SEMEP

Search for ElectroMagnetic Earthquake Precursors

Interpretation of obtained results

Deliverable 4.4

Prepared by:	Valeriy V. Afonin, IKI	31/01/2013

Document Status Sheet

1.8	November 22nd, 2012	Initial draft
1.10	November 28th, 2012	Initial submission to EC
2.2	February 19th, 2013	Resubmission to EC

Document Change Record

Issue		Author	Details
1.8	22/11/12	VA	Initial Draft
1.9	27/11/12	SW	Suggestions for updates
1.10	18/04/12	VA	Implementation of updates
2.0	31/01/13	SW	Updated document status/change records
2.1		VA	Updates based on reviewers comments
2.2	12/02/13	SW	Minor English corrections

Table of Contents

1 INTRODUCTION

1.1 Purpose

This document provides the description of activity and results of executing the step T4.4 of the work package 4 of the SEMEP project.

1.2 Objective and steps of the work package 4

WP4 relates to the analysis of the data on space plasma parameters from COSMOS-900 and DEMETER satellites. The objectives of this analysis are:

1. Finding out whether or not characteristic oscillations of ionospheric plasma related to seismic activity exist.

2. If the answer to the first question is positive, then to determine the main characteristics of these oscillations, their extension in space and time, and if they are magnetically controlled.

Two types of analysis were planned to be performed:

- Statistical analysis
- Spectral analysis.

The following steps were planned:

T4.1. Obtaining the DEMETER dataset on electron/ion density Ne and electron/ion temperature Te/Ti, estimating DMT data for their quality and adequacy for necessary analysis, and making decision on the possibility of use and working with these data.

T4.2. Preparation of COSMOS-900 observational data bank for space and spectral analysis and development the relevant software.

T4.3. Development the data processing methods of plasma parameters analysis and correlation with seismic activity.

T4.4. Interpretation of the results.

2 EXPERIMENTAL DATA

2.1 COSMOS-900 and DEMETR data used in the analysis

The COSMOS-900 data sets relevant to this step are the K900_EDB banks **bOVFm , bOVFc** and **bOVFc_EQ** created during previous steps.

The DEMETER data sets relevant to this step are the **ISL_EQ** files created during **T4.3**.

2.2 Planning of work for step 4.4

1. Search specific wave-like effects and investigation of a possible link with seismic activity.
2 Search for local effects.

3 OBJECTIVE AND STEPS OF STEP T4.4

In step T4.4 we planed to make the following works.

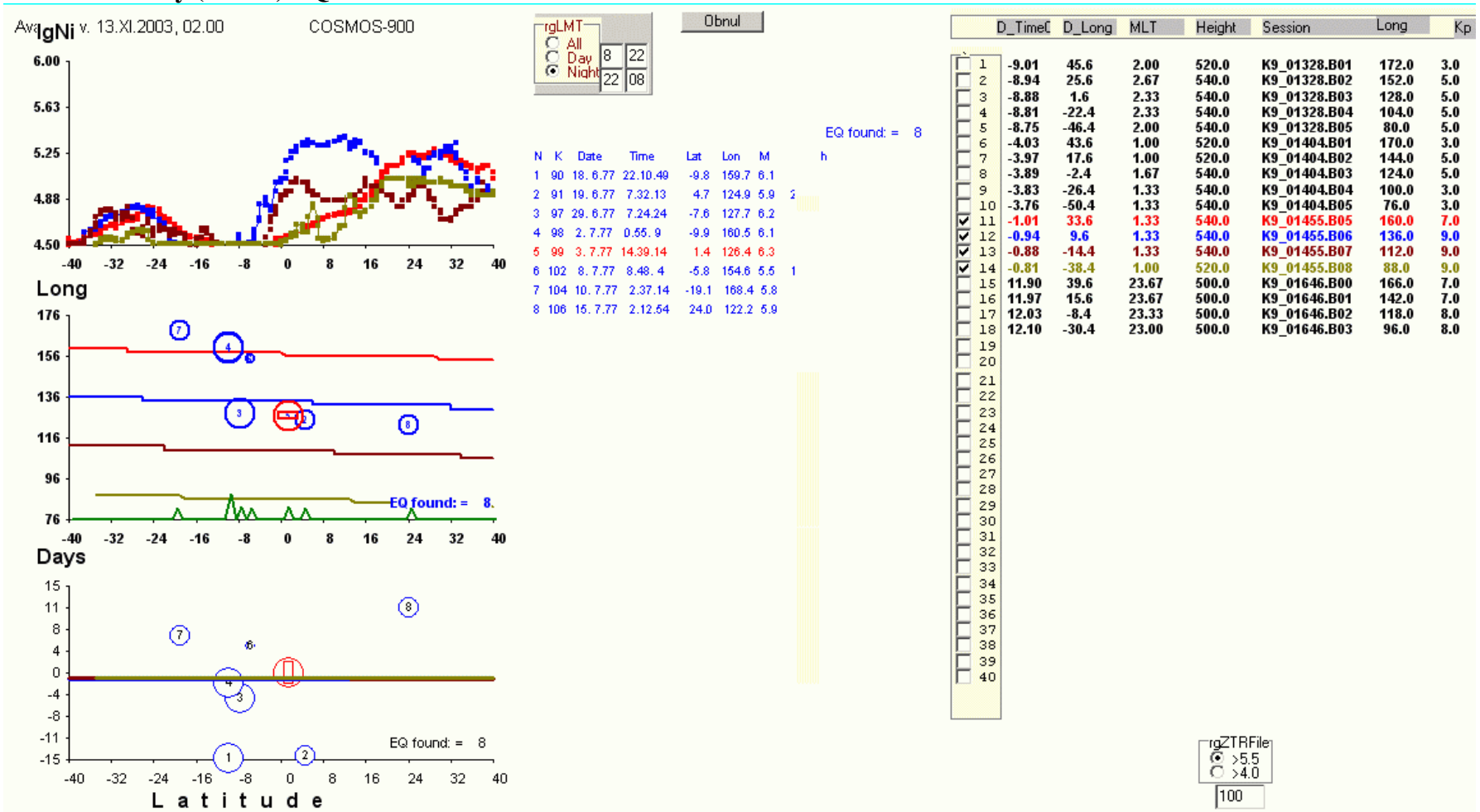
1. Search specific wave-like effects by visual analysis using search_passes instrument.
2. Search specific wave-like effects using wavelet spectra.
3. Search local effects using visual analysis and search_passes instrument.

4 WHAT WAS DONE IN STEP 4.4

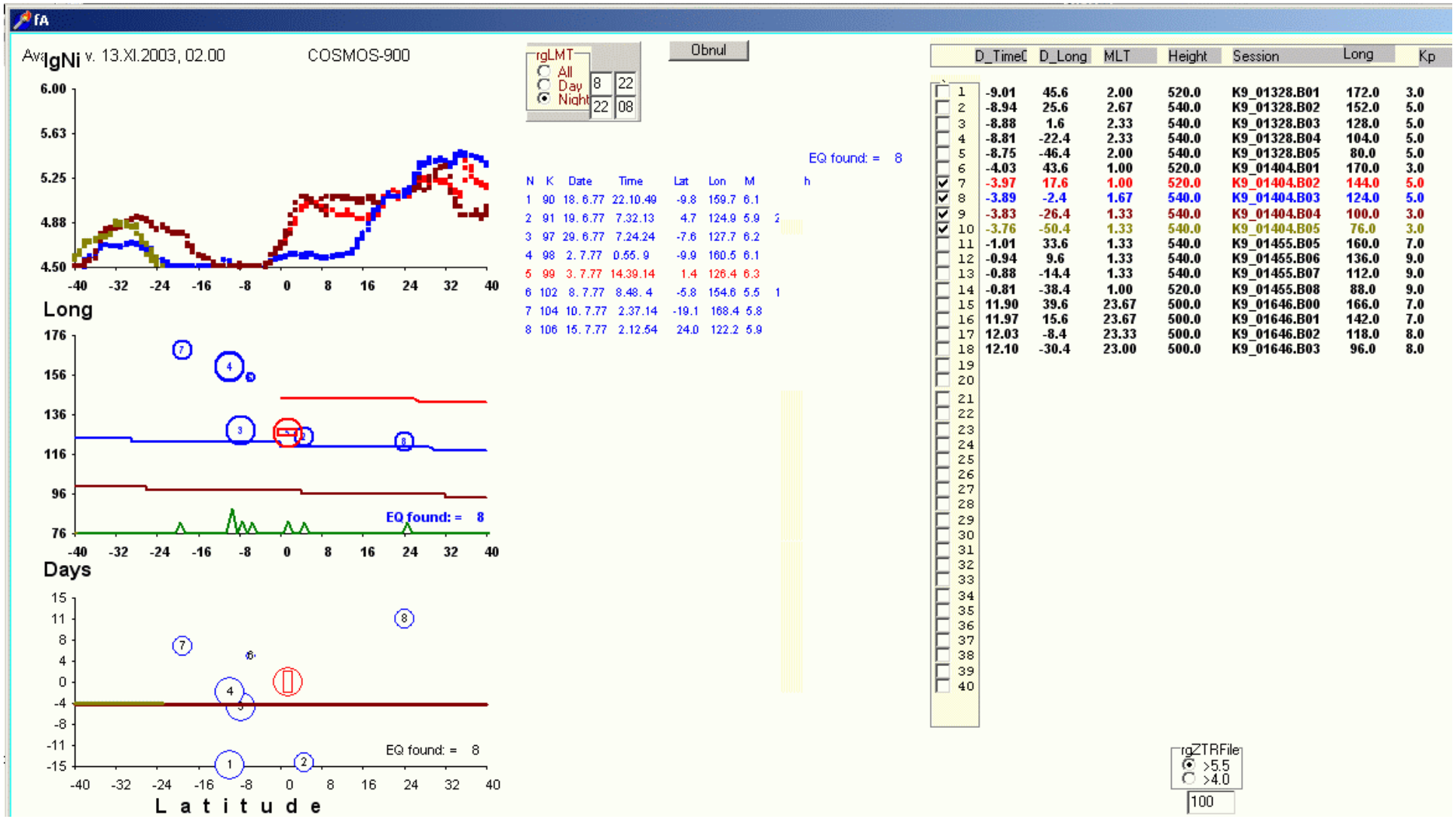
4.1 Search of specific wave-like effects –K900 z99 EQ

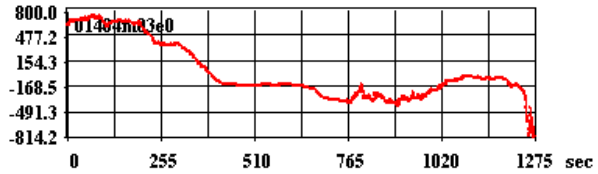
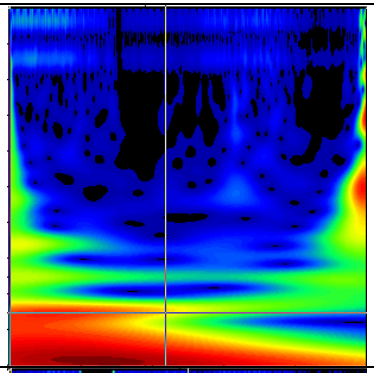
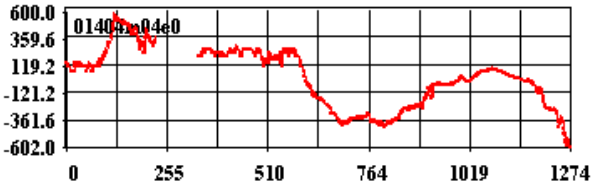
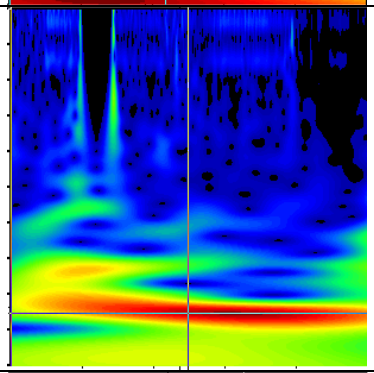
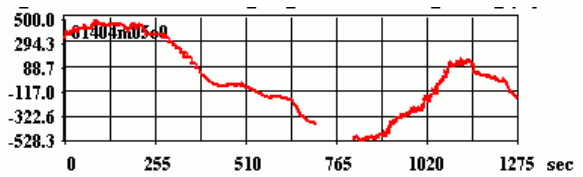
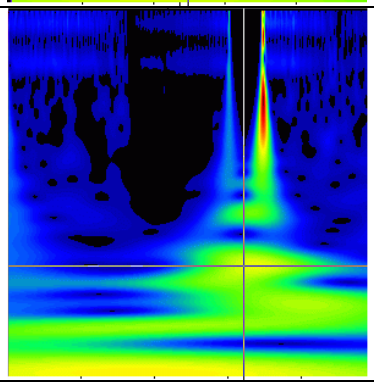
The K900 data were used to analyze plasma parameters for the EQ z99 (M=6.3) which occurred on July 3rd, 1977 at 1439. The location of the epicenter was λ= 126.4, φ=+1.4.

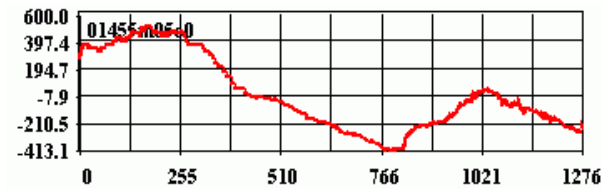
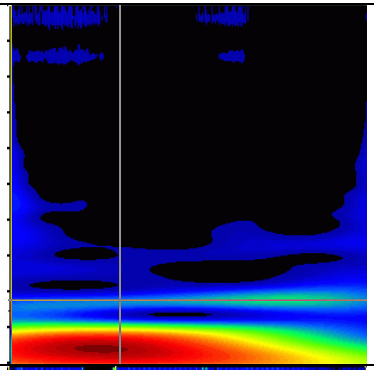
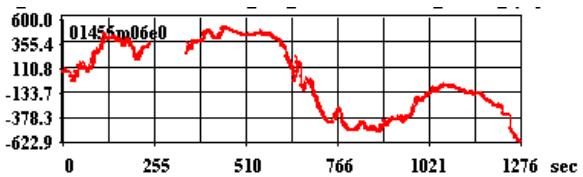
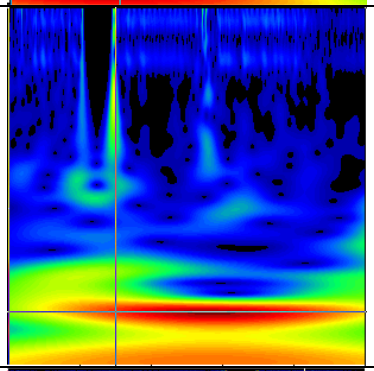
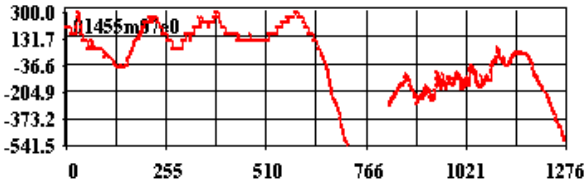
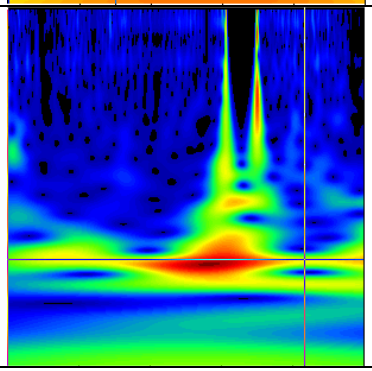
Passes of K900 at – 1 day (before) EQ:

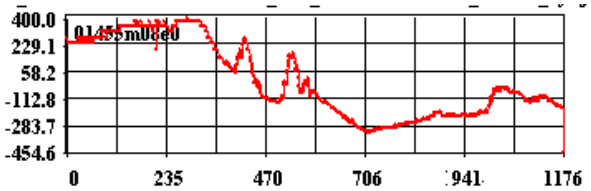
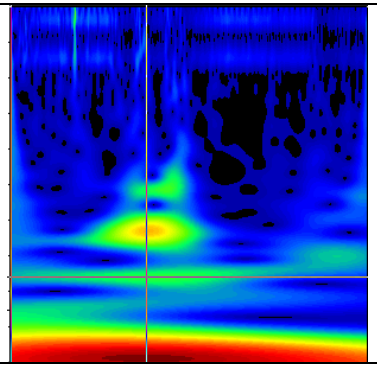


Passes of K900 at – 4 days (before) EQ:



FileName			λeq	Δλeq	Δ days	Teq	Note	Closest EQ
01404m03e02			121	-2.4	-3.89	29.06.79 17h00m		
01404m04e01			97	-26.4	-3.83	29.06.197 7 18h35m	**S=463** S=232	**Z97 M=6.2** Lon=127.7 29.06.1977 7h24m **ΔT=11h** **Δλeq=-30**
01404m05e01			76	-50.4	-3.76			

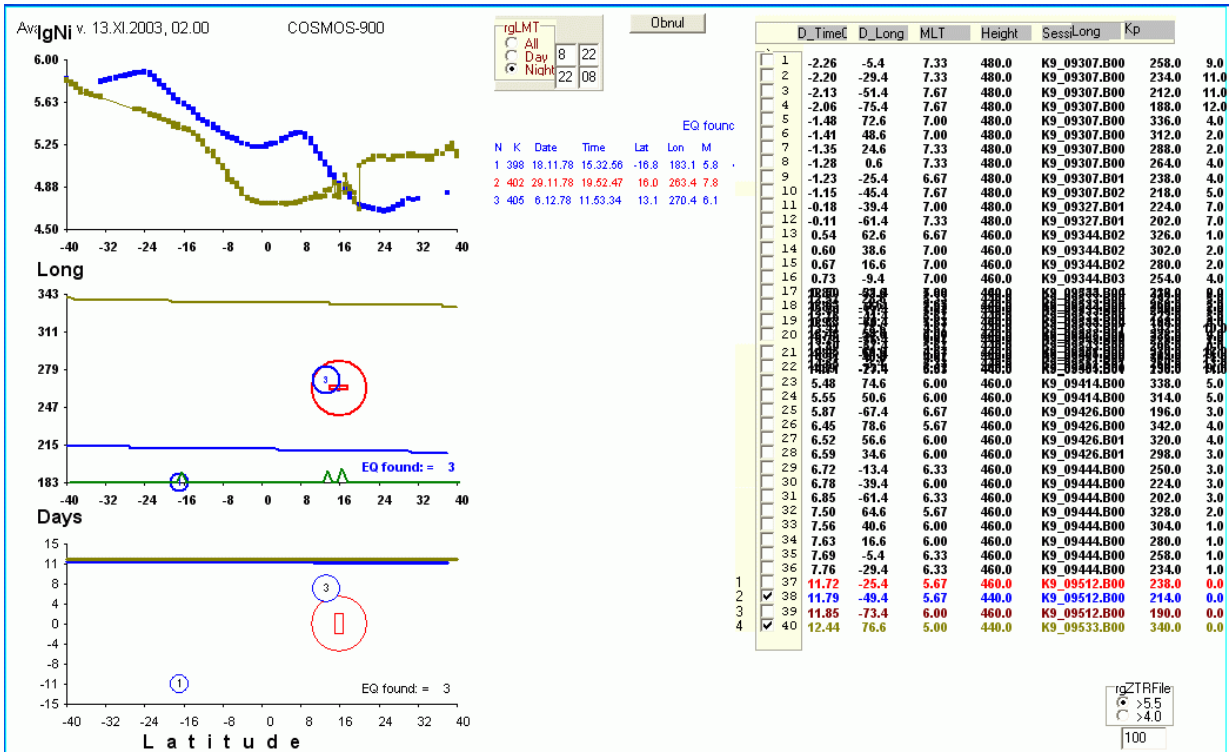
FileName			λeq	Δλeq	Δ days	Teq	Note	Closest EQ
01455m05e01			160	+33 (west ward)	-1.01			
01455m06e01			136	9.6	-0.94		**S=465** S=232	
01455m07e01			112	-14.4	-0.88		S=180 **S=274**	

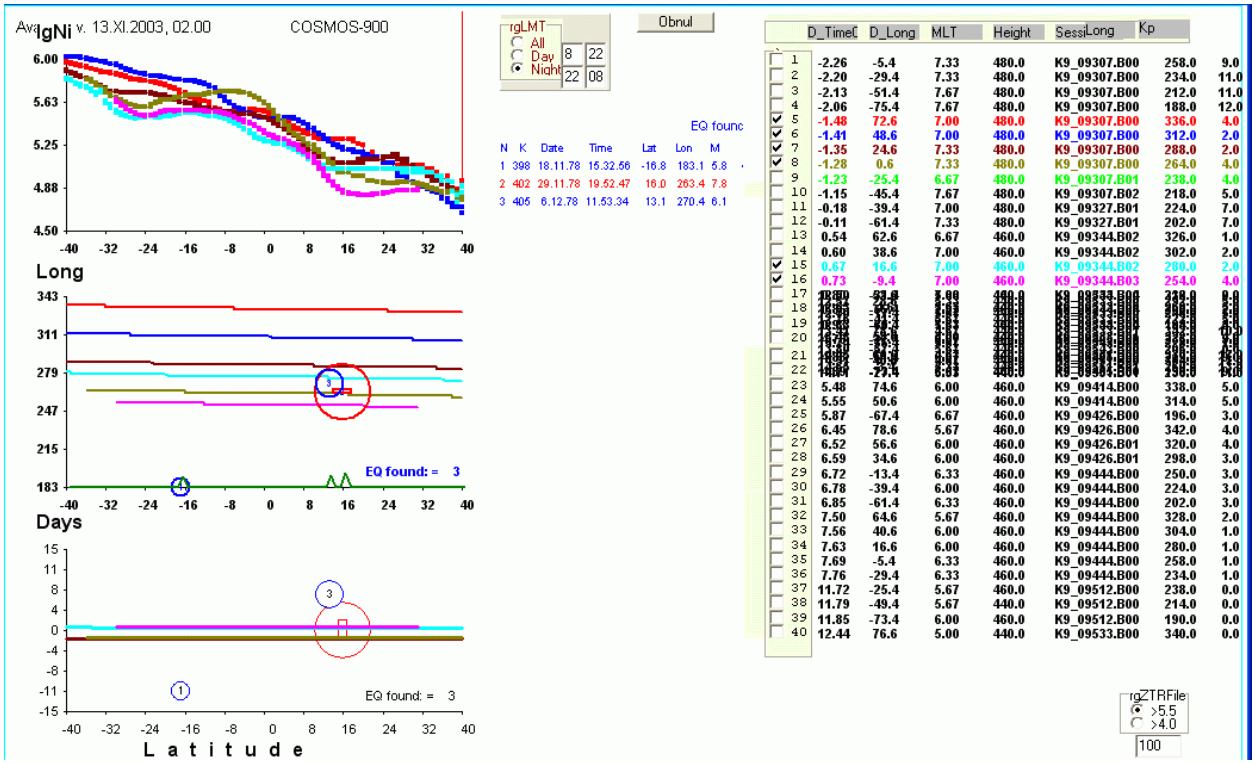
FileName			λeq	Δλeq	Δ days	Teq	Note	Closest EQ
01455m08e01			88	-38.4	-0/81		S=114 S=250 ????	

4.2 Search of specific wave-like effects –K900 z402 EQ

The K900 data were used to analyze situation for z402 quake :

Z402 M= 7.8 λ= 263.4 φ=+16.0 29.11.1978 19h52m



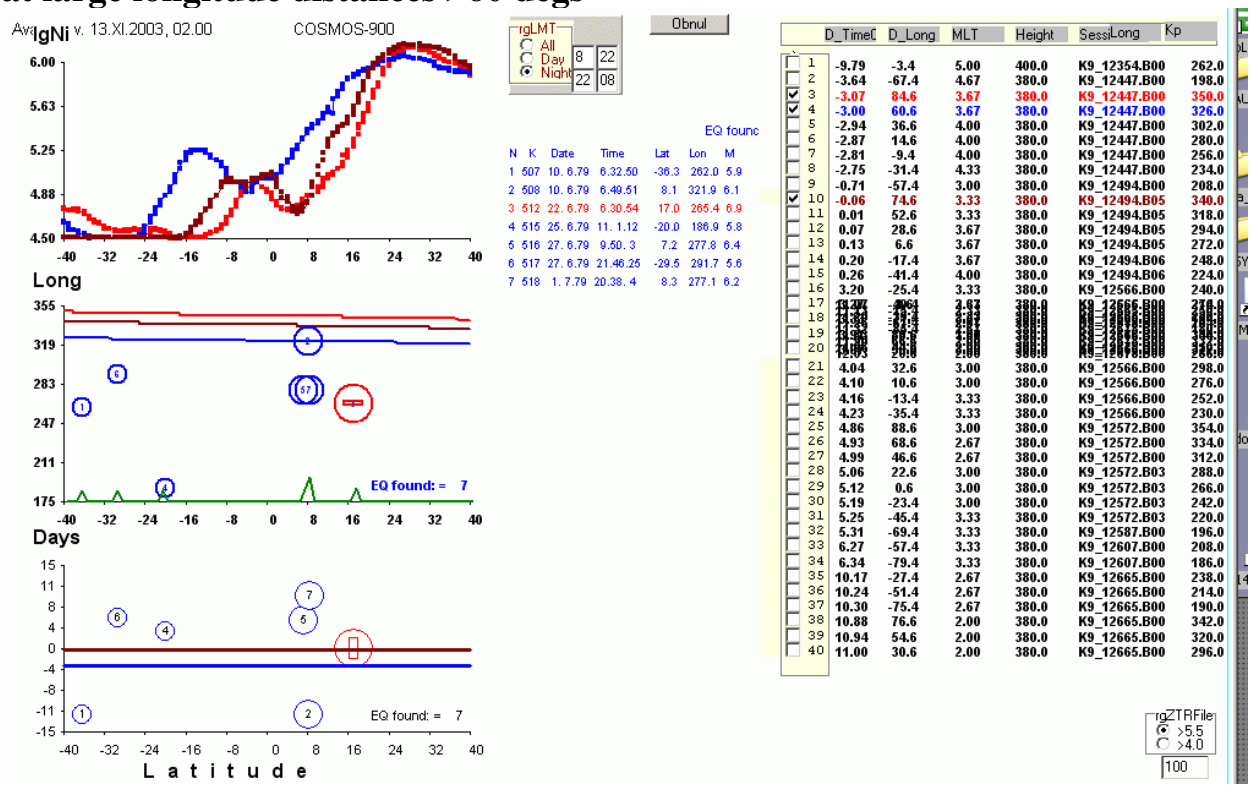


4.3 Search of specific wave-like effects –K900 z512 EQ

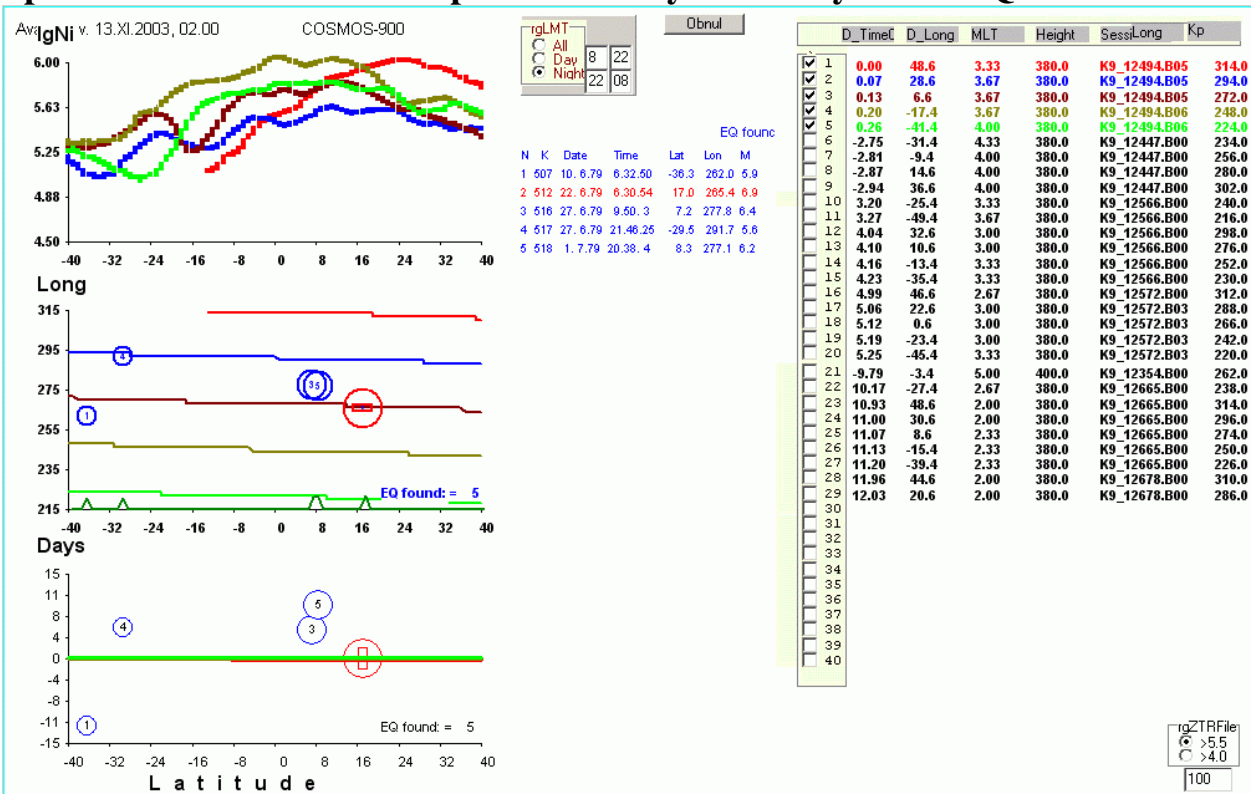
The K900 data were used to analyze situation for z512 quake :

Z512 M= 6.9 λ= 265.4 φ=+17.0 22.06.79 06h31m

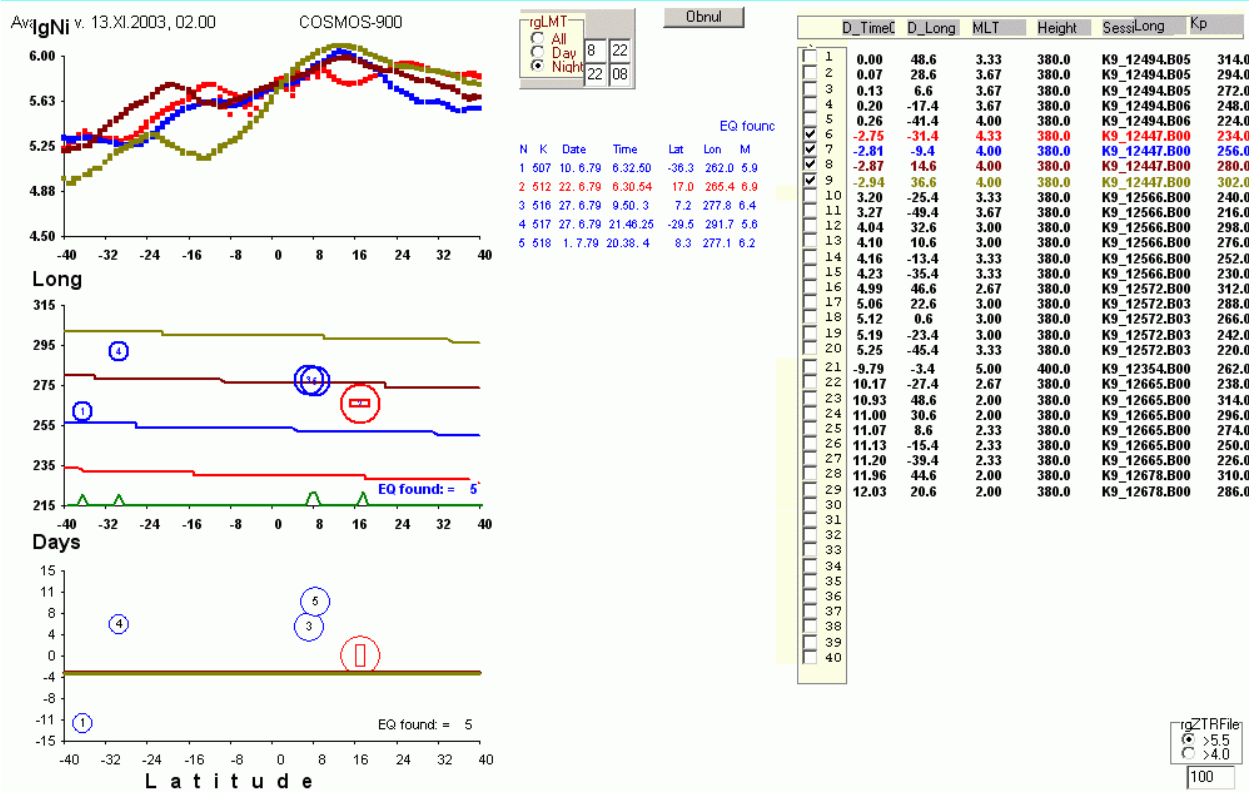
No effect - 2 passes at ~3 days and 1 pass at 0.06 days before EQ z512 at large longitude distances >60 degs



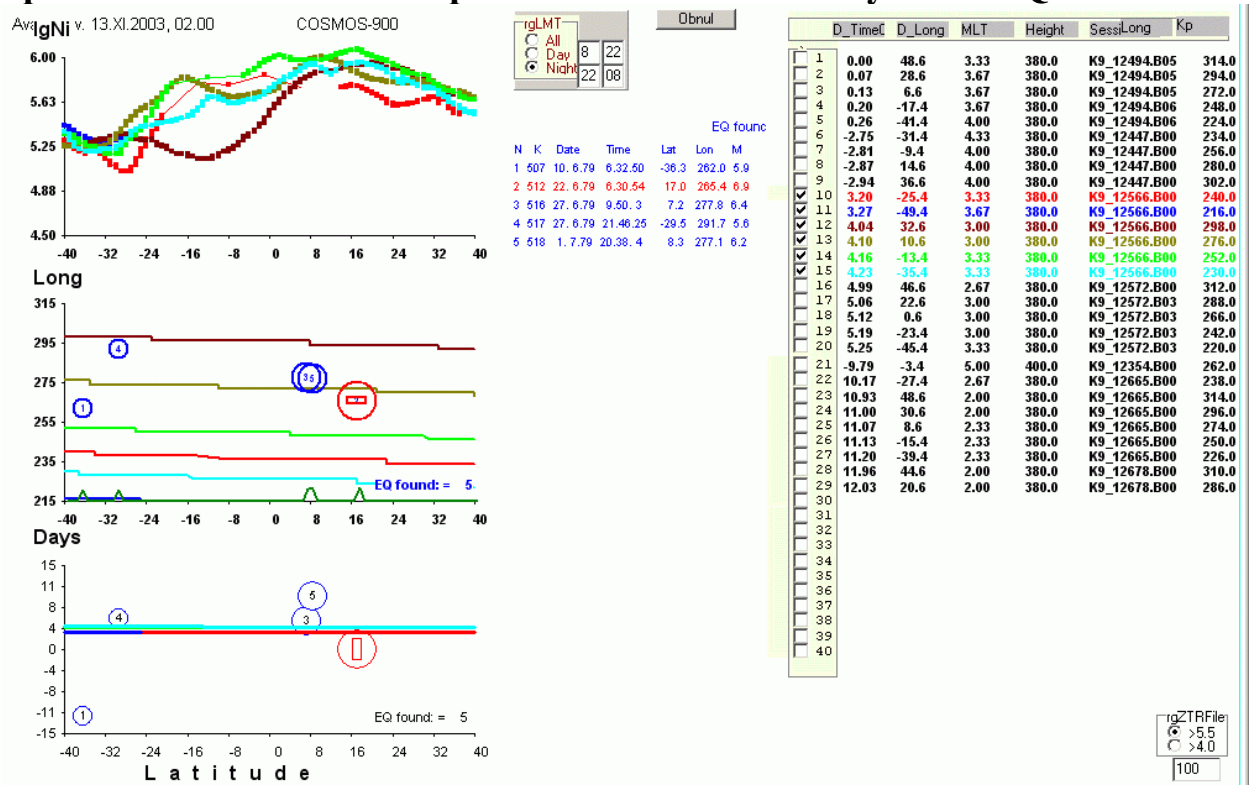
Specific wave-like effect – 5 passes at 0 days – 0.2 days after EQ z512



Specific wave-like effect – 4 passes at -2.75 – 2.94 days before EQ z512

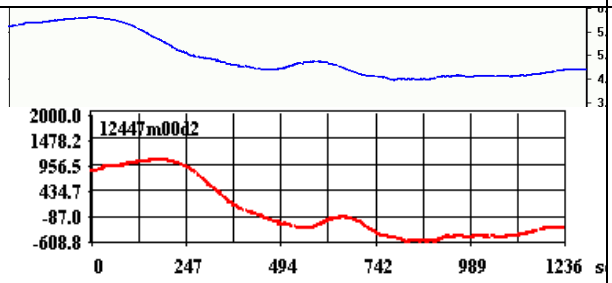
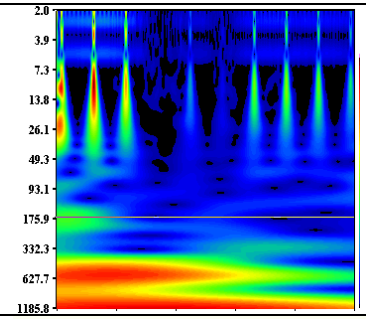
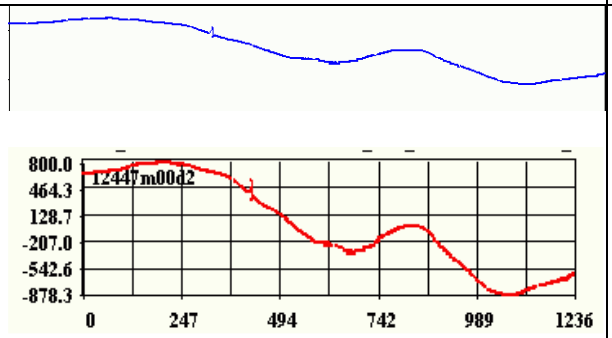
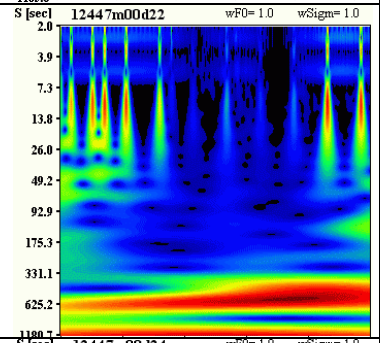
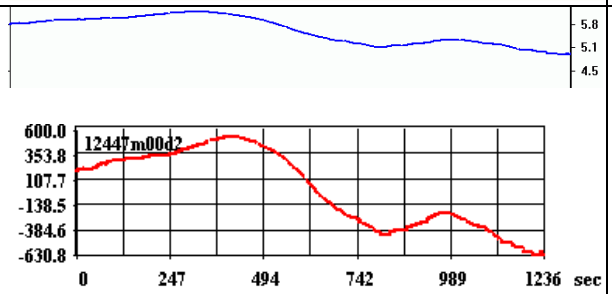
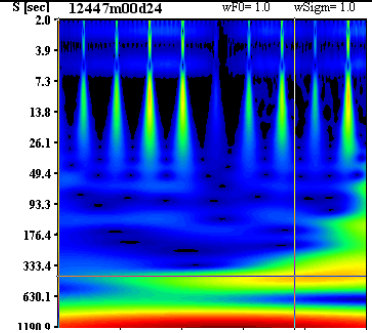


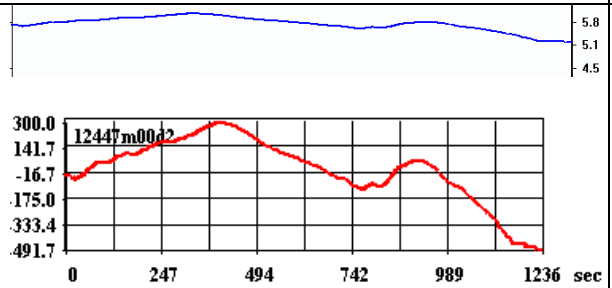
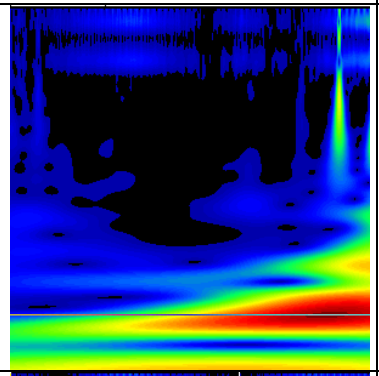
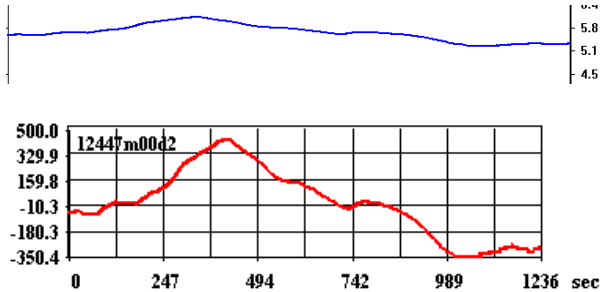
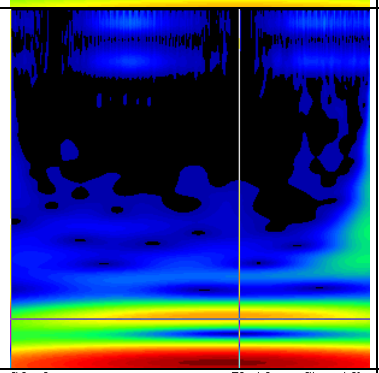
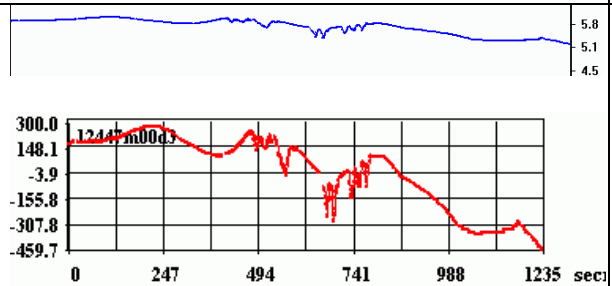
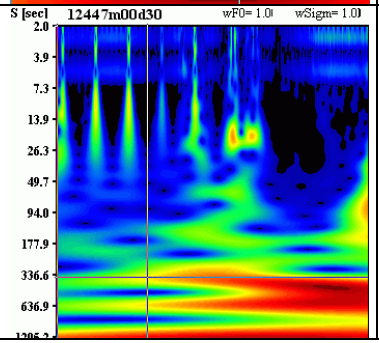
Specific wave-like effect – 5 passes at +3.20 …+4.23 days after EQ z512

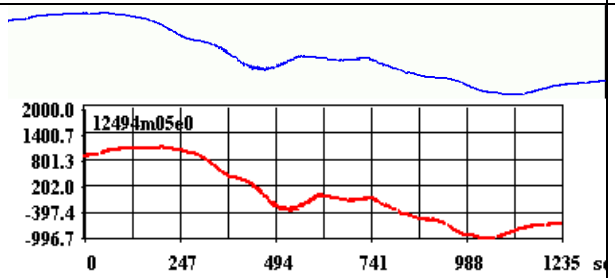
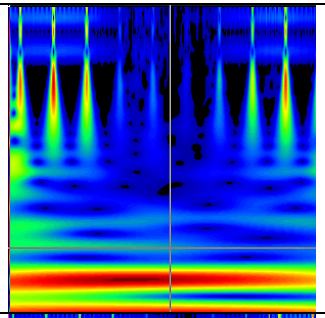
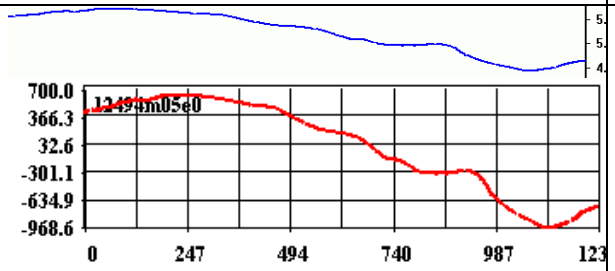
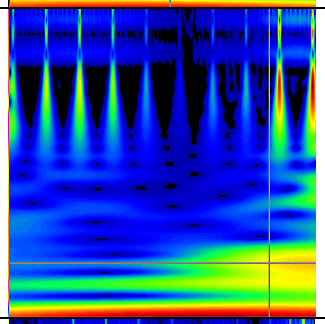
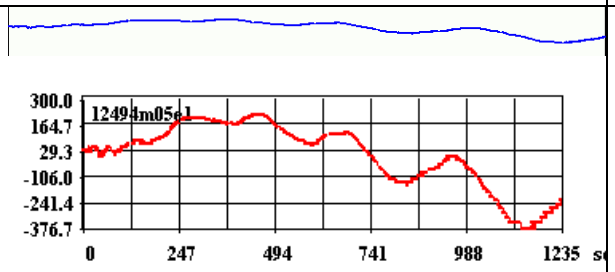
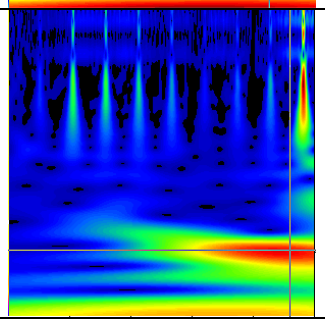


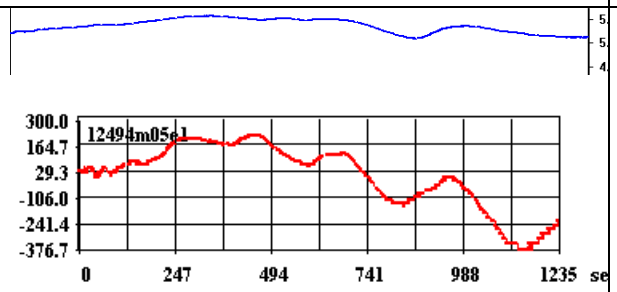
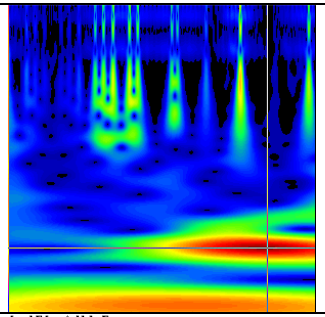
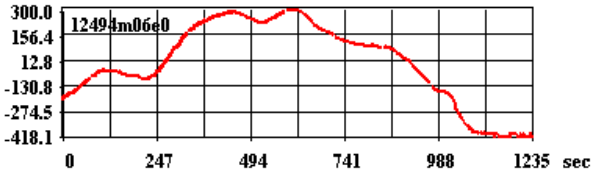
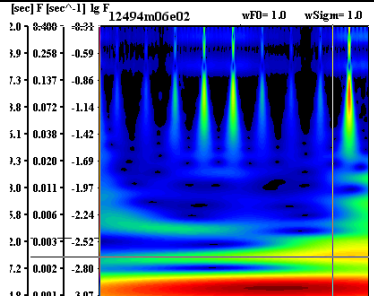
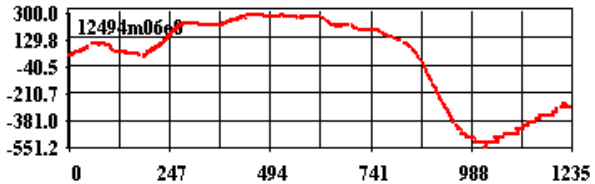
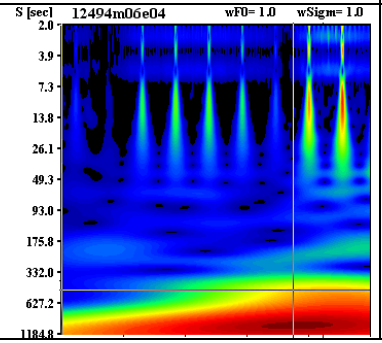
Z512 M= 6.9 λ= 265.4 φ=+17.0 22.06.79 06h31m

SW=340 means Scale =340 weakly defined

FileName			λeq	Δλeq	Δ days	Teq	Note	Closest EQ
12447m00d20 20			346	84.6	-3.07	19.06.79 04h46m	**NoEff** S=612	516m6.4-5d Δλ=13
12447m00d22 22			322	60.6	-3.00	19.06.79 06h18m	**NoEff** S=612	
12447m00d24 24			300	-35	-2.93	19.06.79 07h48m	**NoEff**	

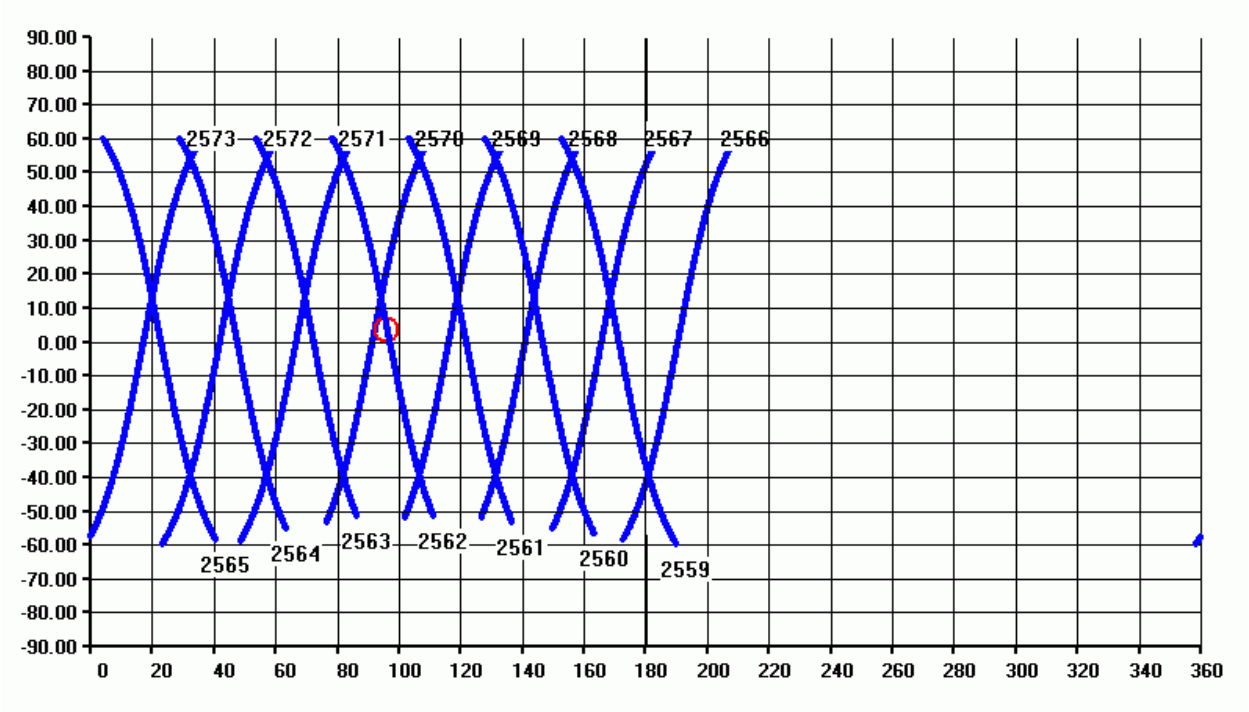
FileName			λeq	Δλeq	Δ days	Teq	Note	Closest EQ
12447m0026			280	14.6	-2.87		**S=430** **S=180** **S=360**	
12447m0028 28			256	-9.4	-2.81		S=1065 **S=485** **S=236**	
12447m00d30 30			234	-31.4	-2.75	19.06.79 12h27m	**S=353**	

FileName			λeq	Δλeq	Δ days	Teq	Note	Closest EQ
12494m05e07			337	**74.6**	-2h37m -0.06d	22.06.79 04h56m	**NoEff** S=1160 S=580	
12494m05e09			314	**48.6**	**0.00**	22.06.79 06h28m	S=1160 S=580 **S=411** **????**	
12494m05e11			291	**28.6**	**0.07**	22.06.79 08h01m	S=1116 S=544 **S=340**	

FileName			λeq	Δλeq	Δ days	Teq	Note	Closest EQ
12494m05e13			268	**6.6**	**0. 13**	22.06.79 09h32m	S=1055 **S=312**	
12494m06e02			248	-17.4	0.20		S=960 S=480 S=340W	
12494m06e04			224	-41.4	0.26			

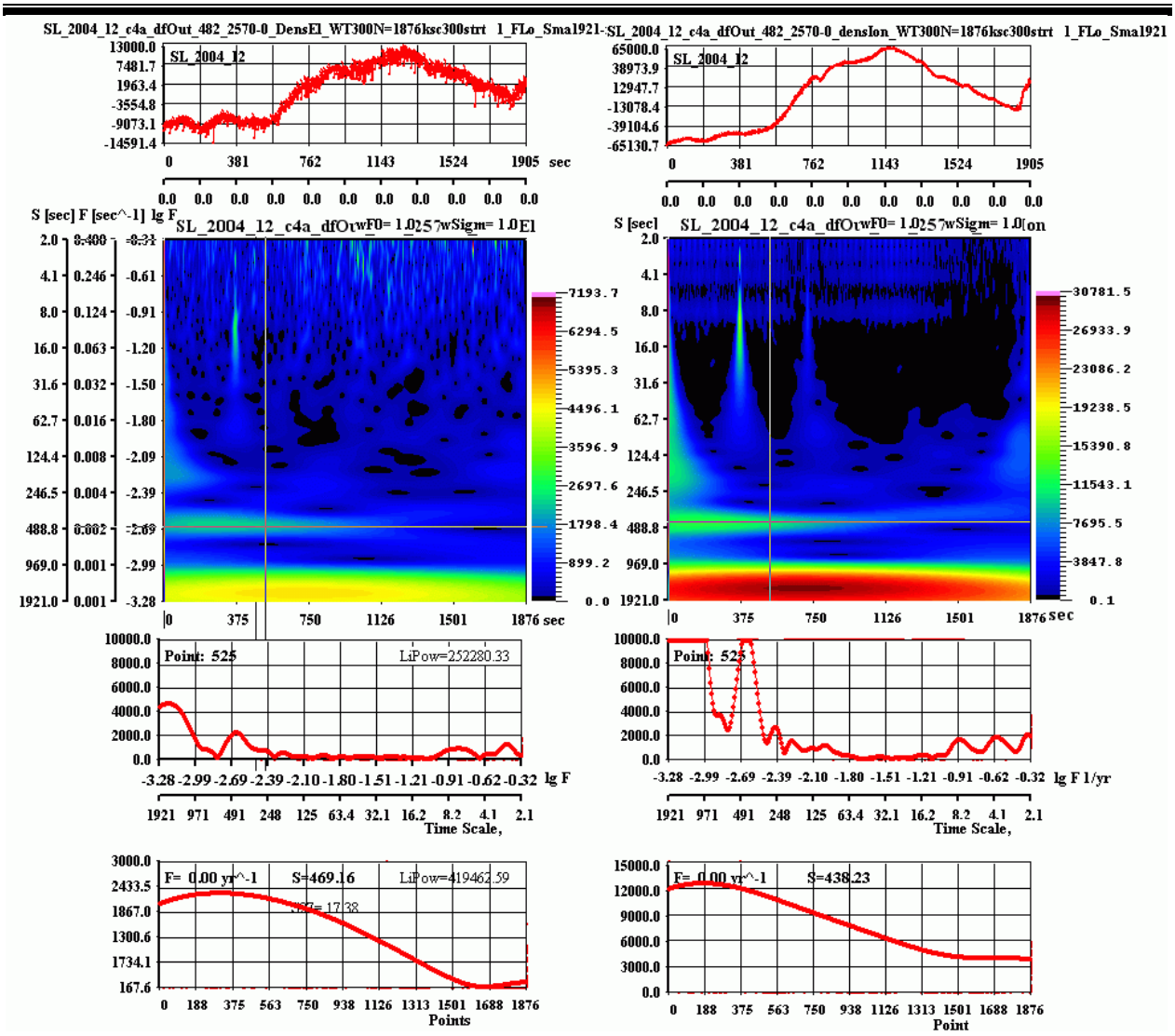
4.4 Search of possible seismic effects in DEMETER data

The DMT ISL_EQ data were used to analyze seismic situation :
Z861 M= 9.0 λ= 96.03 φ=+3.3 26.12.2004 00h58m

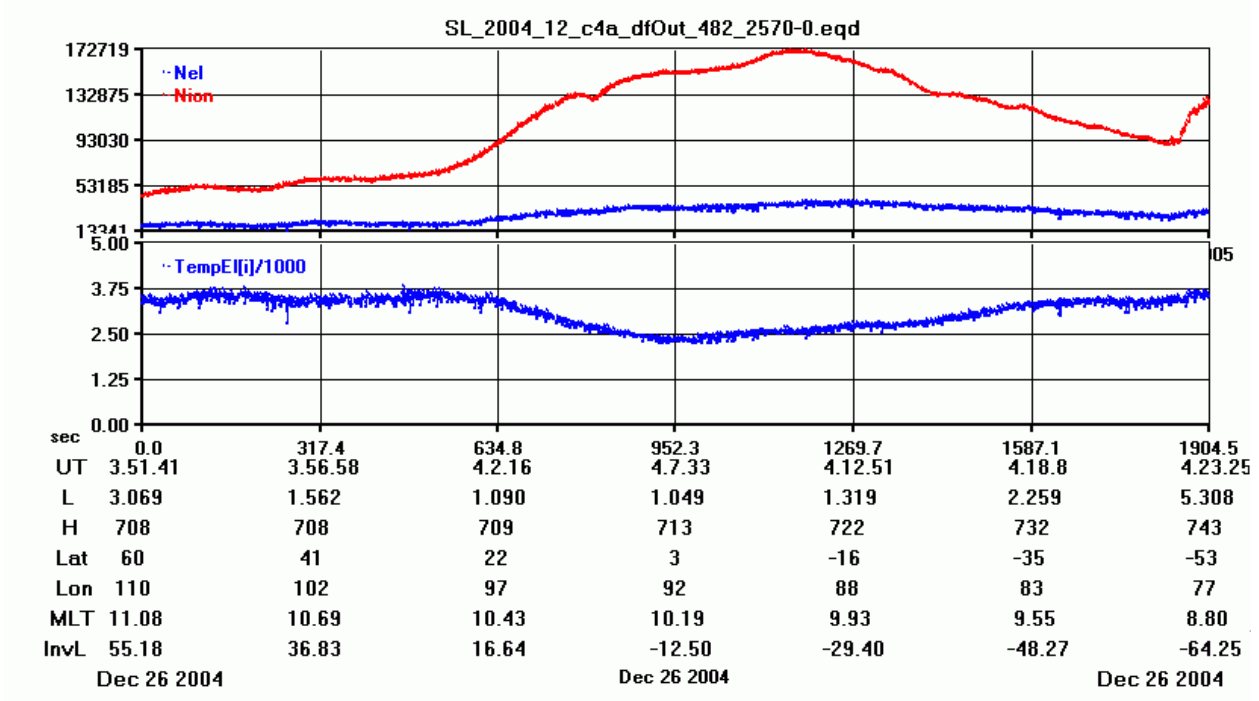


Location of DEMETER passes associated with earthquake event Z861.

Below are shown wavelet spectra for electron density *Ne* (left) and ion density *Ni* (right) for pass of DEMETER (half-orbit 2570-0) 3h after the quake at closest longitude distance +4 deg (eastward of EQ).



Variations of *Ne*, *Ni* and electron temperature *Te* along the same half-orbit 2570-0:

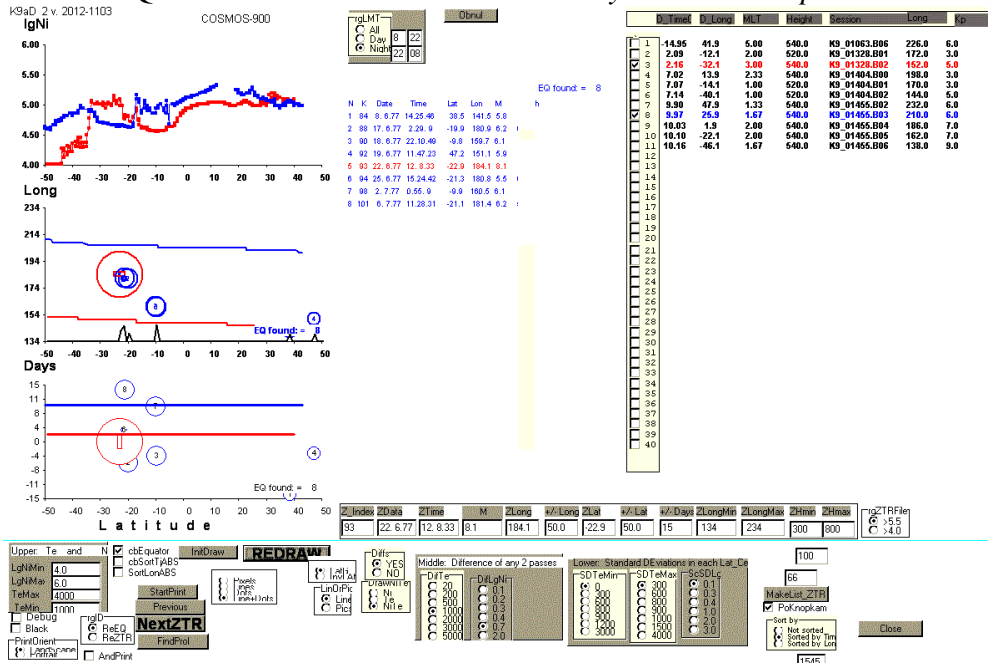


4.5 Local effects

In both sets of data - K900 and DMT – some rather strong local variations in the electron density *Ne* whose magnitude may vary up to 2-3 times are occasionally observed. These variations may be caused by seismic activity.

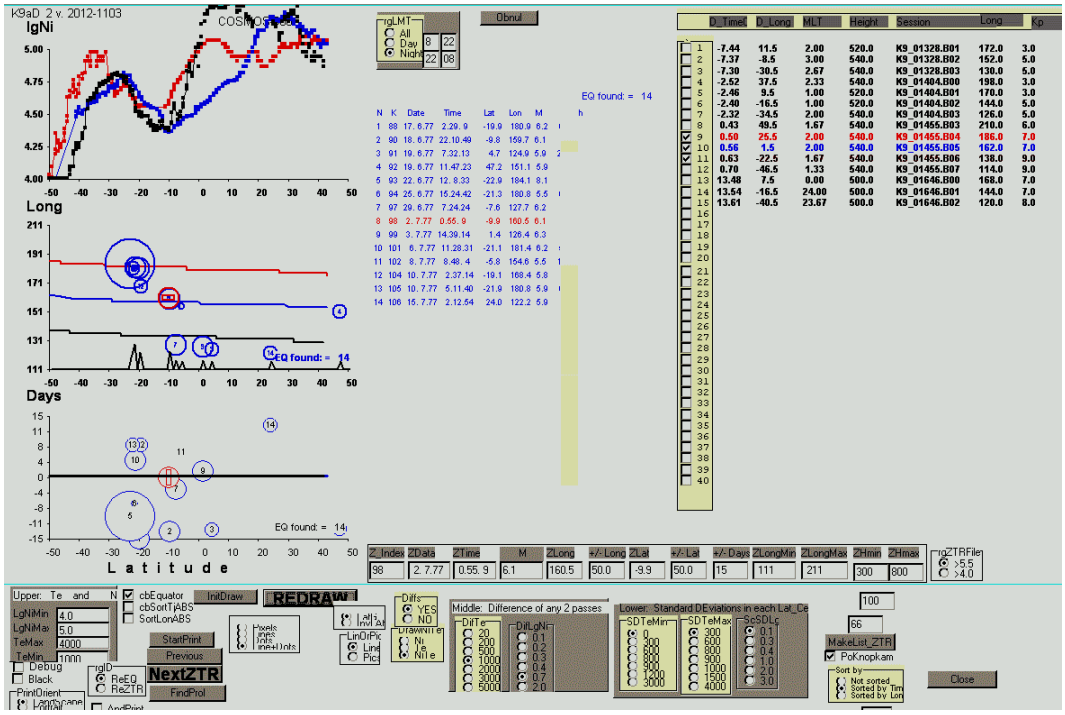
4.5.1 Example of sharp variations:

"Red pass" 2 days after strong EQ z93 with M=8.1. The density was raised by about 3 times. "Blue pass" occurred at about 10 days after the analyzed EQ z93 and thus hardly may be connected to it – see the blue trace in *Days-Latitude map* (lower plot at the left). But strong variations in this blue trace may be caused by EQ z98 with M=6.1 as the satellite passed very close to EQ z98 what is seen from the same *Days-Latitude map*.



4.5.2 Example of density depressions:

Three passes of K900 at ~0.5 days after EQ z98 at Δλ=25.5, 1.5 and -22.5 deg.



5 SUMMARY

Summarising the properties of these wave-like perturbations it is found that:

- They are seen in all plasma parameters. They are most pronounced in the plasma density, less so in the electron temperature. They are not observed in the spacecraft potential.
- They are most pronounced during nighttime periods at altitudes of the F2 region.
- They appear in the form of specific wave-like variations with characteristic time scales *S*=300-450 s - about 5-8 min (frequencies F=012-0.2 min^{-1}).
- They are field-aligned and usually fill the dome-like region up to $\Delta\lambda=\pm 25\text{-}30°$ by longitude and $\Delta\varphi=\pm 40°$ by latitude.
- Similar wave-like variation was observed at altitudes of DEMETER $Alt\approx 700$ km.
- In addition to the wave-like variations the events may appear in the form of either sharp changes in the density (piston-like variation) or local depressions of the density

These wave-like perturbations may be associated with enhancement of seismic activity as a forerunner to a large earthquake. It was found that

- These wavelike perturbations are observed to occur in the vicinity of earthquake epicenters.
- Within the F2 region such events were observed during the period 3-4 days before and after the earthquake.
- The analysis suggests a possible candidate for the signature of an EQ precursor: the appearance of wave-like variation with characteristic scales S=300-450 s.

These possibly seismic related wave-like variations are likely to be caused by dynamic wave-like processes in neutral atmosphere resulting from atmospheric gravity waves generated by the increase in seismic activity.
The localised piston-like variations are most probably caused by sharp appearance of EQ-related transverse electric fields which cause the plasma drift upward (for eastward E-field) or downward (for westward E-field).