Centro di Ricerche Sismologiche

ISTITUTO NAZIONALE DI OCEANOGRAFIA E DI GEOFISICA SPERIMENTALE

TUNING ANTELOPE CONFIGURATION FOR BEST EARTHQUAKE LOCATION

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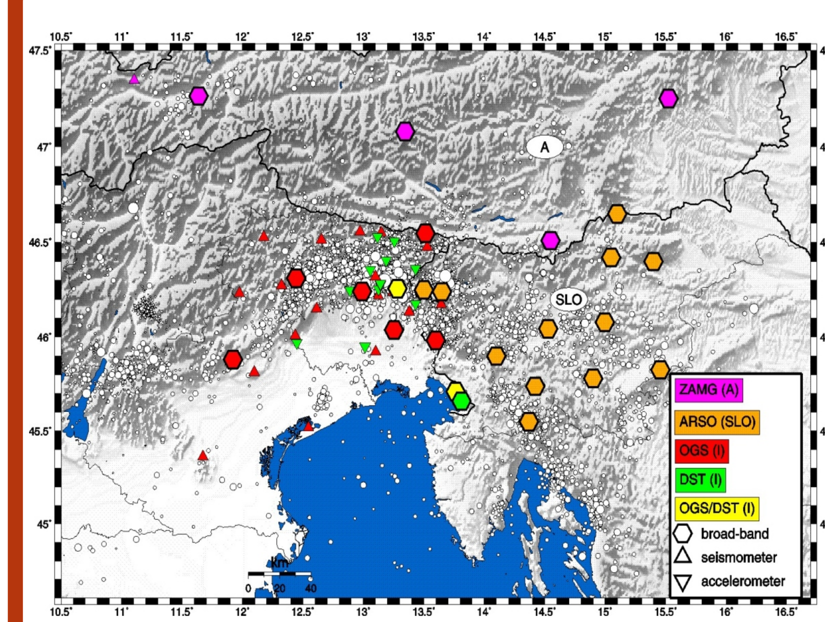


Fig. 1

The large amount of digital data recorded by permanent and temporary seismic networks makes automatic analysis of seismograms and automatic wave onset time picking schemes of great importance for timely and accurate earthquake locations. Since 2002 the Centro di Ricerche Sismologiche (CRS, Seismological Research Center, http://www.crs.inogs.it/) of the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS, Italian National Institute for Oceanography and Experimental Geophysics) is involved in the EU Interreg IIIA project "Trans-national seismological networks in the South-Eastern Alps" together with other four institutions: the Earth Science Department of the Trieste University in Italy, the Civil Protection Department of the Friuli-Venezia Giulia Autonomous Region (DPCFVG) in Italy, the Environmental Agency of the Republic of Slovenia (ARSO), and the Austrian Central Institute for Meteorology and Geodynamics (ZAMG). The Antelope software suite has been chosen as the common basis for real-time data exchange, rapid location of earthquakes and alerting. Each institution has an instance of Antelope running at its data center and acquires data in real-time from its seismic stations and those of the other partners (Fig.1). Antelope detects events by STA/LTA algorithm and the association is based on location by grid search. The initial set up tuned at University of Trieste for fast location capabilities used only P arrivals. The location was performed by grid search over 87x81 nodes for an extension of 7x6.4 degrees (corresponding to cells of 8.9 km in longitude and 8.7 km in latitude) centered in Lat=46.26°, Lon=13.28° with depth steps at 0, 2, 4, 6, 8, 10, 12, 14, 16, 20 and 24 km, using the 1D uniform velocity model IASPEI91.

Recently the CRS acquired a new SUN cluster hardware: consequently a new set up of the Antelope software suite has been tested to improve location accuracy using a denser grid. The results of the performances of the new configuration will be shown. The location is performed by grid search over 87x81 nodes for an extension of 3x2.26 degrees (corresponding to cells of 4.1 km in longitude and latitude) centered in Lat=45.83°, Lon=12.33° with depth steps every 2 km from 0 to 30km, using the 1D uniform velocity model IASPEI91. The performances of the method are compared with the ones of the Friuli Automatic Alert System (FAAS, Bragato and Govoni; 1999) which monitors the Friuli-Venezia Giulia region (NE Italy) and the surrounding area based on 21 short period stations (red triangles in Fig.1, Priolo et al.; 2005 - Bragato et al.; 2003), and with the manually revised data available in the NEI (North Eastern Italy) network bulletin (OGS database)

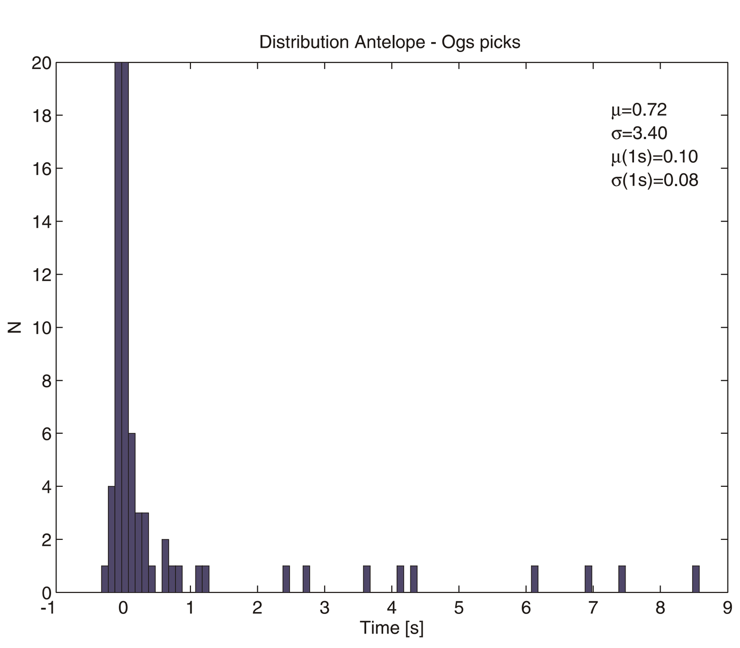


Fig 2

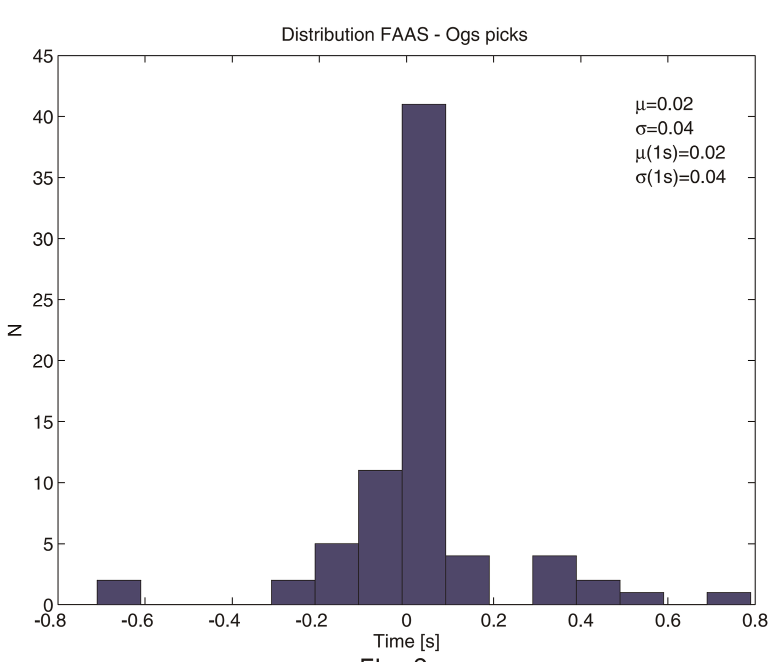


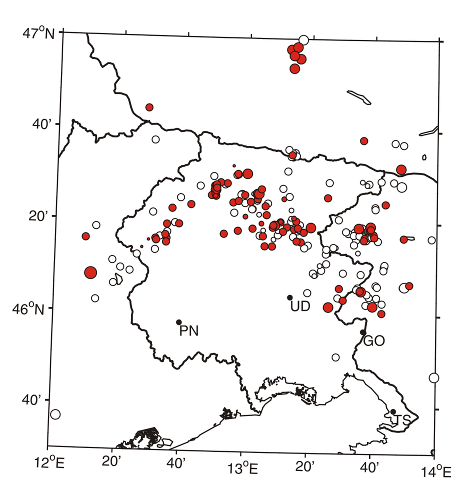
Fig 3

Picking: P waves picking times of FAAS and Antelope have been compared with those in the OGS database. From the Figures 2 and 3 it is possible to see that both FAAS and Antelope pick some hundredth of seconds after the OGS database. The mean and the variance have been calculated considering the entire data set and after eliminating the outliers (picks farther than 1s from the corresponding manual ones). Besides the variance relative to the manual picks, following Gentili and Bragato (2006) we have estimated the absolute variance of the three data sets (i.e. the variance of the difference between the real, unknown arrival times and the picked ones). In general, given two independent data sets A and B, it holds the relation var(A-B)=var(A)+var(B). Combining in a system the three equations derived for the available data sets, we have obtained, after the outlier rejection:

$$\mathrm{var(Antelope)}=0.06\pm0.03s^2,\quad \mathrm{var(FAAS)}=0.011\pm0.08s^2,\quad \mathrm{var(OGS)}=0.013\pm0.007s^2$$

Event detection: the capability of detecting earthquakes depending on their magnitude has been analyzed (maps in the Figures 4-6 and histograms in the Figures 7-18). For the two systems we have considered the area monitored by FAAS (coordinates: LON=[12-14],LAT=[45.5-47]). For Antelope we have also considered the larger trans-national area of interest for the INTERREG project (coordinates: LON=[12.0-15.7], LAT=[44.5-47.4]). It emerges that for the smaller area, the maximum magnitude of not detected earthquakes is 2.7 for FAAS and 2.0 for Antelope. For the larger area, the maximum magnitude of the events lost by Antelope is 4.4. This last is due to the new denser grid being shifted to the East. It must be noted also the short period covered by this preliminary test.

Fig 4



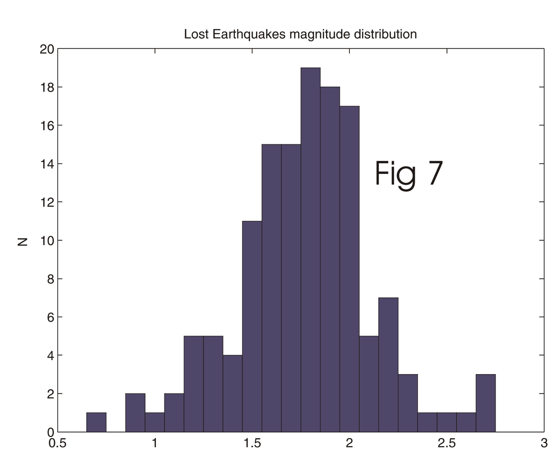


Fig 7

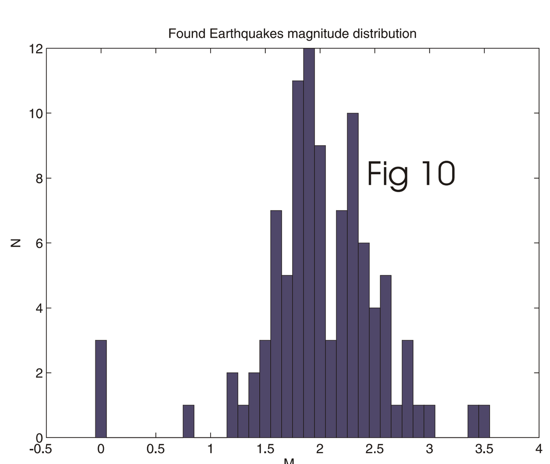


Fig 10

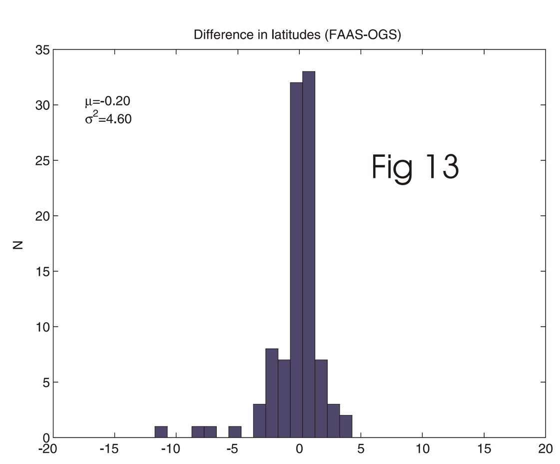


Fig 13

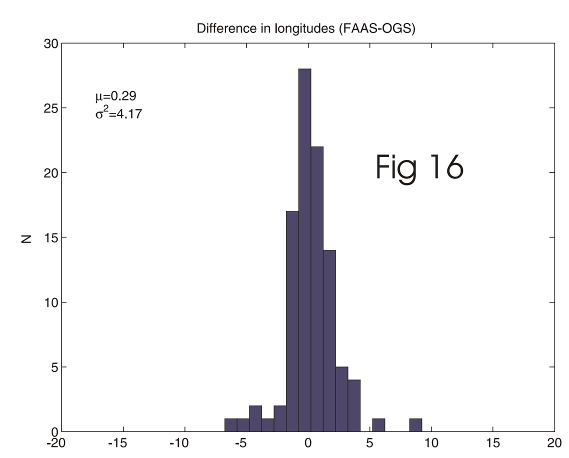
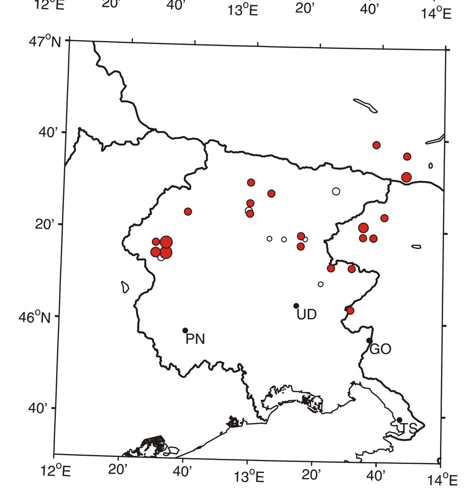


Fig 16

Fig 5



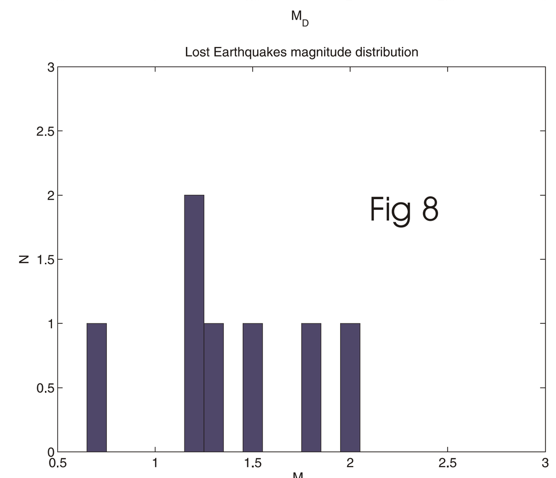


Fig 8

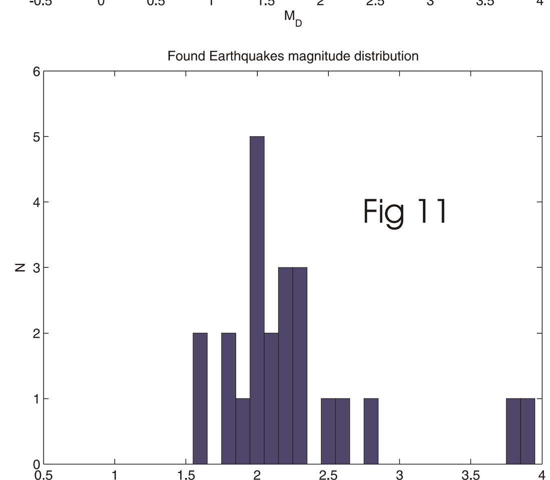


Fig 11

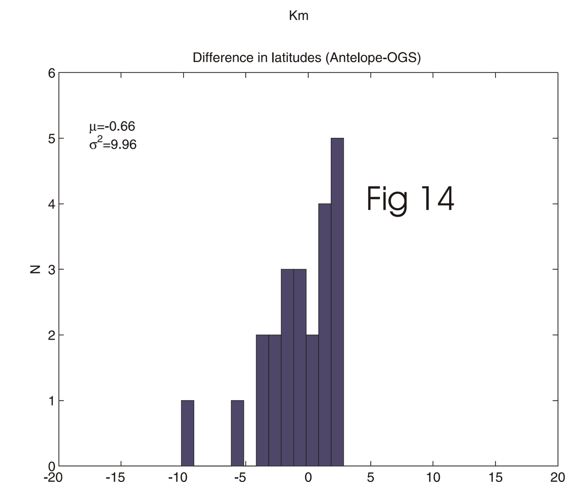


Fig 14

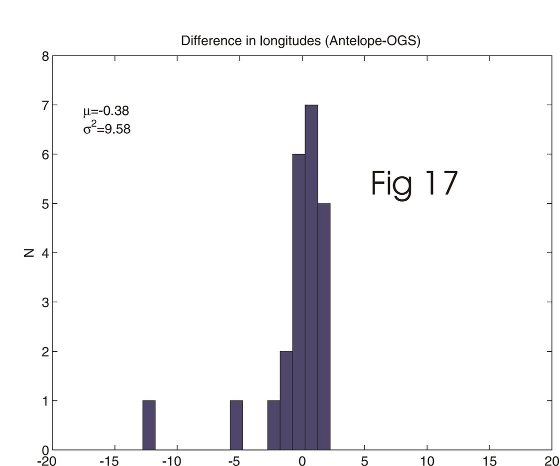
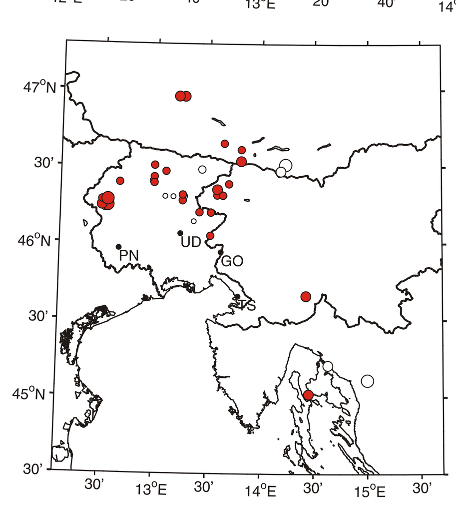


Fig 17

Fig 6



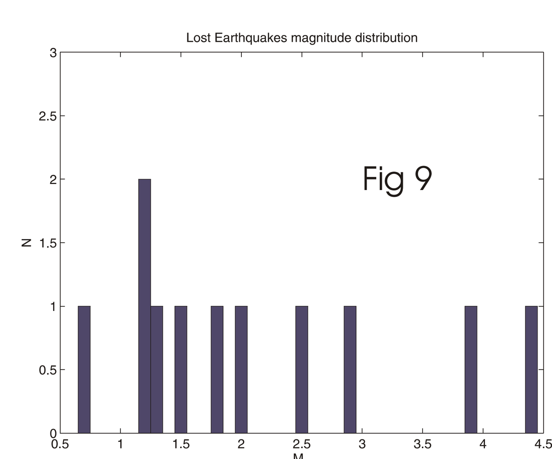


Fig 9

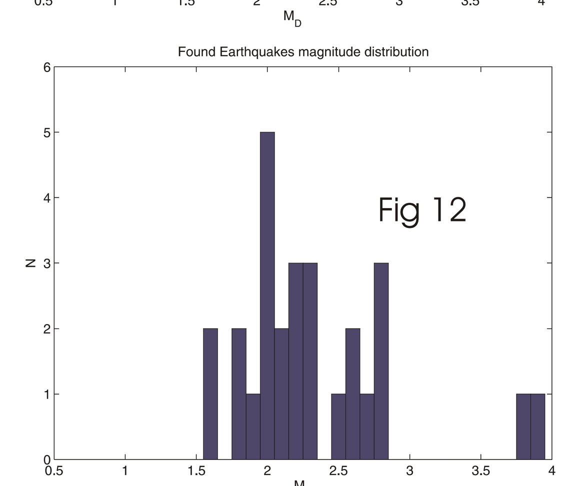


Fig 12

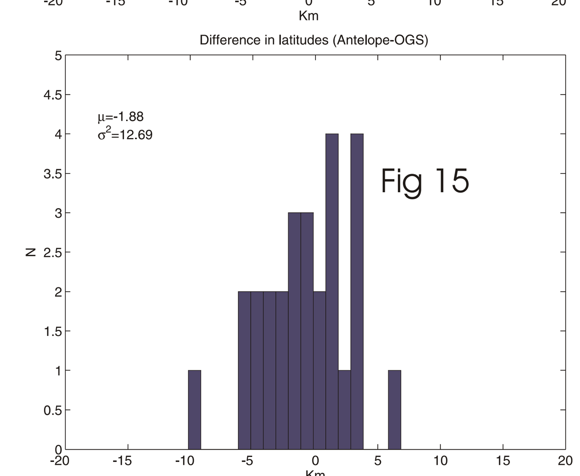


Fig 15

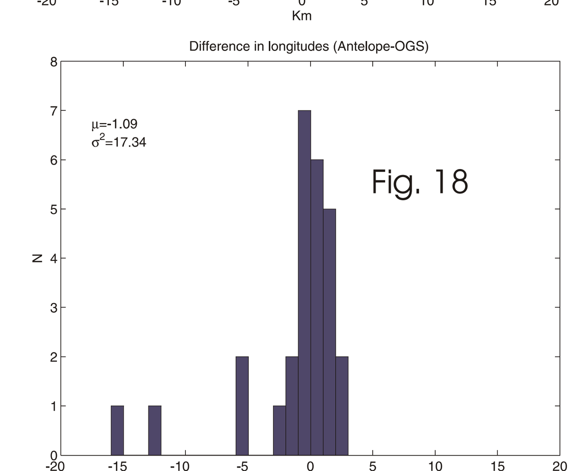


Fig. 18

Conclusions: regarding the accuracy in location, the systematic error of both FAAS and Antelope relative to the OGS bulletin (μ in figures 13-18) is below 1 km for the smaller area: this result does not change passing from the old grid to the denser one. Using the same method described above for the picks and considering the small area monitored by FAAS, we have estimated the absolute variance of the locations in the three data sets referred to the real, unknown epicenters: var_{LONG}(Antelope)=5.1 km^2, var_{LAT}(Antelope)=3.8 km^2, var_{LONG}(FAAS)=5.6 km^2, var_{LAT}(FAAS)=1.6 km^2, var_{LONG}(OGS)=0.0 km^2, var_{LAT}(OGS)=0.0 km^2.

The denser grid therefore enhances the performances of the system that passes from var_{LONG}(Antelope)=30 km^2 and var_{LAT}(Antelope)=16 km^2 with the intial set up (Gentili et al.; 2006) to var_{LONG}(Antelope)=5.1 km^2 and var_{LAT}(Antelope)=3.8 km^2 with the denser grid, i.e. performances comparable with FAAS system ones. The next step in improving Antelope performances will be in improving pickings quality by determining optimum STA/LTA parameters and using S phase arrivals.

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