

Supplement of Geosci. Model Dev., 9, 1567–1596, 2016
<http://www.geosci-model-dev.net/9/1567/2016/>
doi:10.5194/gmd-9-1567-2016-supplement
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Supplement of

SiSeRHMap v1.0: a simulator for mapped seismic response using a hybrid model

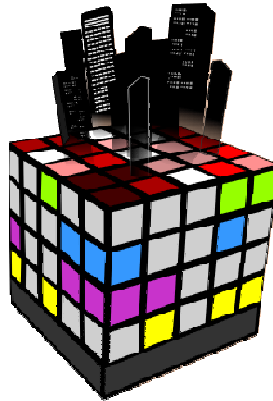
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SiSeRHMap v1.0:

Simulator of mapped Seismic Response using a Hybrid Model



<http://www.geosmartapp.it>

QUICK START GUIDE

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System requirements

Operating system	<u>Windows XP or newer version of Microsoft Windows</u>
CPU	Intel Core i3 or other with similar performance
Memory	16 GB RAM or higher
Hard drive	10 GB available in the hard disk
For map view:	
Graphics software	Geographic Information System platform or Surfer (any version)

Introduction

SiSeRHMap is a computer program methodology aimed at the Simulation of the Seismic Response in a mapped form; it is based on a Hybrid Model. The Hybrid Model consists of an complex computational system composed of a GIS frame model, numerical analytical models (physically based) and metamodeling procedures which are capable to developing set-maps of seismic response taking into account the combined effects of plane-parallel stratigraphy and of topographic features.

SiSeRHMap computational modules

SiSeRHMap is composed of five progressive inter-dependending Python compute modules, each of which necessitates an external input. In this version, the software is instructed by the TUI (Textual User Interface) command lines which write the file "*Instruction.txt*", which is subsequently read by the computational modules. The modules and their computational functions are as follows:

mod.1: Lithodynamic Units parameterization;

mod. 2: Gis Cubic Model frame;

mod. 3: Stratigraphic Response;

mod. 3.1: Plot Seismic Signals;

mod. 4: Training "Spectra";

mod. 5: GCM Maps Executor;

mod. 5.1 Topographic Amplification;

mod. 5.2 Design Spectra.

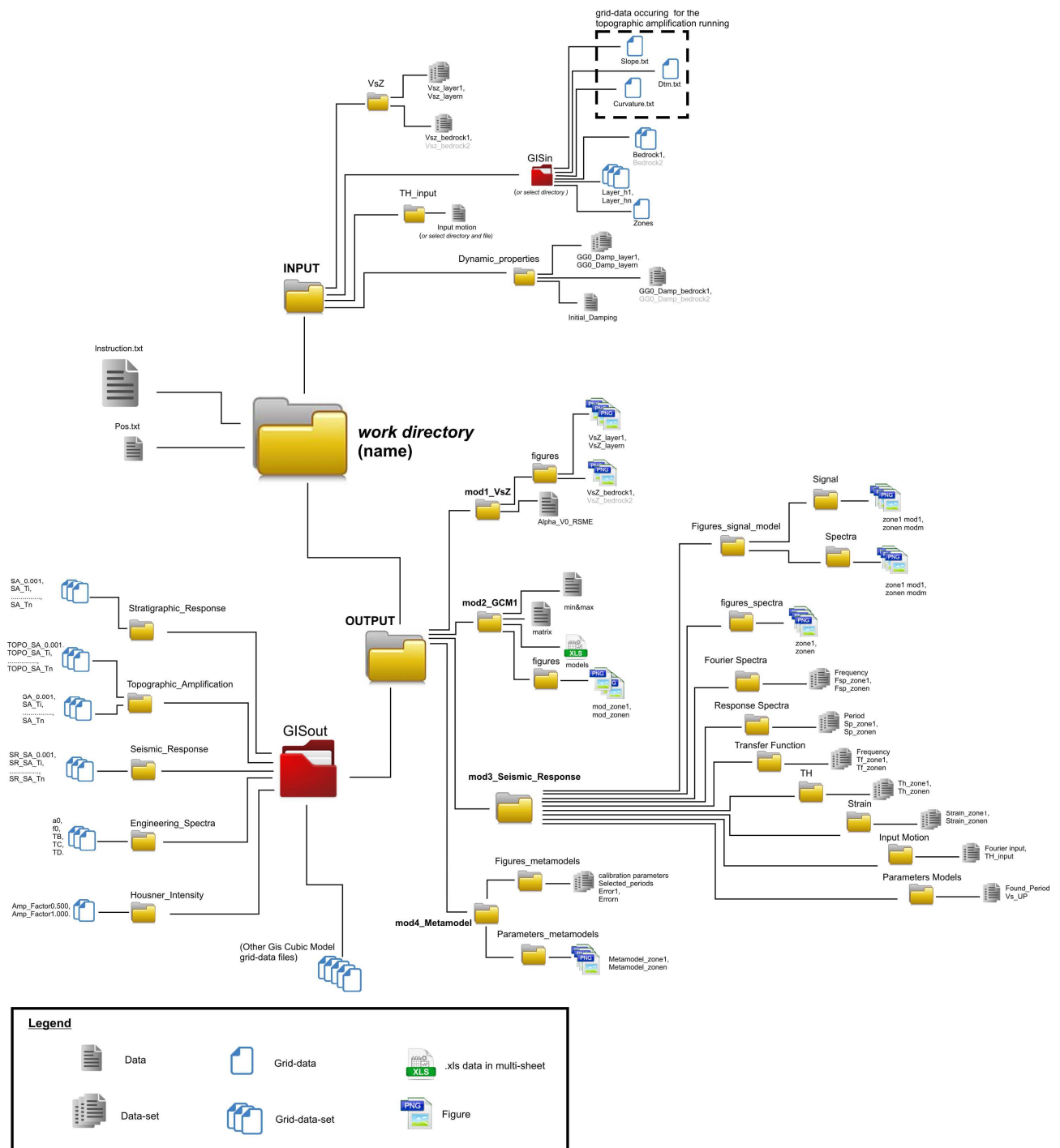
This guide is supported by the file "*instruction.txt*" and input files (in the "*INPUT*" folder) which refer to the case illustrated in the manuscript: "SiSeRHMap v1.0: Simulator of mapped Seismic Response using a Hybrid Model submitted to the GDM. These files show the correct mode for compiling, naming and extending the files used in the running.

Foreword:

Mod.1 and Mod.2 are the main modules related to the loading of the regional model that is accomplished both in terms of parameterization and geometrical setting. This model, as reported in the manuscript (par. 2.1, 2.2), should be constituted on the basis of surveys collection and construed in preliminary studies that are aimed at defining the lithodinamic units and subsequently the zones, in an appropriate way. Subsequent to these studies, the shear wave velocity (V_s) vs deep (z) parameterization of the lithodinamic units must be reported in a column shape as a file.txt; instead, the extension of the lithodinamic units and the zones, must be defined as a grid-data file.txt by means of the use of any GIS platform. The procedure GIS to obtain the input grid-data files is not included in this guide, although their development should be reasonably easy for a normal GIS user.

NOTE: The header lines in the data-set files must not be present.

Project in SiSeRHMap directory



START

from SiSeRHMap.exe

Create the project in the new work directory where you prefer or resume a previously created work directory, in the same way :

```
*****
                                     WELCOME TO  SiSeRHMAP
                                MAPPING ABOUT SEISMIC RESPONSE BY A HYBRID MODEL
                                     Ver.  1.0 beta
                                     2015
                                Author and developer : Gerardo Grelle
                                gerardo.grelle@unisannio.it or gerardo.grelle@uniroma1.it
*****

-----
Insert the WORK-DIRECTORY (e.g.  C:\SiserhMap):>>>>  D:\Project_city
```

- It is advisable to merge the name of the files and folders using underscore .

Excluding the first start, in subsequent starts, the continuation of the last project or the creation of a new project is necessary. In the first case, it is possible to chose the computed module from which to start.

```
-----
Yuo are now in the WORK DIRECTOTY PROJECT: D:\project_sisermmap
Continue the running (1=YES; 0=NO):>>>>  1
Yuo are now in the MODULE 4
Switch to a LOWER MODULE  (1=YES; 0=NO):>>>>  1
Insert level of MODULE (must be < 4):>>>>  2
```

[A1]

NOTE:

If you want to reproduce the computation on the Synthetic Recurrent Scenario that is illustrated in the manuscript, copy the INPUT folder, from the supplementary files provided with SiSeRHMap, and paste and replace in your current work directory.

MODULE 1

Lithodynamic Units parameterization

```

*****
You are now in MOD.1: PARAMETERIZATION OF LITHODYNAMIC UNITS
*****

-----
Insert the NUMBER OF COVERED LAYERS:>>>>  3
-----
Insert the NUMBER OF BEDROCKS (max 2):>>>>  2
-----
Vs thershold  of rigid bedrock [m/s]:>>>>  800
-----
In D:\project_siserm\INPUT\VsZ,
insert the files naming:
vsz_layer1.txt,... & vsz_bedrock1.txt,...
File inserted?  (1=YES; 0=NO):>>>>  1

```

[A2]

1. The numbers of covered layers is unlimited, while the number of bedrocks is max 2;
2. The threshold shear wave velocity, V_{Srig} , of the rigid bedrock should be higher than the V_s of the covered layer and regards only the detecting of rigid/non rigid bedrock; the V_{Srig} value must be given in any case.
3. For non rigid bedrock, the V_s -z data_set must contain V_s values above the V_{Srig} .
4. In the case of two bedrocks, where one is non-rigid, then this latter must be bedrock1: this condition must be used also in the developing of the grid data file produced using the GIS.
5. The V_s of the rigid bedrock is the first value in the column of the relative V_s -z data-set; if this value is less than V_{Srig} , the corresponding bedrock is automatically considered as non-rigid.

E.g. of input file for a $V_{Srig} = 800$ m/s:

NON-RIGID BEDROCK (bedrock1)

vsz_bedrock1.txt - Blocco note	
File	Modifica
10.33	494
26	936
2.7	487
24	1205
17.89	1174
14.88	689
3.7	419
1.31	337
6.48	930
6	597
12.66	1104
2.39	689
21.93	880
11.5	856

RIGID BEDROCK (bedrock2)

vsz_bedrock2.txt - Blocco note	
File	Modifica
20.58	856
26	936
5.5	720
24	880
17.89	753
15.73	807
19.69	1033
7.31	795
10.33	778

MODULE 2

Gis Cubic Model frame

You are now in MOD.2: GIS CUBIC MODEL FRAME

Insert the NUMBER OF ZONES:>>>> 8

Insert the NUMBER OF Vs-H TRAINER PROFILES (suggested 10):>>>> 10

Insert the DEEP of OUTPUT; z-out [m]:>>>> 3

In the BINARY TEMPLATE MATRIX insert the rows(e.g. 1,0,1,1,0):

ZONE 1:>>>>	1,0,1,1,0
ZONE 2:>>>>	1,1,1,1,0
ZONE 3:>>>>	0,0,1,1,0
ZONE 4:>>>>	0,1,1,1,0
ZONE 5:>>>>	0,1,0,1,0
ZONE 6:>>>>	0,0,0,1,0
ZONE 7:>>>>	0,0,0,0,1
ZONE 8:>>>>	0,1,0,0,1

Group 1 (points to rows 1-4)

Group 2 (points to rows 5-8)

Bedrock1 (points to column 2)

Bedrock2 (points to column 4)

Covered Lithodynamic Units (points to column 5)

Insert, in D:\project_sisermmap\INPUT\GISin\, the files naming:
(Layer1.txt,... & Bedrock1.txt...),(H_layer1.txt,...) & (Zones.txt)
Inserted?(1=YES; 0=NO):>>>>

[A3]

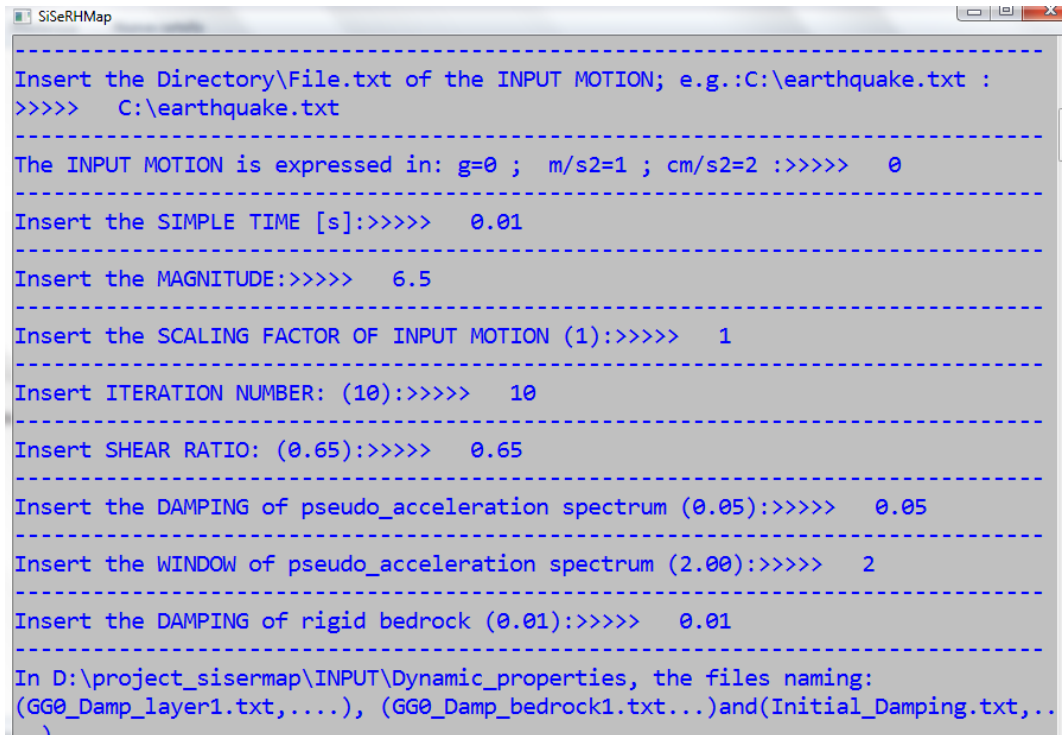
1. The number of Vs-h trainer profiles should be assigned in relation to both the number of cover layers and mainly in relation to their combination of thickness assumed in the layer sequences which constitute the zones. Number of 10 Vs-h trainer profiles is advisable for the normal setting. It should not, however be less than 5. On this topic, the modeller should take into account the theoretic base of SiSeRHMap: a low number of Vs-h trainer profiles could result in an insufficient training of the "Spectra" and consequently possible errors in the generation of maps (mod 5: GCM Maps Executor).

When two bedrocks are present:

2. The co-presence of two bedrocks in a zone is not admitted.
3. Grouping the order of zones in reference to the bedrocks is preferable (you see the above figure).

MODULE 3

Stratigraphic Response



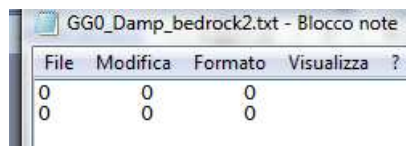
```
SiSeRMap

-----
Insert the Directory\File.txt of the INPUT MOTION; e.g.:C:\earthquake.txt :
>>>>>  C:\earthquake.txt
-----
The INPUT MOTION is expressed in: g=0 ;  m/s2=1 ; cm/s2=2 :>>>>>  0
-----
Insert the SIMPLE TIME [s]:>>>>>  0.01
-----
Insert the MAGNITUDE:>>>>>  6.5
-----
Insert the SCALING FACTOR OF INPUT MOTION (1):>>>>>  1
-----
Insert ITERATION NUMBER: (10):>>>>>  10
-----
Insert SHEAR RATIO: (0.65):>>>>>  0.65
-----
Insert the DAMPING of pseudo_acceleration spectrum (0.05):>>>>>  0.05
-----
Insert the WINDOW of pseudo_acceleration spectrum (2.00):>>>>>  2
-----
Insert the DAMPING of rigid bedrock (0.01):>>>>>  0.01
-----
In D:\project_sisermmap\INPUT\Dynamic_properties, the files naming:
(GG0_Damp_layer1.txt,...), (GG0_Damp_bedrock1.txt...)and(Initial_Damping.txt,..
\)
```

1. The choice of the input motion assumes a key role in SiSeRMap. The hybrid nature of the code shows a high performance when it uses an input motion with a regular spectrum: a better performance is showed when an input motion, matched in frequency with a design spectra shape (as it is required in EC8 and FEMA building codes), is given. More input motion model analysis can be performed in this module, please insert the input motions (having same unit measures) in the "Earthquake" sub-folder that is in the "INPUT" folder.

NOTE: an input motion (*earthquake.txt*) that matches in frequency a design spectrum is provided in the supplementary files.

2. The time column must not be reported in the data-set of the input motion file: the acceleration data can be provided in g, m/s², or cm/s².
3. In this version, the dynamic shear ratio is not related to the magnitude;—however the operator can insert this value.
4. In the Dynamic Properties dataset, the files must contain the values of G/G₀ and damping referred to the same strain values. In addition, for rigid bedrocks, the file needs to contain the following:



File	Modifica	Formato	Visualizza	?
0	0	0		
0	0	0		

5. The damping of the rigid bedrock refers to all the bedrocks in the rigid condition bedrock which are considered to be composed of linearly viscoelastic material.

MODULE 4

Training "Spectra"

```
You are now in MOD.4: TRAINING << SPECTRA >>

*****

-----
Insert the SAMPLING PERIOD [s] (0.1):>>>> 0.1
-----
Insert the number of SAMPLES (15):>>>> 15
The sampling windows is: 1.500 s
-----
Use default MEAN GUESSES parameters (1=YES; 0=NO):>>>> 1
-----
Use default STANDARD DEVIATION GUESSES parameters (1=YES; 0=NO):>>>> 1
-----
Insert the MODAL SCALING FACTOR of SPECTRA (1):>>>> 1
-----
Use the recommended INITIAL TARGET ERRORS
- ([0.03, 0.04, 0.02, 0.03, 0.02, 0.01, 0.01, 0.02]) (1=YES; 0=NO):>>>> 1
-----
Insert the INCREMENTAL ERROR [%] (2):>>>>
```

1. The sampling period and the number of sampling defines the spectral values used for the training of "Spectra" and consequently define the periods of set maps for the seismic response.
2. The sampling windows should be not less than three times the maximum peak spectral period for all the trainer models of all the zones.
3. Before running the evolutionary algorithm, the modeller can decide whether to use default guess parameters or insert new parameters of means and standard deviation. Eight + eight guess parameters are required.
4. In a similar way to the aforesaid points, the modeller must introduce the error target, which is the error that defines the convergence values to the expected performance. Therefore, these parameters play a key role in the adequate optimization. SiSeRMap proposes the target error values in relation to the possible spectral variability and complexity showed by the set zone spectra. The modeller can choose to change the proposed target error values. However, it is important to take into account that relative low target errors require more time for converging; in contrast, high errors can involve premature convergences. Eight target error values are required.
5. The incremental error target increases the target errors during the evolution of solutions: a value in percentage not greater than 2 - 5 is advisable.

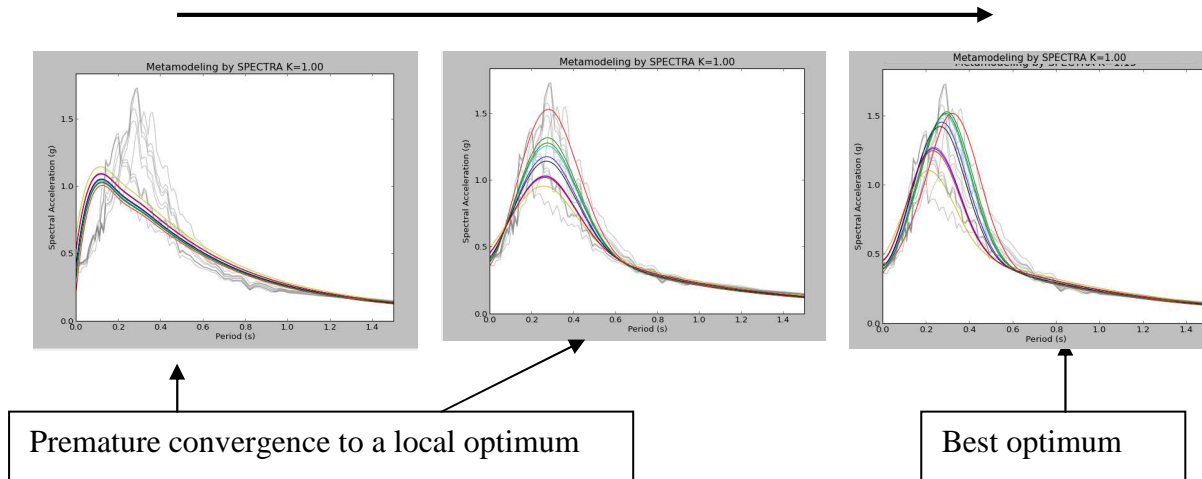
6. At the end of the training, it is possible to see the performance in the optimization of the "Spectra" and the modeller can refine the training in some or all the zones. Therefore, it is possible to select the zone subjected to refinement and scale down the target error, selecting the value of the scaling target errors ratio.

```

1.00000000e-03  1.00000000e-01  2.00000000e-01  3.00000000e-01
4.00000000e-01  5.00000000e-01  6.00000000e-01  7.00000000e-01
8.00000000e-01  9.00000000e-01  1.00000000e+00  1.10000000e+00
1.20000000e+00  1.30000000e+00  1.40000000e+00  1.50000000e+00]
*****
END RUNNING
*****
-----
Do you want to refine? (1=YES; 0=NO):>>>> 1
Insert the zone to refine (e.g.: 2,4,7):    3,5,8
Insert factor scaling of Target Errors (0.1 to 1.00):    0.7

```

Scaling down of target error



MODULE 5

GCM Maps Executor

1. This module is the last and its task is the generation of spectral map sets: the first and main set is the Stratigraphic Response, while the Topographic Amplification and Design Spectra are generated on demand, inserting the option at the beginning of the input data sequence.
2. When the topographic amplification is not chosen in SiSeRHMap, the Design Spectra map set is generated, enveloping only the Stratigraphic Response spectra.

```

*****
                                You are now in MOD.5: GCM MAPS EXCUTOR
*****

-----
Compute the TOPOGRAPHIC AMPLIFICATION (1=YES; 0=NO):>>>> 1
-----
Compute the DESIGN SPECTRA (1=YES; 0=NO):>>>> 1
-----
Insert the UNDER_RESAMPLING FACTOR (1):>>>>
Insert the type of MAPPED DISTRIBUTION FUNCTION
      0=nearest; 1=linear; 2=quadratic; 3=cubic:>>>> 3
-----
Insert the GAUSSIAN FILTER RESOLUTION
      (Standard deviation) (20/40):>>>> 30

```

3. When the topographic amplification is chosen in SiSeRHMap, the following occurs:
 - the parameterization of the specific running module Mod. 5.1 is requested;
 - map sets of Topographic Amplification are generated;
 - the Seismic Response spectral map set that takes into account the Topographic Amplification effect is automatically generated;
 - the Design Spectra map set is generated enveloping the Seismic Response spectra;

Stratigraphic Response mod. 5.0

1. The under resampling options permit the exclusion of one or more local anomalies: this option should be used after observing the maps in the GIS supports. The modeller inserts the under resampling factor (integer value) and the surface interpolation typology; for this latter, it is suggested 3 = cubic. Diversely, insert an under resampling value of 1.
2. Gaussian filter is a surface spatial smoothing tool: It is used for the softening of the slumping that can occur in the boundaries between zones. The value of the Gaussian filter

resolution is the standard deviation expressed in the number of the count (count = spatial resolution unit).

Topographic Amplification mod 5.1

```
[ 0.1765  0.1764  0.1764 ...,  0.1294  0.1294  0.1294]
[ 0.1764  0.1764  0.1763 ...,  0.1294  0.1294  0.1294]
[ 0.1763  0.1763  0.1763 ...,  0.1294  0.1294  0.1294]]
*****
      END RUNNING
*****
*****
      You are now in SUB-MOD.5.1: TOPOGRAPHIC AMPLIFICATION
*****
*****
-----
Insert the SHEAR WAVE VELOCITY OF REGIONAL BEDROCK (m/s):>>>>  1200
-----
In D:\project_sisemap\INPUT\GISin, the files naming:
(Dtm_30.txt,...), (Slope.txt...)and(Curvature.txt,...)
Files inserted?(1=YES; 0=NO):>>>>  1
```

3. The shear wave velocity of the regional bedrock refers to the equivalent uniform material that constitutes the reliefs under the covered layers, if they are present.
4. The topographic attributes (Digital Terrain Model, Slope and Curvature) in the topographic prediction model (A_T) of SiSeRHMap was calibrated for a spatial resolution unit of 30 meters; the grid data must be named: *Dtm_30.txt*, *Slope.txt*, *Curvature.txt*.
5. When the relief is greater than the analysing area which was the object of the stratigraphic response computing (mod 5.0), or when the relief/s are only partially inside this area, the area of the topographic attributes needs to be more extended to the stratigraphic response area up to comprising the whole local topographic feature. However, the area, object of the stratigraphic response, must be the same or must be totally included within the area of the topographic attributes.

Design Spectra mod 5.2

1. Press ENTER and the maps of a_0 , f_0 , T_B , T_C and T_D are developed.