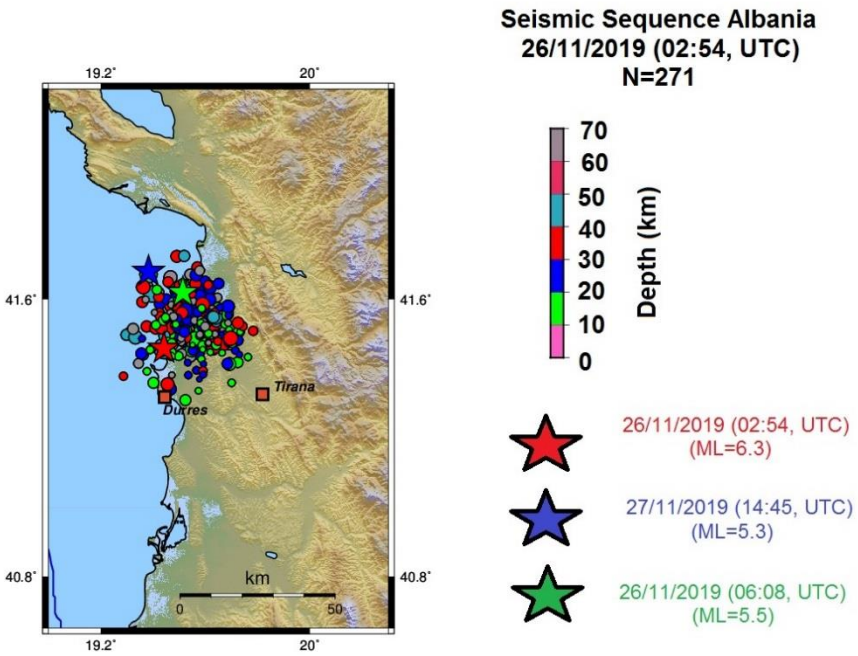
A PRELIMINARY REPORT ON THE 26 NOVEMBER 2019, M_W=6.4 DURRES, ALBANIA



17/12/2019

Preliminary Report at EMSC on December 17, 2019

A PRELIMINARY REPORT ON THE 26 NOVEMBER 2019, Mw=6.4 DURRES, ALBANIA

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1. General Informations:

(by A. Moshou)

On 26 November 2019 (02:54, UTC) a very strong earthquake with magnitude M_L = 6.3 (M_w=6.4) occurred in the port-city of Durres, about 34 km NW of the capital of Tirana. Epicentral coordinates of the earthquake has been manually determined as 41.4456ºN, 19.4141ºE, according to the National Observatory of Athens and 41.4593^{0}N, 19.4418^{0}E, according to the Department of seismology (DS) of Institute of Geosciences, Energy, Water and Environment (IGEWE). The depth estimated according to the DS, is 39.5 km (+/- 1.1 km of vertical error).

This earthquake was also felt in Bulgaria, Italy, Serbia, Bosnia and Herzegovina and part of Greece. As the consequence 51 people have been killed after the 6.4 magnitude earthquake, and more than 900 seriously injured. The quake brought down buildings and left people trapped under rubble. One man died after jumping from a window in panic after the tremor struck. Soldiers, police and emergency workers have been searching through the debris of buildings, where people are still believed to be trapped. So far, more than 50 survivors have been extracted from the ruins, according to officials (www.shqiperiaqeduam.al). The majority of fatalities occurred in the coastal city of Durres and in the town of Thumana, 40 km to the north-west of Tirana and close to the epicenter, according to the defense ministry. In neighboring Kurbini, a man died after jumping from his building in panic, and another died in a car accident when the earthquake tore open parts of the road he was on, AFP reported the ministry as saying. More than 1000 people have been treated in hospitals, according also to the Albanian state media reports.

Fig. 1: Buildings in Thumane have completely destroyed by the earthquake (Source: https://www.bbc.com/news/world-europe-50555776

Fig.2 The city of Durres was hit by the earthquake of 26th November 2019 (Source: https://www.bbc.com/news/world-europe-50555776**)**

One hour before an intermediate earthquake with magnitude M_L=4.3 was occurred in the same region and a few hours later, a separate earthquake struck the city nearby Mostar, in Bosnia and Herzegovina, that quake had a magnitude equal with 5.6. At the time of this report more of one hundred aftershocks followed with magnitude range 1.0 – 5.6 in first 48 hours, while until to the present around 500 events was recorded

and located from DS, Institute of Geosciences, Energy, Water and Environment (IGEWE); Polytechnic University of Tirana (UPT).

2. Seismological Data:

(by A. Moshou)

On November 26, 2019, 02:54 UTC, Albania has been struck by a strong, shallow earthquake (M_L=6.1; M_w = 6.3; depth 22 km and 25 km respectively according to NOA and M_L = 6.3; depth 39.5 km according to DS). According to the National Observatory of Athens, Institute of Geodynamics the geographical coordinates of the earthquake has been located to the central western part of Albania. Based on the Moment Tensor solutions, which calculated for the purpose of this report, the 2019 earthquake occurred on a **thrust fault**. This is also confirmed from the stress inversion constrained from the focal mechanism solutions obtained for this analysis, (Fig. 8). The distribution of the main shock and subsequent aftershocks epicenters, provided by the DS (IGEWE-PUT), are shown on the respective map, (Fig. 3).

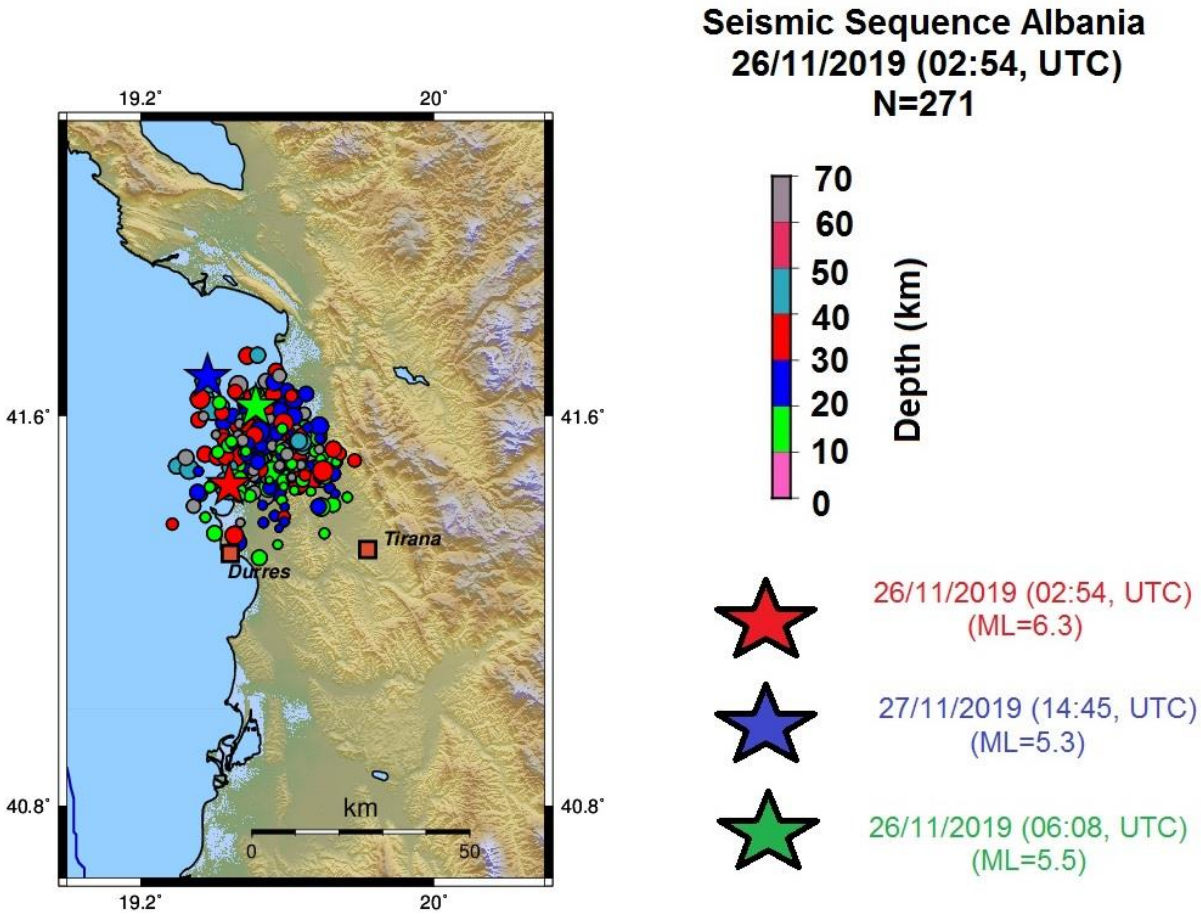

Fig. 3: Distribution of aftershock sequence of the 26th November 2019 (02:54, UTC) earthquake. Data from Department of Seismology, Institute of Geosciences, Energy, Water and

Environment (IGEWE); Polytechnic University of Tirana. Map contains 271 events until 2 December 2019

The red star indicates the main event while with the blue and green star the two largest aftershocks on 26/11/2019 (06:08, UTC) and 27/11/2019 (14:45, UTC) respectively.

3. Aftershocks characteristics:

(by E. Dushi)

The seismic sequence, following the strong shock of November 26 (Mw = 6.4), is recorded by the Albanian National Seismic Network (ANSN) operated by the DS (IGEWE), and by numerous regional seismic stations of NOA, AUTH, INGV, MedNet, etc. Based on the located aftershocks, a homogeneous catalogue comprising 496 events with $M_{min} \geq 2.5$, is assumed to be complete (Fig. 4), for the period Nov 26 to Dec 12.

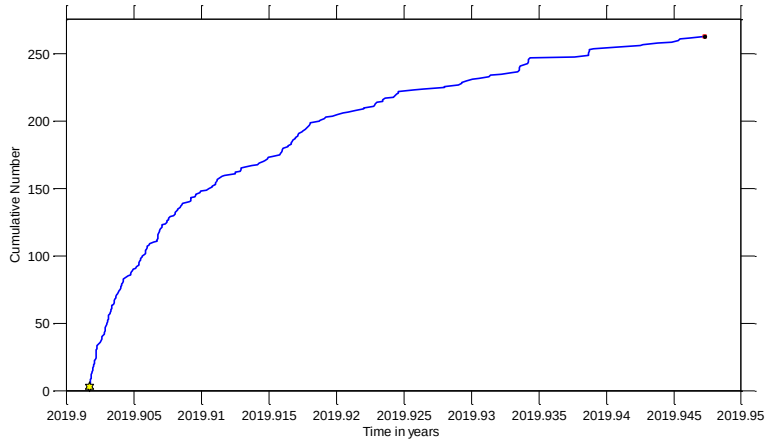

Fig. 4 The cumulative number of aftershocks located by ANSN

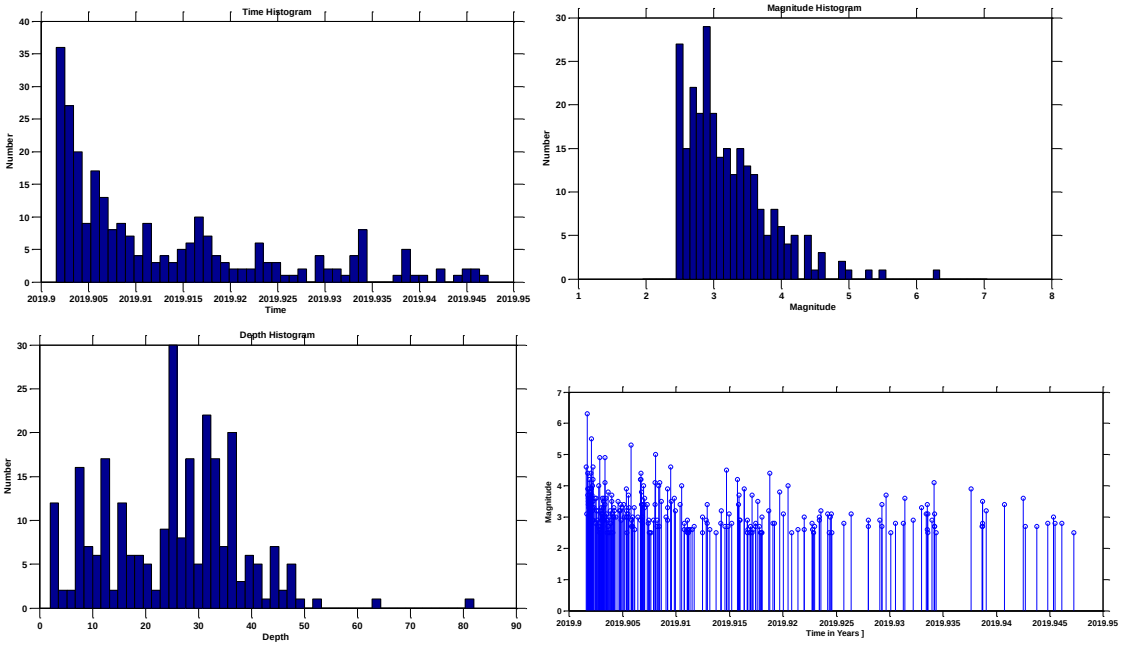

Fig.5 Histograms showing the characteristics of the variation of the number of the events and magnitude with time as well as the predominant magnitude and depth of the sequence.

A general and preliminary analysis is done using the ZMAP (v6.1) code. The main sequence characteristics are showing on respective histograms (Fig.5). It is obvious the slowly decrease of the aftershock number with time, characterized by several repeated gaps, which have been subsequently followed by an increase in the observed magnitude. Although, the general trend of observed magnitudes tends to decrease in their value, it remains still high to be account as background seismicity.
The depth distribution tends to be localized around two predominating intervals namely 10-20 km and 25-38 km.
By applying the modified Omori law, on selected data (Fig.6), a p = 0.98 is determined and in average the prediction model gives a pm = 0.81 (+/- 0.25), values which are much lower comparing to the previously determined local models of aftershock attenuation. This assumes a longer lasting sequence as compared to the region characteristics.

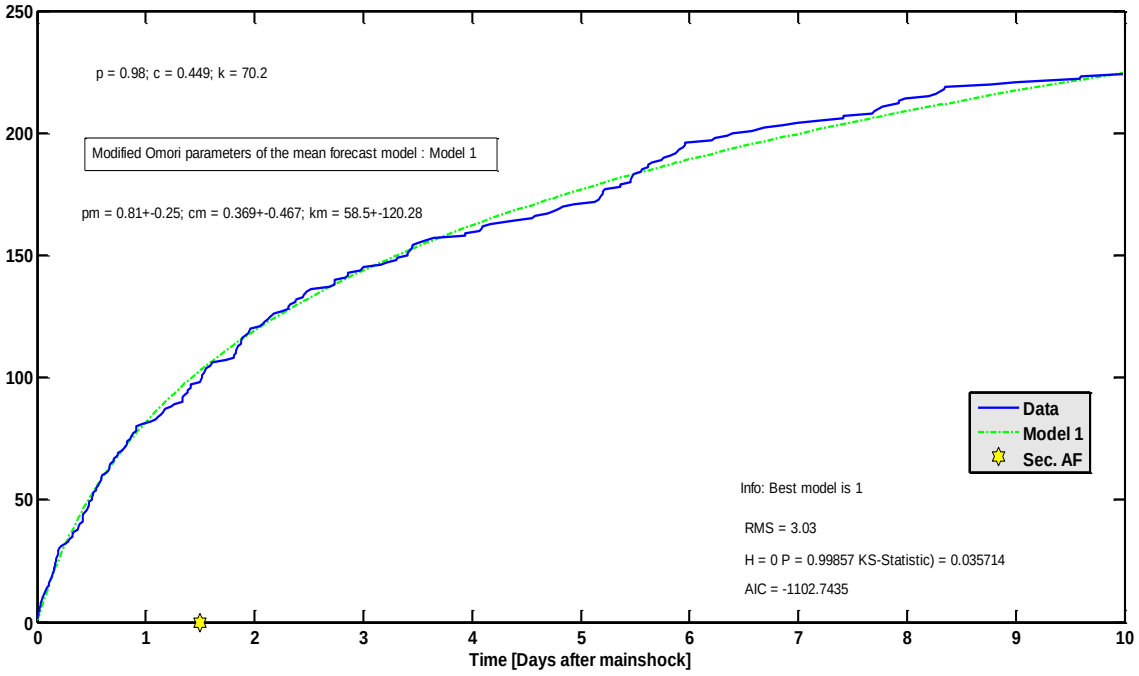

Fig.6 The modified Omori law application on the selected data (around 12 days of aftershock sequence

4. Moment Tensor Determination:

(by A. Moshou)

Focal mechanism solution using the moment tensor inversion has been applied for all the events with magnitude $M_L > 3.8$. To apply the proposed methodology seismological

data from European Integrated Data Archived (EIDA, http://www.orfeus-eu.org/data/eida/) was selected and used. For the main event focal mechanism also is calculated using teleseismic data. The final results from regional, as well as from teleseismic data, are in very good accordance. All the moment tensor solutions appear in Table 1 of Appendix 1.

The result of the applied modeling for the main event of 26th November 2019 indicates a pure thrust fault with parameters φ=155°, δ=72°, λ=85°, for which the focal depth was determined to be 25 km and the Moment Magnitude equal proportional to M_o = 5.2E+25dyn*cm (M_w=6.3).The focal mechanisms solutions for the events that determined in this study are shown in the figure 7.

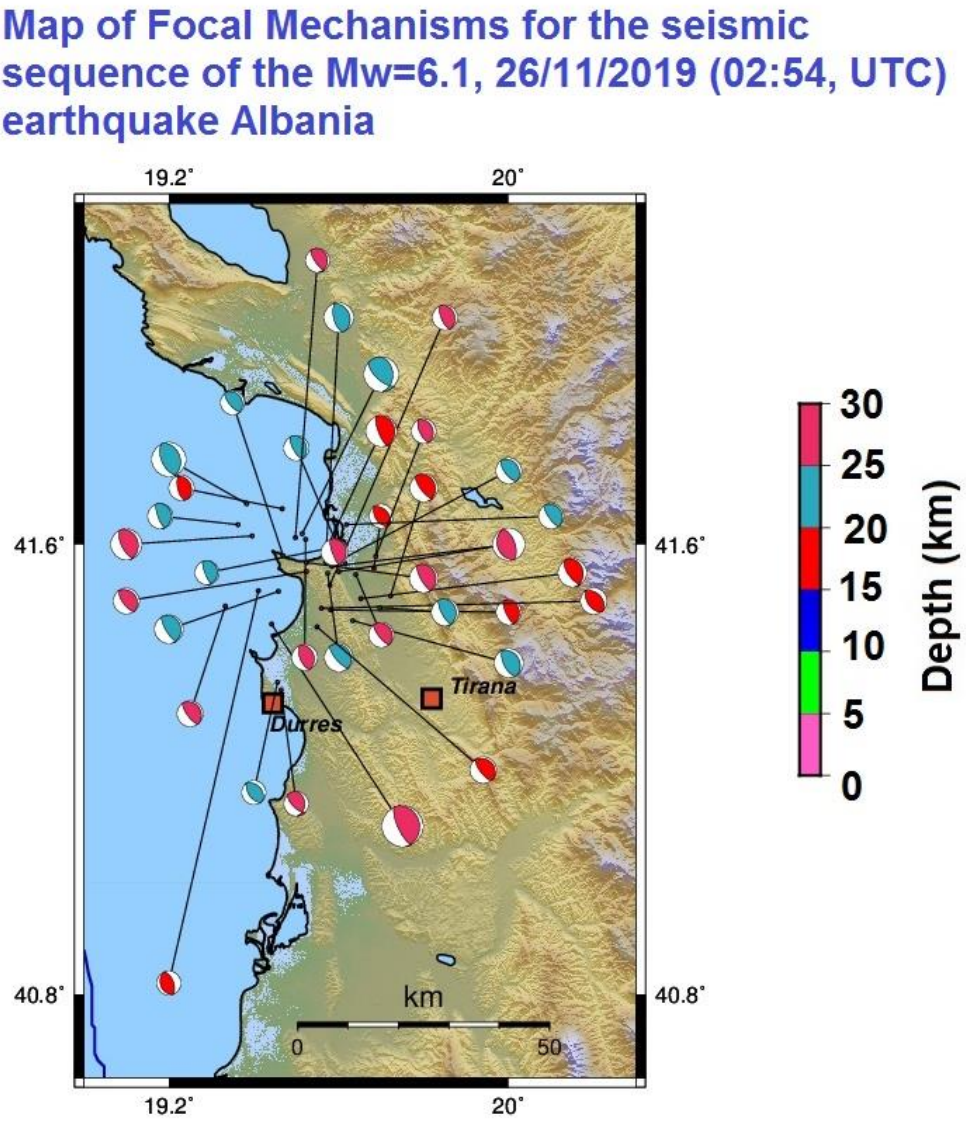

Fig. 7: Focal mechanisms solutions of the aftershock sequence of the 26th November 2019 (02:54, UTC) earthquake

Based on the overall focal mechanisms, as obtained from the Moment Tensor inversion as explained above, a relevant preliminary stress inversion is performed. The used method is that implied in ZMAP seismicity analysing code, known as the linear Michael's method. The results are graphically given in the diagram (Fig. 8), which confirm the findings stated above on the activation of a thrust fault as the causative source of the strongest earthquake during the last 40 years, in Albanian and along the collision tectonic contact Adria-Eurasia.

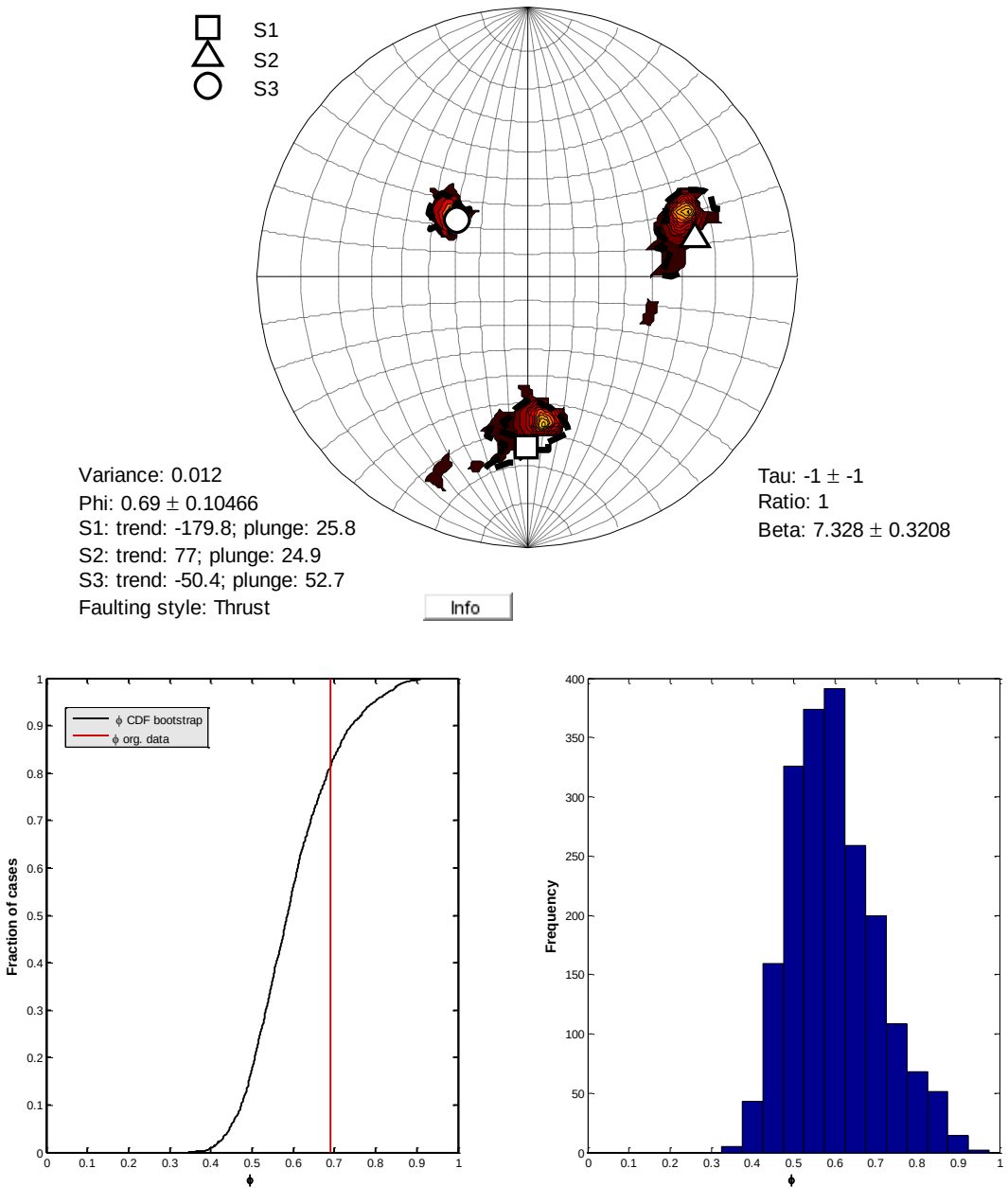

Fig. 8: Stress inversion controlled by focal mechanism of 37 earthquakes (M > 3.8), as determined through inversion by NOA, based on the Michael's Method (ZMAP) –

(Analysis by Dr. E. Dushi)

5. GPS Analysis:

(by P. Argyrakis)

For this study also, the 30sec data of permanent station DUR2 provided free by the ALBOS and IGEWE (Seismology Department) at the web page (http://www.geo.edu.al) for the year 2019 collected and analyzed with software GIPSY-OASIS provided by JPL using the Precise Point Position algorithm at the IGS14 reference frame and final orbits and clock products.

The procedure indicates a displacement of 11 mm West, 17 mm South and 15 mm Up (Fig.9). Due to a periodical signal at Up the displacement may vary. Further investigation and analysis are in progress. The GPS permanent station displacement confirms the Moment Tensor calculations.

Fig. 9: DUR2 permanent GPS station Time series for 2019

A. Appendix 1: Moment Tensor Solutions:

(by A. Moshou)

N/A	Origin Time		Location		Depth (km)	Nodal Plane			Magnitude	
1	Date	Time	Lat (˚)	Lon (˚)		Strike (˚)	Dip (˚)	Rake (˚)	M_w	M_o (dyn*cm)
2	26/11/2019	2:54	41.459	19.442	25	155	72	85	6.3	5.20E+25
3	26/11/2019	2:59	41.504	19.652	18	145	65	80	4.4	5.12E+22
4	26/11/2019	3:03	41.509	19.722	17	143	72	84	4.4	5.12E+22
5	26/11/2019	3:21	41.566	19.615	20	151	70	86	3.9	9.80E+21
6	26/11/2019	3:57	41.612	19.498	26	146	73	80	3.9	9.80E+21
7	26/11/2019	4:22	41.528	19.579	27	157	66	89	4.2	2.72E+22
8	26/11/2019	5:35	41.580	19.469	23	140	68	85	3.8	5.74E+21
9	26/11/2019	5:50	41.558	19.683	19	146	50	95	3.8	5.74E+21
10	26/11/2019	5:56	41.549	19.574	21	140	72	88	4.4	5.12E+22
11	26/11/2019	6:08	41.619	19.514	24	133	64	67	5.5	2.61E+24
12	26/11/2019	6:20	41.579	19.687	25	155	63	89	3.9	9.80E+21
13	26/11/2019	7:12	41.609	19.522	26	158	60	88	4.0	1.48E+22
14	26/11/2019	7:27	41.569	19.569	24	166	62	95	4.6	8.80E+22
15	26/11/2019	7:36	41.454	19.549	19	143	71	94	4.2	2.72E+22
16	26/11/2019	12:14	41.484	19.581	19	155	72	87	4.0	1.48E+22
17	26/11/2019	13:05	41.596	19.573	15	159	75	89	4.9	2.70E+26
18	26/11/2019	17:06	41.566	19.587	21	143	65	90	4.1	1.84E+22
19	26/11/2019	17:19	41.615	19.396	25	154	65	85	4.9	2.70E+26
20	26/11/2019	19:44	41.599	19.616	22	159	76	83	3.8	5.74E+21
21	27/11/2019	11:03	41.552	19.600	29	146	73	91	3.9	9.80E+21
22	27/11/2019	14:45	41.672	19.383	23	155	56	86	5.3	1.18E+24
23	27/11/2019	22:19	41.635	19.363	23	160	75	85	4.2	2.72E+22
24	27/11/2019	22:50	41.517	19.458	21	149	73	85	4.4	5.12E+22
25	27/11/2019	22:51	41.487	19.559	17	146	52	97	4.2	2.72E+22
26	27/11/2019	23:02	41.518	19.411	16	159	32	90	3.8	5.74E+21
27	28/11/2019	0:50	41.663	19.467	15	167	65	96	4.0	1.48E+22
28	28/11/2019	10:25	41.552	19.524	25	145	67	92	4.1	1.84E+22
29	28/11/2019	10:52	41.561	19.584	25	159	31	89	5.0	3.75E+23
30	28/11/2019	13:28	41.635	19.618	21	145	73	90	4.0	1.48E+22
31	28/11/2019	14:22	41.491	19.333	26	144	72	90	4.1	1.84E+22
32	28/11/2019	4:23	41.465	19.633	22	154	62	94	4.6	8.80E+22
33	29/11/2019	8:02	41.547	19.640	25	142	73	89	4.0	1.48E+22
34	30/11/2019	20:53	41.568	19.524	25	150	74	86	4.5	6.07E+22
35	1/12/2019	6:04	41.586	19.590	25	160	77	84	4.2	2.72E+22
36	1/12/2019	11:42	41.342	19.464	28	135	65	68	3.9	9.80E+21
37	2/12/2019	2:08	41.488	19.697	24	152	70	84	4.4	5.12E+22

B. Appendix 2: Photographs

(by E. Dushi)

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