ΣΥΝΕΔΡΙΑ ΤΗΣ 28ΗΣ ΦΕΒΡΟΥΑΡΙΟΥ 2002

ΠΡΟΕΔΡΙΑ ΜΗΤΡΟΠΟΛΙΤΟΥ ΠΕΡΓΑΜΟΥ ΙΩΑΝΝΟΥ (ΖΗΖΙΟΥΛΑ)

ΣΕΙΣΜΟΛΟΓΙΑ. – **A real-time application of spatio-temporal complexity aspects to a recent electric disturbance recorded at Ioannina**, by P. Varotsos, N. Sarlis, E. Skordas, and M. Lazaridou*, διὰ τοῦ Ἀκαδημαϊκοῦ κ. Καίσαρος Ἀλεξοπούλου.

The capability of predicting the parameters of an impending earthquake (EQ) by means of Seismic Electric Signals (SES) has been recently improved by the following two findings: First, there is a measurable time-difference Δt between the two fields (i.e., the electric and the magnetic) associated with an SES activity; this may improve the prediction of the epicenter, because it allows the estimation of the epicentral distance r from every single SES measuring station. Second, when (departing from the conventional time frame and) adopting a new time domain, termed as "*natural time*", there is the following "universality": the natural spectrum of the evolving seismic activity (cf. after the recording of the SES) collapses onto the "natural" spectrum of the SES activity just before the main shock; this allows the estimation of the impending EQ with a time-window of the order of 1 day.

The above findings are applied in the present paper to a recent strong elec-

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tric disturbance recorded at IOA on Feb. 5, 2002. This application reveals a new advantage of the "natural time": since the disturbance under discussion, should lie not far from the station (because it gave $\Delta t<1$ sec, thus reflecting $r\leq 60$ km), it cannot be safely distinguished from a local strong artificial noise. In view of this fact, a study of the evolution of the seismic activity (evolving after Feb. 5, 2002) is envisaged in the "natural time" domain. If a "collapse" will finally occur between the two (natural) spectra, this will enable us to determine whether the disturbance is actually an SES activity or not.

a) *Extension of the sensitivity map*. In addition to PER (i.e., the site at which IOA station is operating since 1981), the electric disturbance was recorded (Figs 1-3) at several dipoles located at the neighboring stations labeled DOU and ZIT in Fig. 1 of *Varotsos et al.* [1998a] (the latter stations lie at distances around 10 km and 20 km SW and NW of PER respectively). Thus, the IOA disturbance is now collected in a broader area than that found for the SES activities preceded the EQs that occurred in the Ionian sea in 1997 and 1998 (*Varotsos et al.* [1998a,b,c]).

b) *Violation of $\Delta V/L$ = const for the long dipoles*. An inspection of Fig. 1 reveals that, the $\Delta V/L$-value on the various dipoles is, on the average, *larger* (by a factor of 2-5) than the SES activities preceded the 6.6 EQ at Grevena-Kozani (cf. The location of the electrodes can be found in *Varotsos et al.* [1996]). However, the $\Delta V/L$-value at the long dipole L's - I (length ~ 5 km) differs from those at the long dipoles L and L' by a factor of ~4. This could be understood *only if* the emitting source is *not* a remote one, but lies very close to the measuring site(s), i.e., at distances around a few tens of km only. This is consistent with the fact that the $\Delta V/L$-value at ZIT is comparable to (but with opposite direction than) that measured at PER.

c) *Magnetic field measurements*. The lower six channels in Figs 1 and 3 depict the measurements from the coil magnetometers (the lower three correspond to DANSK, magnetometers, while the next three to those of EMI). When considering the relevant calibration (*Varotsos et al.* [2001a]), the change in the vertical component $B_Z << B_H$ is also consistent with a nearby emitting source (because it has been shown that at sites around the upper end of a conductive channel, it is likely that the component B_Z is the prominent one).

d) *The time-difference between the arrivals of the E and B fields*. This, as already mentioned, is less than 1 sec. For the sake of comparison, we mention that in the case of Grevena-Kozani EQ, the E-variations preceded those of the B-field by a

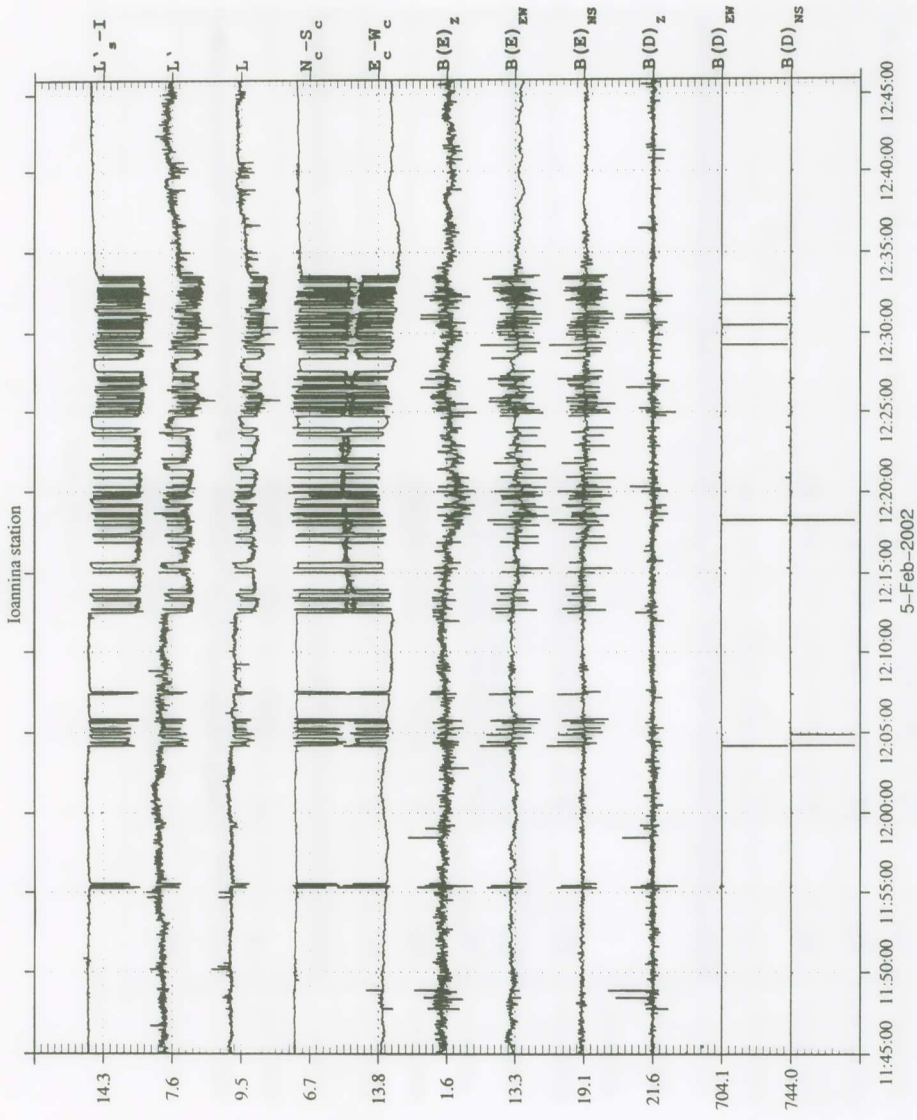
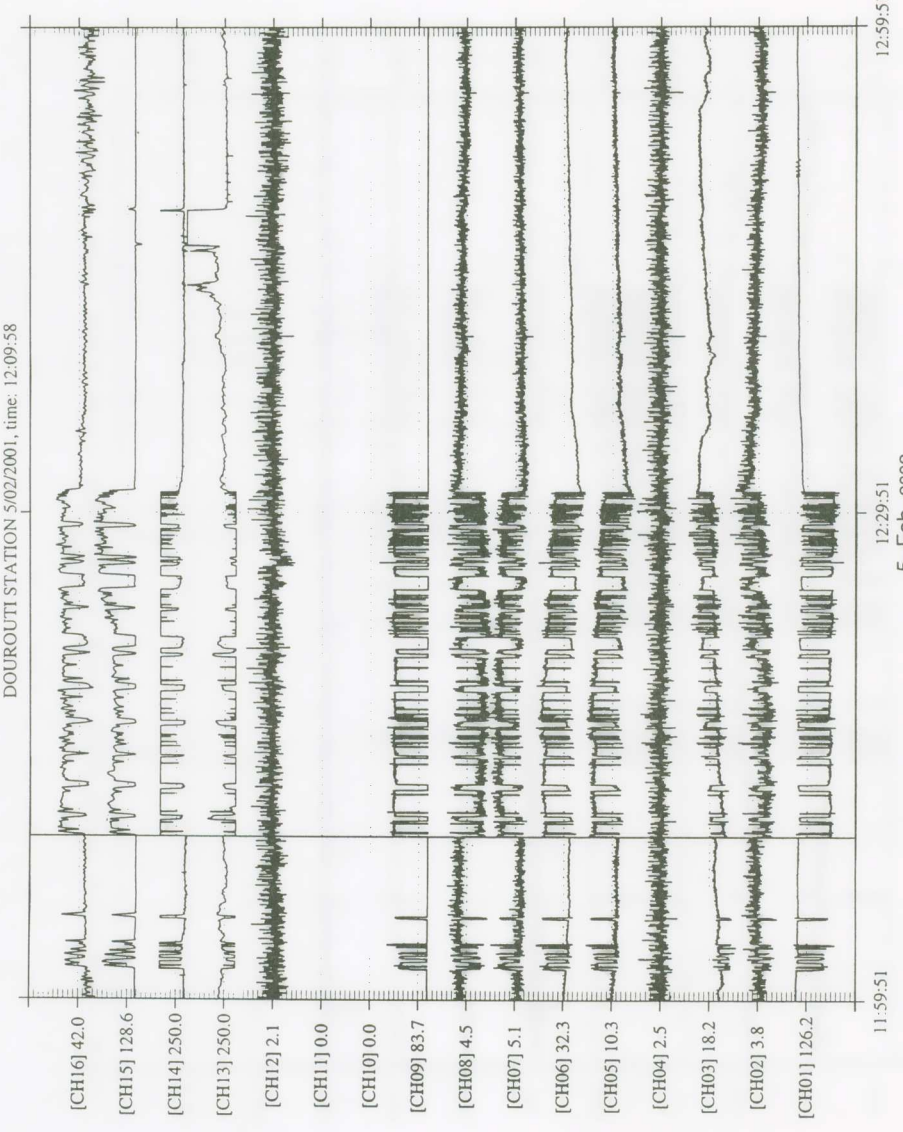

Ioannina station
L' -I s
L'
L
N -S c c
E -W c c
B(E) z
B(E) EW
B(E) NS
B(D) z
B(D) EW
B(D) NS
14.3
7.6
9.5
6.7
13.8
1.6
13.3
19.1
21.6
704.1
744.0
11:45:00 11:50:00 11:55:00 12:00:00 12:05:00 12:10:00 12:15:00 12:20:00 12:25:00 12:30:00 12:35:00 12:40:00 12:45:00
5-Feb-2002

Fig. 1


DOUROUTI STATION 5/02/2001, time: 12:09:58
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[CH15] 128.6
[CH14] 250.0
[CH13] 250.0
[CH12] 2.1
[CH11] 0.0
[CH10] 0.0
[CH09] 83.7
[CH08] 4.5
[CH07] 5.1
[CH06] 32.3
[CH05] 10.3
[CH04] 2.5
[CH03] 18.2
[CH02] 3.8
[CH01] 126.2
11:59:51
12:29:51
12:59:51
5-Feb-2002

Fig. 2

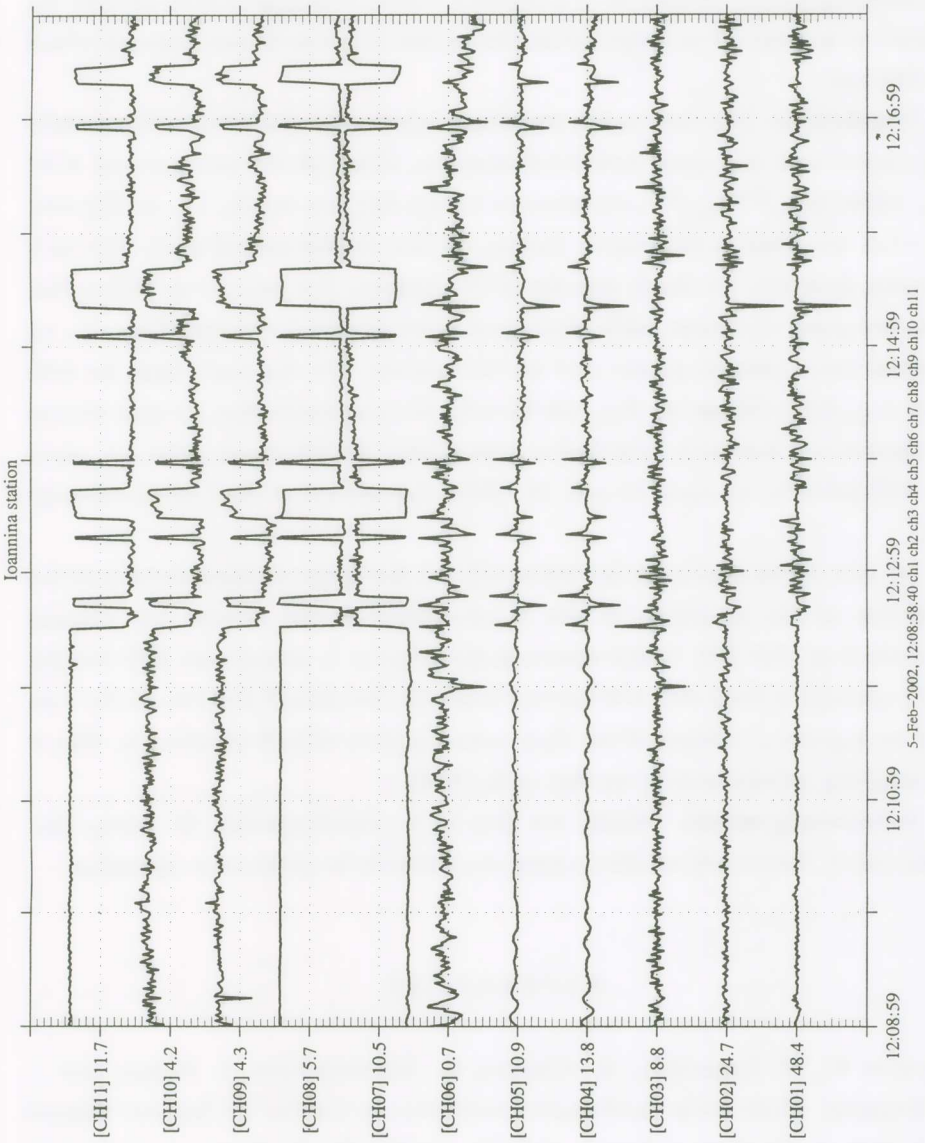
Ioannina station
[CH11] 11.7
[CH10] 4.2
[CH09] 4.3
[CH08] 5.7
[CH07] 10.5
[CH06] 0.7
[CH05] 10.9
[CH04] 13.8
[CH03] 8.8
[CH02] 24.7
[CH01] 48.4
12:08:59
12:10:59
12:12:59
12:14:59
12:16:59
5-Feb-2002, 12:08:58.40 ch1 ch2 ch3 ch4 ch5 ch6 ch7 ch8 ch9 ch10 ch11

Fig. 3

time difference Δt of ~1-2 sec (*Varotsos et al.* [2001b]). Thus, in the present case, the emitting source, should lie at a distance r from IOA appreciably smaller (by a factor of around $\sqrt{3}$ or larger) than that in the Grevena-Kozani case, in which $r \approx 100$ km.

Conclusions. The data under discussion seem to be consistent with an emitting source only at a small epicentral distance, although the area around IOA, e.g., within $N_{39.2}{}^{40.3}E_{20.3}{}^{21.3}$, experiences a large EQ very rarely, i.e., no EQ with ML>6.0, occurred in this region during the last several tens of years. For such a source, however, we clarify that the ΔV/L-criterion (see point b) as well as that of Δt (see point d) cannot safely distinguish between the two possibilities, i.e., an artificial (very intense) source and an SES activity. (In the latter case, we estimate, e.g., for r~30 km, an EQ with M~6.0). We emphasize that no such electrical disturbance has been recorded at IOA during the last seven years, i.e., since the SES activities on April 18 and 19, 1995, that preceded the Grevena-Kozani EQ.

In view of the above, we are left to rely on the spectral characteristics of the evolution of the seismicity, if this is considered in the *natural time* domain (*Varotsos et al.* [2001c]). If the electrical disturbance is actually an SES activity, and *if* enough seismic data will become available, we should observe, as the time evolves, a gradual collapse of the Π(φ) versus φ plots of both spectra (i.e., that of the evolving seismic activity on that ot the SES).

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REFERENCES

Varotsos P., M. Lazaridou, K. Eftaxias, G. Antonopoulos, J. Makris and J. Kopanas, Short term earthquake prediction in Greece by Seismic Electric Signals, in the Critical Review of VAN: Earthquake Prediction from Seismic Electric Signals, ed. Sir J. Lighthill, *World Scientific Publishing Co.*, Singapore, 29-76, 1996.

Varotsos, P., K. Eftaxias, M. Lazaridou, N. Bogris, and J. Makris. Note on the extension of the SES sensitive area at Ioannina station, Greece. Acta Geophysica Polonica, Vol. XLVI, No. 1, 55-60, 1998a.

Varotsos, P., N. Bogris, K. Eftaxias, V. Hadjicontis, M. Lazaridou, and M. Kefalas. Additional evidence on the extent of the SES sensitive area around Ioannina. Acta Geophysica Polonica, vol. XLVI.No 3, 273-275, 1998b.

Varotsos, P., N. Bogris, K. Eftaxias, V. Hadjicontis, M. Lazaridou, and M. Kefalas. On the extent of the SES sensitive area around Ioannina. Additional evidence II. Acta Geophysica Polonica, vol. XLVI. No 4, 411-413, 1998c.

Varotsos, P., N. Sarlis, and E. Skordas, Magnetic field variations associated with the SES. The instrumentation used for investigating their detectability, Proc. Japan Acad. 77B, 87-92, 2001a.

Varotsos, P., N. Sarlis, and E. Skordas, Magnetic field variations associatiated with the SES before the 6.6 Grevena-Kozani earthquake, Proc. Japan Acad. 77B, 93-97, 2001b.

Varotsos, P., N. Sarlis, and E. Skordas, Spatio-temporal complexity aspectss on the interrelation between Seismic Electric Signals and Seismicity, Practica of Athens Academy, session November 22, 2001c.

ΠΕΡΙΛΗΨΗ

Ἐφαρμογὴ τῆς φυσικῆς συνθέτων συστημάτων σὲ μιὰ ἠλεκτρικὴ διαταραχὴ στὰ Ἰωάννινα

Ἡ ἱκανότης τῆς ἐκτίμησης τῶν παραμέτρων ἑνὸς ἐπερχόμενου σεισμοῦ μέσῳ τῆς καταγραφῆς τῶν Ἠλεκτρικῶν Προσεισμικῶν σημάτων (SES) ἔχει πρόσφατα βελτιωθεῖ μὲ τοὺς ἀκόλουθους δύο τρόπους: Πρῶτον, ὑπάρχει μία μετρήσιμη χρονοδιαφορὰ μεταξὺ τῶν δύο πεδίων (δηλαδὴ τοῦ ἠλεκτρικοῦ καὶ τοῦ μαγνητικοῦ) ποὺ συμπαρομαρτοῦν μὲ μία δραστηριότητα SES. Ἡ χρονοδιαφορὰ αὐτὴ βελτιώνει τὴν ἐκτίμηση τοῦ ἐπικέντρου διότι ἐπιτρέπει τὸν ὑπολογισμὸ τῆς ἐπικεντρικῆς ἀπόστασης r ἀπὸ τὸν σταθμὸ ποὺ καταγράφει τὸ ἑκάστοτε SES. Δεύτερον, ἐὰν δὲν ἐργασθοῦμε στὸ σύνηθες πεδίο χρόνου ἀλλὰ υἱοθετήσουμε ἕνα ἄλλο πεδίο ποὺ τὸ ὀνομάζουμε «φυσικὸ» χρόνο ὑπάρχει ἡ ἀκόλουθη γενικὴ σχέση: τὸ φάσμα, στὸν

«φυσικὸ» χρόνο, τῆς ἐξελισσόμενης δραστηριότητας (μετὰ τὴν καταγραφὴ τῶν SES) συμπίπτει τελικὰ μὲ τὸ φάσμα τῆς δραστηριότητας τῶν SES, λίγο πρὶν ἀπὸ τὸ κύριο σεισμικὸ γεγονός. Τὸ τελευταῖο ἐπιτρέπει τὴν ἐκτίμηση τοῦ χρόνου τοῦ ἐπερχομένου σεισμοῦ μὲ ἕνα «παράθυρο χρόνου» τῆς τάξεως τῆς μίας ἡμέρας. Τὰ παραπάνω ἐφαρμόζονται στὴν παροῦσα ἐργασία σὲ μία δραστηριότητα SES ποὺ κατεγράφη στὸ σταθμὸ τῶν Ἰωαννίνων στὶς 5 Φεβρουαρίου 2002.