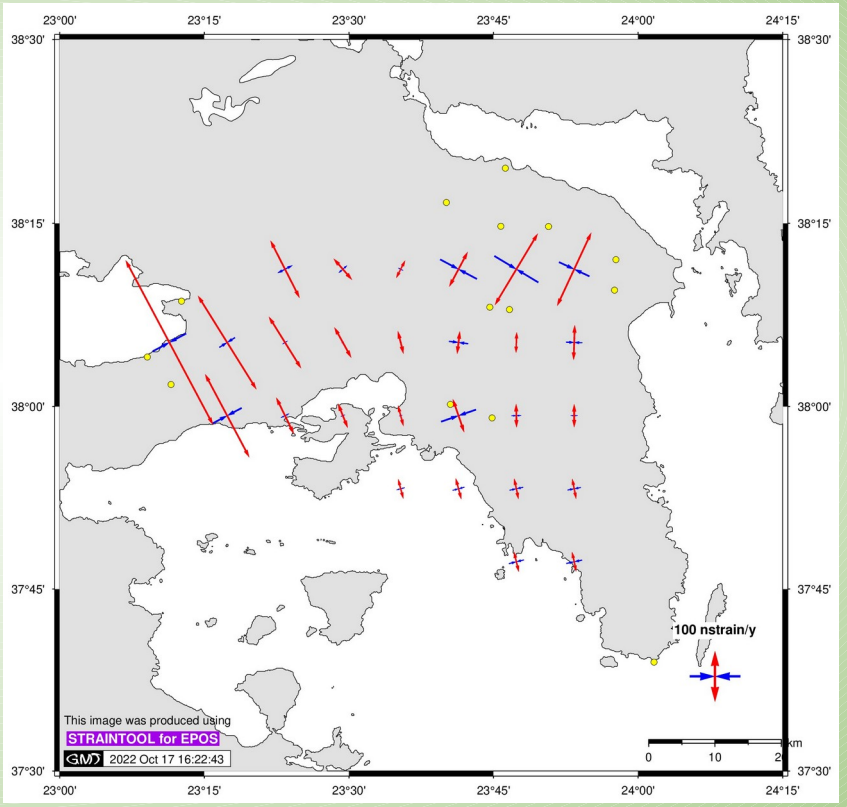
Interpolation | Shen algorithm



STRAIN RATES

(Marinou, 2014)





DISCUSSION & CONCLUSIONS

- Both methods give similar results for the displacements, large differences were observed at sites with obstacle, where we have unreliable results from PPP method.
- Comparing velocities with officially published DYNG velocities showed differences of the order of 1 mm/yr, so the solutions are considered reliable.
- We have reliable results from episodic GNSS campaigns with short duration of observation. Campaigns can be used to densify the network in an area of interest.
- The final velocity field relative to ITRF2014 shows a uniform movement to the SE for the whole region of Attica.
- Velocity field with respect to a stable Europe, it is observed that velocities range from -20 to -27 mm/yr in the North-South direction and from -12 to -19 mm/yr in the East-West direction, with a uniform movement to the SW direction.
- Strain Tensors show that principal axes may have different patterns between east and west Attica although it decreases towards the south.
- Finally, the results are in agreement with other studies that have been published for the region.

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THANK YOU FOR YOUR ATTENTION

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REFERENCES

- Μαρίνου, Α. Α., 2014. *Μελέτη παραμορφώσεων σε περιοχή της κεντρικής Ελλάδας από μετρήσεις GPS εικοσαετίας.* Αθήνας: Εθνικό Μετσόβειο Πολυτεχνείο
- Φουμέλης, Μ., 2009. *Μελέτη επιφανειακής παραμόρφωσης ευρύτερης περιοχής Αθηνών βάσει διαφορικών μετρήσεων GPS και συμβολομετρίας ραντάρ.* Αθήνα: Εθνικό και Καποδιστριακό Πανεπιστήμαιο Αθηνών.
- Χατζηνίκος, Μ. Α., 2013. *Μελέτη των μετακινήσεων του γήινου φλοιού στον Ελλαδικό χώρο με ανάκλαση δορυφορικών δεδομένων GNSS.* Θεσσαλονίκη: Αριστοτέλειο Πανεπιστήμιο Θεσσαλονίκης.
- Serpelloni, E. και συν., 2022. Surface Velocities and Strain-Rates in the Euro-Mediterranean Region From Massive GPS Data Processing. *frontiers in Earth Sience*, 01 June, pp. 1-21.
- Reilinger, R. και συν., 2010. Geodetic constraints on the tectonic evolution of the Aegean region and strain accumulation along the Hellenic subduction zone. *Tectonophysics*, pp. 22-30.
- Nyst, M. & Thatcher, W., 2004. New constraints on the active tectonic deformation of the Aegean. *Journal of Geopgysical research*, 24 November, pp. 1-23.
- Chousianitis, K., Ganas, A. & Evangelidis, P. C., 2015. Strain and rotation rate patterns of mainland Greece from continuous GPS data and comparison between seismic and geodetic moment release. *Journal of Geophysical Research: Solid Earth*, pp. 3909-3931