Processing and analysis of Hussar data for low frequency content

J. Helen Isaac, Gary F. Margrave,
Monika Deviat[1] and Pam Nagarajappa[1]

CREWES

1 CGGVERITAS

Outline

- Brief review of seismic data acquisition at Hussar
- Phase-coherence analysis of stacked seismic data
- Summary

Purpose

- Investigate acquisition of data with low frequency content
- Investigate processing of data to enhance low frequencies
- Ultimate use is in Full Waveform Inversion

Data acquisition

Sources

INOVA 364 vibroseis	custom low-dwell sweep: 1 to 100 Hz	20 m
INOVA 364 vibroseis	linear sweep: 1 to 100 Hz	20 m
Eagle Failing vibroseis	custom low-dwell sweep: 1 to 100 Hz	20 m
Dynamite	2 kg at 15 m depth	20 m

Receivers

448 ARAM SM7	10 Hz 3C geophones	10 m
224 Sunfull	4.5 Hz 1C geophones	20 m
448 Vectorseis	3C accelerometers	10 m

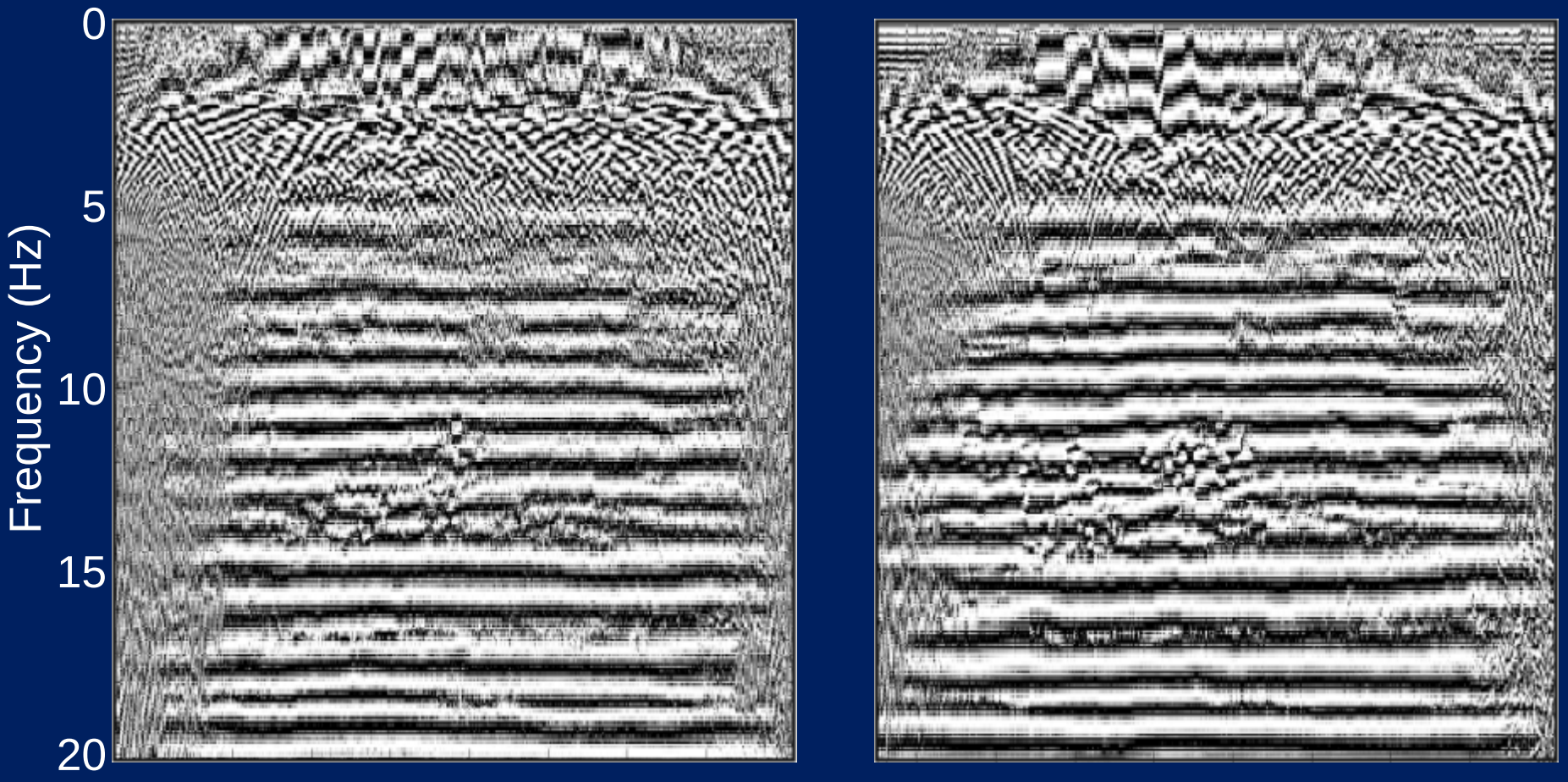
Data analysis by f-x phase-coherence

- Traces within a time window are Fourier transformed from time to frequency domain, giving the f-x spectrum
- Sine and cosine of f-x phase are plotted as consecutive samples for each frequency
- Plot of f-x phase shows spatial coherence where signal dominates
- Examine data for low frequency signal content (<20 Hz)

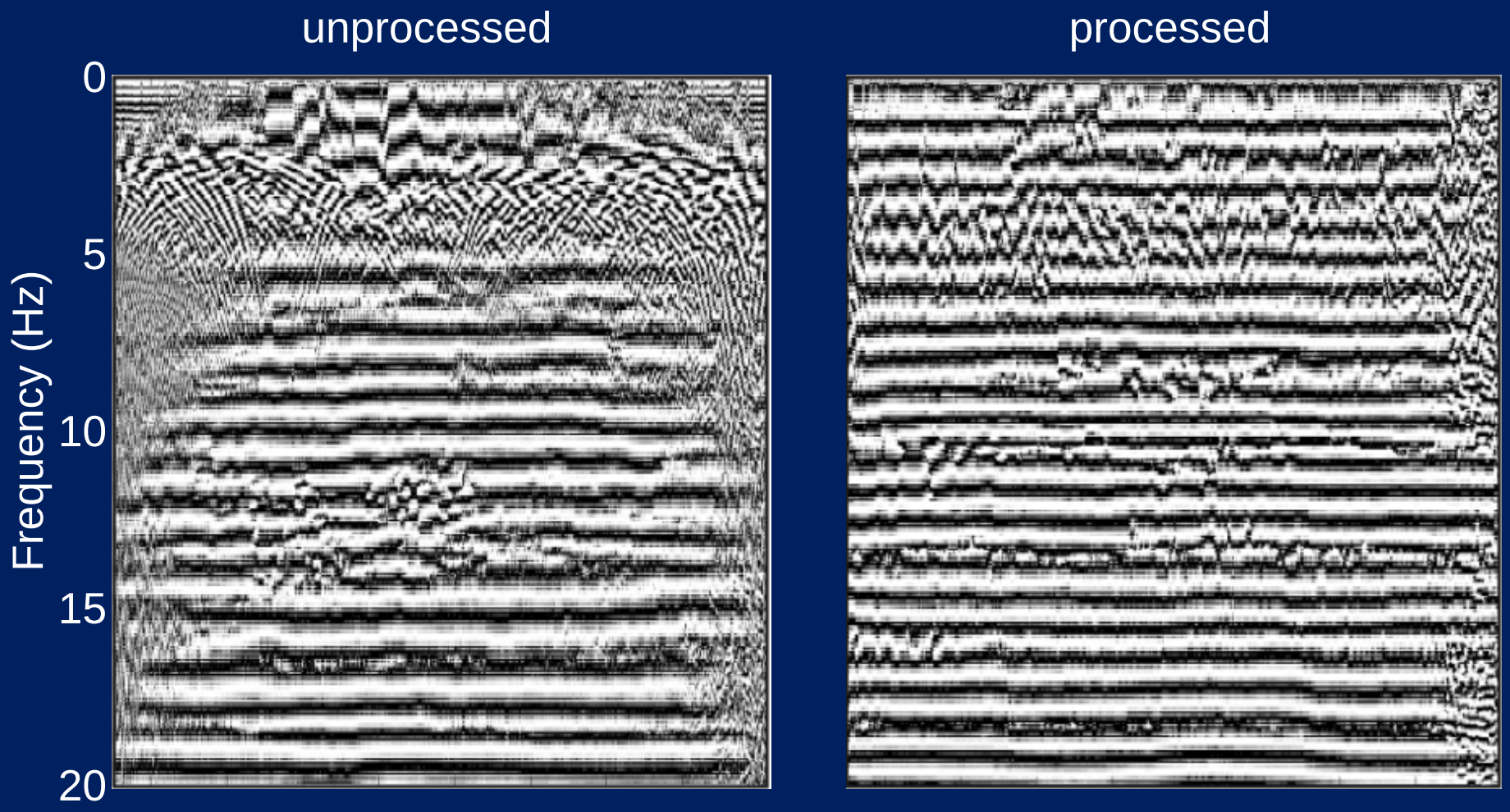
Stacked unfiltered data

vibroseis

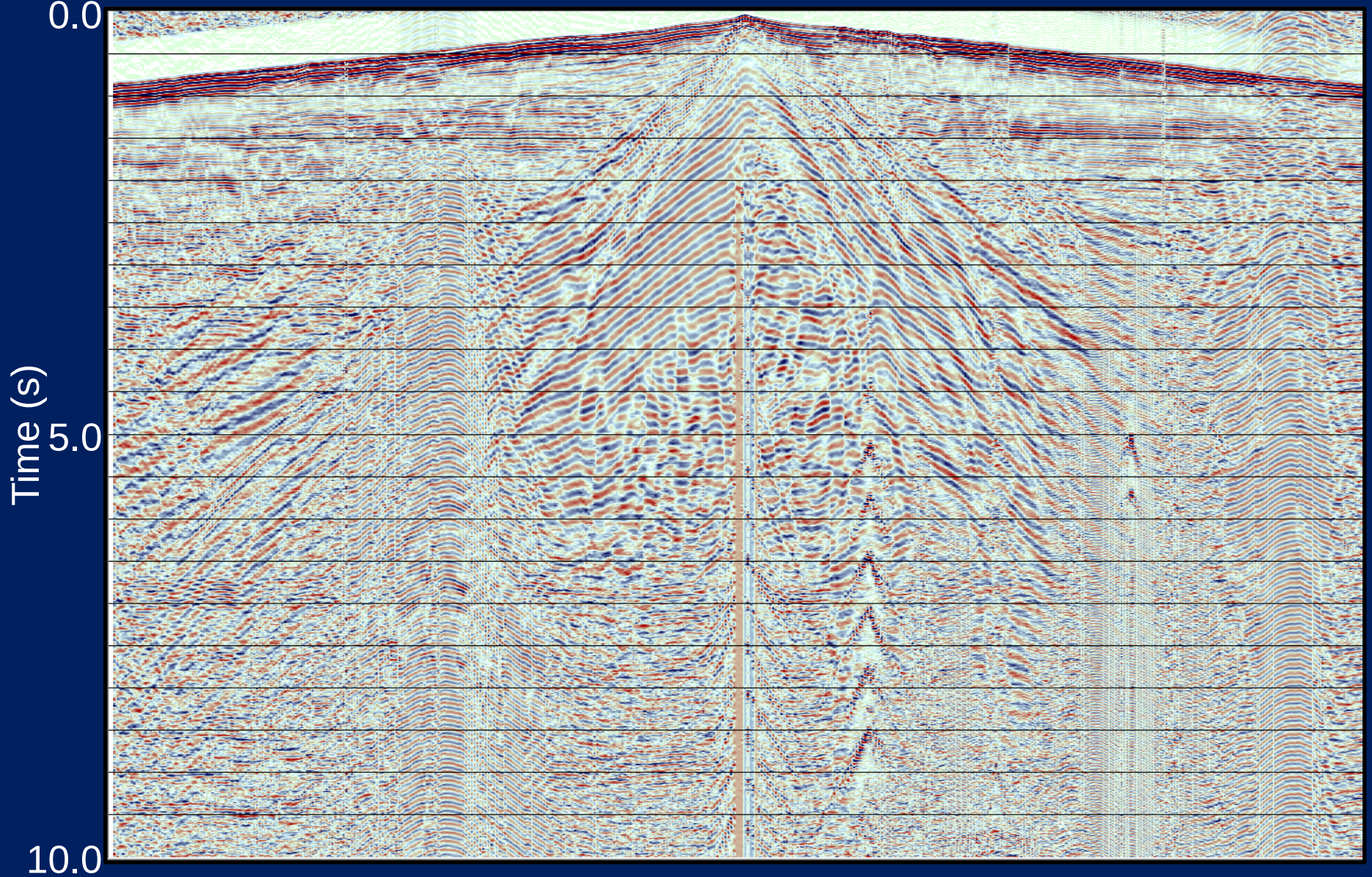
dynamite



Stacked dynamite data



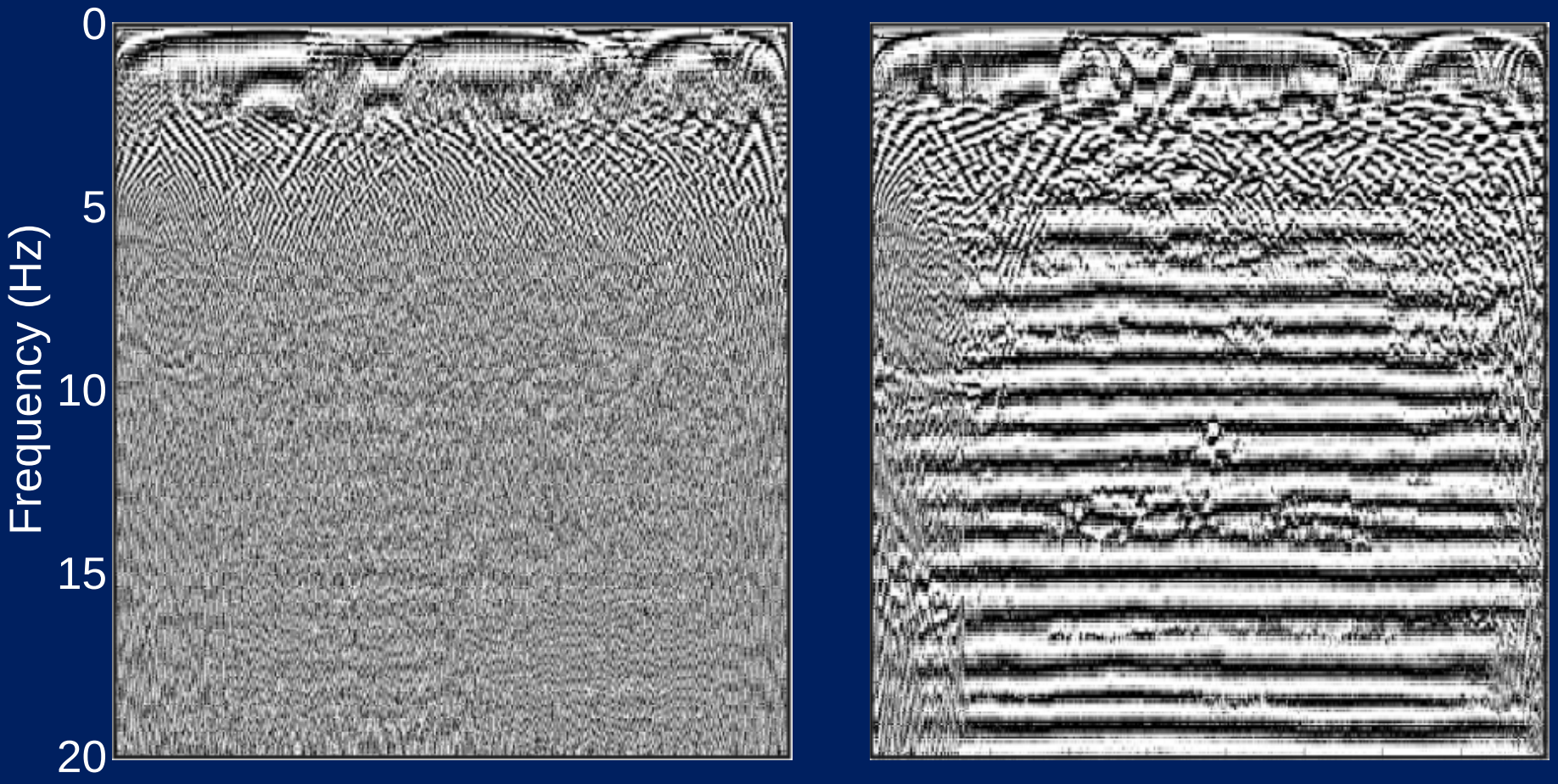
Shot gather



Stacked vibroseis data

ground roll only

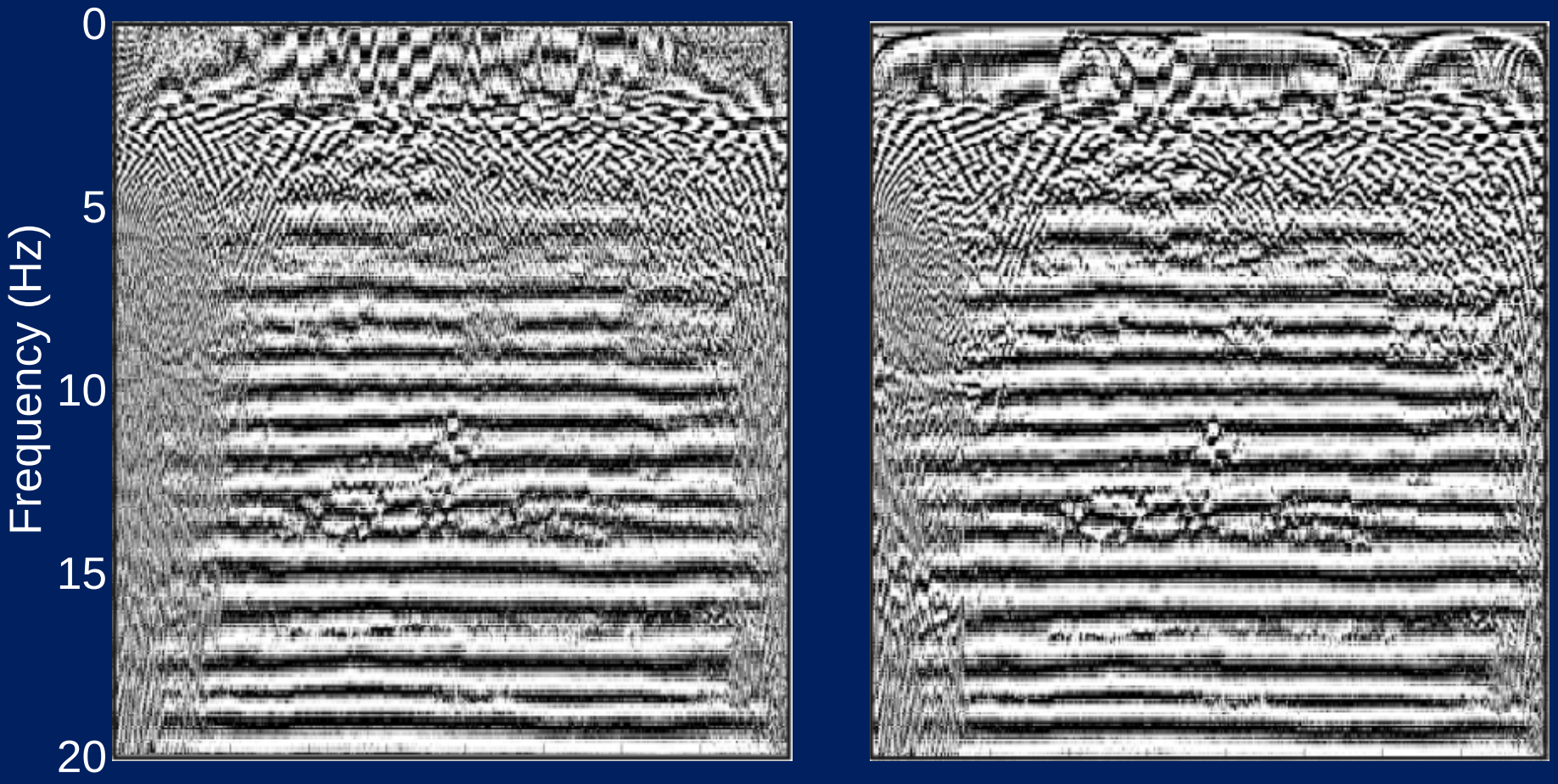
ground roll removed



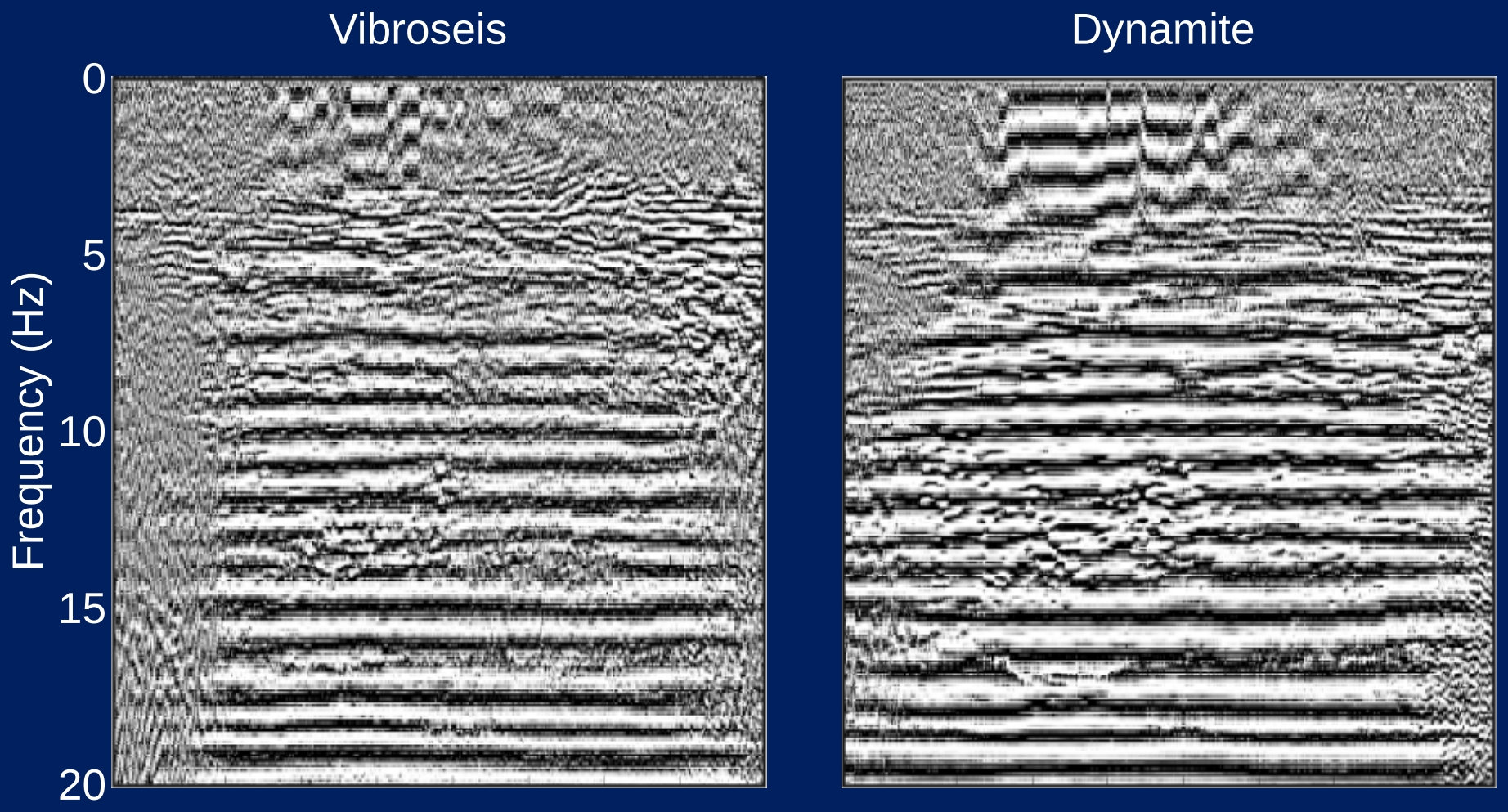
Stacked vibroseis data

before ground roll removal

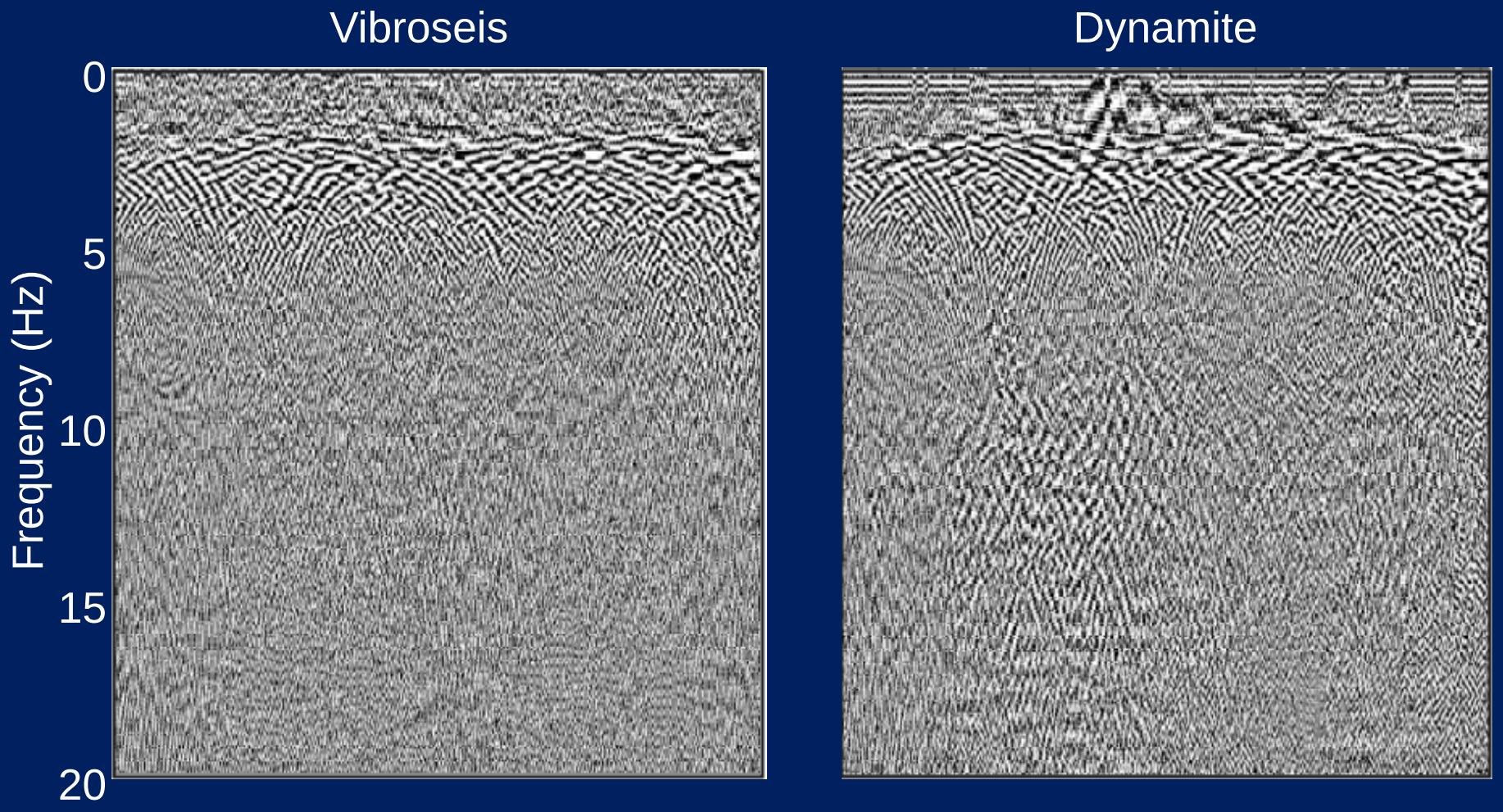
ground roll removed



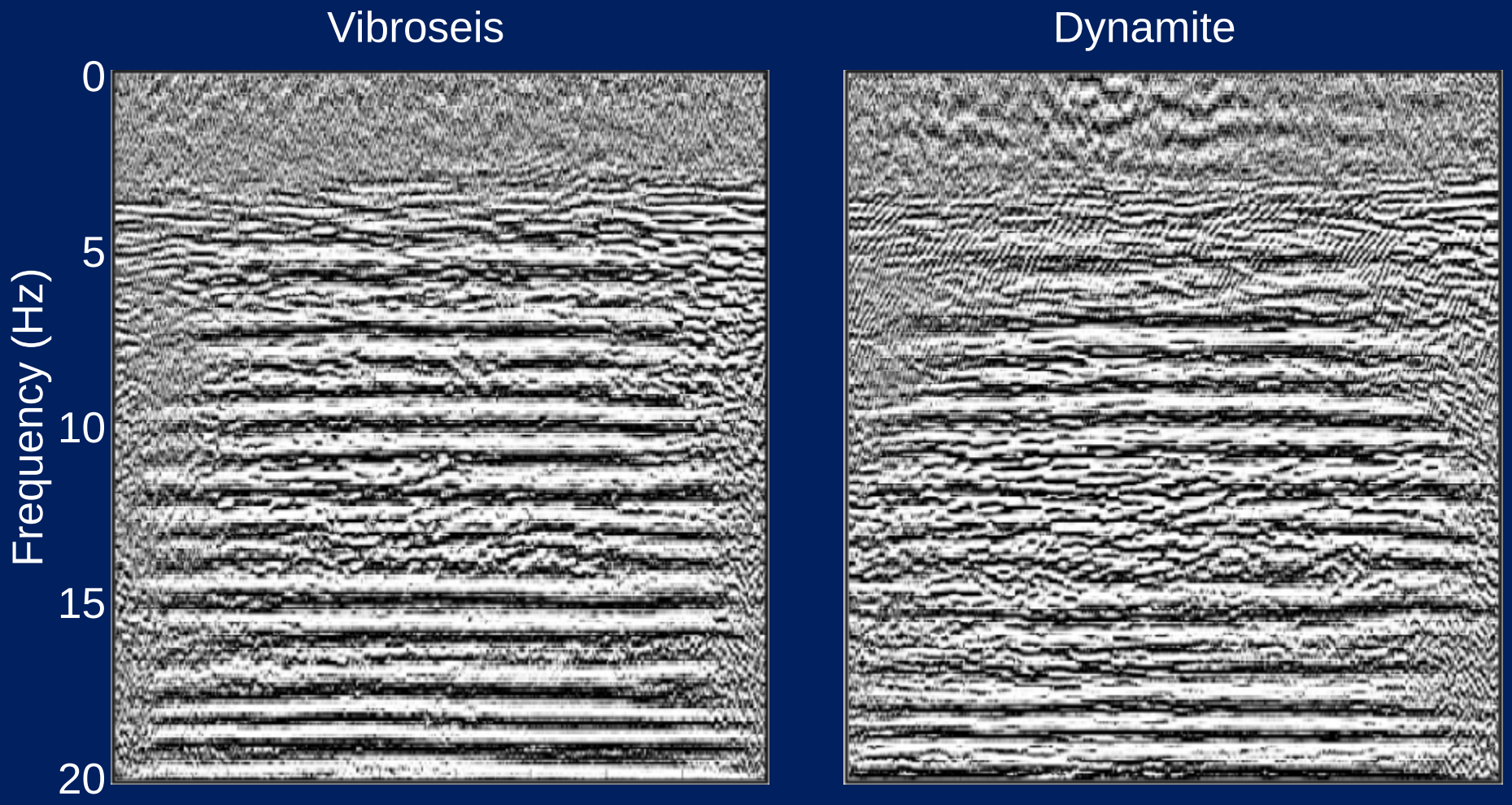
Stacked radial filtered data



Stacked difference between unfiltered and radial filtered data



Stacked radial filtered and Gabor deconvolved data



CGGVeritas processing

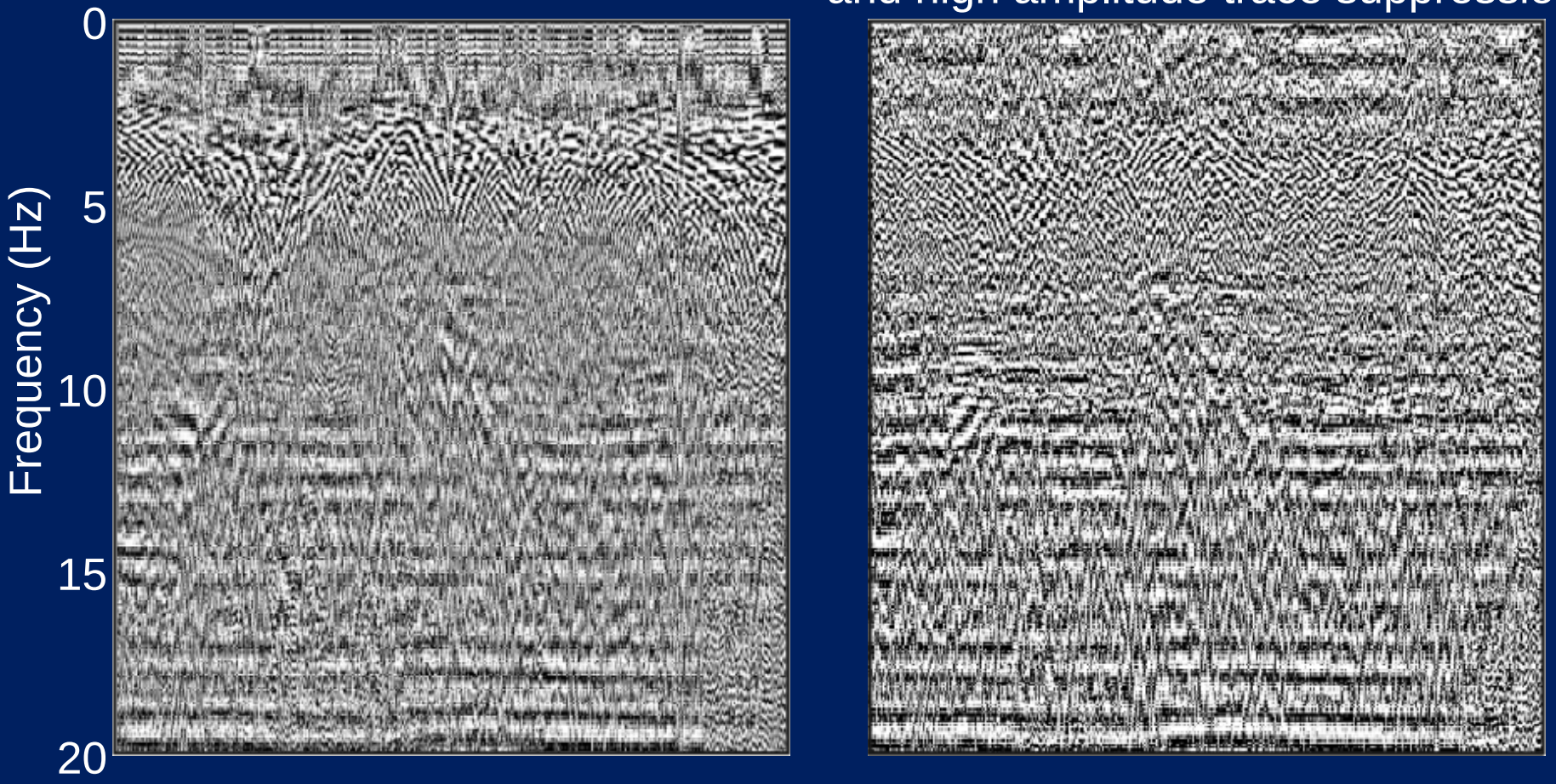
- Sinusoid removal
- High amplitude trace suppression
- Coherent noise attenuation
- Surface consistent scaling
- Spiking deconvolution
- Noise attenuation by semblance weighted dip filter
- Scaling of high amplitude, low frequency noise
- Elimination of high frequency chatter
- Spectral balancing

- Different pre-stack NMO mutes
- Stack with and without prestack AGC
- Geophone instrument response compensation

Stacked dynamite data

after sinusoid removal

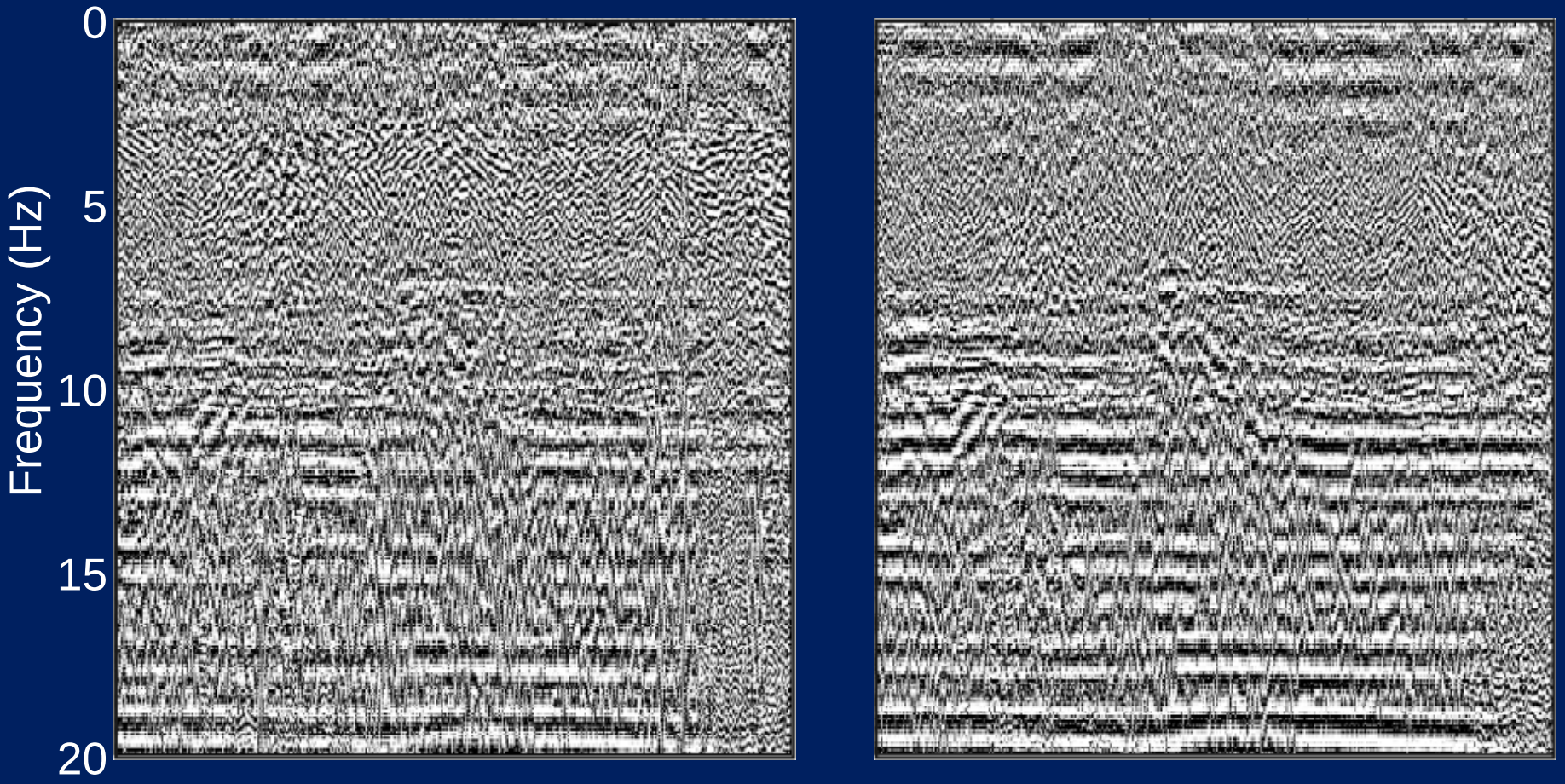
...and coherent noise attenuation
and high amplitude trace suppression



Stacked dynamite data

...and spiking deconvolution

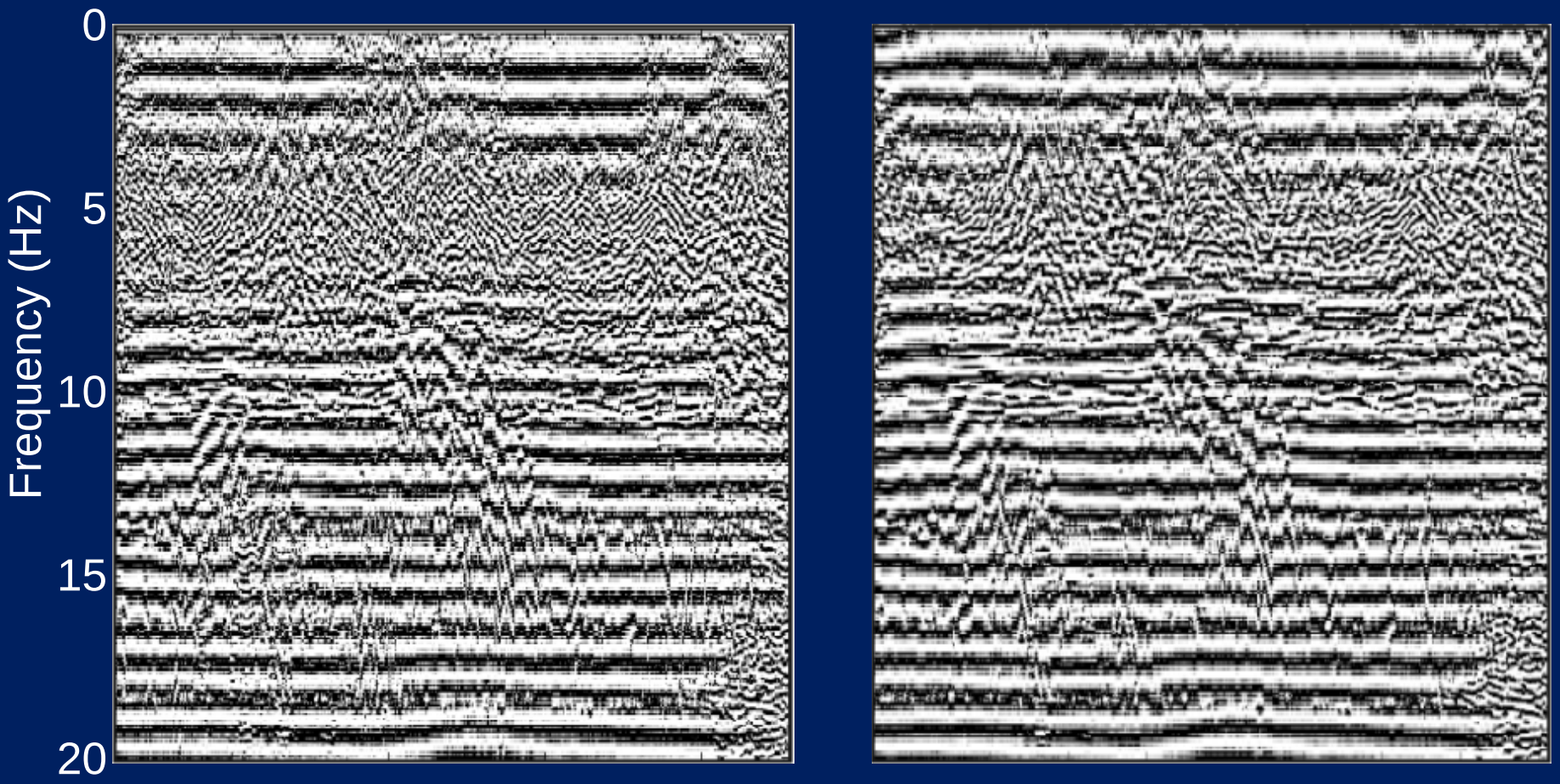
...and further coherent noise attenuation



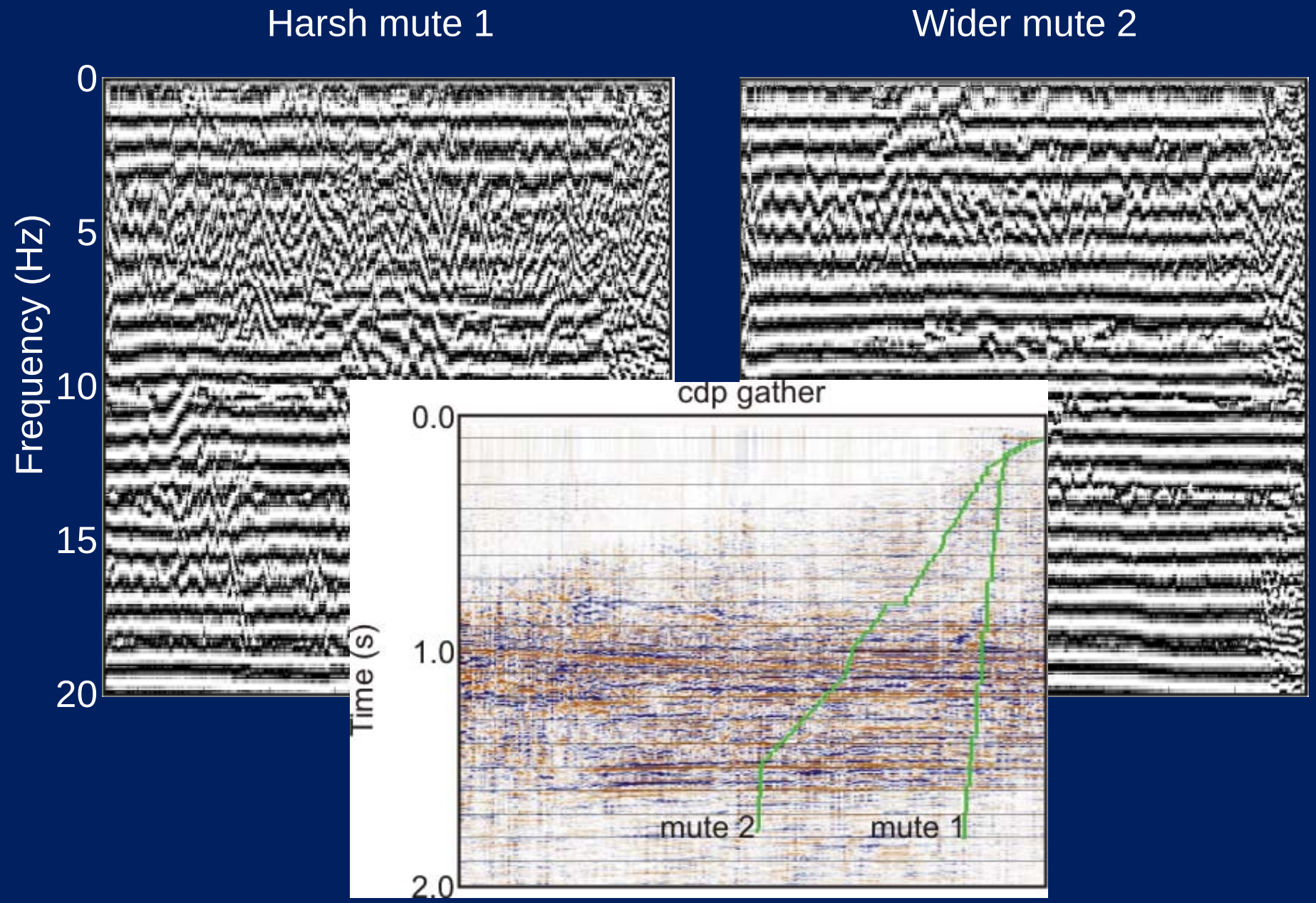
Stacked dynamite data

...and further noise attenuation

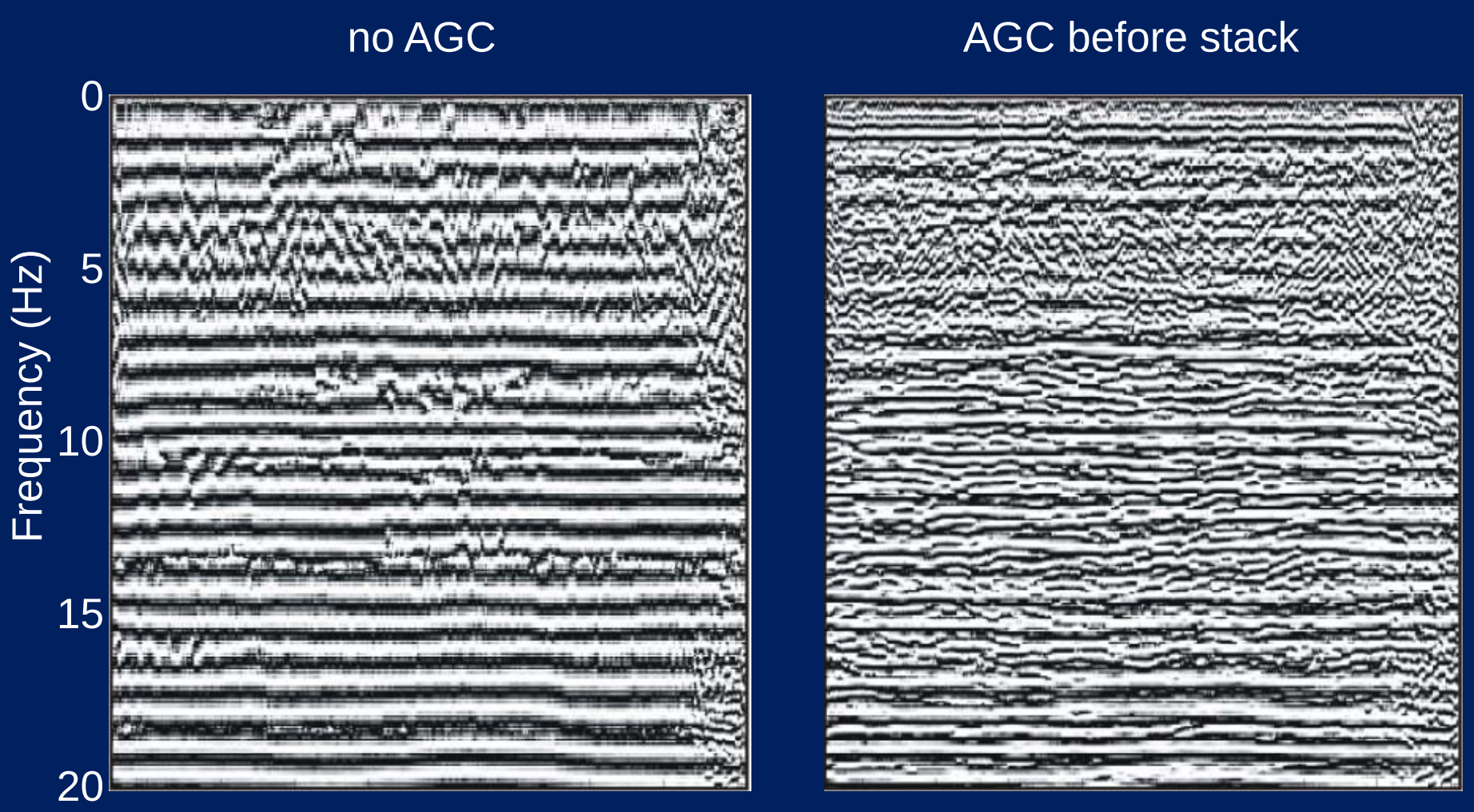
...and final processing



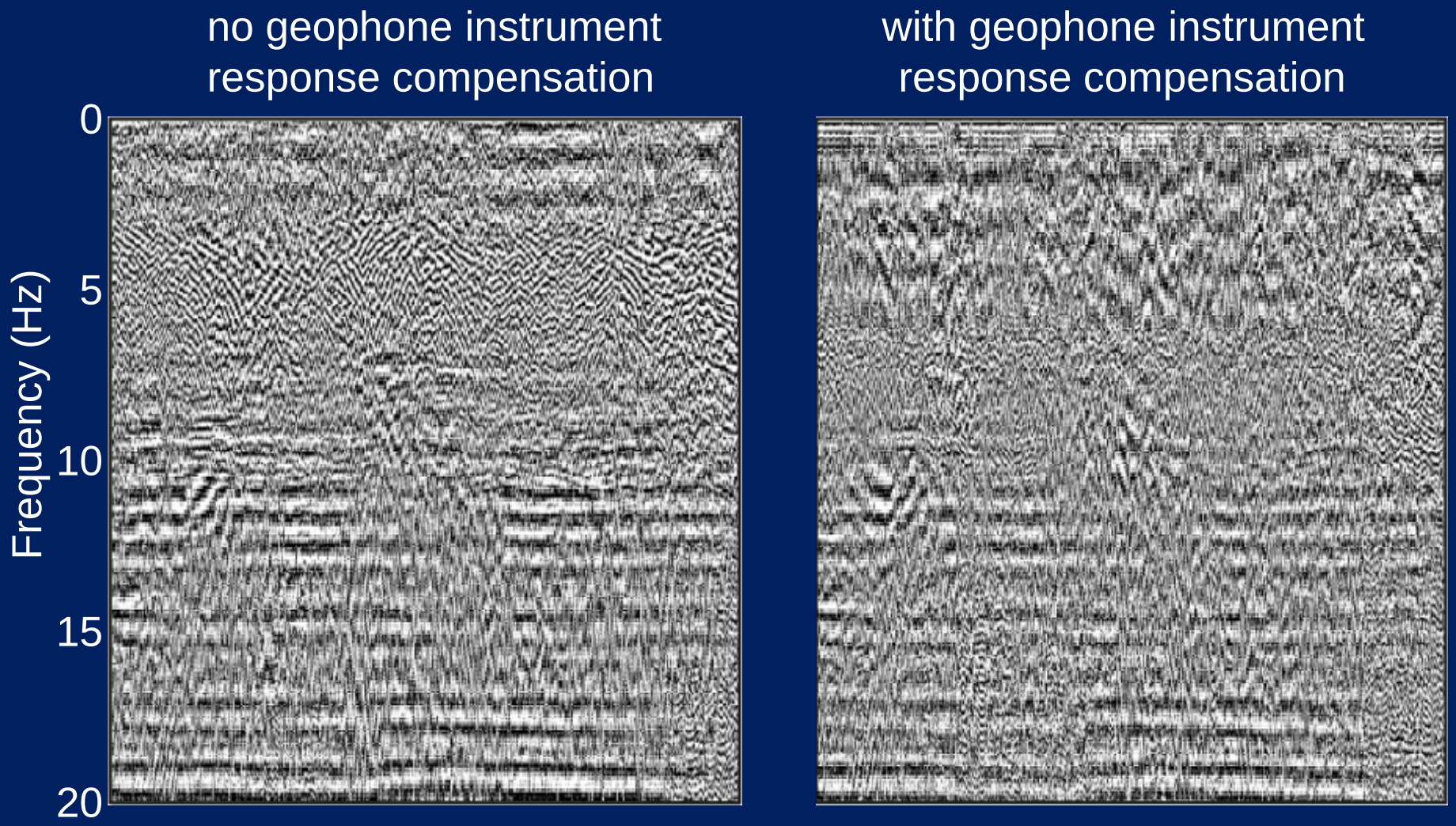
Stacked dynamite data



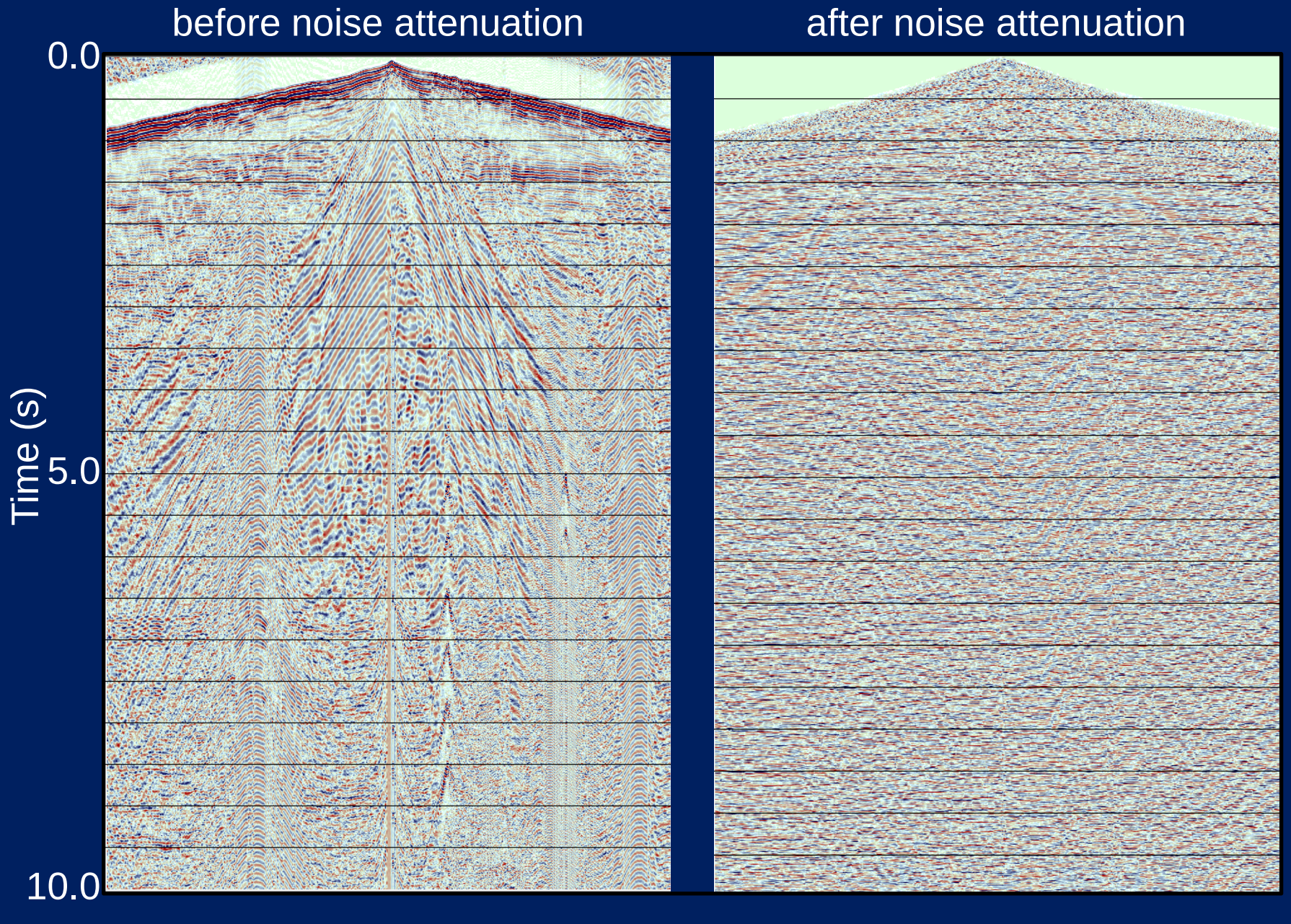
Stacked dynamite data



Stacked dynamite data



Shot gather


before noise attenuation
after noise attenuation
0.0
5.0
10.0
Time (s)

Summary

- The Hussar experiment successfully recorded low frequency signal in the data
- Coherent events at low frequencies appear on phase-coherency plots after noise attenuation
- Little things make a big difference to the analysis: Mute, AGC
- Geophone instrument response compensation does not appear to make a significant difference

Acknowledgements

- CREWES sponsors
- Contributors to the Hussar experiment: Husky, Geokinetics, INOVA, ION-Sensor
- CGGVeritas
- Carbon Management Canada
- Landmark Graphics