Regional Moment Tensor Analysis of Earthquakes in Iran for 2010-2017 Using In-Country Data

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Introduction

Located in the middle of the Arabia-Eurasia continental collision, Iran is one of the most tectonically diverse and seismically active regions in the world. Broadband seismic networks operated by the Iranian Institute of Engineering Seismology (IIEES) and the Iranian Seismological Center (IRSC) currently consist of more than 100 stations, allowing for routine three-component full-waveform regional moment tensor analysis of Mw > 4.0 earthquakes throughout the country. Using openly available data from in-country and nearby IRIS and EIDA stations for the period from 2010 to 2017, we have calculated more than 500 moment tensors for earthquakes from Mw 3.6 to 7.8. The resulting database provides a unique, detailed insight into deformation styles and earthquake depths in Iran.

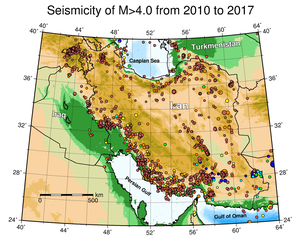

Figure 1:Map of Iran with seismicity plotted for the study period. Red events have published depths less than 10 km, and events deeper than 100 km are dark blue. Most of the seismicity in Iran occurs shallowly in the Zagros Mountains, spanning the area inland from the border with Iraq and the Caspian Sea coast. Deep seismicity occurs rarely, and due to the subduction occurring in the Gulf of Oman.

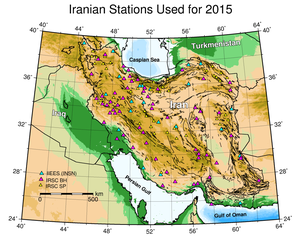

Figure 2:Map of Iran showing locations of broadband stations used in this study, as well as faults from tk. The regional networks are operated by the Iranian Seismological Center (IRSC) of the Institute of Geophysics, University of Tehran and by the International Institute of Earthquake Engineering and Seismology. Not shown but used whenever possible for better azimuthal coverage are nearby (<1200 km) broadband stations operated by Incorporated Research Institutions for Seismology (IRIS), Observatories and Research Facilities for European Seismology (ORFEUS), and GEOFON. The majority of large seismicity in Iran occurs away from the geographic center, requiring stations outside of the country for more adequate coverage.

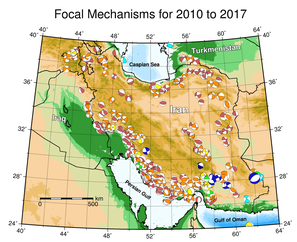

Figure 3:Map of Iran with focal mechanisms from 2017 plotted. For the year 2017, tk events had regional data available, and it was possible to calculate tk focal mechanisms throughout the country.

Comparison to Global Data

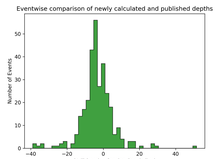

Figure 4:Comparison of calculated earthquake depths from the global ANSS catalog and from this study. The chart shows a roughly normal distribution around -4, indicating that most seismicity in Iran is shallower than the previously published depths. This is due in large part to the minimum resolvable depth in the ANSS catalog being deeper than the average Iranian earthquake.

Placeholder

Image

Figure 5:Placeholder for a more detailed depth comparison, comparing depths published by IRSC to those calculated here, and breaking down the depth change by tectonic province.

4 April 2017, M_w 6.1

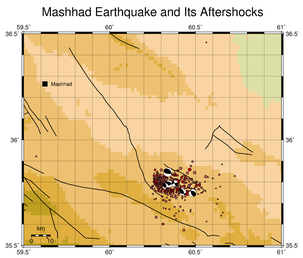

Figure 6:Map of 4 April 2017 mainshock-aftershock sequence. The large square marks the city of Mashhad, the largest nearby population center with more than 2.5 million residents. Seven aftershocks were large enough and had low enough background noise to allow moment tensor inversion. These and the mainshock are plotted as black beach balls. Bright red circles indicate aftershocks that occurred on April 4th and 5th, while dull red circles indicate aftershocks for the remainder of the year. Thick, black lines are faults from tk.

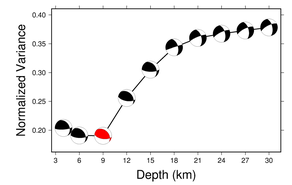

Figure 7:Depth-variance plot for the mainshock. Misfit drops significantly for 4-9 km range, indicating that the event was shallow and principally reverse faulting.

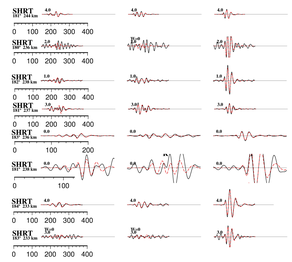

Figure 8:Comparison of station SHRT across events with moment tensor solutions. SHRT was roughly due South and 240 km from the sequence, and had useable components for all eight calculated events. This figure needs to be redone with actual scaling, and also labels for the individual events.

12 November 2017, M_w 7.3

The M_w=7.3 Zgleh earthquake struck the Iran-Irap border region at 18:18 UTC on 12 November 2017. This is globally the deadliest earthquake of 2017 killing more than 500 people. The likely causative fault is a shallow dipping thrust fault probably associated with the Mountain Front Fault system, which extends northwestward, e.g., faults shown near 34N-46E. The largest aftershock reached M_w 4.7, considerably smaller than the main shock. Event depths are primarily in the 8-12 km range with the main shock (centroid) at 15 km.

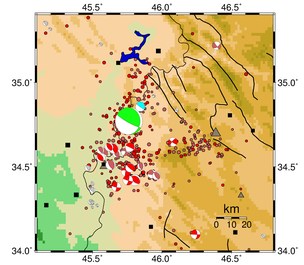

Figure 9:Map of the region on the Iraq-Iran border where the earthquake occurred. Focal mechanisms show the foreshock (cyan), mainshock (green), and 20 larger aftershocks (bright red for first 30 hours following the mainshock and muted red for the following week. Squares mark larger towns and cities. Triangles mark seismic stations–small triangles for short period instruments, and large triangles for broadband. Thick solid lines are faults from Pollastro et al. (1999) after the Haghipour and Aghanabati (1985). Small gray focal mechanisms show background activity from regional moment tensor inversion (1999-2013). The faults north of the events are part of the High Zagros Fault system.

Future Work

Maecenas ultricies feugiat velit non mattis. Fusce tempus arcu id ligula varius dictum.

- Automate or nearly automate inversion process
- Eu facilisis est tempus quis
- Duis porta consequat lorem

References