Single frequency 2D acoustic full waveform inversion

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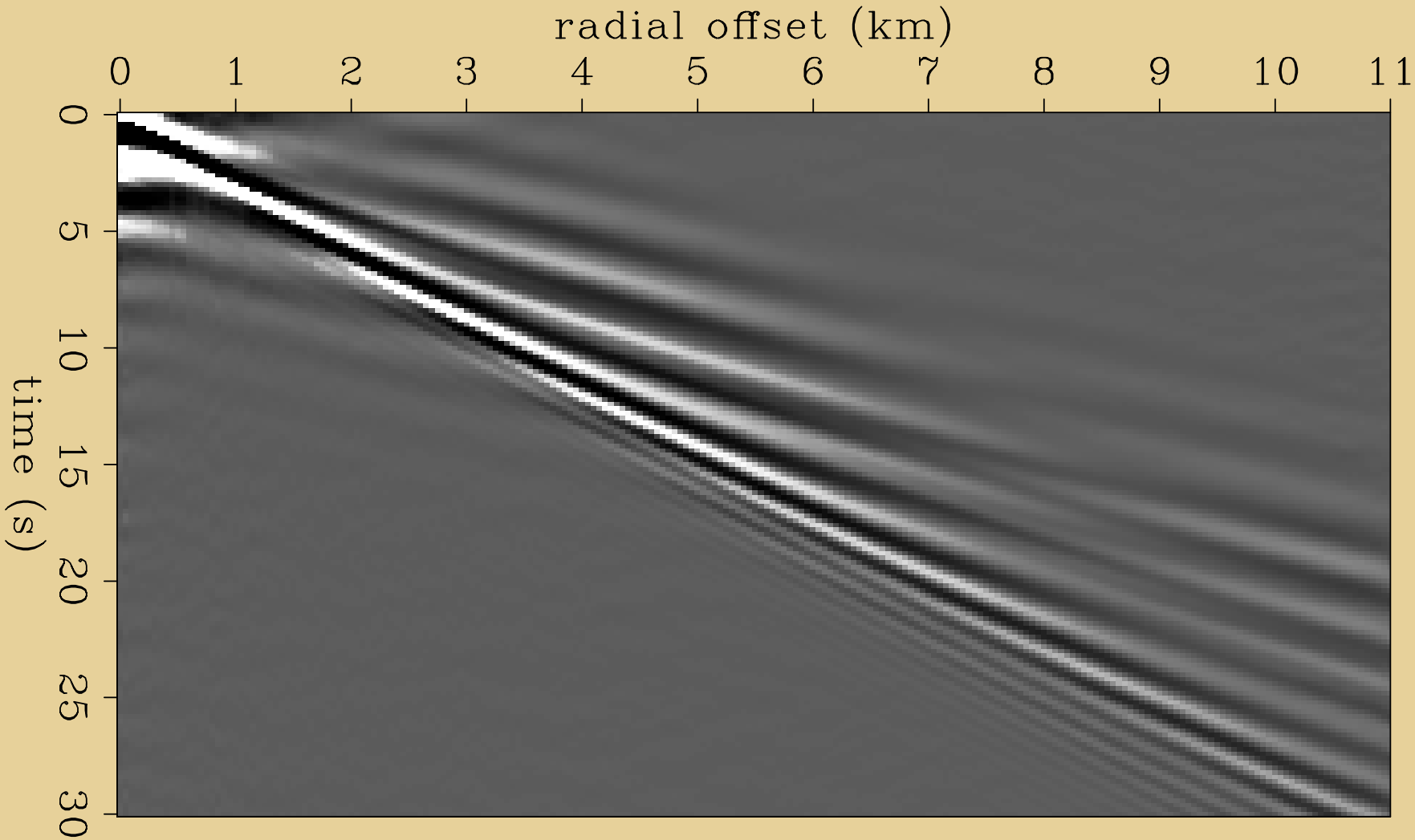
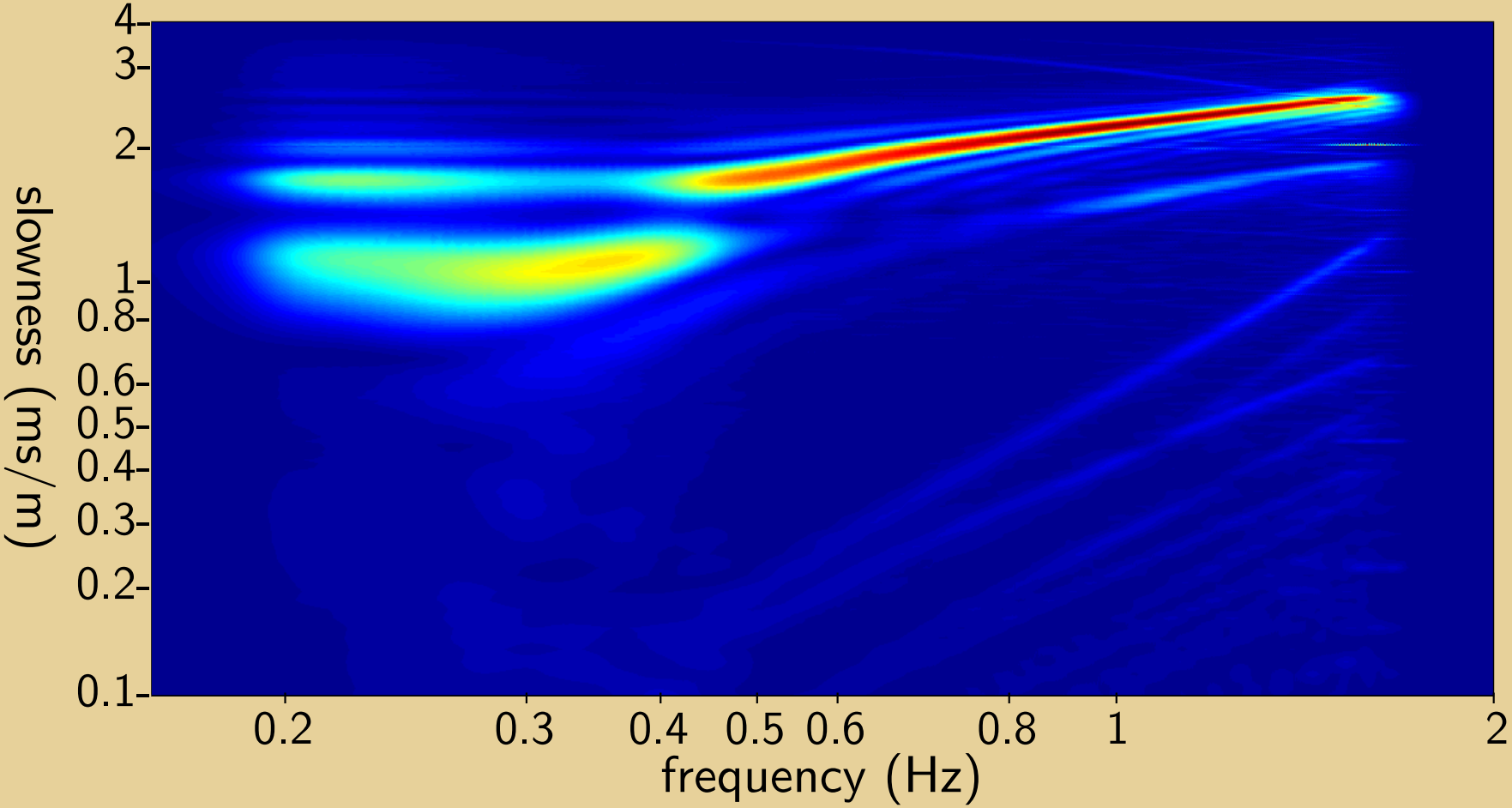
SEP147 p.183

Frequency dependent, single mode, 2D propagation



Frequency dependent, single mode, 2D propagation



Frequency dependent, single mode, 2D propagation

Model for waves of virtual seismic sources:

$$\nabla^2 \mathbf{u}(\omega, \mathbf{x}) - \omega^2 \, \mathbf{s}^2(\omega, \mathbf{x}) \mathbf{u}(\omega, \mathbf{x}) = \mathbf{f}(\omega, \mathbf{x}) \tag{1}$$

$$\mathbf{x} = \begin{pmatrix} x \\ y \end{pmatrix}$$

$$\nabla^2 = \partial_x^2 + \partial_y^2$$

$\mathbf{s}^2(\omega, \mathbf{x})$: slowness

$\mathbf{u}^2(\omega, \mathbf{x})$: particle motion

$\mathbf{f}^2(\omega, \mathbf{x})$: source function

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FWI ingredients

Observed data:

$$\mathbf{u}_{\mathrm{obs}}(\omega, \mathbf{x}) \tag{2}$$

Choice of physical model:

$$\nabla^2 \mathbf{u}(\omega, \mathbf{x}) - \omega^2 \, \mathbf{s}^2(\omega, \mathbf{x}) \mathbf{u}(\omega, \mathbf{x}) = \mathbf{f}(\omega, \mathbf{x}) \tag{3}$$

Objective function (for a single frequency):

$$\mathbf{J}_{\mathrm{FWI}}(\mathbf{s}) = \frac{1}{2} \left|\left| \mathbf{u}(\mathbf{s}) - \mathbf{u}_{\mathrm{obs}} \right|\right|_2 \tag{4}$$

We want to find the $\mathbf{s}(\omega, \mathbf{x})$ that minimizes $\mathbf{J}_{\mathrm{FWI}}(\mathbf{s})$:

Solved by linearization and optimized using conjugate gradients.

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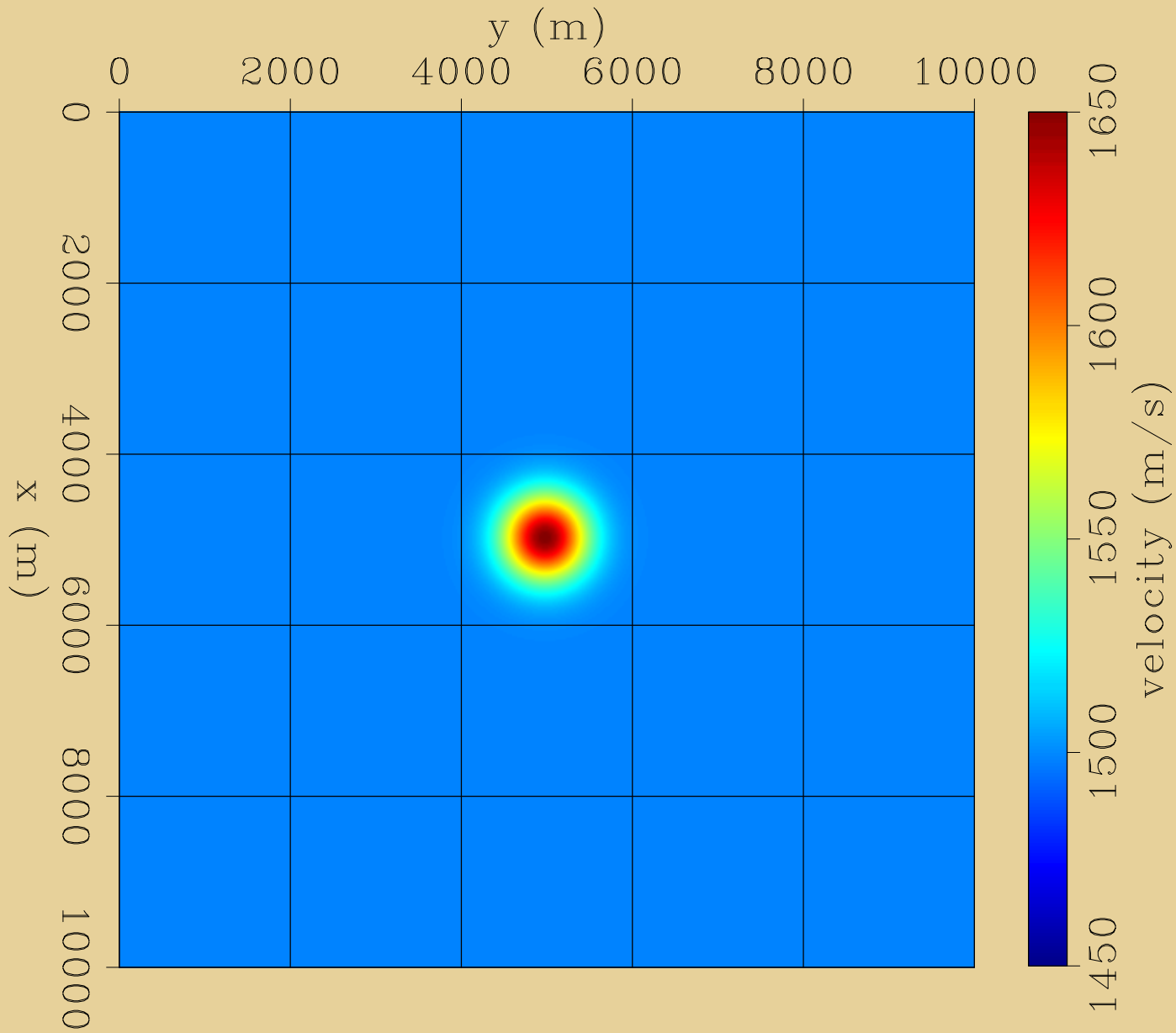
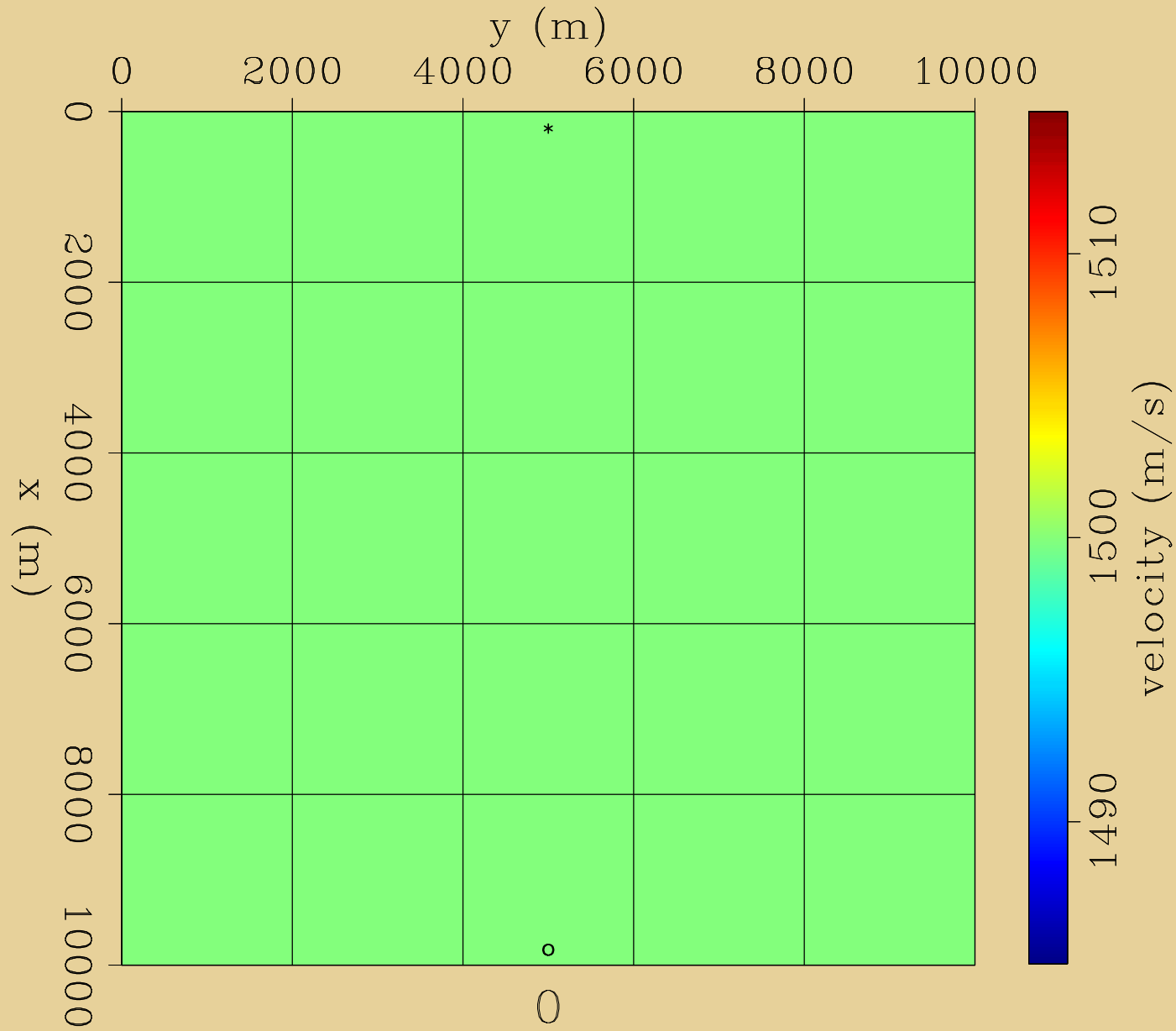
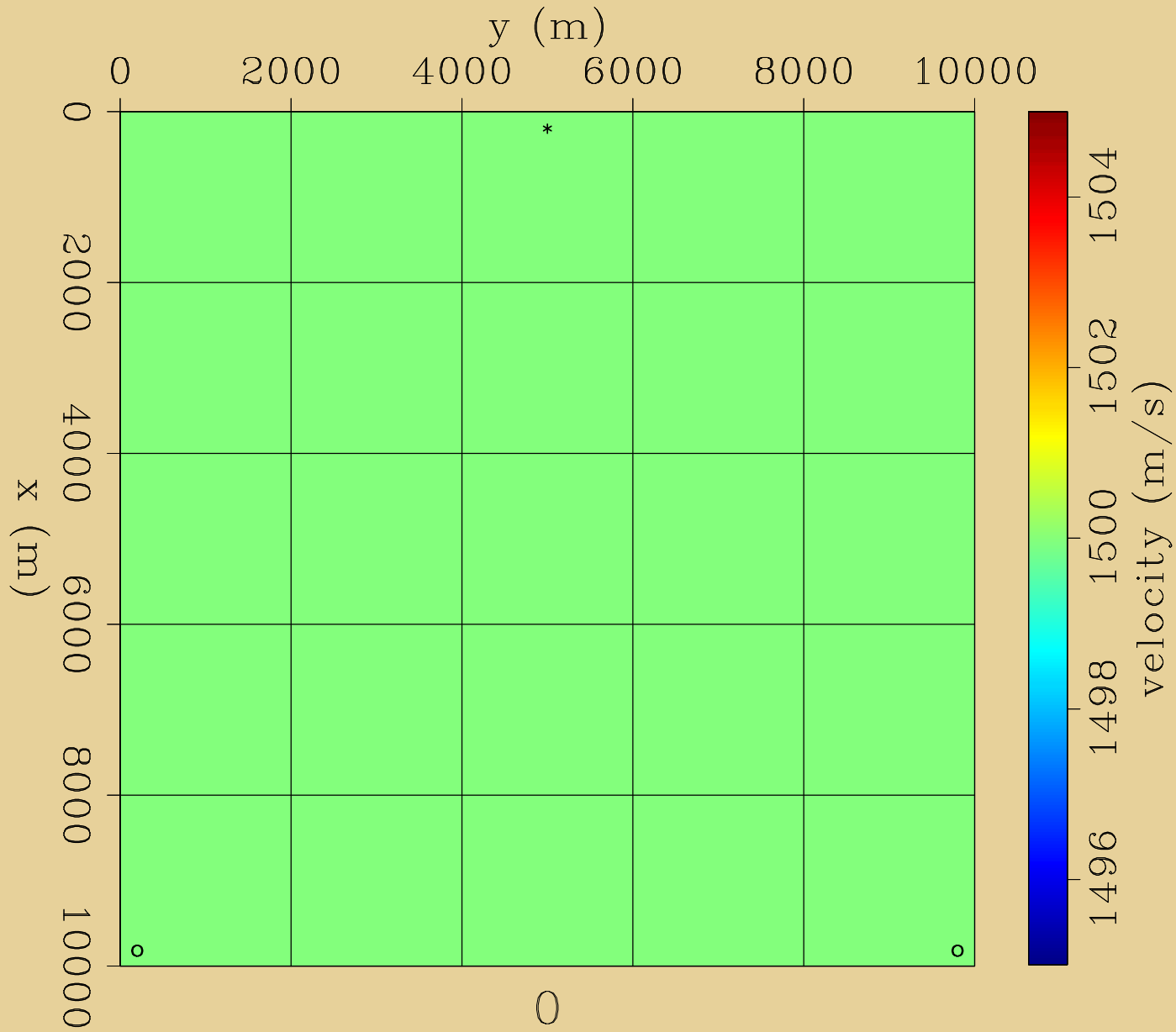
Gaussian anomaly to retrieve



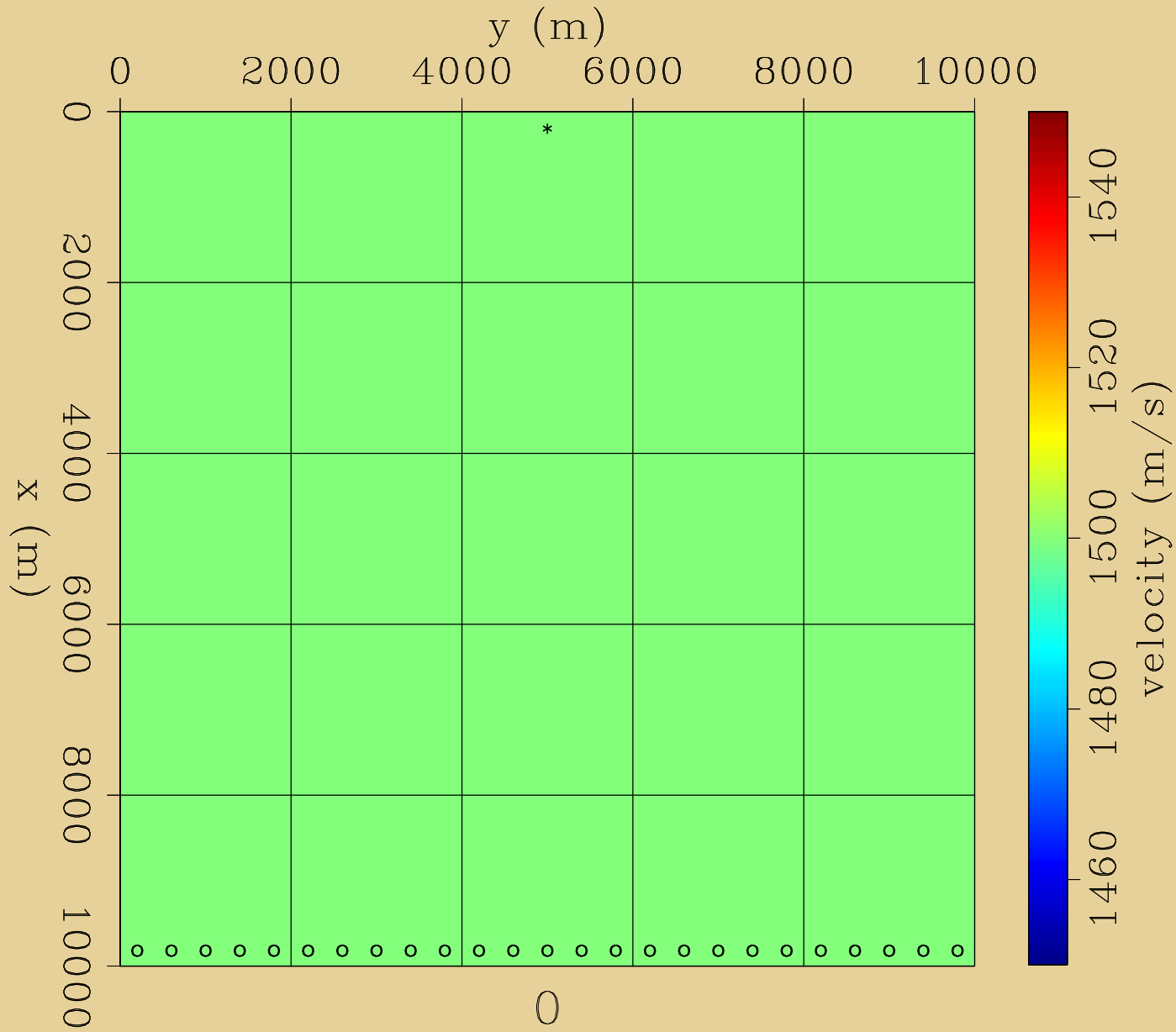
One source and one receiver - 2-Hz



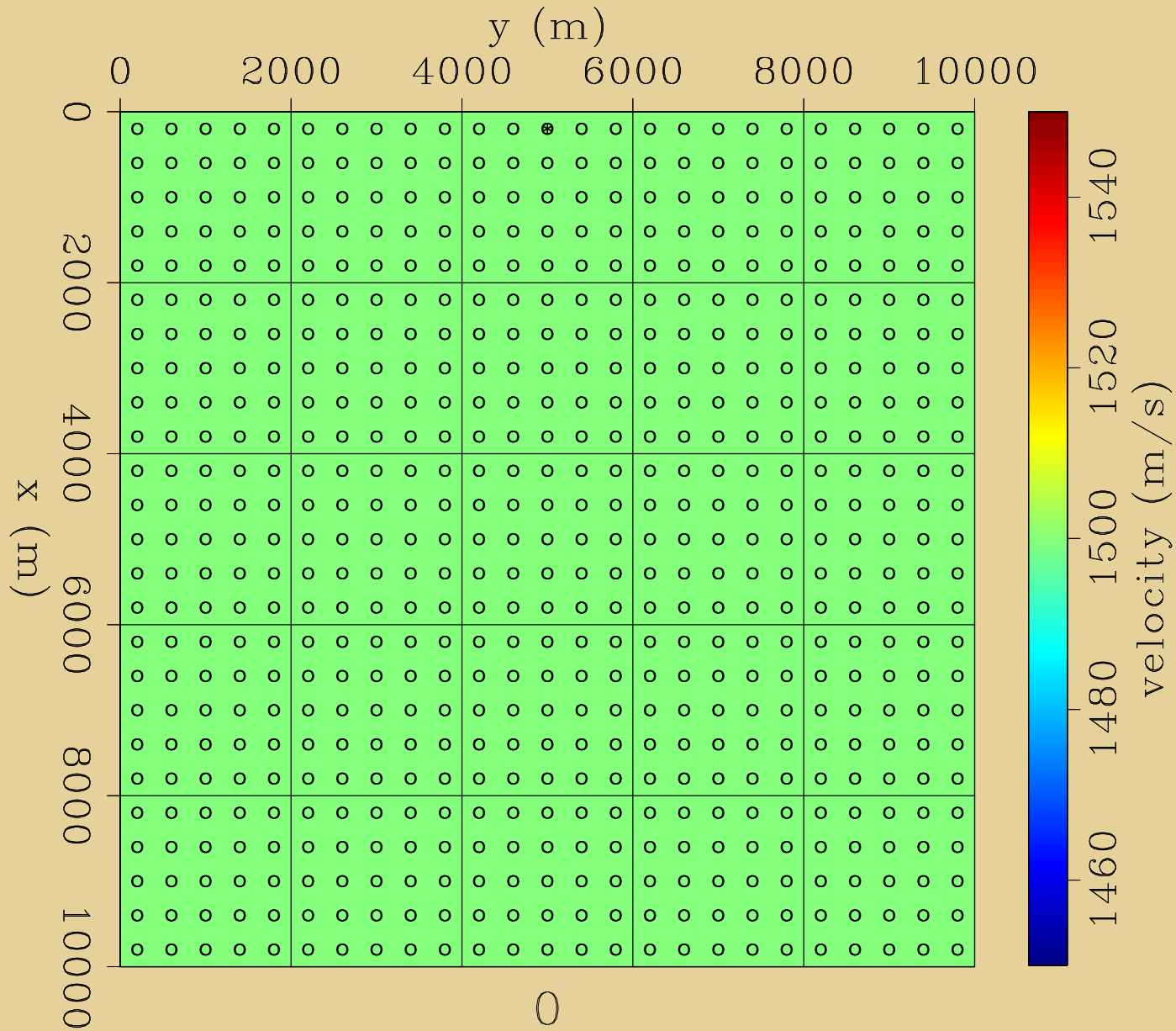
One source and two receivers - 2-Hz



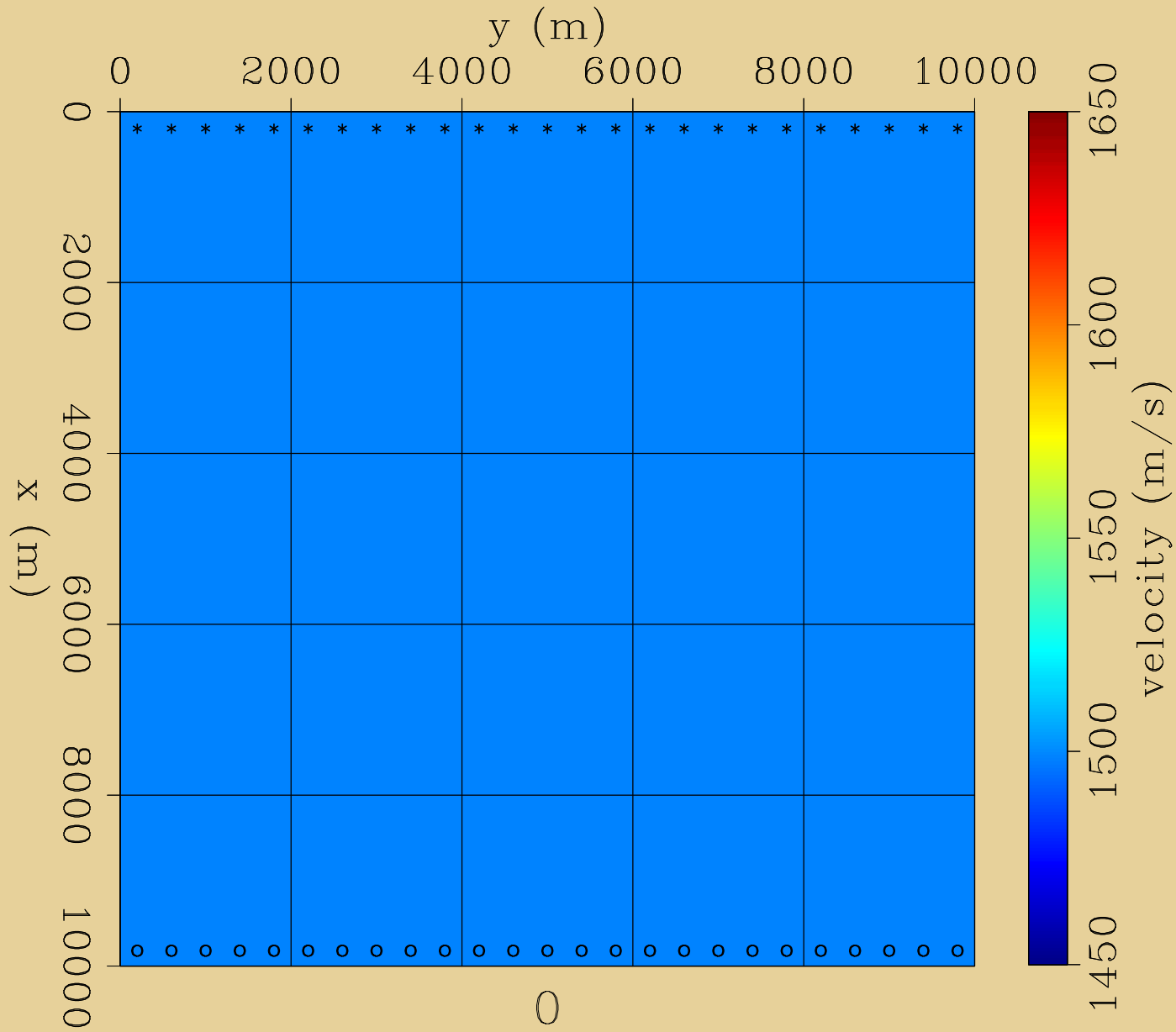
One source and a line of receivers - 2-Hz



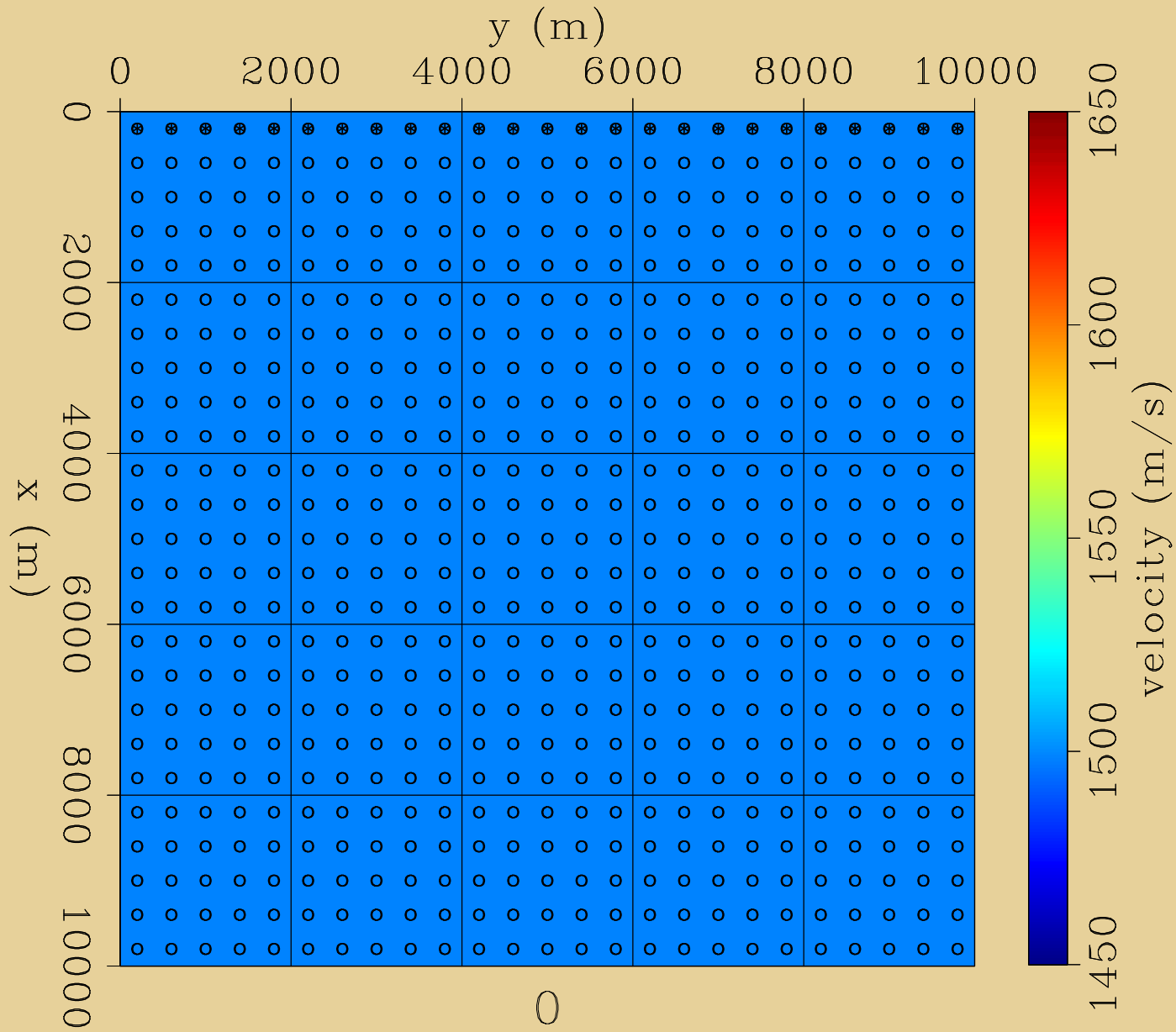
One source and a field of receivers - 2-Hz



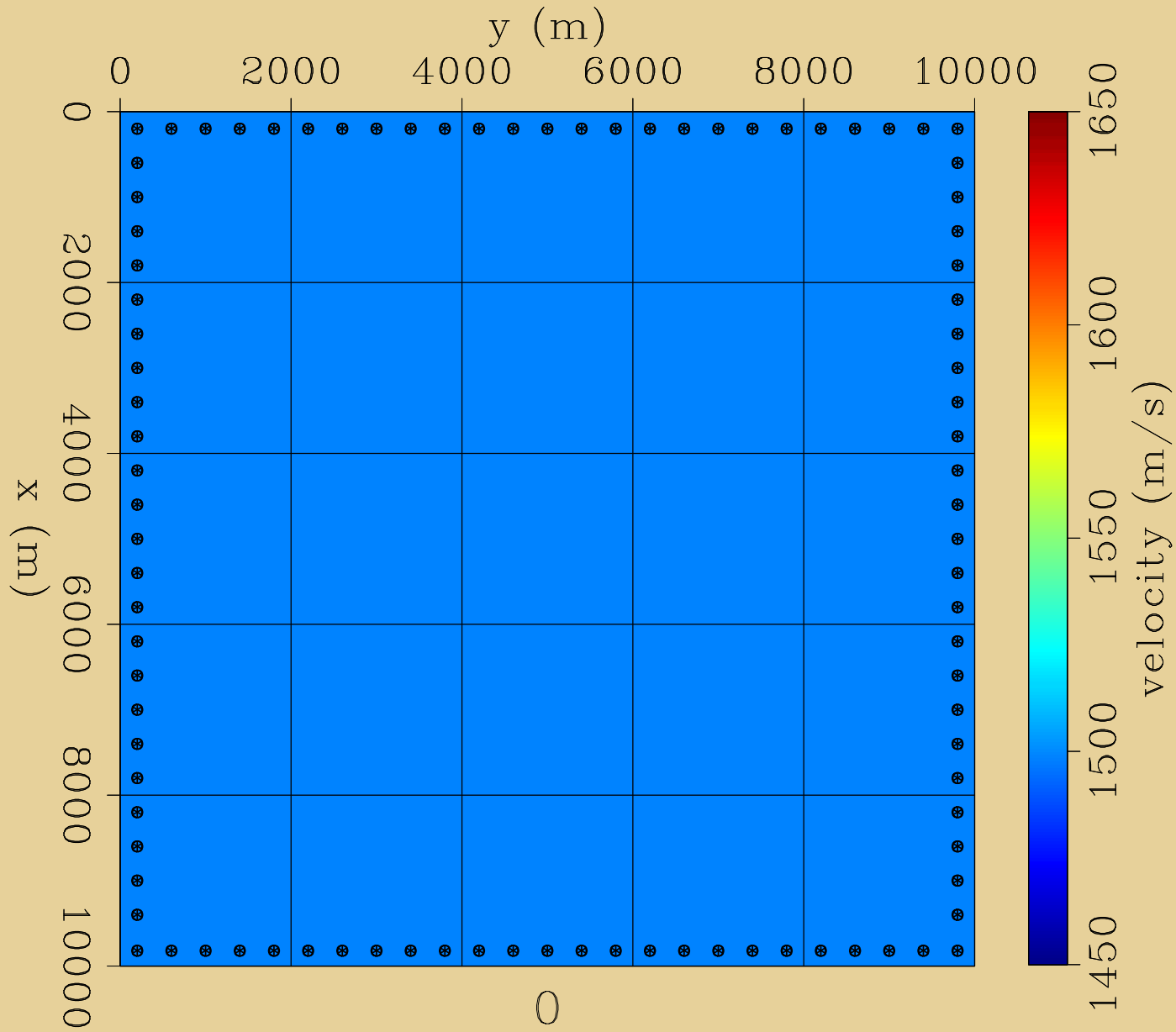
A line of sources and a line of receivers - 2-Hz



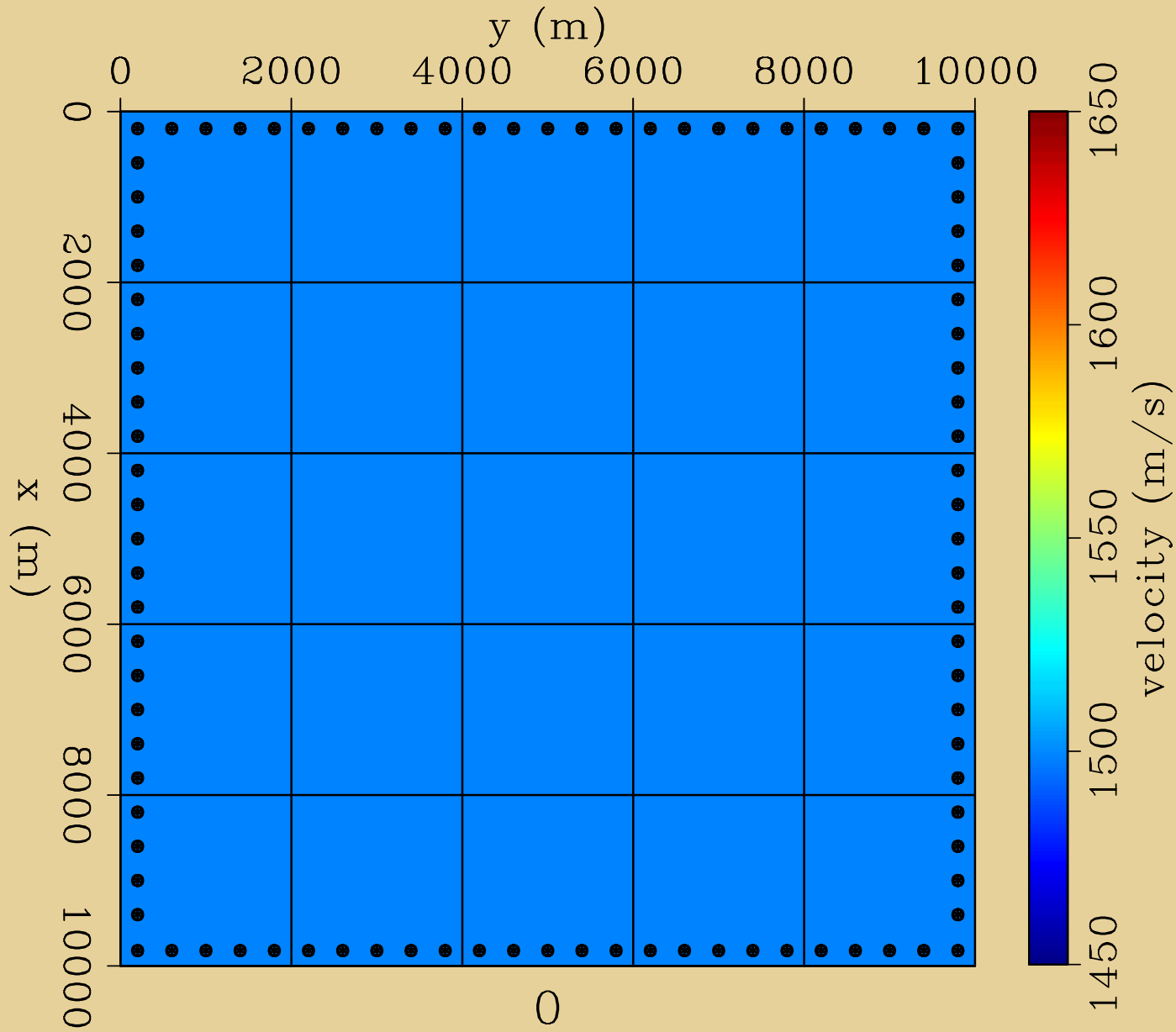
A line of sources and a field of receivers - 2-Hz



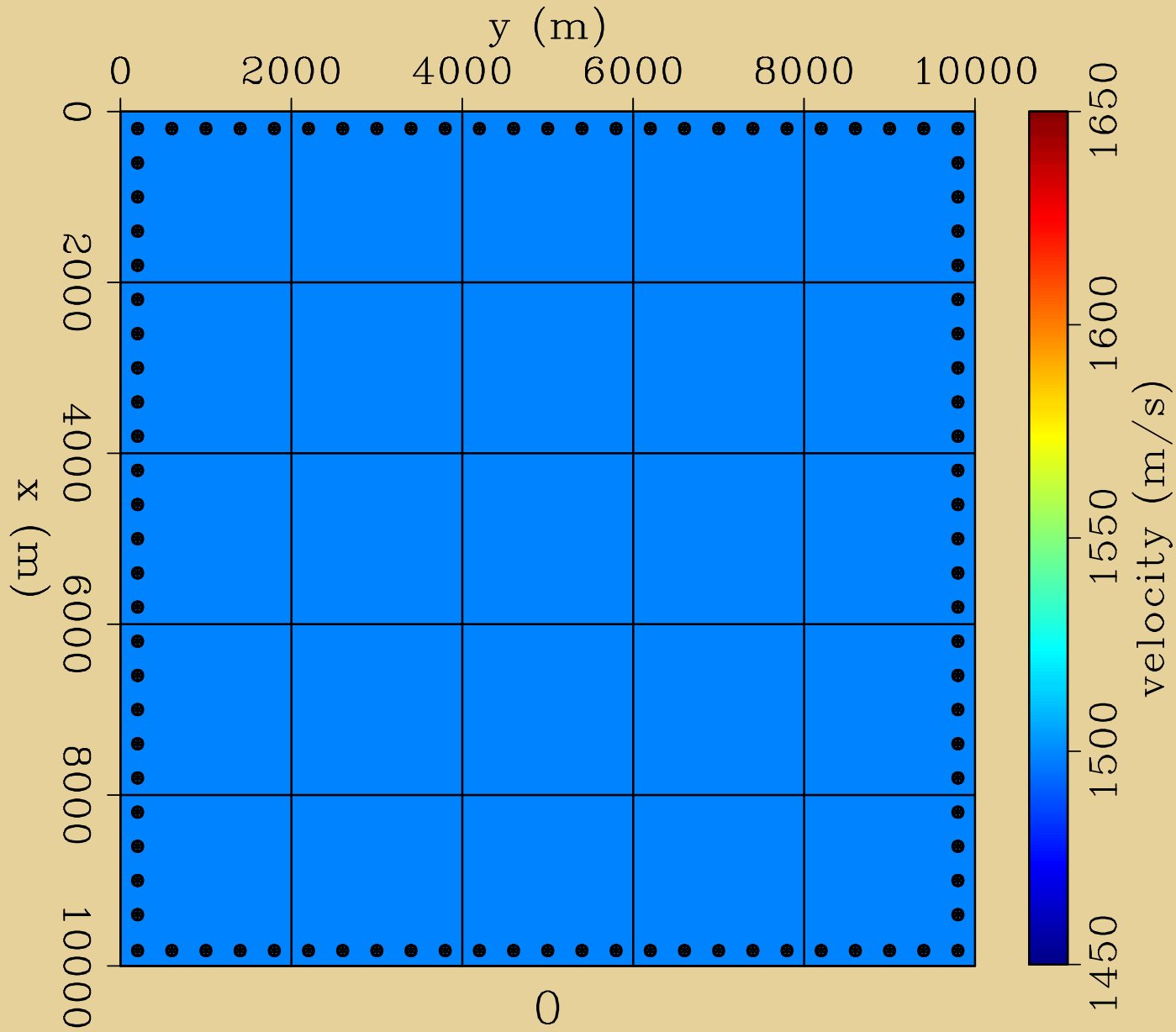
A square of sources and receivers - 2-Hz



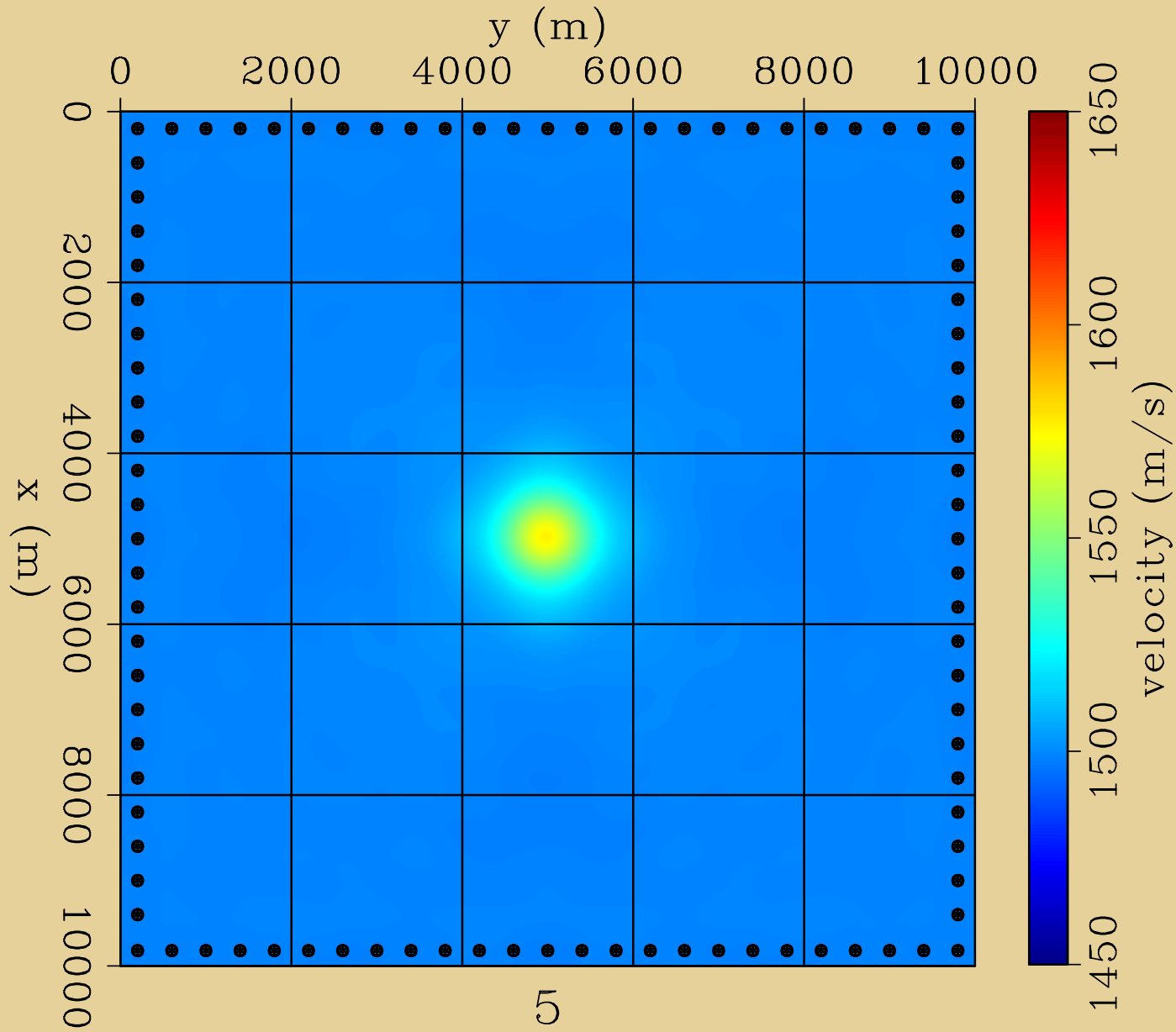
A square of sources and a field of receivers - 1-Hz



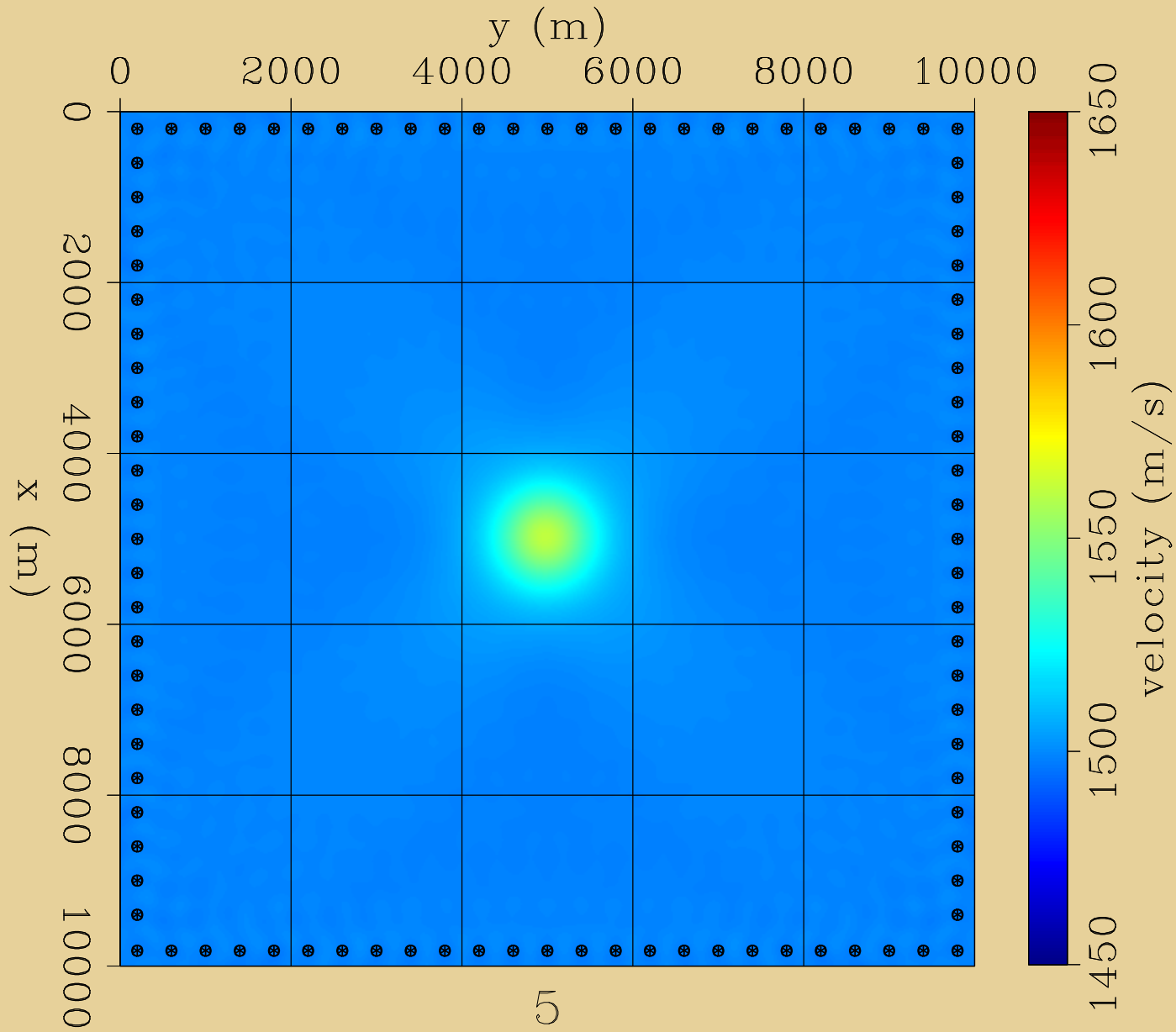
A square of sources and a field of receivers - 4-Hz



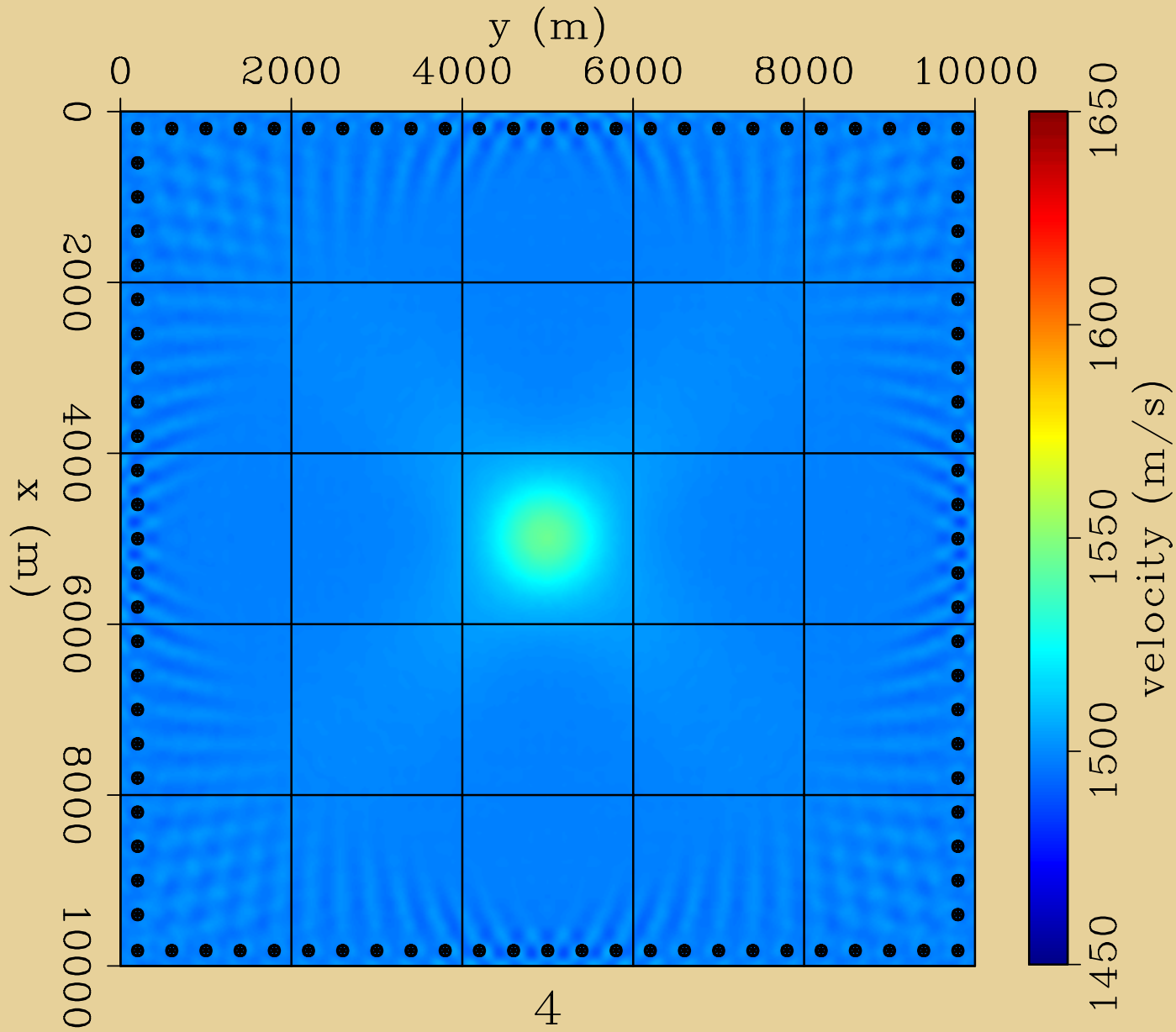
A square of sources and a field of receivers - 1-Hz



A square of sources and a field of receivers - 2-Hz



A square of sources and a field of receivers - 4-Hz



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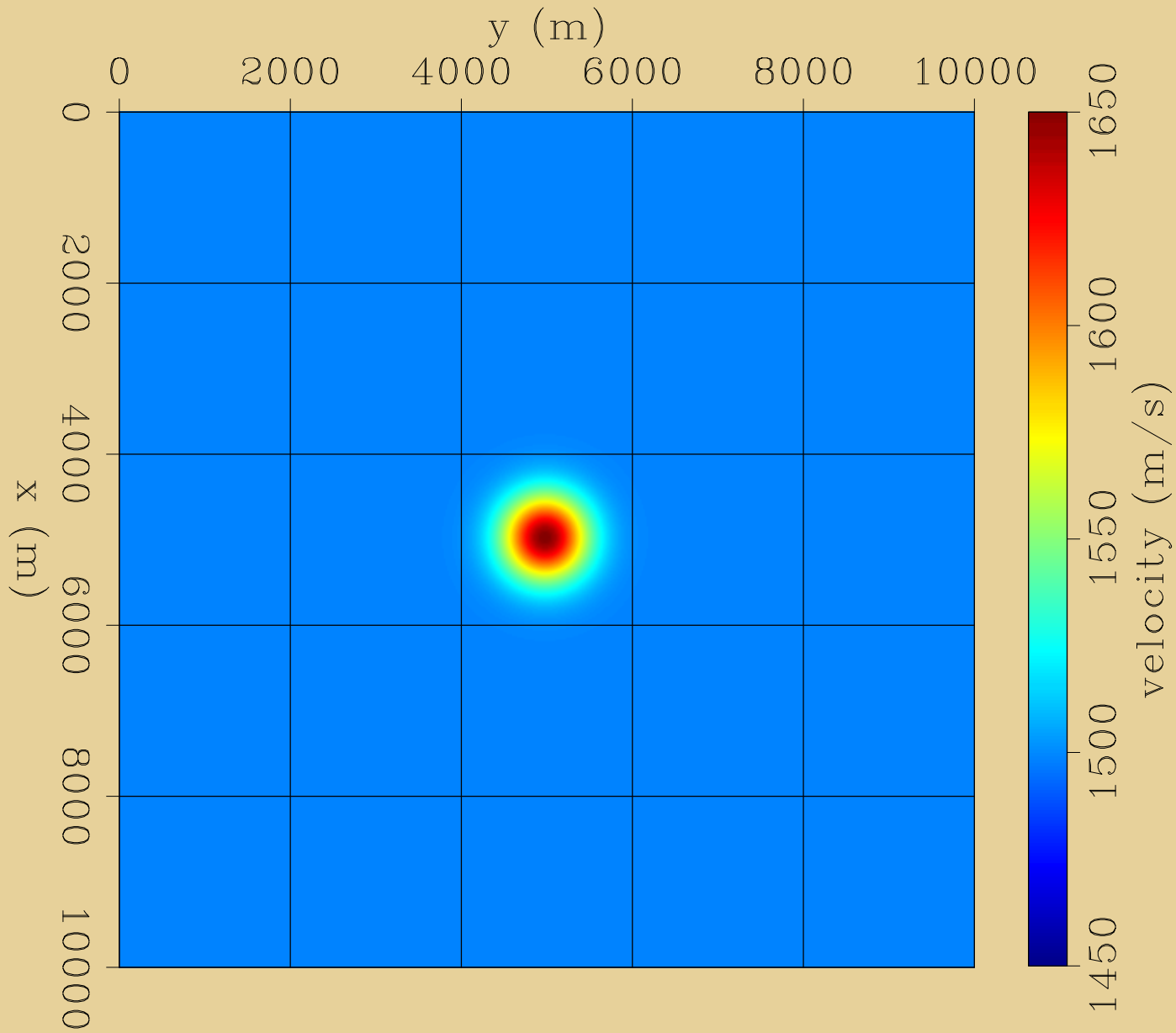
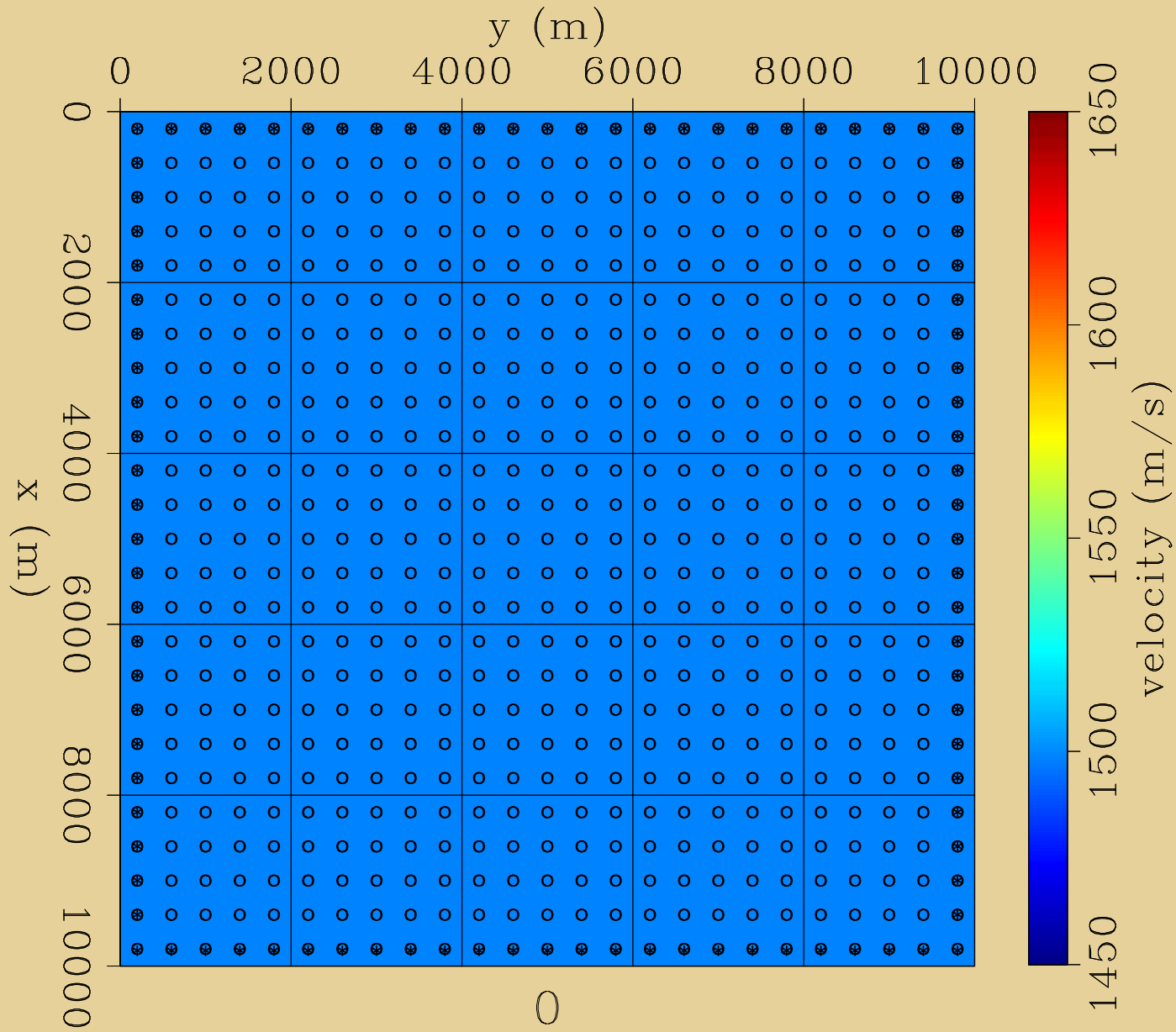


Conclusions

- Illuminating a target from many different angles enables recovering the shape in single frequency FWI.
- Final image is limited by the wavelength of the source field.
- With stations limited to the surface, this approach is relevant for surface waves.

A square of sources and a field of receivers - 2-Hz