Exploiting Environmental Knowledge for Improved Signal Processing

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Agenda

- KBMapSTAP
- Current Efforts, Results, and Status
- Future Plans
- Summary
- Acknowledgements

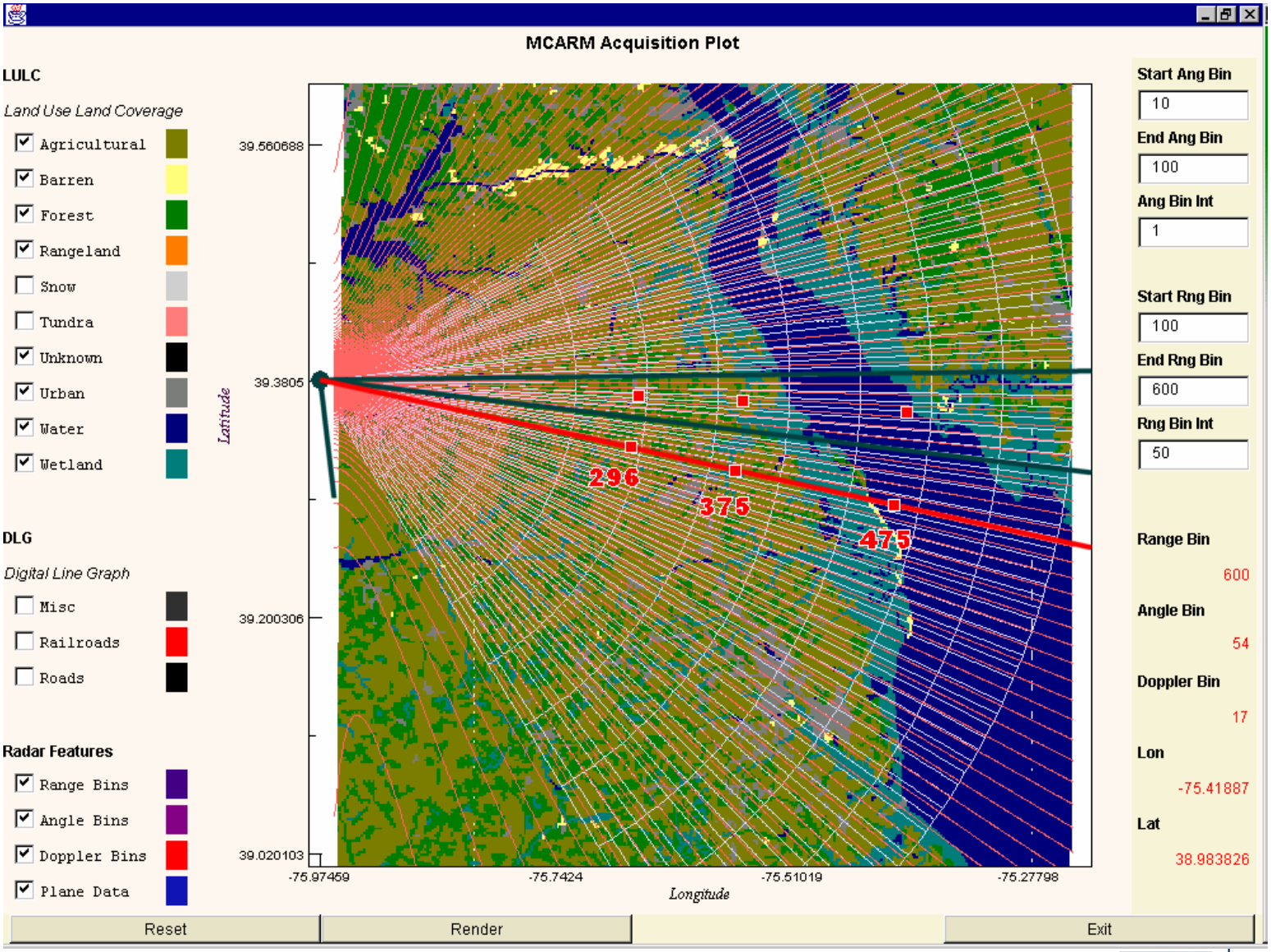
Experimental Results - KBMapSTAP

- Can STAP performance be improved by choosing secondary data based upon a priori map data?
- “Standard Algorithm” - choose secondary data plus & minus N/2 range rings of the test ring (omitting guard cells)
  - Implicit assumption - Nearby range rings of the test ring are homogeneous and are representative of the test ring.
  - Case I - Homogeneous Environment
  - Case II - Heterogeneous Environment

Proposed Algorithm/Conjecture

- Post Doppler Element Space STAP
- Basic Assumption - Major clutter competing with the target cell is due to the patch of earth within the same test ring that passes through the same Doppler filter
- Picking secondary range rings that have the “same” patch of earth and lie along the same Doppler curve as the test ring clutter patch, will provide better performance than the sliding window algorithm.

Radar Registration With Map Data



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MCARM DATA

- L-Band Airborne Radar
  - Twenty Two Channel Phased Array
  - 20 KW peak power
  - Low PRF ~ 1 KHz
  - Moderate Bandwidth ~ 1 MHz
- In Scene Calibration
  - Ground Based Active Radar Calibrator
  - Airborne Test Targets

Performance Measure
Modified Sample Matrix Inversion

$$\mathrm{MSMI}_i = \frac{\left| s^H \hat{R}^{-1} x_i \right|^2}{s^H \hat{R}^{-1} s}$$

where: $\hat{R}$ is an estimate of the clutter covariance matrix,

s is the steering vector,

s^H is the complex conjugate transpose of the steering vector,

χ_i is the radar return vector from the ith range ring,

$\hat{R}^{-1}$ is the inverse of the estimate of the clutter covariance matrix.

MSMI is computed for each range ring - has a threasholding or detection quality, similar to CFAR.

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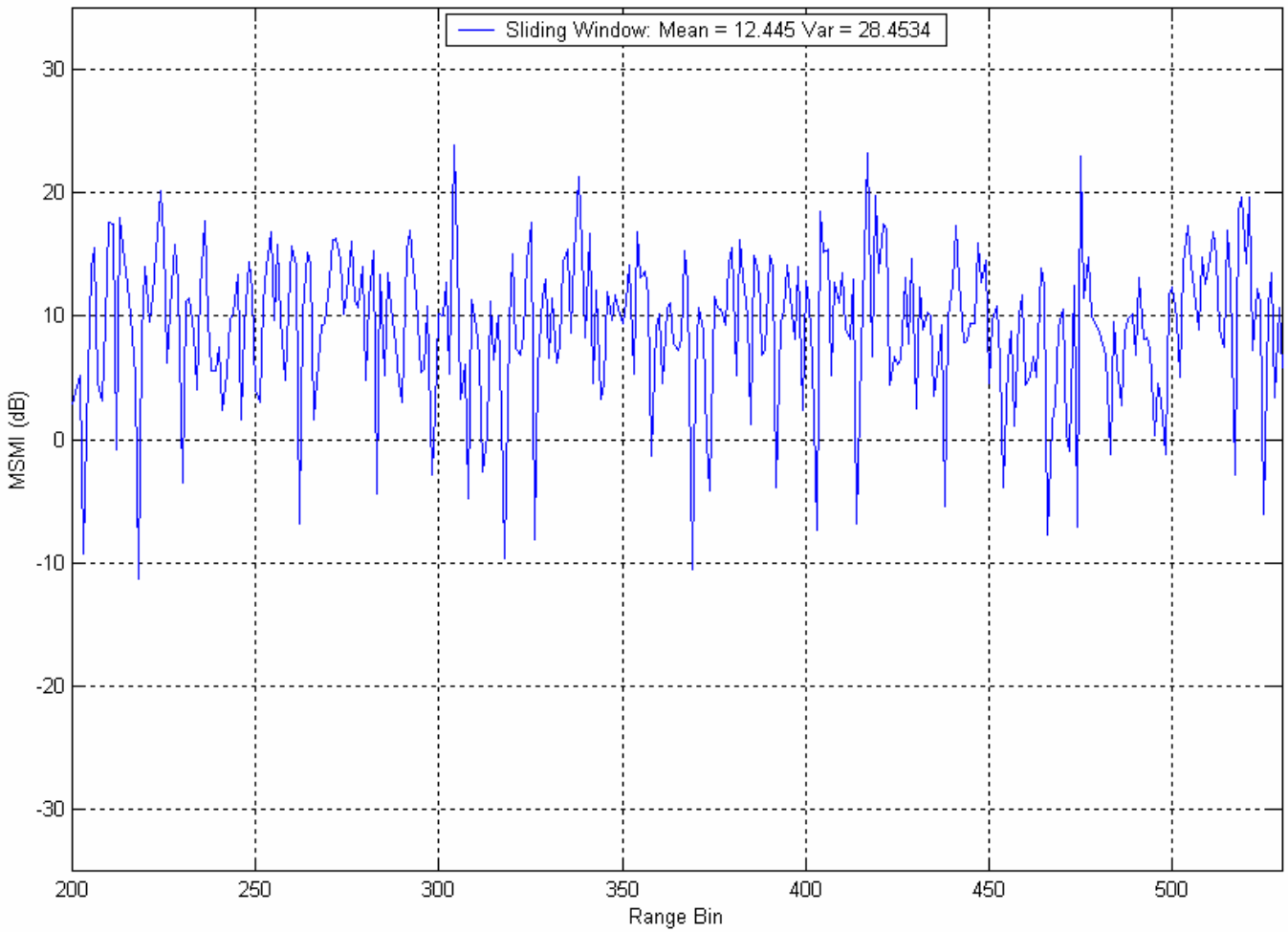
MSMI Output Using Sliding Window Algorithm With Injected Target At Range Bin 475



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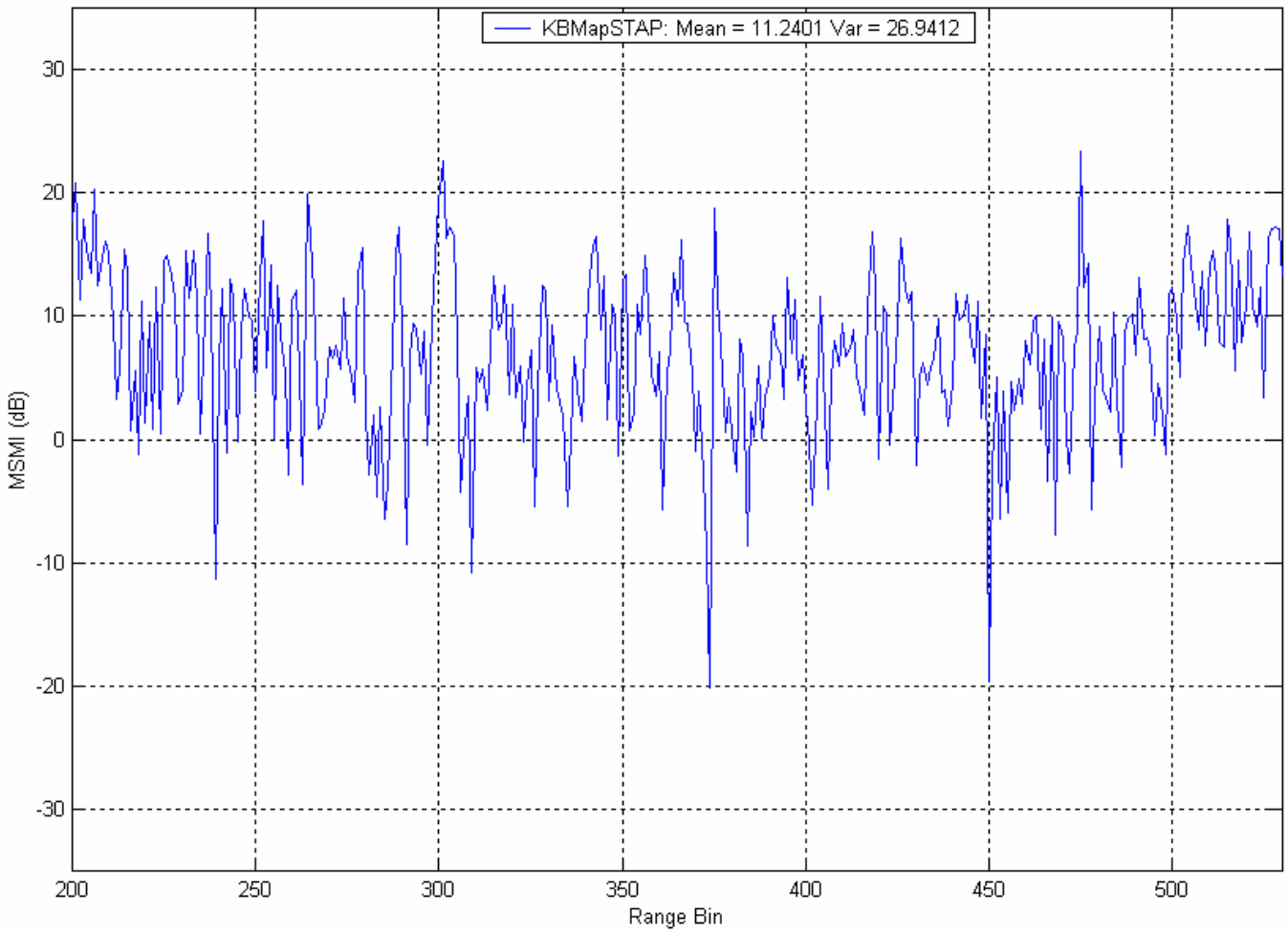
MSMI Output Using KBMapSTAP Algorithm With Injected Target At Range Bin 475



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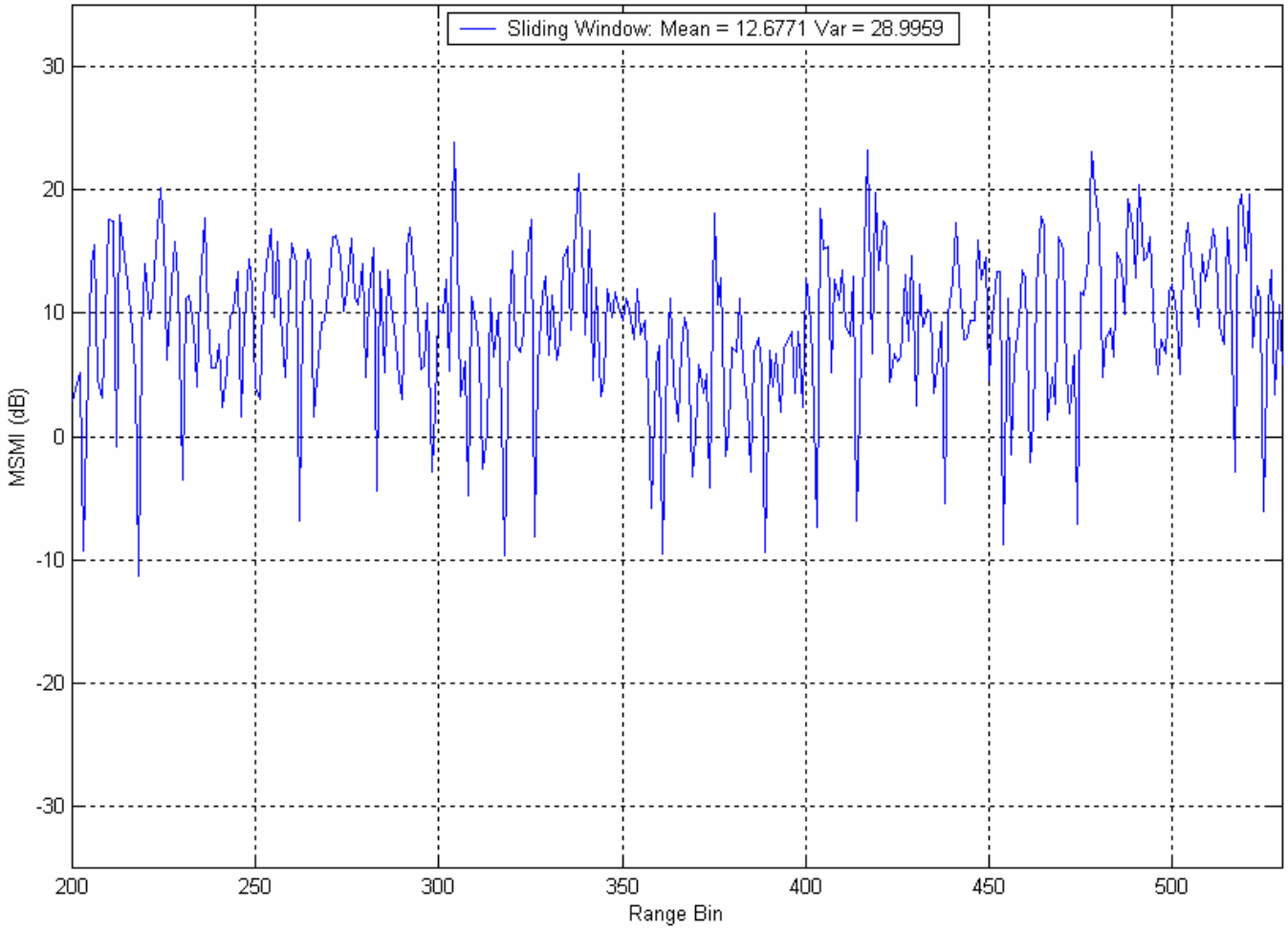
MSMI Output Using Sliding Window Algorithm With Injected Target At Range Bin 375



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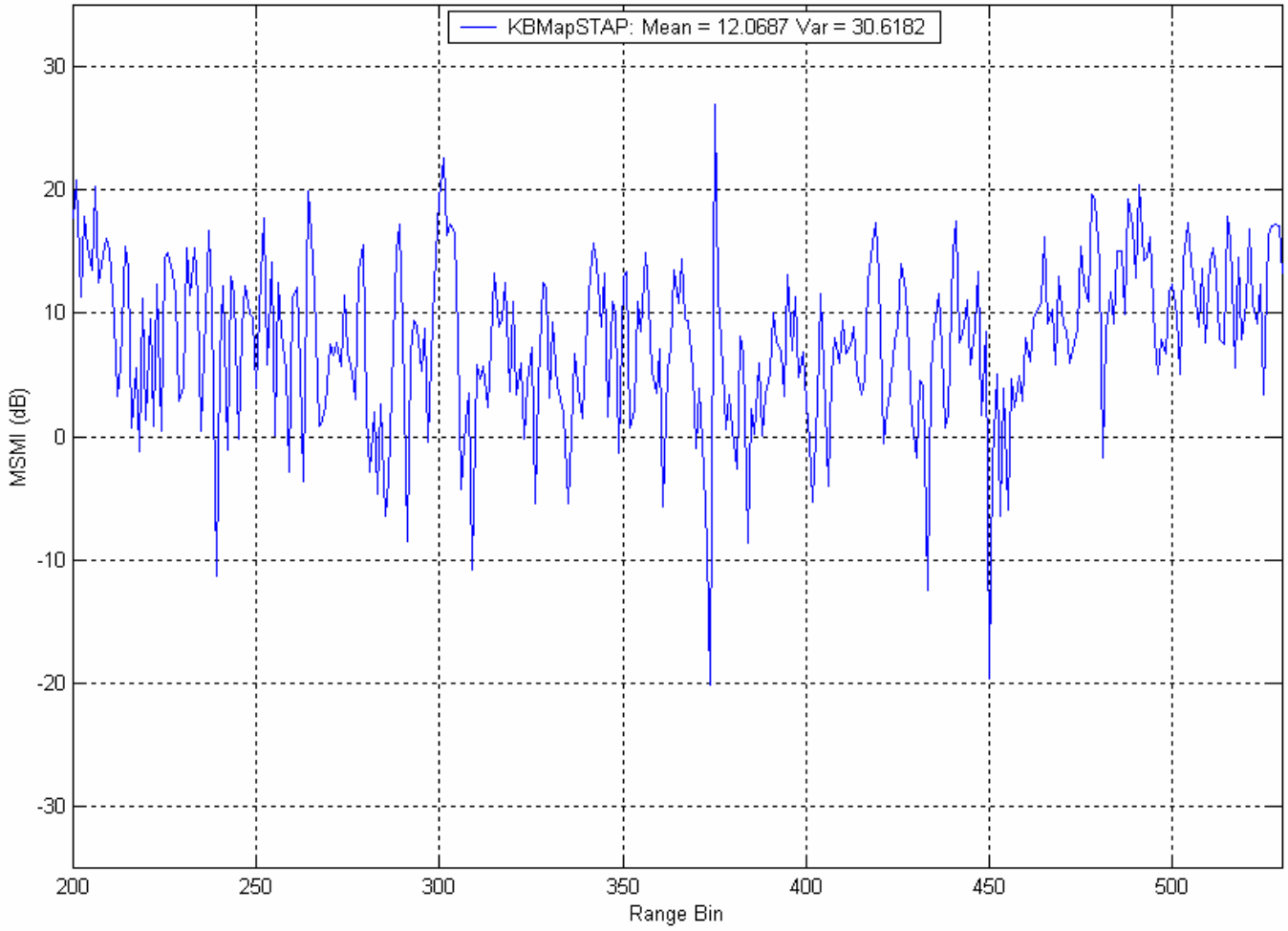
MSMI Output Using KBMapSTAP Algorithm With Injected Target At Range Bin 375



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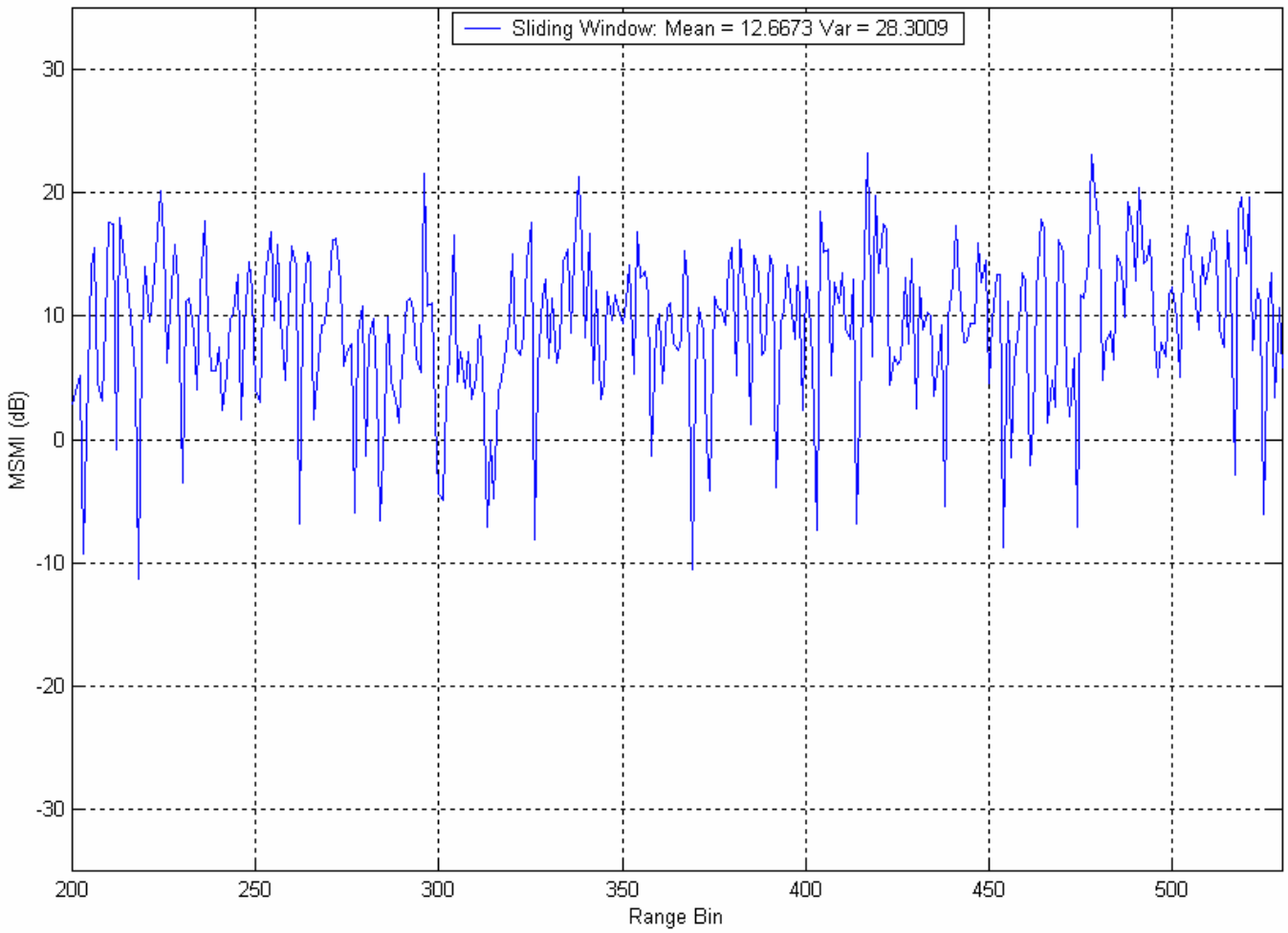
MSMI Output Using Sliding Window Algorithm With Injected Target At Range Bin 296



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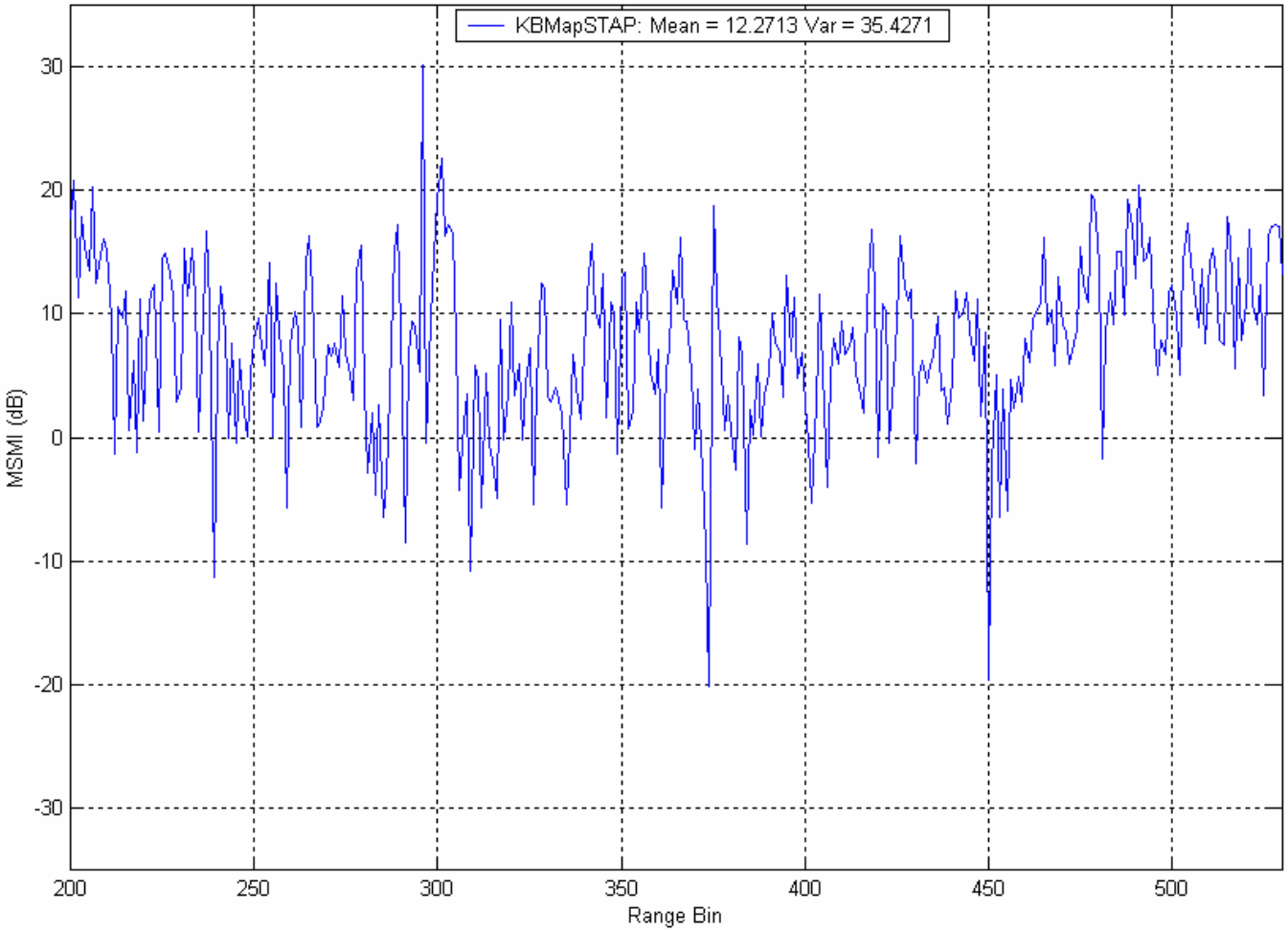
MSMI Output Using KBMapSTAP Algorithm With Injected Target At Range Bin 296



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Results

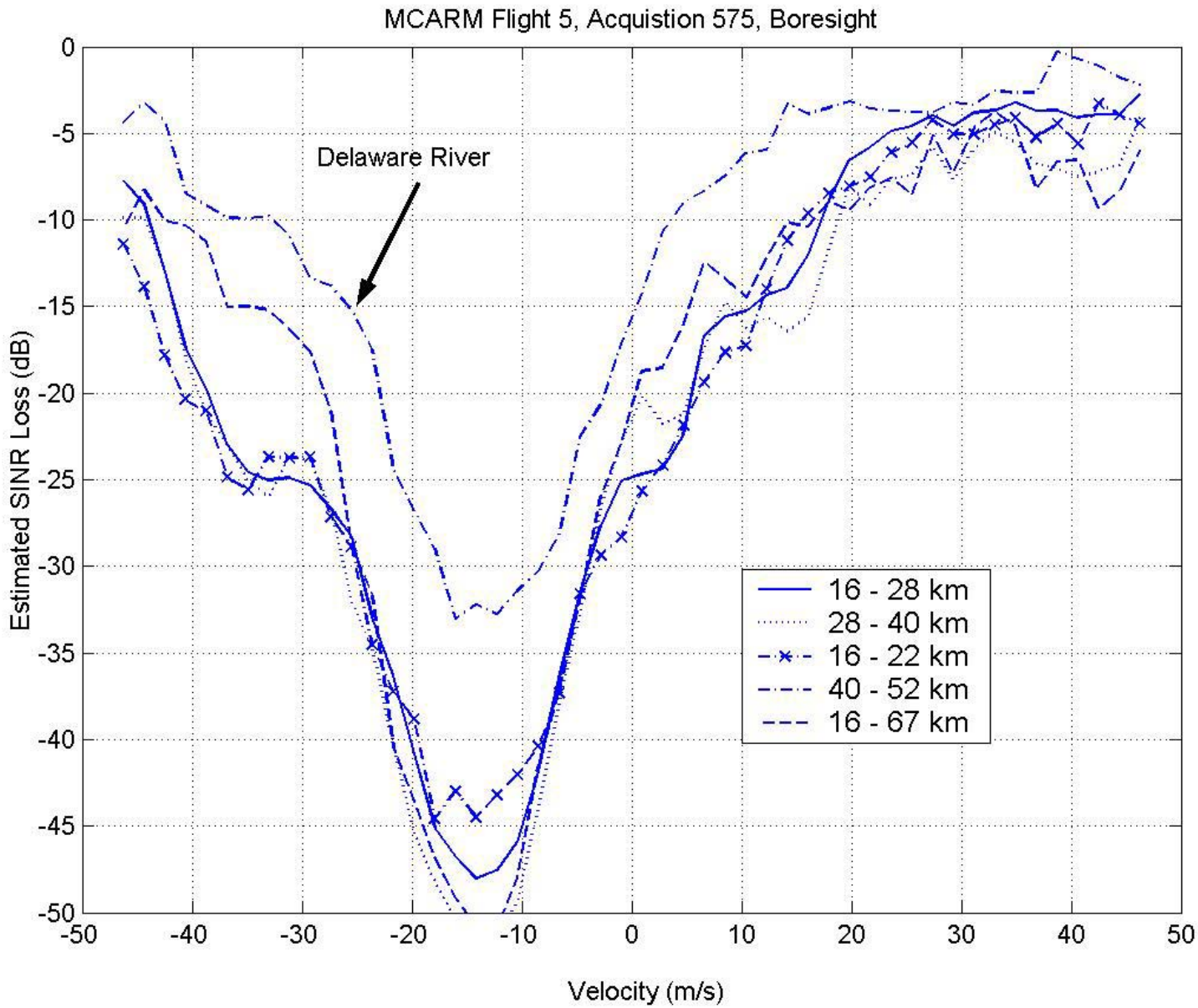
- Outperformed standard windowing approach within heterogeneous environments
- Performed the same as standard windowing approach within homogeneous environments
- However, there are issues with this approach
  - Map data accuracy – data are not always current
  - Digital elevation data needed in mountainous terrains– shadowing effects
  - Weather data is time dependent
  - Time of year – e.g. snow covered terrain
  - Registration and calibration errors must be assessed
- Need to “see what the radar is seeing”
- Map data is necessary but not sufficient for filtering and detection– also need mapping data for tracking (e.g. roads and railroads)

Current KASSPER Tasks

- Explore and quantify multiple automated processes for choosing secondary data
- Rewrite all of the code in MATLAB – for integration into the Signal Processing Evaluation and Analysis Research (SPEAR) facility at AFRL's Rome Site
- Obtain more detailed terrain data – original code 200 meter data – moving to 30 meter data
- Integrate DLG and DEM data – original code only used LULC data

Status To Date

- Added Estimated SINR Loss as a performance measure and obtained excellent results when compared to (J.S. Bergin, P. M. Techau, W.L. Melvin, and J. R. Guerci, “GMTI STAP in Target-Rich Environments: Site-Specific Analysis” 2002 IEEE Radar Conference, April 2002)
- Developed more accurate models for radar registration
  - Added corrections for range, crab, and pitch
- Obtained 30 meter data from USGS (i.e. National Land Cover Dataset (NLCD)) and are currently integrating these data into MATLAB for 3D analysis including LULC, DLG and DEM



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LULC and NLCD Terrain Data Comparison

LULC Terrain Data

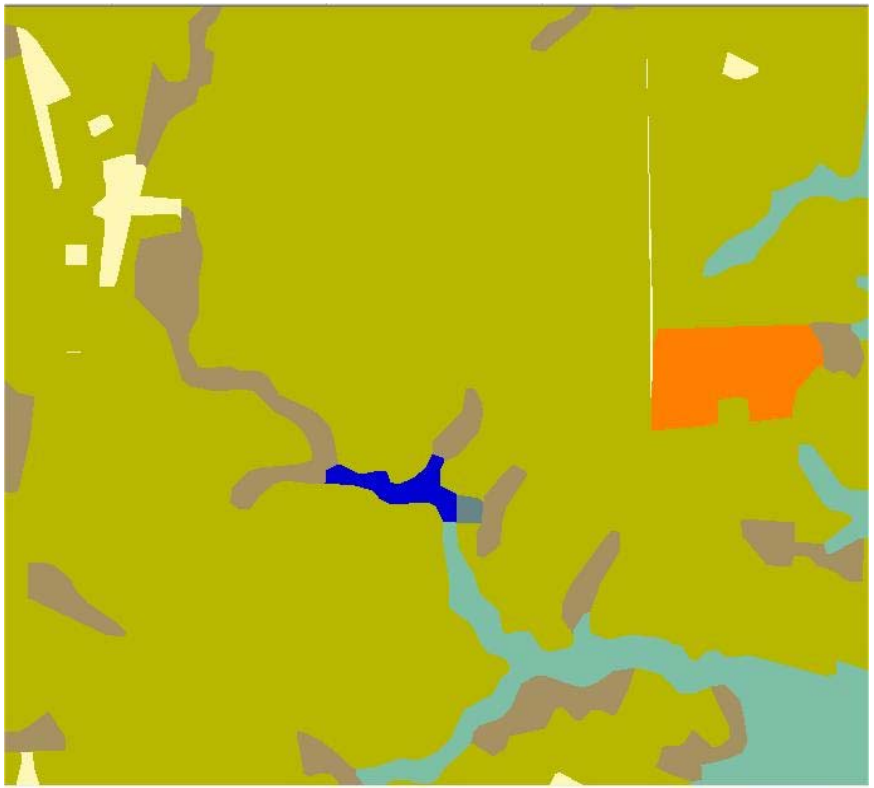
- 200m x 200m resolution
- Manual interpretation of aerial photographs
- Collected in the late 1970's and early 1980's
- 9 major classifications, 37 minor classifications
- Describes vegetation, water, natural surface and cultural features

NLCD Terrain Data

- 30m X 30m resolution
- Automated interpretation of Landsat thematic images (multi-spectral) with manual accuracy assessment and corrections.
- Collected in the early 1990's
- 9 major classifications, 21 minor classifications
- Describes vegetation, water, natural surface and cultural features
- Does a better job of distinguishing major roads and discretes from surrounding terrain

LULC and NLCD Terrain Data Examples

LULC Data



NLCD Data

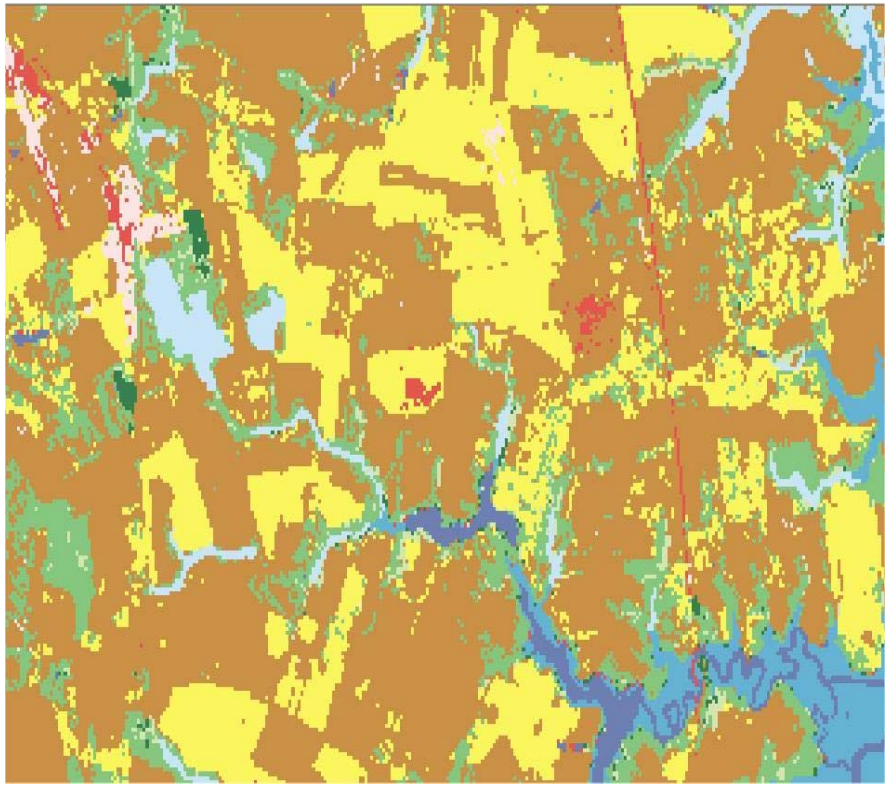
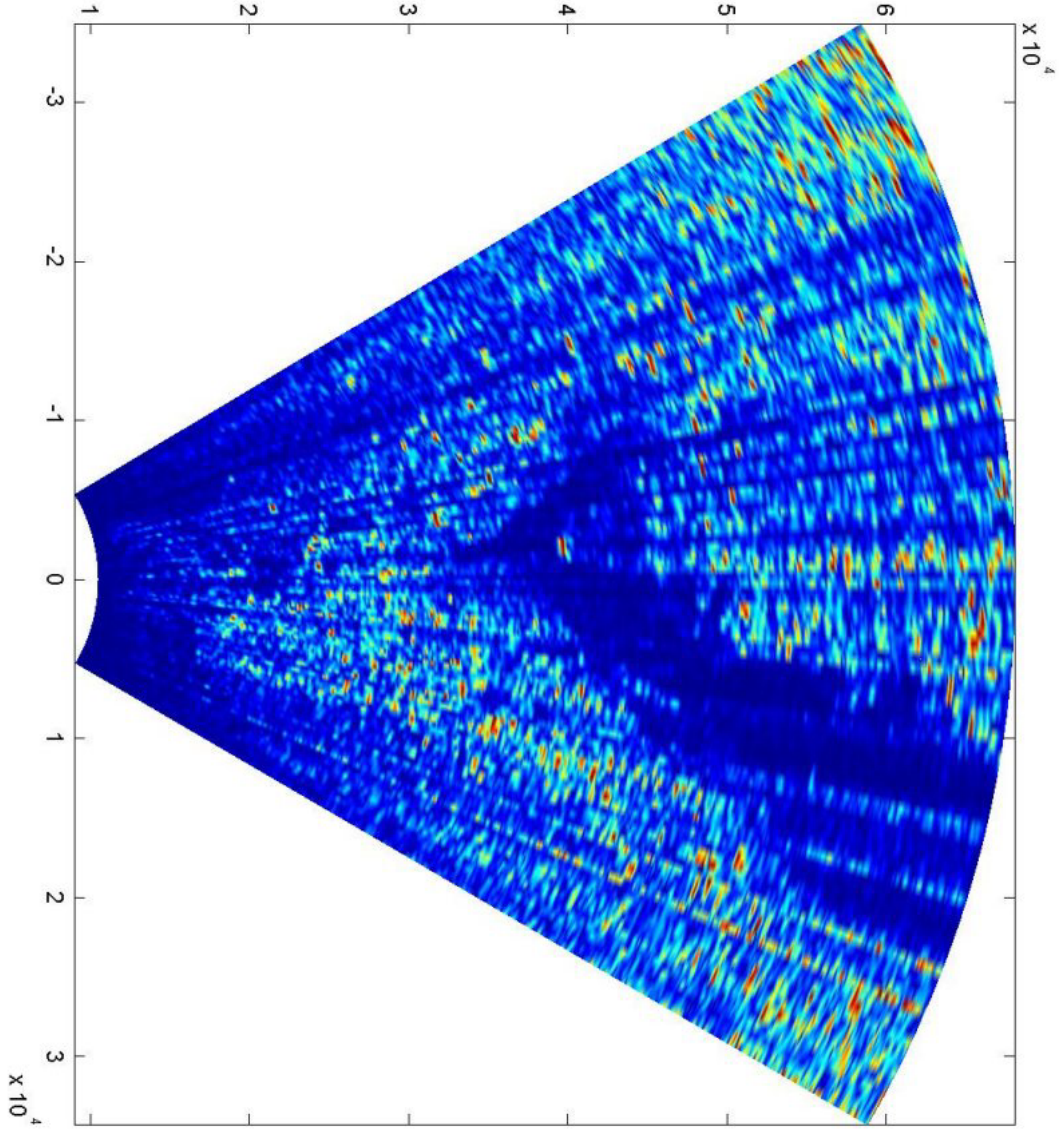


Image Formed With <u>One CPI</u> of MCARM DATA



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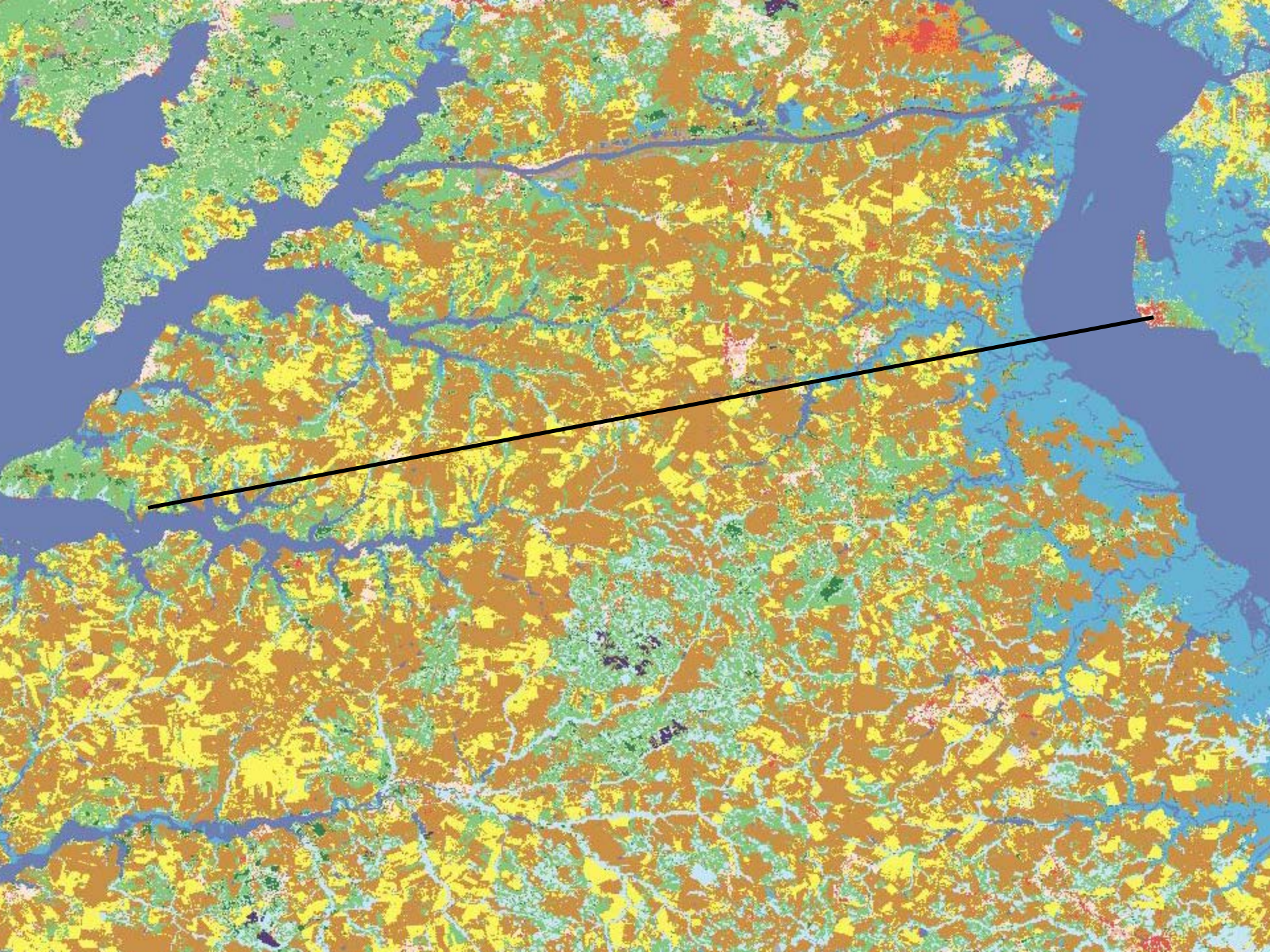

Future Plans

- Implement algorithms in MATLAB for automatically selecting secondary data using LULC and 30 meter data
- Modify algorithm to accept DEM data
- Modify algorithm to accept DLG data
- Quantify improvements obtained by using LULC, DEM, and DLG data
- Integrate MATLAB code into SPEAR facility

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Acknowledgements

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