Using Clutter Models

ISART 2024 Panel 4

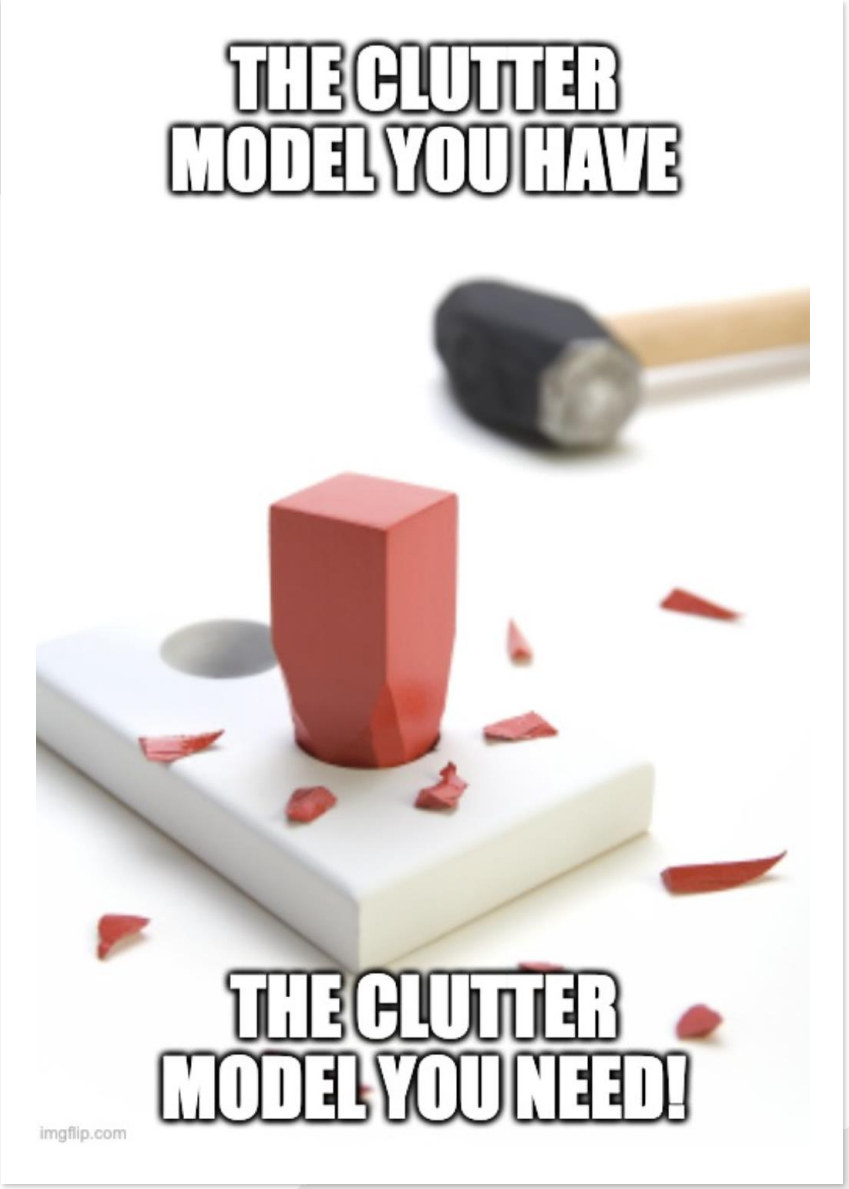
Agenda

- A Starting Point for Today's Discussion – 5 min
- Introductions and Opening Comments from the Panelist – 25 min
- Some Chosen Questions for the Panel - 40 minutes
- Question from the Audience – 20 minutes

Starting Point

- Incorporating clutter models in system-level scenario analysis requires careful attention to both the details of the model itself and the system- and scenario-specific considerations that may require additional tuning or corrections.

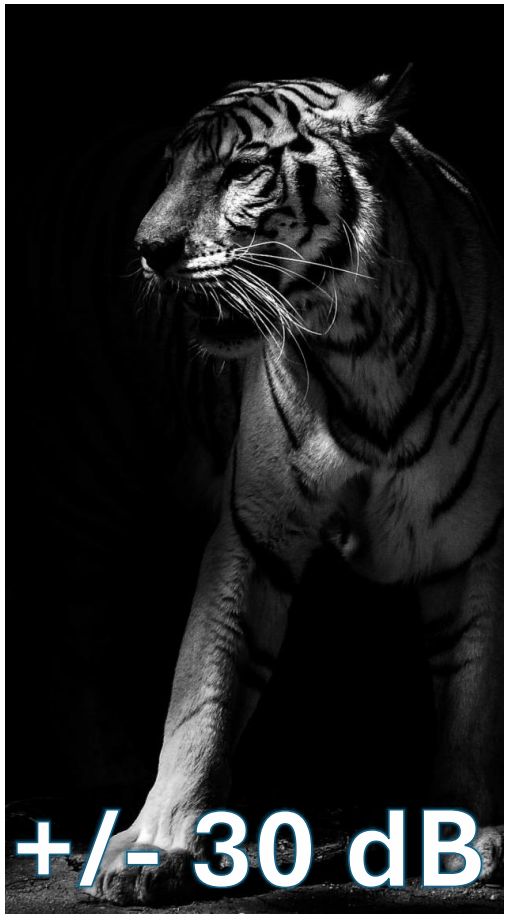
- This panel discusses how systems, sharing architectures, and studies use clutter model outputs, and how models can be adapted to scenarios that may not share the exact assumptions that were used in their development.



And just to make it more interesting…

"All models are wrong, some are useful" – George Box

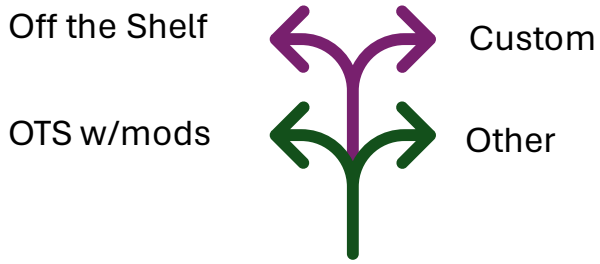
- It is important to be realistic about the achievable "truth" of your effort, also
- Since all models are wrong, the scientist must be alert to what is importantly wrong. It is inappropriate to be concerned about mice when there are tigers abroad



+/- 3 dB

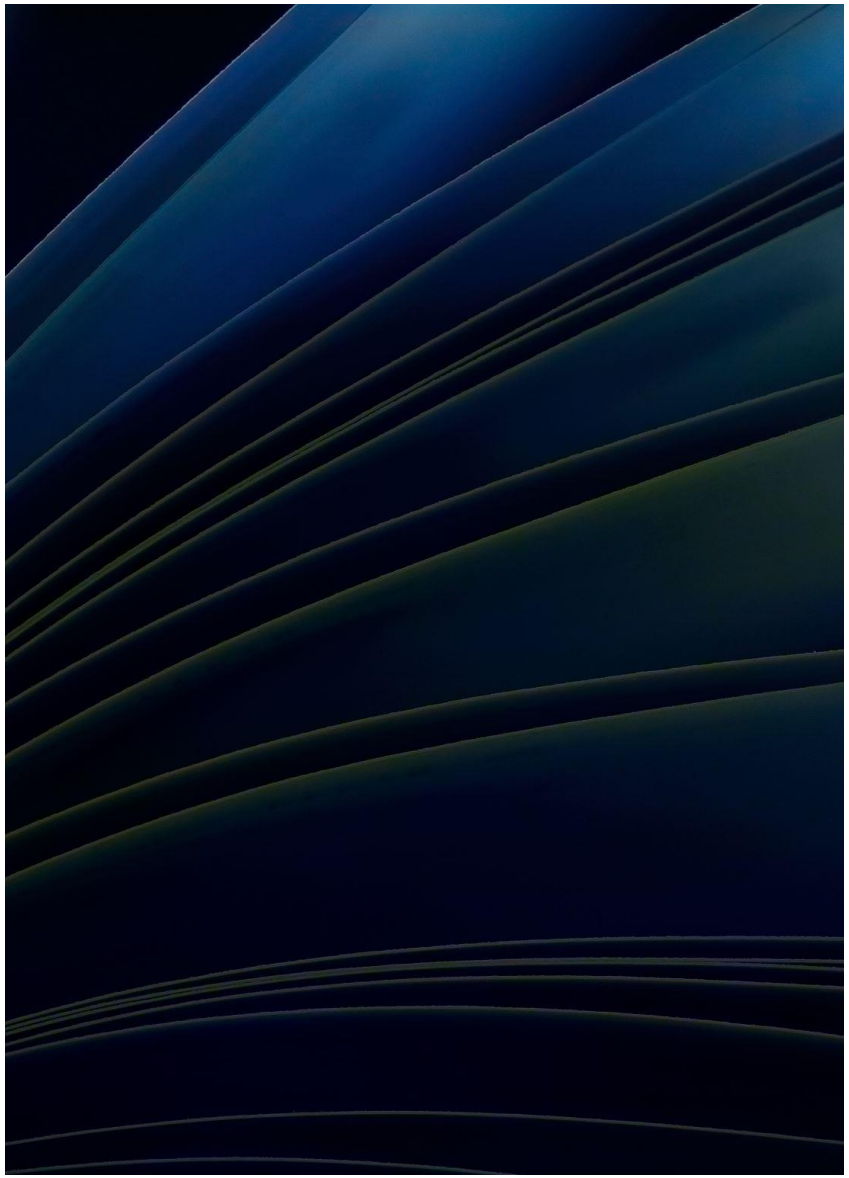
A Modeler's Problem Statement

- What is the objective of the modeling task?
- What model(s) must be used to achieve the objective?
- How should clutter be accounted for in the chosen model(s)?
  - Clutter models, like all other models, are wrong
  - Even if a clutter model could be right, it would likely only be right for its target scenario
- **What is the best course of action?**



Introductions

- Martin Doczkat, Chief of the Electromagnetic Compatibility Division, Office of Engineering and Technology, FCC
- Kasey Pugh, Defense Information Systems Agency (DISA), Program Executive Office Spectrum (PEO-S)
- Todd Summers, Director of Research and Development, SoftWright LLC
- William Young, Subject Matter Expert in Spectrum Dependent Technologies, MITRE Inc.
- Tony Rennier, Chief Spectrum Officer, Foundry Inc.



Martin Doczkat

Kasey Pugh

Todd Summers

Clutter Modeling

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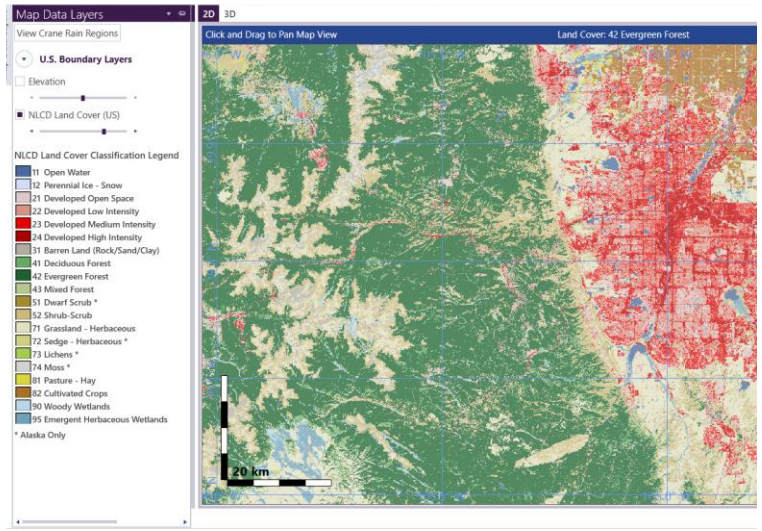
- Objectives
  - Do the best modeling possible with the best data available
  - Scientifically sound modeling that can be replicated by others
  - Clutter use depends on the application, band, data available, and objective



- Study Data Sources
  - Topographic data
    - Digital Elevation Model (DEM)
    - AGL height reference
  - What is the clutter type?
    - Land cover data: category-based, describing what is on the ground
    - Domestically: National Land Cover Dataset (NLCD)
    - Internationally: ESA WorldCover
  - What is the clutter height of the clutter?
    - Discrete surface features (e.g., building footprints / heights)
    - Digital Surface Model (DSM): Canopy and building tops

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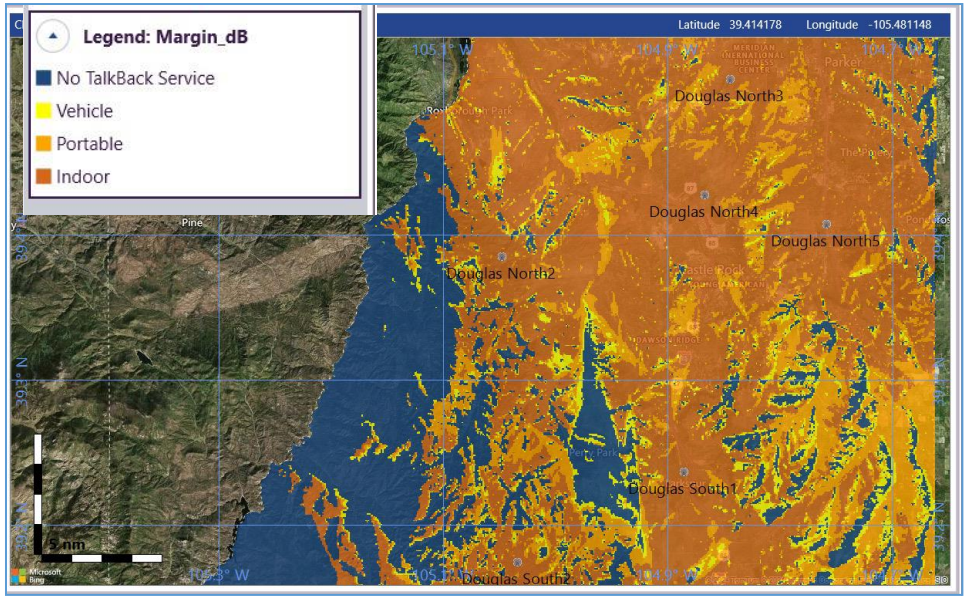
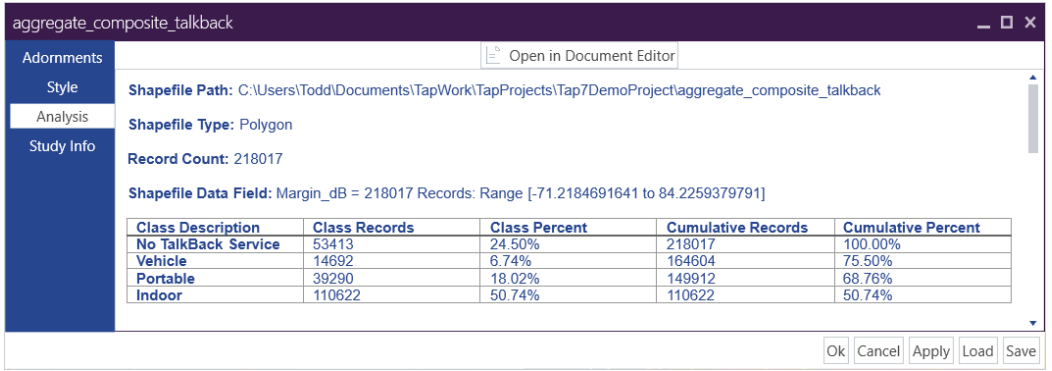
- Study Application 1: Public Safety System Design
  - Statistical assessment
  - Study objective
    - Jurisdiction-wide coverage, to a stated performance, reliability level, and percentage of the area covered
    - Example
      - Handheld and vehicle units
      - Indoor / outdoor
      - Delivered Audio Quality (DAQ) 3.4
      - 95% of the area covered, 95% of the time
  - Data used
    - DEM as bare ground topo data
    - Land cover data
      - Since reliable clutter data not available over the area
      - Clutter loss tables





Class Description	Class Records	Class Percent	Cumulative Records	Cumulative Percent
No TalkBack Service	53413	24.50%	218017	100.00%
Vehicle	14692	6.74%	164604	75.50%
Portable	39290	18.02%	149912	68.76%
Indoor	110622	50.74%	110622	50.74%

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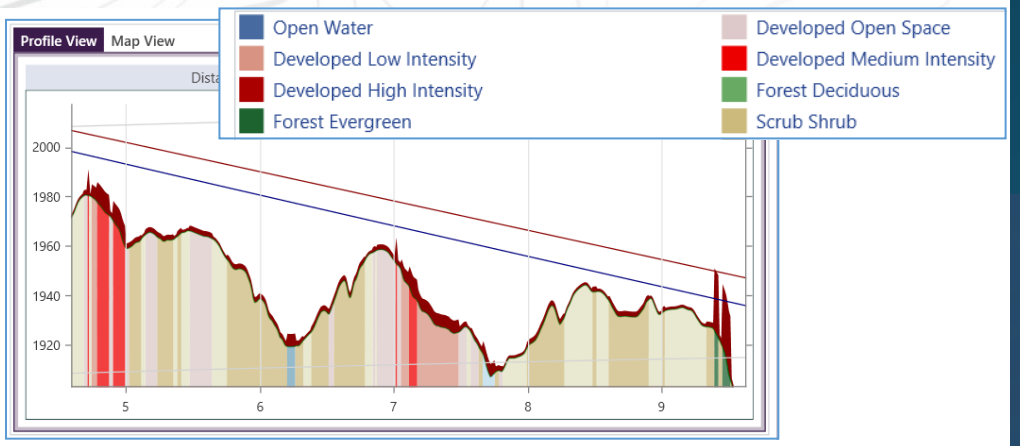
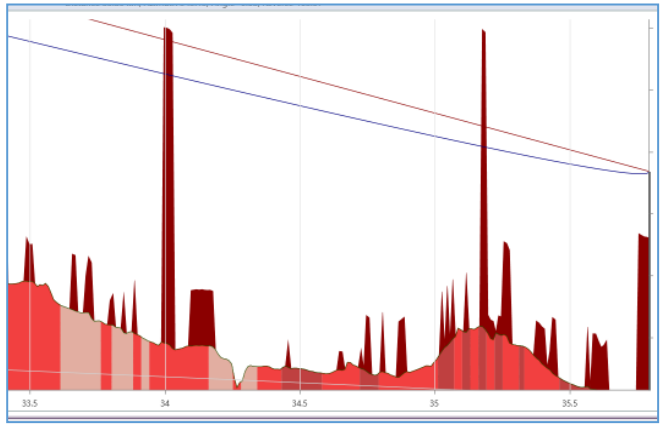
- Study Application 2: Microwave Systems
  - Study objective
    - Line-of-sight along path
    - Reflection analysis
    - F2 clearance for wind farms
  - Data used
    - DEM as bare ground topo data
    - Clutter height modeling
      - Discrete surface features (urban)
      - Height as a function of land cover category (rural, many paths)





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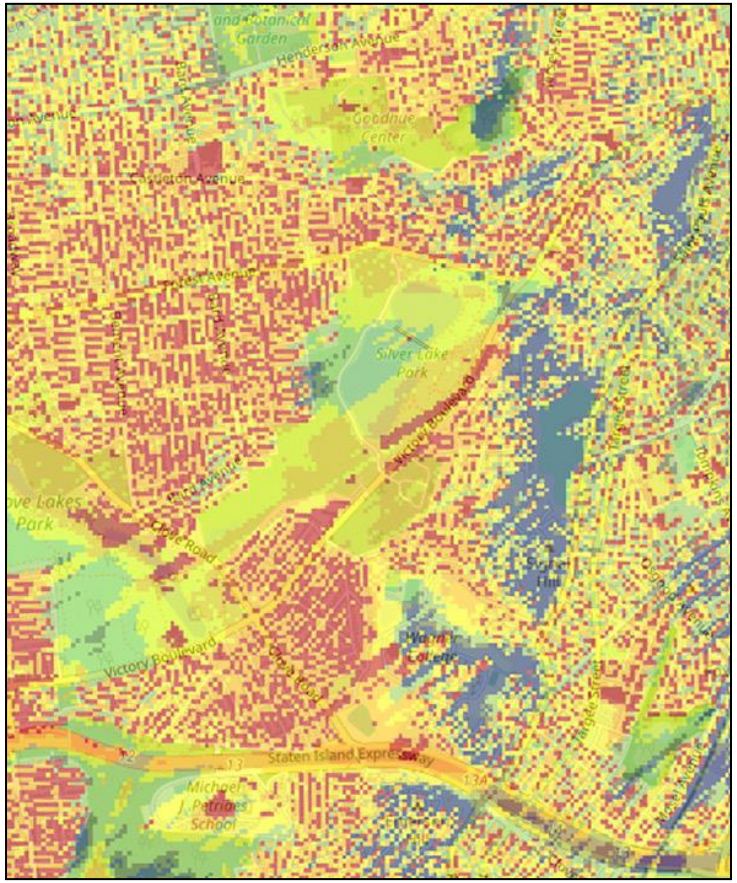
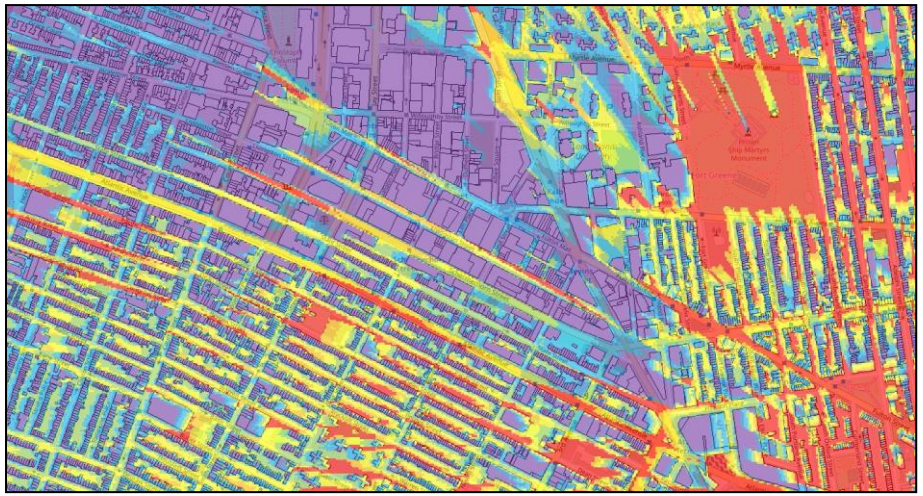
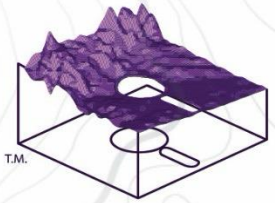
- Study Application 3: Building Penetration / Leakage
  - Study objective
    - Area coverage studies
    - Model signal attenuation across exterior walls
    - Model signal loss as a function of penetration depth
  - Data used
    - DEM as bare ground topo data
    - Discrete surface features
      - Building footprints
      - Building heights





Clutter Modeling



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- We are in a transitional period
- Future: Unified model using DEM, DSM, and land cover data
  - Study objective
    - Path and area coverage studies
    - Improved modeling for foliage penetration
    - More widespread / more precise building data
    - Find dominant propagation mode
  - Data used
    - DEM as bare ground topo data
    - DSM for canopy and building heights
      - Very high resolution
      - Path topography
      - Currently, not widely available
    - Land cover data
      - Identify surface feature type
      - Penetration loss determined by type

Bill Young

An approach to clutter model improvement

- Start with clutter models used in feasibility analyses
- Rely on current models designated for the use cases
- Recognize differences in clutter model applications
  - Example: tower -to- UE ≠ tower –to- incumbent
- Create a path to update clutter models over time
- Pursue clutter model improvement
  - Investigate techniques used elsewhere, e.g., derive clutter profiles from LiDAR
  - Leverage available measurements for when applicable for verification, e.g., field tests

Tony Rennier

Some Recent Clutter Model Use

- Broadcast – Individual Location Longley-Rice (ILLR) + LULC/NLCD clutter loss adjustments
- AWS-1 – None
- AWS-3 – Began with uniform dB distributions, migrated to LiDAR informed simulation-based distributions, and concluded with an astonishing AI/ML model
- CBRS – eHATA, Log Distance Based, P.452, TIREM with buildings as terrain, and P.2108
- 3.45 GHz – Began with P.452 with 6 clutter (land-coverage) categories, migrating to LiDAR-informed clutter loss statistics following AWS-3 approach
- EMBRSS Feasibility Study – P.452 and P.2108
- AFC - – Irregular Terrain Model, P.2108 for urban/suburban, P.452 for rural

Q1

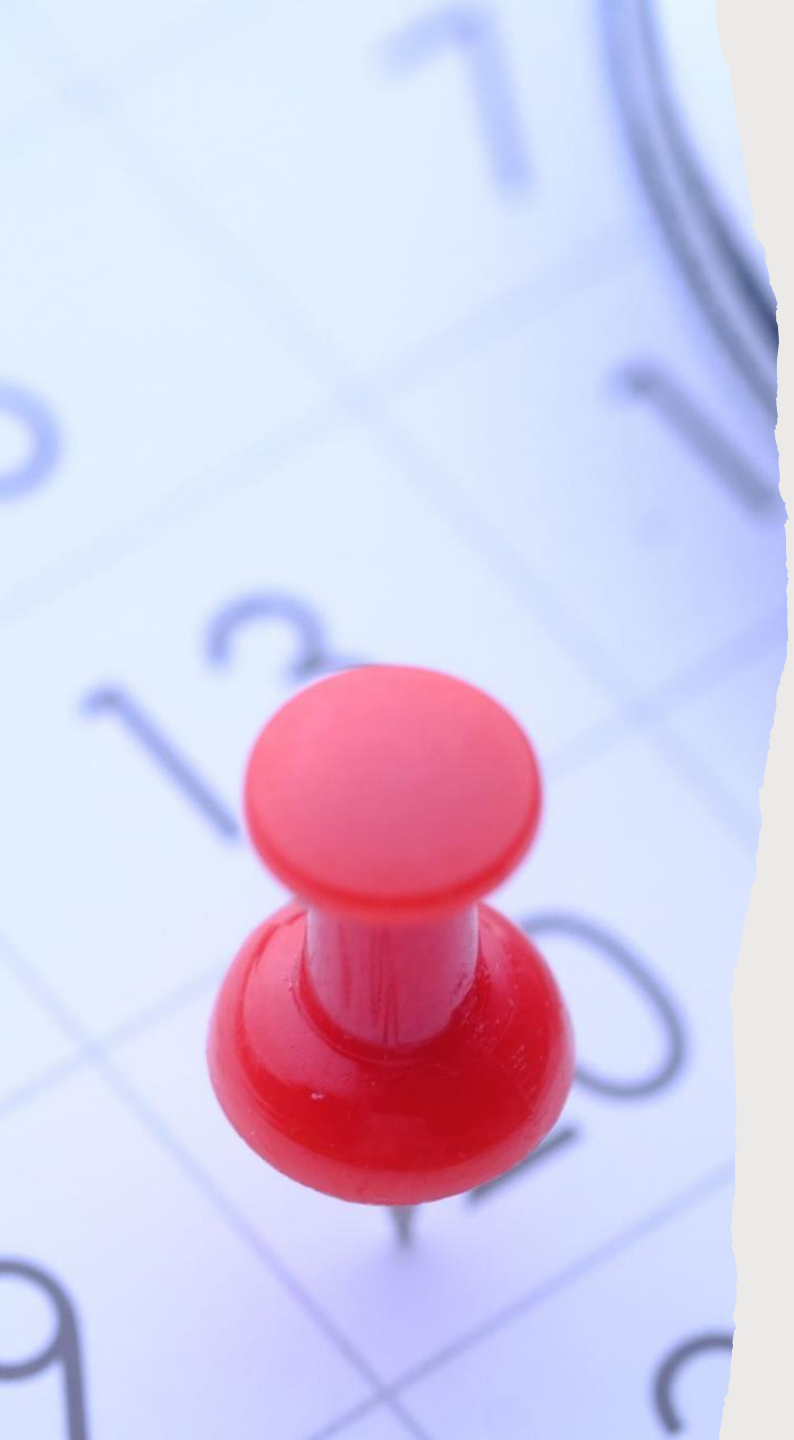
In your opinion, how does George Box’s quote apply to the use of clutter models?

What is your best and worst experience that highlights the importance of keeping George Box’s quote in mind when using clutter models?

Q2

What are the top three items a modeler should consider when choosing a clutter model for use in a parent model?

What is often talked about but is mostly unimportant?



Q3

How should clutter model usage change over time?

When AI/ML and/or other computational improvements become available?

When more measurements become available?

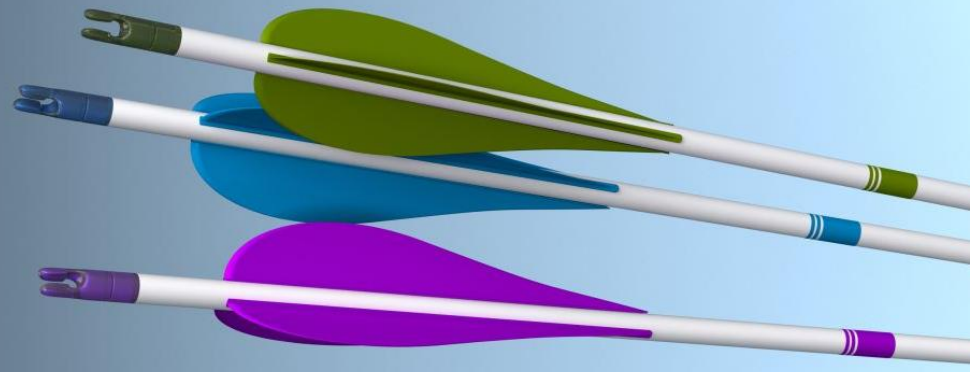
Other?

Q4

Propagation measurements demonstrate that even for a single path, the variability of propagation loss with or without clutter is significant. Statistical clutter models try to capture this but often fall short.

How can we appropriately address the challenges of propagation variability when using clutter models in parent models?

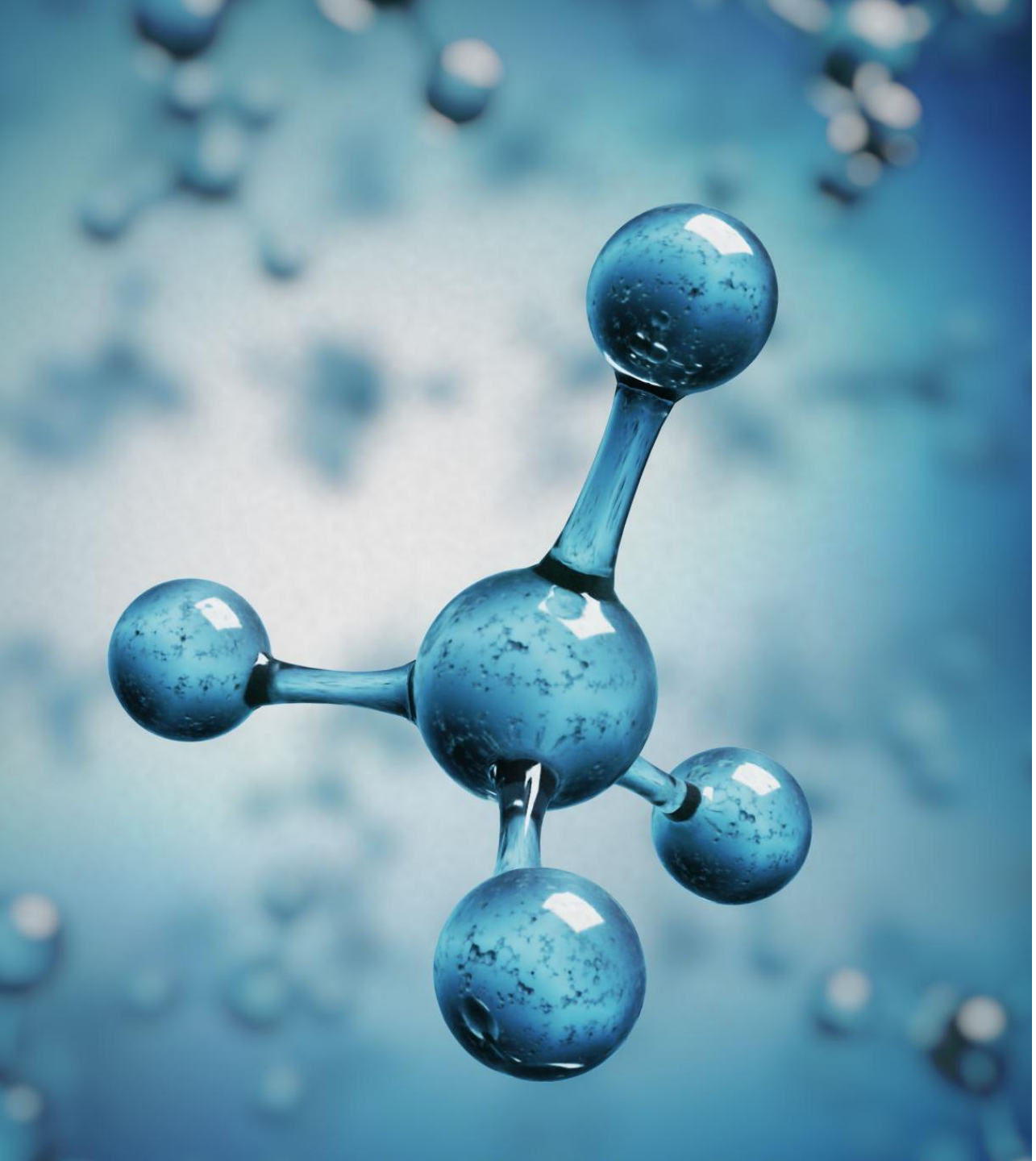
If the parent model can not support modeling clutter as a random variable, how should a scalar value be chosen?



Q5

Right Side of Wrong

Since all models are wrong, how should clutter modelers address the need to ensure that the recommendations, that are based on their models, will provide high confidence that the objective statement of the parent model is met?



Q6

Heuristic vs Physics vs Hybrid

If all three of these types of clutter models are available, what are the trade-offs for choosing amongst them?

Q7

Model Verification

In a perfect world, sufficient data would be available to verify a chosen clutter model for the intended scenario. What are your options when verification data is not readily available?

Q8

Site-General vs Site-specific

What are some considerations for using one or both of these types of clutter models in the parent models?

Q9

Near the end of AWS-3's SSTD R&D program, AI/ML researchers collaborated with the SSTD Propagation WG to look for AI/ML-based improvements to clutter modeling. After an initial look at using the SSTD-measured data directly, researchers settled on, what turned out to be a very successful effort to use AI/ML techniques to speed up physics-based clutter models.

What are some of the considerations for using these or other types of AI/ML-based clutter models in parent models?

Q10

The presence of near-ubiquitous emissions from GPS satellites and ADS-B-enabled aircraft potentially represents an unprecedented opportunity to generate models based on measured data at the frequencies these systems use.

Is it sufficient to incorporate well-known frequency-dependent adjustments to use clutter models derived from these measurements when incorporating clutter models for other frequencies?

If not, what else should a clutter modeler do to take advantage of these models based on these measurements?

Q*

Let's hear from you!

- Martin Dahzkat