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From Raw Pixels to Actionable Intelligence

GLISAR Technology Notebook

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"Make a difference and start with the right data before you lose millions"

The Critical Role of Pre- and Post-Processing

in Satellite Data Analysis

When approaching raw SAR satellite data, an enormous file size is delivered - somehow chaotic, uncalibrated, and exhibiting wide variations in both vertical and horizontal resolution. These raw acquisitions invoke all the inherent drawbacks and bottlenecks of synthetic aperture radar technology: speckle interference, backscattering noise, thermal noise, atmospheric distortions, interaction with terrain and the satellite's own orbital dynamics that compound into a complex web of signal degradation.

What emerges from this initial download is essentially unusable intelligence - a digital haystack of electromagnetic echoes that bears little resemblance to the actionable geospatial insights that decision-makers desperately need. Without sophisticated preprocessing pipelines, these multi-gigabyte files remain nothing more than expensive digital noise, representing millions of dollars in satellite infrastructure producing data that cannot directly inform critical operations or strategic planning initiatives.

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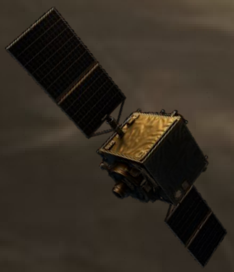
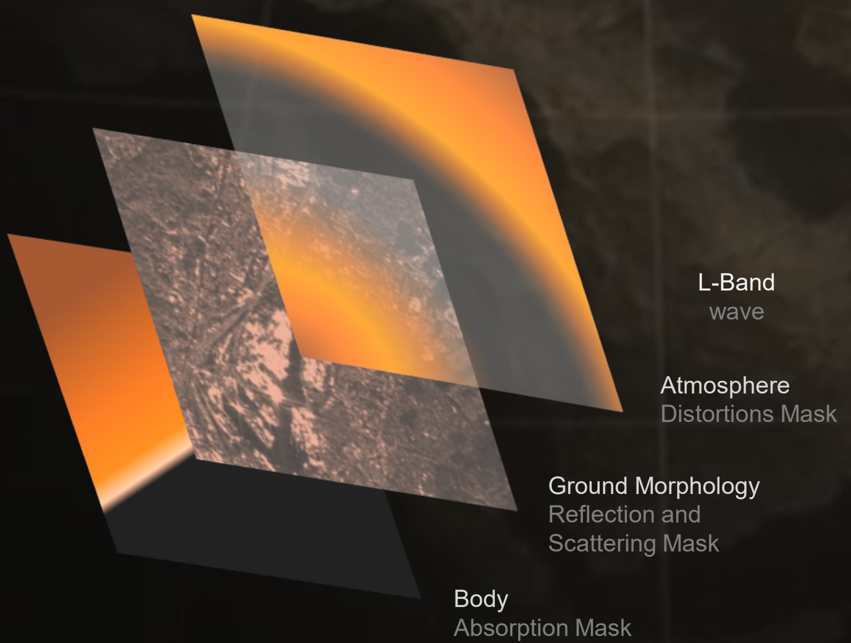
"Let's start from the beginning, when the fuel for your business is created"

Synthetic Aperture Radar (SAR) data generation begins with a sophisticated electromagnetic dance between space and Earth. The satellite-mounted radar system transmits precisely timed microwave pulses, typically in C, X, or L-band frequencies, toward the Earth's surface at oblique angles, creating the characteristic side-looking imaging geometry that SAR systems must use, in contrast to the flexible viewing angles of optical sensors. As these high-frequency electromagnetic waves encounter diverse terrestrial features—urban infrastructure, vegetation canopies, soil compositions, water bodies—each surface material reflects, absorbs, or scatters the radar energy according to its unique dielectric properties and geometric characteristics.



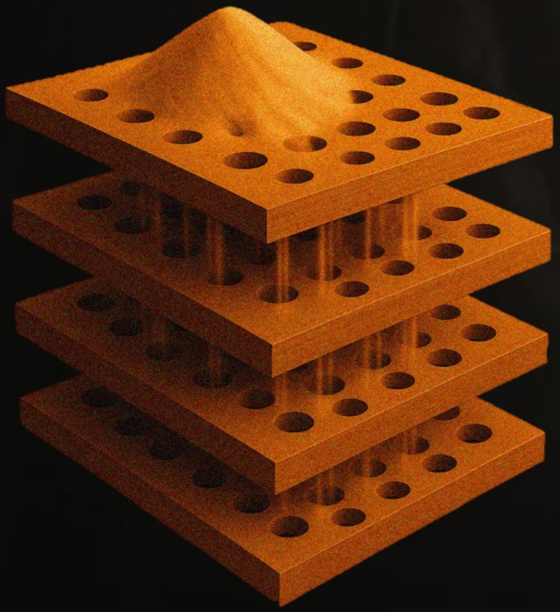


The returning echoes, now carrying encoded information about surface roughness, moisture content, and structural complexity, travel back through the atmosphere to the satellite's sensitive receiving antennas. This backscattered electromagnetic signature is immediately digitized into complex-valued data streams that capture both the amplitude and phase relationships of the returned signals. The raw data is then transmitted via high-speed downlinks to ground-based receiving stations, where it enters vast data storage infrastructures managed by satellite imagery companies or national space agencies. At this stage, what arrives in corporate data centers is essentially a compressed digital representation of electromagnetic interactions - terabytes of numerical values.

„Be certain you know how your data is working for you"

Transforming this electromagnetic chaos into scientifically valid geospatial products requires a meticulously orchestrated preprocessing pipeline that addresses each degradation source systematically:

- The initial step involves precise terrain correction, where digital elevation models (DEMs) are integrated with the raw SAR geometry to compensate for topographic distortions, shadow effects, and layover phenomena that corrupt the spatial fidelity of ground features.
- Subsequently, rigorous geometric transformation algorithms reproject the slant-range radar coordinates into standardized cartographic reference systems - typically UTM zones or national grid systems defined by specific EPSG codes - ensuring that the processed imagery aligns seamlessly with existing GIS databases and cadastral frameworks.



- Following geometric rectification, radiometric calibration becomes critical: the raw digital numbers representing backscattered signal strength are converted into physically meaningful radar cross-section values through application of calibration constants derived from pre-launch laboratory measurements and on-orbit calibration targets.
- The final preprocessing stage involves logarithmic scaling to decibel (dB) units, compressing the enormous dynamic range of radar backscatter values into a manageable format that enhances visual interpretation while preserving the quantitative relationships essential for automated analysis algorithms.

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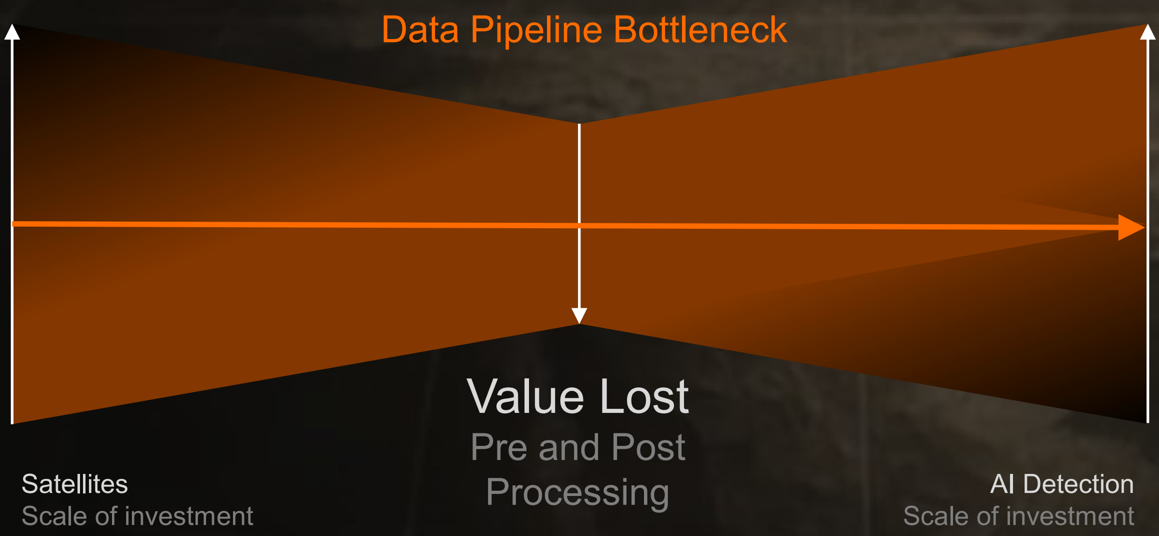
„Now comes the truth: How much of your data is actionable?"

The preprocessing pipeline, while essential, introduces its own constellation of uncertainties and potential data degradation that can compound into significant analytical errors. First and foremost, all scalar calibration constants are merely estimated values derived from pre-launch laboratory measurements and periodic on-orbit calibration maneuvers. These coefficients inevitably drift over time due to sensor aging, thermal cycling, and component degradation, introducing systematic radiometric errors that propagate through all subsequent analyses.



The logarithmic conversion to decibel scale, while necessary for dynamic range compression, inherently introduces quantization losses and can amplify small calibration errors into significant backscatter uncertainties, particularly for low-intensity targets where the signal-to-noise ratio approaches critical thresholds. Geometric rectification algorithms rely on orbital ephemeris data and timing synchronization that carry their own positional uncertainties - typically several meters even under optimal conditions - which can misalign features and create false change detection signals in time-series analyses.

Digital elevation models used for terrain correction often contain elevation errors ranging from 10-100 meters vertically, translating into geometric distortions that vary spatially across the scene and can introduce phantom targets or mask real features in complex topography. Furthermore, atmospheric path delays and ionospheric phase disturbances, inadequately modeled during preprocessing, can introduce range errors and phase inconsistencies that corrupt interferometric measurements and polarimetric decompositions, ultimately degrading the reliability of quantitative retrievals.

„Here comes the millions dollar wake-up call"

For million-dollar satellite acquisitions, systems can rapidly degrade into essentially worthless datasets when preprocessing errors accumulate unchecked, particularly when organizations focus myopically on superficial specifications like nominal pixel resolution rather than comprehensive data quality metrics.

The satellite industry's marketing-driven obsession with centimeter-level resolution claims - often promoted without rigorous consideration of actual positioning accuracy, radiometric fidelity, or geometric consistency - represents a fundamental misunderstanding of SAR data utility for operational intelligence applications. More deceptively, these centimeter-range specifications conveniently omit that radiometric discrimination often requires averaging over 10+ meter scales to achieve acceptable signal-to-noise ratios, meaning that while you can position features to centimeter accuracy, you cannot reliably distinguish what those features actually are without aggregating data over much larger areas.

Effective radiometric resolution can degrade beyond

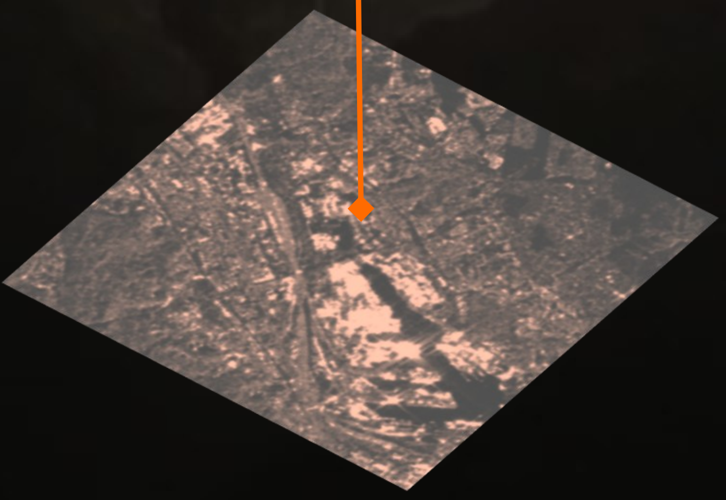
10dB

At this radiometric degradation, your system cannot reliably distinguish between a military facility (+10dB) and surrounding vegetation (-12dB), turning a high-value intelligence acquisition into an expensive failure.

„Here comes the millions dollar wake-up call"

This resolution arms race creates a dangerous misconception where procurement decisions prioritize theoretical spatial sampling over the far more critical factors of calibration stability, temporal consistency, and processing chain validation. Organizations investing substantial budgets in high-resolution SAR datasets while neglecting proper preprocessing infrastructure essentially purchase expensive digital noise that cannot support reliable analytical workflows or decision-making processes.

The harsh reality is that requesting enormous databases based solely on horizontal resolution specifications while ignoring the fundamental radiometric limitations reflects a profound gap in understanding SAR data complexity, a costly misconception that the satellite data industry has been reluctant to address transparently. Without sophisticated preprocessing pipelines that properly handle calibration uncertainties, geometric distortions, and noise mitigation, even the most expensive satellite acquisitions deliver analytical value equivalent to significantly cheaper, lower-quality alternatives, making the premium pricing unjustifiable without corresponding data integrity.



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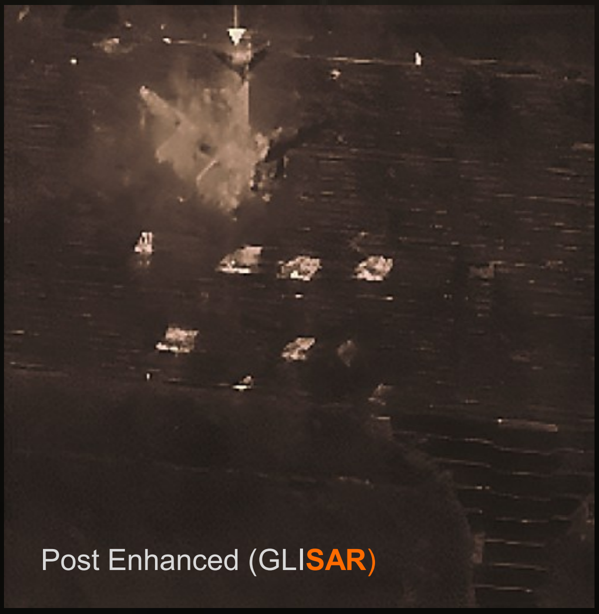
“Unlock this, what Others Can’t.”

Pre/Post Processed (GLISAR)

Original (Hi-Res)



Post Enhanced (GLISAR)

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Product
Quick Guide

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Tools for Map Collection

GLI Scan
Populate any user-defined map range with the selected strategy: Newest or Coverage

GLI Fetch
Leverage available infrastructure for optimal download speed

GLI Clean
Restrict the scene to the precisely defined user range

Complete maps for any range
100-1000 Km

Post-Processing Tools for Map Enhancement

GLI InDepth®
Color Encoding for High Bit-Depth Imaging

GLI Superposition®
Increasing Resolution from Multi-Angle Satellite Passes

GLI ChromaMAX®
End-point chroma amplification

GLI Post-Process
Patented 9-bit dB Mapping with Pre-Histogram Alignment

GLI Align
AI-Driven Uniform Signal Adjustment Across the Map

GLI Merge
Smart Linking of Scenes into a Single User Map

GLI Enhance/Encode
Advanced AI Techniques: De-Spackling, Smart Filtering & Image Up-Sampling

Different 9-bit color trajectories:
- Regular
- Blue MAX
- Green MAX
- Custom

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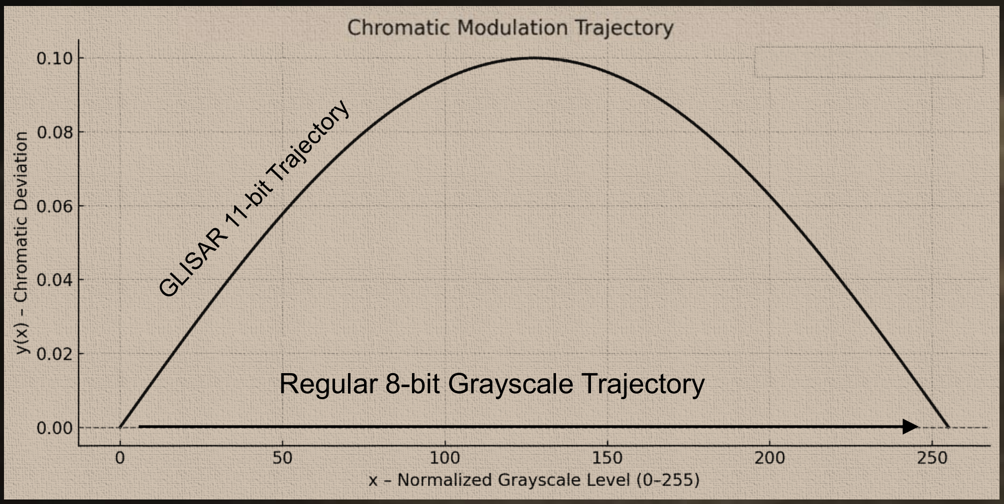
Patent pending



Color Trajectory (GLISAR)

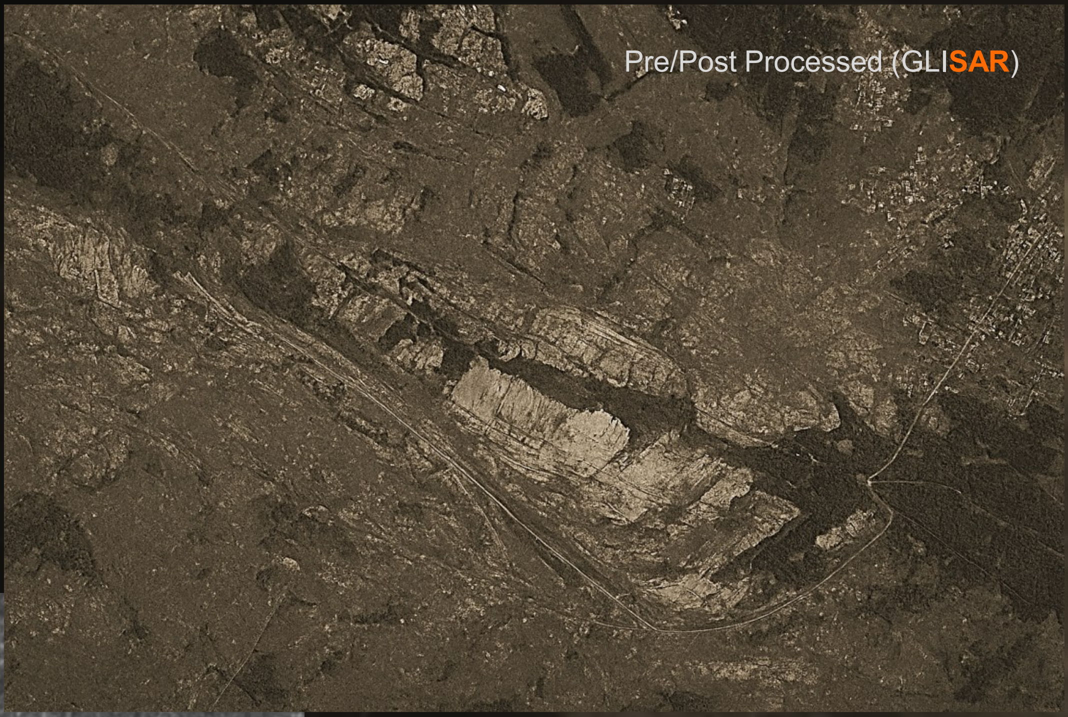
GLI inDepth®

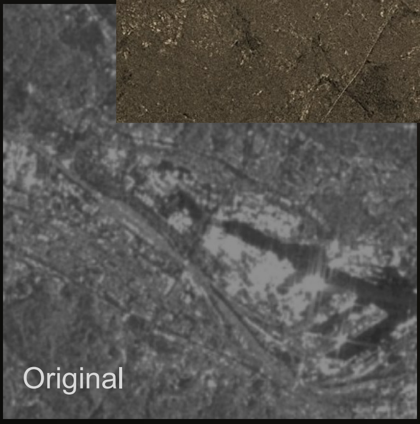
Color Encoding for High Bit-Depth Imaging

Satellite radar images - such as SAR - are typically stored in high bit-depth formats (10, 11, or even 12 bits per pixel) to preserve subtle variations in signal amplitude. However, when these images are visualized on standard displays, they must be compressed into 8-bit RGB formats, leading to significant information loss and poor tonal contrast. Traditional intensity scaling or false-color mapping often distorts the underlying data or introduces perceptual artifacts.

To address this, we apply a method that encodes high-bit-depth grayscale data using controlled trajectories in RGB color space. This technique retains the full tonal range by smoothly mapping each intensity value to a unique position along a continuous curve in perceptual color space. Instead of reducing the image to pure brightness levels, this technique assigns each pixel a position along a precisely defined curve in color space, where tonal depth is preserved through smooth and continuous chromatic variation. This results in images that retain the full dynamic range of the original data, while remaining visually intuitive and easy to interpret.

Unlike conventional approaches, this method preserves the neutrality of black and white tones, avoids color repetition, and allows for the encoding of thousands of distinguishable intensity levels within a standard 8-bit color image. The technique is particularly suited for radar and scientific imaging applications, where tonal fidelity and structural clarity are critical for accurate interpretation.





GLI Superposition*

Increasing Resolution from Multi-Angle Satellite Passes

Satellite images are usually limited by the native resolution of the sensor, which depends on the satellite's orbit, antenna size, and acquisition mode. However, when the same area is captured multiple times from different angles - such as from ascending and descending orbits - it becomes possible to reconstruct images with higher effective resolution. We call this method pixel superposition.

Each pass captures slightly shifted versions of the same objects on the ground. These small displacements - often less than a pixel - contain additional spatial information. By aligning the images with sub-pixel accuracy and merging them, it is possible to recover details that are not visible in any individual image.

In SAR imaging, this method can also take advantage of different scattering responses from different angles, allowing for more accurate reconstruction of structural features. The result is an image that has higher spatial resolution and better-defined edges and textures, without changing the sensor or increasing the data acquisition cost. This technique can be applied to both radar and optical data, provided that multiple overlapping observations from different geometries are available.

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Patent pending

Sentinel-1A Encoded (GLISAR)

GLI ChromaMAX®

End-point chroma amplification

Satellite radar images from GLISAR systems are stored in high bit-depth formats to preserve signal variations yet contain critical high-amplitude signals requiring immediate visual identification. When compressed to 8-bit RGB for display, these crucial signals - typically the highest 9-bit values - become difficult to distinguish using conventional methods.

GLI colorMAX addresses this by applying selective brightness enhancement to the upper intensity palette, ensuring important targets are immediately visible at any zoom level while focusing enhancement precisely where critical information resides.

Unlike global contrast enhancement techniques that can wash out subtle details or create artifacts, GLI colorMAX maintains the integrity of lower-intensity regions while specifically amplifying the visibility of high-priority signals. This approach is particularly valuable for operational applications where quick identification of important objects and strong radar echoes is essential for effective map interpretation and decision-making.

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