Pn Tomography and Location in Eurasia

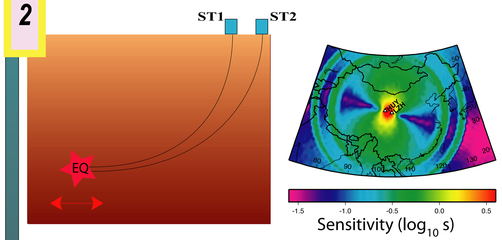
Lee Steck[1], Scott Phillips[1], Charlotte Rowe[1], Michael Begnaud[1], Kevin Mackey[2], Kaz Fujita[2] and Hans Hartse[1]
[1]Los Alamos National Laboratory and [2]Michigan State University

LAUR05-6407

1 INTRODUCTION

We are exploring the use of relative travel-time residuals to better constrain models of the earth for use in event location, and to use-fully augment station correction information, using residual estimates from events which were previously thought to have little utility due to poor ground truth (GT) parameters.

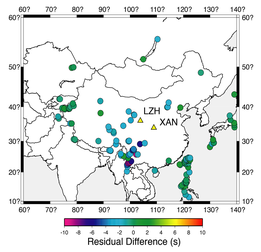
2



Above: (Left) Moderate mislocations in epicenter should have a small effect on residual differences. (Right) Geographic sensitivity pattern for 20 km Gaussian event mislocations for two nearby stations.

3

We begin exploring the method by relocating all events in the zABCE catalog, using the IASP91 earth model, applying no station corrections. This ensures that the relocated events will have consistent phase residuals to a common reference model, using a uniform location method. Approximately 32,550 events with over six million arrivals were used.



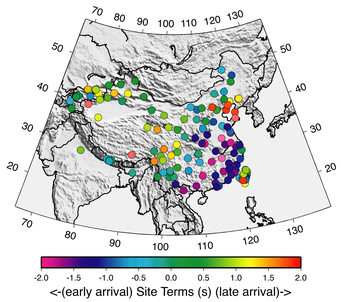
Residual Differences for Station Pair LZN/XAN

For each zABCE station pair we select event-station geometries such that a 20 km change in source location results in less than 0.2 s change in travel-time residual differences, based on synthetic sensitivity studies, and we restrict our source-receiver distances to 2-20 degrees. A median smoother is run over a one degree grid to remove residual difference outliers. These residual difference maps (example above) become the input for inversion.

4

RESIDUAL DIFFERENCE INVERSION

By combining all relative residual information and performing an inversion for consistent differential patterns, we derive a 2D function that maps laterally-varying residual slowness deviations from the background model, along with site terms based on the residual differentials.



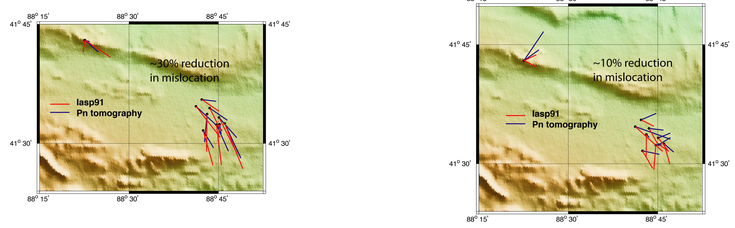
Inversion station term results ....and slowness perturbations

We observe regional slowness patterns similar to those obtained by other authors using single ray (Pn tomography) techniques. These include fast mantle velocities in central and western China, in particular under the Tarim, Jungar, Tsaidam and Sichuan basins, and slower velocities beneath eastern China, including the continental shelf and Shanxi graben regions. Site terms are negative throughout eastern China, reflecting thinner crust, and are positive for western China, especially Tibet.

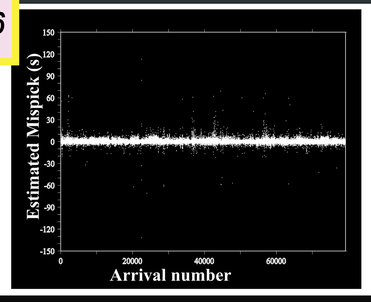
5

We test the utility of our Pn pertubations by forming Pn corrections for all zABCE stations observing 11 nuclear tests at Lop Nor. These events are then relocated with and without the corrections using only Pn. Below we show two relocation examples: Pn between 2-20° and Pn between 5-15°.

A) 2-20 degrees: B) 5-15 degrees:



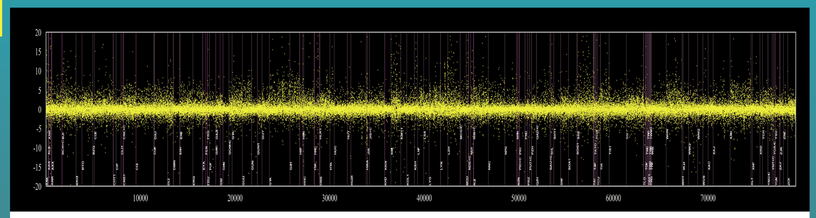
6



The differential results also provide catalog pick quality control, which may help us to identify outliers that contaminate the data set. In cases with few recording stations, this may be critical. Here we show results from inversion of differences for an estimate of picking error. Note at left the lineations at +/- 60, 20 and 10 s, which are clearly typographical errors in the catalog that were made during data entry. Box 7, above right, shows the same dataset sorted by station.

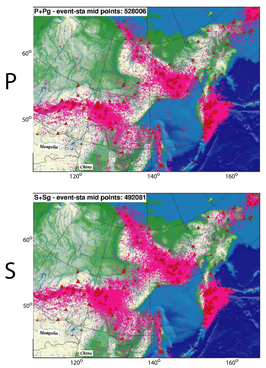
7

This is the same data as in Box 6, but sorted by station to reveal station problems.

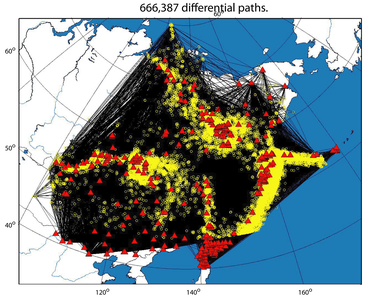


8

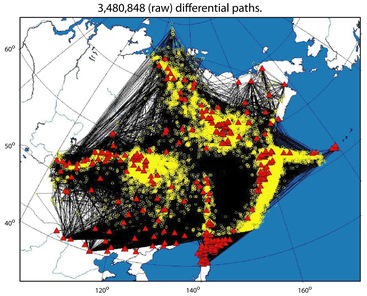
We next turn our attention to the recently compiled MSU Siberia dataset. This dataset is a compilation of numerous local catalogs merged with data from instruments deployed by MSU and represents the most comprehensive dataset currently available for this region. We intend to produce Pn, Sn, Lg and Pg velocity models for the region. A first look at the available travel time data (station/event raypath midpoints) is shown below left, for P and S. Below right are the differential datasets for P and S.



Differential P dataset: 459 stations, 65,489 events, 666,387 differential paths.



Differential S dataset: 341 stations, 56,410 events, 3,480,848 (raw) differential paths.



SUMMARY

This study is a work in progress. Initially our focus was only to derive improved utility for the more poorly constrained events in the data set. We have found that the regional slowness perturbation mapping and the catalog QC features of the differential analysis are an added benefit to the work. Our initial relocation results show improvement in location accuracy through the use of our Pn tomography corrections; however, they also reveal zABCE dataset limitations and weak resolution in Tibet. Additional constraints on our Pn model will be provided by new local and regional catalogs. Our initial look at Siberia suggests plentiful data for Pn, Pg, Sn, and Sg analysis. We are currently relocating the Siberia dataset in order to normalize all hypocentral information to one model, prior to implementing our differential Pn analysis.