

Event location using a 3D velocity model

InSite v 3.17 incorporates an interface to import 3D velocity models saved as 3Dvoxels in a .csv file. The grid is expected to be regular in all 3 dimensions and smooth, i.e. no voxels should be blank or with zero velocity value as this would be interpreted as a void and result into reflection or nonpropagation of rays through them. The velocity model grid must include all the volume where the location search will be performed and include all the sensors or seismic stations used in the process. An example velocity model file is shown in Figure 1.

	А	В	С	D	E	F	G	н	I.	J	К	
1	Easting	Northing	Depth (Ft)	Vp (ft/s)	Vs (ft/s)	Vp/Vs	K(Gpa)	Lame <mark>(</mark> Gpa	G(Gpa)			
2	1759445	411186.8	-2936.3	17000	10000	0	0	0	0			
3	1759945	411186.8	-2936.3	17000	10000	0	0	0	0			
4	1760445	411186.8	-2936.3	17000	10000	0	0	0	0			
5	1760945	411186.8	-2936.3	17000	10000	0	0	0	0			
6	1761445	411186.8	-2936.3	17000	10000	0	0	0	0			
7	1761945	411186.8	-2936.3	17000	10000	0	0	0	0			
8	1762445	411186.8	-2936.3	17000	10000	0	0	0	0			
9	1762945	411186.8	-2936.3	17000	10000	0	0	0	0			
10	1763445	411186.8	-2936.3	17000	10000	0	0	0	0			
11	1763945	411186.8	-2936.3	17000	10000	0	0	0	0			
12	1764445	411186.8	-2936.3	17000	10000	0	0	0	0			
13	1764945	411186.8	-2936.3	17000	10000	0	0	0	0			
14	1765445	411186.8	-2936.3	17000	10000	0	0	0	0			
15	1765945	411186.8	-2936.3	17000	10000	0	0	0	0			
16	1766445	411186.8	-2936.3	17000	10000	0	0	0	0			
17	1766945	411186.8	-2936.3	17000	10000	0	0	0	0			
18	1767445	411186.8	-2936.3	17000	10000	0	0	0	0			
19	1767945	411186.8	-2936.3	17000	10000	0	0	0	0			
20	1768445	411186.8	-2936.3	17000	10000	0	0	0	0			
21	1768945	411186.8	-2936.3	17000	10000	0	0	0	0			
22	1769445	411186.8	-2936.3	17000	10000	0	0	0	0			
23	1769945	411186.8	-2936.3	17000	10000	0	0	0	0			
24	1770445	411186.8	-2936.3	17000	10000	0	0	0	0			
25	1770945	411186.8	-2936.3	17000	10000	0	0	0	0			
26	1771445	411186.8	-2936.3	17000	10000	0	0	0	0			
27	1771945	411186.8	-2936.3	17000	10000	0	0	0	0			
20	4770445	411100.0	2026.2	17000	10000	0		0	0			

Figure 1: Example csv 3D velocity model. The values in columns F-I are not used in the current version of InSite

The following steps must be followed in order to locate events using a 3D forward velocity model:

 Import the velocity model into InSite using the 'Fast Sweeping Method Builder' Tool. This is launched from the Tools menu item in the menu bar within InSite's data visualiser (Figure 2). A dialog window is launched (Figure 3). In this dialog, select the 'CSV File' option and browse for the location of the csv velocity model file.

The dialog will automatically fill with the values for the boundaries of the velocity model from the file. It also automatically fills the values for the boundaries of the 'Lookup table'. Please note the units for this are cell numbers (labelled as grid). The default value includes all the volume defined in the velocity model, however for a faster process, this can be reduced.

Global But	tton Bar	Launch Auto-Processor Launch InSite Leach Launch Calendar Map	Ctrl+Alt+L Ctrl+Alt+M	No
		Launch Event Filter Launch Wave Builder		Ty.
		Launch Fast Sweeping Method Builder		
	Data Visu	Launch Lookup Table Builder		
		Launch InSiteDB Events	Ctrl+Alt+B	
		Launch InSiteDB Measurements	Ctrl+Alt+A	
		Launch Parameter Visualiser	Ctrl+Alt+C	
		Launch CSV Auto-import		
A		Launch Split SEED/miniSEED Files Dialogue		
		Launch Structural Analysis		
	Wavefc	Launch Array Analysis		

Figure 2: Launch fast sweeping Method builder

D Velocity Model		Binary	Files CSV File		
/p velocity file;					Browse
/s velocity file:					Browse
CSV format file: G:\s	support\calpine	2020.09.22	High_Resolution_Study_Velo	city_Model_Rx	Browse
elocity Volume			Look up Table Volu	me	
North Min:	410936.8	(m)	North Min:	0	(grid)
North Max:	434436.8	(m)	North Max:	47	(grid)
North Cell:	500	(m)	North Grid:	1	(grid)
East Min:	1759195.1	(m)	East Min:	0	(grid)
East Max:	1782695.1	(m)	East Max:	47	(grid)
East Cell:	500	(m)	East Grid:	1	(grid)
Depth Min:	-3186.28055	(m)	Depth Min:	0	(grid)
Depth Max:	15312.28055	(m)	Depth Max:	37	(grid)
Depth Cell:	499.9611111	(m)	Depth Grid:	1	(grid)
Use PPL					

Figure 3: Fast Sweeping Method Travel Time Builder

2. Build the Travel Time Lookup table by clicking 'Start Build'. The info panel at the bottom will inform about the progress. When the process is complete the info panel will show

'Operation Complete' (Figure 4). An hdf5 binary file (extension .h5) containing the travel times is automatically created in the folder containing the csv velocity model. If any warnings have been raised during the process, they will be stored in a log file (Fast Sweeping Method.log) at: C:\ProgramData\ASC\InSite

D velocity model		0	Files @ courts		
Zo velocity file:		Usinary	Files CSV File		Rrowss
					0101136
ve velocity met					Browse
CSV format file: G:\:	support\calpine	2020.09.22	High_Resolution_Study_Velo	city_Model_Ra	Browse
elocity Volume			Look up Table Volu	me	
North Min:	410936.8	(m)	North Min:	0	(grid)
North Max:	434436.8	(m)	North Max:	47	(grid)
North Cell:	500	(m)	North Grid:	1	(grid)
East Min:	1759195.1	(m)	East Min:	0	(grid)
East Max:	1782695.1	(m)	East Max:	47	(grid)
East Cell:	500	(m)	East Grid:	1	(grid)
Depth Min:	-3186.28055!	(m)	Depth Min:	0	(grid)
Depth Max:	15312.28055	(m)	Depth Max:	37	(grid)
Depth Cell:	499.9611111	(m)	Depth Grid:	1	(grid)
Use PPL. Idclating S-wave travel riting S-wave travel riting S-wave travel idclating travel time rforming ray tracing idclating travel time rforming ray tracing riting S-wave azimut riting S-wave azimut riting S-wave azimut riting S-wave azimut riting S-wave azimut	vel times (I=3) times to output times to output gradient (I=3) (I=1) gradient (I=2) (I=2) (I=2) th, plunge and r h, plunge and r	file (I=3) file (I=1) file (I=2) ay length valu ay length valu ay length valu	ues to output file (I=3) ues to output file (I=1) ues to output file (I=2)		

Figure 4: Running the Travel Time table builder

 Import the Travel time table: The created travel time file (extension .h5) is imported into InSite from Project->Import Travel Time Data... Please note that once the project is closed, the travel time data is not saved into the project and will need to be reloaded the following time the project is opened.



Figure 5:Import Travel Time File

- 4. Select the Location algorithm in the 'Locater' tab of InSite's processing settings. Event location using complex velocity models can be inverted using one of the two location algorithms:
 - a. Collapsing Grid Search
 - b. Source Scan
- 5. Select the Velocity Structure: Complex (Travel Time Grid method)

Site Proces	sing Properties					
Auto-picking	Source Vectors	Channel	Processing	FFT Propert	ies Locater	Sc 4
Inversion	Algorithm					
COLLAPS	ING GRID SEARC	н		~	Settings	
Velocity S	tructure					
Complex	(Travel Time Gri	d Method))	\sim	Settings	
P-Wave	and S-Wave Arriv	als		× [
Distance U	nits = Metres	\sim	Working 1	Time Units =	Seconds	\sim
Minimum P	wave Arrivals =	0	Minimur	n S-wave Arr	ivals = 0	
	м	aximum R	esidual (Wo	orking Time U	nits) = 100	
]Display t	heoretical t	imes for all in	struments	
Start at the	e centroid of the a	rray		~		
- User Defin	ed					
Start Pos	ition at N,E,D =	0	0		0	
Write inf	ormation to Repo	rt File (Ri	РТ)			
					Brows	se
Source Pa	rameters					
Calcul	ate Automatic So	urce Para	meters			
Alway	s calculate source	e vector al	t the start of	f a manual loc	ation	
Enable	parallel processi	ing				
			ОК	Can	cel	Apply

Figure 6: Settings in the Locater tab of InSite's Settings dialog