CREWES

Nonstationary Predictive Deconvolution

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Outline

- Motivation
- Partitions of Unity (POU)
- Nonstationary operators
- Nonstationary prediction filtering
- Testing on nonstationary Q synthetic
- Testing on synthetic with multiples
- Conclusions

Motivation

- Predictive deconvolution has a historical basis in multiple attenuation. While not entirely successful, the technique has been useful.
- Nonstationary effects are a limiting factor.
- Gabor deconvolution generalizes spiking deconvolution, can we generalize gapped predictive deconvolution?

Partitions of Unity

$$\sum_{k=1}^{N} \Omega_k(x) = 1, \forall x \in [a,b]$$

Definition of a POU

$$g_k(x) = \Omega_k^p(x), \quad p \in [0,1]$$

Analysis window (applied before the operator)

$$\gamma_k(x) = \Omega_k^{1-p}(x), \quad p \in [0,1]$$

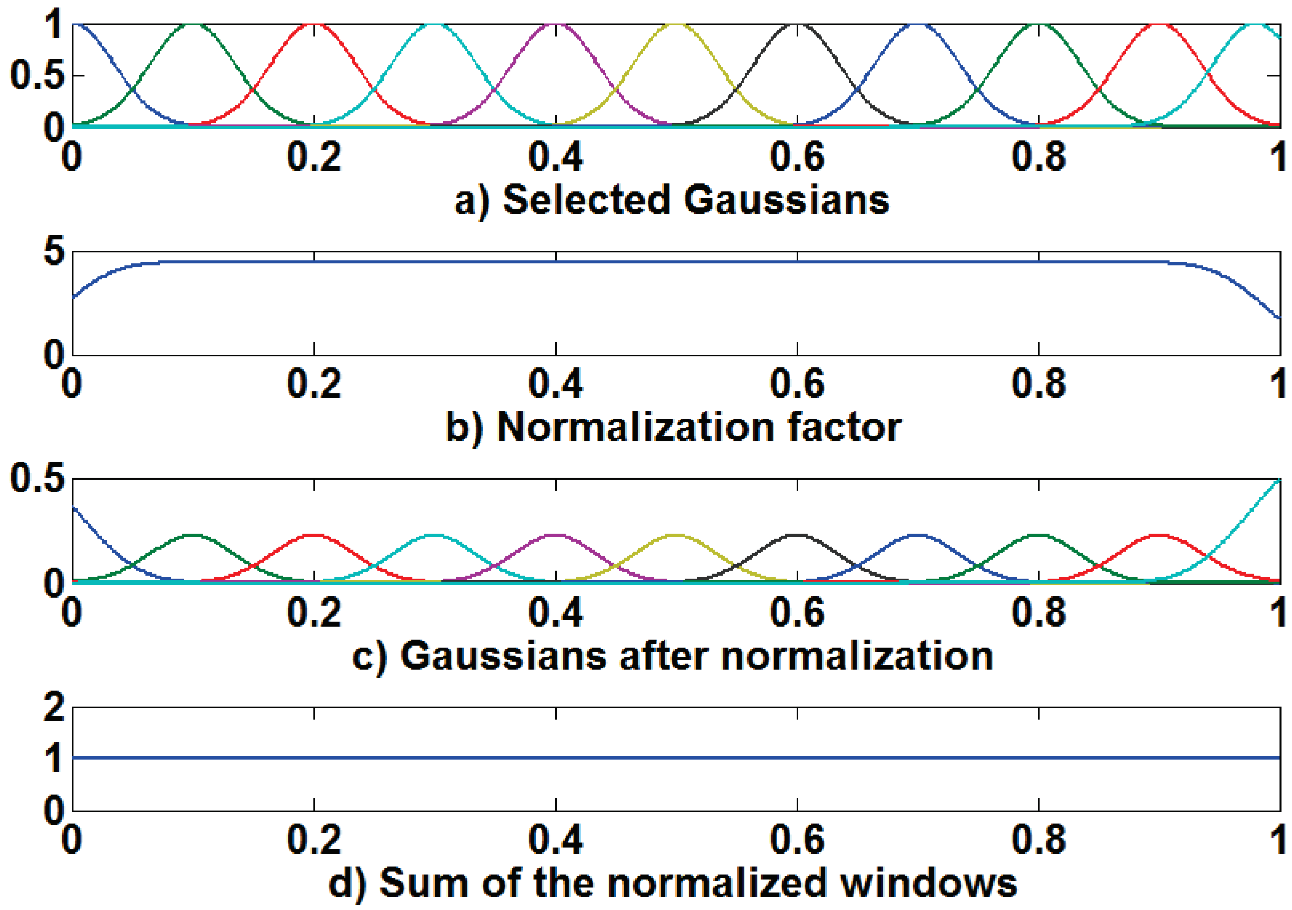
Synthesis window (applied after the operator)

$$\sum_{k=1}^{N} g_k(x)\gamma_k(x) = \sum_{k=1}^{N} \Omega_k^p(x)\Omega_k^{1-p}(x) = \sum_{k=1}^{N} \Omega_k(x) = 1$$

Analysis and synthesis windows together form a POU

Uniform POU

normalized for finite interval



Making Approximate POU's Exact

$$\sum_{k=1}^{N} \tilde{\Omega}_k(x) \approx \text{Constant},$$

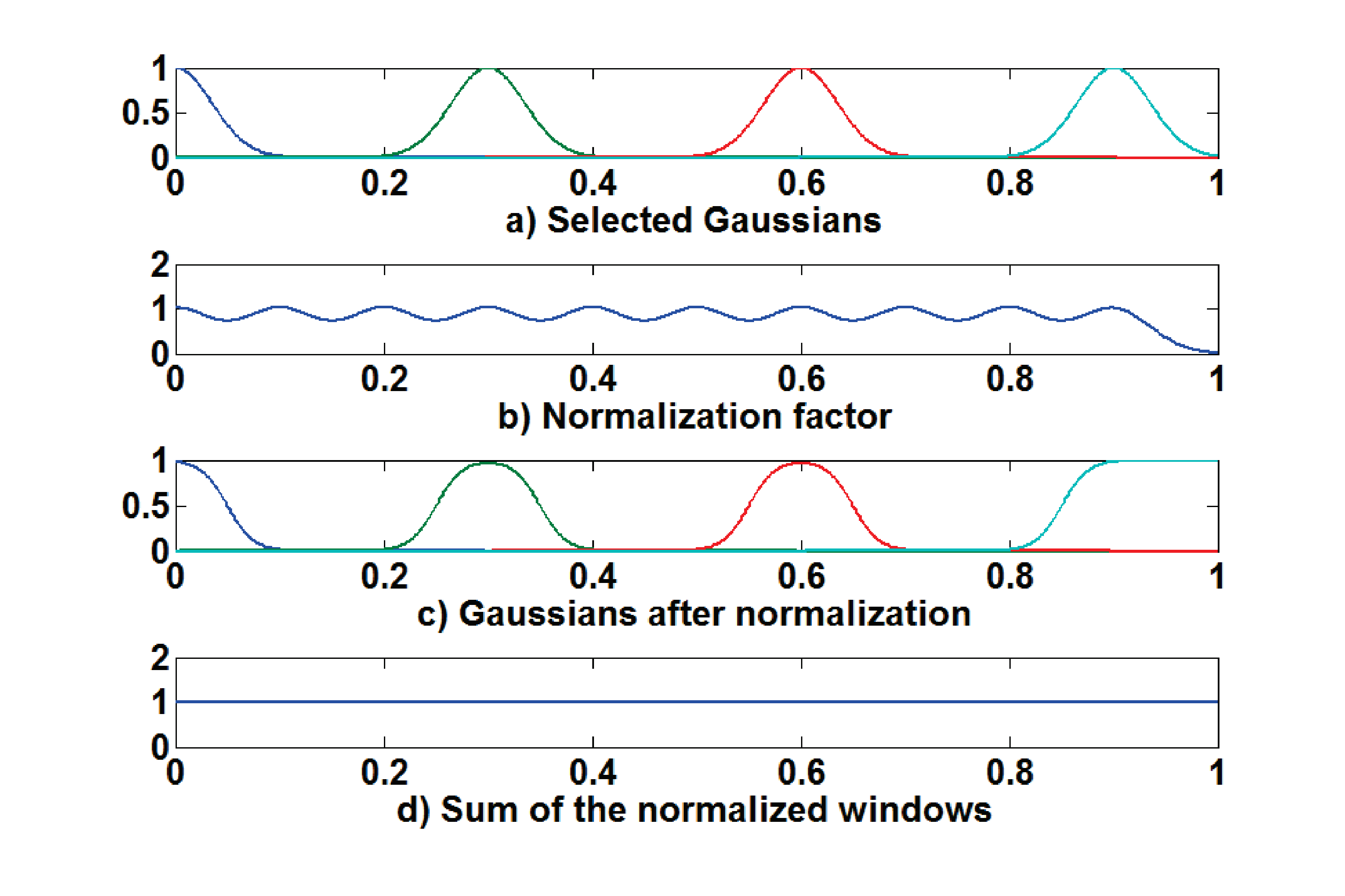
Approximate POU

$$\Omega_k(x) = \frac{\tilde{\Omega}_k(x)}{\sum_{j=1}^{N} \tilde{\Omega}_j(x)}$$

Exact POU formed from approximate one.

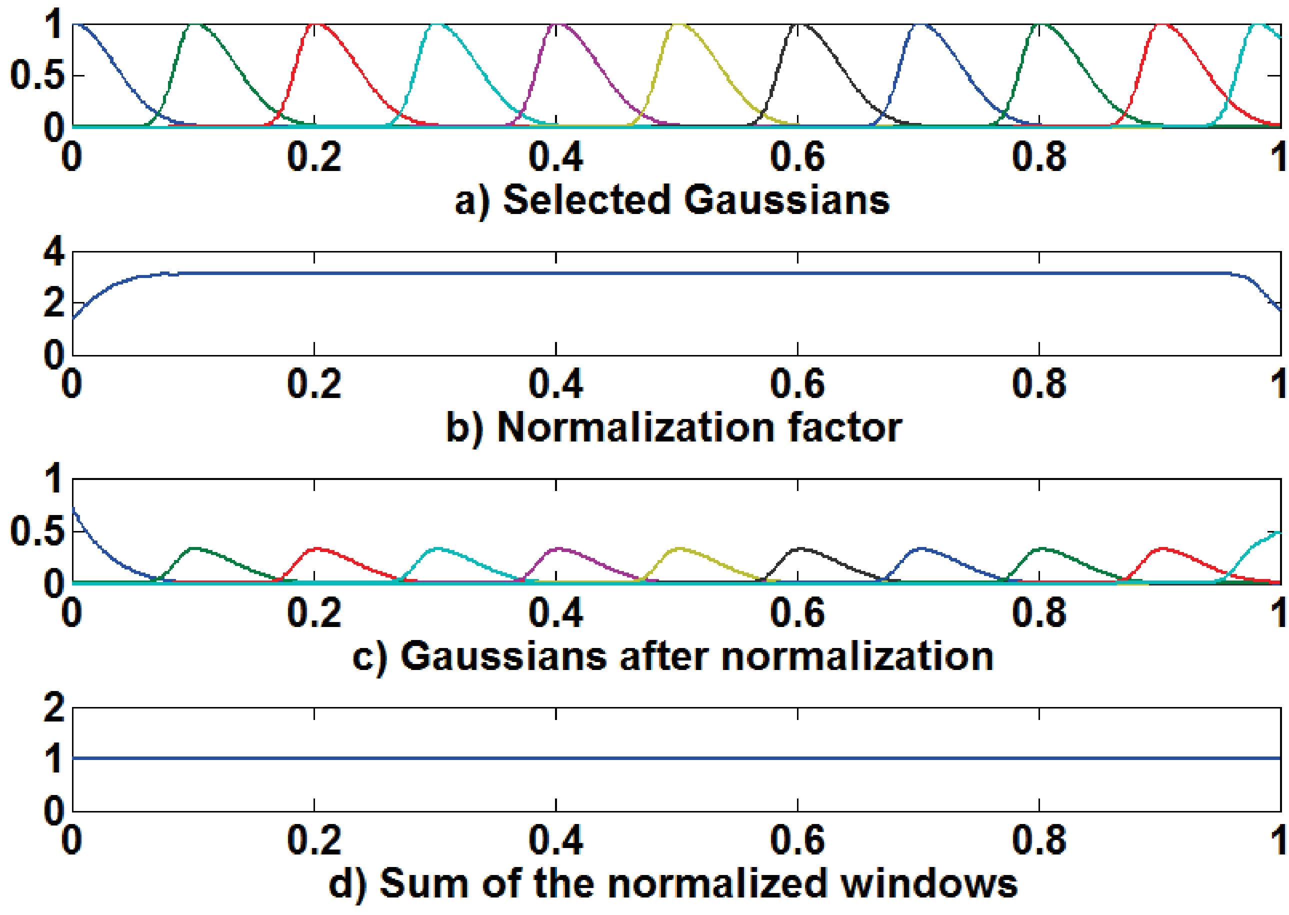
Uniform POU

normalized for wide spacing



Uniform POU

normalized for asymmetry



Nonstationary Operators

$$s_k(t) = g_k s(t)$$

A Gabor slice of the signal

$$s(t) = \sum_{k=1}^{N} \gamma_k s_k = \sum_{k=1}^{N} \gamma_k g_k s$$

A signal is the sum of a complete set of slices

$$(\mathbf{T}s)(t) = \sum_{k=1}^{N} \gamma_k T_k s_k = \sum_{k=1}^{N} \gamma_k T_k g_k s$$

Inserting a linear operator between the analysis and synthesis windows gives a nonstationary operator

Nonstationary Predictive Deconvolution

"slicedecon"

$d_k^{m_k}(t)\ldots$ A conventional PEF (prediction error filter) of lag m_k designed on the k^{th} Gabor slice.

Then we define nonstationary predictive deconvolution as

$$s_d = \sum_{k=1}^{N} \gamma_k d_k^{m_k} \bullet s_k = \sum_{k=1}^{N} \gamma_k d_k^{m_k} \bullet (g_k s)$$

This is the simplest possible definition with the PEF's independently designed for each slice. A more sophisticated method would require that the PEF's re related by physics.

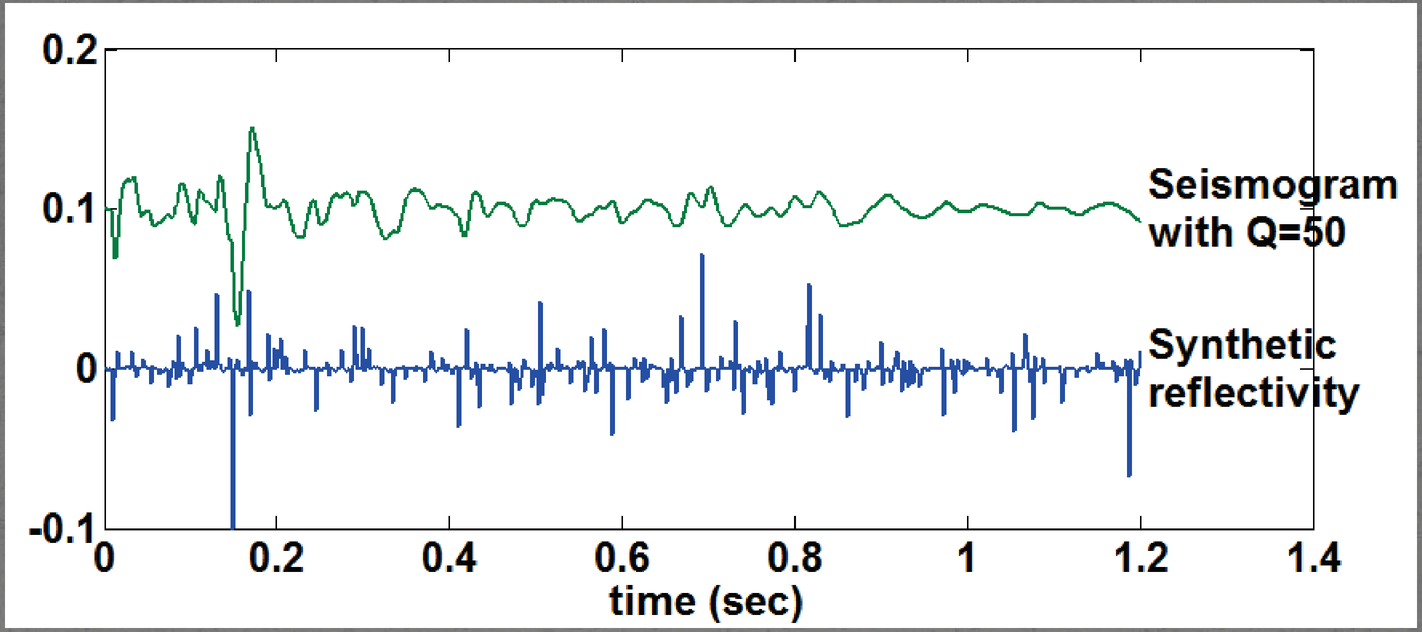
Fact

Stationary, unit-lag, predictive deconvolution is identical to minimum-phase Weiner spiking deconvolution.

Question:

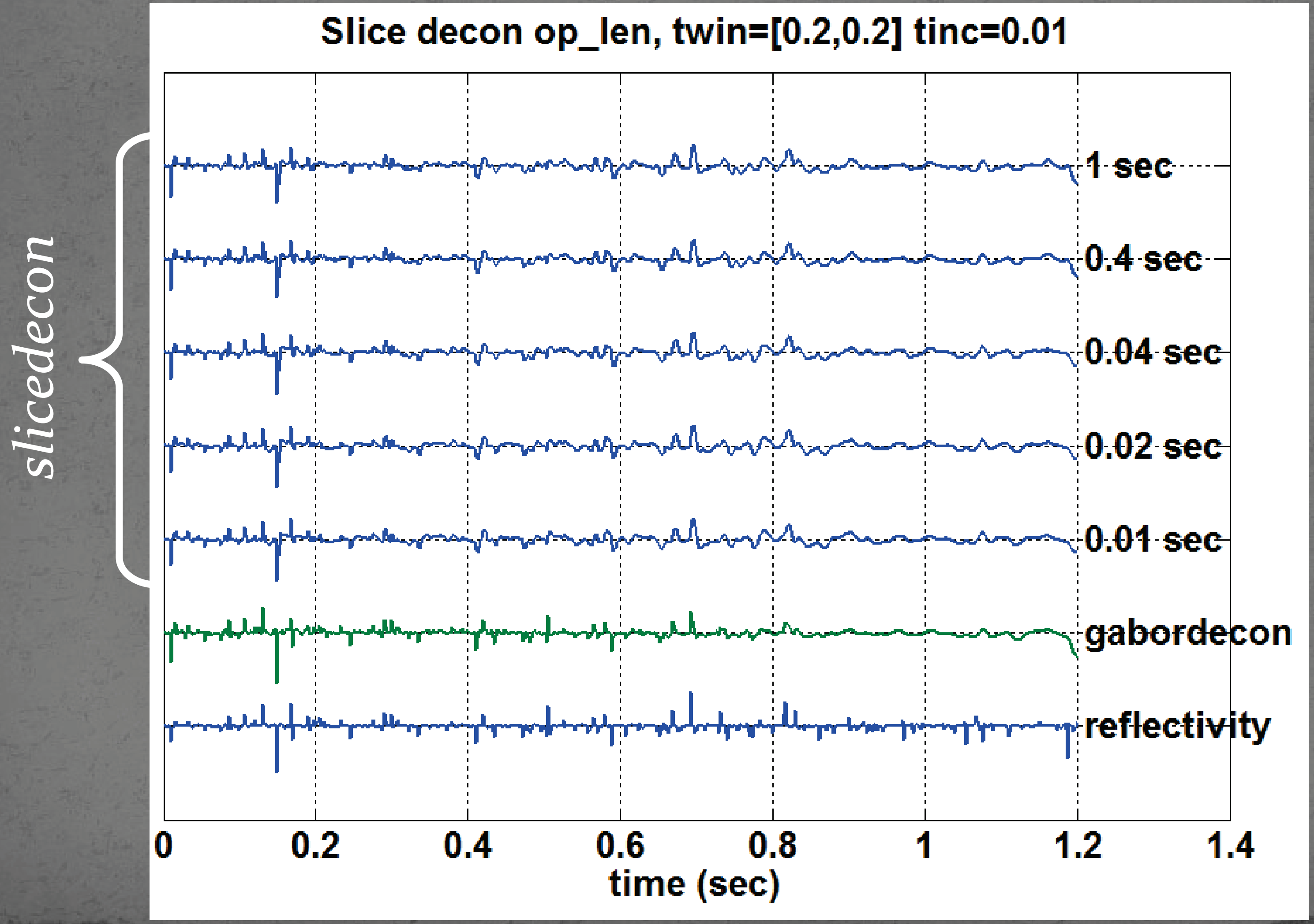
Will something similar be true for *slicedecon*? Specifically, will unit-lag *slicedecon* perform similarly to *gabordecon*?

A Constant Q Synthetic
no multiples



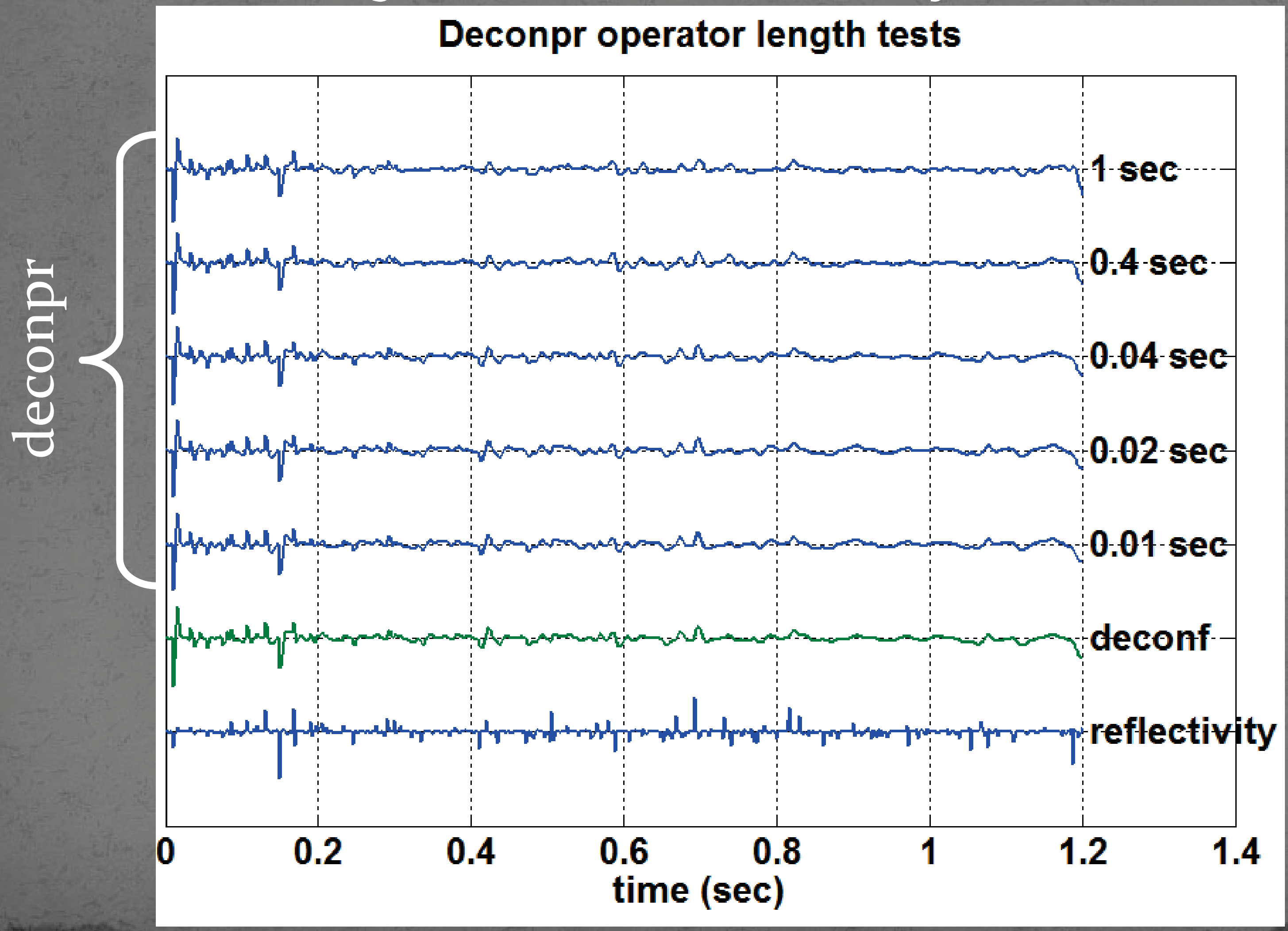
slicedecon versus *gabordecon*

testing operator length

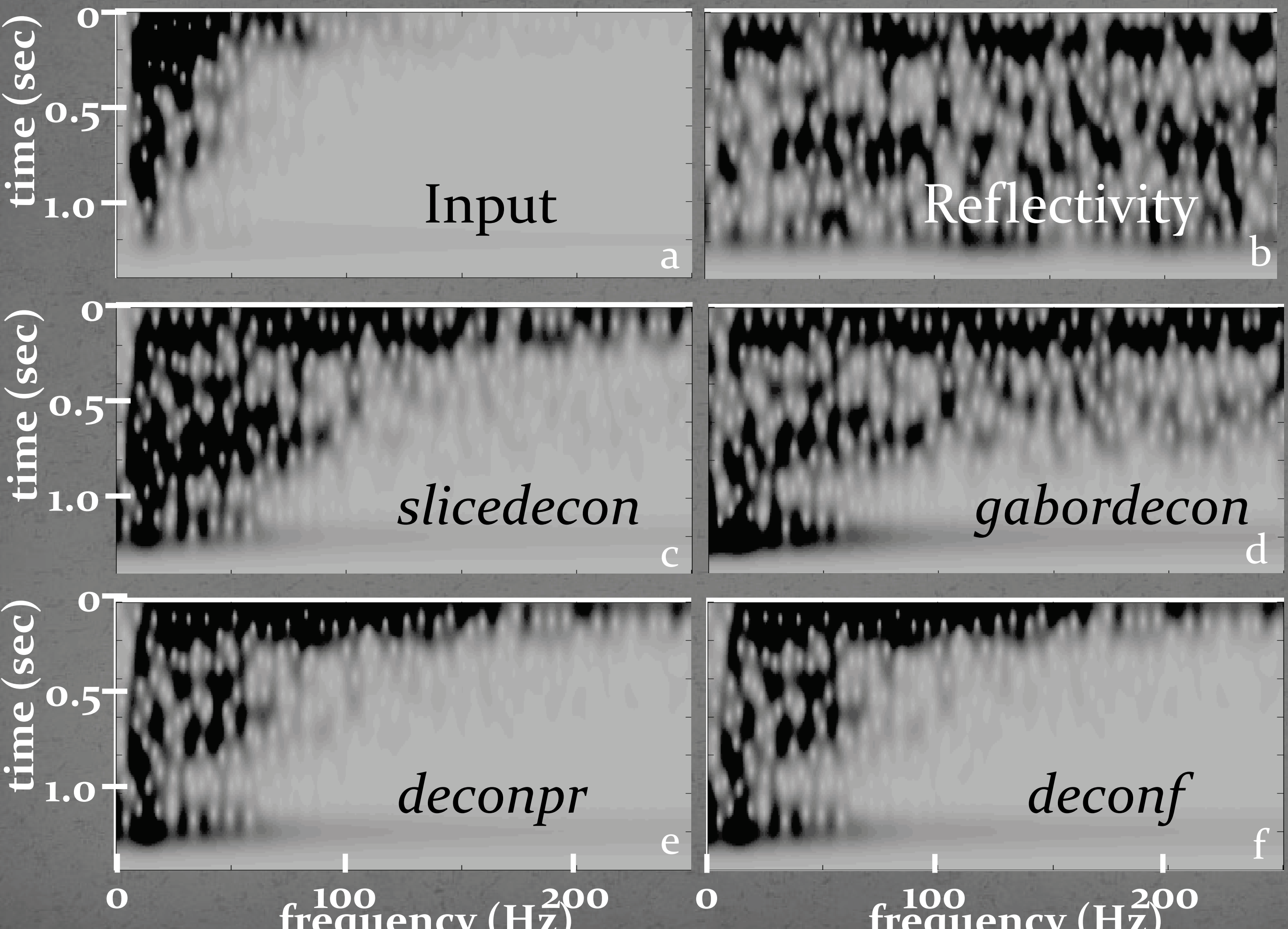


Stationary algorithm comparison

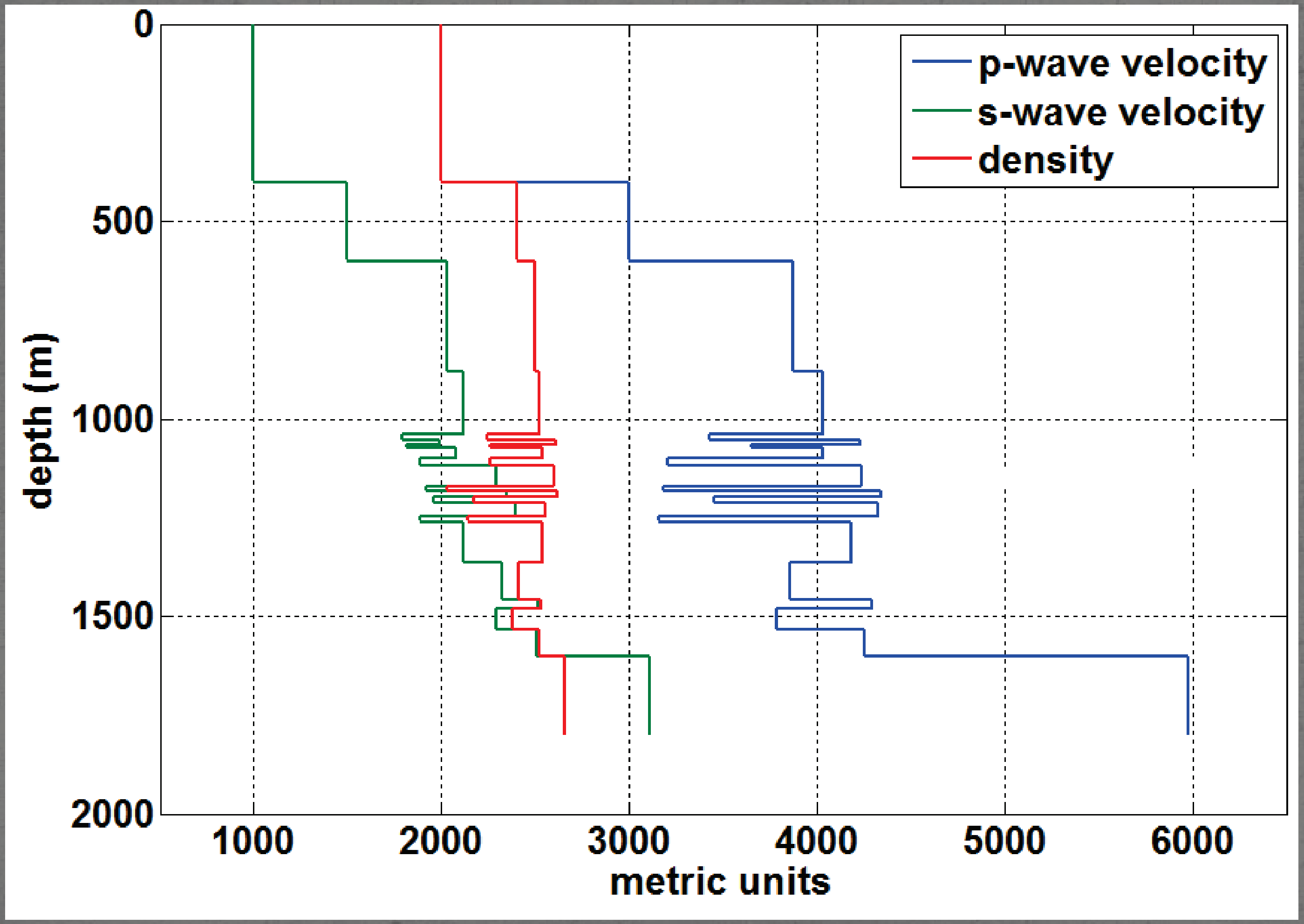
slicedecon ⟶ *deconpr*
gabordecon ⟶ *deconf*



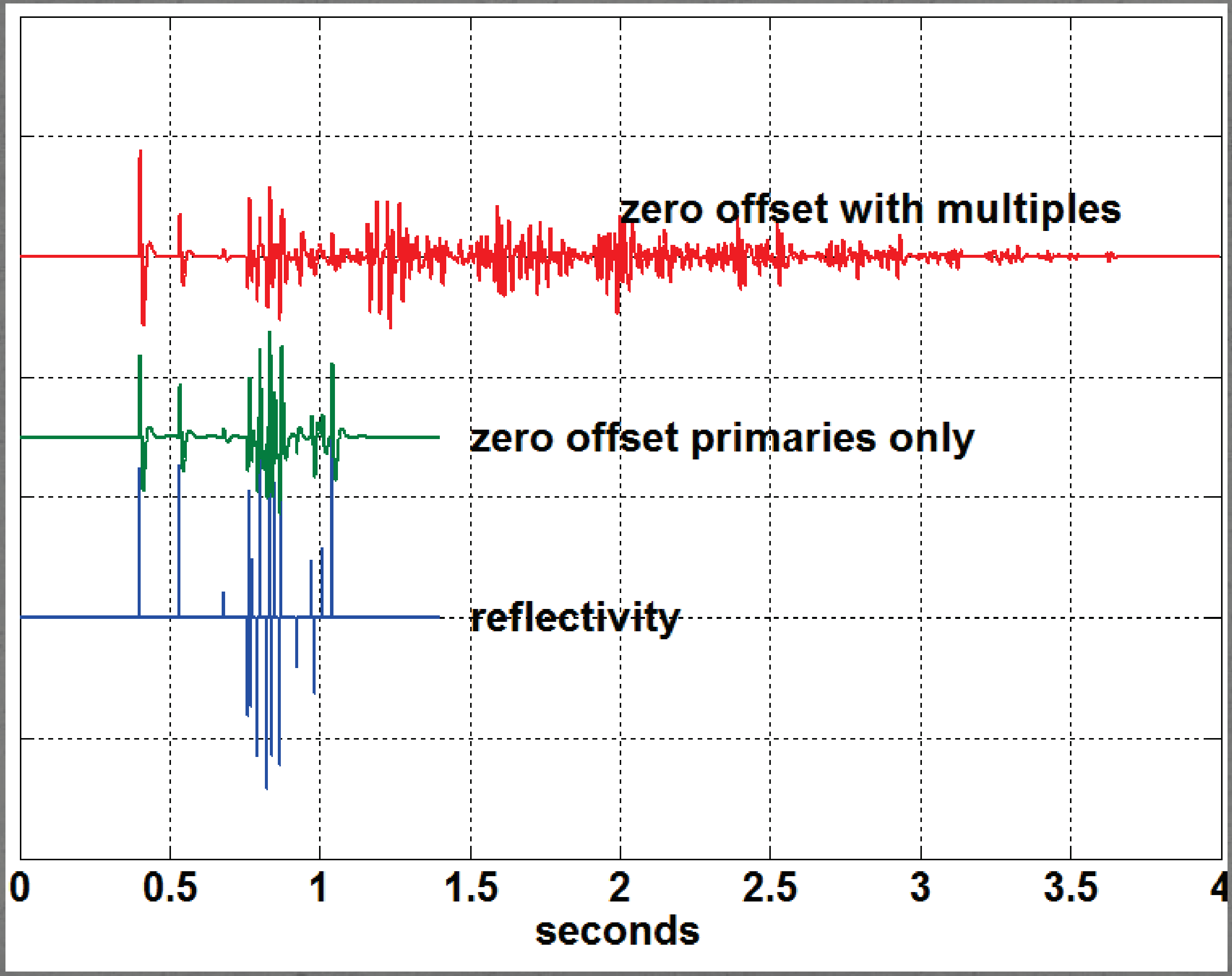
Gabor domain comparison



Well-log based model

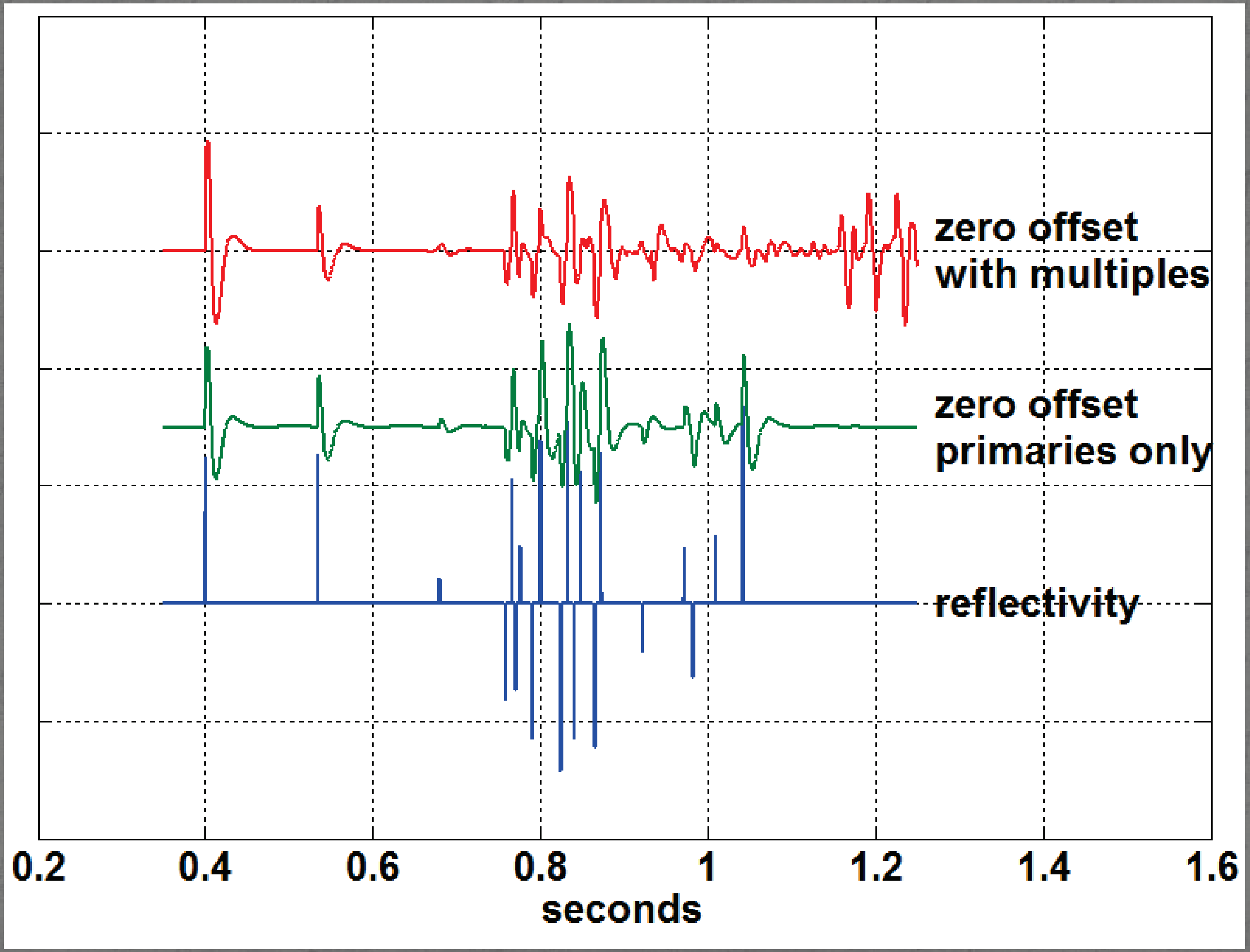


Zero-offset Traces

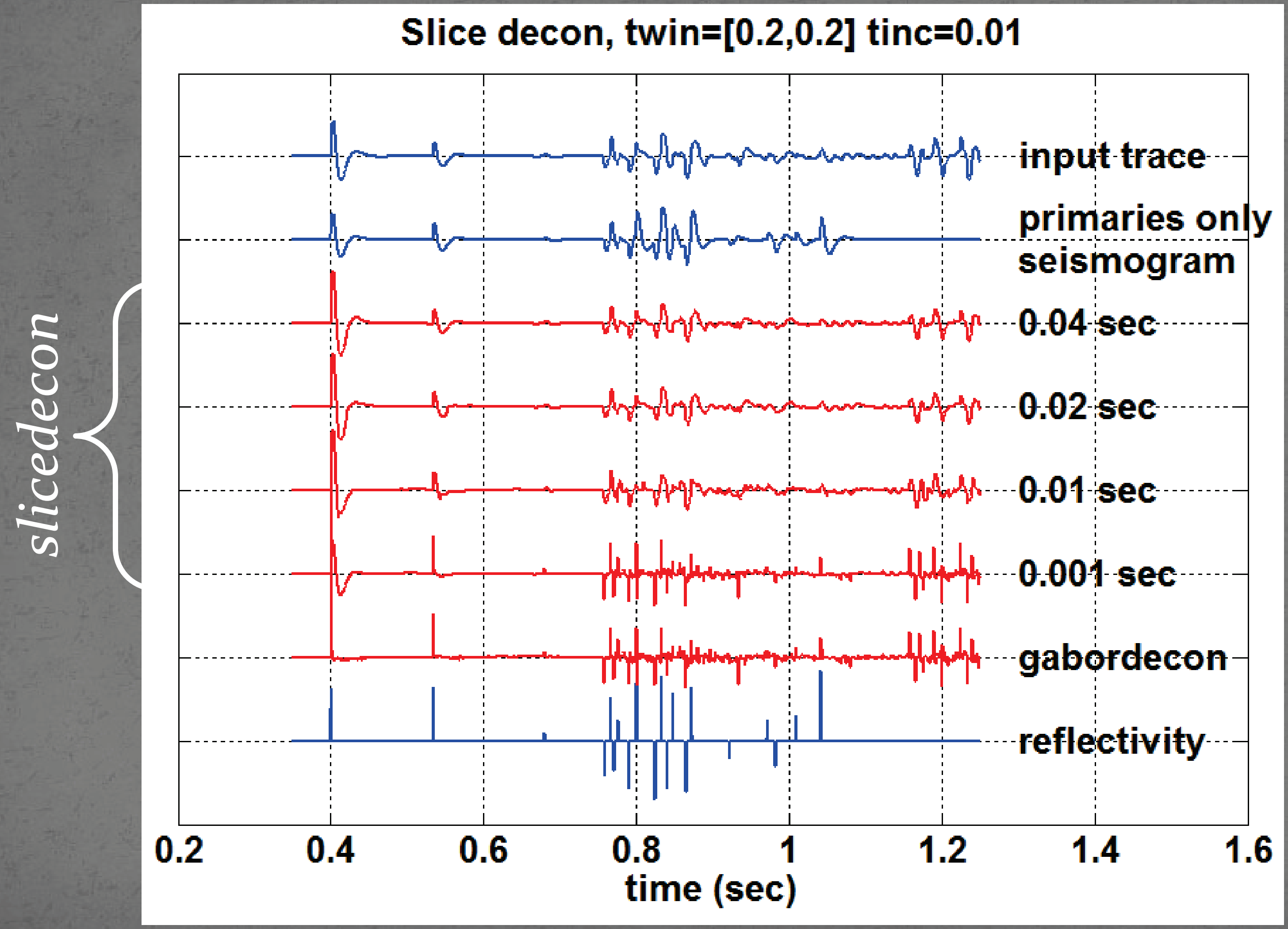


Zero-offset traces

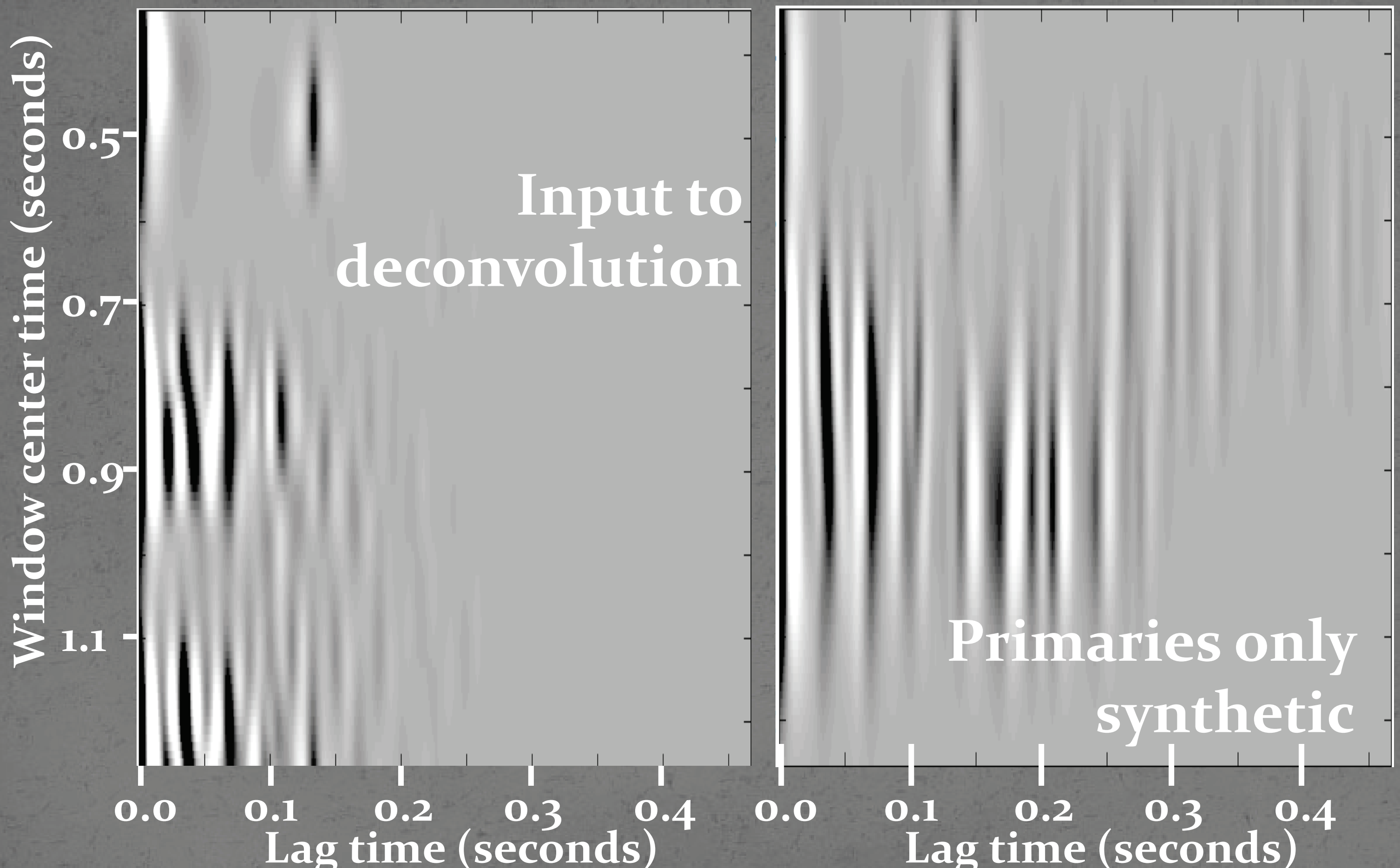
enlargement



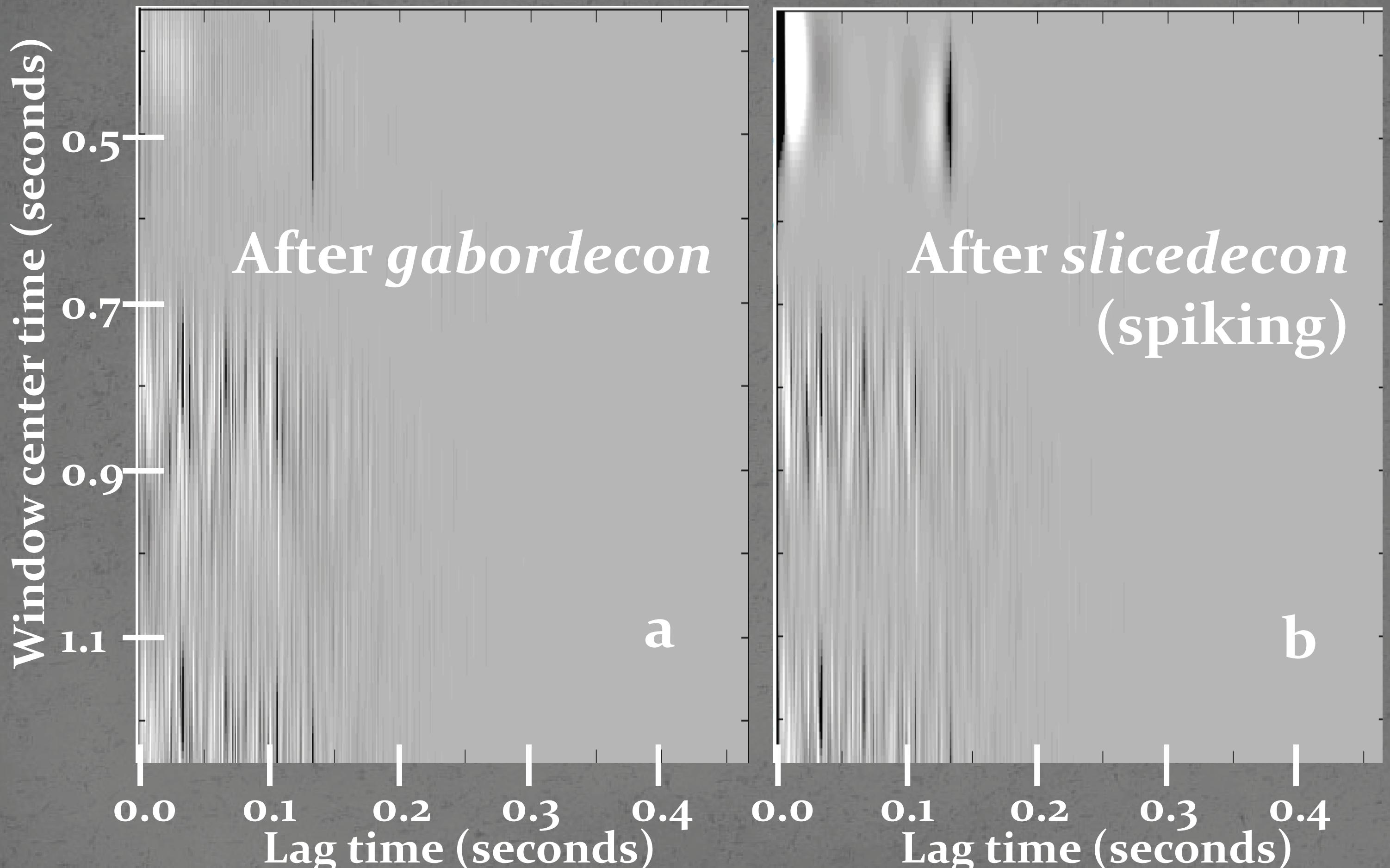
slicedecon: varying prediction lag



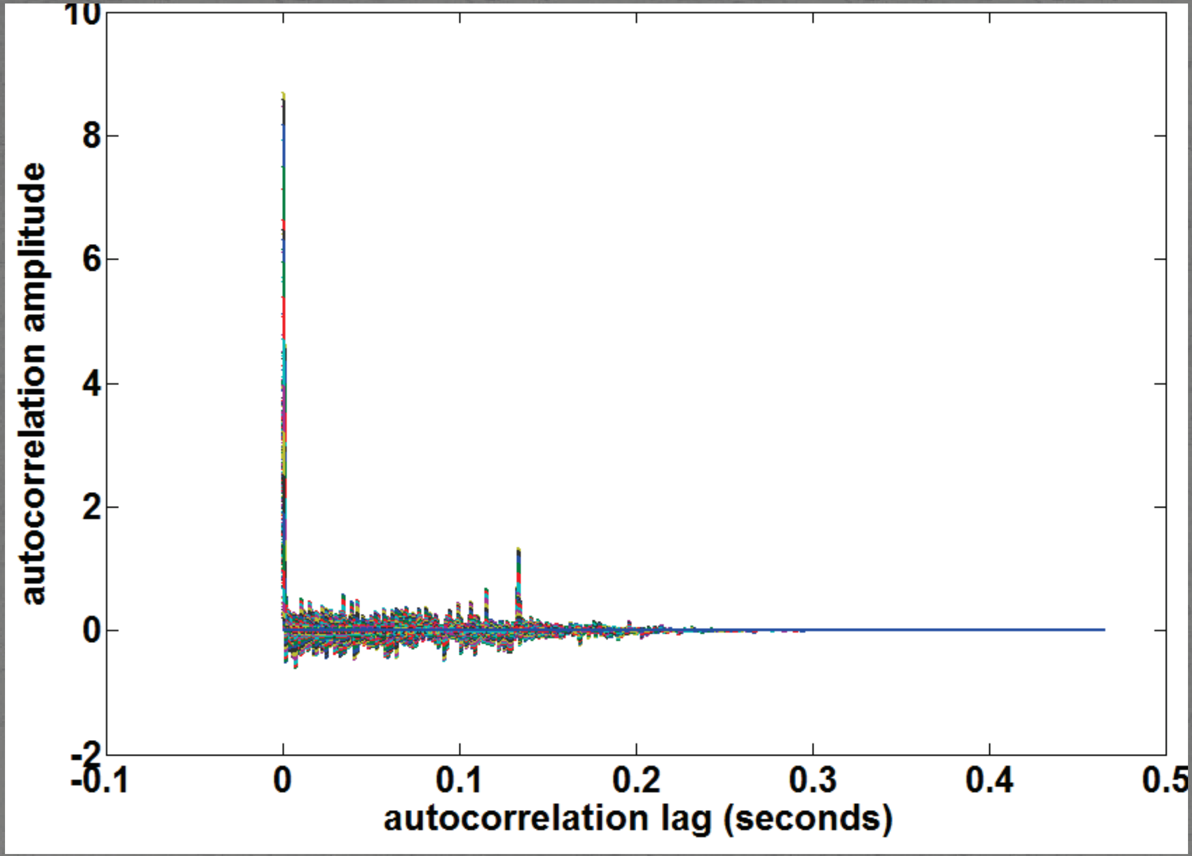
Nonstationary Autocorrelations



Nonstationary Autocorrelations

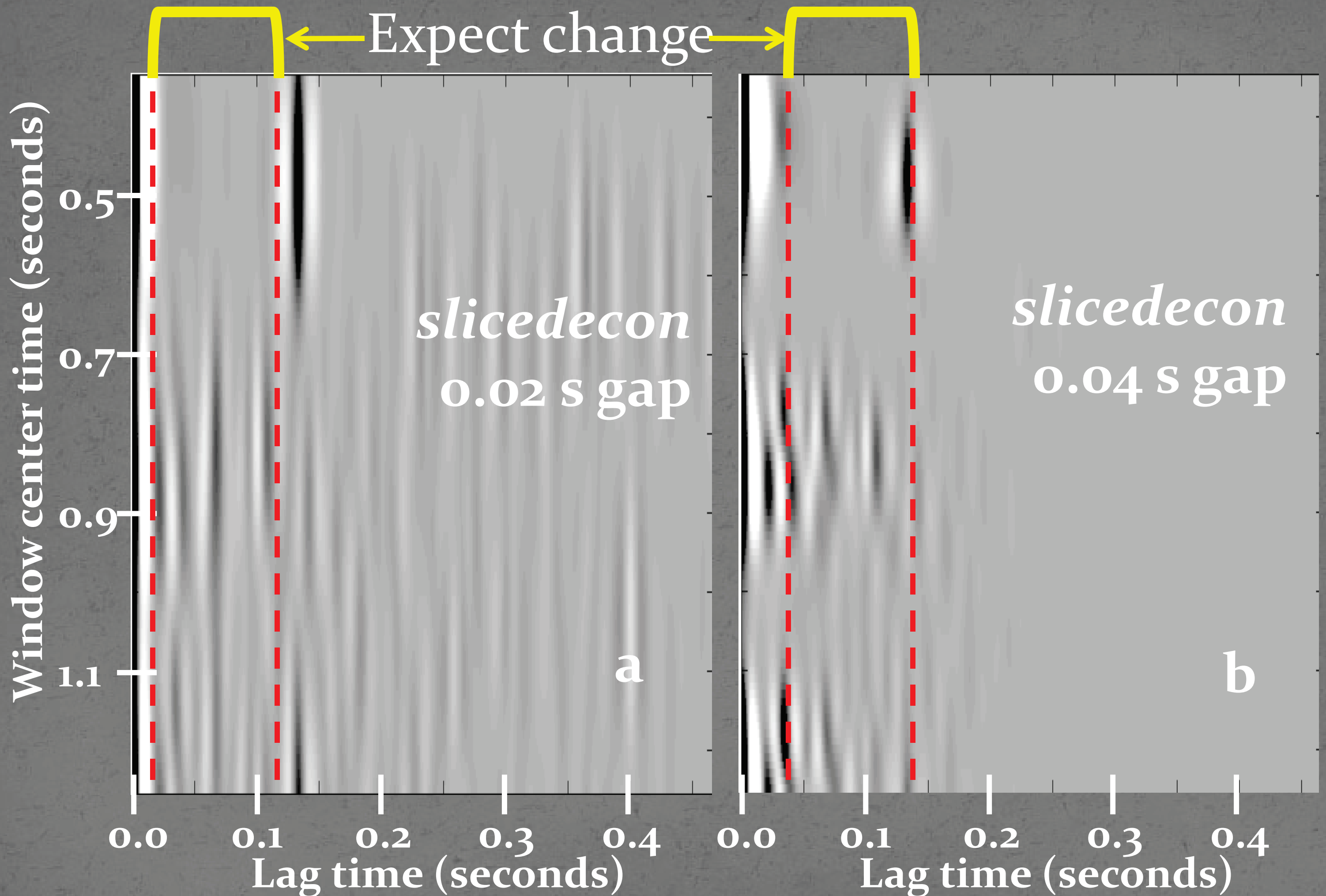


Nonstationary Autocorrelation sideways

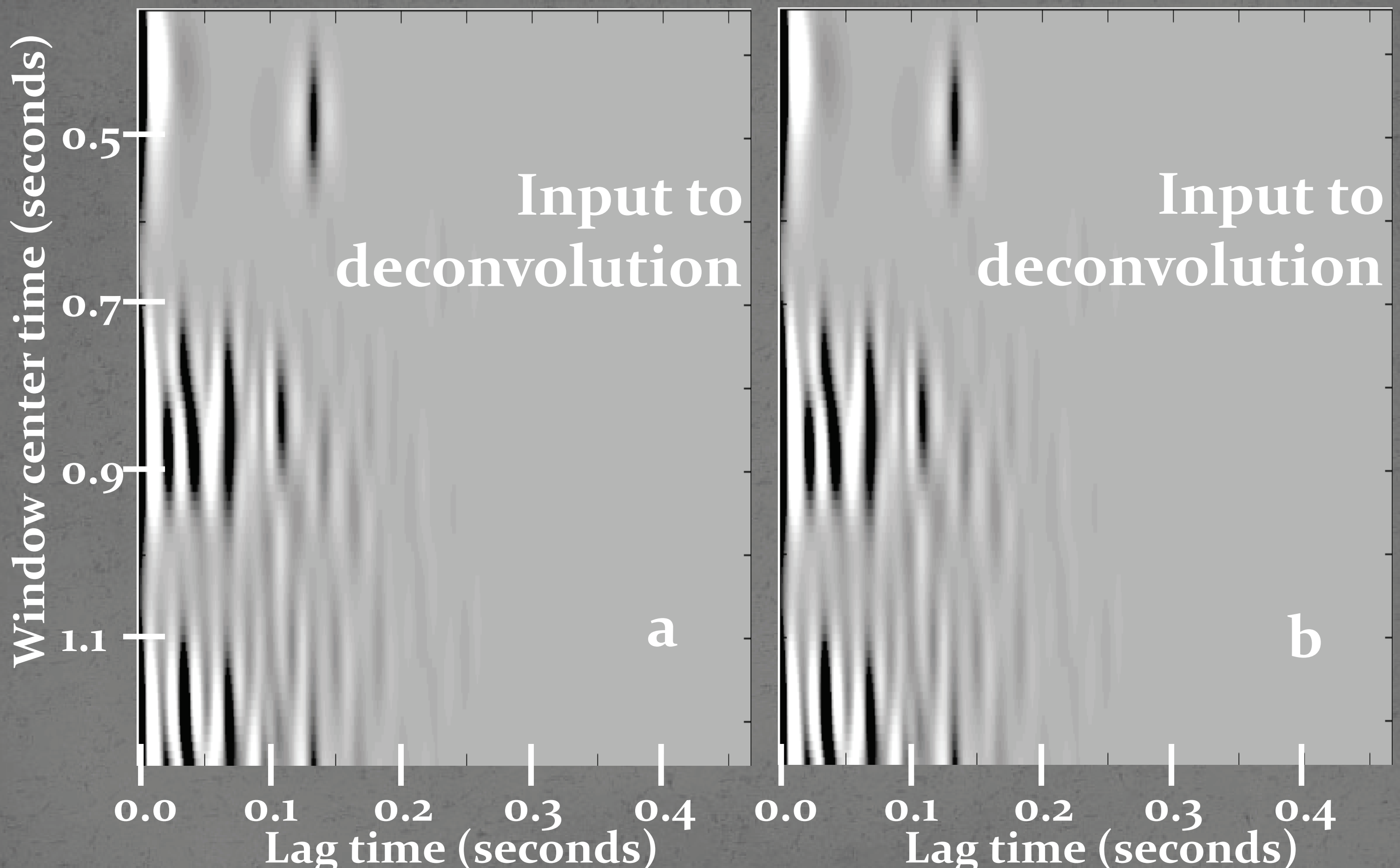


The timeslices of the nonstationary autocorrelation after *gabordecon* are plotted superimposed.

Nonstationary Autocorrelation

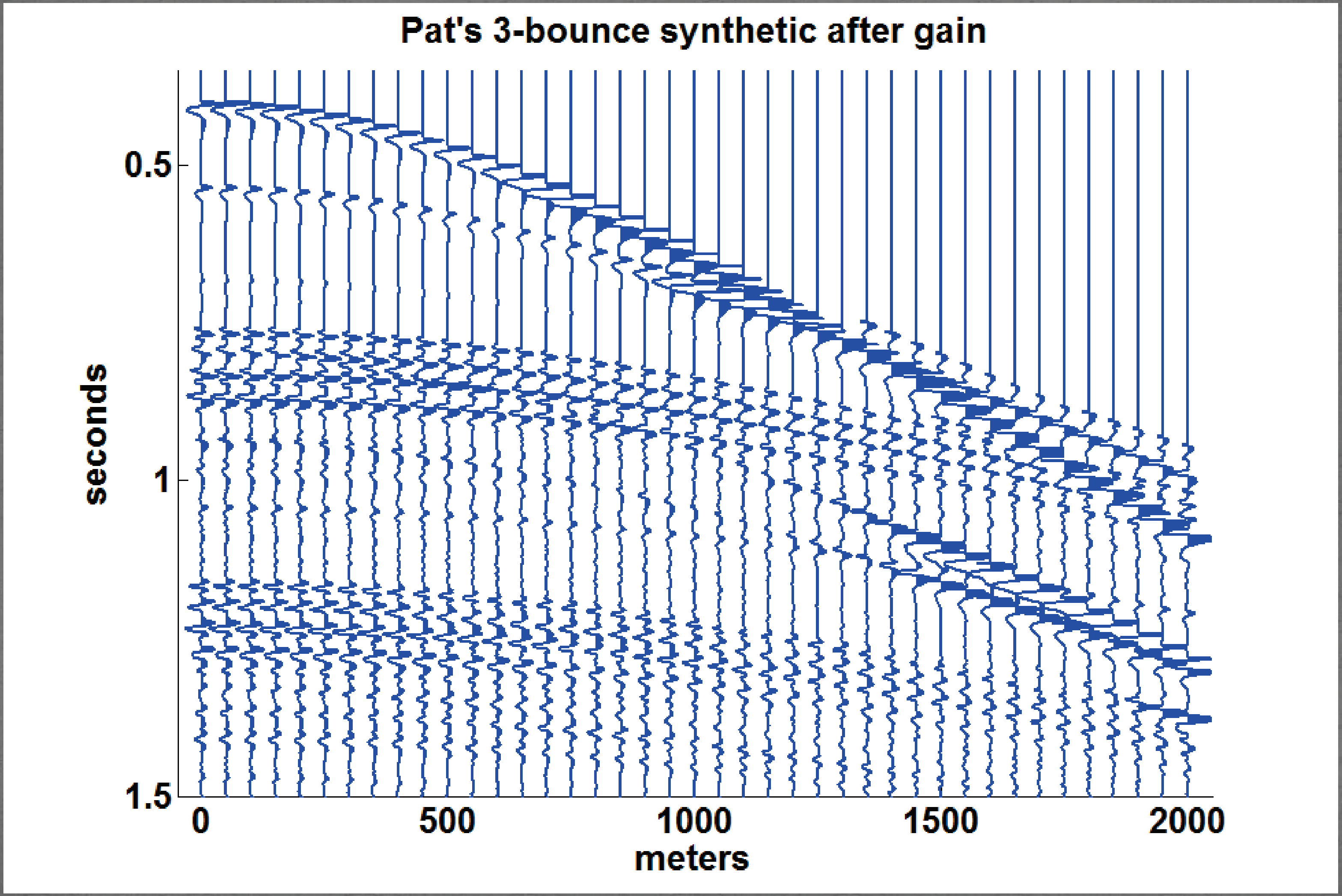


Nonstationary Autocorrelation

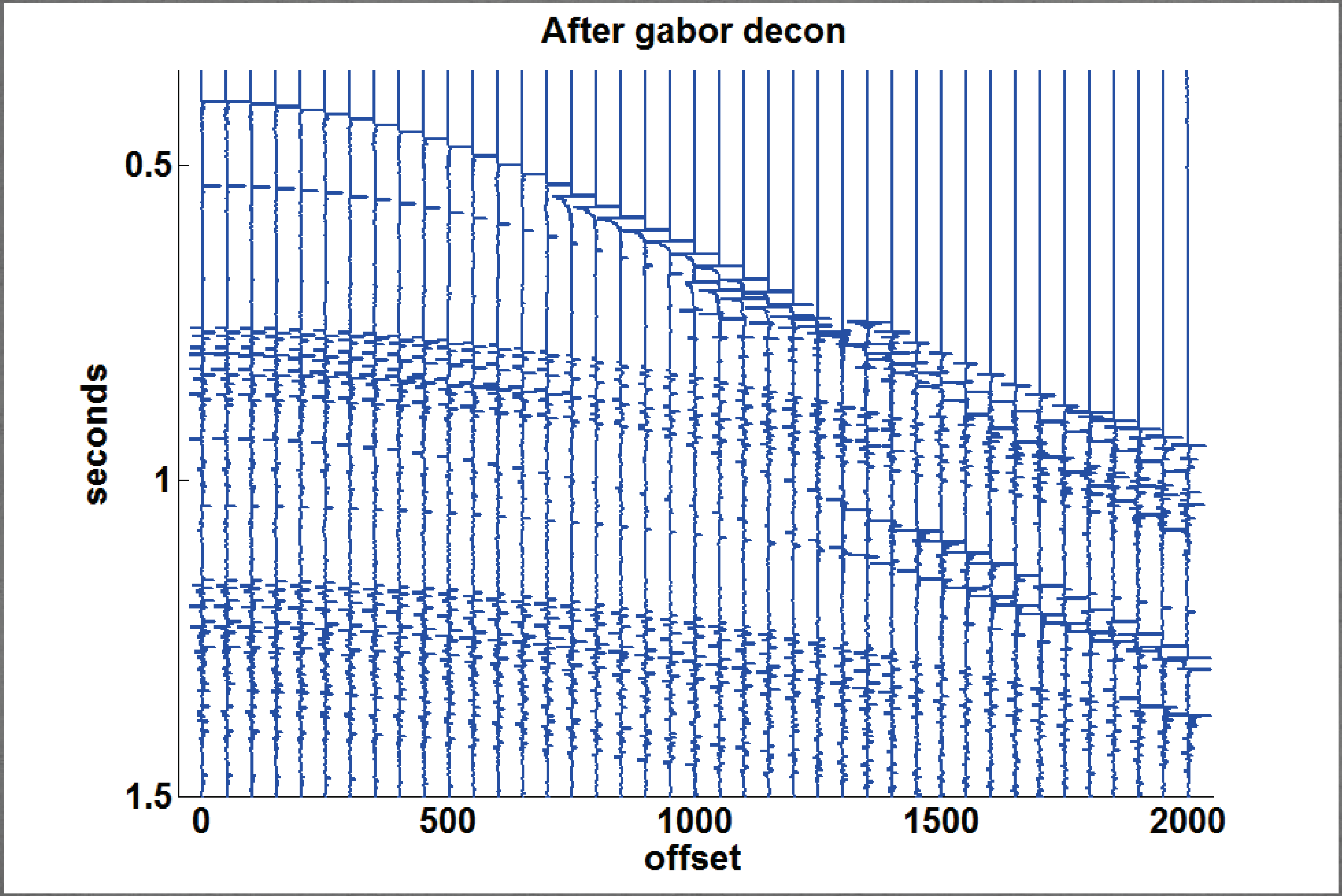


Synthetic Gather

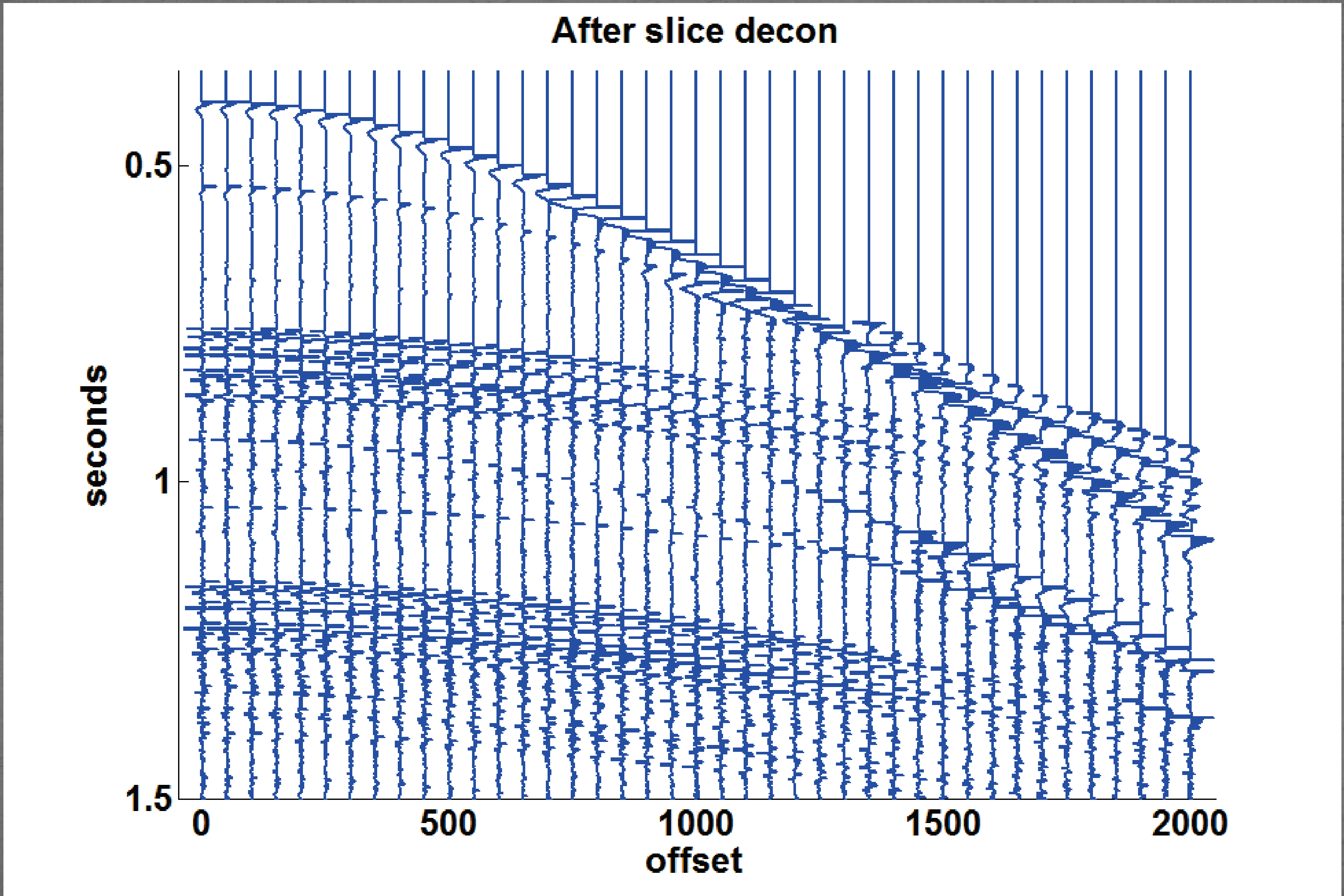
thanks to Pat Daley



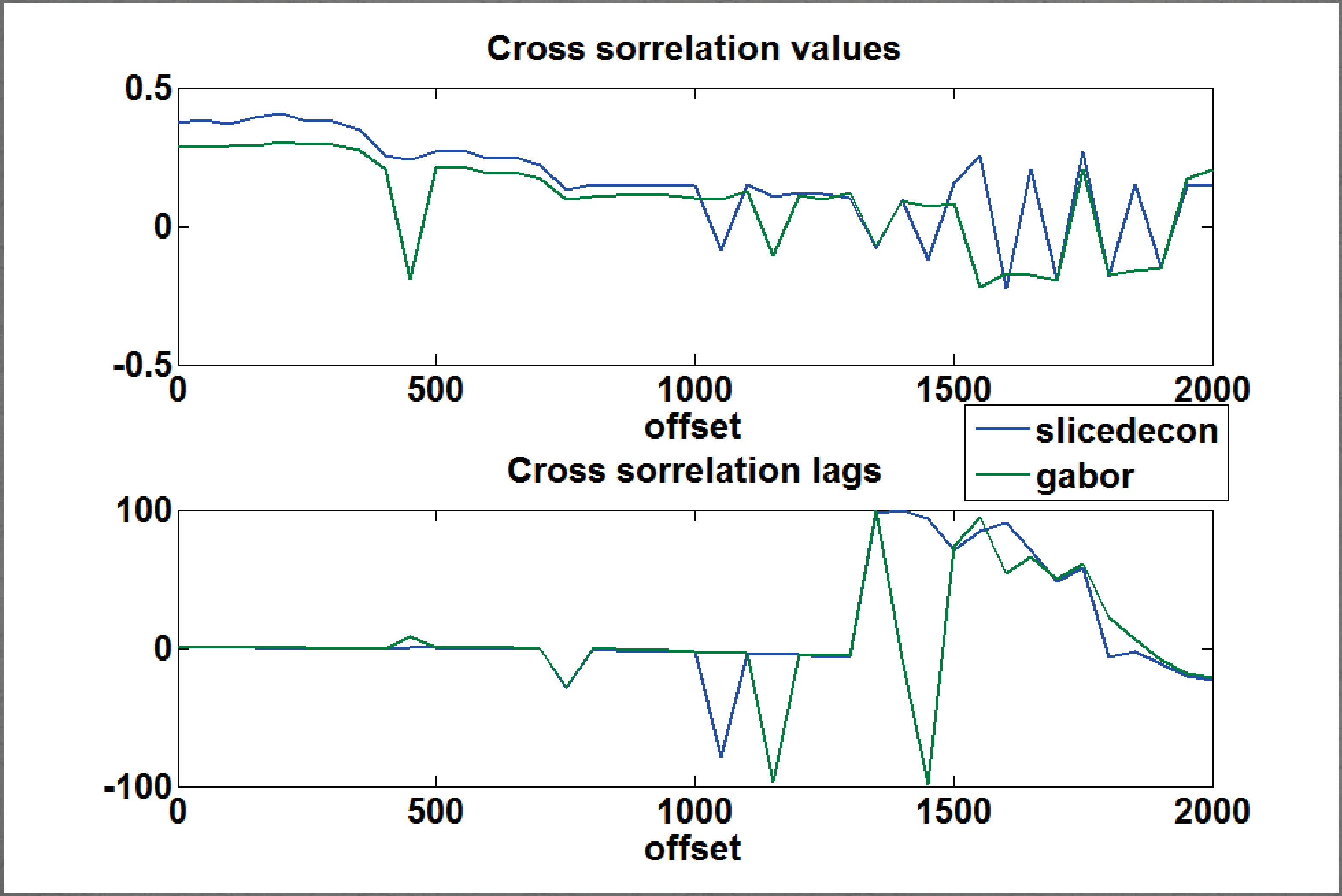
After *gabordecon*



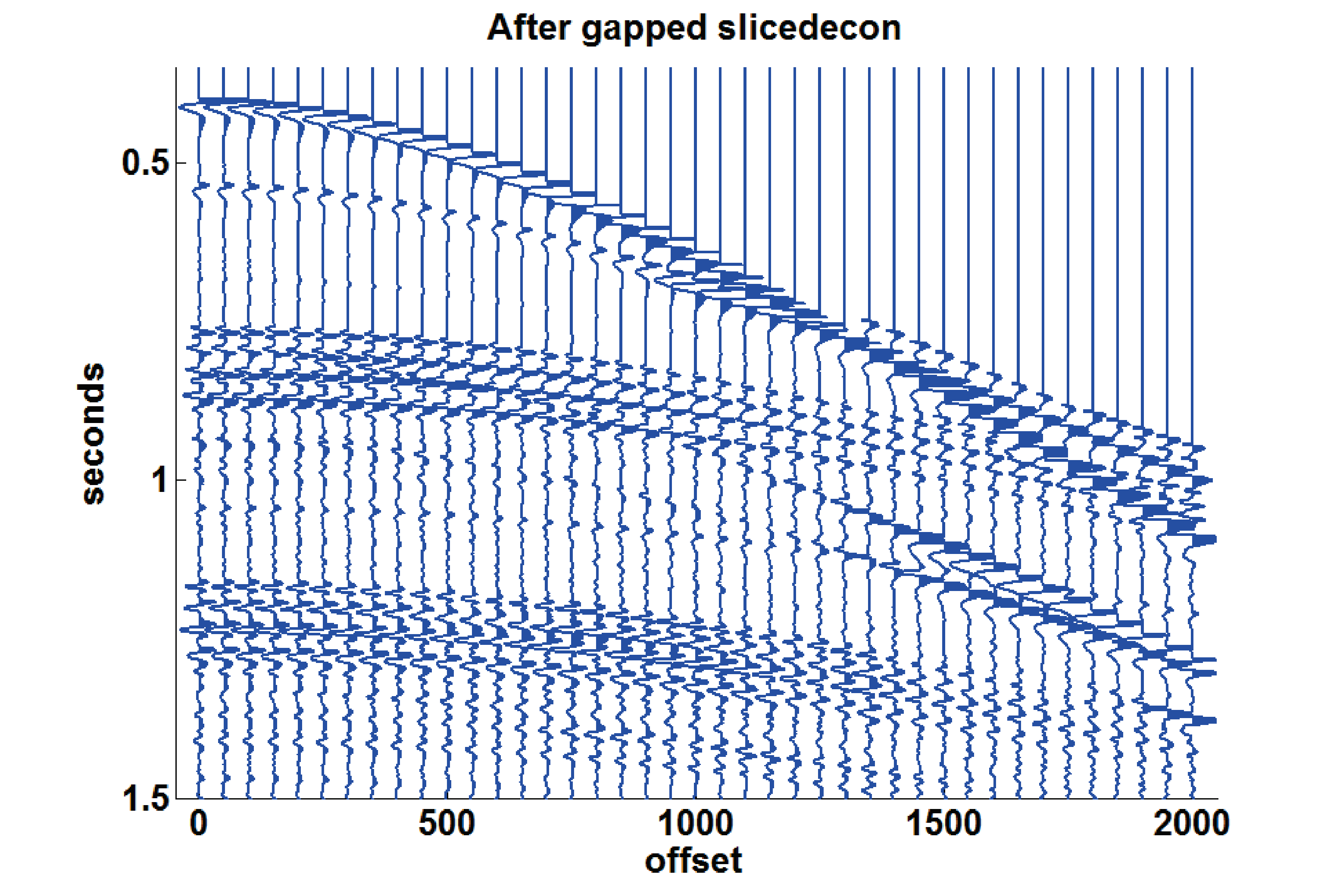
After *slicedecon* (spiking)



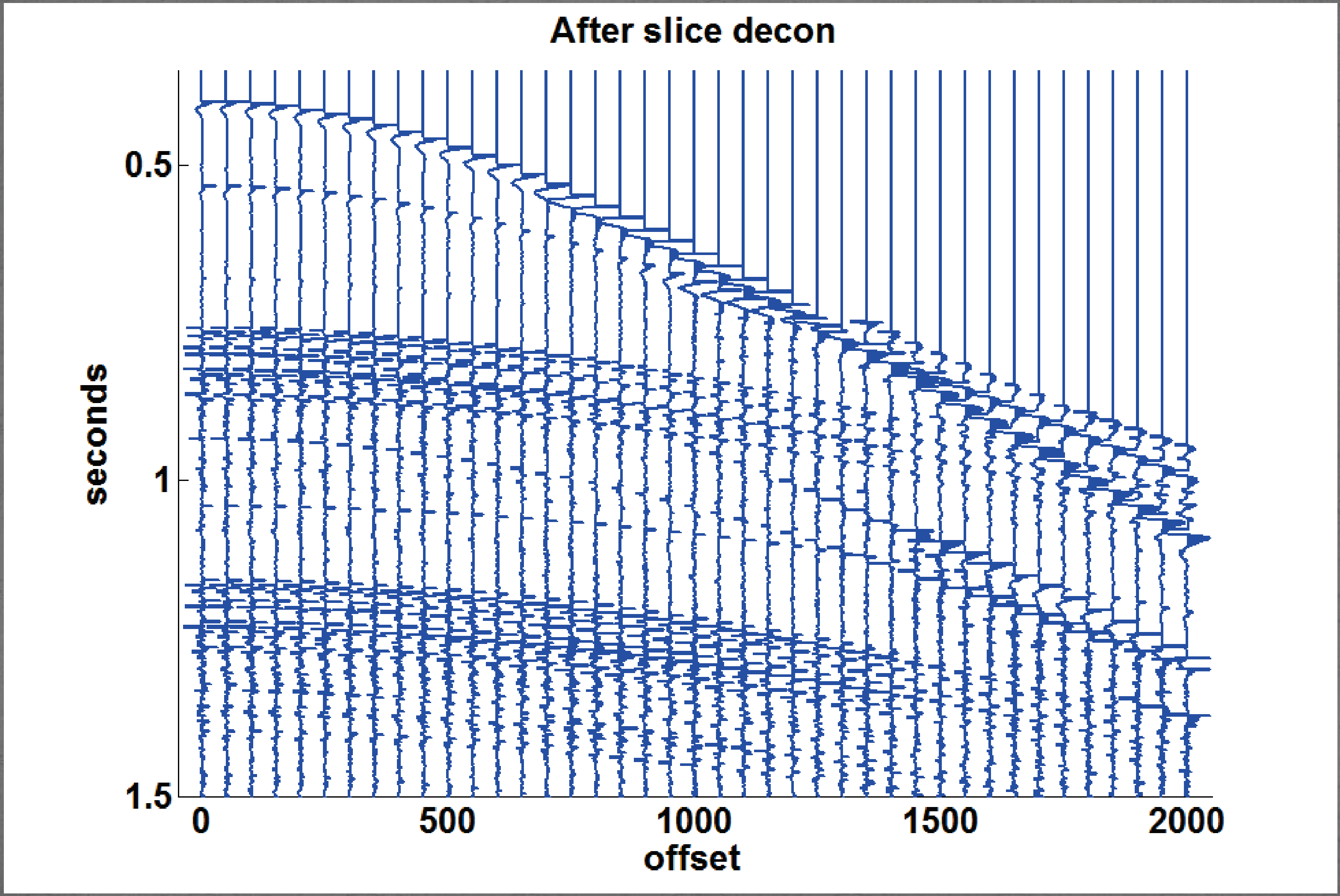
Comparisons to Reflectivity



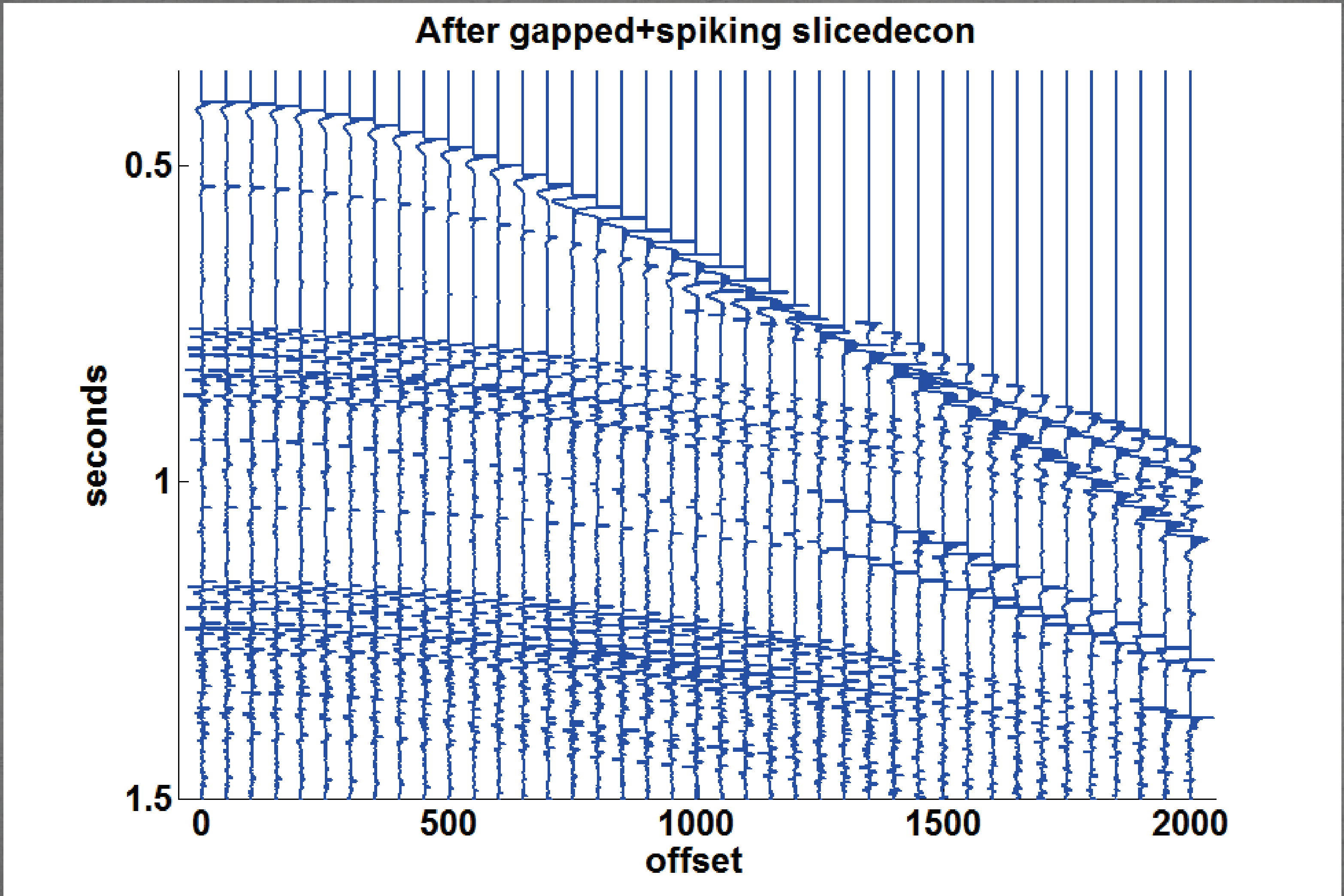
After *slicedecon* (gap 0.1 seconds)



After *slicedecon* (spiking)



After *slicedecon* (gapped+spiking)



Conclusions

- A direct extension of gapped predictive deconvolution to a nonstationary process has been accomplished.
- Prediction operators are designed independently in each Gabor window.
- When *slicedecon* is run as a spiking deconvolution, the results are comparable to *gabordecon*.
- When *slicedecon* is run as a gapped process, nonstationary autocorrelations show expected changes, but trace changes are very subtle.
- Gapped *slicedecon* followed by spiking *slicedecon* shows subtle but encouraging results.

Acknowledgements

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