SINBAD Consortium
Meeting Fall 2013

FWI from Vancouver: lessons learned from "Gulf of Mexico Imaging Challenge Part II: FWI, WEMVA, Workflows &...

Dream team

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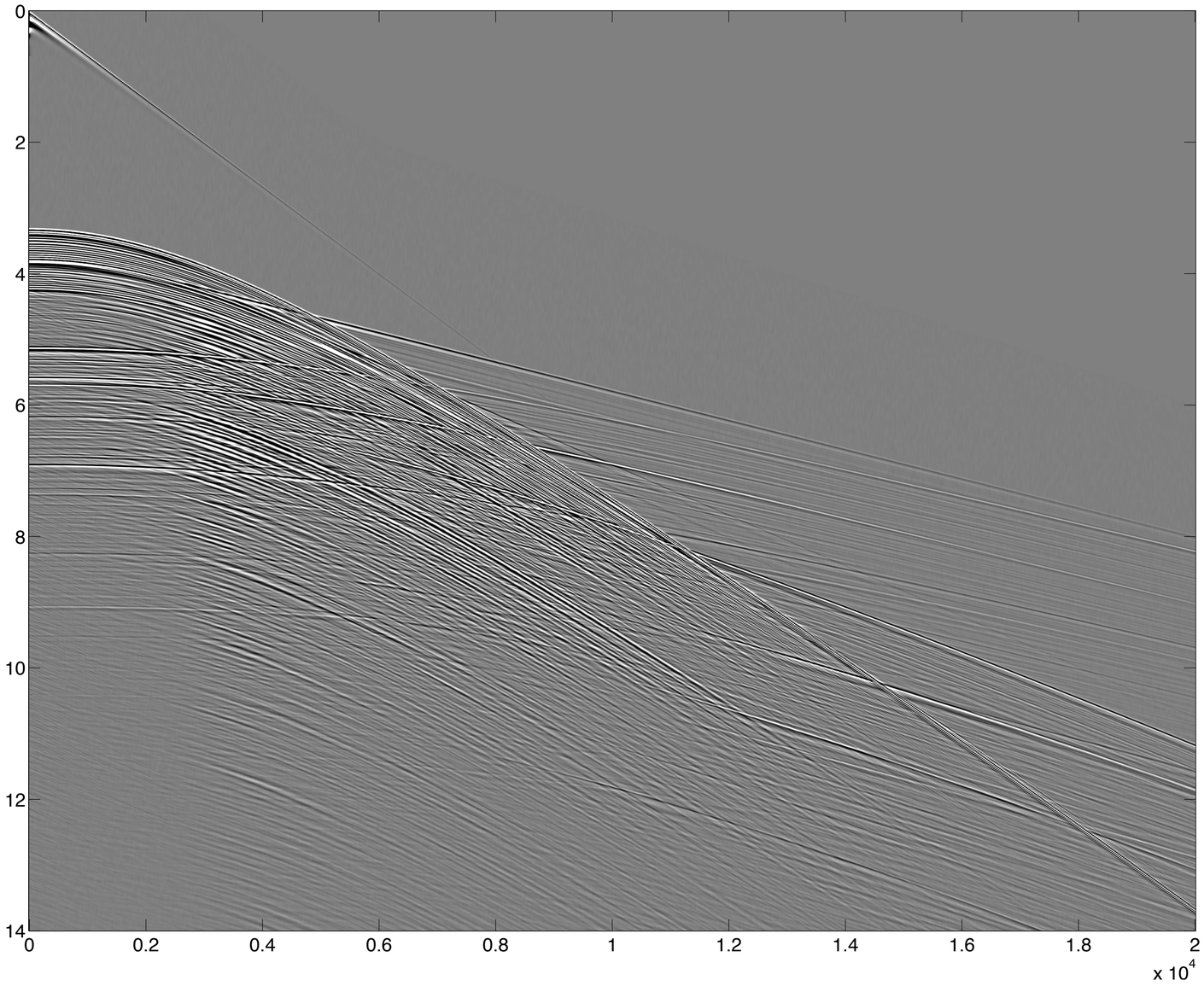
GOM data set (released in 2012)

- 3201 shots with interval 25 m
- 801 receivers with interval 25 m, yielding 20km offset
- record time 14s, sample rate 4ms
- no surface related multiple, but free surface ghost
- isotropic elastic

One shot record



Preprocessing

Travel-time *tomography* based on hand-picked *first* breaks

$\longrightarrow$ *initial velocity model*

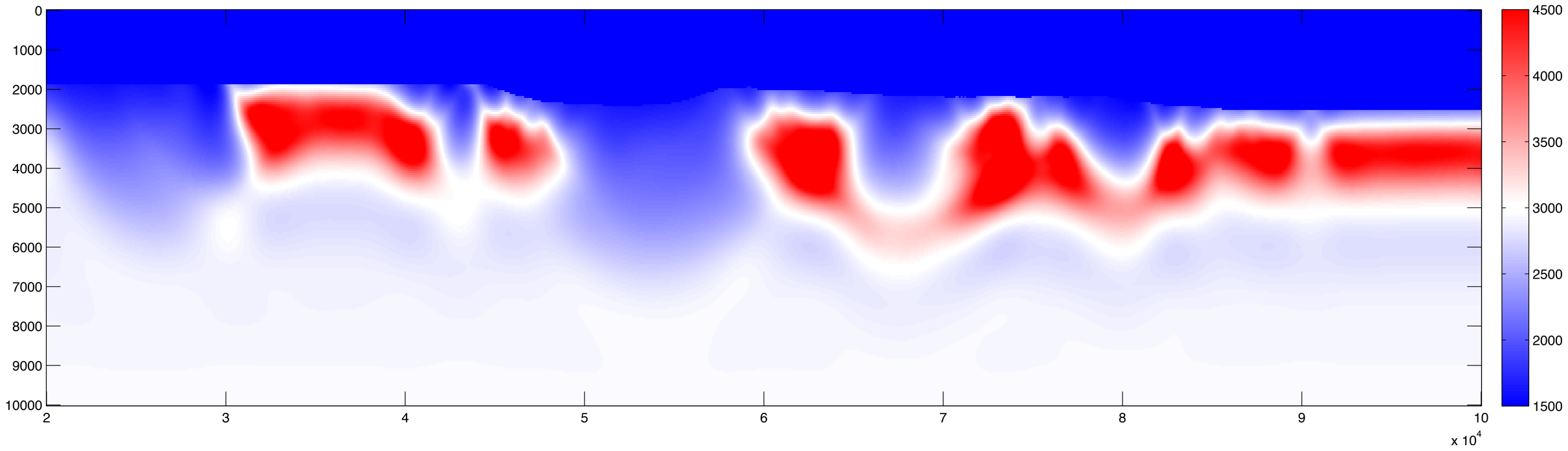
Curvelet-denoising at selected *low*-frequencies

$\longrightarrow$ *improve SNR* for FWI

Initial model

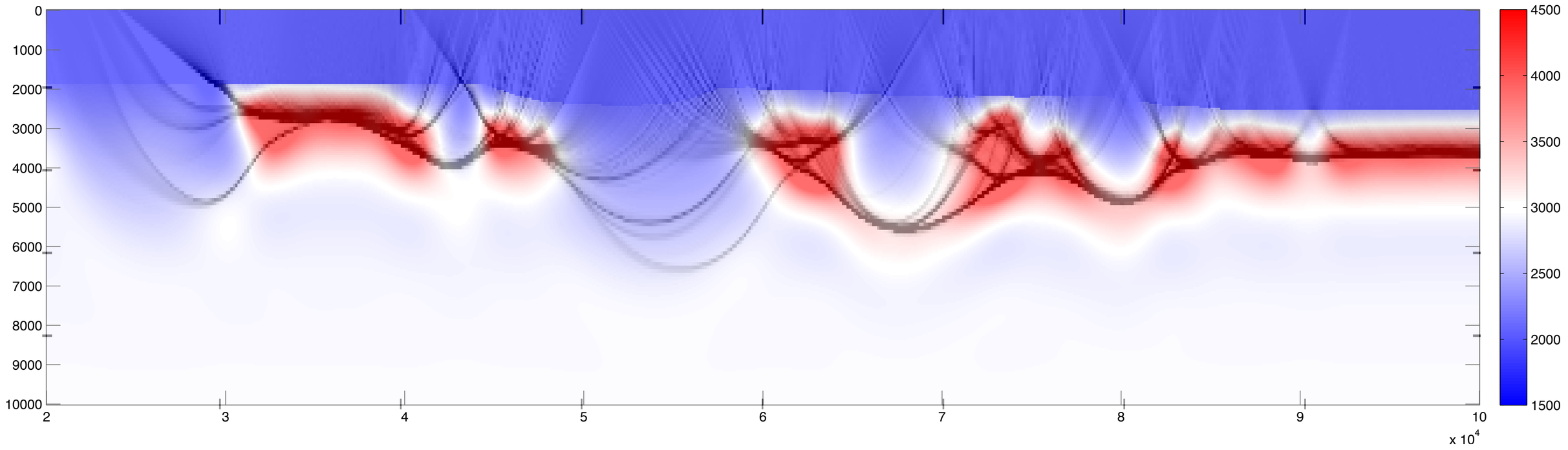
ray based tomography from *first* breaks

Andrew J. Calvert



Ray paths
[RMS traveltime misfit 11ms]

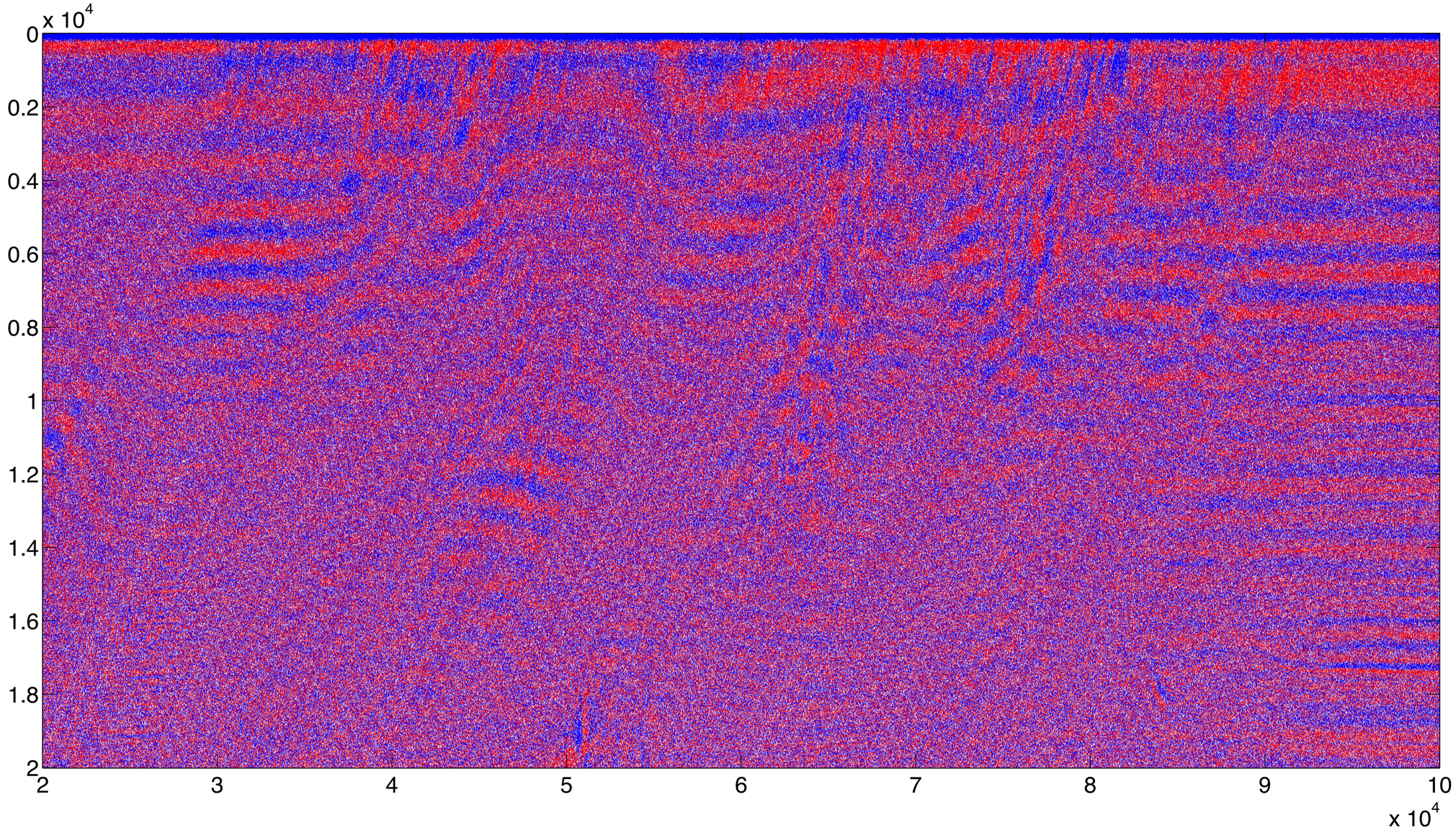
ray based tomography from *first* break



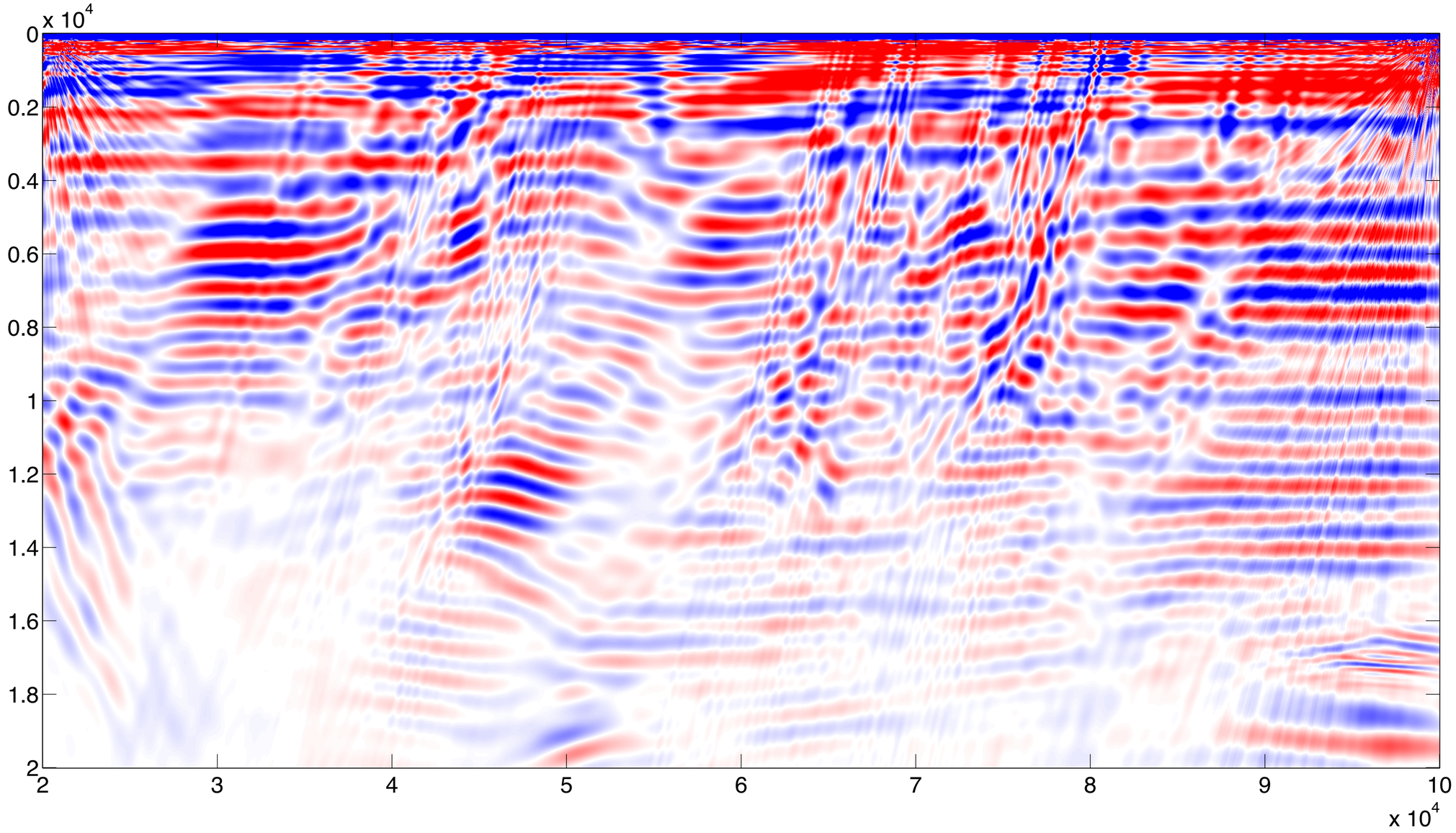
Curvelet denoise

- Work on “frequency slices” in the source/offset plane
- Find support by hand-selected thresholding of synthesis curvelet coefficients
- Followed by debiasing to restore amplitudes...

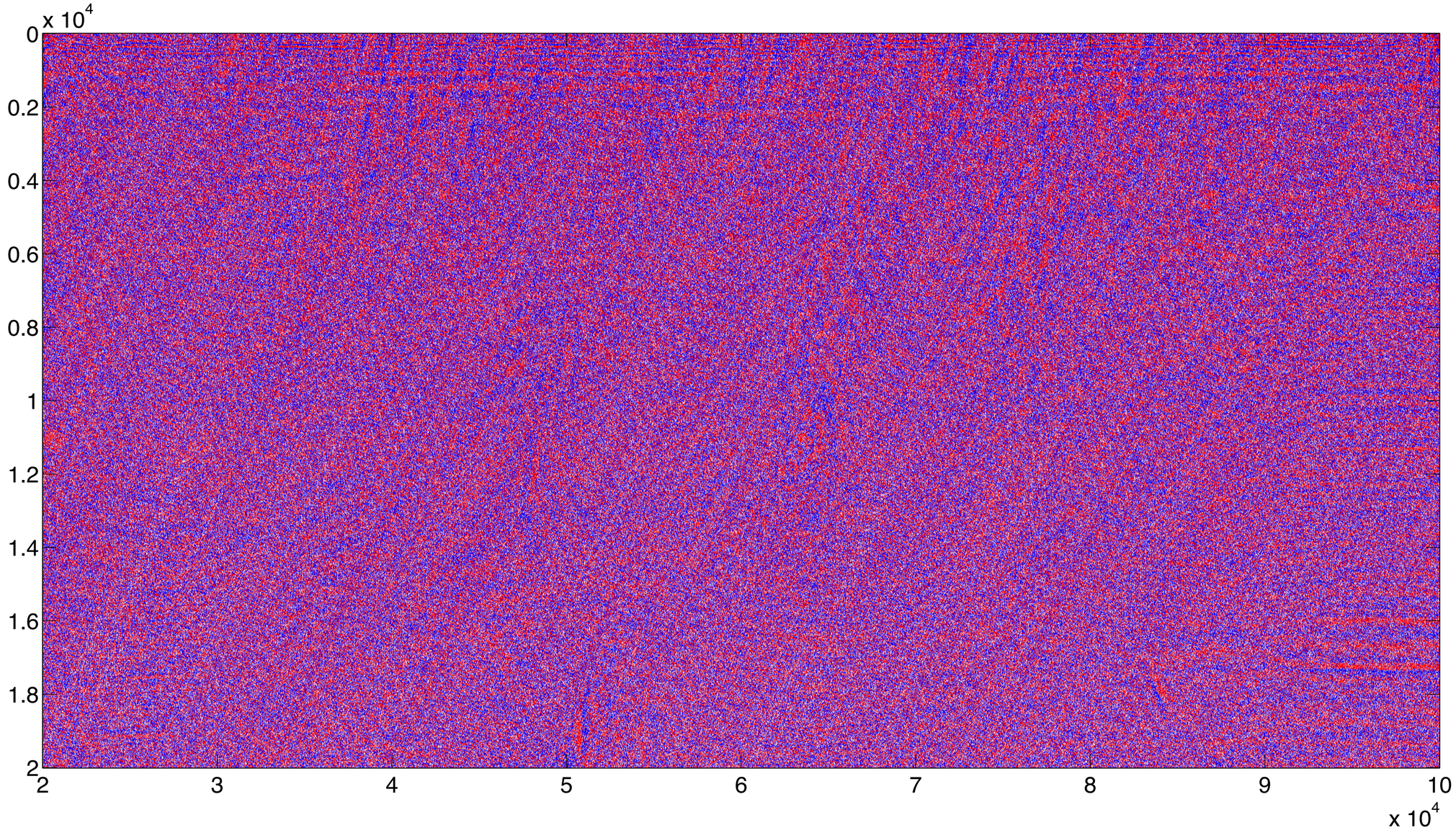
Before denoising [real part 2Hz]



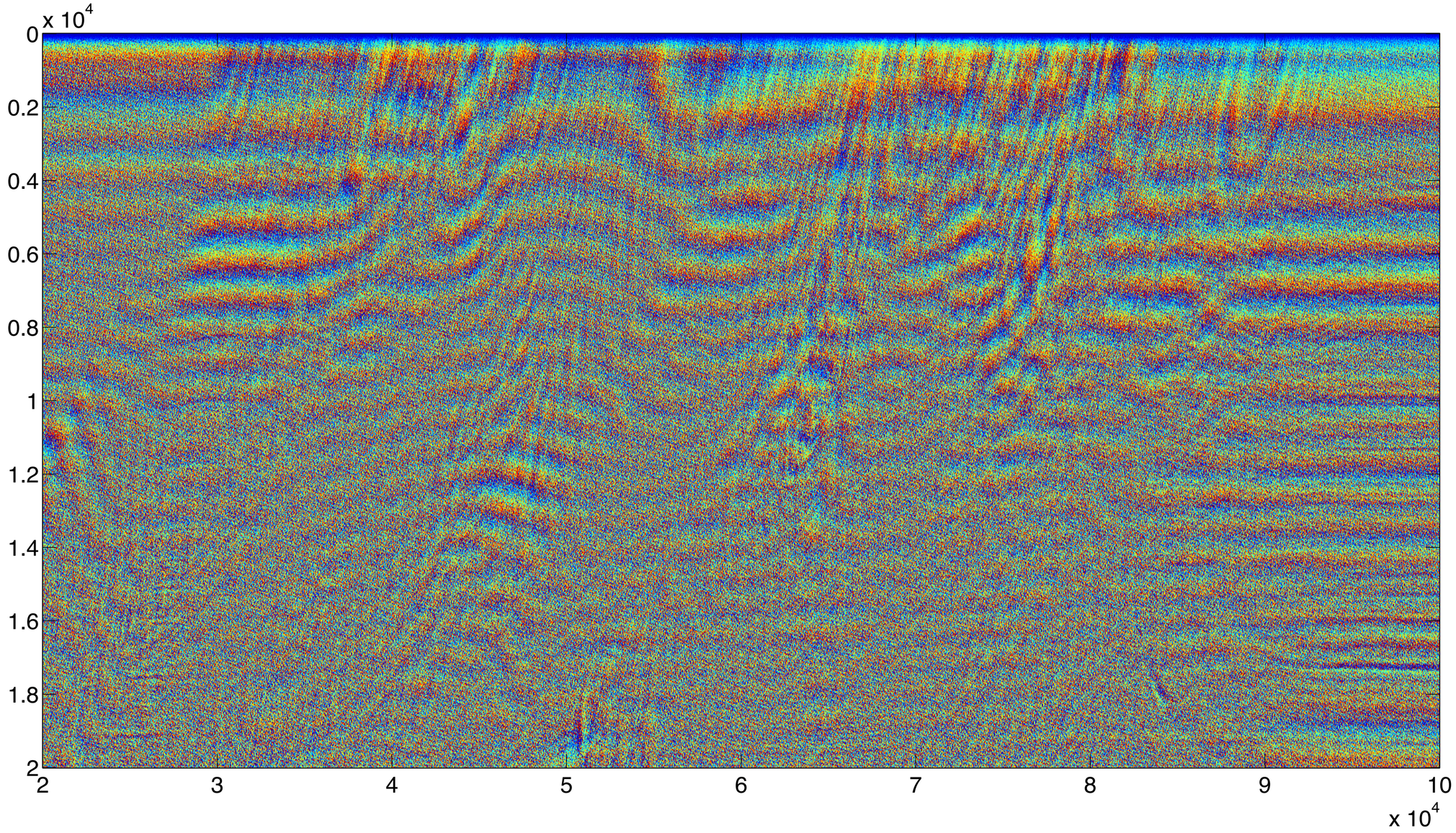
After denoising [real part 2Hz]



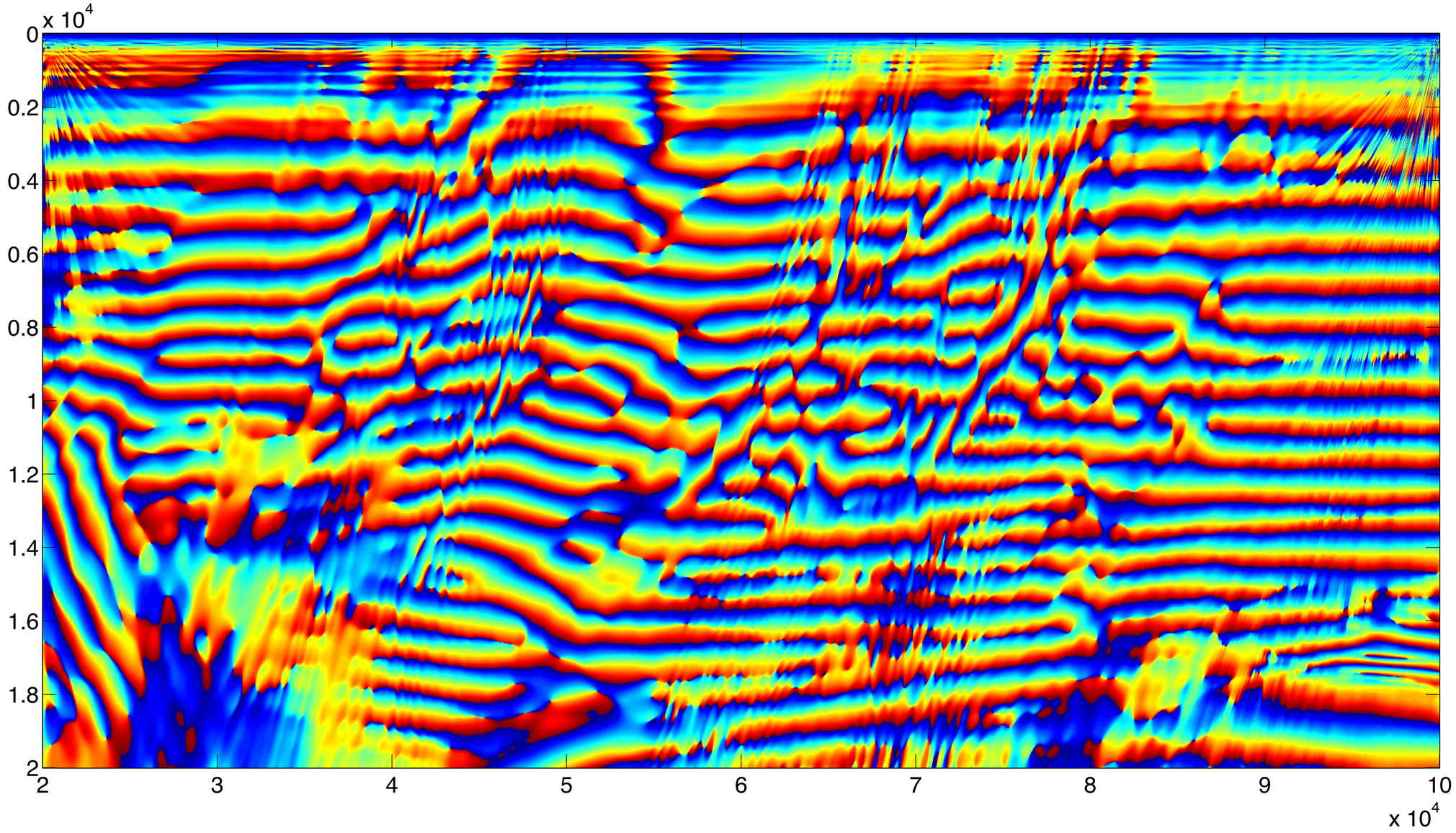
Difference



Before denoising [phase 2Hz]



After denoising [phase 2Hz]



Modified Gauss-Newton

F. J. Herrmann, X. Li, A. Y. Aravkin, and T. van Leeuwen, "A modified, sparsity promoting, Gauss-Newton algorithm for seismic waveform inversion", in Proc. SPIE, 2011, vol. 2011.

X. Li, F.J. Herrmann, A.Y. Aravkin and T. van Leeuwen - Fast randomized full waveform inversion with compressed sensing. Geophysics 77 (A13), 2012.

F.J. Herrmann, X. Li, A.Y. Aravkin, and T. van Leeuwen - A modified, sparsity-promoting, Gauss-Newton algorithm for seismic waveform inversion. Proc. SPIE 8138, 81380V, 2011

Inversion setting

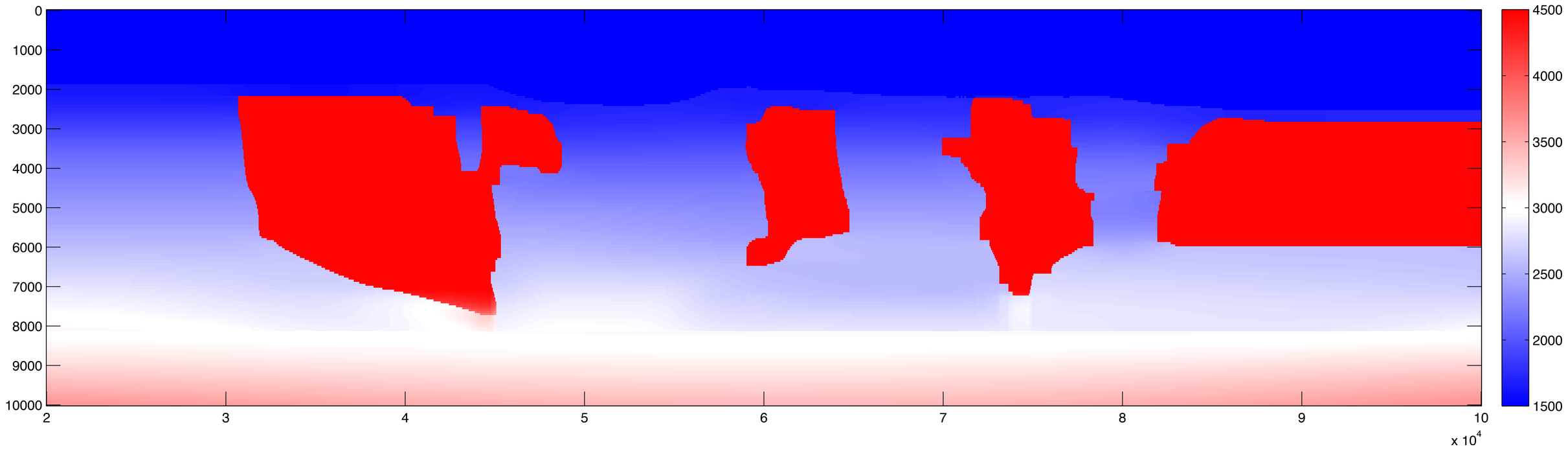
Modified Gauss-Newton:

- frequency continuation (10 bands, each band has 3 freqs, 2-5Hz)
- *r*erandomized *subsets* of shot, using *only* 600 at a time
- 6 GN *iterations* per frequency *band*
- *preconditioning* of *Jacobian* by depth *weighting*
- *projection* of water *layer*

One-norm curvelet *regularized* gradients...

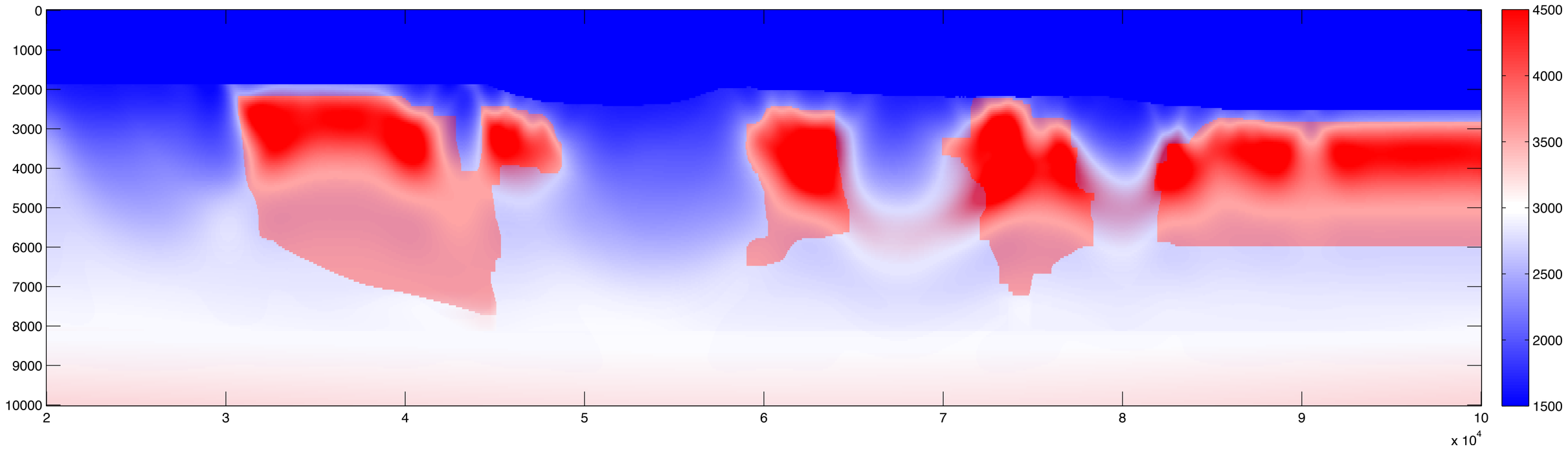
Initial model

released by Chevron (2013)



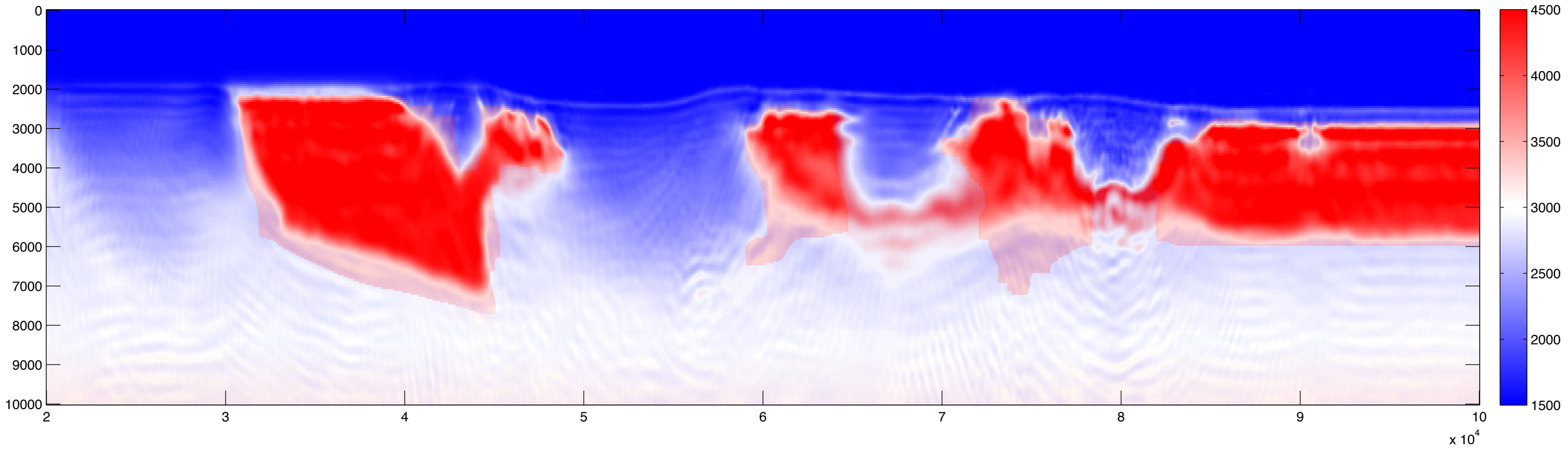
Model comparison

overlay with ray based tomography initial model



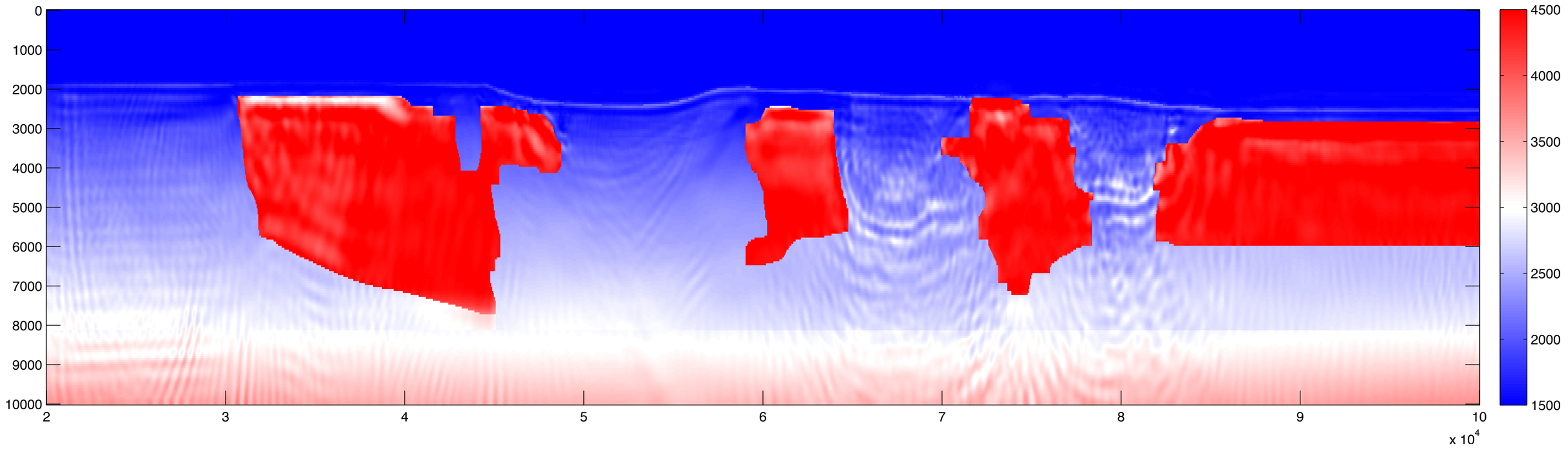
Model comparison

overlay with FWI result



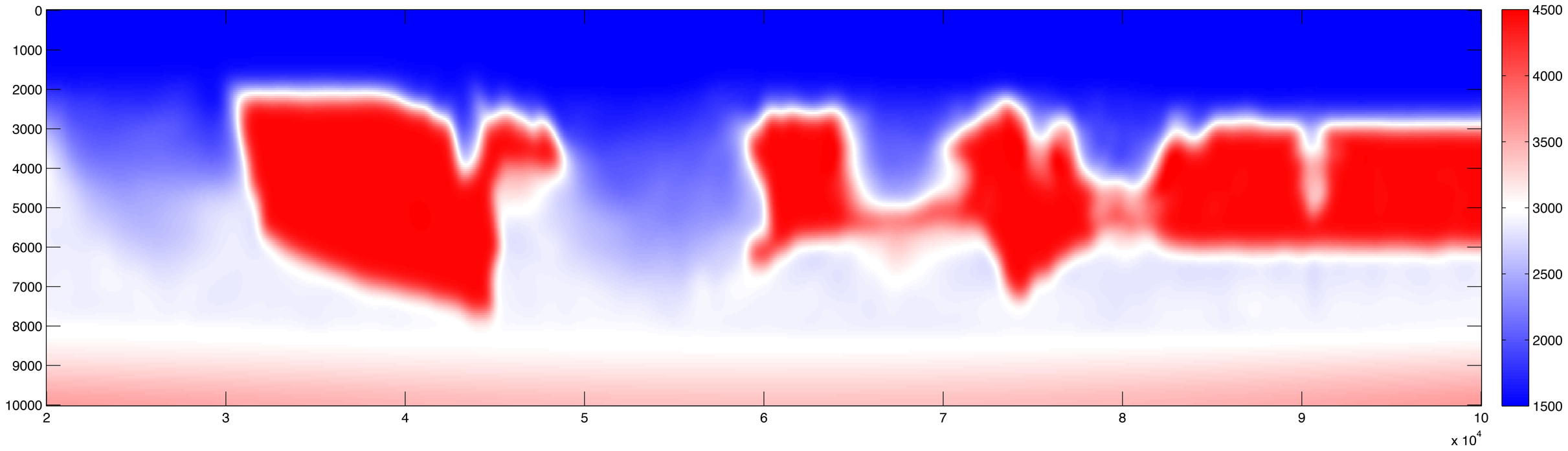
FWI result

with new released model & 2012 data set



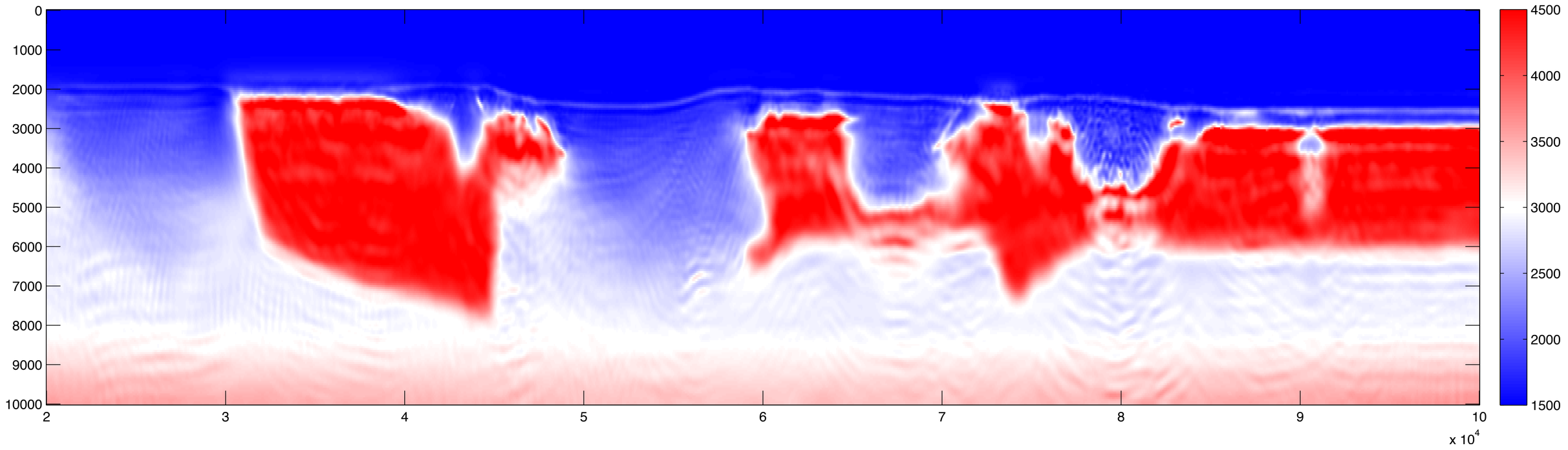
Initial model

combination of TOMO initial model and new released model

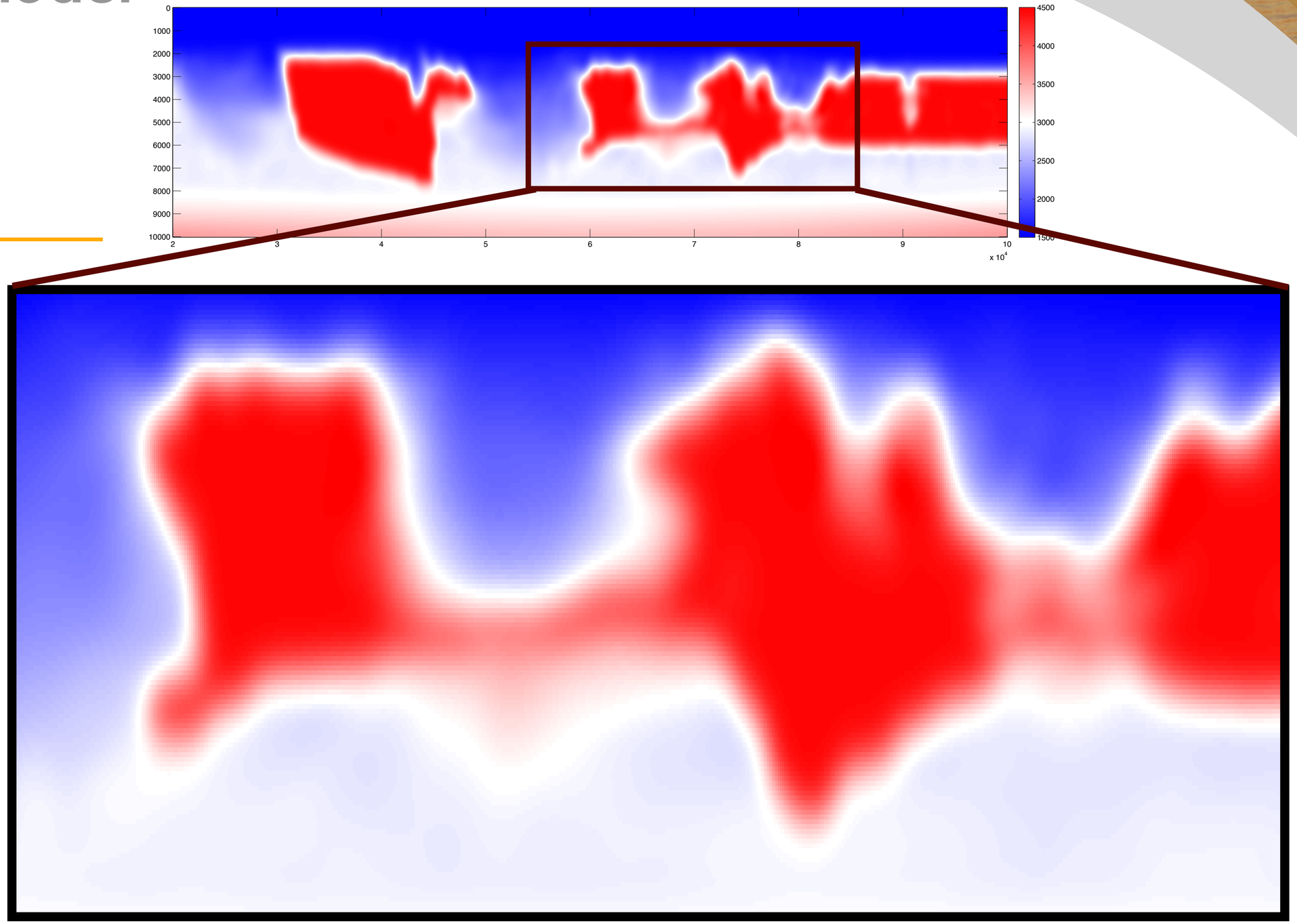


FWI result

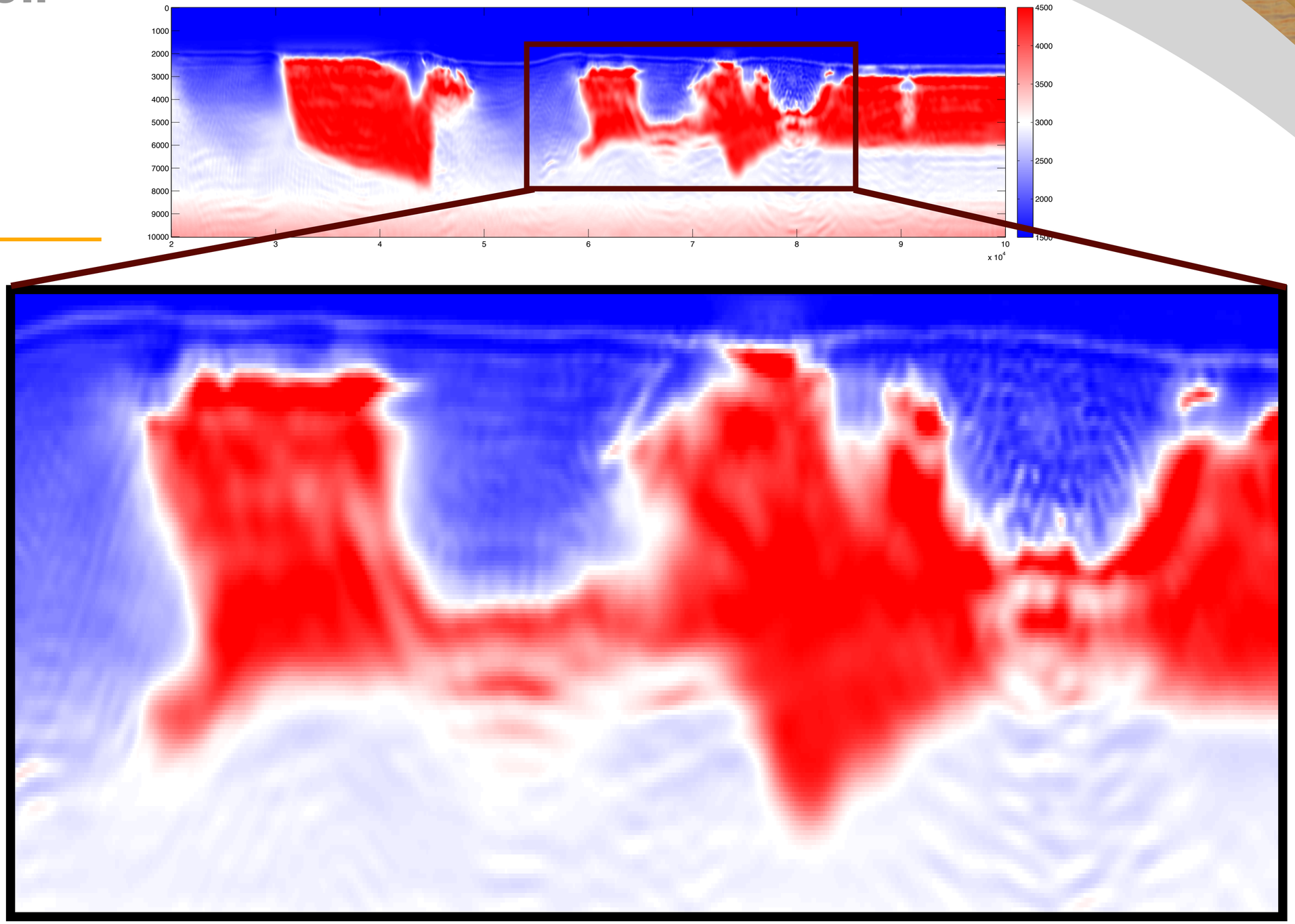
with combined model and 2012 data set



Initial model



FWI result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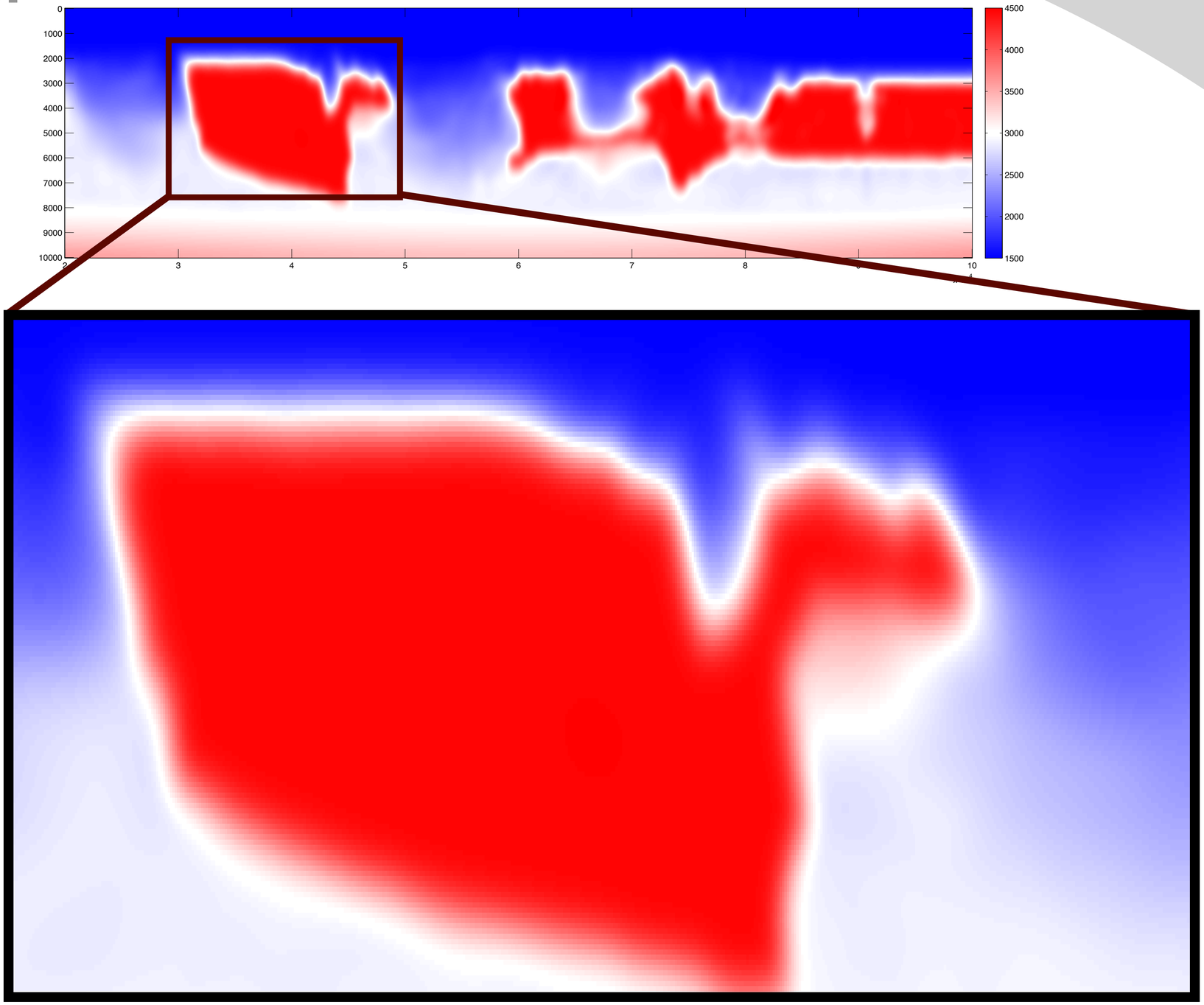
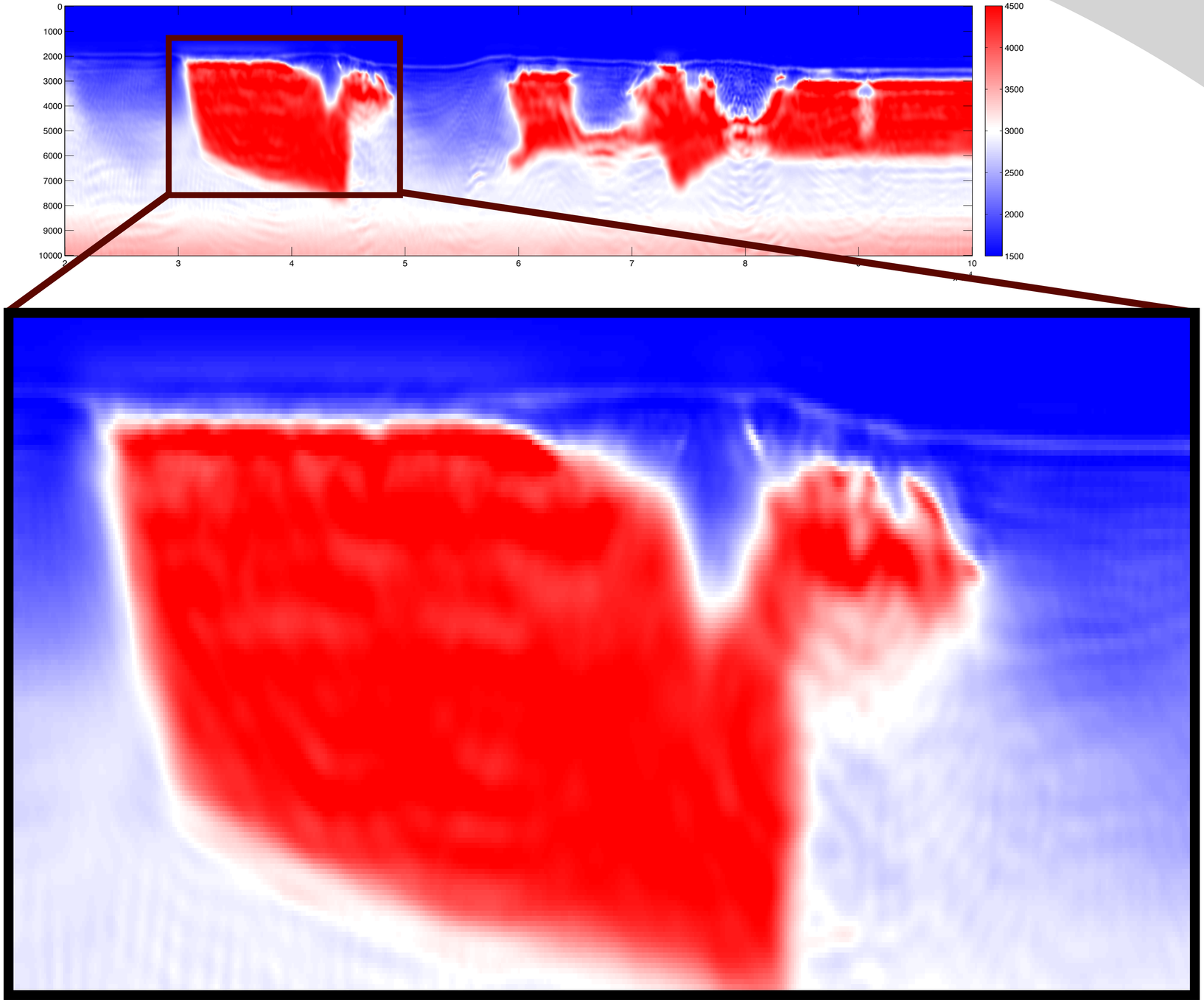
Initial model



FWI result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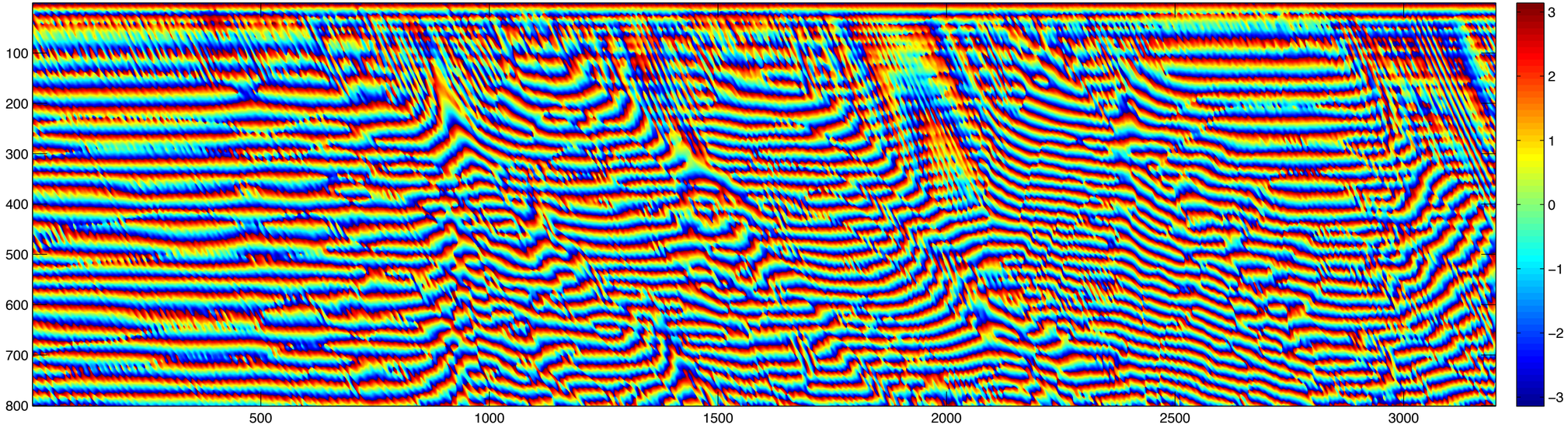
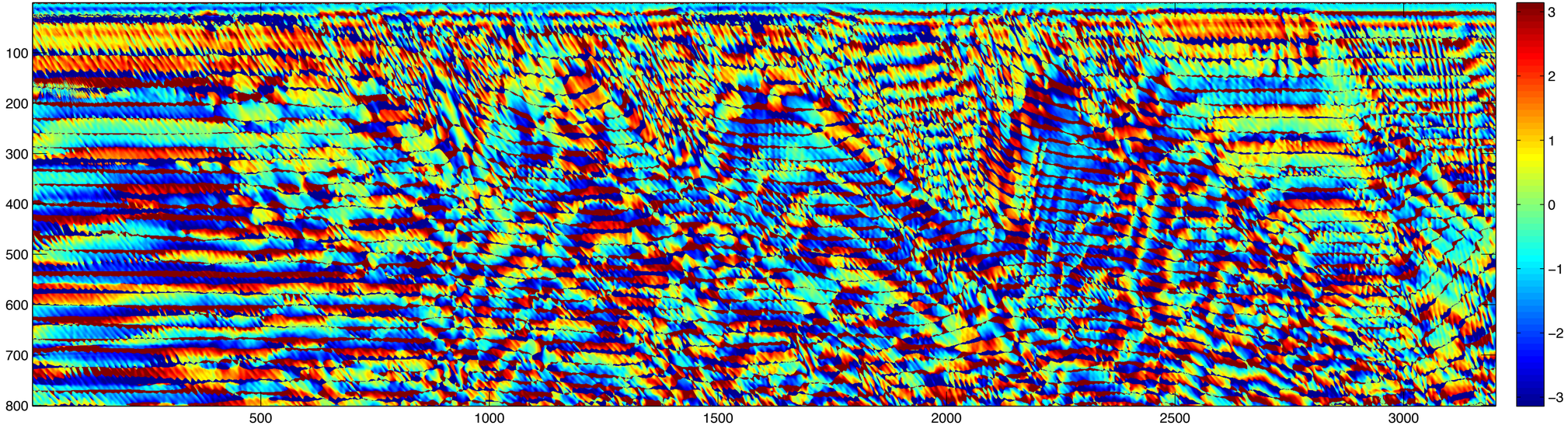
1500

Data fitting in frequency domain

frequency slide from initial model at 3Hz

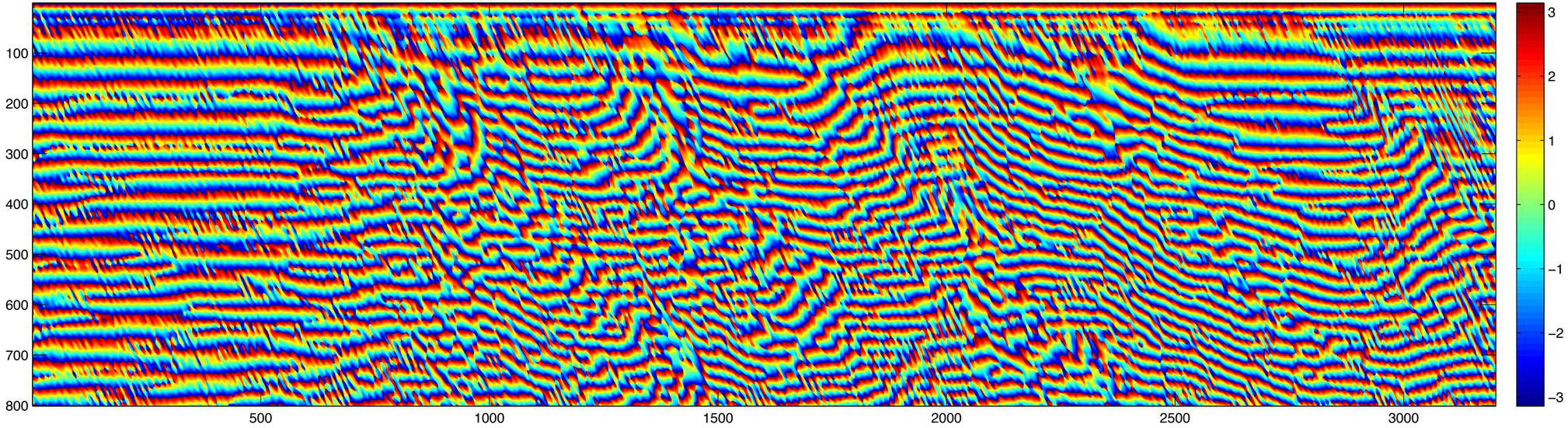


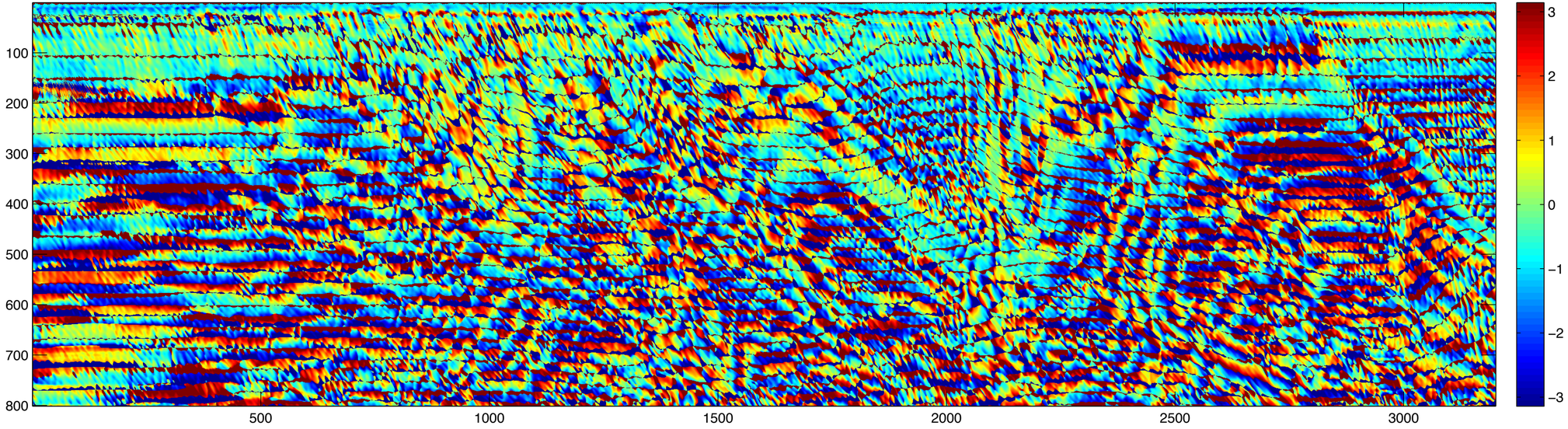


difference

Data fitting in frequency domain

frequency slide from FWI result at 3Hz

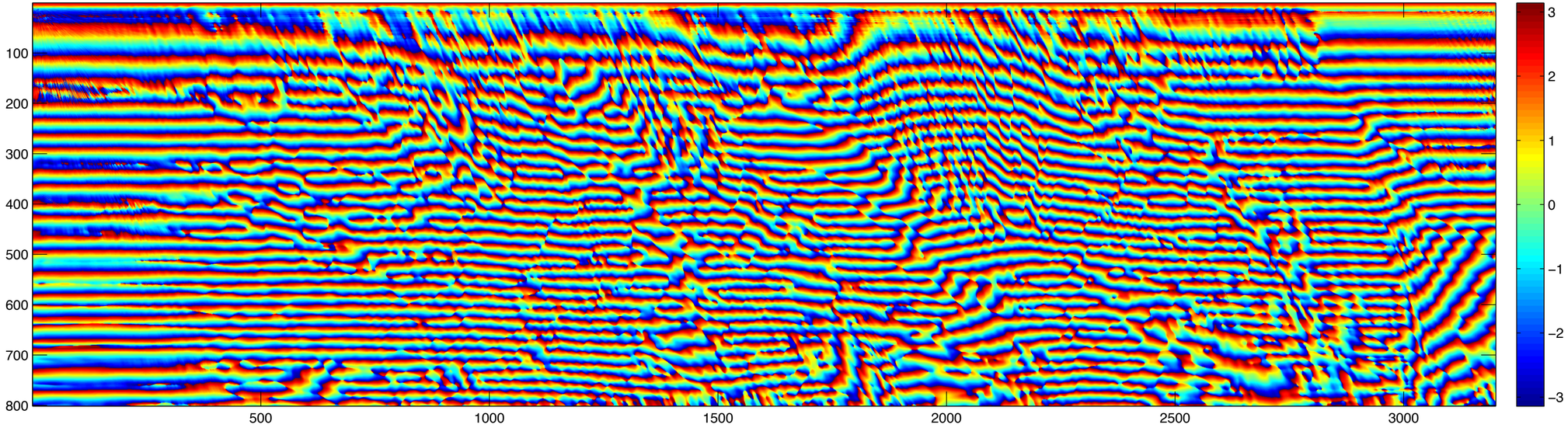




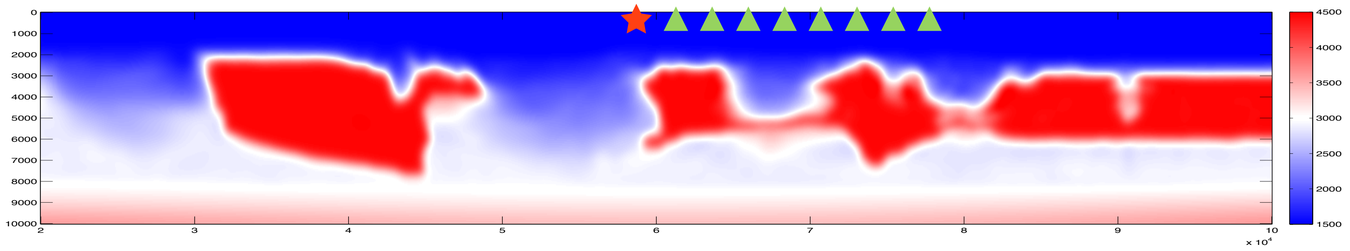
difference

Data fitting in frequency domain

frequency slide from true data at 3Hz

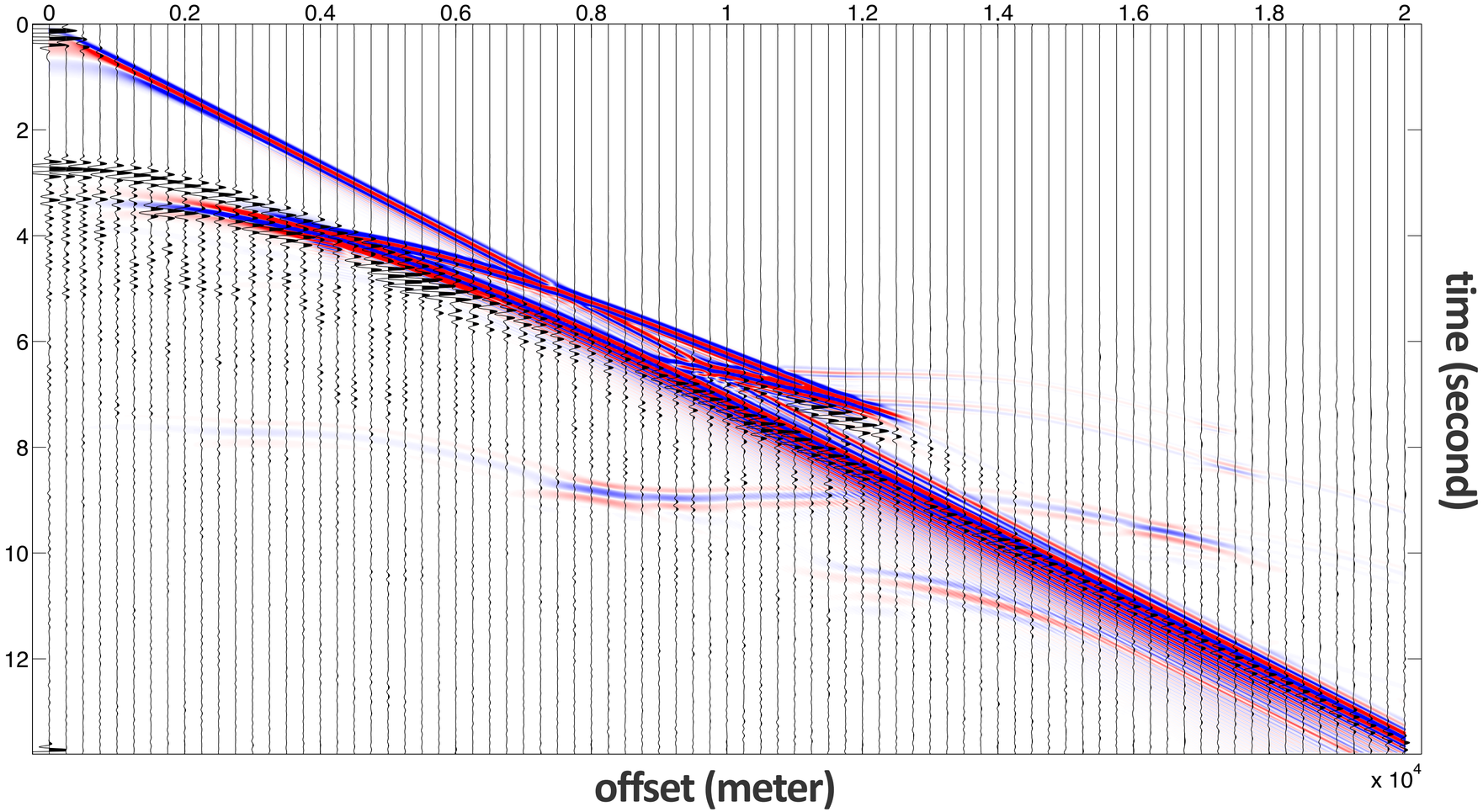


Data fitting in time domain

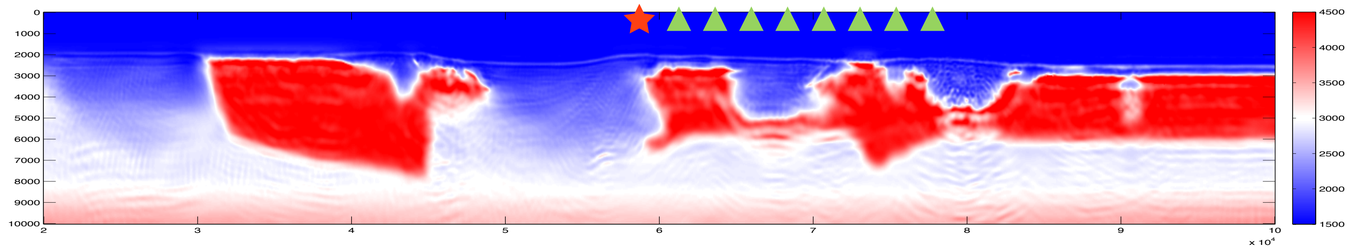


: source

: receiver

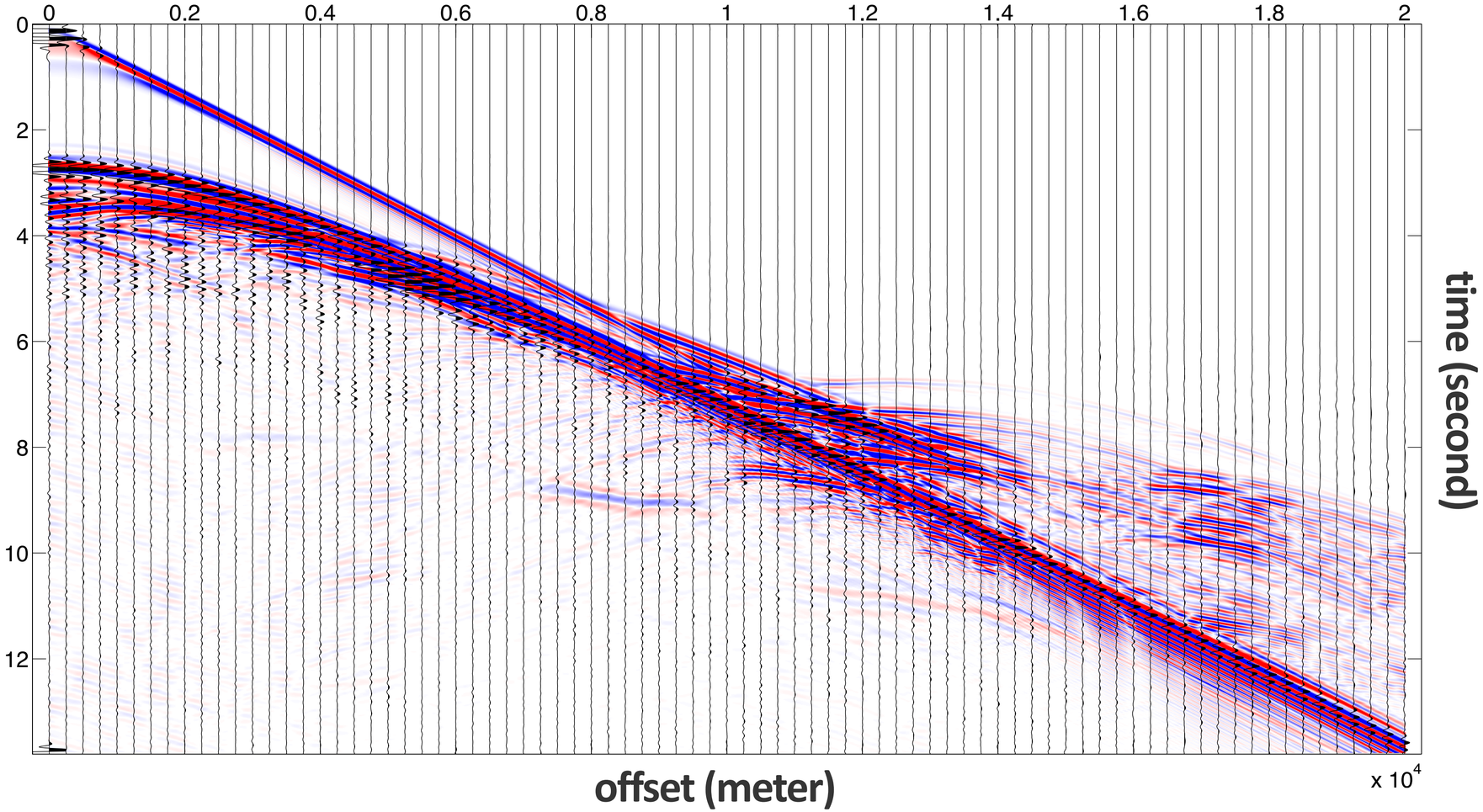


Data fitting in time domain



: source

: receiver

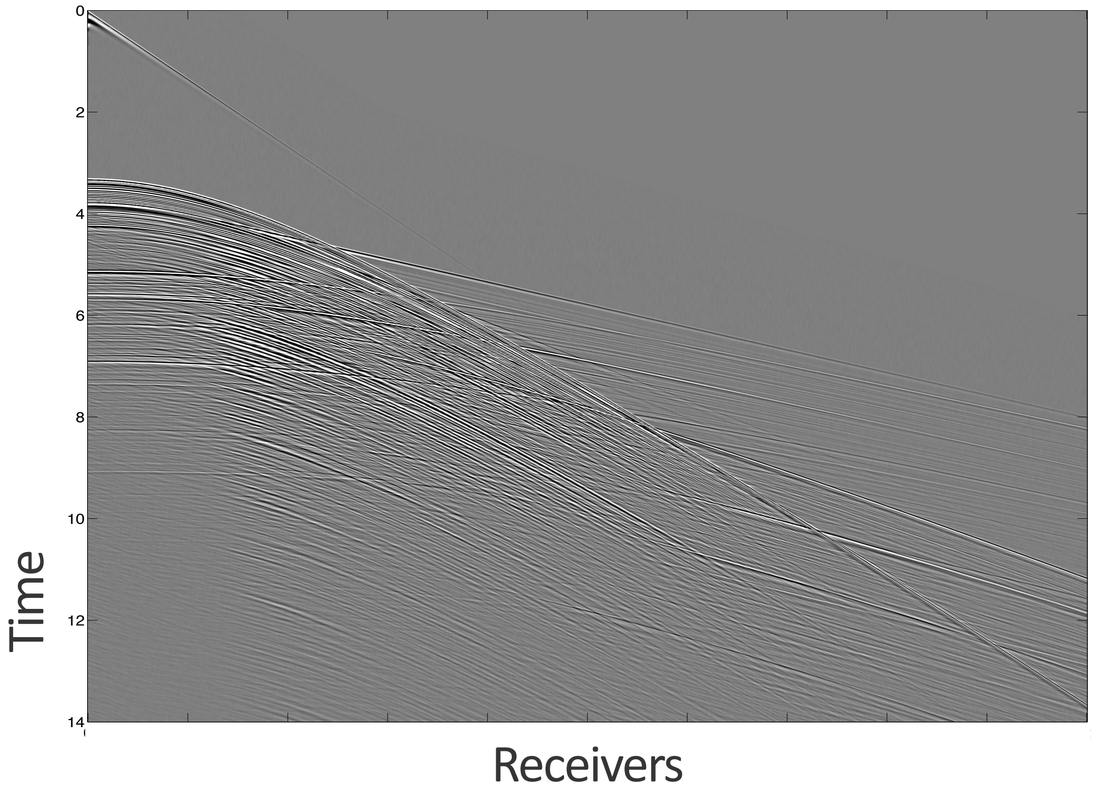


GOM data set (released in 2013)

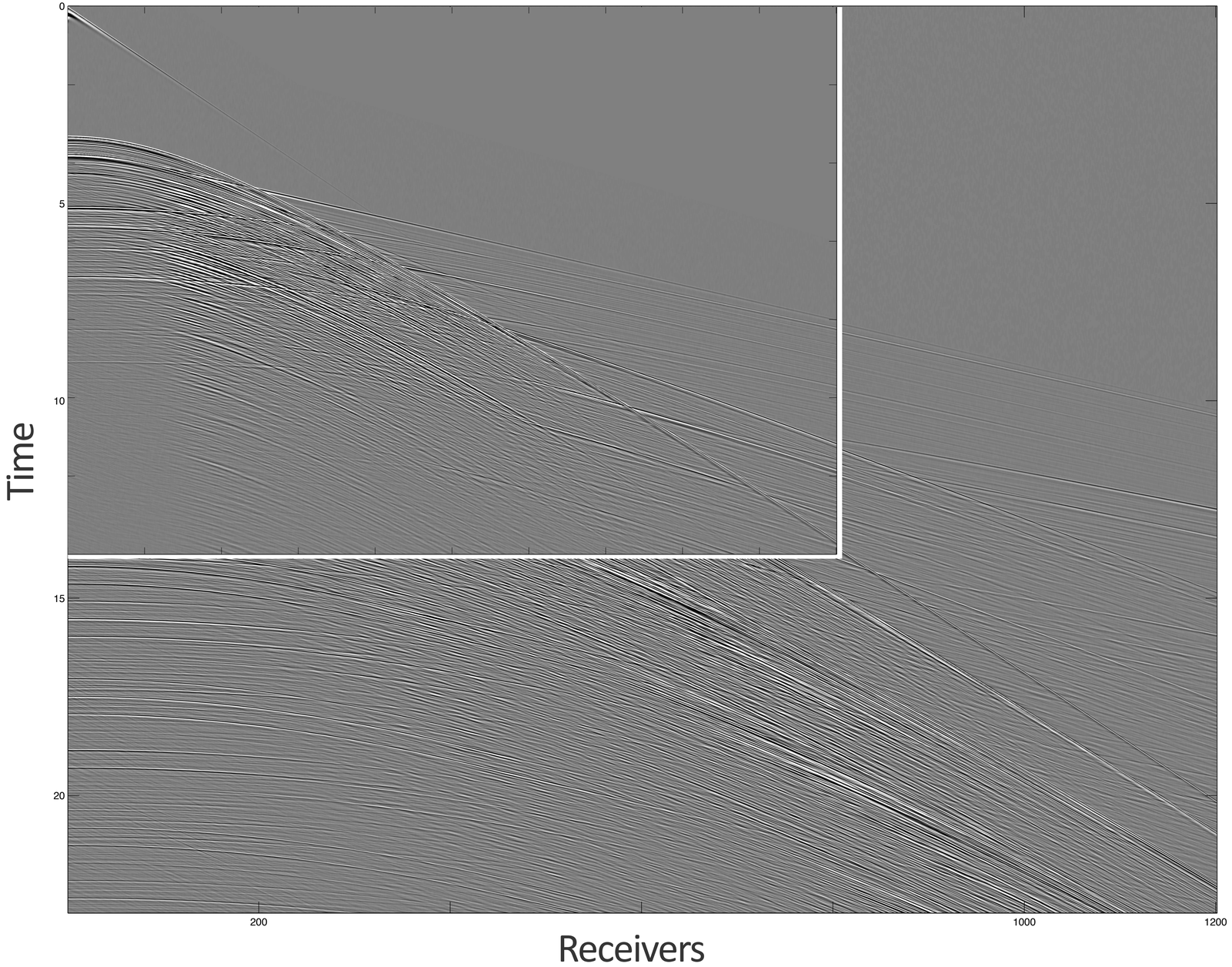
- 3201 shots with interval 25 m
- 1201(801) receivers with interval 25 m, yielding 30km(20km) offset
- record time 22s(14s), sample rate 4ms
- free surface
- isotropic elastic

value in brackets are from the original 2012 data set

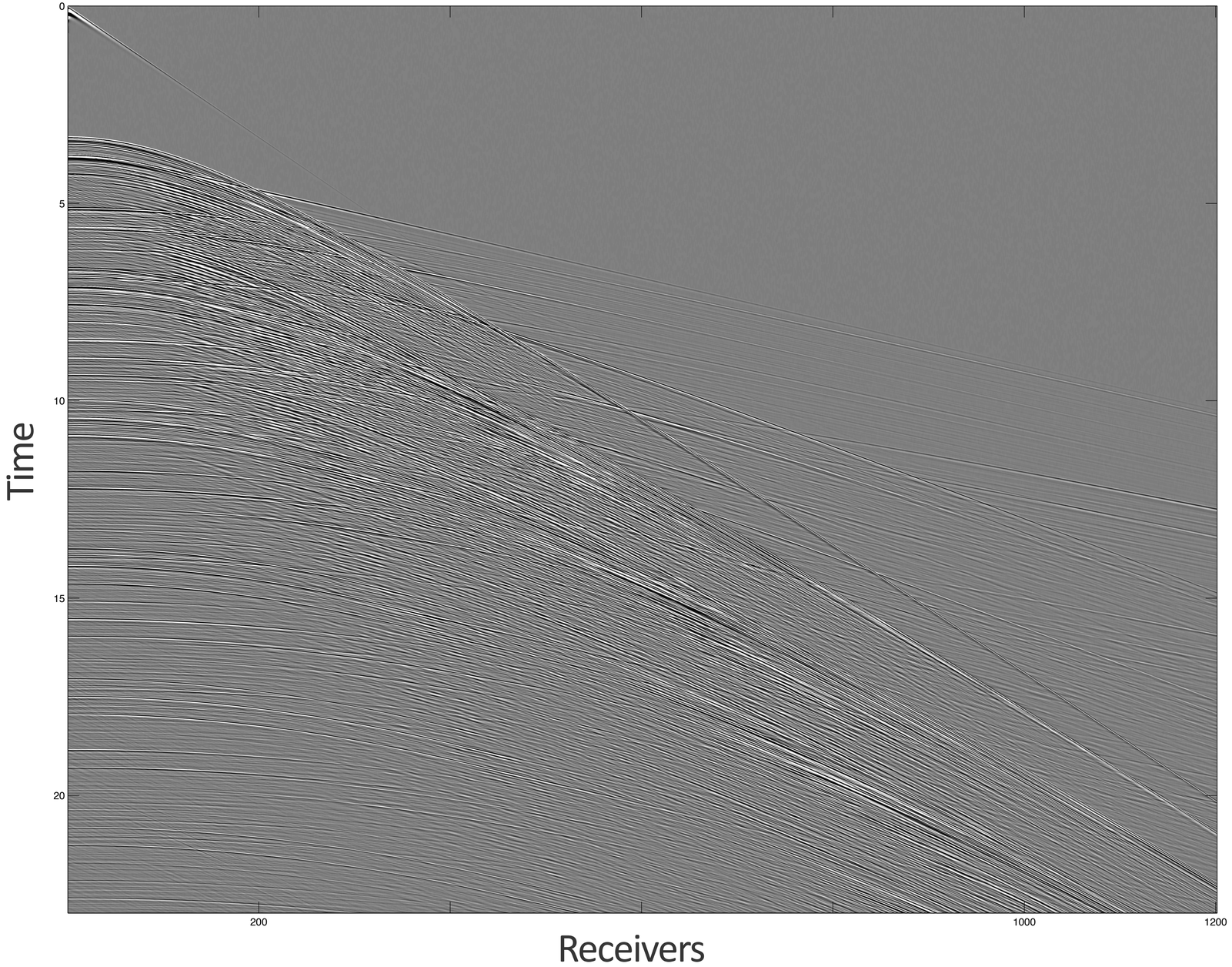
One shot record (2012)



One shot record

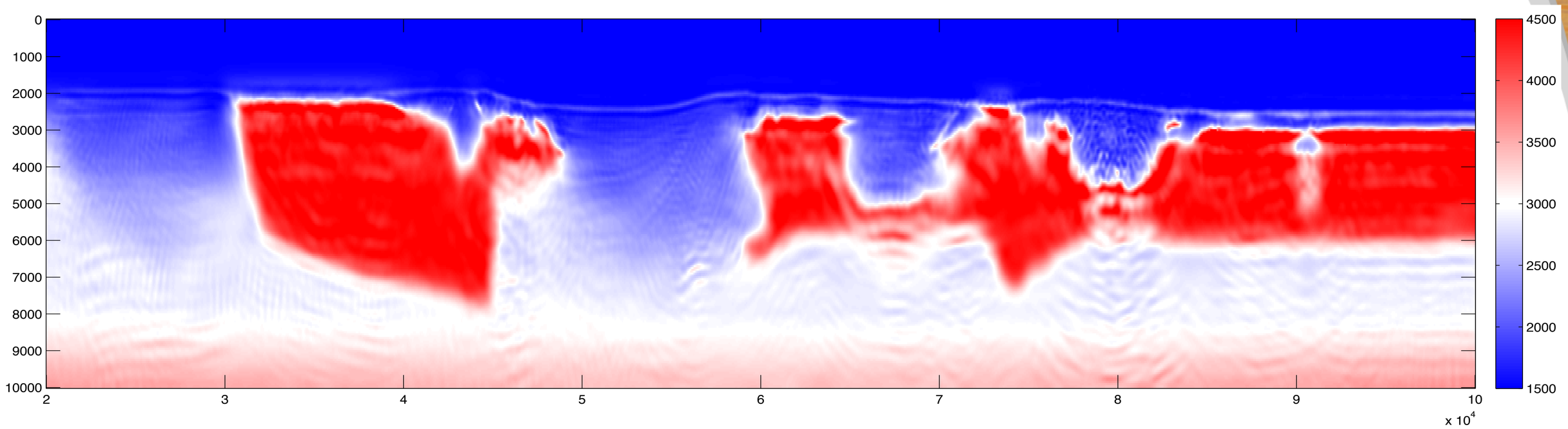


One shot record (2013)



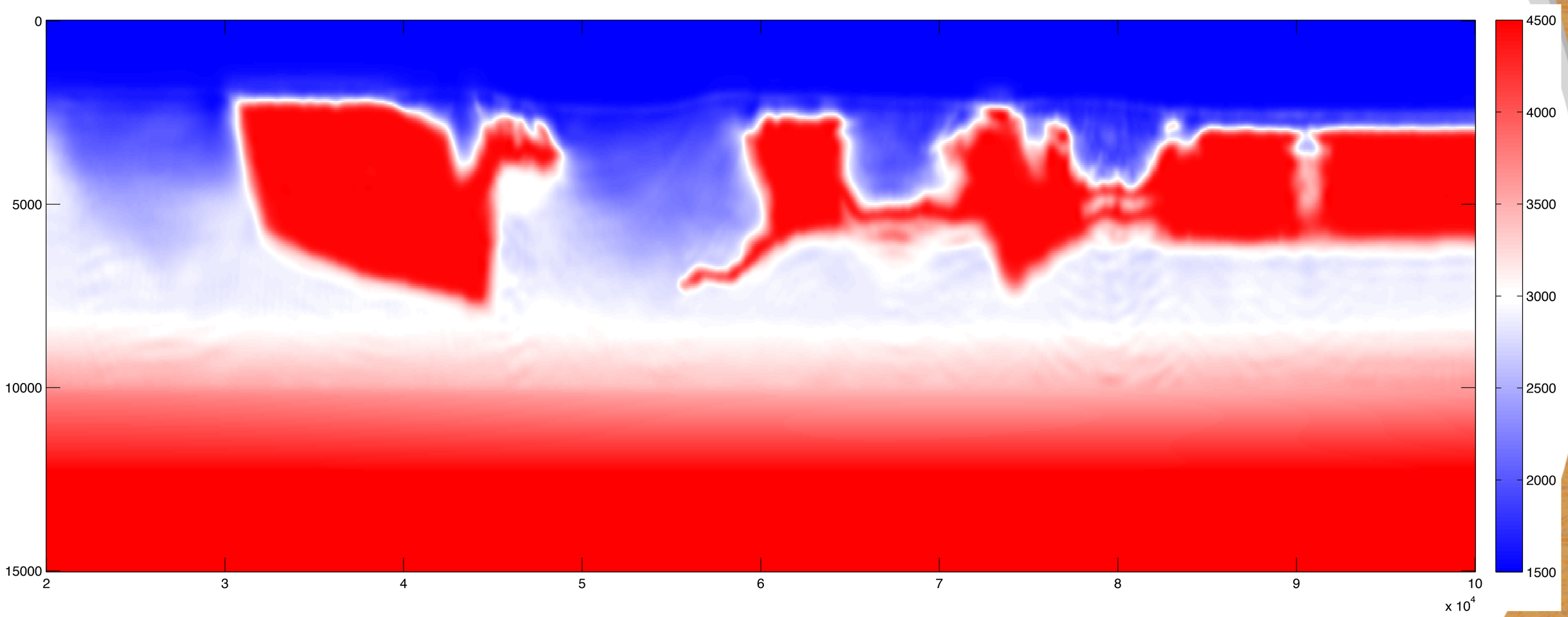
FWI result

with combined model and 2012 data set



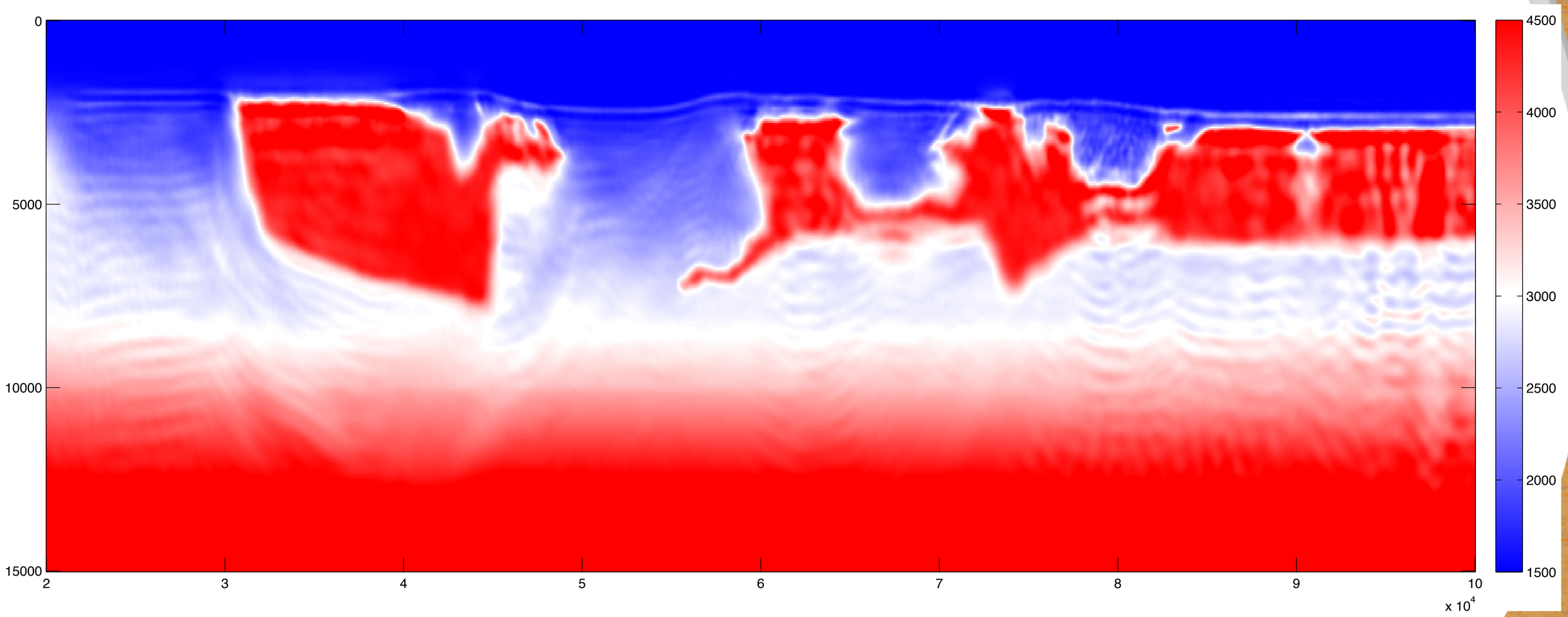
Initial model

salt correction & smoothing



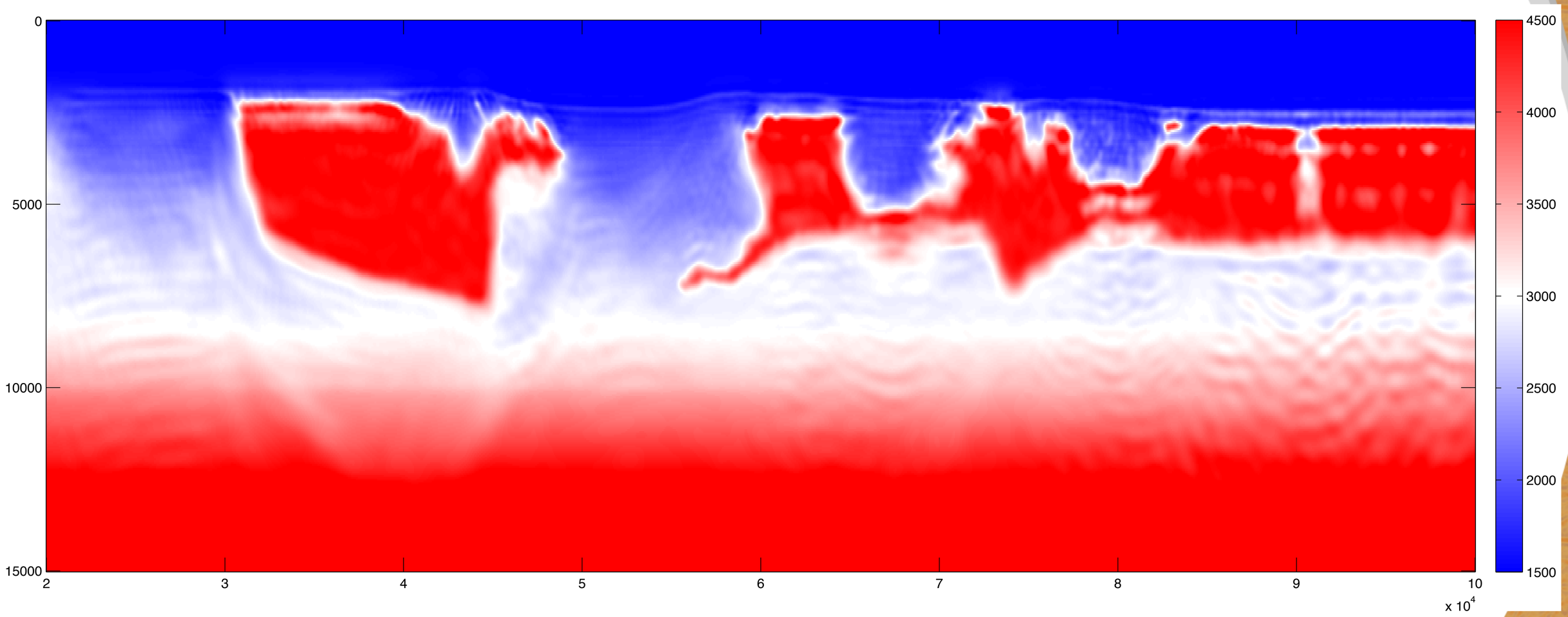
FWI result

inversion without free surface

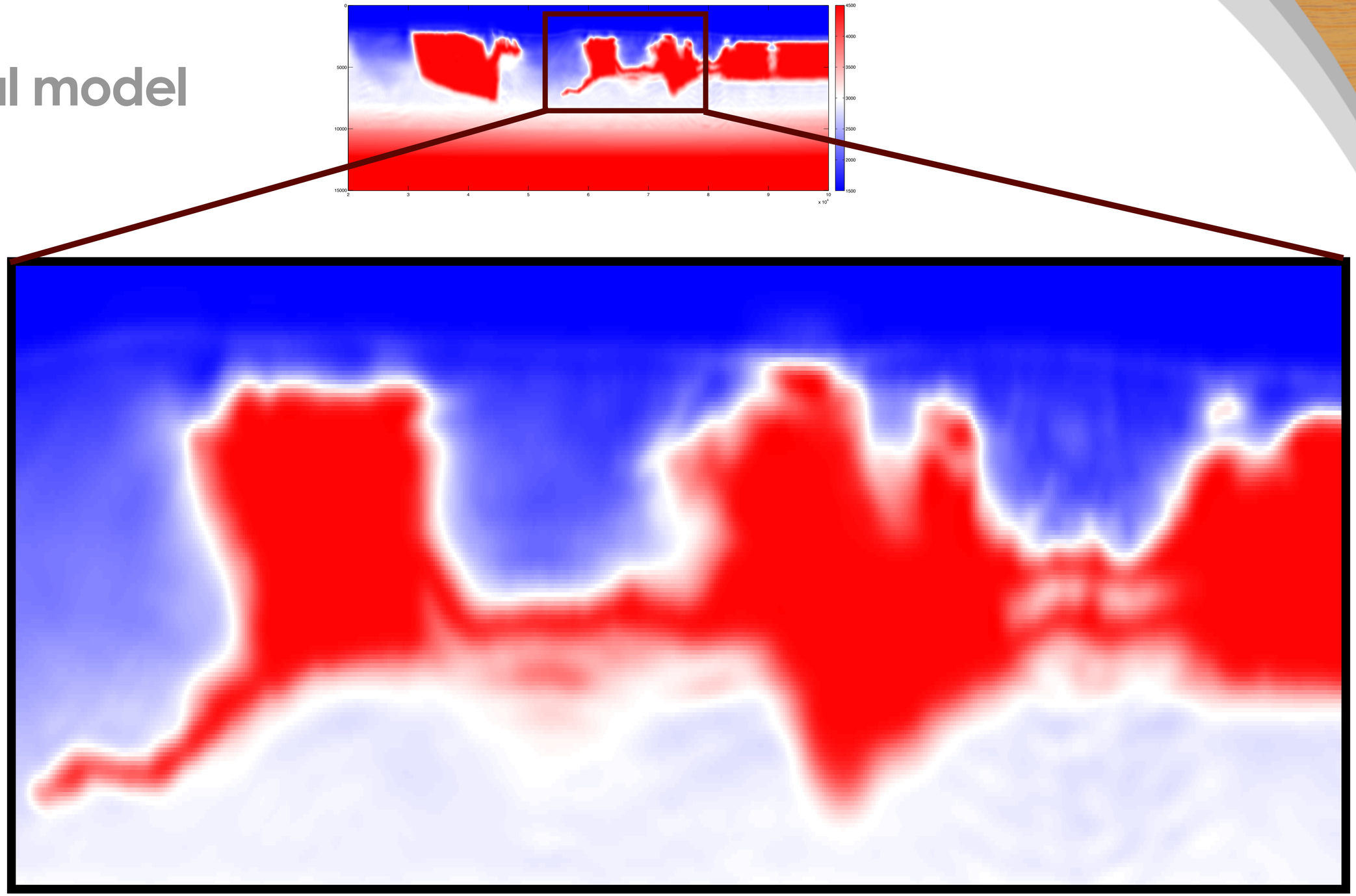


FWI result

inversion with free surface

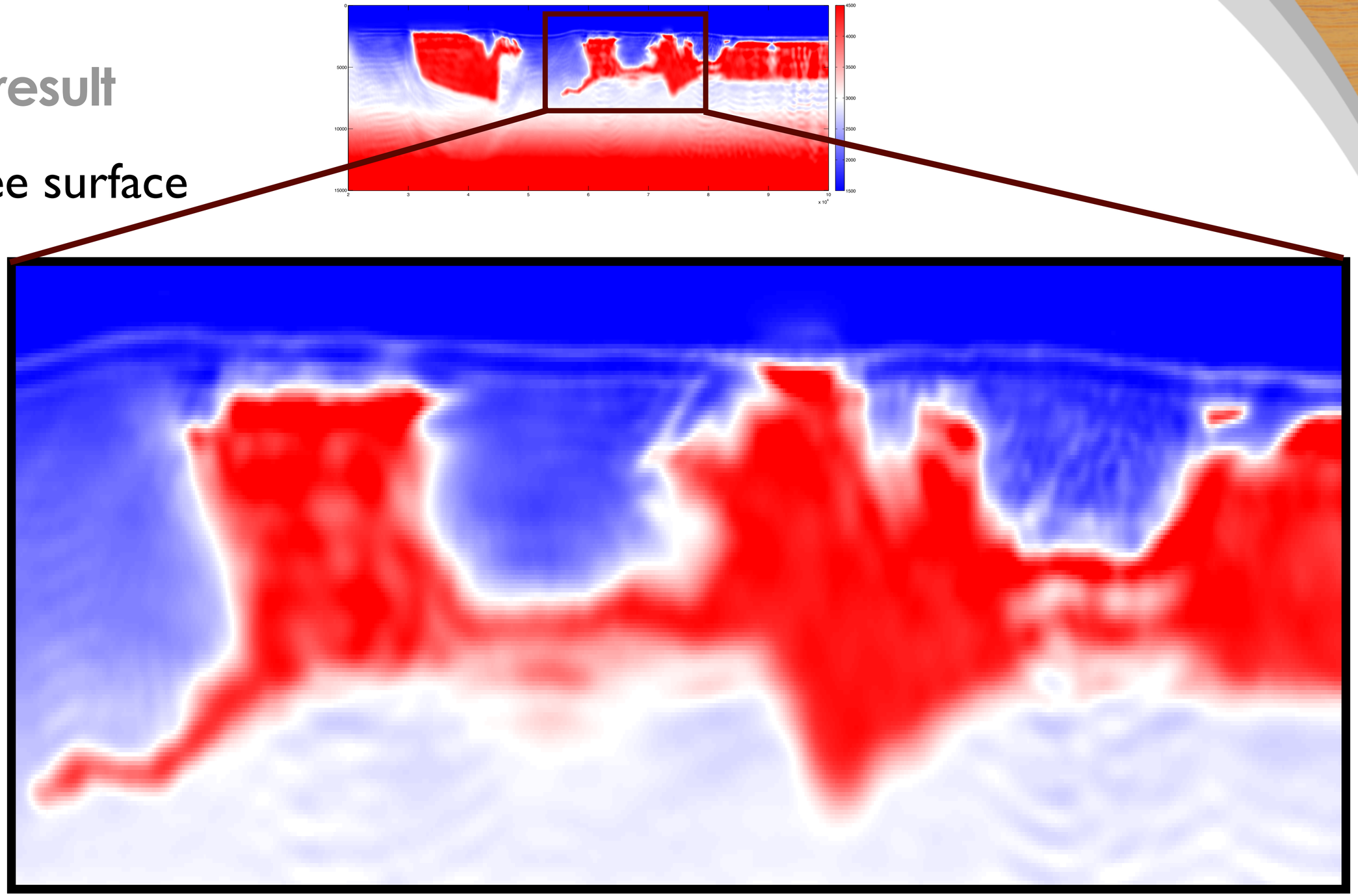


Initial model



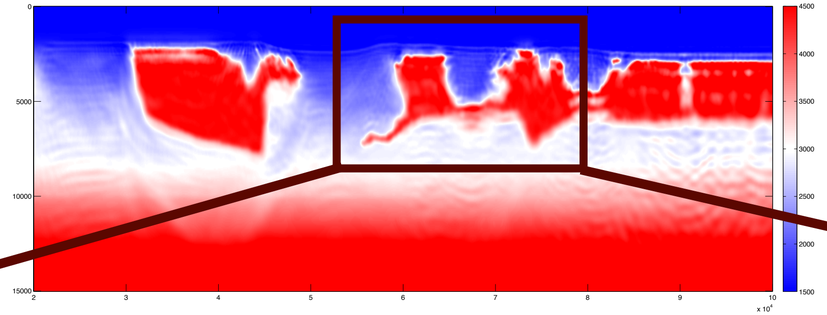
FWI result

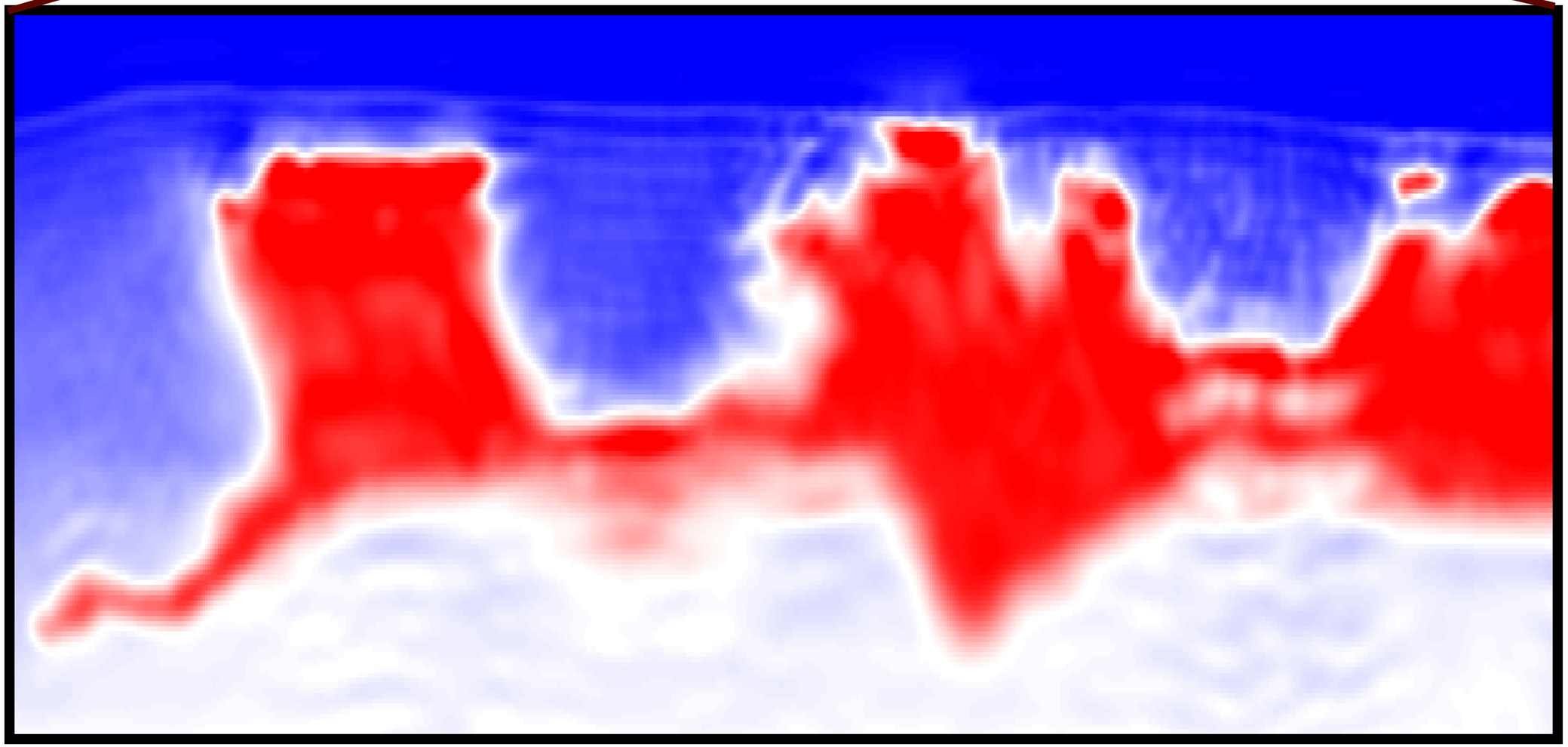
w\o free surface



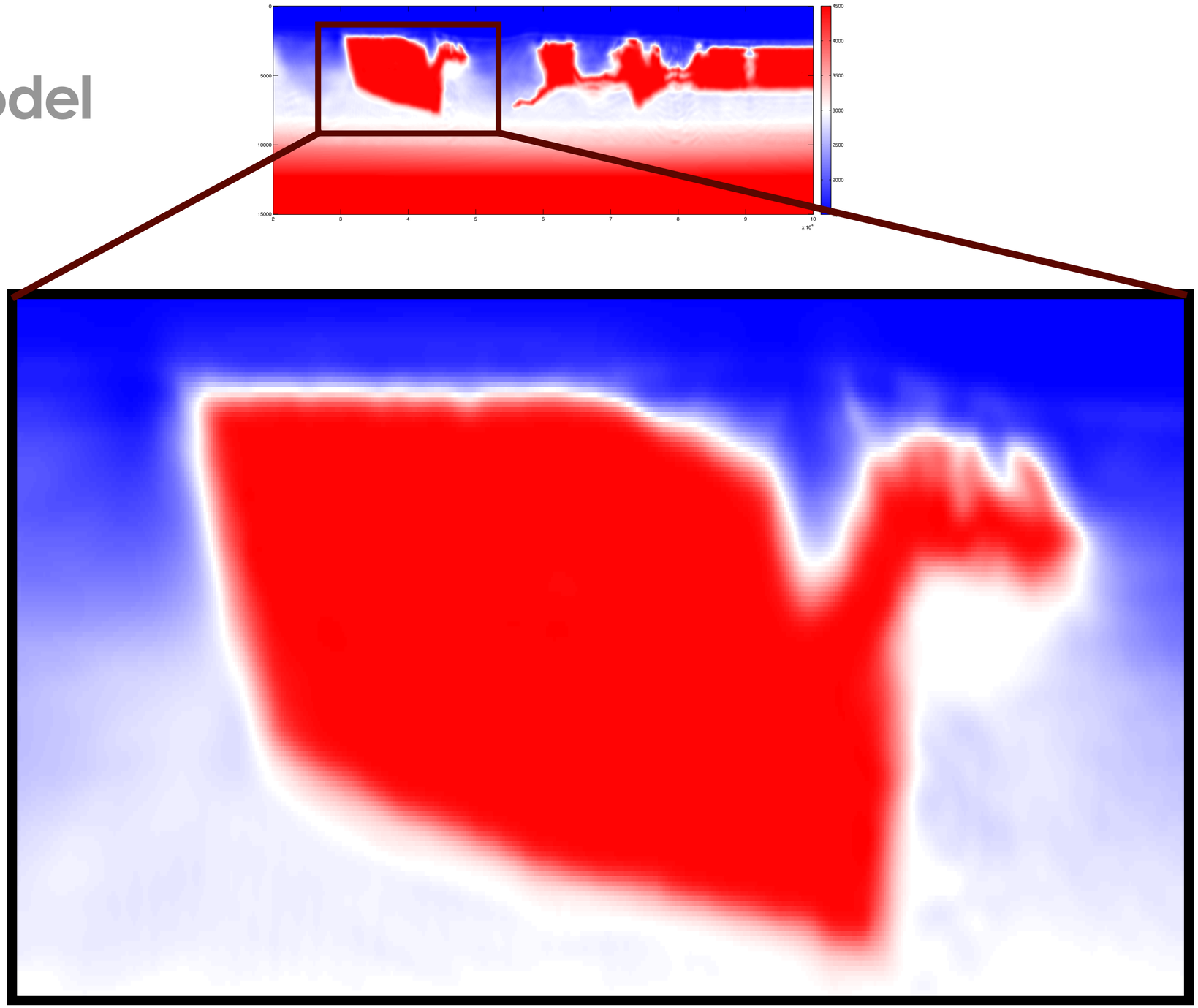
FWI result

w\ free surface



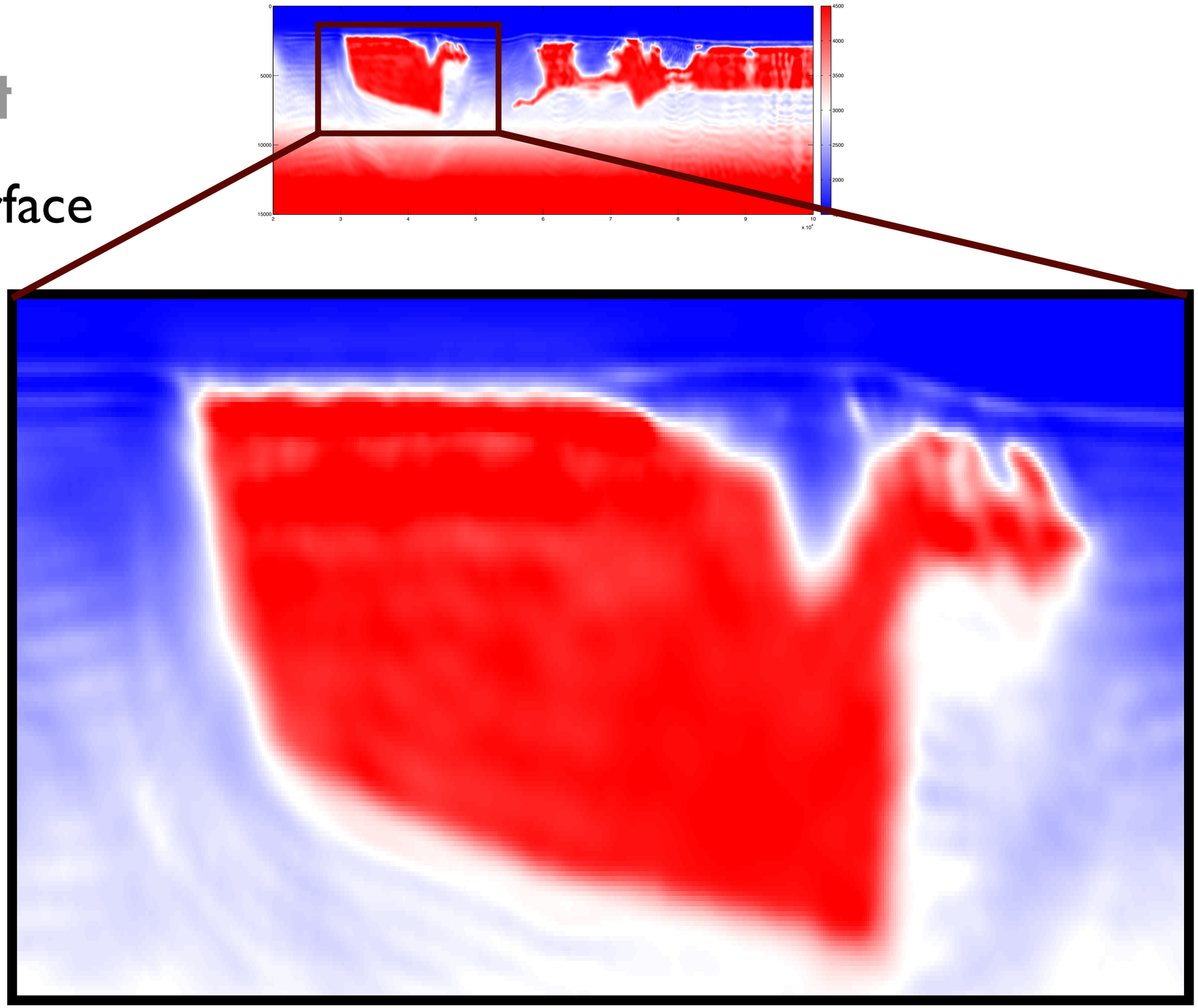


Initial model



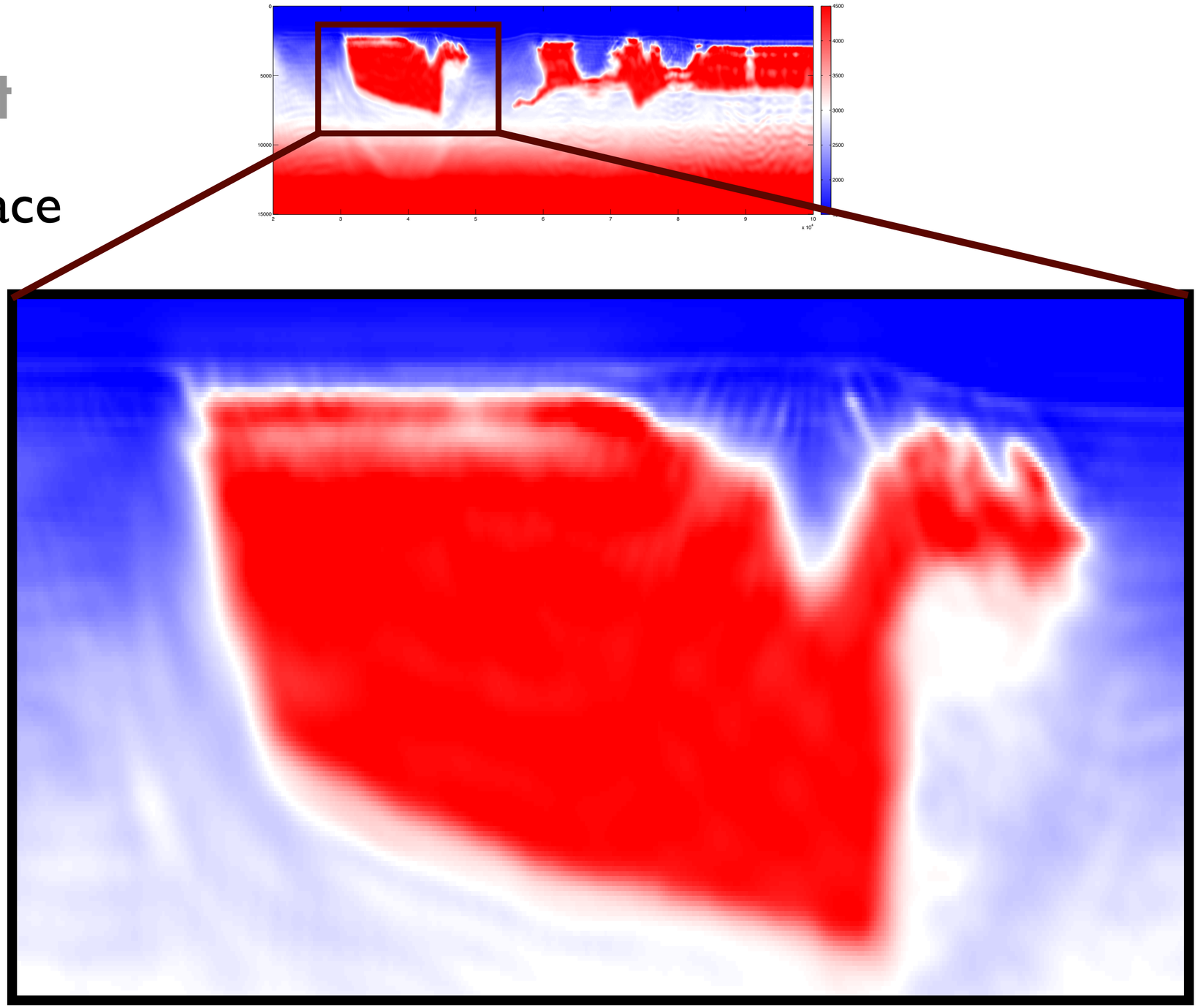
FWI result

w\o free surface



FWI result

w\ free surface



Observations

- Our FWI benefits from *initial model* and *curvelet denoising*
- *Curvelet* transform is efficient in representing *model updates* and "frequency slides"
- *Sparsity regularization* in Curvelet domain of *model updates* can significantly suppress model space artifacts
- "Salt flooding" is a way to help inversion get out of local minima

Acknowledgements

Thank you for your attention !

https://www.slim.eos.ubc.ca/

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