TRAVEL-TIME SOURCE SPECIFIC STATION CORRECTION IMPROVES LOCATION ACCURACY

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INTRODUCTION

Accurate earthquake locations are crucial for investigating seismogenic processes, as well as for applications like verifying compliance to the Comprehensive Test Ban Treaty (CTBT). Earthquake location accuracy is related to the degree of knowledge about the 3-D structure of seismic wave velocity in the Earth. It is well known that modeling errors of calculated travel times may have the effect of shifting the computed epicenters far from the real locations by a distance even larger than the size of the statistical error ellipses, regardless of the accuracy in picking seismic phase arrivals.

We have developed a method of seismic location to minimize this systematic shifts affecting hypocentral locations. These methods are based on the fact that each shift is quite similar for events far from the hypocenters are close to each other with respect to their distance from the recording stations. So this method is based on a set of Ground Truth events recorded by a dense local seismic network in seismically active regions.

The applications concern seismic sequences recorded in Italy and Iran.

We show that mislocations of the order of 10-20 km affecting the epicenters, as well as larger mislocations in hypocentral depths, calculated from a global seismic network can be effectively removed by applying source-specific station corrections applied to the standard IASPEI91 travel times.

METHODOLOGY

We located the selected events using a least-square single-event location algorithm developed at our Institute (Istituto Nazionale di Geofisica e Vulcanologia – INGV) applied to a global network of seismic stations. In our algorithm the hypocentral positions are computed from geometrical coordinates through the WGS84 ellipsoid model of the Earth. Moreover the travel-times are based on IASPEI91 tables and they are corrected both for the ellipticity of the Earth and for station elevation.

Assuming the local seismic network determined as a reference data set, we computed the differences between the observed arrival times and those computed starting from the hypocenters and origin times reported by the local seismic network at all the recording stations. For each station we computed the average and the standard deviation. The mean residuals were applied to the hypocenter location algorithm as corrections to the computed standard travel times.

ITALIAN CLUSTER

P-wave arrival times at 59 seismic regional or teleseismic stations from 16 earthquakes located in central Italy, were obtained from the online Bulletin of International Seismological Centre (ISC, http://www.isc.ac.uk). All the events occurred during the sequence in March-June 2009 in the area of L’Aquila (4.1 ≤ ML ≤ 5.9).

We considered two clusters of events, the first to the north-west of the country (Area A) and the second to the south of the country (Area B). The local seismic network taken as reference is TEH (operated by the Iranian Seismological Center, IRSC).

IRANIAN CLUSTERS

We have also addressed the question of how the size of the error ellipses depends upon the number of arrivals included in the input data. The method adopted starts from the whole dataset with the elimination of the number of stations by steps of 3, and then relocation of all the events at each step. A comparison between the epicenters obtained including or not systematic travel-time corrections and the INGV epicenters (blue dots) is shown below for only two steps. The shape and orientation of the error ellipses depend on the geometry of the observing seismic stations with respect to the hypocenters.

CONCLUSION

A comparison between the epicenters obtained including or not systematic travel-time corrections and TEH epicenters (blue dots) is shown above. The shape and orientation of the error ellipses depend on the geometry of the observing seismic stations with respect to the hypocenters.

We have developed a method of seismic location to minimize this systematic shifts affecting hypocentral locations. These methods are based on the fact that each shift is quite similar for events far from the hypocenters are close to each other with respect to their distance from the recording stations. So this method is based on a set of Ground Truth events recorded by a dense local seismic network in seismically active regions.

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