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Terrain-Driven Uplink Localization in Mountainous Environments Based on Moving UAV Anchors



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Motivation



In mountainous emergency scenarios, precise localization is the lifeline for search-and-rescue operations.

GNSS-Denied: Terrain and vegetation block LoS links, rendering traditional GNSS useless in mountain rescues.

Terrain-Blindness: Existing UAV-assisted methods ignore how mountains severely alter signal propagation.

Core Gap: Conventional Gaussian assumptions fail to handle systematic biases caused by NLoS and multipath.

Key Ideas

Problems

Idealized Channels

Simple Terrain Functions

Gaussian Noise Fallacy

Ideas

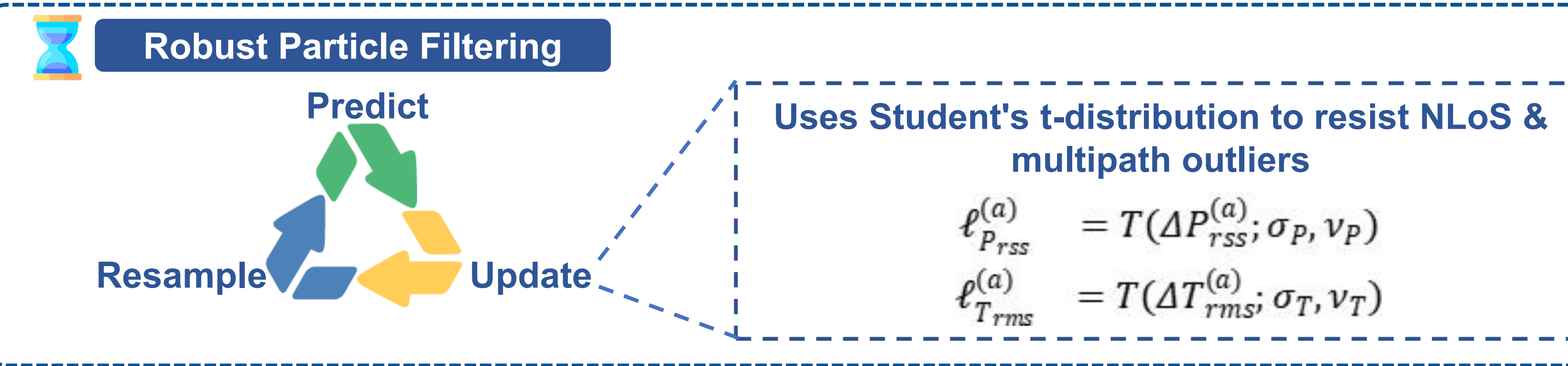
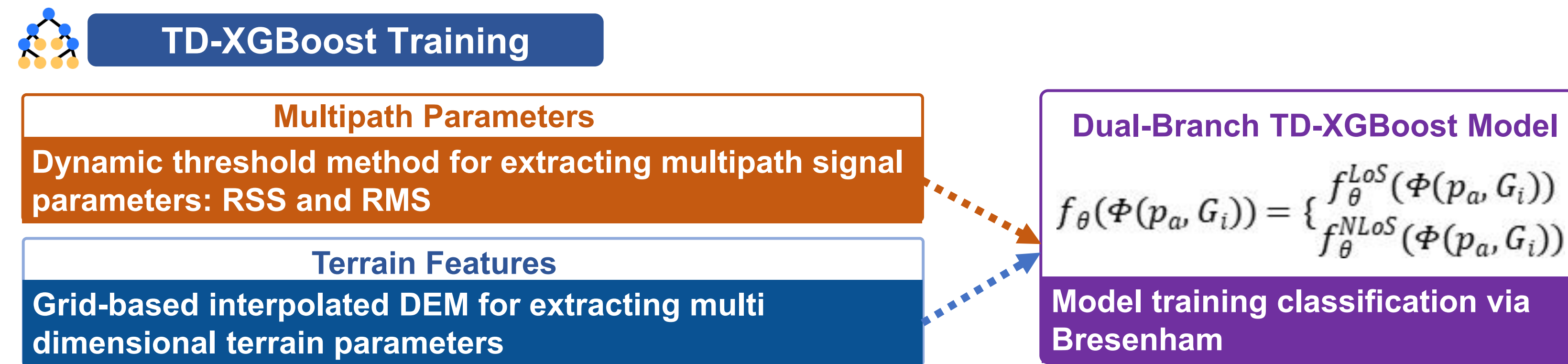
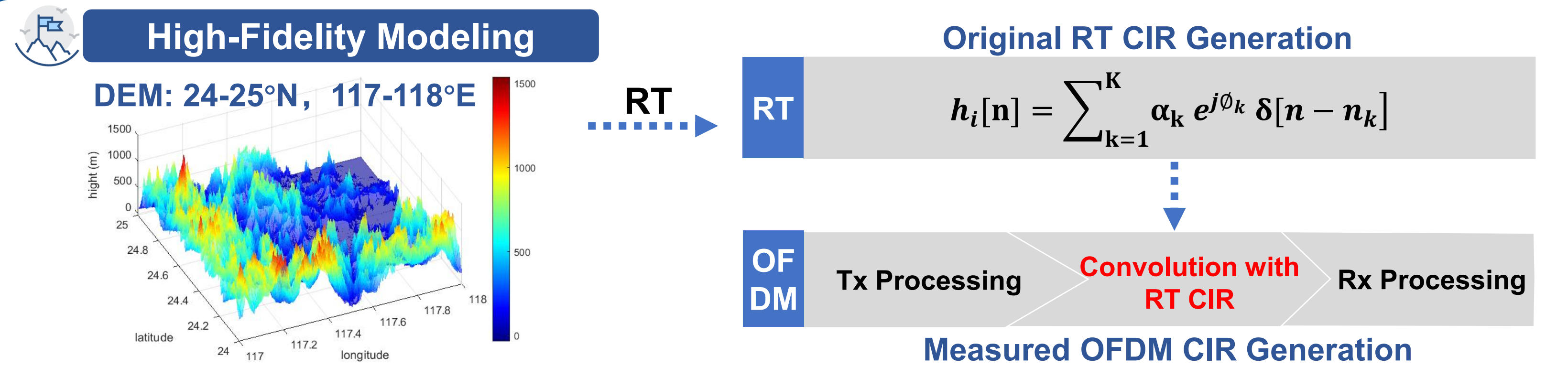
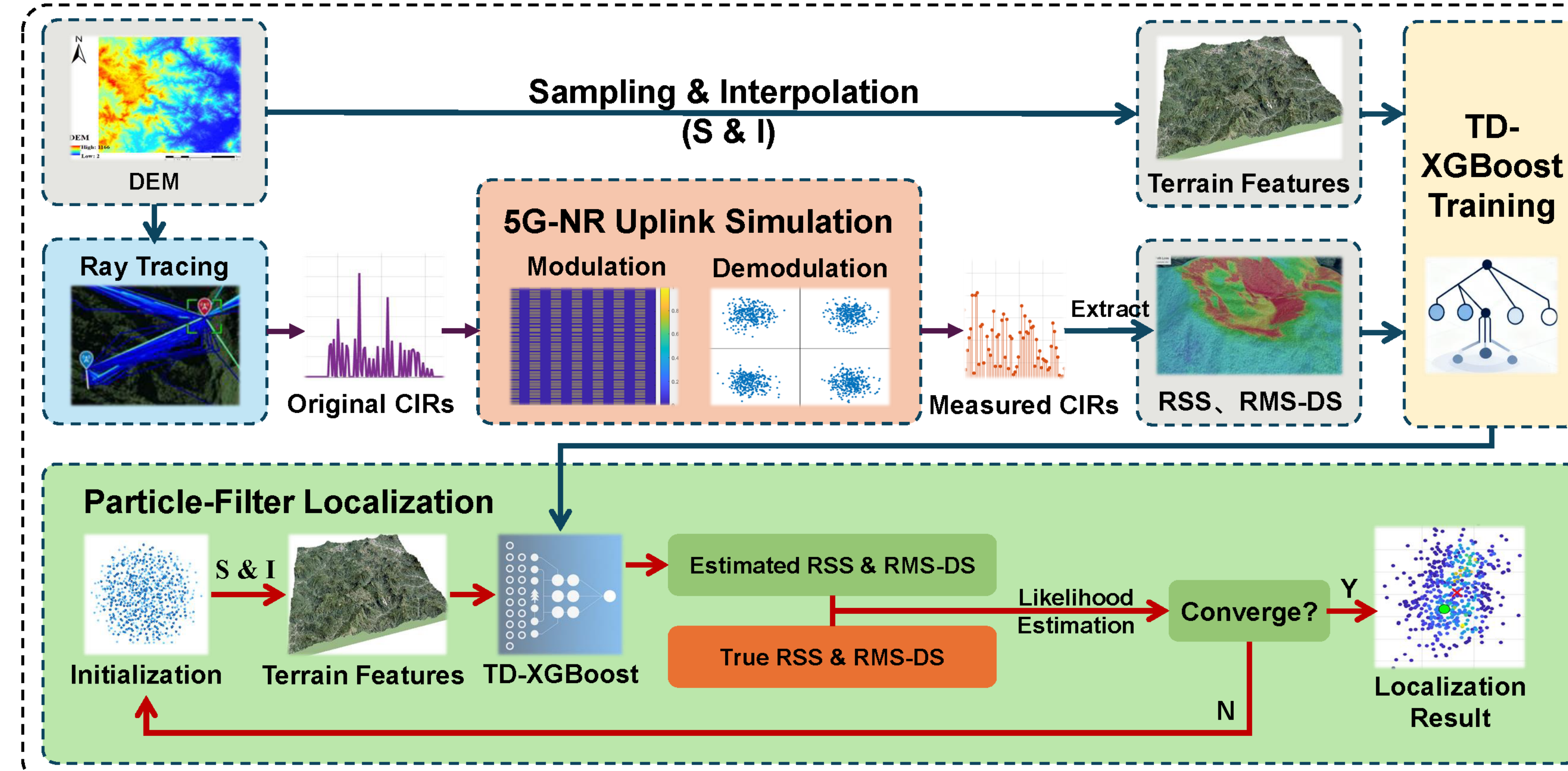
High-Fidelity Modeling: Fuses DEM and RT for 5G-NR multipath channel simulation

TD-XGBoost: Maps terrain features to multipath parameters, capturing terrain-channel coupling

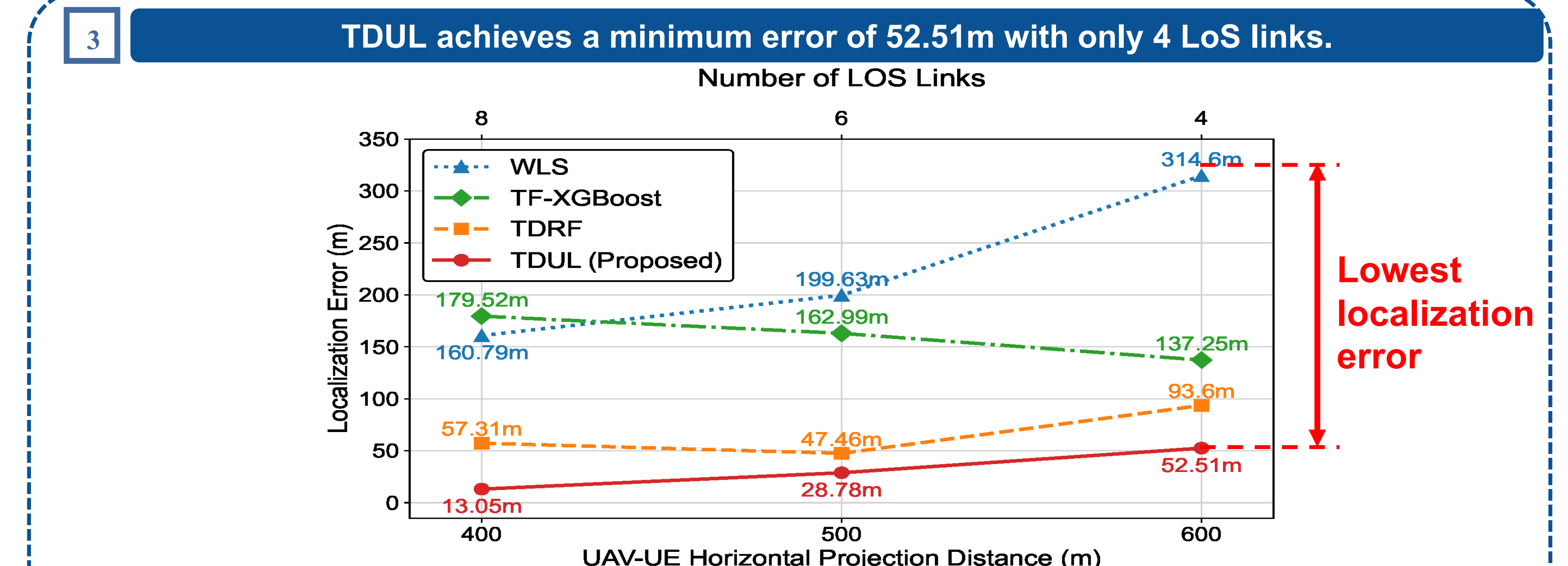
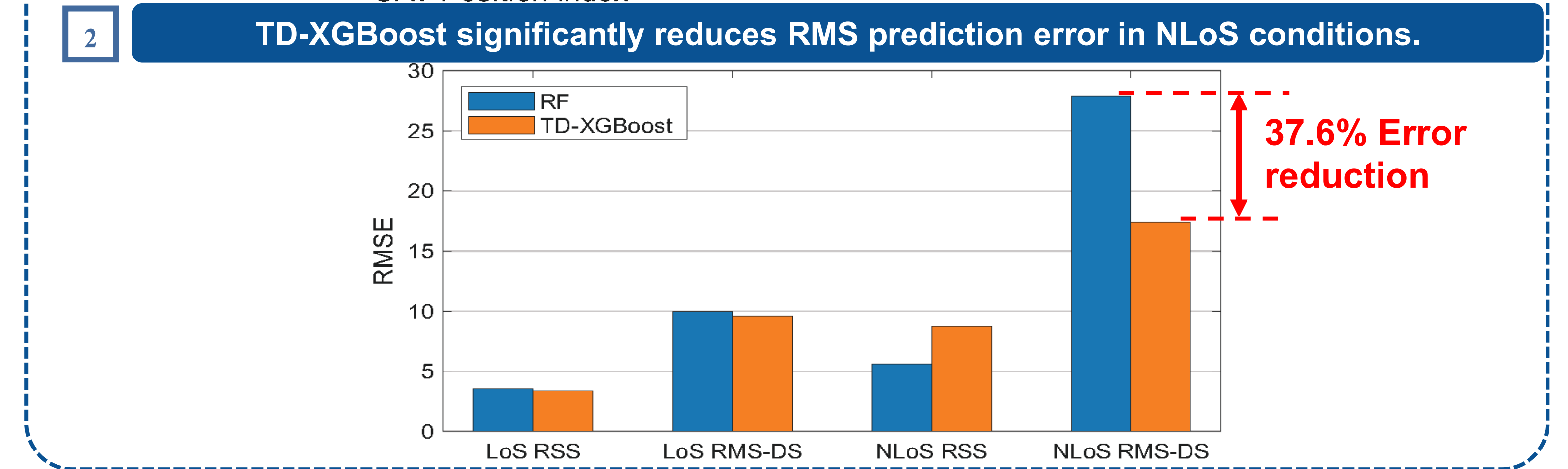
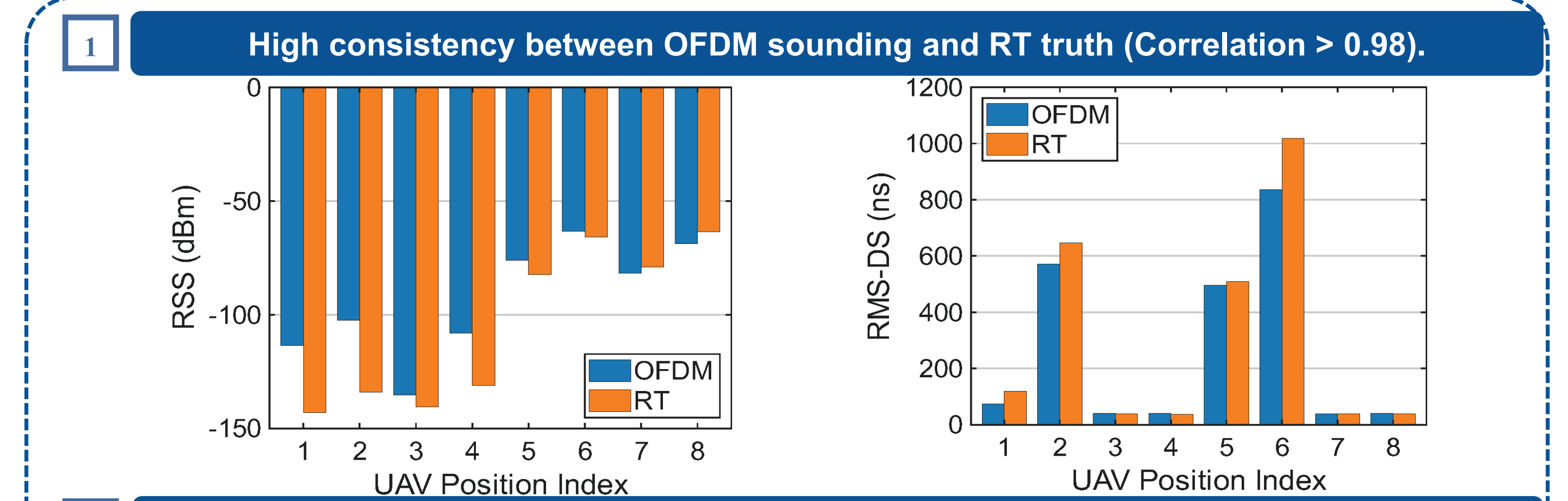
Robust Filtering: Employs Student's t-distribution in a particle filter to resist NLoS outliers

Method

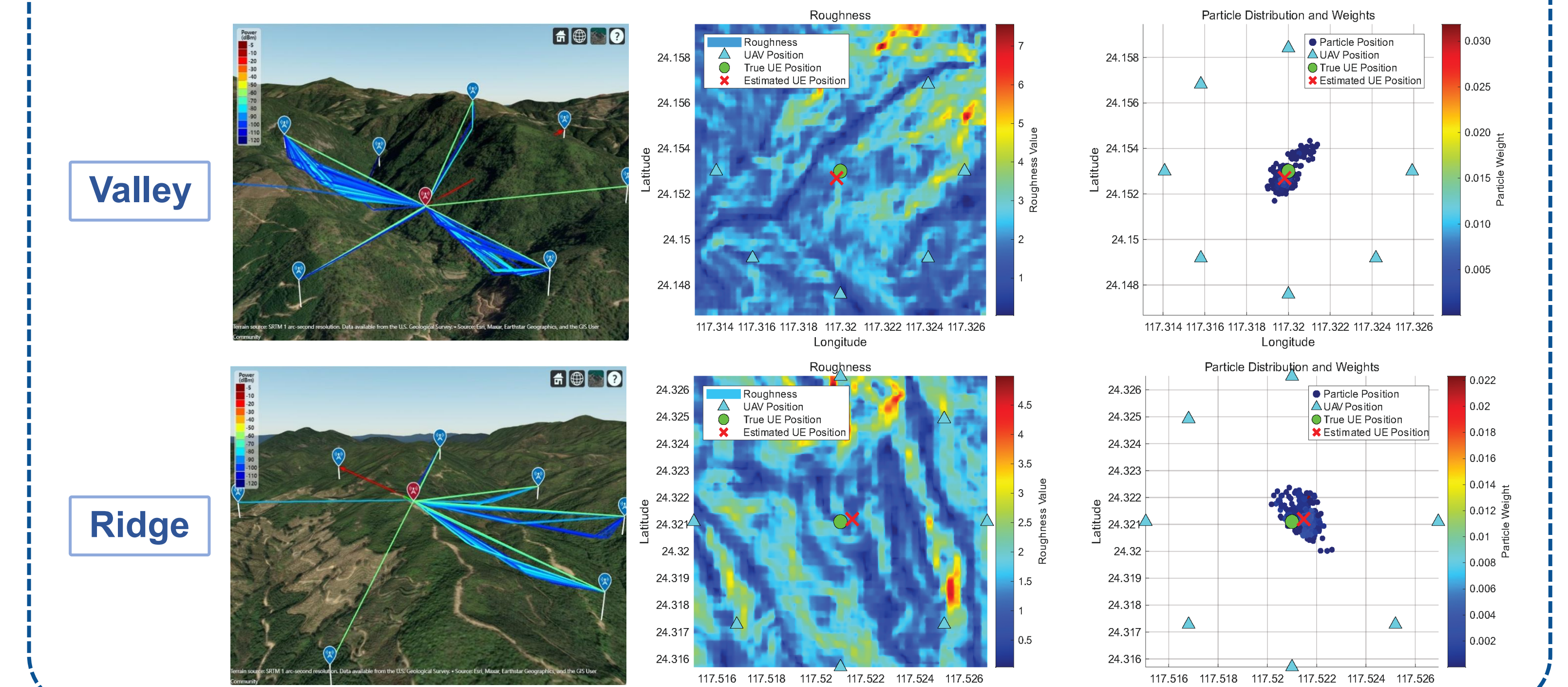
Terrain-Driven Uplink Localization (TDUL) framework



Results



Strong Cross-Terrain Generalization: 38.74m error in a new valley and 49.04m in ridge terrain.



Takeaways

83% Error reduction vs WLS

37.6% Error reduction in RMS

Robust across unseen terrains

TDUL integrates terrain modeling with robust machine learning, enabling reliable UAV-assisted localization in GNSS-denied mountains.