



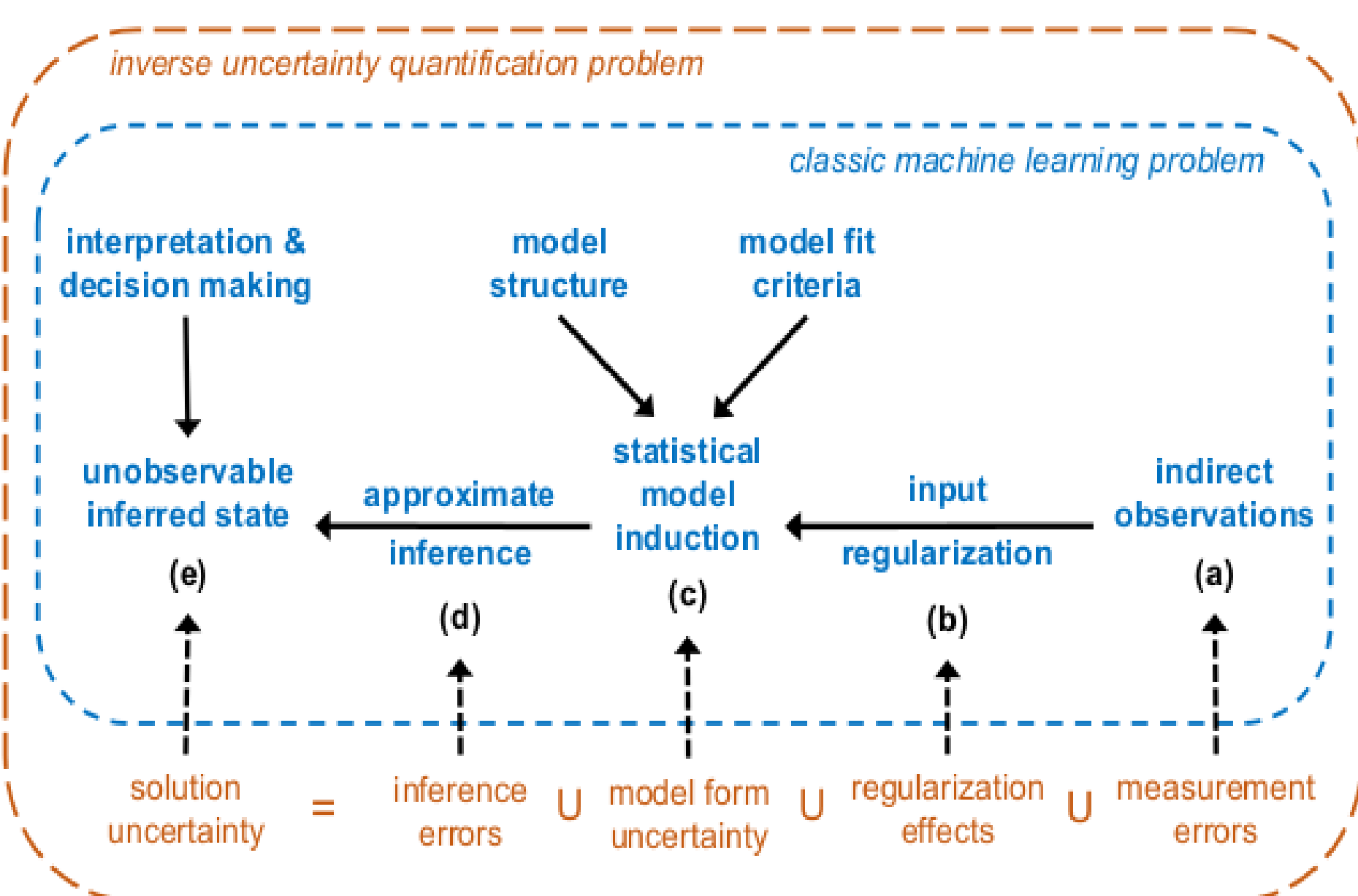
# UQ Pipeline for Seismic Onset Detection

## PROBLEM

- *Seismic Onset Detection* is a precursor to other analyses
  - Precision has a major impact on results
  - Current approaches calculate a point estimate with uniform error (confidence) window
- Providing a detailed error window may improve sensitivity of downstream analysis**, such as determining event location, event type, and overall decision making quality.

## UQ PIPELINE

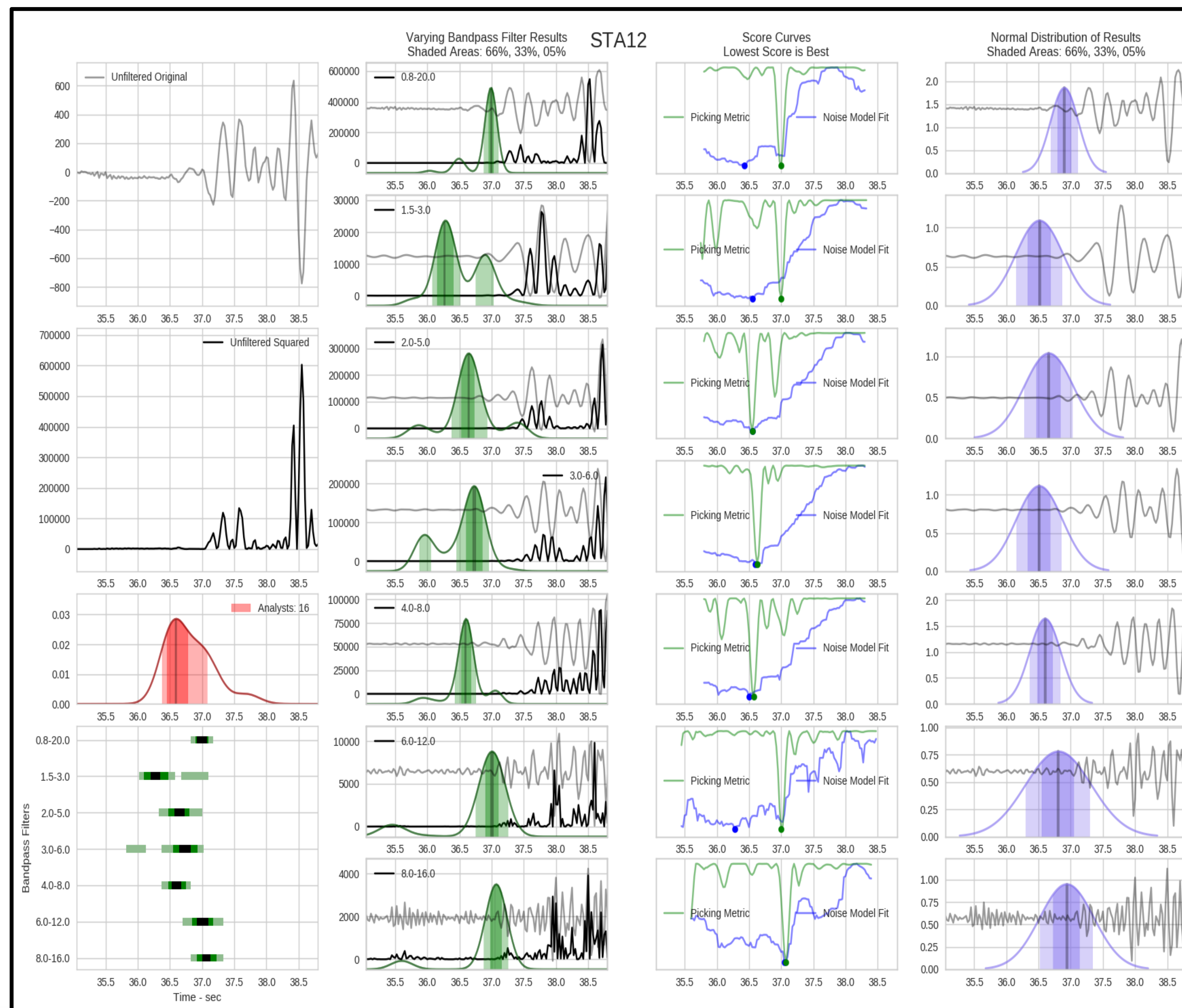
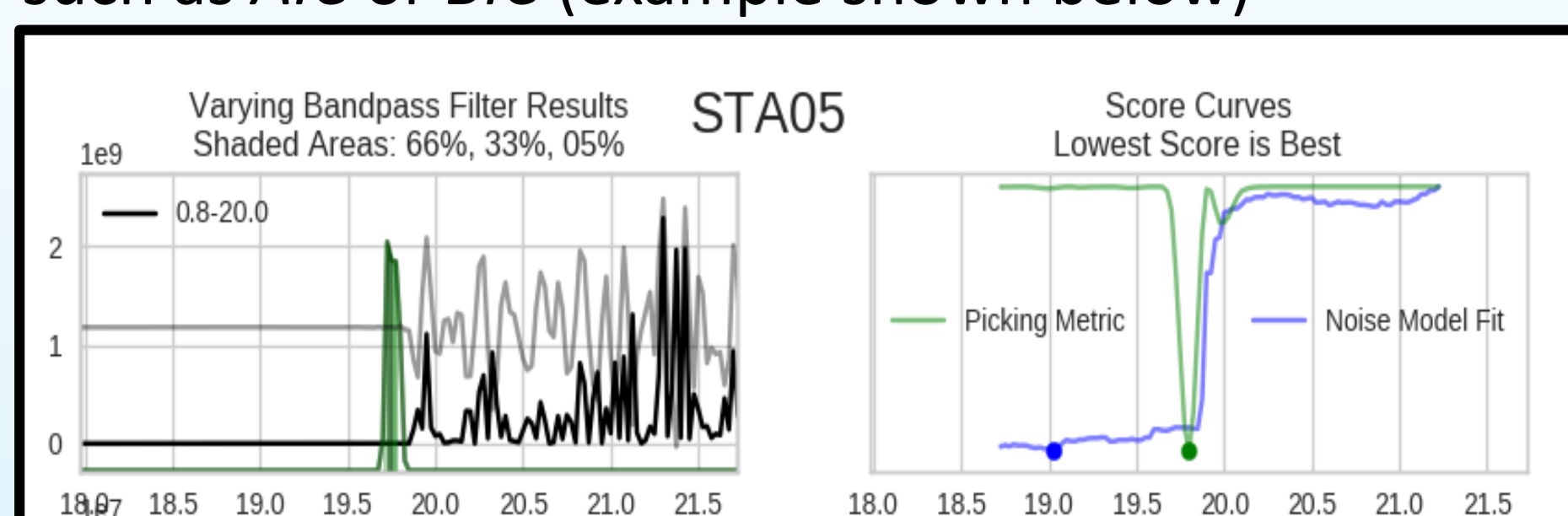
Uncertainty arises from many aspects of machine learning and statistical modeling.



## (c) model form uncertainty

**Model Structure:** For *Autoregressive (AR)* models, this would be different sized lags

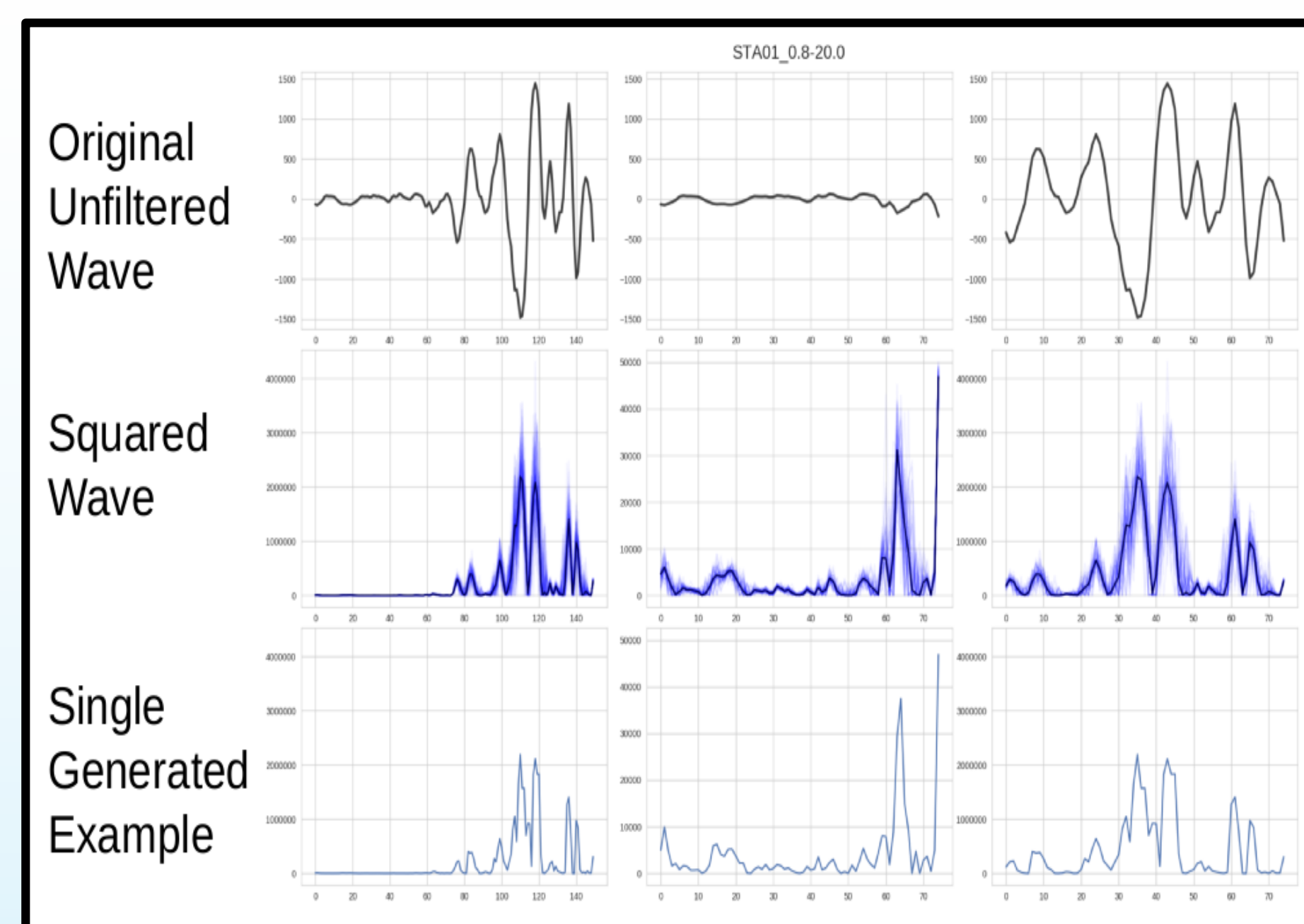
**Model Fit Criteria:** Varying information criterions, such as *AIC* or *BIC* (example shown below)



## (d) Inference errors

For a given waveform window, **generate samples using a Gaussian Blur technique** to run through the algorithm (examples shown in left figure)

- Generate 300 samples for each Bandpass Filter
- Randomly choose 50% of the points to blur
- Blur each point's amplitude by a random gaussian pick where the standard deviation is calculated by the amplitude of the point's neighbors.



## (a) measurement errors

Seismic signals contain **background noise** which can deter us from correctly identifying the true onset time of a signal

Take a look at the unfiltered signal in the upper left corner of the center figure, **where does the noise truly end and the signal begin?**

## (b) regularization effects

- **Varying bandpass filters** obtain different results
  - Look at filters *0.8-20* and *1.5-3.0* in the figure to the left
- **Input manipulation** can also have an effect
  - *Squaring the inputs* makes all values positive and the signal larger, resulting in consistent picking (seen in center figure)
  - *Absolute value* makes the signal less apparent, resulting in less consistent picking but a better search space

## (e) solution uncertainty

- How to interpret distributions.
- **Use High Density Regions (HDRs)** to emphasize important regions
  - **Multiple peaks** of the distribution indicates more than one possible correct answer
  - **Tighter distributions** indicate a confident result

## CONCLUSION

**Using the full distribution** (the green distributions) compared to the basic approach of using a normal distribution (the blue distributions), **our results can provide greater details** such as,

- Multiple possible onset picks
- Tighter distributions
- Automated results comparable to analysts