D6.3 Website deploying a suite of geophysical tests for wave propagation problems on extreme scale machines
Version 1.0

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Change Log

Version	Author	Description of Change
V0.1	*Josep de la Puente*	First version, tested internally and at COPPE.
V1.0	*Josep de la Puente*	*http://hpc4e.eu/downloads/datasets-and-software hosts the models*

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Executive Summary

We have developed the “HPC4E Seismic Test Suite”, a collection of four 3D models and sixteen associated tests that can be downloaded freely at the project's website (https://hpc4e.eu/downloads/datasets-and-software). The models include simple cases that can be used in the development stage of any geophysical imaging practitioner (developer, tester …) as well as extremely large cases that can only be solved in a reasonable time using ExaFLOPS supercomputers. The models are generated to the required size by means of a Matlab/Octave script and hence can be used by users of any OS or computing platform. The tests can be used to benchmark and compare the capabilities of different and innovative seismic modelling approaches, hence simplifying the task of assessing the algorithmic and computational advantages that they pose.

1. Introduction

This deliverable is meant to be a useful tool for Tasks 6,1 and 6,2 as well as an option for code benchmarks, i.e. Task 6,4

2. Specific section(s)

2.1 Models

The models have been designed as a set of 16 layers with constant physical properties. The top layer delineates the topography and the other 15 different layer interface surfaces or horizons. In the following, an interface horizon is associated with properties that apply to the layer that exists between itself and the immediately next layer horizon. The model covers an area of 10 x 10 x 5 km, with maximum topography at about 500 m and maximum depth at about 4500 m. The layer horizons have been sampled very finely with 1.6667 m spacing so that a highly accurate representation can be honored at high frequencies. For simulation schemes based on unstructured grids, the layer horizons can be used easily to constrain model blocks. For simulation schemes based upon Cartesian grids, a simple script is provided that can generate 3D grids for any desired spatial sampling. Table 1 shows the properties of each of the layers included in the models.

Layer ID	V_P (m/s)	V_S (m/s)	Density (Kg/m3)	Max. depth (m)	Min. depth (m)
1	1618.92	500.00	1966.38	-135.55	-476.35
2	1684.08	765.49	1985.88	41.50	-394.90
3	1994.35	920.51	2071.63	428.70	-7.06
4	2209.71	1035.89	2125.42	751.69	262.14
5	2305.55	1098.03	2148.11	771.69	381.94
6	2360.95	1142.60	2160.89	890.74	451.19
7	2381.95	1171.71	2165.68	971.18	477.43
8	2223.41	1112.01	2128.71	1353.56	779.26
9	2712.06	1379.47	2237.11	1805.48	890.08
10	2532.22	1310.26	2199.06	1919.60	977.77
11	2841.03	1495.93	2263.24	2021.98	1051.28
12	3169.31	1698.68	2325.96	2589.46	1461.64
13	3252.35	1774.99	2341.05	3009.07	1565.44
14	3642.28	2024.72	2408.27	3741.53	2052.85
15	3659.22	2072.65	2411.06	3761.53	2074.03
16	4000.00	2309.40	2465.34	4480.78	2388.28
2*	1684.08	765.49	1985.88	0.00	0.00
3*	1994.35	920.51	2071.63	428.70	20.00

Table 1: Layer constant properties and their depth range. "Star" layers are only used in the flat case, in substitution of their non-star equivalents

Flat models have been designed too, having layers removed, which both simplifies the geometry of the case and increases the minimum velocity available in the model. Layers 2* and 3*, substituting layers 2 and 3, are thus the free-surface and the first geological layer, respectively, in the flat case.

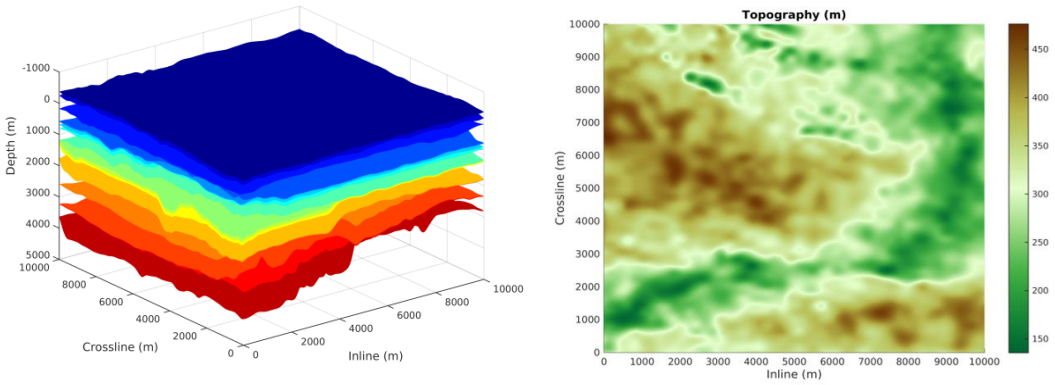

Figure 1: An overview of the layer horizons generating the model (left) and the upper layer or topography (right).

In Table 2 we describe all four models involved in the HPC4E Seismic Test Suite. They are all isotropic lossless 3D models, some with acoustic and some with elastic physical representation.

Table 2: Four models of the HPC4E Seismic Test Suite, with properties described in Table 1

	MODEL AF	**MODEL AT**	**MODEL EF**	**MODEL ET**
Physics	Acoustic	Acoustic	Elastic	Elastic
Free surface	Flat	Topography	Flat	Topography
Min. velocity (m/s)	1684.08	1618.92	765.49	500.00
Max. velocity (m/s)	4000.00	4000.00	4000.00	4000.00
Max. time (s)	6	6	10	10
Samples per trace	1200	1200	2000	2000
MB per shot	1406	1406	2344	2344
Size (km^3)	10 x 10 x 4.5	10 x 10 x 5	10 x 10 x 4.5	10 x 10 x 5
Z origin (m)	0	-500	0	-500

2.2 Tests

A test requires modelling one of the models described above, together with an acquisition geometry (i.e. the location and type of all sources and receivers) and wavelet. We define the following cases

2.2.1 Acquisition geometry

All shots will be explosive sources buried at a depth of 10 m below the free surface. All receivers will record all three components of the particle velocity at the free surface. Receivers are located at all combinations of rx=25*(i-1)+1012.5 with i=1,...,320 and ry=25*(j-1)+1012.5 with j=1,...,320 for a total of 102,400 receivers. Receiver sampling is set at 5 ms. Receiver data will be stored in IEEE 754 binary (i.e. float) format:

1) UNIT: A single shot located at sx=5000 m and sy=5000 m

2) SURVEY: 1681 shots distributed in the x-dimension and y-dimension following all possible combinations of: sx=200*(i-1)+1000 with i=1,...,41 and sy=200*(j-1)+1000 with j=1,...,41. Notice that the (i,j)=(21,21) shot is coincident with the UNIT test.

As a result, a UNIT test will result in approximately 1.4 GB of binary data for acoustic tests and 2.3 GB of data for elastic cases, growing to 2.3 TB and 3.8 TB in their respective SURVEY tests.

2.2.2 Wavelet

The wavelet will be a 0.2 s time-delayed Ormsby wavelet for a very flat frequency response. Two cases are considered, their waveforms provided in binary files:

1) 20Hz wavelet

2) 50 Hz wavelet

In summary, any test will be defined by a model, acquisition and wavelet. For example, test AT-SURVEY-20Hz uses the AT model with SURVEY acquisition and 20 Hz wavelet. Notice that a total of sixteen different tests can be assembled by combining the available models, acquisitions and wavelets.

2.3 Input files

The compressed file including everything necessary to set up the tests can be downloaded from the HPC4E webpage. This includes the layer horizons in binary format, the wavelets in binary format, the properties of each layer in plain text and a script to generate gridded 3D volumes, if necessary. A README file explains how to generate these grids in detail.

The file format is:

2.3.1 Layers

IEEE 754 binary (float) files with 6001 x 6001 samples each, corresponding to depth (positive downwards, zero is sea level), with ordering X-Y (i.e. inline-crossline). Spatial sampling is 1.66667 m. A total of 19 files are included, 16 for the topography case and 3 substitutes for the flat case.

2.3.2 Values

ASCII files with 16 values each, corresponding to the physical properties (homogeneous inside each layer) for the compressional velocity, shear velocity and density.

2.3.3 Wavelets

IEEE 754 binary (float) files with 201 samples each, corresponding to temporal samples of the wavelet (first is time=0). Temporal sampling is 0.005 s.

2.3.4 Volumes (an output of the script)

IEEE 754 binary (float) files with variable (user defined) spacing in meters and, correspondingly, different size. They are the output of the generate_hpc4e_grid.m script. The ordering is Z-X-Y (depth-inline-crossline) and the origin is oz=-500 for topography cases and oz=0 for flat cases. One different file is generated per physical quantity. The cell count in each direction is directly given in the filename.

As an example, if the user wants to run test AF-UNIT-50Hz and has a 4 point per wavelength requirement in his algorithm, he should require a spatial step of 20 m for his simulation. Thus he should run the generate_hpc4e_grid.m code with argument 1 (specifies a flat case) and specify “20” when asked about the spatial sampling desired. He should then use the resulting “vp” and “den” binary files generated by the script, discarding the “vs” file that has no use in the acoustic case. Alternatively, the regridded layer horizons are also available in the “volumes” folder and can be used as input to generate an unstructured mesh by the user. In Figure 2 we can see a slice of the gridded models for an extremely coarse case (d=100 m).

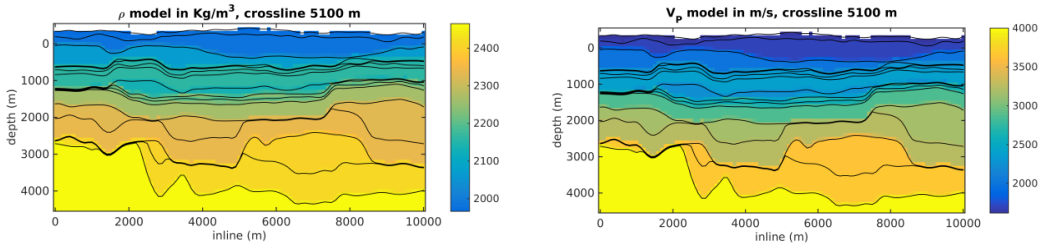

Figure 2: Slices of the density (left) and P-wave velocity (right) gridded models for a 100m discretization, superposed to the layer interfaces.

3. Results and impacts

The deliverable fulfills 50% of the WP6 “Specific Technical Objective 2 – Cost and accuracy evaluation on an open-access set of benchmarks”, together with 100% of its target “website with three very large-scale examples proposed by the industry”.

4. Conclusion

This deliverable being a set of models and their hosting webpage does not have any conclusions.