

BOXER User Guide

Version 3.0
(August 1999)

The “Boxer” program was written by P. Gasperini in the April 1999. It is a revised and simplified version of several computer codes which, starting from 1993, have been developed by the author, and with the contribution of F. Bernardini and G. Ferrari, to compute focal parameters of earthquakes from macroseismic data and have been actually used to make the computation of the *Catalogo dei Forti Terremoti in Italia dal 461 a.C. al 1990* [Boschi et al. 1995, 1997] and of the BSSA paper [Gasperini et al., 1999]. The present version of the program also took advantage of important improvements by G. Vannucci and G. Valensise (who also suggested the name of the program).

While the computed macroseismic epicenter, epicentral intensity and azimuth fully coincide with the published papers, the magnitude may be slightly different (some tenth of magnitude unit at most) due to some differences in the relative weighting of intensity classes. A description of the procedure to determine the azimuth and to draw the “boxes” representing the seismogenic structure can be found in *Gasperini et al.* [1999]. More details on the computation of epicenter and of the magnitude can even be found (but only in italian) in *Gasperini and Ferrari* [1995,1997]

Input and output

The program reads optional parameters from the file INPPARM.DAT. The macroseismic data are read instead from a separate file whose name and format can be specified by the user (see below). Both summary data for each earthquake (date, magnitude etc.) and the list of intensity points are read from this file. All the files must reside in the same folder with the program executable. The program writes two output files: a short one on the file OUTSUMMARY.DAT which contains a record for each earthquake including source parameters, magnitude, azimuth , and a long one on file OUTFULL.DAT. See Appendix below for a sample of input and output files.

Option cards on file INPPARM.DAT

Each option cards includes a “tag” field (from column 1 to 10) and a “parameters” field from column 11 to 80. Some option card may be followed by one or more additional “data” cards containing a “parameters” field from column 1 to 80.

The tag identifies the purpose of the card and must be written beginning with column 1 with either upper or lower case characters. A percent character (“%”) in column 1 indicate comments and make the card content to be ignored by the program.

An alphabetical list of the available option cards tag follows:

AZPAR - Assign parameters of the azimuth computation algorithm

CRAMCOEF – Assigns coefficient of the distance weighting formula in the azimuth algorithm

FILE - Define the name of the macroseismic input data file

FORMATE - Specifies the Fortran format of the event summary records of the input data file

FORMATI - Specifies the Fortran format of the intensity point records of the input data file

LENGCOEF - Assigns coefficients of the fault length formula

MAGCOEF - Assigns coefficients of the magnitude formula using the radius method

MAPINFO - Direct the program to produce graphic input files for MAP-INFO.
 M-I0COEF - Assigns coefficients of the magnitude-intensity formula
 OUTLOOK - Direct the program to write a fixed format summary file
 OUTPUT - Select type of output
 SELMAG - Defines the minimum magnitude for azimuth computations.
 USEMAG - Direct the program to use the magnitude reported on the event summary record
 WIDCOEF - Assigns coefficients of the fault width formula

A detailed explanation of the format of each option is given below:

AZPAR

Assigns the values of the minimum allowed number of data-points and the maximum allowed number of half degree decrements with respect to maximum intensity in the azimuth computation algorithm (see: *Gasperini et al.* [1999]).

Parameter field:

- 1) Name: *Nmin*
 Function: minimum allowed number of data-points
 Columns: 11-15
 Type: Integer
 Default: 3
- 2) Name: *Ndecr*
 Function: maximum allowed number of half degree decrements with respect to maximum intensity
 Columns: 16-20
 Type: Integer
 Default: 4

Additional data cards

None

Example

1	11	21
AZPAR	6	4

CRAMCOEF

Assigns the values to the coefficients of the *CRAM* [*Berardi et al.*, 1993] formula to compute the distance weights in the azimuth determination algorithm (see: *Gasperini et al.* [1999])

$$\Delta I = a + b\sqrt[3]{D}$$

where ΔI is the difference between epicentral and local intensity and D is the epicentral distance. Default values were empirically estimated for Italy by *Gasperini et al.* [1999].

Parameter field:

- 1) Name: *Acram*
 Function: *a* coefficient of the *CRAM* equation
 Columns: 11-20
 Type: Real
 Default: -0.46
- 2) Name: *Bcram*
 Function: *b* coefficient of the *CRAM* equation
 Columns: 21-30
 Type: Real
 Default: 0.93

Additional data cards

None

Example

1	11	21
CRAMCOEF	-0.3	1.1

FILE

Assigns the name of the macroseismic data file containing the event summary and the intensity points.

Parameter field:

- 1) Name: *Filename*
 Function: name of the input data file
 Columns: 11-80
 Type: Alphanumeric
 Default: INPUT.DAT

Additional data cards:

none

Example

1	11
FILE	INPUT2.DAT

FORMATE

Specifies the Fortran format of the event summary records of the input data file. The format must be embedded in parenthesis. It must contain 9 fields in the following order: Year (integer), Month (integer), Day (integer), Hour (integer), Minute (integer), Second (integer), Epicentral Area (alphanumeric), Magnitude (real), Number of intensity points (integer). Tabulation (T fields) can be used to accomplish this order if different.

Parameter field:

none

Additional data cards:

Card 1

1) Name: *Formate*

Function: Fortran format of event summary records

Columns: 1-80

Type: Alphanumeric

Default : (I5, 5I2, 15X, A20, 1X, F5.1, 1X, I5)

Example:

1 11

FORMATE

(8X, I5, 5I3, 1X, A20, 64X, F3.2, T58, I4)

FORMATI

Specifies the Fortran format of the intensity point records of the input data file. The format must be embedded in parenthesis. It must contain 4 fields in the following order: Latitude (real), Longitude (real), Intensity (real), Locality name (alphanumeric). Tabulation (T fields) can be used to accomplish this order if different. Latitude and longitude must be given in degrees with decimals (not primes). West longitude is negative. Uncertain intensity values (i.e. VII-VIII) may be given as fractional (i.e. 7.5)

Parameter field:

none

Additional data cards:

Card 1

1) Name: *Formati*

Function: Fortran format of intensity point records

Columns: 1-80

Type: Alphanumeric

Default : (2F7.3, 1X, F4.1, 1X, A20)

Example:

1 11

FORMATI

(48X, 2F8.4, F6.1, T30, A20)

LENGCOEF

Assigns the values to the coefficients of the formula to compute fault length from moment magnitude

$$\text{Log}_{10}(L) = a + bM$$

where M is the moment magnitude and L is the fault length in kilometers. Default values are empirical estimates for subsurface rupture length of "all types of fault" according to *Wells and Coppersmith* [1993].

Parameter field:

- 1) Name: *Alen*
 Function: *a* coefficient of the fault length formula
 Columns: 11-20
 Type: Real
 Default: -2 . 44
- 2) Name: *Blen*
 Function: *b* coefficient of the fault length formula
 Columns: 21-30
 Type: Real
 Default: 0 . 59

Additional data cards

None

Example

1	11	21
LENGCOEF	-2 . 11	0 . 65

MAGCOEF

Assigns the values of the coefficients of the *Sibol et al* [1987] formula to compute the macroseismic magnitude with the radius method (see *Gasperini et al.* [1999]) for different intensity class. Default values are empirical estimates for Italy from the data of the *Catalogo dei Forti Terremoti in Italia dal 461 a.C. al 1990* [*Boschi et al.* 1995, 1997].

Parameter field:

- 1) Name: *Ncoef*
 Function: number of intensity classes used to compute magnitude
 Columns: 11-15
 Type: Integer
 Default: 10

Additional data cards

Card 1

- 1) Name: *Aiv(1)*
 Function: Lower limit of the intensity class (the higher limit is specified in the next card)
 Columns: 1-15
 Type: real
 Default: see below
- 2) Name: *Coef(1,1)*
 Function: *a* coefficient of the *Sibol et al* [1987] formula
 Type: real
 Columns: 16-30
 Default: see below
- 3) Name: *Coef(1,2)*
 Function: *b* coefficient of the *Sibol et al* [1987] formula
 Type: real
 Columns: 31-45
 Default: see below
- 3) Name: *Coef(1,3)*

Function: c coefficient of the *Sibol et al* [1987] formula

Type: real

Columns: 46-60

Default: see below

Cards 2 to *Ncoef*

Repeat the above format for different intensity classes (in increasing order of intensity).

Example:

(The example values are the default ones)

1	11	21	31	41	51	61
MAGCOEF	10					
2.	3.554		0.025		0.024	
3.	3.422		0.038		0.023	
4.	3.034		0.074		0.019	
4.5	4.340		0.022		0.015	
5.	3.277		0.103		0.012	
6.	3.829		0.070		0.015	
6.5	4.198		0.094		0.009	
7.	4.394		0.091		0.009	
7.5	5.078		0.110		0.000	
8.	5.348		0.116		0.000	

MAPINFO (undocumented)

Direct the program to produce graphic input files for MAP-INFO mapping code.

M-I0COEF

Assigns the values of the coefficients of the formula to compute magnitude from epicentral intensity alone when data not enough to apply the radius method (see: *Gasperini et al.* [1999])

$$M = a + bI_0$$

where M is the moment magnitude and I_0 the epicentral intensity. Default values have been empirically estimated on the basis of the italian magnitude-intensity database by *Rebez and Stucchi* [1999]

Parameter field:

1) Name: *Aint*

Function: a coefficient of the M-I0 equation

Columns: 11-20

Type: Real

Default: 0.94

2) Name: *Bint*

Function: b coefficient of the M-I0 equation

Columns: 21-30

Type: Real

Default: 0.56

Additional data cards

None

Example

1	11	21
M-IOCOEF	1.5	0.5

OUTLOOK(undocumented)

Direct the program to write a fixed format summary file

OUTPUT

Select type of output (1- normal output, 2-log output)

Parameter field:

- 1) Name: *Iout*
Function: type of output
Columns: 11-15
Type: Integer
Default: 1

Additional data cards

None

Example

1	11	21
OUTPUT	2	

SELMAG

Direct the program to compute the azimuth only for earthquakes with magnitude larger than a given threshold.

Parameter field:

- 1) Name: *Aminmg*
Function: minimum magnitude threshold above which the azimuth is computed
Columns: 11-15
Type: Real
Default: none (no threshold)

Additional data cards

none

Example

1 11
SELMAG 5.5

USEMAG

Direct the program to use the magnitude value specified on the event summary line instead of the computed one.

Parameter field:
none

Additional data cards
none

Example
1 11
USEMAG

WIDCOEF

Assigns the values of the coefficients of the formula to compute fault width from moment magnitude

$$\text{Log}_{10}(W) = a + bM$$

where M is the moment magnitude and W is the fault length in kilometers. Default values are empirical estimates for subsurface rupture width of "all types of fault" according to *Wells and Coppersmith* [1993].

Parameter field:
1) Name: *Alen*
Function: a coefficient of the fault width formula
Columns: 11-20
Type: Real
Default: -1.01

2) Name: *Blen*
Function: b coefficient of the fault width formula
Columns: 21-30
Type: Real
Default: 0.32

Additional data cards
None

Example
1 11 21
WIDCOEF -1.3 0.29

References

- Berardi, R., C. Petrongaro, L. Zonetti, L. Magri and M. Mucciarelli (1993). *Mappe di sismicità per l'area Italiana*, ISMES/ENEL, 51 pp.
- Boschi, E., G. Ferrari, P. Gasperini, E. Guidoboni, G. Smriglio and G. Valensise (1995). *Catalogo dei forti terremoti in Italia dal 461 a.C. al 1980*, ING-SGA, Bologna, 973 pp. and a CD-ROM.
- Boschi, E., E. Guidoboni, G. Ferrari, G. Valensise and P. Gasperini (1997). *Catalogo dei forti terremoti in Italia dal 461 a.C. al 1990*, ING-SGA, Bologna, 644 pp. and a CD-ROM.
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- Gasperini P., Bernardini F., Valensise G. and Boschi E. (1999). Defining Seismogenic Sources from Historical Earthquake Felt Reports, *Bull. Seism. Soc. Am.*, 89, 94-110.
- Rebez A. and Stucchi M. (1999). Determinazione dei coefficienti della relazione tabellare I_0/M_s , in *Catalogo Parametrico dei Terremoti Italiani*, ING,GNDT,SGA,SSN, 90 pp..
- Sibol, M. S., G. A. Bollinger and J. B. Birch (1987). Estimations of magnitudes in central and eastern North America using Intensity and Felt Area, *Bull. Seism. Soc. Am.*, 77, 1635-1654.
- Wells, D. L. and K. J. Coppersmith (1994). New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement, *Bull. Seism. Soc. Am.*, 84, 974-1,002.

Appendix

Sample INPPARM.DAT file:

```
% INPUT TEST FILE
%
% USES CATALOGUE MAGNITUDES
USEMAG
% COMPUTE AZIMUTH ONLY IF M>=5.5
SELMAG      5.5
FILE        TEST
FORMATE     (8x,I5,5I3,1X,A20,64x,F3.2,T58,I4)
FORMATI     (48X,2F8.4,F6.1,T30,A20)
```

Sample of TEST.DAT file

```

11 DI 79 08 25 07 Area vesuviana CFTI 6 80 80 40.800 14.380 A 622 38 540 28 M 569 22 48
50043
000018 Miseno 40.7861 14.0853 7.5
000015 Napoli 40.8554 14.2604 7.5
000019 Nola 40.9257 14.5287 8.0
000020 Sorrento 40.6243 14.3782 7.0
000017 Nocera Inferiore 40.7428 14.6418 8.0
000021 Salerno 40.6788 14.7654 5.0
1841 DI 1930 07 23 00 08 Irpinia CFTI 511 100 100 41.050 15.370 A 678 08 660 30 M 670 05 O 672 04 498 1543
30013
000052 Brescia 45.5439 10.2144 4.6
000640 Sal~ 45.6057 10.5223 2.5
000100 Vicenza 45.5491 11.5492 2.5
000740 Volterra 43.4019 10.8590 4.0
008220 Cortona 43.2746 11.9864 2.0
012798 Molino 43.5659 13.3363 2.0
000611 Ancona 43.6031 13.5074 2.5
008255 Filottrano 43.4344 13.3510 2.0
001765 Sirolo 43.5214 13.6201 2.0
005099 Civitanova Marche 43.3066 13.7296 4.0
001502 Macerata 43.2994 13.4524 3.0
001503 Matelica 43.2557 13.0094 3.0
001504 Recanati 43.4029 13.5499 3.5
001505 Tolentino 43.2095 13.2827 3.5
012799 Ussita 42.9438 13.1362 3.0
002335 Visso 42.9304 13.0878 2.5

```

OUTSUMMARY.DAT file

DATE	TIME	LON	LAT	ME	LOCALITY	NTOT	NAZ	AZIMUTH	RAYLEIGH	KUIPER
08/25/79	07:00	40.79	14.39	5.7	Area vesuviana	6	5	087+-053	uniform	uniform
07/23/1930	00:08	41.05	15.36	6.7	Irpinia	511	16	109+-011	<0.01	<0.01
05/07/1984	17:50	41.67	14.06	5.6	Appennino abruzzese	911	3	152+-034	<0.10	uniform

OUTFULL.DAT file

Input Cards:

```
% INPUT TEST FILE
```

```

%
% USES CATALOGUE MAGNITUDES
USEMAG
% COMPUTE AZIMUTH ONLY IF M>=5.5
SELMAG      5.5
FILE        TEST
FORMATE     (8x,I5,5I3,1X,A20,64x,F3.2,T58,I4)
FORMATI     (48X,2F8.4,F6.1,T30,A20)

```

Parameters summary

Input file: TEST.DAT

Event fmt: (8x,I5,5I3,1X,A20,64x,F3.2,T58,I4)

Intensity fmt: (48X,2F8.4,F6.1,T30,A20)

Magnitude coef:

Intensity	a	b	c
2.0	3.55400	.02500	.02400
3.0	3.42200	.03800	.02300
4.0	3.03400	.07400	.01900
4.6	4.34000	.02200	.01500
5.0	3.27700	.10300	.01200
6.0	3.82900	.07000	.01500
6.5	4.19800	.09400	.00900
7.0	4.39400	.09100	.00900
7.5	5.07800	.11000	
8.0	5.34800	.11600	

Cram coef (a, b): -.460 .930

M-Io coef (a, b): .940 .560

Length coef (a, b): -2.440 .590

Width coef (a, b): -1.010 .320

Use magnitude on event card (if not 0)

Compute Boxes only for M .GE. 5.50

Events summary

Event : 79 8 25 7 0 0 5.7 Area vesuviana
No. of intensity data : 6

Computed epicenter : 40.7948 14.3891
No. of data used : 5
Maximum intensity : 8.0
Epicentral intensity : 8.0

Moment magnitude : 6.11
No. of radii used : 1

Used magnitude : 5.69
Fault length (Km) : 8.3
Fault width (Km) : 6.5

Fault azimuth (deg) : 86.5
Azimuth std : 52.7
No. of data used : 5
Rayleigh Test : uniformity ho hypothesis not rejected
Kuiper Test : uniformity ho hypothesis not rejected

Box vertices : 40.8130 14.3385 40.8176 14.4364
40.7720 14.3418 40.7765 14.4397

Event : 1930 7 23 0 8 0 6.7 Irpinia
No. of intensity data : 511

Computed epicenter : 41.0536 15.3588

No. of data used : 3
 Maximum intensity : 10.0
 Epicentral intensity : 10.0

 Moment magnitude : 6.69
 Magnitude std : .07
 No. of radii used : 9

 Used magnitude : 6.72
 Fault length (Km) : 33.5
 Fault width (Km) : 13.8

 Fault azimuth (deg) : 108.9
 Azimuth std : 10.9
 No. of data used : 16
 Rayleigh Test : uniformity ho hypothesis rejected s.l. < 0.01
 Kuiper Test : uniformity ho hypothesis rejected s.l. < 0.01

 Box vertices : 41.1438 15.1887 41.0465 15.5666
 : 41.0607 15.1510 40.9633 15.5289

Event : 1984 5 7 17 50 0 5.6 Appennino abruzzese
 No. of intensity data : 911

 Computed epicenter : 41.6664 14.0571
 No. of data used : 3
 Maximum intensity : 8.0
 Epicentral intensity : 8.0

 Moment magnitude : 5.82
 Magnitude std : .09
 No. of radii used : 8

 Used magnitude : 5.64
 Fault length (Km) : 7.7
 Fault width (Km) : 6.2

 Fault azimuth (deg) : 151.6
 Azimuth std : 33.9

No. of data used : 3
Rayleigh Test : uniformity ho hypothesis tent rej s.l. < 0.10
Kuiper Test : uniformity ho hypothesis not rejected

Box vertices : 41.7064 14.0584 41.6453 14.1026
41.6875 14.0117 41.6265 14.0559