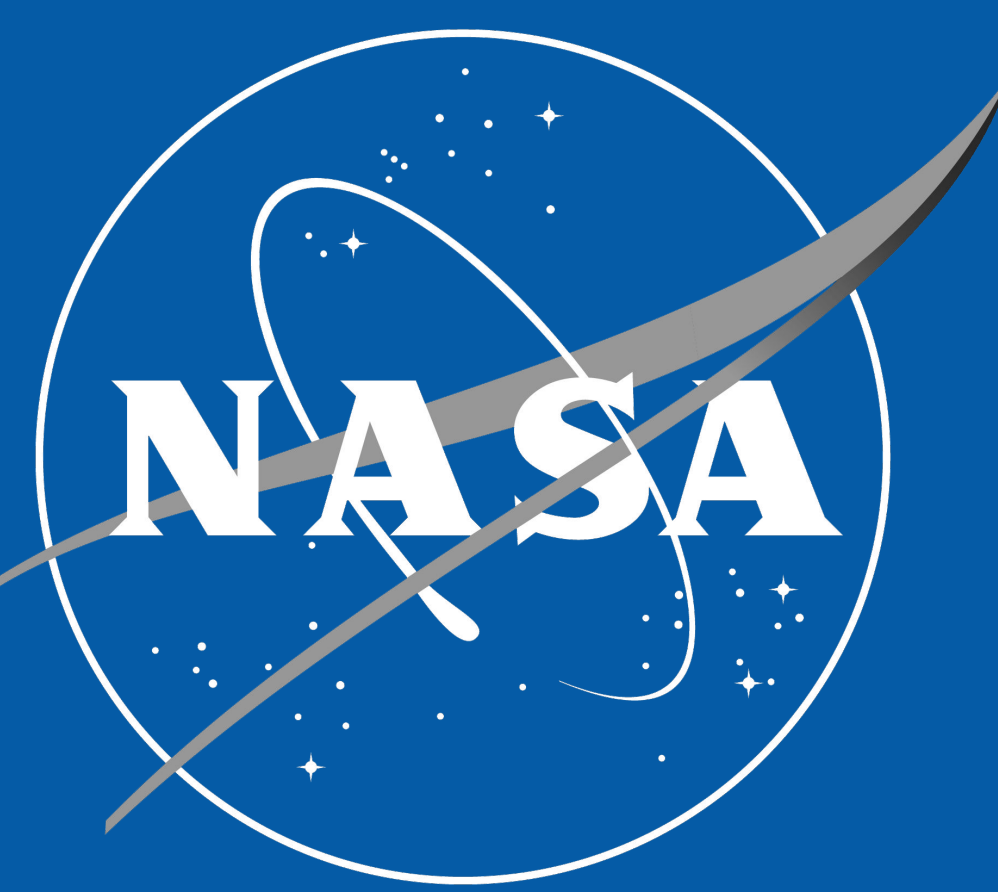




Generative Framework Approach to Match Landsat and Sentinel-2 Data

Sujit Roy^{*1,2}, Madhu Sridhar^{1,2}, John Mandel¹, Brian Freitag¹, Junchang Ju³, Rahul Ramachandran¹

¹NASA Marshall Space Flight Center, Huntsville, AL, United States of America

²The University of Alabama in Huntsville, Huntsville, AL, United States of America

³University of Maryland, College Park, MD, USA

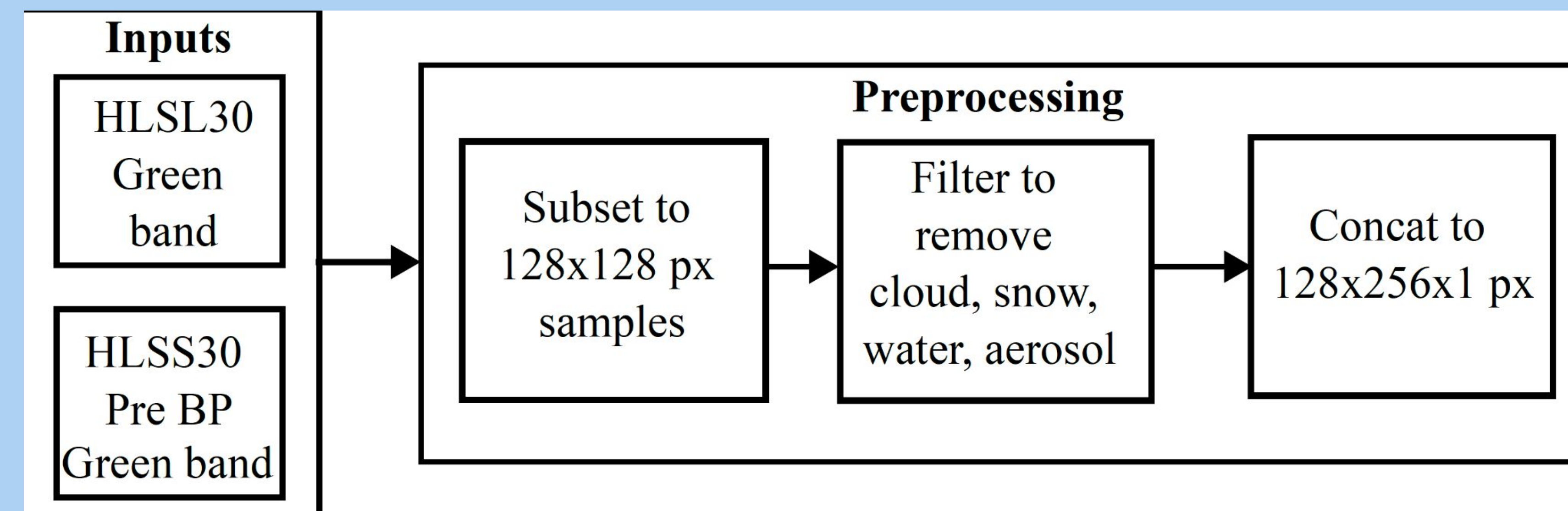


Abstract

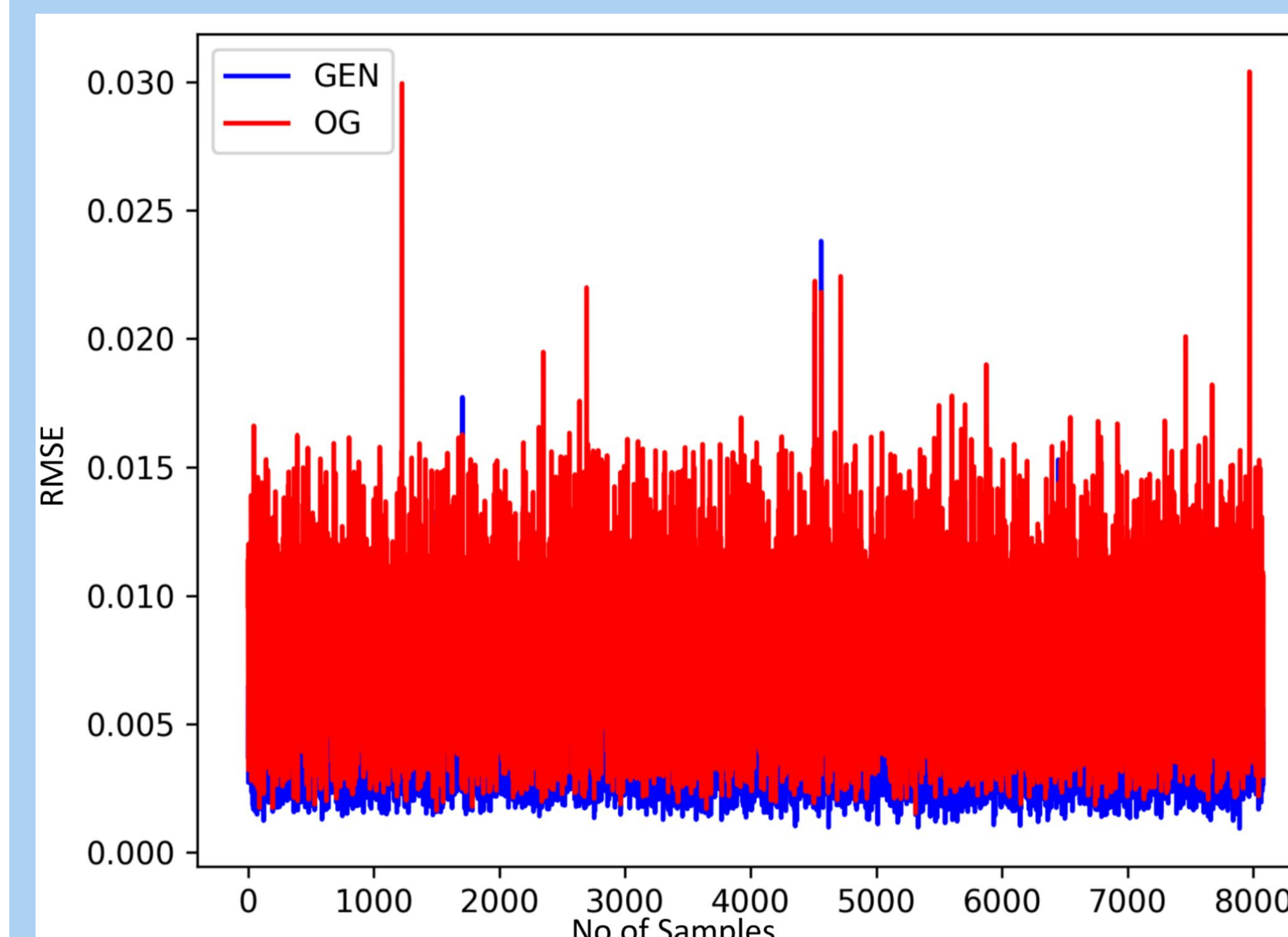
Linear regression and histogram matching-based techniques have been widely used to minimize the surface reflectance difference between two similar satellite observations such as Landsat-8/9 and Sentinel-2A/B products. Generative adversarial network (GAN) has shown promise in the field of image processing for domain or style transfer. In this work we aim to minimize the surface reflectance difference between Landsat and Sentinel-2 products based on GAN.

Background

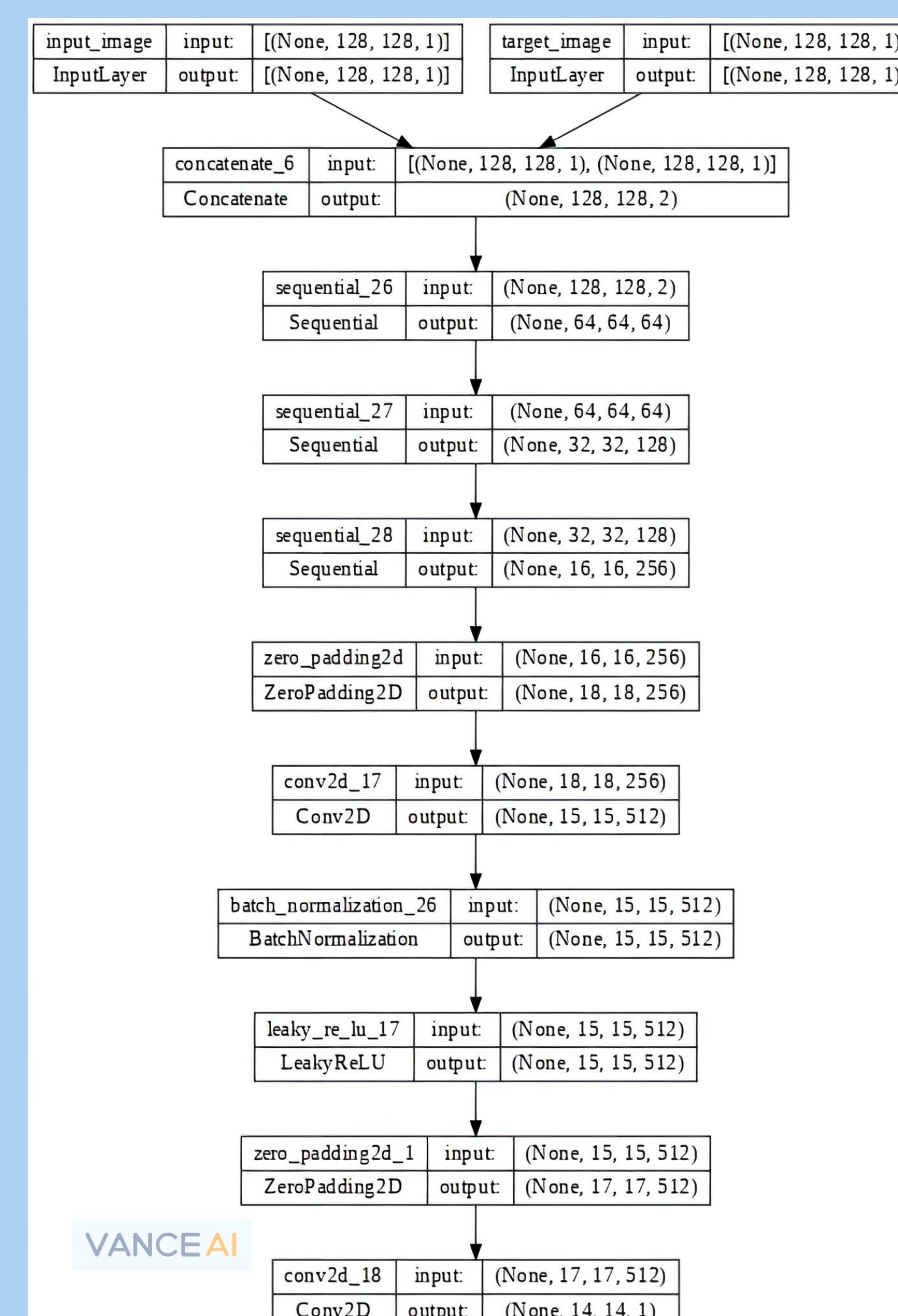
- Remote sensing data is commonly used to build time series to study changes in regions of the Earth. There is considerable research on physics-based atmospheric compensation to convert satellite imagery to surface reflectance[1].
- Researchers have explored the methods to perform bandpass adjustment using machine learning methods like least square solutions, Artificial Neural networks for single and multi-band.
- HLS granule of 3660x3660 pixel from the green spectral band was divided into non-overlapping 128x128-pixel subsamples.
- Retained a subsample only if all its constituent pixels were free of cloud, high concentration of aerosol, snow, and water (indicated by Fmask quality layer value of 64 or 128)
- Resulted in a total of 1562 pairs of training samples out of which 150 were kept for test and the remaining were used in training
- Generator and discriminator architecture described in [2] with minor modifications was used. Generator architecture was in the shape of a U-net, and PatchGan discriminator model was used.
- GAN was trained for around 43000 iterations.



Data Preprocessing Methodology



Root Mean Squared Error After Histogram Matching for Original and Generated Images



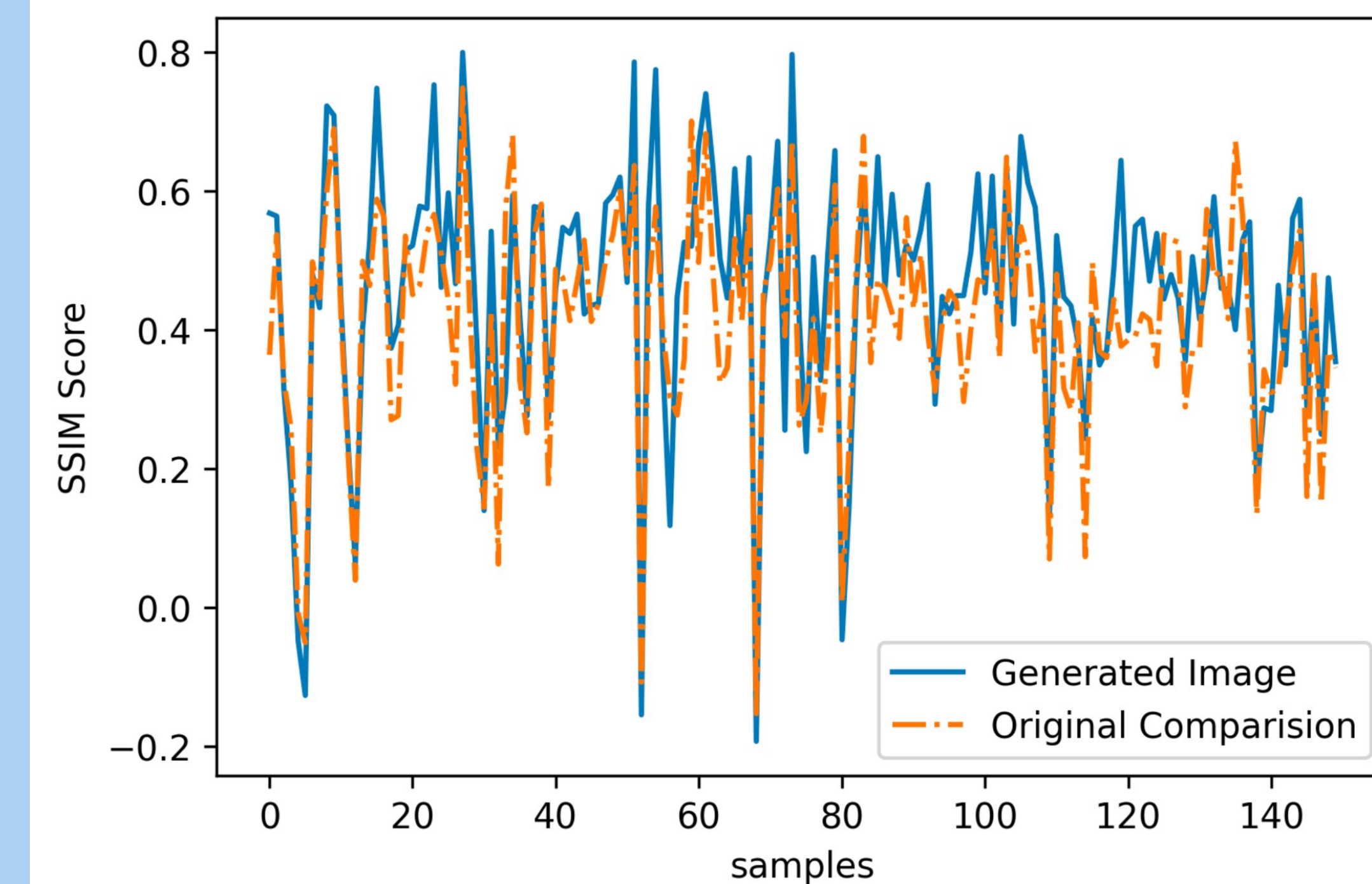
Discriminator Architecture



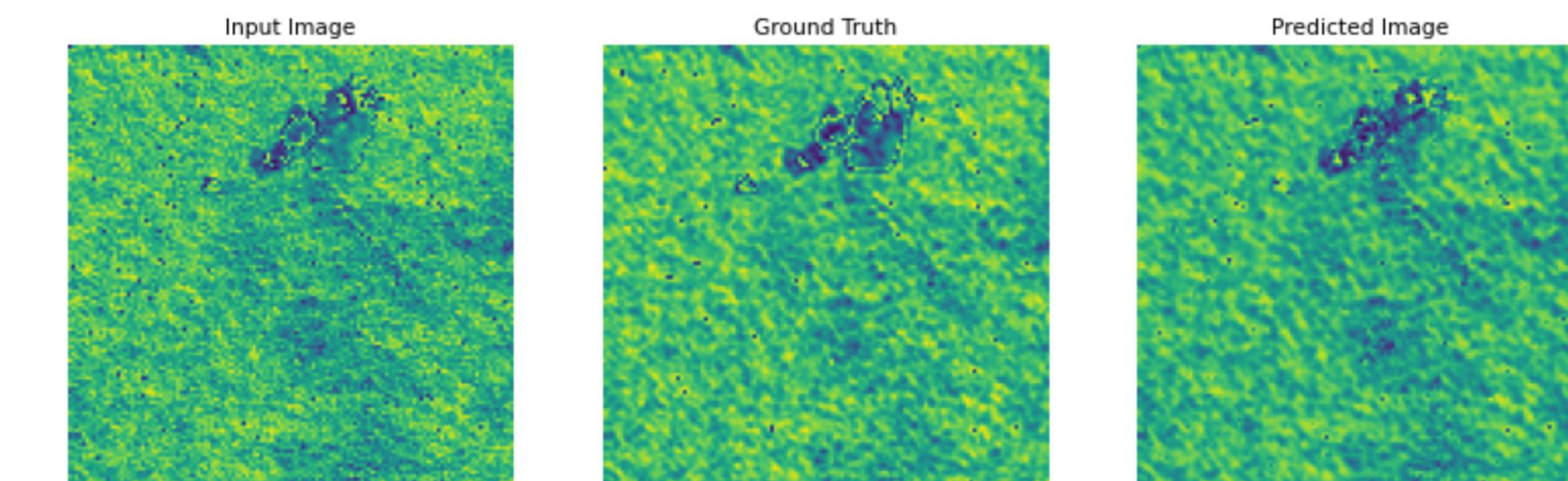
Loss for Generator

Layer (type)	Output Shape	Param #
Conv2d-1	[-1, 8, 64, 64]	136
Conv2d-2	[-1, 16, 32, 32]	2,064
BatchNorm2d-3	[-1, 16, 32, 32]	32
Conv2d-4	[-1, 32, 16, 16]	8,224
BatchNorm2d-5	[-1, 32, 16, 16]	64
Conv2d-6	[-1, 64, 8, 8]	32,832
BatchNorm2d-7	[-1, 64, 8, 8]	128
Conv2d-8	[-1, 64, 4, 4]	65,600
BatchNorm2d-9	[-1, 64, 4, 4]	128
Conv2d-10	[-1, 64, 2, 2]	65,600
BatchNorm2d-11	[-1, 64, 2, 2]	128
Conv2d-12	[-1, 64, 1, 1]	65,600
ConvTranspose2d-13	[-1, 64, 2, 2]	65,600
BatchNorm2d-14	[-1, 64, 2, 2]	128
ConvTranspose2d-15	[-1, 64, 4, 4]	131,136
BatchNorm2d-16	[-1, 64, 4, 4]	128
ConvTranspose2d-17	[-1, 64, 8, 8]	131,136
BatchNorm2d-18	[-1, 64, 8, 8]	128
ConvTranspose2d-19	[-1, 32, 16, 16]	65,568
BatchNorm2d-20	[-1, 32, 16, 16]	64
ConvTranspose2d-21	[-1, 16, 32, 32]	16,400
BatchNorm2d-22	[-1, 16, 32, 32]	32
ConvTranspose2d-23	[-1, 8, 64, 64]	4,104
BatchNorm2d-24	[-1, 8, 64, 64]	16
ConvTranspose2d-25	[-1, 1, 128, 128]	257
BatchNorm2d-26	[-1, 1, 128, 128]	2
Tanh-27	[-1, 1, 128, 128]	0
Total params: 655,235		
Trainable params: 655,235		
Non-trainable params: 0		
Input size (MB): 0.06		
Forward/backward pass size (MB): 2.04		
Params size (MB): 2.50		
Estimated Total Size (MB): 4.60		

Generator Architecture Used for Training



SSIM Comparison After GAN Training



Input, Ground Truth, and GAN Prediction

Takeaways

Presented a generative approach for performing a bandpass adjustment on the Sentinel-2 data to assess the capability of GANs in harmonizing satellite images

- RMSE for the generated data is $0.001 > \text{RMSE} > 0.0001$.
- SSIM score for generated data is higher than in the original data.
- Generator showed that it was able to learn the structure of the data and also transfer the information learned from the Landsat 30 m data

Future Work

We have currently evaluated the model on individual ecosystems and would like to evaluate the performance of GAN in case of a multi-band scenario and also fine-tune it for reducing the RMSE.

References

- Claverie, M., Ju, J., Masek, J.G., Dungan, J.L., Vermote, E.F., Roger, J.C., Skakun, S.V. and Justice, C., 2018. The Harmonized Landsat and Sentinel-2 surface reflectance data set. Remote sensing of environment, 219, pp.145-161.
- Isola, P., Zhu, J.Y., Zhou, T. and Efros, A.A., 2017. Image-to-image translation with conditional adversarial networks. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 1125-1134).