Taming Super-Resolution Models for Cross-Sensor Applications

Christian Mollière, Patricio Massaro, Lukas Kondmann, Julia Gottfriedsen, Martin Langer
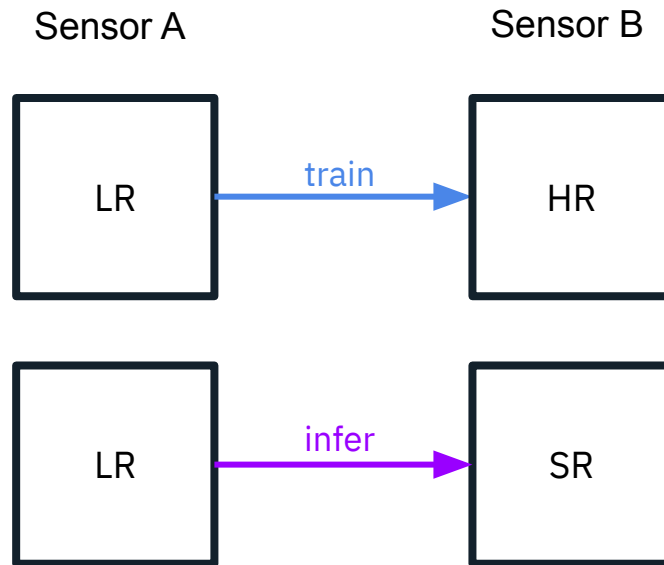
OroraTech GmbH, 2024

SR Methodologies

1. **Supervised**
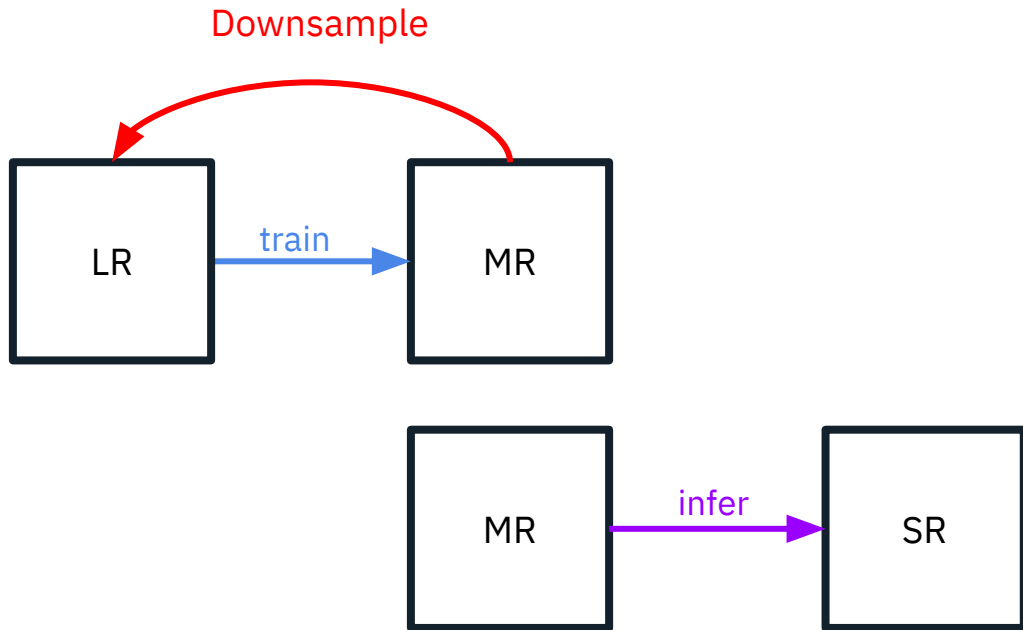   Paired datasets (LR and HR)

Sensor A

Sensor B

LR — train → HR

LR — infer → SR

SR Methodologies

1. **Supervised**
   Paired datasets (LR and HR)

2. **Self-supervised**
   Employ downsampling and scale-invariant inference
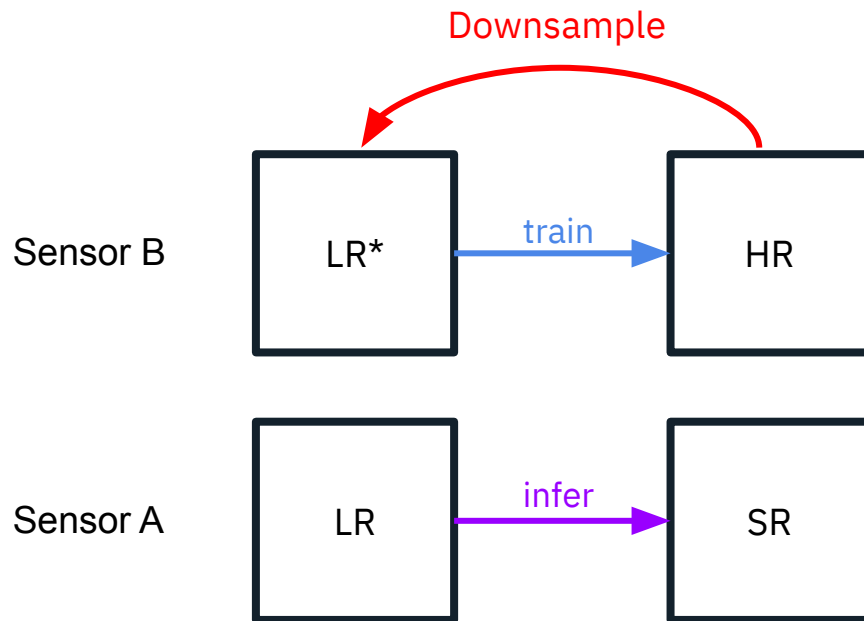
SR Methodologies

1. **Supervised**
   Paired datasets (LR and HR)

2. **Self-supervised**
   Employ downsampling and
   scale-invariant inference

3. **Semi-supervised**
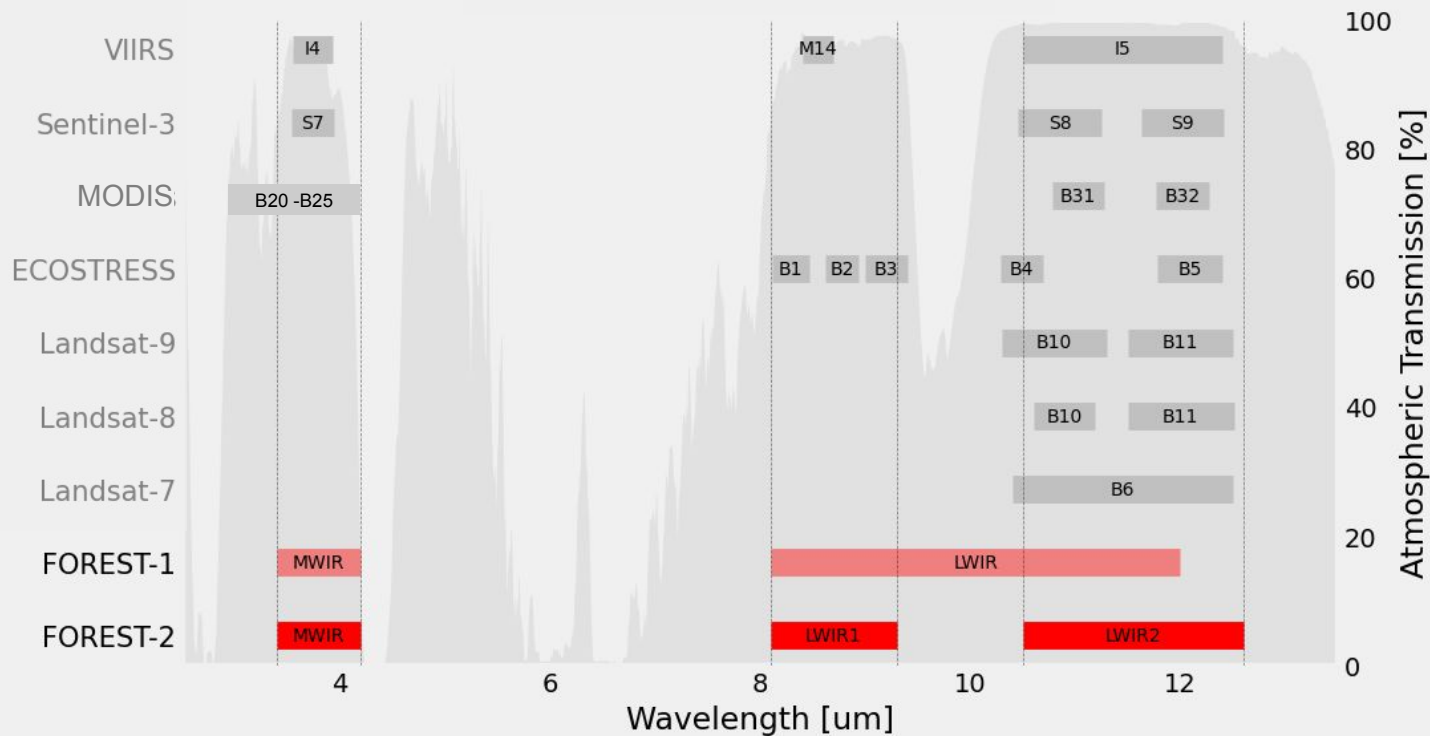   Use domain-adaptation to
   train on unpaired datasets

Finding Paired Data is hard

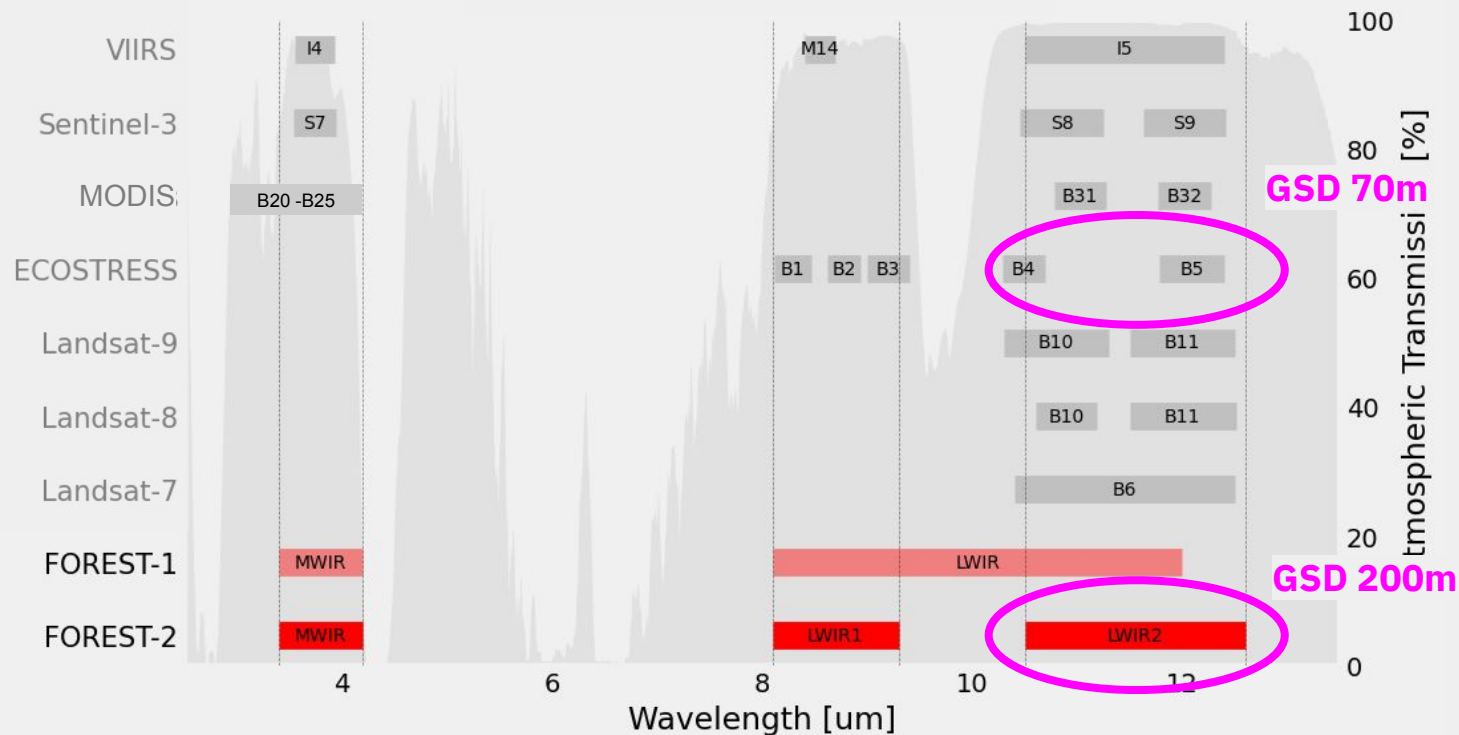| Mission	GSD [m]	Opportunities
FOREST	200	-
ECOSTRESS	70	rare (> weekly)
ASTER	90	very rare
LANDSAT	100	very rare
VIIRS	375	frequent (few days)

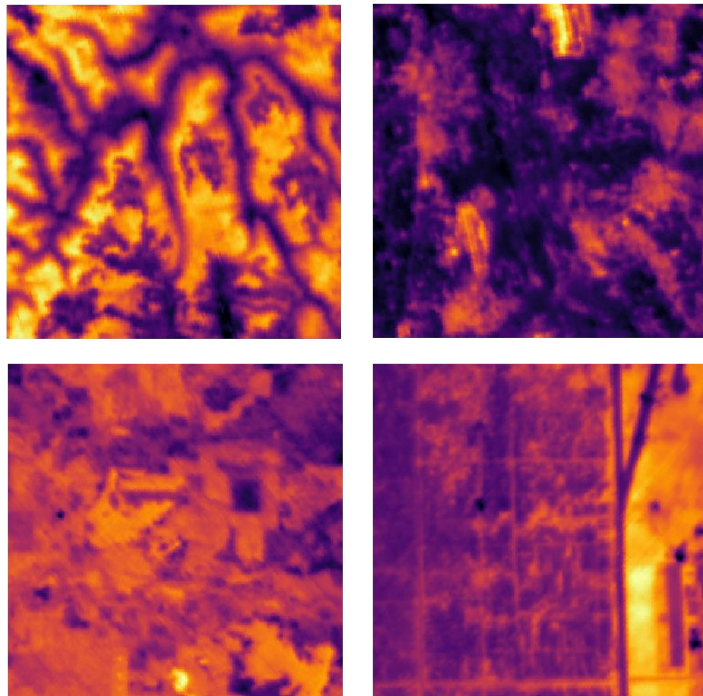# Band Specifications

Band Specifications

Dataset

Selection of scenes in urban areas, agricultural zones, coastlines and forests.

ECOSTRESS
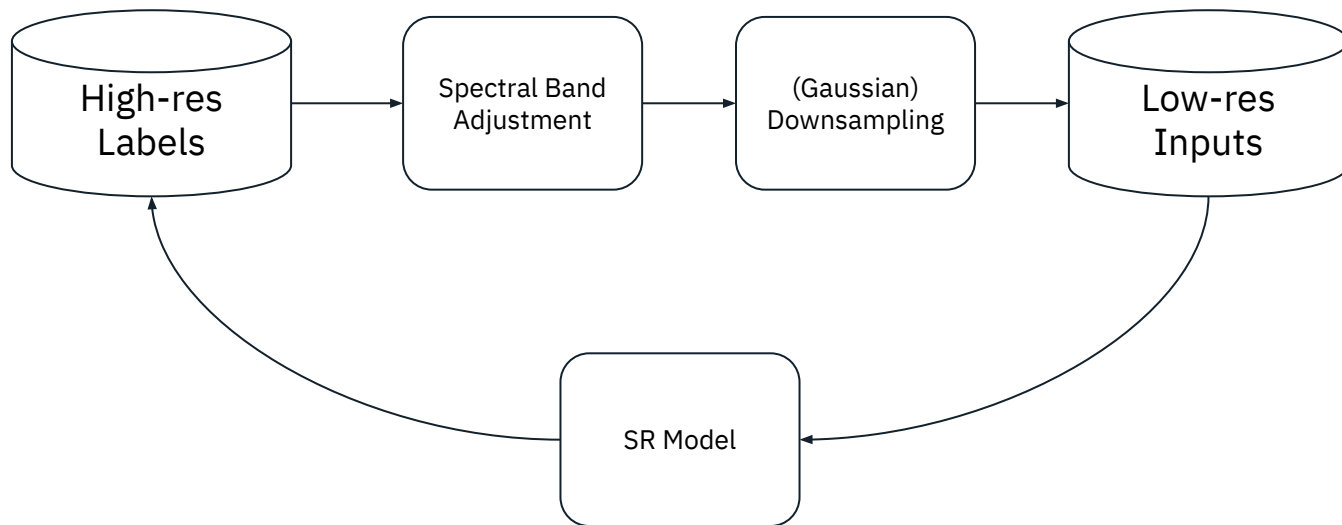- around 15K crops
- 80%/20% validation split
- TIR TOA Radiance

FOREST-2 (Unpaired)
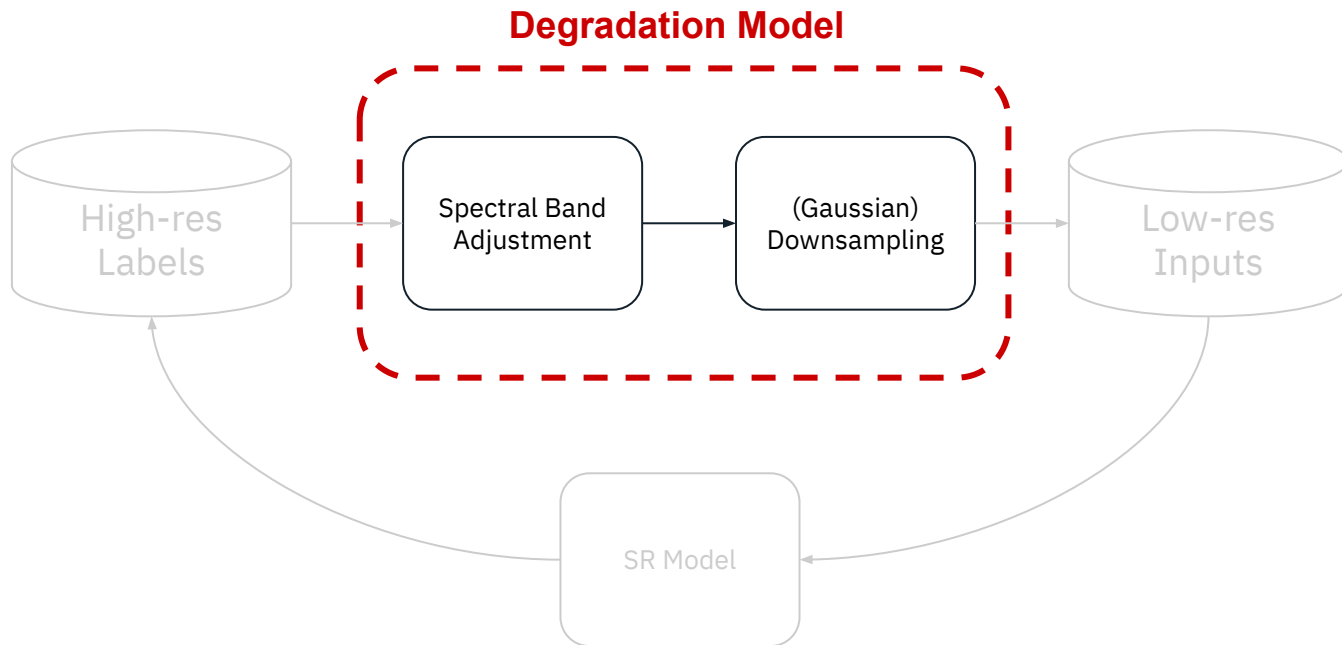- around 1.2K crops
- TIR TOA Radiance

Naive SR Architecture

Naive SR Architecture

Degradation Model

High-res Labels

Spectral Band Adjustment

(Gaussian) Downsampling

Low-res Inputs

SR Model

Naive SR Performance

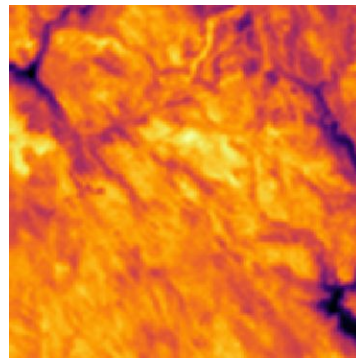| Model	PSNR [dB] ⬆	SSIM ⬆	LPIPS ⬇
Bicubic	18.73	0.89	0.14
Naive SRResNet	**23.36**	**0.94**	**0.12**

trained and validated on ECOSTRESS, 3x SISR task

Naive SR Performance

Model	PSNR [dB] ⬆️	SSIM ⬆️	LPIPS ⬇️
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trained and validated on ECOSTRESS, 3x SISR task

Input   Bicubic   **Naive SR**   Label
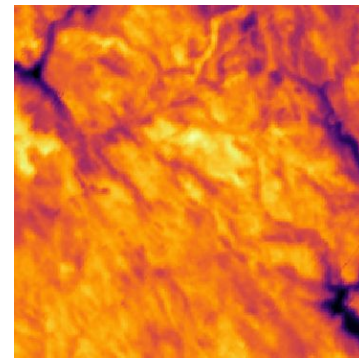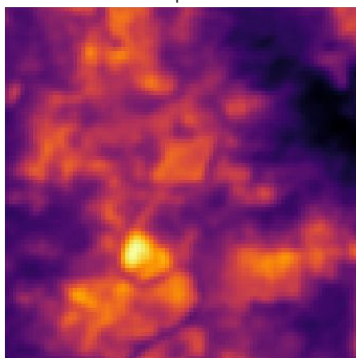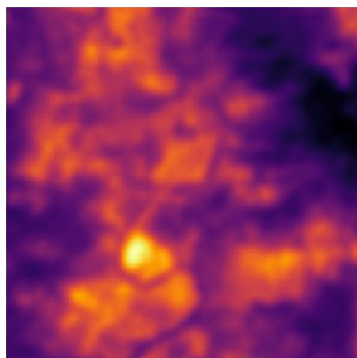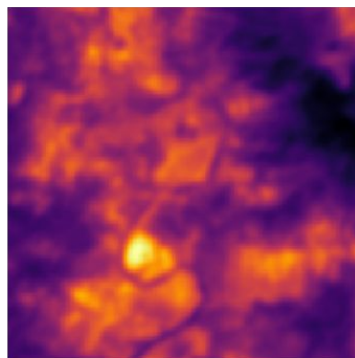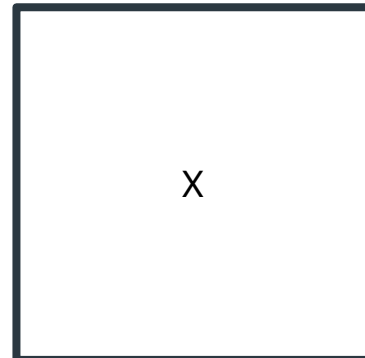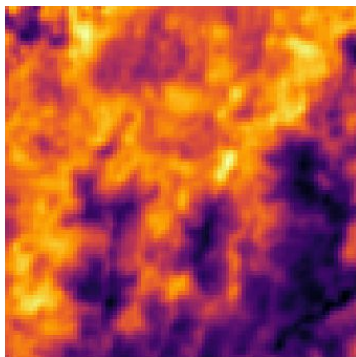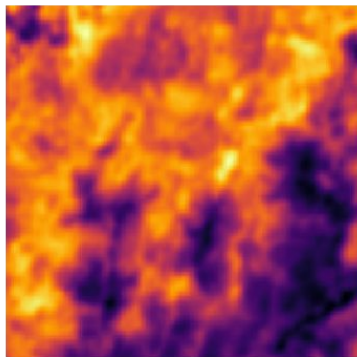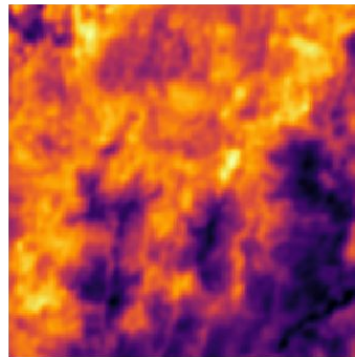
Naive SR on FOREST

Input   Bicubic   **Naive SR**   Label
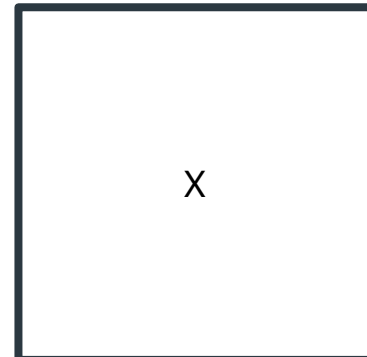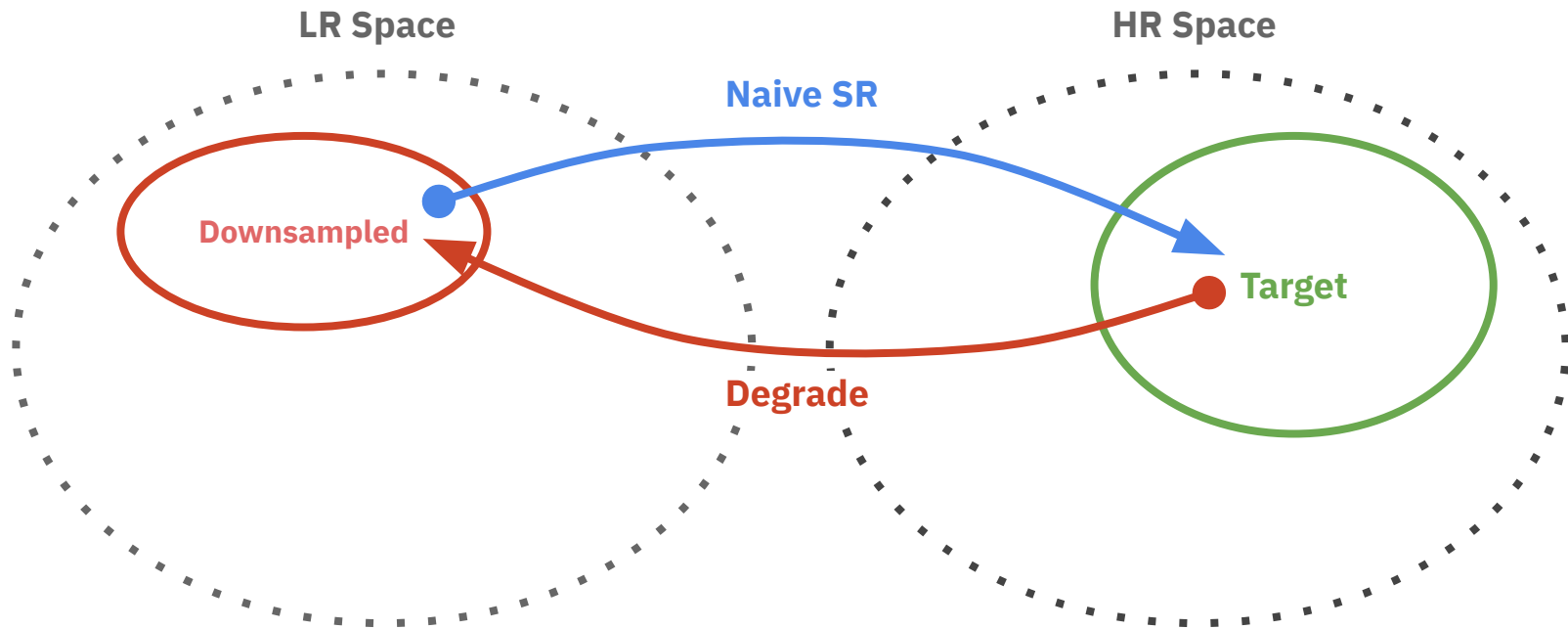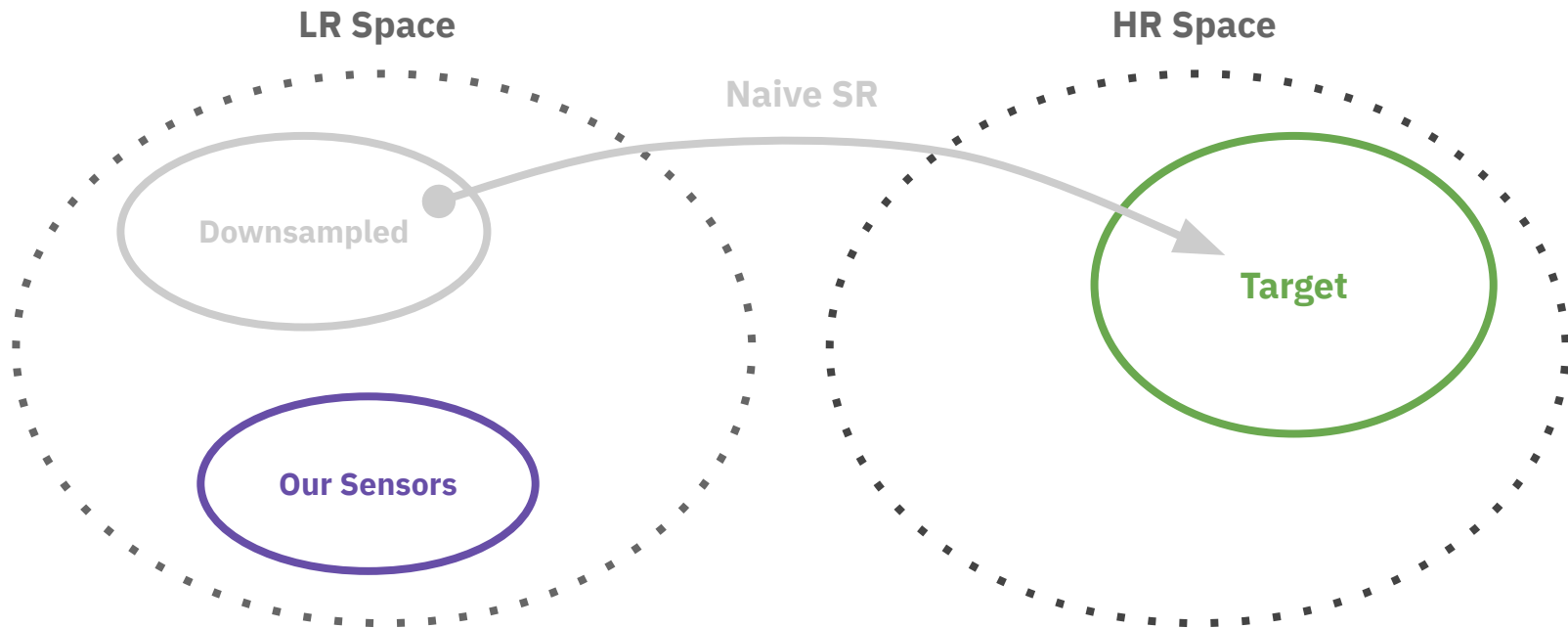
Naive SR on FOREST
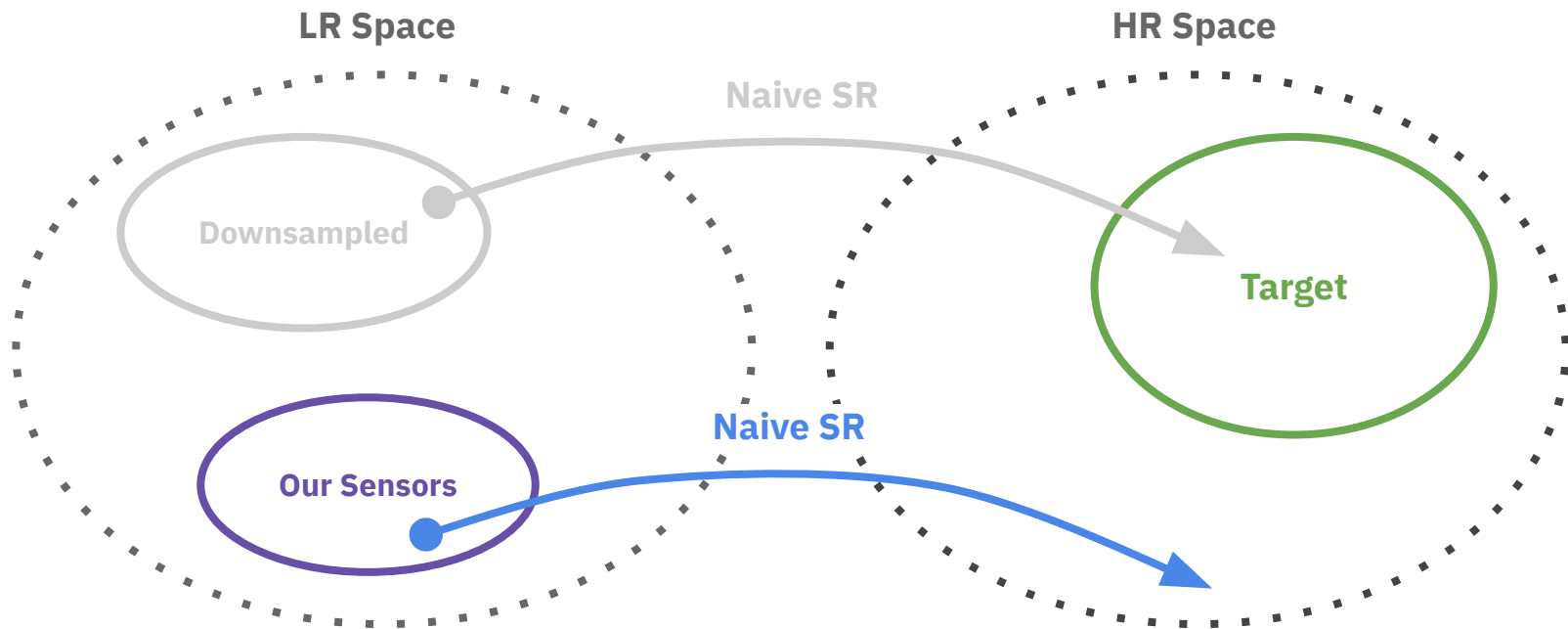

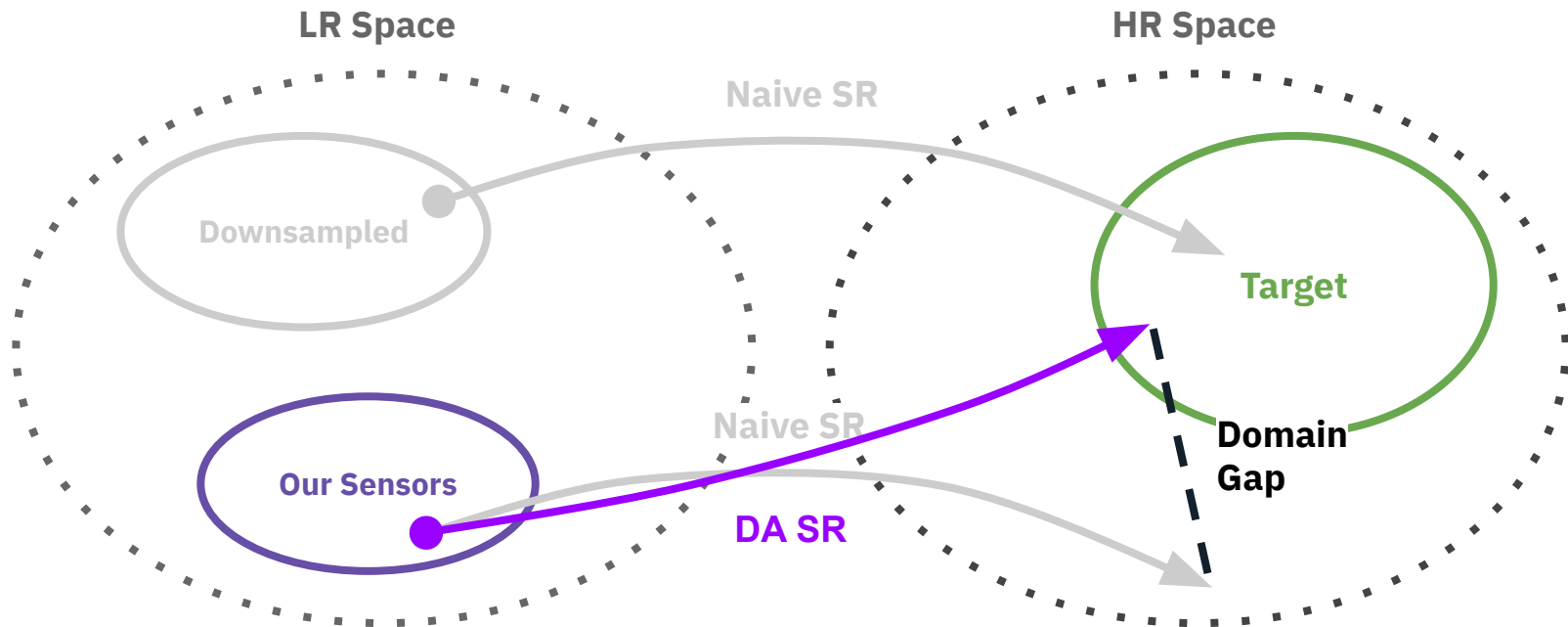Input   Bicubic   **Naive SR**   Label

The Domain Gap

The Domain Gap

LR Space

HR Space

Naive SR

Downsampled

Target

Our Sensors

Liu et al. (2021). Blind Image Super-Resolution: A Survey and Beyond. *CoRR, abs/2107.03055.*

The Domain Gap

LR Space

HR Space

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The Domain Gap

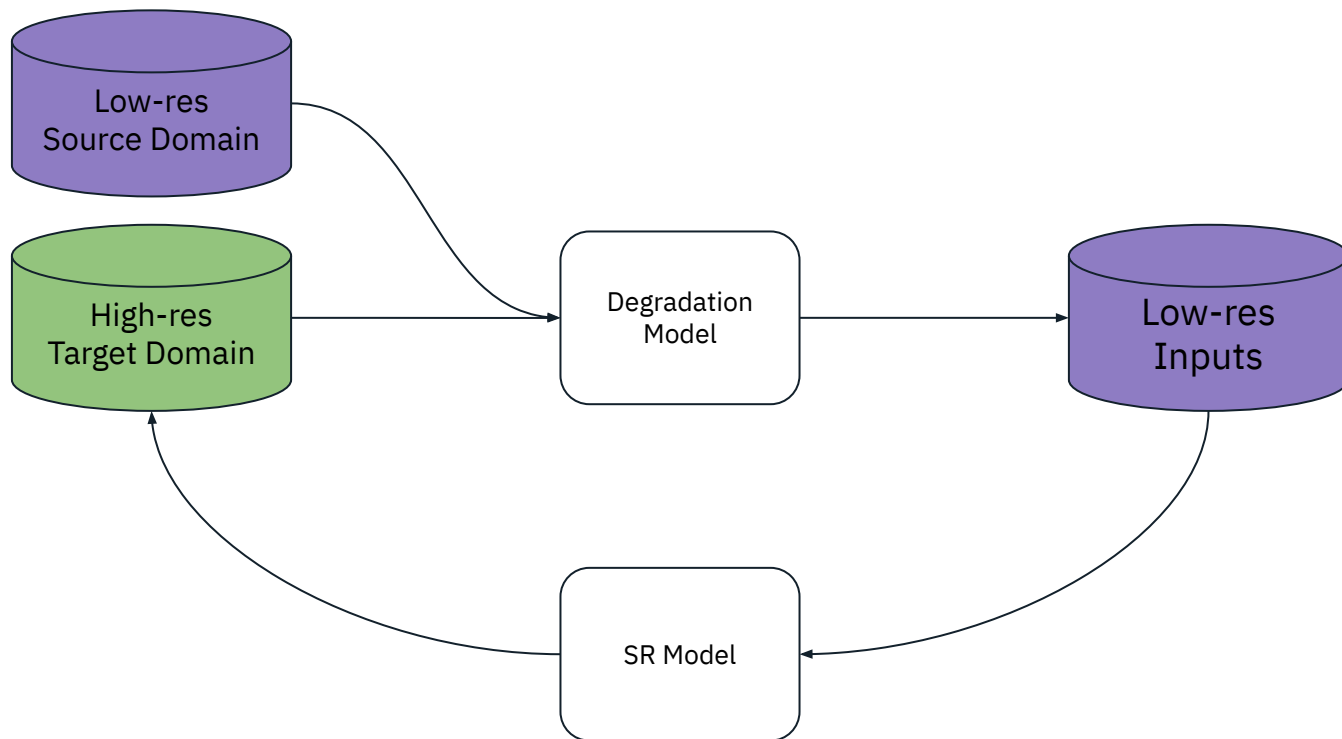Liu et al. (2021). Blind Image Super-Resolution: A Survey and Beyond. *CoRR, abs/2107.03055.*

The Domain Gap

- Ground Sampling Distance

- Spectral Response Function

- Modulation Transfer Function
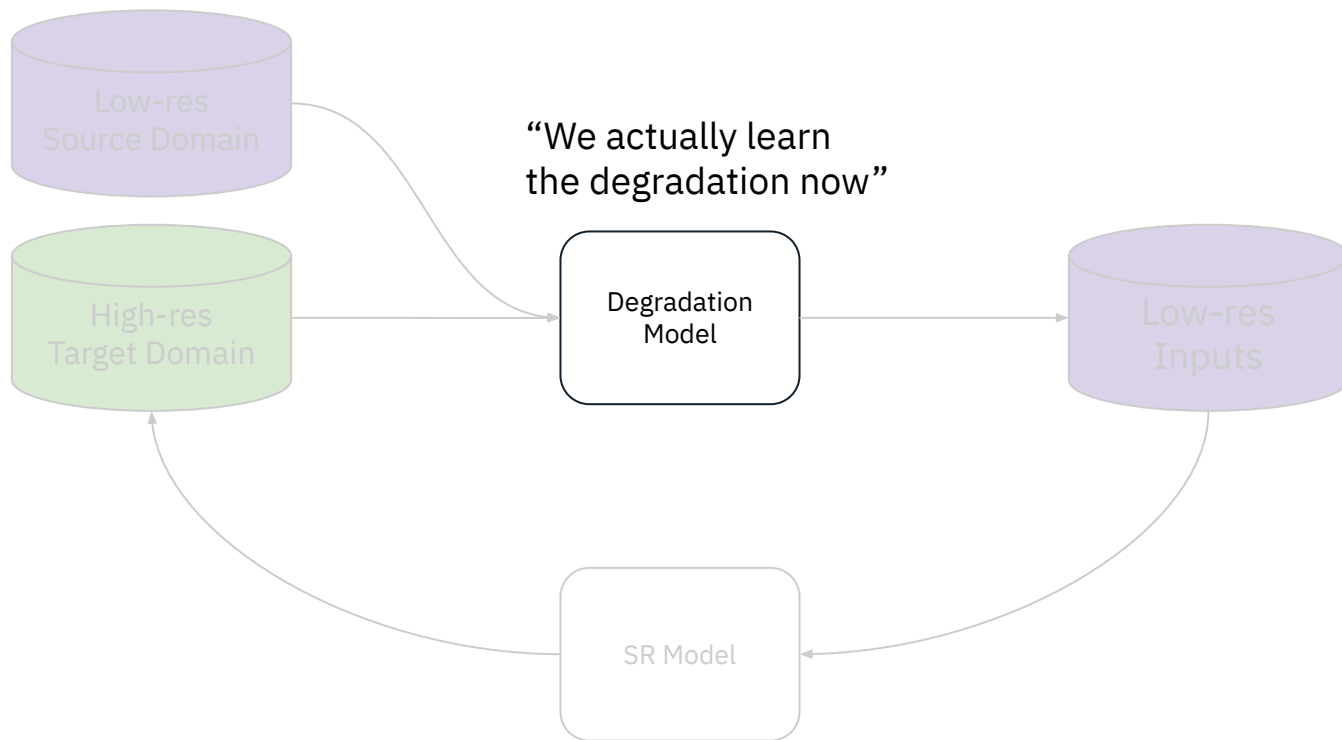
- Point Spread Function

- Noise

- Viewing Geometry (Zenith Angle)
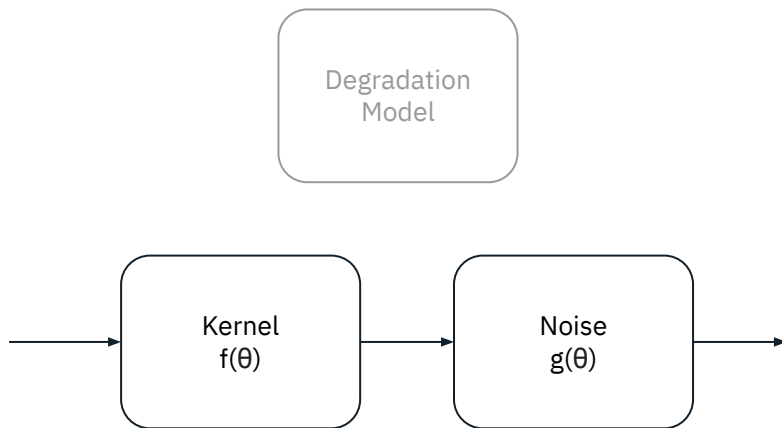
- Processing

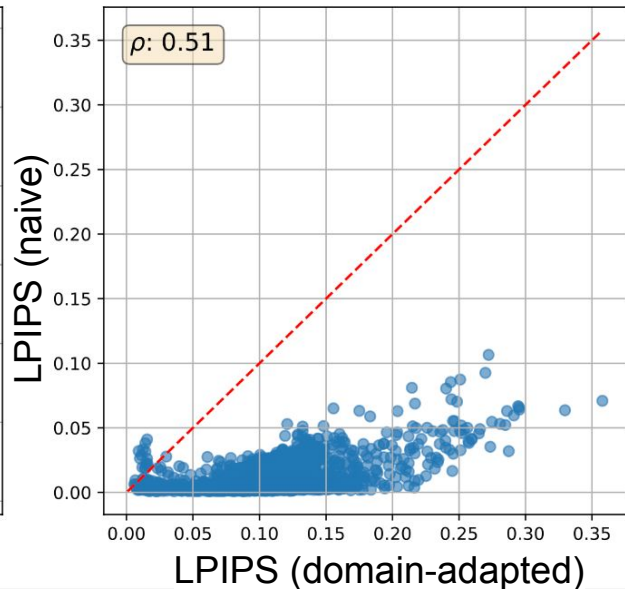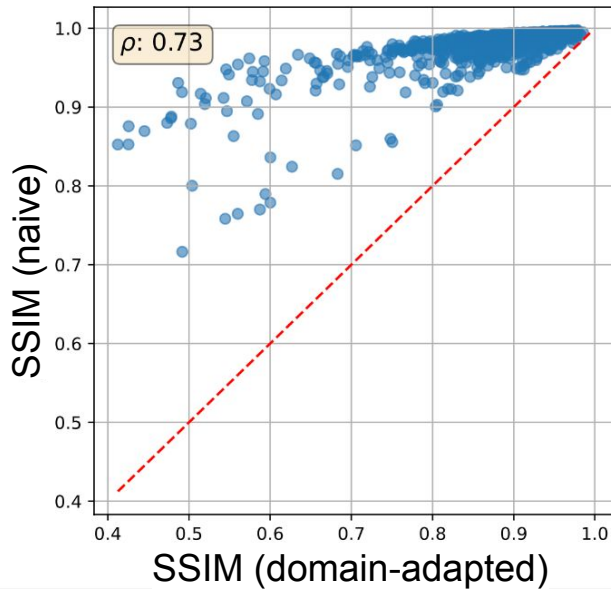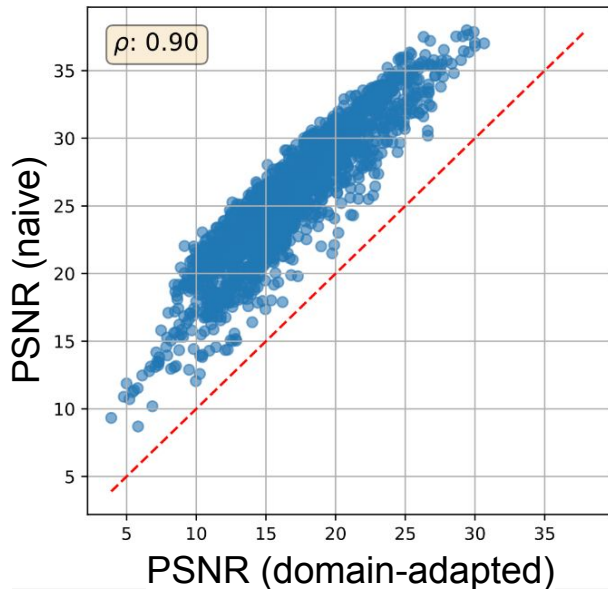# Domain-adapted SR

Domain-adapted SR

Low-res
Source Domain

High-res
Target Domain

"We actually learn
the degradation now"

Degradation
Model

Low-res
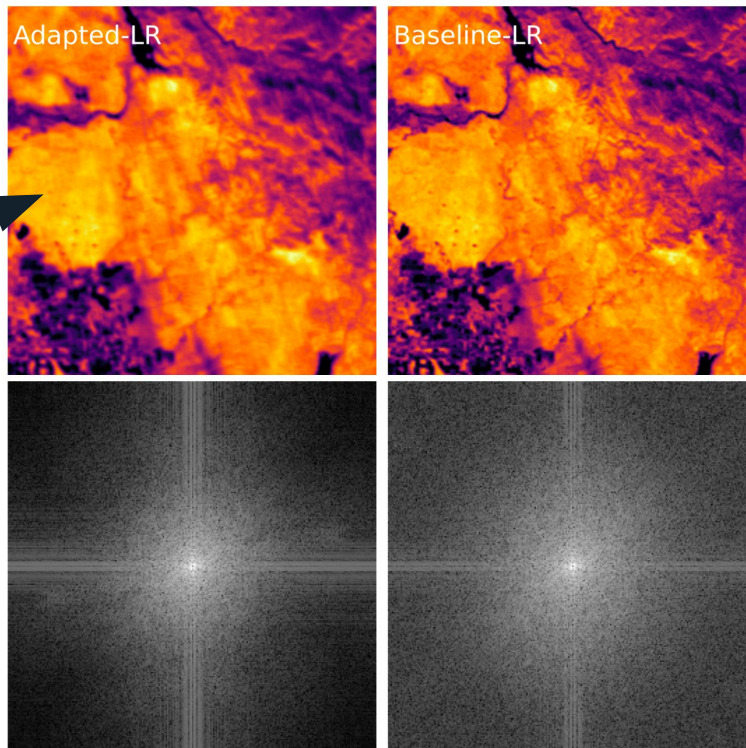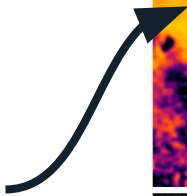Inputs

SR Model

Domain-adapted SR

"We actually learn
the degradation now"

Degradation
Model

Kernel
f(θ)

Noise
g(θ)

Differences in Degradation

HR → Degrade → Bicubic → SR   Metric(SR,HR)
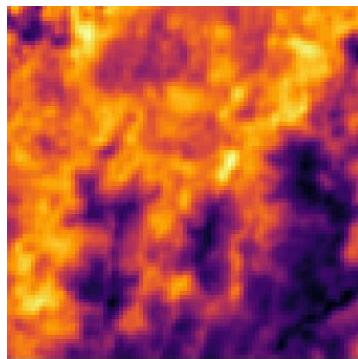
Differences in Degradation

Learned degradation

Domain-Adapted SR Performance

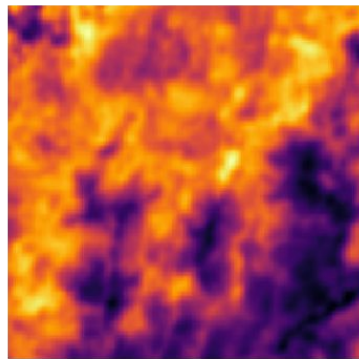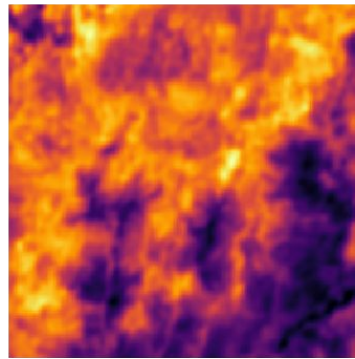| Model	PSNR [dB] ⬆️	SSIM ⬆️	LPIPS ⬇️
Bicubic	18.73	0.89	0.14
Naive SRResNet	**23.36**	0.94	**0.12**
DA-SRResNet	23.09	**0.95**	0.13

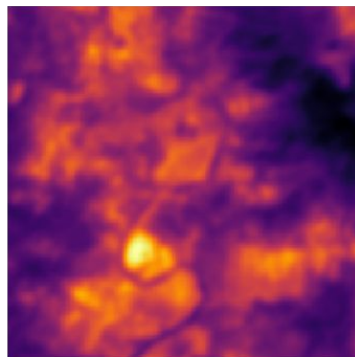trained on unpaired FOREST-2 & ECOSTRESS, validated on ECOSTRESS, 3x SISR task
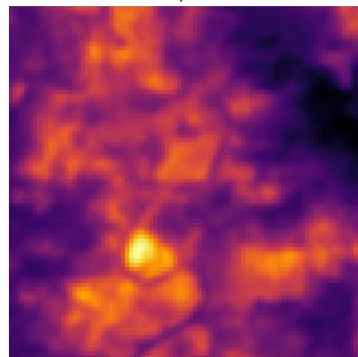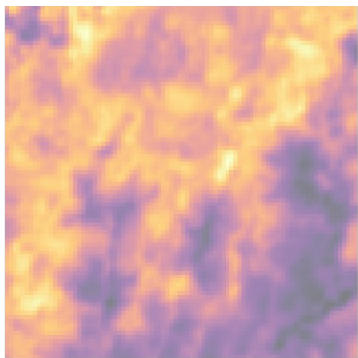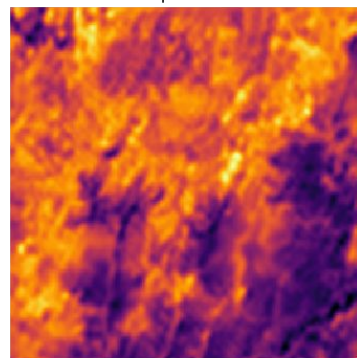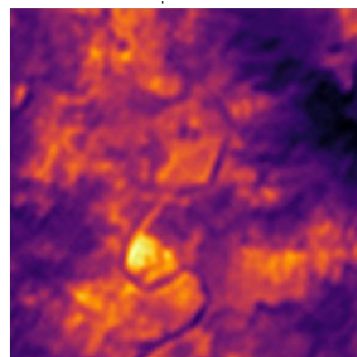
DA-SR on FOREST

Input
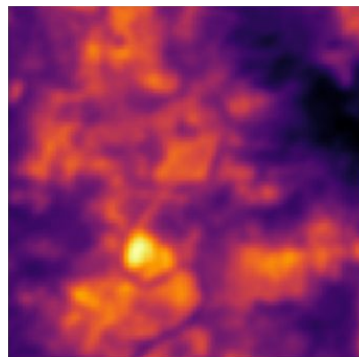
Bicubic

Naive SR

DA-SR on FOREST

Input
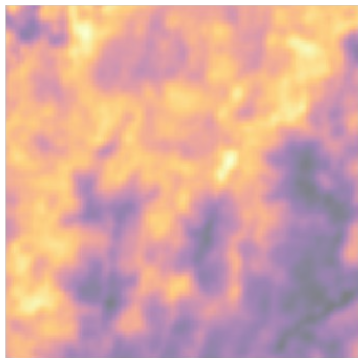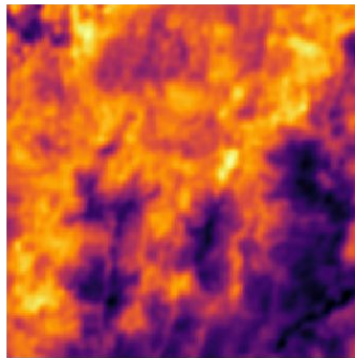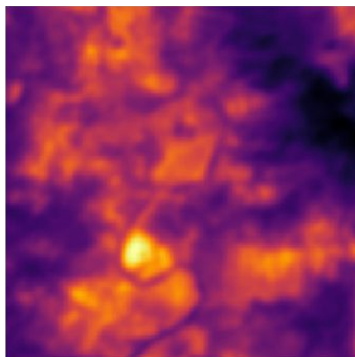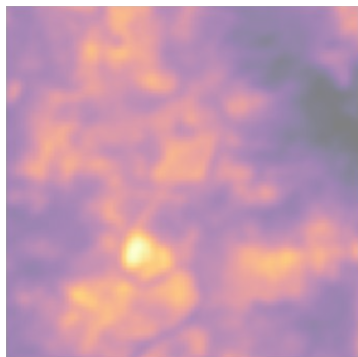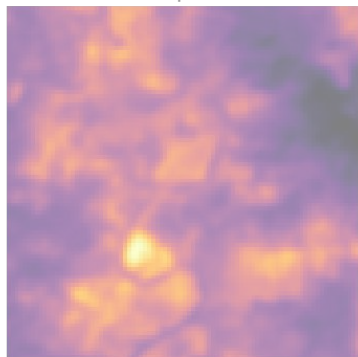
Bicubic

Naive SR

DA-SR
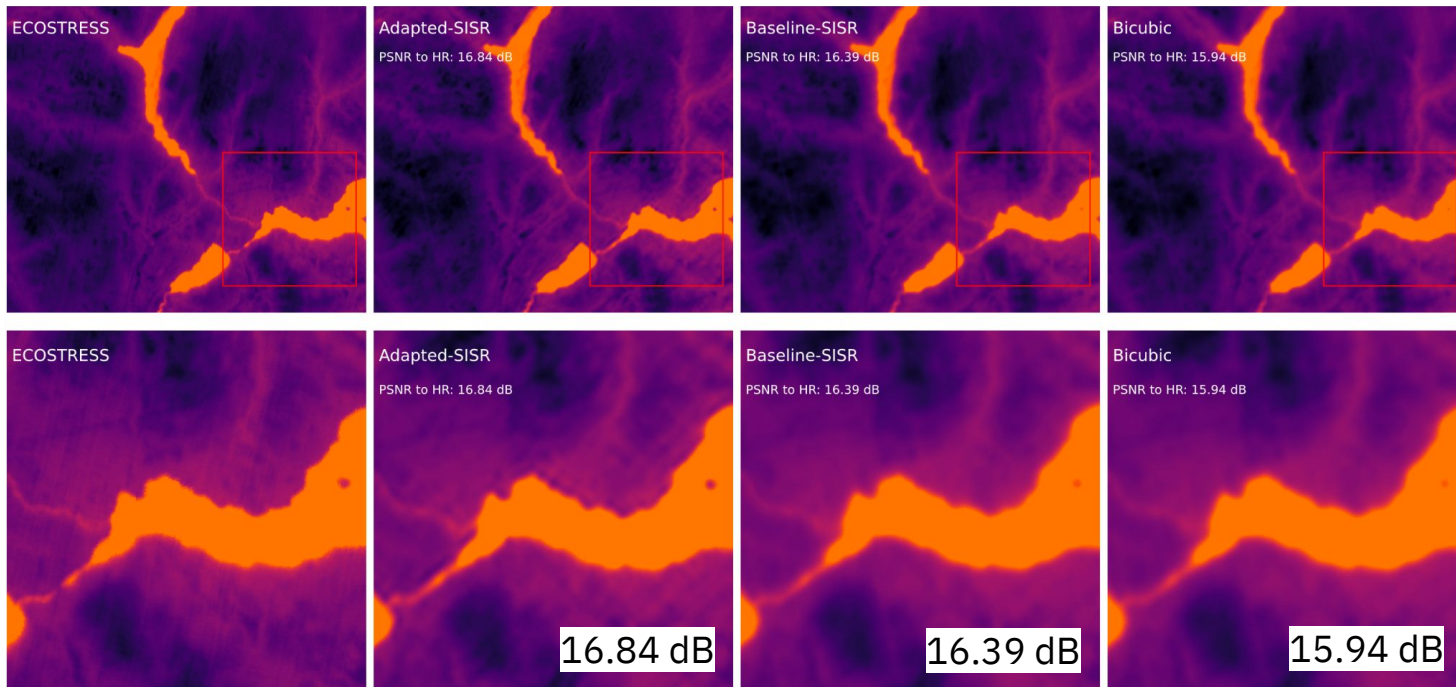
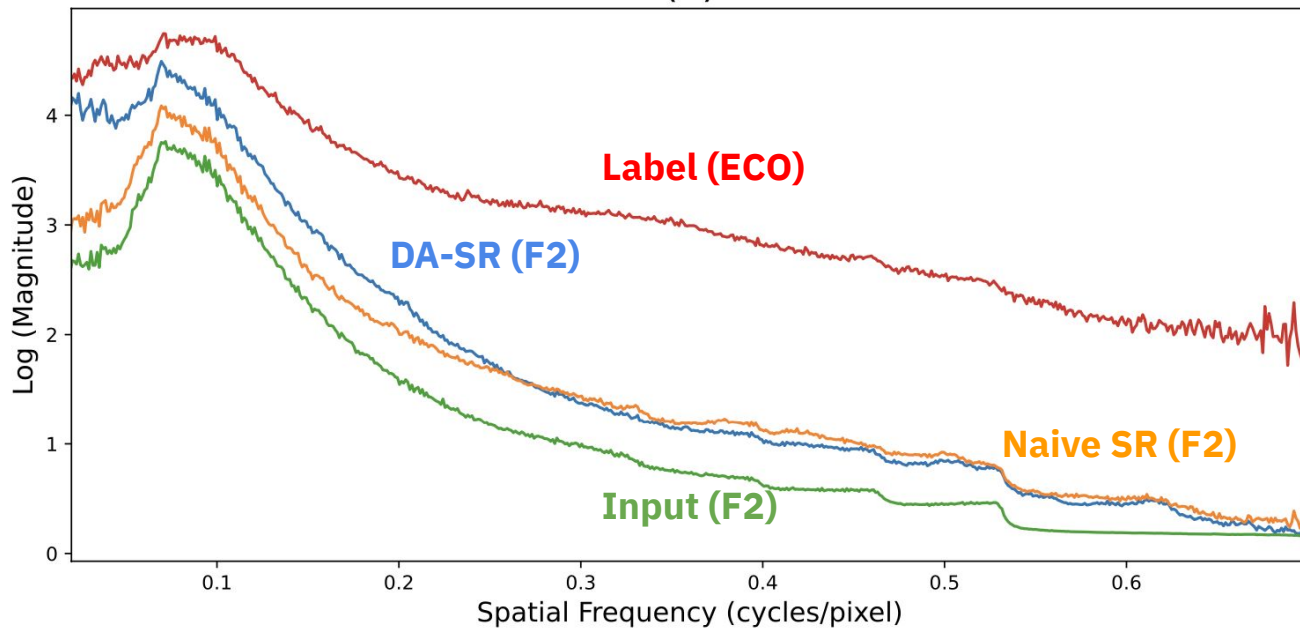# Paired Datasets
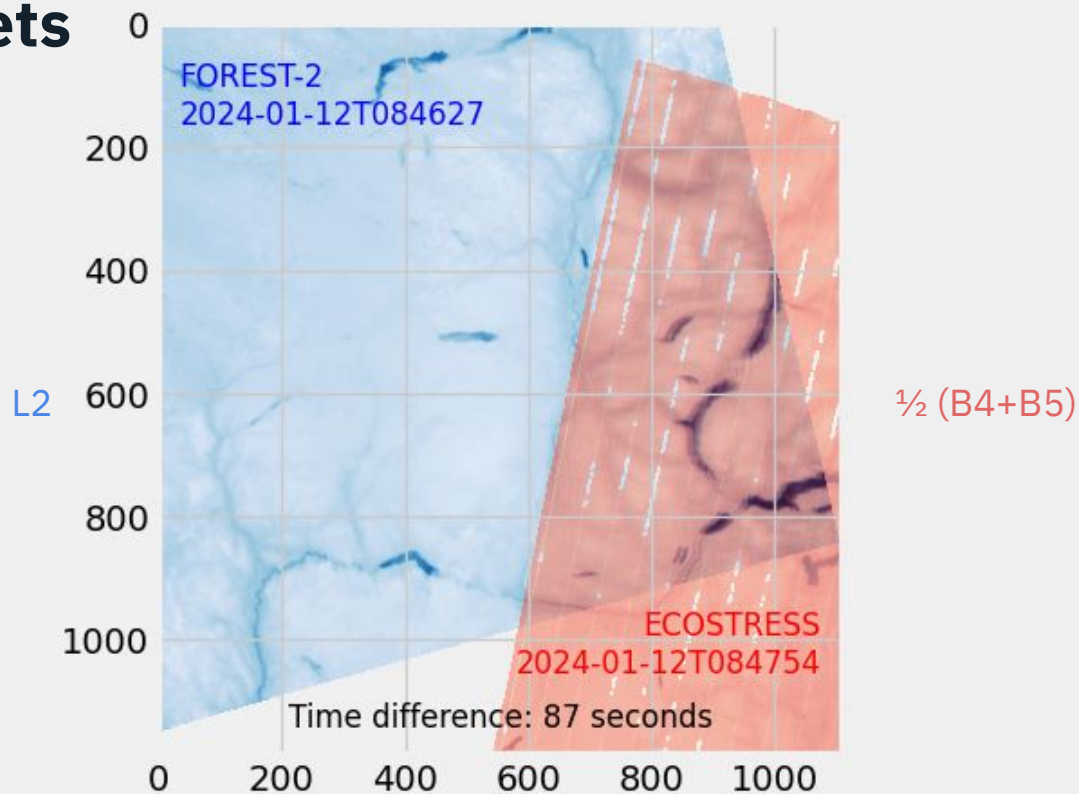
Early Results

| Label (ECO) | **DA-SR (F2)** | Naive SR (F2) | Bicubic (F2) |

Frequency Analysis

Conclusion

- Domain Adaptation is a great tool to leverage high-resolution datasets of other sensors.

- Potential to enable SR models across different sensor iterations and degradations.

- We need to collect more ECOSTRESS cross-overpasses to confirm our early results.

Greater Los Angeles Area
9th May 2024
FOREST-2

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