Accessible SAR and InSAR Processing

phidown and sarpyx: from CDSE to geocoded interferograms, a burst-centric Sentinel-1 InSAR processing packages

Roberto Del Prete & Jose Manuel Delgado Blasco (ESA Φ-lab)

The Innovation Hub: ESA Φ-lab

Based in ESRIN (Frascati, Italy) and directed by Giuseppe Borghi, the Φ-lab is the epicenter of European Earth Observation innovation.

Its mission is to accelerate the future of Earth Observation by adopting disruptive technologies. It acts as the ultimate hub bridging industry, academia, and deep-tech investors, providing unparalleled access to ESA's competence, computing resources, and open-source AI models.

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Φ-lab Explore Office

Technology Innovators

Connecting the Earth Observation sensor revolution with the digital revolution through innovation funding (FutureEO).

Φ-lab Invest Office

Business Innovators

Fostering the growth of entrepreneurial initiatives and stimulating competitiveness through the InCubed commercial co-funding programme.

The Traditional SAR Bottleneck

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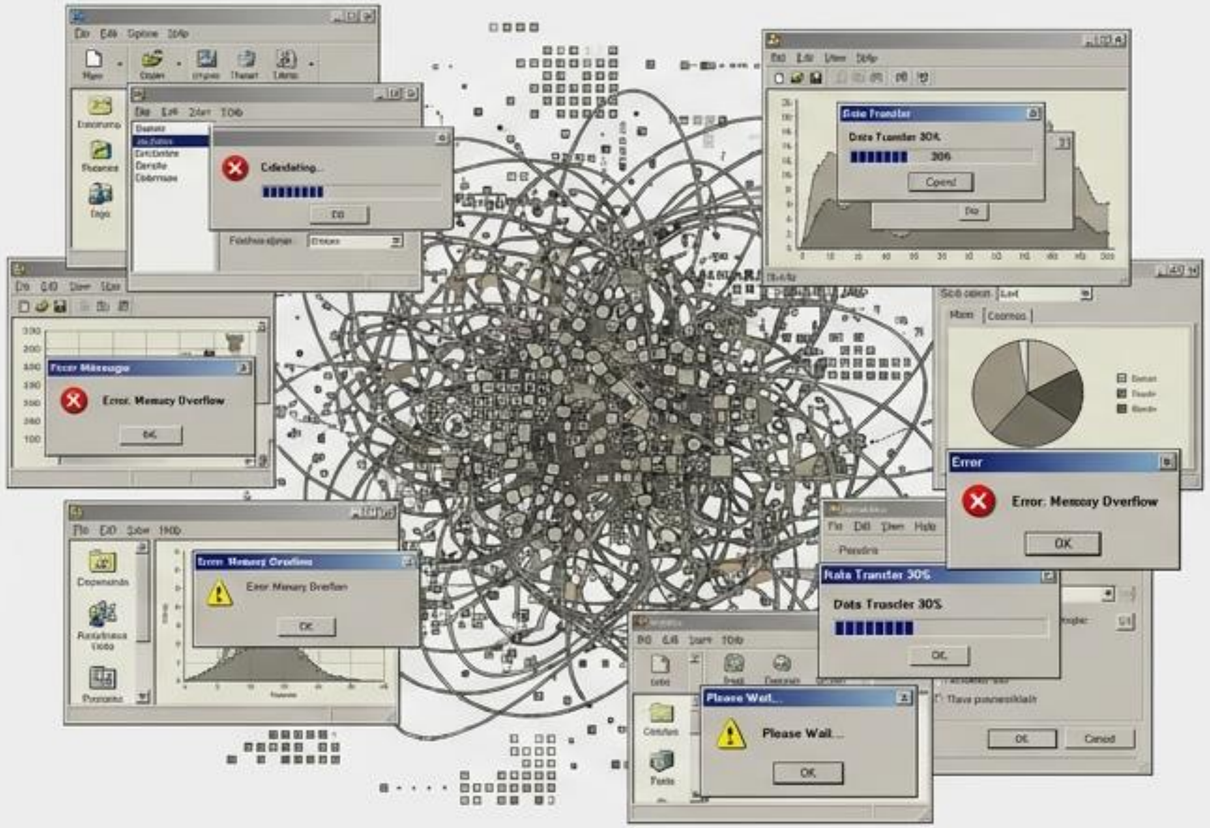
The Old Way



⚠ **Massive Full-Scene Downloads**

⚠ **Manual GUI Operations**

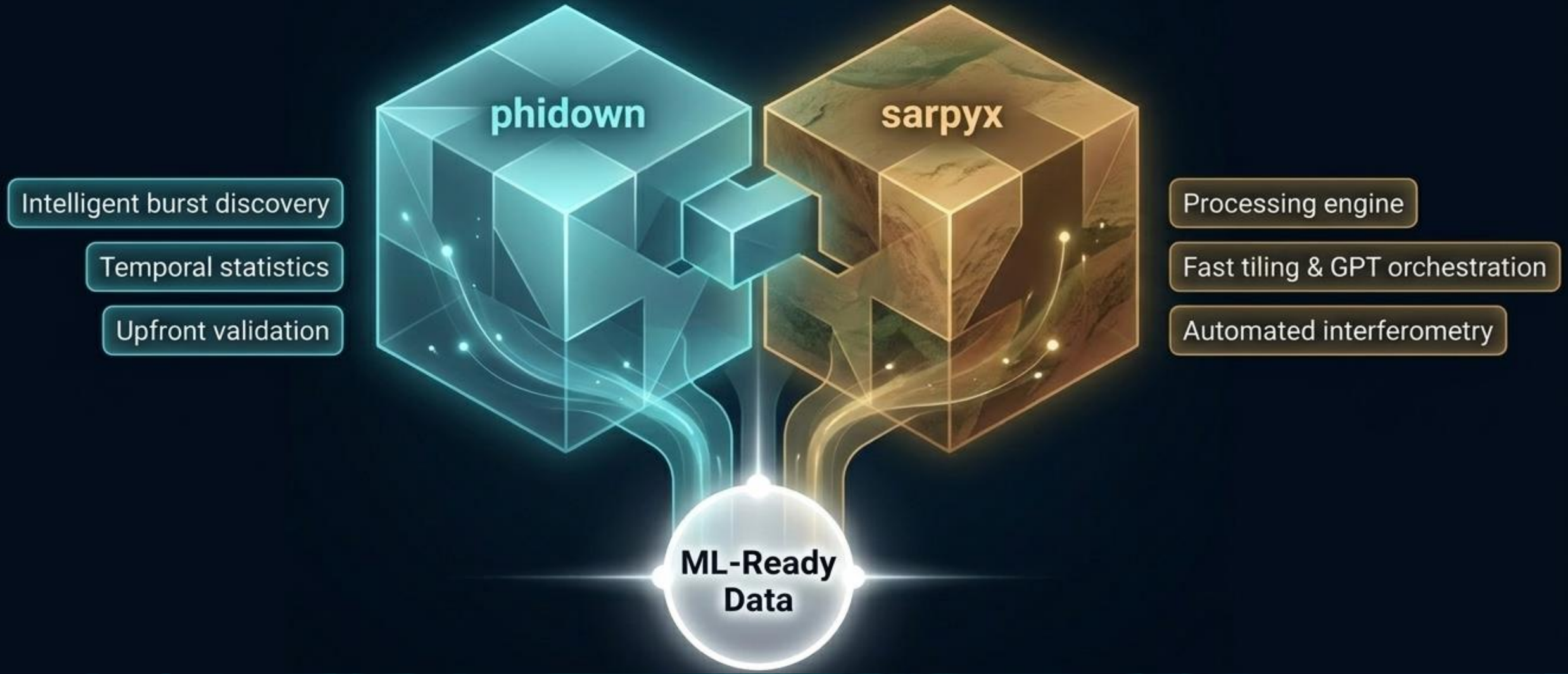
⚠ **Intimidating Local Compute**

The Goal

A streamlined, programmatic Earth Observation workflow for modern data science.

A Dual-Toolkit Architecture for Modern Pipelines

Introducing a seamless, programmatic approach to radar processing.

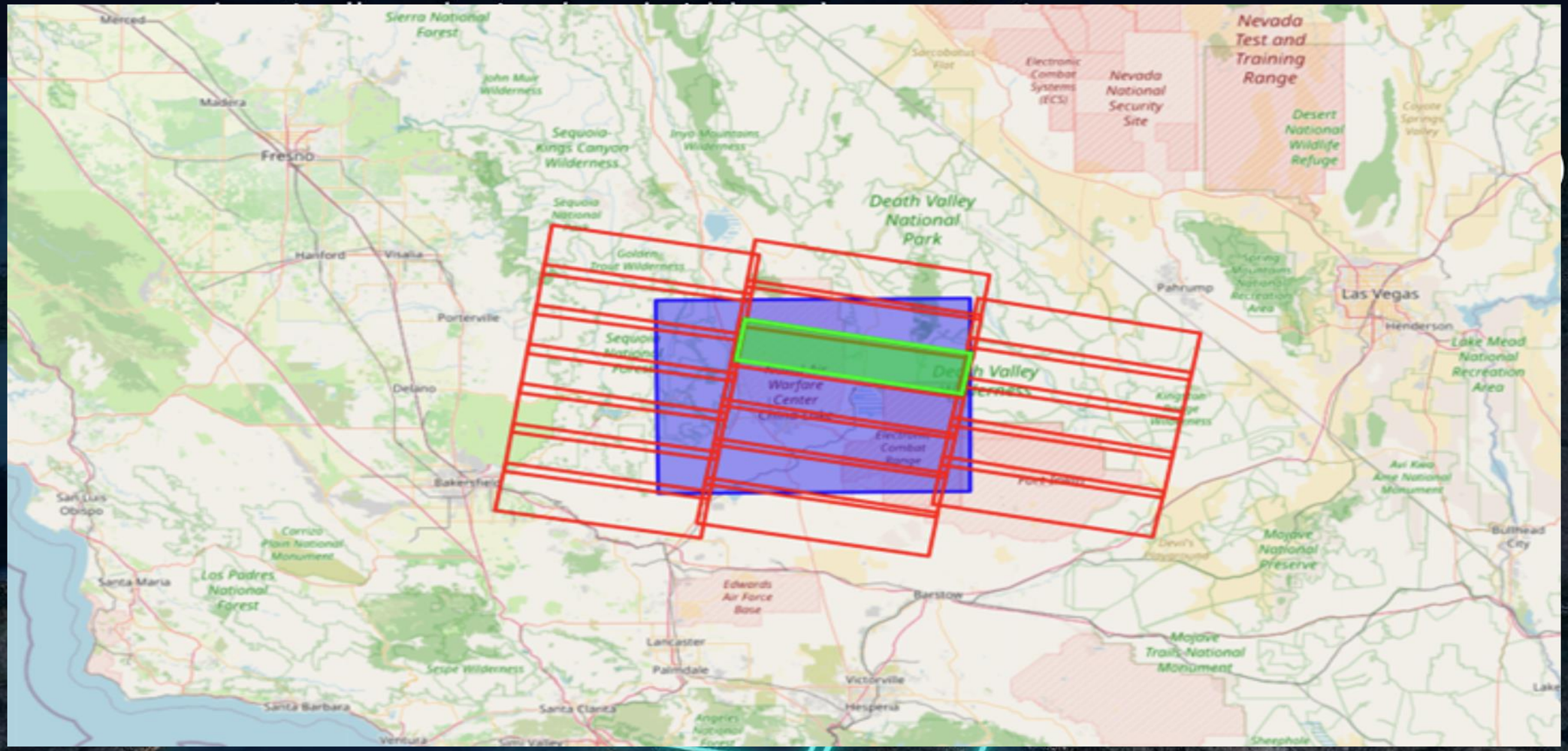


Porting the Engine into the Environment

Separate, painful software installations are no longer required. Native dependencies are perfectly managed, wrapped in an editable interface.

Shifting the Paradigm to Burst-Native Processing

Why download a multi-gigabyte scene when your Area of Interest only covers a fraction of it? Utilizing the Copernicus Data Space Ecosystem (CDSE), the toolkit targets specific bursts,



- Image source: https://eo4society.esa.int/2026/05/18/sentinel%E2%80%911-insar-processing-with-openeo-in-cdse/

The snapflow_insar Pipeline

From raw space signals to interpretable maps, the notebook executes a strict, reproducible sequence.

Search
(Discover candidates)

Validate
(The Verification Gate)

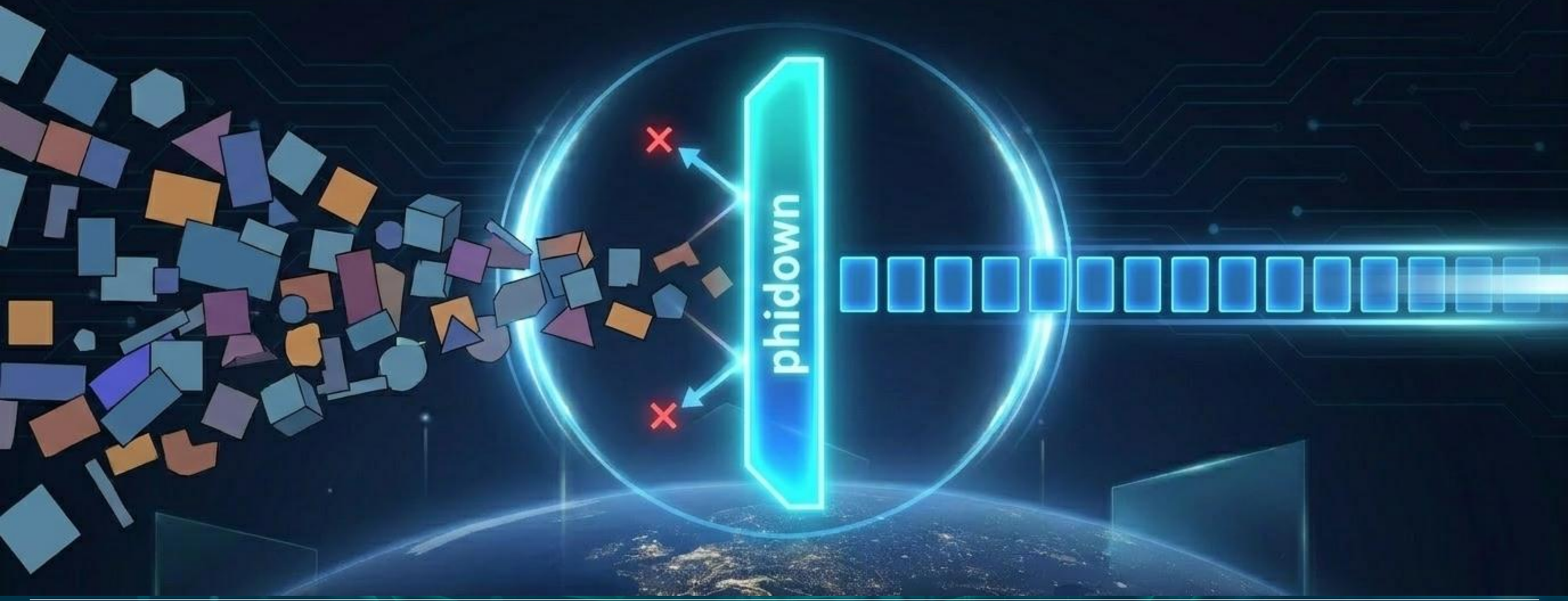
Extract
(CDSE on-demand)

Process
(The sarpyx Engine)

Interpret
(Geocoded Outputs)

The Verification Gate

Before a single second of SNAP runtime is spent, phidown acts as a strict verification gate. It confirms Area of Interest coverage, evaluates temporal statistics, and ensures the candidate footprints are valid.



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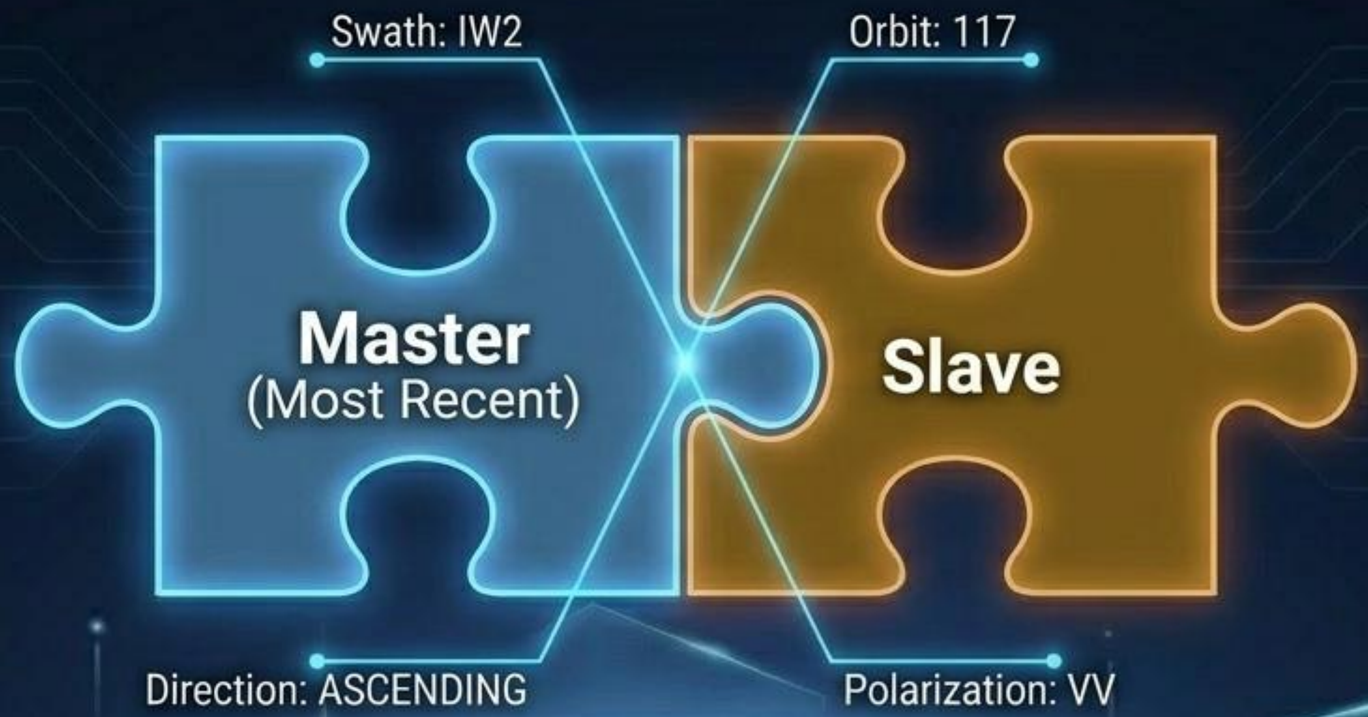
Resolving the Perfect Interferometric Pair

Burst-level InSAR is only meaningful when acquisitions share the exact same geometry. phidown groups results and ranks them by maximum coverage and recency to automatically select the optimal pair.



On-Demand CDSE Burst Extraction

The tool requests only the required burst products via the CDSE endpoint. It extracts them into a clean, well-formed product tree locally. Failing early prevents hours of downstream frustration.

Delegating the Heavy Lifting to sarpyx

The notebook leaves manual SNAP operators behind. It simply passes the extracted bursts to the s1_insar.py recipe. The user only configures top-level parameters.

```
run_pipeline(
    master=master_burst,
    slave=slave_burst,
    DEM_NAME='SRTM 3Sec',
    PIXEL_SPACING_M=20
)
```

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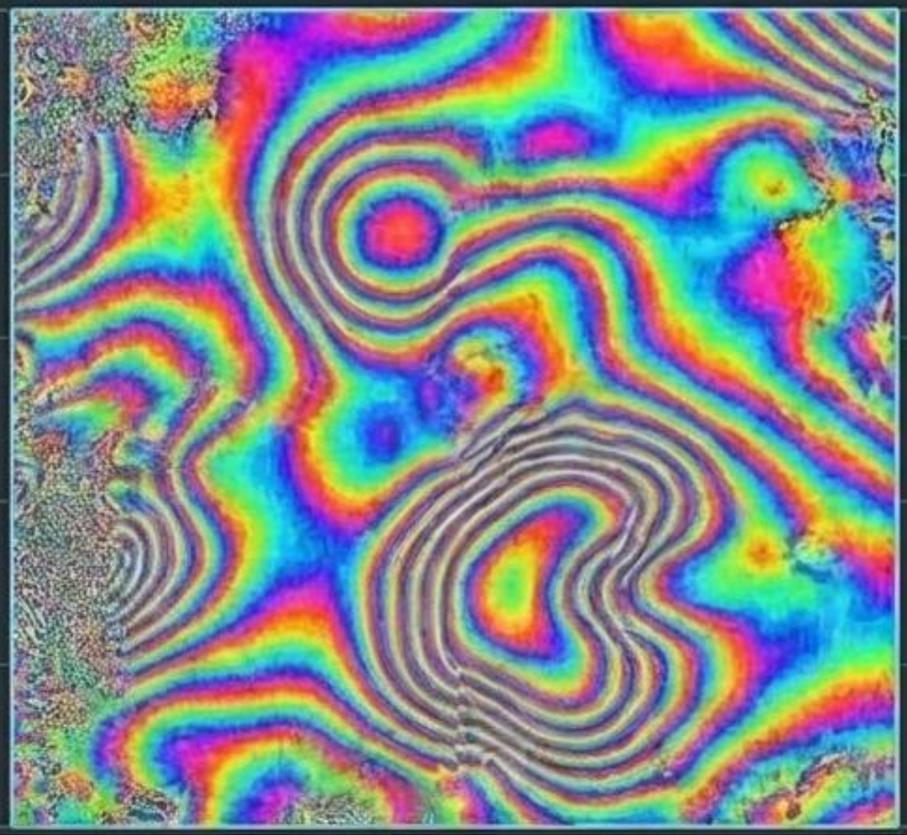
Inside the sarpyx Processing Engine

Five automated steps transform raw bursts into terrain-corrected observables.

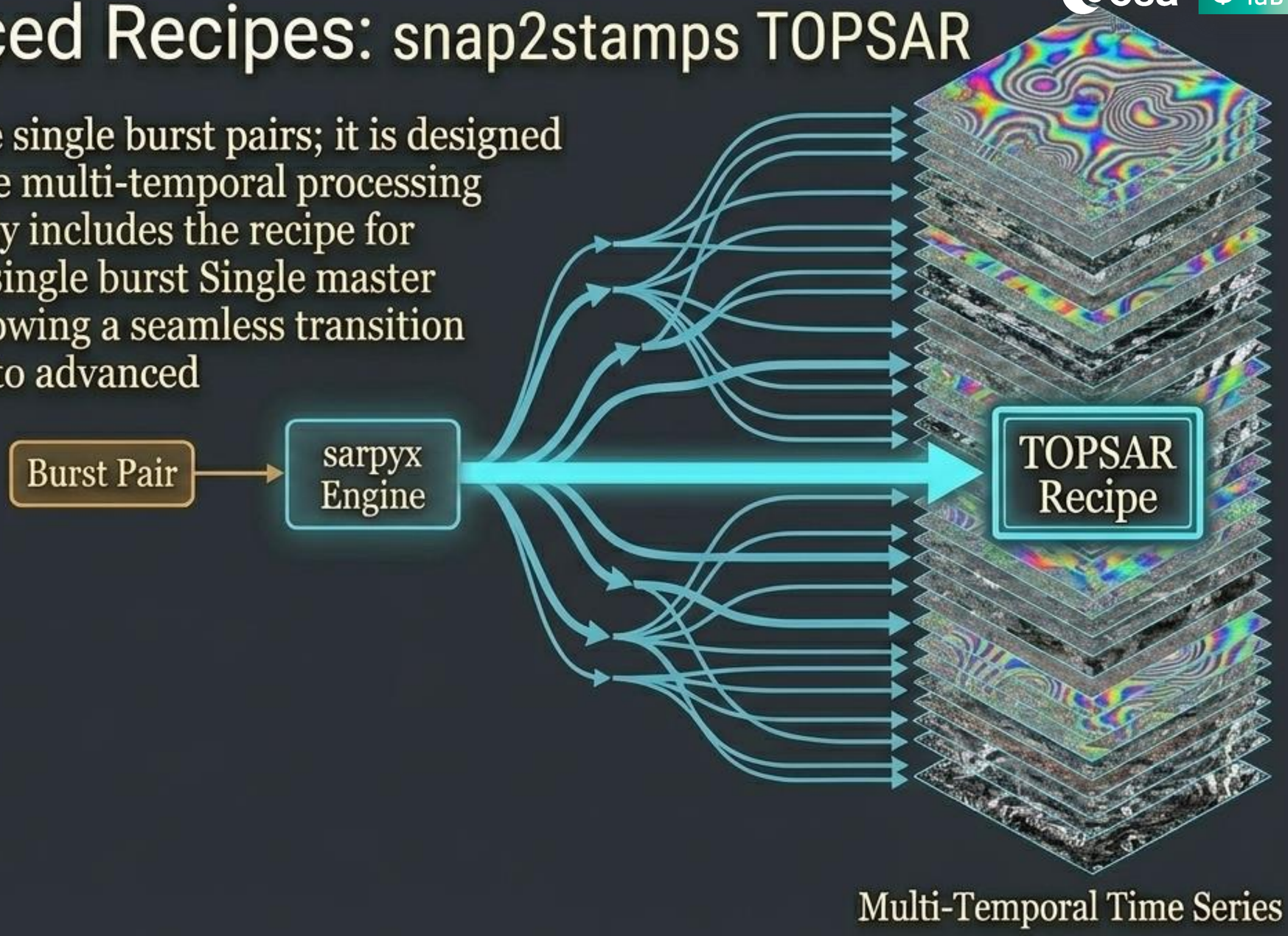
Clear and Diagnostic Artifacts

The pipeline automatically surfaces concise tables and restrained figures for immediate spatial quality assessment. It separates wrapped phase (using cyclic color) from coherence (using sequential color) to make spatial variations easy to assess, contextualized by terrain support rasters like local incidence angle.



Built-In Advanced Recipes: snap2stamps TOPSAR

sarpyx does not just handle single burst pairs; it is designed to scale into comprehensive multi-temporal processing stacks. The package natively includes the recipe for **snap2stamps TOPSAR** single burst Single master InSAR data processing, allowing a seamless transition from basic interferograms to advanced time-series preparation.



Reproducible SAR for Modern Workflows

Complex interferometry is now distilled into an accessible, fast, and robust Jupyter notebook. SAR is finally ready for modern data science.

ESA Φ-lab Maintainers

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StaMPS Renewal for the Modern Era

pystamps leaves MATLAB behind. An accessible Python frontend powered by a memory-safe, hyper-optimized Rust backend.

Acceleration via pystamps

Authored by Roberto Del Prete, this package streamlines the heavy time-series phase of SAR analysis. It completely renews the old StaMPS implementation, replacing legacy scripts with a lightning-fast, optimized Python wrapper powered entirely by a low-level Rust backend.

Zero Compromise on Scientific Accuracy

Massive speed gains cannot come at the cost of scientific validity. The new architecture is rigorously verified via the parity notebook, proving absolute mathematical and scientific parity between the legacy Matlab implementation and the new Rust backend.

Legacy Matlab Output

Rust Backend Output

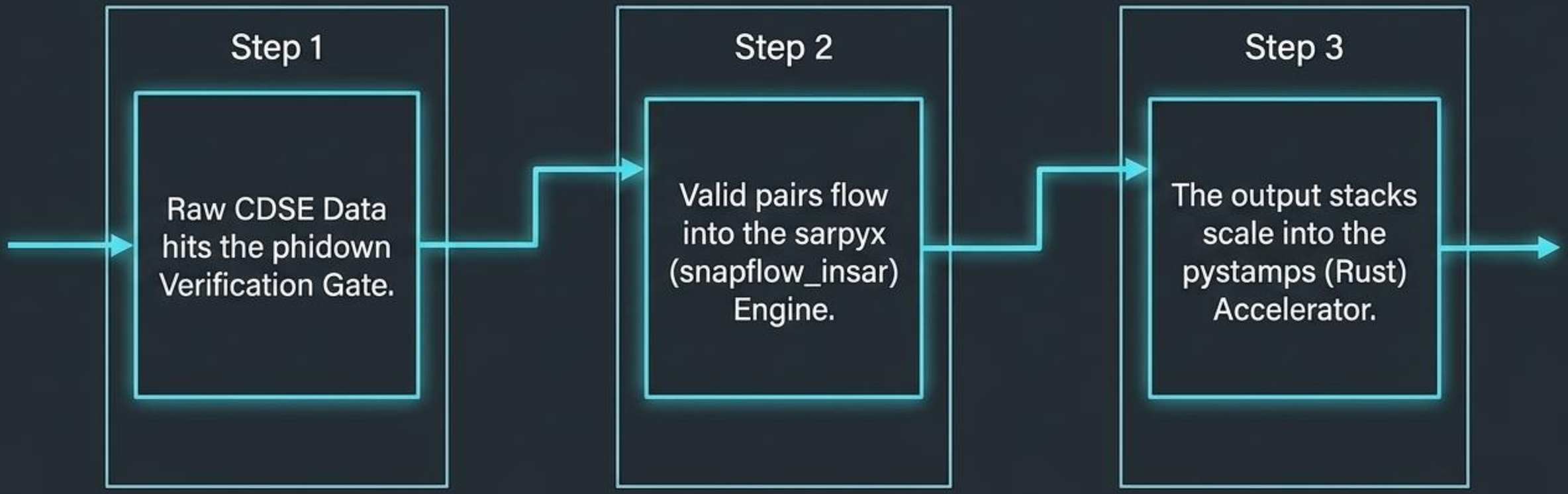
Parity Verified

`04_rust_end2end_parity_validation.ipynb`

A Complete, Reproducible Framework

From initial CDSE burst discovery to highly optimized Rust-backed time-series analysis—a linear, unbroken pipeline. We have replaced fragmented, math-heavy legacy workflows with a unified, scalable Python ecosystem engineered specifically for modern Earth observation.

The Life of a Pixel



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Start Processing Today

Tailored for researchers and developers.

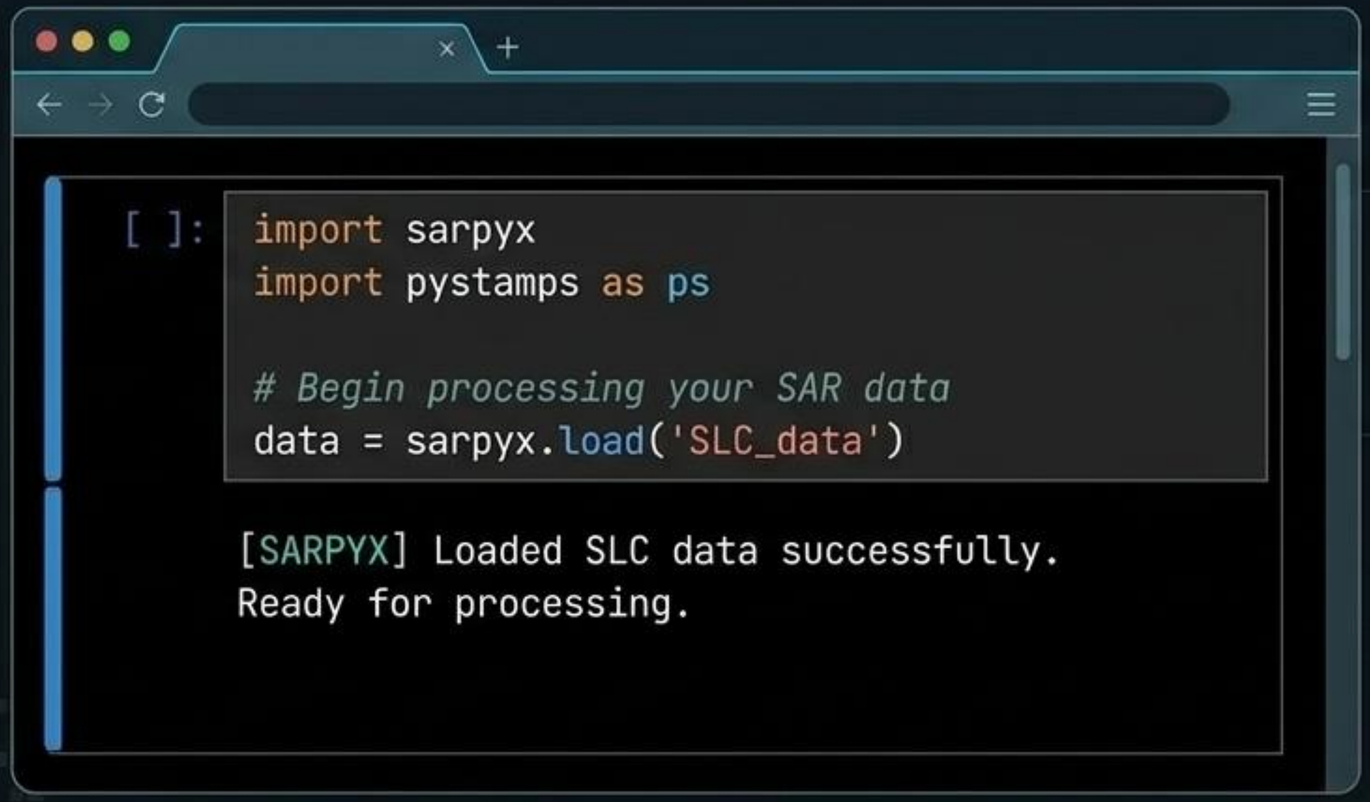
github.com/ESA-PhiLab/sarpyx

github.com/ESA-PhiLab/phidown

github.com/ESA-PhiLab/pystamps

Run the Notebooks Today

Extract the clear signal from your SAR data.



GitHub: ESA-PhiLab/sarpyx
GitHub: ESA-PhiLab/pystamps

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