Inverse and Predictive Modeling

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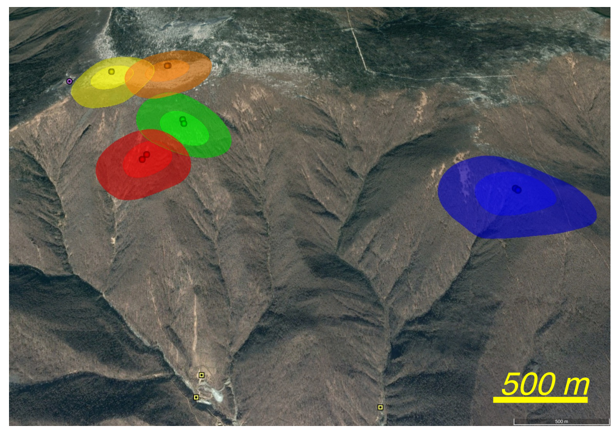
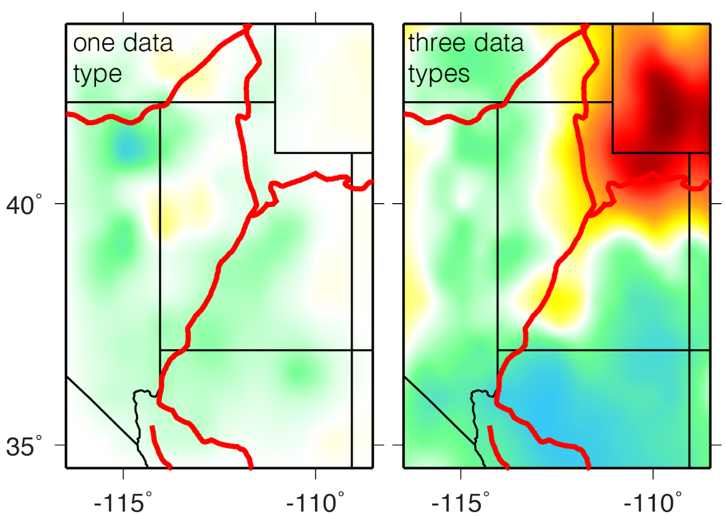
The LANL Seismoacoustics Team has a strong capability in developing data-driven models that accurately predict a variety of observations. These models range from the simple – one-dimensional models constrained by a single dataset and used for quick and efficient predictions – to the complex – multi-dimensional models constrained by several types of data and result in more accurate predictions. Team members typically build Earth models at scales of 1 to 1000s of km, and the techniques used are applicable for other types of physical characteristics at an even greater range of scales. The following cases provide a snapshot of some of the modeling work done by the Seismoacoustics Team at LANL.

Case 1: Source location determination

When an event of interest occurs, accurately determining where and when it occurred is critical to understanding the type of event and its cause. The Seismoacoustics Team employs a variety of techniques to accurately determine source locations of both natural and anthropogenic events, including those that excel in recovering accurate locations in cases of individual events and those that excel in recovering precise locations in cases of multiple neighboring events. Depending on the particular situation, inverse or grid-search methods may be employed. Future directions of research include increasing the robustness of uncertainty calculations.



Locations and associated uncertainty ellipses of five reported DPRK nuclear tests, 2006-2016.



Seismic shear-wave velocity models based on multiple datasets better recover Earth structure and geologic provinces (outlined in red) than those based on a single dataset.

Case 2: Inversion of disparate datasets

While many inversions consider one type of data to constrain a model, incorporating multiple types of data in to a single inversion can produce a model that is simultaneously consistent with all data types and accurately predicts all types of observations. This exploits the differing sensitivities of each dataset, allowing the strengths of one dataset to accommodate for the weaknesses in another. In this process, the weighting and influence of each dataset must be considered in order to understand the value of the final model. Future directions of research include expanding the types of data that can be used simultaneously, expanding the spatial scales of modeling capabilities, and moving toward exploiting signals from the full waveform.

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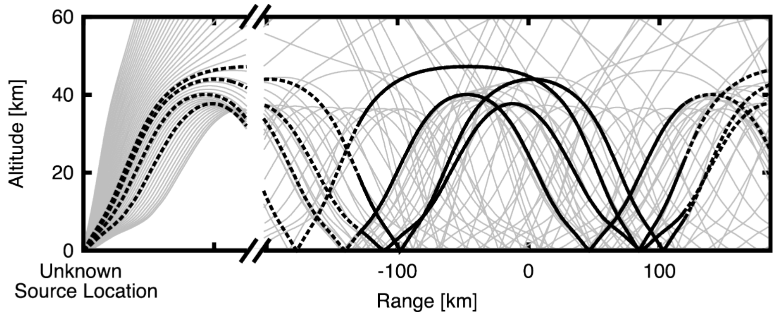
Case 3: Propagation Modeling

In many cases, the utility of a model is dependent upon the ability to accurately propagate a signal, i.e., forward model, through it. Beyond the model itself, it may be necessary to incorporate the effects of additional information on propagation, such as topography, scattering/focusing, or an imprecisely known source location. The computational time and intensity of these propagation calculations depends upon the complexity of the model, effects of additional information, and the needs of the user.



Infrasound propagation paths through the atmosphere from source at an unknown location at a known time.

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Recent Publications

Ballard, S., J. R. Hipp, **M. L. Begnaud**, C. J. Young, A. V. Encarnacao, E.P. Chael, **W. S. Phillips** (2016), SALSA3D - A tomographic model of compressional wave slowness in the earth's mantle for improved travel time prediction and travel time prediction uncertainty, *Bull. Seismol. Soc. Am*., 106, 2900-1916, doi:10.1785/0120150271.

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Cleveland, K. M., T. F. VanDeMark, C. J. Ammon (2015), Precise relative locations for earthquakes in the northeast Pacific region, *J. Geophys. Res*., 120, doi:10.1002/2015JB012161.

Nishitsuji, Y., **C. A. Rowe**, K. Wapenaar, D. Dragonov (2016), Reflection imaging of the Moon's interior using deep-moonquake seismic interferometry, *J. Geophys. Res*., 121, 695-713, doi:10.1002/2015JE004975.

Phillips, W. S., K. M. Mayeda, L. Malagnini (2014), How to invert multi-band, regional phase amplitudes for 2-D attenuation and source parameters: Tests using the USArray, *Pure and Appl. Geophys*., 171, 469-484, doi:10.1007/s00024-013-064601.

Syracuse, E. M., H. Zhang, M. Maceira (2017), Joint inversion of seismic and gravity data for imaging seismic velocity structure of the crust and upper mantle beneath Utah, United States, *Tectonophysics*, doi:10.1016/j.tecto.2017.07.005.

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