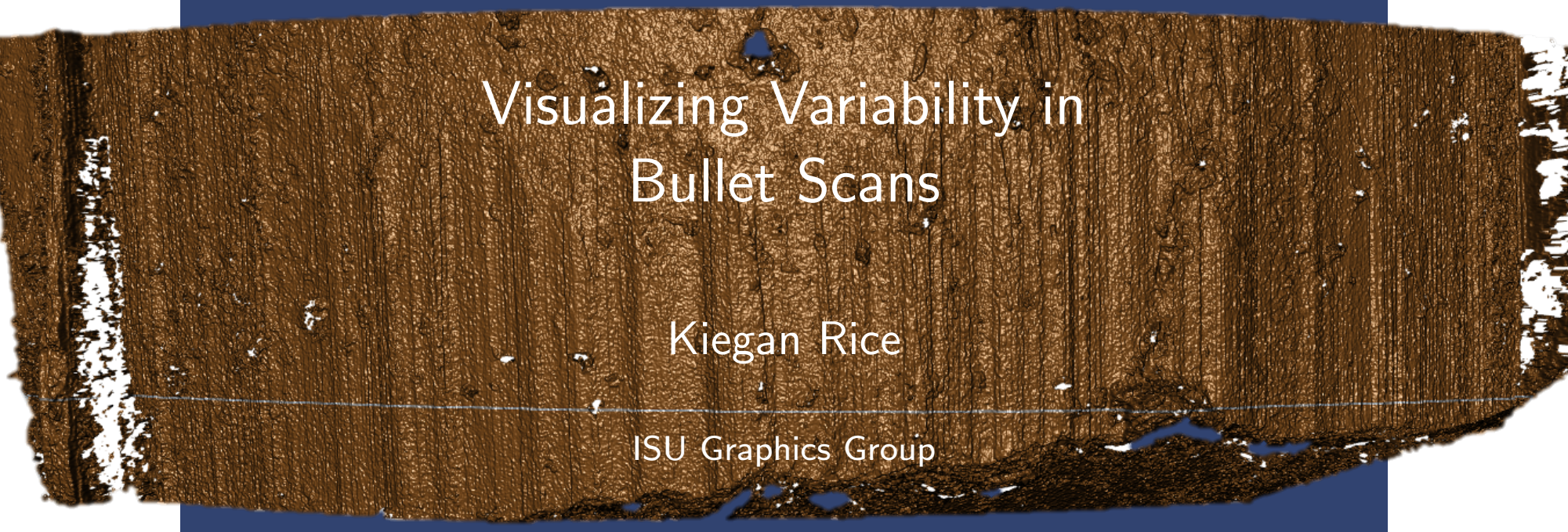


Visualizing Variability in Bullet Scans

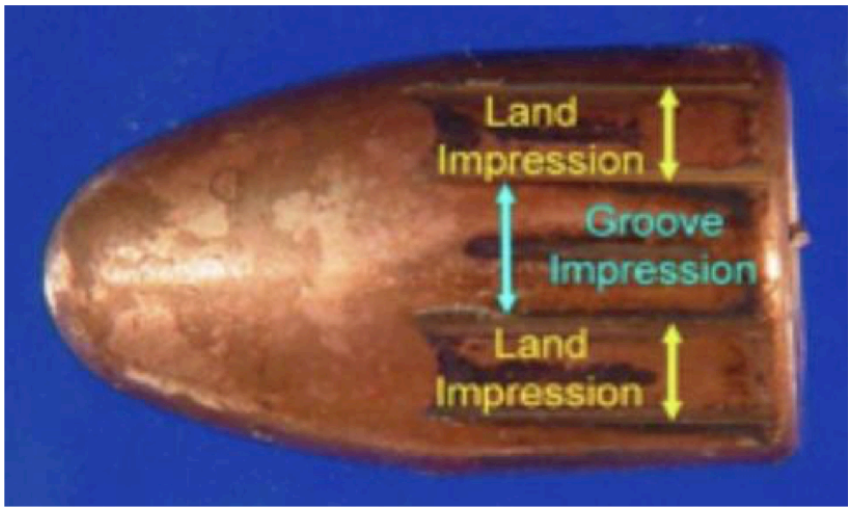
Kiegan Rice

ISU Graphics Group

September 19, 2019

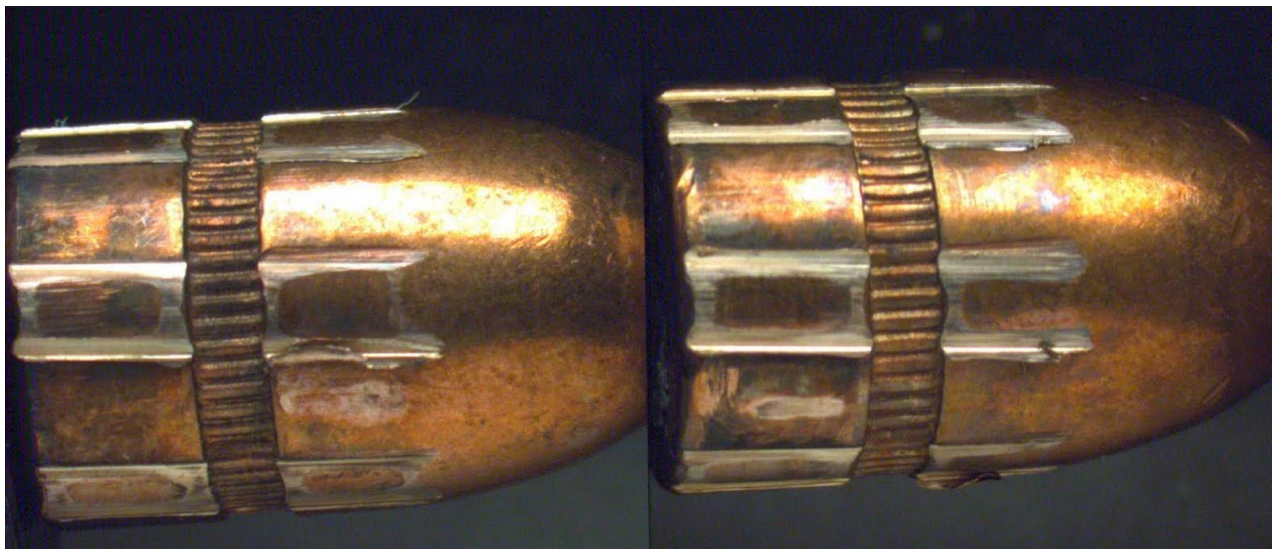
Background

- Bullet striations result from contact with a gun barrel
- Striations are observed on *land engraved areas* (LEAs)
- Land engraved areas are separated by *groove engraved areas* (GEAs)



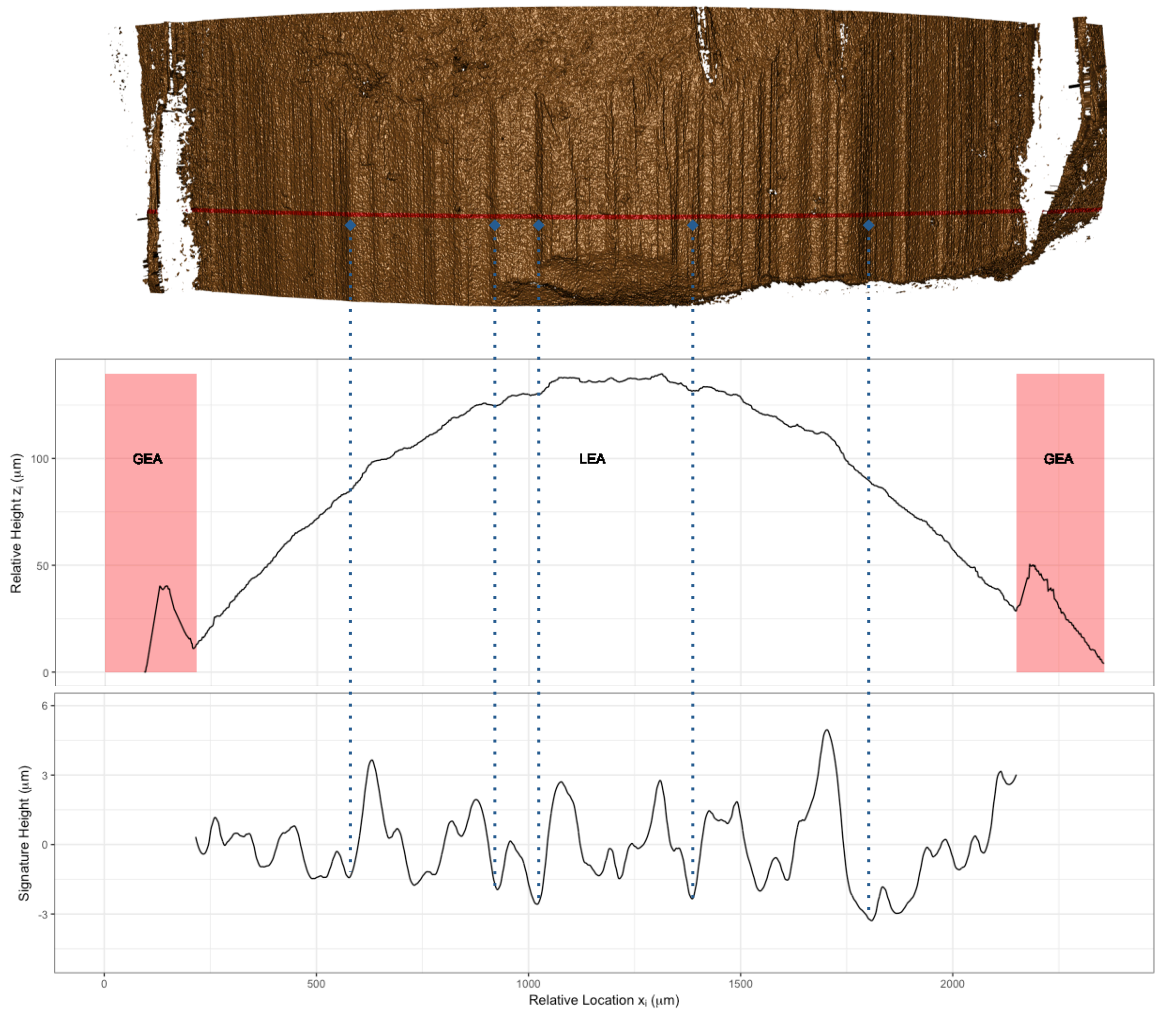
Comparing Bullets

- Fired bullets are compared to one another by comparing LEAs under comparison microscopes
- Conclusions based on level of similarity in striation patterns between LEAs



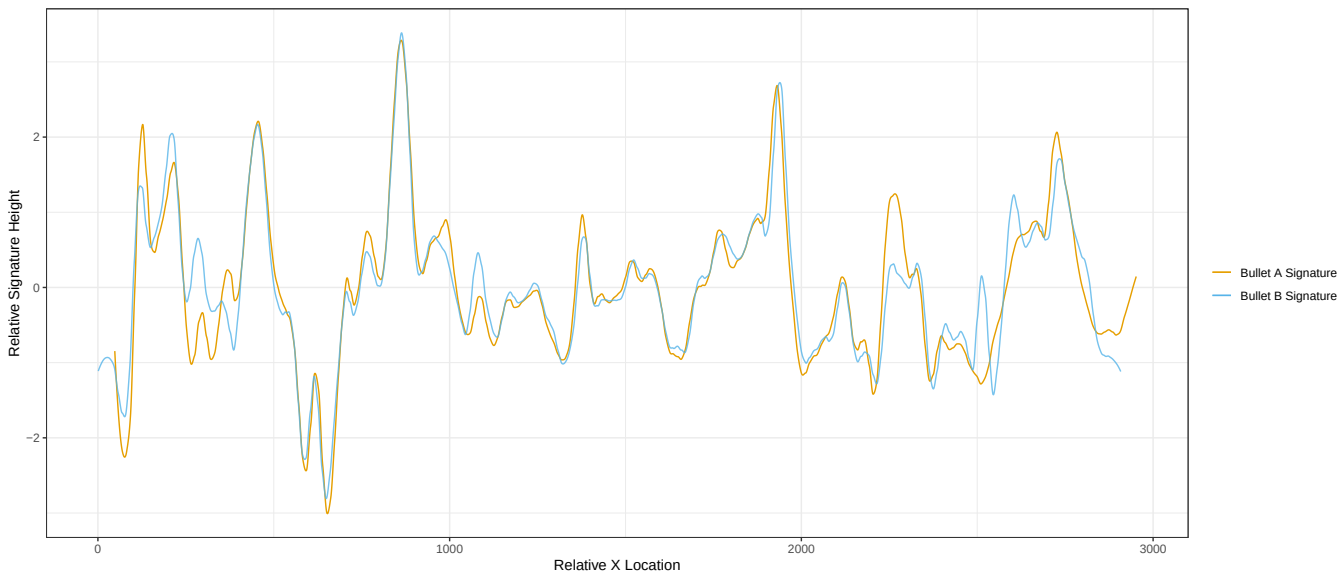
LEA to 3D Scan

3D Scan to 2D Signature



Comparing 2D Signatures

Signatures are compared to one another, and pairwise features are extracted from aligned pairs of signatures.

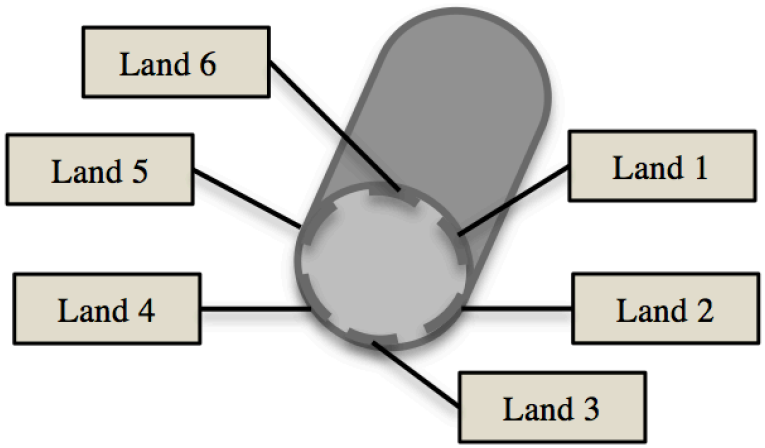


My role on the bullet project!

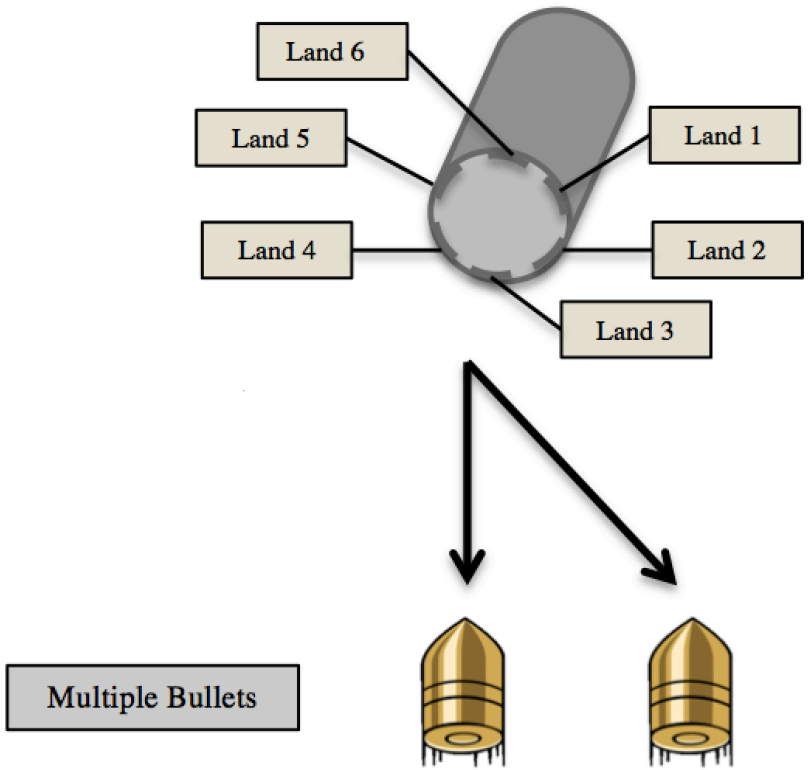
- Thinking about the "pipeline" of data decisions
- Just in the data process so far, 5 data decisions were made:
  1. Who scanned the LEA
  2. What machine the LEA was scanned on
  3. What crosscut was used to extract a profile
  4. Method to ID and remove GEA data
  5. Method to remove curvature (LOESS)
- What are the possible outcomes we could see if different decisions are made?

Let's consider decisions (1) and (2): Environmental conditions of 3D scanning!

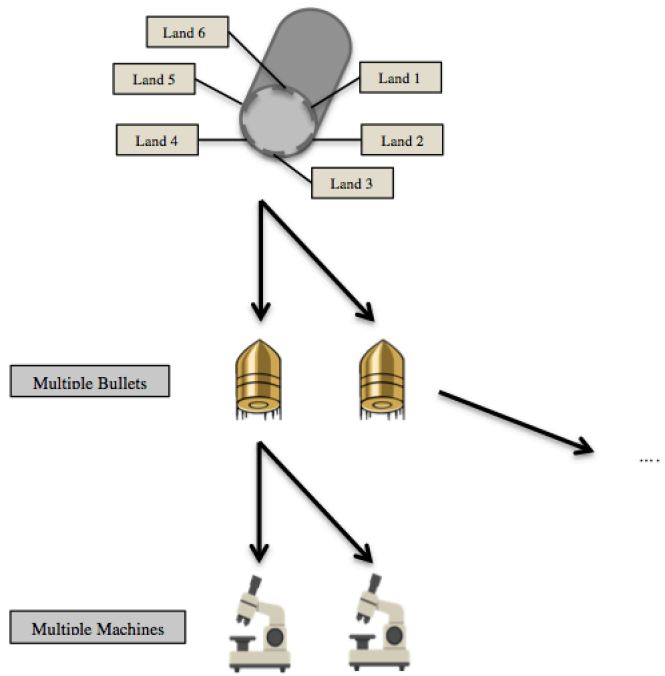
Introduced Variability in Scanning



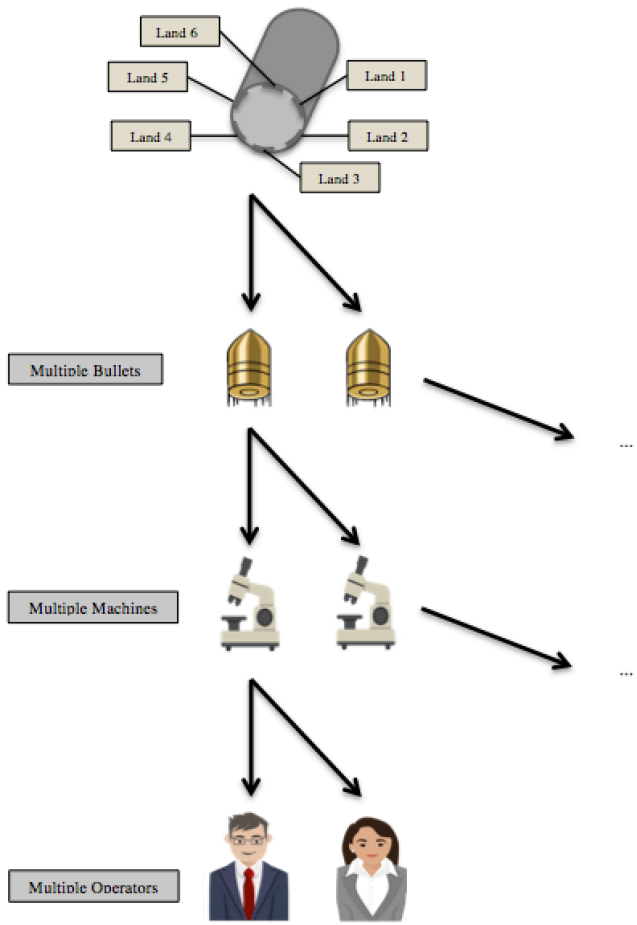
Introduced Variability in Scanning



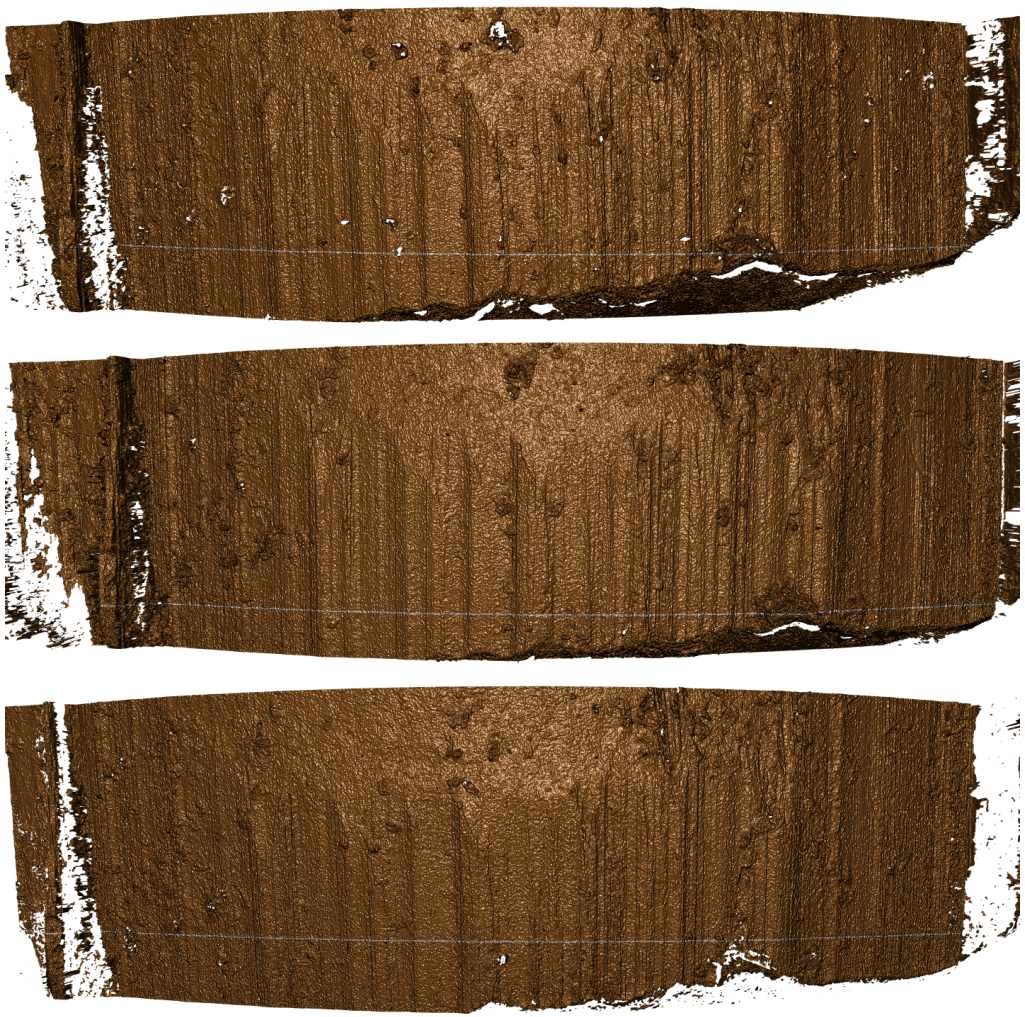
Introduced Variability in Scanning



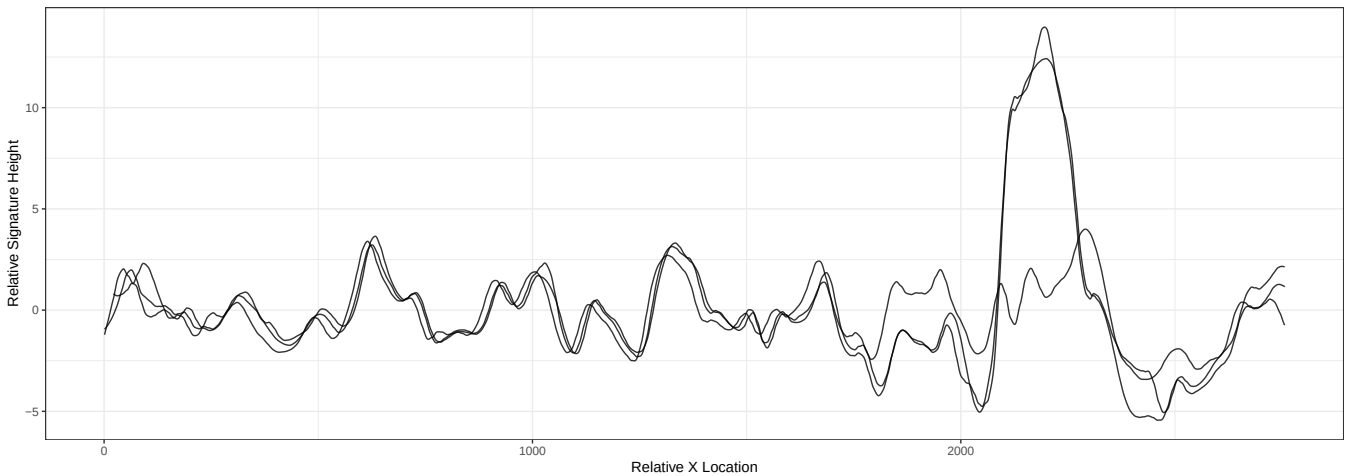
Introduced Variability in Scanning



Variability in Scan Data



Variability in Extracted Data



Variability Study Description

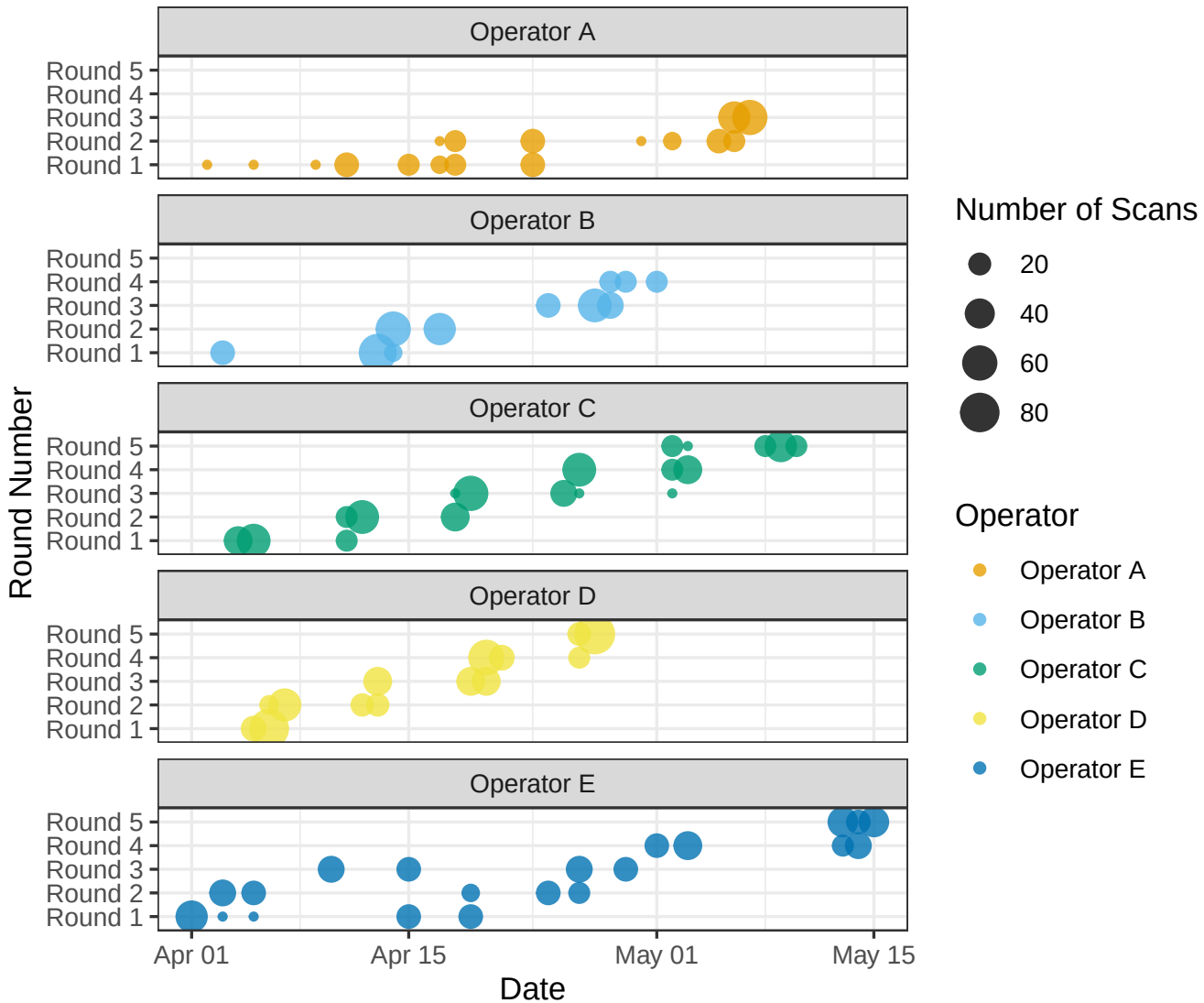
We collected repeated scans of 9 bullets:

- 3 bullets each from 3 different barrels
  - each bullet has 6 LEAs
- 5 microscope operators
- 2 microscopes
- 3+ repetitions per operator-microscope combination

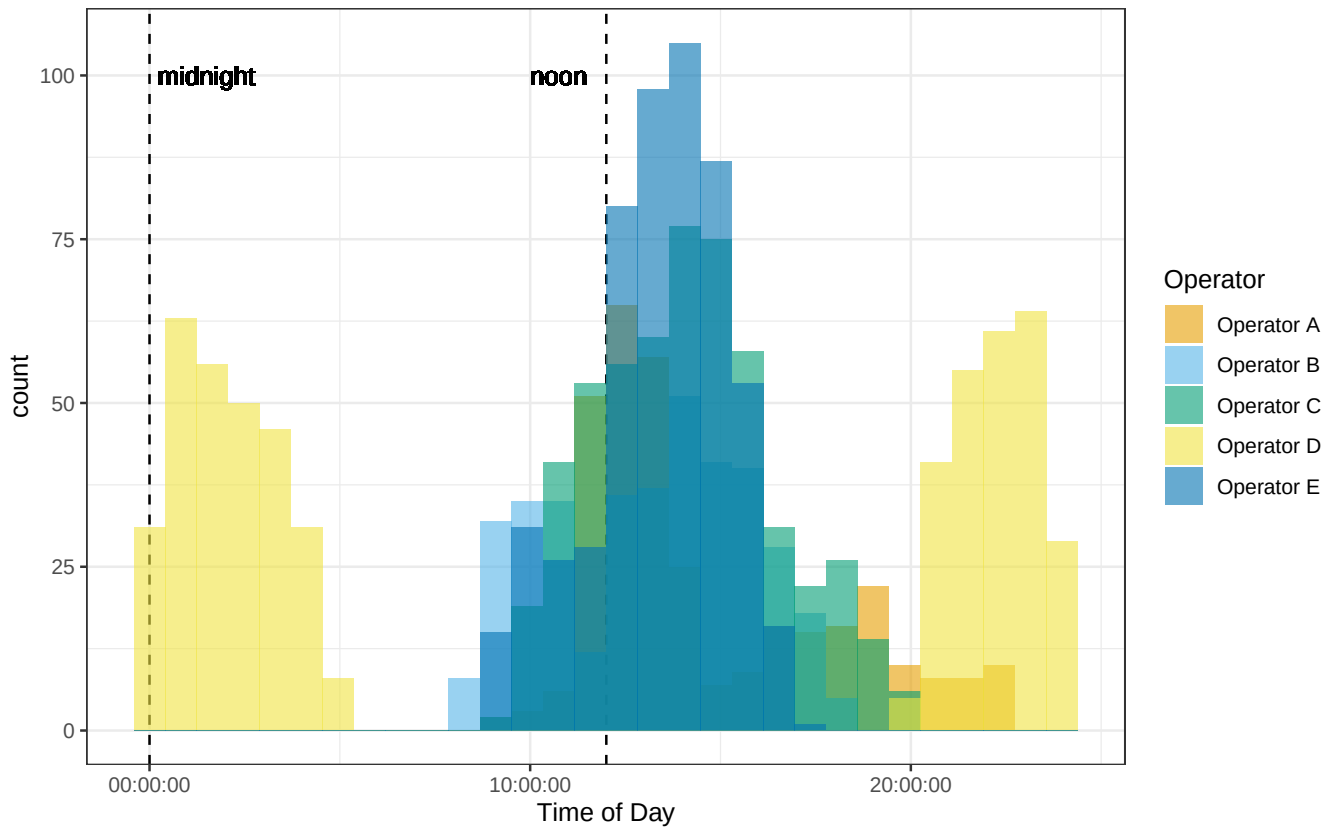
This resulted in 30+ scans of each physical LEA, 90+ scans of each "barrel-land".

Let's visualize some variability!

Variability in Data Collection :)

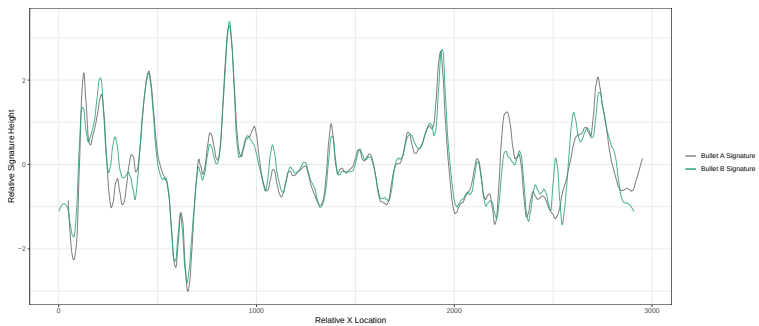


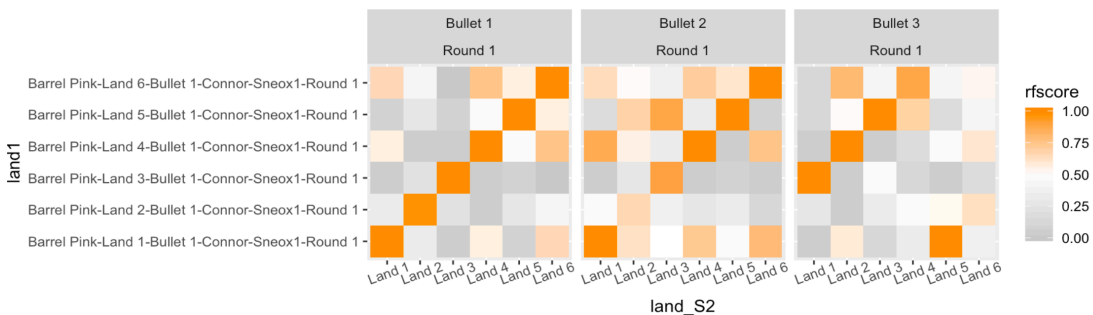
Variability in Scanning Times



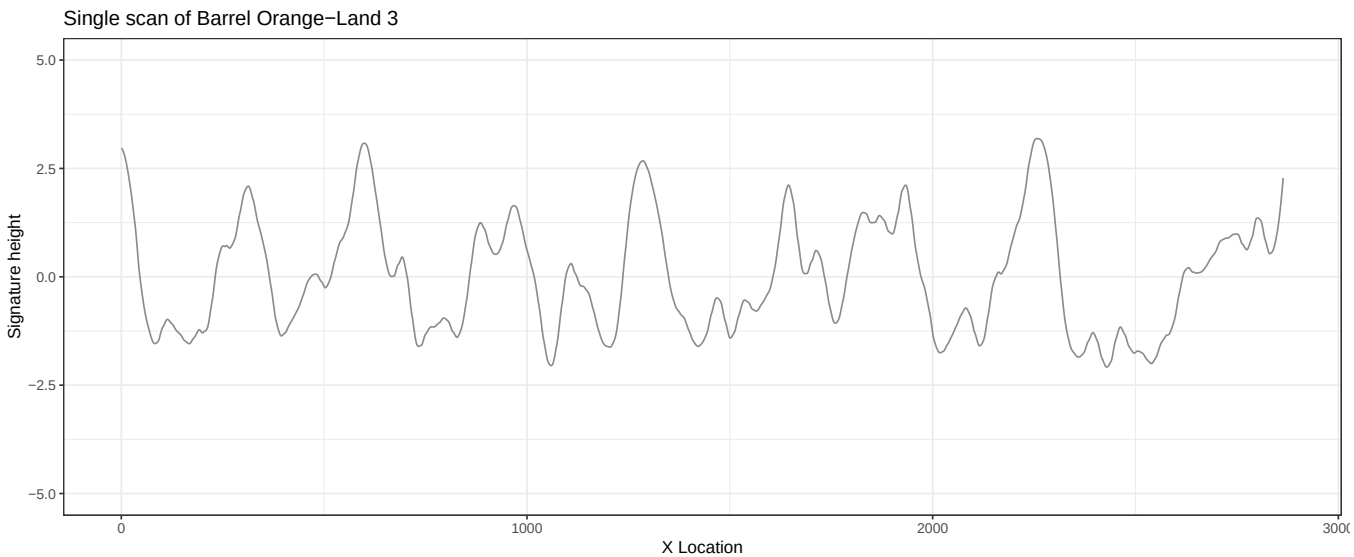
Places to Visualize Variability

1. Signature level
2. Score level - signatures and bullet-to-bullet

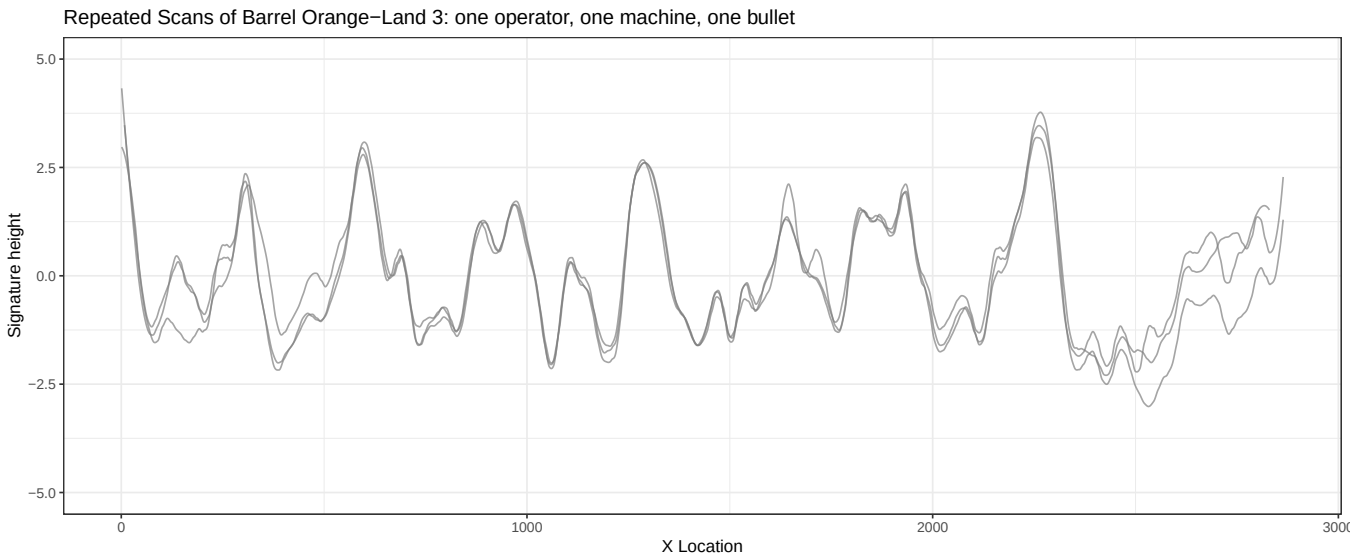




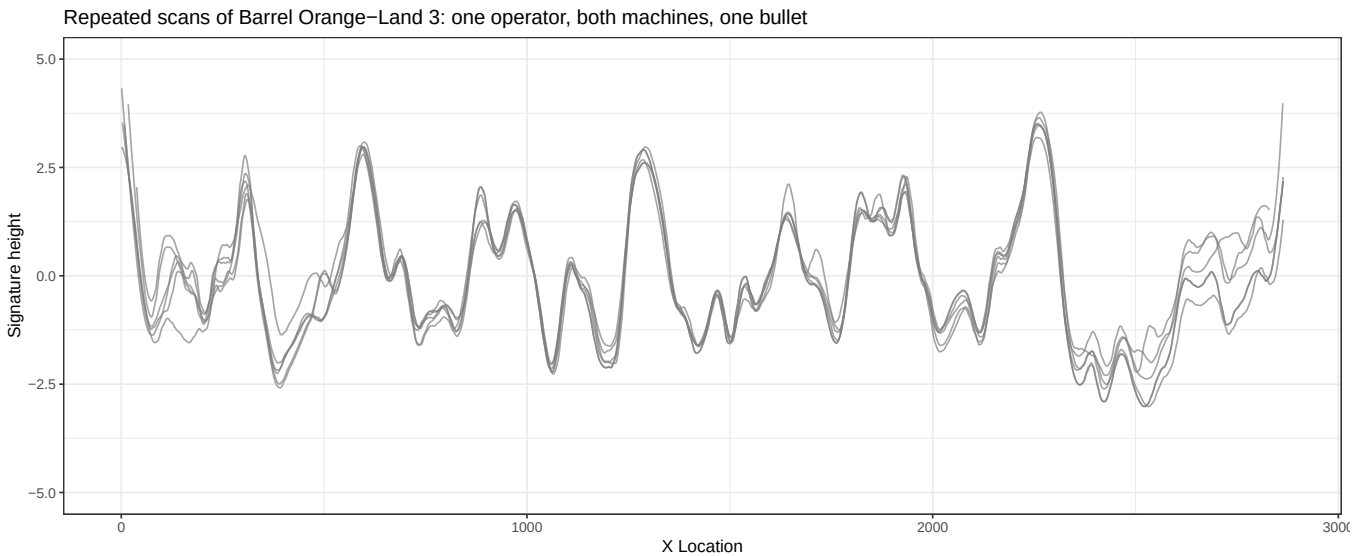
Variability at Signature Level



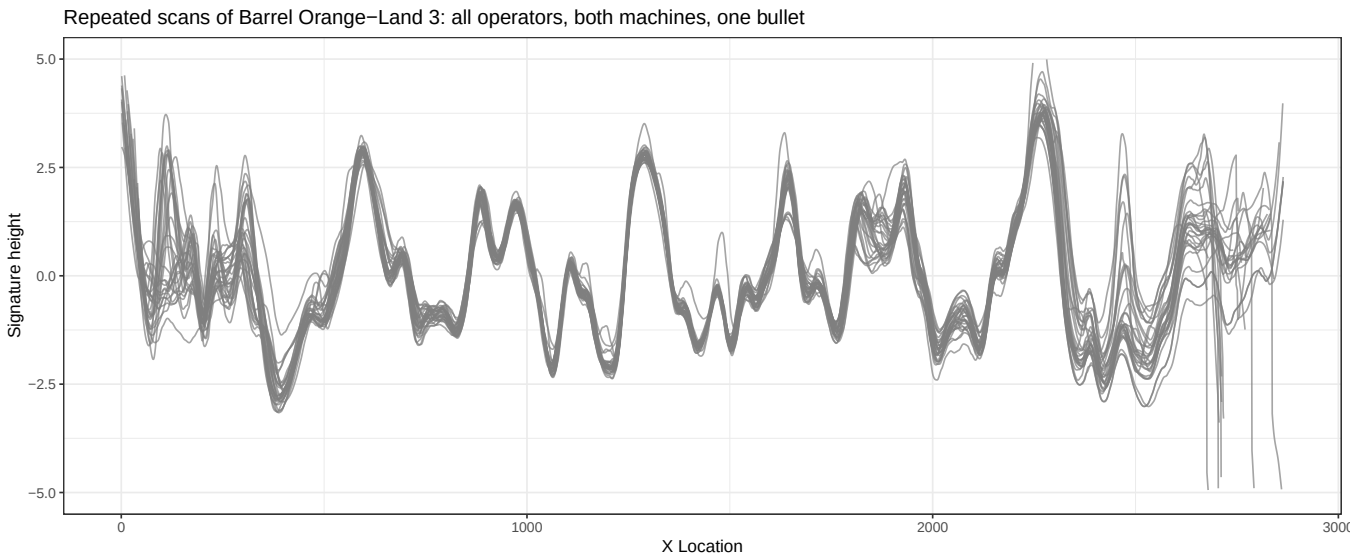
Variability at Signature Level



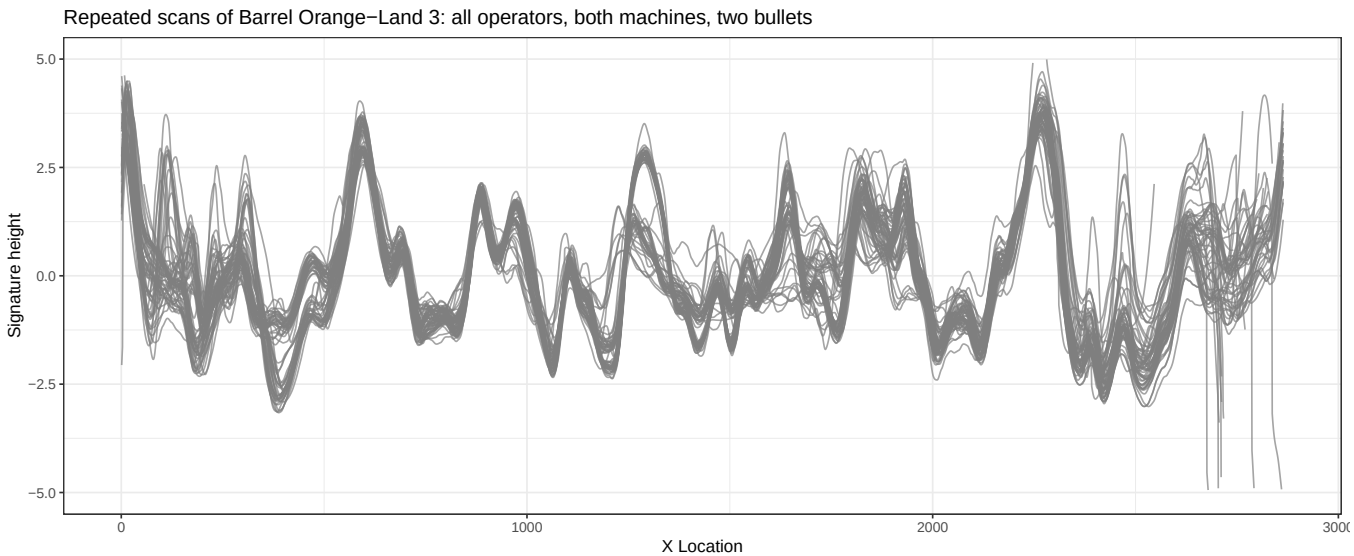
Variability at Signature Level



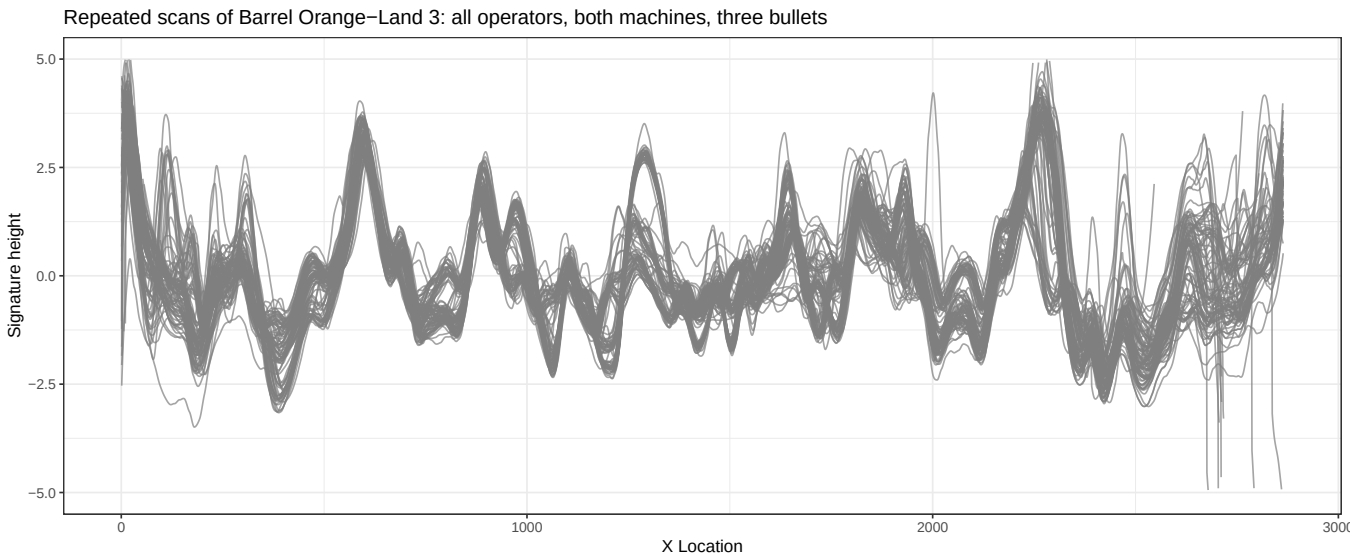
Variability at Signature Level



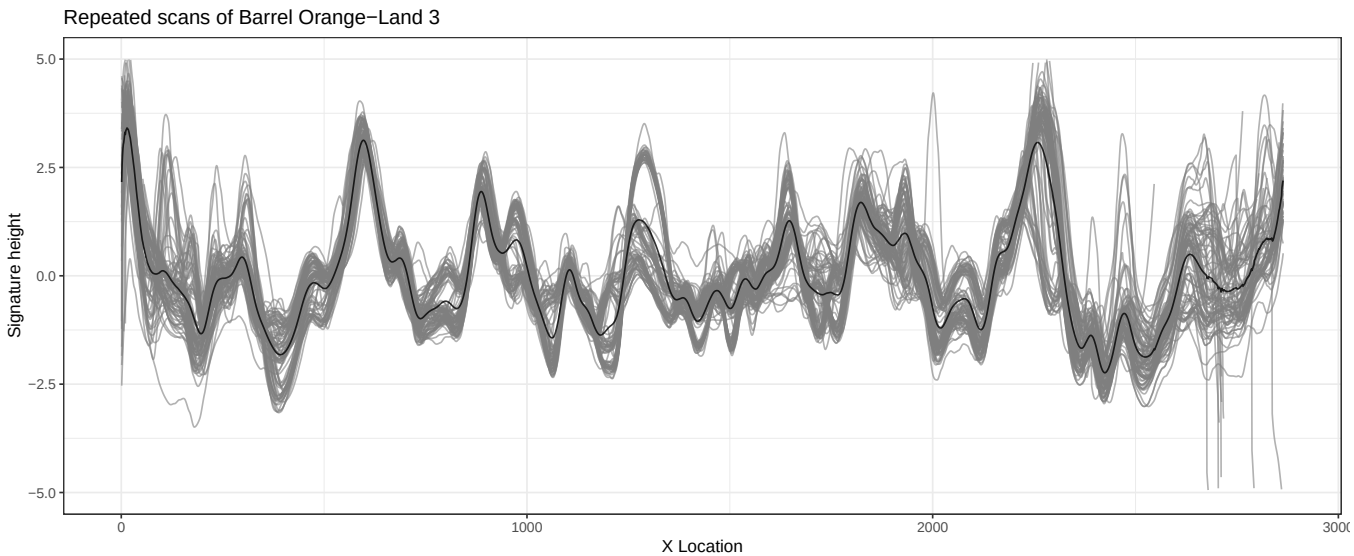
Variability at Signature Level



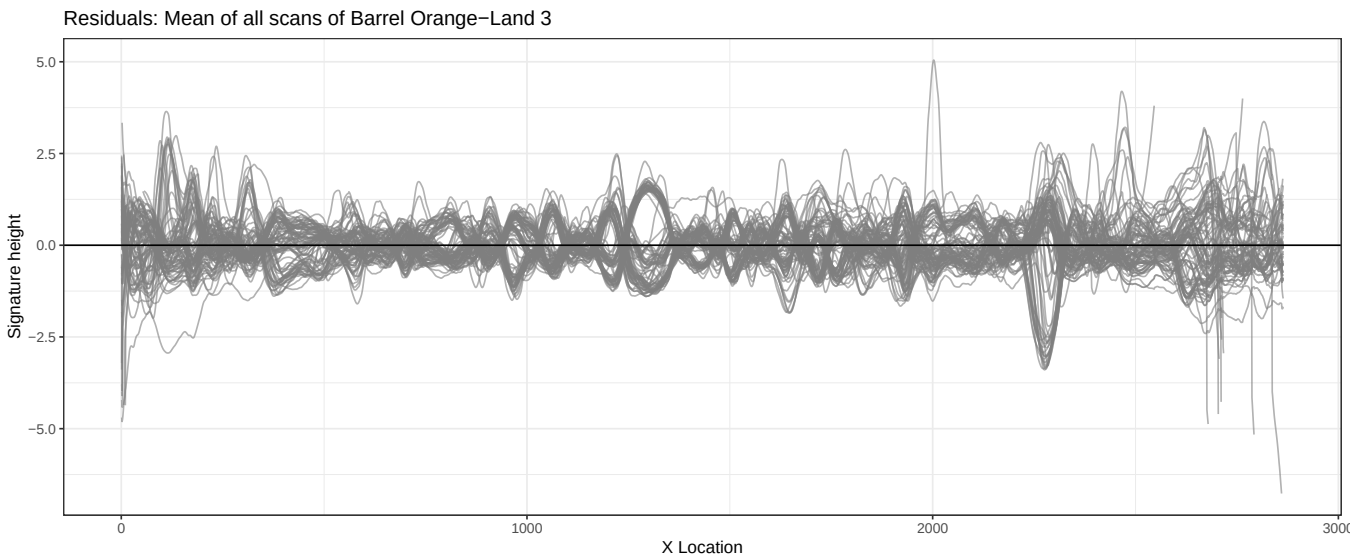
Variability at Signature Level



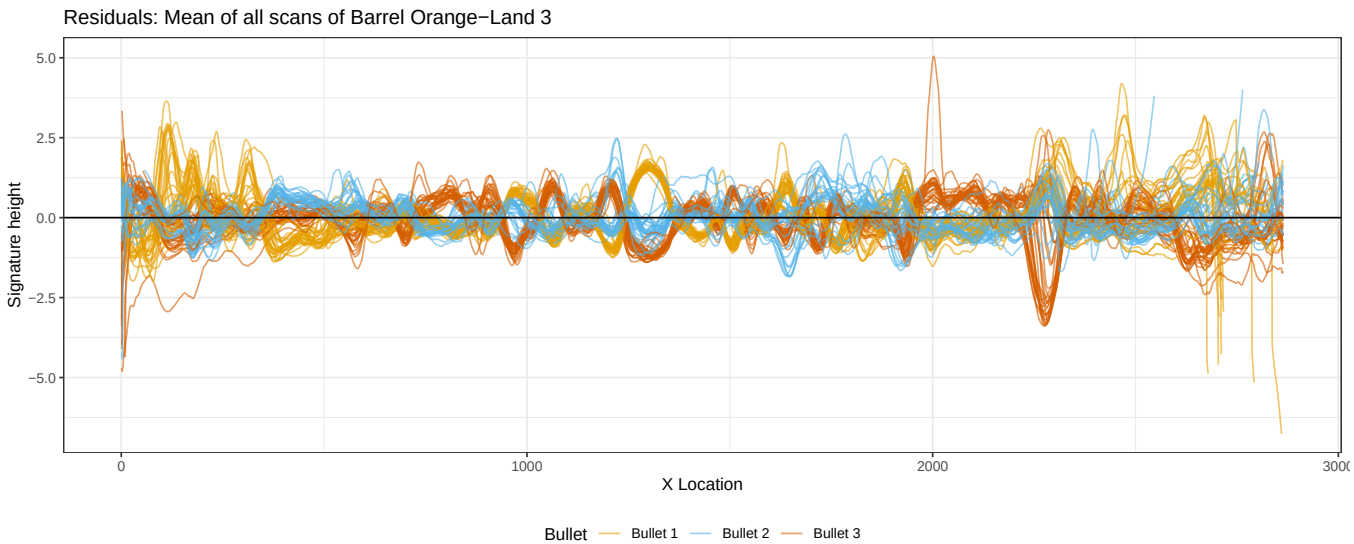
Variability at the Signature Level



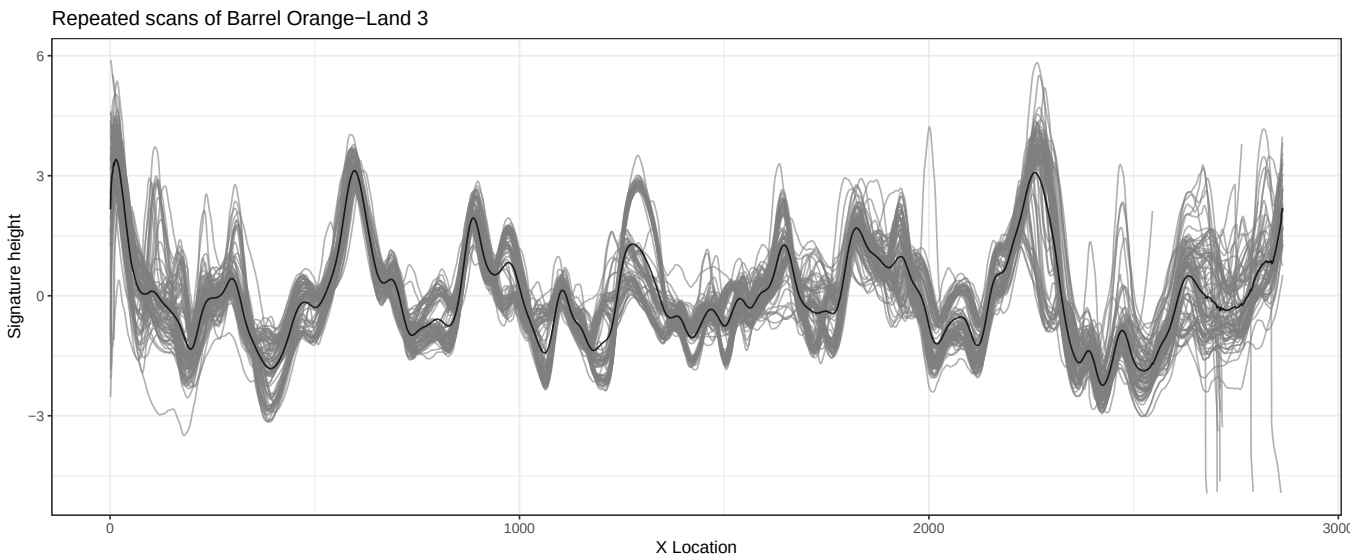
Variability at the Signature Level



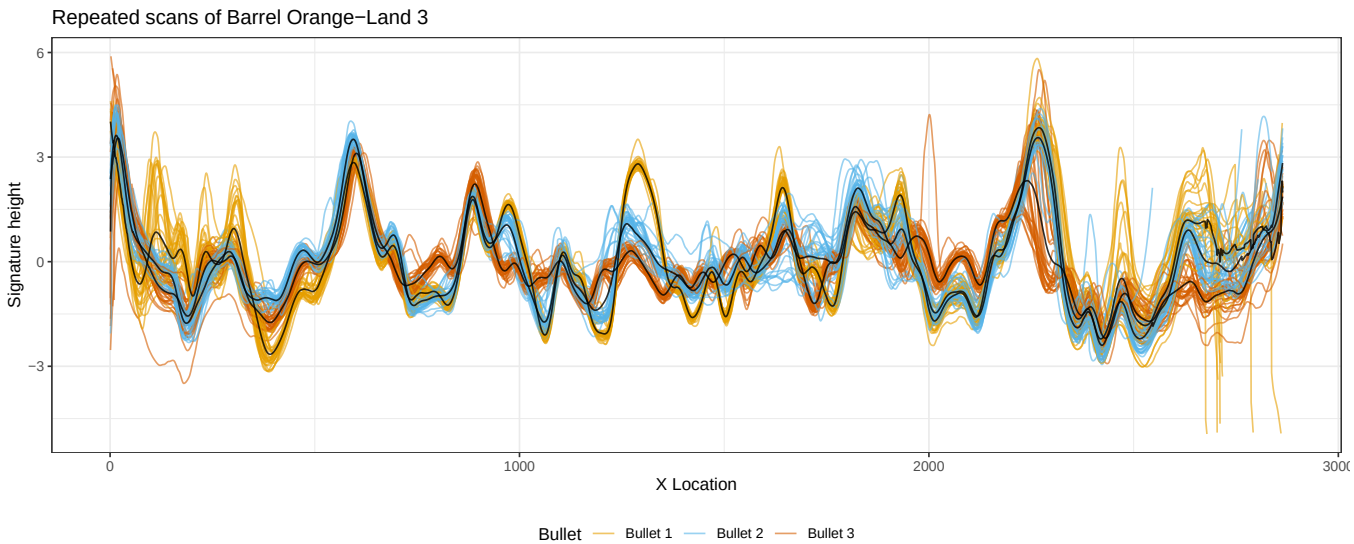
Variability at the Signature Level



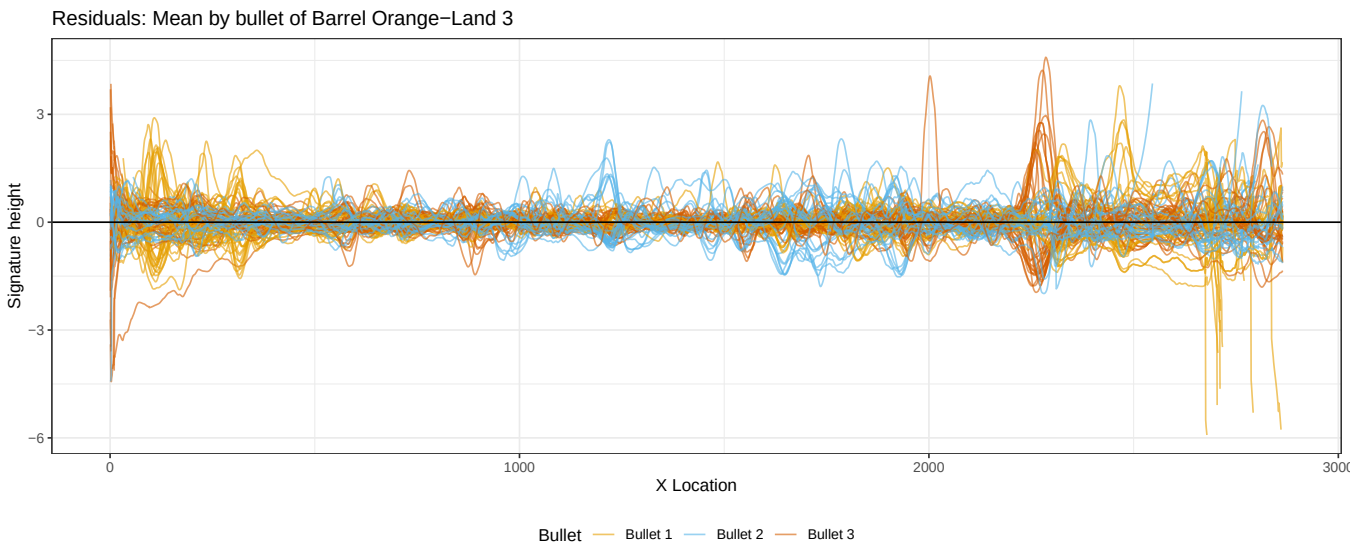
Variability at the Signature Level



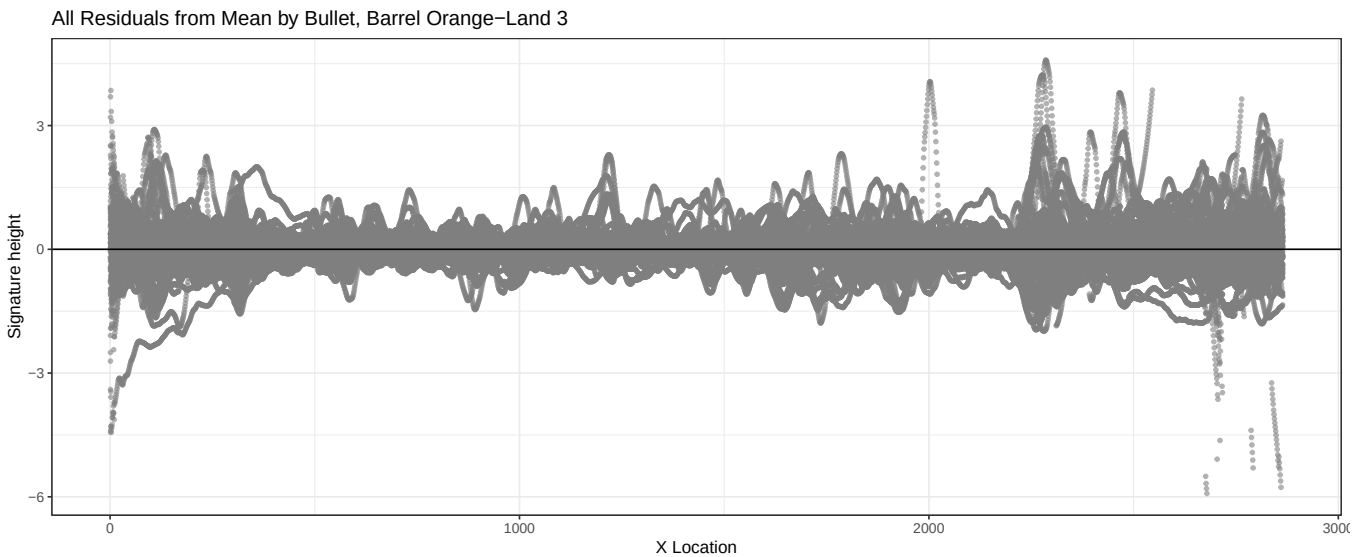
Variability at the Signature Level



Variability at the Signature Level



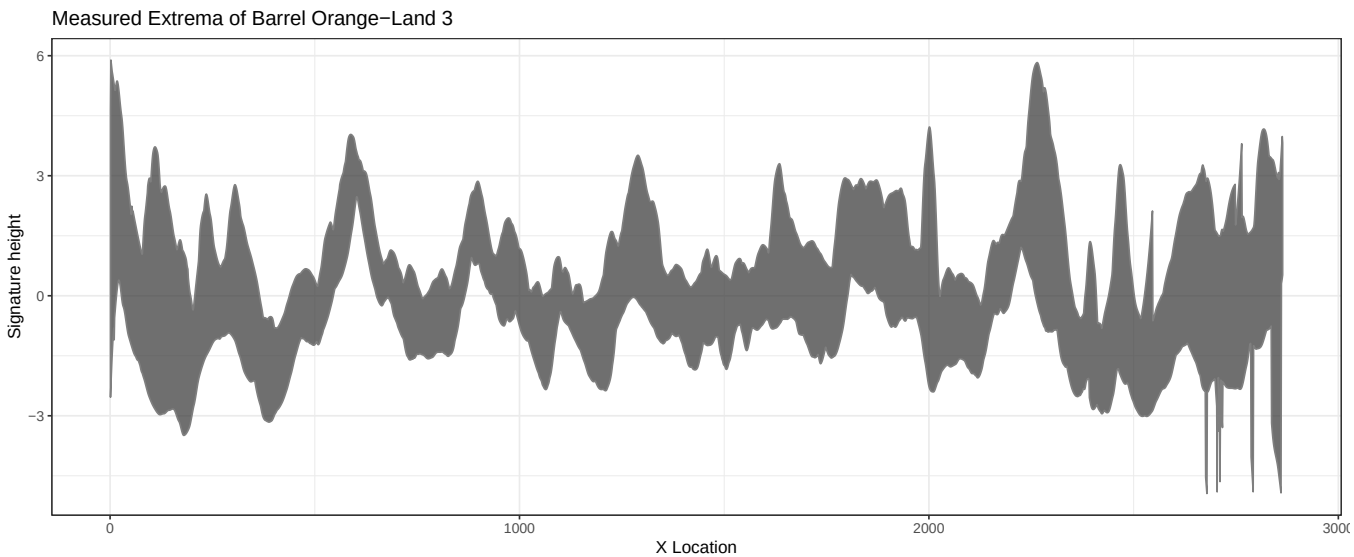
Variability at the Signature Level



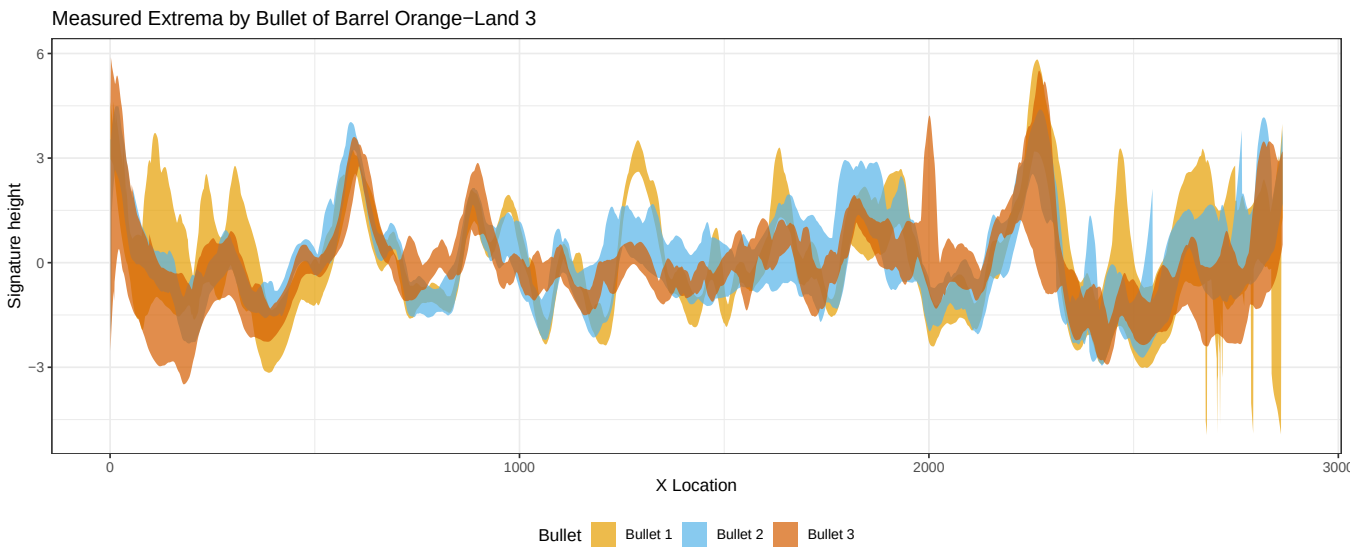
Variability at the Signature Level

If time, visual inference stuff goes here!

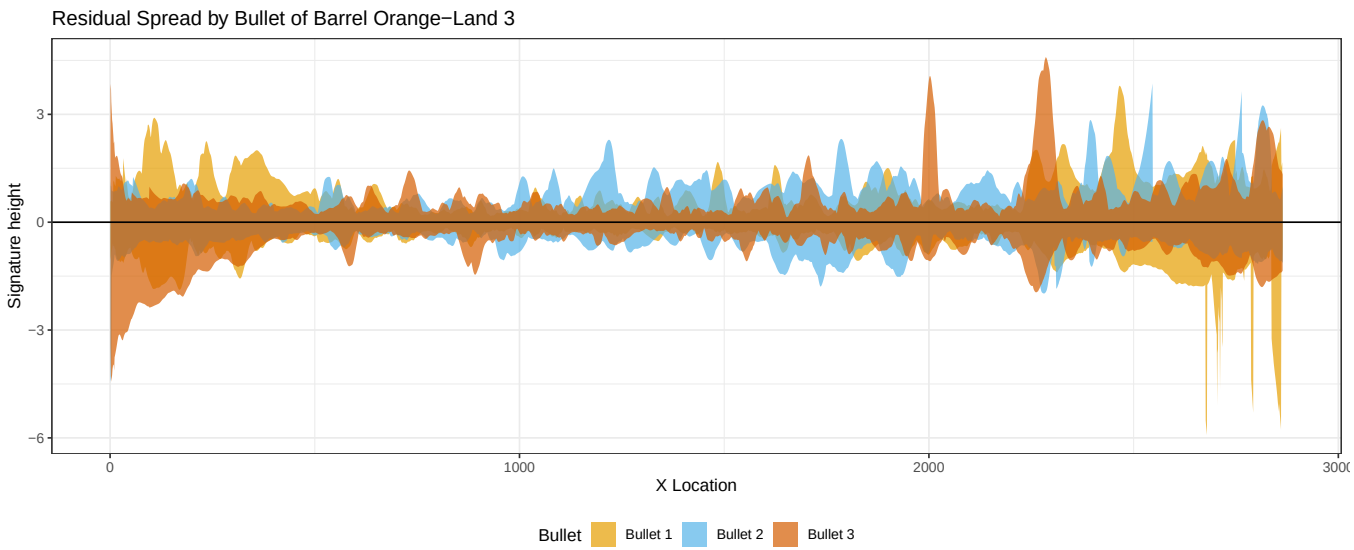
Variability at Signature Level



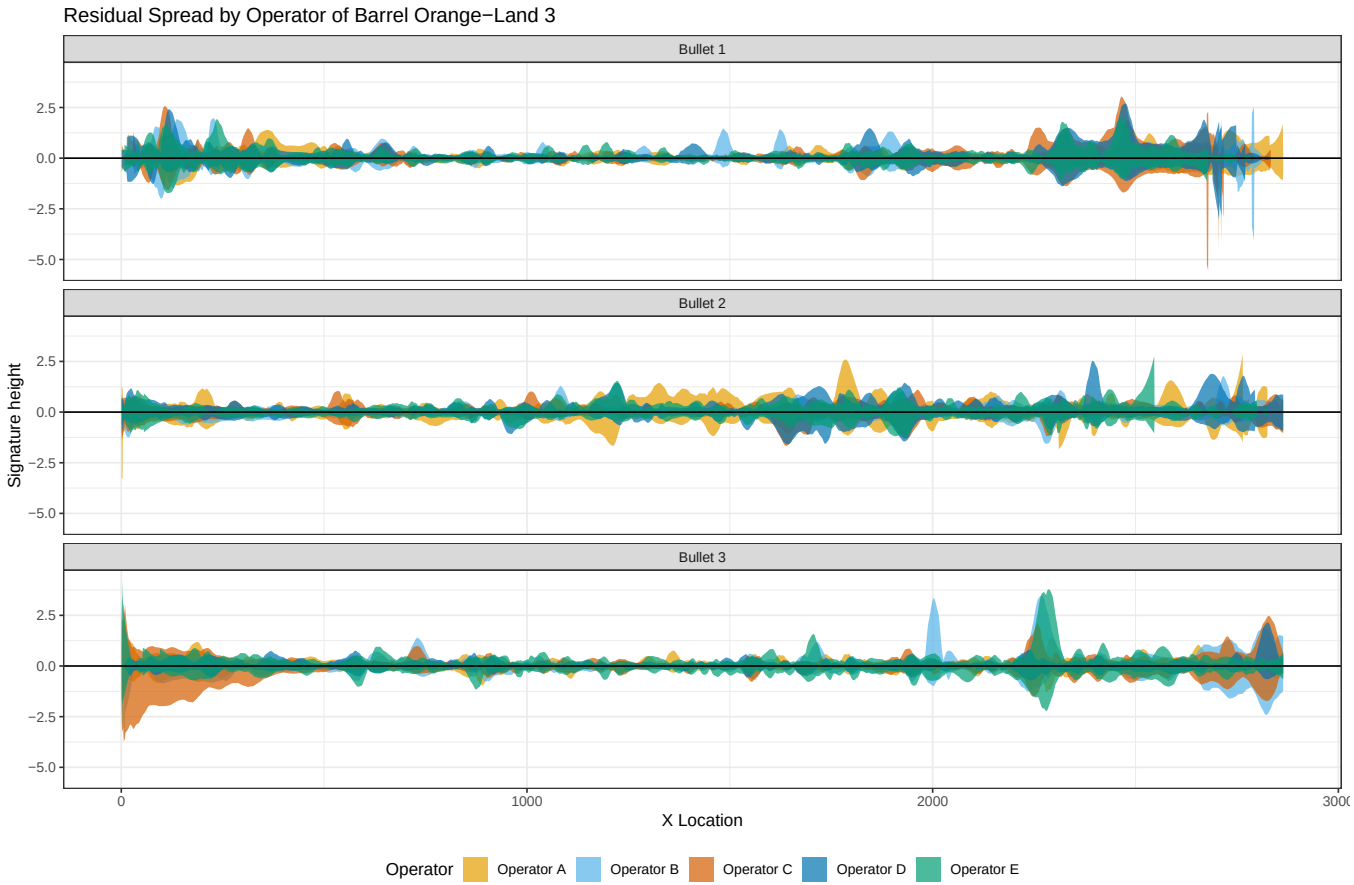
Variability at Signature Level



Variability at Signature Level



Variability at Signature Level

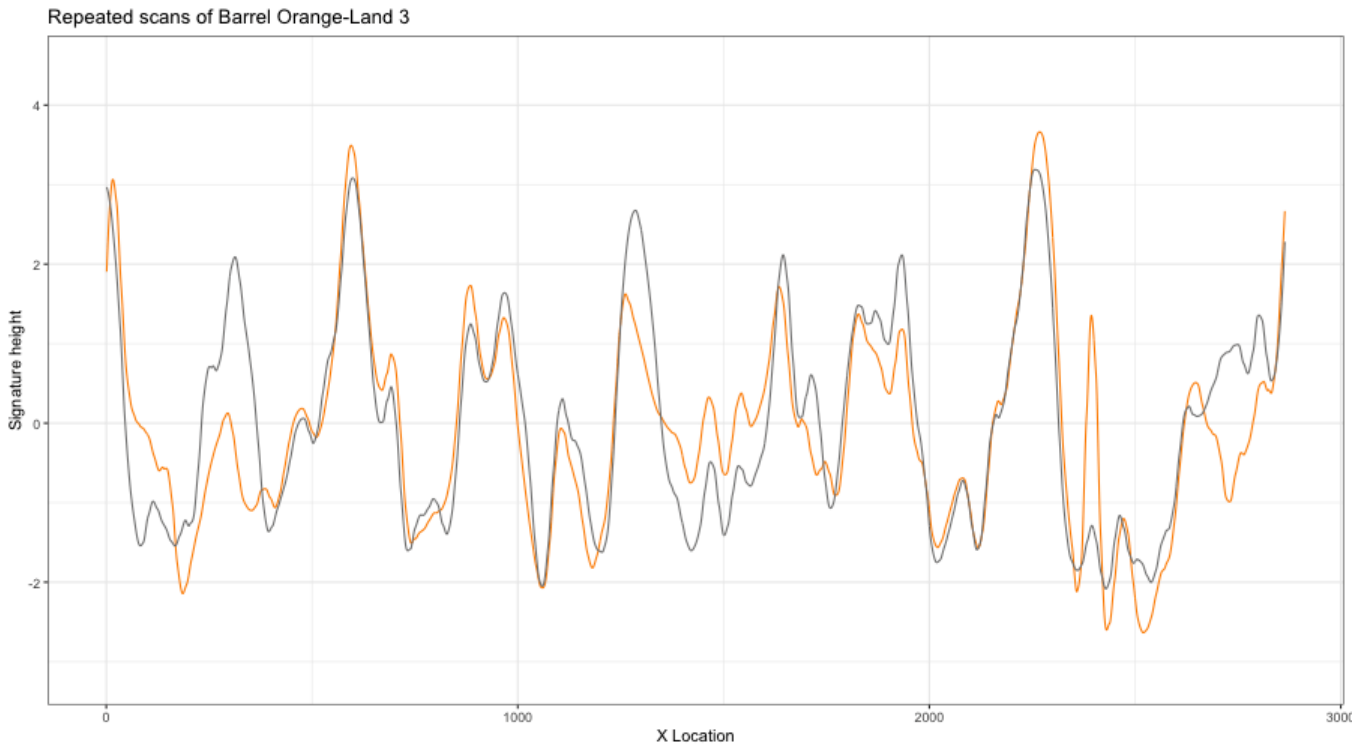


Now what?

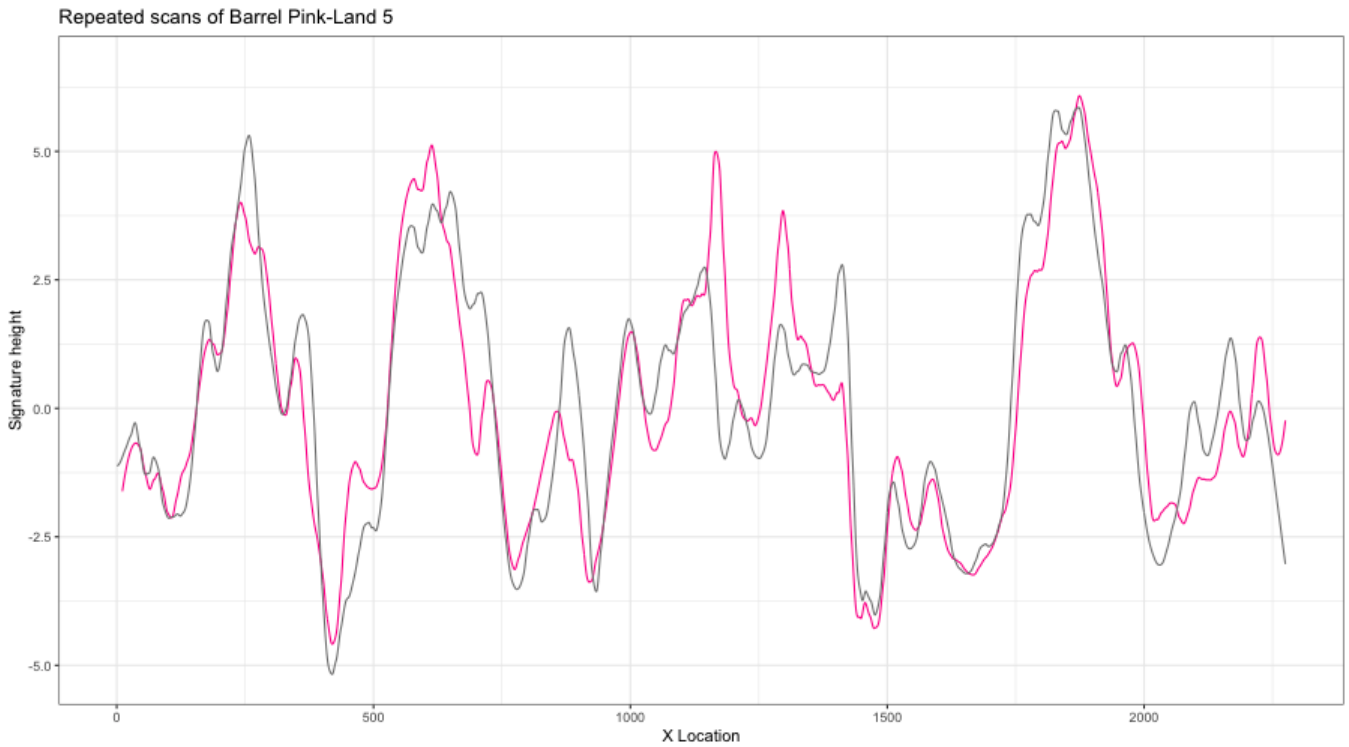
So, we have seen some examples of how to display the variability of data collection and extraction. But the data process doesn't end with signatures! Signatures are *paired up* and compared to one another to get a **pairwise similarity score**.

1. Same-source score distribution
2. Iterating through randomly sampled pairs (same-source)
3. Bullet-to-bullet score grids

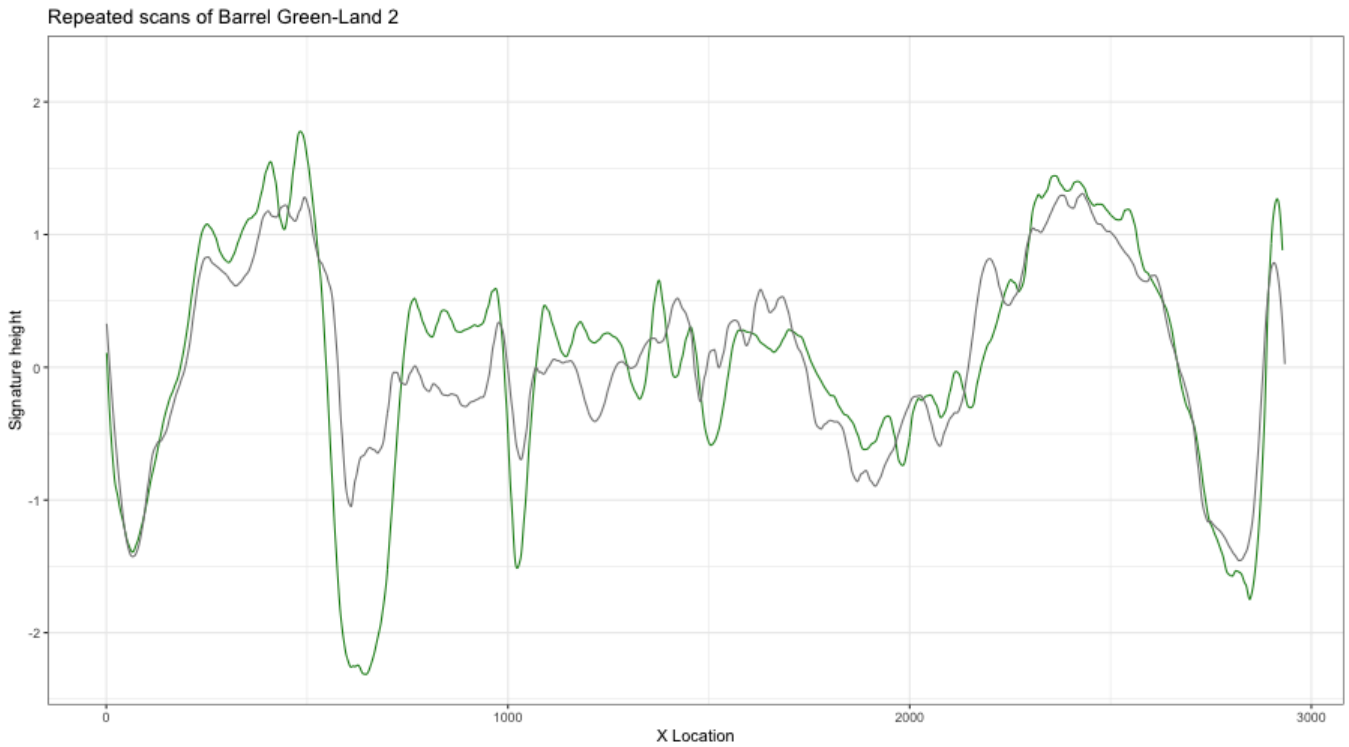
Variability in Same-Source Pairs



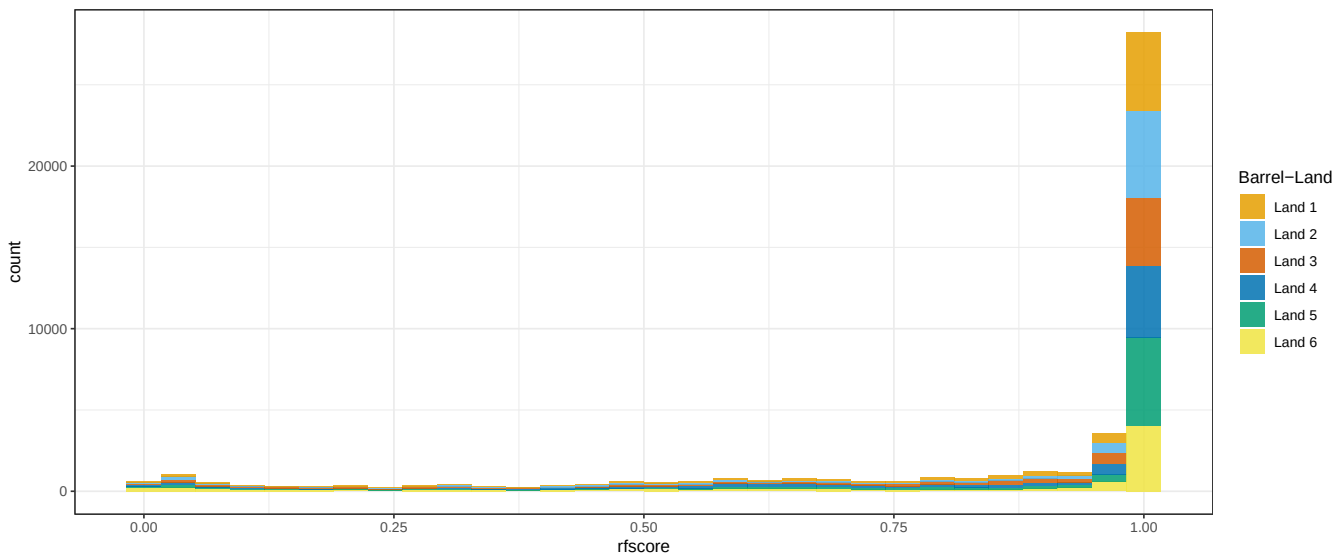
Variability in Same-Source Pairs



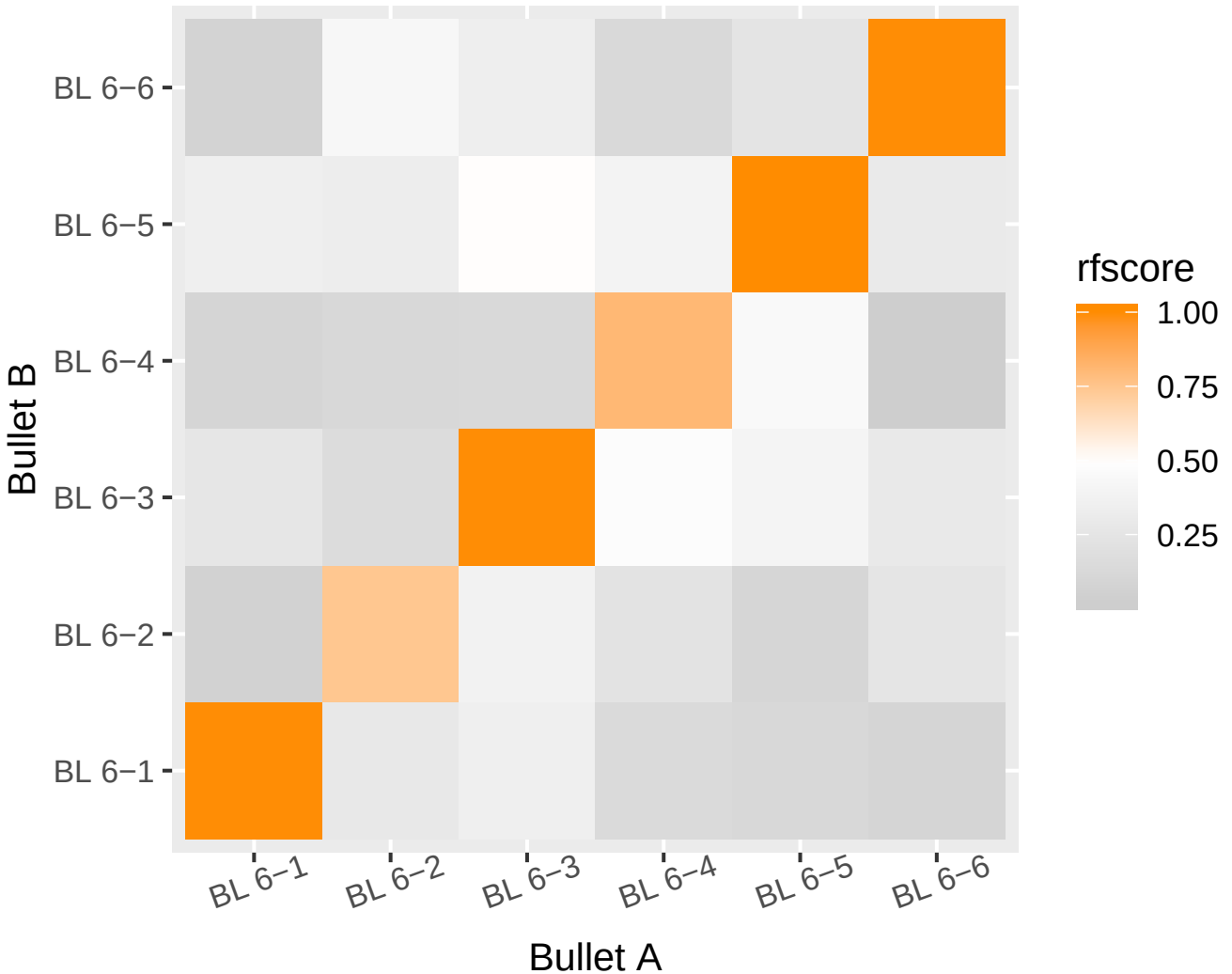
Variability in Same-Source Pairs



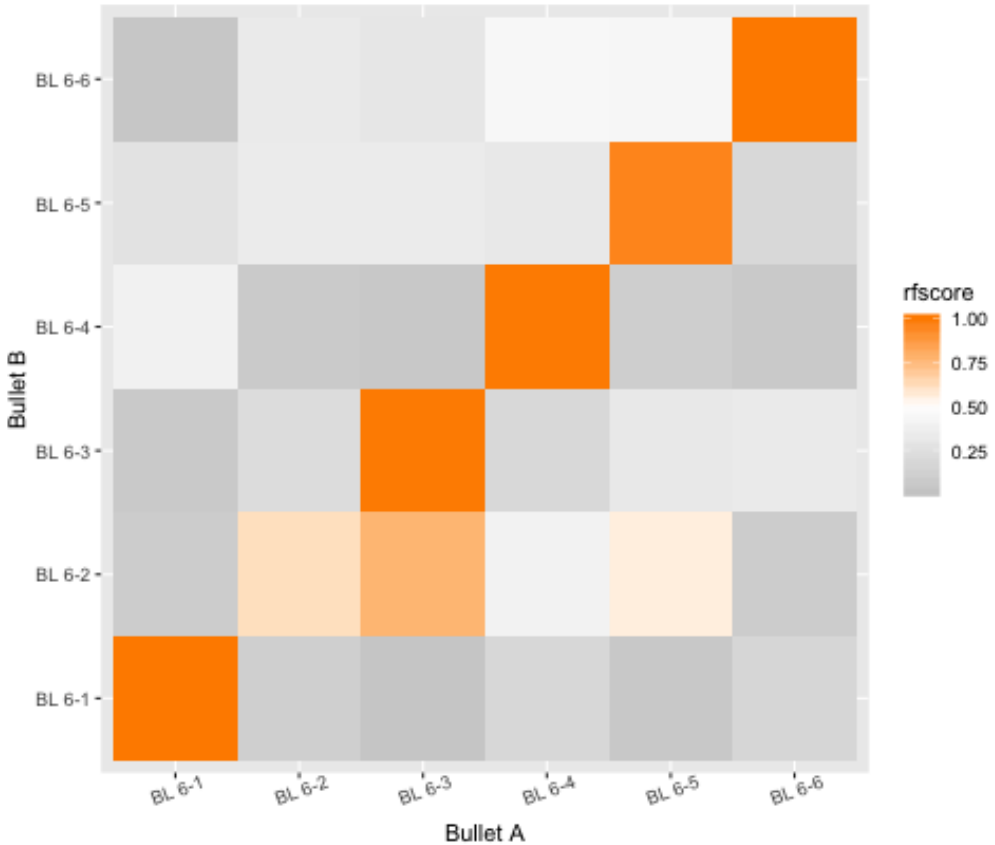
Variability in Same-Source Pairs



Variability in Bullet-to-Bullet



Variability in Bullet-to-Bullet



@

Conclusions

Things I'm still working on:

- Modeling at the signature level
  - Visual inference to test different modeling assumptions!
  - Visualizing CI's for mean based on estimated variability components
  - Visualizing different variability components better?

Does anybody have any other ideas/thoughts/suggestions?

Thank you!!!!