

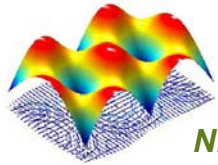
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Northwest Electromagnetics &
Acoustics Research

Overview

- **Use ambient noise in ocean to determine environmental parameters**
 - Seabed depth
 - Sub-bottom sediment layering & properties
- **Sponsor: ONR (Office of Naval Research)**
- **People**
 - Dr Martin Siderius (Associate Professor)
 - John Gebbie (PhD research assistant)
 - Lanfranco Muzi (PhD research assistant)
 - Joel Paddock (B.S. student)



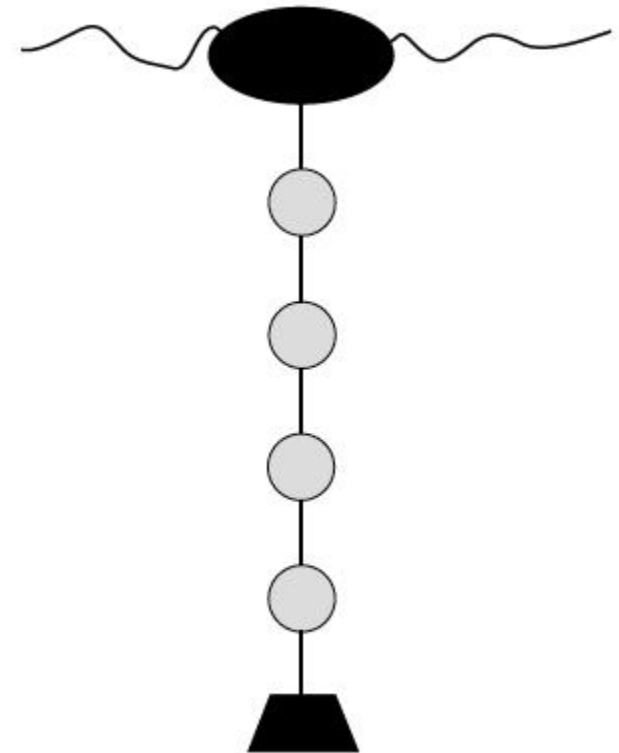


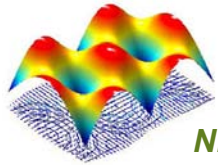
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Vertical Line Array

- **32 elements**
- **.18 m spacing**
- **12 kHz sampling**
- **Buoyed at surface, but depth adjustable**
- **Drifting**



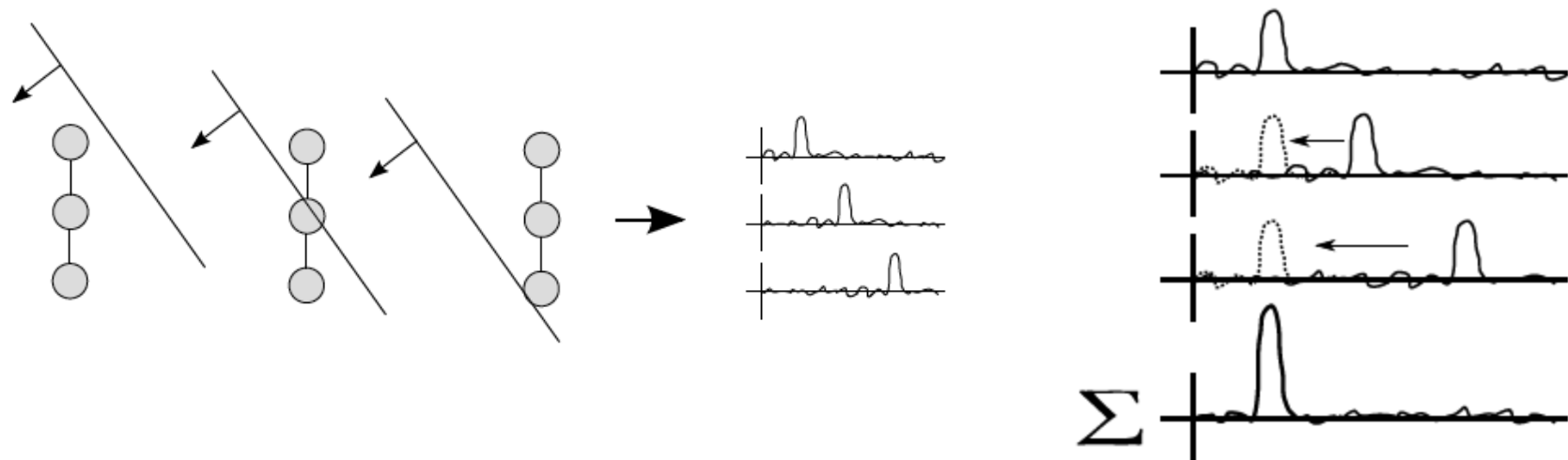


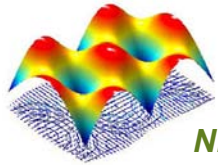
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Conventional Beamforming

- Delay-and-sum
- Increase gain in certain direction



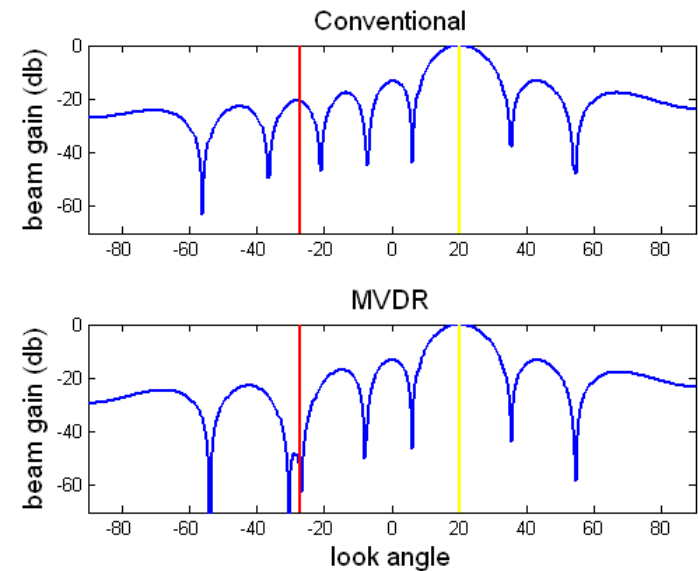
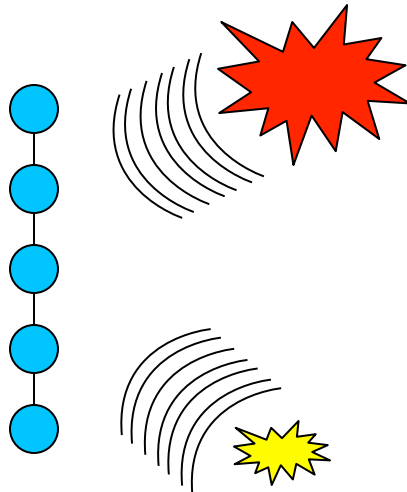


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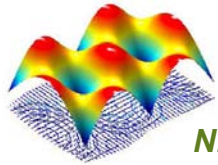
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MVDR Adaptive Beamforming

- MVDR drives a NULL to reduce off-look-angle noise sources
- K is cross-spectral density matrix



$$\hat{W}_{mvdr} = \frac{K^{-1} \hat{W}_c}{\hat{W}_c^+ K^{-1} \hat{W}_c}$$



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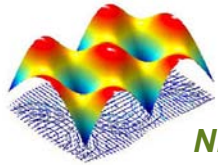
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WNGC Adaptive Beamforming

- **White Noise Gain Constraint**
- **Helps deal with**
 - **Mismatch (small errors in array geometry)**
 - **Snapshot deficiency (causes cross spectral density matrix to be less than full rank)**

$$\hat{W}_{wngc} = \frac{[K + \epsilon I]^{-1} \hat{W}_c}{\hat{W}_c^+ [K + \epsilon I]^{-1} \hat{W}_c}$$





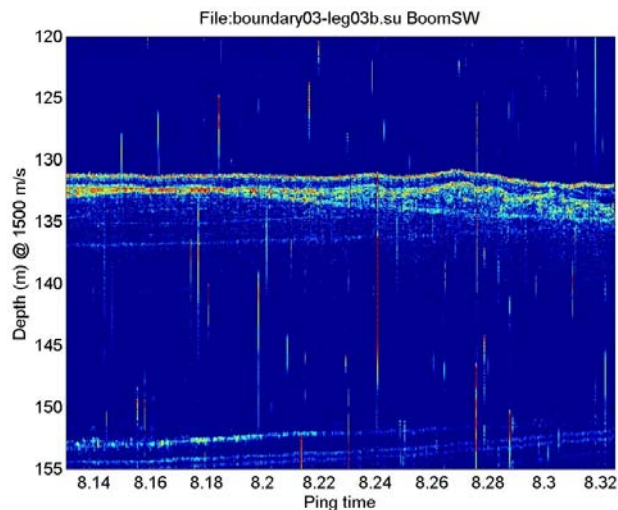
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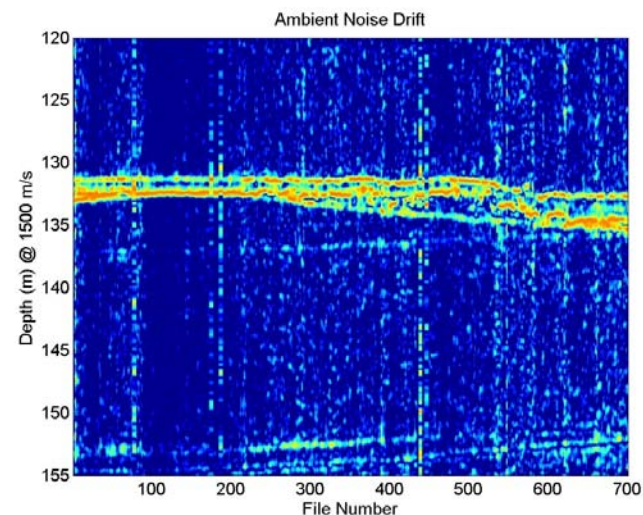
Coherent 90° Results

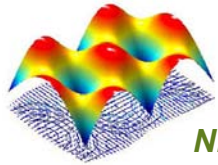
- At $\pm 90^\circ$, reflections from seabed are coherent with noise at surface
- Can cross-correlate to obtain seabed impulse response
- Comparison to active sonar (different data)

Active sonar (left)



Ambient noise (right)





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Publications

- M. Siderius, H. Song, P. Gerstoft, W. S. Hodgkiss, P. Hursky, and C. Harrison, "Adaptive passive fathometer processing," *The Journal of the Acoustical Society of America*, vol. 127, no. 4, pp. 2193-2200, April 2010. [Online]. Available: <http://dx.doi.org/10.1121/1.3303985>
- M. Siderius, C. H. Harrison, and M. B. Porter, "A passive fathometer technique for imaging seabed layering using ambient noise," *The Journal of the Acoustical Society of America*, vol. 120, no. 3, pp. 1315-1323, September 2006. [Online]. Available: <http://dx.doi.org/10.1121/1.2227371>
- P. Gerstoft, W. S. Hodgkiss, M. Siderius, C.-F. Huang, and C. H. Harrison, "Passive fathometer processing," *The Journal of the Acoustical Society of America*, vol. 123, no. 3, pp. 1297-1305, March 2008. [Online]. Available: <http://dx.doi.org/10.1121/1.2831930>
- C. H. Harrison and M. Siderius, "Bottom profiling by correlating beam-steered noise sequences," *The Journal of the Acoustical Society of America*, vol. 123, no. 3, pp. 1282-1296, March 2008. [Online]. Available: <http://dx.doi.org/10.1121/1.2835416>
- M. Siderius, H. Song, P. Gerstoft, W. S. Hodgkiss, P. Hursky, and C. Harrison, "Adaptive passive fathometer processing," October 2009.

