STATICS DECONVOLUTION VS INTERFEROMETRY

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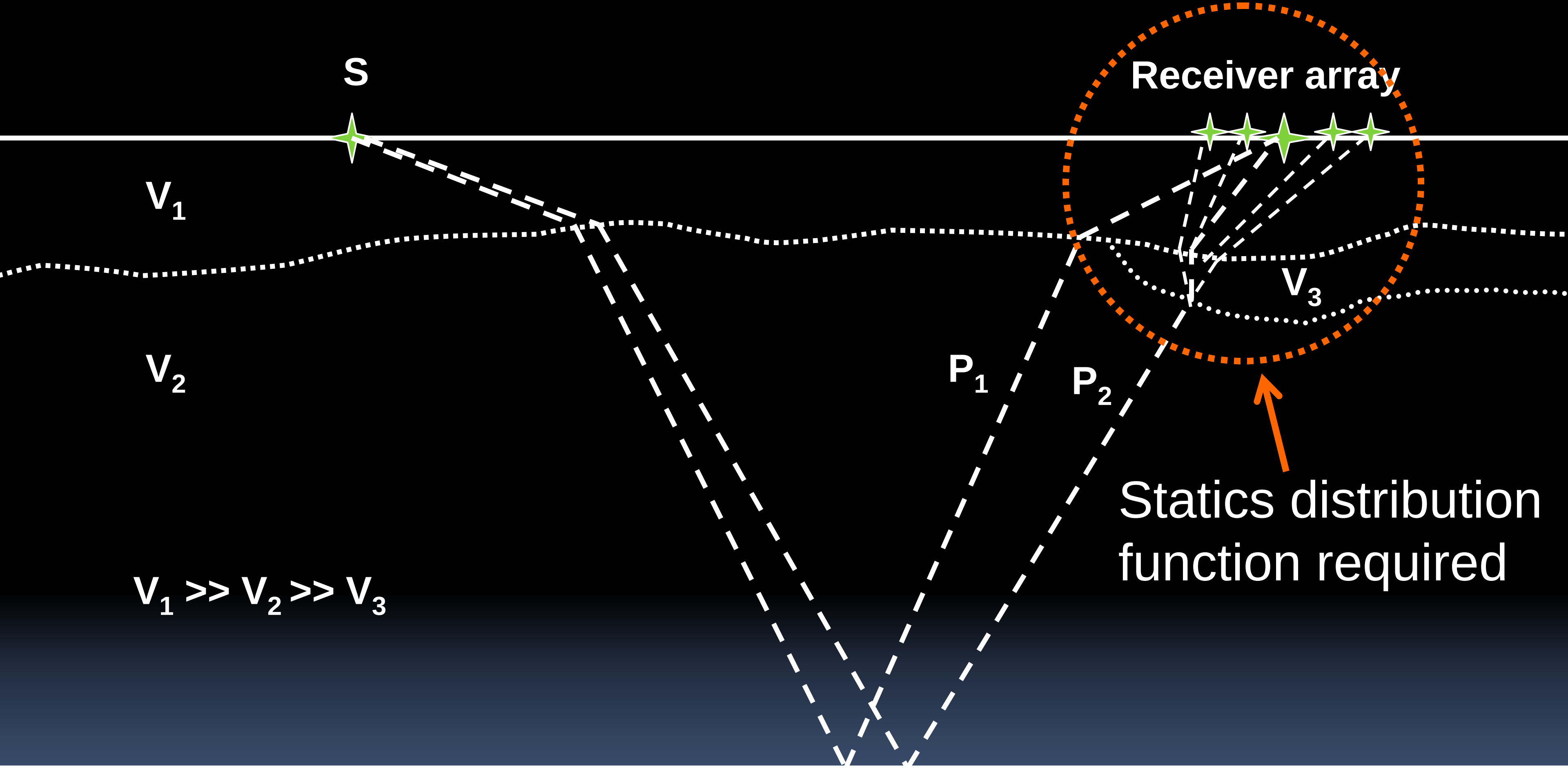
Outline

- Motivation—**similarity** between techniques **gives insight** for further development
- Statics deconvolution—the basics
- Seismic interferometry—the basics
- Comparing the techniques on field data
- Conclusions and conjectures

Statics deconvolution

- Simple **time shift** model replaced by more general **‘statics distribution function’** model
- Statics distribution functions for seismic traces estimated from **cross-correlations** of raw traces with ‘pilot traces’
- **Match filter** or inverse filter derived for each statics distribution function
- Application of **unique** filter corrects each trace

Conventional statics assumptions ***violations***



Raypath segments beneath surface points not vertical; Sources and receivers can be arrays, with different statics for each point in the array. Multiple raypaths possible between source and receiver location (P_1 and P_2), due to buried velocity anomalies (V_3)

Ideal seismic trace

Actual statics distribution function

Input seismic trace

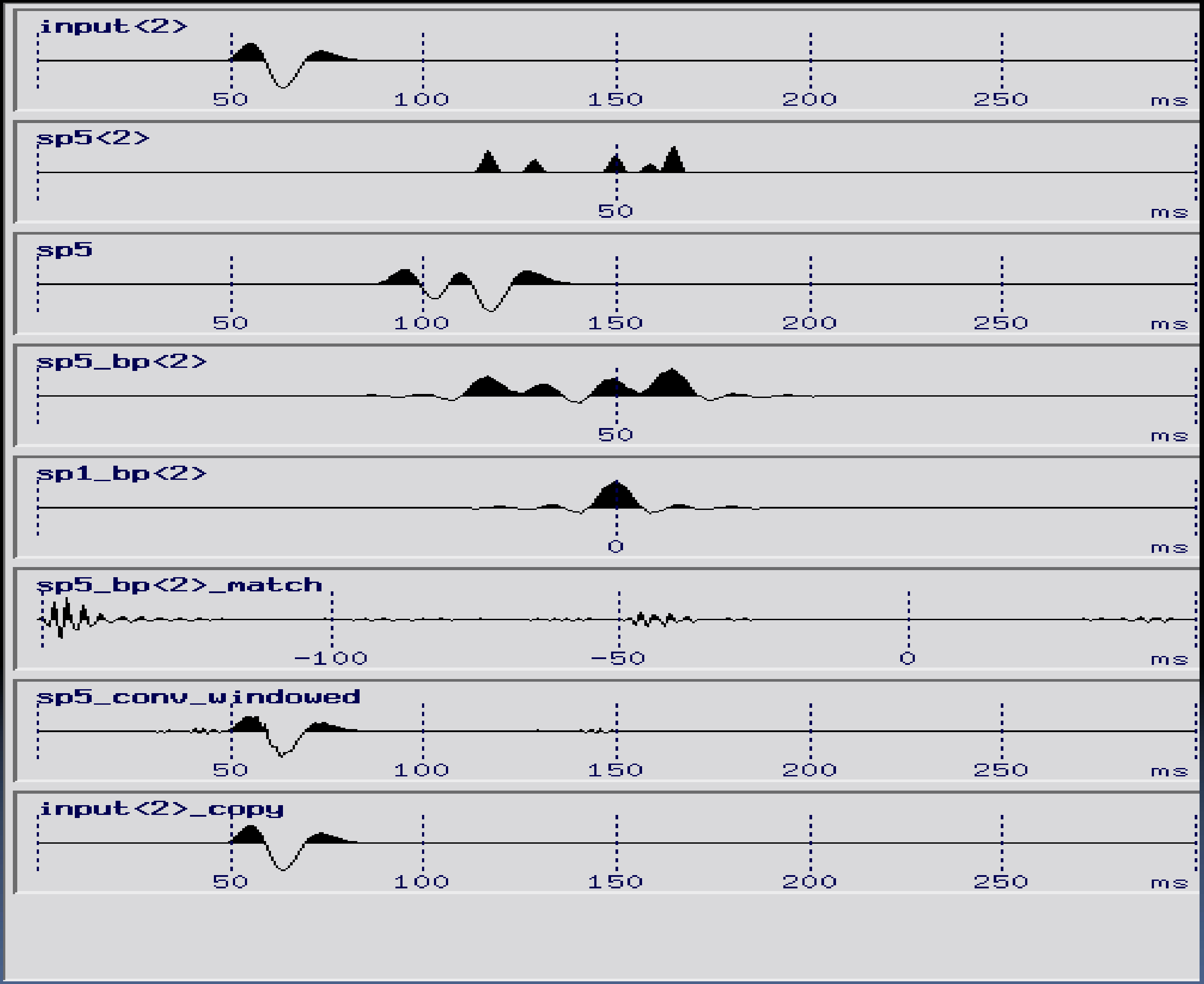
Estimated statics distribution function

Desired statics distribution function

Match filter

Match filtered seismic trace

Ideal seismic trace



The static deconvolution principle

Statics deconvolution

$$\mathrm{T}_{k\beta}(t) = w(t) * s_k(t) * R_{k\beta}(t) * r_\beta(t)$$

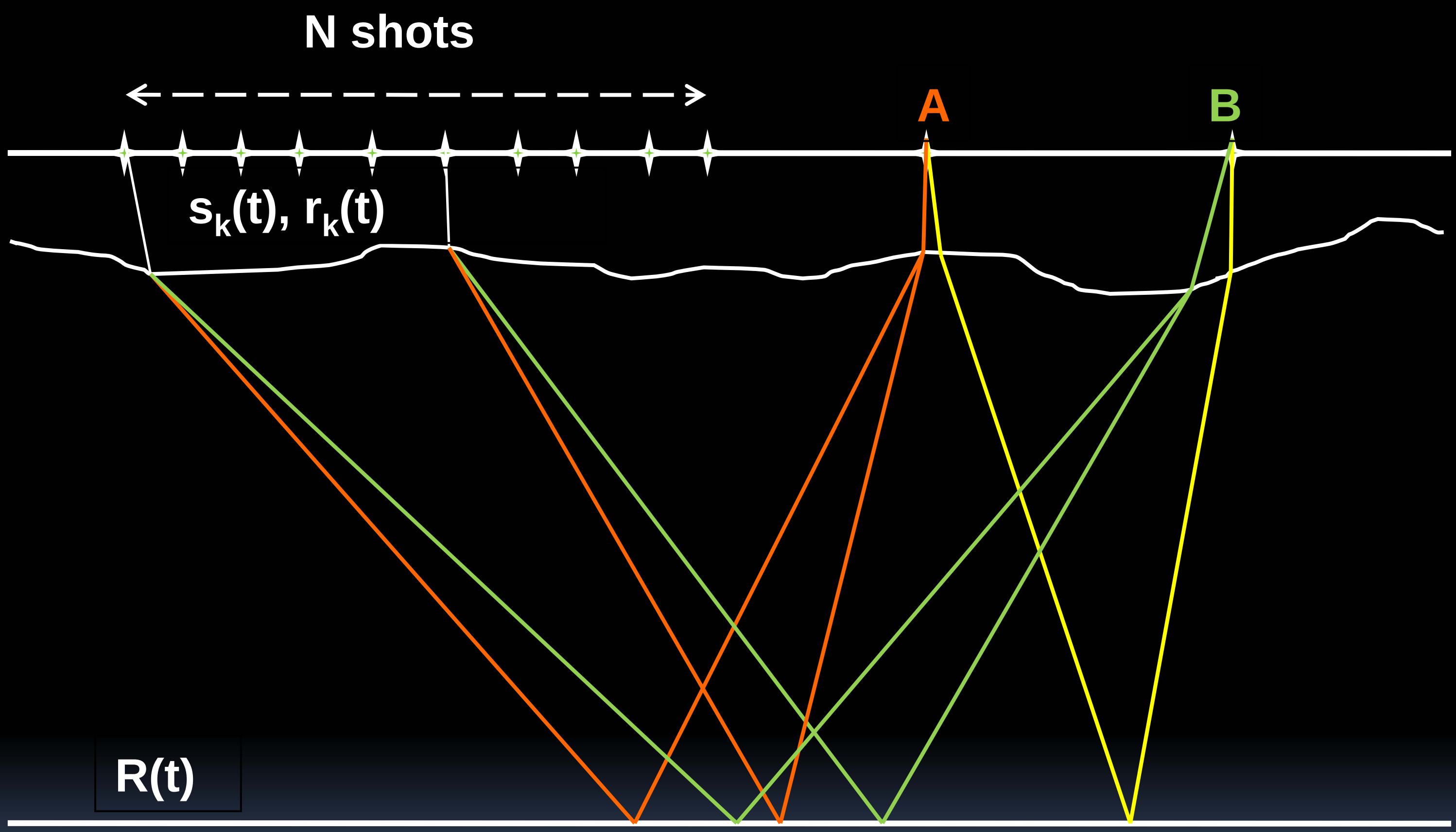
Raw seismic trace

$$\hat{\mathrm{T}}_{\alpha\beta}(t) = \mathrm{T}_{\alpha\beta}(-t) * \mathrm{T}_{\alpha\beta}(t) * \sum_{k=1}^{N} \mathrm{T}_{k\beta}(t).$$

Corrected seismic trace

Seismic interferometry

- The principles of **reciprocity** and **time reversal** are used to create **'virtual traces'** from recorded traces
- Time-reversed portion of a raw trace is used as a **filter** to remove surface-related effects
- **Sum of filtered traces** over an aperture creates a new trace with a **'virtual'** source and **no surface-related effects**



Raw trace pairs from receiver gathers at A and B (common source k) cross-correlated to cancel source phase $s_k(t)$. Cross-correlations convolved (as match filters) with traces of receiver gather A to cancel receiver phase $r_A(t)$, then summed over shot aperture N to approximately cancel residual source phase $s_k(t)$. This is a 'virtual trace', between A and B for a virtual source (receiver) gather.

Seismic interferometry

$$\mathrm{T}_{k\beta}(t) = w(t) * s_k(t) * R_{k\beta}(t) * r_\beta(t)$$

Raw seismic trace

$$\hat{\mathrm{T}}_{\alpha\beta}(t) = \sum_{k=1}^{N} \left[\mathrm{T}_{k\alpha}(-t) * \mathrm{T}_{k\alpha}(t) \right] * \mathrm{T}_{k\beta}(t)$$

Virtual seismic trace

How they're related

$$\hat{\mathrm{T}}_{\alpha\beta}(t) = \mathrm{T}_{\alpha\beta}(-t) * \mathrm{T}_{\alpha\beta}(t) * \sum_{k=1}^{N} \mathrm{T}_{k\beta}(t) .$$

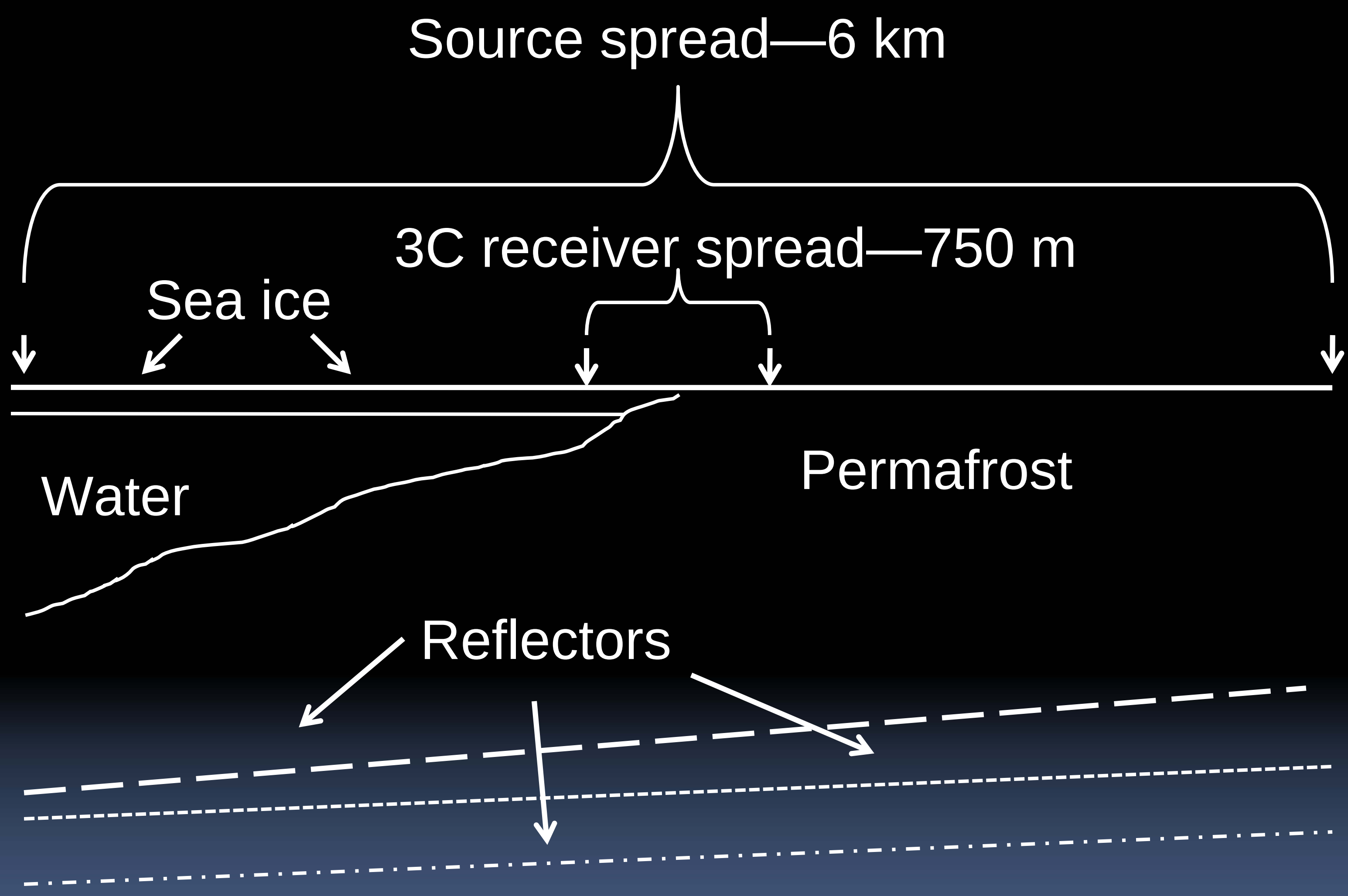
Statics deconvolution

$$\hat{\mathrm{T}}_{\alpha\beta}(t) = \sum_{k=1}^{N} \left[\mathrm{T}_{k\alpha}(-t) * \mathrm{T}_{k\alpha}(t) \right] * \mathrm{T}_{k\beta}(t)$$

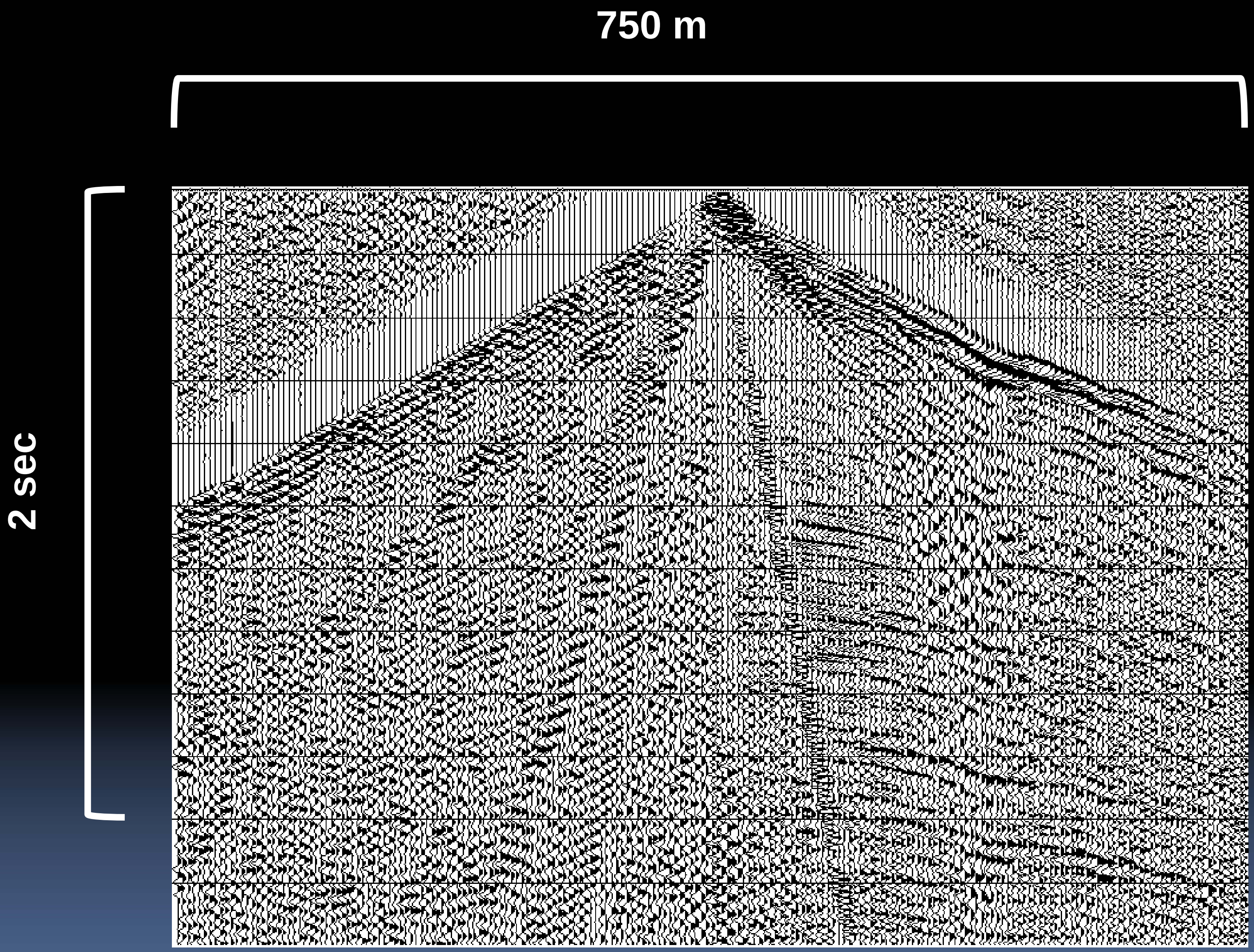
Seismic interferometry

Hansen Harbour field example

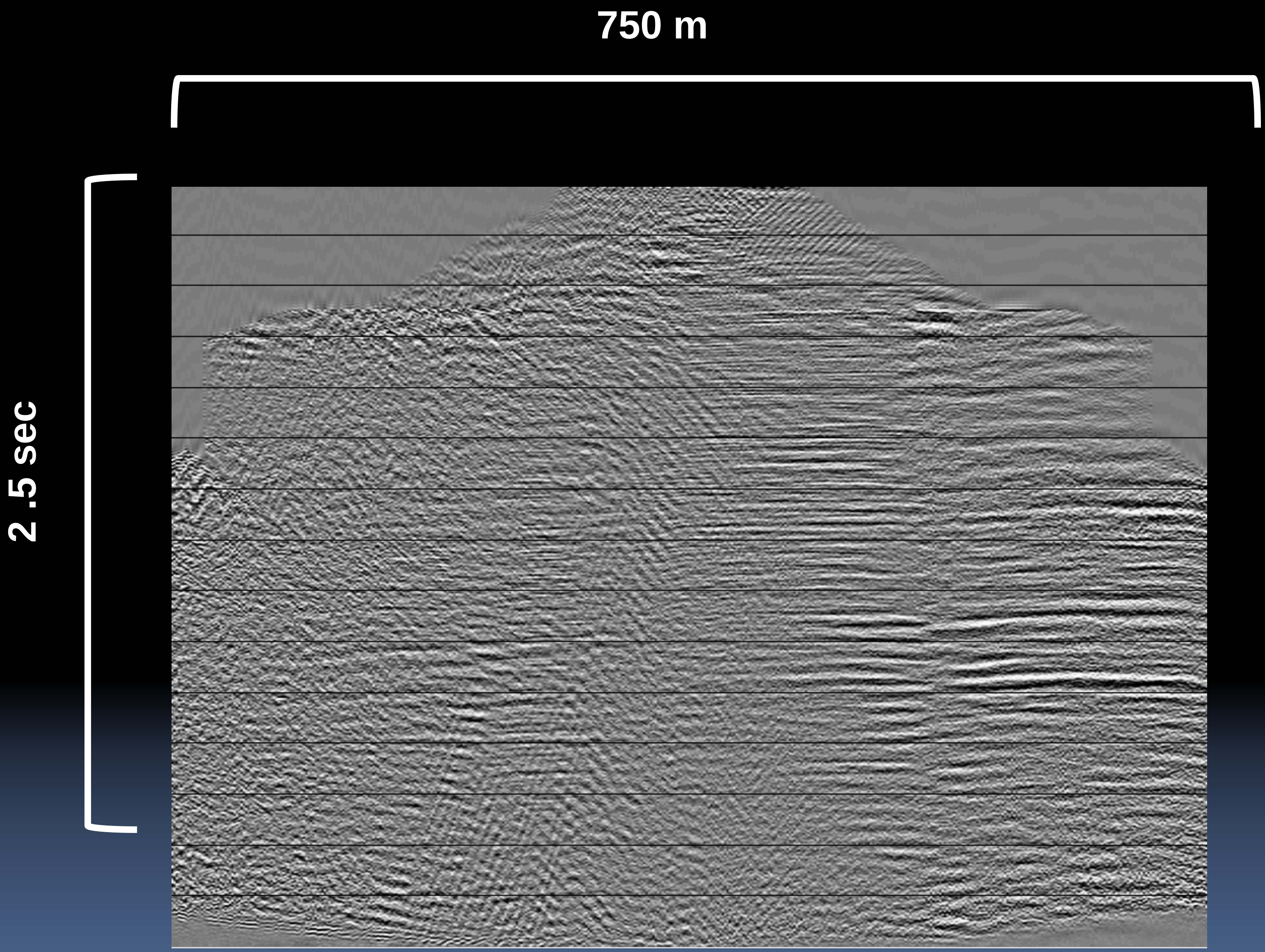
- Receiver spread only **50 stations** **(15m interval)**, no appreciable surface functions
- Source spread **200 stations** **(30m interval)**, visible variations in coupling, statics
- Raw receiver gathers show source statics and coupling variations, as well as coherent noise



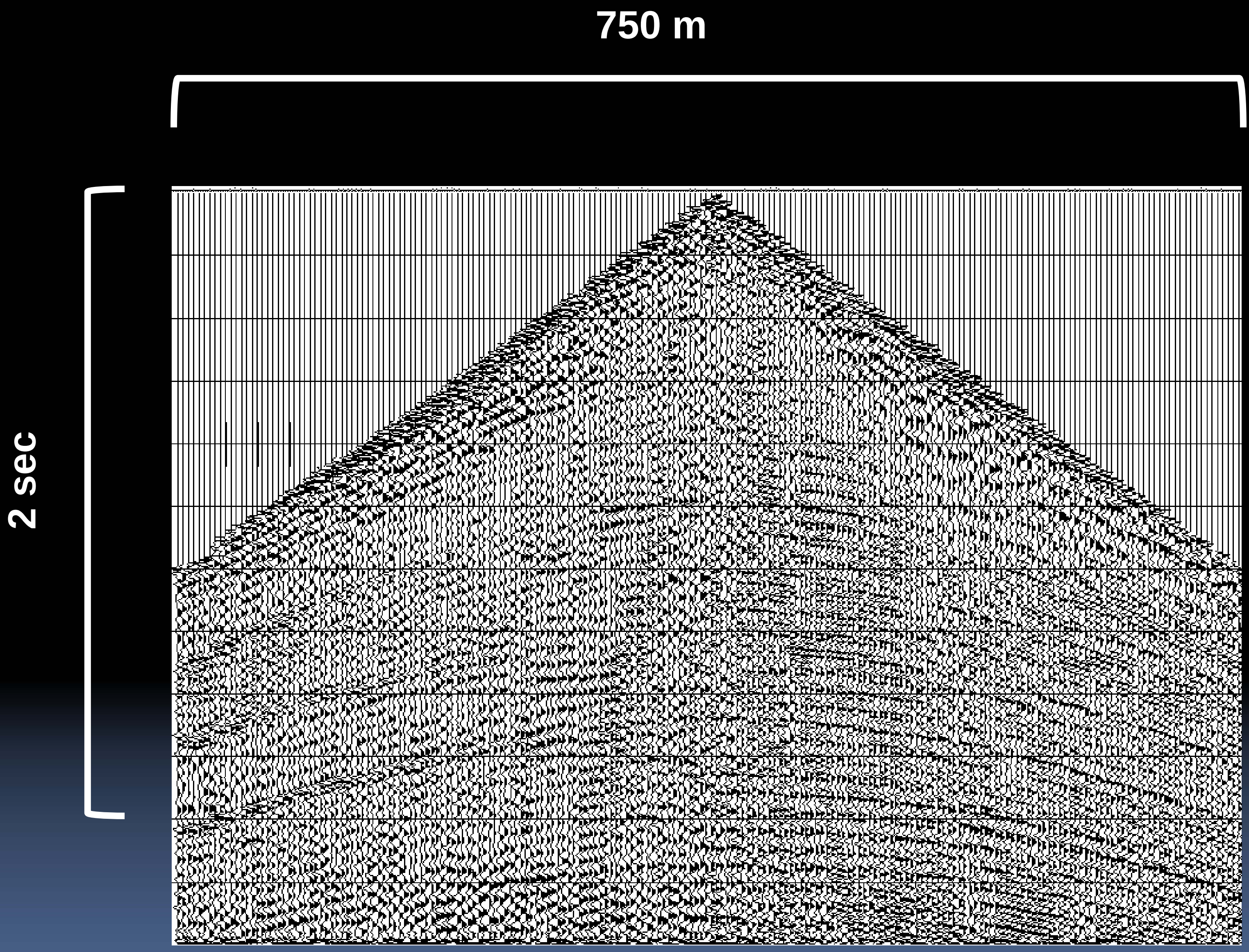
Hansen Harbour 3C seismic line geometry



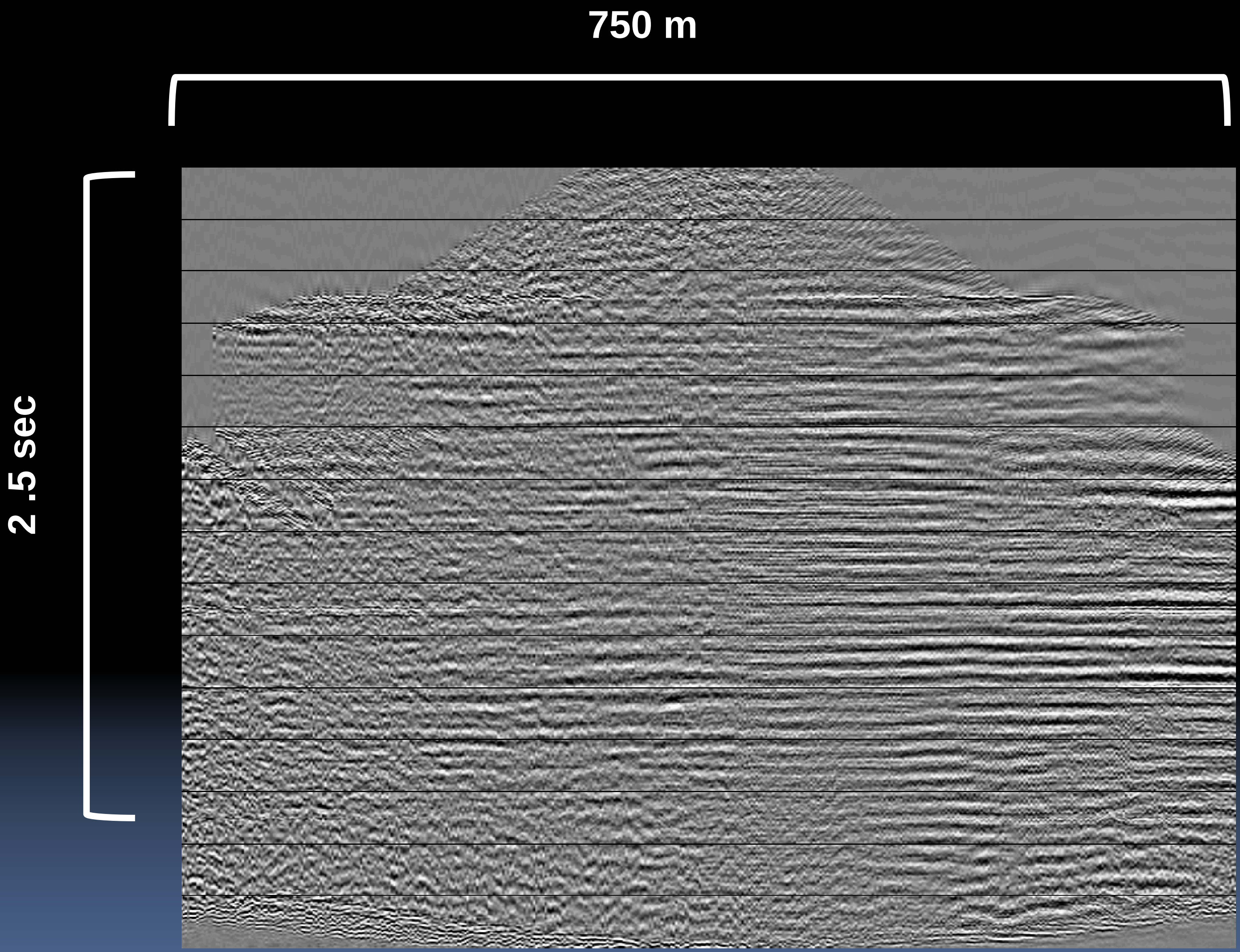
Hansen Harbour receiver gather, bandpass, AGC



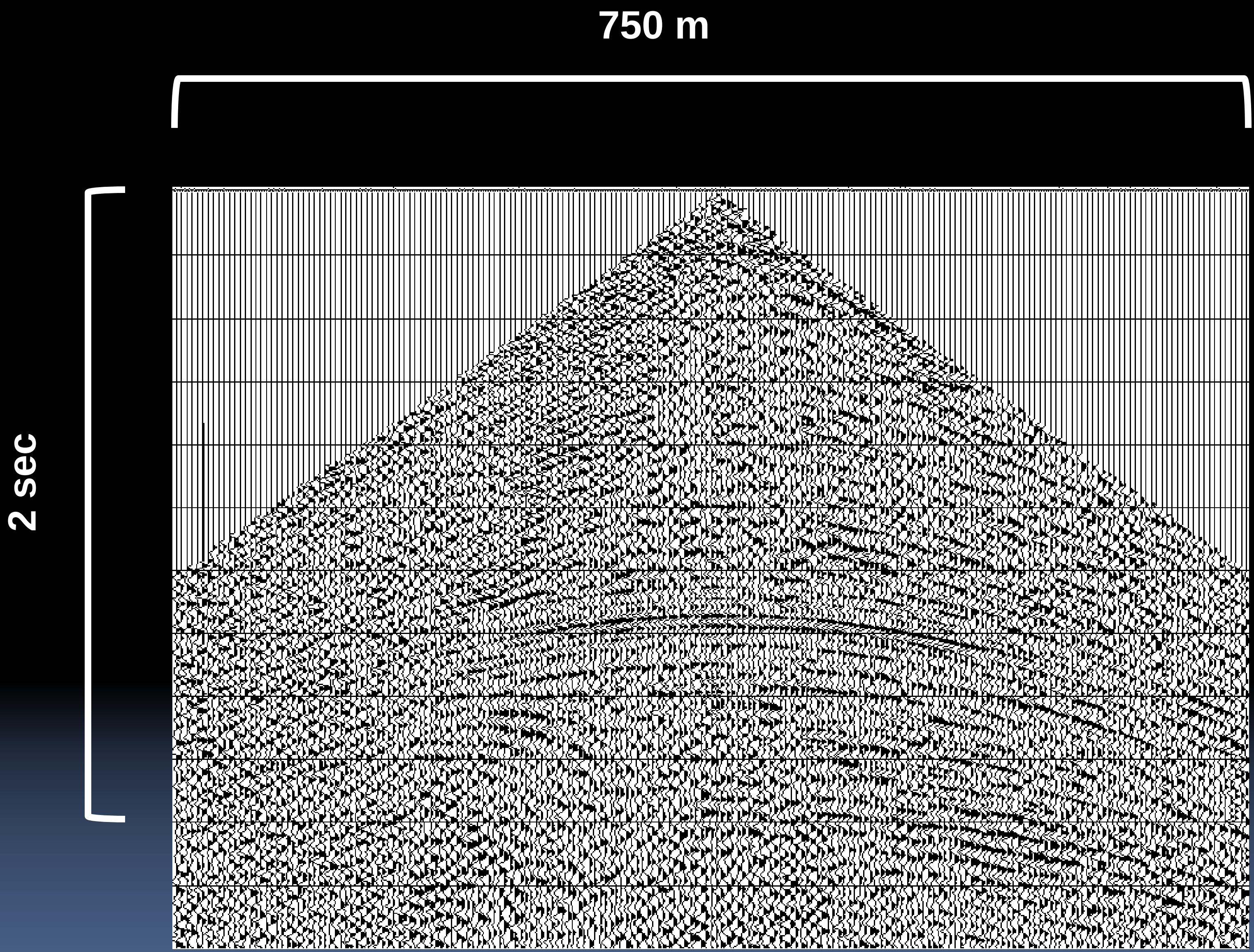
Hansen Harbour stack—no filtering, no statics



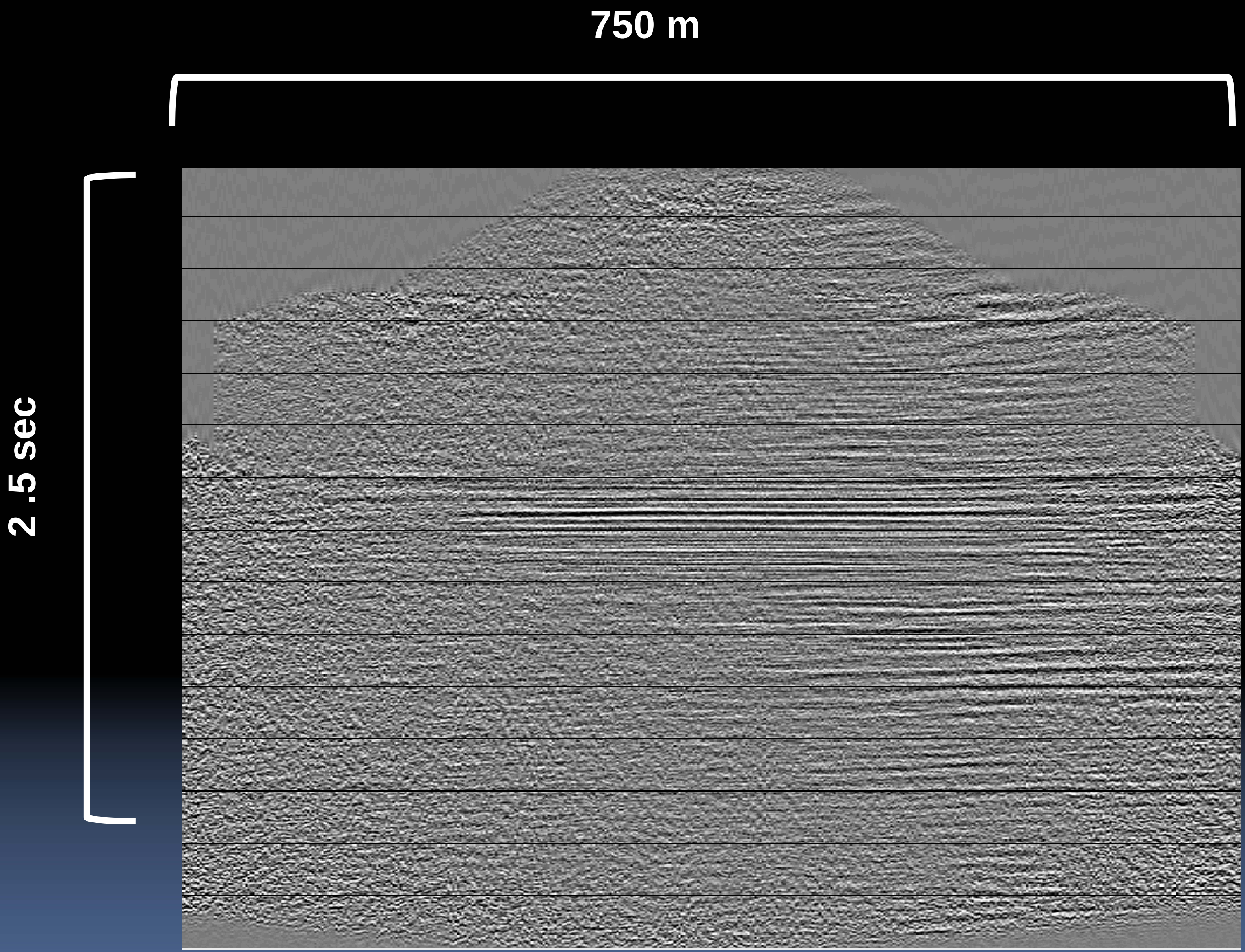
Hansen Harbour receiver gather after **coherent noise attenuation** and **statics deconvolution**



Hansen Harbour stack—**coherent noise attenuated**, **statics deconvolved**



Hansen Harbour **virtual receiver gather** from raw traces, **no noise attenuation**



Hansen Harbour stack—**virtual receiver gathers**,
no noise attenuation

Conclusions and conjectures

- **Statics deconvolution** and **interferometry** obviously ***similar*** in their effects
- **Cross-correlation** or **match-filtering** is the key to removing phase effects of surface functions
- ***Coherent noise attenuation an unexpected benefit of interferometry***
- Further exploration of interferometry for correcting surface effects is warranted

Acknowledgements

- The authors wish to acknowledge the support of CREWES sponsors