Fast long-period waves in near-regional records of a shallow earthquake

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Efpalio 2010 earthquake

Unusual long-period waves were observed during the recent shallow earthquake in the Corinth Gulf, Greece (Mw 5.3, January 18, 2010). The waves with periods of ~5 sec were recorded at near-regional seismic stations in initial parts of records, see Figures 1 and 2. Starting simultaneously with the P-wave group, they are much faster than the fundamental modes of surface waves. Compared to the source duration of the earthquake (about 1 sec), the period of the observed waves is significantly longer and it indicates a structural effect, most likely the leaking-mode PL wave.

Table 1. Parameters of the Efpalio 2010 earthquake

date / time	hypocenter
hypocenter	38.4198° N, 21.9153° E, depth 6.6 km
centroid	38.42201° N, 21.94160° E, depth 4.5 km
moment	M0 = 0.97 · 1017 Nm
magnitude	Mw = 5.3
strike / dip / rake	102° / 55° / -83° 270° / 36° / -100°

See also EGU 2011-SM2.1/GD2.12/TS8.6

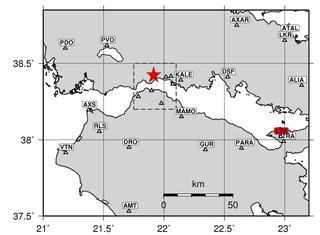

Fig. 1. Epicenter of the earthquake (star) and seismic stations close to the Gulf of Corinth. From Sokos et al., in prep.

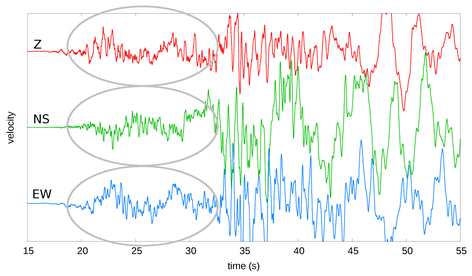

Fig. 2. The Efpalio earthquake recorded at Loutraki (LTK) seismic station. The investigated wave group is highlighted.

SVAL program for dispersion analysis

The SVAL program is an interactive software for frequency-time analysis of dispersed signals, based on the multiple-filter technique [Kolínský, 2004]. The code constructs several branches of the dispersion curve (all modes present in the seismogram) and enables extraction of the signal corresponding to a given mode.

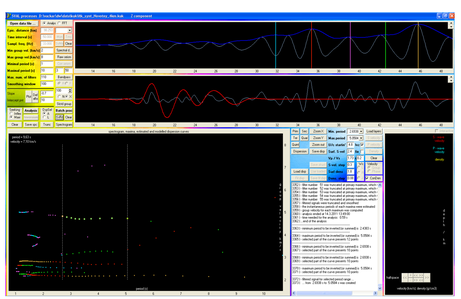

Fig. 3. Screenshot of SVAL program. The left bottom corner shows the spectrogram (period on x-axis, group velocity on y-axis, color points representing the dispersion curves). Top: The analyzed seismogram passed through one of the filters; the vertical lines correspond to the individual branches of the dispersion curve. Middle: The analyzed seismogram (gray) and the seismogram for the selected branch of the dispersion curve (red).

Frequency-time analysis of observed seismograms

Figure 4 demonstrates that the fast long-period wave group corresponds to a specific branch of the dispersion curve.

Multiple filtering method

$$S(F,t)=\int_{-\infty}^{\infty} G(f)W(f;F)e^{2\pi i f t}df$$

where *G(f)* is spectrum and *W(f; F)* is weight function with central frequency *F* and period *T*.

The spectrogram is defined as

$$P(F,t)=|S(F,t)|^2$$

We use Gaussian filter with constant relative width

$$W(f;F)=e^{\alpha(F)\frac{(f-F)^2}{F^2}}$$

$$\alpha(F)=\alpha\left(\frac{1}{T}\right)=a+b\frac{1}{T}$$

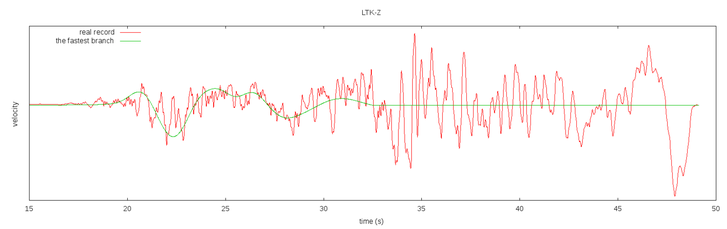

Fig. 4. Real seismogram from Efpalio earthquake recorded at Loutraki seismic station (red) with the signal corresponding to the fastest branch of the dispersion curve as found by the SVAL program (green).

Crustal models

Several crustal models are available for the region under study. Figure 5 shows models used to calculate synthetic seismograms.

The work in progress investigates the sensitivity of the models with respect to the (presumably) PL wave. The next step will be inversion of those parameters affecting especially the PL wave. The intention is *not* to construct a completely new crustal model, but rather to *modify* several paramerers in existing models, for example, in the Vp/Vs ratio in certain layers. It will be possible to invert either the seismograms of the extracted PL waves, or their dispersion curves.

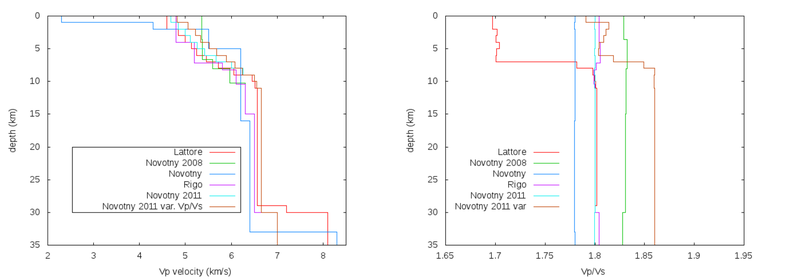

Fig. 5. Crustal models for the studied region, used to compute synthetic seismograms. Novotny [Novotny et al., 2001], Novotny 2008 [Novotny et al., 2008], Rigo [Rigo et al., 1996] and Latorre [Latorre et al., 2004]. Novotny 2011 are two models from simultaneous inversion of the structure and location, based on P and S arrival times of the Efpalio 2010 earthquake sequence, not yet published.

Frequency-time analysis of synthetic seismograms

At this preliminary stage we only demonstrate that some of the existing models, even without any modification, are able to display the features similar to the observed PL group. Synthetic seismograms are calculated by program AXITRA, based on the discrete wavenumber method [Bouchon, 1981]. The advantage is that the location and focal mechanism of the studied event have been recently investigated in detail (Sokos et al., in prep.). Figure 6 shows the identification of the fast long-period wave group by the frequency-time analysis.

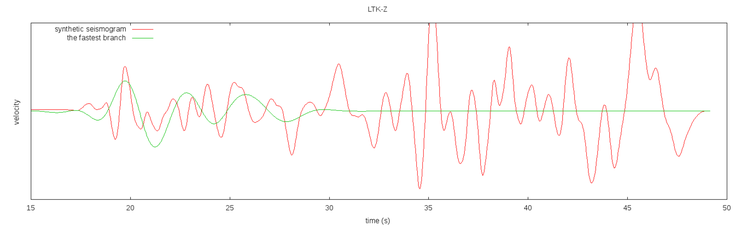

Fig. 6. Synthetic seismogram (red) for a point source with parameters similar to the Efpalio earthquake (the triangular time function, duration 1 sec, depth 4 km, other parameter according Table 1). Crustal model Novotny was used. The wave group coresponding to the fastest branch of the dispersion curve for this seismogram is in green.

Conclusion

This is a very preliminary report of the work in progress within the framework of the M.S. thesis. It is based on observation that many seismograms recorded during the recent event in Greece show features strongly resembling PL waves. The frequency-time analysis proved that a specific branch of the dispersion curve corresponds to the observed waves. Forward modeling of seismograms in existing crustal models of the region will enable sensitivity analysis of the studied wavegroup to certain parameters of the crustal model. The next study will be devoted to modification of the crustal models, e.g. Vp/Vs ratios, to improve the fit between the observed and calculated PL waves.

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