RadExPro
seismic software

Interactive Boulder Detection on 3D migrated seismic cubes

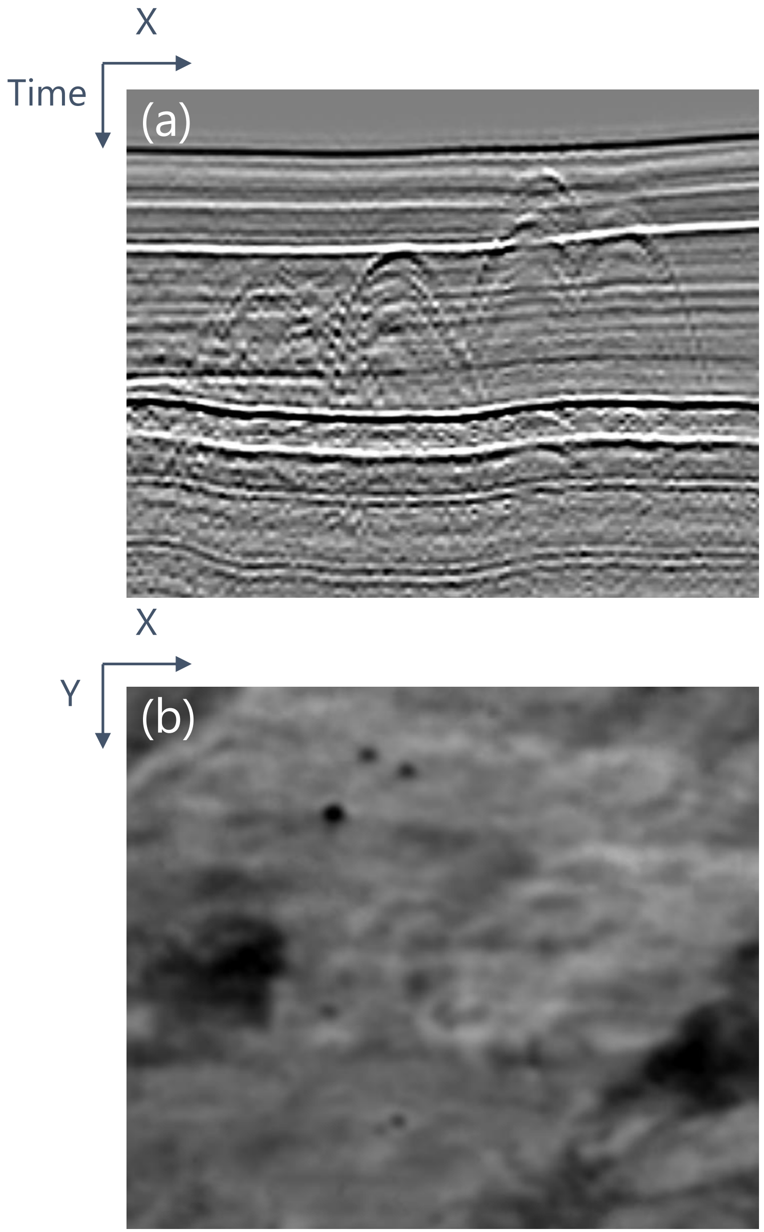
Motivation

- Detecting boulders in subbottom sediments is critical for de-risking offshore wind farm installations and minimizing their costs.
- High-resolution (HR) and ultra-high-resolution (UHR) seismic is a suitable geophysical method. If the frequency content of the seismic source is fit for the task, the boulders appear on seismic cubes as diffracted events.
- The boulder detection method in RadExPro is based on the detection of diffracted events caused by boulders on 3D seismic cubes.

Our boulder detection approach

Overview

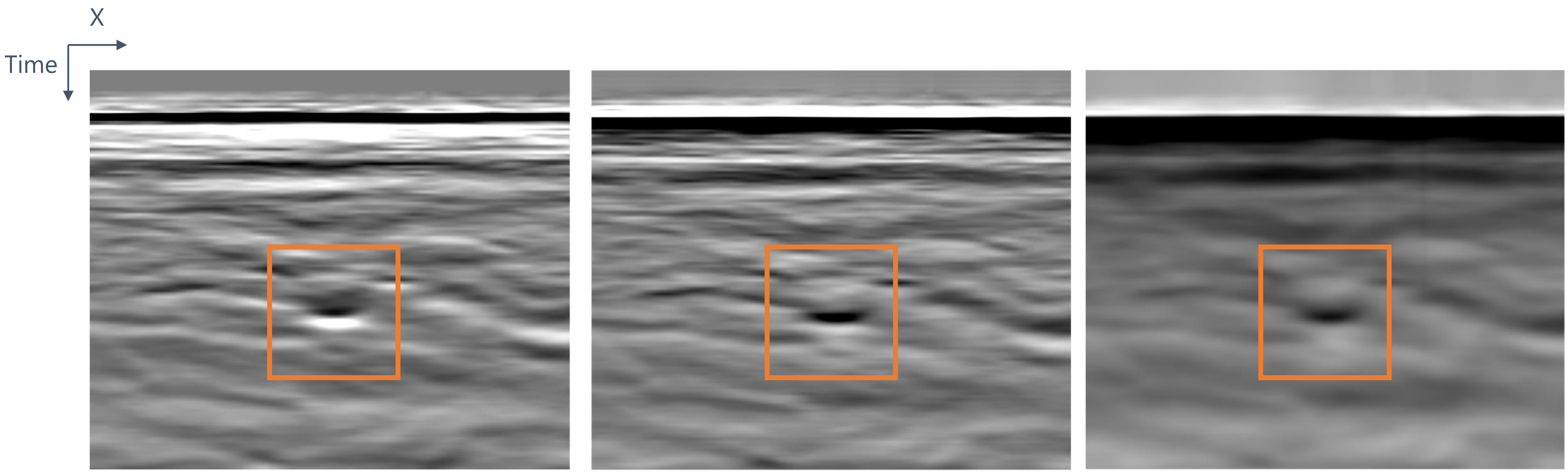
- On pre-migration stacked data, boulders appear as hyperbolic events (a).
- After migration, they are focused into local amplitude anomalies, which are particularly easy to notice on time slices (b).
- In RadExPro, we aim to interactively detect these post-migration amplitude anomalies by computing a qualitative boulder probability attribute which highlights the anomalies and applying a threshold to this attribute.
- Our algorithm takes conventional migrated seismic cubes as input, however it can also process separately migrated diffractions, or even input semblance (Schwarz and Krawczyk, 2020) computed using the diffracted wavefield.
- Migration, diffraction images and semblance-like attributes can be computed by existing RadExPro tools.



Schwarz, B., & Krawczyk, C. M. (2020). Coherent diffraction imaging for enhanced fault and fracture network characterization. Solid Earth, 11(5), 1891-1907.

Diffraction waveform correction

As the diffraction waveforms are asymmetric after a typical migration (Denisov, 2017), the module includes phase or phase-and-amplitude corrections of diffraction waveforms.



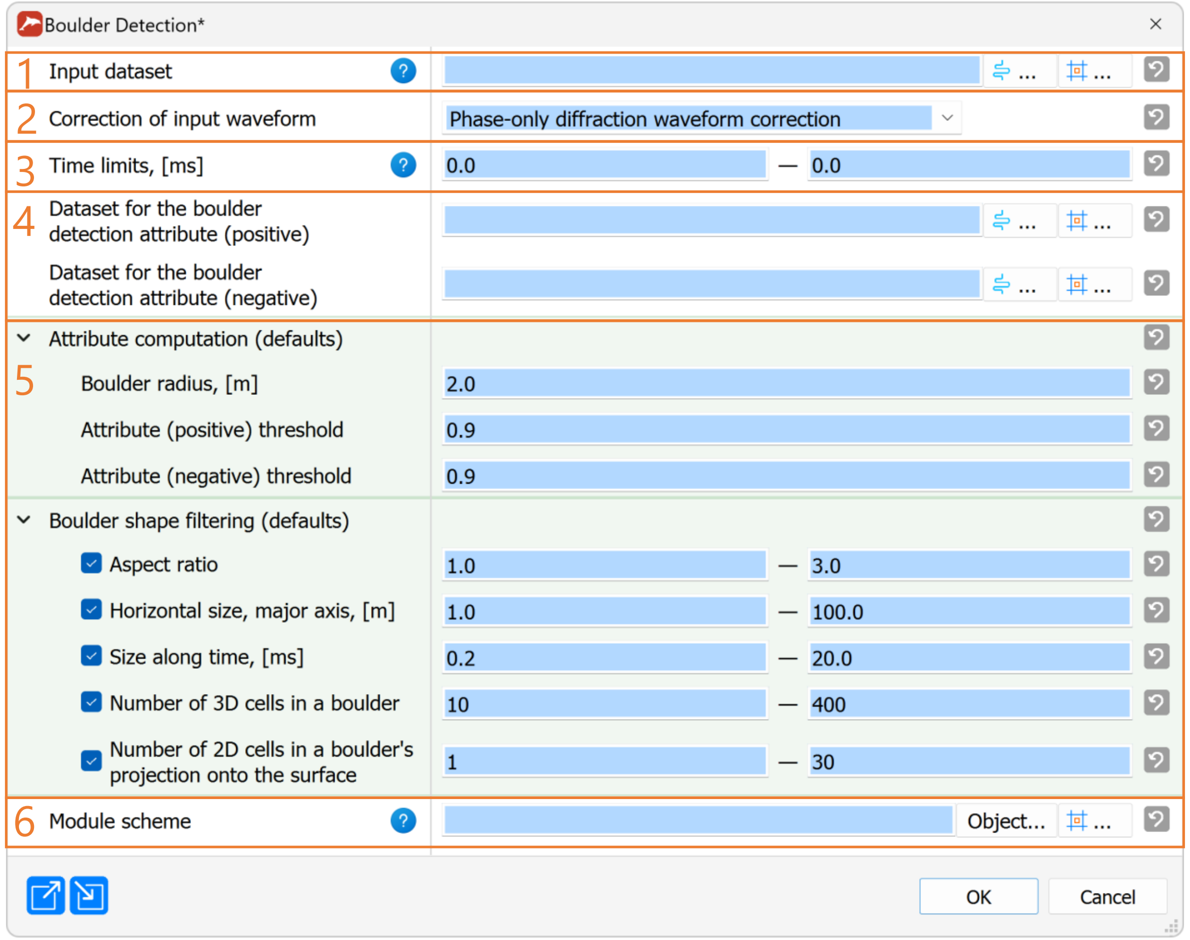
Raw migration result | Phase correction | Phase and amplitude correction

Denisov M.S. Seismic migration as a tool for true amplitude depth imaging of small objects // Seismic technology, 2017, (4). pp. 51–72. (in Russian)

Workflow

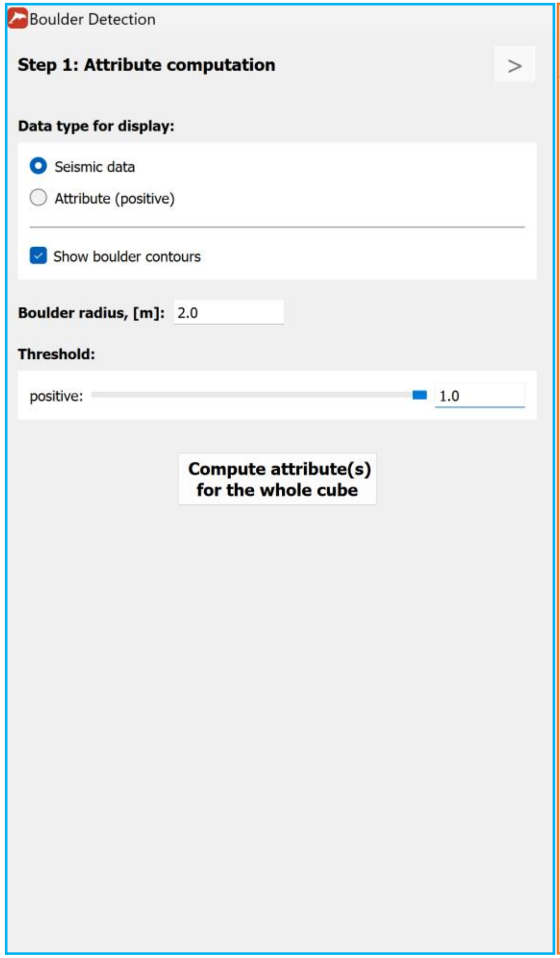
Parameter window

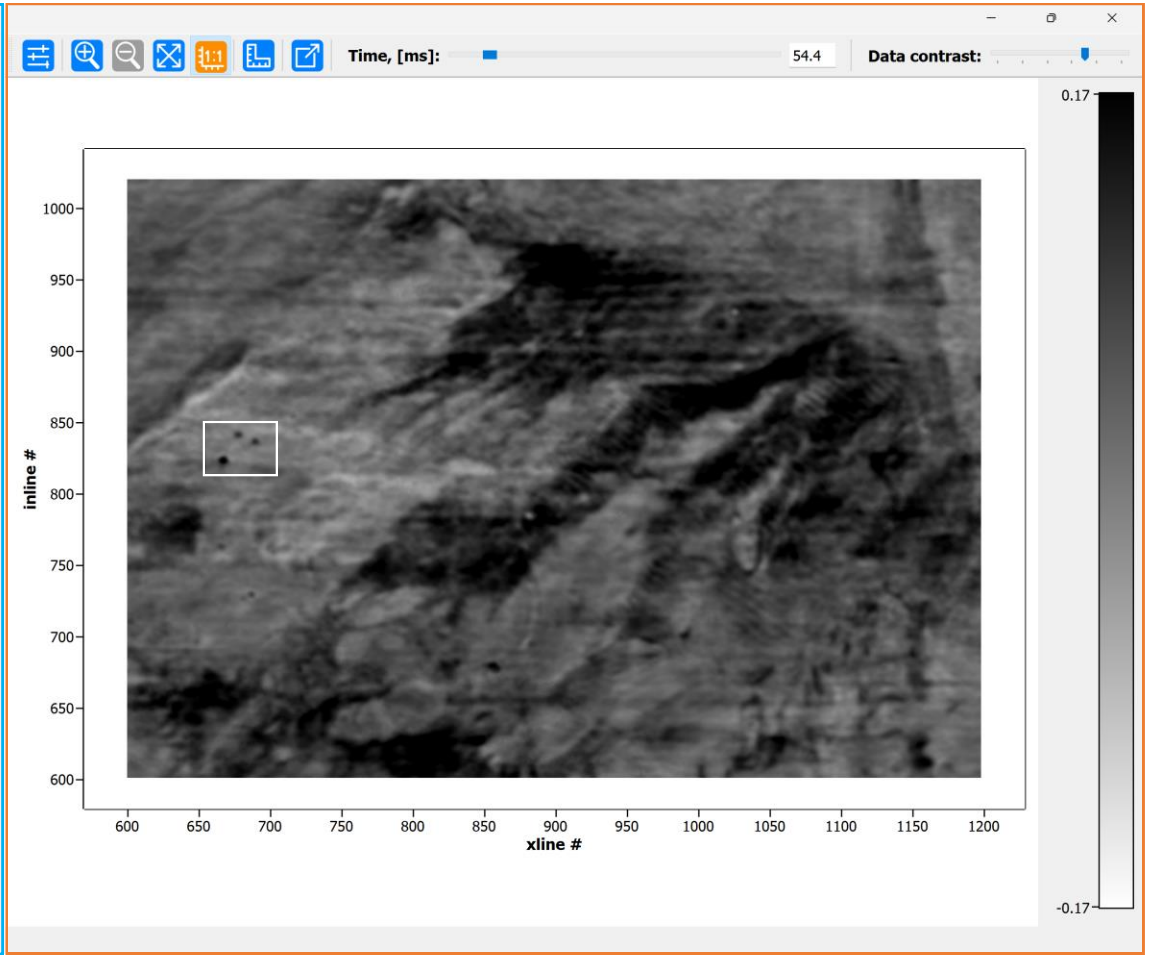
1. Input is a migrated seismic cube.
2. A suitable waveform correction is chosen (‘no correction’ is also an option).
3. Time limits allow one to run boulder detection only inside the interval of interest (e.g., target subbottom layers).
4. The qualitative boulder probability attribute used for thresholding/classification of boulders can be computed internally by an image processing technique, or imported from external software (e.g., can be generated by AI, or diffraction imaging).
5. These are default values of interactively set parameters
6. Module scheme allows one to save the current work status, exit and return at any point in the future.



Step 1 – Attribute generation and thresholding

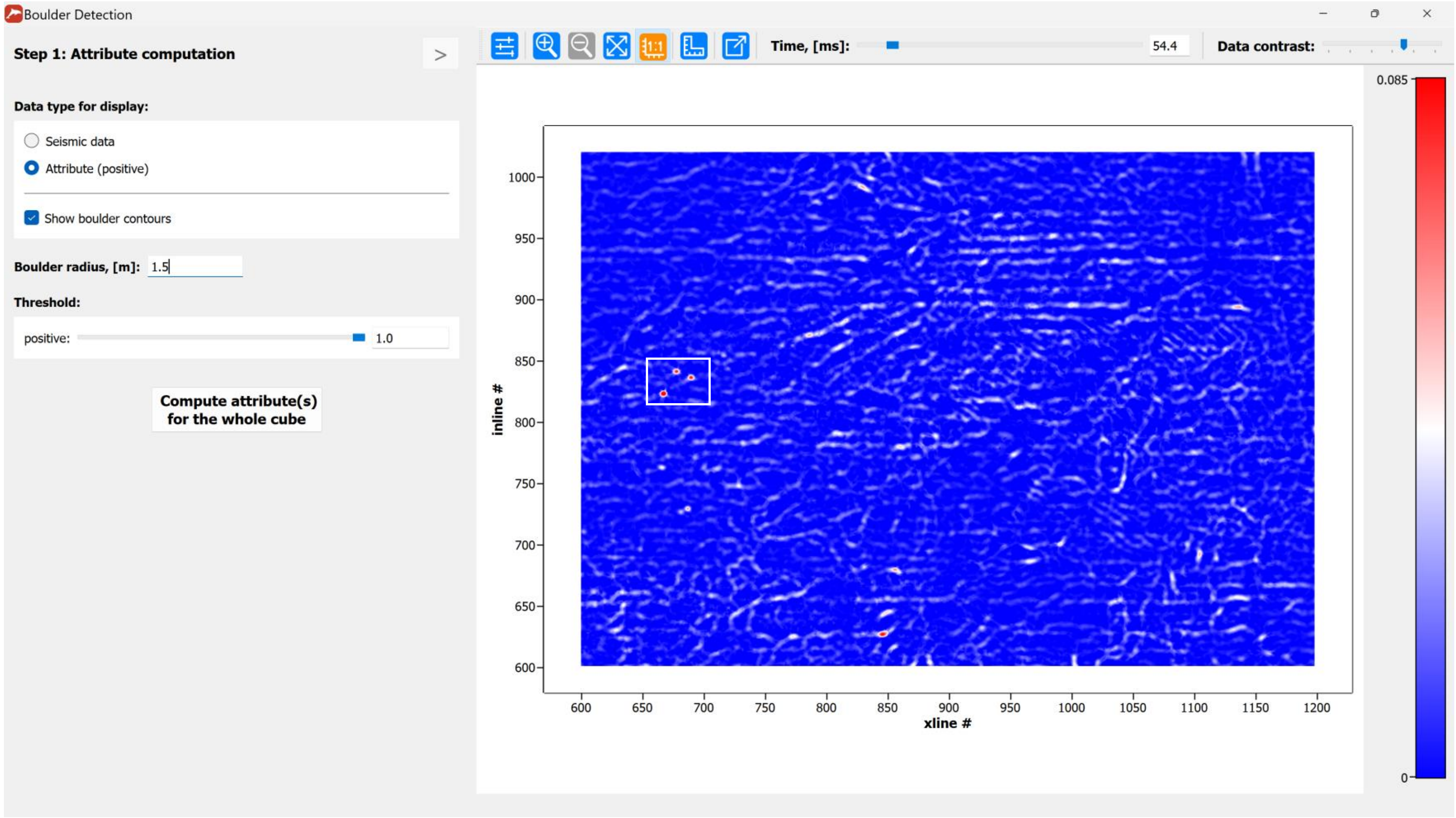
- The module window contains a display of the current time slice (example boulders are highlighted with a white box) and boulder detection parameters.
- First, the user generates an attribute highlighting the boulders, which is then used for thresholding.





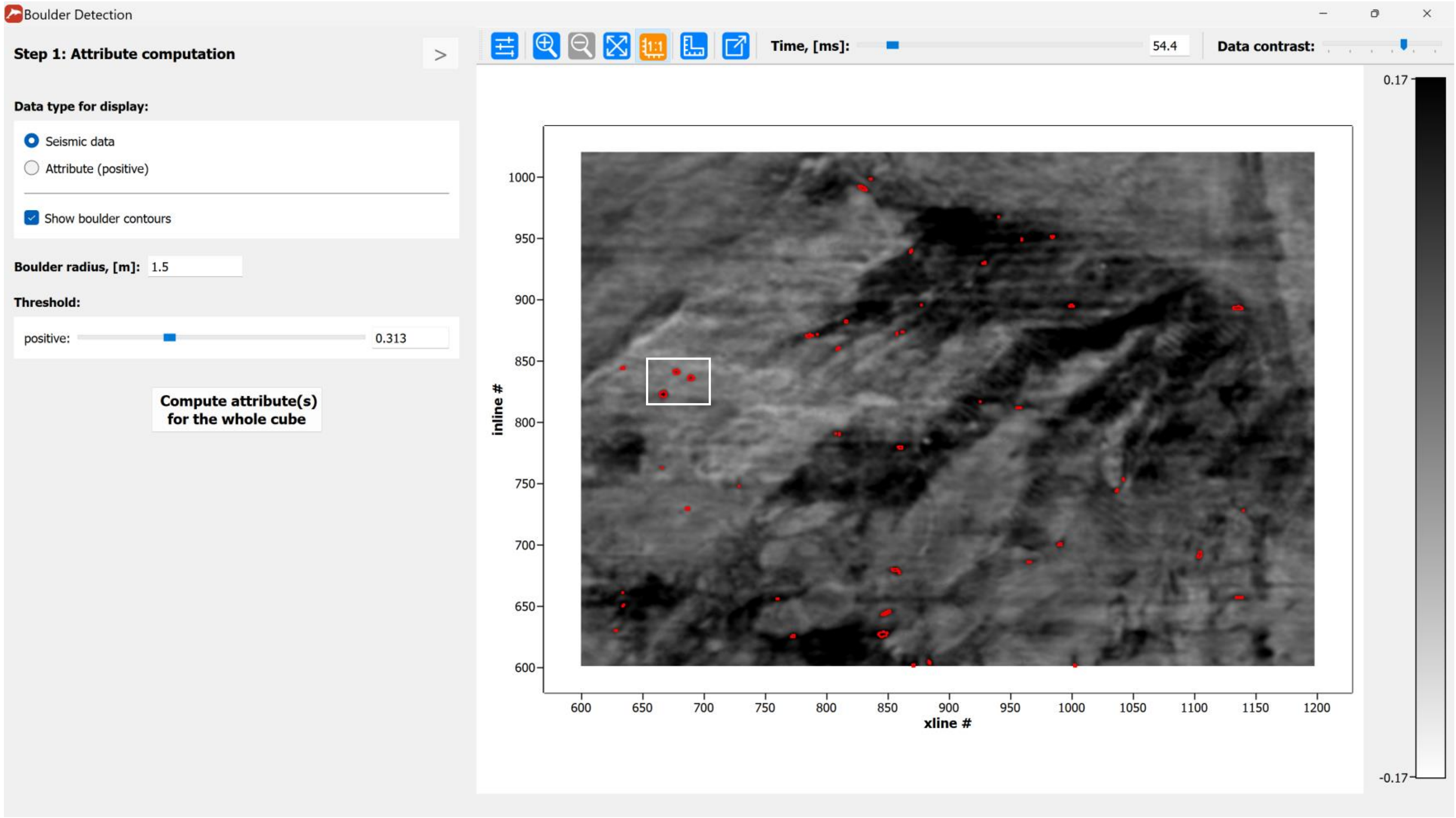
Step 1 – Attribute generation and thresholding

- The attribute is computed by an image processing technique which highlights objects of a defined size on images.
- One can also import an externally generated attribute.
- One can observe that the boulders have the highest amplitudes on the attribute image.



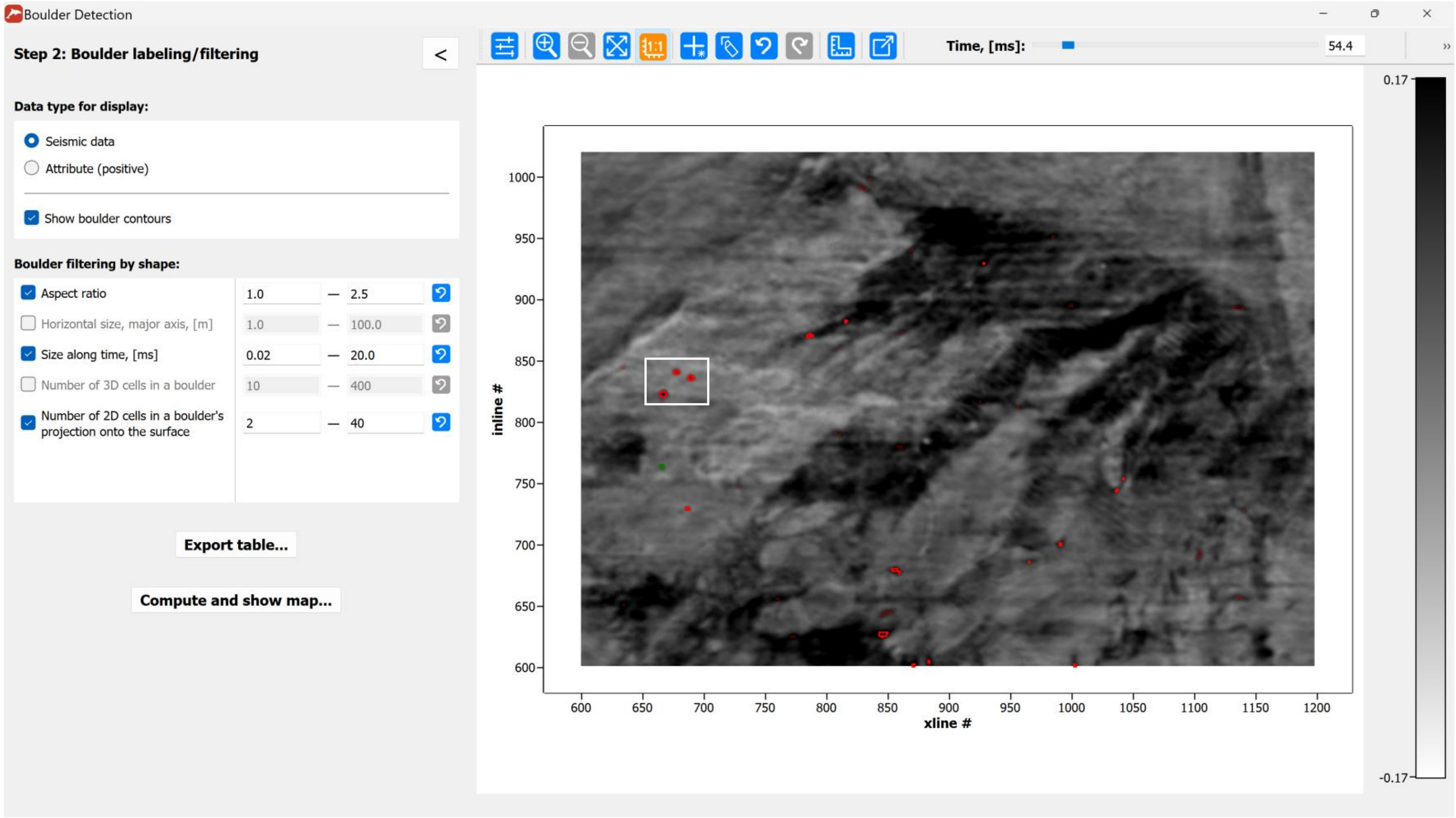
Step 1 – Attribute generation and thresholding

- With the attribute computed or imported, one can apply a threshold to it.
- The samples with values above the threshold are considered as potential boulders (*boulder candidates*).



Step 2 – Filter and output

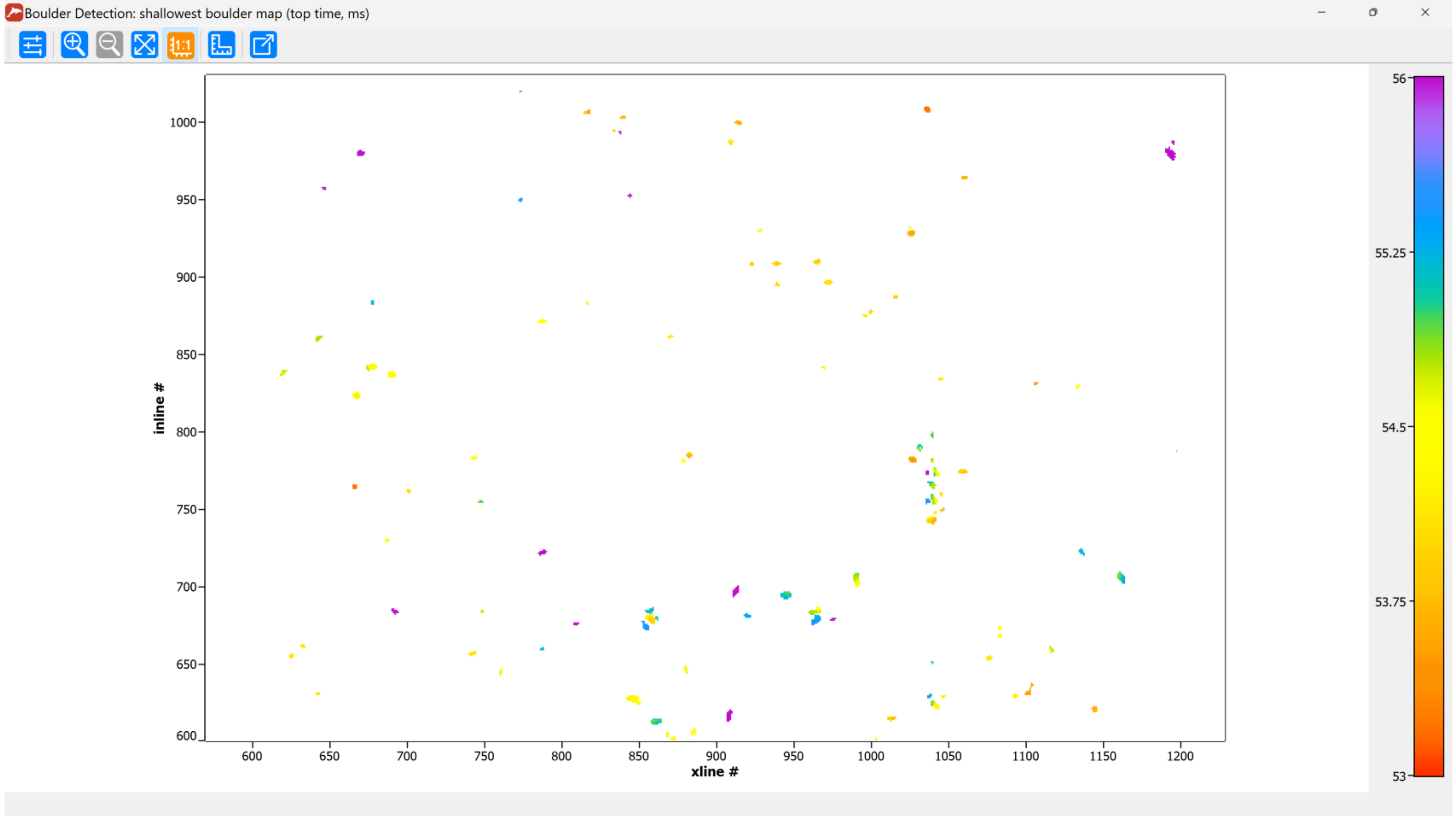
- Following the thresholding, one switches to step two of the workflow.
- A 3D labeling algorithm identifies all the boulder candidates and computes their spatial properties.
- These properties can then be used to filter out the boulder candidates which do not fit the a priori constraints on the boulder shape – too elongated, too flat, too small/big, etc.
- Manual editing can also be performed at this stage.
- Finally, the deliverables are exported.



Deliverables

Boulder map

As a result, the user obtains a boulder map, where each sample on the surface is colored according to the two-way traveltime to the top of the shallowest boulder at that location.



Boulder table

The main deliverable of the module is the boulder table, which contains the locations and properties of all the identified boulders.

centroid-x-(m)	centroid-y-(m)	centroid-TWT-(ms)	top-TWT-(ms)	bot-TWT-(ms)	TWT-span-(ms)	major-axis-(m)	minor-axis-(m)	aspect-ratio
376.66667	373.72222	54.95	54.9	55.0	0.1	1.65831	0.8165	2.03101
503.23333	518.23333	53.3	53.2	53.4	0.2	2.0702	1.5353	1.3484
390.22881	513.49153	53.65	53.4	53.9	0.5	2.40001	1.72914	1.38798
336.3	431.2	55.15	55.1	55.2	0.1	0.86603	0.86603	1.0
444.1	337.9	55.05	55.0	55.1	0.1	1.5	0.61237	2.44949
327.88462	549.30769	53.55	53.5	53.6	0.1	1.80463	1.57241	1.14769
414.77778	553.16667	53.55	53.5	53.6	0.1	1.73205	0.70711	2.44949
341.46	428.38	55.2	55.1	55.3	0.2	3.33691	1.36906	2.43738
309.75	572.38636	53.7	53.6	53.8	0.2	1.82248	1.78429	1.02141

THANK YOU FOR YOUR ATTENTION!

CONTACTS:

RadExPro Europe OÜ, Tallinn, Estonia

RadExPro Seismic Software LLC, Tbilisi, Georgia

www.radexpro.com