

SatExt: Generative AI framework for Spatio-Spectral Satellite Unification and Beyond

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Peder Olsen (Microsoft Research), Vaishnavi Ranganathan (Microsoft Research)

Why is Satellite Imagery important?

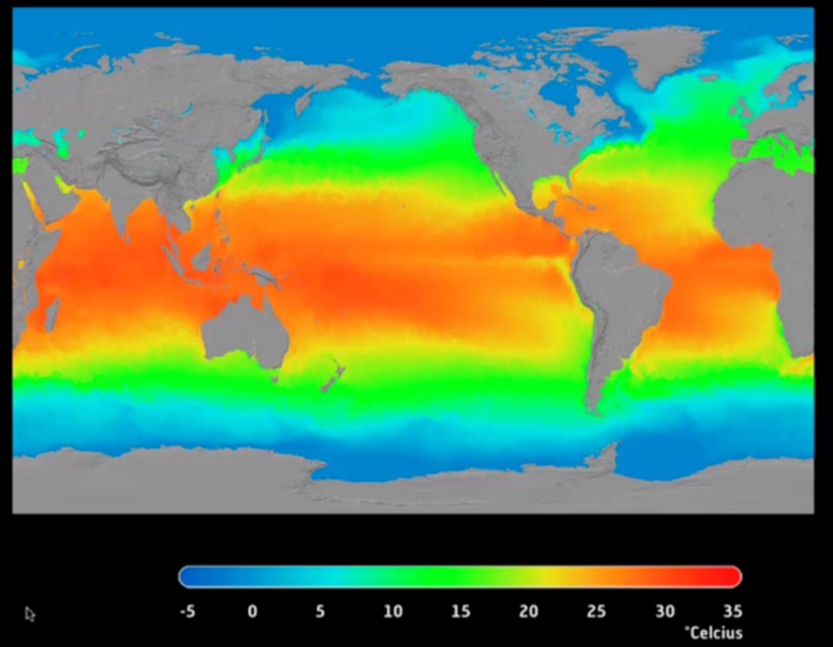
Enables Remote Sensing Applications



Agriculture



Forestry



Climate Monitoring

Existing Satellite Networks offer Sparse and In-frequent Observations

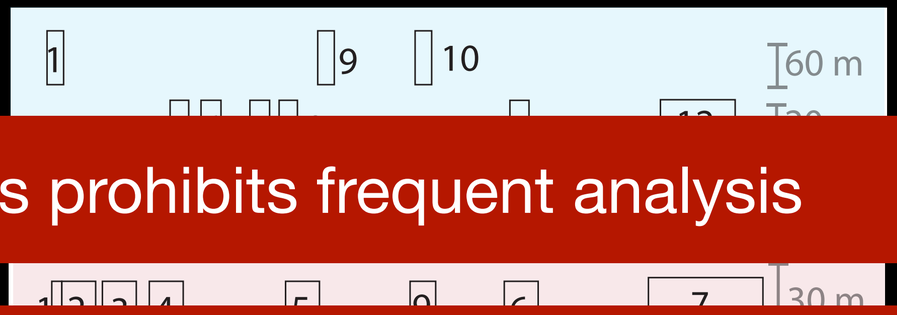
>1000 EOS

Different Spectral Bands

Different Spatial Resolution



Satellite B



Heterogeneity among various satellite constellations prohibits frequent analysis

Past Work has harmonized the satellite data in lowest common spectral and spatial resolution

Wavelength

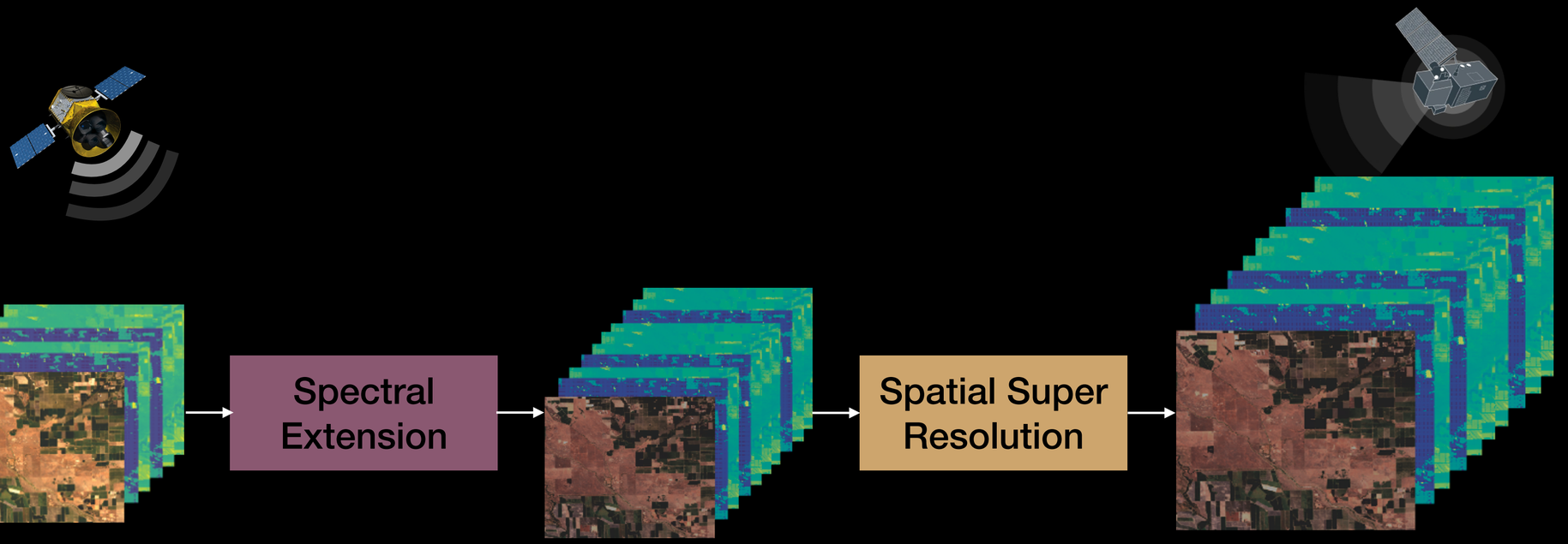
Can we convert satellite images into a standardized, high-resolution format that enables frequent and accurate remote sensing?

SatExt

- A GenAI framework that unifies heterogeneous satellites while maintaining high spectral and spatial resolution
- Achieves impressive performance on state-of-the-art satellite datasets
- Highlight how SatExt can go beyond unification to enable various tasks

SatExt's Design

Strategically decouple spectral extension and spatial resolution



Source Resolution

Lower Spectral & Spatial Resolution

e.g., Landsat-8

Intermediate Stage

Spectral Resolution of Target Satellite

Spatial Resolution of Source Satellite

Target Resolution

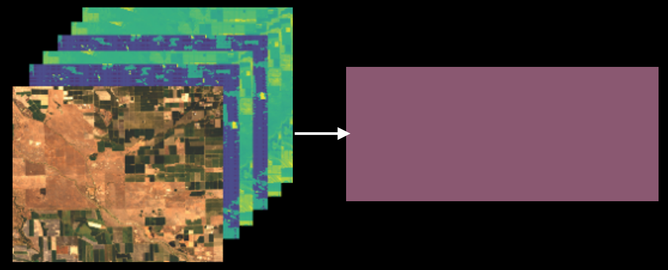
Higher spatial & Spectral Resolution

e.g., Sentinel-2

Spectral Extension

Key Insight: Spectral Extension is a low-rank problem

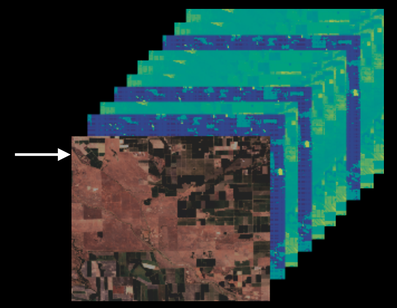




Source Resolution

Lower Spectral & Spatial Resolution

e.g., Landsat-8



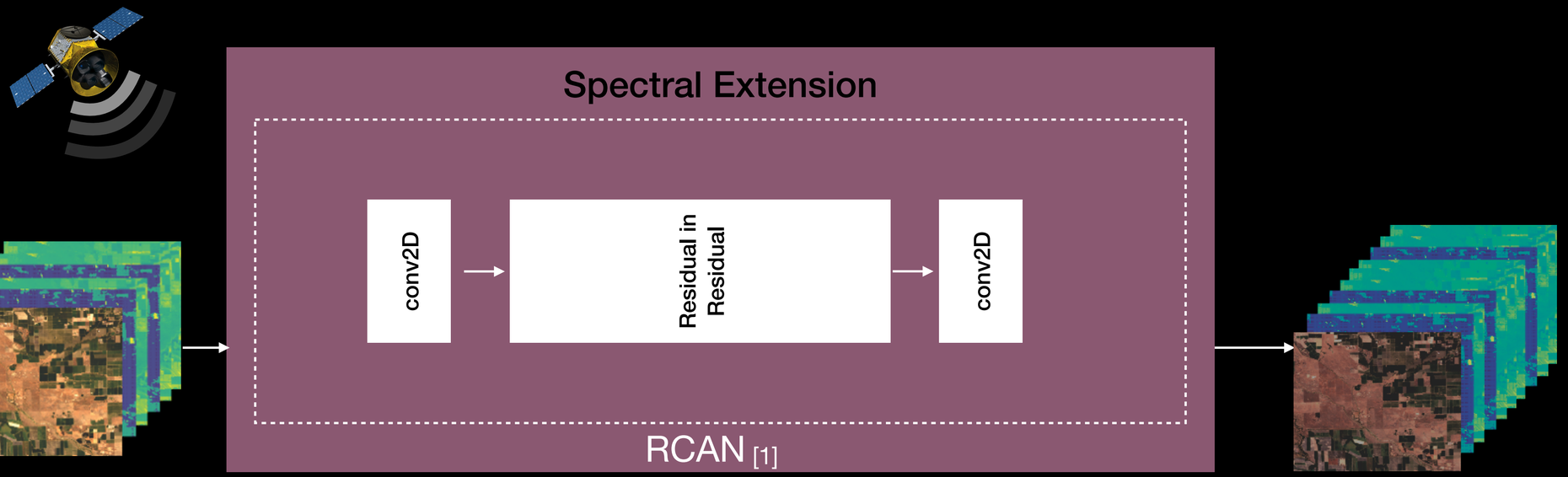
Intermediate Stage

Spectral Resolution of Target Satellite

Spatial Resolution of Source Satellite

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Intermediate Stage

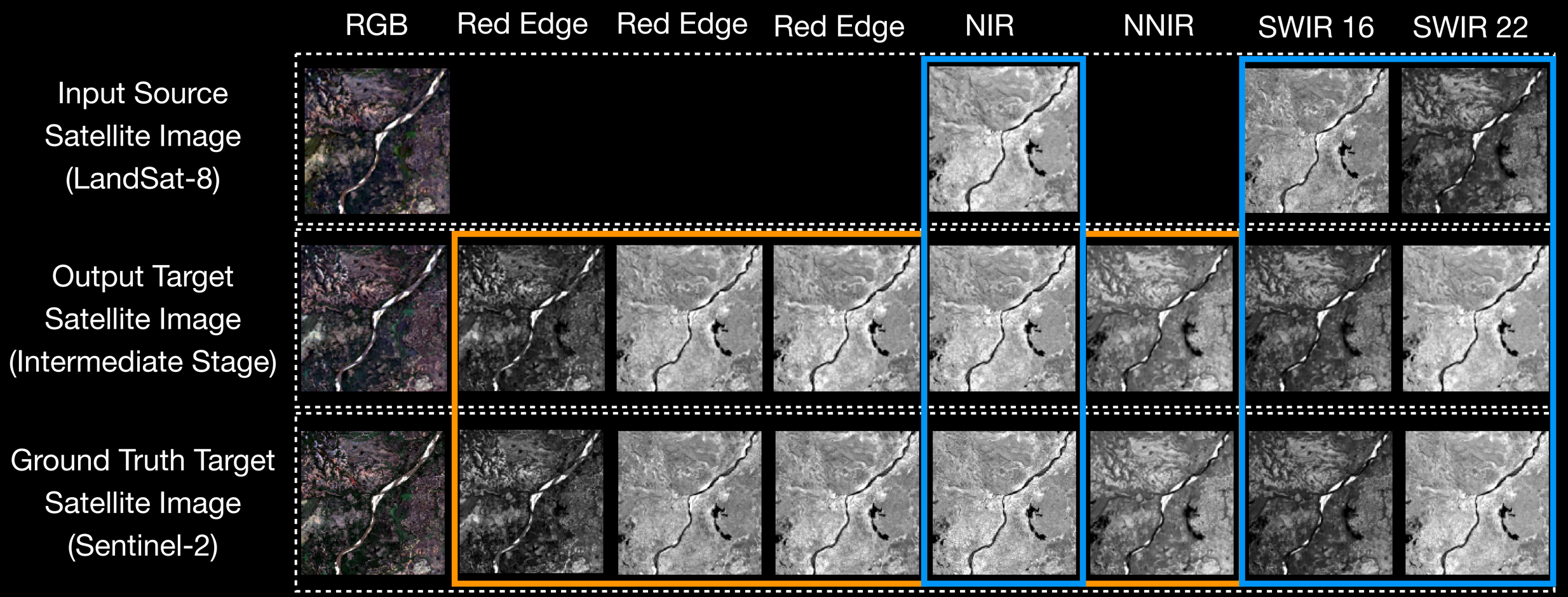
Spectral Resolution of Target Satellite

Spatial Resolution of Source Satellite

[1] Zhang, Yulun, et al. "Image super-resolution using very deep residual channel attention networks." Proceedings of the European conference on computer vision (ECCV). 2018.

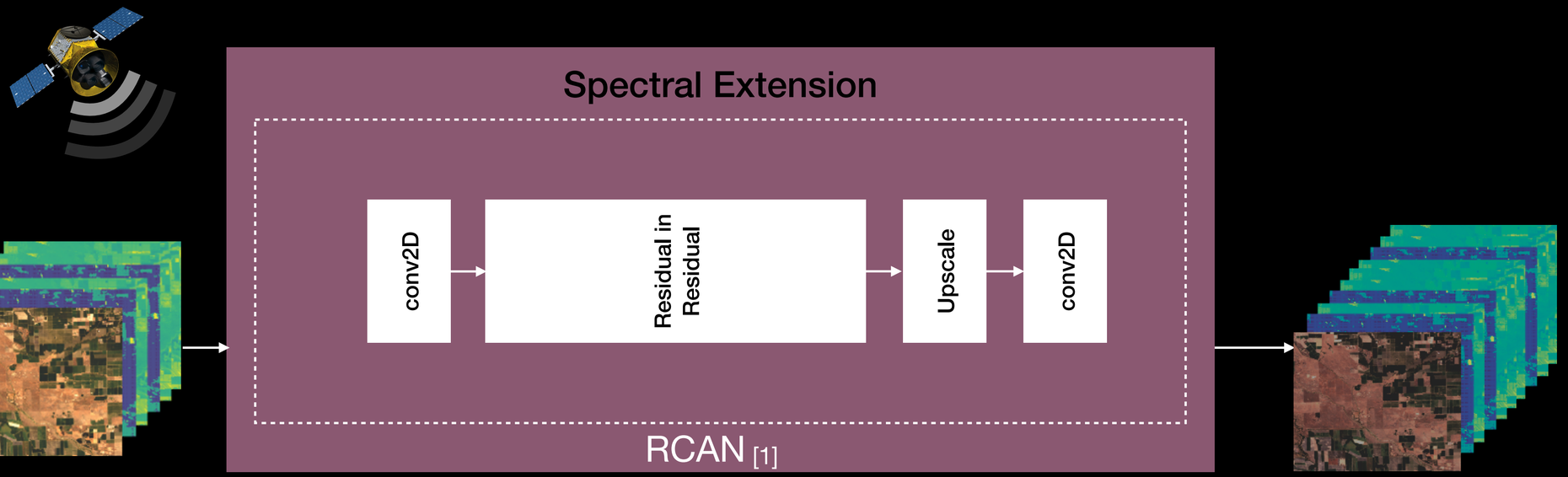
Results

Spectral Extension



Spectral Extension

Key Insight: Spectral Extension is a low-rank problem



Source Resolution

Lower Spectral & Spatial Resolution

e.g., Landsat-8

Intermediate Stage

Spectral Resolution of Target Satellite

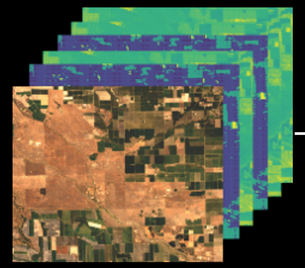
Spatial Resolution of Source Satellite

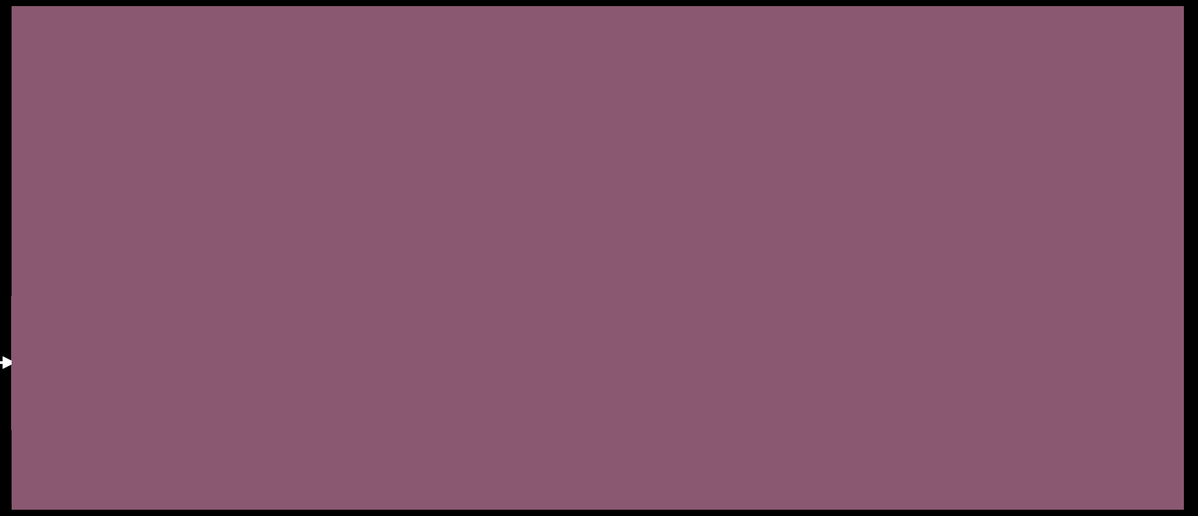
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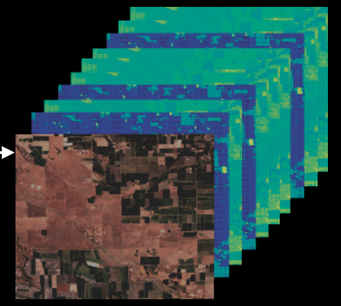
Spectral Extension

Key Insight: Spectral Extension is a low-rank problem









Source Resolution

Lower Spectral & Spatial Resolution

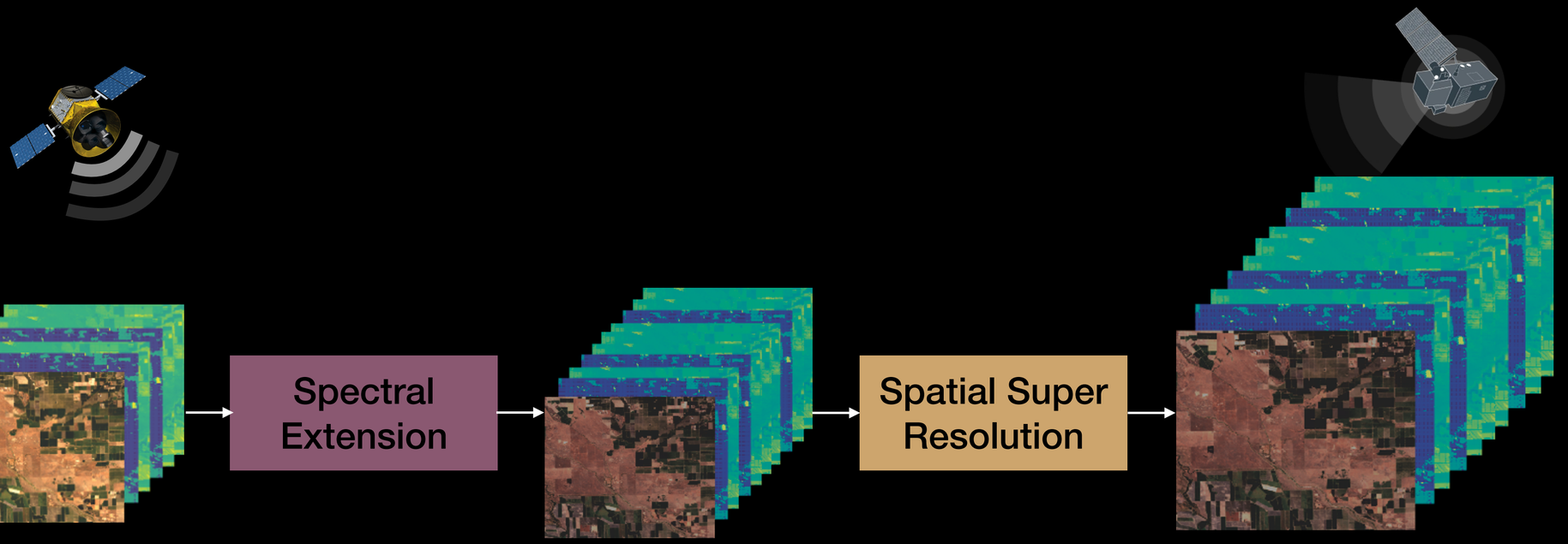
e.g., Landsat-8

Intermediate Stage

Spectral Resolution of Target Satellite

Spatial Resolution of Source Satellite

Spatial Super Resolution



Source Resolution

Lower Spectral & Spatial Resolution

e.g., Landsat-8

Intermediate Stage

Spectral Resolution of Target Satellite

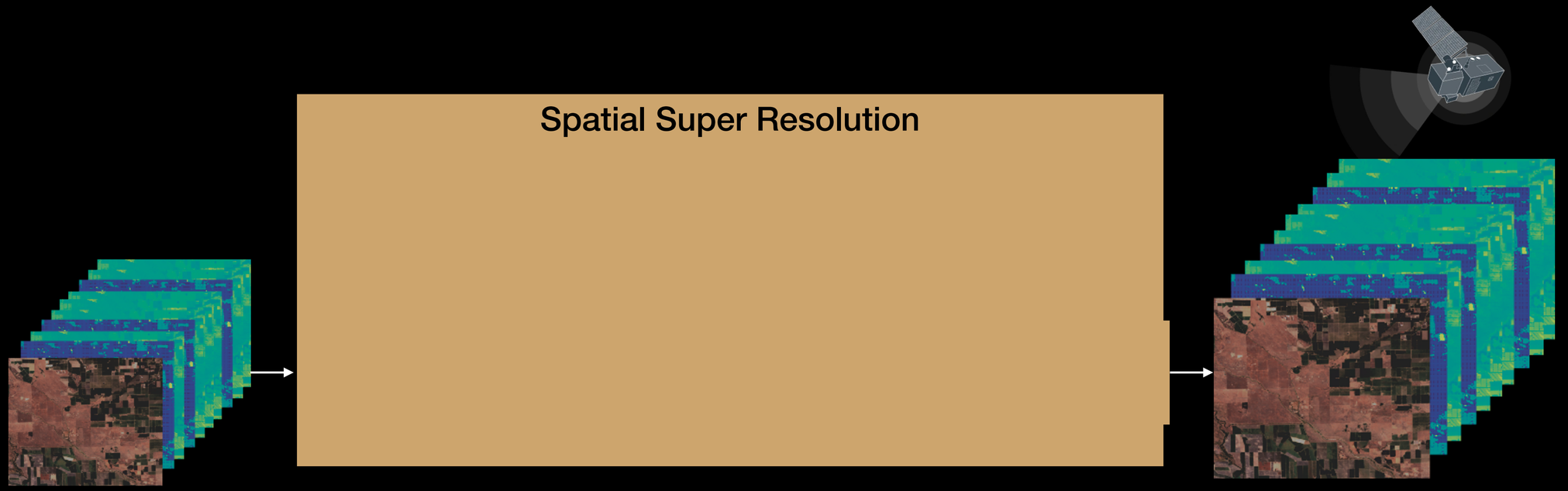
Spatial Resolution of Source Satellite

Target Resolution

Higher spatial & Spectral Resolution

e.g., Sentinel-2

Spatial Super Resolution



Intermediate Stage

Spectral Resolution of Target Satellite

Spatial Resolution of Source Satellite

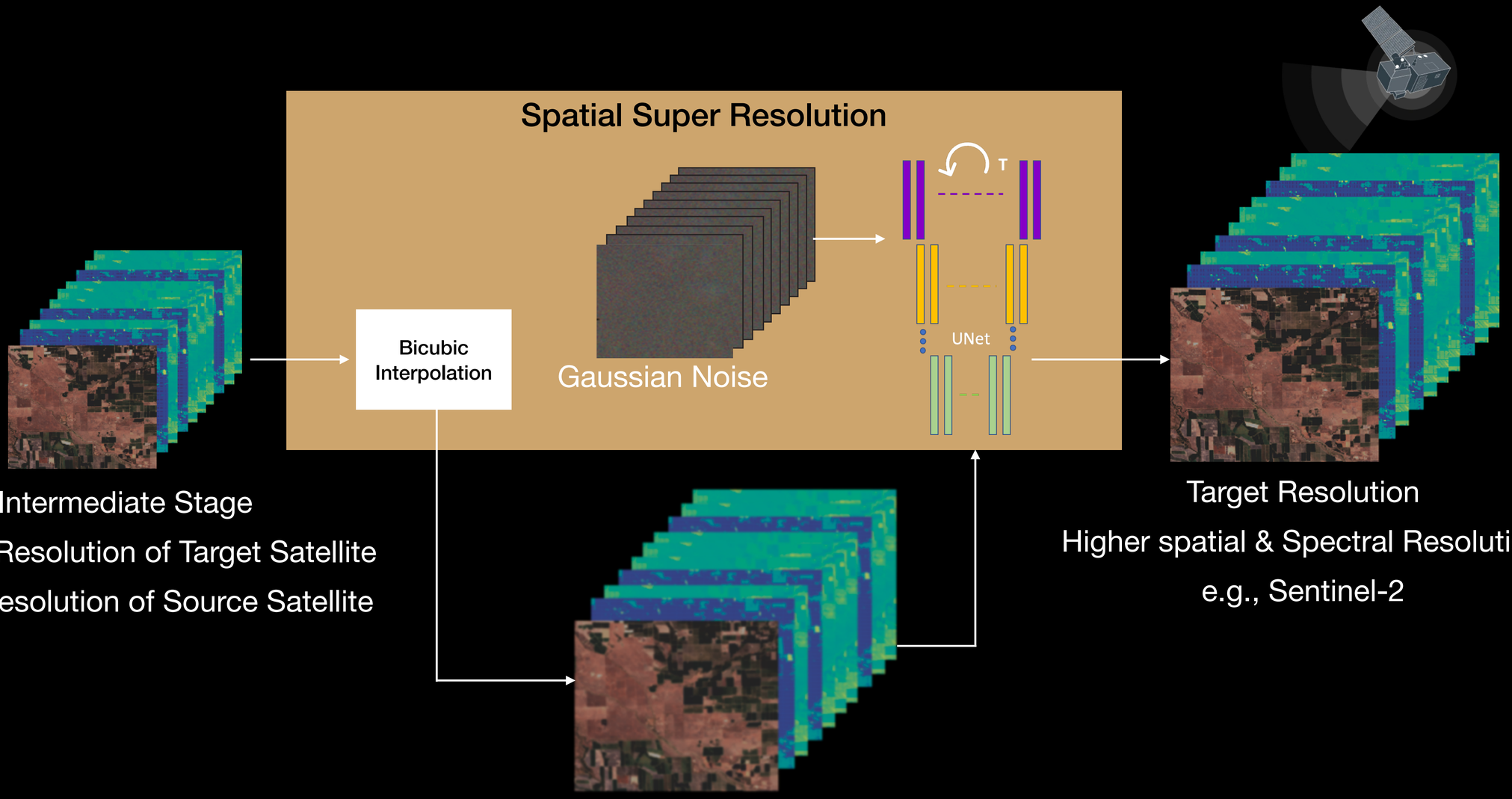
Target Resolution

Higher spatial & Spectral Resolution

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Spatial Super Resolution

Leverages Denoising Diffusion Probabilistic Model

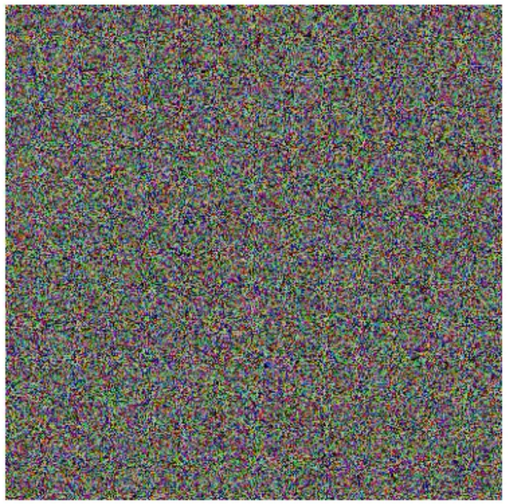


Results

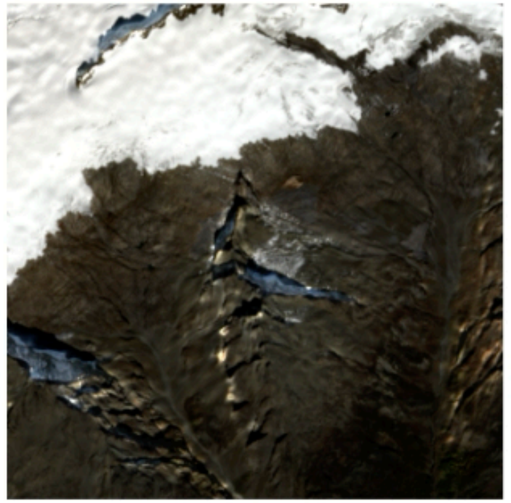
Spatial Super Resolution



Low Spatial Resolution
Conditioning Image



High Spatial Resolution
Target Satellite Image
(Predicted Output)



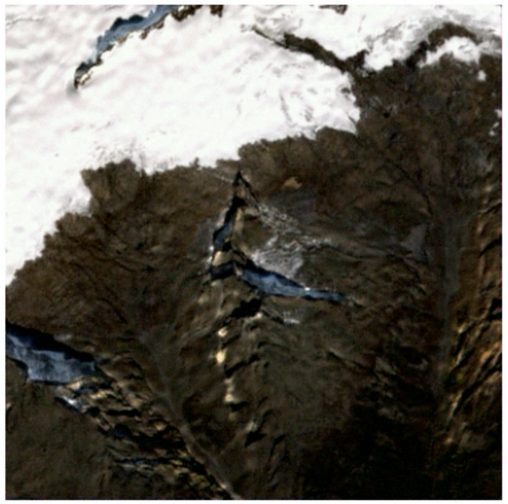
High Spatial Resolution
Target Satellite Image
(Ground Truth)

Results

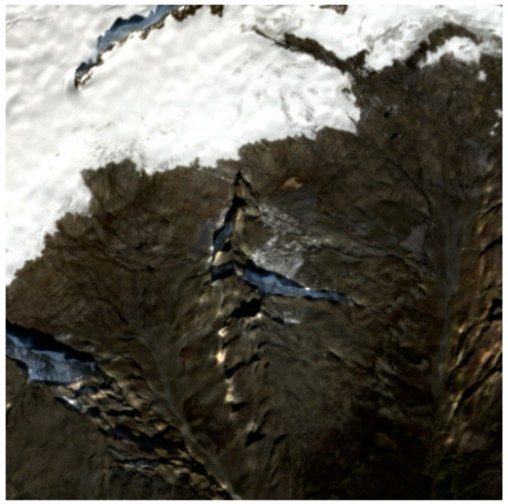
Spatial Super Resolution



Low Spatial Resolution
Conditioning Image



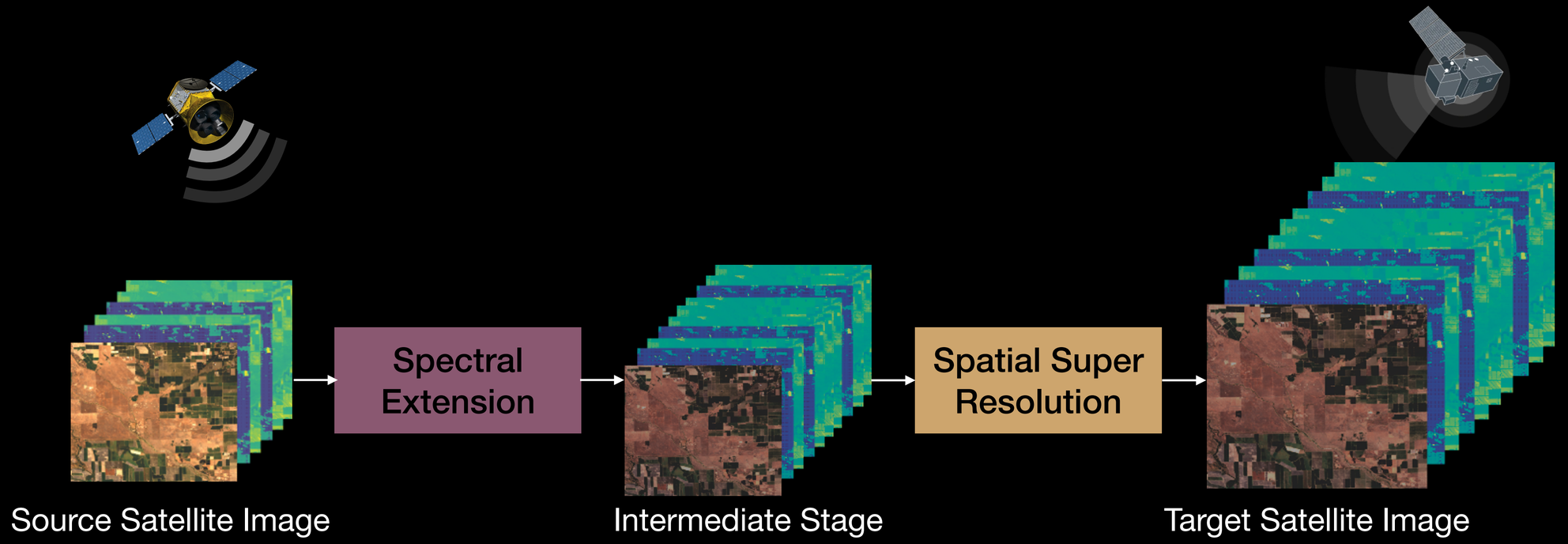
High Spatial Resolution
Target Satellite Image
(Predicted Output)



High Spatial Resolution
Target Satellite Image
(Ground Truth)

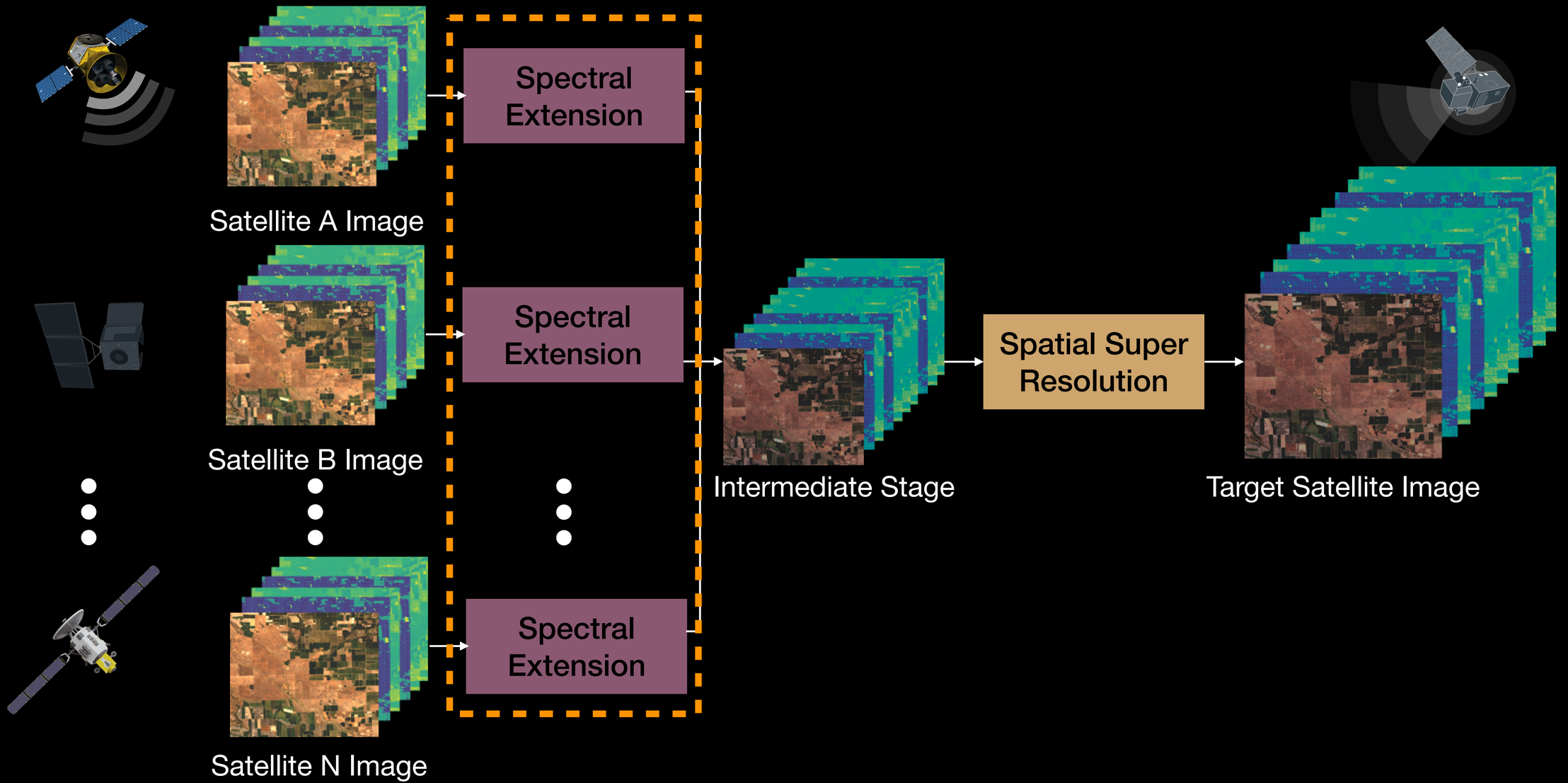
SatExt

Towards Multi-Constellation Unification



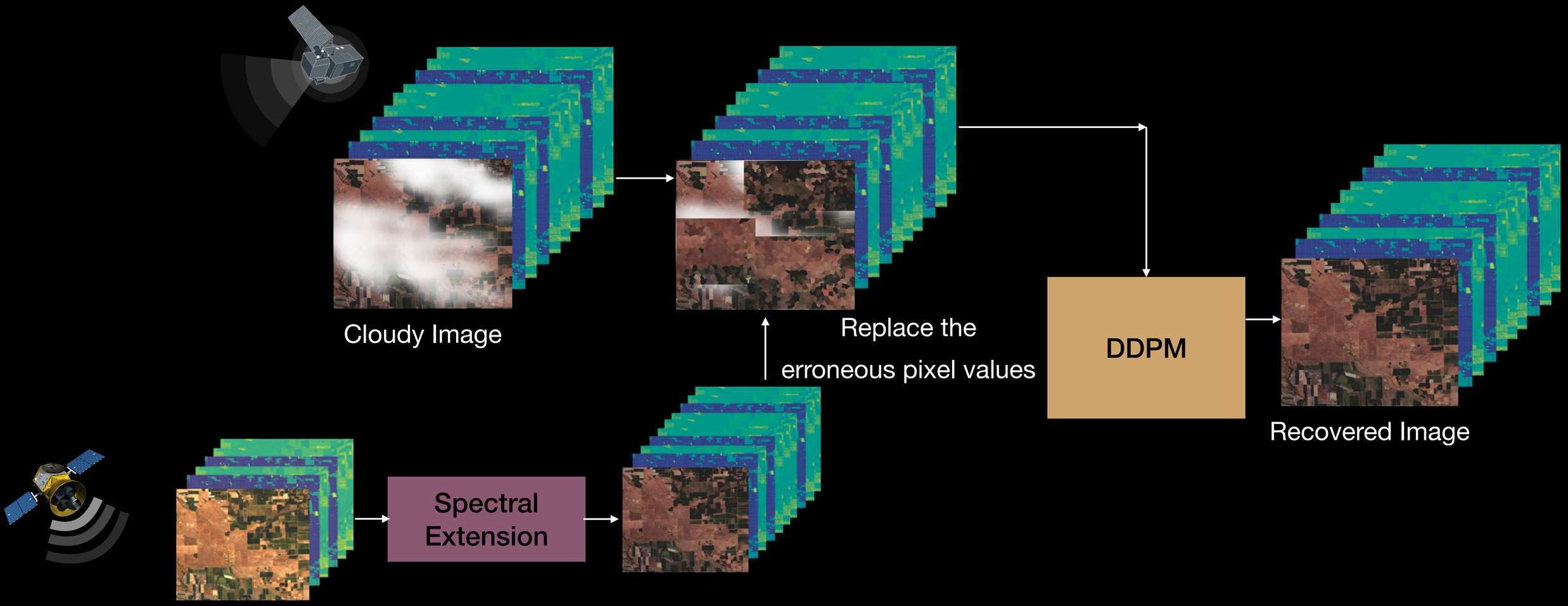
SatExt

Towards Multi-Constellation Unification



SatExt Beyond Unification

Blind Satellite Image Restoration (BSIR)



Conclusion

SatExt: Generative AI framework for Spatio-Spectral Satellite Unification and Beyond

- A GenAI framework that unifies heterogeneous satellites while maintaining high resolution
- Leverages a modular approach to decouple spectral extension and spatial resolution tasks
- Its modular design can go beyond unification to advanced remote sensing tasks such as multi-constellation unification and blind satellite image restoration

