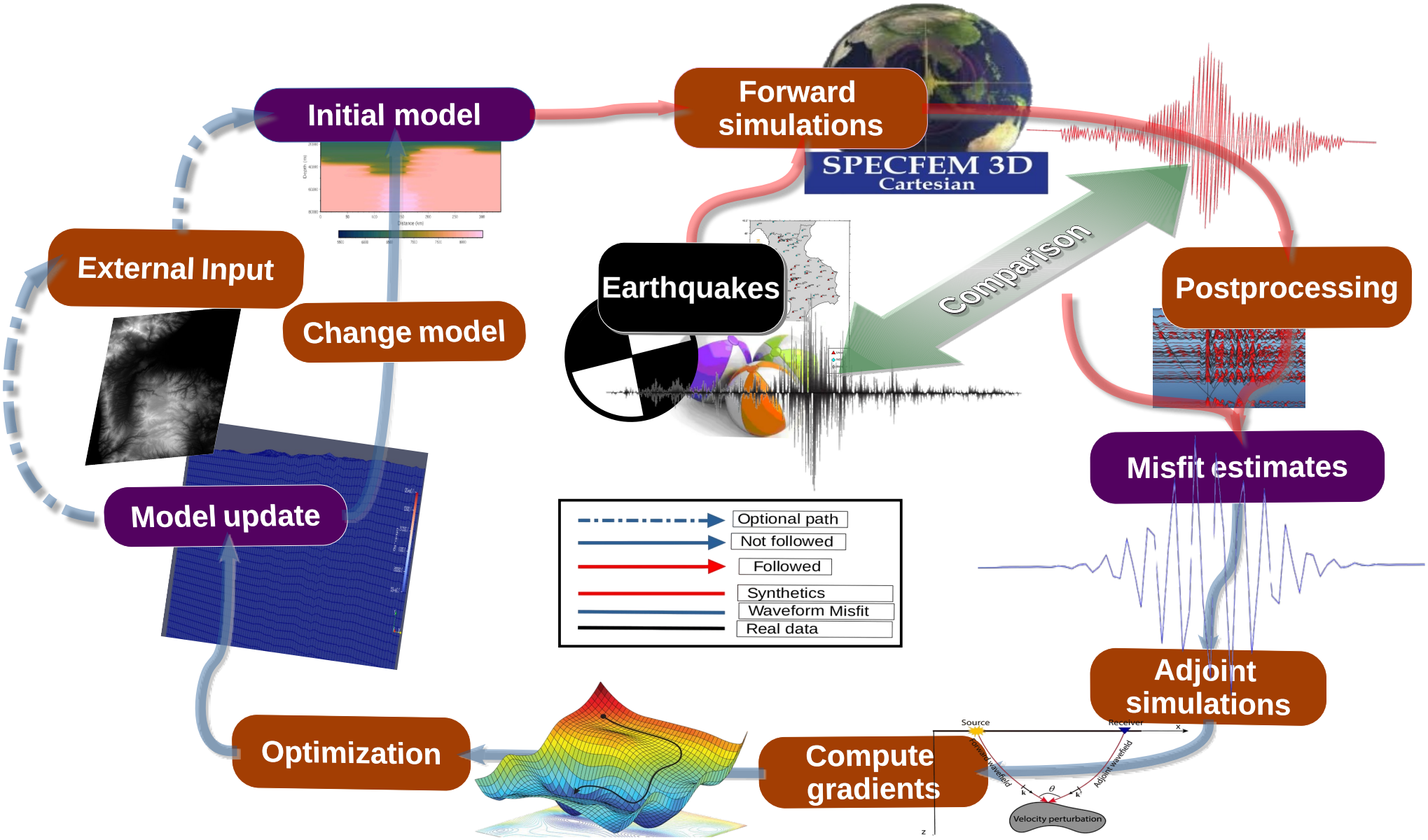
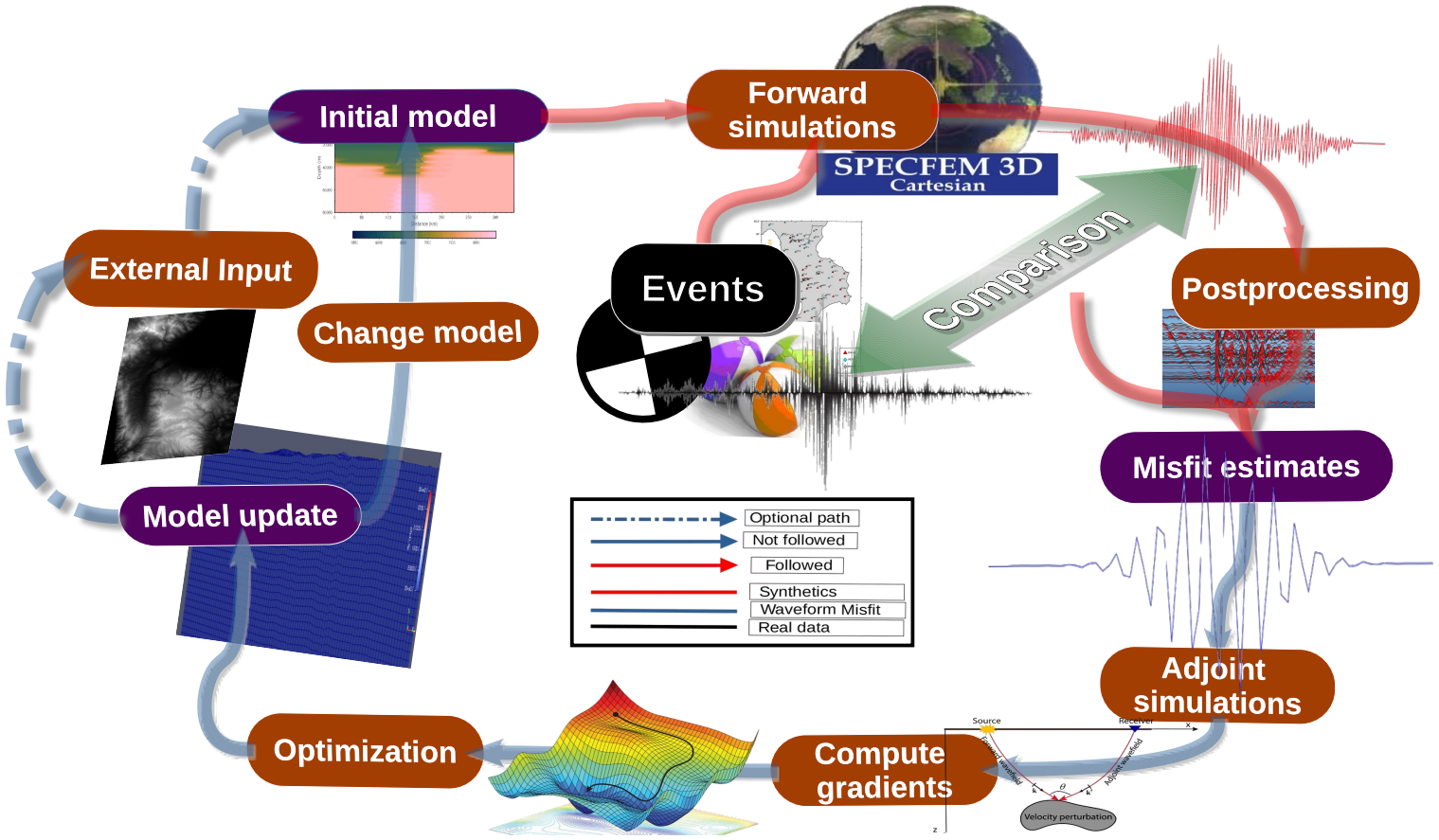

Initial model
Forward simulations
SPECFEM 3D
Cartesian
External Input
Change model
Earthquakes
Comparison
Postprocessing
Misfit estimates
Model update
Optional path
Not followed
Followed
Synthetics
Waveform Misfit
Real data
Adjoint simulations
Optimization
Compute gradients
Source
Receiver
Velocity perturbation



Optional path

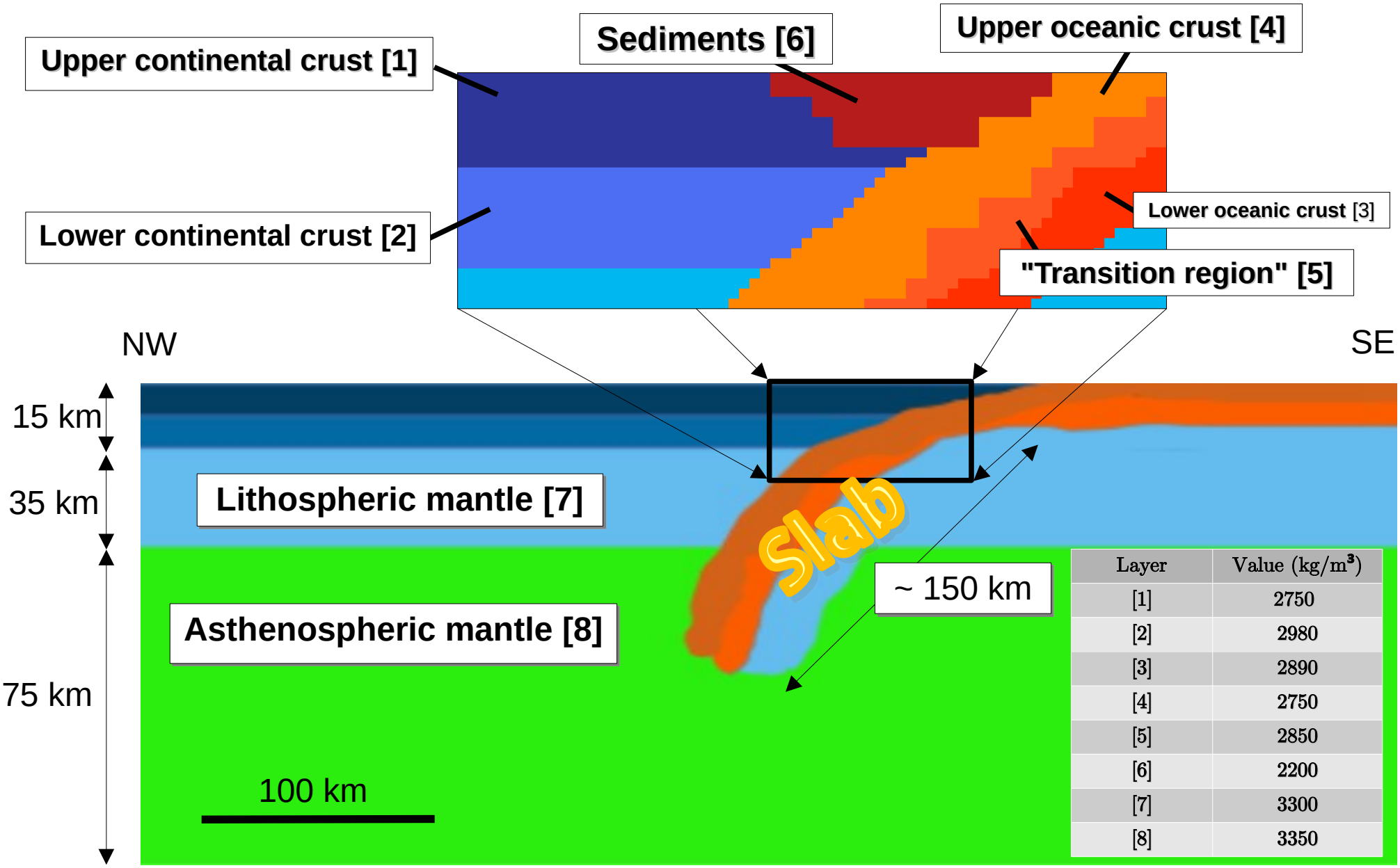
Not followed

Followed

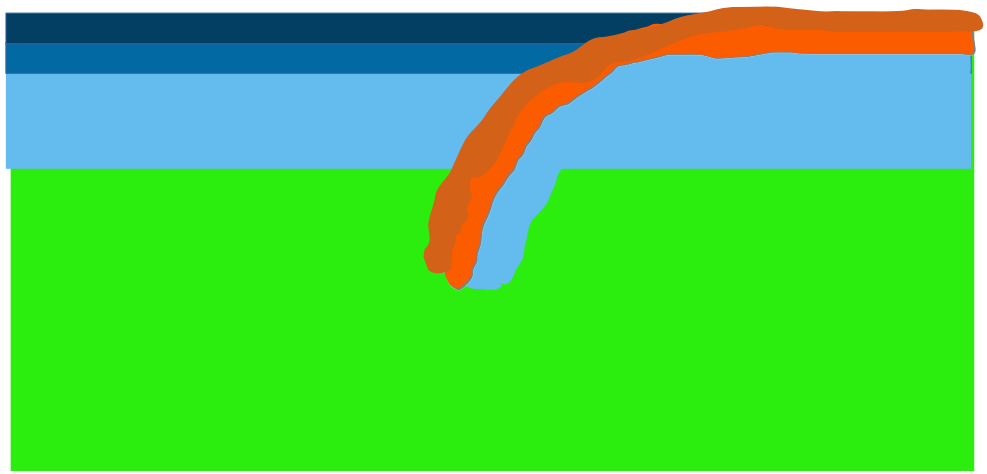
Synthetics

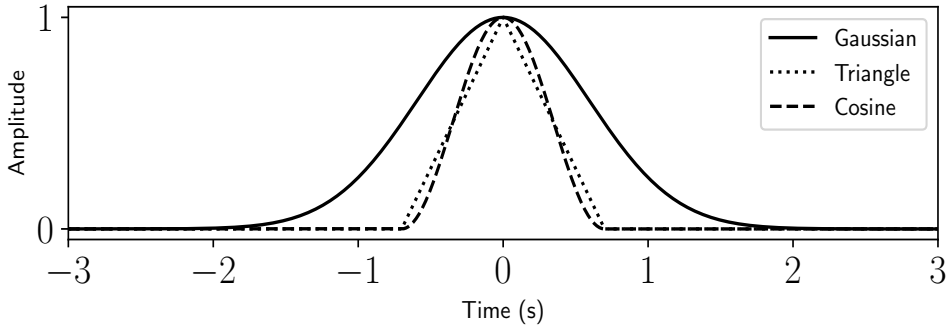
Waveform Misfit

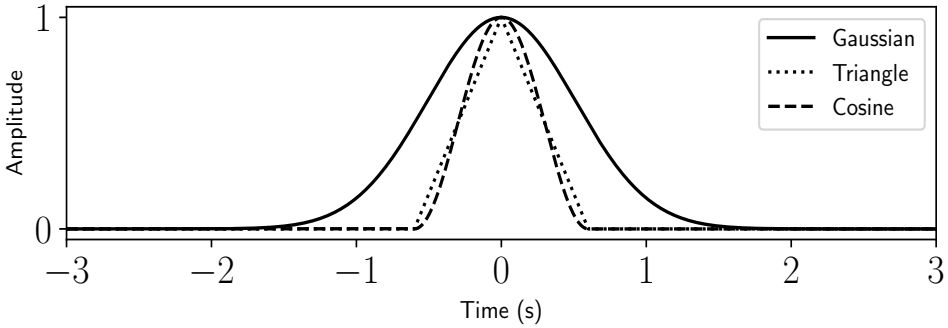
Real data

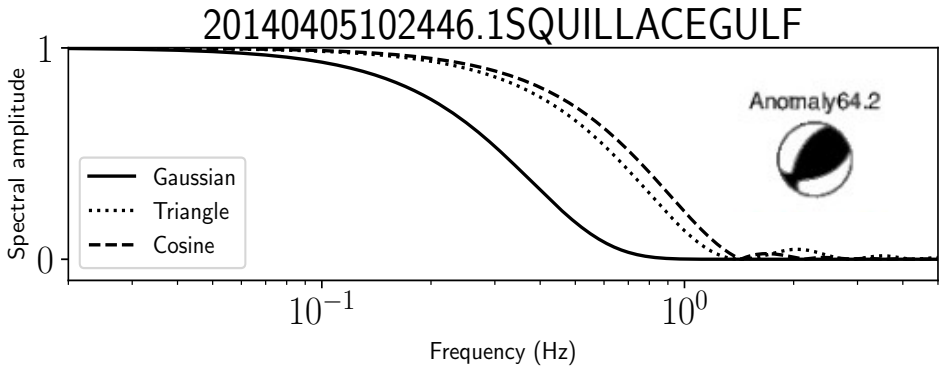


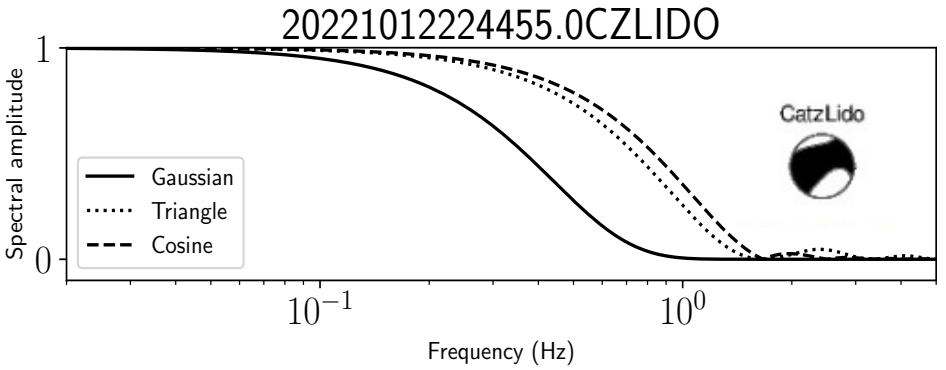
Layer	Value (kg/m^3)
[1]	2750
[2]	2980
[3]	2890
[4]	2750
[5]	2850
[6]	2200
[7]	3300
[8]	3350

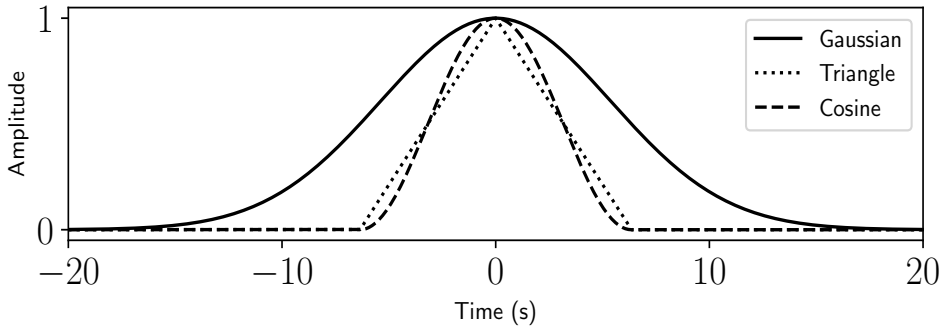


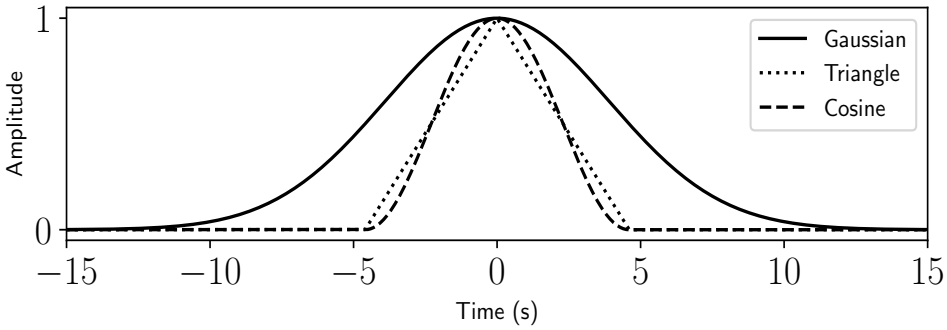

Amplitude
Time (s)
Gaussian
Triangle
Cosine

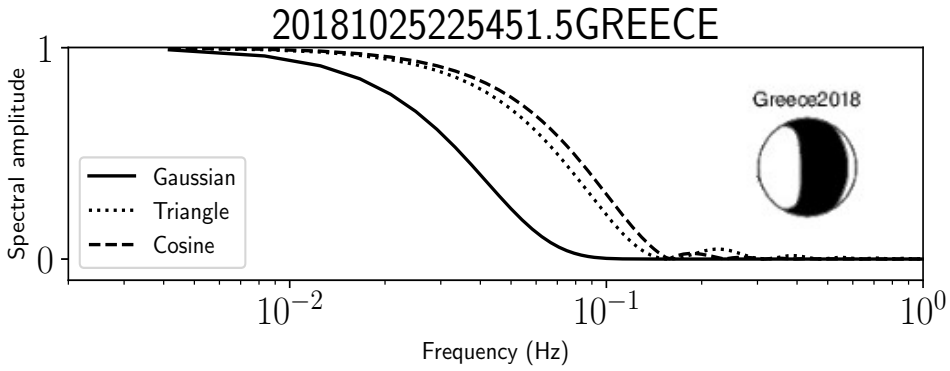

Amplitude
Time (s)
Gaussian
Triangle
Cosine

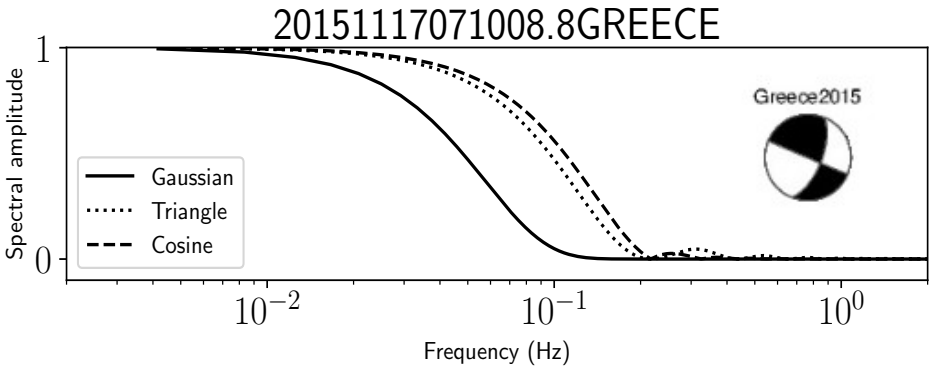

20140405102446.1SQUILLACEGULF
Spectral amplitude
Frequency (Hz)
Gaussian
Triangle
Cosine
Anomaly64.2

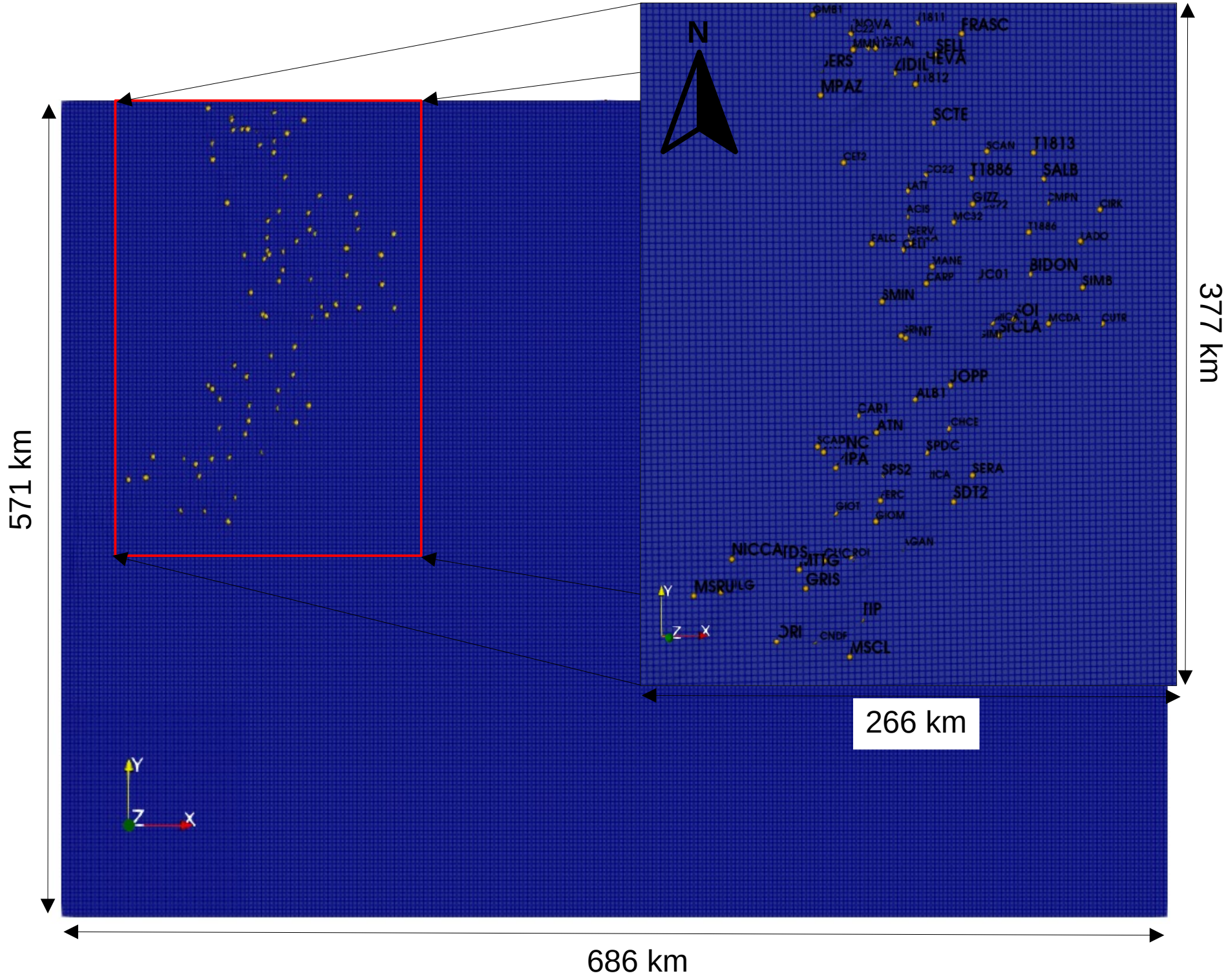

20221012224455.0CZLIDO
Spectral amplitude
Frequency (Hz)
Gaussian
Triangle
Cosine
CatzLido

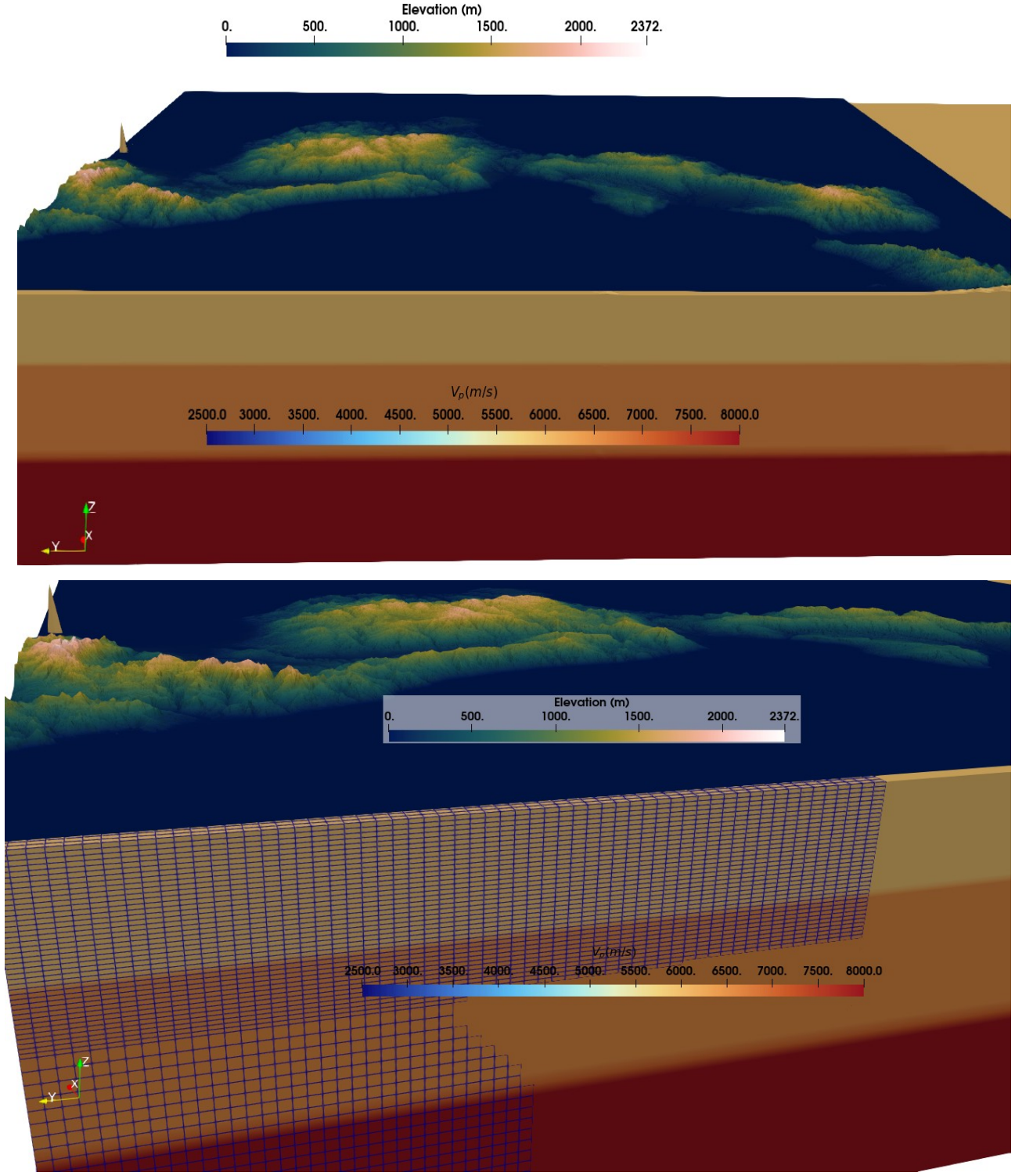

Amplitude
Time (s)
Gaussian
Triangle
Cosine

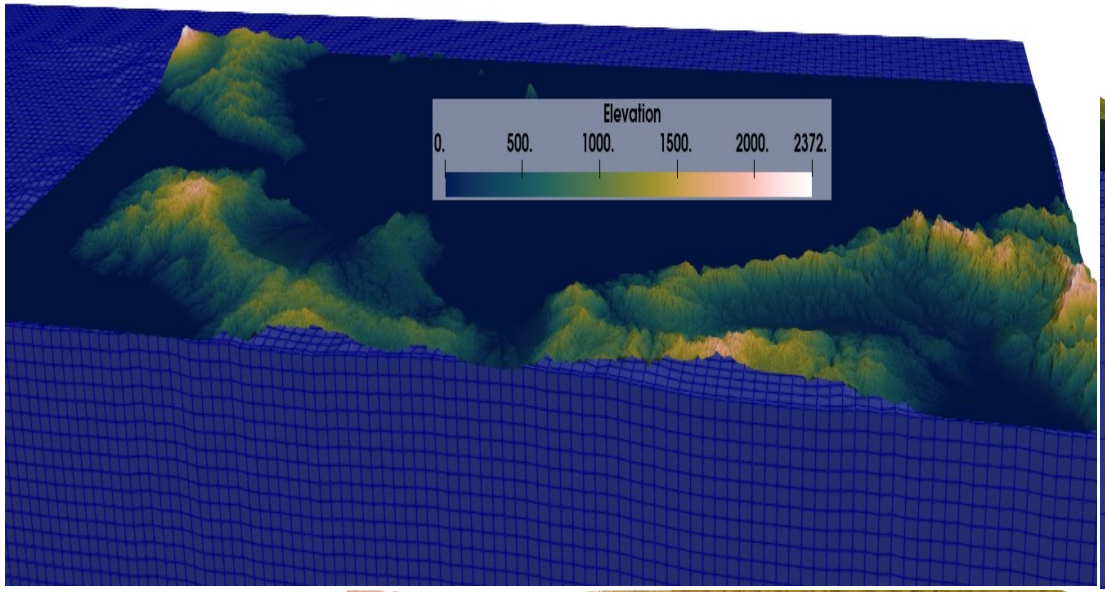

Amplitude
Time (s)
Gaussian
Triangle
Cosine

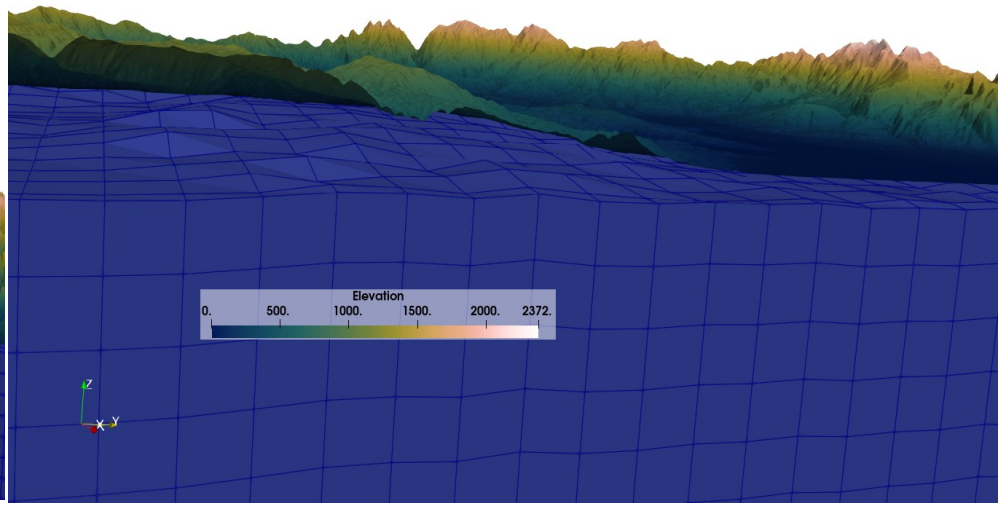

20181025225451.5GREECE
Spectral amplitude
Frequency (Hz)
Gaussian
Triangle
Cosine
Greece2018

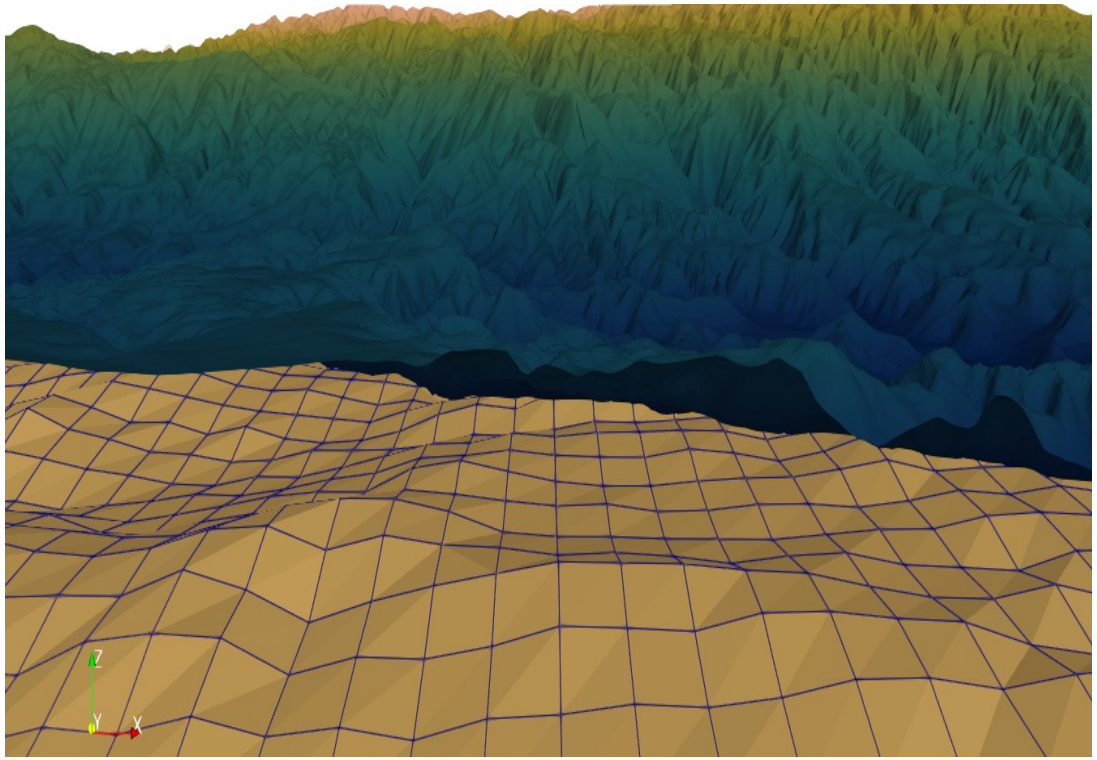

20151117071008.8GREECE
Spectral amplitude
Frequency (Hz)
Gaussian
Triangle
Cosine
Greece2015

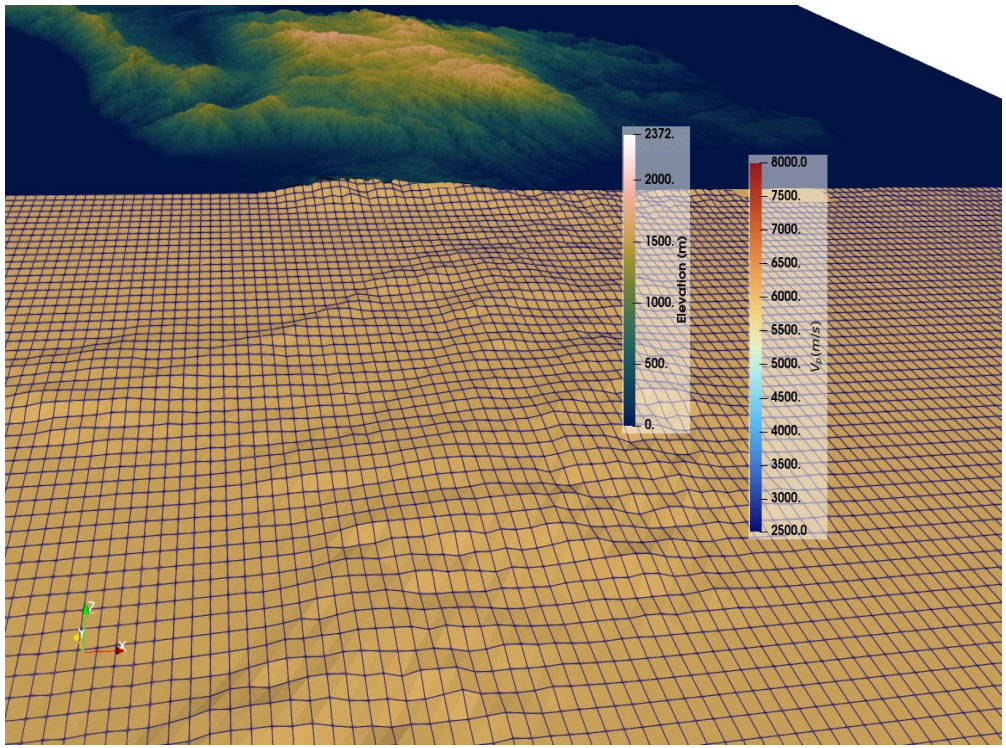

N
571 km
377 km
266 km
686 km
Y
Z
X
FRASC
MPAZ
SCTE
T1813
T1886
SALB
BIDON
JOPP
ALBT
CARI
ATN
SPDC
SPS2
SERA
SDT2
NICCA
GRIS
MSCL
SICLA

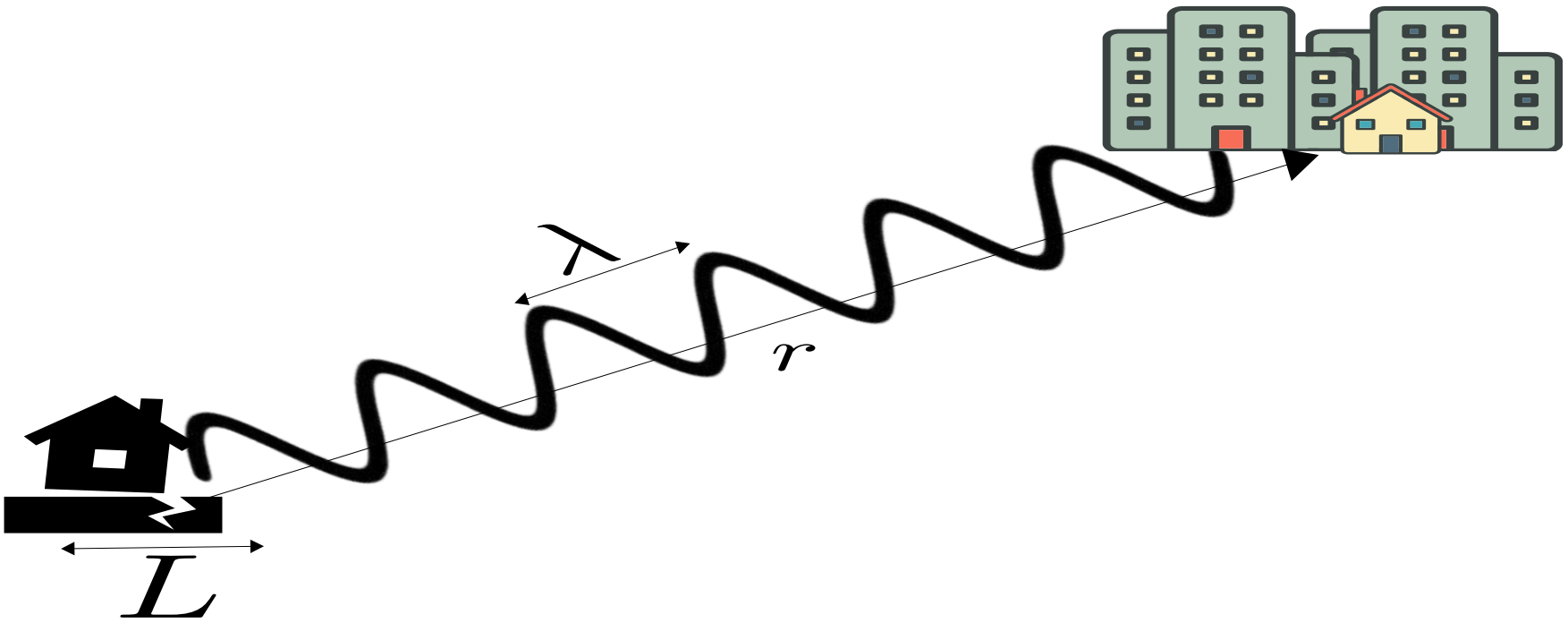

Elevation (m)
0. 500. 1000. 1500. 2000. 2372.
$V_p(m/s)$
2500.0 3000. 3500. 4000. 4500. 5000. 5500. 6000. 6500. 7000. 7500. 8000.0
Z
X
Y
Elevation (m)
0. 500. 1000. 1500. 2000. 2372.
$V_p(m/s)$
2500.0 3000. 3500. 4000. 4500. 5000. 5500. 6000. 6500. 7000. 7500. 8000.0
Z
X
Y

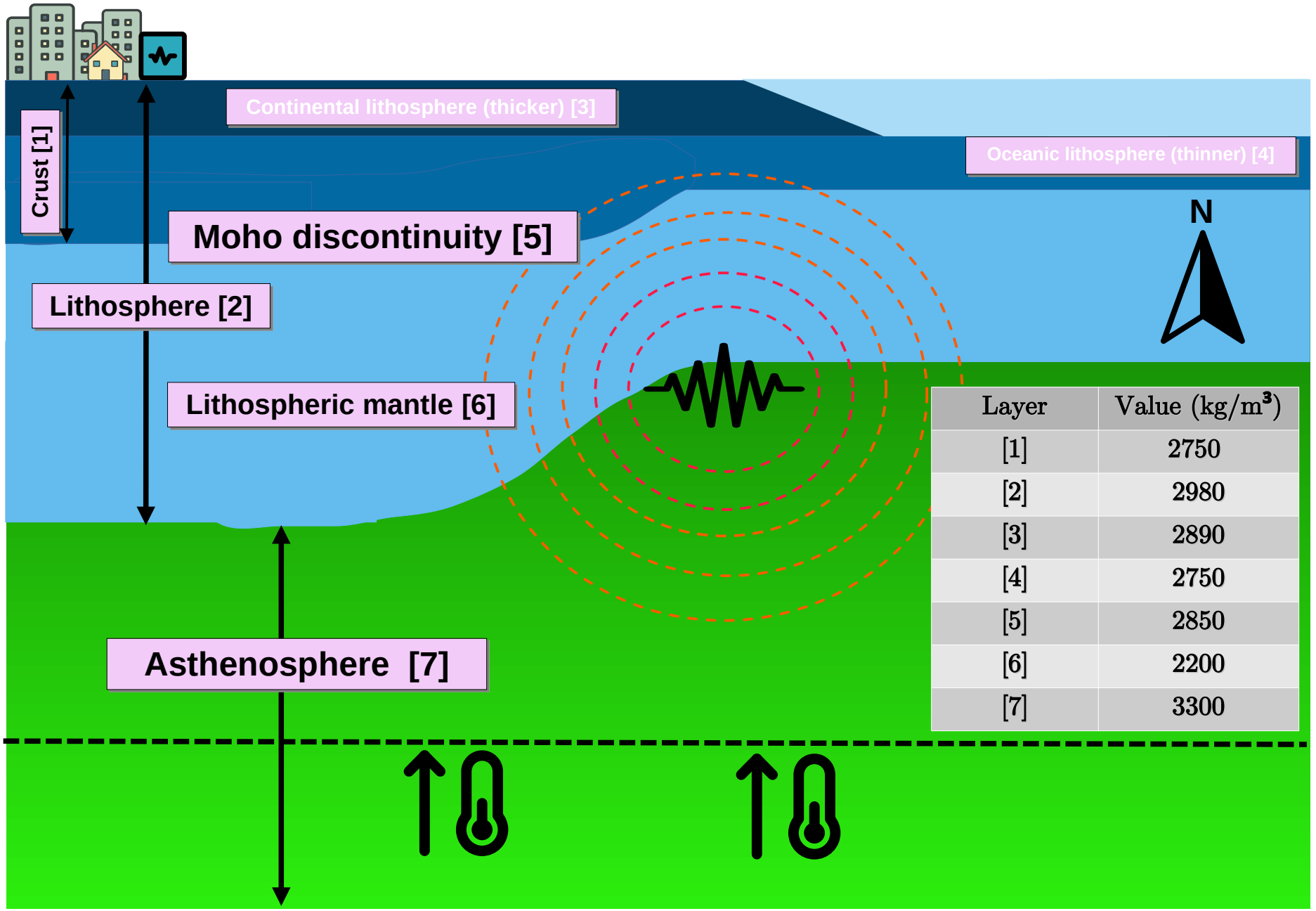

Elevation
0.
500.
1000.
1500.
2000.
2372.


Elevation
0.
500.
1000.
1500.
2000.
2372.
Z
X
Y

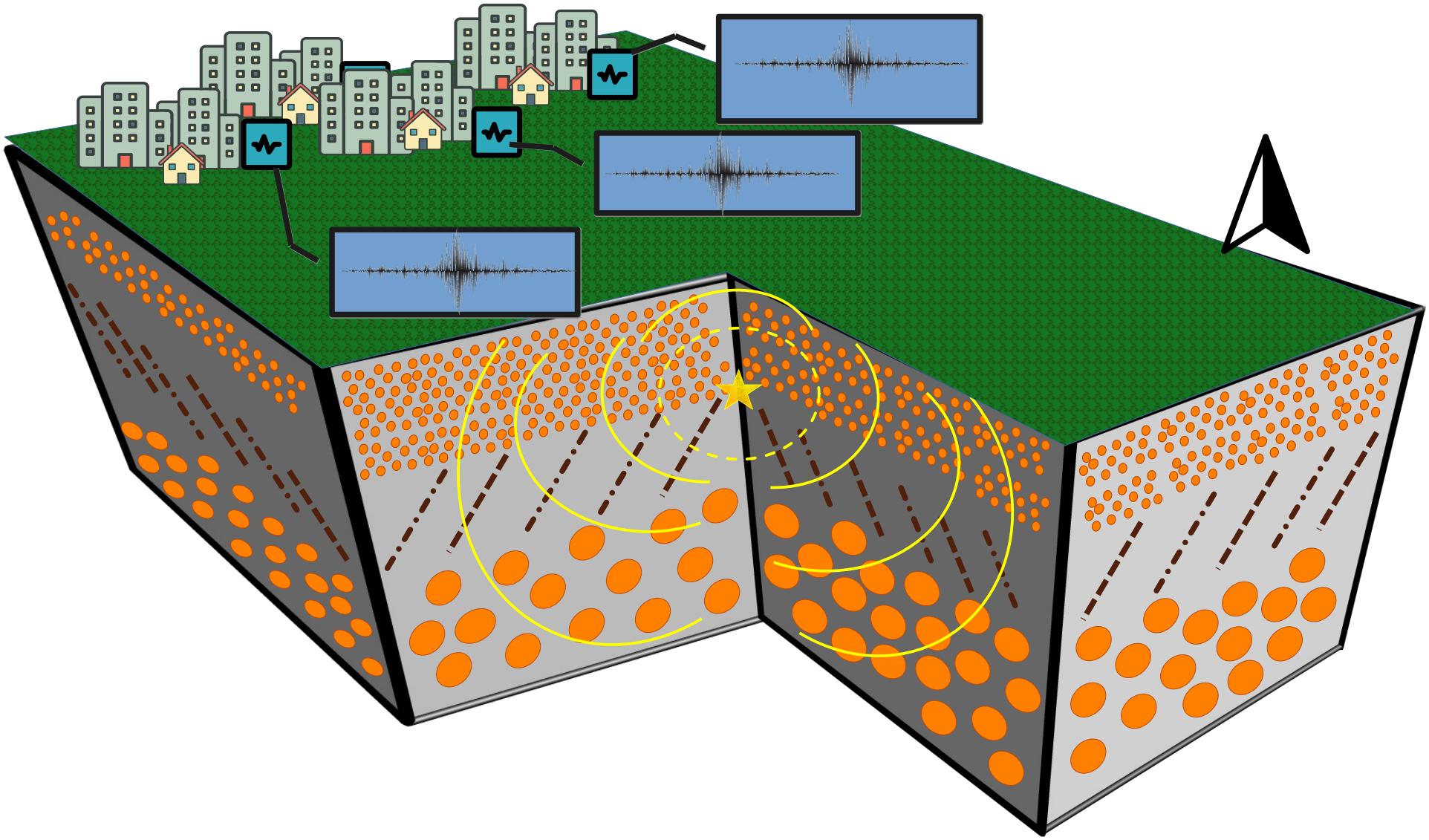

Z
Y
X

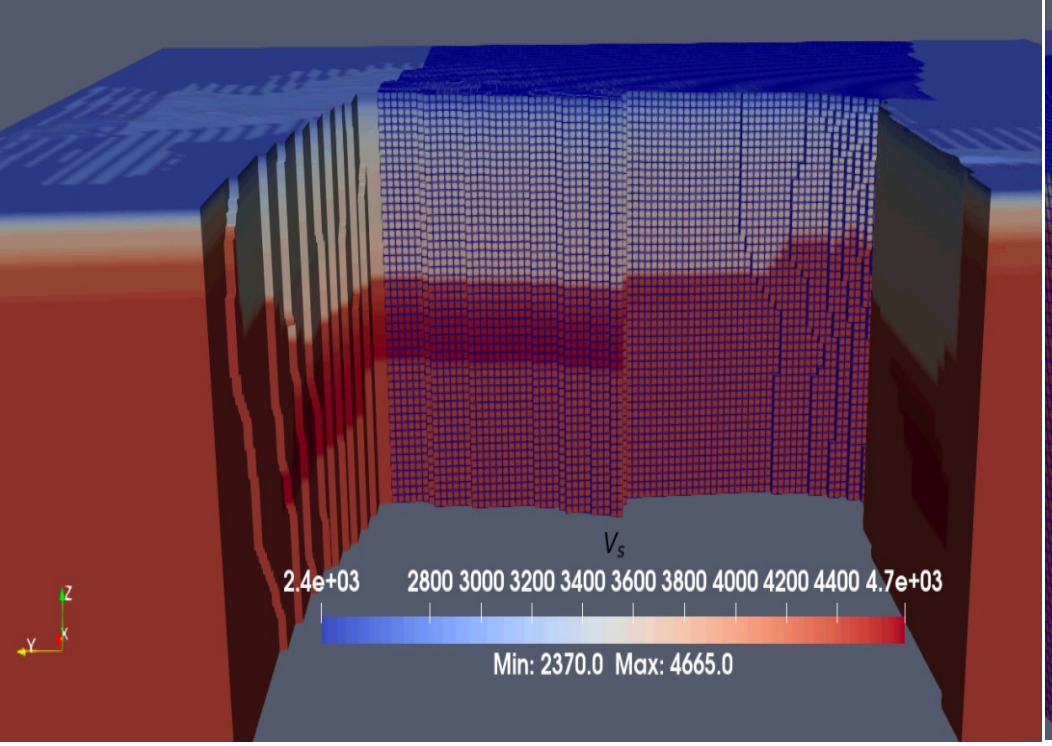

2372.
2000.
1500.
1000.
500.
0.
Elevation (m)
8000.0
7500.
7000.
6500.
6000.
5500.
5000.
4500.
4000.
3500.
3000.
2500.0
V_P (m/s)
Z
Y
X

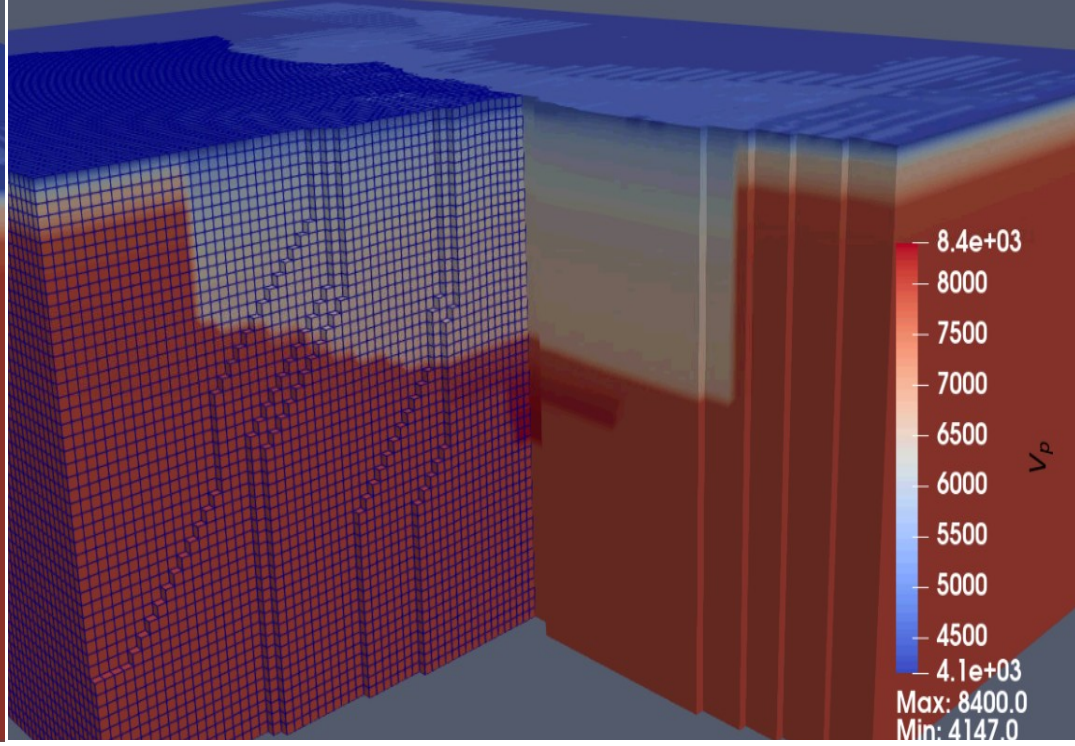

λ
r
L

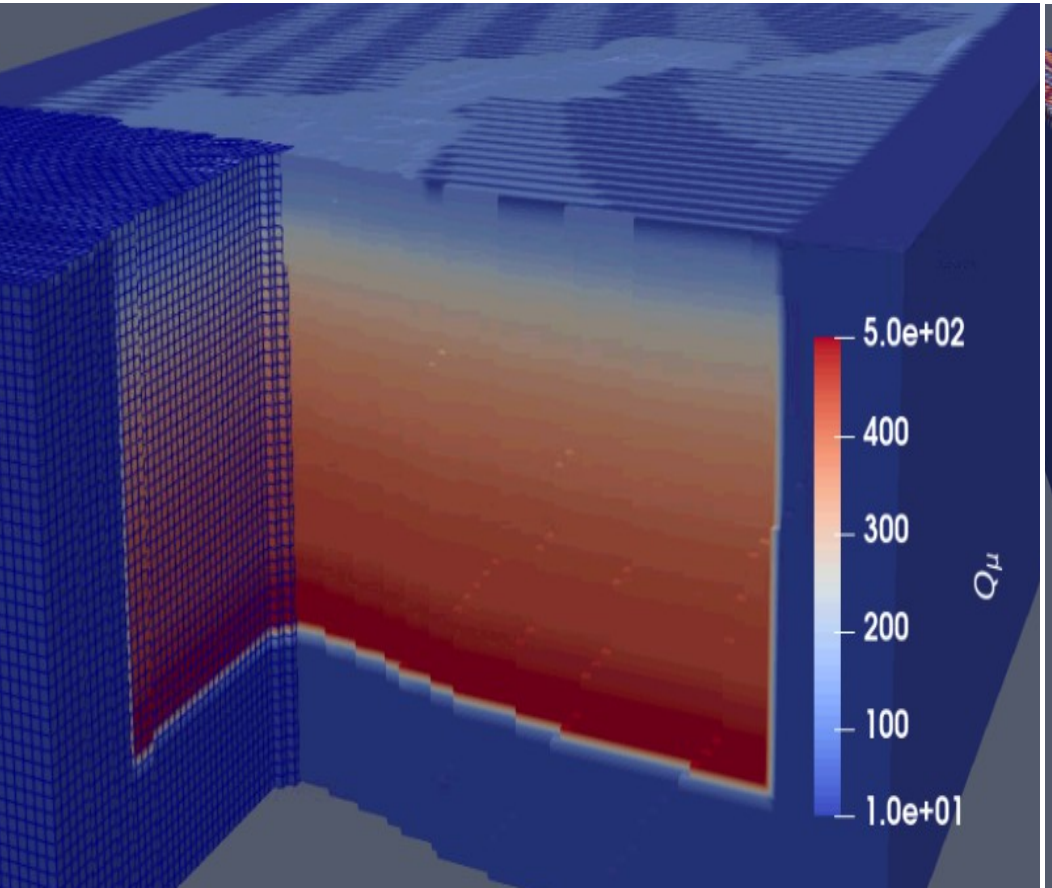


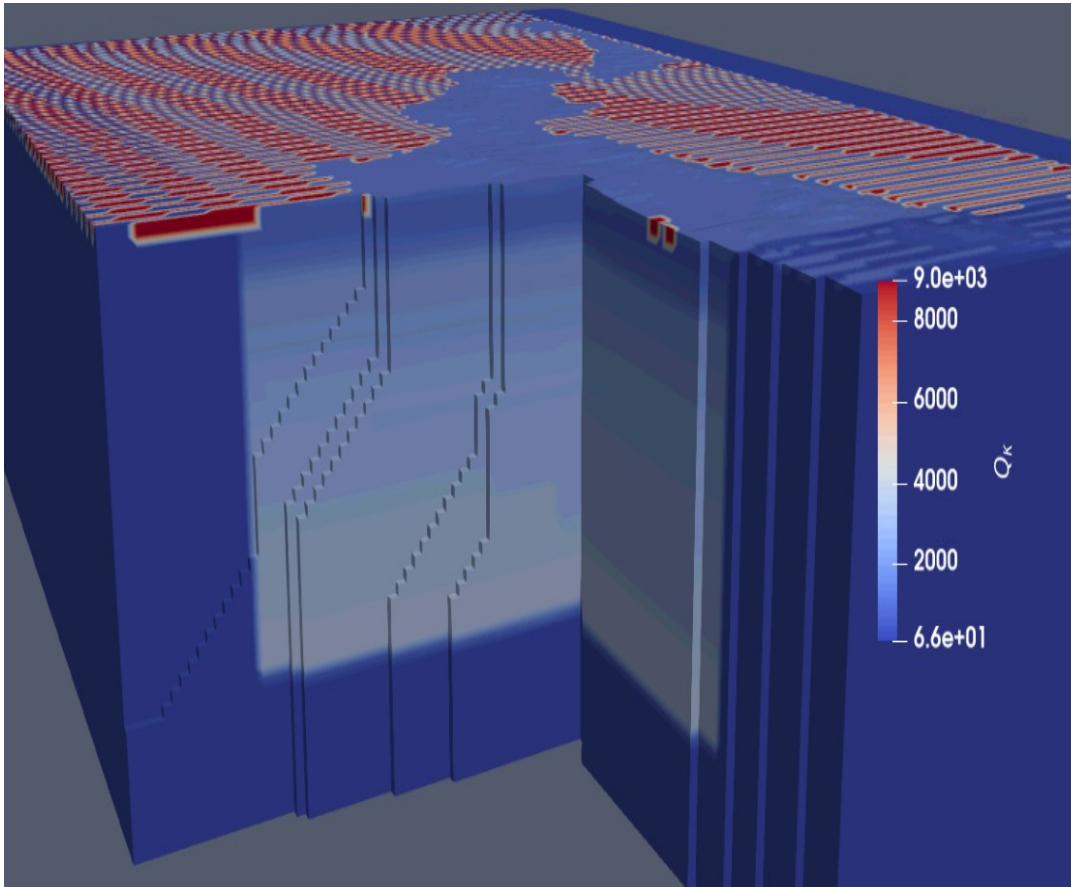
Layer	Value (kg/m^3)
[1]	2750
[2]	2980
[3]	2890
[4]	2750
[5]	2850
[6]	2200
[7]	3300

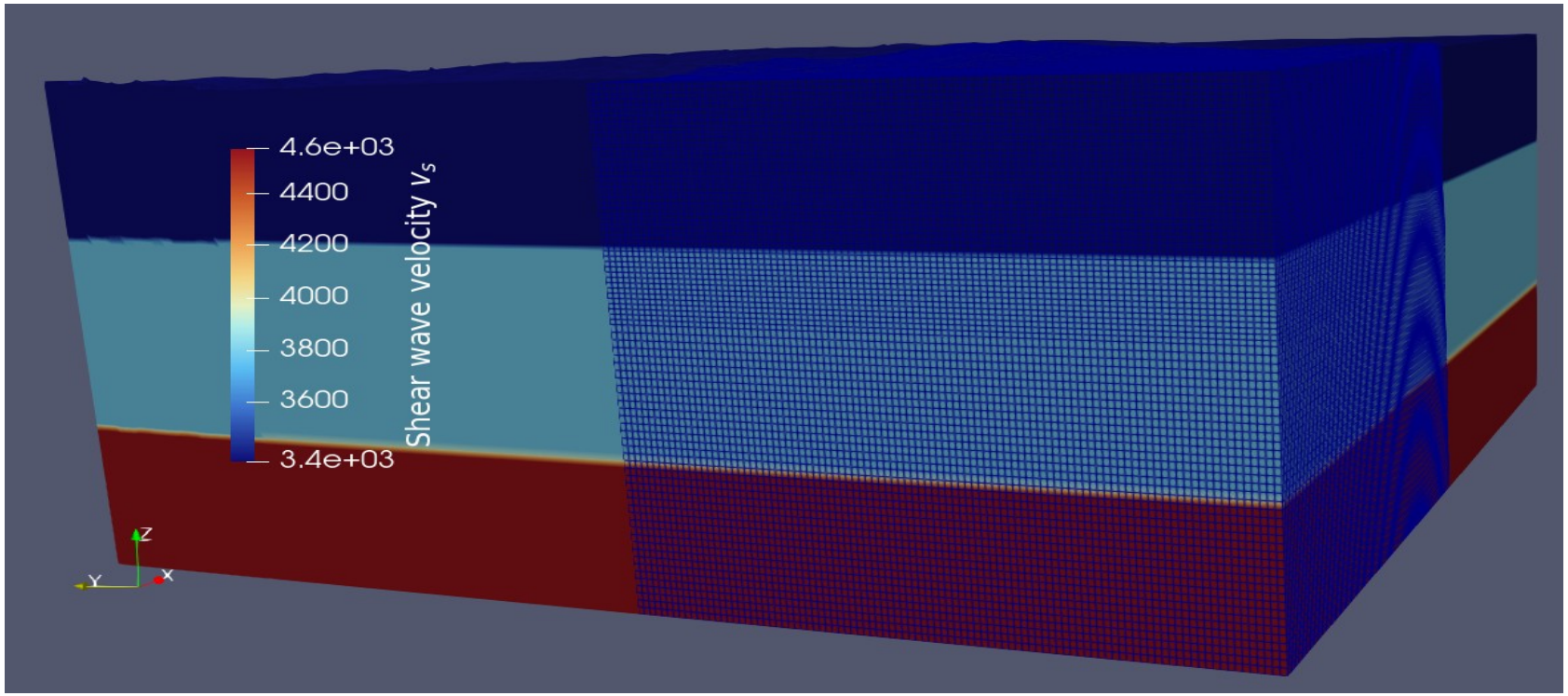


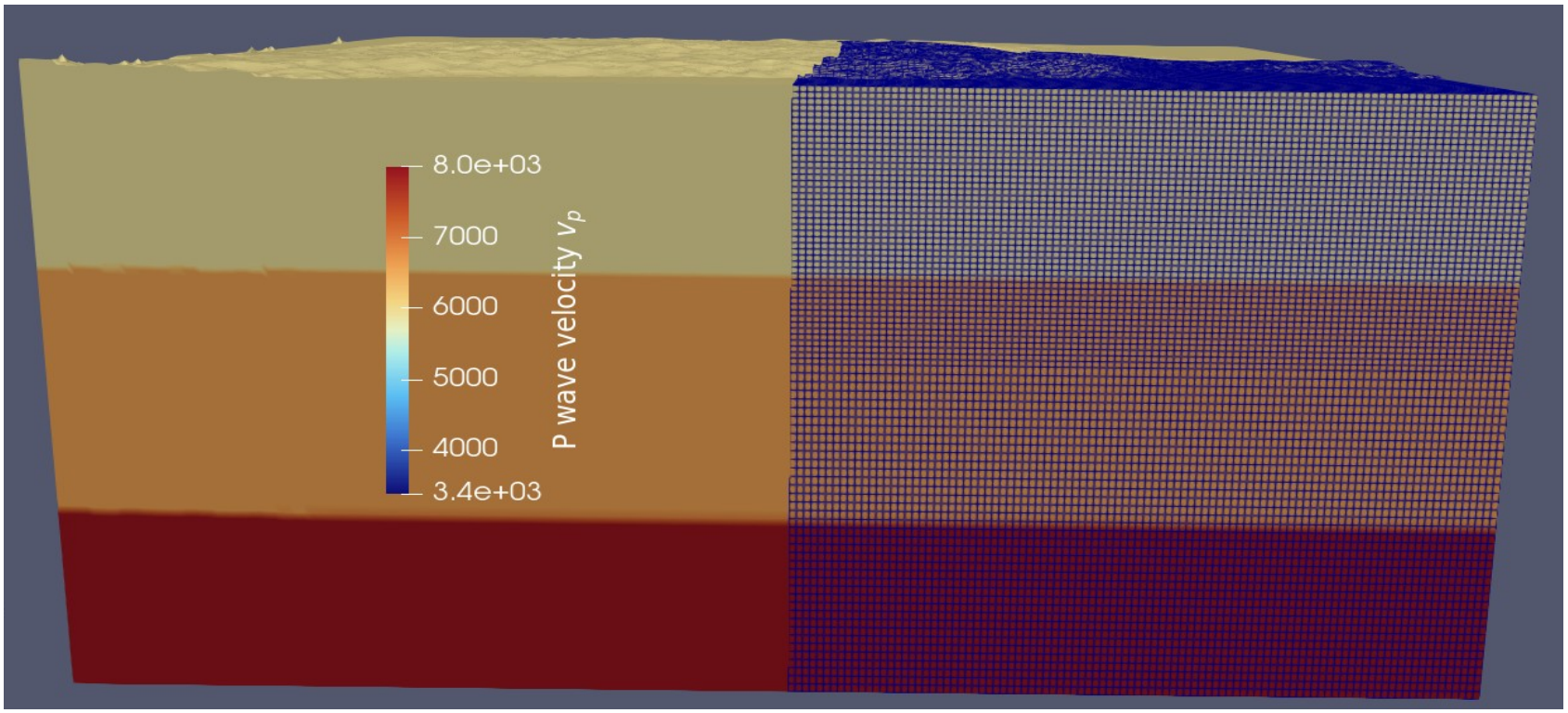

V_S
2.4e+03 2800 3000 3200 3400 3600 3800 4000 4200 4400 4.7e+03
Min: 2370.0 Max: 4665.0


8.4e+03
8000
7500
7000
6500
6000
5500
5000
4500
4.1e+03
V_P
Max: 8400.0
Min: 4147.0


5.0e+02
400
300
200
100
1.0e+01
Q_μ


9.0e+03
8000
6000
4000
2000
6.6e+01
Q_κ


4.6e+03
4400
4200
4000
3800
3600
3.4e+03
Shear wave velocity v_s
Z
Y
X


8.0e+03
7000
6000
5000
4000
3.4e+03
P wave velocity v_p

Mesh details	Value	Mesh details	Value
Domain length (km^2)	232	Domain length (km^2)	232
Depth (km)	80	Depth (km)	80
# of spec element on each surface direction	200 x 200	# of spec element on each surface direction	200 x 200
# spec elements along depth	85	# spec elements along depth	85
Max size of element (km^3)	764 x 756 x 23	Max size of element (km^3)	764 x 756 x 23
Min size of element (km^3)	321 x 322 x25	Min size of element (km^3)	321 x 322 x25
Total GLL points	5 million	Total GLL points	5 million
DOF	3 million	DOF	3 million
Timestep	0.0025	Timestep	0.0025
Minimum period resolved	25s	Minimum period resolved	25s
Minimum model velocity	3770	Minimum model velocity	3770

L(km)	NEXXI=NEXETA
500	48
D(km)	Nz
120	8
vsC(km/s)	fmax
3.6	0.33
vpC(km/s)	elperlambda
6.5	1
vsM(km/s)	h(km)
4.5	10.91
vpM(km/s)	gridpoints
8	2304000
dt_min	lambdamin(km)
0.7873	10.91

L(km)	NEXXI=NEXETA
500	88
D(km)	Nz
120	24
vsC(km/s)	fmax
3.6	0.33
vpC(km/s)	elperlambda
6.5	2
vsM(km/s)	h(km)
4.5	5.45
vpM(km/s)	gridpoints

L(km)	NEXXI=NEXETA
500	136
D(km)	Nz
120	32
vsC(km/s)	fmax
3.6	0.33
vpC(km/s)	elperlambda
6.5	3
vsM(km/s)	h(km)
4.5	3.64
vpM(km/s)	gridpoints

L(km)	NEXXI=NEXETA
120	48
vsC(km/s)	fmax
3.6	0.33
vpC(km/s)	elperlambda
6.5	4
vsM(km/s)	h(km)
4.5	2.73
vpM(km/s)	gridpoints
8	203136000
dt_min	lambdamin(km)
0.1968	10.91

L(km)	NEXXI=NEXETA
500	232
D(km)	Nz
120	56
vsC(km/s)	fmax
3.6	0.33
vpC(km/s)	elperlambda
6.5	5
vsM(km/s)	h(km)
4.5	2.18
vpM(km/s)	gridpoints
8	376768000
dt_min	lambdamin(km)
0.1575	10.91

L(km)	NEXXI=NEXETA
500	272
D(km)	Nz
120	64
vsC(km/s)	fmax
3.6	0.33
vpC(km/s)	elperlambda
6.5	6
vsM(km/s)	h(km)
4.5	1.82
vpM(km/s)	gridpoints
8	591872000
dt_min	lambdamin(km)
0.1312	10.91

Minimum period resolved

$$T_{max} = \frac{\text{avg\_distance}}{\text{v\_min}} \times \text{num\_points\_per\_wavelength}$$

5

Average distance between each element

$$\text{AVG\_DISTANCE} = \frac{\text{MAX\_ELEMENT\_SIZE}}{\text{NGLL} - 1}$$

NGLL=5

Time step suggested CFL condition
KOMATITSCH2005 CMAX=0.35
CMAX=0.5 Hom Nath Gharti

$$\text{DELTA\_T\_SUGGESTED} = \text{C\_MAX} \times \frac{\text{MIN\_GLL\_POINT\_DISTANCE}}{\text{VMAX}}$$

IN QUESTO CASO
Vs=3370
vp=8000

```
*****************************************

*** Xmin and Xmax of the model =    517071.938        722459.812
*** Ymin and Ymax of the model =    4094891.00        4430751.00
*** Zmin and Zmax of the model =   -83000.0000       2000.44995

*** Max GLL point distance =    2902.93750
*** Min GLL point distance =    11.8247070
*** Max/min ratio =    245.497620

*** Max element size =    8868.61328
*** Min element size =    68.4799805
*** Max/min ratio =    129.506653

*** Minimum period resolved =    3.28954482
*** Maximum suggested time step =    7.35000009E-04

*** for DT :    5.0000000000000001E-004
*** Max stability for wave velocities =   0.338274747

Elapsed time for checking mesh resolution in seconds =   0.12590262499999999
saving VTK files for Courant number and minimum period
```

$$\chi(m) = \frac{1}{2}\sum_{i=1}^{N_s}\sum_{i=1}^{N_r}\left[\left(\frac{A_{ij}^{obs}}{A_{ij}^{syn}(m)} - 1\right)\right]^2 \qquad \chi = \frac{1}{2}\sum_{i=1}^{N_r}\left[\left(\frac{A_i^{obs}}{A_i^{syn}} - 1\right)\right]^2$$

$$\chi(m) = \frac{1}{2}\sum_{i=1}^{N_s}\sum_{j=1}^{N_r}\frac{\int_0^T [d_{ij}(t) - s_{ij}(t,m)]^2 dt}{\int_0^T d_{ij}^2(t) dt}$$

Normalized amplitude misfit

$$\chi = \frac{1}{2}\sum_{i=1}^{N_s}\sum_{i=1}^{N_r}[T_{ij}^{obs} - T_{ij}^{syn}]^2$$

Traveltime misfit

$$\chi(m) = \frac{1}{2}\sum_{i=1}^{N_s}\sum_{i=1}^{N_r}\left[\ln\left(\frac{A_{ij}^{obs}}{A_{ij}^{syn}(m)}\right)\right]^2$$

Amplitude misfit

[5] We define the correlation function between the observed, $d(t)$, and synthetic, $s(t)$, waveforms within a window W by:

$$\Psi_{ds}(\tau) = \int_W d(t)s(t-\tau)\mathrm{d}t\,. \tag{1}$$

First, we determine the time shift τ_m of the synthetic waveform for which $\Psi_{ds}(\tau)$ has its maximum value. This time shift is regarded as the body-wave travel-time delay. Given τ_m, we define two quantities that characterize the amplitude ratio between $d(t)$ and $s(t-\tau_m)$:

$$A_1 = \frac{\Psi_{ds}(\tau_m)}{\Psi_{ss}(\tau_m)}$$

and

$$A_2 = \frac{\Psi_{dd}(\tau_m)}{\Psi_{ds}(\tau_m)}. \tag{2}$$

A_1 and A_2 minimize, respectively,

$$\int_W [d(t) - A_1 s(t-\tau_m)]^2 \mathrm{d}t$$

and

$$\int_W \left[A_2^{-1} d(t) - s(t-\tau_m)\right]^2 \mathrm{d}t\,. \tag{3}$$

Using vertical component recordings, we measure A_1^{P}, A_2^{P}, A_1^{PP}, and A_2^{PP} for 80-s wide time windows centered on the theoretical arrival times of P and PP, respectively. A_1 is equal to A_2 only when the waveforms of $d(t)$ and $s(t)$ in the cross-correlation window W are identical. Therefore we obtain

$$A_1^{\mathrm{pp/p}} = \frac{\min\left(A_1^{\mathrm{PP}}, A_2^{\mathrm{PP}}\right)}{\max\left(A_1^{\mathrm{P}}, A_2^{\mathrm{P}}\right)}$$

and

$$A_2^{\mathrm{pp/p}} = \frac{\max\left(A_1^{\mathrm{PP}}, A_2^{\mathrm{PP}}\right)}{\min\left(A_1^{\mathrm{P}}, A_2^{\mathrm{P}}\right)}, \tag{4}$$