Screening Experiments in Mobile Channel Measurements

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Outline

What You'll Learn:

- What the main sources of variability in mobile channel measurements are.
- How we learn this.

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Overview

What do we want to learn?

What are the main sources of *variability* in mobile channel measurements?

- List all potential sources sources of variability:
  - ________
  - ________
  - ________
  - ________
  - ________
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  - ________
  - ...
- Which are the largest and most important?
- Separate the vital few from the trivial many.

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How do we learn this?

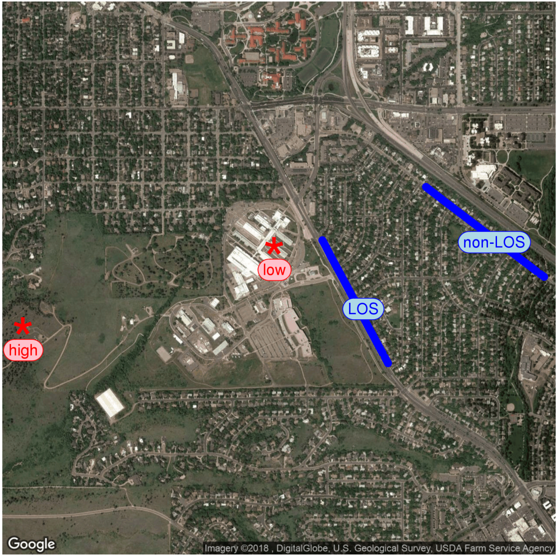
- Experimental design
- Proper research methods

We studied 15 potential sources of variation:

- Five main effects
- Ten two-way interactions

Overview

What did we do?



We manipulated 5 variables:

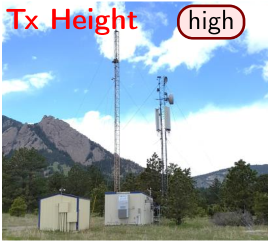
- Transmitter Height
  low high
- Transmitter Power
  37dBm 47dBm
- Route
  LOS non-LOS
- Rx Vehicle Speed
  20mph 30mph
- Traffic Conditions
  off peak peak

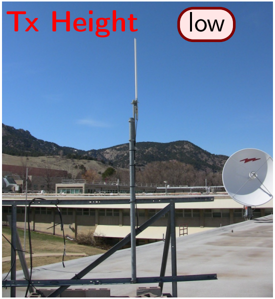
We measured RF power on the highlighted roads. We computed `clutter loss`.

Here's how we did it.

Transmitter and Receiver

Also varied: Tx Power 37dBm 47dBm





Here's how we did it.

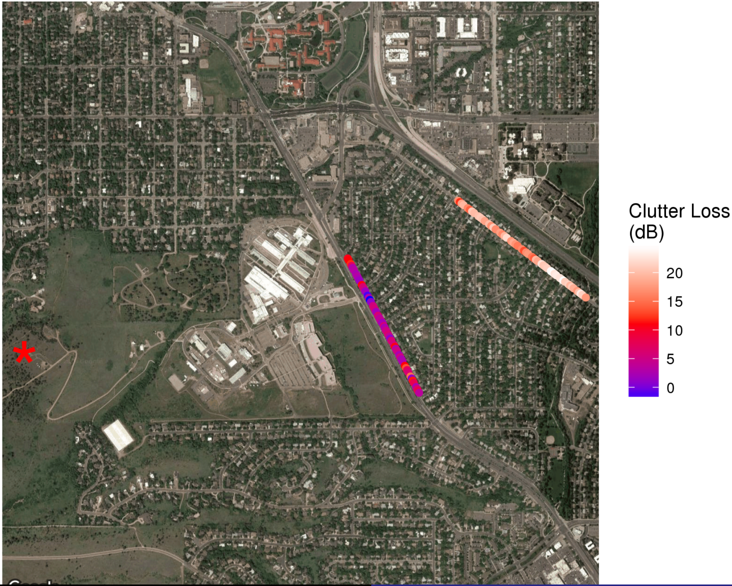
View from LOS route looking at transmit sites (both unobstructed, but for leaves)

Here's how we did it.

View from non-LOS route in direction of transmit sites (both obstructed)

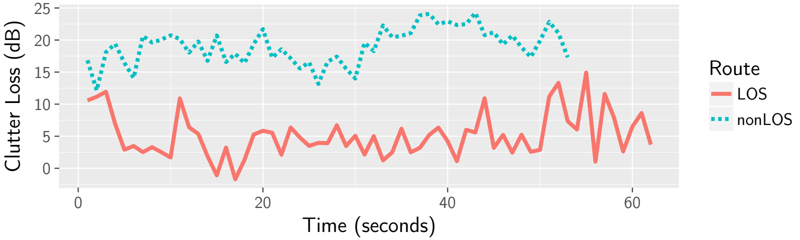
Outline

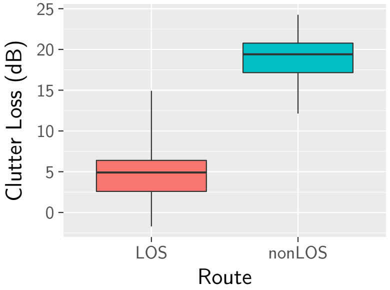
One Run: 47dBm high offPeak 20mph

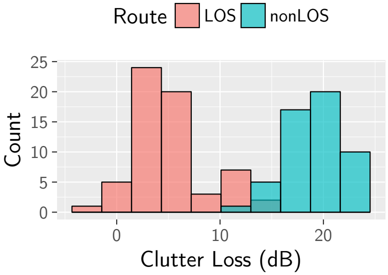


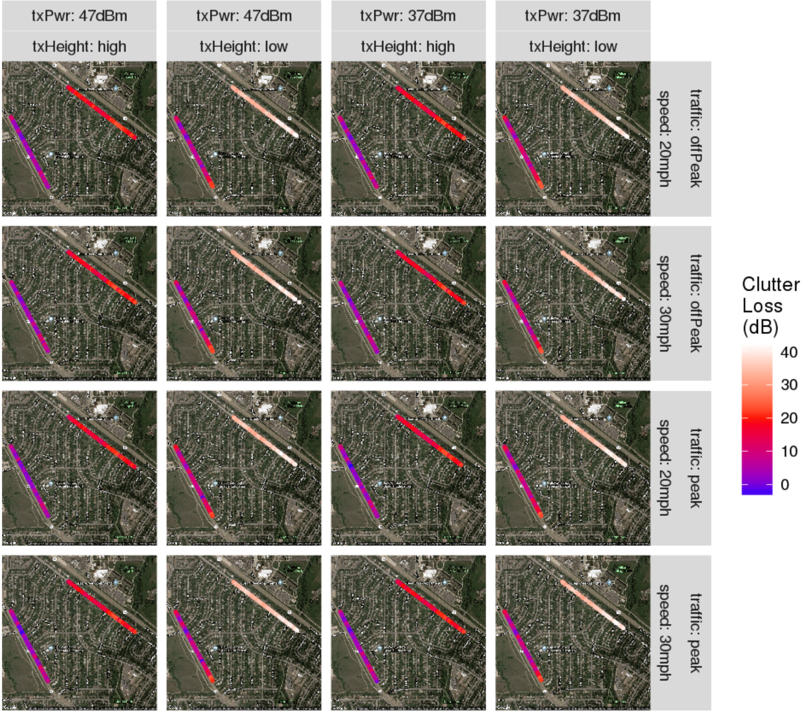
One Run: 47dBm high offPeak 20mph

Data shown as time series, boxplots, and histograms.








txPwr: 47dBm
txHeight: high
txPwr: 47dBm
txHeight: low
txPwr: 37dBm
txHeight: high
txPwr: 37dBm
txHeight: low
traffic: offPeak
speed: 20mph
traffic: offPeak
speed: 30mph
traffic: peak
speed: 20mph
traffic: peak
speed: 30mph
Clutter Loss (dB)
40
30
20
10
0

Experimental Design
The Split-Plot

The design tells us how to set each variable and collect the data.

- Split-plot design was developed for agriculture in 1930s.
- Used when some variables are hard to change.
  - `Transmitter height`
  - `Traffic`

1930s $\Longleftrightarrow$ 2018

Agriculture $\Longleftrightarrow$ Radio Science

Outline

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Results

Sources of Variation - Central Tendency

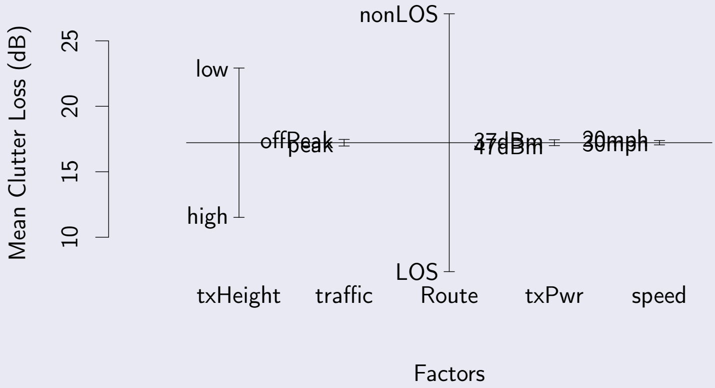
Three statistically significant sources of variation in `clutter loss` central tendency:

- Two main effects:
  - `Route` (LOS/non-LOS condition)
  - `Transmitter height` (low/high)
- One interaction effect:
  - Between `route` and `transmitter height`

Results

Clutter Loss Main Effects Plot - Central Tendency

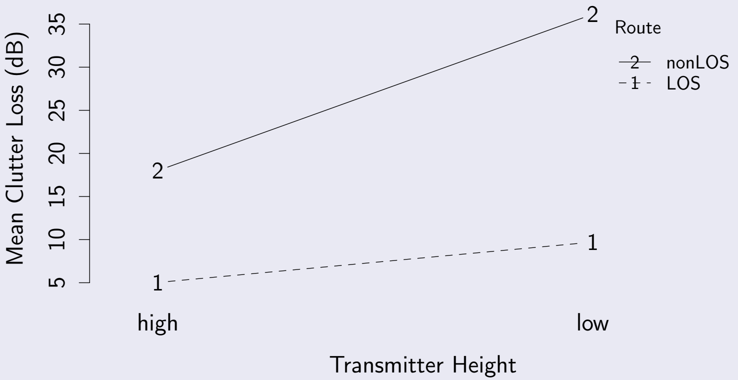
Two main effects: `transmitter height` and `route`



Results

Clutter Loss Interaction Plot - Central Tendency

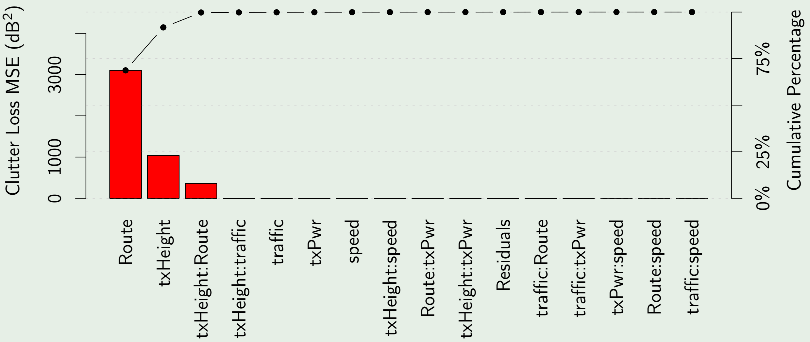
One interaction: between route and transmitter height



Results

Clutter Loss Pareto Chart - Central Tendency

99% of variability in clutter loss due to only two variables!



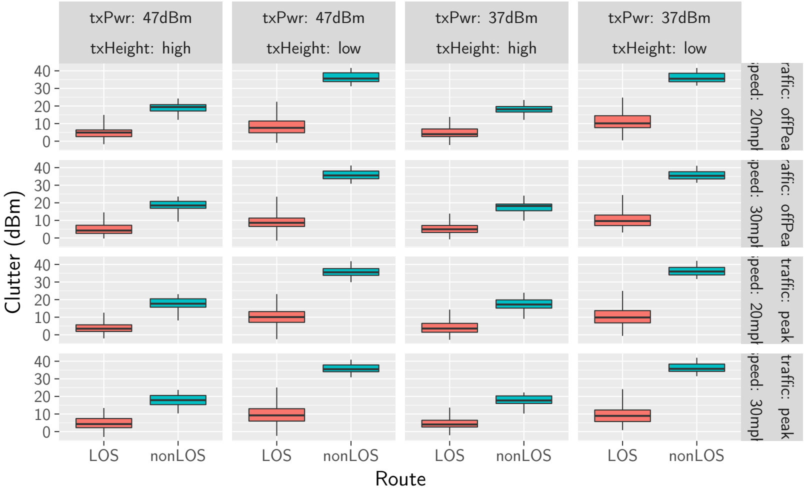
A significant finding!

Outline

Results

Sources of Variation - Dispersion

No statically significant effect



Another significant finding!

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Conclusions

We learned:

- Which factors in our study influence central tendency.
- No factors in our study influenced dispersion.
- We separated the vital few from the trivial many. 😎

We found similar results for ***K*-Factor** and **Coefficient of Variation** as criterion measure. (not presented)

Impact

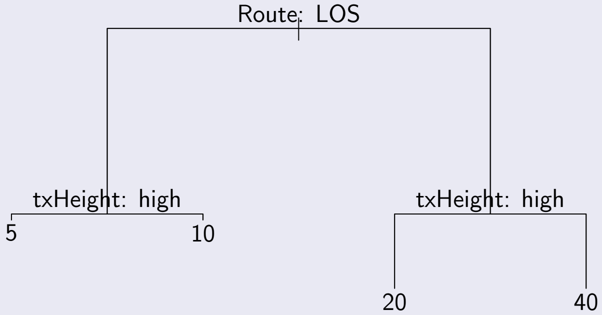
- Best practices
- Understanding the mobile radio channel
- **Modeling**

Conclusions

Clutter Loss Regression Tree Model

A very simple model. . .

If condition is true, ☜. Else, ☞.

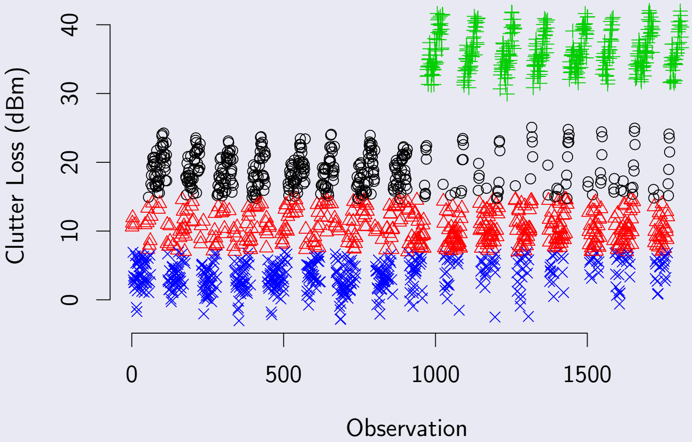


Going the other way: great candidate data for *classification*.

Unsupervised Learning

Can a computer classify measurement data? Yes, in this case.

Classification through Clustering



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Outline

You should know about this!

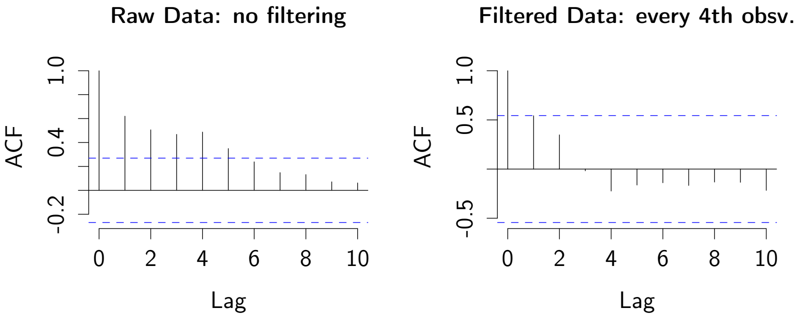
Irreproducibility Crisis

50–95% of all published research cannot be reproduced!

- Improper use of statistics
- Arbitrary research methods
- Lack of accountability
- Political correctness
- Groupthink
- Culture

Read the *National Association of Scholars'* shocking report, "The Irreproducibility Crisis of Modern Science."

Best Practices
Verify Independence of Observations



No statistical test is robust to a violation of the assumption of independence of observations! I had to take every fourth observation to remove dependence, as shown with the autocorrelation function plots.

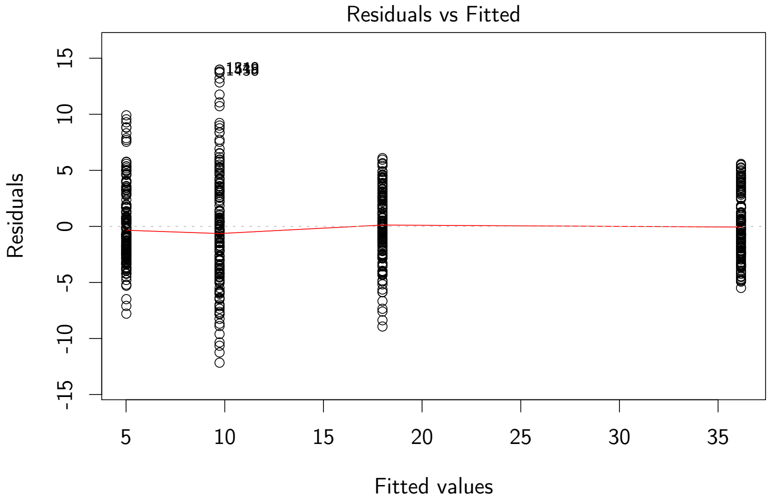
Modeling
A Clutter Loss Linear Model

	Clutter Loss Model
(Intercept)	5.01 (0.31)***
Route.nonLOS	12.98 (0.45)***
txHeight.low	4.72 (0.43)***
Route.nonLOS:txHeight.low	13.45 (0.64)***
R^2	0.90
Adj. R^2	0.90
Num. obs.	604
RMSE	3.94

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Modeling Impact

Clutter Loss Linear Model Residuals



lm(clutter ∼ route + txHeight + route×txHeight)