

ESA OpenSR Project

Robust, accountable super-resolution for Sentinel-2 and beyond



Super-Resolution of Multispectral Sentinel-2 Imagery with Latent Diffusion Models

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Cesar Aybar (UV)

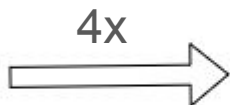
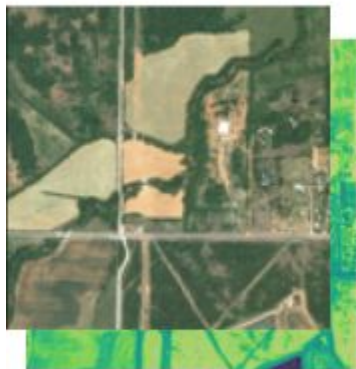
Luis Gómez-Chova (UV)

Freddie Kalaitzis (UOX)



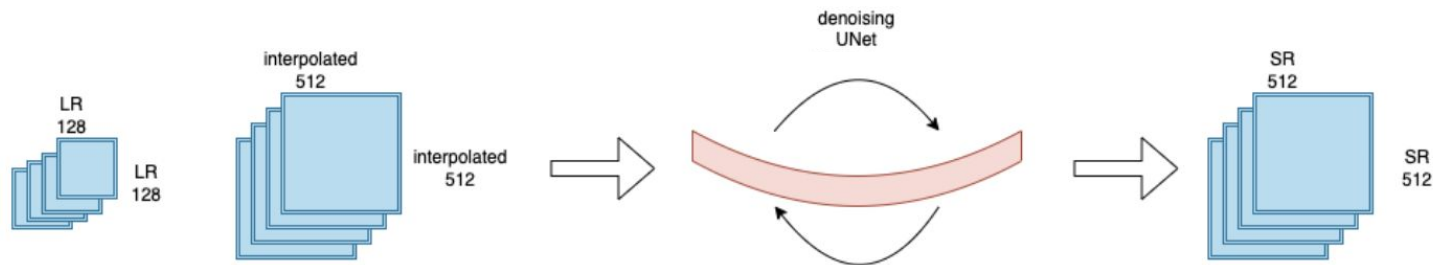
Problem Description

S2 RGB-NIR

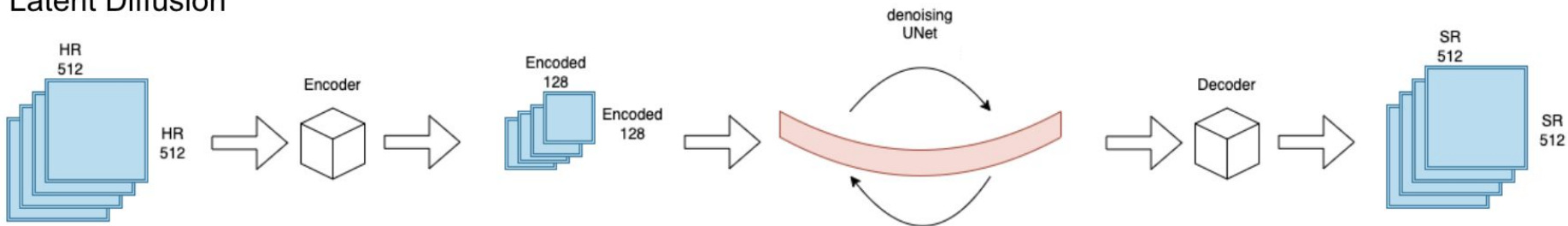


Latent Diffusion Models for SR

Pixel-Space Diffusion



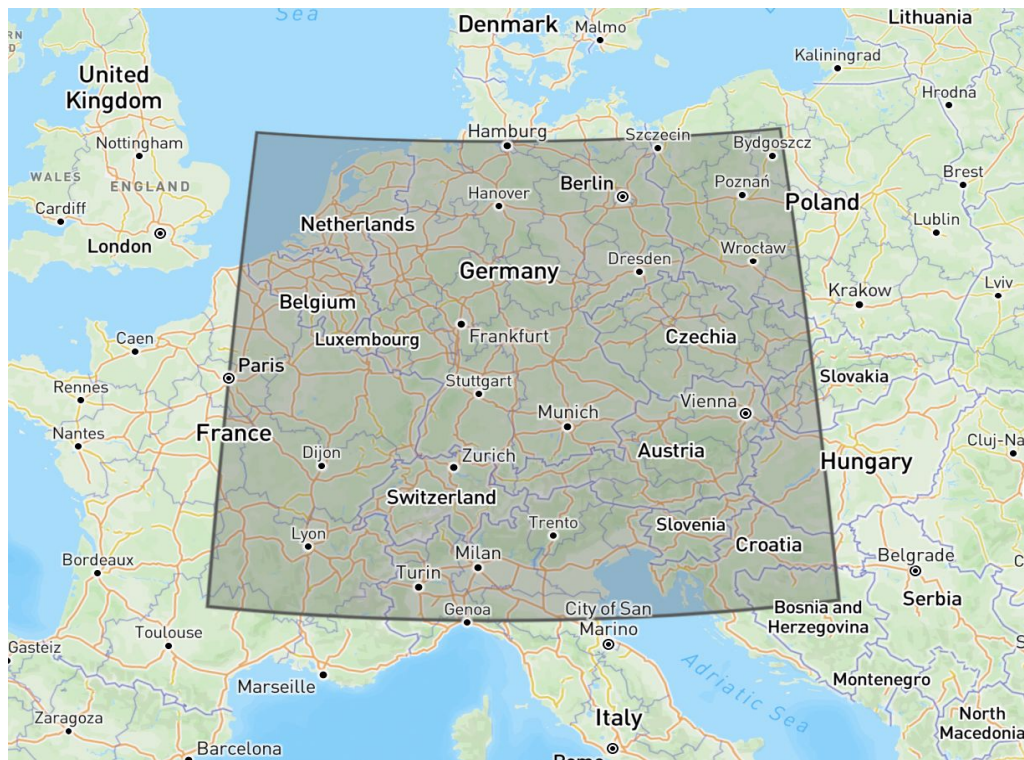
Latent Diffusion



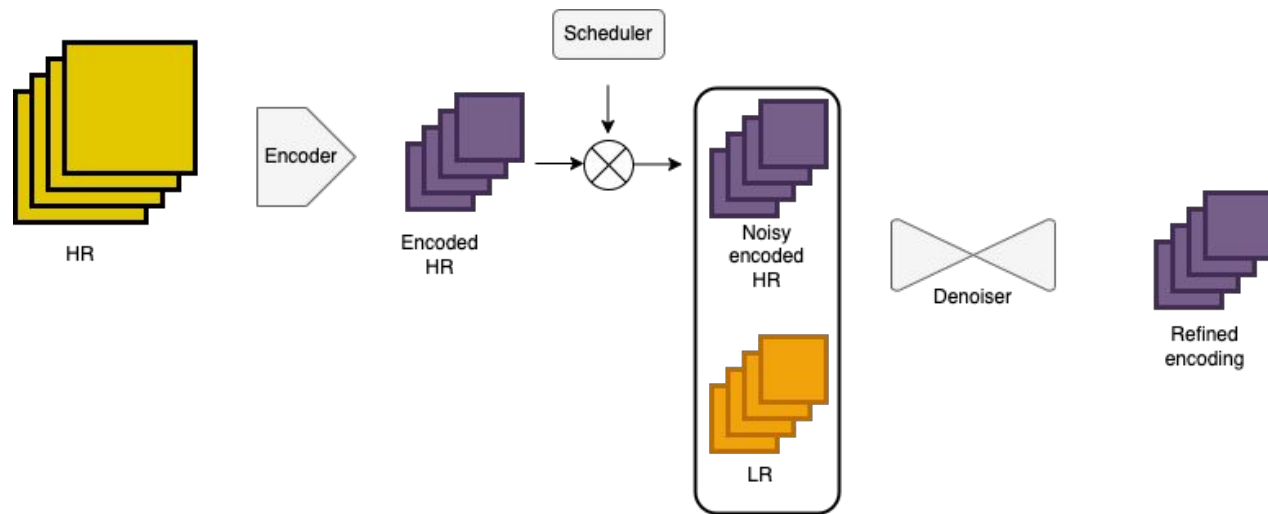
Why LDM?

Inference Speed for 1M sqkm

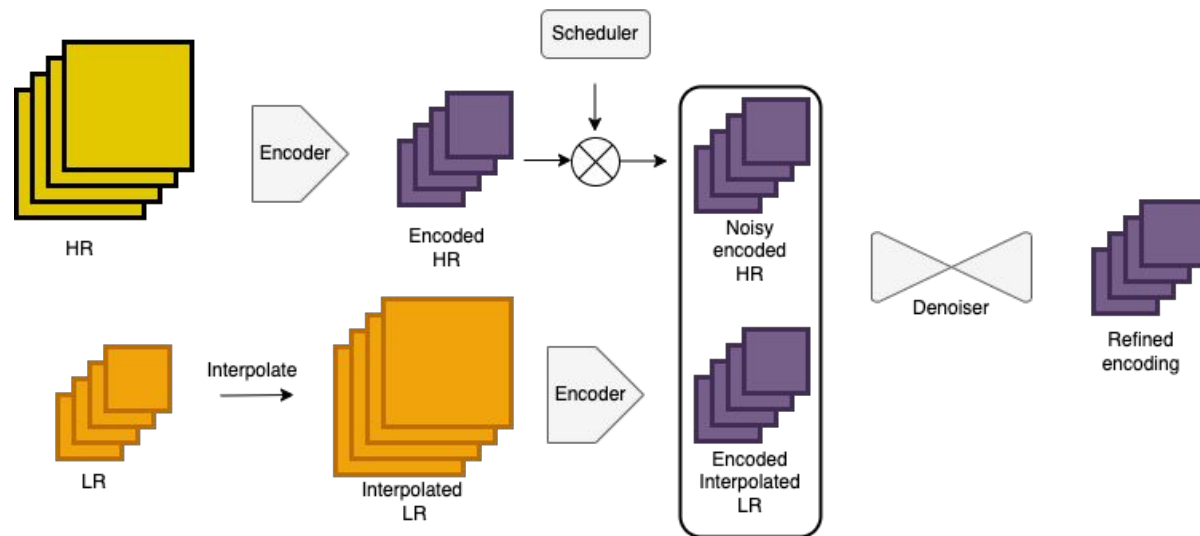
Latent-Space Diffusion	Pixel-Space Diffusion
≈ 16 hrs	≈ 11 weeks



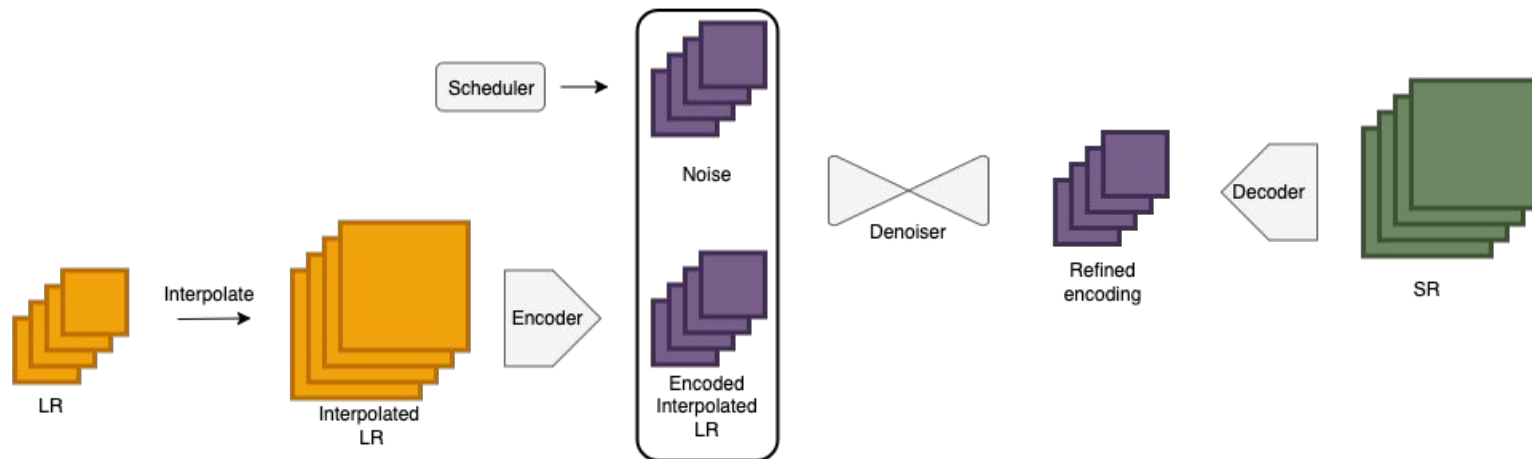
LDM -Training Step



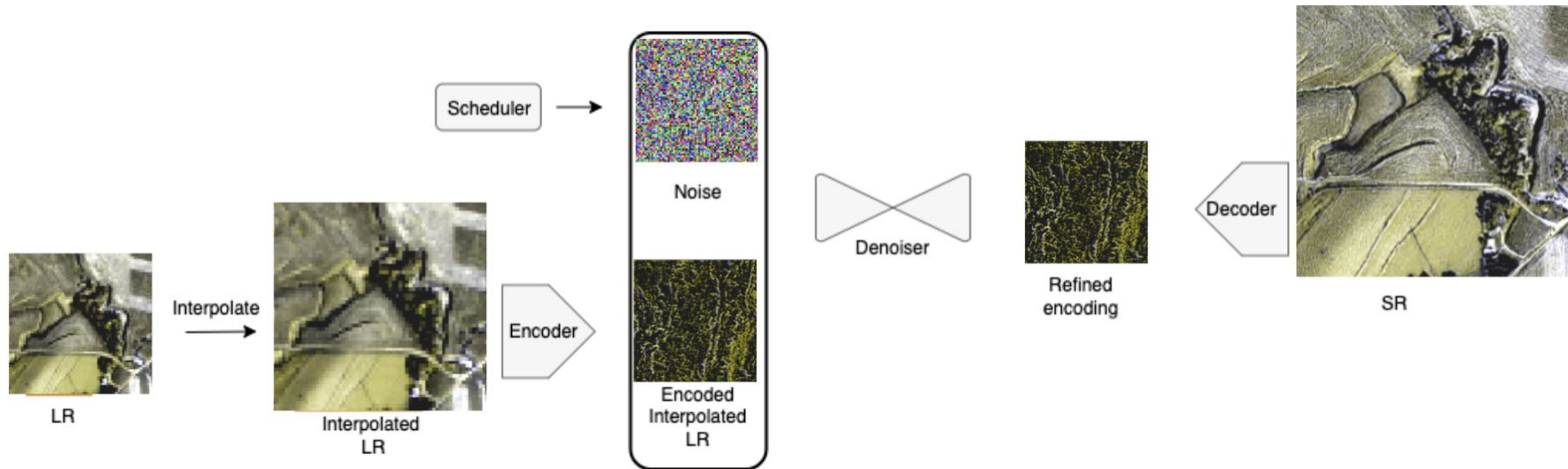
LDM - Adapted Training Step



LDM - Inference Step

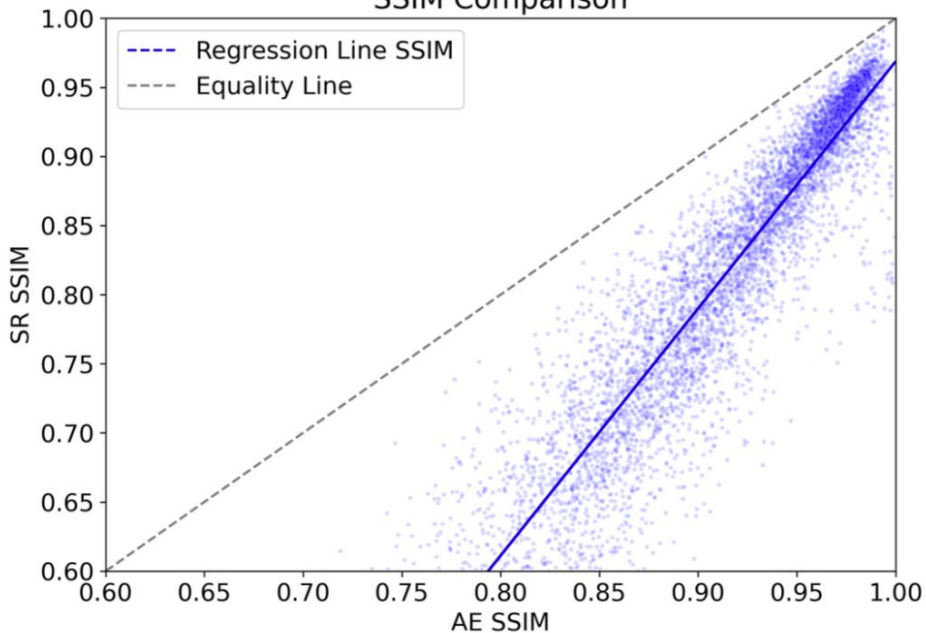


LDM - Inference Step

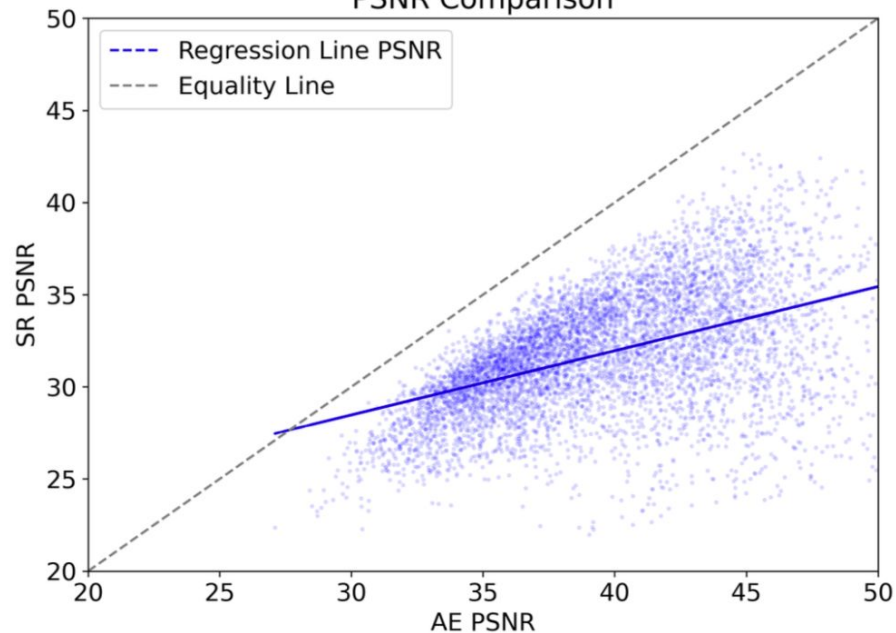


LDM - Autoencoder

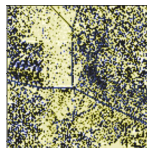
SSIM Comparison



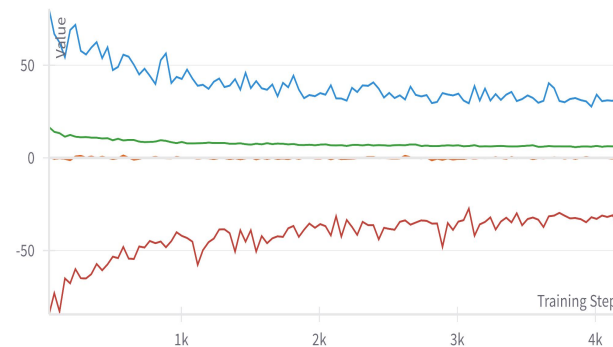
PSNR Comparison



LDM - Autoencoder



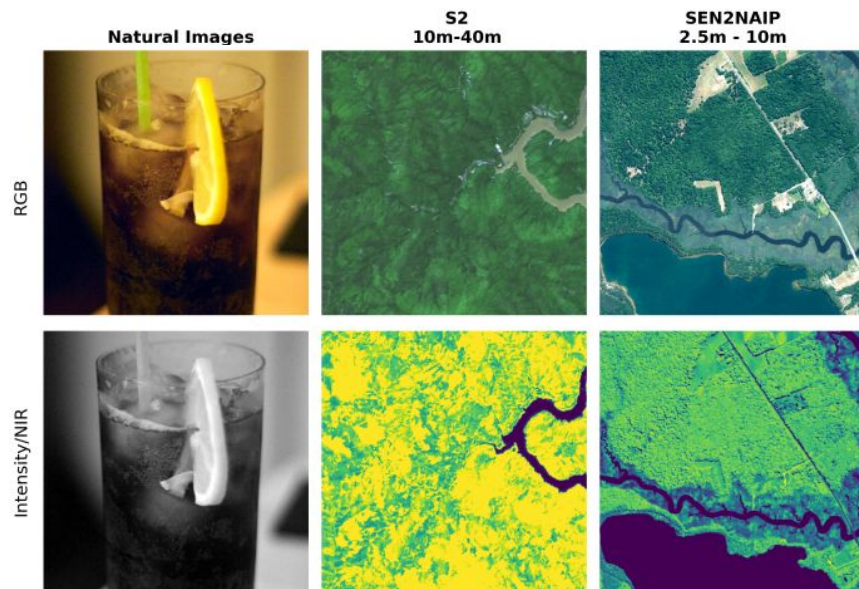
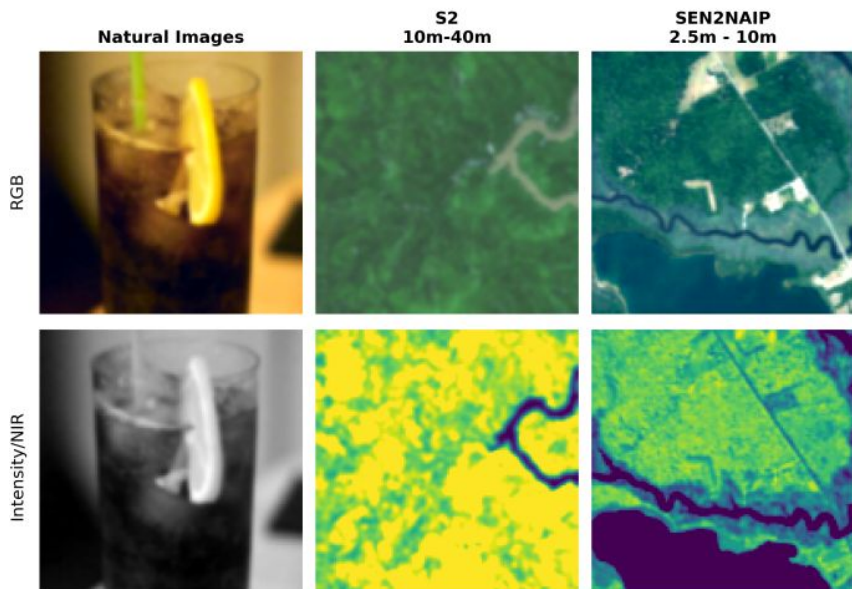
- L1 Reconstruction Loss
- GAN loss
- Perceptual Loss (LPIPS)
- Histogram Divergence Loss



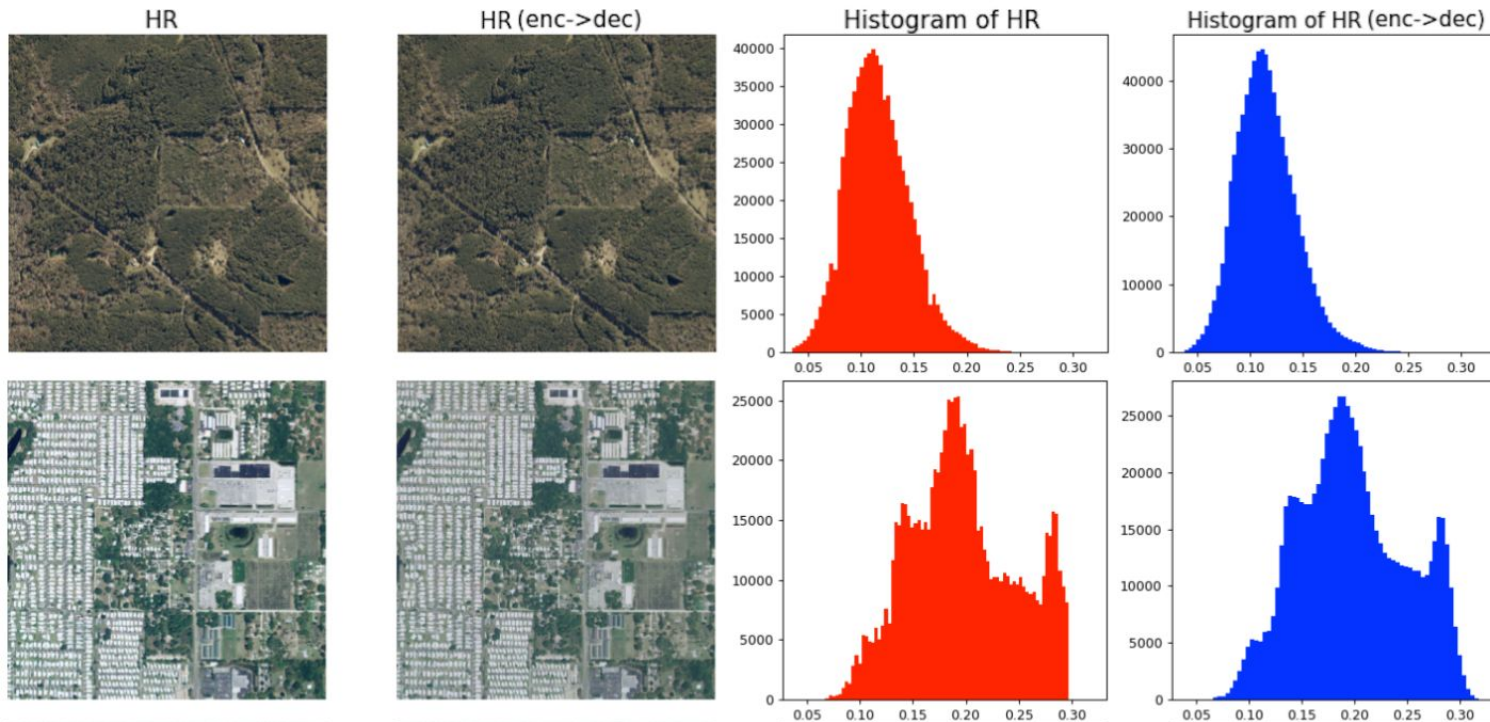
Training Data

LR

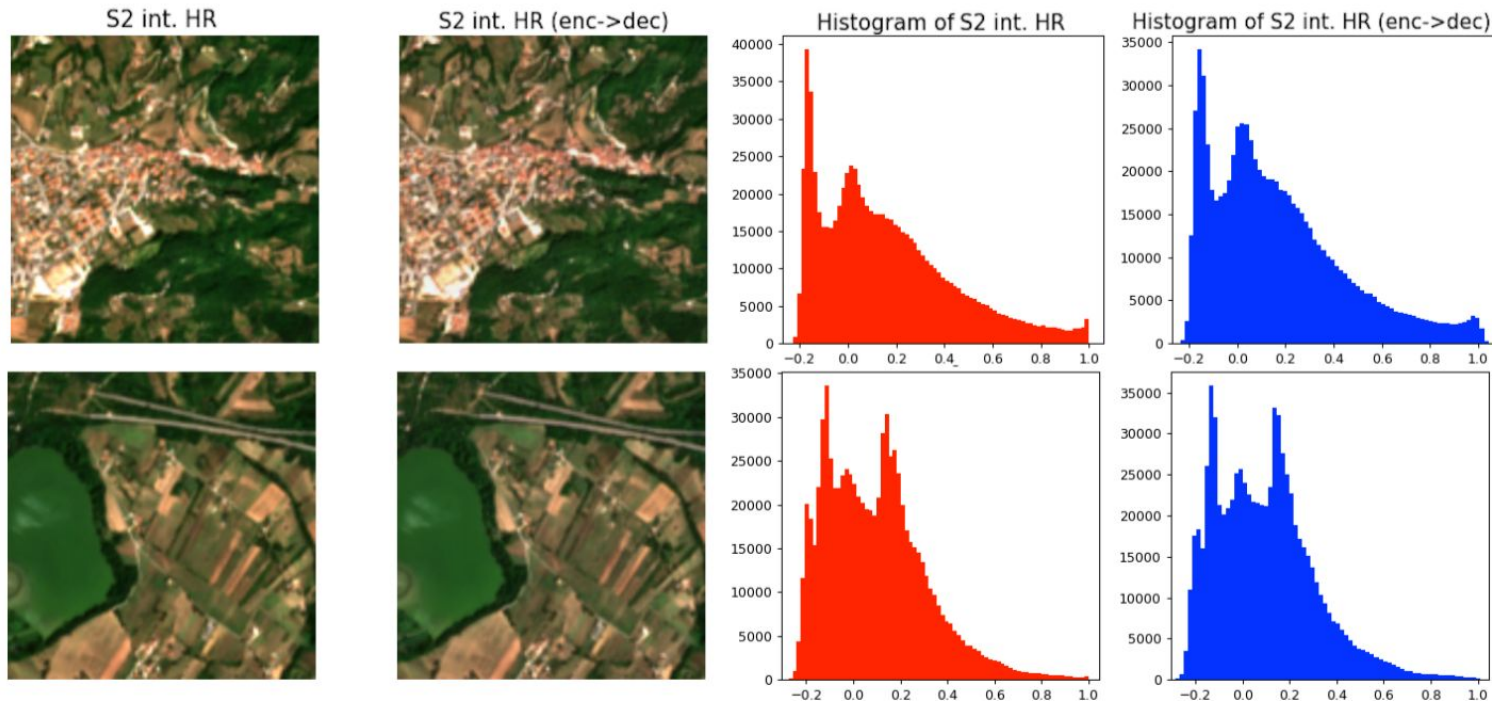
HR



Results - AE - Synthetic Data



Results - AE - S2 Data



Results - SR - *Synthetic Data*

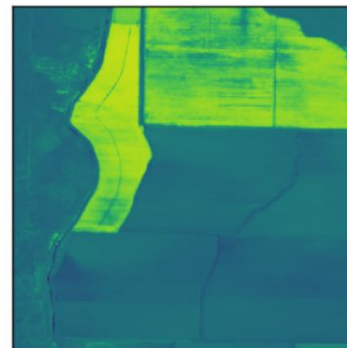
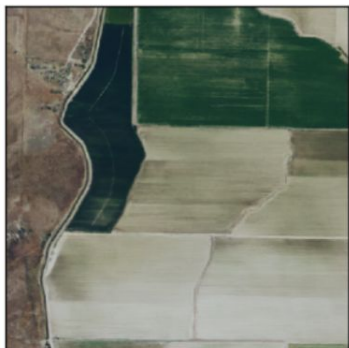
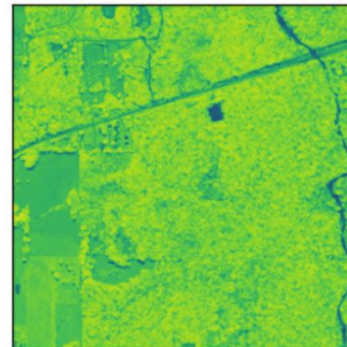
HR (RGB)

SR - RGB

SR - F. CI.

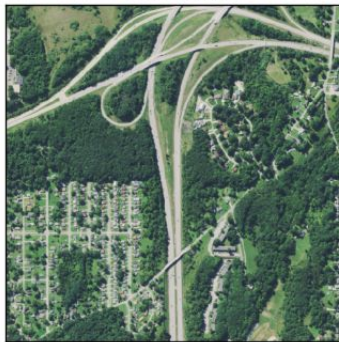
NDVI

LR (RGB)

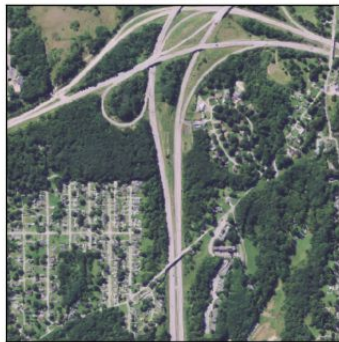


Results - SR - *Synthetic Data*

HR (RGB)



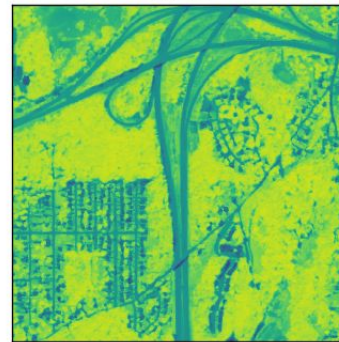
SR - RGB
temp:1.0



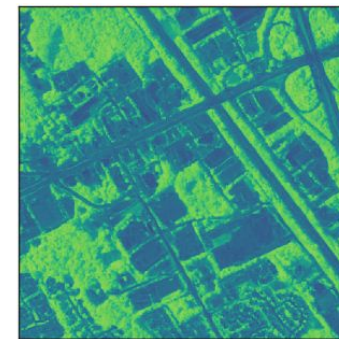
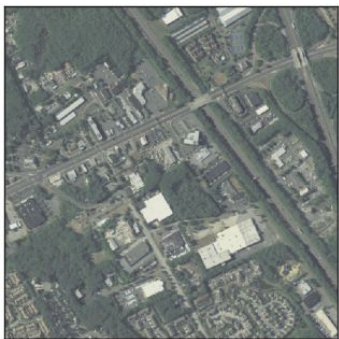
SR - F. Cl.
temp:1.0



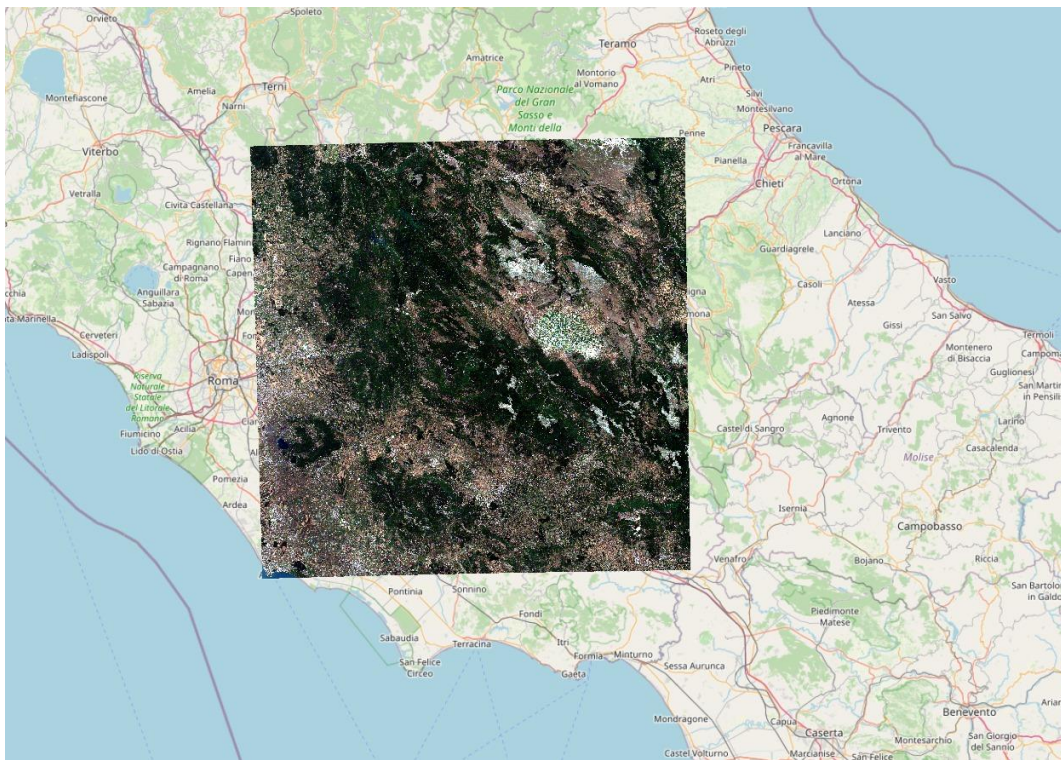
NDVI



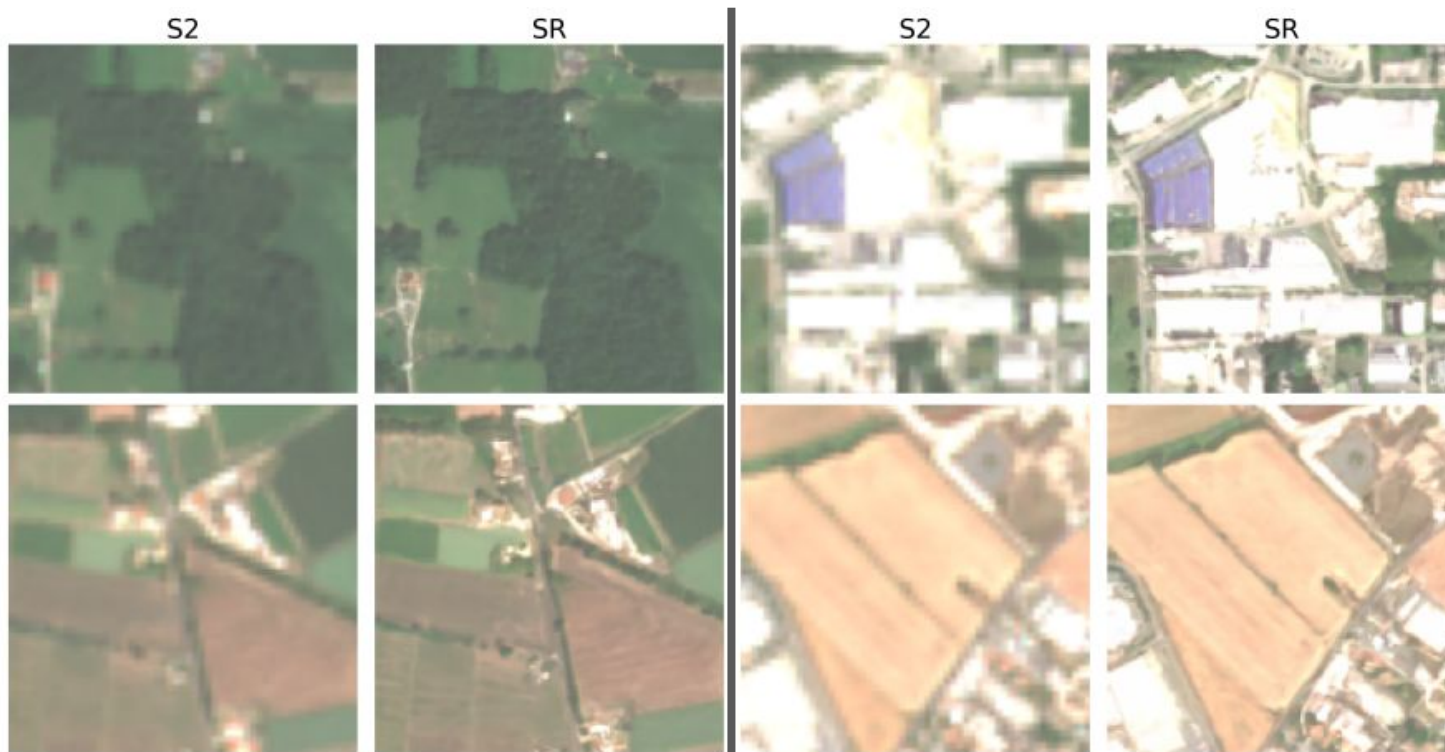
LR (RGB)



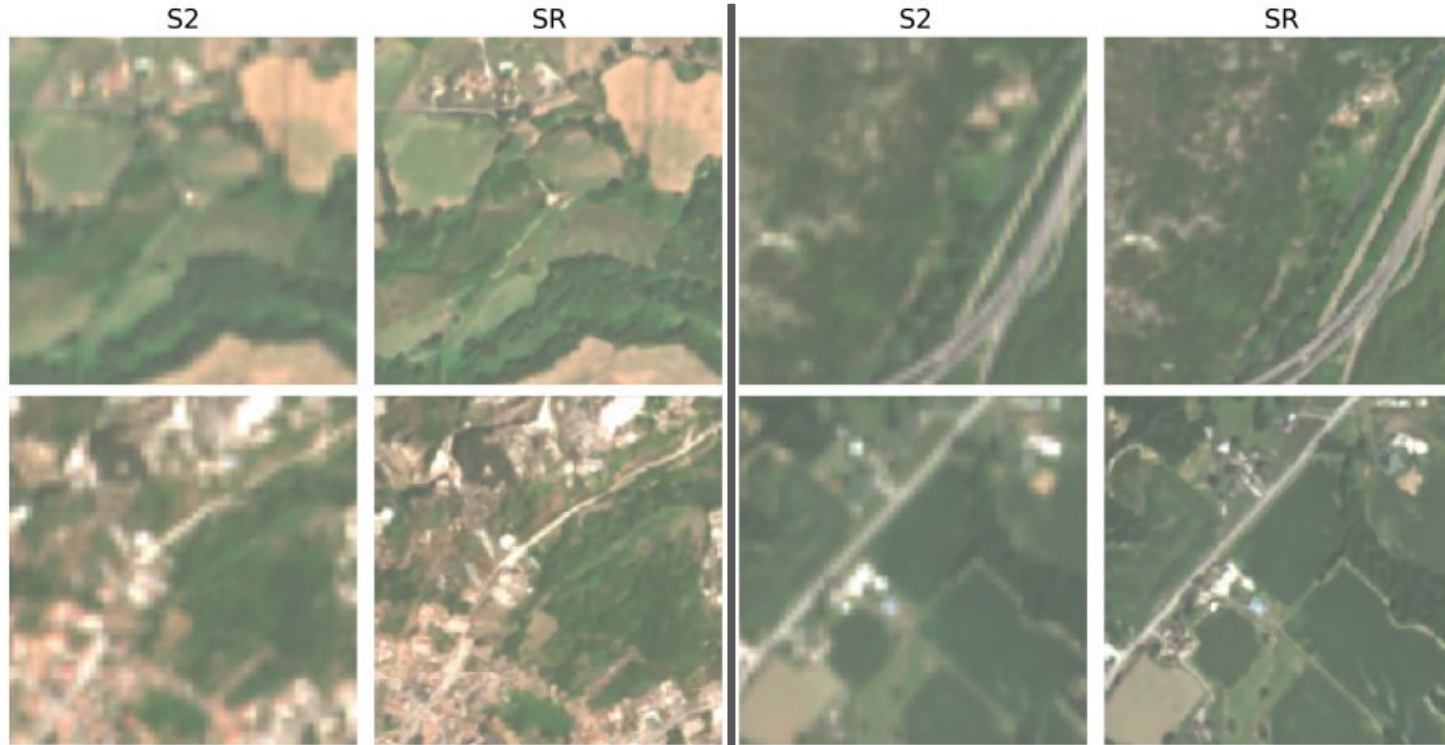
Results - SR - S2 Data



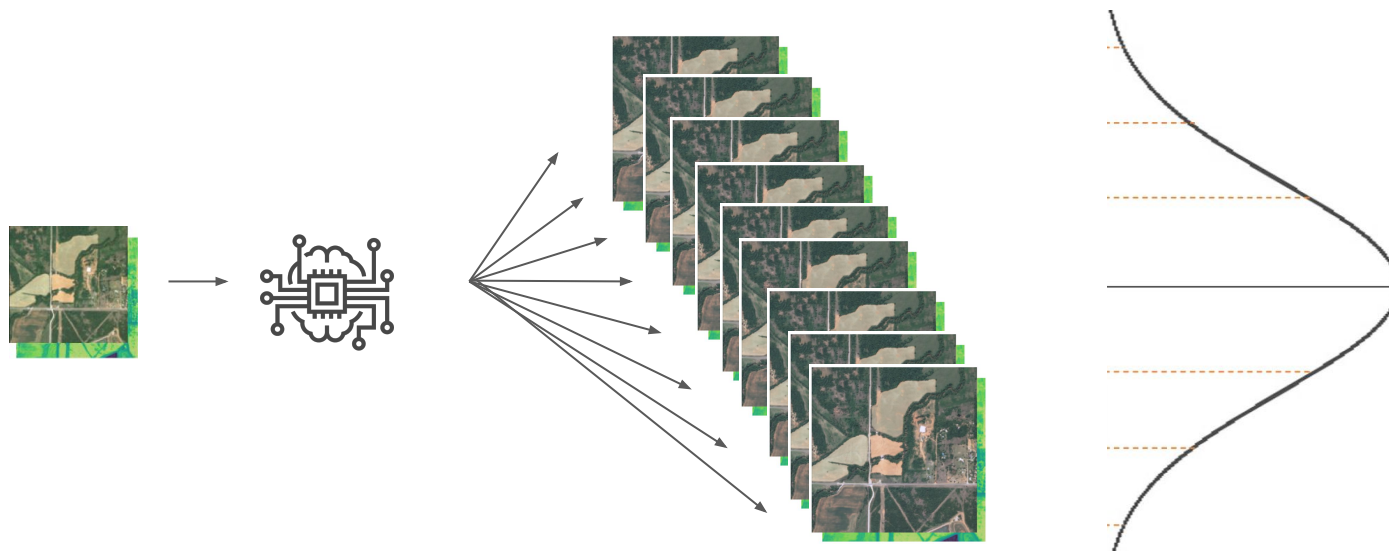
Results - SR - *S2 Data*



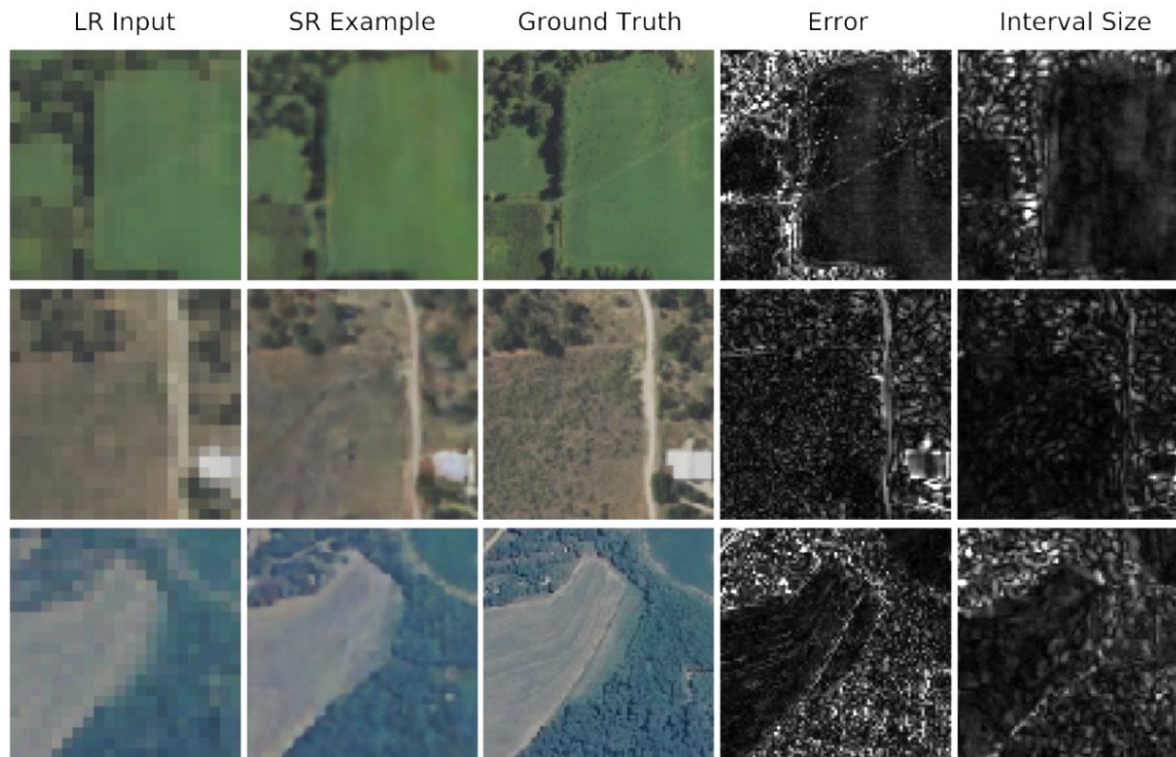
Results - SR - *S2 Data*



Uncertainty



Uncertainty - *Synthetic Data*



Uncertainty - *S2 Data*

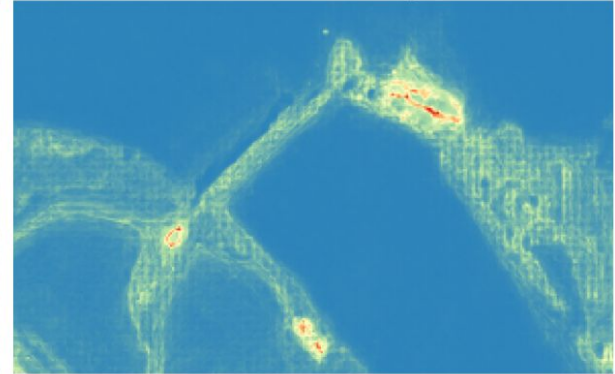
S2



SR



Uncertainty

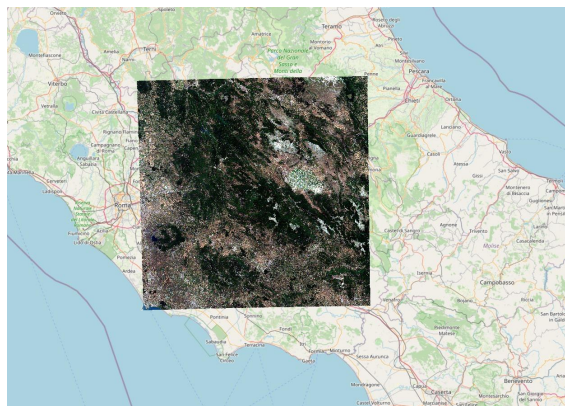
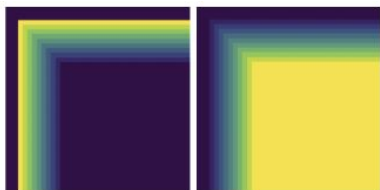
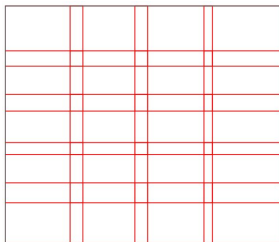


Outcomes

- LDM for 4x SR of multispectral S2
- Model + Weights Package Publication
- Utilities Package Publication

```
model = opensr_model.SRLatentDiffusion(bands=model_type,device=device) # 10m  
model.load_pretrained("opensr_10m_v4_v2.ckpt") # 10m
```

pypi.org/project/opensr-model



github.com/ESAOpenSR/opensr-utils

Outlook

- Better Generalization
- SR of 20m bands
- MISR Implementation

