Initial models for Full Waveform Inversion

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2. Initial models for FWI
3. WEMVA
4. Inversion in the image and data spaces
5. Synthetic data example
6. Real data example
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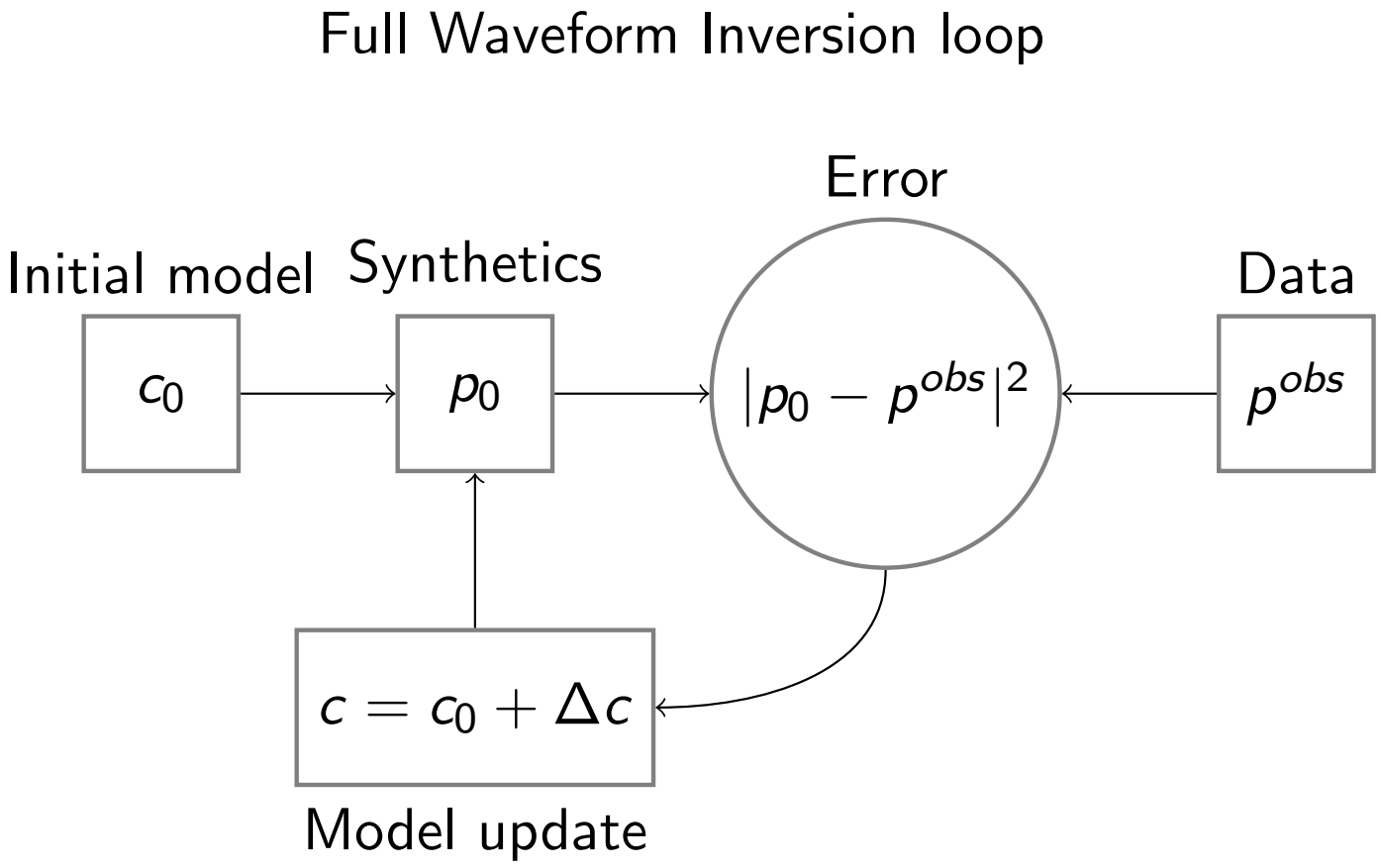
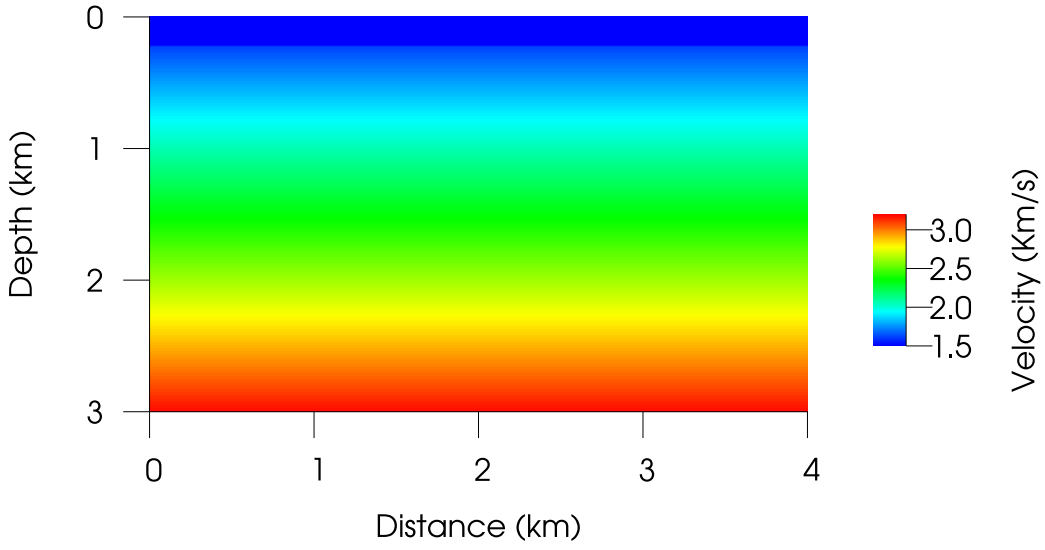
Introduction

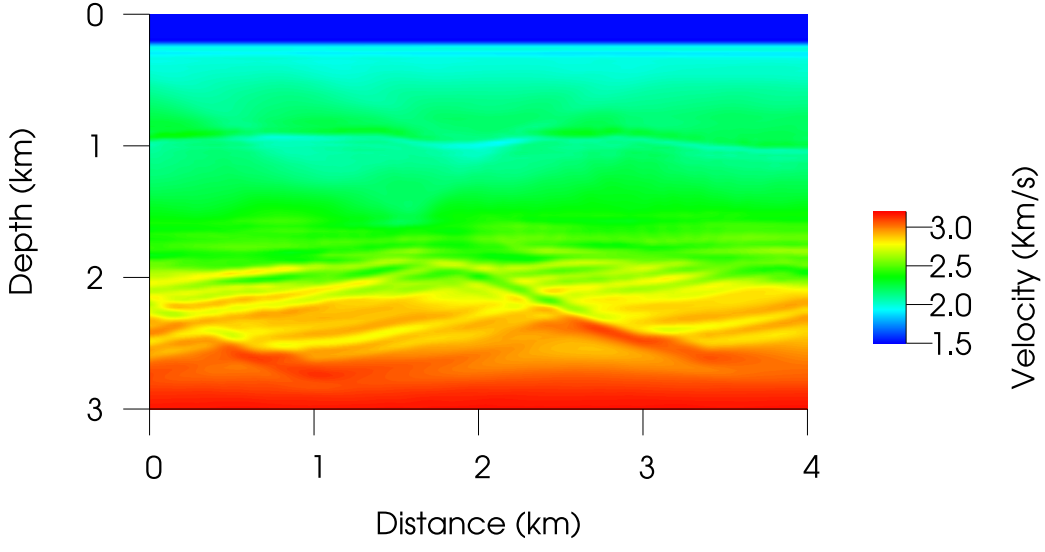


Initial models for FWI

Initial model A

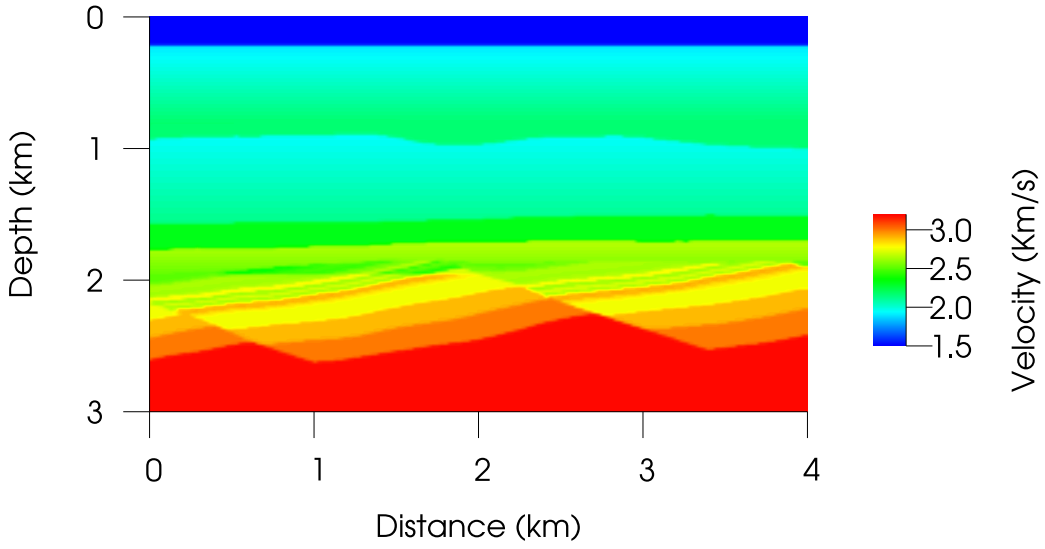


FWI

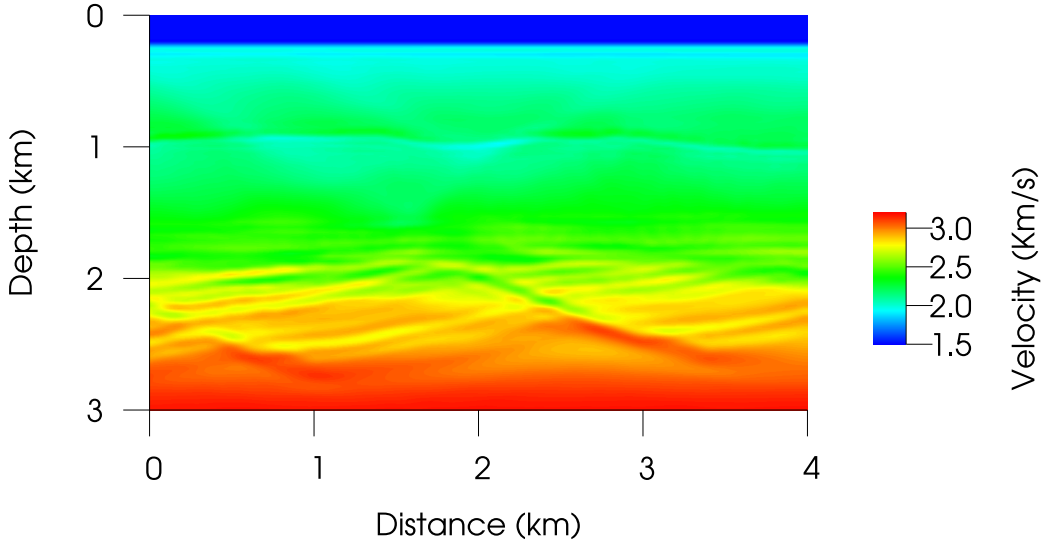


Initial models for FWI

Exact model

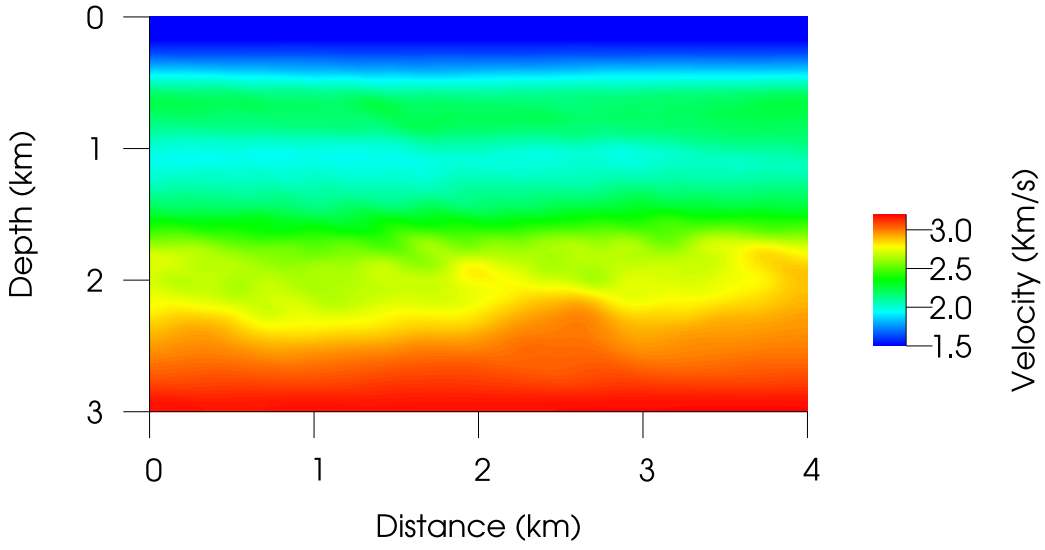


FWI

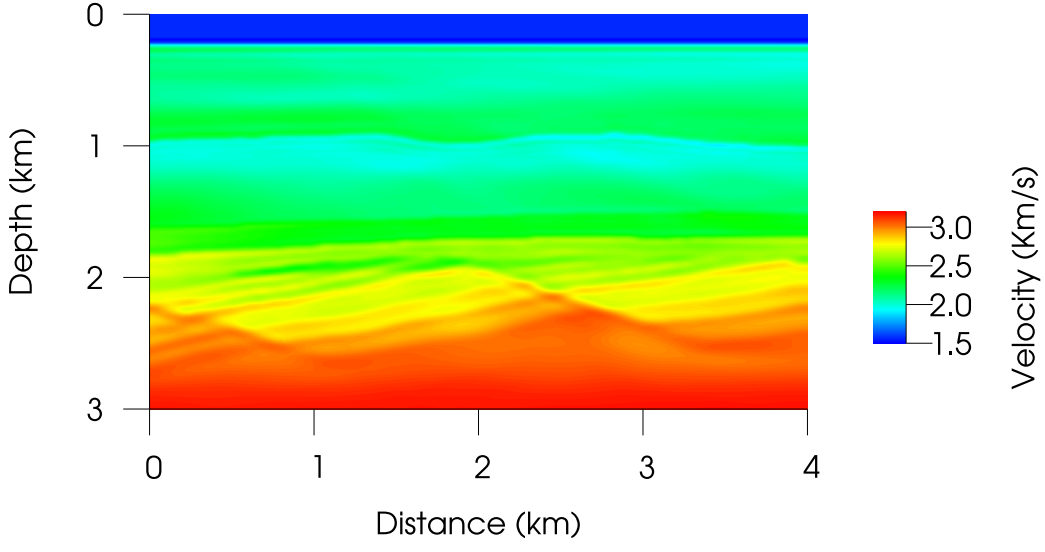


Initial models for FWI

Initial model B



FWI



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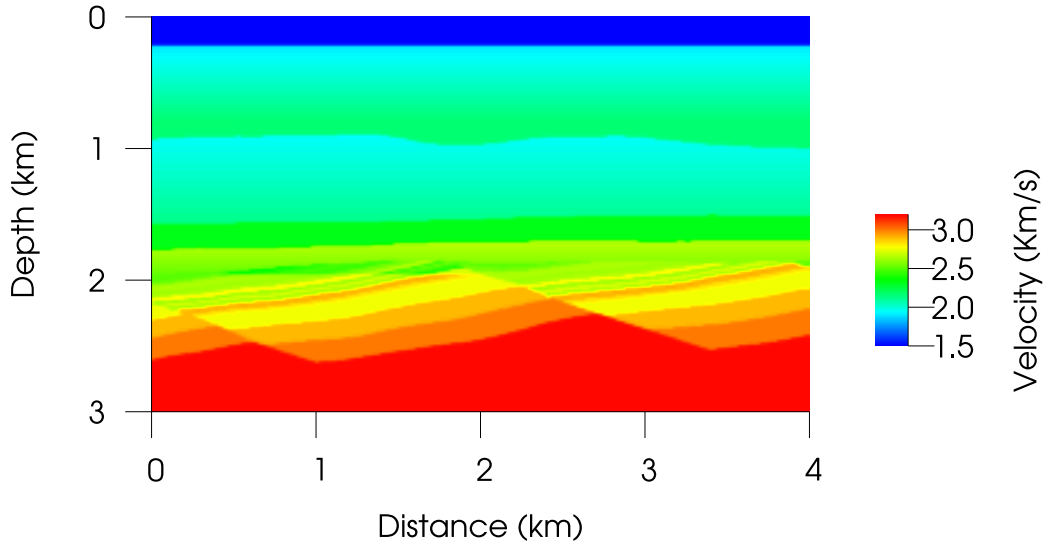
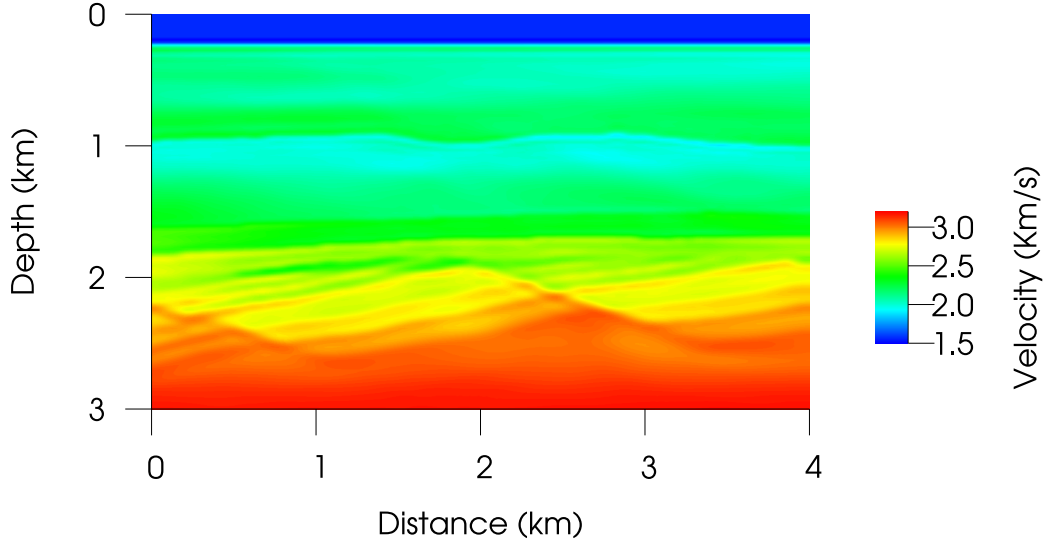


FWI



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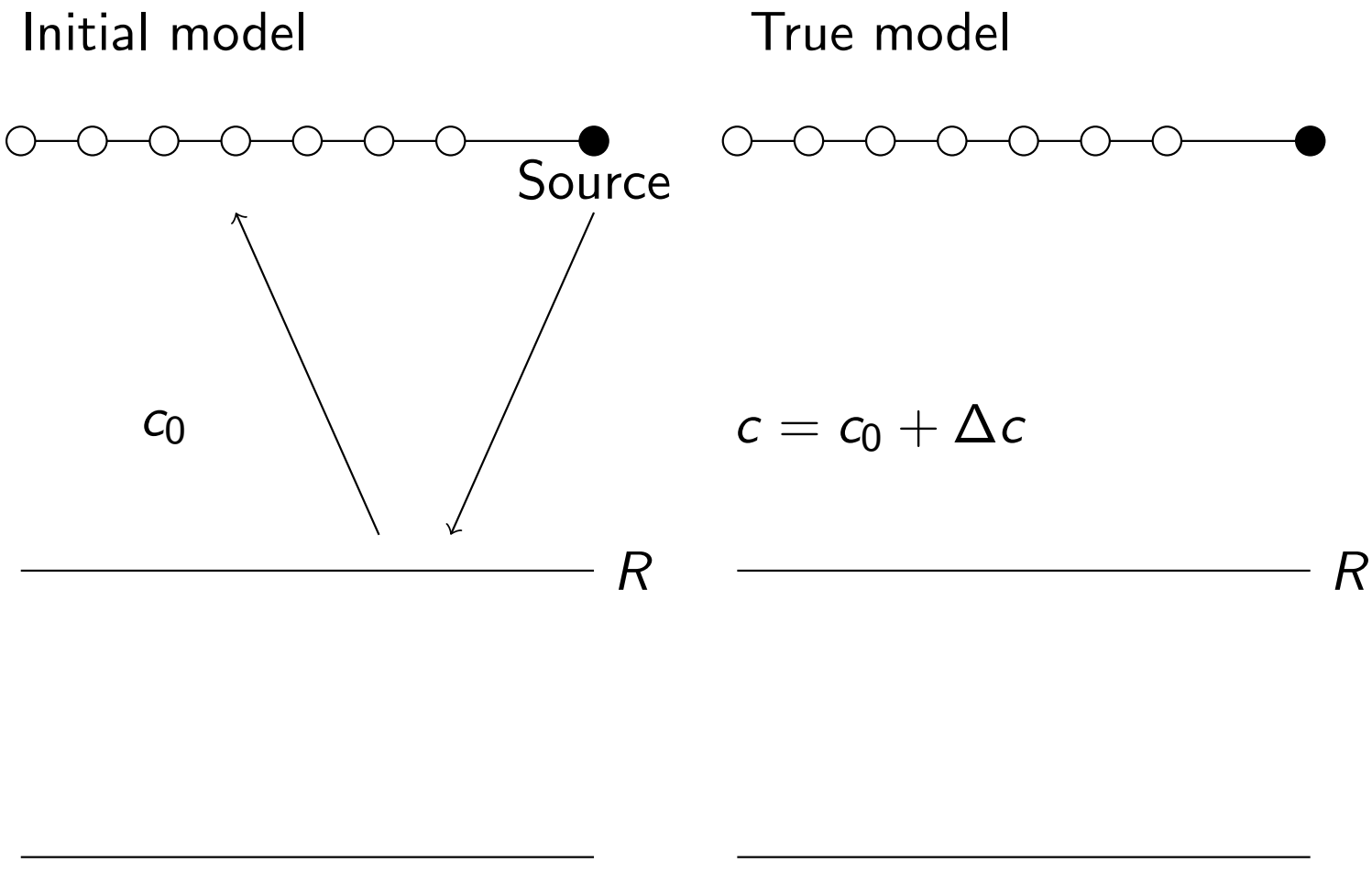

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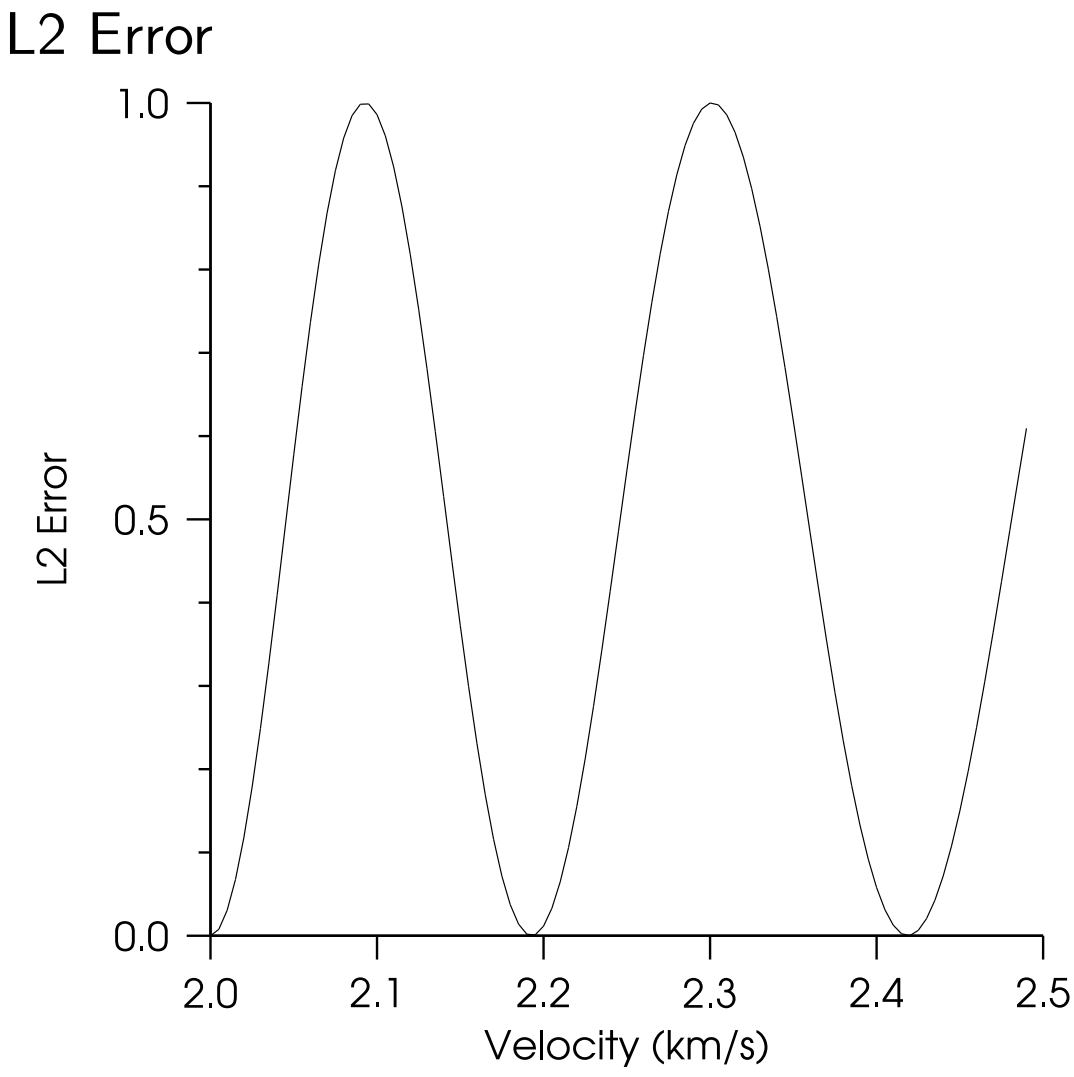


Initial models for FWI

Born approximation holds (Beydoun and Tarantola, 1988)

$$\Delta T < \frac{1}{2f_0} \tag{1}$$

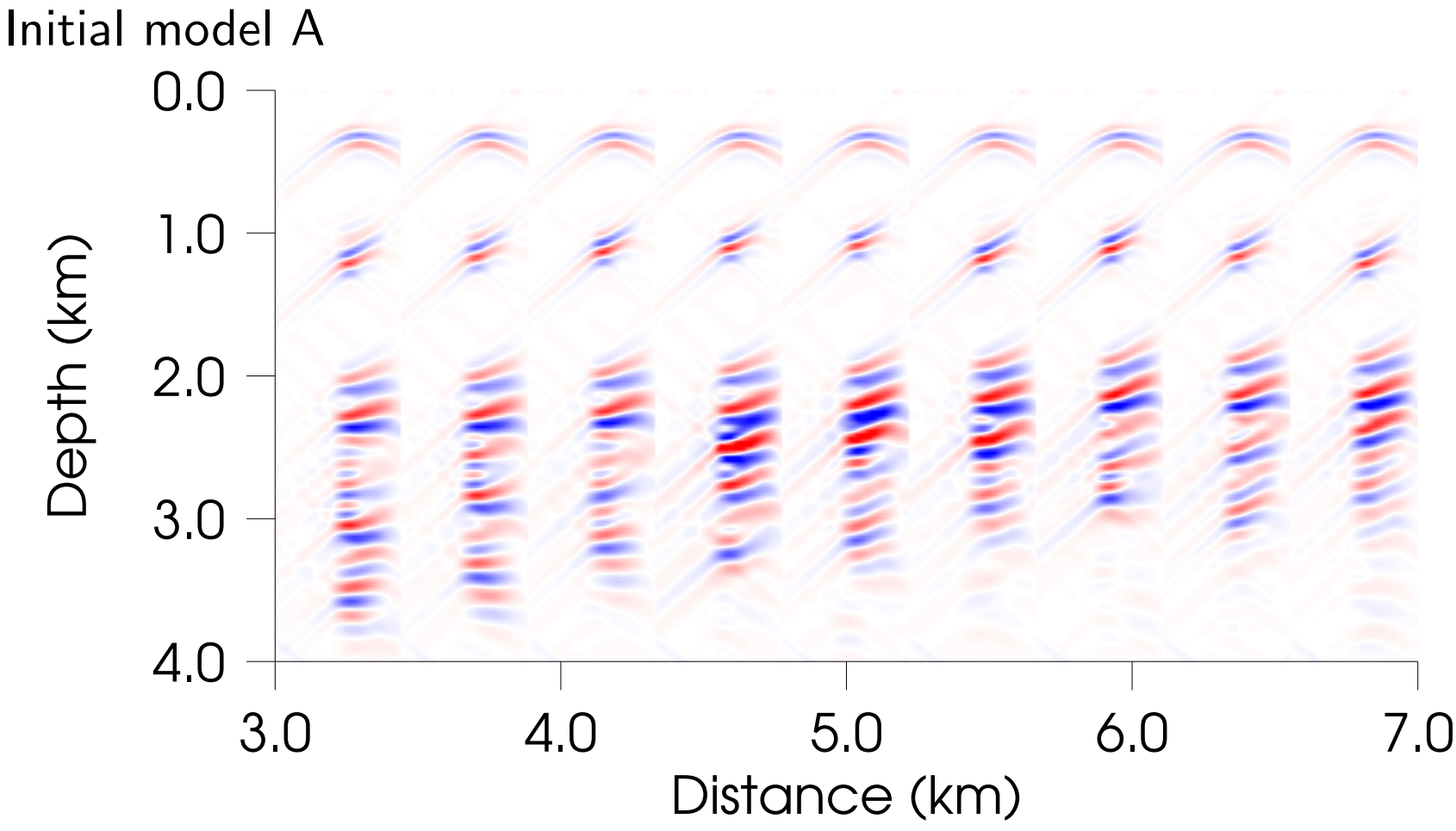
- Δt : Traveltime error between model and data
- f_0: Dominant frequency

or (Pratt et al. 2008)

$$\frac{\Delta T}{T} < \frac{1}{N_\lambda} \tag{2}$$

- N_λ : No of wavelengths
- T : Record time

Initial models for FWI



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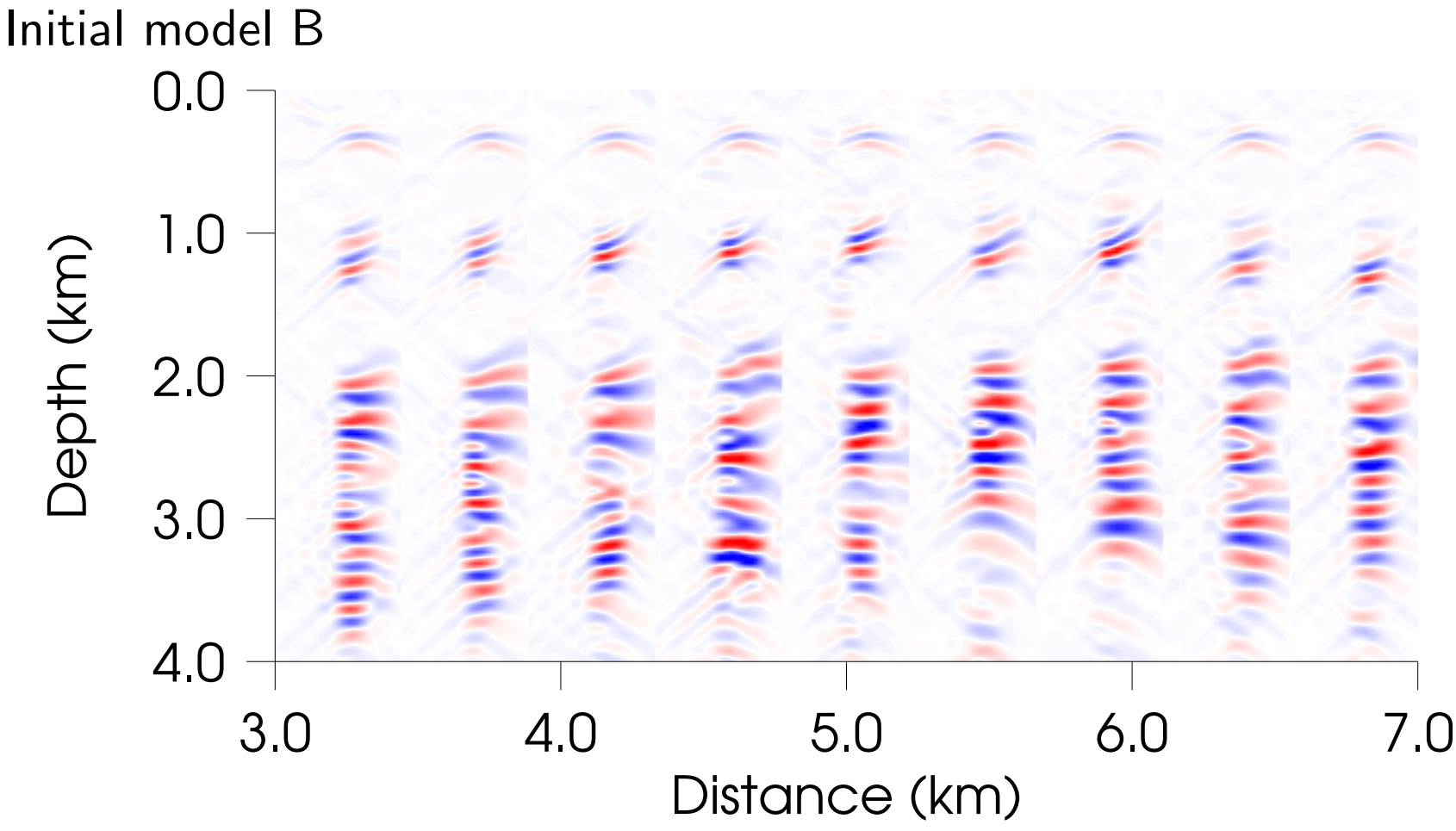
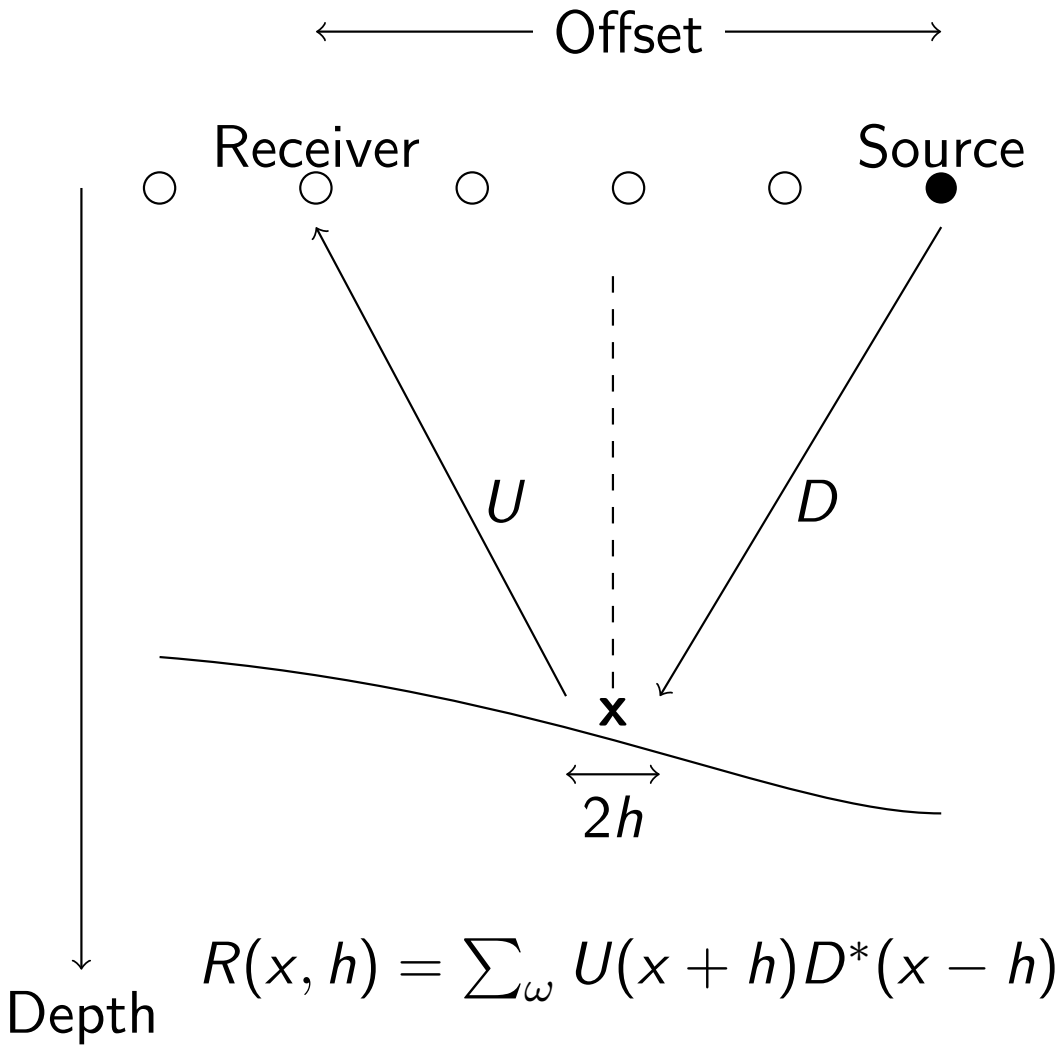


WEMVA

Wave Equation Migration Velocity Analysis (WEMVA)



$$R(x,h) = \sum_{\omega} U(x+h)D^*(x-h)$$

WEMVA

Minimize e_s w.r.t c

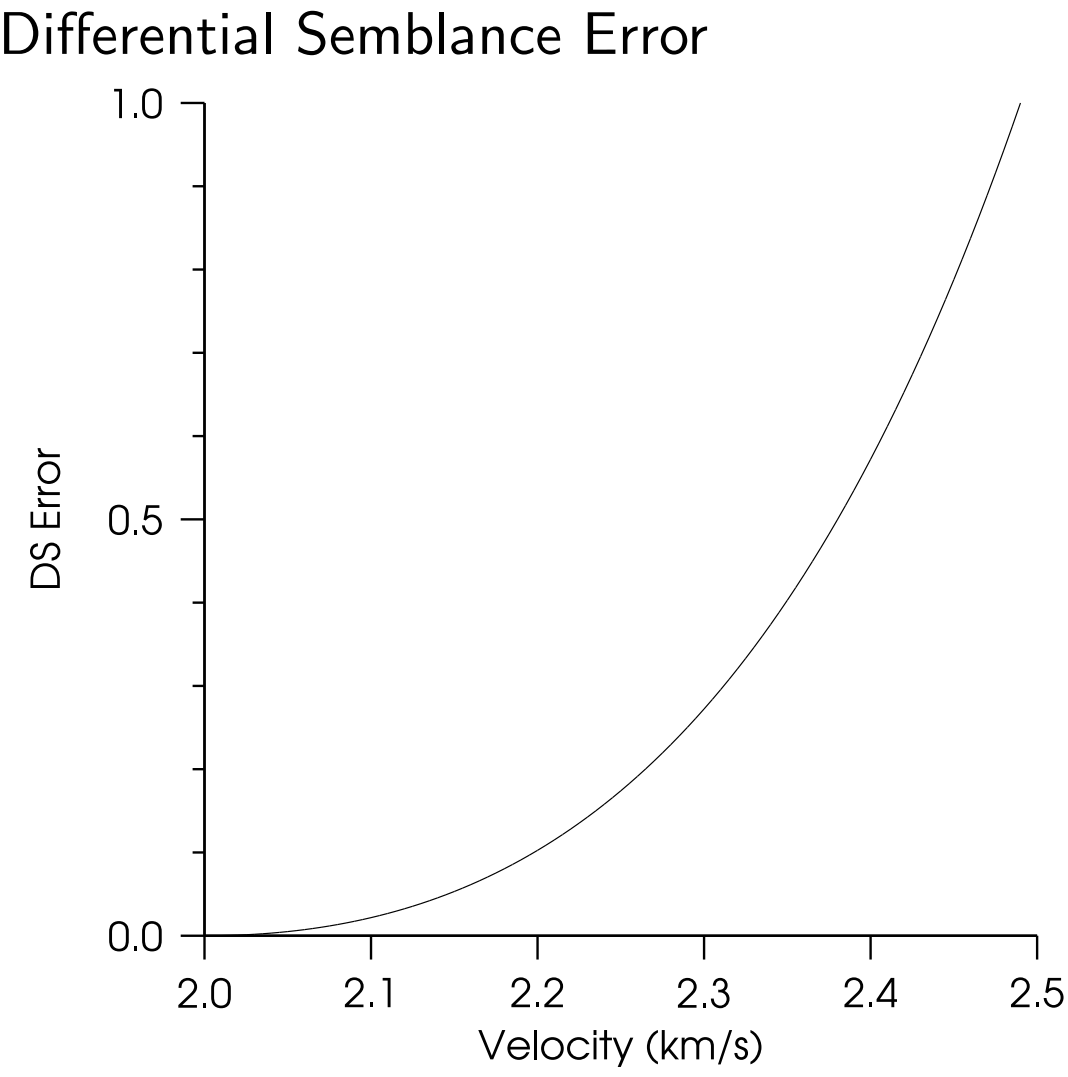
$$e_s = \sum_x \sum_h h^2 \left[\frac{\partial R(\mathbf{x}, \mathbf{h})}{\partial z} \right]^2, \tag{3}$$

Iterative solution

$$\begin{aligned} c &= c_0 + \Delta c \\ \Delta c &\approx \alpha \nabla_c e_s \end{aligned} \tag{4}$$

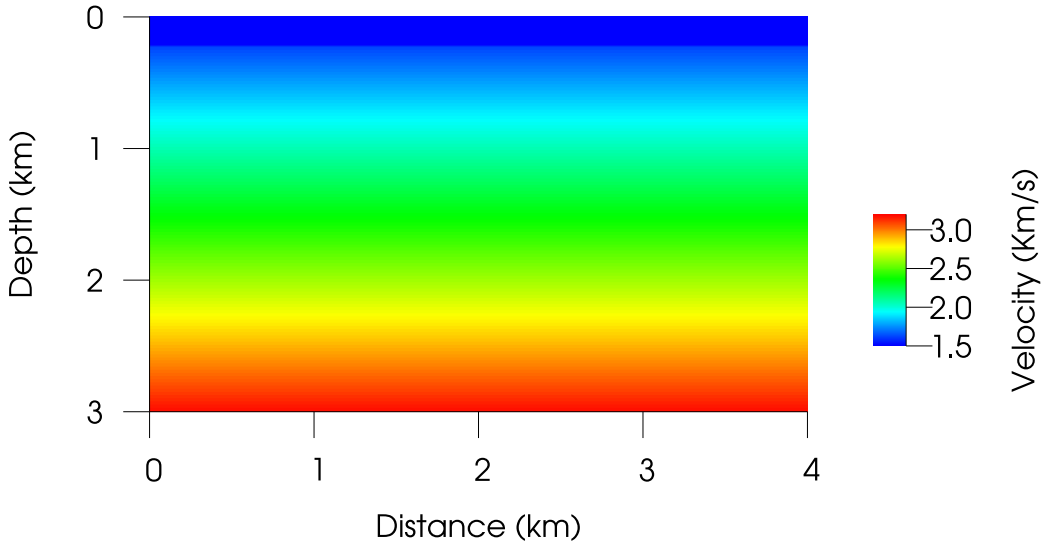
- e_s is mainly sensitive to travel-time
- Low resolution
- Relies on the Born Approximation

WEMVA

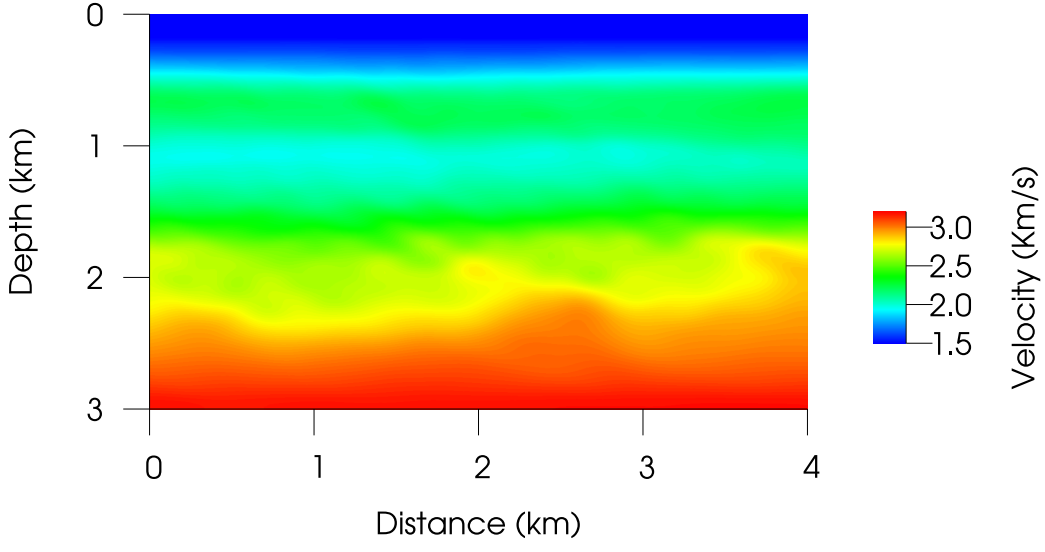

Differential Semblance Error
DS Error
1.0
0.5
0.0
2.0
2.1
2.2
2.3
2.4
2.5
Velocity (km/s)

WEMVA

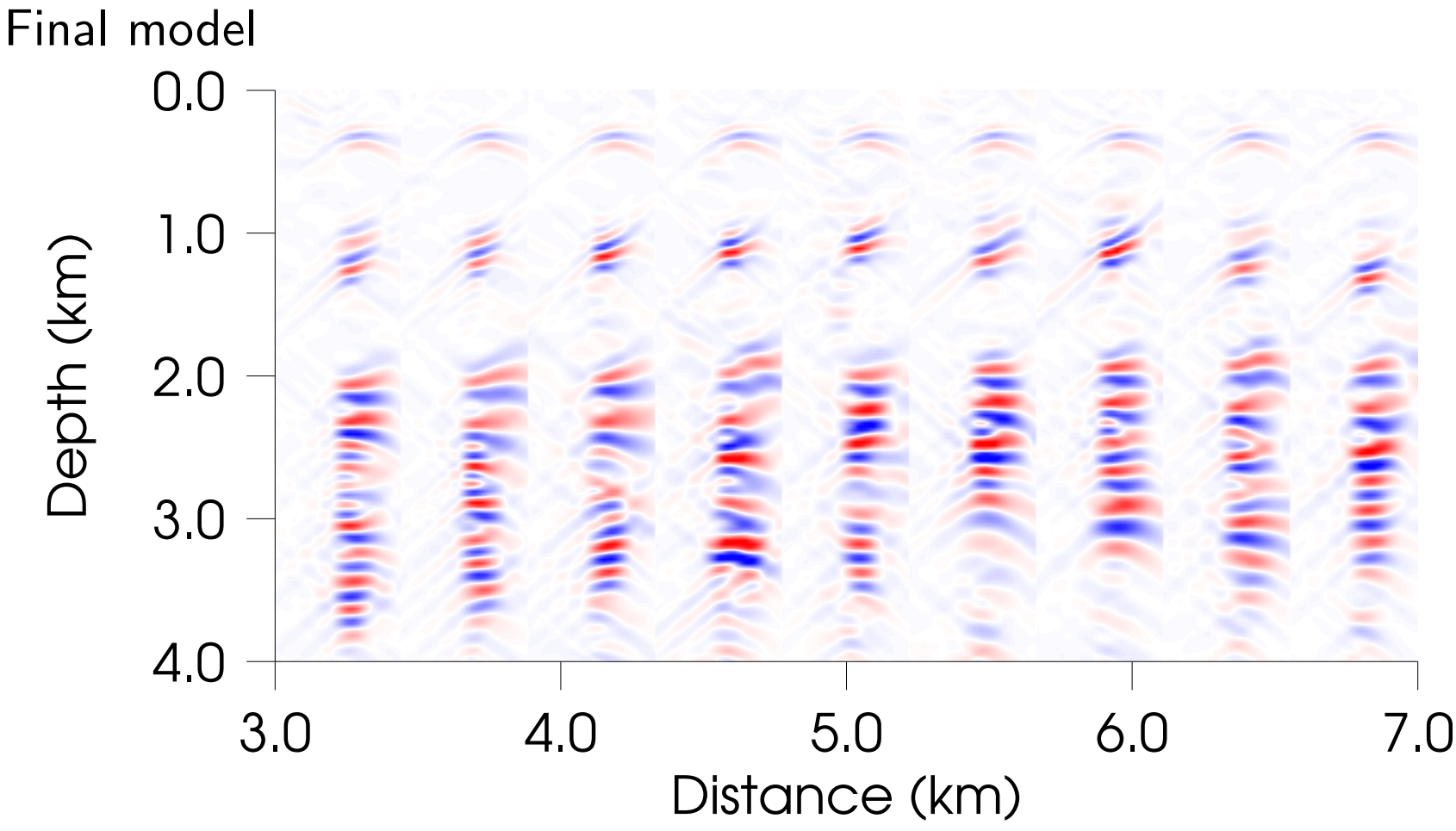
Initial model



WEMVA 25 iterations

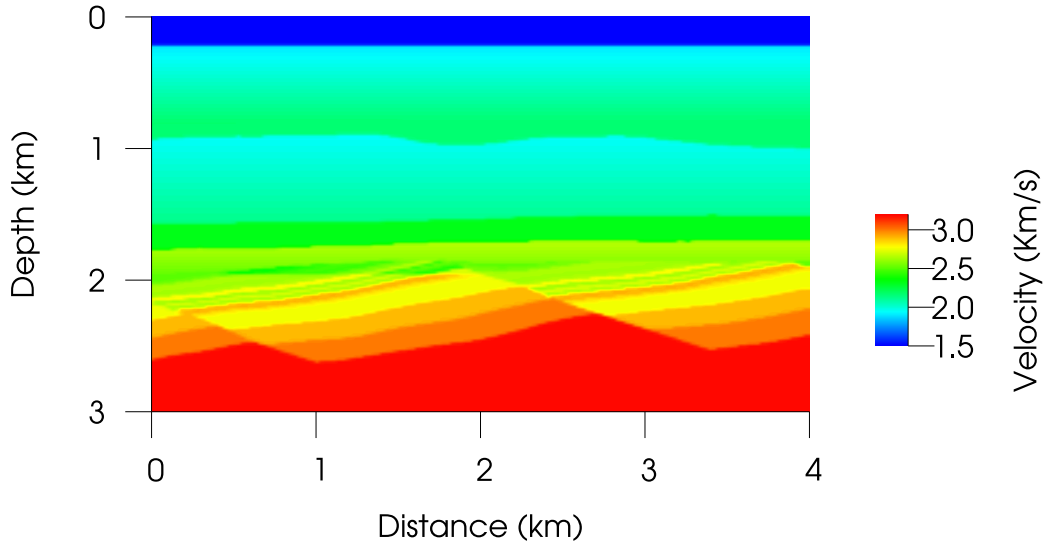


WEMVA

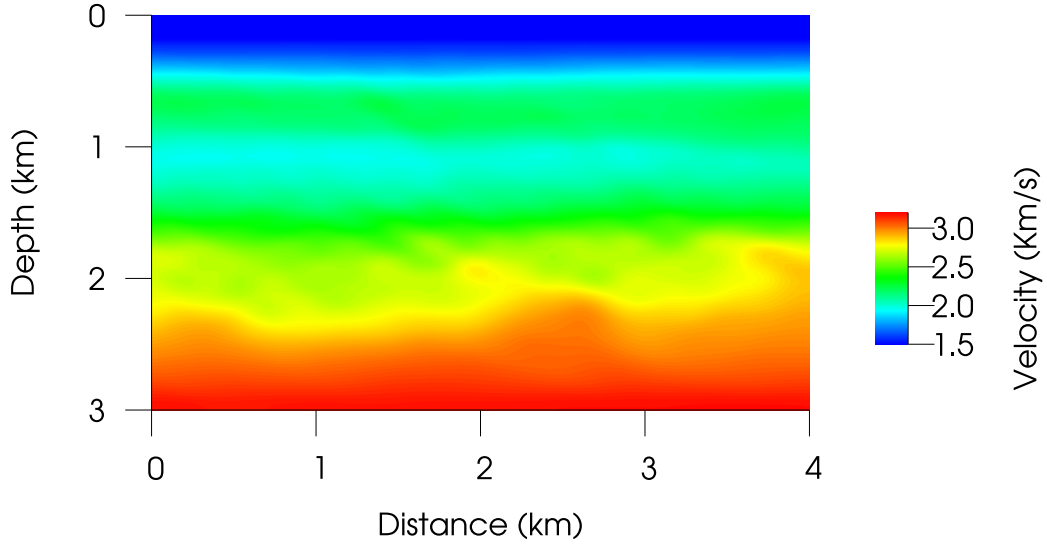


WEMVA

Exact model



WEMVA 25 iterations



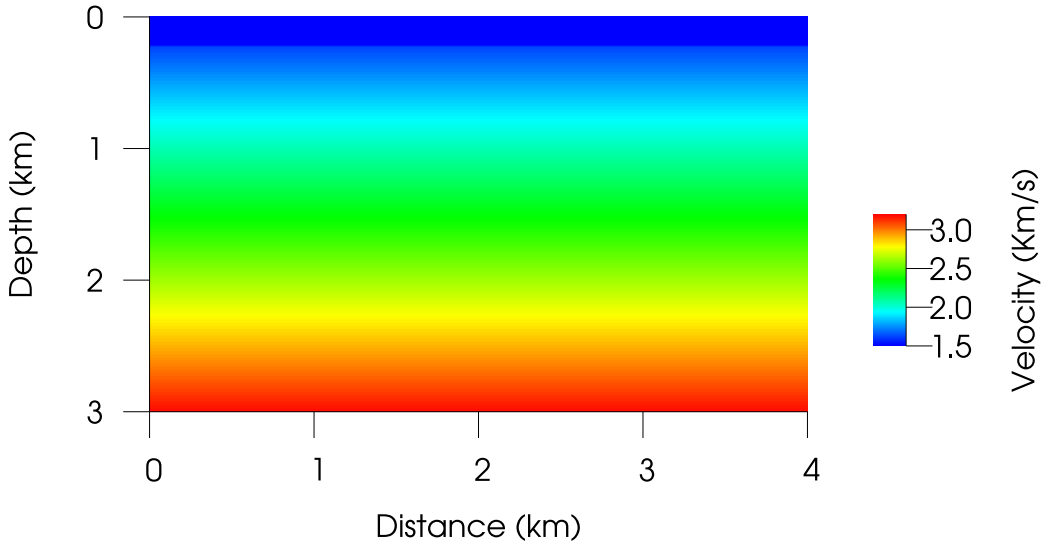
Inversion in the image and data spaces

$$e = w_I e_I + w_s e_s \tag{5}$$

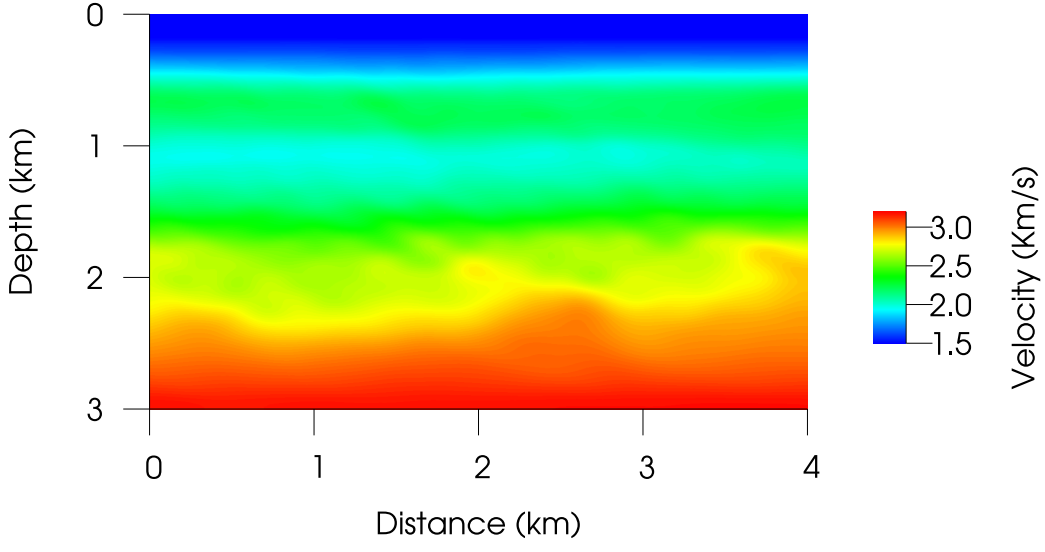
- w_I, w_s: Weights
- e_I: Least-squares Inversion error
- e_s: Differential semblance error

Synthetic Data Example

Initial model A

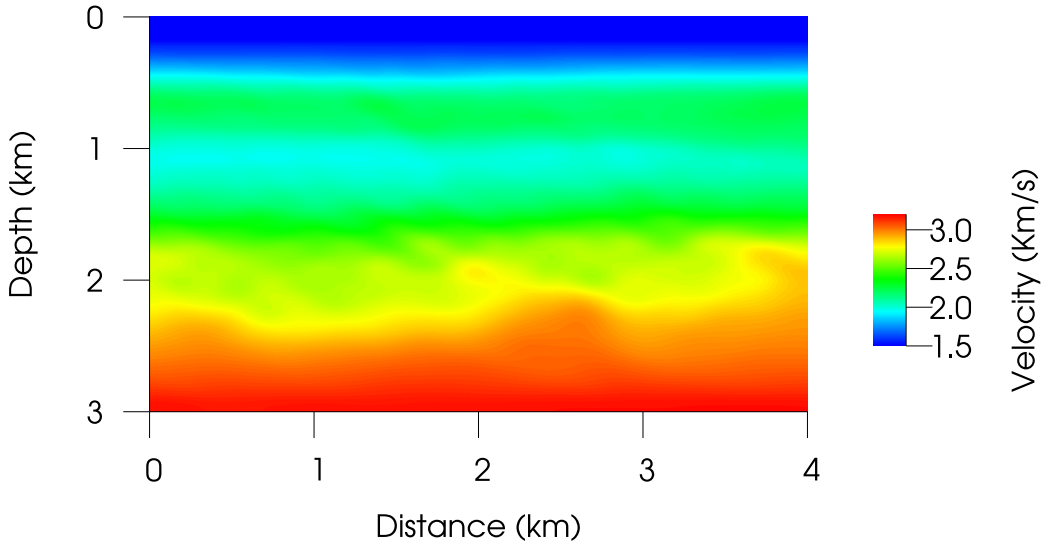


WEMVA after 25 iterations

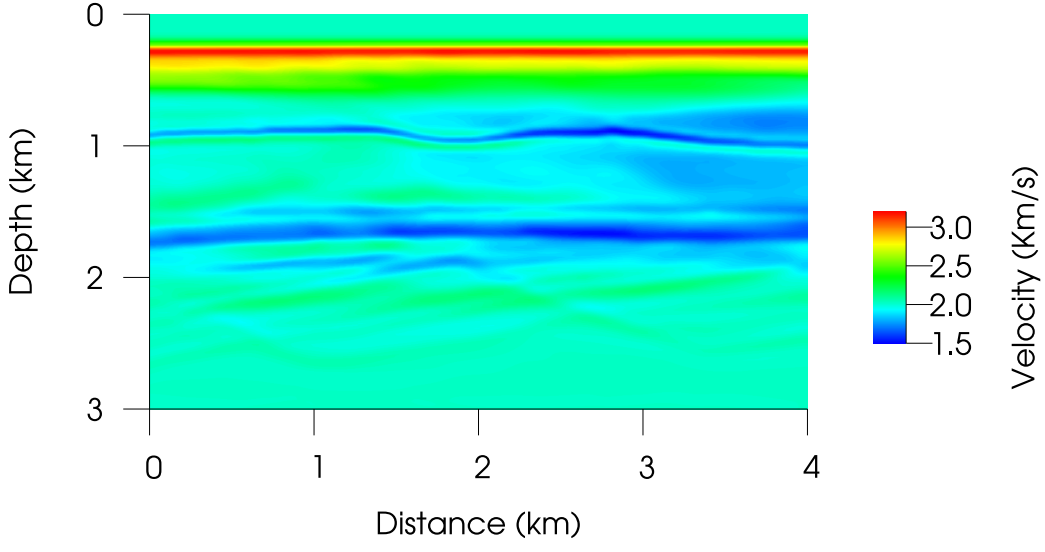


Synthetic Data Example

Initial model from WEMVA



FWI Iteration 1 - Initial model $= \Delta c$



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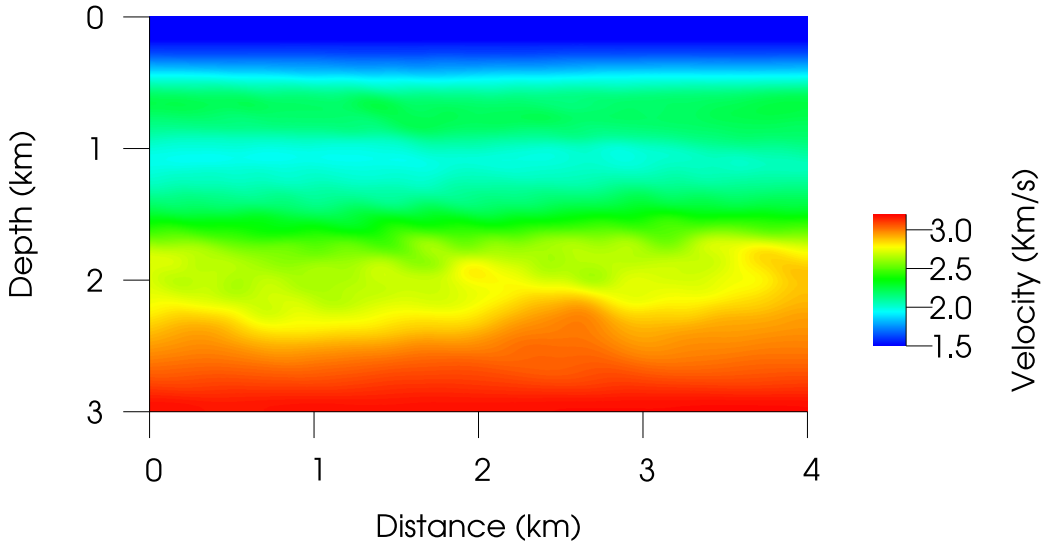
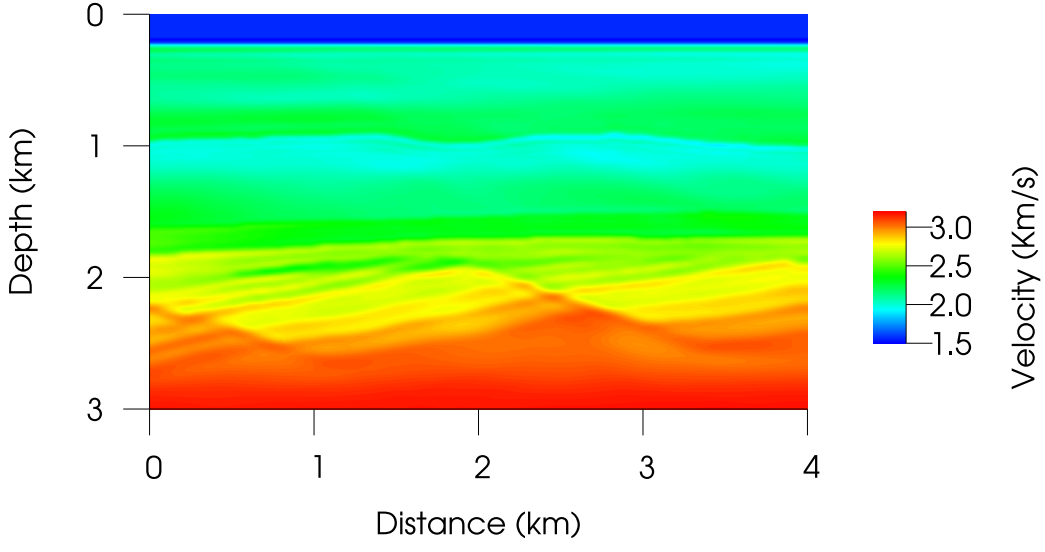
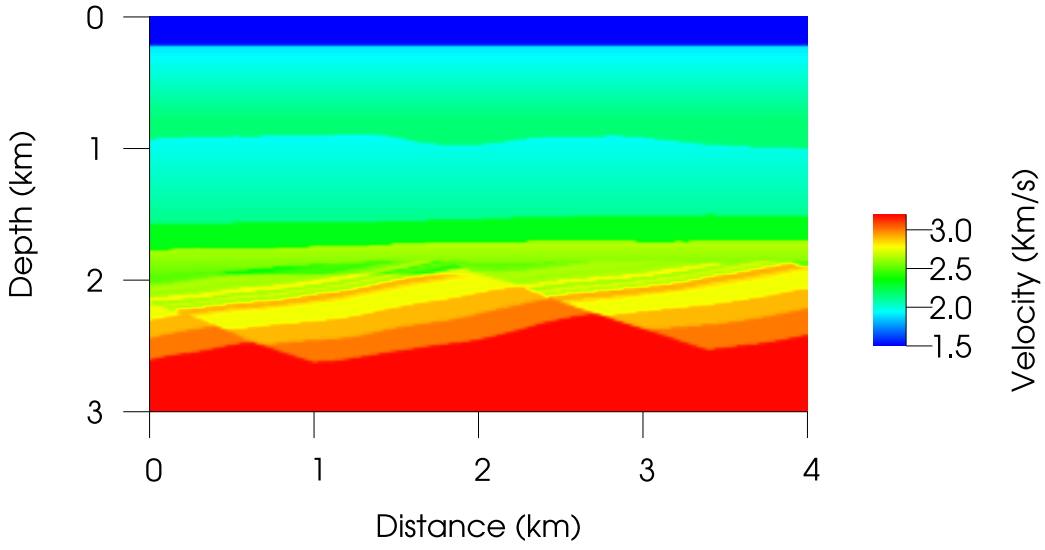


FWI after 25 iterations



Synthetic Data Example

Exact Model



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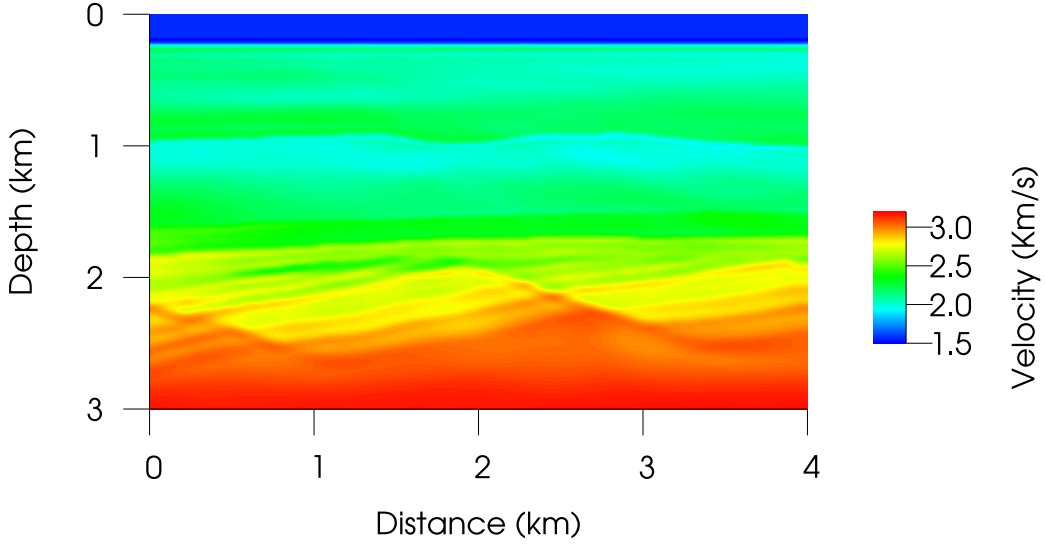
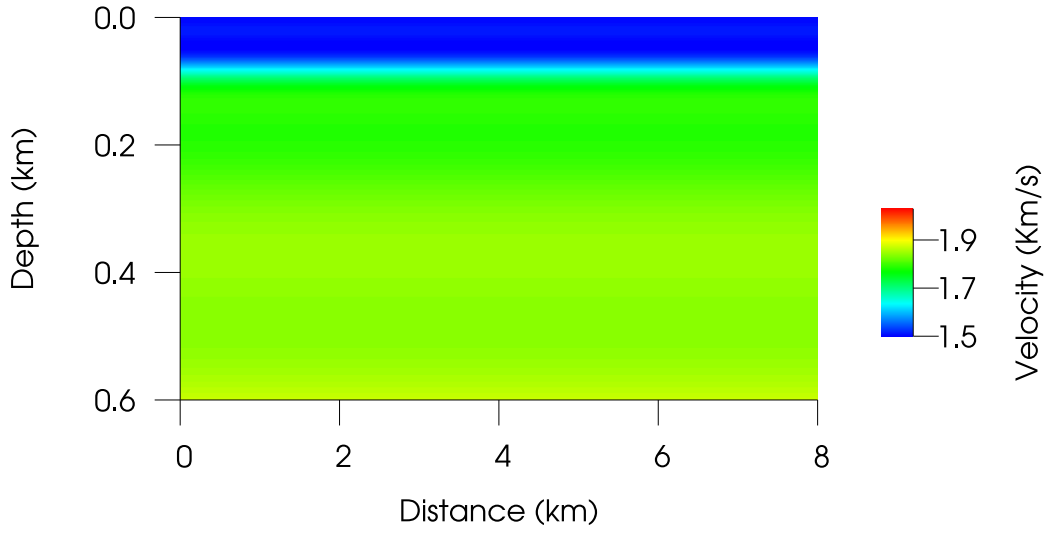
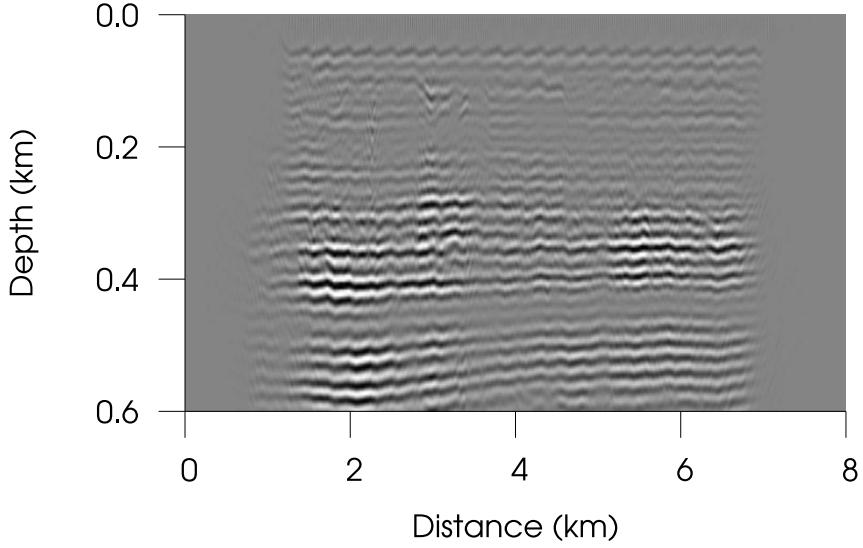


Real Data Example

Initial Model

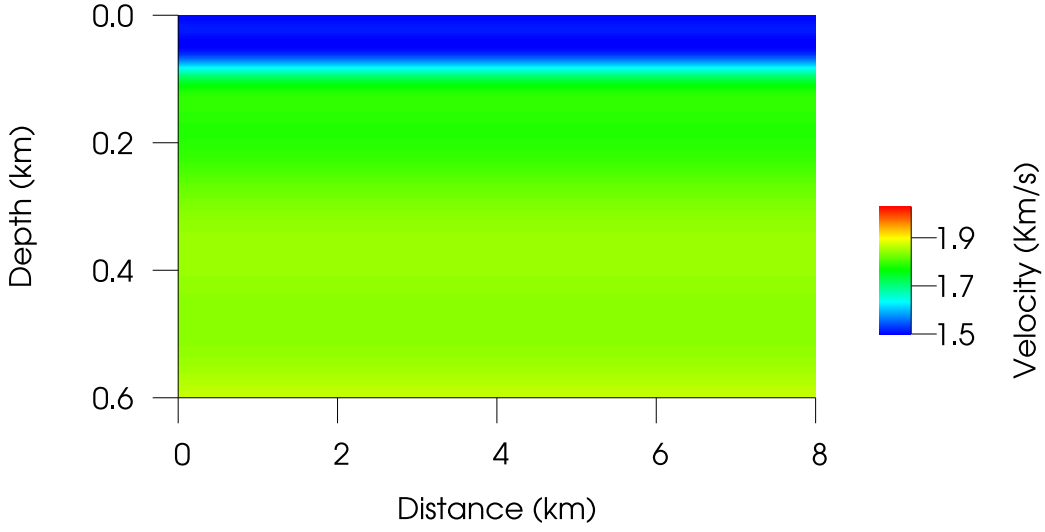


Migrated Data

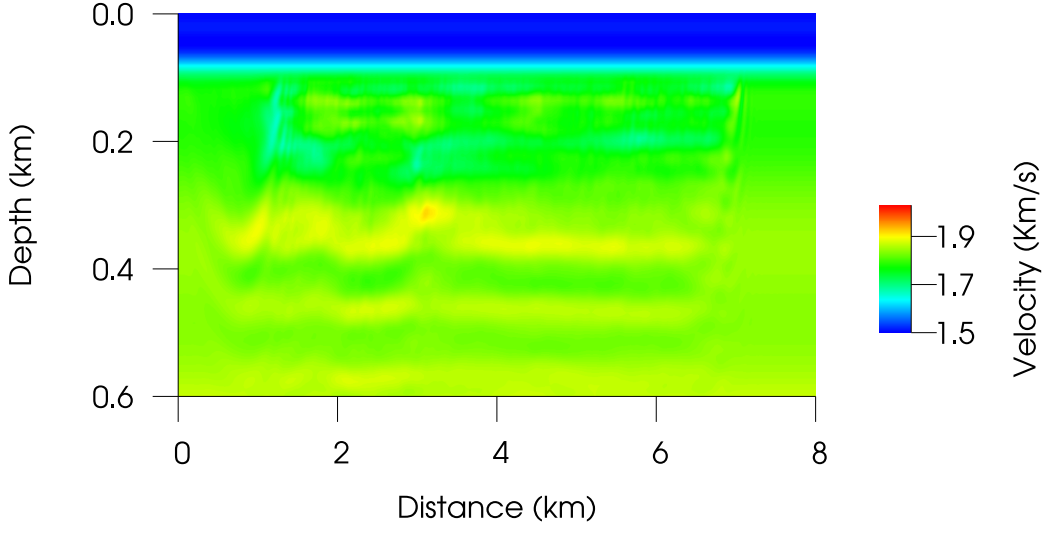


Real Data Example

Initial Model

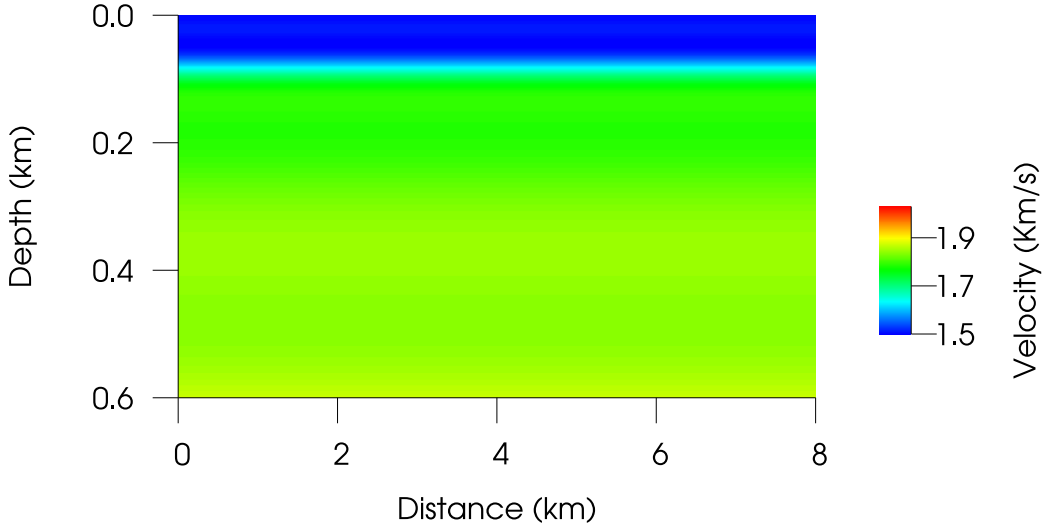


FWI after 25 iterations

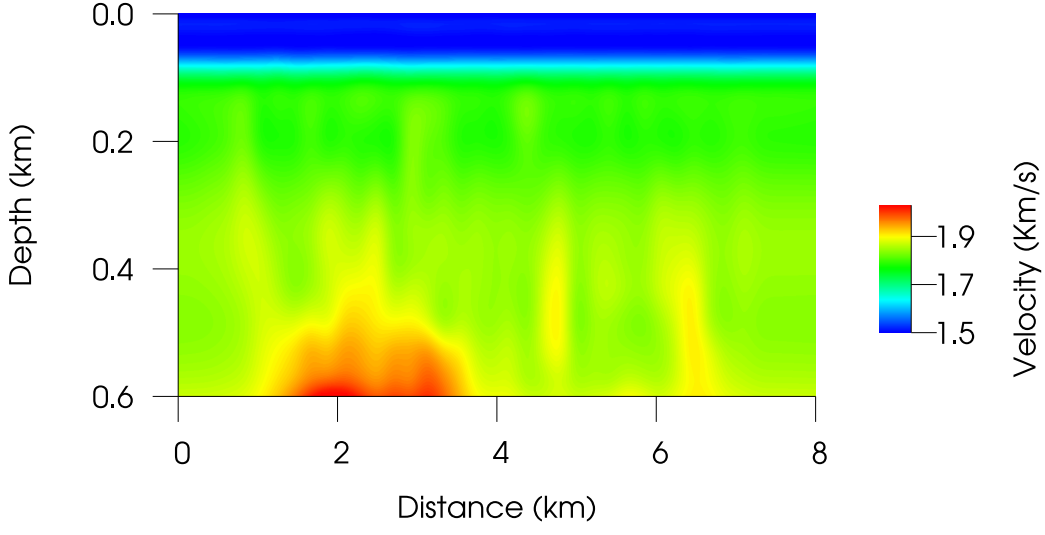


Real Data Example

Initial Model

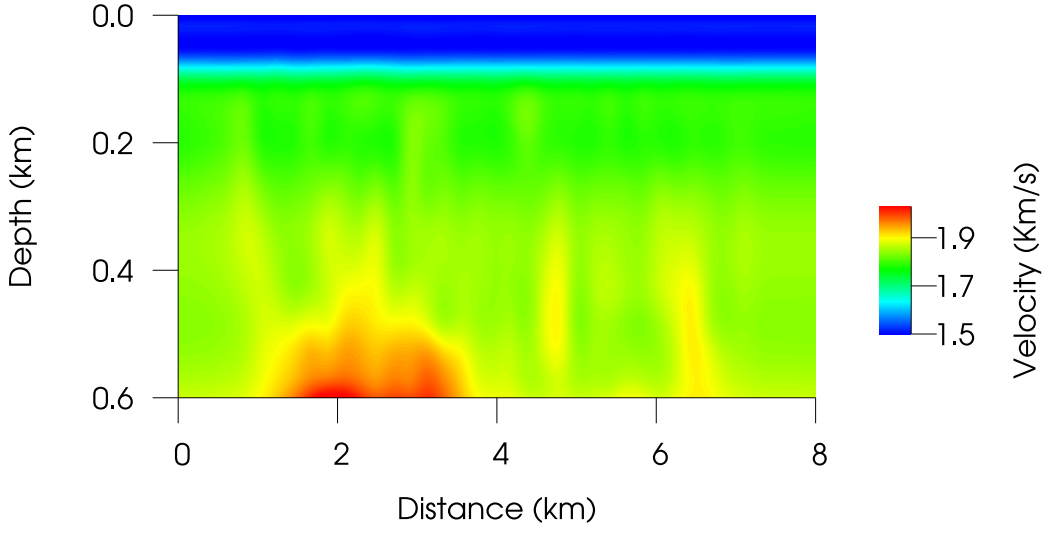


WEMVA after 13 iterations

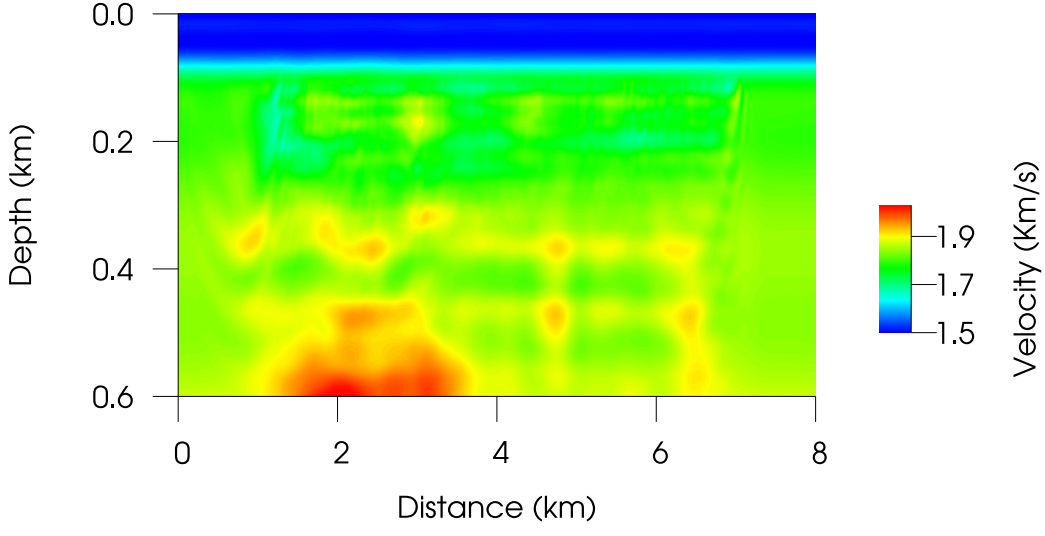


Real Data Example

Initial Model From WEMVA



FWI after 23 iterations



Conclusions

- WEMVA produces low resolution velocity models with reasonable good kinematic properties from simple initial models
- WEMVA velocity models can be used as initial models for FWI to obtain high resolution velocity models

Acknowledgements

- ROSE consortium, Norwegian Research Coiuncil and Statoil for financial support.