

Using Data-Driven Uncertainty Quantification to Support Decision Making

Sandia National Laboratories

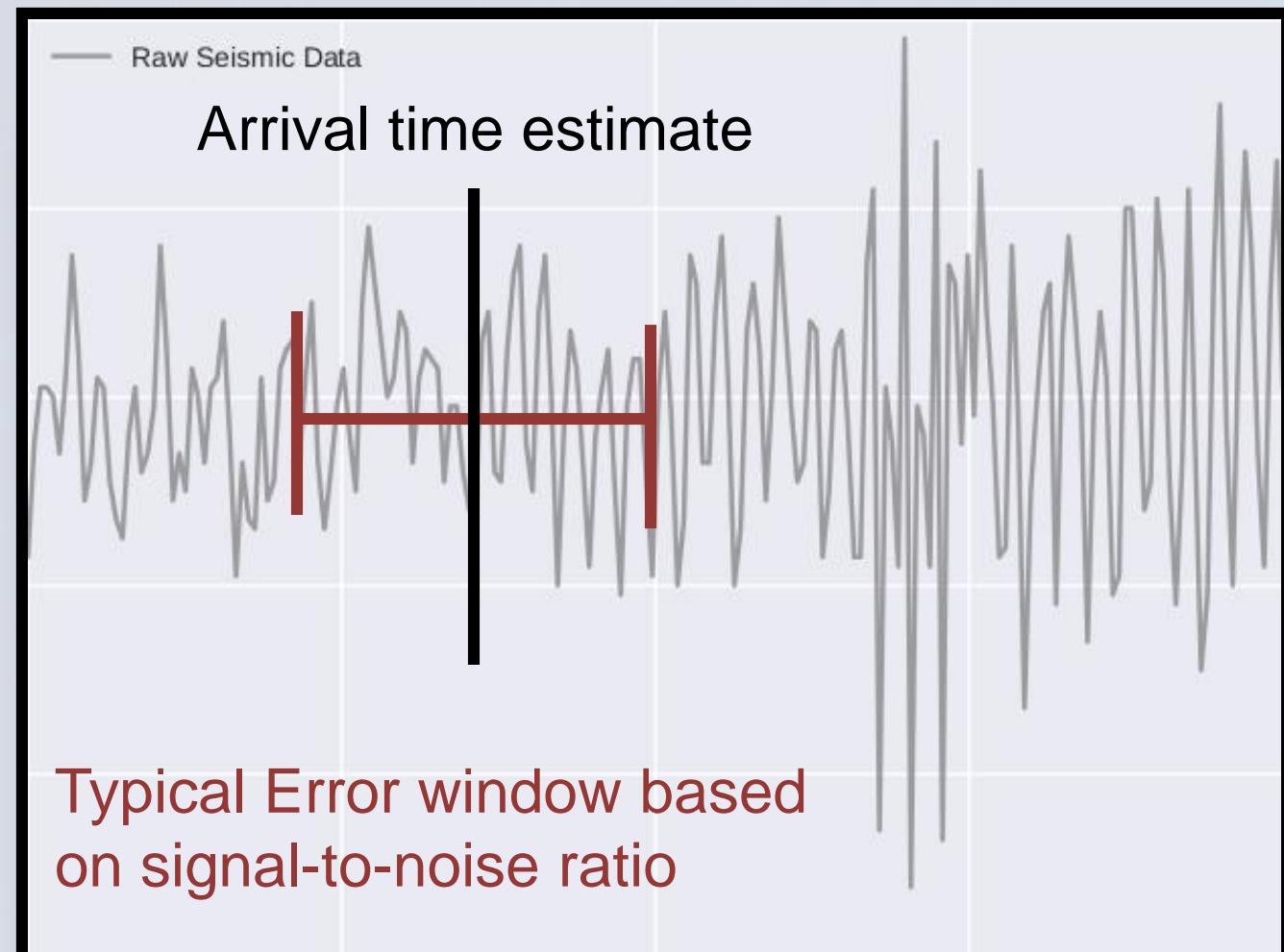
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Problem

- Seismic onset detection is a precursor to many other analyses
- Precision has a major impact on results.
- Current approaches calculate a point estimate with a uniform error (confidence) window.
- Our goal is to improve this error window by presenting a probability distribution over when the onset may occur.

Providing a detailed error window may improve the sensitivity of downstream analysis; such as determining event location and event type.



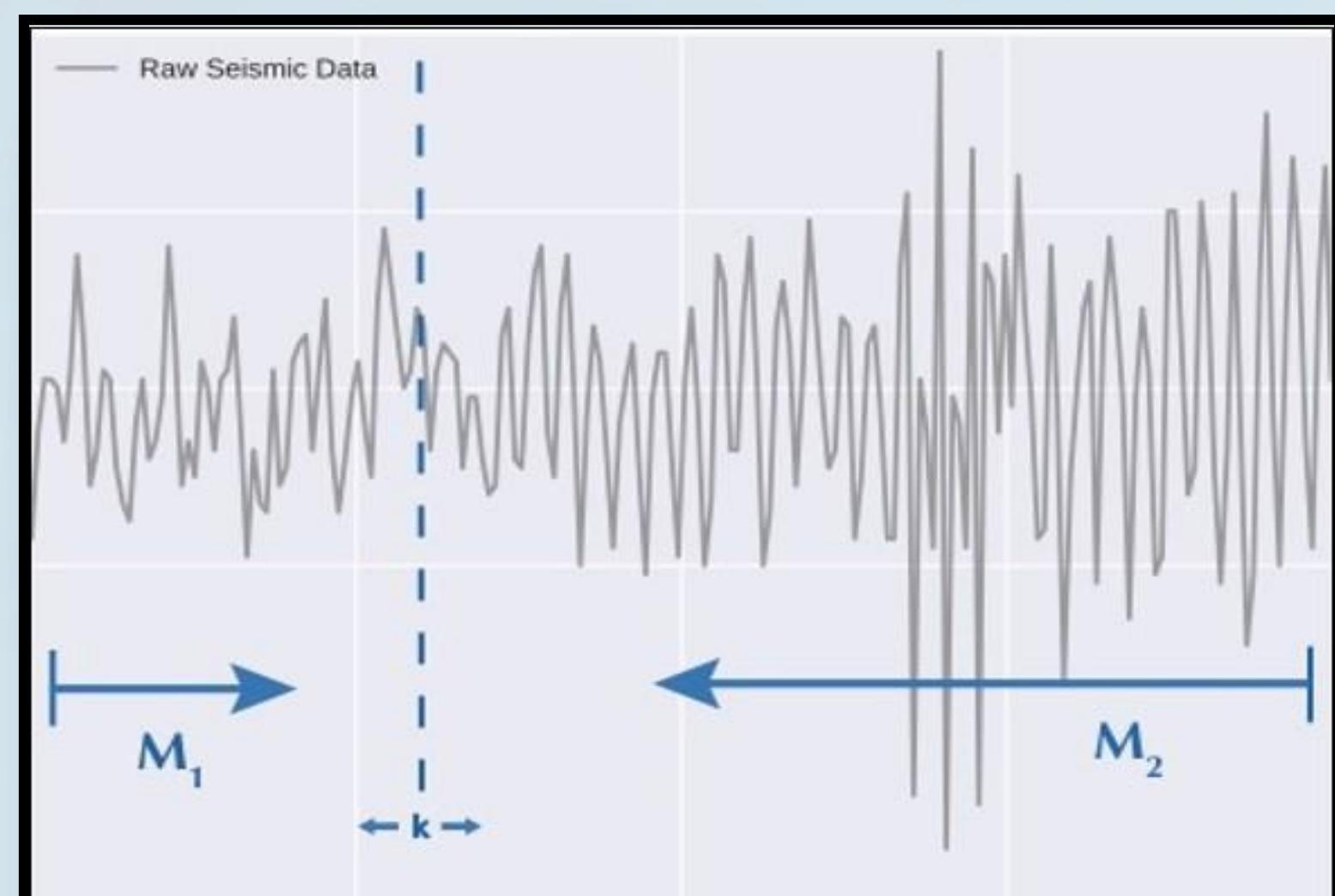
Given

Waveform data containing both noise and seismic signals

Produce

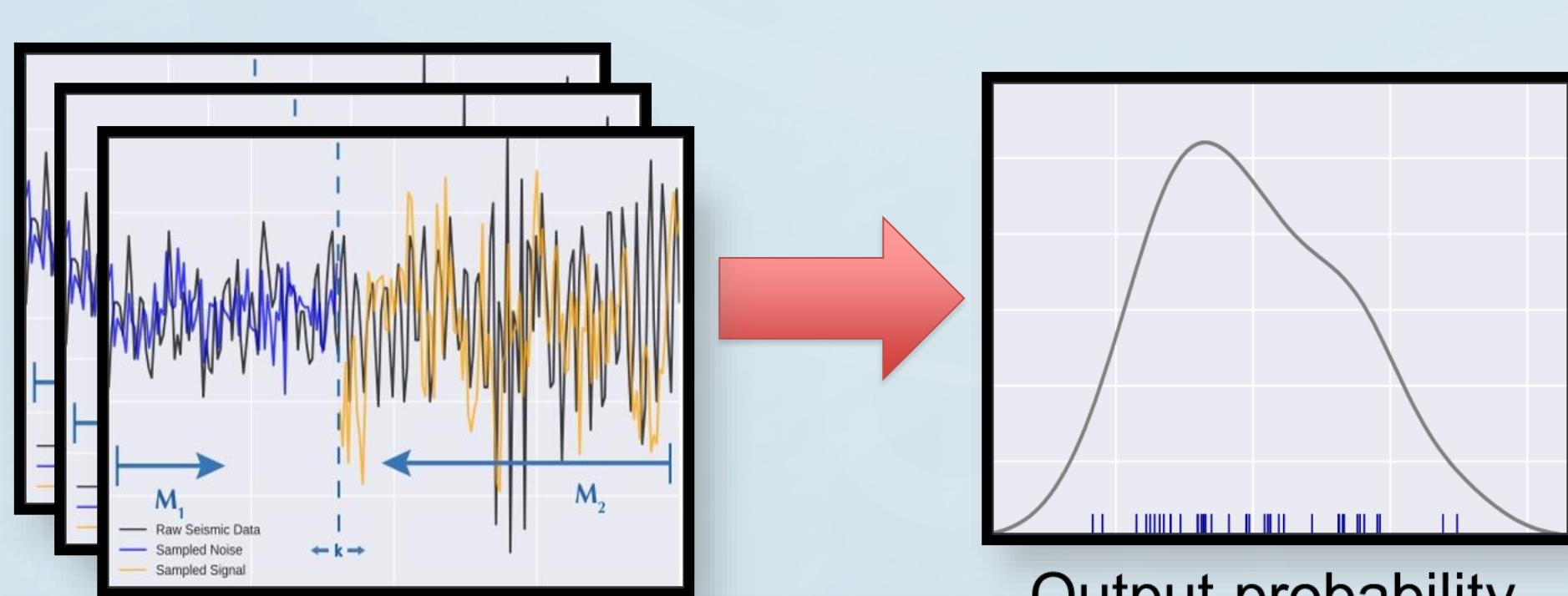
Signal onset/arrival time (i.e. change point from noise to signal)

Approach



Apply *parametric bootstrap* to construct distribution over likely onset times, k .

1. Separately model the noise (M_1) and the signal (M_2)
2. Fit M_1 & M_2 to the data, optimizing over all possible k .
3. Generate new waveforms, w^i , from M_1 & M_2 by sampling.
4. Fit new models, M_1^i & M_2^i , to each sample and record k^i .
5. Compose k^i into sampling distribution for onset time k .

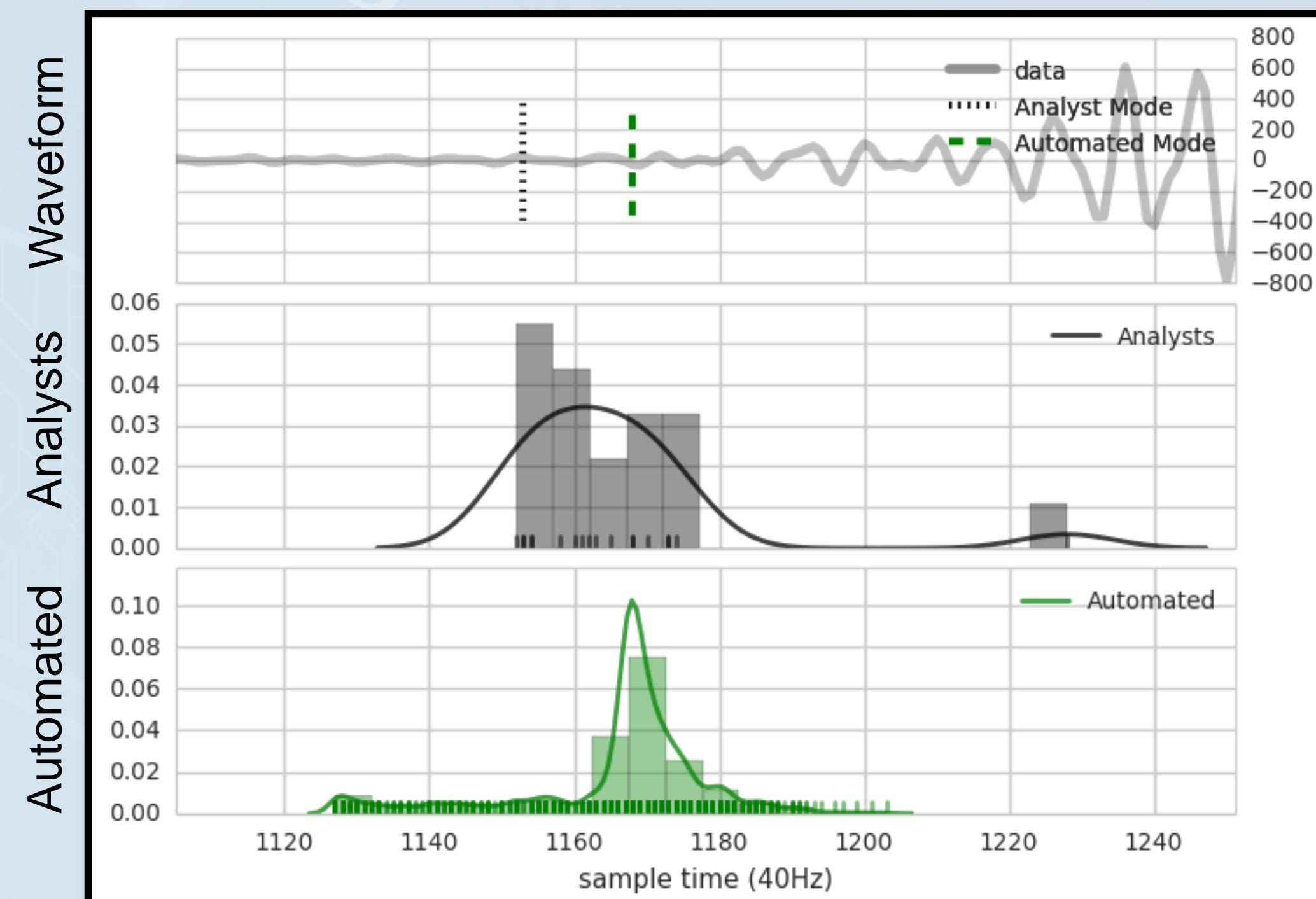


Generated data samples w^i

Output probability distribution over k

Results

We compared our automated distributions to onset estimates chosen by a set of human analysts.



The modes of the distributions indicate the most likely onset times. Notice the analysts have three different modes. The automated method has a minor mode at sample time 1130 implying the true onset might be much earlier.

Would the analyst that picked at 1225 have done so if presented with the automated method first?

Significance

This work impacts national security domains such as nonproliferation monitoring. The output of this analysis propagates to many other analyses

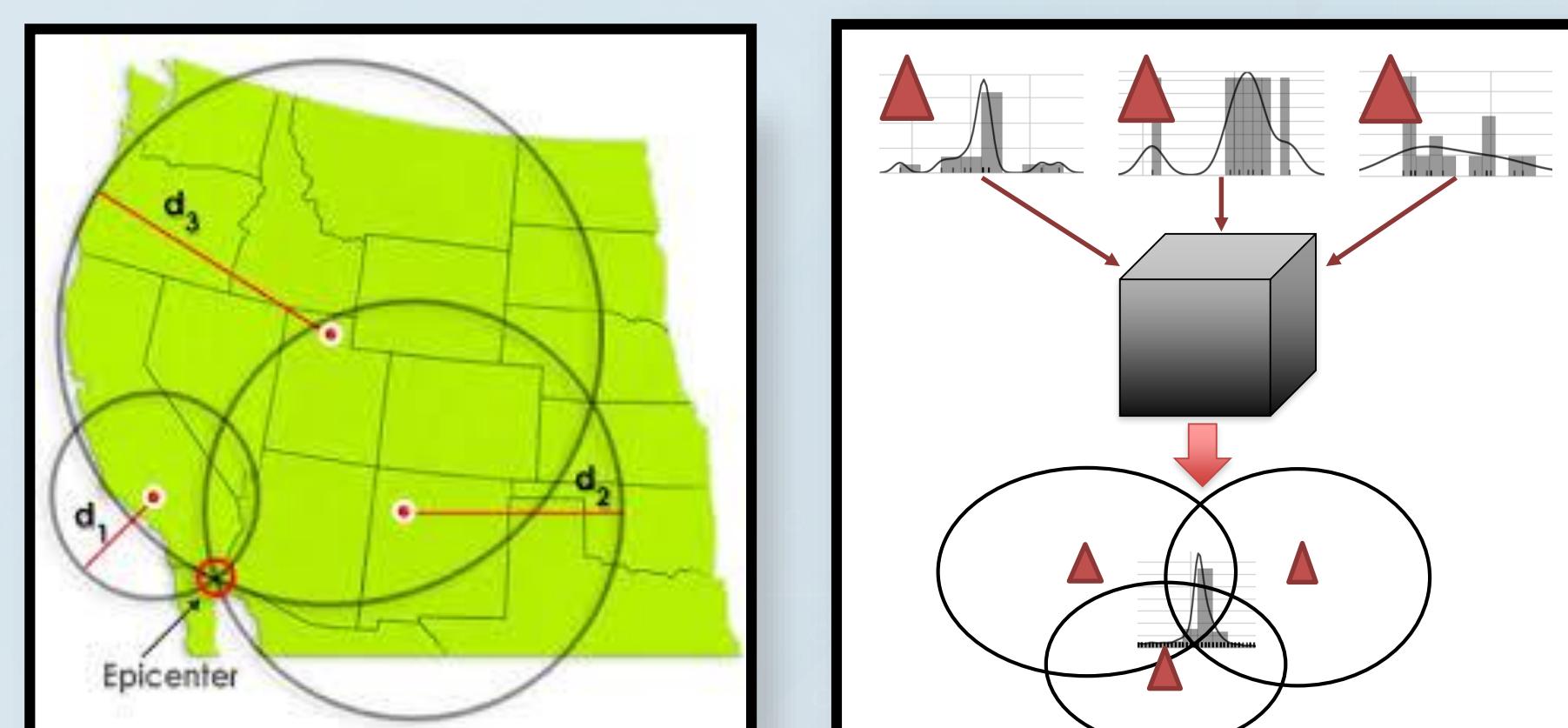
- Event Origin Location
- Event Type
- Event Magnitude/Size

We can improve analytical results

- Sensitivity (weak signals close to noise floor)
- Subsurface Tomography (measuring the density of rock)
- Distinguish reliability of sensors
- Support multiple sensor types e.g., seismic and infrasonic

Not supported by current methods

Future work includes combining multiple distributions from multiple stations to create a single arrival time estimate distribution that can be used in downstream methods.



Convert uniform location ellipse to a spatial distribution.

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