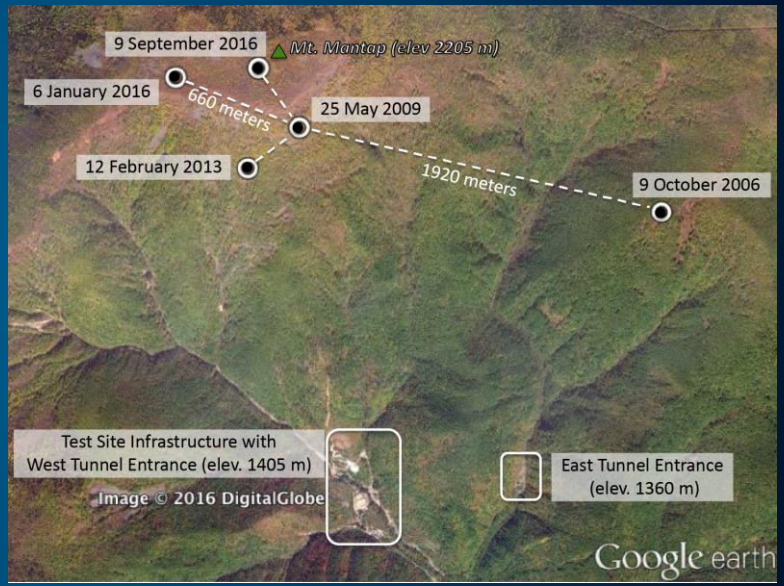
T2.1-0.11

Source Array Analysis for Accurate Relative Event Location at the North Korea Nuclear Test Site

Steven J. Gibbons
Tormod Kværna
Sven Peter Näsholm
and
Svein Mykkeltveit

NORSAR



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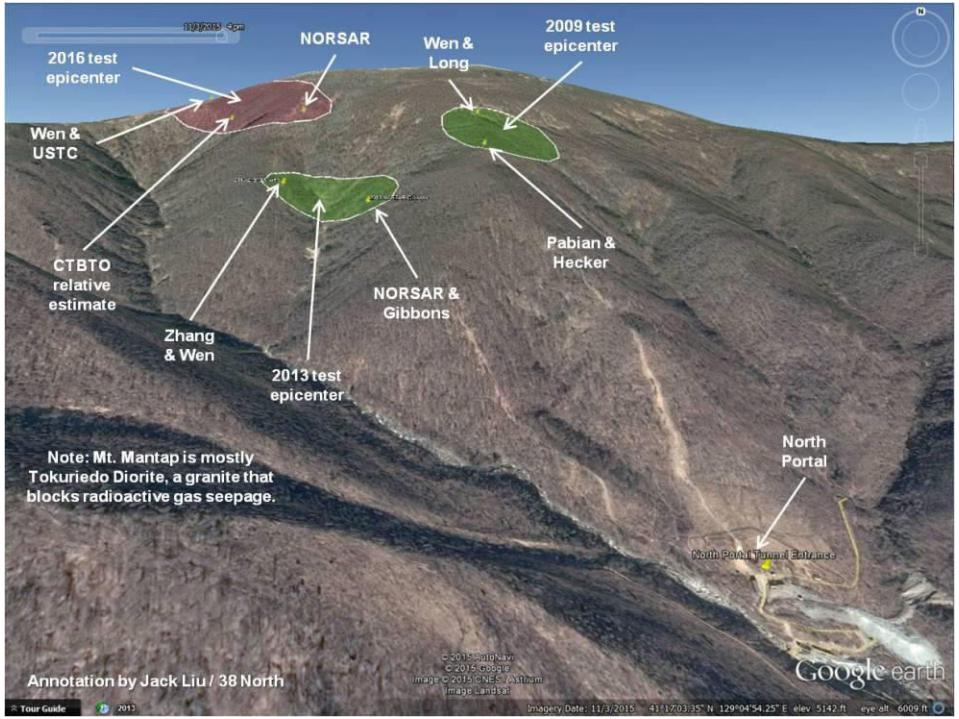
Accurate Relative Event Location at the North Korea Nuclear Test Site

Why is accurate relative event location important?

- Constraints on possible absolute locations in observable terrain.
- Estimation of likely depth of burial.
- Yield considerations and likelihood of further developments.



Source: http://38north.org/2016/02/punggye020116/fig1_punggye-020116/

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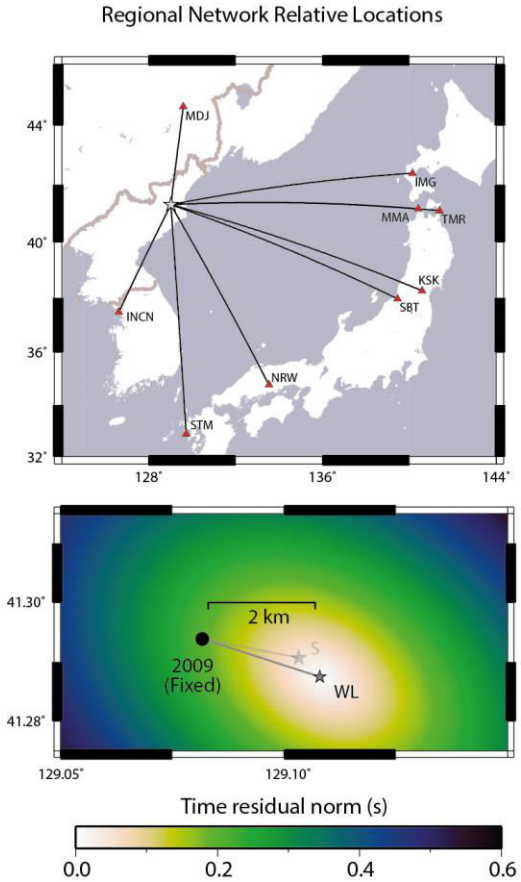
The North Korea nuclear test-site

High accuracy relative event location estimates can provide much information about the likely yield and state of the testing infrastructure.



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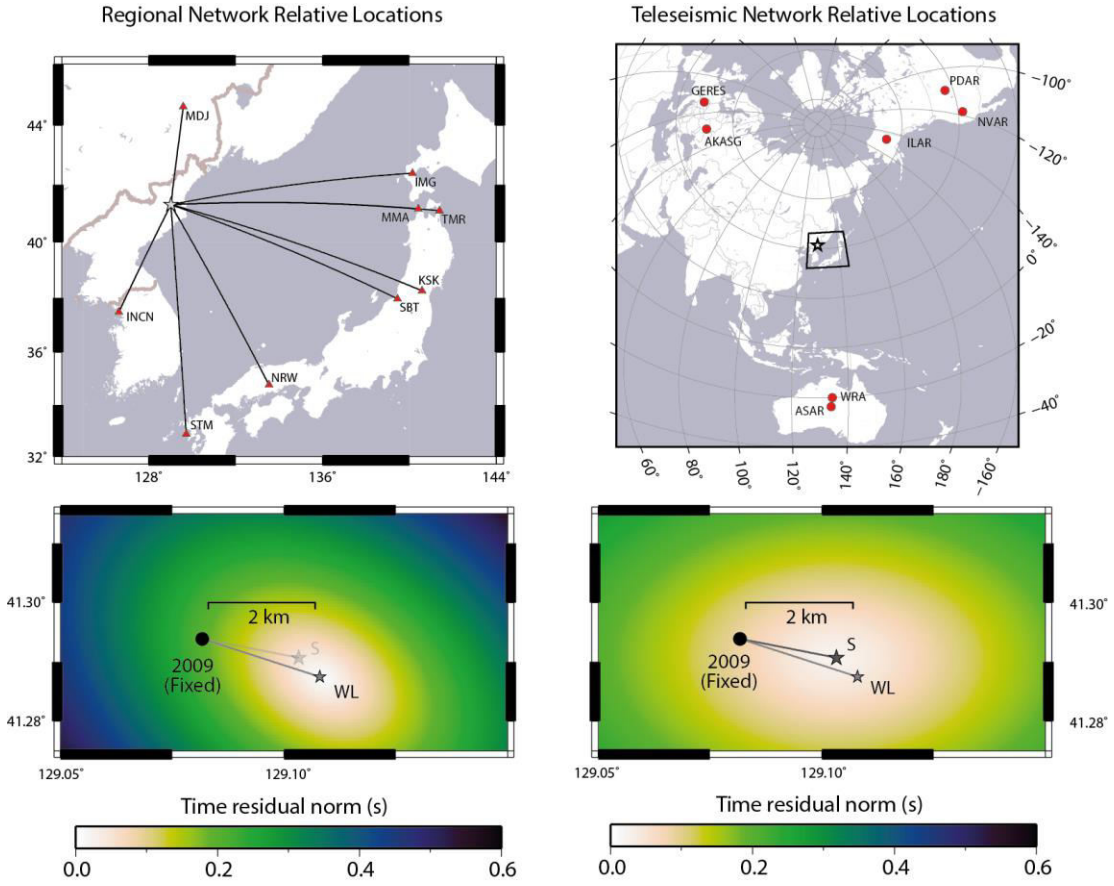
The North Korea nuclear test-site

High accuracy relative event location estimates can provide much information about the likely yield and state of the testing infrastructure.

The relative location estimates for the DPRK test site appear to depend upon the stations used and wave propagation assumptions.



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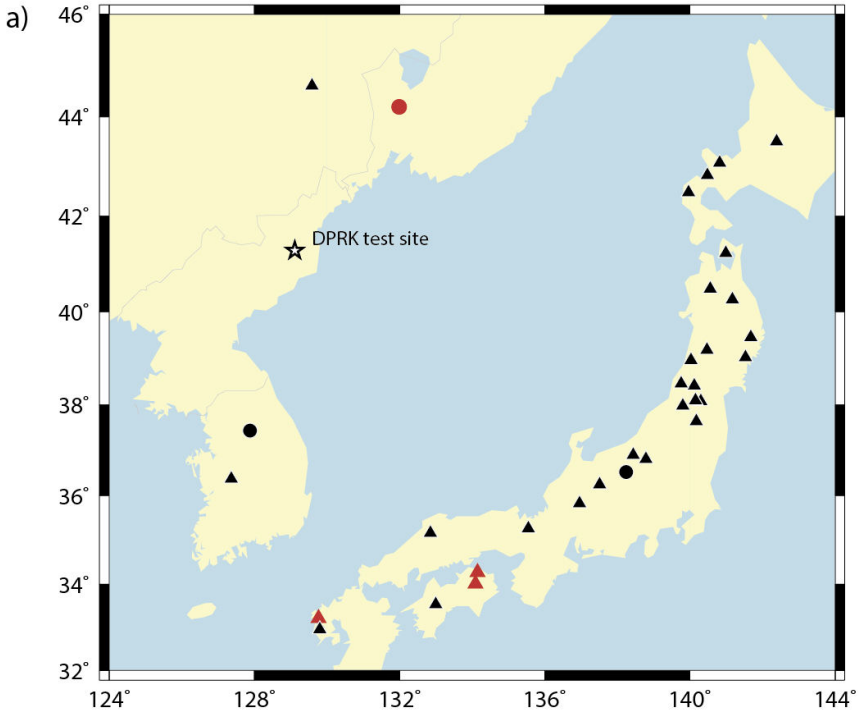
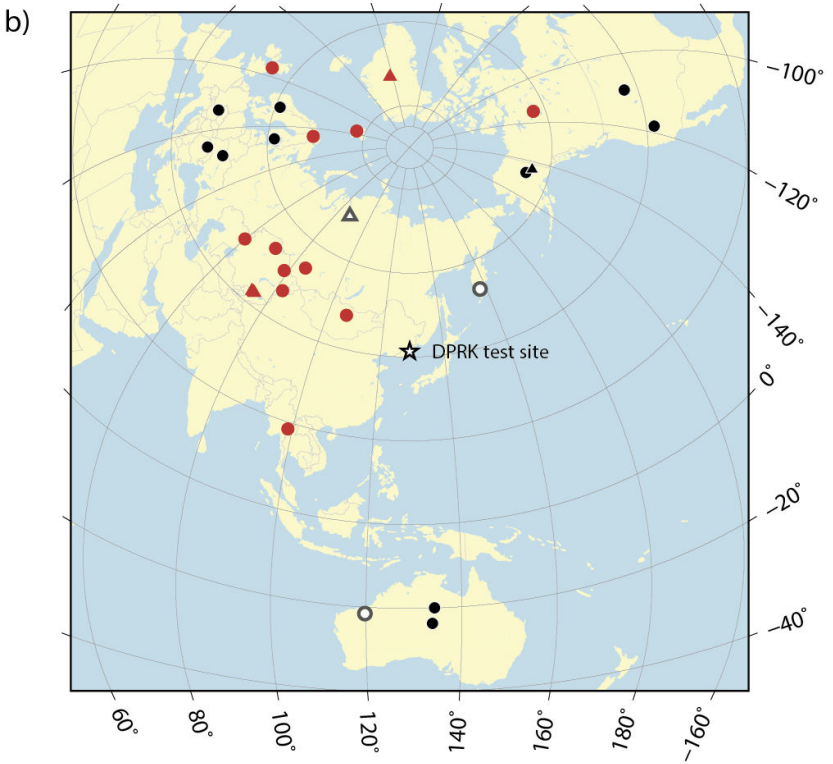
Regional stations



Teleseismic stations



How accurate are the predicted traveltime differences for each of the arrivals used?

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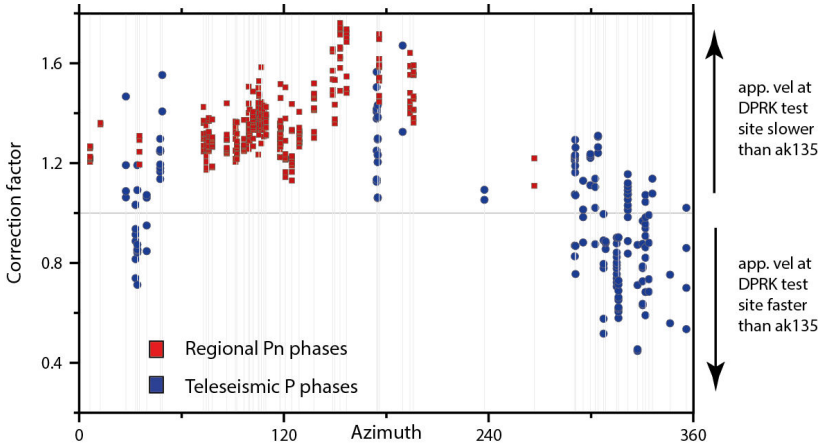

We attempt to find deviations from the predicted traveltime differences that make all relative location calculations consistent ...

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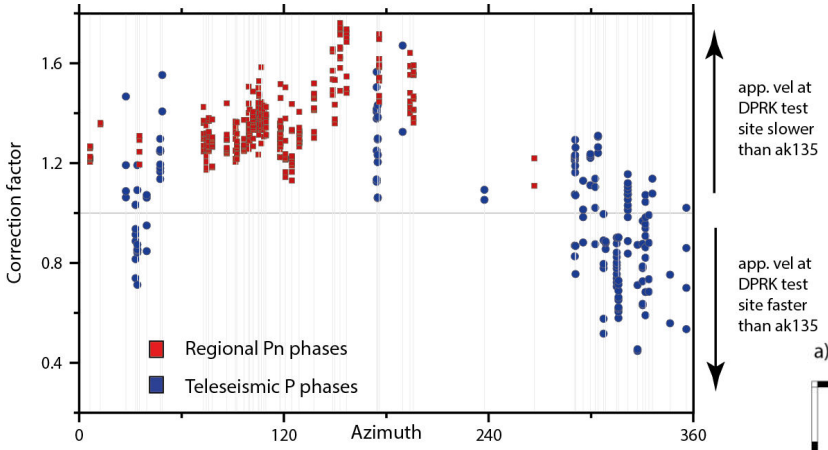

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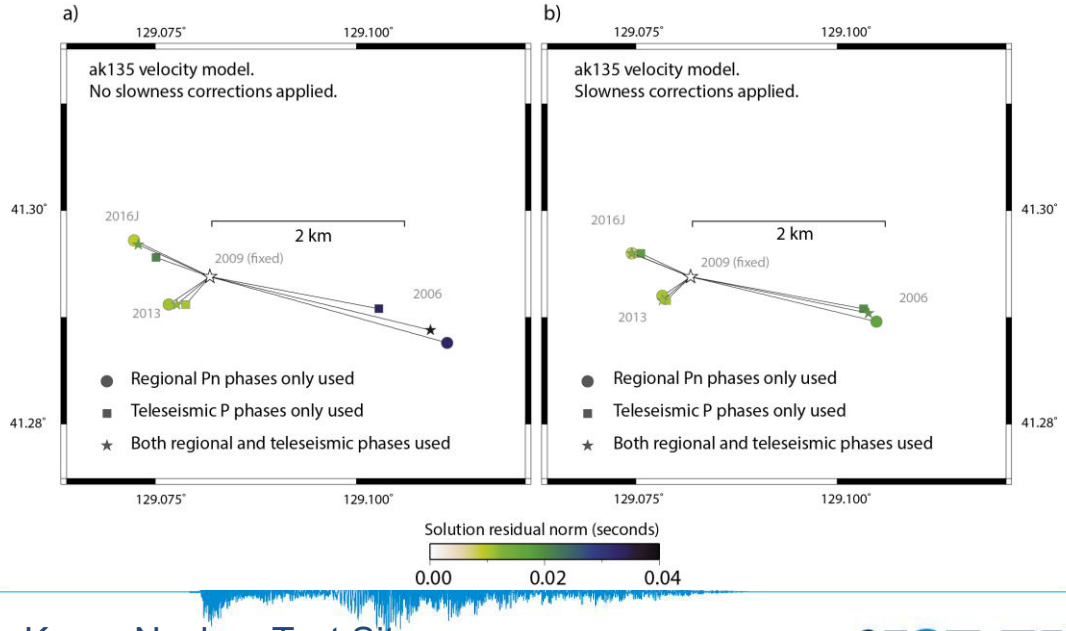

... and the improvement in consistency is substantial!

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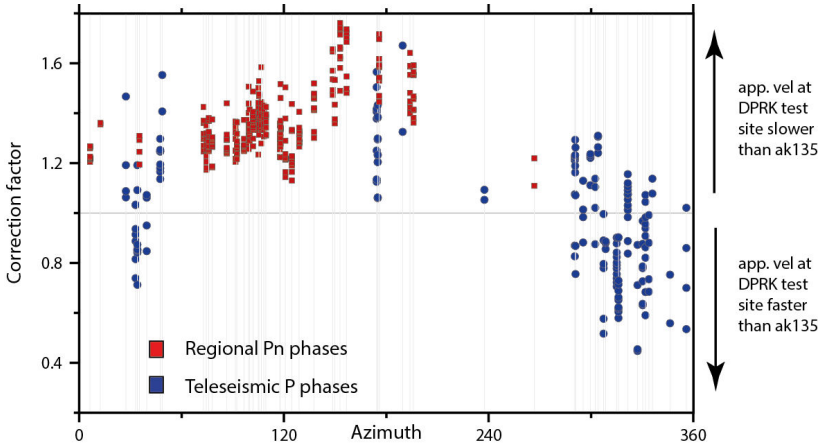

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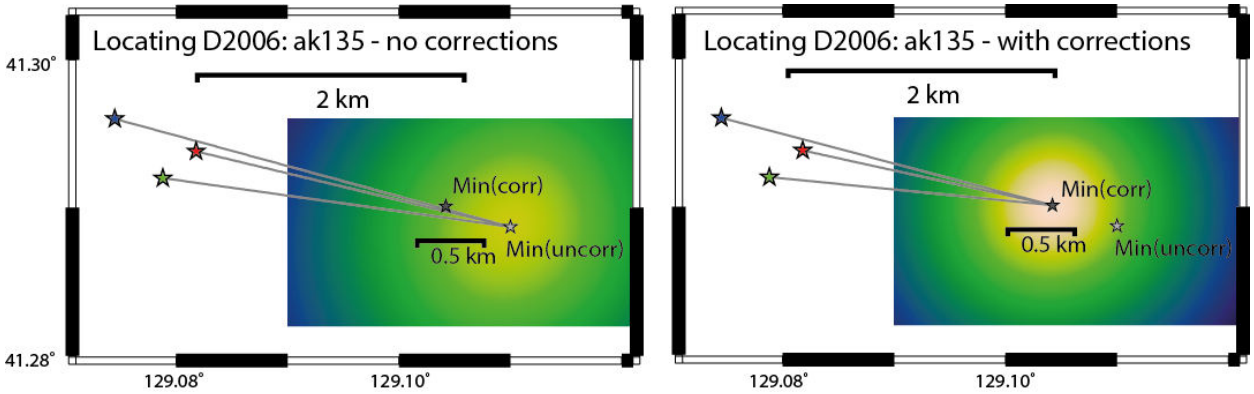

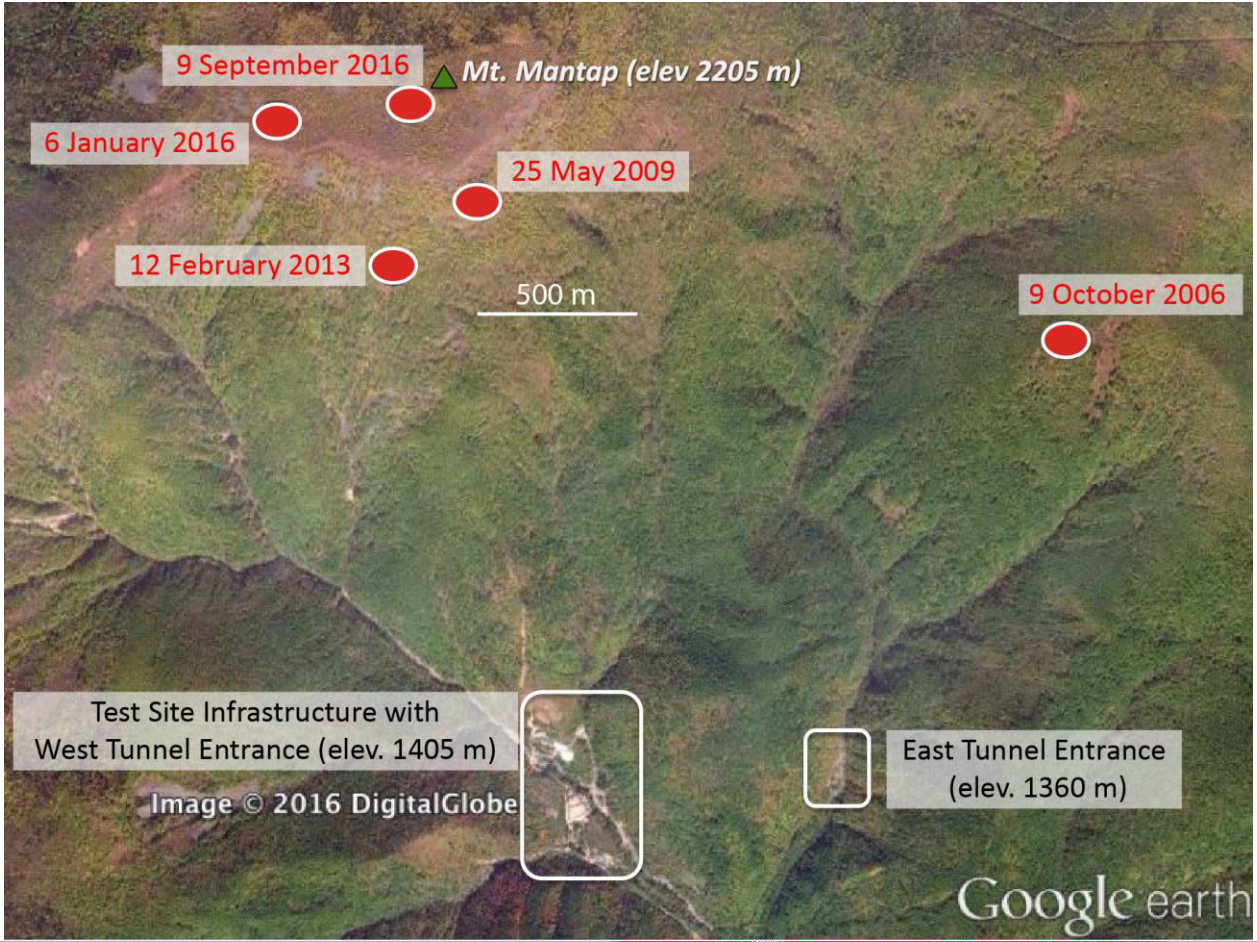

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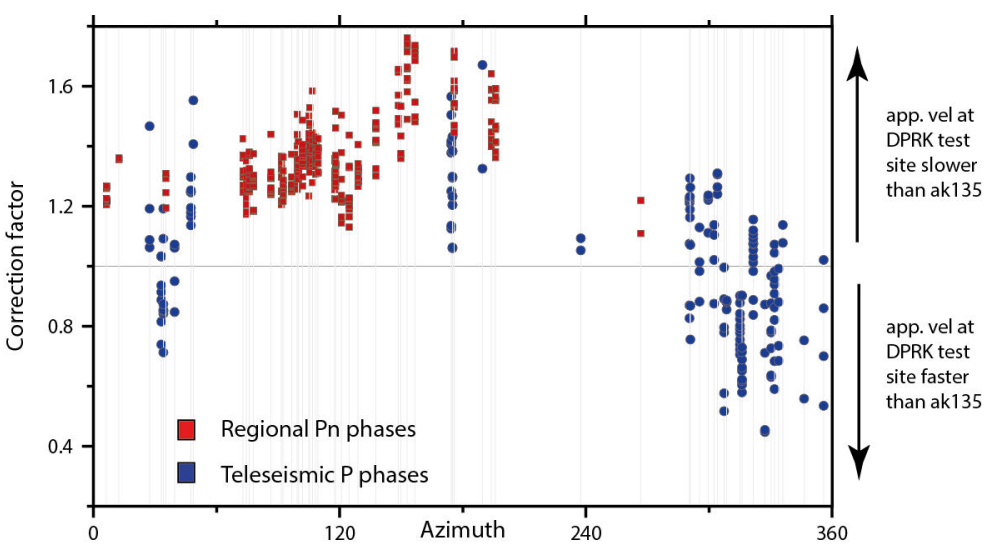
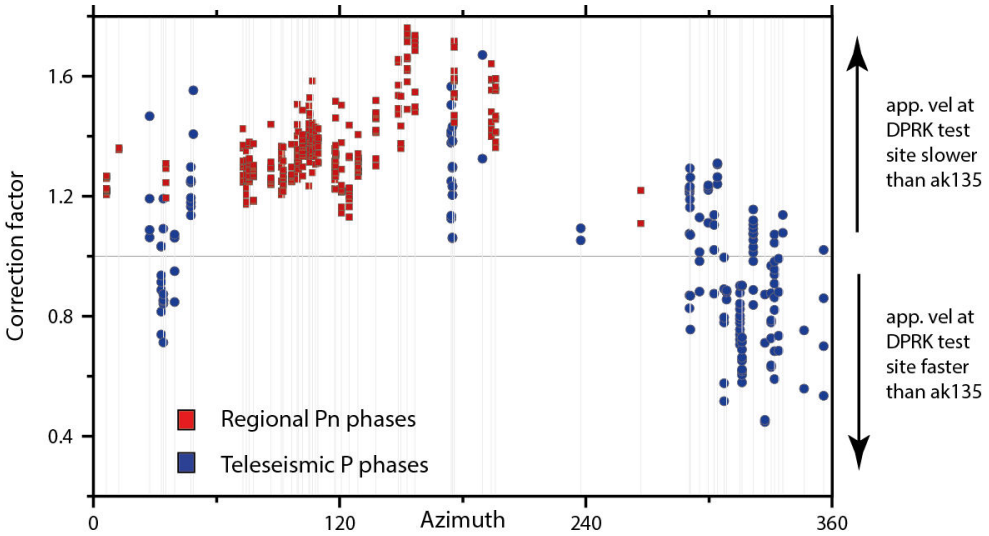


Left: estimated deviations in slowness for DPRK nuclear test-site.



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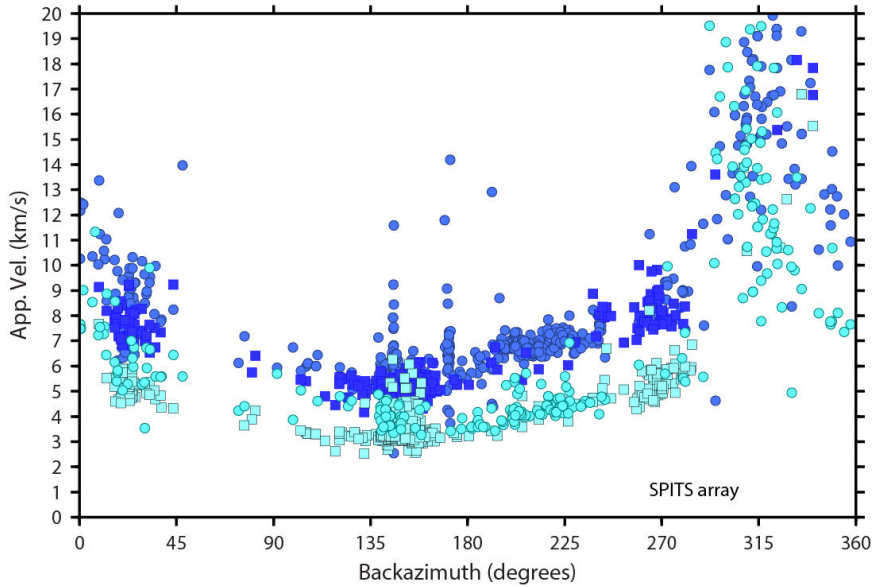

Right: observed deviations in slowness for the SPITS seismic array.

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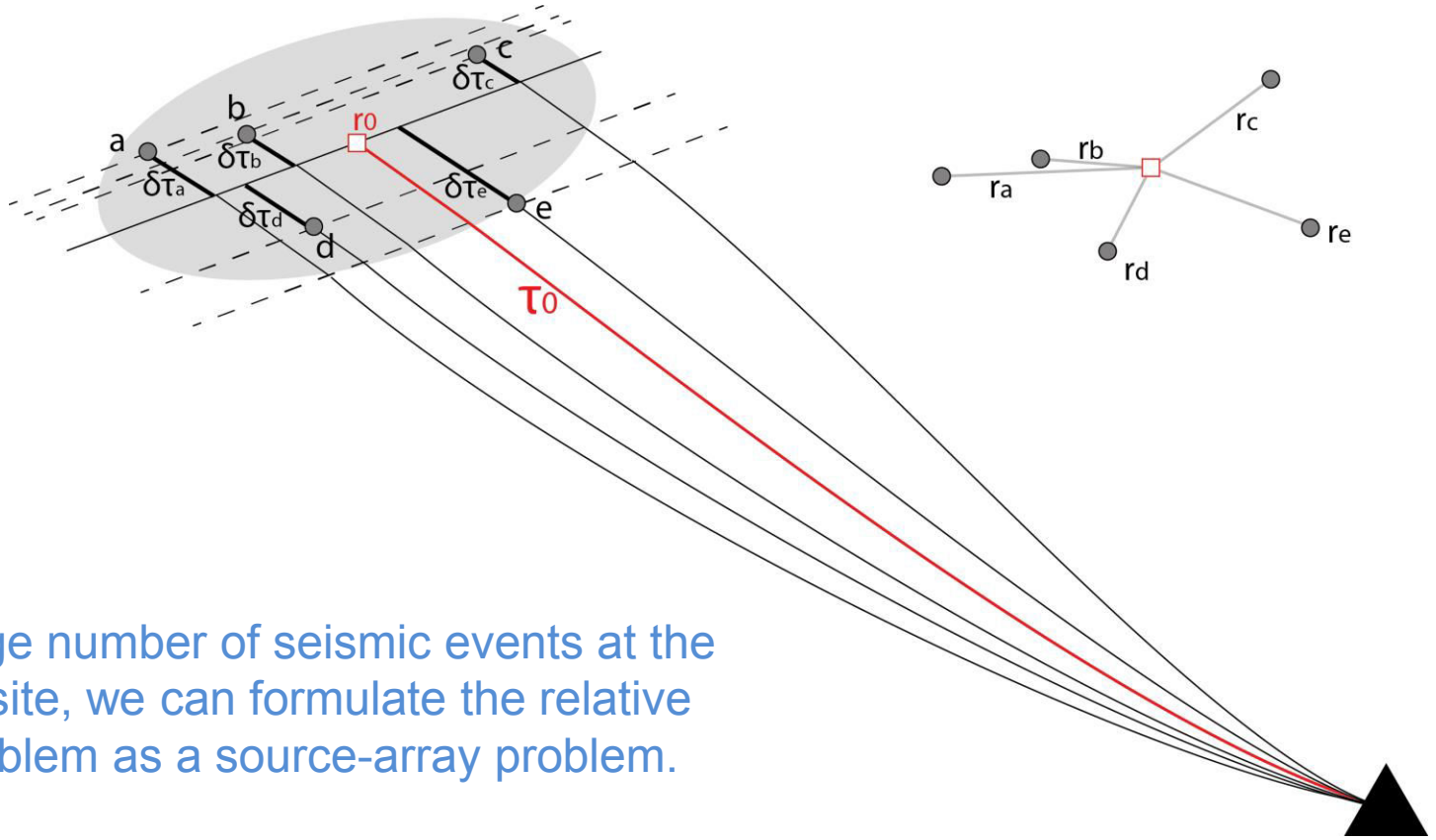

Given a large number of seismic events at the DPRK test site, we can formulate the relative location problem as a source-array problem.

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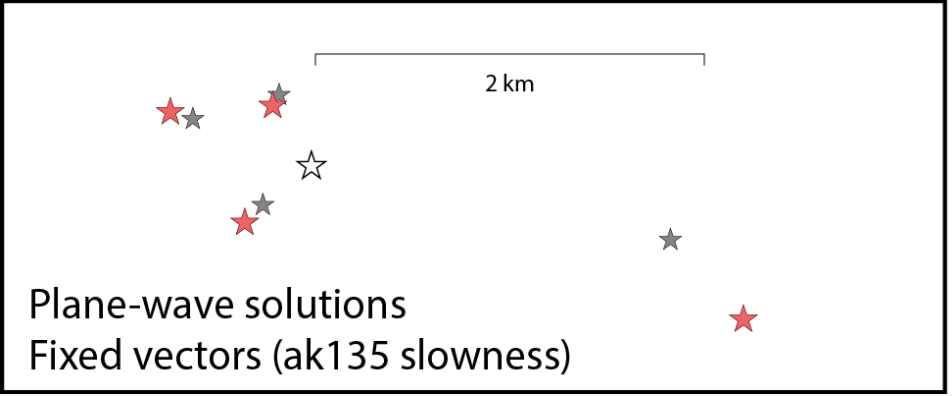

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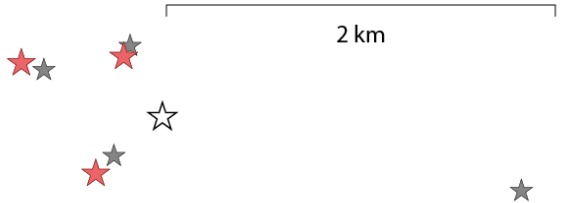
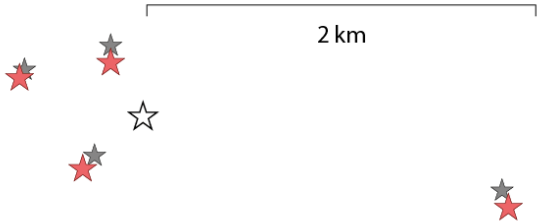
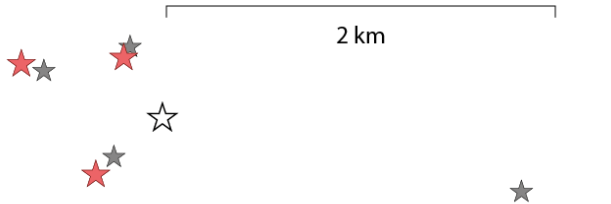


Plane-wave solutions
Fixed vectors (ak135 slowness)



Plane-wave solutions
Adaptive vectors (slowness from linear regression)



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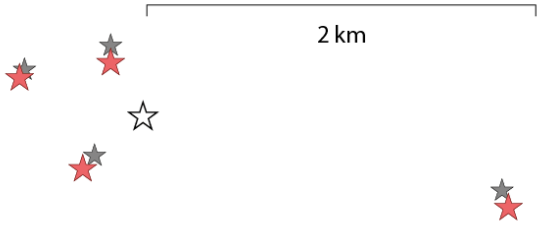

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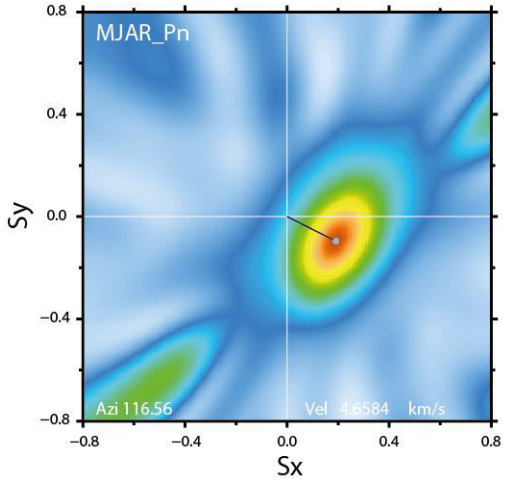

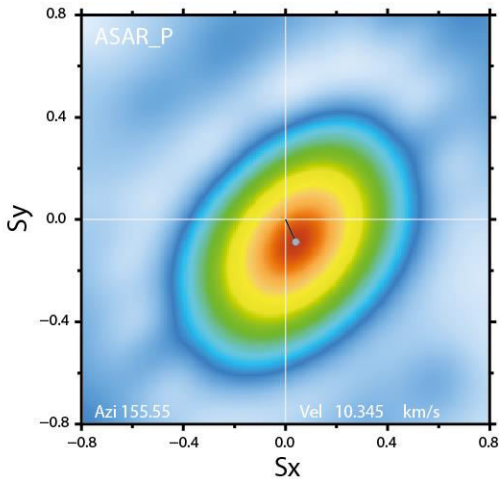

Accurate Relative Event Location at the North Korea Nuclear Test Site

SUMMARY

- Accurate relative location estimates from seismic data are crucial for placing constraints upon the absolute event locations.

- **The seismic wavefield leaving the test site is more complicated than we assume!**
  Teleseismic estimates probably more accurate than regional estimates despite an apparent lower precision.
  (There are almost certainly improvements to be made in our models for wave propagation at the test site.)

- We can now use source-array calculations to measure the directions in which wavefronts leave the test-site.
  (These support earlier estimates of corrections to the baseline model.)