The Rupture Characteristics of the 1999 Izmit Earthquake Sequence Using Iris Data

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Introduction

We have used a new technique to calibrate the path effects of a large earthquake with a smaller aftershock for source determination. The arrival time picking has a significant role in determining the location of asperities in a source inversion. However, for large events, picking arrival times in teleseismic distances is a tricky practice. We overcome this difficulty by calibrating the path effects using a smaller event that is geographically close to the main event. We test our method using 1999 Izmit Earthquake sequence (Figure 1).

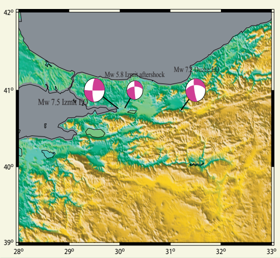


Figure 1: Local network (Kandilli) locations and Harvard CMT solutions of the events used in this study

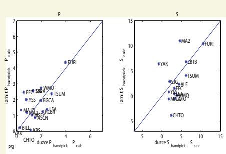
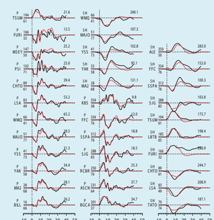


Figure 2: Comparison of variations in handpicked arrival times from the arrival times calculated with IASP 90 model.

Especially for S waves, the process of picking arrival times turns out to be harder for large events because of the presence of PS-coda arriving on top of the initial S onset. Since S waves have a slower apparent velocity, they are more sensitive to the rupture details. Hence picking their right arrival times is of critical importance.

The conventional method of doing source inversion involves "handpicking" of the arrival times of P and SH waves. The variations of handpicked arrival times from a reference one dimensional model are interpreted as a consequence of velocity variations. If that is the case, then two close events are predicted to have the same path corrections.

However, as can be seen in Figure 2, the variations of handpicked arrival times from IASP 90 model, differ significantly despite the proximity of the two events. Especially, the incompatibility of the SH wave arrival picks is significant. In most stations, Izmit SH handpicks are earlier compared to Duzce picks.



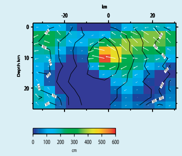


Figure 3, 4: Waveform fits and spatial distribution of slip for Nov 12, 1999, Mw7.2 Duzce Event using the inversion method by Ji, *et al*, 2002. Note that the slip is concentrated around the hypocenter.

We used the KOERI (Turkey) location for inversion. A single plane dipping 54°, from InSAR and GPS studies of Burgmann, et al, 2002 was used for the source inversion.

Inversion was done in two steps. First we perform an inversion with only handpicked P waves to get a preliminary distributed slip. We use this preliminary model to forward calculate synthetic seismograms and cross-correlate them with all the records that will be used in inversion. The time shifts obtained in this process are used to perform a second inversion with both P and SH waveforms.

Our inversion fits the teleseismic body waves very well. This inversion is also consistent with the result of joint InSAR and GPS inversion of Burgmann, et al, 2002.

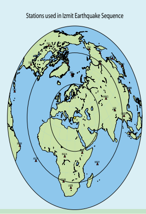


Figure 5: Stations used in Izmit Earthquake series.

A key point here is to use the same station distribution for both Duzce and Izmit Earthquakes. The Duzce Earthquake study provides us the time shifts reference to IASP 90 model

Results for 17 Aug, 1999, Izmit Earthquake

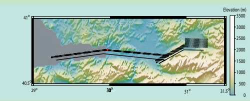


Figure 6: Izmit Earthquake is modelled with four segments based on the surface rupture observations (Delouis *et al*, 2002).
The dip of each segment is modified from a model by Wright *et al*;,2001, based on inversion of InSAR data for six segments.

Figure 7: Waveform fits, Rupture Pattern , Static Field and GPS predictions for the inversion with the Calibrated Arrival Times

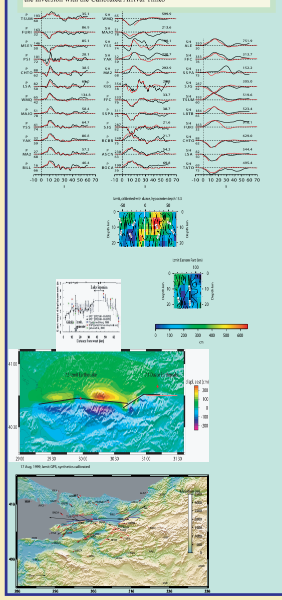
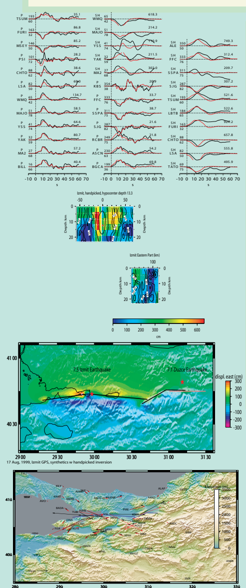


Figure 8: Waveform fits, Rupture Pattern, Static Field and GPS predictions for the inversion with the Handpicked Arrival Times.



Results

Using calibrated arrival times reduces the overall waveform mismatch of the teleseismic data (~0.20 vs. 0.25).

The slip distribution for the two inversions differ considerably. For the calibrated inversion, the maximum displacement is to the east of the hypocenter, while it is west in the handpicked inversion. The asperity to the west is deeper in calibrated inversion. This effect is clearly revcealed in the estimated static field plots.

The SPOT data is more consistent with the calibrated arrival time inversion. The maximum slip in east-west direction is on the eastern end of Lake Sapanca as it is revealed in spot data.

The GPS predicted from handpicked inversion fits the data better than calibrated inversion. Relatively poor fit of the calibrated inversion is due to north south component of the slip. The reason for this could be the complexities of the fault geometry as well as the slip distribution. However, understanding the actual reason for this inconsistency (fitting SPOT data better, but fitting GPS poorer) remains as a future work for us.

References

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Conclusions and Future Work

The method of picking the arrival times changes the size and significance of asperities and their relative locations. We argue that the handpicking of arrival times may end up not only correcting for the ray path, but also changing the locations of the asperities.
The SH wave arrivals are harder to pick for larger events due to PS-coda arriving on top of the initial S onset. For large events this coda is more significant. Therefore, the calibration method can improve the SH wave arrival picks.

The SPOT data is more consistent with our preferred method of calibrating the arrival times; however, GPS predictions are not. This remains as a future problem for us to solve. Therefore future work will involve using geodetic data (GPS, InSAR and SPOT) to further constrain fault geometry and slip.