RU DST-UNITS: Fast moment magnitude estimation and ShakeMaps computation in the Southeastern Alps.

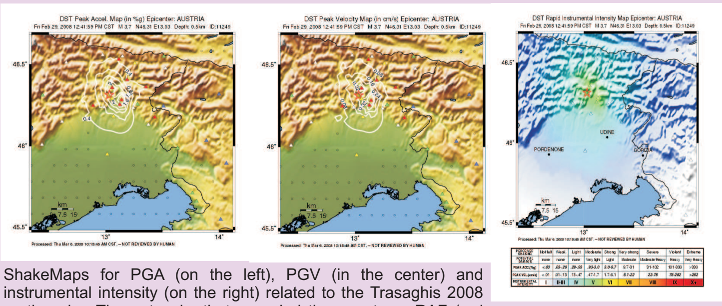
Costa G., Gallo A., Laprocina E., Moratto L., Suhadolc P.

Dipartimento di Scienze della Terra, University of Trieste, via Weiss1- 34127 Trieste, costa@units.it

ABSTRACT

In the framework of Project INGV-DPC S3 (2007-2009), a stable and automatic method is implemented at DST to estimate in real time the seismic moment, moment magnitude and corner frequency from broad-band and accelerometric data. The procedure has two steps: the first one consists in interfacing with the Antelope system from where waveforms are retrieved. The second step consists in estimating the seismic moment and the corner frequency following Andrews method (1986). At the end the results are stored in a database table. The procedure is tested with the recordings of some strong earthquakes: Carnia 2002 (Mw=4.9), Bovec 2004 (Mw=5.1), Parma 2008 (Mw=5.4) and Aquila 2009 (Mw=6.1), some its aftershock and those of some minor events occurred in the SE Alps area, for which independent seismic moment and Mw estimates, obtained by waveform inversion, are available. The real-time procedure is running at DST and the results are visible on the web page www.dst.units.it/RAF06. The Mw computation together with the moment tensor estimation (TDMT) will also provide better input data for the real-time ShakeMap computation. At DST the "ShakeMap" software has been implemented for the SE Alps area to obtain a stable interface with "Antelope" acquisition system in order to extract the ground motion parameters from waveforms and to generate ShakeMaps within five minutes of the earthquake occurrence. The real-time waveforms come from the transfrontier network which integrates the Friuli Venezia Giulia (DST, OGS), Austrian (ZAMG) and Slovenian (ARSO) networks. The "ShakeMap" software has been regionally calibrated by adopting a specific near-surface geological classification, different GMPEs for weak and strong motion, and the relationship proposed by Faccioli and Cauzzi (2006) to compute the instrumental intensity. The model is validated by comparing the observed intensity maps data with the instrumental intensities derived from the related scenarios calculated for three important past seismic events in the studied area (Cansiglio 1936, Friuli 1976, Bovec 1998). The computation of the intensity misfit value gives satisfactory results. Finally, an automatic procedure has been developed to exchange in real-time the ground motion parameters with INGV and the other partners of the INGV-DPC S3 project. The results are posted automatically on the department web pages (www.dst.units.it/RAF06).

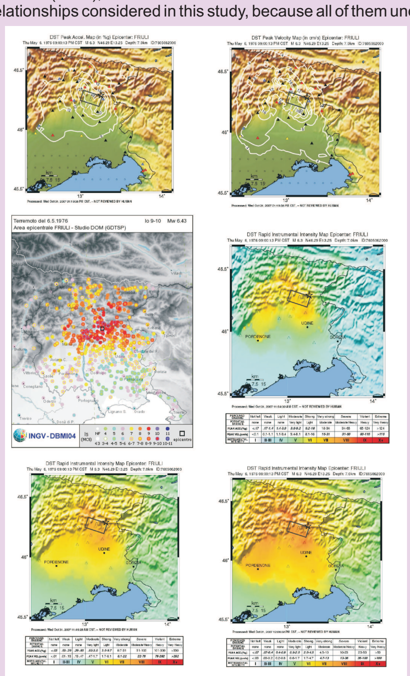
SHAKEMAPS



ShakeMaps for PGA (on the left), PGV (in the center) and instrumental intensity (on the right) related to the Trasaghis 2008 earthquake. The networks that recorded the event are RAF (red triangles), RAN (yellow triangles), NEI (green triangles), RSFVG (white triangles) and ARSO (blue triangles).

The "ShakeMap" software has been adapted to the South-Eastern Alps region and implemented to obtain a stable interface with the "Antelope" acquisition system in order to extract the ground motion parameters from the waveforms and to generate ShakeMaps within five minutes of the earthquake occurrence. The related maps are generated in real-time or quasi-real time using the region-specific ground motion predictive equations (GMPEs) and empirical relations that predict the macroseismic intensity from the recorded ground motion.

We validate the model for the Friuli-Venezia Giulia region comparing the macroseismic observations with the ShakeMaps instrumental intensity derived by synthetic PGA, PGV computed for three past earthquakes occurred in the area (Cansiglio 1936, Friuli 1976, Bovec 1998). Since a good validation requires that the simulation is identical to the real situation, the receivers are placed at the sites where the recording instruments are already operative and at the sites where the stations are going to be installed in the future. Various relationships between the ground motion parameters and the macroseismic intensity are tested and the misfit computation indicates that the best results are obtained when the macroseismic intensities are estimated using the relationship proposed by Kästli and Fäh (2006); on the other side macroseismic intensities larger than VII should not be fitted by the relationships considered in this study, because all of them underestimate the observed data.



On the left: ShakeMaps validation considering the 1976 Friuli earthquake. The ShakeMaps for PGA (in %g) (above, on the left) and PGV (above, on the right); the star is the epicenter, the black rectangle is the rupture area, red triangles are RAF stations, blue triangles are NEI stations, yellow triangles are RAN stations and black triangles are future RAN stations. In the centre on the left there is the map with the macroseismic observations (DBMI04, after Stucchi et al., 2007). The other figures are, respectively, the macroseismic intensity maps derived by Wald et al. (1999) (center right), Faccioli and Cauzzi (2006) (bottom left) and Kästli and Fäh (2006) (bottom right). The empty triangles denote the stations where the synthetic seismograms are computed.

FAST MOMENT MAGNITUDE ESTIMATION

The signal, in acceleration or displacement, and the instrument response are extracted from the database of the Antelope system

↓

Average and instrument response are removed and bandpass filter applied

↓

EW and NS components are combined to obtain the trasversal one to minimize P-wave interferences

↓

"noise" window and "S" window are retrieved

↓

Signal-to-Noise spectral ratio is used to determine the frequency window

Integrate to obtain velocities and displacements

↓

FFT
Correction for geometrical spreading and anelastic attenuation

↓

Velocity and displacement spectra estimated at the source

↓

Seismic moment and the corner frequency are determined following Andrews method

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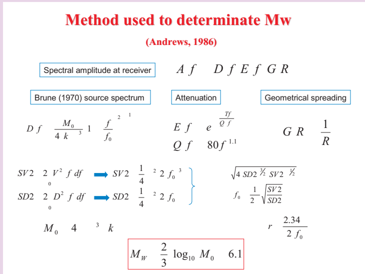
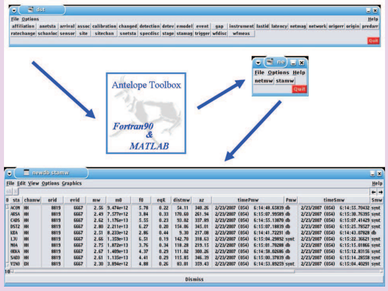
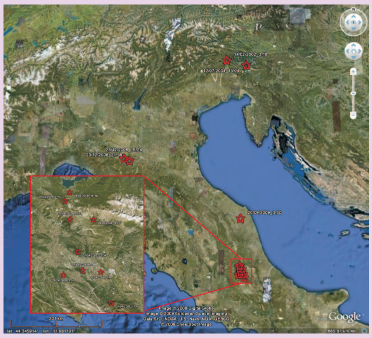
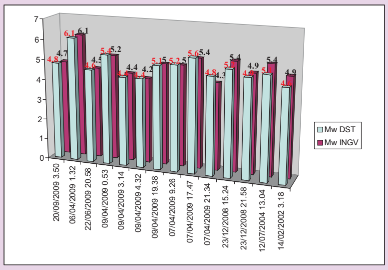
Results are stored in new database tables







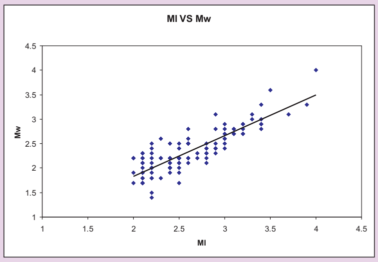
Map of the events, for which an indipendent Mw determination is available, used to test the procedure.



Comparison between moment magnitude determinated at DST and moment magnitude of INGV obtained by waveform inversion. There are in a very good agreement.

STA	Mw	Mo	fo	eqR	distMw	rotaz
ASS	6.1	2.09E+18	0.27	4.73	103	232
BOJ	6.7	1.41E+19	0.48	2.65	132	46
ISR	6.3	4.29E+18	0.3	4.2	109	49
MMP1	5.8	7.66E+17	0.28	4.56	54	168
PDM	6.1	1.96E+18	0.38	3.37	139	53
PTF	6.4	5.71E+18	0.45	2.82	132	33
SBC	5.4	1.56E+17	0.34	3.77	54	115
SEP	6.5	6.86E+18	0.39	3.24	148	32
SPC	5.9	1.09E+18	0.29	4.37	69	220
SPO	5.7	5.33E+17	0.45	2.81	69	219
SUL	6.1	2.12E+18	0.34	3.7	55	32
TMO	6.7	1.62E+19	0.3	4.16	138	16
VRP	6.3	3.37E+18	0.4	3.17	131	60

Results obtained by DST program for the Aquila main event.



Comparison between Ml (determined by Antelope) and Mw (determined by DST) of small events occured in Southeastern Alps.

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