QUake-MD GUI - User Manual

I. Introduction

This software QUake-MD GUI creates a graphical interface between a user and the QUake-MD tool. The QUake-MD tool estimates a weighted space of magnitude (M), depth (H) and epicentral intensity (I_0) based on historical intensity data points (IDP), their associated uncertainties and empirical intensity prediction equations (IPE). The final space of solution aims to be representative of the IDPs and their quality and of IPE epistemic uncertainties. The QUake-MD methodology is published in Provost and Scotti 20xx (submitted).

QUake-MD GUI offers in addition to a QUake-MD interface a data visualization tool. The IDP visualization is an important step for M/H/I_0 estimates from macroseismic data. It is strongly recommended to visualize the macroseismic data before M/H/I_0 estimates.

The user manual describes first how to run QUake-MD GUI, then how to use the data visualization part of QUake-MD GUI and finally how to use the QUake-MD part.

II. Installation

1. Requirements

To run QUake-MD GUI, python 3 is needed with the python libraries listed in Table 1. The Anaconda distribution of python includes all these libraries except for the Basemap library. The open-source Basemap library can be downloaded and installed from the Anaconda cloud.

QUake-MD GUI has been tested with Python 3.7.3 and 3.6.8 and the python library versions mentioned in Table 1 on a linux environment.

Library	Version
Matplotlib	3.0.3
Basemap	1.2.0
Numpy	1.16.2
Pandas	0.24.2
Scipy	1.2.1

Table 1 : Python libraries used in QUake-MD GUI

2. Install

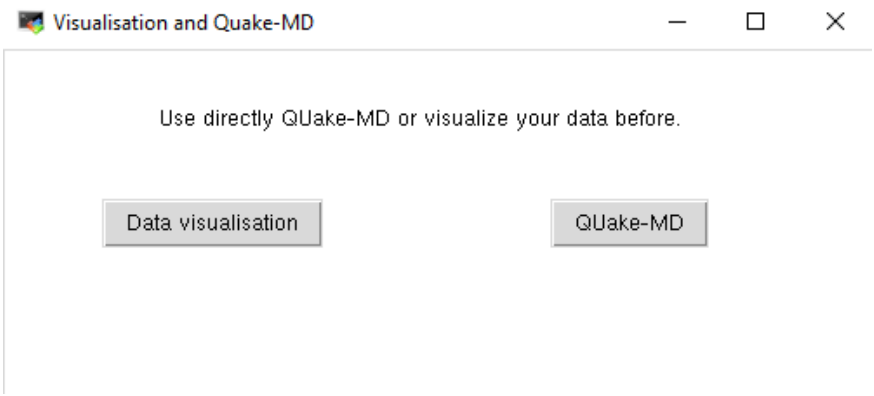
Git clone or git download

III. Running QUake-MD GUI

To run QUake-MD GUI, open an ipython terminal/Konsole, move to the QUake-MD GUI repertory and enter:

run Quake-MD/AppliInterface.py

The following start window will open:



By clicking on the Data visualization button, the Data Visualization window will open (see chapter IV).

By clicking on the QUake-MD button, the QUake-MD window will open (see chapter V).

NB: the QUake-MD window can open from the Data Visualization window.

IV. Data visualization interface

QUake-MD GUI will start on the data visualization window. On this window, the user can select a macroseismic database, one event by event ID or date of the earthquake occurrence.

Once the event selected the software will draw a macroseismic map with the IDP and a plot of the epicentral projection of the IDP. Additional information will be also projected on the window, like the I_0 quality and the epicenter localization quality.

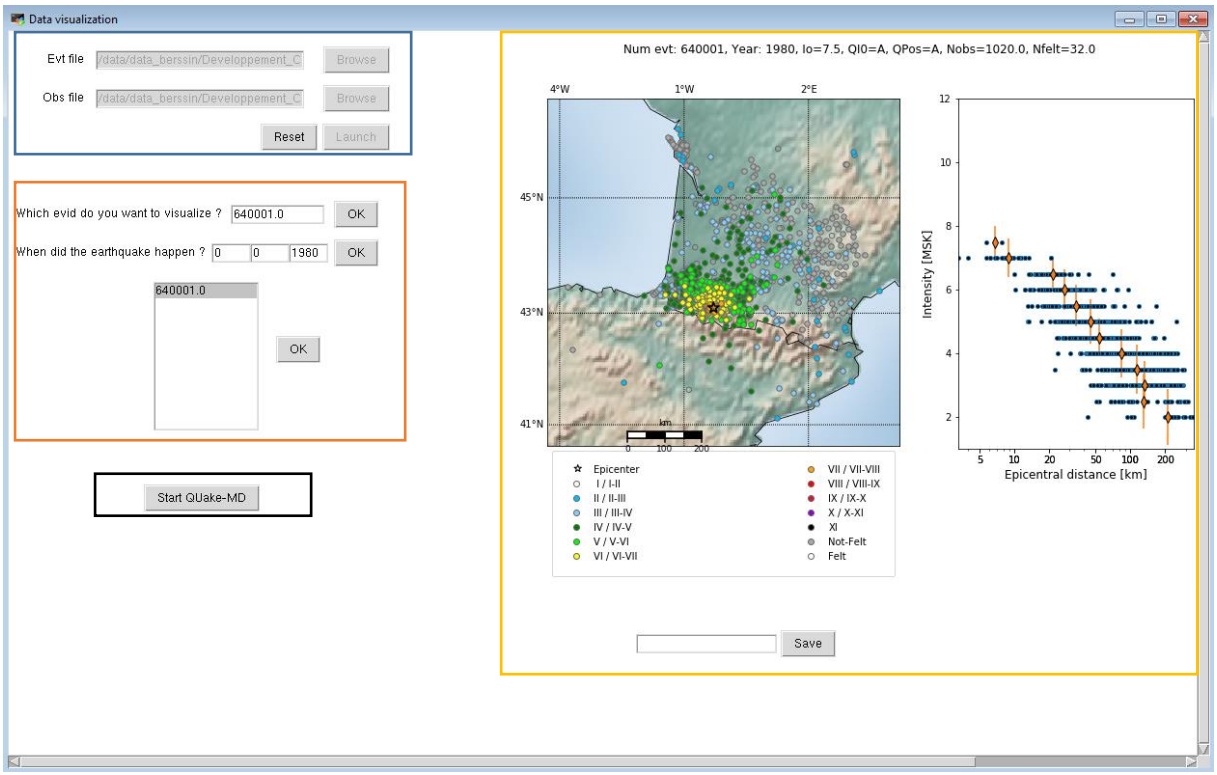


Figure 1 : Data Visualization interface. Each colored square correspond to a part of the Data Visualization interface, which are detailed in part IV. 2.

1. Preparation of the input files

Different data are needed to visualize the macroseismic data associated to an historical earthquake. First data are the epicentral parameter, i.e. longitude and latitude of the epicenter, the epicentral intensity, quality associated to epicentral localization and intensity. IDPs, i.e. intensity values associated to a locality are also needed, meaning an intensity value, quality of this intensity value and the longitude and latitude of the associated locality. An earthquake ID is also necessary to link all the data. These data have to be stored in two separate files: one Event file and one Observation file. These two files and their format are described in the two following paragraphs.

a. Event File

The Event file contains data which describe the epicenter parameter of historical earthquakes, i.e. the epicenter localisation, time of earthquake occurrence and value of the intensity at the epicenter. After a headline, each line describes one on this model in the following order:

- The ID of the event (name of the column: EVID),
- The macroseismic epicentral intensity (name of the column: I0) ,.
- The quality of the previous element, graded A (good quality), B (middle quality), C (poor quality) or E (very poor quality) (name of the column: QI0).
- The longitude of the epicenter in WGS84 (name of the column: Lon)

- The latitude of the epicenter in WGS84 (name of the column: Lat)
- The quality of the position, graded A (very good location quality), B (good location quality), C (middle location quality), D (poor location quality), E (very poor location quality) or I (location very uncertain, set arbitrary based on one IDP) (name of the column: QPos)
- The day of the earthquake (name of the column: Day)
- The month of the earthquake (name of the column: Month)
- The year of the earthquake (name of the column: Year)
- A name, surrounded by quotation marks and used for legibility (name of the column: Name).

The headline is composed by the columns names, in the same order. Each column is separated by a space.

b. Observation File

The Observation file contains all observations by localities associated to the earthquakes stored in the Event file. After a headline, each line describes an observation at one locality so many lines can be associated to one earthquake. Here is how it's build:

- The ID of the event (name of the column: EVID),
- The value of intensity at this IDP. It's equalled to -1 when the earthquake was felt but no value could be attributed (lack of information) (name of the column: IObs),
- The quality of the intensity, graded A(good quality), B (middle quality) or C (poor quality) (name of the column: QIobs),
- The longitude of the locality in WGS84 (name of the column: Lon),
- The latitude of the locality in WGS84 (name of the column: Lat),

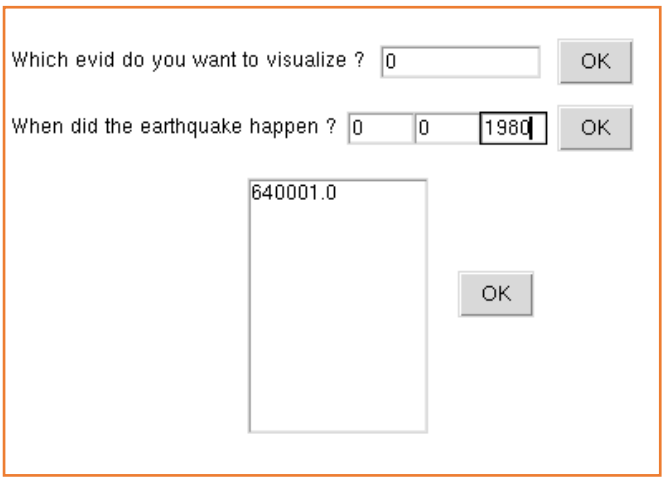
The headline is composed by the columns names, in the same order. Each column is separated by a space.

2. Use of the Data Visualization interface

To use this interface, you have to give the Event and the Observation files.

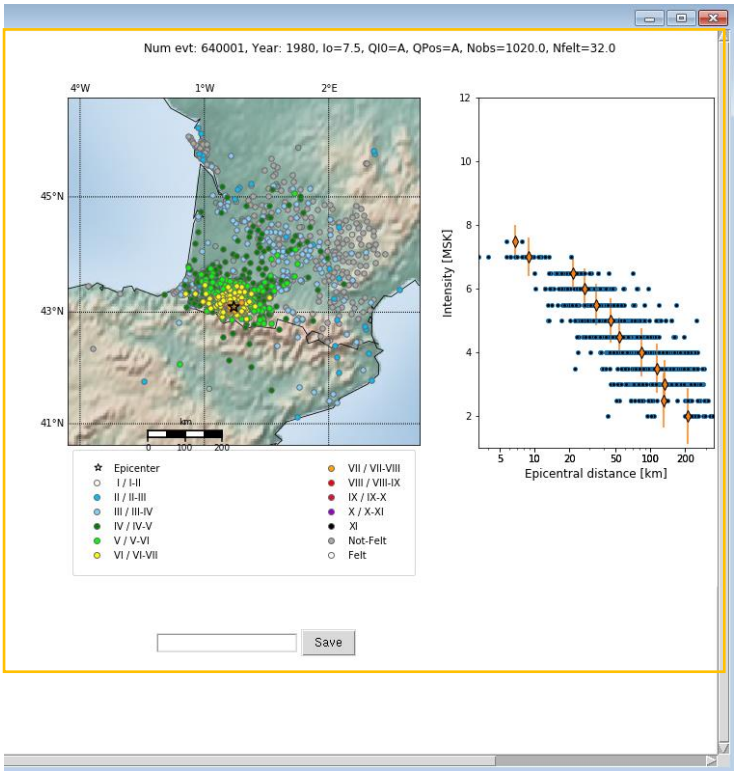
1. To begin, you have to select the 2 files, entering the path in the text zone directly or by clicking on the Browse button and choosing the corresponding file. Then, just click on the Launch button. If a problem is detected while the files are opened, an error window will appear.

2. Once files are launched, you can select your event, directly by its ID or search it by date.

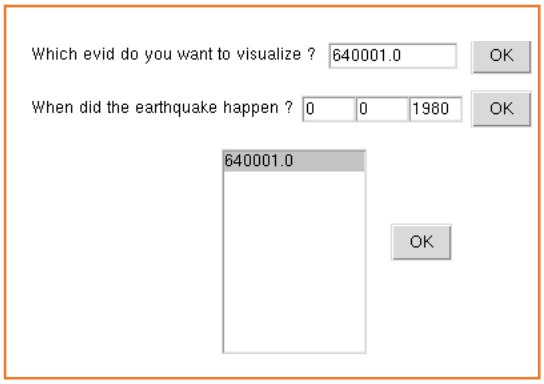


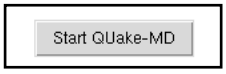
3. You can enter a complete date or a couple month/year or just the year. For that, make sure other fields are completed with a 0. Then, click on the Ok button or press Enter.

If you search the event by date, a list with the corresponding earthquake ID will appear below in the dedicated field. Click on the one you want to visualize, then click on the Ok button or press Enter.



4. Now, wait some second, calculus take a while. The map and the graph will appear on the window, or an error will occur and you will be adverted.

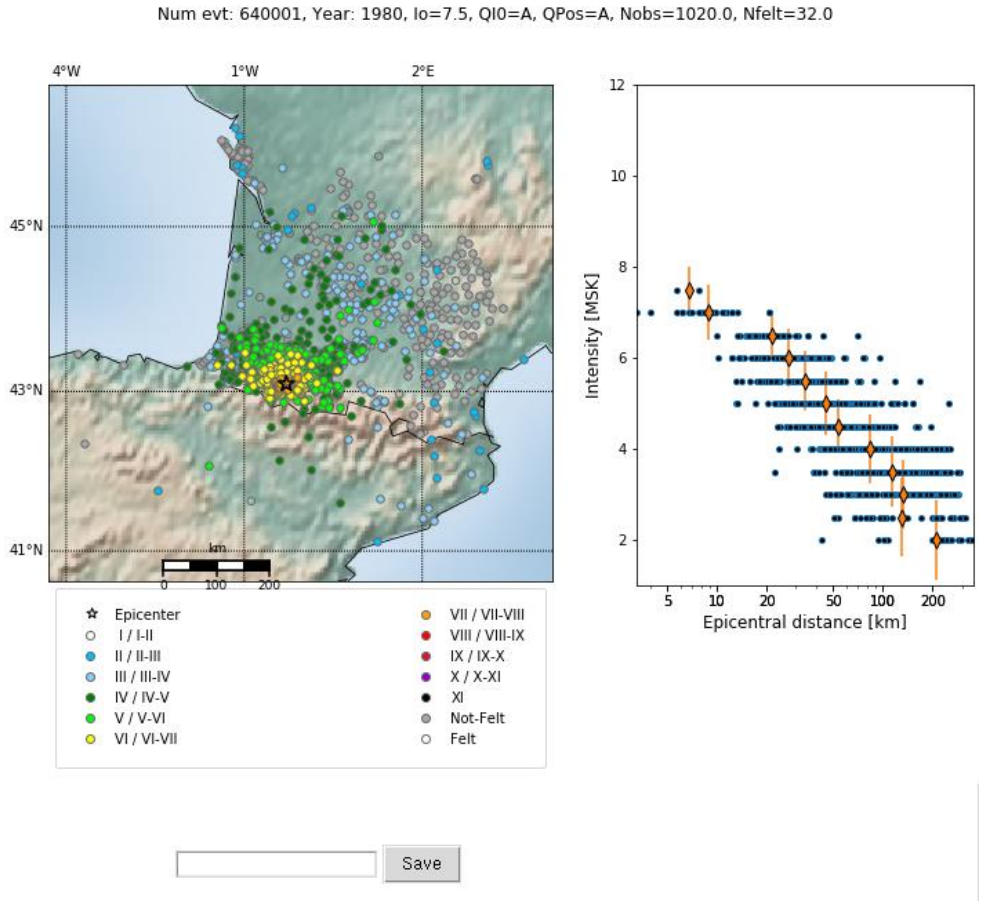




5. You can now start Quake-MD.

3. Output description

The output is a figure with left the macroseismic map for the selected event. Each color corresponds in an intensity level. The legend of the macroseismic map is below the map. Right is an epicentral projection of the IDP. The title of the figure indicates the event ID, the year of occurrence, the I0 value, the associated quality, the epicenter location quality, the number of IDP Nobs and the number Nfelt of Felt testimonies (no intensity level could be attributed to the locality and the earthquake was felt)



The figure can be saved by clicking on the Save button.

V. QUake-MD interface

QUake_MD interface can be launched from the start window or from the Data Visualization interface window.

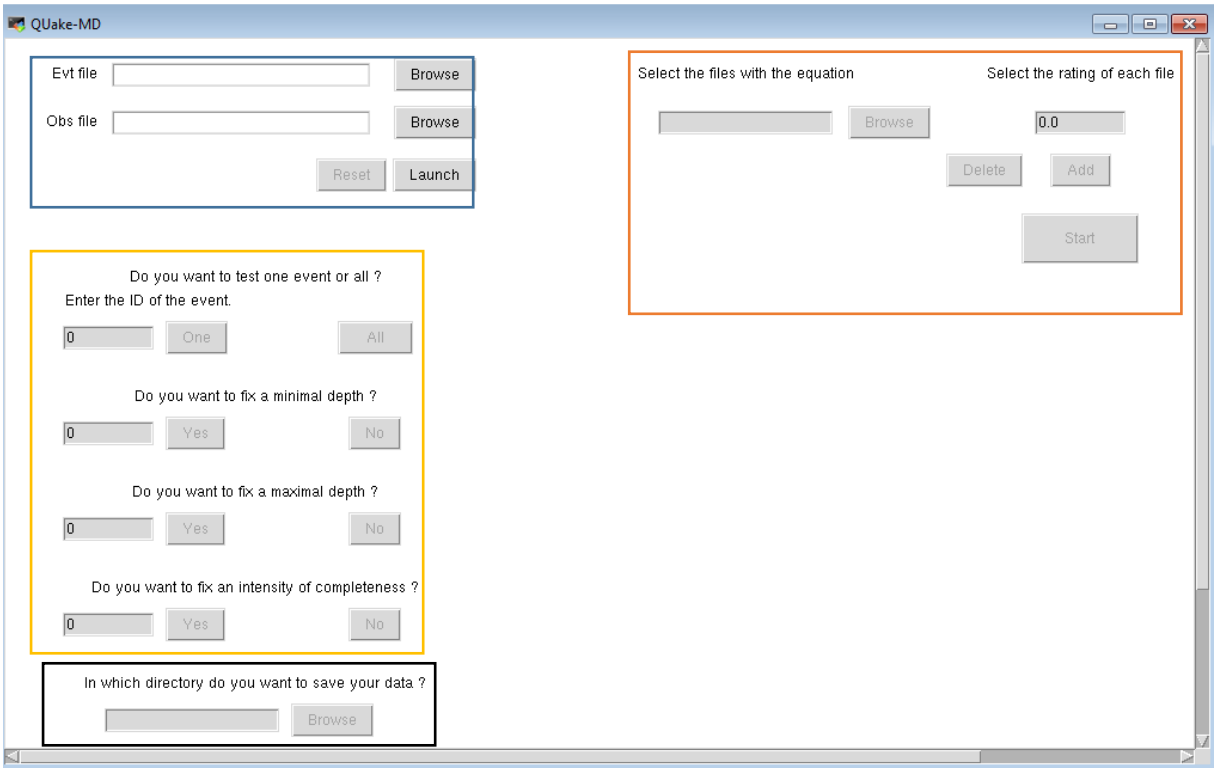


Figure 2 : QUake-MD interface. Each colored square correspond to a part of the Data Visualization interface, which are detailed in part V. 2.

1. Preparation of the input files

QUake_MD will need some inputs files.

For the macroseismic data, the same input file as the Data Visualization part of Quake-MD are required (see paragraph IV. a. and IV.b.). Another type of input file is needed: the IPE files. These files contain the IPEs which will be used in the inversion process of Quake-MD, with the following mathematical formulation:

$$I = C_1 + C_2 M + \beta \log(D_{hypo}) + \gamma D_{hypo}$$

With C_1 and C_2 the magnitude coefficient, M the magnitude, β the geometrical attenuation coefficient, log the decimal logarithm operator, D_{hypo} the hypocentral distance and γ the intrinsic attenuation coefficient.

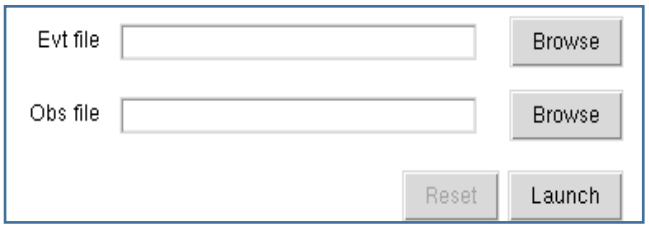
The IPEs files have the following format: one head line with information about the origin of the IPE (useful just for the user, Quake-MD GUI will not use this line), one blank line, one line with the column's names, another blank line and 5 columns with the IPEs:

- The first column is the weight of the IPE
- The second column is the C_1 coefficient
- The third column is the C_2 coefficient
- The fourth column is the β coefficient
- The fifth column is the γ coefficient

Each column is separated by tabulation. The sum of the weight column must be equal to one.

2. Use of the Quake-MD interface

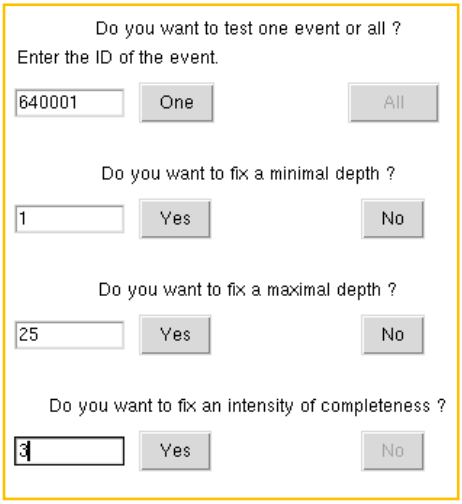
If QUake_MD interface is launched from the Data Visualization interface window, please start with the step 2.



1. First step is to enter the macroseismic data files (see paragraphs IV.1. a and IV.1.b).

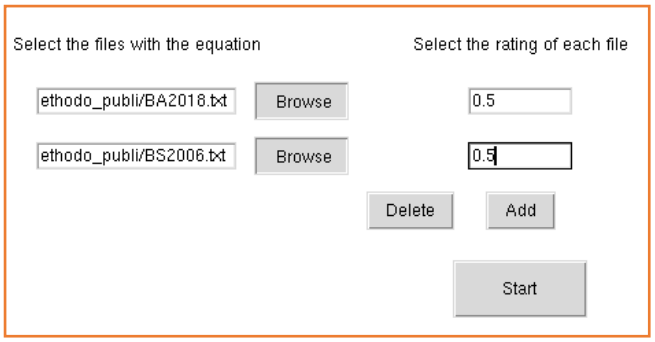
If that part is called from the data visualisation, the files are already launched. Else you have to put them as in the data visualisation (see paragraph IV.2).

Do not forget to push the Launch button.



2. Then, you enter the event ID. You can also fix an intensity of completeness, a minimal or maximal depth. Default values of intensity of completeness, minimal (shallow) depth limit and maximal (deep) depth limit are 3, 1 km and 25 km respectively.

3. You have to select an output folder to store the results.



4. Now, you have to select the IPEs files with a rating. The sum of those ones must be 1. Add or delete a file with the corresponding buttons.

5. Now, you can start the algorithm (Start button). It will create files in the output folder given in step 3 with the results.

3. Outputs description

In the ouput folder, different type of output can be found. First a log file which report each step of the calculation and the input parameters. The name of the log file is the time of the calculation start: *year-month-day_hour:minute:second.txt*.

```
Output_folder: Tests_git/Sorties
Number of events: 1
Event File: /Tests_git/Data/Evt2016b.test.txt
Observation File: Tests_git/Data/Obs2016b.test.txt


Id of the event : 640001
Minimal depth limit: 1
Maximal depth limit: 25
Sigma sampling :2
Output folder for individual results created
StdI_0 = 0.5
Ic = 3
IPE: Tests_git/QUake-M_methodo_publi/BA2018.txt
Inversion: BasedOnIobs
I = 3.297 + 1.306M -2.997log10(Dhypo) + 0.0Dhypo
M = 5.12; H = 2.52; I0=8
StdM = 0.14; StdH = 0.96
Pourcent of solutions compatible with I0: 38.25%
Inversion: BasedOnIobs
I = 2.378 + 1.544M -3.078log10(Dhypo) + 0.0Dhypo
M = 5.00; H = 2.89; I0=8
StdM = 0.12; StdH = 1.07
Pourcent of solutions compatible with I0: 41.5%
Inversion: BasedOnIobs
I = 3.237 + 1.387M -3.258log10(Dhypo) + -0.00121Dhypo
M = 5.22; H = 5.14; I0=8
StdM = 0.13; StdH = 1.67
```

Figure 3 : *Logfile* example. Only the beginning of the *logfile* is represented

The other .txt file is the *file_temp_.txt* and contains a summary of the results, i.e. the event ID, the epicentral intensity of the input macroseismic catalogue, its associated quality, the intensity of completeness used, the barycenter of the magnitude solutions estimated by Quake-MD and its associated weighted 16th and 84th percentiles, the barycenter of the depth solutions estimated by

Quake-MD and its associated weighted 16th and 84th percentiles and the barycenter of the epicentral intesnity solutions estimated by Quake-MD and its associated weighted 16th and 84th percentiles.

```
EVID  I0 cat.    QI0   Ic    Mbary M16th M84th Hbary H16th H84th
      I0bary     I016th      I084th
640001     7.5   A     3.0   5.1927     5.0508     5.3559
      6.0807     3.4838      9.9662     7.9578     7.5556
      8.3636
```

Figure 4 : file_temp example

A folder will be created with the event ID as name. This folder contains 4 types of figure and 6 types of .txt files. The 4 types of figure represent:

- the observed IDP and associated intensity bins and the predicted data as a function of epicentral distance for each IPE file (*eventID_fit_intensity_index.jpeg*, where *index* is the position in the IPEs file list, beginning at 0), for each IPE file given by the user,
- the estimated space of solutions in the M/H/I0 space (*HMIo.png*) for all IPEs,
- the estimated space of solutions in the M/H space (*HM.png*) for all IPEs,
- the estimated space of solutions in the H/I0 space (*HIo.png*) for all IPEs,

The 6 .txt files represent:

- *HMIo.txt* (Figure 5): the estimated M/H/I0 space of solutions with their associated weights, with four headlines and four columns in which are stored the points of the estimated M/H/I0 space of solutions: depth [km] (H[km]), magnitude (Mag), epicentral intensity (Io) and the weight (PDF)
- *HM.txt* (Figure 6): the estimated M/H space of solutions with their associated weights, with four headlines and three columns in which are stored the points of the estimated M/H space of solutions: depth [km] (H[km]), magnitude (Mag) and the weight (PDF)
- *HIo.txt* (Figure 7): the estimated M/Io space of solutions with their associated weights, with four headlines and three columns in which are stored the points of the estimated M/Io space of solutions: depth [km] (H[km]), magnitude (Mag) and the weight (PDF)
- *Law_index_HM.txt* (where index is the position in the IPEs file list, beginning at 0) (Figure 6): the estimated M/H space of solutions with their associated weights for one IPEs file, with four headlines and three columns in which are stored the points of the estimated M/H space of solutions: depth [km] (H[km]), magnitude (Mag) and the weight (PDF). It will be as many *Law_index_HM.txt* as the number of IPEs file given by the user
- *All_IPEs_classical_results.txt* (Figure 8): central solutions of each IPE associated to their standard deviation used to define the Gaussian space of solution, with one headline name of the columns) and 11 columns: index of the row (beginning at 1), eventID, C1 coefficient of the IPE, C2 coefficient of the IPE, β coefficient of the IPE, γ coefficient of the IPE, magnitude central solution of the IPE, associated standard deviation, depth central solution of the IPE, associated standard deviation, last epicentral intensity used in inversion of magnitude and depth. Columns are separated by comma.
- *IDP_binning.txt* (Figure 9): the intensity bins used in the inversion of magnitude and depth associated to epicentral distance. One headline (name of the columns), each following row representing one intensity bin. First column, index of the row, beginning at 0, the index 20 represent the epicentral intensity bin. Second column, the event ID, third column, epicentral distance of the intensity bin (geometrical mean of the epicentral distances of the concerned intensity level IDPs), fourth column intensity level of the bin, fifth column epicentral intensity

value, sixth column, associated standard deviation, seventh column, intensity standard deviation associated to the bin, eighth column epicentral distance standard deviation associated to the bin, last column, number of IDP in the intensity bin.

```
NumEvt: 640001, year=1980, I0 from catalogue = 7.5
Barycenter Io:7.96
Barycenter M:5.19
Barycenter H:6.08
H[km] Mag   Io    PDF
12.9612     4.9492      6.8485      0.000036
12.9612     5.0508      6.8485      0.000090
12.1372     4.9492      6.9495      0.000130
12.1372     5.0508      6.9495      0.000404
12.9612     5.0508      6.9495      0.000234
12.1372     5.1525      6.9495      0.000114
12.9612     5.1525      6.9495      0.000318
8.7392      4.9492      7.0505      0.000032
11.3655     4.9492      7.0505      0.000240
11.3655     5.0508      7.0505      0.000552
12.1372     5.0508      7.0505      0.000970
12.9612     5.0508      7.0505      0.000136
11.3655     5.1525      7.0505      0.000222
12.1372     5.1525      7.0505      0.001250
12.9612     5.1525      7.0505      0.000543
12.9612     5.2542      7.0505      0.000435
7.6632      4.9492      7.1515      0.000012
8.1835      4.9492      7.1515      0.000091
8.7392      4.9492      7.1515      0.000075
```

Figure 5 : *HMIo.txt file example.* Only the beginning of the *HMIo.txt* file is represented

```
NumEvt: 640001, year=1980, I0 from catalogue = 7.5
Barycenter Io:7.96
Barycenter M:5.19
Barycenter H:6.08
H[km] Mag   PDF
2.6788      4.7458      0.000220
2.8607      4.7458      0.000223
3.0549      4.7458      0.000218
3.2623      4.7458      0.000205
3.4838      4.7458      0.000185
3.7204      4.7458      0.000161
3.9730      4.7458      0.000134
4.2427      4.7458      0.000108
4.5308      4.7458      0.000145
4.8384      4.7458      0.000044
5.1670      4.7458      0.000030
2.0598      4.8475      0.000338
2.1996      4.8475      0.000324
2.3490      4.8475      0.000385
2.5085      4.8475      0.001417
2.6788      4.8475      0.001949
```

Figure 6 : *HM.txt file example.* Only the beginning of the *HM.txt* file is represented

```
NumEvt: 640001, year=1980, I0 from catalogue = 7.5
Barycenter Io:7.96
Barycenter M:5.19
Barycenter H:6.08
H[km] Mag   PDF
1.5838      8.4646      0.000068
1.6914      8.3636      0.000071
1.6914      8.4646      0.000256
1.8062      8.3636      0.000330
1.8062      8.4646      0.000628
1.9288      8.2626      0.000176
1.9288      8.3636      0.000621
1.9288      8.4646      0.000731
2.0598      8.1616      0.000068
2.0598      8.2626      0.000443
2.0598      8.3636      0.000736
2.0598      8.4646      0.001956
2.1996      8.1616      0.000296
2.1996      8.2626      0.000589
2.1996      8.3636      0.001723
2.1996      8.4646      0.002486
2.3490      8.0606      0.000147
2.3490      8.1616      0.000360
2.3490      8.2626      0.001370
2.3490      8.3636      0.002558
```

Figure 7 : *HIo.txt file example.* Only the beginning of the *HIo.txt* file is represented

```
,NumEvt,C1,C2,Beta,Gamma,Mag,StdM,H,StdH,Io
1,640001.0,3.297,1.306,-2.997,0.0,5.1187943380824485,0.13968034679438793,2.51547400888751,0.9628824801178062,8.499999965804362
2,640001.0,2.378,1.544,-3.078,0.0,5.00640197697549,0.11760510909749387,2.894517292323553,1.072289480598208,8.499996918386552
3,640001.0,3.237,1.387,-3.258,-0.00121,5.222362536312865,0.12604338664366985,5.139999481698805,1.6661303835013808,8.15745943687324
4,640001.0,2.188,1.574,-3.048,-0.00411,5.1512659442486495,0.11107276919337757,5.138242564170121,1.757131308502197,8.108273905235554
5,640001.0,3.052,1.285,-2.742,-0.00167,5.152115016231484,0.14284301756169857,1.9119072710411038,0.8023057123864077,8.4999914008581
6,640001.0,1.789,1.613,-2.939,0.0,5.027801256352868,0.11304566407020507,2.553484376015827,0.9962054871139974,8.499998523093483
7,640001.0,2.947,1.388,-3.058,-0.00164,5.20061393822763,0.12951500241020833,3.601869184892962,1.3190278777193098,8.454854562074287
8,640001.0,1.411,1.682,-2.948,-0.00268,5.1337810184445205,0.10714169493203123,3.438959986773118,1.3082533480164449,8.4528798796360
9,640001.0,3.064,1.221,-2.478,-0.0064,5.26964391735459,0.14988736363665267,2.2181519667388825,1.0166368490078104,8.499940100924404
10,640001.0,2.475,1.507,-2.978,-0.00394,5.098335374207557,0.118366551131949,4.076999406158663,1.4954244633590448,8.32416865450399
11,640001.0,3.321,1.362,-3.225,-0.00175,5.238217139552541,0.12831187385697787,5.156936728542551,1.6830362651342048,8.1486169548459
12,640001.0,2.327,1.59,-3.243,-0.00198,5.136507876112496,0.10968107604624301,5.257594307546863,1.6939028268958316,8.14579930766826
13,640001.0,2.902,1.218,-2.348,-0.00659,5.261861001452352,0.15085839114222266,1.7921996444853698,0.8712700656501113,8.499998654247
14,640001.0,2.066,1.553,-2.861,-0.00405,5.094828070420862,0.11600966753697055,3.4572858637495654,1.3487056173737226,8.422488247208
15,640001.0,3.071,1.363,-3.052,-0.00209,5.2143669798631604,0.13168691534732166,3.7005476892249347,1.3518221566646607,8.43515614178
16,640001.0,1.579,1.689,-3.116,-0.00107,5.120443275974533,0.10630350375191897,3.680324226471275,1.3218199728721465,8.4570055155192
17,640001.0,4.81,1.27,-3.87,0.0,5.236927295566154,0.12431583784493026,8.962804365567257,1.8675853764480108,7.7749160969305064
18,640001.0,4.66,1.27,-3.83,0.0,5.3062582558537095,0.12473590495059626,8.857814143012762,1.8872809371766448,7.770666283189213
```

Figure 8 : *All_IPEs_classical_results.txt* example

```
,EVID,Depi,I,Io,QIo,StdI,StdlogR,Ndata
0,640001.0,6.893555566256284,7.5,7.5,0.5,0.5020458146424487,0.022866422997013594,2.0
1,640001.0,9.45898848604366,7.0,7.5,0.5,0.3003860542055329,0.08582458691586654,30.0
2,640001.0,21.95077472612918,6.5,7.5,0.5,0.47197320217118155,0.1348494863346233,36.0
3,640001.0,27.725119626557667,5.999999999999995,7.5,0.5,0.5631071554374656,0.16088775869641875,88.0
4,640001.0,34.32098839745917,5.500000000000001,7.5,0.5,0.6167545798890932,0.17621559425402664,87.0
5,640001.0,45.72750191984382,4.999999999999994,7.5,0.5,0.6597006246538032,0.1884858927582295,146.0
6,640001.0,53.666669541735295,4.500000000000001,7.5,0.5,0.5722712889773102,0.16350608256494575,187.0
7,640001.0,84.75580862512047,4.0,7.5,0.5,0.7365598002262106,0.21044565720748876,175.0
8,640001.0,113.2350926576989,3.4999999999999982,7.5,0.5,0.7498740463498028,0.2142497275285151,117.0
9,640001.0,131.87120925875962,2.9999999999999973,7.5,0.5,0.7405647493108941,0.2115899283745412,104.0
20,640001.0,0.0,7.5,7.5,0.5,0.5,99.0,1.0
```

Figure 9 : *IDP_binning.txt* example