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Research Interests: Acoustic propagation modeling with application to infrasound and hydroacoustics; application of hydroacoustics and infrasound to nuclear test-ban verification and hazard monitoring; use of dense seismic networks to analyze infrasound signals.

Infrasound: A primary goal in infrasound research is to understand the transmission of infrasound - sound at frequencies lower than human hearing - to distances of several hundreds to thousands of kilometers.

Shockwaves: de Groot-Hedlin is sole-PI on a project to develop numerical methods to compute the propagation of nonlinear acoustic waves through the atmosphere – this nonlinearity arises when pressure perturbations associated with acoustic waves are a significant fraction of the ambient atmospheric pressure; such situations can arise from meteoroid explosions in the upper atmosphere or man-made explosions.

Infrasound observations at dense seismic networks: de Groot-Hedlin is currently collaborating with other members of the Laboratory for Atmospheric Acoustics (L2A) at UCSD to analyze infrasound signals detected at a dense network of seismic stations operated by the USarray. An analysis of infrasound signals from the re-entry of the space shuttle Atlantis was presented in de Groot-Hedlin et al. (2008a). Currently, the L2A group is working on the analysis of infrasound signals at this network generated by explosions at the Utah Test and Training Range (UTTR), see Figure 1.

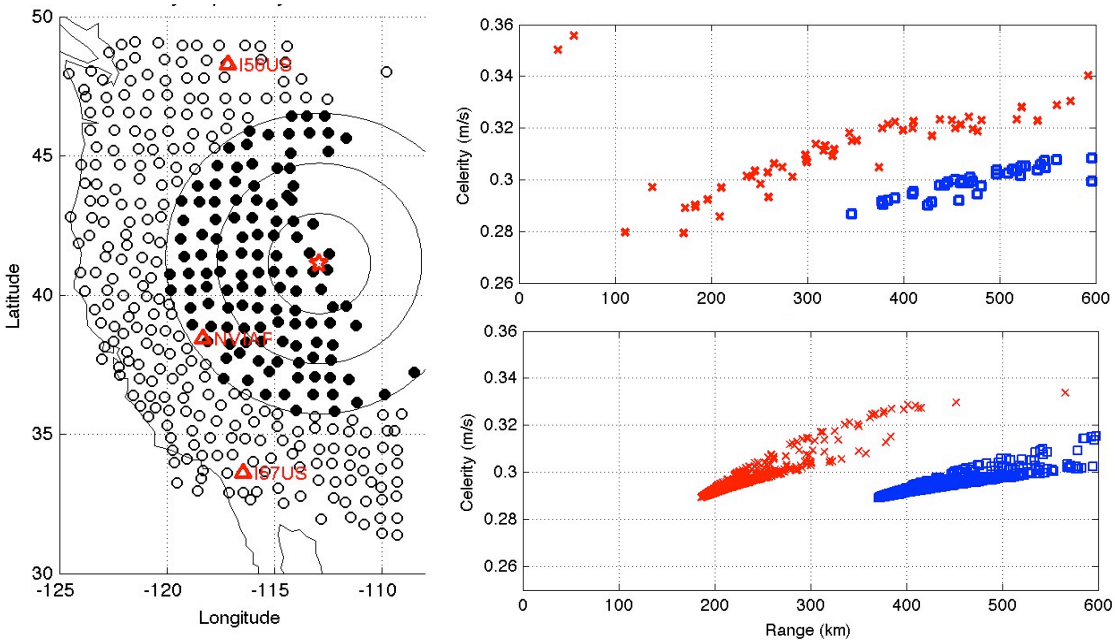

Figure 1. (left) A map of the configuration of the USarray seismic network in June 2007 (circles), also showing the source location (diamond) and sites of infrasound arrays (triangles). Signals at sites within 600 km of the source (dark circles) were analyzed. (right top) Observed celerities (=horizontal range/time). (right bottom) Predicted celerities.

The presence of the transportable USArray in this region provides this study with a much broader and denser array of sensors than would otherwise be available. Arrival times, predicted using standard atmospheric specifications that give variations in wind and sound speed with altitude, indicate that the arrivals are mulit-pathed; the earlier arrivals are ducted within the thermosphere, later ones are refracted within the stratosphere. An unexplained observation is the presence of high frequency infrasound arrivals, near the acoustic frequency band. This suggests that propagation may be non-linear at upper altitudes, where non-linear steepening of the sound waves can take place to maintain the higher acoustic frequencies. Propagation algorithms to explain this phenomenon are under development.

Hydroacoustics: Work is continuing on the analysis of hydroacoustic data recorded on hydrophones that comprise part of the global International Monitoring System (IMS) network. In the past, data from IMS hydrophones has been used to investigate the generation of ocean-borne sound waves by submarine earthquakes (de Groot-Hedlin and Orcutt, 1999 and 2001), the rupture of the 2004 Great Sumatran rupture, that released a devastating tsunami (de Groot-Hedlin, 2005), as well as a series of investigation into long-range acoustic propagation in the Indian Ocean (Blackman *et.al.,* 2004) and through the Antarctic Circumpolar Current (de Groot-Hedlin *et.al.,* 2009).

Relevant Publications

de Groot-Hedlin, C.D., and J.A. Orcutt, 1999, Synthesis of earthquake-generated T-waves, *Geop. Res. Lett.,* 26, 1227-1230.

de Groot-Hedlin, C.D., and J.A. Orcutt, 2001, T-phase observations in northern California: Acoustic to seismic coupling at a weakly elastic boundary, *PAGEOPH,* 158, 513-530.

Blackman, D.K., C. de Groot-Hedlin, P. Harben, A. Sauter, and J.A. Orcutt, 2004, Testing low/verylow frequency acoustic sources for basin-wide propagation in the Indian Ocean*, J.Acoust. Soc. Am*., **116,** 2057-2066.

de Groot-Hedlin, C.D., M.A.H. Hedlin, K.T. Walker, D. D. Drob, and M.A. Zumberge, Evaluation of infrasound signals from the shuttle Atlantis using a large seismic network, *J. Acoust. Soc. Am.*, 124, 1442-1451, (2008a)

de Groot-Hedlin, C.D., Finite-difference synthesis of infrasound propagation through an absorbing atmosphere, *J. Acoust. Soc. Am.,* 124, 1430-1441, (2008b)

de Groot-Hedlin, C.D., D.K. Blackman, and C.S. Jenkins, 2009, "Effects of variability associated with the Antarctic Circumpolar Current on sound propagation in the ocean", *Geop. J. Int.,* 176, 478-490 (2009)

Herrin, E.T., Bass, H.E., B. Andre, R.L. Woodward, D. D. Drob, M.A.H. Hedlin, M.A. Garces, P.W. Golden, D.E. Norris, C.D. de Groot-Hedlin, K.T. Walker, C.A. L. Szurbela, R.W. Whitaker, and F.D. Shields, High-altitude infrasound calibration experiments, Acoustics Today, 4, 9-21, (2008)

Matoza, R.S., M.A. Garces, B.A. Chouet, L., D'Auria, M.A.H. Hedlin, C. de Groot-Hedlin, and G.P. Waite, 2009, "The source of infrasound associated with long-period events at Mount St. Helens", accepted by *Journal of Geophysical Research (Solid Earth)*, 114, B04305, doi:10.1029/2008JB006128.