Scientific report of the Short Term Scientific Mission (STSM)

STSM title: Investigation of possible ionospheric anomalies prior to the recent large European earthquakes

COST Action: CA15211

Reference: ECOST-STSM-Action CA15211 - 39687

1. GRANTEE

Last name: Veronika

First name: Barta

Present position: Research Fellow, Geodetic and Geophysical Institute, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences

2. HOST

Last name: Haralambous

First name: Haris

Full address: Frederick University, Department of Electrical Engineering

7, Y. Frederickou Str., Pallouriotisa, Nicosia 1036, Cyprus

.

3. STSM PERIOD: 21 April 2018 to 29 April 2018

Overall context and objectives of the STSM

In order to understand and interpret the link between seismic activity and ionospheric changes many investigations have been performed using a large amount of experimental and model data during the last two decades (Pulinets and Boyarchuk, 2004; van Dam et al., 2009; Klimenko et al., 2011; Harrison et al. 2010; Pulinets and Ouzounov 2011; Harrison et al. 2014). Based on these studies the Lithosphere–Atmosphere–Ionosphere Coupling (LAIC) model has been proposed in order to describe the physical processes that are responsible for the geochemical, atmospheric, and ionospheric anomalies observed up to approximately 12 days prior to the strong earthquakes within the earthquake preparation area. (This area is a function of the earthquake magnitude (M) defined as a circle with radius $r=10^{0.43*M}$ km.)

Possible coupling is explained by the emission of radioactive gases from the Earth's crust before major Earthquakes which cause changes in the surface layer air conductivity reducing the surface-ionosphere electrical resistance and increasing the vertical fair weather current (Harrison et al. 2010). According to theoretical models these anomalous vertical electric field over the active tectonic faults can lead to ionospheric anomalies.

Based on the results of Silva et al (2012) seismic activity leaves its mark on the atmospheric electrical field in the preparation area, with a trend to reduce the atmospheric electrical field. Furthermore, a significant decrease of the vertical component of the atmospheric electrical field (Ez) was found in Portugal during the M = 4.1 Sousel earthquake of 27 March 2010 (Silva et al. 2011). The observation site falls within the theoretical earthquake preparation radius in this case as well. Moreover ionospheric anomalies related to large earthquakes (M> 7.5) were observed few hours and few days prior to the earthquakes using statistical and spectral analysis of GNSS data (Oikonomou et al. 2016, 2017). These were large-scale positive TEC anomalies and small-scale TEC oscillations with periods of 20 min.
Large earthquakes have been observed in Europe in the recent years. In 2016, the central Apennines (Italy), between the towns of Amatrice and Norcia, have been struck by a huge and long seismic sequence consisting in five moderate magnitude earthquakes (5.4 <= M <= 6.5) and about 45000 aftershocks (http://cnt.rm.ingv.it), while two big earthquakes occurred in Greece (in Lesvos Island on 12 June and Kos Island on 20 July in 2017).

The objectives of the Short Term Scientific Mission are:

1.) The main objective of the STSM is to investigate possible ionospheric anomalies prior to large European Earthquakes adopting a multi-technique approach, by applying both statistical and spectral analysis on TEC data obtained from the GNSS global network and the vertical component of the atmospheric electrical field (Ez) measured at the Nagycenk Geophysical Observatory, Hungary or at other European atmospheric electricity measuring stations which were situated within the preparation area of the selected earthquakes. The distance of the Nagycenk Observatory from the epicentre of the Italian Earthquakes were around the radius of the preparation zone, the sensor was within the earthquake preparation area in the case of the events with M > 6.2. We hope that the common investigation of the TEC and Ez data will help to disclose the missing link of the Lithosphere–Atmosphere–Ionosphere Coupling (LAIC) model.
2.) The secondary goal of the STSM is to visit the Cyprus digital ionosonde station which consists of a Digisonde DPS-4D system, located near Nicosia (35°N, 33°E), Cyprus, and to learn the technique and operational methods of the this system. A similar Digisonde system (manufactured by the Lowell Digisonde International) is under installation at the Nagycenk Geophysical providing new techniques to measure the state and anomalies of the ionosphere. The STSM would give a good opportunity for the applicant to learn these methods from the members of the host group.

Referencies:

- Harrison, R. G., Aplin, K. L., & Rycroft, M. J. (2010). Atmospheric electricity coupling between earthquake regions and the ionosphere. Journal of Atmospheric and Solar-Terrestrial Physics, 72(5), 376-381.

- Harrison, R. G., Aplin, K. L., & Rycroft, M. J. (2014). Brief Communication: Earthquake-cloud coupling through the global atmospheric electric circuit. Natural Hazards and Earth System Sciences, 14(4), 773.
- Klimenko, M.V., Klimenko, V.V., Zakharenkova, I.E., Pulinets, S.A., Zhao, B., Tsidilina, M.N., 2011. Formation mechanism of great positive TEC disturbances prior to Wenchuan earthquake on May 12, 2008. Adv. Space Res. 48 (3), 488–499
- Oikonomou, C., Haralambous, H., & Muslim, B. (2016). Investigation of ionospheric TEC precursors related to the M7. 8 Nepal and M8. 3 Chile earthquakes in 2015 based on spectral and statistical analysis. Natural Hazards, 83(1), 97-116.
- Oikonomou, C., Haralambous, H., & Muslim, B. (2017). Investigation of ionospheric precursors related to deep and intermediate earthquakes based on spectral and statistical analysis. Advances in Space Research, 59(2), 587-602.
- Pulinets, S.A., Boyarchuk, K., 2004. Ionospheric Precursors of Earthquakes. Springer, Berlin
- Pulinets, S.A., Ouzounov, D., 2011. Lithosphere-Atmosphere-Ionosphere Coupling (LAIC) model-an unified concept for earthquake precursors validation. J. Asian Earth Sci. 41, 371–382.
- Silva, H. G., Bezzeghoud, M., Reis, A. H., Rosa, R. N., Tlemçani, M., Araújo, A. A., ... & Biagi, P. F. (2011). Atmospheric electrical field decrease during the M= 4.1 Sousel earthquake (Portugal). Natural Hazards and Earth System Sciences, 11(3), 987-991.
- Silva, H. G., Oliveira, M. M., Serrano, C., Bezzeghoud, M., Reis, A. H., Rosa, R. N., & Biagi, P. F. (2012). Influence of seismic activity on the atmospheric electric field in Lisbon (Portugal) from 1955 to 1991. Annals of Geophysics, 55(1).
- van Dam, J.W., Horton, W., Tsintsadze, N.L., Kaladze, T.D., Garner, T. W., Tsamalashvili, L.V., 2009. Some physical mechanisms of precursors to earthquakes. J. Plasma Fusion Res. 8, 199–202

The work carried out during the STSM

I. In the first 3 days of the STSM I looked over the literature focusing on the observed mark of the earthquakes in potential gradient measurements. I looked for the typical changes a couple of hours to a couple of days prior to earthquakes in order to know the traces which we should search in our atmospheric electricity measurements. I wrote a report about the observational results what I found in the literature. I also write a brief summary of the results about the typical E_z changes prior to earthquakes here as follows:

- A significant decrease of the Ez was reported by Silva et al. (2011) in the Evora region (Portugal) during the M = 4.1 Sousel earthquake of 27 March 2010. The decrease lasted for nearly 4 days. During this period the Ez did not exceed 20 V m −1 , which is much smaller than the typical mean daily fair-weather VAE that ranges from 70 V m −1 to 110 V m −1 (Serrano et al., 2006). The Sousel earthquake occurred approximately 3 days after the time of the Ez decrease (Fig. 1.).

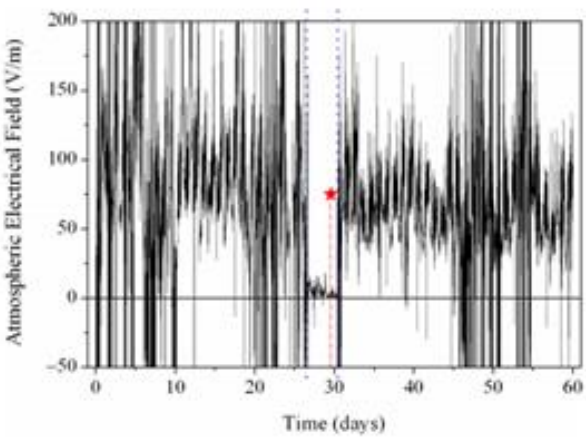

Fig. 1. Ez data from the Evora region from 27 February to 27 April 2010. The Sousel earthquake (M 4.1) that occurred on 27 March 2010 is represented by a red star. The decrease of the Ez is marked by the dotted blue lines (Fig. 2. in Silva et al. (2011))

Furthermore, the results of Silva et al. (2012) showed that the major influence of the seismic activity on the PG occurs over an interval of 14 days centered on the seismic event.

- A negative bay-like depressions in strength have been reported in several studies (Smirnov 2008; Pulinets et al. 2006; Choudhury et al. 2012, 2013) recent years. A sample for the observed bay-like variation and its comparison with fair-weather and with thunderstorm caused changes is shown in Fig. 2. (adapted from Choudhury et al. 2012).

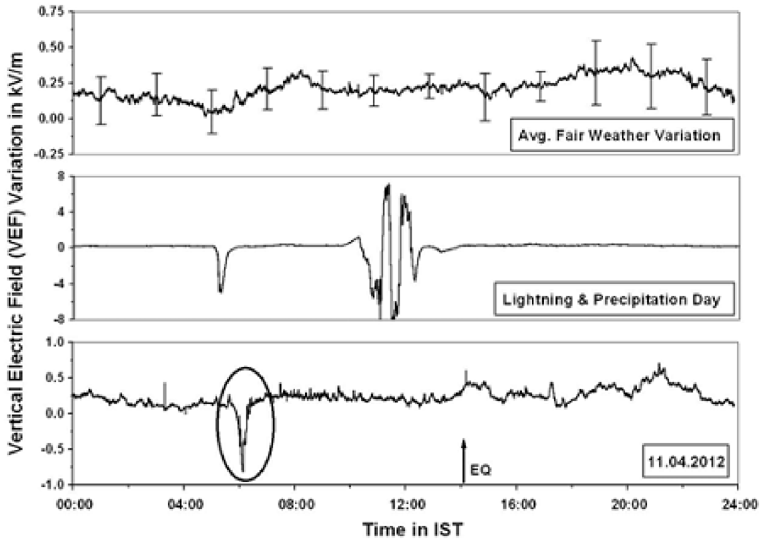

Figure. 4 The first panel shows the average fair weather VEF diurnal variation with its standard deviation. The middle panel shows the VEF diurnal variation during thunderstorm lightning and precipitation day. While the last panel shows the anomalous VEF variation 8 hrs before the earthquake strikes.

Fig. 2. A sample for the observed bay-like variation and its comparison with fair-weather and with thunderstorm caused changes (Fig. 4. in Choudhury et al. 2012).

According to a statistical report (Choudhury et al. 2013) from an earthquake-prone zone in northeast India from July 2009 to July 2012 the average Ez bay durations and depths were ca. 50 min to 70 min, with the corresponding magnitudes of 500 Vm-1 to 800 Vm-1 and it occurred 7 to 12 hour prior to the earthquakes. The bay-like anomaly were observed in 10 days among the 30 days when earthquakes were occurred and there were fair-weather conditions. Thus it indicates a 31% probability that an Ez bay would show as an earthquake precursor.

While Pulinets et al. 2006 observed a similar bay-like variation in Ez measurement 2-3 hours prior to an earthquake in Mexico which was not not similar nor to the cloud passing over the sensor, nor to the thunderstorm and its depth was ~ 2000 V/m.

Furthermore, one hundred three cases of these bay-like depression in the strength of the Ez, observed from 1997 to 2002 on Kamchatka, have been analyzed statistically (Smirnov et al. 2008). According to this study this study the most probable length of a bay is 40–60 min while the most probable drops in Ez are minus 106–300 V/m. The probability of earthquake prediction over 24 h before an earthquake based on the Ez anomaly is 36%.

- A multiple bay-like anomaly has been observed by Mikhailov et al. 2004 prior to earthquake (Fig. 3.). Furthermore, they analyzed the power spectrum of the diurnal variations of Ez. The Ez power spectrum variations in the period of fine weather have been shown to exhibit two bands of the periods of natural atmospheric oscillations with T=1-5 and 6-24 h. These oscillations are the modes of the internal gravity and tidal waves in the lower atmosphere. During the pre-earthquake period, when the diurnal Ez variation had the above mentioned anomaly, the intensity of harmonics with T=1.8, 2.2, and 3.8 h increased by an order of magnitude or more in comparison with the Ez spectra in fine weather. Two additional spectral bands with T=0.6 and 1 h have appeared simultaneously.

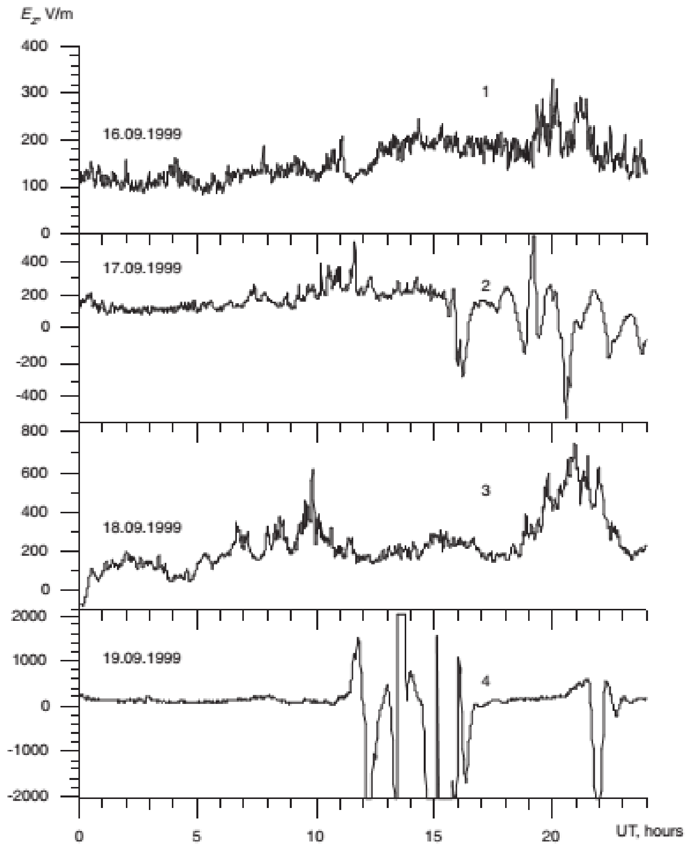

Fig. 1. Typical diurnal variations in a *quasi*-static electric field E_z in the near-Earth atmosphere: 1-3 = days without atmospheric precipitation; 2 = a day before the earthquake; 3 = for the earthquake day; 4 = day with heavy atmospheric precipitation.

Fig. 3. Diurnal variation of Ez during fair-weather days (1-3), one day prior to (2) and for the earthquake day (3) and during heavy precipitation (4)(Fig. 1. in Mikhailov et al. 2004.).

References:

- Choudhury, A., Guha, A., De, B. K., & Roy, R. (2012, December). Simultaneous perturbation observed on VLF and atmospheric vertical electric field for Sumatra earthquake on 11 th April 2012. In Computers and Devices for Communication (CODEC), 2012 5th International Conference on (pp. 1-4). IEEE.
- Choudhury, A., Guha, A., De, B. K., & Roy, R. (2013). A statistical study on precursory effects of earthquakes observed through the atmospheric vertical electric field in northeast India. Annals of Geophysics, 56(3), 0331.
- Mikhailov, Y. M., Mikhailova, G. A., Kapustina, O. V., Buzevich, A. V., & Smirnov, S. E. (2004). Power spectrum features of the near-Earth atmospheric electric field in Kamchatka. Annals of Geophysics.
- Pulinets, S., Bisiacchi, G., Berlinski, J., Dunajecka, M., & Vega, A. (2006). First results of the new type of measurements of atmospheric electric field in Mexico. Bol-e, 2(4).
- Silva, H. G., Bezzeghoud, M., Reis, A. H., Rosa, R. N., Tlemçani, M., Araújo, A. A., ... & Biagi, P. F. (2011). Atmospheric electrical field decrease during the M= 4.1 Sousel earthquake (Portugal). Natural Hazards and Earth System Sciences, 11(3), 987-991.
- Silva, H. G., Oliveira, M. M., Serrano, C., Bezzeghoud, M., Reis, A. H., Rosa, R. N., & Biagi, P. F. (2012). Influence of seismic activity on the atmospheric electric field in Lisbon (Portugal) from 1955 to 1991. Annals of Geophysics, 55(1).

- Smirnov, S. (2008). Association of the negative anomalies of the quasistatic electric field in atmosphere with Kamchatka seismicity. Natural Hazards and Earth System Sciences, 8(4), 745-749.

II. According to the results of the literature the measurements stations should be located within the earthquake preparation area in order to observe the atmospheric electricity and/or ionospheric anomalies. Moreover, these anomalies were detected approximately from 14 days to a couple of hours prior to the strong earthquakes. Based on the PG data availabilities the following large (M > 5) European earthquakes have been selected for analysis:

EQ No in EQ study proposal	DATE	TIME (UTC)	Magnitude (R)	Preparation area (km)	Depth (km)	Latitude (°)	Longitude (°)	Country	PG station in the area
EQ11	30-Oct-16	6:40:18	6.6	689	8	42.86	13.1	ITALY	Nagycenk
EQ12	26-Oct-16	19:18:08	6.1	420	10	42.96	13.07	ITALY	Nagycenk
EQ13	24-Aug-16	1:36:32	6.2	463	4.44	42.72	13.19	ITALY	Nagycenk
EQ17	11-Jul-00	2:49:47	5.3	190	10	48.013	16.419	AUSTRIA	Nagycenk
EQ18	1-Jul-01	1:48:59	5.1	156	10	47.75	16.137	AUSTRIA	Nagycenk
EQ8	24-May-14	9:25:02	6.9	927	6.43	40.29	25.39	GREECE	Xanthi
EQ20	23-Oct-11	10:41:23	7.1	1130	18	38.72	43.51	TURKEY	Aragath Yerevan Xanthi

Method: Based on the observational results found in the literature we compared the Ez variation for three different time periods: (1) 1 month before and one month after the EQ (2) 10 days before and 10 days after the EQ (3) 2 days before and 2 days after the EQ. In every cases we plotted the PG variation for the three above mentioned time periods. We looked for similar anomalies that were detected in other studies.
In those cases when it was possible we compared the PG variation with TEC anomalies and wave-like variation of the TEC.

Preliminary results:

EQ 11 30-Oct-16 6:40:18, EQ 12 26-Oct-16 19:18:08, ITALY

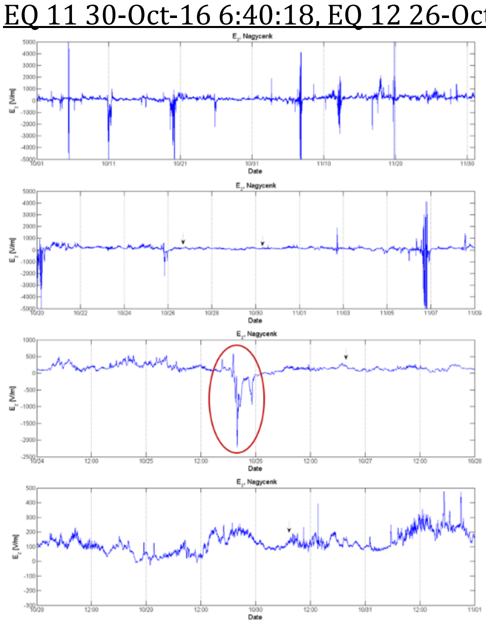

Fig. 4. The variation of Ez measured at Nagycenk between 2016-10-01 and 2016-11-30 (top), between 2016-10-20 and 2016-11-09 (upper middle), between 2016-10-24 and 2016-10-28 and between 2016-10-28 and 2016-11-01 respectively (lower panels). The arrows indicate the time of the EQs. The bay-like reduction of the Ez is marked by red circle.

The typical changes of the Ez during the thunderstorms (with fields > 2000 V/m) can be seen on the top panels (Fig. 4.). A bay-like decrease of the Ez was detected ~ 12 hours before the EQ occurred on 26h October (red circle). This anomaly is similar to those reported in the literature.

Using the spectral analysis of Total Electron Content (TEC) a wave oscillation of the TEC was detected (around 11.5-12.5 UT) one day prior to both EQs (Fig 5., Fig. 6.). EQ11 & EQ12 are successive events, EQ12 occurred 4 days after EQ11 at the same place. In both earthquakes TEC anomalies happened at the same hour of the day, around 11-12 UT.

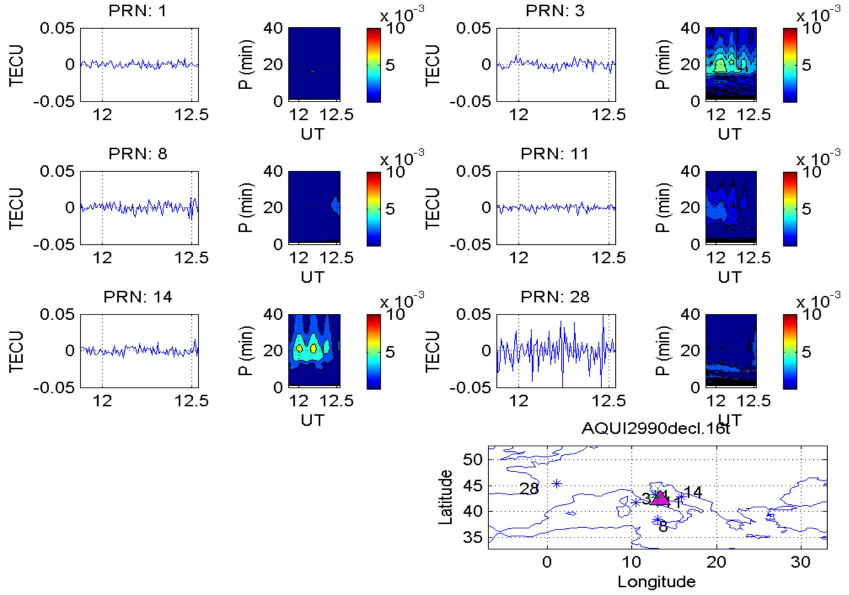

Fig. 5. Snapshots of TEC fluctuations (T up to 40 min) obtained from measurements of 6 satellites (PRN) passing over the area of interest during 12-12.5 UT on **25th October 2016.** The power spectra of amplitude are also shown. Map shows the number and position of IPPs (blue asterisks), AQUI receiver location (pink triangle) and earthquake epicenter (green asterisk).

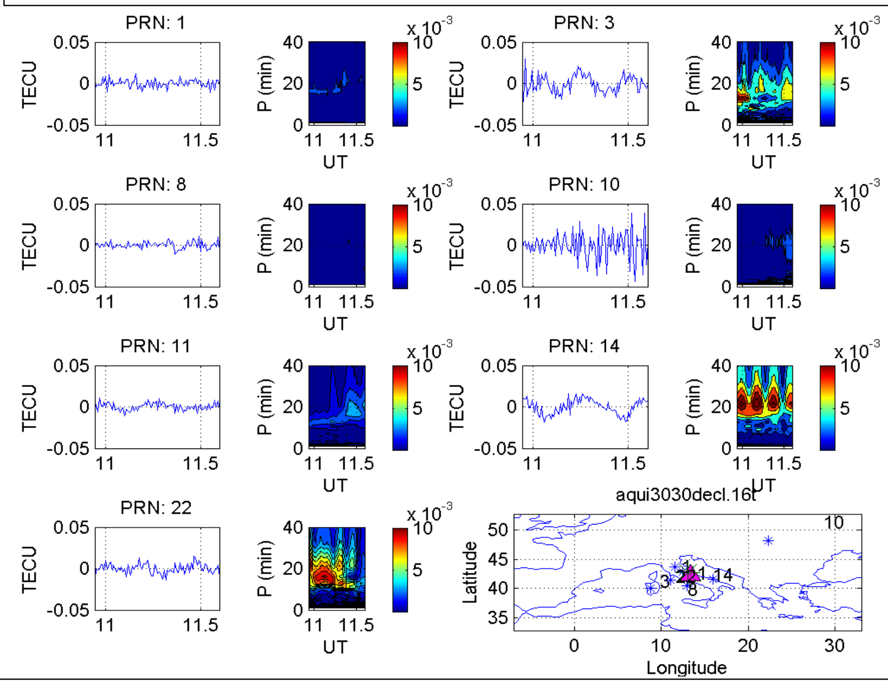

Fig. 6. Snapshots of TEC fluctuations (T up to 40 min) obtained from measurements of 6 satellites (PRN) passing over the area of interest during 11-11.5 UT on **29th October 2016**. The power spectra of amplitude are also shown. Map shows the number and position of IPPs (blue asterisks), AQUI receiver location (pink triangle) and earthquake epicenter (green asterisk).

EQ 13 24-AUG-16 1:36:32, ITALY

In this case we didn't observe any anomaly prior to the EQ (Fig. 7.).

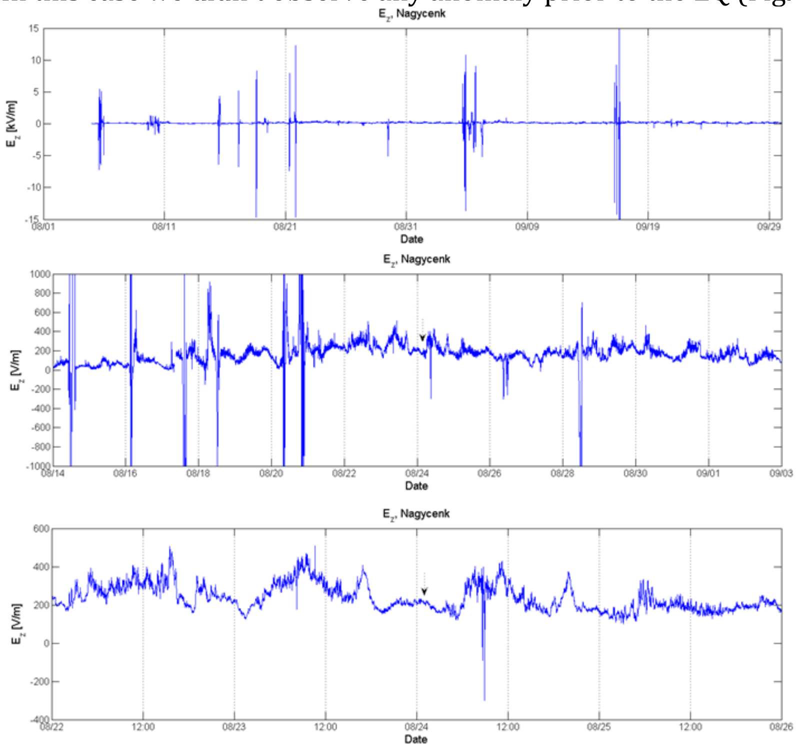

Fig. 7. The variation of Ez measured at Nagycenk between 2016-08-01 and 2016-09-30 (top), between 2016-08-14 and 2016-09-03 (middle), and between 2016-08-22 and 2016-08-26 respectively (lower panel).

However, an increased TEC anomaly was detected a day prior to the EQ (Fig. 8.). The vTEC anomalies was identified following the statistical envelope method: Assuming a normal distribution with mean l and standard deviation r of TEC, the expected values of upper bound and lower bound of the envelope are l ± 1.34r. If the observed TEC falls out of either the associated lower or upper bounds of such an envelope, then an abnormal signal is detected at a confidence level of about 82 % (Klotz and Johnson 1983).

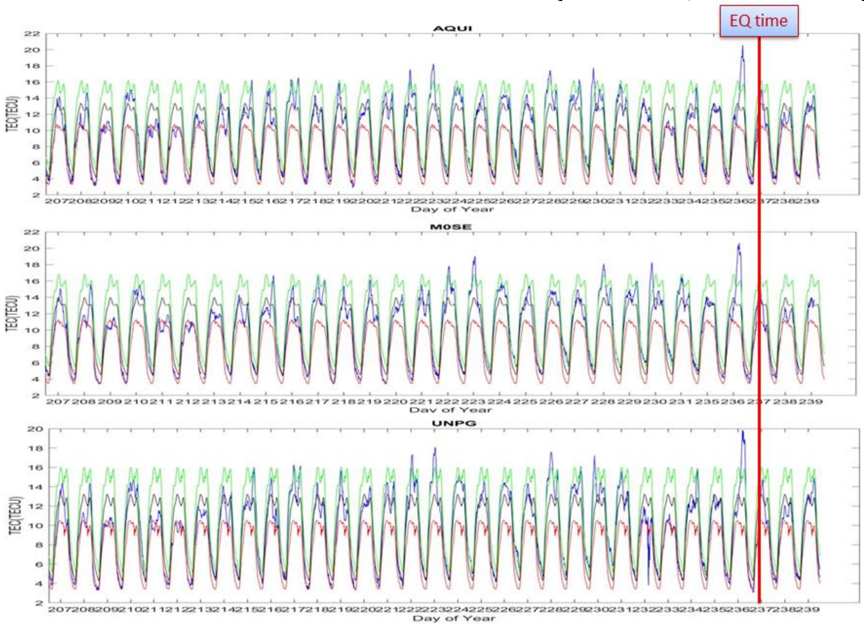

Fig. 8. The variation of TEC before and during the days of the EQ. The Black line=mean I, Green line= +1.34r, Red line= -1.34r, while the Blue line = vTEC. The VTEC anomaly is seen 1 day prior to the EQ.

<u>EQ 17 11-Jul-00 2:49:47, AUSTRIA</u>

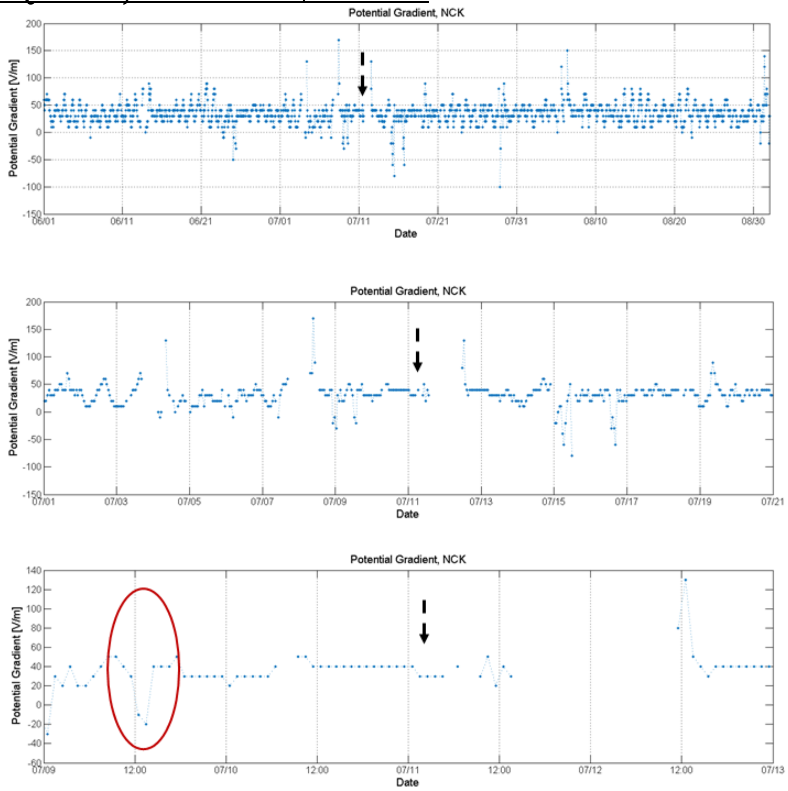

Fig. 9. The variation of Ez measured at Nagycenk between 2000-06-01 and 2000-08-31 (top), between 2000-07-01 and 2000-07-21 (middle), and between 2000-07-09 and 2000-07-13 respectively (lower panel). The arrows indicate the time of the EQ. The bay-like reduction of the Ez is marked by red circle.

A bay-like decrease of the Ez (Fig. 9., red circle) was detected ~ 1,5 days before the EQ occurred on 11 July. The depth of the reduction is ~ 70 V/m which is smaller than the similar anomalies reported in the literature. However, it is worth to mention that in that period an analog device measured the PG at the Nagycenk observatory so we have hourly mean values of the Ez from that period. Thus it is possible that the reduction was greater that as seen in the plot.
Furthermore, in this case a wave oscillation of the TEC was also detected one day prior to the EQ (Fig. 10.).

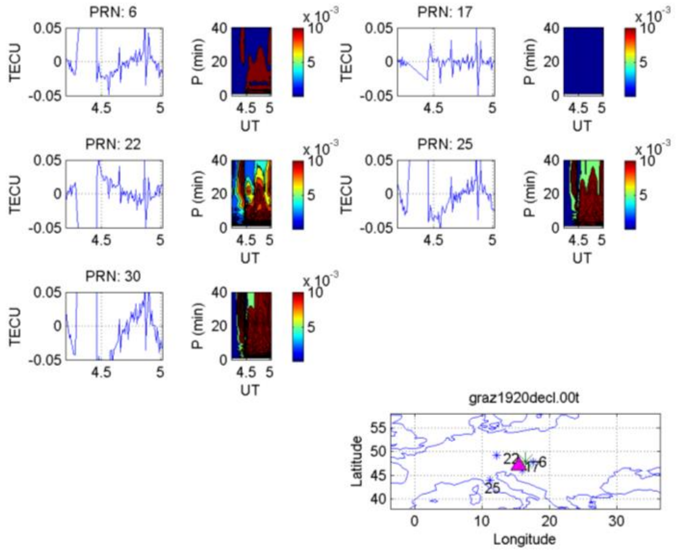

Fig. 10. Snapshots of TEC fluctuations (T up to 40 min) obtained from measurements of 5 satellites (PRN) passing over the area of interest during 4.5-5 UT on **10th July 2000.** The power spectra of amplitude are also shown. Map shows the number and position of IPPs (blue asterisks), AQUI receiver location (pink triangle) and earthquake epicenter (green asterisk).

EQ 18 1-Jul-01 1:48:59, AUSTRIA

In this case we didn't observe any anomaly prior to the EQ (Fig. 11.).

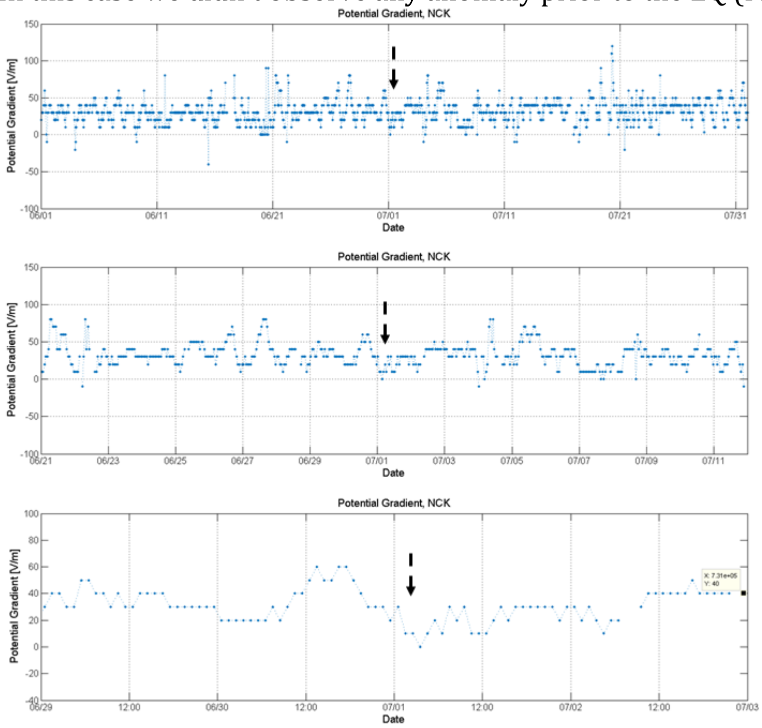

Fig. 11. The variation of Ez measured at Nagycenk between 2001-06-01 and 2001-07-31 (top), between 2001-06-21 and 2001-07-12 (middle), and between 2001-06-29 and 2001-07-03 respectively (lower panel). The arrows indicate the time of the EQ.

EQ 8 24-May-14 9:25:02, GREECE

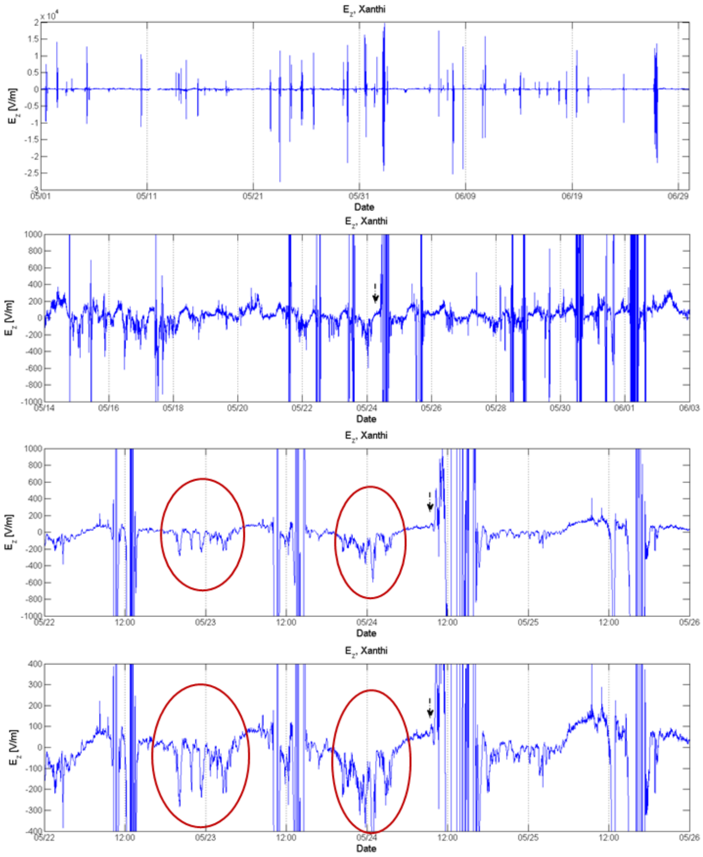

Fig. 12. The variation of Ez measured at Xanthi between 2014-05-01 and 2014-06-30 (top), between 2014-05-14 and 2014-06-03 (middle), and between 2014-05-22 and 2014-05-26 respectively (lower panels). The arrows indicate the time of the EQ. The multiple bay-like reductions of the Ez is marked by red circles.

Multiple bay-like reductions of the Ez (Fig. 12., red circles) was detected a couple of hours and ~ 1,5 day before the EQ which occurred on 24 May. This reductions are similar to the anomalies reported by Mikhailov et al. 2004. However, it is important to mention that the typical traces of thunderstorms are seen on the plot during the daytime the days before and after the EQ. Thus in this case it would be extremely important to compare the Ez observation with local meteorological data to exclude the meteorological origin of the detected reductions.
Furthermore, wave oscillations with periods T=20 min of the TEC was also detected two and one day prior to the EQ (Fig. 13, 14.).

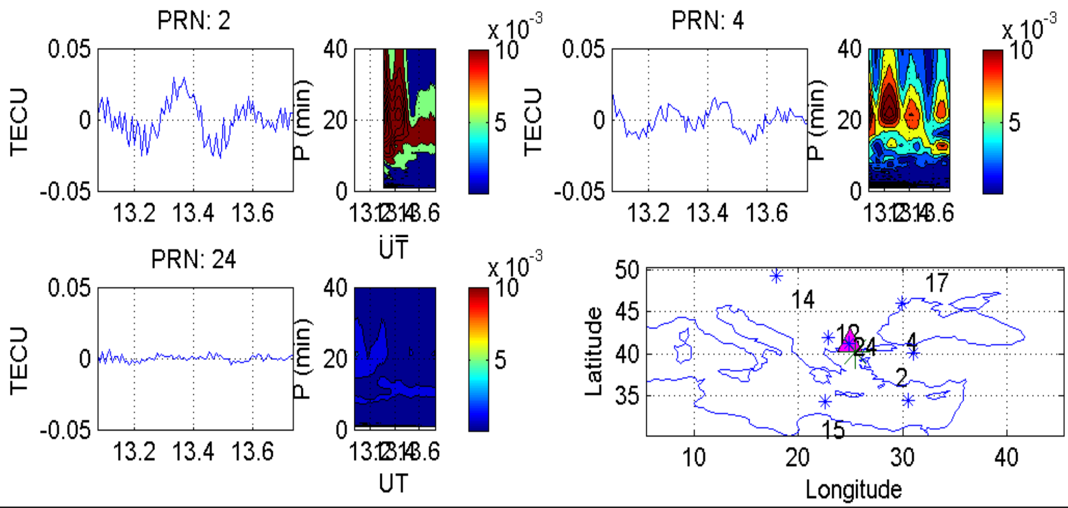

Fig. 13. Snapshots of TEC fluctuations (T up to 40 min) obtained from measurements of 3 satellites (PRN) passing over the area of interest during 13-14 UT two days prior to the EQ. The power spectra of amplitude are also shown. Map shows the number and position of IPPs (blue asterisks), AQUI receiver location (pink triangle) and earthquake epicenter (green asterisk).

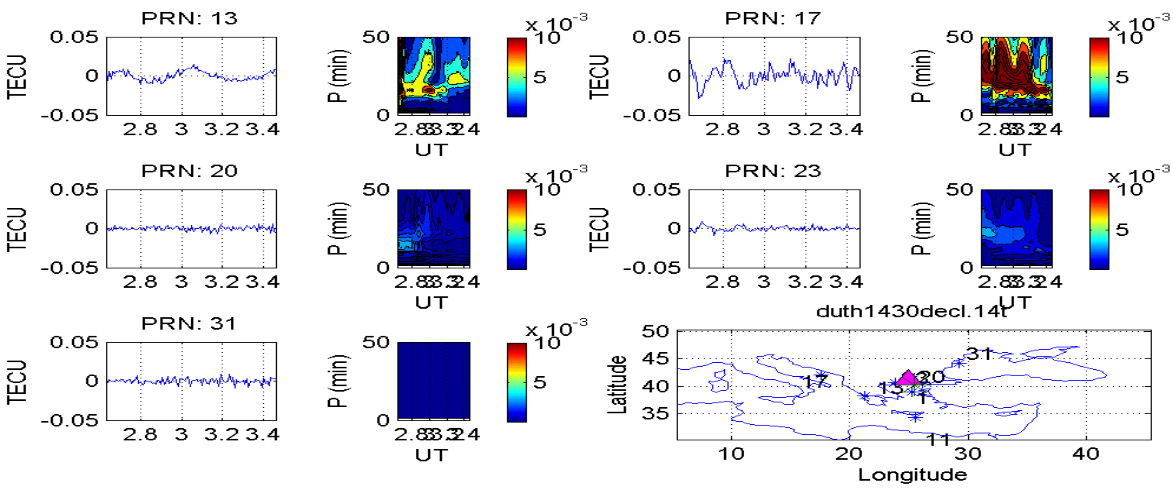

Fig. 14. Snapshots of TEC fluctuations (T up to 40 min) obtained from measurements of 5 satellites (PRN) passing over the area of interest during 2.8-3.4 UT one day prior to the EQ. The power spectra of amplitude are also shown. Map shows the number and position of IPPs (blue asterisks), AQUI receiver location (pink triangle) and earthquake epicenter (green asterisk).

<u>EQ 20 23-Oct-11 10:41:23, TURKEY</u>

Atmospheric electricity data was available from three stations (Aragath, Yerevan, Xanthi) within or close to the preparation area of this EQ.

There is no any anomalies observed at Aragath's or Yerevan's data prior to the EQ (Fig 15, 16.)

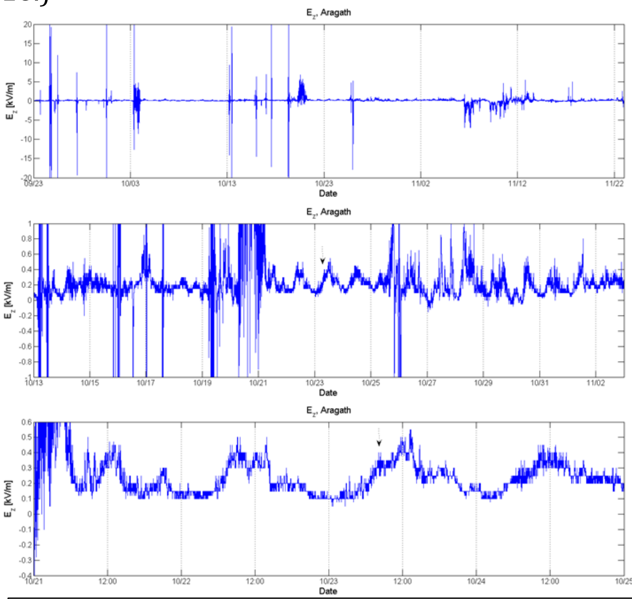

Fig. 15. The variation of Ez measured at Aragath between 2011-09-23 and 2011-11-23 (top), between 2011-10-13 and 2011-11-03 (middle), and between 2014-10-21 and 2011-10-25 respectively (lower panel). The arrows indicate the time of the EQ.

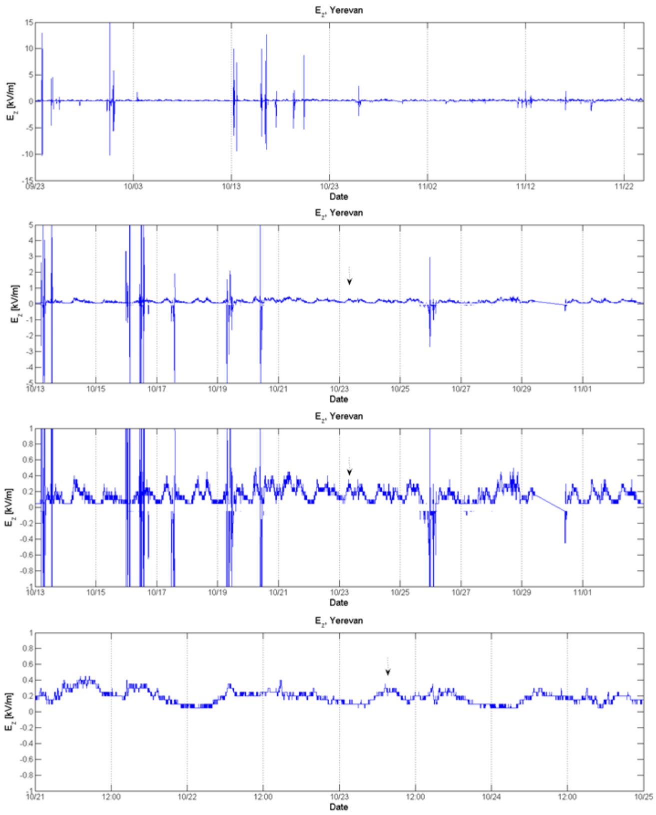

Fig. 16. The variation of Ez measured at Yerevan between 2011-09-23 and 2011-11-23 (top), between 2011-10-13 and 2011-11-03 (middle panels), and between 2014-10-21 and 2011-10-25 respectively (lower panel). The arrows indicate the time of the EQ.

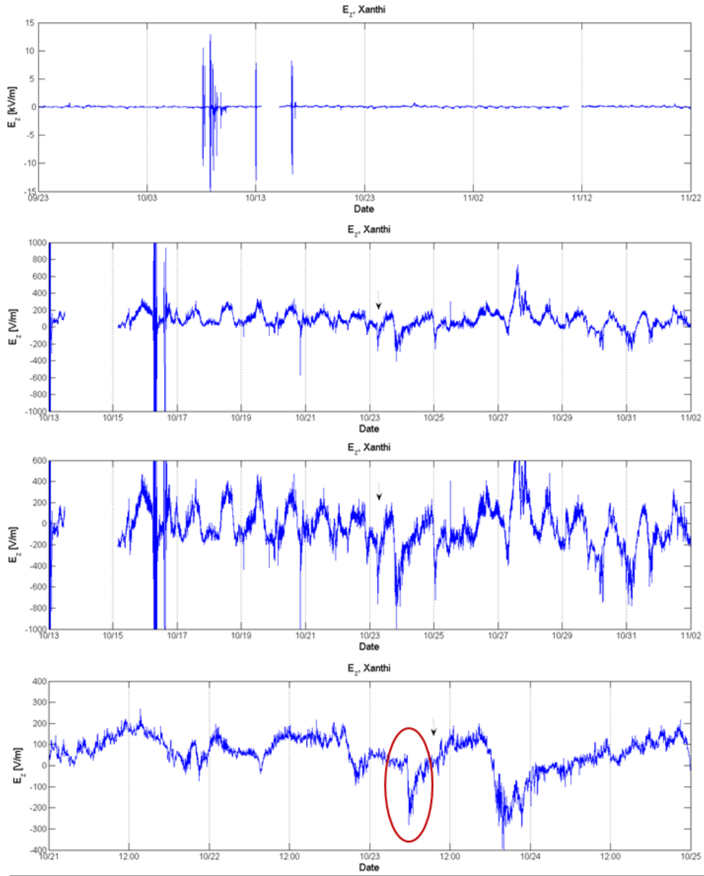

Fig. 17. The variation of Ez measured at Xanthi between 2011-09-23 and 2011-11-23 (top), between 2011-10-13 and 2011-11-03 (middle panels), and between 2014-10-21 and 2011-10-25 respectively (lower panel). The arrows indicate the time of the EQ. The bay-like reduction of the Ez is marked by red circle.

A bay-like decrease of the Ez (Fig. 17., red circle) was detected at Xanthi a couple of hours before the EQ occurred on 23 October. The depth of the anomaly is ~ -300 V/m which is similar to the reductions prior to EQs in the literature. A similar variation can be seen o couple of hours after the EQ however this anomaly is wider.

Moreover, an increased TEC anomaly was detected 2 days prior to the EQ (Fig. 18.) using the statistical envelope method on the vTEC data (the method was detailed previously).

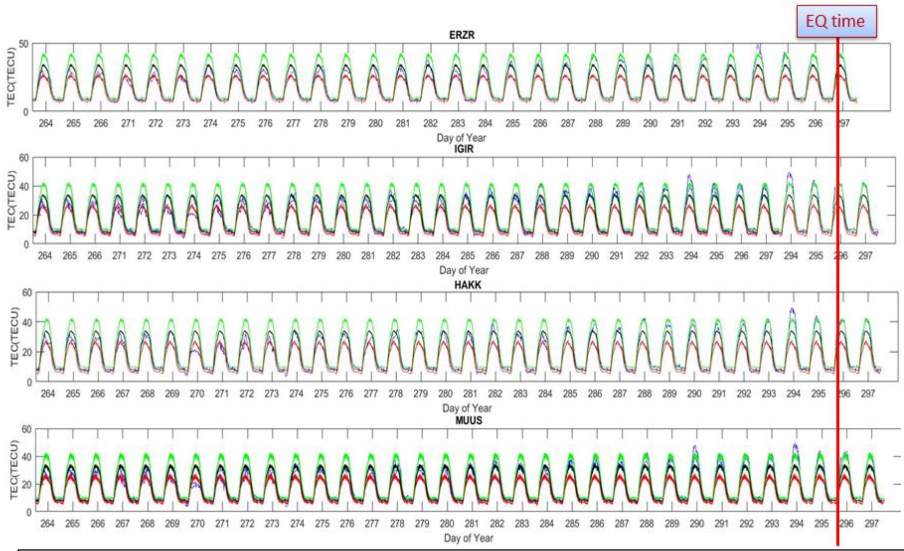

Fig. 18. The variation of TEC before and during the days of the EQ. The Black line=mean I, Green line= +1.34r, Red line= -1.34r, while the Blue line = vTEC. The VTEC anomaly is seen 2 days prior (DoY=294) to the EQ.

Summary of preliminary results, planned future work:

A bay-like or multiple bay-like reductions of the vertical atmospheric electric field were detected a couple of hours to 1,5 day prior to four large European earthquakes among the 7 selected events. The observed anomalies were similar to those that were reported in the literature recently (Mikhailov et al. 2004;Smirnov 2008; Pulinets et al. 2006; Choudhury et al. 2012, 2013). The depth of the detected reductions were between 70 and 2000 V/m similar to the values mentioned in the recent papers. The duration of the anomalies were 1 to a couple of hours which is similar to the results of previous studies as well. No precipitation was detected in the time of the observed reduction so the anomalies were not caused by precipitation. However, a detailed comparison of the Ez variation with local meteorological data is necessary to exclude the meteorological origin of the detected reductions.

The atmospheric electricity changes were compared with vTEC anomalies and analysis of wave-like fluctuations of TEC when it was possible. No simultaneous anomalies were observed by the different measurements/methods. Wave oscillations with periods T=20 min of the TEC were detected two and one day prior to the EQs in 3 cases among the 7 selected event. Furthermore, increased TEC anomalies were detected one and two days prior to the EQ in two cases.

We plan to continue the study. The Ez data comparison with the local meteorological data and with satellite infrared maps is the most important next step of the research. Then we would like to perform similar investigations for other large earthquakes.

III. During the short term visit the grantee had the opportunity to learn about the products of the DPS-4D digisonde and to talk about the special measurement techniques provided by the device. A similar Digisonde system (manufactured by the Lowell Digisonde International) is under installation at the Nagycenk Geophysical Observatory. The grantee received some very useful materials and scientific papers about case studies which have been performed using the different techniques of the digisonde by the researchers of the host institution. These samples will be very useful when she start to use the device for different scientific purposes.

Acknowledgements

The vertical atmospheric electricity data of the other stations for this study were provided by GloCAEM: Atmospheric electric potential gradient measurements, Centre for Environmental Data Analysis (http://catalogue.ceda.ac.uk/uuid/bffd0262439a4ecb8fadf0134c4a4a41) and by the Cosmic Ray Division of Yerevan Physics Institute. The grantee thanks Haris Haralambous and Christina Oikonomou their great help in the realization of the STSM. The grantee is grateful to the MC and STSM committee of the Action for supporting her application.

Sopron, Hungary, 04th May, 2017.

Barta Veronika

Veronika Barta